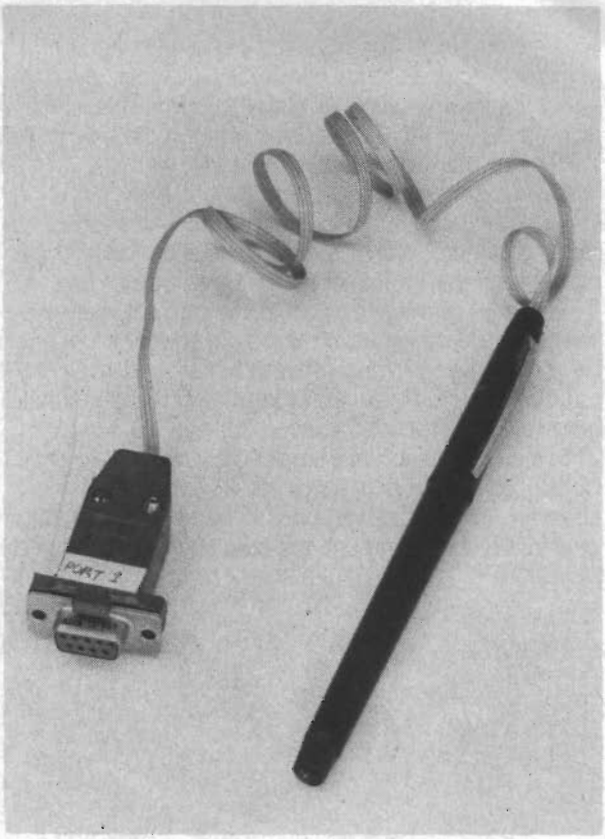
BUILD A LIGHT PEN FOR YOUR COMMODORE 64



Here's an inexpensive and easy way to add that "Magic Pencil."

JIM STEPHENS

■What follows is a simple light pen that can be used to demonstrate light pen/computer operations, menu selection and can even be used for simple design drawings with the proper programming.

How light pens operate

In order to fully understand how a light pen works, a few details on how the TV creates the picture are necessary. Once these are understood, the operation of the light pen will seem simple.

The picture on the screen is "painted" by a rapidly moving light beam that starts at the top of the screen and scans line-by-line down to the bottom. The movement is so fast that our eyes cannot see the change. There are 512 lines in the picture and a complete screen picture is painted on the screen many times each second. If the painted area of the screen is to be white, the beam is turned on. if the area is to be black, the beam is turned off. The screen glows when the beam strikes the front of the picture tube. If a fast-acting light sensor such as a simple photo-transistor was placed near the screen, the emitted light would trigger the sensor each time the beam went under it. This is exactly what our light pen will do.

The Commodore 64 creates its own picture information by producing pulses that cause the picture tube beam to scan and turn on and off at the right time. This work is done by a specialized chip in the computer called the "Video Interface Controller" or VIC. The controller constantly reads a selected portion of memory in the computer and converts the data from these locations into readable characters on the screen. More importantly, the controller keeps up with where the beam is located by measuring the time from starting the current line. It does this by incrementing special counters in its circuitry. These counters effectively give the X and Y coordinates of the beam. If these two counters could be read, we could tell where the beam was located at any one instant.

What is needed is a device that would cause the controller to place this information into memory so it could be read out by a special program. This can be accomplished easily using only four components.

Game Port 1 has a pin called A/LP. The LP stands for "Light Pen." If this pin is rapidly switched to ground (negative), the controller will place the contents of its X and Y counters into memory. The X counter data is placed into memory location 53267 and the Y counter data is placed into 53268. If we were to peek these locations as pin 6 of the game port was pulsed, we could see the contents of these locations as they changed from each update. This can be easily done using the following two line program and a joystick plugged into port 1.

```
10 PRINT PEEK (53267), PEEK (53268)
20 GOTO 10
```

Since the fire button is connected to the Light Pen connection of the port, all we need to do is to pulse the fire button to update the memory locations. The contents are printed out each time the program goes through line 10. The fire button does not switch the LP pin clean enough to produce a clear change but you can see the contents change intermittently each time a good pulse is obtained. If a photo-transistor was placed on the screen, and a small switching circuit was

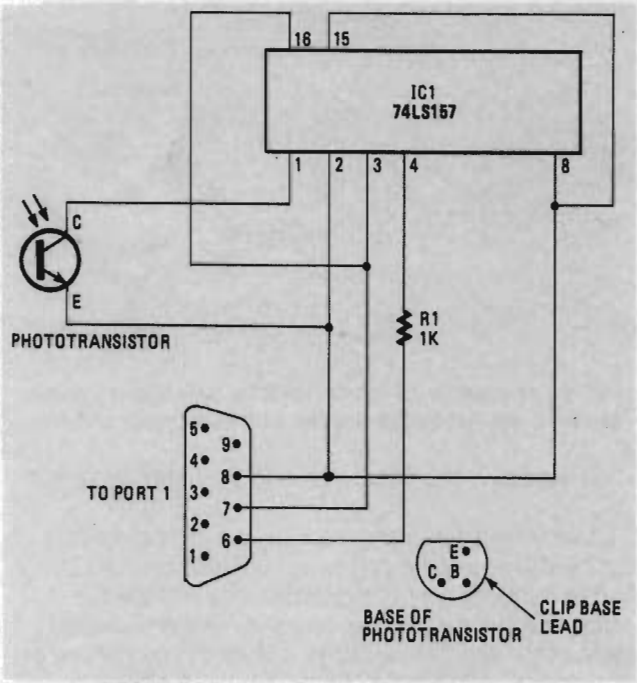


FIG. 1—COMPLETE WIRING DIAGRAM. Only one gate is needed for proper operation.

substituted for the fire button, the numbers would numerically tell us where on the screen the photo-transistor was located.

My major purpose is to demonstrate the operation and construction of a light pen, but the final product can be an extremely useful tool in your programming. Those that are more expert in the field of programming can make this little gadget do all that a far-more expensive pen could do.

The parts count for the project is very low. Only four components are required to make it work. None of the parts cost more than a dollar each.

First, you need a good photo-transistor. Radio Shack sells the FPT 100 type. This is a silicon unit with a built-in lens for light gathering. The switching will be done using a 74LS157 IC. This is an electronic toggle switch that switches the LP pin from high to low and back again each time the photo-transistor detects the light beam on the screen. The 74LS157 can be bought at most any electronic supply house. You'll need a female connector that will connect the three wires to the pins of Port 1. There is also a little 1K ohm resistor which is needed, but it is only used so that the keyboard will work correctly when the joystick is plugged in.

If you have a solderless breadboard, this would be a good time to use it to test the circuit before making the complete pen. However, there are so few connections, most pens work on the first try.

Construction.

You will need a plastic felt-tip pen with a cap that snaps over the pointed end. These usually have plastic plugs in the end opposite the felt tip. Proceed as follows to construct the light pen body.

The cap of the felt pen snaps on to cover the tip. This is usually the result of either small nibs on the barrel or an indentation. Remove the cap and saw off the end of the pen right above the nibs. Leaving the nibs will allow the cap to be snapped back on. Remove the plastic plug on the other end of the pen and push out the wick that holds the ink. Throw the felt tip piece away and wash the remaining parts.

Next, take the 74LS157 IC and clip all of the leads down close to the IC chip. Leave about an eighth of an inch of lead on the IC. See Fig. 1. With the leads shortened, the IC should readily slide into the pen's cap. If so, you are ready to work on the pen barrel. If the IC seems too large for the pen's cap, you'll need a larger felt tip pen. Again, Fig. 2 shows how the circuit will be inserted.

The photo-transistor comes with three leads. The base or B lead will need to be clipped off. Figure 1 has a bottom view of the transistor that will help in identifying which lead to clip.

Make the hole in the end of the barrel of the pen big enough to insert the photo-transistor. If, after removing the plastic plug, the hole is too large, you can wrap the transistor with tape later when you insert it permanently into the pen housing.

Solder two different color light-gauge wires to the two leads coming from the photo-transistor. Make a note on which of the colors goes to the collector or C lead and which goes to the E or emitter. These wires should be flexible and slightly longer than the barrel of the pen. The solder joints at the transistor should be wrapped with one turn of masking tape to keep them from shorting together. Thread these two wires through the end of the barrel as shown in figure 2.

PARTS LIST

R1—1000 ohm, ⅛-watt resistor
IC1—74LS157 two-to-one line multiplexer
Phototransistor—FPT 100
9-Pin subminiature female connector, 24-inch ribbon cable, Felt-tip pen body (see text).

Drill a small hole into the end of the pen's cap and insert three wires that are about 24-inches long. These should be flexible, insulated and multi-strand types. I used three color coded wires which were from a piece of ribbon cable. Pull about three inches of the wires through the cap and tie a knot in these to create a strain relief. Don't pull the knot back into the cap until ready to assemble the complete pen.

Make sure you have a good pencil-type soldering iron rated at 25 watts. Large soldering irons could over-heat the pins of the IC since we are going to be soldering directly to them.

Using the connection diagram in figure 1 and small lengths of insulated wire, solder the inter-connections on the 74LS157. Use as little solder as possible and do not over-heat the pin. Notice that pins 2, 8 and 15 are all connected together. Pins 3 and 16 also connect together. The 1K ohm resistor can be placed flat on top of the IC and one of its leads can be soldered directly to pin number 4. The diagram in figure 1 shows the

74LS157 as it would appear from the top with its leads pointing down. Notice that a notch in the IC marks the end on which pin one is found. Some IC's may not have the notch but a small dot placed over pin 1.

The C or collector lead wire from the photo-transistor connects to pin 1 of the IC and the E or emitter lead connects to pin 2. Be careful not to un-solder the connection made to this pin earlier. One of the colored wires coming through the cap is soldered to pin 2, 8 or 15 also. One of the other colored leads solders to pin 3 and the remaining wire solders to the unused end of the 1K resistor.

Now solder the 24 inch-long wires to the female joystick socket. This socket is sold by Radio Shack and other outlets. The parts list gives the Radio Shack part number. Figure 1 shows the rear of the connector that receives the wires. This view is as though it were plugged into the joystick port and you were looking at it. The pins are numbered along the bottom as 6,7,8, and 9. We will be using pins 6 through 8 only.

The wire from the 1K resistor solders to pin 6 of the socket.This is the Light Pen connection. It is a good idea to get some small lengths of 1/8th-inch heat-shrink tubing to fit on these connections since they are very closely spaced. The wire coming from pin 3 of the IC is the positive power connection and it goes to pin 7 of the socket since this is the plus or positive connection of the computer power supply. The remaining wire comes from the ground connection of the IC at pin 8 and goes to pin 8 of the socket.

After you are sure all connections are correct and with the computer off, you can plug the connector into port 1. Now turn on the computer. The 64 Ram System message should come up within two seconds. If not, turn the 64 off and unplug the socket. Recheck all of the wiring, especially the power connections.

If the System notice comes up as it should, but the cursor is moving across the screen on its own, then turn the computer off since the LP pin is getting a negative voltage when it should be positive. Again, recheck the wiring using figure 1. Double check that the correct leads from the photo-transistor are going to the correct pins on the IC. Unless you used a blow-torch on the IC and it doesn't look like it's half-melted, the IC is probably OK. However, if you connected the leads going to pins 7 and 8 on the socket backward, this can ruin the IC if left on for more than 2 or 3 seconds. If the cursor remains at the first location on the screen, you are ready to test the circuit using software.

Testing the Light Pen.

Listing 1 is a test of the light pen's response to the screen. This short routine lets you set the intensity of the monitor or TV in order to obtain the best response from the light pen. Line 30 is entered simply as a print command and the control key is held down as the numeral 2 key is pressed. This changes the character color to bright white. Line 50 is entered also by a print command that prints while lines (reverse spaces) on the screen 24 times. This is done by first holding down the Control key and pressing numeral 9 key. Then space over 39 spaces and turn off the reverse print by holding down the control key and pressing the numeral 0.

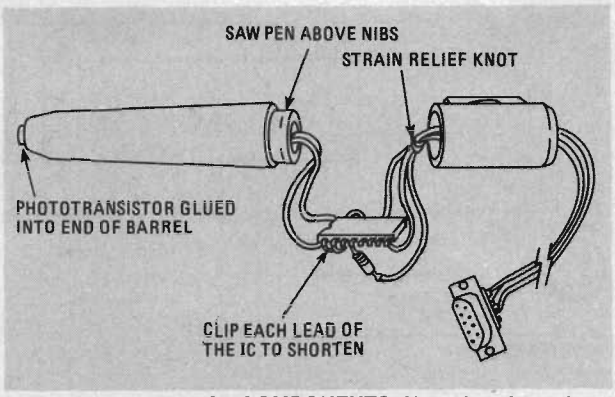


FIG. 2—ASSEMBLY OF COMPONENTS. Note that the points on the IC are wired point-to-point with short lengths of wire.

Line 90 is a command that uses the print character string (19) as a command to instruct the computer to go to the beginning of the screen. Line 100 prints a clear line at the top of the screen to give an indication area of the light pen readings. It does this by printing a blank area of 20 regular spaces. Type in the program listing and save it. With the pen plugged in, run the program. The screen will turn bright white with a dark border. Look at the column and line numbers at the top of the screen. These are the numbers placed in the memory registers when the system was turned on. Place the photo-transistor near the screen and these numbers will start to change as the pen is moved around. If they do not change, turn up the brightness or intensity of the screen. If the numbers still don't respond, check your typing of the program. If it looks OK, turn the computer off and recheck your wiring. Some black and white sets have a shaded plastic cover over the picture tube. This may have to be removed before enough brightness can be obtained.

Most likely the pen will work correctly. But, if the numbers are changing before the pen is placed near the screen, then the pen may be picking up light from the room and the photo-transistor will need to be placed deeper into the pen's tip for shielding.

LISTING 1 - Short routine by which to test the operation of the light pen. The intensity of the screen can be properly set using this program.

```
10 REM SCREEN INTENSITY TEST
15 REM LIGHT PEN TEST
20 REM JIM STEPHENS-NASHVILLE, TN.
25 REM C=COLUMN L=LINE
30 PRINT" [CONTROL 2]"
40 FOR N = 1 TO 24
50 PRINT " [RVS ON] [39 SPACES] [RVS OFF]"
60 NEXT N
65 PRINT" "TAB(12)"INTENSITY TEST"
70 C=PEEK (53267)
80 L=PEEK (53268)
90 PRINT CHR$(19);"C=";C;TAB(10)"L=";L
100 PRINT CHR$(19); "[20 SPACES]"
110 GOTO 70
```

Place the tip of the photo-transistor near the middle of the screen. Notice that the numbers remain within a small range even though they are still changing. Notice too, that the column number changes much more than the line number. This is normal and the program will take this into account by looking for ranges rather than a specific column or line numbers. If the numbers start changing before the pen touches the screen, turn the brightness down.

Place the pen in the top left corner of the white area and the column number should be in a range of around 30 to 40. The line number will be around 55-60. Moving the light pen down increases the line numbers and moving the pen to the right increases the column numbers. When the pen is in the bottom right-hand corner of the white area, the column and line numbers should be around 230. If this test is successful then slip the IC and wires into the pen cap and snap the cap and barrel together. The light pen is now complete. You may also improve the socket by adding the socket shroud on the plug.

Make the Light Pen Useful.

If the Light Pen responded correctly to the intensity test shown in Listing 1, then type in the small demo program in Listing 2 and save it. Enter RUN and the screen will clear and present you with four options. These options could have been most any menu but I chose fruit since my mind has turned to mud and I couldn't think of anything clever. This short program shows the ability of the light pen to sense where it is on the screen. By placing a white square in various areas on the screen with an explanation by each, the computer will respond according to the area at which the screen command is located. For example, you might place the square in the lower left and write "sound" by it. If the computer sensed the pen in that area, it would go to a sound producing routine. In Listing 2, four choices are provided. Apple, Pear, Orange, and a comand to clear the whole screen. When the pen is placed over the appropriate square, the computer responds as though it saw where the pen was placed. It does this as follows:

Line 25 is a print command. By holding down the CONTROL key and pressing the numeral 2, the screen color is changed to bright white again. This makes the light brighter for the sensor. Line 30 is a FOR NEXT loop that prints the character string 17 twenty-two times. CHR$(17) means to move the cursor down one line. This has the same effect as clearing the whole screen. Line 70 tells the computer to go to the beginning of the screen by using the print command and a CHR$ (19). Then, by printing one "CURSOR DOWN" the cursor will drop down one line on the screen. Lines 90 through 120 print the white squares and the words by each. This is done in line 90 by first printing one Cursor Down (CURS DWN) which means typing your first quote sign and then pressing the cursor down arrow. The result as in line 70, is a reversed Q. You then tab over to column 20 and place a white square. The white square is done by again printing a "reverse on (RVS ON) which is written by holding the CONTROL key and pressing the

LISTING 2 - This program shows what can be done with the light pen. This same prodecure could be used for many other purposes.

```
  5 REM LIGHT PEN DEMO
 10 REM BY JIM STEPHENS - NASHVILLE, TN.
 15 B=0
 20 C=0
 25 PRINT "[CONTROL 2]"
 30 FORN=1TO22:PRINTCHR$(17):NEXTN
 40 LETA$= "APPLE"
 50 LETB$= "PEAR"
 60 LETC$= "ORANGE"
 70 PRINT CHR$(19); "[CURS DWN]"
 80 PRINT " CHOOSE YOUR FAVORITE FRUIT"
 90 PRINT "[CURS DWN] TAB(20)"ON][5 SPACES]
    [RVSOFF]"A$; "[3 CURS DWN]"
100 PRINT "[CURS DWN] TAB(20)"[RVSON]
    [5 SPACES][RVSOFF]"B$;"[3 CURS DWN]"
110 PRINT "[CURS DWN]" TAB(20)"[RVSON]
    [5 SPACES][RVSOFF]"C$;"[3 CURS DWN]"
120 PRINT "[CURS DWN]" TAB(20)
    "[RVSON][5 SPACES][RVSOFF] CLEAR
    SCREEN"
130 Y=PEEK (53268):C=C+1:IF C=1 THEN B=Y
140 IF B=Y THEN GOTO 130
150 IF Y> 190 AND Y< 210 THEN GOTO 10
160 IF Y> 70 AND Y< 90 THEN 220
170 IF Y> 110 AND Y< 130 THEN GOTO 230
180 IF Y> 190 AND Y< 210 THEN GOTO 10
190 B=Y
200 PRINTCHR$ (19); "YOU CHOSE THE";C$
210 GOTO 130
220 PRINTCHR$(19); "YOU WANT THE"
    A$:B=Y:GOTO 130
230 PRINTCHR$(19); "SO YOU WANT A";B$: B=Y:
    GOTO 130
240 B=Y
250 GOTO 130
```

Numeral 9. You enter spaces (which are now white) then again hold the CONTROL Key and press the numeral 0 key for a reverse off (RVS OFF). The word "APPLE" is printed in response to the A$ and then three cursor downs are printed inside the quotes to make the cursor drop on the screen 3 lines. This is repeated in lines 100 through 120 to place the white squares and words in the appropriate places.

Lines 200 through 230 are the routines to which the program jumps when it has read the value of the light pen registers. The printing of the CHR$ (19) simply tells the computer to print on the first line of the screen.

Place the pen on your choice and watch the response of the computer at the top of the screen. Lines 150 to 180 of the program checks the range of the line coordinate and lines 200 to 230 prints the appropriate responses. The "clear screen" option was included to demonstrate that most any operation can be executed by just a touch of the screen.

Summary

The light pen shown here is not as exact as those $200 units. Neither are much good without the proper programming however. I think that this small inexpensive unit can be made to be more exact and more useful by good software routines. ◀CD▶