Instructions For

Light Pen

for the VIC-20™ & C-64™

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Well, you bought it! What do you do with it?

You can use the Cardriter 1 Light Pen for many types of input and user response on Commodore VIC-2Ø (tm) and Commodore 64 (tm) computers. The pen is great for doing input fast, without using the keyboard. Some of the best uses include:

* Selecting an item from a list of options (menu selection)

* Pointing at a position on the screen for games (like the TIC-TAC-TOE game on the cassette)

* Picking an answer to a multiple-choice question (like the Computer Literacy Quiz on the cassette)

* Telling the computer to display the next screen of information

The light pen is great for responding to a program fast without having to use the keyboard. The pen allows you to point at an answer rather than type it in. By using the pen, anyone can respond to displayed prompts and questions, even if they don't know how to type. It also eliminates spelling errors in input because nothing has to be typed in.

Contrary to popular belief, the Cardriter 1 can not be used very well to draw pictures or write words (or your name) on the screen (too bad!). The microprocessors in the VIC and 64 are just not able to handle that type of use. Some computers can be used to draw fancy graphics with a light pen; notice, however, how much those computers cost! Few people (certainly not me!) can afford that type of computer.

This manual and the programs on the cassette show you how to use the Cardriter 1 Light Pen for selecting items from a menu, for responding to prompts, for answering multiple-choice questions, and for playing games. We'll also give you details on programming for the light pen and on how the pen works.

WHAT'S IN THE BOX I BOUGHT?

Three things were in the box that you bought: the Cardriter 1 Light Pen, this manual, and a cassette. You have obviously unpacked the manual and started reading it, so I won't tell you to do that. What you should do now, however, is to remove the Cardriter 1 Light Pen from the box and carefully unwind the cord. Before you get started, you should know what is on the cassette and what this manual describes.

The cassette contains six programs that describe how to operate and program for the pen and give examples of the pen's use for games and practical applications. The programs are actually on both sides of the caon one side are for the VIC-2Ø while the others are for the Commodore 64. The sets are alike except that the programs for the Commodore 64 access different memory locations and 5oes of the caregisters than the programs for the VIC. The VIC-2Ø programs are named 1/2Ø, 2/2Ø, 3/3Ø, 4/2Ø, 5/2Ø, and 6/2Ø. The programs for the Commodore 64 are named 1/64, 2/64, 3/64, 4/64, 5/64, and 6/64. Both sets are stored on the cassette in the following order, one set per side:

* Introduction To The Light Pen-- An informational program that tells how to operate the pen, gives an overview of the technical information, and lets you use the pen to "get the feel of it."

* Pen Map -- An informational program that shows the vertical and horizontal coordinates of each screen position as seen by the computer

* Fun With Numbers -- The ultimate in fun educational programs. A program for younger people who are learning their numbers; adults who want an intellectual challenge will also find the higher skill levels stimulating. You use the light pen rather than the keyboard to indicate your answers.

* Computer Literacy Quiz -- A fun but informative quiz on using the light pen and computer for multiple-choice tests. You actually use the light pen to pick answers in this quiz.

* Tic-Tac-Toe -- That's right, that famous old game, but with a new and fun way of playing using the light pen. It can't be beaten!

* Mailing List -- One of the best mailing list programs around (you are lucky to get it free with your light pen!). You use the Cardriter 1 Light Pen with it to make mailing lists a pleasure instead of a chore.

All the programs but the Mailing List run in an unexpanded VIC and, of course, a Commodore 64. The Mailing List program requires an 8 K byte memory expansion on the VIC-2Ø.

All the programs on the cassette are written in BASIC and are not protected. You can see them by LISTing them; they have some good examples of programming in general and using light pen input. Study them and read this manual if you are going to write programs which use light pen input.

You should make a backup copy of the programs when you first run them. The easiest way to do this is to LOAD the program, then remove the cassette and insert one for backup, then store the program by entering SAVE and the program name. If you happen to destroy the programs on the Light Pen Instruction Package cassette, we will replace them; send us the original cassette and $1.5Ø for shipping expenses. If you can't send the original cassette, send us $5.ØØ for tape and shipping expenses, and we will send you a new cassette containing the programs.

SET-UP
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Now that you have everything out of the box, do the following things to get set up.

1. Turn on your TV or (if you are lucky enough to have one) your monitor. Also turn on your computer and, if necessary, your cassette drive. If you have a printer, turn it on too. You don't really need it, but the Pen-Map program lets you print some handy technical info. If you're like me and don't have a printer, don't worry; you can display the same info on the screen. You may also want to create a mailing list with the (well-named!) Mailing List program; if you want to print your results, you'll need to turn on your printer.

2. Get the Light Pen Instruction Package cassette out of its protective case and put it in your computer's cassette drive. Be sure to put the proper side up (the VIC-20 side if you are using a VIC, or the other side if you are using a Commodore 64.) If you don't have a Commodore Dataset, you can use an audio cassette player with an interface (such as CARDCO's Cardette 1). Be sure to put the cassette in your computer cassette drive, not your stereo. (This cassette wouldn't be too pleasing to the human ear!) Rewind the cassette if necessary.

3. If you have a joystick or a set of paddles plugged in, unplug them now.

4. Plug in the Cardriter 1 Light Pen just like you would a joystick. It goes into the port labeled "Control Port" on the right end of your computer. Be sure you insert the plug the right way; it only fits into the port one way (just like a joystick plug).

5. Enter LOAD and the name of the program you want to run. (For example, LOAD "1/2Ø".) The program names are as follows:

* 1/2Ø or 1/64: Introduction To The Light Pen
* 2/2Ø or 2/64: Pen-Map
* 3/2Ø or 3/64: Fun With Numbers
* 4/2Ø or 4/64: Computer Literacy Quiz
* 5/2Ø or 5/64: Tic-Tac-Toe
* 6/2Ø or 6/64: Mailing List

You really should start with the 1/2Ø (or 1/64, for Commodore 64 users). It tells how to use the pen, tells a little about the mechanics of the pen, and has a program that you use the pen with.

6. Press PLAY on the cassette drive.

7. While the program is being loaded from cassette, let me tell you a little of the history of the light pen.

THE FASCINATING HISTORY OF THE LIGHT PEN

No, Virginia, the people of CARDCO, Inc. did not invent the light pen. (They just made it affordable!) It was used, surprisingly enough, almost 30 years ago--in the mid 1950's. Its first general use was on the SAGE system of the U.S. Department of Defense. The SAGE system was used to track the positions of aircraft in and around the United States. The light pen was used for the same purposes as you can use it for on the VIC-20 and Commodore 64, responding to displayed questions and pointing to positions on the screen. The light pen idea was used in a few other systems, but didn't really catch on for a few years.

Two applications of the early 60's stand out because of their innovativeness: the M.I.T. Sketchpad project, pioneered by Ivan Sutherland, and the Digigraphic System that Itek Corporation developed. Both these systems allowed the user to manipulate, store, and retrieve pictures and drawings. Other technological advances occurred through the years to make the light pen one of the most versatile and "user-friendly" computer peripherals around. These days, automobile manufacturers and many other businesses use light pens on very sophisticated (but expensive) systems to draw blueprints, engineering models, and other graphics.

8. Now that you've had your history lesson, you need to learn the secrets of operating the pen. Read the section entitled "Operating The Light Pen" now. When you finish it, come back to here.

9. Well, the first program should be loaded by now. If it isn't, wait a little longer for it. When READY is displayed, enter RUN.

10. If you are just going to use the pen with the programs on the cassette and with other programs you buy, don't worry about learning the information presented about screen positions and maps. If you are going to write programs that use the light pen for user responses, pay attention to the information but don't worry about writing it down. After all, that's one of the things this manual is for--to tell you how to write programs which use the light pen for input.

OPERATING THE LIGHT PEN
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This section of the manual tells you in detail how to use the Cardriter 1 Light Pen. You should read this section even if you aren't going to do any programming for the pen. (The programming information is covered in the "Programming For The Light Pen" section of this manual.)

Plug the light pen into the Control Port on the right end of your computer, where you would plug in a joystick or set of paddles. Because only one device can be plugged into the port, you can't have both the light pen and a joystick (or paddles) hooked up at the same time.

Hold the pen like an ink pen, with the button on top so that you can reach it with your forefinger. (If that isn't comfortable, hold it however you like!) On the tapered end you'll see what looks like glass. This is called the lens; it is the part that you hold up to the screen.

To use the pen to respond to a prompt displayed on the screen, pick up the pen, touch it lightly to the screen at the prompt, and press the button for a moment. Hold the pen at a right angle to the screen.

Don't worry about touching the screen with the pen; the lens is plastic and won't scratch the screen.) When the program reacts to the pen's input, you can let up on the button and put the pen back down.

If nothing happens, do the following things.

* Release the button on the pen, then press it again.

* Slowly sweep the tip of the pen in an area the size of a fingertip where the prompt is displayed.

* Turn up the contrast and brightness controls of your TV or monitor. This will make it easier for the light pen to distinguish the light areas from the dark areas.

* Make sure the pen is plugged in and that you are pressing the button on the pen while you hold the pen to the screen.

If none of these actions seems to clear up the problem, and if you are using a TV that is more than two years old, then (I'm sorry to say) your TV may be in need of repair. If you have another TV, hook it up to your computer and try using the pen again.

Remember that the pen has no effect unless a program is looking for its presence at the screen. You can't just start writing your name on the screen; the pen won't work like that. What it is used for is to respond to prompts a program displays on the screen, to pick an item in a displayed list of options, or to point to a spot on the screen at which a program is to take action.

Well, those are the secrets of operating the pen. Enjoy using it!

PROGRAM 1 -- INTRODUCTION TO THE LIGHT PEN

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The first program on the cassette describes how to use the light pen and gives some basic information on how a program uses it for input. It also has a program with which you can use the Cardriter 1 Light Pen to see X, Y, and screen map coordinates.

Read the information on each screen and follow the instructions displayed. Take all the time you need; the program is not timed, so each screen is displayed until you press a key.

The details of using the screen map formulas are covered in detail in the "Converting X And Y To Screen Map Locations" section of the manual. You may be wondering how the computer determines the X and Y values. That info is covered (in non-technical language) in the section entitled "How Is The Screen Scanned?". The information on X and Y values and on the sixteen coordinates per screen map position is covered in detail in the "X And Y Coordinates" section of this manual.

THE NEAT PROGRAM

The "neat" program at the end of the informational screens of program 1 is useful for seeing how the X and Y values relate to screen map positions, as well as for seeing how unstable the X coordinate is on your TV or monitor. You can also use the program to fine-tune the formulas for the screen map location; different TVs and monitors have different beginning X and Y values. Details on fine-tuning the formula are covered in the "Converting to Screen Map Locations" section.

If you followed the set-up instructions, you've already plugged in the light pen. Otherwise, plug it in now. When the "neat program" is started, touch the light pen to the screen (anywhere) and press the pen's button. The X, Y, and screen map coordinates are displayed. The row and column numbers, and the formulas used to calculate those numbers, are also displayed. Move the pen around slowly on the screen to see how the coordinates change. (Remember to keep the pen at a right angle to the screen.)

If you do it right, the coordinates change. If you don't do it right, the computer just sits there patiently, displaying the same coordinates. You may have to wiggle the tip or press the button a few times. If nothing still happens, you'll need to read the "Operating The Light Pen" section of this manual. It contains some helpful hints for making the pen work (or determining why it won't work).

Use the pen to point at various places on the screen for which you want coordinates displayed. Some good places are in the corners of the screen, up and down the left side of the screen, and across the top or bottom of the screen. Those places show you how the X and Y values change in relation to the pen's location. Experiment a little: start the pen in the top left corner, then go straight to the right. You'll see the X value increase. Start on the top line of the screen and go down, and you'll see the Y value increase. Go from the top left corner to the bottom right corner, and you'll see both variables increase to their maximum values.

To check how unstable the X coordinate is on your screen, hold the pen in one place for about a minute. You may have to press the pen's button several times to get new coordinates displayed. You'll probably see that the X value (and therefore the coordinattes calculatd from X) change even though the pen doesn't move. This happens because the electron gun doesn't scan evenly. The computer can't determine which X value is the right one, so it uses them all. (A technique for reducing this problem is described in the "Smoothing X And Y" section of the manual.) If you are using a monitor, you may not see this problem; if not, consider yourself lucky!

ENDING PROGRAM 1

To end the program, press the RUN/STOP and RESTORE keys. Program 1 is ended; you can then go on to one of the other programs. The VIC-2Ø programs are titled 1/2Ø, 2/3Ø, and so on, through 6/2Ø. The Commodore 64 programs are titled 1/64, 2/64, and so on, through 6/64. The programs are in the same order on both sides of the cassette, as follows:

* 1: Introduction To The Light Pen
* 2: Pen-Map
* 3: Fun With Numbers
* 4: Computer Literacy Quiz
* 5: Tic-Tac-Toe
* 6: Mailing List

To load one of them, enter LOAD and the program title (for example, LOAD "1/2Ø"). You may be instructed to press the PLAY switch on the cassette drive. As with any program stored on cassette, there is quite a wait while the program is being loaded. You might take this time to look at one of the sections of the manual mentioned above.

PROGRAM 2 -- PEN-MAP
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The Pen-Map program gives you the technical details of light pen coordinates. It explains how each screen map location is composed of multiple X and Y coordinates (16 for the VIC-20 and 40 for the Commodore 64). It also shows you those coordinates, and the screen map location, for every screen map location you desire. The coordinates can be displayed or printed. If you are going to write programs that use light pen input, this program will be very helpful in determining what X and Y coordinates the program should look for.

Detailed information on programming for light pen input, on X and Y coordinates, and on other technical considerations is presented in the "Programming For The Light Pen" section of this manual. To get the best use from this program, you should read the "X And Y Coordinates" section of this manual now.

When you start Pen-Map, it asks you whether you need instructions. Answer Y the first time through so you can see the background info. Two screens of info are presented, then a demonstration of the screen locations is run. (These screen locations are the places you can access with a POKE instruction, as you well know.) To stop the cursor during the demonstration, press *; to restart it, press any alphabetic key. To go on to the rest of the program, press RETURN.

After you go through the screen location demonstration, or if you enter N to the INSTRUCTIONS? question at the first, a menu is displayed. To display the coordinates of the first screen line, enter 1. The coordinates for the upper left character position are displayed first. To see the coordinates of the next character on the right, press RETURN. To return to the menu, press *.

The next menu option is to print the coordinates of character positions. (To use this option, you need a printer!) Start the option by entering 2. You are then asked for the line number of the first screen line for which you want coordinates; enter the number (Ø-22 for the VIC; Ø-24 for the C-64). You are then asked how many lines you want coordinates for, starting with that line; enter that number. Next, turn on your printer and position the paper, then press any character key to start printing. The printed coordinates are not in the same format as the displayed ones; instead, they are in this format:

```
LOCATION nnnn = ROW # rr   COLL. # cc
                yy,xx      yy,xx
              yy,xx      yy,xx
```

The nnnn is the screen map location number, the rr is the screen line number, the cc is the character column number, the yy is the Y coordinate, and xx is the X coordinate. The X and Y coordinates are printed as they would be seen on the screen, from left to right on each row of "dots" of the character position.

The third menu option is to display coordinates for selected screen lines. To start this option, enter 3. Next, you are asked for the number of the screen line for which you want coordinates; enter the number (Ø-22 for the VIC; Ø-24 for the C-64). To display the coordinates of the next character position on the right, press RETURN. To return to the menu, press *.

The last menu option is to end the program. To do so, enter 4, then press the RUN/STOP and RESTORE keys.

After you end the program, you can load another program from the cassette. To do this, enter LOAD "name" where name is the program's name; for example, LOAD "1/2Ø". The VIC-2Ø programs are named 1/2Ø, 2/2Ø, and so on through 6/2Ø. The Commodore 64 programs on the other side of the cassette are named 1/64, 2/64, and so on through 6/64. The programs on both sides of the cassette are stored in this order:

* 1:Introduction To The Light Pen
* 2:Pen-Map
* 3:Fun With Numbers
* 4:Computer Literacy Quiz
* 5:Tic-Tac-Toe
* 6:Mailing List

PROGRAM 3 -- FUN WITH NUMBERS
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The Fun With Numbers program lets you test your math skills. There are ten skill levels to choose from: they range from simple addition to square roots. You use the light pen to point to the type of problems you want to solve and to point to the correct answer. After the program is loaded, no keyboard input is required. Fun With Numbers is an easy and fun way for younger folks with little typing experience to practice the math skills they learn in school. The higher skill levels also provide a little intellectual exercise for adults who are tired of "shoot-'em-up" game programs.

When you start the program, you have a choice of ten types of problems (skill levels) as follows:

Ø: Addition
1: Subtraction
2: Both addition and subtraction
3: Multiplication
4: Division
5: All of the above
6: Fractions
7: Percentages
8: Square roots
9: All of the above types of problems

Point the light pen at the box next to the type of problems you want to solve and press the pen's button.

When you pick a type of problem, twenty problems of that type are displayed, one at a time. One of the numbers in each problem is replaced by a "?"; your job is to figure out what number should be where the "?" is. The answer is always one of the numbers on the left side of the screen, Ø through 9. To answer the problem, point the light pen at the box next to the correct answer and press the pen's button. (You may have to wiggle the pen just a bit.)

If you pick the correct answer, the program tells you so and adds 1 to your score. If you were wrong, the program tells you so and tells you the correct answer. After you have answered all twenty questions, your score is displayed. You then have the choice of going again or ending the program. To go back to the menu to pick a type of problem, point the pen at Ø and press the pen's button. To end the program, pick 1.

After you end the program, you can load another one from the cassette. To do so, enter LOAD "name" where name is the name of a program on the cassette; for example, LOAD "1/2Ø". The VIC-2Ø programs are named 1/2Ø, 2/2Ø, and so on through 6/2Ø. The Commodore 64 programs are named 1/64, 2/64, and so on through 6/64. Both sets of programs are stored on the cassette in this order:

* 1:Introduction To The Light Pen
* 2:Pen-Map
* 3:Fun With Numbers
* 4:Computer Literacy Quiz
* 5:Tic-Tac-Toe
* 6:Mailing List

PROGRAM 4 -- COMPUTER LITERACY QUIZ
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The Computer Literacy Quiz is a rather light-hearted, multiple-choice quiz program. You use the light pen to pick your answer from those displayed, then the program tells you whether you picked the correct one. This program is a good example of how such a test could be structured, while it gives reasons why to use the light pen in schools and other educational environments.

To pick an answer from those displayed, touch the light pen to the screen and press the pen's button. You may have to wiggle the tip of the pen very slightly.

If you pick the wrong answer, the program displays the correct one, then goes on to the next question. At the end of the quiz, your score is displayed. To end the program, press the RUN/STOP and RESTORE keys.

If you are interested in writing programs for testing students and using the light pen as the input method, the Quiz program is an example of an easily-written testing program. List or print it after you finish running it. To print it, prepare your printer, then enter the following BASIC lines after you stop the program:

```
OPEN1,4
CMD1
LIST
```

After the program is printed, enter this line:

```
PRINT#1:CLOSE1
```

If you don't have a Commodore printer, the printout might contain some strange characters. If so, list the program on the screen and see what the characters actually are.

As you can see, the program is really quite short to provide so many questions. The text of the questions is stored in DATA statements, and the answers are stored with the text. There are other, possibly better, ways to write this type of program; this one is just an example. If you are not an experienced programmer, you can get started by using some of the techniques shown in this program.

After you finish this program, you can load another program from the cassette. To do this, enter LOAD "name" where name is the program name (for example, LOAD "1/20"). The VIC-20 programs are named 1/20, 2/20, and so on through 6/20. The Commodore 64 programs on the other side of the cassette are named 1/64, 2/64, and so on through 6/64. The programs on both sides of the cassette are stored in this order:

* 1:Introduction To The Light Pen
* 2:Pen-Map
* 3:Fun With Numbers
* 4:Computer Literacy Quiz
* 5:Tic-Tac-Toe
* 6:Mailing List

PROGRAM 5 -- TIC-TAC-TOE
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The Tic-Tac-Toe program is one that is hard to beat! You play against the computer, using the light pen to point at the square you want. (Be sure to point exactly at the prompt and to press the pen's button.) If neither of you wins, the "cat" gets the game. As soon as one game is finished, the winner gets 1 added to his, her, or its score, and another game is started.

When you lose, the computer really tells you about it! Play hard, and good luck. (Hint: Get the center square first, if you can.)

When you have had enough playing, end the program by pressing the RUN/STOP and RESTORE keys. You can then go on to another program on the cassette if you like. The VIC-2Ø programs are titled 1/2Ø, 2/2Ø, and so on through 6/2Ø. The Commodore 64 programs are titled 1/64, 2/64, and so on through 6/64. Both sets of programs are stored on the cassette in the following order:

* 1: Introduction To The Light Pen
* 2: Pen Map
* 3: Fun With Numbers
* 4: Computer Literacy Quiz
* 5: Tic-Tac-Toe
* 6: Mailing List

To load one of these programs, enter LOAD "name" where name is the program name; for example, LOAD "1/2Ø".

PROGRAM 6 -- MAILING LIST
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The Mailing List program is one of the most complete and easy-to-use programs available for microcomputers. You really got a bargain when you got it with your Cardriter 1 Light Pen. The program has extensive prompting, so that you are never left wondering what to do (unlike several other expensive mailing list programs!). It is quite versatile; you can store mailing lists on either disk or cassette, and can do these things:

* Create, edit, extend, and print a mailing list
* Sort a list by name or by ZIP code
* View the contents of the list, with the ability to "jump" to previous and following records as far as 128 records away
* Print multiple labels from a single record; the light pen can be used to specify the number of labels, using an unusual software analog method
* Put a specified number of blank lines between labels when printing
* Create a file from the list for use by CARDCO's Write Now! word processor
* Search for specified records in the list

The program is menu-driven, with complete prompting. Really, all you have to do is follow the instructions displayed. The following paragraphs, however, explain some things you might otherwise discover through experience.

There are two ways to respond to the prompts and menu options. One is to enter the first letter of the option, or to press RETURN in response to a prompt. The other way is to touch the light pen to the option or prompt; this is allowed only for highlighted options or prompts. (Be sure to press the pen's button when you touch the screen!)

The program centers around a main menu. When you start the program, though, some preliminary prompts and questions are displayed. First, you are asked which media you are using--disk or tape. You are then asked whether a new file is to be created or an old (existing) file is to be used. If you specify that an old file is to be used, you are asked to load the media containing the file. The file is read into memory, then the main menu is displayed.

If you are creating a new file, you start by entering the data. You are prompted for each field; after you have entered an entire record, you can either specify that it is the last one to be entered or continue entering another one. After you specify that the records have all been entered, the main menu is displayed.

Some of the functions available through the main menu have their own menus. Again, just follow the instructions displayed. When the function is completed, the main menu is displayed again. To end the program, pick the Quit option.

When editing a record, enter the unchanged data as well as the new data. If you press RETURN, spaces are written into the field regardless of the former field contents.

When printing multiple labels from a record, there are two ways to specify the number of labels to be printed. One is to enter the number by using the keyboard; the other is to use the light pen. To use the pen, point the pen at the vertical bar on the left side of the screen. This bar is something like an upside-down thermometer, where the degrees would correspond to the number of labels. For more labels, move the pen down the bar; for fewer labels, move the pen up the bar. You must move the pen slowly, and you may have to wiggle it somewhat to get the exact number desired. When the desired number is displayed at the bottom of the screen, point the pen at the highlighted P near the top of the screen to start printing the labels.

When using the Search option of the Edit function, you must enter the entire name you are searching for. The program doesn't look for names containing a partial string, but instead looks for exact matches.

When you have fnished using the Mailing List program, be sure to save your data if you made any changes or additions. You may then exit the progran by using the "QUIT" option from the main menu.

The MAILING LIST is the last program on the tape.

TECHNICAL INFORMATION

HOW IS THE SCREEN SCANNED?

(Just try to say that title three times fast!) Time now for a primer on how a TV or monitor works--just so you can understand how the computer determines where the light pen is pointing. Go ahead and read it even if you don't consider yourself a technical genius. It is written in layman's terms and should be easy to understand.

Inside your TV or monitor is an electron gun. This gun squirts electrons at the screen from behind to make the screen glow. (A color TV or monitor has three electron guns, one for each primary color.) The gun squirts electrons very fast, going back and forth in rows from top of the screen to the bottom. As the computer sends characters to the TV or monitor, the electron gun squirts different patterns of electrons. This action results in areas on the screen which electrons don't hit; those areas remain dark (or a different color) and appear as the characters. (In effect, therefore, the electron gun squirts electrons for the background rather than for the characters themselves.)

The computer keeps track of where the electron gun is pointing. This location is stored as a horizontal coordinate and a vertical coordinate. I'm going to call the horizontal coordinate X and the vertical coordinate Y. (The terms X and Y will be used here just like they are for graphs in algebra.)

The Cardriter 1 Light Pen contains an electronic gizmo in the tip called a photocell, just behind the lens. This gizmo can sense electrons hitting it. When you hold the light pen to the screen, the pen senses the electrons as they are squirted on the screen. When you press the pen's button, the pen signals the computer to catch the current X and Y coordinates. The computer then puts those coordinates in two memory locations. Those coordinates can be used by programs to determine how the user responded or what to do next.

PROGRAMMING FOR THE LIGHT PEN

The light pen can not be used to draw or point to things on the screen on its own. A program must determine where the pen is pointing on the screen and must use that data to determine what actions to perform. Most programs should also display prompts or menus at which the user can point the light pen. This section of the manual describes how to use BASIC statements to write programs which use light pen input. If you aren't going to do any such programming, you don't need to read this section. First of all, let's discuss how you access and use the X and Y coordinates.

X AND Y COORDINATES

This section describes what the X and Y coordinates are, how to access them, and how to use them. In this manual, the term "X" will be used to mean the value stored in memory location 36870 on the VIC and in location 53267 on the Commodore 64; it is the horizontal position. The term "Y" will be used to mean the value stored in the memory location 36871 on the VIC-20 and in location 53268 on the Commodore 64; it is the vertical position of the light pen. The variable name for the X coordinate doesn't have to be X, and the Y variable doesn't have to be named Y. Those names, X and Y, are just used here for clarity.

The PEEK statement is used to obtain the X and Y coordinates from their memory locations. For example, the following BASIC lines could be used to access the X and Y coordinates. (The variable names X and Y are only examples; any valid variable names can be used.)

```
VIC-20:
   100 X=PEEK(36870)
   110 Y=PEEK(36871)

Commodore 64:
   100 X=PEEK(53267)
   110 Y=PEEK(53268)
```

The X and Y coordinates are not the same range of numbers as are used in POKE statements. The number you put in a POKE statement to display a character on the screen is a screen map location number. It is a number calculated from X and Y coordinates.

For example, on the VIC the character position in the upper left corner of the screen has X coordinate 34 and Y coordinate 24; its screen map coordinate, however, is 7680. The screen map coordinate can not be directly determined by PEEKing a memory location. Instead, the X and Y coordinates are used to calculate the screen map coordinate.

The ranges of coordinates for X and Y are as follows.

	VIC-20	C-64
X:	34-122	45-245
Y:	24-116	50-250
Screen Map	7680-8186	1024-2023
Color Map	38400-38906	55296-56295

Where did these numbers come from? Before I explain, let me give you a little background on what the light pen really sees on the screen.

Each character position on the VIC-20 screen is made up of sixteen X and Y coordinates. I'll call each such coordinate a "dot" because that's what the light pen sees at an X-Y coordinate, a dot of light or dark (or color). If you are technically oriented, you might be interested to know that each "dot" is a square of four pixels. The dots are arranged in a four-by-four square, like this:

```
****
****
****
****
```

On the Commodore 64, each character position is made up of 40 dots; they are arranged in a rectangle 5 dots wide and 8 dots high.

Because there are 22 characters on each row of a VIC-20 screen, and there are 23 rows, there is a total of 506 (22 x 23) character positions on the VIC screen. Now each one of those character positions is made up of 16 dots. If my rusty math skills prove correct, that is a whopping 8096 dots on the screen! The light pen can sense any one of them. You may not have realized that your Cardriter 1 Light Pen had such a fine touch! (This can be both a nice feature and a headache.) On the Commodore 64, the screen is made up of 200 x 200 dots, for a total of 40,000 dots.

The screen on a VIC-20 looks something like this to the light pen. (Only the ten screen map locations of the upper left corner of the screen are shown.)

```
          7681 7682 7683   etc.
7680 **** **** **** **** ****
     **** **** **** **** ****
     **** **** **** **** ****
     **** **** **** **** ****
          7703 7704 7705 etc.
7702 **** **** **** **** ****
     **** **** **** **** ****
     **** **** **** **** ****
     **** **** **** **** ****
etc. **** **** **** **** ****
```

Here is how the X and Y coordinates are used. Each dot has an address, a X coordinate and an Y coordinate. For the upper left dot of the upper left character position of the VIC-2Ø screen, the X coordinate is 34 and the Y coordinate is 24. On a Commodore 64, this dot's X coordinate is 45 and its Y coordinate is 5Ø. The lower right dot in the lower right character on a VIC-2Ø screen has X and Y coordinates of 122 and 116 respectively. This same dot on a Commodore 64 has X and Y coordinates of 245 and 25Ø respectively.

WHERE X AND Y COME FROM

The upper left dot in the upper left character on the screen is not the first dot with an address. The dots in the border of the screen also have an address of X and Y coordinates. Although these dots can be seen by the light pen, programs can not access this area with PRINT or POKE instructions. For that reason, you shouldn't look for X and Y coordinates smaller than the range given in the table earlier.

The upper left dot of the border has X and Y coordinates of 1 and 1. On a VIC-2Ø, there are 34 dots horizontally between the left edge of the border and the edge of the accessible screen, so the first X coordinate possible for a dot in the screen is--you guessed it--34. Similarly, there are 24 rows of dots in the top border, so the first Y coordinate for a dot on the screen is 24. The

same principle applies to the Commodore 64 and its first X and Y values.

The high values for the X and Y coordinates depend on the number of character positions on the screen and the number of X or Y coordinates per character, as described earlier. Because a VIC-2Ø has 22 horizontal character positions, the last X value is 122 (34 + (22 character positions each containing 4 X coordinates)). Similarly, the high value of Y on a VIC-2Ø is 116 (24 + (23 rows of characters, each row containing 4 Y coordinates)). On a Commodore 64, the maximum X value is 245 (45 + (4Ø columns each containing 5 X coordinates)). The highest Y value is 25Ø (5Ø + (25 rows, each containing 8 Y coordinates)).

CONVERTING X AND Y TO SCREEN MAP LOCATIONS

****

As noted previously, the X and Y coordinates can not be used for POKE statements. The coordinates roughly correspond to a screen map location, but you must first convert them by using the following formulas.

* The column (CL) to which the X coordinate is equivalent is calculated as:

```
CL=INT((X - LX) / DX)
```

On a VIC-2Ø, the low X value (LX) is 34. On a Commodore 64, LX is 45. On a VIC-2Ø, the dots per screen location (DX) is 4; on a Commodore 64, DX is 5.

* The row (RO) to which the Y coordinate is equivalent is calculated as:

```
RO=INT((Y - LY) / DY)
```

On a VIC-2Ø, the low value for Y is 24. On a Commodore 64, LY is 5Ø. On a VIC-2Ø, the dots per location (DY) is 4; on a Commodore 64, DL is 8.

* The screen map position (LO) to which POKE statements refer is calculated as:

```
LO=SC + CL + (NC * RO).fj
```

* SC is the first position of the screen map or color map as follows.

VIC-20:

Additional Memory	Screen Map Position	Color Map Position
Unexpanded	7680	38400
3K	7680	38400
8K; 16K; 3K+8K; 8K+16K	4096	37888

(You can also calculate SC by using the formulas in the Appendix)

Commodore 64:

Screen Map = 1024
Color Map = 55296

NOTE: NC (number of columns) for a VIC-20 is 22; NC for a Commodore 64 is 40.

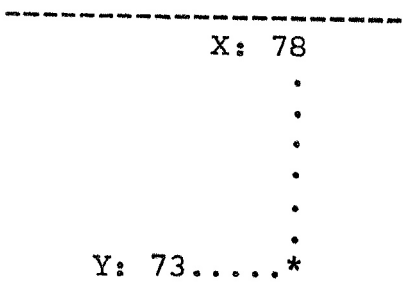
EXAMPLE: Assume that a program on a VIC-20 checked the contents of the X and Y memory locations, and determined that the X coordinate was 78 and the Y coordinate was 73. Those coordinates would be used as follows to determine the screen map position.

CL=INT((78-34)/4) or CL=INT(11.00) or CL=11

RO=INT((73-24)/4) or RO=INT(12.25) or RO=12

LO=7680+11+(22*12) or RO=7955

Thus the light pen was at a point just below the center of the screen. The following figure shows how the X, Y, and screen map locations relate to each other in this example.



Screen map coordinate:7955

NOTE: If the color map location were required, it would be calculated as follows:

```
LO (color) = 38400 + 11 + (22 * 12)
           = 38675
```

SMOOTHING X

****

A big problem is that, on most TVs, the X coordinnte is rather unstable. This makes it difficult to determine the proper X coordinate and, therefore, the actual location of the light pen on the screen. Monitors have less of a problem because they are built for displaying characters from a computer instead of cowboy movies.

One method of determining a more accurate X coordinate is to sample it several times, then "smooth" the results. The following BASIC statements can be used to do that.

```
100 FOR A=1 TO 5
110 X=PEEK(36870)
120 XB=XB+X
130 NEXT A
140 X=INT(XB/5)
150 Y=PEEK(36871)
```

What happens is that five samples of the X coordinate are taken; that's what the FOR loop does. Line 140 then produces the average coordinate for X. On some TVs the X coordinate is so unstable that it may range from the highest to the lowest possible value while the pen is at a single place on the screen. The Y coordinate is usually quite stable, and doesn't need to be smoothed.

To determine an even more accurate X coordinate, make the FOR loop run more than five times. The higher the upper limit for A, the more accurate the X coordinate. Keep in mind, though, that the more times the loop is performed, the longer the program takes and the longer you must point the light pen at the appropriate spot.

There are various enhancements to this smoothing method, each of which increases the amount of time required for calculations but which produces more accurate X coordinates. One such enhancement is to discard the lowest and highest samples before averaging; another is to ignore the first few samples. If you are an experienced assembly-language programmer, you could write the smoothing algorithm (with enhancements) in assembly language so that it would run fast. If you program using BASIC, the program lines given here are sufficient to begin with.

CALIBRATING THE CONVERSION FORMULAS
****

The low values for X and Y differ on various TVs and monitors. For best results, you need to adjust the low values of X and Y in the formulas for converting X-Y coordinates to screen map locations. To determine what the low X and Y values are, run the first program on the cassette and go through the screens to the "neat" program.

When that program is started, point the pen at the center of the top line of the screen and press the pen's button. Hold it there (while pressing the button several times) for about a minute. Watch the Y coordinates displayed to see what coordinate is displayed most often. (It may not change, because Y is generally stable.) That number is the one to use in the RO formula rather than the 24 (for the VIC-2Ø) or the 5Ø (for the Commodore 64). It should be no less than 24 (or 5Ø); if it is, you pointed the pen at a spot in the background area, just outside the screen. Do it again to get a valid number.

To get the X coordinate, point at the center of the leftmost part of the screen. Hold the pen there for about a minute while pressing the button. Watch the X coordinates displayed to see the smallest one shown. It must not be less than 34 for the VIC or 45 for the Commodore 64, however; if it is, try again but point at a spot just to the right of the previous spot. Use it in the CL formula instead of 34 (for the VIC-2Ø) or 45 (for the Commodore 64).

HELPFUL HINTS ON PROMPTS
****

If you write a program that displays prompts (like the programs on the cassette do), your program must determine that the light pen is being pointed at the prompt. If you display multiple prompts, the program must also determine which one the pen is pointing at. Because the X coordinate is unstable on many screens, this can be a real problem. You will have a hard time determining which X coordinate is the valid one, even after smoothing it.

One way to keep from having to worry about the X coordinate is to use the Y coordinate as the determining number. By putting prompts on different lines, you could check the Y coordinate to see at which line the pen was pointed rather than checking for a particular X coordinate.

Prompts can be put anywhere on the screen, but the screen should be easy to read. It is best, therefore, to put the prompts in a column or in a "stairstep" form. A good exmple of the column format is shown in the Fun With Numbers program and in the Computer Literacy Quiz program on the cassette; a good stairstep example is shown in the Tic-Tac-Toe program on the cassette.

APPENDIX
****

PROGRAM NAMES AND SEQUENCE
****

There are two sets of programs on the Light Pen Instruction Package cassette, one for the VIC-2Ø and the other for the Commodore 64. The programs for the VIC-2Ø are named 1/2Ø, 2/2Ø, 3/2Ø, 4/2Ø, 5/2Ø, and 6/2Ø. The Commodore 64 programs are named 1/64, 2/64, 3/64, 4/64, 5/64, and 6/64. Both sets of programs are stored on the cassette in this order:

* 1:Introduction To The Light Pen
* 2:Pen-Map
* 3:Fun With Numbers
* 4:Computer Literacy Quiz
* 5:Tic-Tac-Toe
* 6:Mailing List

LOCATION OF X AND Y VALUES
****

The memory locations of the X and Y values are as follows:

	VIC-2Ø	C-64
X:	3687Ø	53267
Y:	36871	53268

RANGE OF COORDINATE VALUES

The X, Y, and screen map coordinates have the following range of values:

	VIC-20	C-64
X:	34-122	45-245
Y:	24-116	50-250
Screen Map:	7680-8186	1024-2023
Color Map:	38400-38906	55296-56295
Expanded Memory	37888-38394	

CONVERSION FORMULAS
****

VIC:

```
COLUMN     = INT(((PEEK(36870)-34)/4)

ROW        = INT(((PEEK(36871)-24)/4)
```

***EXPANDED VIC:

```
LOCATION   = 4096+INT(((PEEK(36870)-34)/4)+
                (INT(((PEEK(36871)-24)/4)*22)
```

***UNEXPANDED VIC:

```
LOCATION   = 7680+INT(((PEEK(36870)-34)/4)+
                (INT(((PEEK(36871)-24)/4)*22)
```

Commorore 64:

```
COLUMN     = INT(((PEEK(53267)-45)/5)

ROW        = INT(((PEEK(53268)-50)/8)

LOCATION   = 1024+INT(((PEEK(53267)-45)/5)+
               (INT(((PEEK(53268)-50)/8)*40)
```

The formulas used for converting X and Y coordinates to a screen map location are as follows.

COLUMN

```
CL = INT((X - LX) / DX)
```

* LX: On a VIC-20, LX is 34 or calibrated value. On a Commodore 64, LX is 45 or calibrated value.

* DX: On a VIC-20, DX is 4; on a Commodore 64, DX is 5.

ROW

```
RO = INT((Y - LY) / DY)
```

* LY: On a VIC-20, LY is 24 or the calibrated value. On a Commodore 64, LY is 50 or the calibrated value.

* DY: On a VIC-20, DY is 4; on a Commodore 64, DY is 8.

SCREEN LOCATION

LO = SC + CL + (NC * RO)

SC is the first position of the screen map or color map as follows.

VIC-2Ø:

Additional Memory	Screen Map Position	Color Map Position
Unexpanded	768Ø	384ØØ
3K	768Ø	384ØØ
more than 3K exp.	4Ø96	37888

Commodore 64:

Screen Map = 1Ø24
Color Map = 55296

NC: On a VIC-2Ø, NC is 22; on a Commodore 64, NC is 4Ø.

VIC SC FORMULAS
****

The two following formulas can be used to determine the SC value of the screen location conversion formula for a VIC-2Ø. SC is where the screen map memory locations start. (These locations change with the amount of memory available to the VIC-2Ø.)

Screen map =

```
4*(PEEK(36866)AND128)+64*(PEEK(36869)AND112)
```

Color map =

```
37888+(4*(PEEK(36866)AND128)
```

CR1/IB (10-83)