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Production of a Computer Based Lesson Teaching Employees How to Use an Air Data Tester

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ABSTRACT

Production of a Computer Based Lesson
Teaching Employees How to Use an Air Data Tester

Deborah Barker

The Technical Operations branch of Air Canada recently purchased three new Air Data Testers for use in checking and calibrating certain systems and components on the company's aircraft. These testers are of a new generation, operating in a manner significantly different from the ones that they replace. A computer based lesson was developed in order to provide Maintenance personnel quality and timely training on how to operate the new tester. Dick and Carey's (1985) instructional design model was used to guide the design of the lesson. Using company equipment, and Wicat Systems, Inc.'s WISE authoring system, a portion of the lesson was produced. Three types of people participated in a formative evaluation of the lesson. An instructional design expert evaluated the lesson's design and found it to be acceptable. A subject matter expert evaluated the programmed portion of the lesson for technical accuracy. A few minor changes were required. Eight members of the target population worked through the lesson's programmed portion. Oral and written comments were positive. Some technical errors were identified. There was a statistically significant improvement between the pre-test (35%) and post-test (93%) mean scores, indicating that the students learned from the program.

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CHAPTER 1

Introduction

Present Situation

The Technical Operations branch of Air Canada recently purchased three new Air Data Testers for use in Montreal, Toronto and Winnipeg. These testers are of a new generation, operating in a manner significantly different from the ones that they replace.

Maintenance personnel uses the Air Data Tester to check and calibrate systems and components which rely on air data. One such system is the air data system. It supplies the airspeed and altitude instruments with their appropriate values. Other systems and components relying on air data include the ground proximity warning system, stall warning, altitude alert, autoflight, altitude and speed dependent switches, and more. Proper functioning of these systems and components is essential for the safe and accurate operation of the aircraft in flight.

The people qualified to use the Air Data Tester are Certificated Avionics Technicians (CAVTs) and Category 38 Mechanics. (CAVTs are people who hold a license on one or

more type of aircraft (DC-9, B-767, etc.), giving them certain responsibilities and authority for the maintenance of that aircraft type. Category 38 Mechanics are people who are trained to work on an aircraft's avionic items.) There are about 400 people who occupy these positions system-wide. While not all of these people work in Montreal, Toronto and Winnipeg, they are, by virtue of holding those positions, expected to be able to operate the tester.

It is important that the CAVTs and Mechanics be able to properly and efficiently operate the tester. This is not so much because the aircraft systems and components must be accurate, because the employees would not claim the job to be complete until they were certain that all was correct. Proper and efficient use of the tester is important more because of the expense that could result from its ineffective use. The tester itself is considered very durable, with functions built into it so that damaging it would be difficult. However, it is possible to damage some instruments on the aircraft were the tester to be used improperly when connected to them. Another circumstance which could make use of the tester expensive is that in which the user is inexperienced and inefficient with it. Taking an excessively long time to complete a task could result in flight delays.

In addition to its financial benefits, ensuring that the employees quickly learn to operate the tester should enhance employee satisfaction. It can be very frustrating to spend time figuring out how to use something if the schedule assumes familiarity with that item. If the employees can become proficient in the use of the tester before they have to use it to complete an actual job, their level of satisfaction in performing the job is bound to be higher than if they had to learn to use the equipment on the job.

Some CAVTs have already been shown the operation of the tester. A representative from the manufacturer came from England to give a demonstration to a half dozen people in Montreal, some of whom were CAVTs. This demonstration was done in the cockpit of an aircraft with Air Canada personnel standing around the representative while he operated the tester.

Some other CAVTs have been exposed to the tester during recurrent training sessions. (Recurrent training is training that is held periodically to keep CAVTs up-to-date with the aircraft on which they hold licenses.) Exposure consisted of a lecture on how the tester operates. The more recent training sessions have included a video, made in-house, showing parts of the operation of the tester. In each of these sessions, students were given a manual to take

home with them for reference.

There are a number of problems associated with using recurrent training sessions to teach employees how to use the Air Data Tester. Two points of detail about recurrent training are noted so that the problems with it can be explained:

1. Recurrent training is a week-long classroom session held once every three years for each aircraft type. It is given to CAVTs holding a license on that particular aircraft type. If, for example, a CAVT holds a licence on two aircraft types - say, B-747 and A320 - then he or she would attend recurrent training once every three years for the B-747 and once every three years for the A320.

2. The content of the training sessions varies according to the priorities the company has at the time. The instructors must determine what topics are of highest priority and then cover these topics in the time that they have available to them.

Recurrent training is not offered to Mechanics. This is one of the major reasons why it is not appropriate to link the teaching of the Air Data Tester with recurrent training.

Many of the people who must use the tester will never have the opportunity to be trained on its use.

Another difficulty is with the timing of the recurrent training sessions. Suppose a CAVT is licensed on only one aircraft type. Suppose also that the last recurrent training session for this aircraft type was a few months ago, before the new Air Data Tester had been purchased. This CAVT will have to wait three years before receiving training on the tester. The chances are high that he or she will have had to use the tester before that time.

In addition to having to wait three years, there is no guarantee that the Air Data Tester will form part of the curriculum of that next session. It all depends on where the tester fits on the instructors' priority lists.

The number of licenses a CAVT holds is also a problem. If a CAVT holds three licences, for example, he or she may be trained on the use of the tester three times, whether he or she needs the training or not. This is not cost effective.

Still another difficulty lies with the quality of the training. It would be ideal to allow the opportunity for each student to practice using the tester. However, this is not practical in the classroom situation. The tester only

works when attached to either the aircraft or special equipment found in a standards room (a room where special tests on equipment are conducted). Scheduling, and efficient use of everyone's time, becomes a real problem. Also, an actual need for the tester on the floor takes priority over its use for training purposes, so the tester could become unavailable without prior notice.

Alternatives

The question becomes how to get the employees to learn to use the tester in a cost effective manner. One alternative is to distribute the training manual to employees and have them read it. This is inexpensive but presents some problems. One is that these employees are already sent a lot of written material (newsletters, memos, etc.) that they are expected to read to optimize th 'r performance on the job. A fifty page document to be read on free time will probably not be well received. Also, reading a document on how to operate something is far removed from actually operating that item. Transfer of learning to the actual job is not optimized.

Another alternative is to plan stand-up training sessions that are not linked to existing structures (such as recurrent training) so that they can be offered to the

complete target population. This would require, however, a shift in present policy. In addition, it would be fairly costly because people would have to travel to receive (or give) less than one hour's training. Also, while the classroom training may improve the student's understanding of the operation of the tester, the types of practice that can be offered are somewhat limited.

A third alternative is to use the computer to deliver training on the use of the Air Data Tester. This is an alternative which holds much promise.

The computer based training option

The company has an extensive computer system set up for the training of Maintenance personnel. There are presently twenty workstations across the country - eight each in Montreal and Toronto, and two each in Winnipeg and Vancouver. There are plans for more installations in some of these areas, as well as in new locations.

This system solves the problems previously mentioned because it can deliver a self-contained course (i.e., a course which does not require a human instructor) on the Air Data Tester to all members of the target population. It can permit students to schedule training at a time that is suitable for

their needs and that accommodates their other commitments. And it can allow the student to train as often as deemed necessary.

The computer brings other benefits to this situation as well. One is that it offers much flexibility in the instructional strategies that can be used. For example, practice exercises can be developed that let the student use the tester as if it were real. This increases the potential that the student's learning will transfer to the job.

Another benefit is that the computer accommodates individuality. Each student can proceed at his or her own pace, working with the course as much or as often as he or she feels is necessary. On the software side, the course can be designed to accommodate individuality through careful planning of such issues as learner control of the program, responses to student input, etc.

The computer based method of delivery has some cost implications. Considering the number of people to take the course, the computer based method of training is estimated to be about 7% more expensive than the stand-up method presently being used (Appendix A). The avoidance of one flight delay, or the prevention of damage to one instrument, can more than recuperate this difference in cost. In

addition, the computer based method offers value that is not expressed in monetary terms and that is not found in the stand-up method. Therefore, the computer based course is the one of choice.

The company agreed to put the course on computer. To do this, the project was undertaken by the author, who designed, developed (with a programmer) and evaluated the course. A subject matter expert was involved to offer technical expertise on the Air Data Tester's use and operation.

Course Goal

The Air Data Tester can be used for many maintenance functions. The various parameters on the tester are set to different values depending on the needs of the situation. Also, the output obtained from the Air Data Tester must be interpreted and acted upon according to the particular situation.

To develop a course which covers all possible maintenance functions and interpretations of output would be a tremendous project spanning many job tasks and applications. On the other hand, since the tester is operated in the same manner, no matter what the task at hand, a course which

covers the operation of the tester is manageable and worthwhile.

If the employee can be taught how to use the Air Data Tester so that the tester becomes a tool which is used "automatically", then he or she can concentrate on the other parts of the job task and function more effectively and efficiently to complete the task. The employee's job is to make the aircraft serviceable, and the Air Data Tester is one of the tools he or she must use to render the aircraft serviceable. The Air Data Tester, then, is a tool for a job task, not really the job task in itself.

With this orientation in mind, the goal of the course can be stated in the following manner:

The student will be able to:

(1) set up the Air Data Tester for use
(2) operate the Air Data Tester
(3) prepare the Air Data Tester to be put away after use.

To operate the Air Data Tester means to:

(a) access and page through the on-line help, returning to the main menu when done.

(b) set the parameters which are used for all non-pre-programmed operations to specific values.

(c) perform a leak check using two different methods.

(d) properly vent the system.

(e) perform all Air Canada-customized pre-programmed operations.

The student should be able to use the tester without using the paper documentation that presently exists. The help features should be sufficient to remind the employee of points he or she may have forgotten.

No time limit has been assigned to any part of the goal. Although the aim is that the student efficiently use the tester, it is more important that he or she concentrate on using it correctly and safely. Efficiency as defined here relates to avoiding trial-and-error procedures rather than to pure time on task.

The Air Canada-customized, pre-programmed operations mentioned in section (e) above are not yet available for use. While this section ultimately forms part of the goal, it does not form part of this project. When this feature

becomes available, it will be incorporated into the course.

CHAPTER 2

Literature Review

Effective communication between the computer and the student is essential if efficient learning is to take place. The computer should be easy to use and its messages should be readily understood.

Before design and production began, the literature was reviewed to obtain guidelines concerning how to use the capabilities of the computer to design effective communication. In particular, functional and screen design considerations were sought. The literature presented the following information:

Functional Considerations

Learning is enhanced when the features of the computer are used in such a way as to make the system virtually transparent to the student. A transparent system allows the student to concentrate on the course content rather than on the mechanics of the system (DeJoy & Mills, 1989; Galitz, 1989). It also enhances student acceptance of a system (Galitz, 1989). Ease of use is particularly important when the student is expected to work alone with the system.

Transparency is partly achieved through consistency. A course should look, act and feel the same from beginning to end (Galitz, 1989). Consistent screen displays allow a student to always know where to look for information. Consistent methods assist a student in quickly and easily selecting his or her next course of action.

The efficiency with which a student selects his or her next course of action is also dependent upon the directions that are supplied to him or her. Clear instructions or on-line cues are essential to guide the student through the program (DeJoy & Mills, 1989; Caffarella, 1987; Duin, 1988).

The easier the modes of interaction with the computer, the more transparent the system will be to the student. For example, pressing a single key to execute an action is much easier for a student than is typing a long command (Caffarella, 1987).

Finally, a transparent system is free from programming errors - not only in normal situations but in unusual ones as well. A student may respond to the computer in unexpected ways. The program should be able to supply appropriate feedback to the student, leaving him or her in a position of knowing what he or she can do next (Hazen, 1985; Gold, 1984; Caffarella, 1987; DeJoy & Mills, 1989).

Screen Design Considerations

The computer screen can present information in many different ways, using many different features. Screen displays which are planned carefully and which follow generally accepted design guidelines help to ensure proper interpretation of information. This, in turn, promotes student satisfaction with the computer system and effective learning situations (Rambally & Rambally, 1987; Heines, 1984).

A screen should be designed so that it is clear, simple and understandable. The various features available for use (such as graphics, colour, text and so forth) should be combined in such a way as to accomplish this goal (Galitz, 1989; DeJoy & Mills, 1989).

The combination of features can offer many interesting effects. However, care must be taken to ensure that these effects do not overshadow the subject matter and instructional intent of the course (Heines, 1984).

The following have been offered as guidelines for creating effective screen designs.

Relevant information

Screens should be designed so that the student is able to focus on important information (Alessi & Trollip, 1985; Bork, Franklin, Von Blum, Katz, & Kurtz, 1983; Galitz, 1989). This can be done by removing unnecessary information from the screen (Bork et al., 1983; England, 1984a). The message becomes clear and simple.

The important information can also become the focal point by use of attention-getting features, such as colour, size, blinking, or other effects (Galitz, 1989; Jay, 1983).

Composition

The composition of a screen should be such that it presents only one idea at a time. This will help to prevent information overload for the student (Kearsley & Hillelson, 1982).

The screen should also be composed in a way that makes it neat, attractive, and well spaced. This is done by taking into consideration such principles as proportion, sequence, unity, balance and emphasis and using them to create a clear, simple design (Nelson, 1981; Galitz, 1989). Benefits of doing this include improved screen interpretability

(Caffarella, 1987; Gold, 1984), a decrease in the time it takes to search for relevant information (Galitz, 1989), and reduced eye fatigue (Kearsley & Hillelson, 1984).

Screen components

A screen should be divided into functional areas to provide consistency. A specific area should be used for graphics, another should be used for text, another for error messages, and so forth (Heines, 1984; Reilly & Roach, 1986; Galitz, 1989; Rambally & Rambally, 1987; Olson & Wilson, 1985).

This can be done while still maintaining flexibility to adapt the screen to the needs of the situation. While the functional areas should remain in the same relative position on the screen, they can be expanded or contracted to almost any size (Heines, 1984).

Eye movement

The North American culture reads from left to right, top to bottom. A screen should be designed for the same general flow of viewing (Alessi & Trollip, 1985; Galitz, 1989).

As the eye moves from left to right, top to bottom, it is attracted to certain features. It moves from large to small

objects, from bright to dull colours, from odd to regular shapes and from animate to inanimate objects (Taylor, 1960). This natural attraction should be planned carefully to send a clear message to the student.

Show versus tell

The amount of text on a screen should be kept to a minimum. Large amounts of text are generally unappealing (Bork et al., 1983) and can be difficult for the student (Caldwell, 1980; Jay, 1983).

Graphics are often very effective in areas where text is cumbersome, sending clear messages which can be quickly understood by the student. They should be used as much as possible in this manner. Other features of the computer, such as selective erasing, rewriting, flashing and animation can also be used to reduce the amount of text required on a screen (Caldwell, 1980).

Graphics for learning

Graphics should be included on a screen only when they have an instructional purpose for beinq there (Bork et al., 1983; Caffarella, 1987). Otherwise, they may hinder the intent of the message or the efficiency with which the message is

conveyed.

Symbols

If symbols or icons are to be used, they should be used for concrete concepts as opposed to more abstract ones. Students will recognize and learn them more easily. They should also be used in limited quantity as the student should not have to spend a lot of energy learning them (Galitz, 1989).

Colour

Colour's ability to focus attention, differentiate between items, and add clarity (Caldwell, 1980; Jay, 1983; England, 1984b) is very useful, particularly when space on the screen is restricted (Galitz, 1989; England, 1984b). However, as with all of the computer's features, colour must be used carefully. Conservative use will enhance the display (Brown, Burkleo, Mangelsdorf, Olsen, & Williams, 1981; Galitz, 1989).

For easy visibility, a screen's colours should have good contrast and they should differ in brightness. In addition, displaying several highly visible, extreme colours (such as yellow and purple) at the same time should be avoided as the

eye cannot focus on many colours at one time (Galitz, 1989).

Cuteness/Decorations

What is cute to one person may be annoying to another. Those students who do not see the humour in the cute features incorporated into the lesson may find them degrading, which may result in the students hesitating to apply themselves to the subject matter. Therefore, cuteness should always be avoided (Heines, 1984).

In addition, graphics which draw slowly can be tiresome and can interrupt the flow of the lesson. The same holds true for decorative graphics which are repeated throughout the lesson. Both should be avoided (Hazen, 1985).

Text

Text readability is a very important feature of a screen display. Readability is accomplished not only by the words that are chosen but also by how these words are presented.

Readability is enhanced when text is given a clutter-free appearance. This can be achieved by leaving much of the area on the screen blank (Bork et al., 1983), or by placing the text on a series of screens rather than crowding it onto

a single display (Rubens & Krull, 1985). It can also be achieved by breaking up the text on a screen (Caldwell, 1980) such as by leaving blank lines between paragraphs (Galitz, 1989; Rubens & Krull, 1985).

Limiting the number of words on a line is another way to enhance text readability. It reduces the amount of eye movement required by the student, putting less strain on the eyes (Heines, 1984; Bork et al., 1983).

Upper and lowercase letters should be used on the screen (Heines, 1984; Galitz, 1989; Olson & Wilson, 1985). A text of all capital letters is more difficult to process (Heines, 1984).

Text is easier to read when words are not hyphenated to place part of them on one line and the rest of them on the next line (Galitz, 1989; Bork et al., 1983). It is also easier to read when punctuation is avoided with abbreviations, mnemonics and acronyms (Galitz, 1989).

Text readability can be enhanced by using features such as boldface, reverse video, rotation, size, and others. However, once again, overuse, or poor use, of these features can detract from the message instead of enhance it (Heines, 1984). Careful thought must be given to the needs of the

situation before any feature is used.

In conclusion, functional and screen design considerations play an important role in the success of computer based instruction. Following the guidelines offered in the literature, and using common sense in applying these guidelines, will help to ensure an effective product.

CHAPTER 3

Method

Design and Development

The first step in the design and development of the Air Data Tester course was to produce a video, demonstrating how to operate the tester, for reference purposes. This was done because the accessibility and availability of the Air Data Tester was somewhat limited. The tester was located in the maintenance hangar, which was fifteen minutes away from the computer based training development site and the work location of the subject matter expert. To operate the tester, it had to be hooked up to an aircraft or to special test equipment. In either instance, special arrangements had to be made to hook up, and use, the tester.

At the same time as the video was produced, photographs were taken of the tester. These were used for reference purposes as well, particularly when developing the graphics for the program.

With the manufacturer's documentation, a video and photographs on hand, the actual design of the course began. Dick and Carey's (1985) instructional design model was used

as a guide for the design process. The model is diagrammed in Appendix B. Its behavioural orientation (Dick & Carey, 1985) and its validated effectiveness in the production of a small course (Andrews & Goodson, 1980) made this model an appropriate one to use in this situation.

Instructional Analysis/Entry Behaviours

The goal of the Air Data Tester course requires the development of intellectual skills. Most of the skills are procedural in nature, and the remainder are background information required to carry out the procedures.

A combination analysis (Jonassen, 1989) was carried out to identify the skills and sub-skills needed to achieve the instructional goal of the program. The process consisted of documenting the procedures associated with the goal. Then, the subordinate skills required to accomplish each step of the procedures were identified and recorded in a hierarchical format.

Once the analysis was complete, the entry behaviours (i.e., the skills the students are expected to possess when they begin the Air Data Tester course) were identified. The remaining skills formed the content of the Air Data Tester course.

It was found that the information available in the reference materials and the nature of the program's content made a review of the entire instructional analysis with the subject matter expert unnecessary. Instead, a few parts of the analysis were reviewed with the subject matter expert, and the other parts were verified through review of the reference material and questioning the subject matter expert when required.

Performance Objectives

The course goal and the instructional analysis were used in the development of the performance objectives. These objectives are presented below:

Set-up.

(1) Given a simulated Air Data Tester, the student will correctly identify the proper set-up of the tester for use.

(2) Given the self-test sequence on the Air Data Tester, the student will correctly identify whether or not the tester is functional.

Operate.

(3) Given a simulated Air Data Tester, the student will correctly operate the Air Data Tester. To operate the tester means to:

(a) access and page through the on-line help, returning to the main menu when done.

(b) set the parameters which are used for all non-pre-programmed operations to specific values.

(c) perform a leak check at specified pressure values, using the method which requires manual calculation of the leak.

(d) perform a leak check at specified pressure values, using the method in which the pitot and static leak rates are automatically calculated.

(e) nudge the altitude or airspeed up or down.

(f) abort from a menu option to the main menu, leaving the pressures within the system intact.

(g) correct an entry error.

(h) correct an error made on a previous line of the tester's display page.

(i) enter and exit menu option 9.

(j) enter and exit menu option 0.

Prepare tester to be put away after use.

(4) Given a simulated air data tester, the student will correctly perform the operation(s) required before the power is turned off and the set-up disassembled.

Testing

Dick and Carey (1985) suggest developing test items at this stage in the design process - after the development of the performance objectives and before the elaboration of the instructional strategy. This helps to ensure that the performance required in the test items matches that required in the objectives. In addition, the nature of the test items provides some information as to the instructional strategy that should be chosen for the course.

The Air Data Tester course was developed in a slightly unique manner at this point in the design process. This

course is not one that the company requires be taught. Instead, it is one that the company feels is useful to offer. Therefore, employees will take the course on a volunteer basis only. Since a voluntary course implies that no formal test be given to the student, none was planned for the program.

On the other hand, the course was planned so that there would be three components to it:

- the Introduction, which explains the purpose of the course and how to use the program,

- the Instruction, which teaches the students how to operate the Air Data Tester, and

- the Exercises, which gives students real life scenarios with which to practice operating the tester.

The Exercises component is identical to a testing situation, except that no scores are attached to the exercises. Because it is basically the same as a test, it was the first component of the course to be storyboarded.

While the Exercises component of the program was the first to be storyboarded, it was necessary to make instructional

strategy decisions to guide the creation of this component. The Exercises component is, in reality, part of the instructional package, and so it was desirable to make the overall look and operation of the Exercises component consistent with the look and operation of the Introduction and Instruction components. Therefore, in this project, the instructional strategy was developed before creating the "test".

Instructional Strategy

The instructional strategy selected was that of a tutorial combined with elements of a simulation (Godfrey & Sterling, 1982). The strategy was designed on a course level and on a segment level. Together, the two levels describe how a student works with the program to achieve the objectives.

Course Structure.

The overall structure of the Air Data Tester course is presented in Appendix C. The program is designed for self-study. The student sits at a workstation, takes the course, and leaves when finished with the program. The first time the student takes this course, he or she should start with the Introduction. This is standard for all courses on the system which have an Introduction component, and students

are informed (in person and/or in writing) of this recommended course of action before they begin a lesson. To select the Introduction option on the Main Menu, the student touches, or uses a mouse to touch, that option on the screen.

The Instruction and Exercises components of the course are both divided into segments. The size of the segments and their sequence were chosen according to information obtained from the instructional analysis and according to the logic of presenting information in a start-to-finish format (i.e., start up the tester, operate it, and then prepare it to be put away). In both the Instruction and Exercises sections, it sometimes did not matter which segment was presented first. For example, the segment entitled "Leak Check - Automatic Calculations" could have been presented before "Leak Check - Manual Calculations". In these cases, the sequence was chosen by preference and common sense.

There are several benefits to segmenting the program into smaller parts. One is that it provides some organization to the material so that the student can more easily learn from it (Bonner, 1982; Grabowski & Aggen, 1984). Another is that segmentation gives the student more control over his or her instructional experience. This can be a motivating factor for the student (Alessi & Trollip, 1985) and it allows the

student to be more involved with ensuring the objectives of the program match his or her own objectives (Bonner, 1982). In addition, a segmented program is better able to meet the different needs of the students (Caffarella, 1987; Spille, Galloway, & Stewart, 1985). In the case of the Air Data Tester course, the target population consists of people with varying exposure to the Air Data Tester. Some students may want to skip segments, while others may want to go through the entire program. Also, on repeated visits, a student may want to review only certain segments of the program. The segmented feature allows the student to find, and get to, the areas of interest easily.

While some learner control over the sequence is a positive feature, it is important to balance this control with appropriate guidance. Students who are unfamiliar with the learning tasks of the program benefit from a recommended course of action (Hannafin, 1984). This has been seen to be true with other computer based training programs at Air Canada. Some students find it very important to be informed of the best way to proceed. Not only does this add to the comfort level of the student, but it helps the student create an efficient learning experience.

In the Introduction component of the Air Data Tester course, the student is advised that the order of options shown on

the Instruction and Exercises menus is the recommended sequence to follow. The program itself is designed such that the student automatically follows this sequence unless he or she deliberately chooses another one. This is done through the program's navigation capabilities. Once the student selects a menu option, he or she goes from one segment to another without returning to the menu. For example, suppose the student selects the third option on the Instruction menu. He or she then works through the frames in that segment. After going through all the frames in that segment, the student is automatically shown the first frame in the fourth segment. After the student reaches the last frame of the last Instruction segment, he or she is automatically shown the first frame of the first Exercises segment. The student works through all the exercises. Once the last frame of the last Exercises segment has been reached, the student returns to the Exercises menu.

The program is set up to automatically route the student from one segment to another so that the student is able to concentrate on the course content rather than on selecting menu items. The student who wants to move from one segment to another can easily do so. From any frame in any segment, the student can return to a menu and select another menu option. If the student is in the Instruction component, he or she will return to the Instruction menu. If the student

is doing the exercises, he or she will return to the Exercises menu.

Segment Structure.

The screen layout for the non-menu frames in the course is shown in Appendix D. Graphics are presented on the left side of the screen and text on the right. A heading on the top right side of the screen tells the student in which segment of the course he or she is presently working.

The arrows at the bottom right of the screen allow the student to navigate within the program. When the student touches the arrow which points to the left, he or she is presented the information on the previous frame. When the student touches the arrow which points upwards, he or she is presented the Instruction or Exercises menu, depending on the component in which the student is presently working. Both the "left" and "up" arrows are present on every frame in the course. This allows the student to review material, to move to another part of the course, or to exit the course at any time.

The arrow which points to the right is displayed only on certain frames. It provides one of the two ways a student can move forward in the course. When the function of a

frame is only to present information for the student to read, the right arrow appears on the frame so that the student can move to the next frame when ready. When the function of a frame is to ask the student to perform a particular task, the right arrow is not displayed on the frame. The student must perform the task in order to move on.

The right arrow is used as little as possible in the course. A student should play an active role in the learning experience, as this improves the learning process (Jonassen, 1985; Bork, 1985; Caldwell, 1980; Pritchard, Micceri & Barrett, 1989). The right arrow places the student in a passive mode, and so it is used only when it is absolutely necessary to explain a concept. When not using the right arrow, the student works with the course content. Most of the time, this work consists of using the tester in the same way the employee will use it in real life.

The student operates the tester in incremental steps in the course. At first, the student is shown how to perform certain tasks, and the student performs these short tasks to see what actually happens on the tester. As the instruction continues, the student combines his or her previously acquired skills to perform longer procedures with the tester. This provides some meaningful repetition for the

student and concurrently builds the student's ability to perform an entire procedure. In the Exercises portion of the program, the student performs procedures in their entirety.

The quality of the feedback that is given as the student works with the course material impacts the effectiveness of the learning. Feedback should be timely, specific, informative (Cohen, 1985; Wager & Wager, 1985) and positive in tone (Smith, 1989; Hazen, 1985).

In the Air Data Tester course, the feedback given to the student depends on the student's actions. If the student performs a task successfully, the tester reacts as it would in real life and the student moves on in the program. If the student performs the task unsuccessfully, then feedback in the form of text appears on the screen and the student is asked to re-do the task. The text that is presented is specific to the particular action that the student had taken.

Storyboarding

With the details of the course and segment structures planned, the development of the storyboard was possible. The Exercises component was storyboarded first, the

Instruction second and the Introduction last. The Exercises and Instruction components were created before the Introduction because their development could point to items that should be included in the Introduction.

A copy of the storyboard format is presented in Appendix E. This is a modified version of Air Canada's standard storyboard format. The company's standard format is the page shown on the left side. There was not enough room on this page to record all the necessary graphics, programming and feedback specifications, and so an additional page was used for this purpose (the page on the right). The left and right pages were placed face-to-face in a binder so that as much information as possible relating to a particular frame would be visible at once. Sometimes the graphics, programming and feedback specifications were so lengthy, several pages were used and placed one behind the other on the right side.

The Instruction storyboard was shown to the subject matter expert for verification of technical content. A few adjustments were made to the storyboard.

The other two storyboards were not shown to the subject matter expert. The Exercises storyboard was not shown because all the technical content covered in this component

was present in the Instruction component. Asking the subject matter expert to review technical content twice would have been a waste of his time. The Introduction component was not shown to the subject matter expert because it did not contain technical content that had to be verified.

Production

The Air Data Tester course was produced on company equipment using the WISE authoring system from Wicat System's, Inc. The colour palette was created and then actual production of the course began.

While the Exercises component was the first to be storyboarded, it was not the first to be produced. Rather, the Instruction component was the first one programmed because it was the most critical in terms of value to the company.

As the production progressed, it became evident that the size of the program was large. It was decided that, for the purposes of this thesis, only a portion of the course would be programmed. A diagram of the part of the course that was produced is presented in Appendix F. This section was chosen because it represented the bulk of the course content

and it was a discrete chunk of information. It was also a section of the program which still permitted an effective formative evaluation to be implemented. An added benefit was that this section involved the least amount of graphic work.

All the graphic and text items were created alone. The programming, however, was done with a programmer. The programmer was not an Air Canada employee and so he did not have security clearance to enter the office where the authoring stations were located. Therefore, the program was created on paper, and was input into the computer afterwards. Since each line of code had been thoroughly explained by the programmer, little debugging assistance was required of him. However, on occasion, the programmer was telephoned from the office for help.

After completing the programming, the course was ready for evaluation.

Formative Evaluation

Formative evaluation is the term designated for the evaluation of a product which is in its draft form. This is done in order to improve the product before it is finalized (Weston, 1986).

As a final step in this project, a formative evaluation was conducted on the Air Data Tester course. Results of the evaluation were analyzed and necessary revisions to the program identified.

The decision of how to conduct a formative evaluation depends primarily upon the questions the evaluation is expected answer. In this case, the following questions were posed:

1. Is the course designed effectively to meet the stated objectives?
2. Is the content of the course accurate?
3. Are the objectives of the evaluated part of the course fulfilled?
4. Can the students operate the course with a minimum of effort so that they can concentrate on the content of the course?
5. What are the students' attitudes toward the evaluated part of the course with respect to ease of use, comprehensibility, and completeness?
6. What do students like most and least about the course?

The first five questions were asked for the sole purpose of finding areas of the Air Data Tester course that required revision. The fifth question was asked not only to identify

changes required to this course but also to guide future course designs. Often, there is more than one way to present an item to students, and if the designer is aware of the students' preferences, he or she will be better able to tailor-make a course for them.

Three types of people were asked to participate in the evaluation. One was an instructional design expert from Concordia University, the second was the subject matter expert, and the third was members of the target population.

The literature supports the participation of experts in an evaluation. The instructional design expert is an appropriate person to comment on, and offer suggestions, with respect to the instructional design of a course (Geis, 1987; Weston, 1987). The subject matter expert is the best qualified to verify the correctness of the course content (Weston, 1987; Levin, 1986). He or she is also able to comment on the appropriateness of the emphasis given the content, and on omissions (Geis, 1987).

The literature also supports the inclusion of members of the target population in a formative evaluation. One important reason is that data on the target population's performance is a very strong indicator of the effectiveness of a product (Kandaswamy, 1980). In addition, students can verify

assumptions that are made about them by the developer or developers (Geis, 1986). They can, for example, identify steps that were left out that may have seemed obvious to the designer or subject matter expert, or they may point to difficulties in other areas, such as in vocabulary (Weston, 1987).

Subject Matter Expert

The role of the subject matter expert was to answer question 2 stated above: "Is the content of the course accurate?". The subject matter expert had already reviewed the storyboard, but what is written on paper and what is seen as the final product can be different, be there errors in development, oversights during the expert's review of the material, or other problems.

The evaluation proceeded as follows:

- A time was set up with the subject matter expert to review the Air Data Tester program, and arrangements were made to use one of the computer based training workstations for this purpose.

- Before the meeting, two chairs were placed in front of the workstation. The computer was turned on, and the

program was placed at the Instruction menu.

- When the subject matter expert arrived, he was greeted and asked to sit in front of the computer. A brief description of the process of the session was given to the subject matter expert. The course components were briefly reviewed, and the part of the course that was going to be studied during this session was put into perspective. The subject matter expert was reminded that he had already reviewed the paper version (storyboard) of the program. The purpose of the review this day was to ensure technical accuracy of the computerized version. The role of the evaluator was to observe and to take notes of observations made by the evaluator and by the subject matter expert. It was stressed that dialogue was crucial to the success of this evaluation.

- The structure and navigation features of the course were described so that the subject matter expert would be able to use the program appropriately. This information can be found in the Introduction component, but since it had not been produced, a verbal explanation was required.

- The subject matter expert was asked if he had any

questions. Since he had none, the evaluation began.

- At the end of the session, the subject matter expert was thanked for his time.

As a result of this session, some minor changes to the program were required. These changes were made before the other evaluation sessions were conducted.

Instructional Design Expert

At approximately the same time as the subject matter expert was asked to evaluate the Air Data Tester course, the instructional design expert was asked to review it. The design expert's role was to answer question 1 stated above: "Is the course designed effectively to meet the stated objectives?".

A package of the following materials was delivered to the expert prior to him reviewing the programmed course:

- Background information of the situation, putting the course and its design into context

- Course goals and objectives

- Course overview (diagram of structure)

- Notes about navigation

- Structural diagram of programmed part of course

- Storyboard (Introduction, Instruction, Exercises)

- Flowchart of the Exercises component.

The instructional design expert then came to Air Canada to review the program. By this time, the problems that were identified in the subject matter review of the program had been changed. This was not considered a problem for the instructional design review because the changes did not affect the design of the course.

The instructional design expert was given a brief review of the course, the expert's role in this evaluation, and how to use this particular computer system. Then the expert tested various aspects of the program. After reviewing the program, he commented on it. The expert was thanked for his time and the evaluation was concluded.

Target Population

An opportunity arose at the time the Air Data Tester course was ready for formative evaluation. The subject matter expert was scheduled to be the instructor for a recurrent training session involving eight CAVTs. He was willing to reserve a few hours for the conduct of the program's formative evaluation. Since this was a good way, and, actually, the only feasible way, of obtaining members of the target population to participate in the evaluation, the offer to use this time was accepted.

The role of the target population was to provide information with respect to questions 3 through 6 stated previously:

3. Are the objectives of the evaluated part of the course fulfilled?
4. Can the students operate the course with a minimum of effort so that they can concentrate on the content of the course?
5. What are the students' attitudes toward the evaluated part of the course with respect to ease of use, comprehensibility, and completeness?
6. What do students like most and least about the course?

The evaluation session took about 2.5 hours. It was conducted as follows:

- The formative evaluation began in a classroom. Introductions were made and the purpose of the evaluation was explained.

- An overhead transparency was projected (Appendix G) and the process for achieving the purpose of the formative evaluation was described. This discussion involved assuring the students that the pre- and post-tests were being used to evaluate the effectiveness of the course and not to evaluate the students' performance in any way.

- After the process was described, it was implemented. First, the students were given a pre-test (Appendix H). Numbers were assigned to the students to make the tests anonymous. Students identified themselves on the pre-test, and on the post-test, using the same number.

- Before the students began the pre-test, they were given two instructions:

  - The students were not to guess at the answers. If the answer to a question was not known, the

students were to write a dash on the page to indicate that they had seen the question but did not know the answer to it.

- The students were to answer the questions in the order that the questions were presented, and they were not to go back to previous questions. The reason for this was that question 5 hints at the answer to question 4.

- Students were allowed as much time as they wanted to complete the pre-test. When a student had completed the test, he took a break while he waited for the others to finish. To ensure that students did not acquire knowledge about the tester through talking with others, students were requested not to talk about the Air Data Tester or the pre-test during the break.

- After the pre-test, students went to the room in which eight computer based training workstations were situated. One person sat in front of each workstation. The Instruction menu of the Air Data Tester course was displayed on each monitor.

- Since only part of the course was programmed, it was necessary to give some preliminary information about

the Air Data Tester before students took the program. Specifically, students we e explained that the Air Data Tester consisted of a base part and a control display unit (CDU). The part of the course that was programmed was that in which students learned how to use the CDU. In addition, the students were given a handout which diagrammed the CDU (Appendix I). The functional areas of the CDU's display were described to the students (title line, prompt lines and status line). The explanation was necessary because the programmed part of the course referred to some of these functional areas. This information does form part of the course content, but not part of the content that was programmed.

- Every student had used the computer based training system recently, so it was not necessary to teach them how to use the system. This was confirmed when the students were asked to select the first option on the Instruction menu. Every student did so right away.

- The option that the students were asked to select routed the students to a frame w ich displayed all three navigation arrows. The overall layout of the screen and the function of each arrow was described to the students so that they knew how to operate the

course. The information given to the students is all contained in the Introduction component of the course.

- The students were asked to return to the menu, and they all did this successfully. Once at the menu, the students were informed that the sequence of the options on the menu was the recommended sequence of the program. In addition, the students were told that one segment led automatically to the other, rather than returning the student to the menu so that he or she may select the next segment.

- Students were then pointed to the fact that a pen and some paper had been placed in front of them. This was to be used to make note of any area within the course that caused them difficulty.

- Finally, the students were asked to refrain from talking to other people while taking the course. The intent of the program was that it be self-sufficient, and it was necessary to find out if this was the case. If a student had a problem which would not allow him to proceed in the program, then he was to ask for help. If a problem could wait, he was to record it on paper and to mention it during the discussion that was to follow.

- Students then worked on the Air Data Tester course. Casual observations were made at this time as to progress with the program.

- The average time for course completion was one half hour. As each student finished the program, he requested a post-test (Appendix J). The handout of the CDU was taken back from the student so that he could not refer to it, and the student completed the post-test as he did the pre-test. When finished with the post-test, the student submitted it, along with any comments he had recorded on paper, and left the room. Each student was asked to return to the classroom by a specific time for a final discussion of the course.

- After everyone had completed the post-test, a debriefing was conducted back in the classroom. Students were first asked for overall comments. Then, the following questions were asked:

    - How easy did you find it to use the program?
    - Was it always clear to you what you should be doing next?
    - How easy was it to understand the material that was presented to you?
    - Was the material covered in enough detail,

considering the objectives of the course?

- Comments made during the discussion were recorded.

- The students were informed of the next step in this project. This was done to ensure they understood how their efforts were going to be used. They were then thanked for their participation and the session was concluded.

CHAPTER 4

Results

Subject Matter Expert Evaluation

As a result of the subject matter expert evaluation, some graphic and wording changes were identified. These changes were minor, and they were completed in a short period of time.

Instructional Design Expert Evaluation

The instructional design expert stated that the program was acceptable as is. Therefore, no further changes to the program were identified as a result of this session.

Target Population Evaluation

This evaluation session produced three sets of results: written comments, oral comments, and pre-test/post-test scores.

The written and oral comments that students made are presented in Appendix K. Some spelling errors and a technical error were identified. Individual students made

some other comments and recommendations for improvement.

The written and group discussion comments supported the observations made while the students were taking the course. Students appeared to progress through the program easily and at a reasonable pace.

The pre- and post-tests were used to obtain information about whether or not students learned from the Air Data Tester course. Pre-test and post-test comparisons are presented in Appendix L. The mean pre-test score was 35% and the mean post-test score was 93%. The difference between these mean scores is significant at $p < .05$.

The mean score for each question was compared between pre-test and post-test (Appendix L). Four of the twelve questions (2, 6, 7 and 10) did not show a significant improvement in scores. Five of the eight students answered question 2 correctly on both the pre-test and the post-test. There was a slight improvement in performance on question 6, with five students answering the question correctly on the pre-test and seven answering it correctly on the post-test. Question 7 was answered correctly by four students on the pre-test and by five students on the post-test. Five students responded to question 10 correctly on the pre-test and all eight responded to it correctly on the post-test.

Time Records

The time spent designing, producing and evaluating the programmed part of the Air Data Tester course is presented in Appendix M. Resulting production costs are also included.

The time spent on the programmed part of the project was approximately 30% longer than estimated. This increases the difference in cost between delivering the course by way of computer and by way of stand-up instruction. As a result, 625 students must take the course on computer in order to reach a break-even point in cost. More than 625 students will be required after the program has been completed.

CHAPTER 5

Discussion

Target Population Evaluation

Student Comments

The comments that students wrote while taking the program pointed to some spelling and technical errors which must be corrected. The other comments that were made did not point to changes that had to be made to the course. There were no recurring comments or suggestions for improvement, and the few suggestions that were made would not have significantly improved the effectiveness of the program, if at all.

Pre-test/Post-test

The significant difference between the mean pre-test and post-test scores indicates that, overall, the Air Data Tester course was successful in effecting learning.

The individual questions on the tests were compared to determine if there were any areas of weakness in the course. Two of the four questions which did not show a significant improvement in scores (questions 2 and 7) related to tasks

that were described in the instruction, but were not included in any form of practice. This lack of practice may explain why the mean post-test score was not significantly higher than the mean pre-test score.

Another possible reason for the finding of no significant difference is that the mean pre-test scores for these two questions were fairly high. It appears some students read the information on the graphic carefully, and applied common sense, to arrive at the correct answer. This is what the students should do in real life with the tester as well.

Despite the finding of no significant difference in mean scores, the instruction should not be changed. One reason is because of the relatively high pre-test scores. The other reason has to do with the resources available to the student when he or she uses the tester in real life. Questions 2 and 7 deal with support functions of the tester - how to correct input errors. When appropriate, the prompt lines on the Air Data Tester's display page inform the student about how to correct these errors. Therefore, it is not worthwhile to put more emphasis on these topics than what is presently in the course.

The other two questions which did not result in a significantly higher post-test mean score were questions 6

and 10. The pre-test means for both of these questions were high. Seven of the eight people answered question 6 correctly on the post-test, and everyone answered question 10 correctly. Because performance on the post-test was very high, there is no need to change the instruction.

Lessons Learned

A number of lessons were learned from this project. One involves the Dick and Carey (1985) instructional design model that was used to guide the design of the Air Data Tester course. This model provided a sound, easy-to-follow process which resulted in a successful instructional program. Because of its utility and effectiveness, this model will be considered for use in future projects that have similar goals.

Another lesson learned was that the video and photographs that were taken of the Air Data Tester were invaluable as reference material throughout the project. They provided easy access to a piece of equipment that was somewhat inaccessible, and they drastically reduced the support time required of the subject matter expert.

A third lesson involves the instructional analysis. A complete, written analysis was made for all aspects of the

goal. That is, all the procedures to fulfil the goal were written out, and a hierarchy of subordinate skills was recorded for the steps of the procedures. This repeated existing documentation because the procedures were shown on the video. In addition, the recording of subordinate skills became repetitive, as many of the procedures required the same ones.

Time could have been saved by performing the analysis on paper for some of the procedures, and then mentally analyzing others. The written analysis could have been done for the more involved procedures, and the mental analysis for the shorter ones, and for the ones that were very similar to those that were documented already.

A fourth lesson concerns the order in which some of the activities within the design process were carried out. The storyboards for the three components of the Air Data Tester course (Introduction, Instruction, Exercises) were created before part of the program was produced and evaluated. This made sense originally, because the program was thought to be small enough to warrant producing the entire course and then evaluating it. However, the program turned out to be larger than expected. It became sensible to evaluate only a portion of the course. Evaluation questions could be answered which would point to necessary revisions to the

existing program, and which could guide the production of the rest of the program.

The formative evaluation of the Air Data Tester program did, in fact, produce results which affect how to proceed with the remainder of the course. Because the mean post-test score was very high (93%), and because it is costly to produce a computer based lesson, the Exercises component of the course should not be produced. It may be an interesting component for the student, but it has not been demonstrated to be a required component.

On the design side, production of the Exercises component did help to guide and focus the writing of the storyboard for the Instruction component. However, an effective Instruction component could certainly have been created without reference to the Exercises.

Assuming that the Exercises component will not be produced, the time taken to create the Exercises storyboard is basically wasted. Since the Introduction component refers to the structure of the program, it will have to be revised. This means that some time was wasted in the storyboarding of the Introduction as well.

The lesson learned from this experience is that the most

critical parts of a program should be the first to be storyboarded. Then, consideration should be given as to whether or not these parts will suffice for a formative evaluation. If yes, the evaluation should be conducted. Assuming that the evaluation indicates that the rest of the course is still warranted, only then should those storyboards be created.

Conclusion

The bulk of the Air Data Tester course has now been completed. A few corrections are required as a result of the formative evaluation. In addition, the first two instructional segments, and the Introduction component, must be produced in order for students to be able to take the course on their own.

This course will offer many benefits to the students. Among the more important ones will be its availability to all those who must use the Air Data Tester to perform their jobs. In addition, students will be able to take the course as often as is necessary, and when it suits their schedules.

Each time a student takes the Air Data Tester course, he or she will engage in an individualized learning experience. The student will control the pace at which to work, the

amount of content to cover, and the sequence in which to cover the content. The program will individualize the lesson further by giving feedback that is specific to the input the student has made. These features, coupled with the realistic way in which the student learns to use the Air Data Tester, will create a powerful learning environment for the student.

While the computer based course offers many benefits, it has a downside as well. The cost of producing the program was high, and it will be even higher once the program has been completed. It will take many more students than Air Canada has, or will have in the near future, before the cost per student for the computer based course will approach that of an instructor-led course.

It may be possible to reduce, or eliminate, the cost disadvantage of the Air Data Tester course. Air Canada may be able to find companies that are interested in purchasing the course. Potential buyers would be companies which use the Air Data Tester or the manufacturer of the tester.

In order to get any benefit out of the course, monetary or non-monetary, the program must be completed. This should not take long, and so will be done. Once the entire course has been produced, it will be put on-line across the system

for use by the students.

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APPENDIX A

Estimated Production Time and Costs

ESTIMATED PRODUCTION TIME AND COSTS

ONE TIME COURSE PREPARATION

	CBT	Stand-up
Number of hours of instruction	0.50	0.65
Preparation time per hour of instruction (hrs)	750.00	8.00
Total preparation time (hours)	375.00	5.20
Preparation cost at $20/hours	$6,860	0
Preparation cost at $25/hour	$800	$130
Material costs	$15	$115
Total preparation cost	$7,675	$245

Difference in course preparation cost	$7,430

SUMMARY OF COURSE DELIVERY COSTS

	CBT	Stand-up
Computer equipment cost ($5.50/hr/student)	$5.50	$0.00
Material costs/student/hr instruction	$0.00	$11.00
Instruction pre-course preparation	$0.00	$4.16
Instruction support (CBT) or Instructor in class	$0.00	$2.08
Computer personnel support cost (@ 3 min/hr instr.)	$1.00	$0.00
Travel costs - Instructor	$0.00	$0.73
Travel costs - Students	$0.00	$4.38
Backfill (to replace students away from work)	$0.00	$8.83
Cost per student hour of instruction	$6.50	$31.18
Number of hours per course	0.50	0.65
Cost per course per student	$3.25	$20.27

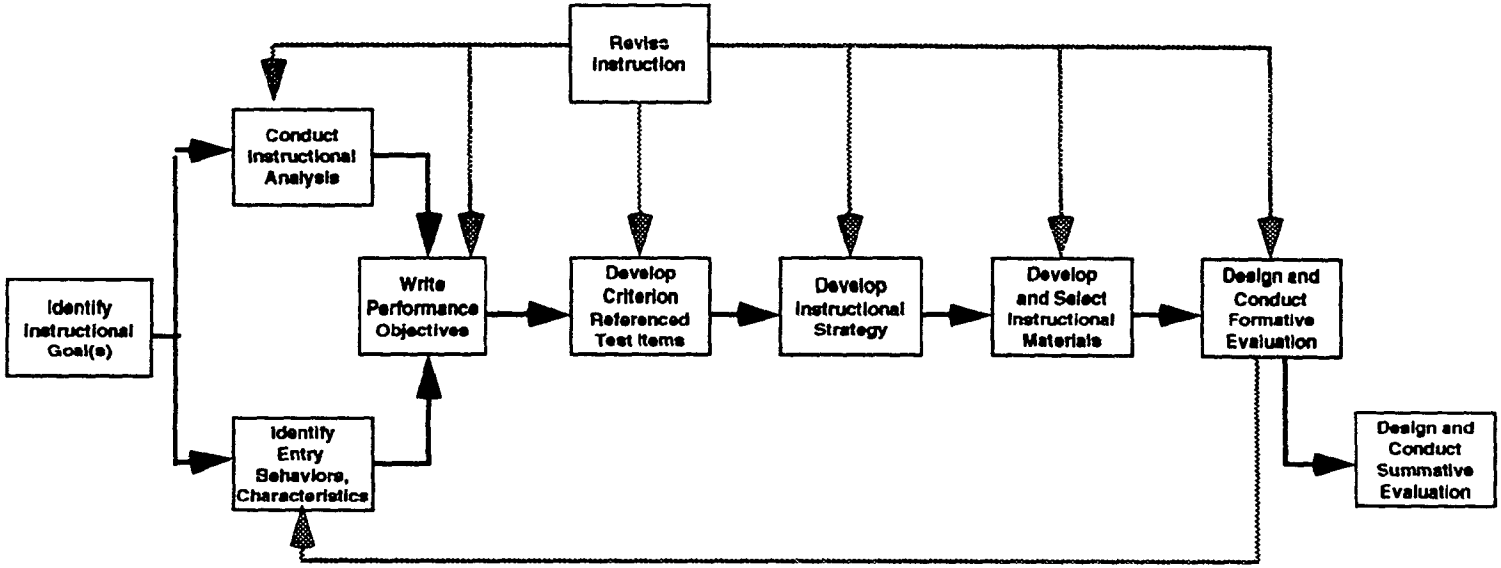
Difference in course delivery costs	$17.02

BREAKEVEN

Number of people required to take course to cover CBT production costs:	437

APPENDIX B

Dick and Carey's (1985) Instructional Design Model

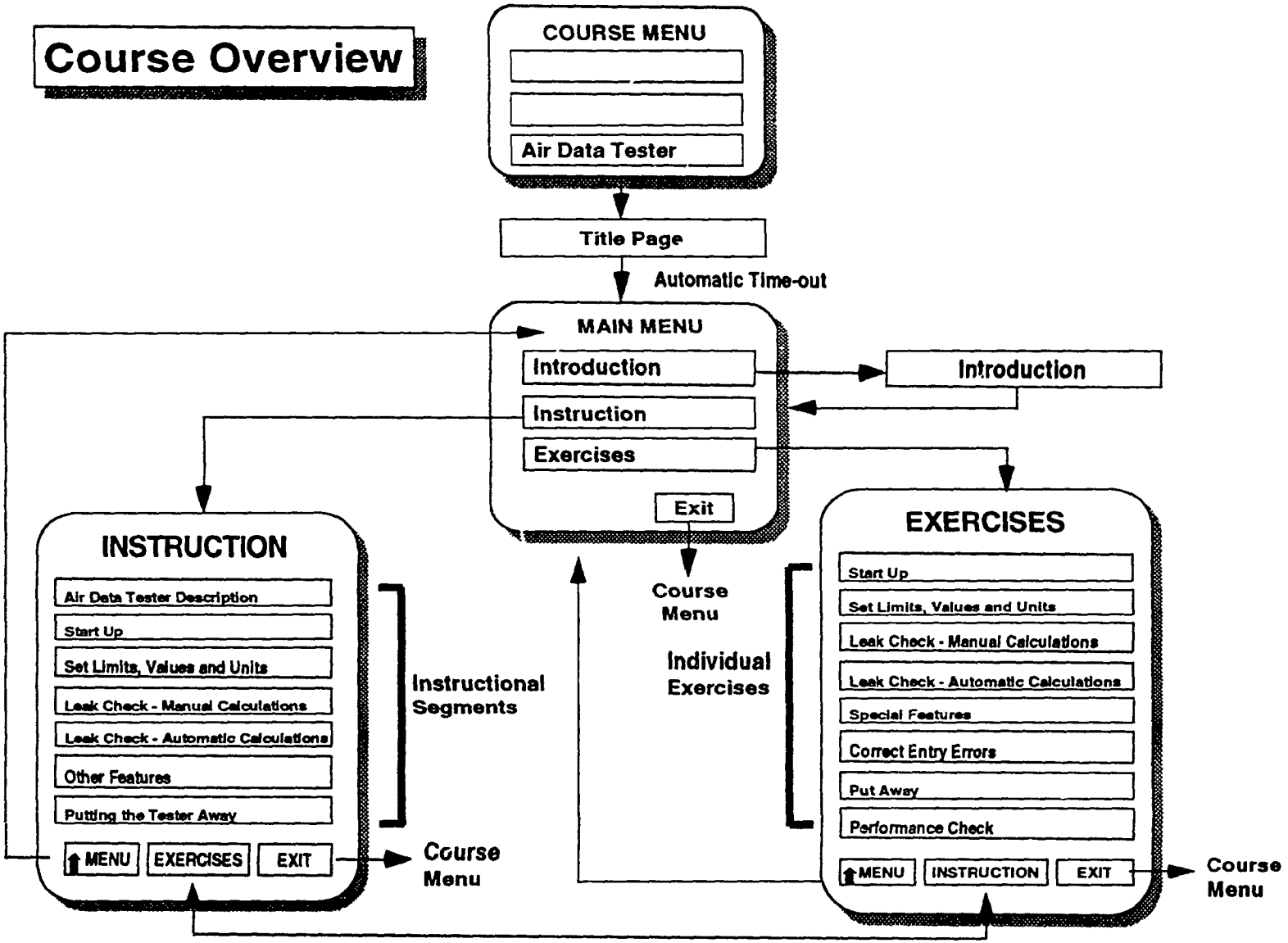


Dick & Carey, 1985

APPENDIX C

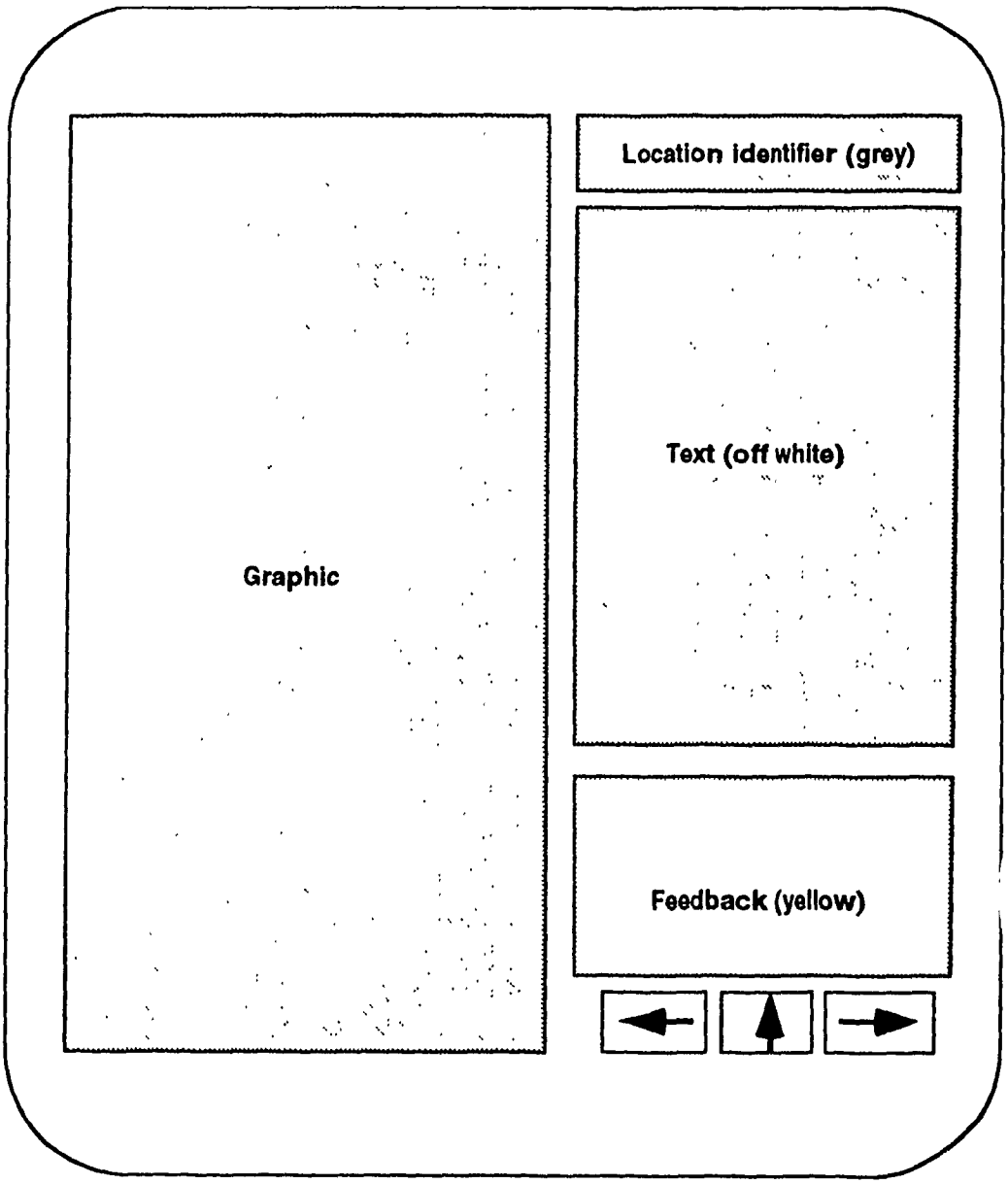
Course Overview

Course Overview



APPENDIX D

Screen Layout


Graphic
Location identifier (grey)
Text (off white)
Feedback (yellow)

APPENDIX E

Storyboard Format

Page·

CHAPTER. TOPIC/UNIT:

SUBJECT NUMBER: REV. FRAME: FRAME:

GRAPHIC ID: GRAPHIC ARTIST:

Graphic Photocopy _____ Other _____ Source

Reproduction Total _____ Partial _____ Stylized _____

Highlighted areas # _____ % _____ Borders _____ Blocks _____

Library name: **Directory:**

Fields: # of _____ Overlay _____ Replace _____

TEXT:

CORRECT ANSWER:

Fb:

WHICH ANSWERS:

Fb:

DESTINATIONS: **RIGHT:** **LEFT:**

MENU: **AUDIO:**

COMMENTS:

This is a new frame _____

Alter present frame as indicated· _____

Change text/graphic of frame as indicated· _____

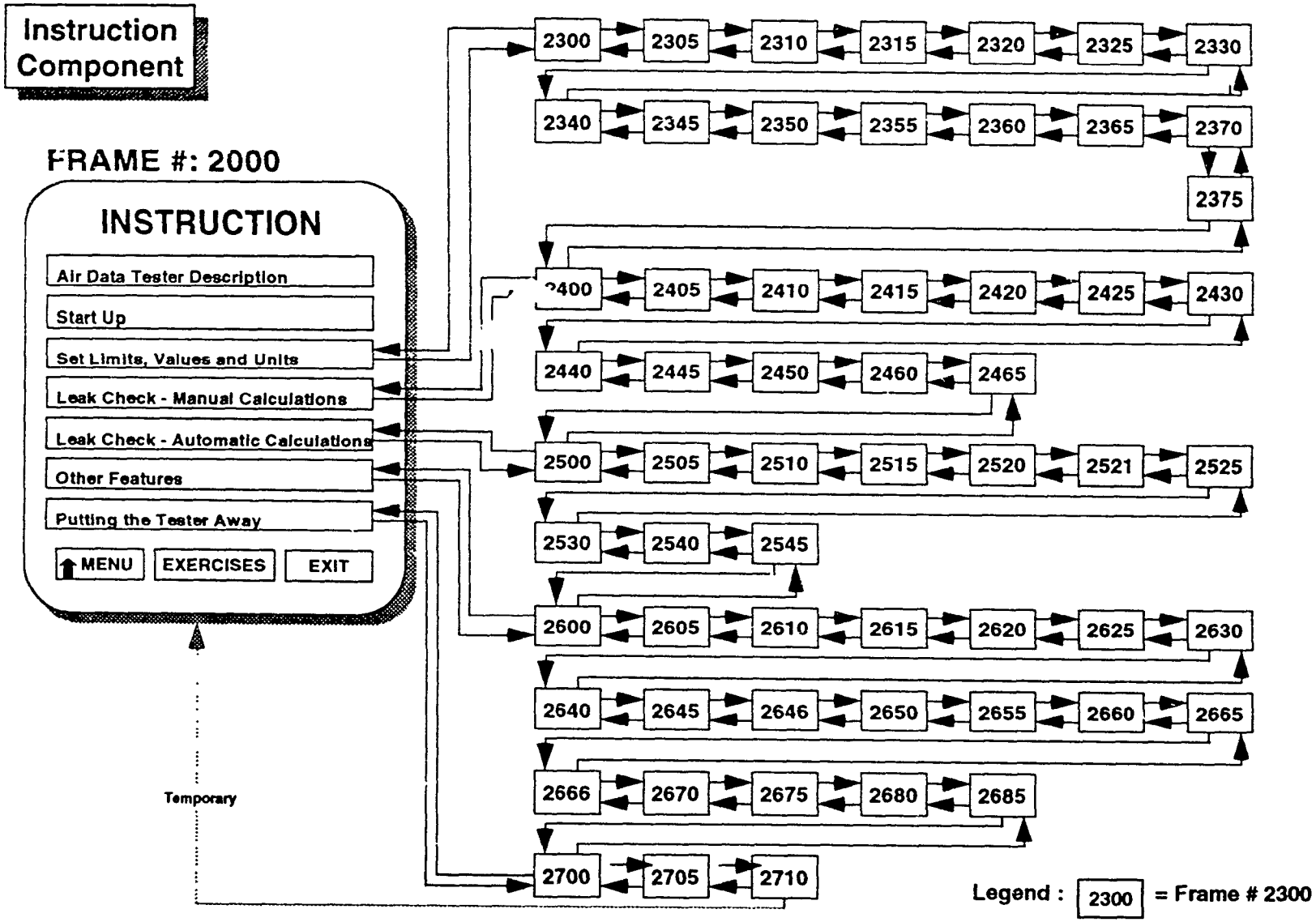
Delete present frame (parts shown here) _____ Replace with _____

Screen type:

Specifications for Frame X

APPENDIX F

Instruction Component


Instruction Component
FRAME #: 2000
INSTRUCTION
Air Data Tester Description
Start Up
Set Limits, Values and Units
Leak Check - Manual Calculations
Leak Check - Automatic Calculations
Other Features
Putting the Tester Away
MENU
EXERCISES
EXIT
Temporary
2300
2305
2310
2315
2320
2325
2330
2340
2345
2350
2355
2360
2365
2370
2375
2400
2405
2410
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2605
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2620
2625
2630
2640
2645
2646
2650
2655
2660
2665
2666
2670
2675
2680
2685
2700
2705
2710
Legend :
2300
= Frame # 2300

APPENDIX G

Process Steps for the Formative Evaluation with the Target Population

Agenda

- Pre-test
- Air data tester description
- Using the computer
- Take lesson
- Post-test
- Discussion

APPENDIX H

Pre-test

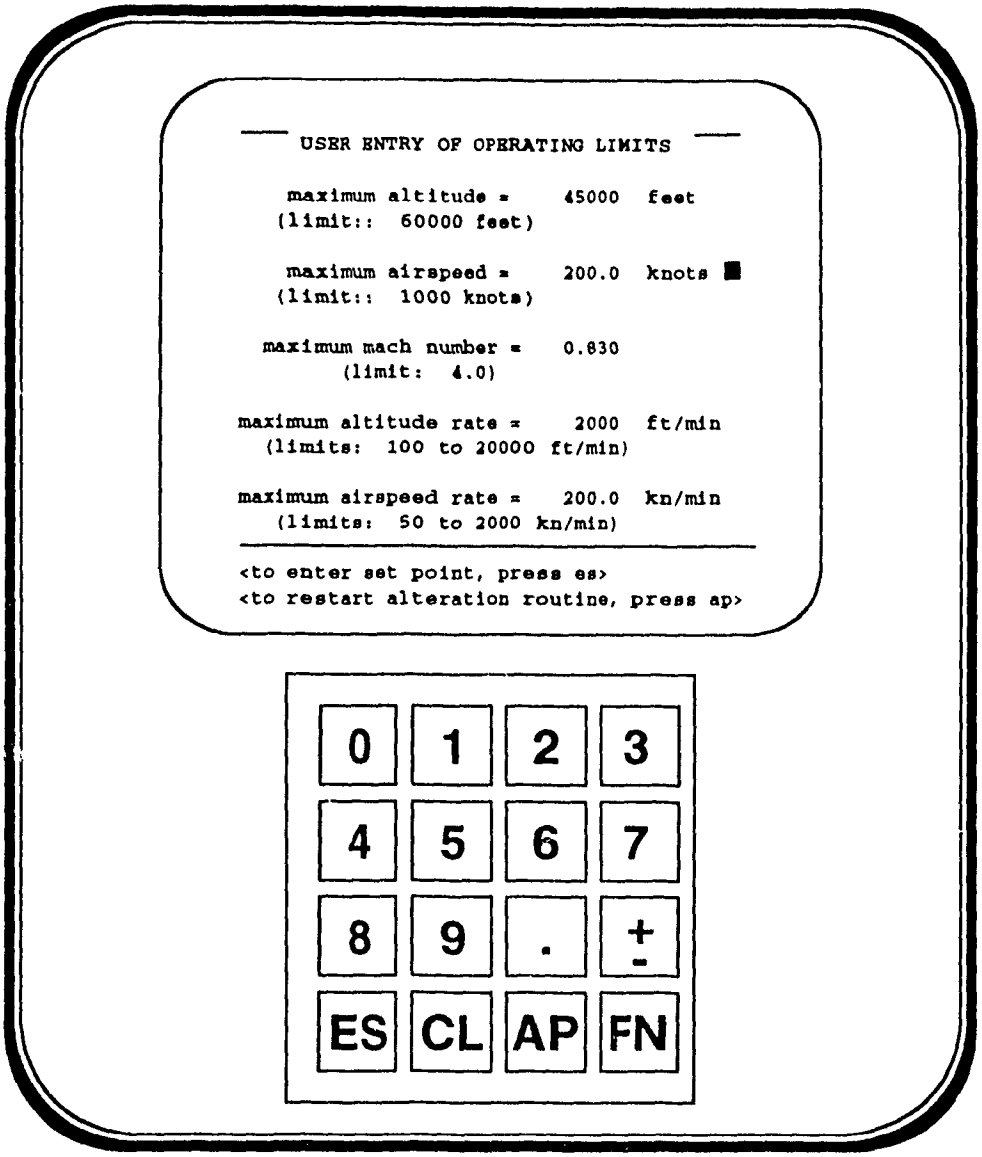
AIR DATA TESTER

FORMATIVE EVALUATION 1

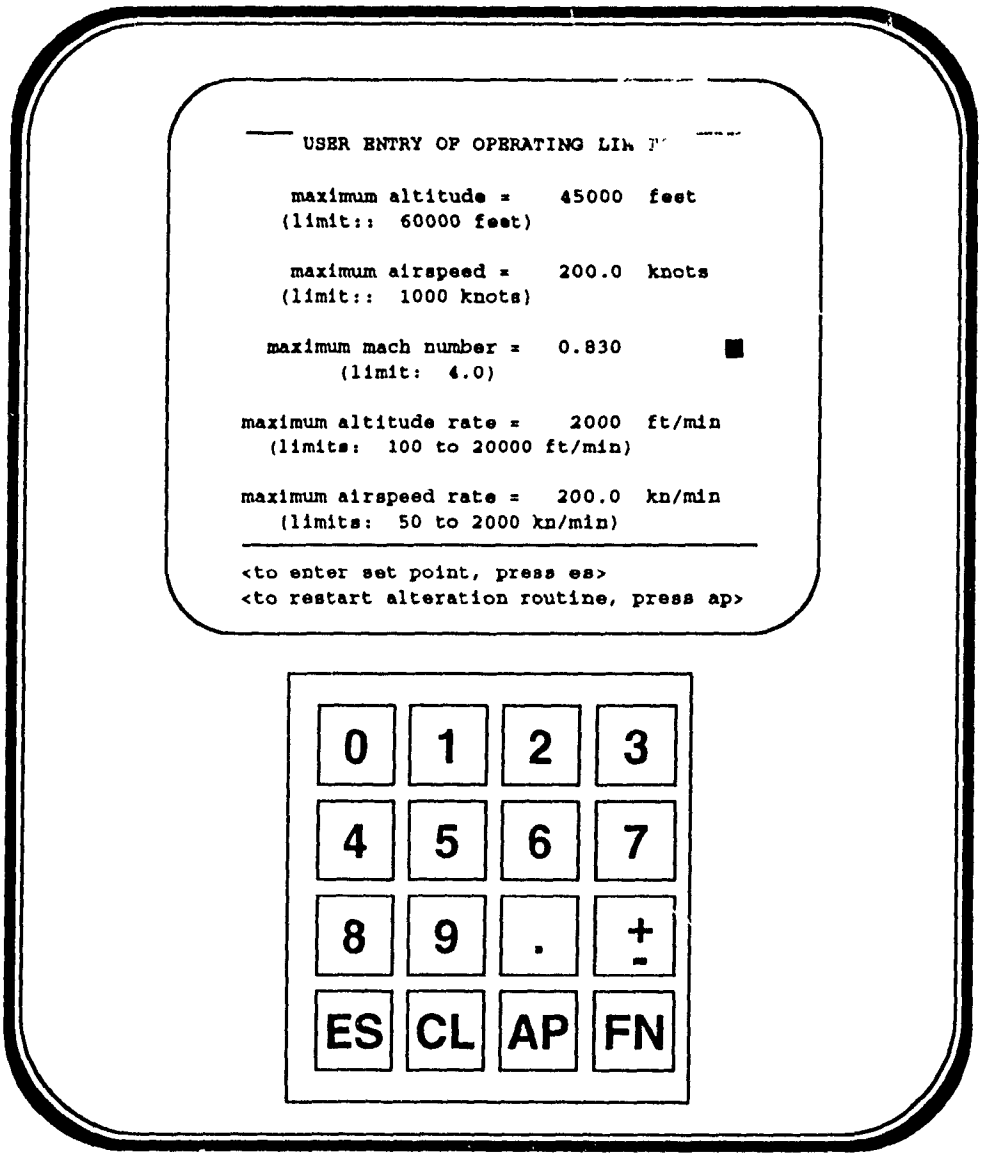
Participant number: _____

Have you ever used the Penny and Giles Air Data Tester?

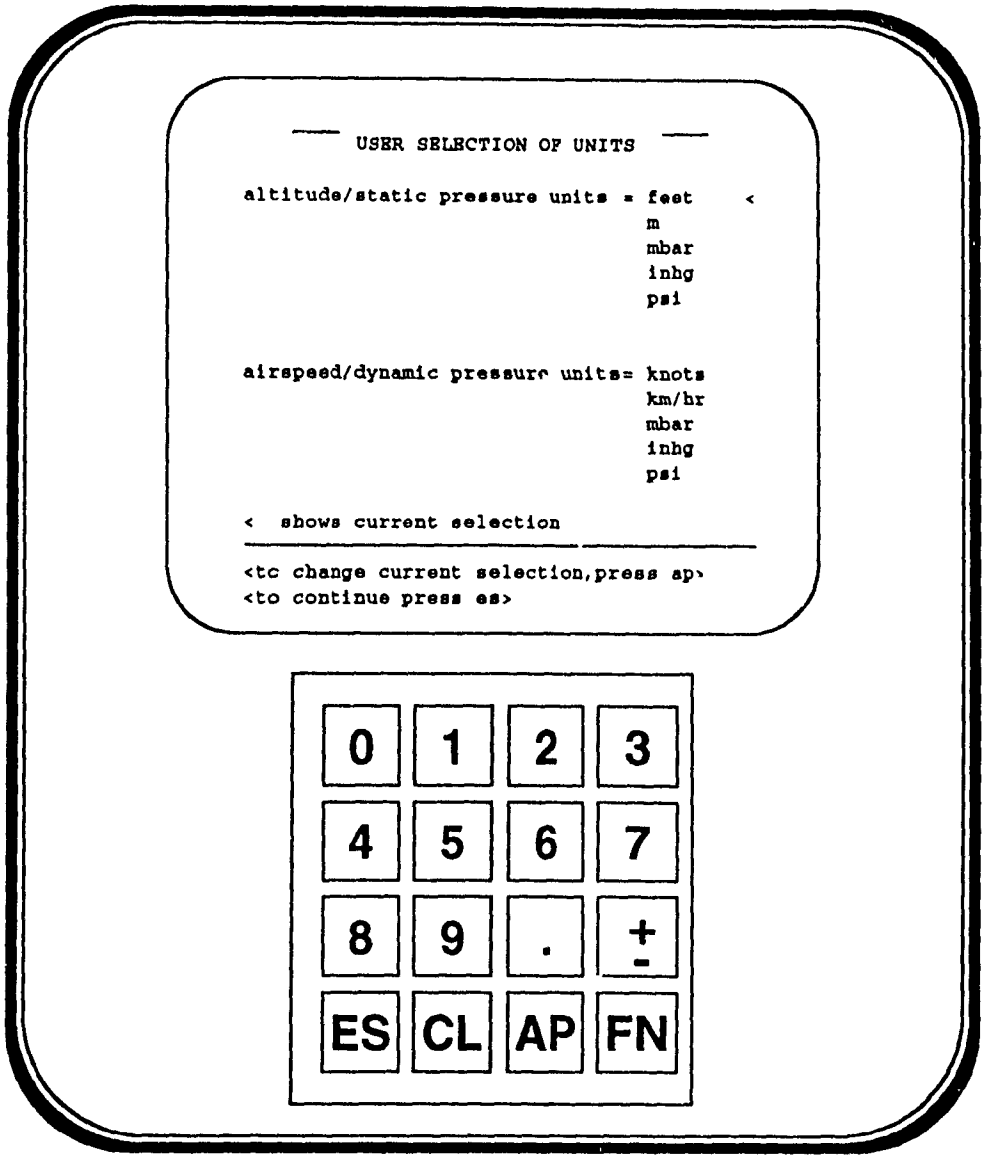
Yes _____ No _____



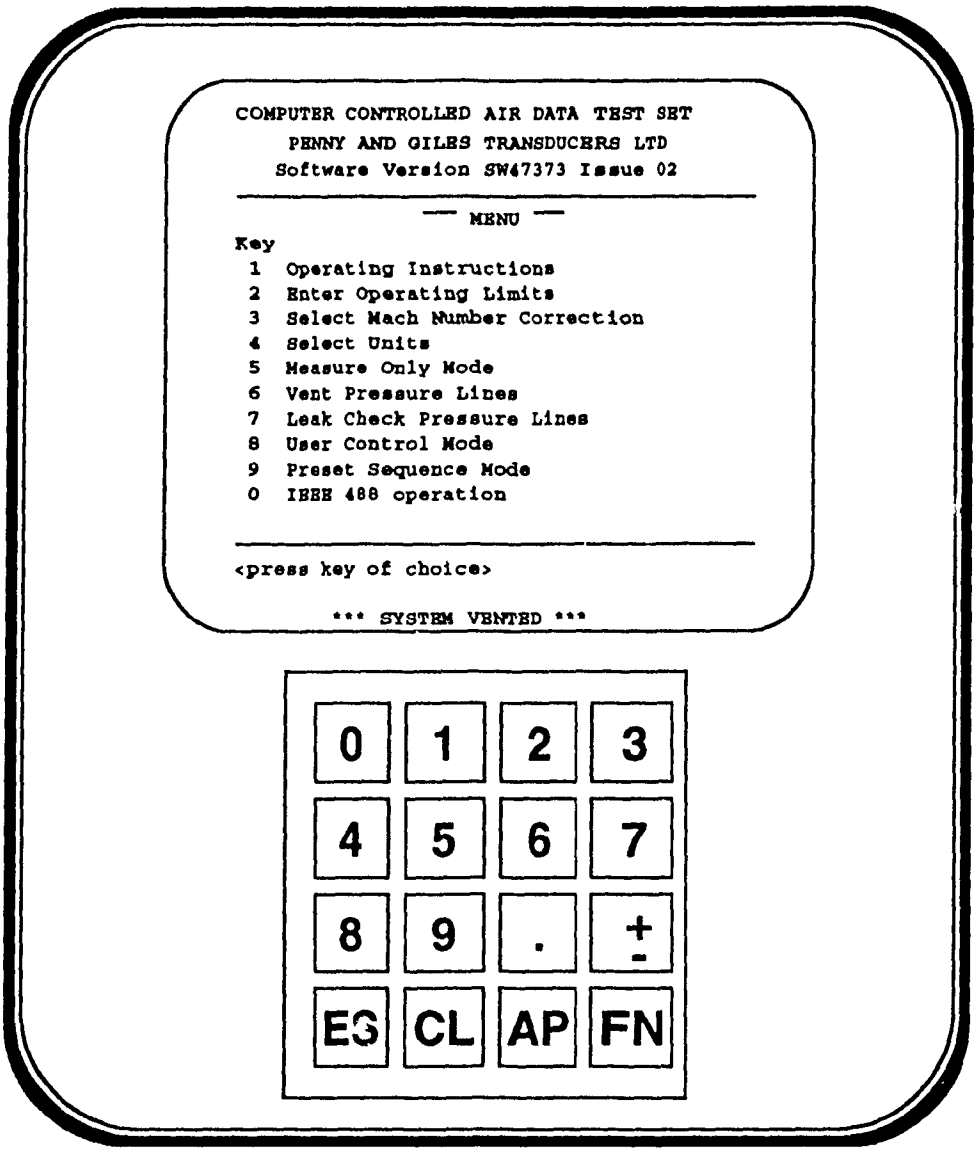
1) You are on the User Entry of Operating Limits page. The cursor is flashing on the maximum airspeed line. The value that is displayed (200.0) does not need to be changed. How do you move on to change the mach number value?



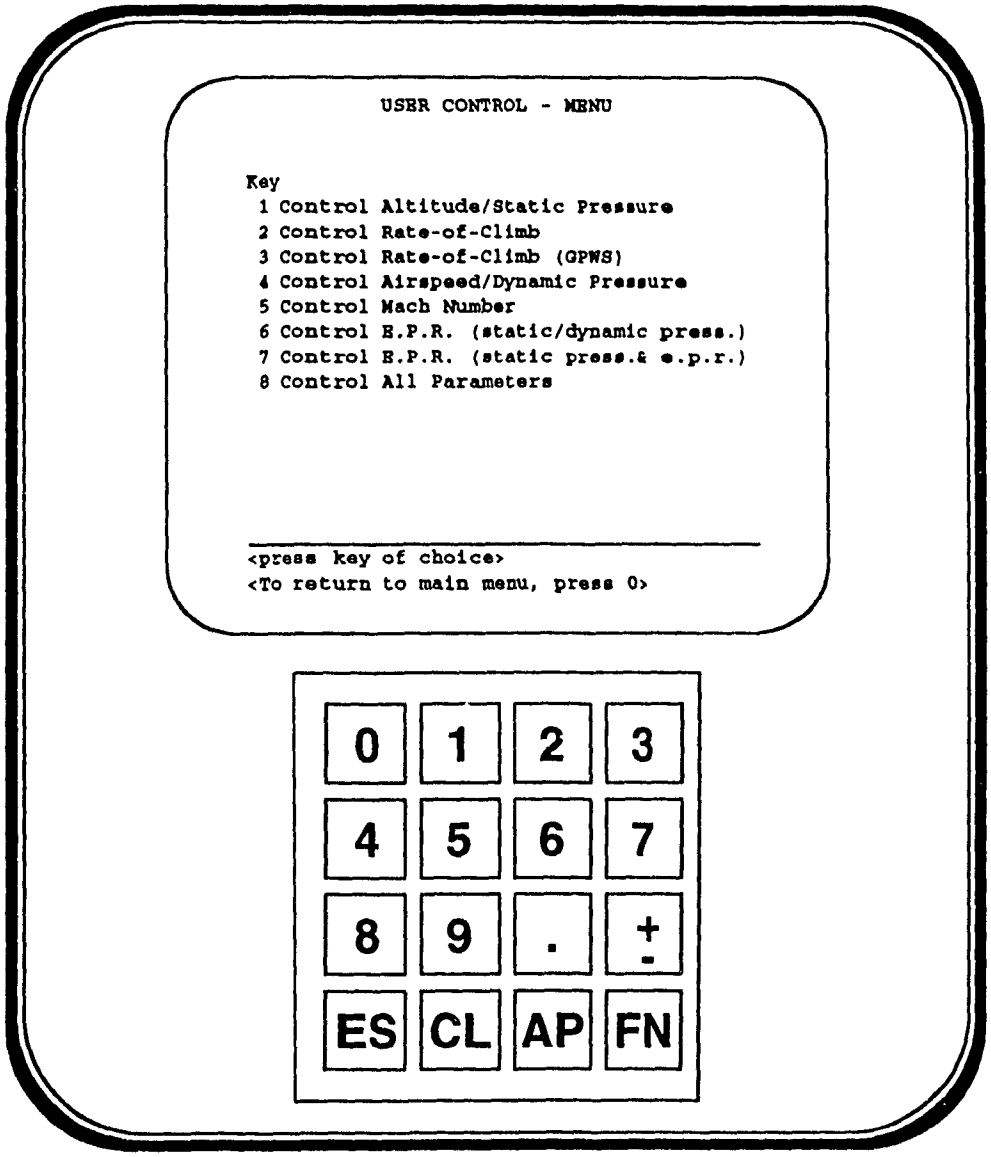
2) The cursor is now flashing on the maximum mach number line. You suddenly remember that you wanted to change the maximum altitude to 35000 feet. How do you get back to the maximum altitude line so that you can change the value ?



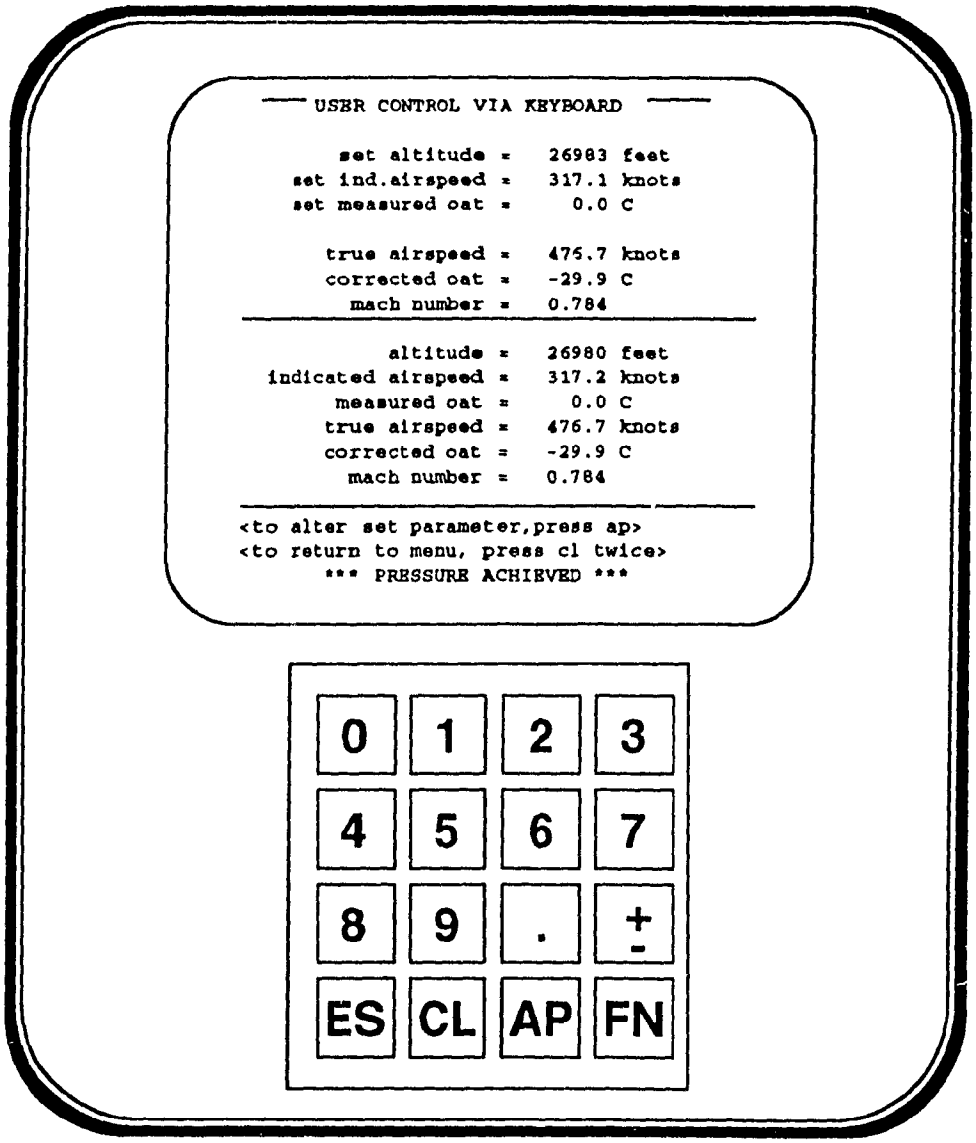
3) Suppose you want to work in units of psi. Describe, step-by-step, what you would do to select these units, starting at the altitude/static pressure units and going to the airspeed/dynamic pressure units.



4) You want to perform a leak check and you want to use the method which will allow you to calculate the leak rate yourself. Which menu option(s) would you use to do this ?



5) You plan to do a leak check. You have selected menu option 8 so that you can pressurize the system. You are now on this page. Which menu option will you select ?

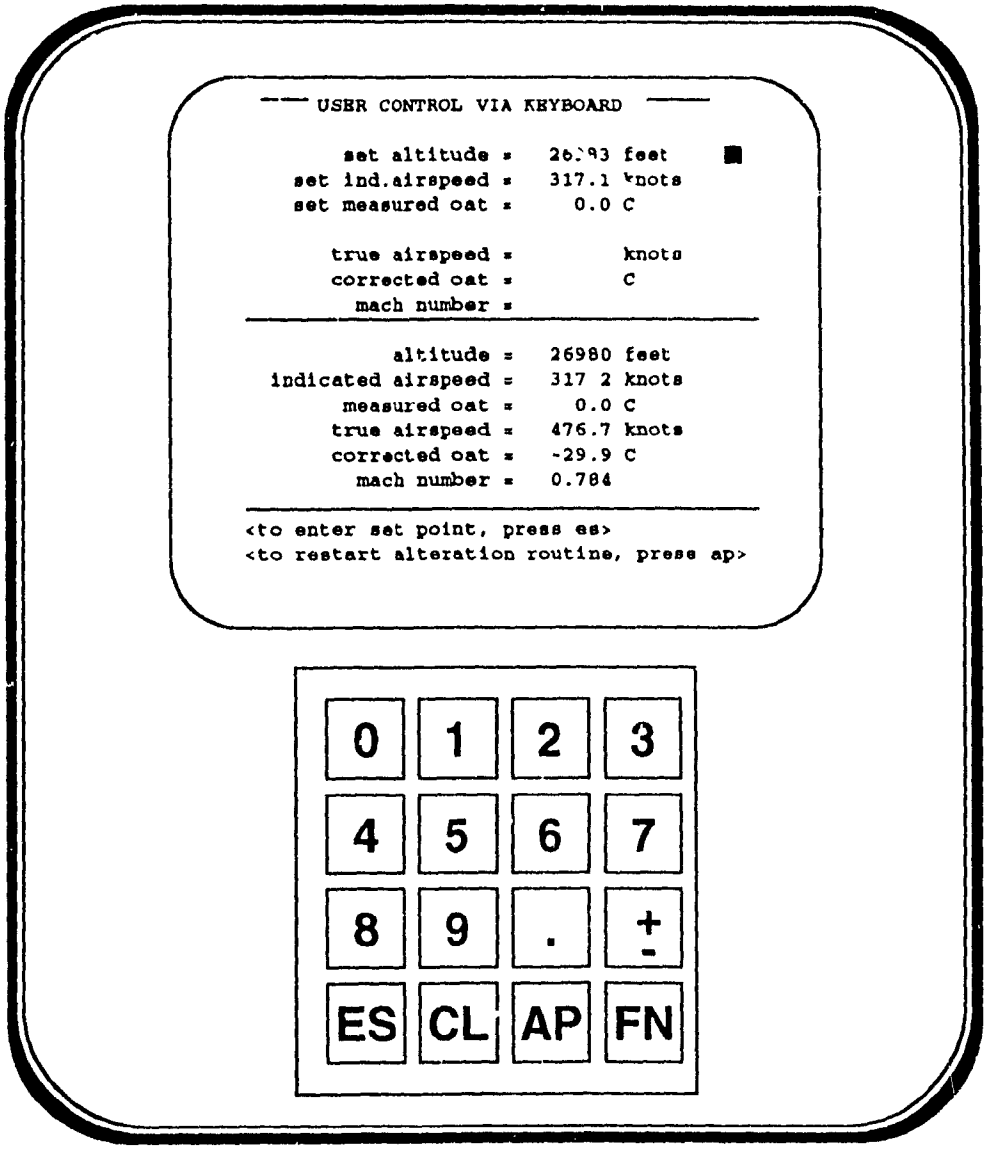


6) You are still going through the process to pressurize the system. You want to pressurize to 30000 feet, 250 knots and 10 degrees C.

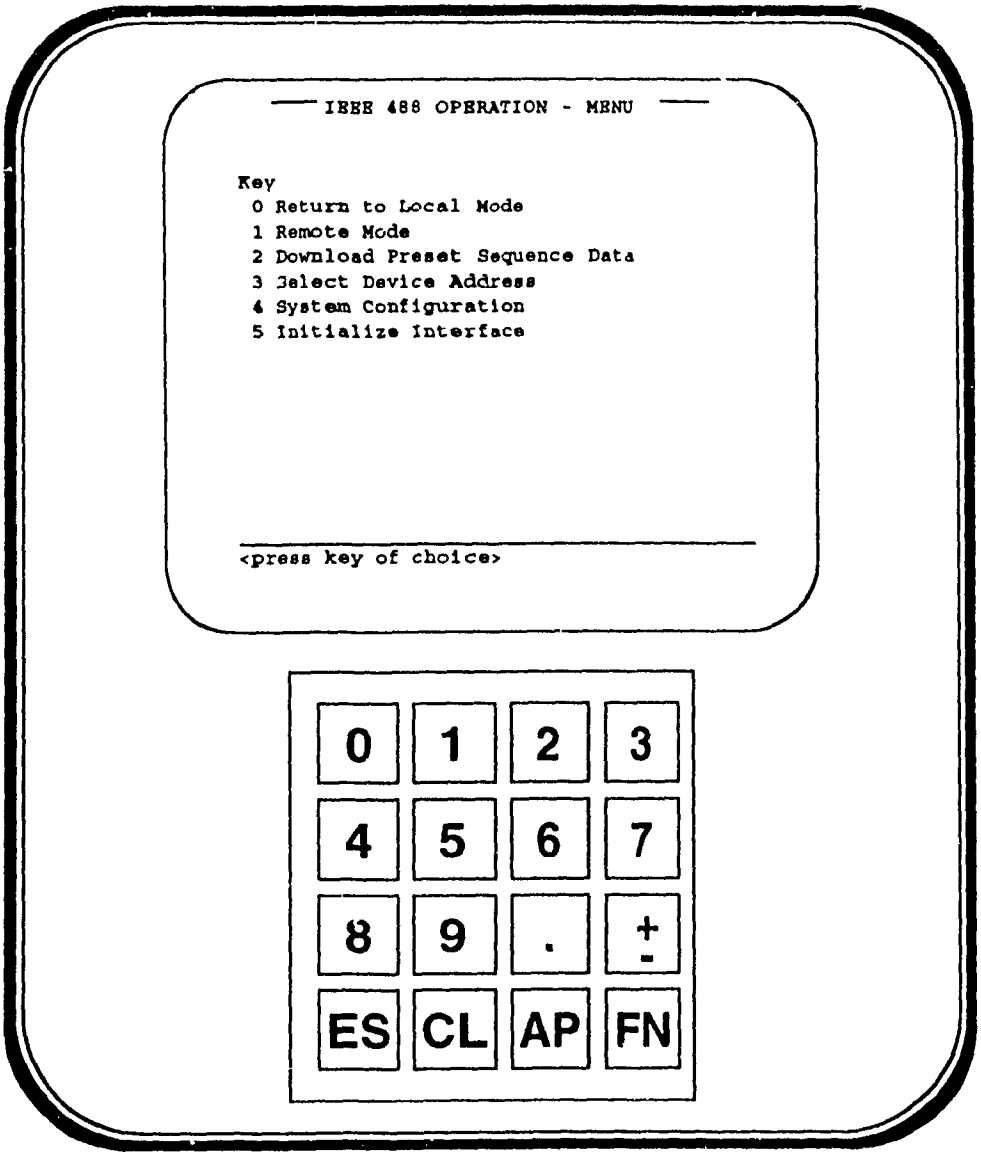
So far, you have done the following:

- You have selected menu option 8.
- You have selected the Control All Parameters page, which is what you see now.

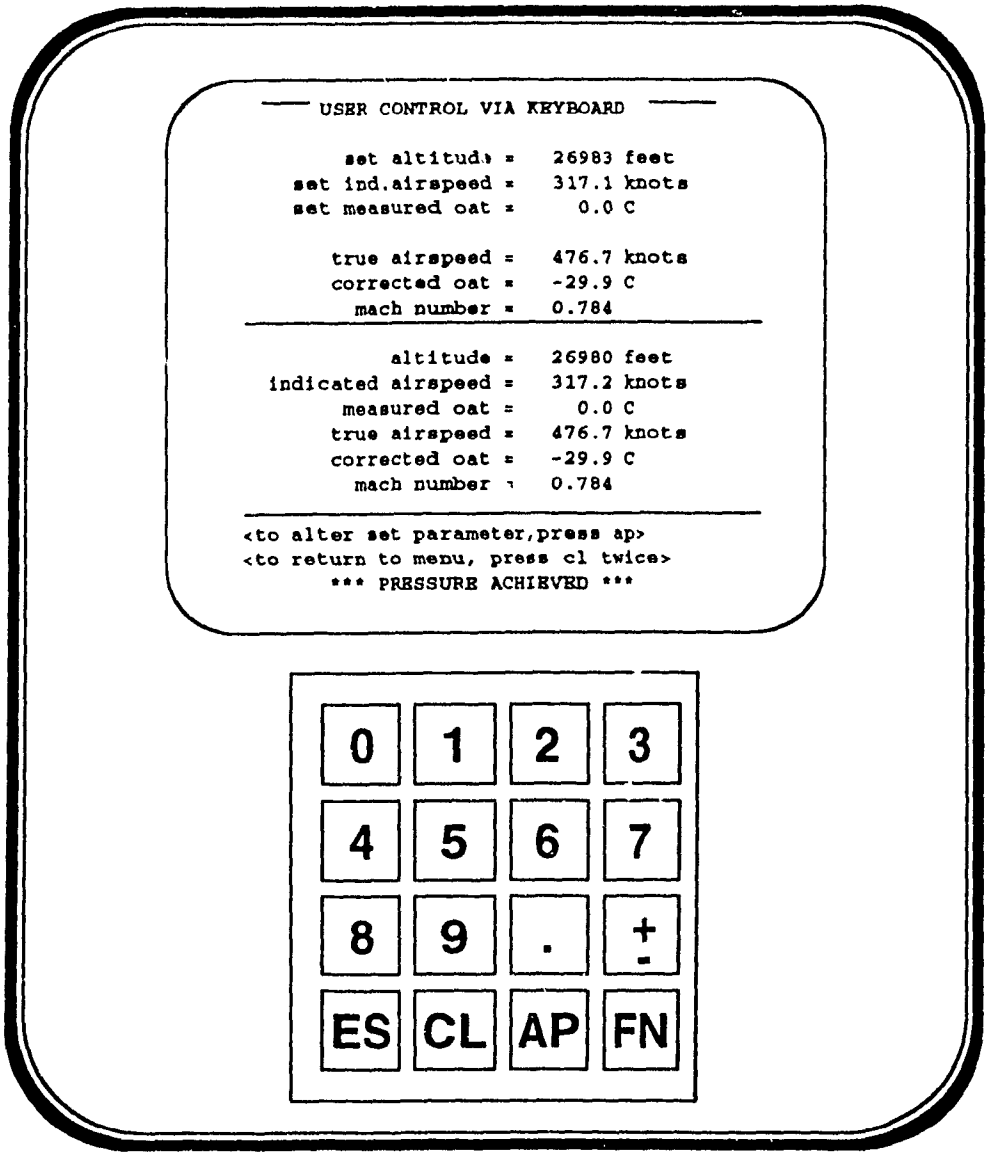
What is the next key to press ?



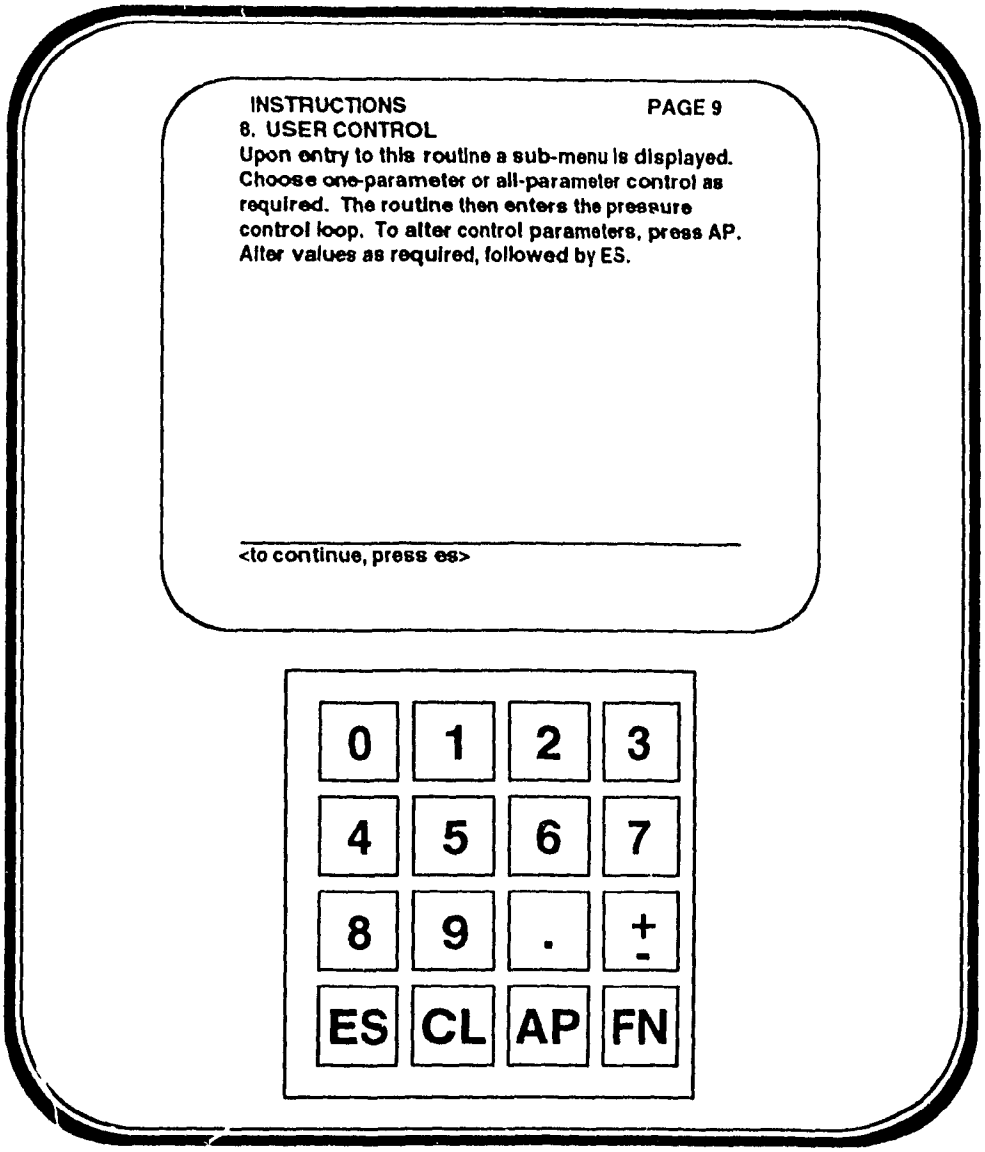
7) Suppose you start typing a number and you press the wrong digit. How do you erase this value to start typing the number over again ?



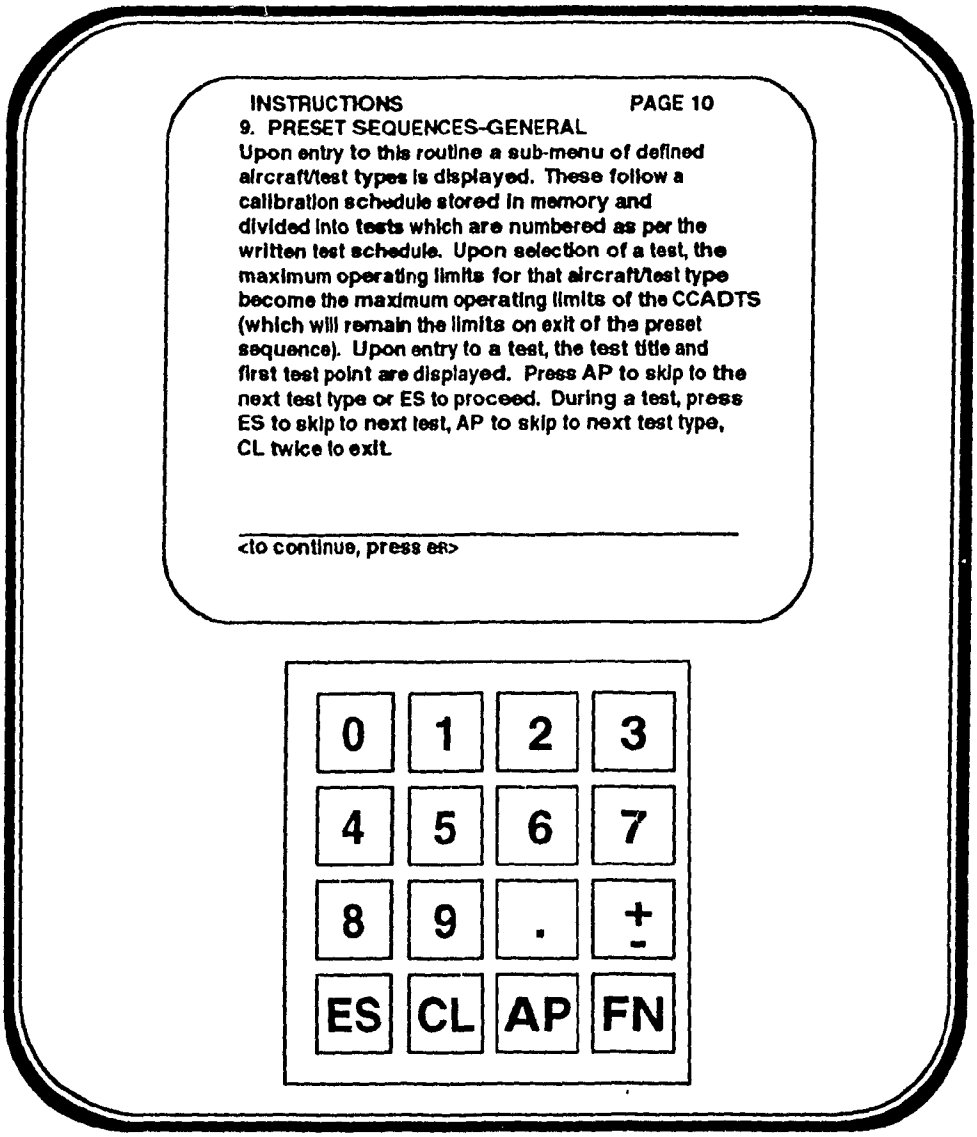
8) Suppose you accidentally selected menu option 0 and so you arrived at this page. How do you get back to the main menu?



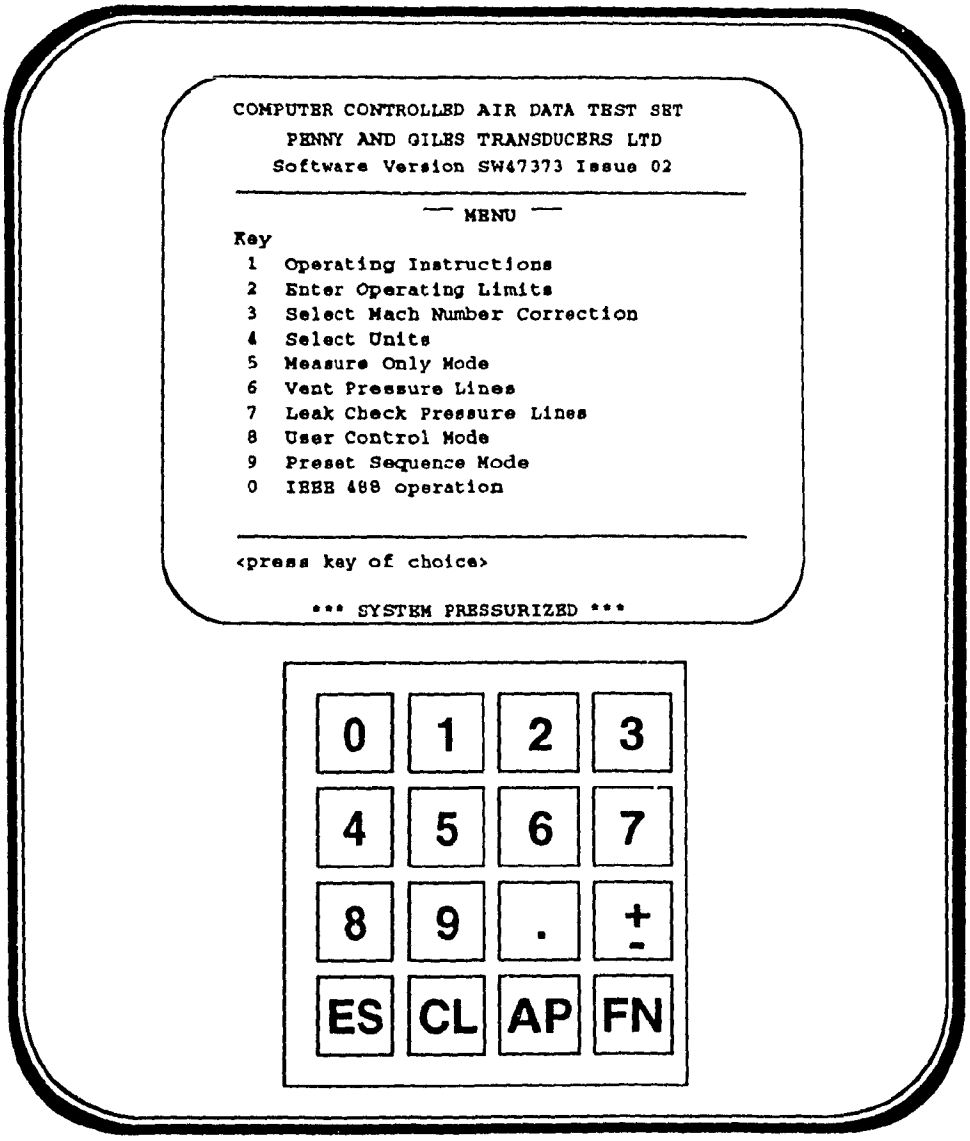
9) **You have pressurized the system to the values shown on the display. What key would you now press if you wanted to nudge the altitude down one foot ?**



10) You are on page 9 of the on-line help. How do you get to page 10 ?



11) You are on page 10 of the on-line help. How do you get back to the main menu ?



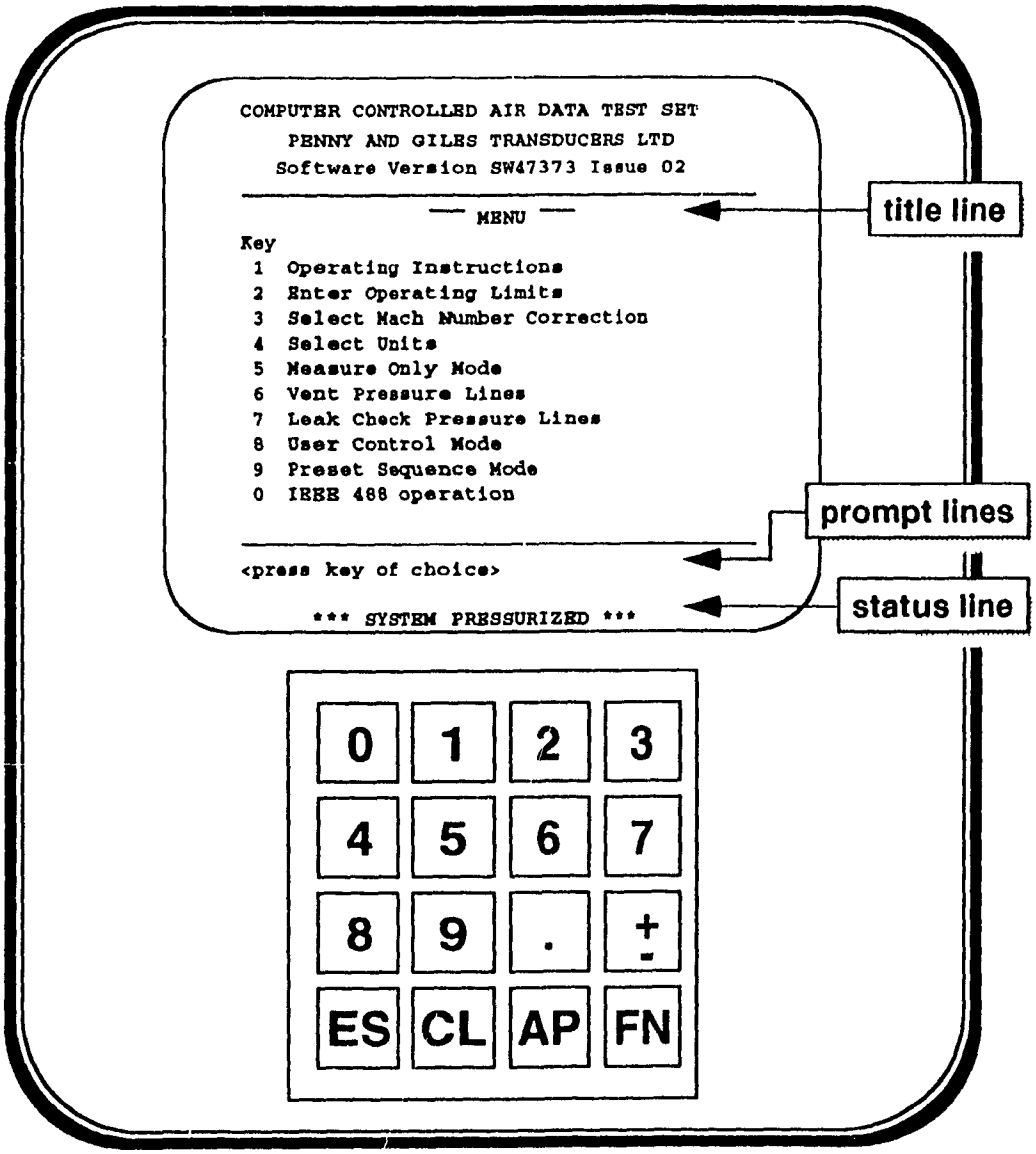
12) You have finished with the tester and want to put it away. What must you do before you turn the power off ?

APPENDIX I

The Air Data Tester's CDU

Air Data Tester

CDU



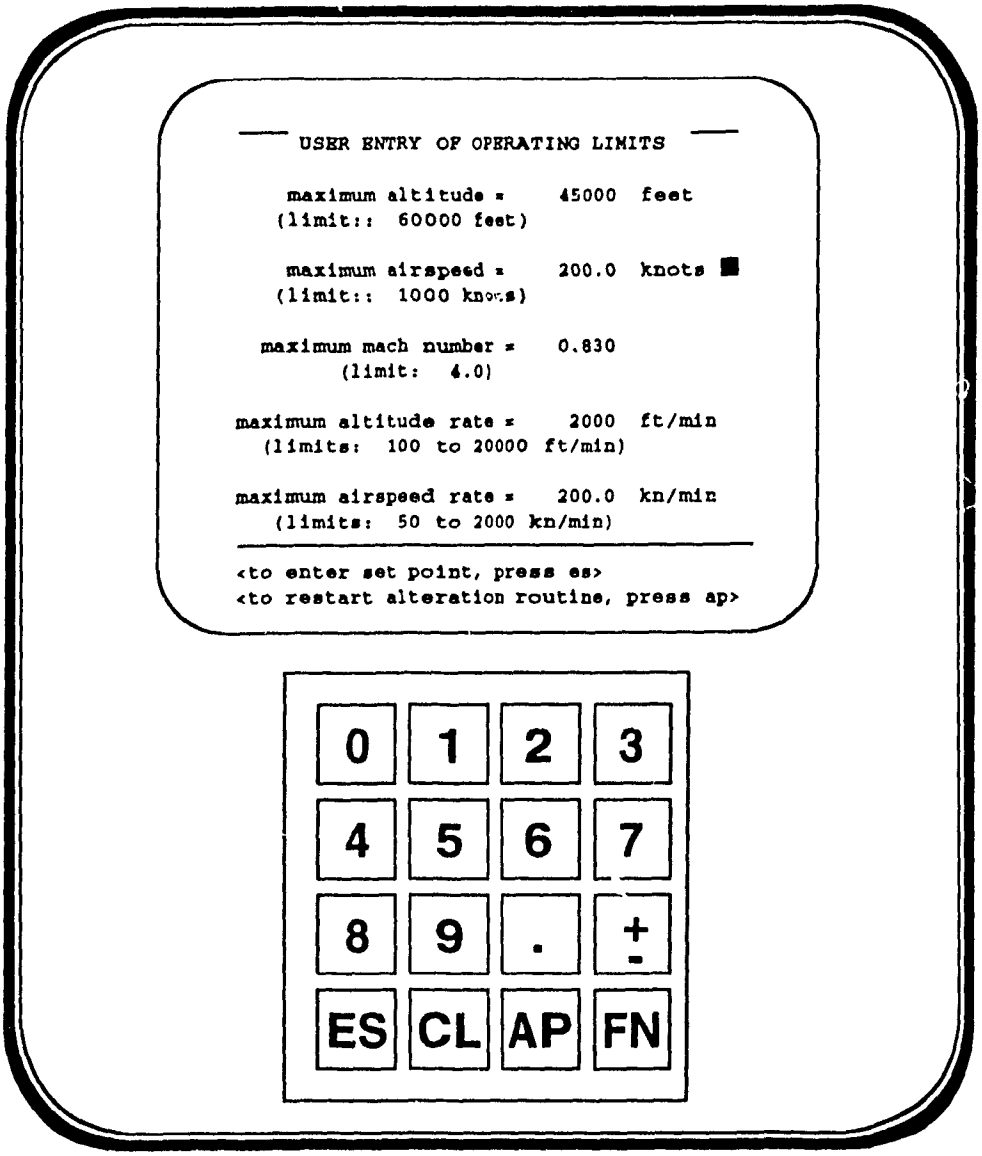
APPENDIX J

Post-test

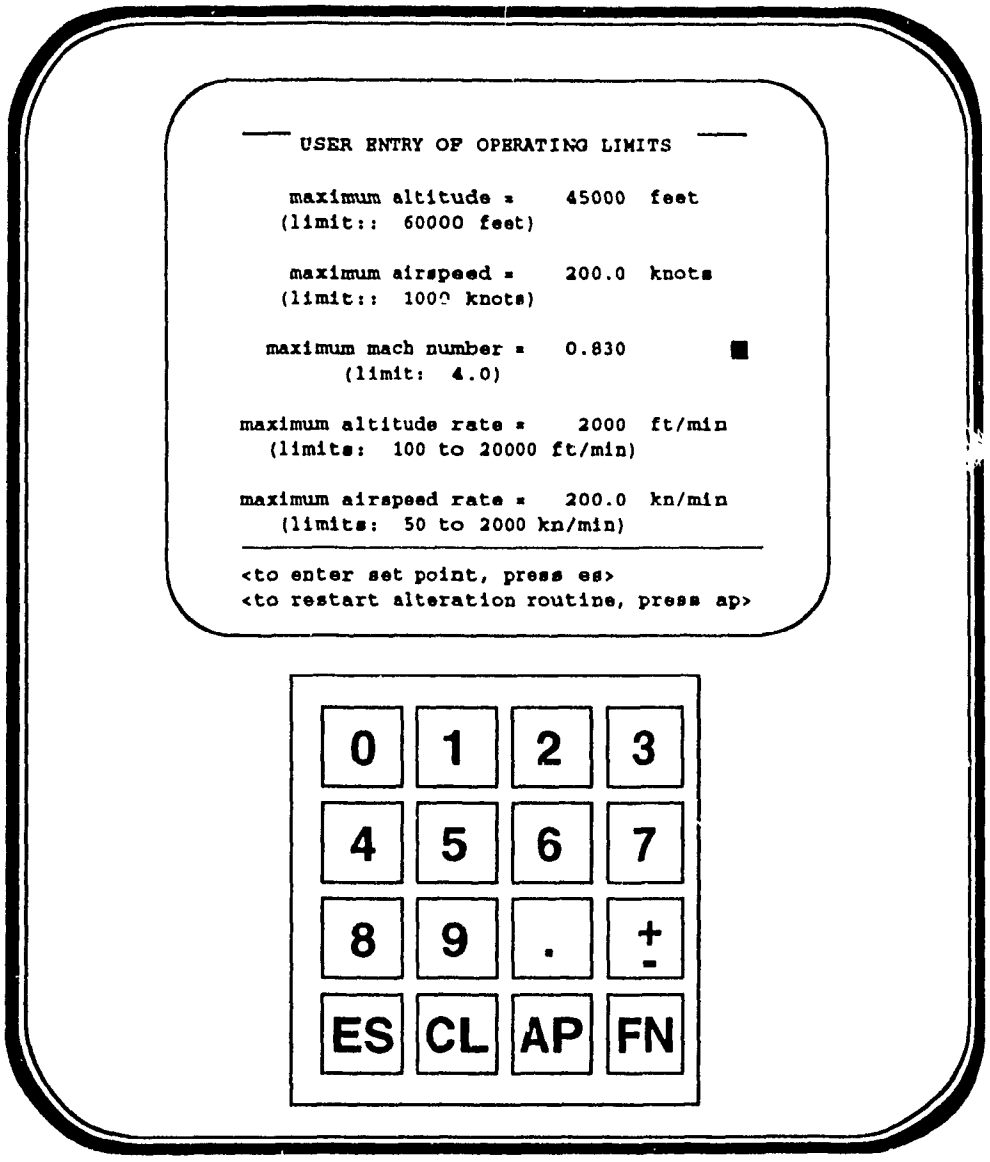
AIR DATA TESTER

FORMATIVE EVALUATION 2

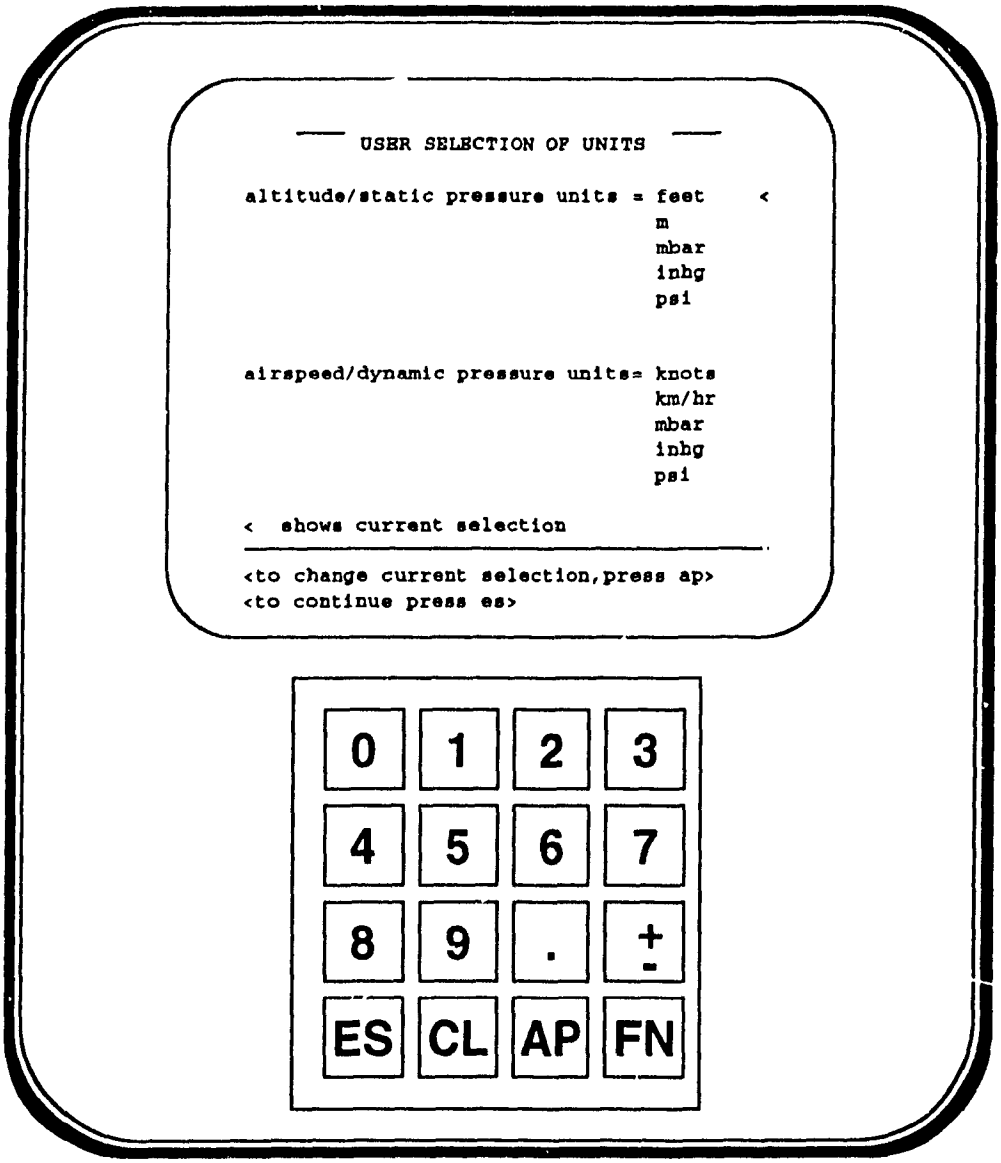
Participant number: _____



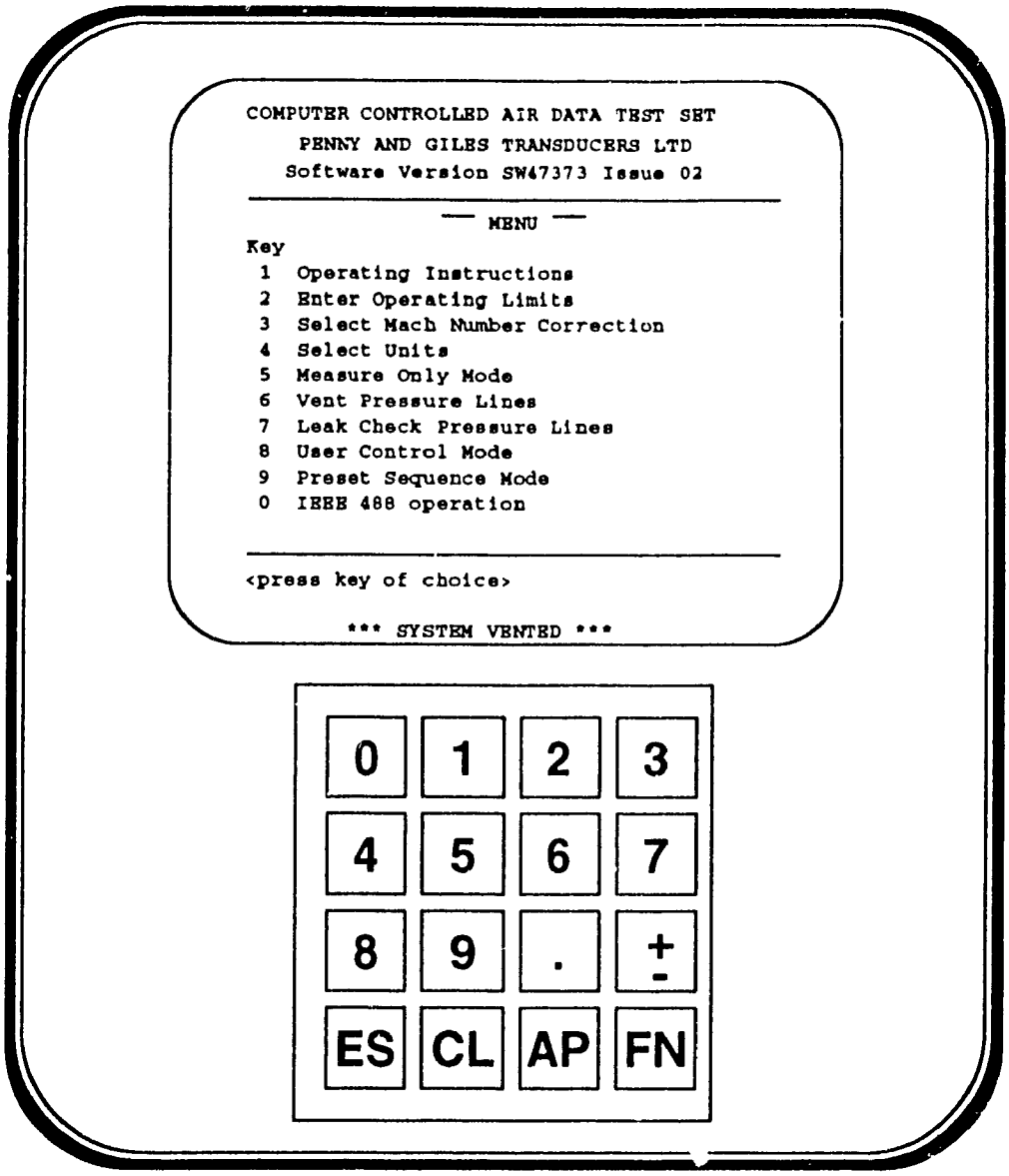
1) You are on the User Entry of Operating Limits page. The cursor is flashing on the maximum airspeed line. The value that is displayed (200.0) does not need to be changed. How do you move on to change the mach number value?



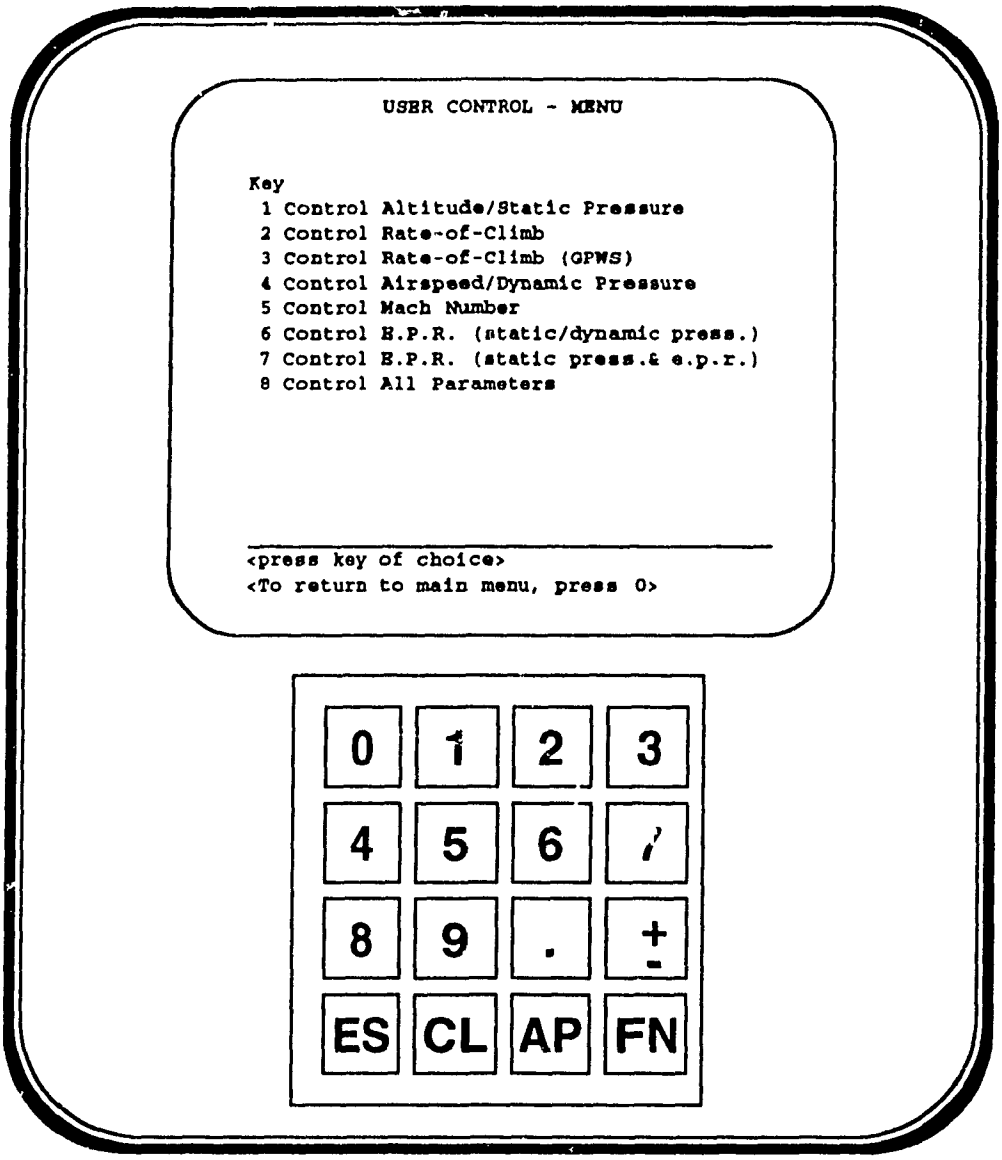
2) The cursor is now flashing on the maximum mach number line. You suddenly remember that you wanted to change the maximum altitude to 35000 feet. How do you get back to the maximum altitude line so that you can change the value ?



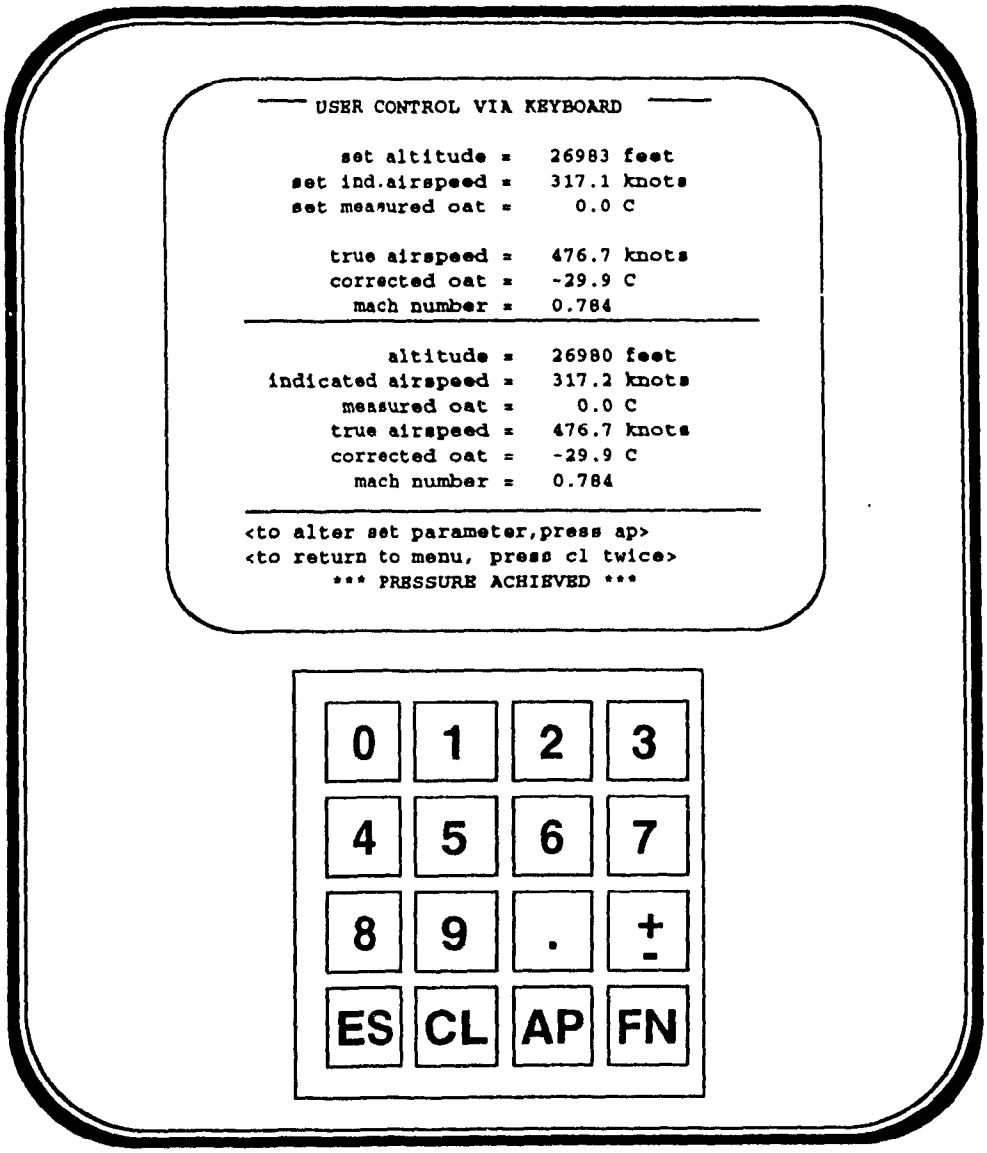
3) Suppose you want to work in units of psi. Describe, step-by-step, what you would do to select these units, starting at the altitude/static pressure units and going to the airspeed/dynamic pressure units.



4) You want to perform a leak check and you want to use the method which will allow you to calculate the leak rate yourself. Which menu option(s) would you use to do this ?



5) You plan to do a leak check. You have selected menu option 8 so that you can pressurize the system. You are now on this page. Which menu option will you select ?

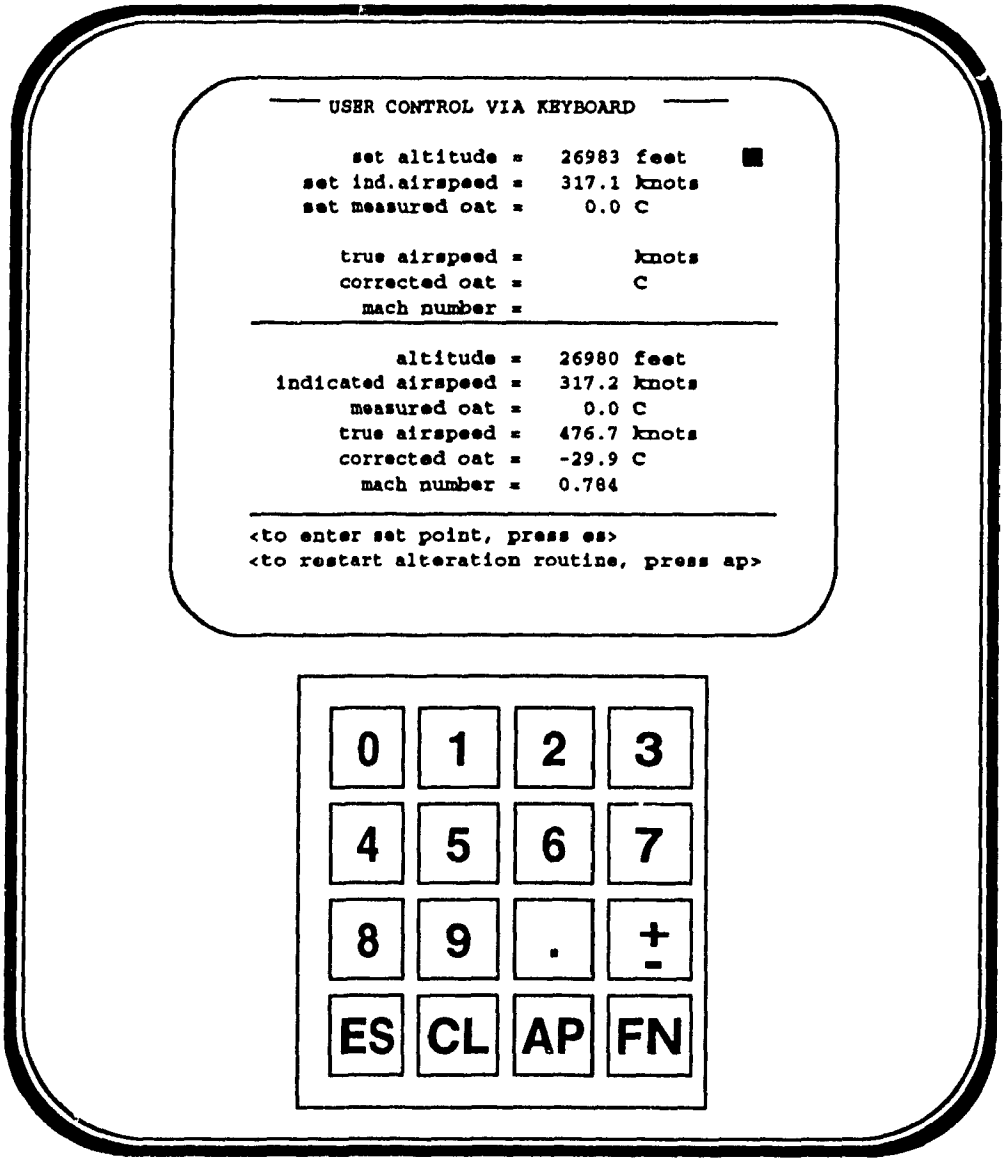


6) You are still going through the process to pressurize the system. You want to pressurize to 30000 feet, 250 knots and 10 degrees C.

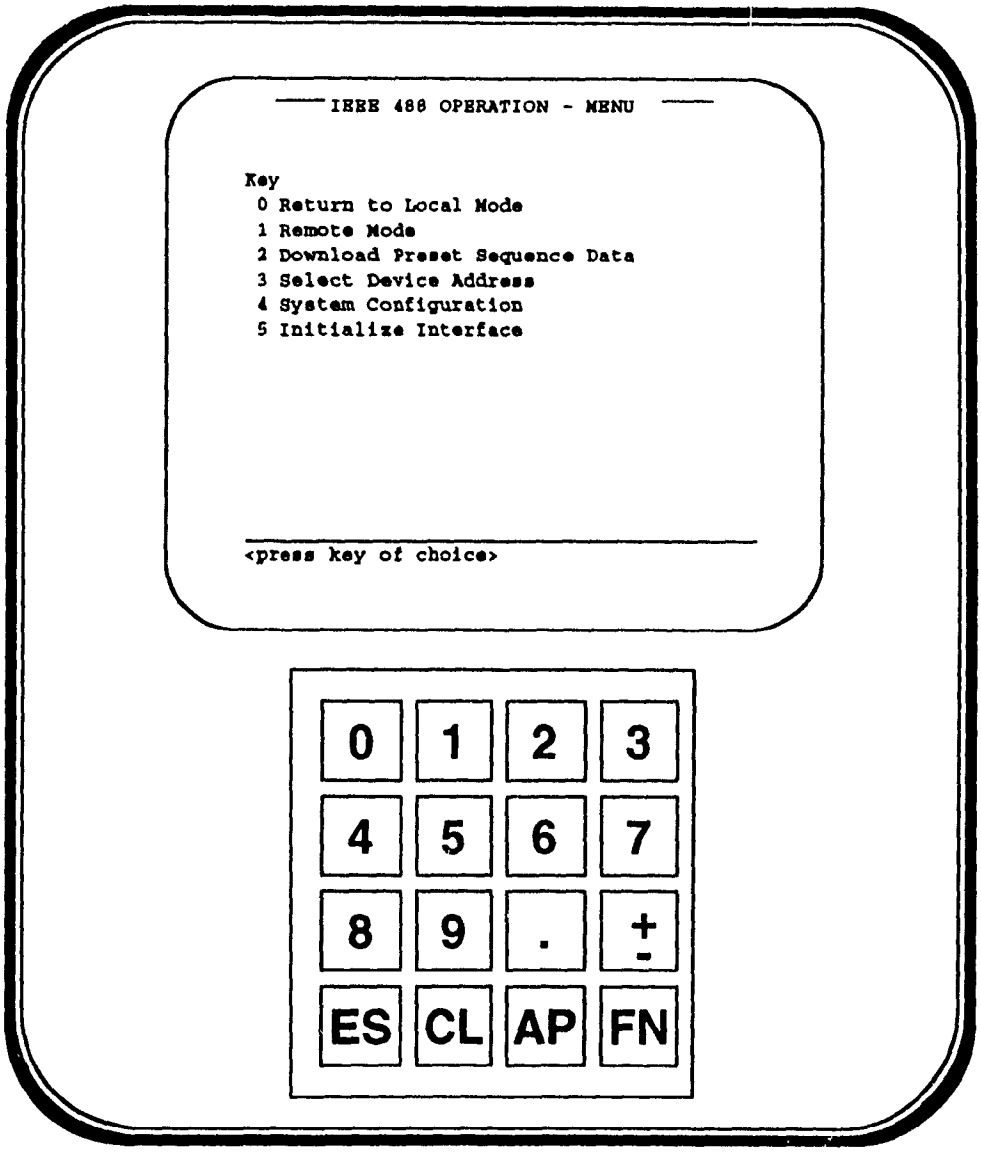
So far, you have done the following:

- You have selected menu option 8.
- You have selected the Control All Parameters page, which is what you see now.

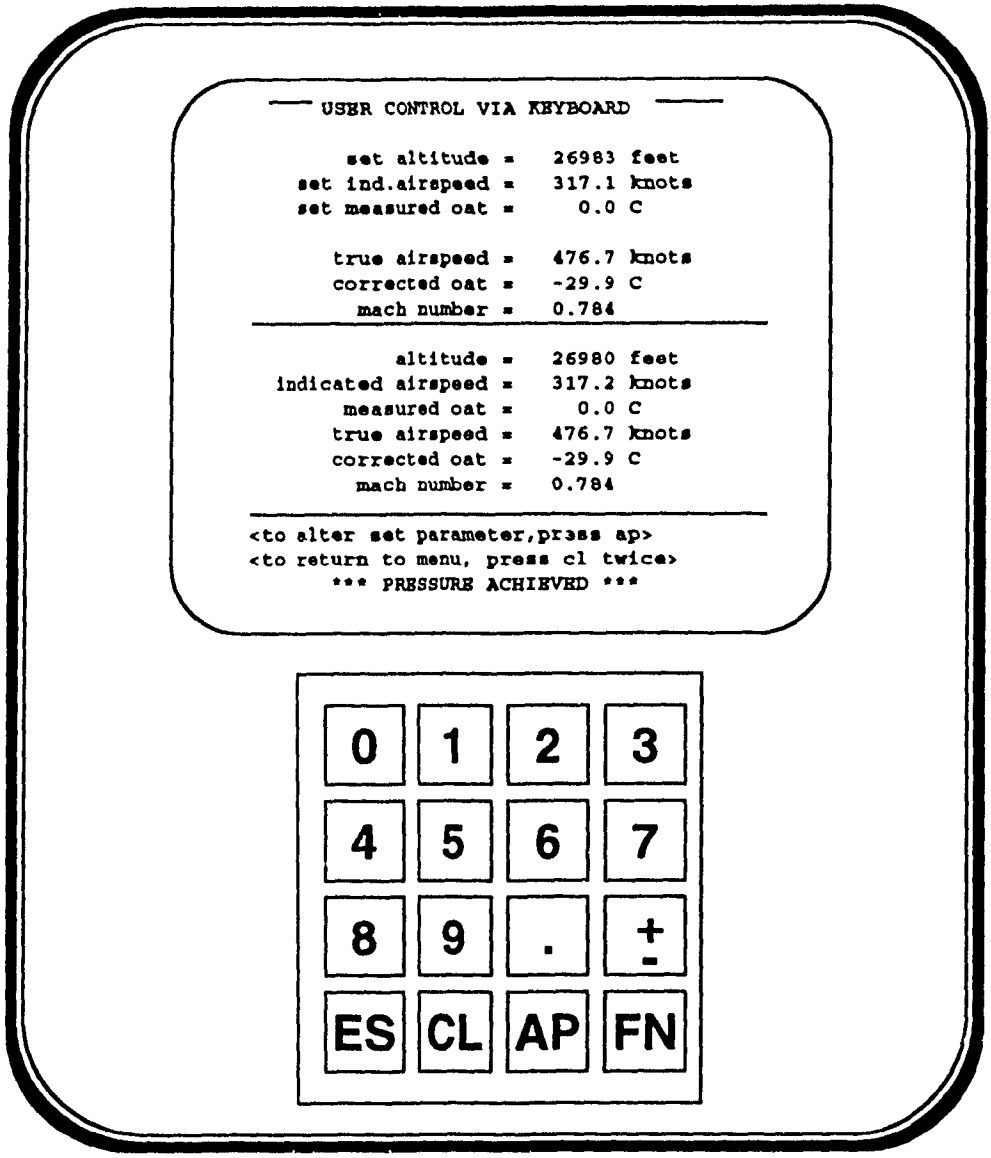
What is the next key to press ?



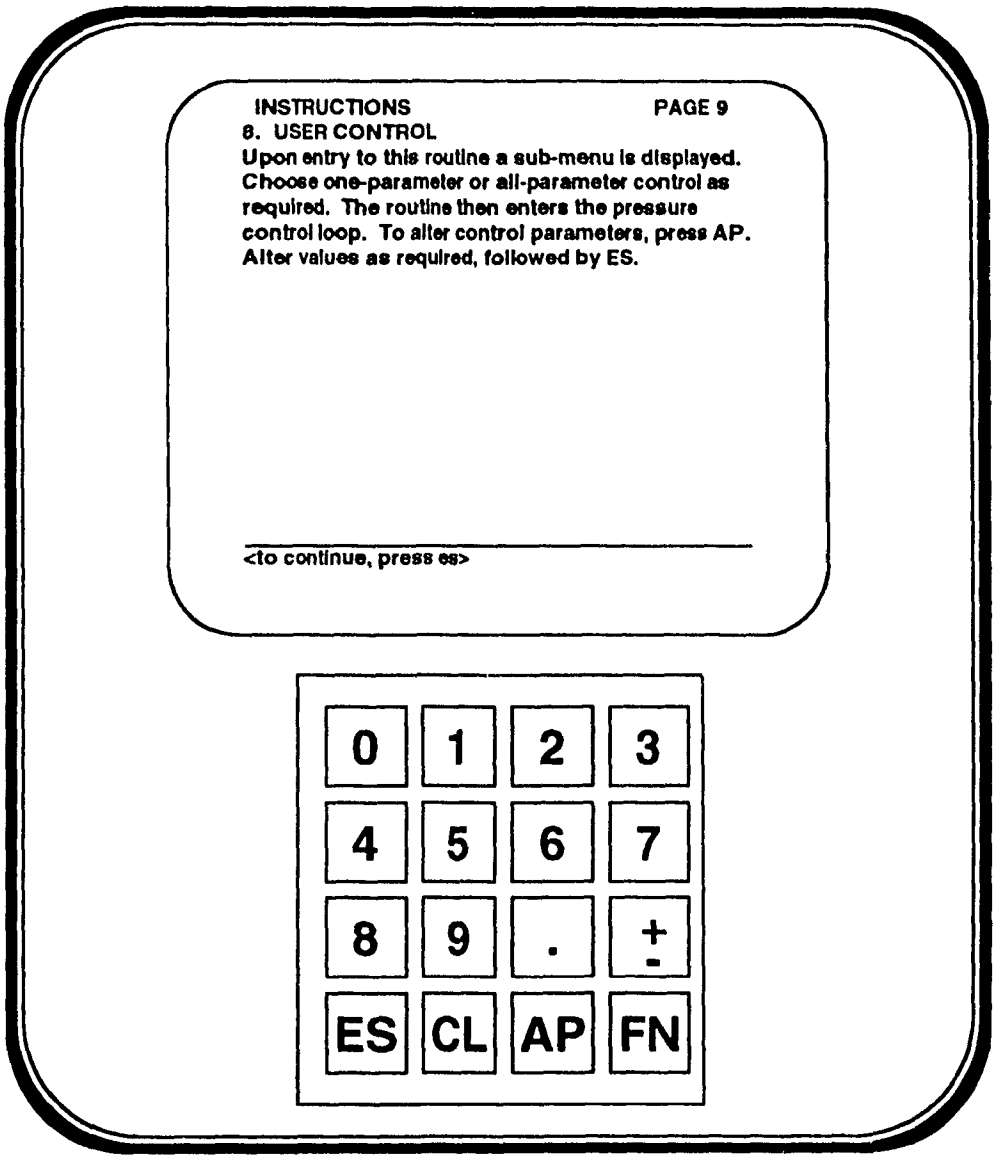
7) Suppose you start typing a number and you press the wrong digit. How do you erase this value to start typing the number over again ?



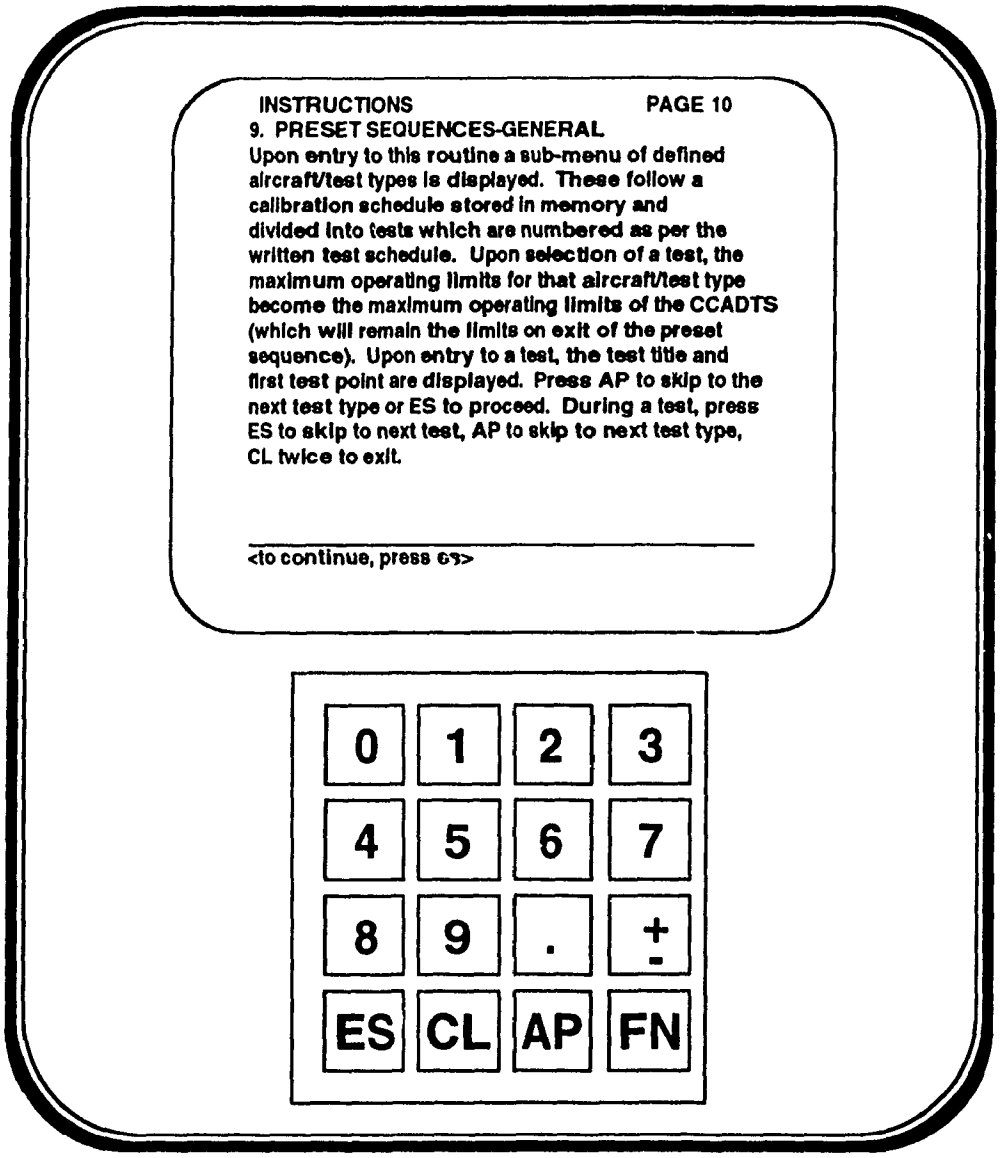
8) Suppose you accidentally selected menu option 0 and so you arrived at this page. How do you get back to the main menu?



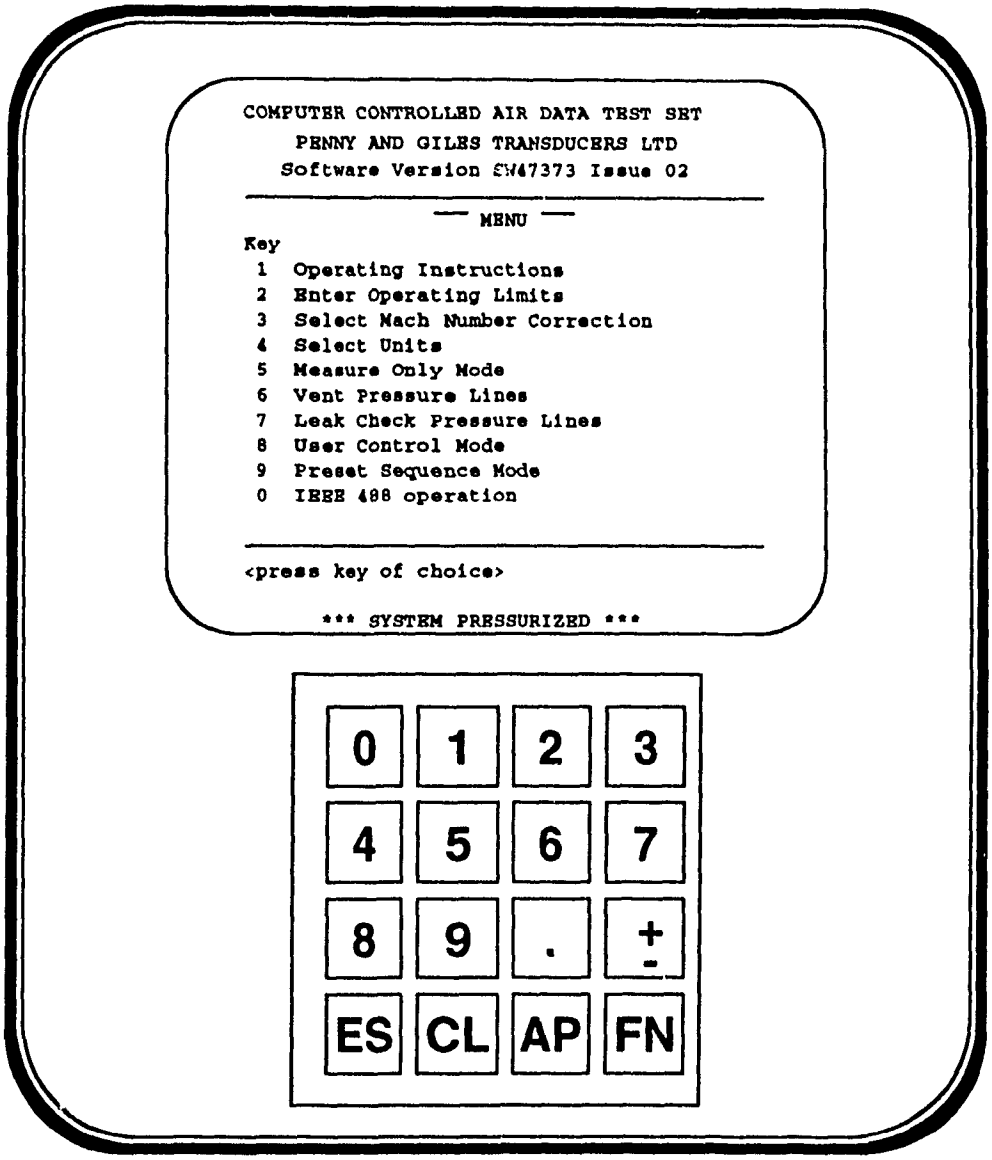
9) You have pressurized the system to the values shown on the display. What key would you now press if you wanted to nudge the altitude down one foot ?



10) You are on page 9 of the on-line help. How do you get to page 10 ?



11) You are on page 10 of the on-line help. How do you get back to the main menu ?



12) You have finished with the tester and want to put it away. What must you do before you turn the power off ?

Additional Questions

What did you like most about this lesson?

What did you like least about this lesson ?

APPENDIX K

Written and Oral Comments

Table K-1. Comments that were written while taking the lesson.

	Comment	Number of times comment given	Remarks
1.	"After setting the limits it would be nice to SEE an example of what will happen if AP is selected and then continue with the lesson as per the sequence."	1	
2.	"There is always some attemp that a student will do some are useless and some will be covered in the futur or as the lesson is going on. It would be nice to have an answering promp to inform that the selection make will be covered during the progression of the lesson, or having a very brief reminder of the function when this is pertinent. SOME ARE AS MY NOTE."	1	
3.	"I did remark that there is some frame that do lead you to a selection as some others has no leading feature e.g. select 4, press ES, etc..."	1	This comment came from same person who made comment in Table K-3 (#3)
4.	"It would be nice to press the CDU keyboard to select, continue instead of the arrows selection, when this is possible. Note: Some frame are making use of it."	1	
5.	"This page allows you....Drawn out and repetitive - already told this before."	1	This comment came from same person who made comment in Table K-3 (#2).
6.	Spelling mistakes:		
	(obrained) pg 1	2	
	latered pg 3	1	
	teh pg 6 item 6	1	
	teh pg 8	2	
	ten pg 12	1	
7.	"Title of menu highlite (capitals)"	1	
8.	"At leak check auto calculations. The leak rate shows 40 ft/min static 4 kn/min pitot However the altitude still shows 25,000 feet and the indicated airspeed is still 200 k. These figures should be 24952 and 196 knots."	1	

Table K-2. Responses to the posttest question: What did you like most about this lesson.

	Response (verbatim)	Number of times response given
1.	Very good description using CRT.	1
2.	Instructions very clear.	1
3.	No problem.	1
4.	User friendly.	1
5.	Easy to understand. Using the computer is almost like using the real tester.	1
6.	The possibility to restart at will, learn from our bad selection and the description of what is actually taking place with an estimate of the duration of the step in real time compared to the computer time.	1
7.	Excellent.	1

Table K-3. Responses to the posttest question: What did you like least about this lesson.

	Response (verbatim)	Number of times response given
1.	More exercise using the computer would be nice (ex., more leak check, using the computer tester to do ground prox would also be nice).	1
2.	I tend to find too much info on screen at one time (both the menu on the Air Data instrument & instructions for use).	1
3.	The lack of consistency. I mean that there is some frame that gives some leading instruction and some others none.	1

Table K-4. Comments made during the debrief.

	Comment	Number of times comment given	Remarks
1.	Good break from class.	1	
2.	Easy to use.	1	
3.	Realistic.	1	
4.	Straight forward.	1	
5.	Lot of writing on screen.	1	Comment made by same person who made comment in Table K-3 (#2).
6.	Prefer more writing on screen than having multiple frames.	1	Comment was in response to #5.
7.	Some prompts (feedback) should give more info, such as "will be covered later on", "not useful because..."	1	Comment made by same person who made comment in Table K-1 (#2).
8.	Would like more room to make mistakes and see results.	1	
9.	In beginning, explain what to expect and what will be able to do.	1	
10.	Add a "help" feature: Touch the key on the keypad and get description of what the key is used for.	1	

APPENDIX L

Pre-test/Post-test Statistical Results

Table L-1. Sums for the pre-test - post-test comparison

Subject	Pre-test**	Post-test**	Sum
1	2.5	9.5	12
2	0	7	7
3*	6.5	11.5	18
4	0	11	11
5*	6	9	15
6*	3	9.5	12.5
7	7.5	10.5	18
8*	9	12	21
Sum of scores	34.5	80	114.5
Sum of squared scores	230.75	818	
Mean	4 3	10	
Standard Deviation	3.4	1.6	

* Students who have previously used the Air Data Tester
** Maximum possible score: 12.

Table L-2. Analysis of variance: Pre-test - post-test

Source	Sum of squares	df	MS	F
A	129.39	1	129.39	33.26
S	72.73	7	10.39	
A x S	27.23	7	3.89	
Total	229.36	15		

The F is significant at $\alpha = .05$

Table L-3. Sums Question 1

Subject	Pre-test	Post-test	Sum
1	0	1	1
2	0	1	1
3	0	0	0
4	0	1	1
5	1	1	2
6	0	1	1
7	1	1	2
8	1	1	2
Sum of scores	3	7	10
Sum of squared scores	3	7	

Table L-4. Analysis of variance: Question 1

Source	Sum of squares	df	MS	F
A	1.00	1	1.00	7
S	1.75	7	0.25	
A x S	1.00	7	0.14	
Total	3.75	15		

The F is significant at $\alpha = .05$

Table L-5. Sums Question 2

Subject	Pre-test	Post-test	Sum
1	1	1	2
2	0	0	0
3	1	1	2
4	0	1	1
5	0	0	0
6	1	0	1
7	1	1	2
8	1	1	2
Sum of scores	5	5	10
Sum of squared scores	5	5	

Table L-6. Analysis of variance: Question 2

Source	Sum of squares	df	MS	F
A	0.00	1	0.00	0
S	2.75	7	0.39	
A x S	1.00	7	0.14	
Total	3.75	15		

Accept the null hypothesis.

Table L-7. Sums Question 3

Subject	Pre-test	Post-test	Sum
1	0	1	1
2	0	1	1
3	0	1	1
4	0	1	1
5	0	0.5	0.5
6	0	1	1
7	1	1	2
8	0	1	1
Sum of scores	1	7.5	8.5
Sum of squared scores	1	7.25	

Table L-8. Analysis of variance: Question 3

Source	Sum of squares	df	MS	F
A	2.64	1	2.64	38.16
S	0.61	7	0.09	
A x S	0.48	7	0.07	
Total	3.73	15		

The F is significant at $\alpha = .05$

Table L-9. Sums Question 4

Subject	Pre-test	Post-test	Sum
1	0.5	0.5	1
2	0	1	1
3	0.5	0.5	1
4	0	1	1
5	0.5	0.5	1
6	0	0.5	0.5
7	0.5	0.5	1
8	0	1	1
Sum of scores	2	5.5	7.5
Sum of squared scores	1	4.25	

Table L-10. Analysis of variance: Question 4

Source	Sum of squares	df	MS	F
A	0.77	1	0.77	6.24
S	0.11	7	0.02	
A x S	0.86	7	0.12	
'	1.73	15		

The F is significant at $\alpha = .05$

Table L-11. Sums Question 5

Subject	Pre-test	Post-test	Sum
1	0	1	1
2	0	1	1
3	0	1	1
4	0	1	1
5	1	1	2
6	0	1	1
7	1	1	2
8	1	1	2
Sum of scores	3	8	11
Sum of squared scores	3	8	

Table L-12. Analysis of variance: Question 5

Source	Sum of squares	df	MS	F
A	1.56	1	1.56	11.67
S	0.94	7	0.13	
A x S	0.94	7	0.13	
Total	3.44	15		

The F is significant at $\alpha = .05$

Table L-13. Sums Question 6

Subject	Pre-test	Post-test	Sum
1	1	1	2
2	0	1	1
3	1	1	2
4	0	1	1
5	1	1	2
6	0	0	0
7	1	1	2
8	1	1	2
Sum of scores	5	7	12
Sum of squared scores	5	7	

Table L-14. Analysis of variance: Question 6

Source	Sum of squares	df	MS	F
A	0.25	1	0.25	2.333
S	2.00	7	0.29	
A x S	0.75	7	0.11	
Total	3.00	15		

Accept the null hypothesis.

Table L-15. Sums Question 7

Subject	Pre-test	Post-test	Sum
1	0	1	1
2	0	1	1
3	1	1	2
4	0	0	0
5	1	0	1
6	1	1	2
7	0	0	0
8	1	1	2
Sum of scores	4	5	9
Sum of squared scores	4	5	

Table L-16. Analysis of variance: Question 7

Source	Sum of squares	df	MS	F
A	0.06	1	0.06	0.304
S	2.44	7	0.35	
A x S	1.44	7	0.21	
Total	3.94	15		

Accept the null hypothesis.

Table L-17. Sums Question 8

Subject	Pre-test	Post-test	Sum
1	0	1	1
2	0	0	0
3	0	1	1
4	0	1	1
5	0	1	1
6	0	1	1
7	0	1	1
8	1	1	2
Sum of scores	1	7	8
Sum of squared scores	1	7	

Table L-18. Analysis of variance: Question 8

Source	Sum of squares	df	MS	F
A	2.25	1	2.25	21
S	1.00	7	0.14	
A x S	0.75	7	0.11	
Total	4.00	15		

The F is significant at $\alpha = .05$

Table L-19. Sums Question 9

Subject	Pre-test	Post-test	Sum
1	0	0	0
2	0	0	0
3	0	1	1
4	0	1	1
5	0	1	1
6	0	1	1
7	0	1	1
8	0	1	1
Sum of scores	0	6	6
Sum of squared scores	0	6	

Table L-20. Analysis of variance: Question 9

Source	Sum of squares	df	MS	F
A	2.25	1	2.25	21
S	0.75	7	0.11	
A x S	0.75	7	0.11	
Total	3.75	15		

The F is significant at $\alpha = .05$

Table L-21. Sums Question 10

Subject	Pre-test	Post-test	Sum
1	0	1	1
2	0	1	1
3	1	1	2
4	0	1	1
5	1	1	2
6	1	1	2
7	1	1	2
8	1	1	2
Sum of scores	5	8	13
Sum of squared scores	5	8	

Table L-22. Analysis of variance: Question 10

Source	Sum of squares	df	MS	F
A	0.56	1	0.56	4.2
S	0.94	7	0.13	
A x S	0.94	7	0.13	
Total	2.44	15		

Accept the null hypothesis.

Table L-23. Sums Question 11

Subject	Pre-test	Post-test	Sum
1	0	0	0
2	0	1	1
3	1	1	2
4	0	1	1
5	0	1	1
6	0	1	1
7	0	1	1
8	1	1	2
Sum of scores	2	7	9
Sum of squared scores	2	7	

Table L-24. Analysis of variance: Question 11

Source	Sum of squares	df	MS	F
A	1.56	1	1.56	11.67
S	1.44	7	0.21	
A x S	0.94	7	0.13	
Total	3.94	15		

The F is significant at $\alpha = .05$

Table L-25. Sums Question 12

Subject	Pre-test	Post-test	Sum
1	0	1	1
2	0	0	0
3	1	1	2
4	0	1	1
5	0.5	1	1.5
6	0	1	1
7	1	1	2
8	1	1	2
Sum of scores	3.5	7	10.5
Sum of squared scores	3.25	7	

Table L-26. Analysis of variance: Question 12

Source	Sum of squares	df	MS	F
A	0.77	1	0.77	6.24
S	1.73	7	0.25	
A x S	0.86	7	0.12	
Total	3.36	15		

The F is significant at $\alpha = .05$

APPENDIX M

Programmed Portion: Production Time and Costs

TABLE M-1: TIME SPENT ON DESIGN, PRODUCTION AND EVALUATION

Task	Designer/producer, Programmer, Evaluators (hours)	Subject Matter Expert (hours)	% of total time
Instructional analysis and storyboard	58	7	12
Programming	400	-	76
Evaluation	59	1	12

PROGRAMMED PORTION: PRODUCTION TIME AND COSTS

ONE TIME COURSE PREPARATION

	CBT
Number of hours of instruction	0.5
Preparation time per hour of instruction (hrs)	1050.00
Total preparation time (hours)	525 00
Preparation cost at $20/hours	$10,000
Preparation cost at $25/hour	$625
Material costs	$15
Total preparation cost	$10,640