The PC Game Adapter — Chapter 24

One need look no farther than the internals of several popular games on the PC to discover than many programmers do not fully understand one of the least complex devices attached to the PC today – the analog game adapter. This device allows a user to connect up to four resistive potentiometers and four digital switch connections to the PC. The design of the PC's game adapter was obviously influenced by the analog input capabilities of the Apple II computer[1], the most popular computer available at the time the PC was developed. Although IBM provided for twice the analog inputs of the Apple II, thinking that would give them an edge, their decision to support only four switches and four potentiometers (or "pots") seems confining to game designers today – in much the same way that IBM's decision to support 256K RAM seems so limiting today. Nevertheless, game designers have managed to create some really marvelous products, even living with the limitations of IBM's 1981 design.

IBM's analog input design, like Apple's, was designed to be dirt cheap. Accuracy and performance were not a concern at all. In fact, you can purchase the electronic parts to build your own version of the game adapter, at retail, for under three dollars. Indeed, today you can purchase a game adapter card from various discount merchants for under eight dollars. Unfortunately, IBM's low-cost design in 1981 produces some major performance problems for high-speed machines and high-performance game software in the 1990's. However, there is no use crying over spilled milk – we're stuck with the original game adapter design, we need to make the most of it. The following sections will describe how to do exactly that.

24.1 Typical Game Devices

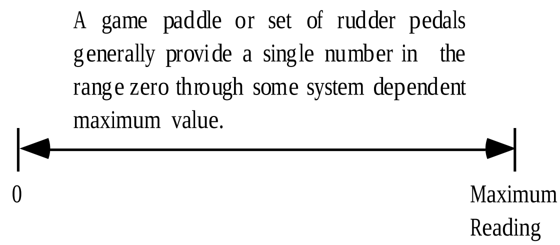
The game adapter is nothing more than a computer interface to various game input devices. The game adapter card typically contains a DB15 connector into which you plug an external device. Typical devices you can obtain for the game adapter include *paddles*, *joysticks*, *flight yokes*, *digital joysticks*, *rudder pedals*, *RC simulators*, and *steering wheels*. Undoubtedly, this is but a short list of the types of devices you can connect to the game adapter. Most of these devices are far more expensive that the game adapter card itself. Indeed, certain high performance flight simulator consoles for the game adapter cost several hundred dollars.

The digital joystick is probably the least complex device you can connect to the PC's game port. This device consists of four switches and a stick. Pushing the stick forward, left, right, or pulling it backward closes one of the switches. The game adapter card provides four switch inputs, so you can sense which direction (including the rest position) the user is pressing the digital joystick. Most digital joysticks also allow you to sense the in-between positions by closing two contacts at once. for example, pushing the control stick at a 45 degree angle between forward and right closes both the forward and right switches. The application software can sense this and take appropriate action. The original allure of these devices is that they were very cheap to manufacture (these were the original joysticks found on most home game machines). However, as manufacturers increased production of analog joysticks, the price fell to the point that digital joysticks failed to offer a substantial price difference. So today, you will rarely encounter such devices in the hands of a typical user.

The game paddle is another device whose use has declined over the years. A game paddle is a single pot in a case with a single knob (and, typically, a single push button). Apple used to ship a pair of game paddles with every Apple II they sold. As a result, games that used game paddles were still quite popular when IBM released the PC in 1981. Indeed, a couple manufacturers produced game paddles for the PC when it was first introduced. However, once again the cost of manufacturing analog joysticks fell to the point that paddles couldn't compete. Although paddles are the appropriate input device for many games, joysticks could do just about everything a game paddle could, and more. So the use of game paddles quickly died out. There is one thing you can do with game paddles that you cannot do with joysticks – you

1. In fact, the PC's game adapter design was obviously stolen directly from the Apple II.

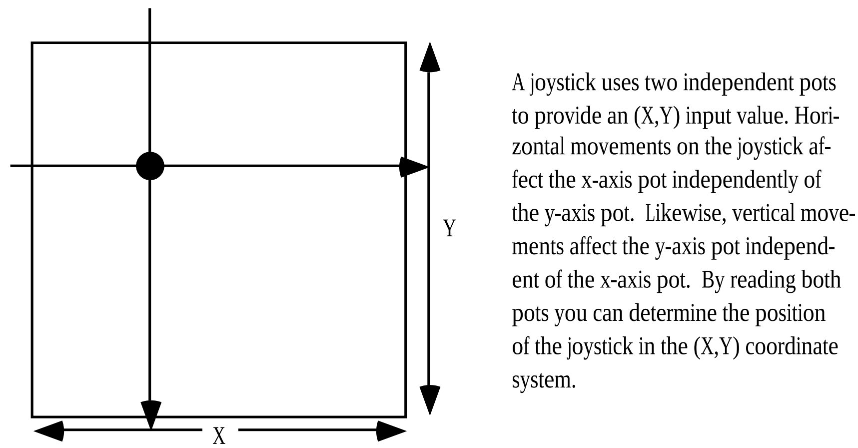
can place four of them on a system and produce a four player game. However, this (obviously) isn't important to most game designers who generally design their games for only one player.



Game Paddle or Rudder Pedal Game Input Device

Rudder pedals are really nothing more than a specially designed game paddle designed so you can activate them with your feet. Many flight simulator games take advantage of this input device to provide a more realistic experience. Generally, you would use rudder pedals in addition to a joystick device.

A joystick contains two pots connected with a stick. Moving the joystick along the x-axis actuates one of the pots, moving the joystick along the y-axis actuates the other pot. By reading both pots, you can roughly determine the absolute position of the pot within its working range.

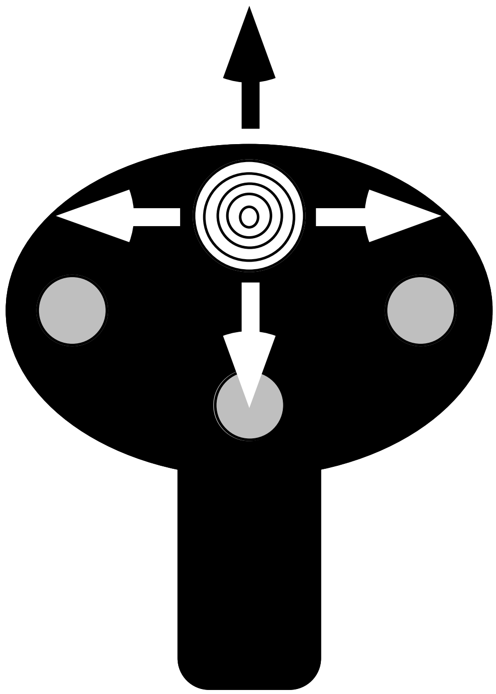


Joystick Game Input Device

An RC simulator is really nothing more than a box containing two joysticks. The yoke and steering wheel devices are essentially the same device, sold specifically for flight simulators or automotive games[2]. The steering wheel is connected to a pot that corresponds to the x-axis on the joystick. Pulling back (or pushing forward) on the wheel activates a second pot that corresponds to the y-axis on the joystick.

Certain joystick devices, generically known as *flight sticks*, contain three pots. Two pots are connected in a standard joystick fashion, the third is connected to a knob which many games use for the throttle control. Other joysticks, like the Thrustmaster™or CH Products' FlightStick Pro, include extra switches including a special "cooley switch" that provide additional inputs to the game. The cooley switch is, essentially, a digital pot mounted on the top of a joystick. Users can select one of four positions on the cooley switch using their thumb. Most flight simulator programs compatible with such devices use the cooley switch to select different views from the aircraft.

2. In fact, many such devices are switchable between the two.

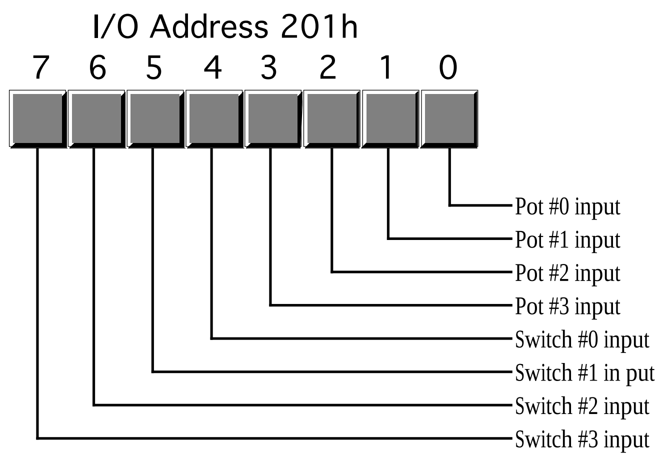


The cooley switch (shown here on a device layout similar to the CH Products' FlightStick Pro) is a thumb actuated digitial joystick. You can move the switch up, down, left or right, activating individual switches inside the game input device.

Cooley Switch (found on CH Products and Thrustmaster Joysticks)

24.2 The Game Adapter Hardware

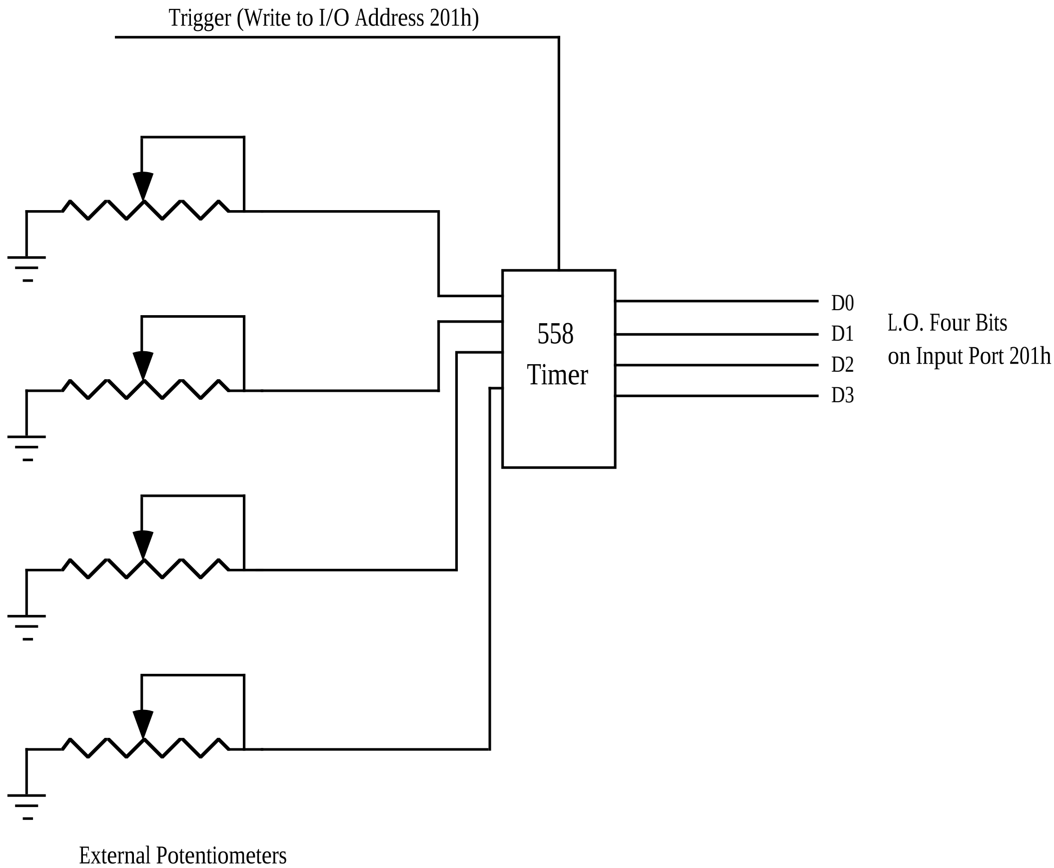
The game adapter hardware is simplicity itself. There is a single input port and a single output port. The input port bit layout is



Game Adapter Input Port

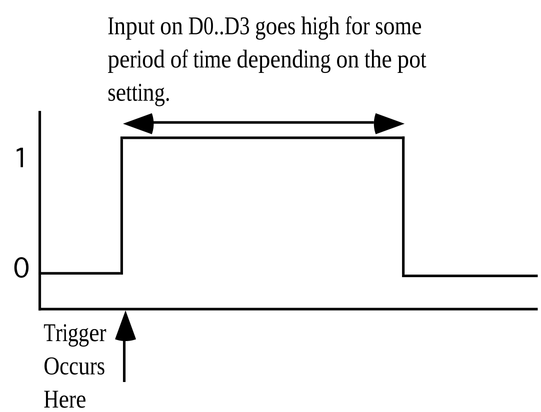
The four switches come in on the H.O. four bits of I/O port 201h. If the user is currently pressing a button, the corresponding bit position will contain a zero. If the button is up, the corresponding bit will contain a one.

The pot inputs might seem strange at first glance. After all, how can we represent one of a large number of potential pot positions (say, at least 256) with a single bit? Obviously we can't. However, the input bit on this port does not return any type of numeric value specifying the pot position. Instead, each of the four pot bits is connected to an input of a resistive sensitive 558 quad timer chip. When you trigger the timer chip, it produces an output pulse whose duration is proportional to the resistive input to the timer. The output of this timer chip appears as the input bit for a given pot. The schematic for this circuit is



Joystick Schematic

Normally, the pot input bits contain zero. When you trigger the timer chip, the pot input lines go high for some period of time determined by the current resistance of the potentiometer. By measuring how long this bit stays set, you can get a rough estimate of the resistance. To trigger the pots, simply write any value to I/O port 201h. The actual value you write is unimportant. The following timing diagram shows how the signal varies on each pot's input bit:



Analog Input Timing Signal

The only remaining question is "how do we determine the length of the pulse?" The following short loop demonstrates one way to determine the width of this timing pulse:

```
                mov     cx, -1          ;We're going to count backwards
                mov     dx, 201h        ;Point at joystick port.
                out     dx, al          ;Trigger the timer chip.
CntLp:          in      al, dx          ;Read joystick port.
                test    al, 1           ;Check pot #0 input.
                loopne  CntLp           ;Repeat while high.
                neg     cx              ;Convert CX to a positive value.
```

When this loop finish execution, the cx register will contain the number of passes made through this loop while the timer output signal was a logic one. The larger the value in cx, the longer the pulse and, therefore, the greater the resistance of pot #0.

There are several minor problems with this code. First of all, the code will obviously produce different results on different machines running at different clock rates. For example, a 150 MHz Pentium system will execute this code much faster than a 5 MHz 8088 system[3]. The second problem is that different joysticks and different game adapter cards produce radically different timing results. Even on the same system with the same adapter card and joystick, you may not always get consistent readings on different days. It turns out that the 558 is somewhat temperature sensitive and will produce slightly different readings as the temperature changes.

Unfortunately, there is no way to design a loop like the above so that it returns consistent readings across a wide variety of machines, potentiometers, and game adapter cards. Therefore, you have to write your application software so that it is insensitive to wide variances in the input values from the analog inputs. Fortunately, this is very easy to do, but more on that later.

24.3 Using BIOS' Game I/O Functions

The BIOS provides two functions for reading game adapter inputs. Both are subfunctions of the int 15h handler.

To read the switches, load ah with 84h and dx with zero then execute an int 15h instruction. On return, al will contain the switch readings in the H.O. four bits (see the diagram in the previous section). This function is roughly equivalent to reading port 201h directly.

To read the analog inputs, load ah with 84h and dx with one then execute an int 15h instruction. On return, AX, BX, CX, and DX will contain the values for pots zero, one, two, and three, respectively. In practice, this call should return values in the range 0-400h, though you cannot count on this for reasons described in the previous section.

Very few programs use the BIOS joystick support. It's easier to read the switches directly and reading the pots is not that much more work that calling the BIOS routine. The BIOS code is *very* slow. Most BIOSes read the four pots sequentially, taking up to four times longer than a program that reads all four pots concurrently (see the next section). Because reading the pots can take several hundred microseconds up to several milliseconds, most programmers writing high performance games do not use the BIOS calls, they write their own high performance routines instead.

This is a real shame. By writing drivers specific to the PC's original game adapter design, these developers force the user to purchase and use a standard game adapter card and game input device. Were the game to make the BIOS call, third party developers could create different and unique game controllers and then simply supply a driver that replaces the int 15h routine and provides the same programming interface. For example, Genovation made a device that lets you plug a joystick into the parallel port of a PC.

3. Actually, the speed difference is not as great as you would first think. Joystick adapter cards almost always interface to the computer system via the ISA bus. The ISA bus runs at only 8 Mhz and requires four clock cycles per data transfer (i.e., 500 ns to read the joystick input port). This is equivalent to a small number of wait states on a slow machine and a gigantic number of wait states on a fast machine. Tests run on a 5 MHz 8088 system vs. a 50 MHz 486DX system produces only a 2:1 to 3:1 speed difference between the two machines even though the 486 machine was over 50 times faster for most other computations.

Colorado Spectrum created a similar device that lets you plug a joystick into the serial port. Both devices would let you use a joystick on machines that do not (and, perhaps, cannot) have a game adapter installed. However, games that access the joystick hardware directly will not be compatible with such devices. However, had the game designer made the int 15h call, their software would have been compatible since both Colorado Spectrum and Genovation supply int 15h TSRs to reroute joystick calls to use their devices.

To help overcome game designer's aversion to using the int 15h calls, this text will present a high performance version of the BIOS' joystick code a little later in this chapter. Developers who adopt this *Standard Game Device Interface* will create software that will be compatible with any other device that supports the SGDI standard. For more details, see "The Standard Game Device Interface (SGDI)" on page 1262.

24.4 Writing Your Own Game I/O Routines

Consider again the code that returns some value for a given pot setting:

```
                mov         cx, -1              ;We're going to count backwards
                mov         dx, 201h            ;Point at joystick port.
                out         dx, al              ;Trigger the timer chip.
CntLp:          in          al, dx              ;Read joystick port.
                test        al, 1               ;Check pot #0 input.
                loopne      CntLp               ;Repeat while high.
                neg         cx                  ;Convert CX to a positive value.
```

As mentioned earlier, the big problem with this code is that you are going to get wildly different ranges of values from different game adapter cards, input devices, and computer systems. Clearly you cannot count on the code above always producing a value in the range 0..180h under these conditions. Your software will need to dynamically adjust the values it uses depending on the system parameters.

You've probably played a game on the PC where the software asks you to *calibrate* the joystick before use. Calibration generally consists of moving the joystick handle to one corner (e.g., the upper-left corner), pressing a button or key and them moving the handle to the opposite corner (e.g., lower-right) and pressing a button again. Some systems even want you to move the joystick to the center position and press a button as well.

Software that does this is reading the *minimum*, *maximum*, and *centered* values from the joystick. Given at least the minimum and maximum values, you can easily scale any reading to any range you want. By reading the centered value as well, you can get slightly better results, especially on really inexpensive (cheap) joysticks. This process of scaling a reading to a certain range is known as *normalization*. By reading the minimum and maximum values from the user and normalizing every reading thereafter, you can write your programs assuming that the values always fall within a certain range, for example, 0..255. To normalize a reading is very easy, you simply use the following formula:

$$\frac{(CurrentReading - MinimumReading)}{(MaximumReading - MinimumReading)} \times NormalValue$$

The MaximumReading and MinimumReading values are the minimum and maximum values read from the user at the beginning of your application. CurrentReading is the value just read from the game adapter. NormalValue is the upper bounds on the range to which you want to normalize the reading (e.g., 255), the lower bound is always zero[4].

4. If you want a different lower bound, just add whatever value you want fro the lowest value to the result. You will also need to subtract this lower bound from the NormalValue variable in the above equation.

To get better results, especially when using a joystick, you should obtain three readings during the calibration phase for each pot – a minimum value, a maximum value, and a centered value. To normalize a reading when you've got these three values, you would use one of the following formulae:

If the current reading is in the range minimum..center, use this formula:

$$\frac{(Current - Center)}{(Center - Minimum) \times 2} \times NormalValue$$

If the current reading is in the range center..maximum, use this formula:

$$\frac{(Current - Center)}{(Maximum - Center) \times 2} \times NormalValue + \frac{NormalValue}{2}$$

A large number of games on the market today jump through all kinds of hoops trying to coerce joystick readings into a reasonable range. It is surprising how few of them use that simple formula above. Some game designers might argue that the formulae above are overly complex and they are writing high performance games. This is nonsense. It takes two orders of magnitude more time to wait for the joystick to time out than it does to compute the above equations. So use them and make your programs easier to write.

Although normalizing your pot readings takes so little time it is always worthwhile, reading the analog inputs is a very expensive operation in terms of CPU cycles. Since the timer circuit produces relatively fixed time delays for a given resistance, you will waste even more CPU cycles on a fast machine than you do on a slow machine (although reading the pot takes about the same amount of *real* time on any machine). One sure fire way to waste a lot of time is to read several pots one at a time; for example, when reading pots zero and one to get a joystick reading, read pot zero first and then read pot one afterwards. It turns out that you can easily read both pots in parallel. By doing so, you can speed up reading the joystick by a factor of two. Consider the following code:

```
              mov     cx, 1000h        ;Max times through loop
              mov     si, 0            ;We'll put readings in SI and
              mov     di, si           ; di.
              mov     ax, si           ;Set AH to zero.
              mov     dx, 201h         ;Point at joystick port.
              out     dx, al           ;Trigger the timer chip.
CntLp:        in      al, dx           ;Read joystick port.
              and     al, 11b          ;Strip unwanted bits.
              jz      Done
              shr     ax, 1            ;Put pot 0 value into carry.
              adc     si, 0            ;Bump pot 0 value if still active.
              add     di, ax           ;Bump pot 1 value if pot 1 active.
              loop    CntLp            ;Repeat while high.
              and     si, 0FFFh        ;If time-out, force the register(s)
              and     di, 0FFFh        ; containing 1000h to zero.

Done:
```

This code reads both pot zero and pot one at the same time. It works by looping while either pot is active[5]. Each time through the loop, this code adds the pots' bit values to separate register that accumulator the result. When this loop terminates, `si` and `di` contain the readings for both pots zero and one.

Although this particular loop contains more instructions than the previous loop, it still takes the same amount of time to execute. Remember, the output pulses on the 558 timer determine how long this code takes to execute, the number of instructions in the loop contribute very little to the execution time. However, the time this loop takes to execute one iteration of the loop does effect the *resolution* of this joystick read routine. The faster the loop executes, the more iterations the loop will run during the same timing period and the finer will be the measurement. Generally, though, the resolution of the above code is much greater than the accuracy of the electronics and game input device, so this isn't much of a concern.

5. This code provides a time-out feature in the event there is no game adapter installed. In such an event this code forces the readings to zero.

The code above demonstrates how to read two pots. It is very easy to extend this code to read three or four pots. An example of such a routine appears in the section on the SGDI device driver for the standard game adapter card.

The other game device input, the switches, would seem to be simple in comparison to the potentiometer inputs. As usual, things are not as easy as they would seem at first glance. The switch inputs have some problems of their own.

The first issue is keybounce. The switches on a typical joystick are probably an order of magnitude worse than the keys on the cheapest keyboard. Keybounce, and lots of it, is a fact you're going to have to deal with when reading joystick switches. In general, you shouldn't read the joystick switches more often than once every 10 msec. Many games read the switches on the 55 msec timer interrupt. For example, suppose your timer interrupt reads the switches and stores the result in a memory variable. The main application, when wanting to fire a weapon, checks the variable. If it's set, the main program clears the variable and fires the weapon. Fifty-five milliseconds later, the timer sets the button variable again and the main program will fire again the next time it checks the variable. Such a scheme will totally eliminate the problems with keybounce.

The technique above solves another problem with the switches: keeping track of when the button first goes down. Remember, when you read the switches, the bits that come back tell you that the switch is currently down. It does not tell you that the button was just pressed. You have to keep track of this yourself. One easy way to detect when a user first presses a button is to save the previous switch reading and compare it against the current reading. If they are different and the current reading indicates a switch depression, then this is a new switch down.

24.5 The Standard Game Device Interface (SGDI)

The Standard Game Device Interface (SGDI) is a specification for an int 15h service that lets you read an arbitrary number of pots and joysticks. Writing SGDI compliant applications is easy and helps make your software compatible with any game device which provides SGDI compliance. By writing your applications to use the SGDI API you can ensure that your applications will work with future devices that provide extended SGDI capability. To understand the power and extensibility of the SGDI, you need to take a look at the *application programmer's interface* (API) for the SGDI.

24.5.1 Application Programmer's Interface (API)

The SGDI interface extends the PC's joystick BIOS int 15h API. You make SGDI calls by loading the 80x86 ah register with 84h and dx with an appropriate SGDI function code and then executing an int 15h instruction. The SGDI interface simply extends the functionality of the built-in BIOS routines. Note that and program that calls the standard BIOS joystick routines will work with an SGDI driver. The following table lists each of the SGDI functions:

Table 87: SGDI Functions and API (int 15h, ah=84h)

DH	Inputs	Outputs	Description
00	dl = 0	al- Switch readings	Read4Sw. This is the standard BIOS subfunction zero call. This reads the status of the first four switches and returns their values in the upper four bits of the al register.
00	dl = 1	ax- pot 0 bx- pot 1 cx- pot 2 dx- pot 3	Read4Pots. Standard BIOS subfunction one call. Reads all four pots (concurrently) and returns their raw values in ax, bx, cx, and dx as per BIOS specifications.

Table 87: SGDI Functions and API (int 15h, ah=84h)

DH	Inputs	Outputs	Description
01	dl = pot #	al= pot reading	ReadPot. This function reads a pot and returns a *normalized* reading in the range 0..255.
02	dl = 0 al = pot mask	al = pot 0 ah = pot 1 dl = pot 2 dh = pot 3	Read4. This routine reads the four pots on the standard game adapter card just like the Read4Pots function above. However, this routine normalizes the four values to the range 0..255 and returns those values in al, ah, dl, and dh. On entry, the al register contains a "pot mask" that you can use to select which of the four pots this routine actually reads.
03	dl = pot # al = minimum bx= maximum cx= centered		Calibrate. This function calibrates the pots for those calls that return normalized values. You must calibrate the pots before calling any such pot functions (ReadPot and Read4 above). The input values must be *raw* pot readings obtained by Read4Pots or other function that returns raw values.
04	dl = pot #	al = 0 if not calibrated, 1 if calibrated.	TestPotCalibrate. Checks to see if the specified pot has already been calibrated. Returns an appropriate value in al denoting the calibration status for the specified pot. See the note above about the need for calibration.
05	dl = pot #	ax = raw value	ReadRaw. Reads a raw value from the specified pot. You can use this call to get the raw values required by the calibrate routine, above.
08	dl= switch #	ax = switch value	ReadSw. Read the specified switch and returns zero (switch up) or one (switch down) in the ax register.
09		ax = switch values	Read16Sw. This call lets an application read up to 16 switches on a game device at a time. Bit zero of ax corresponds to switch zero, bit 15 of ax corresponds to switch fifteen.
80h			Remove. This function removes the driver from memory. Application programs generally won't make this call.
81h			TestPresence. This routine returns zero in the ax register if an SGDI driver is present in memory. It returns ax's value unchanged otherwise (in particular, ah will still contain 84h).

24.5.2 Read4Sw

Inputs: ah= 84h, dx = 0

This is the standard BIOS read switches call. It returns the status switches zero through three on the joystick in the upper four bits of the al register. Bit four corresponds to switch zero, bit five to switch one, bit six to switch two, and bit seven to switch three. One zero in each bit position denotes a depressed switch, a one bit corresponds to a switch in the up position. This call is provided for compatibility with the existing BIOS joystick routines. To read the joystick switches you should use the Read16Sw call described later in this document.

24.5.3 Read4Pots:

Inputs: ah= 84h, dx = 1

This is the standard BIOS read pots call. It reads the four pots on the standard game adapter card and returns their readings in the ax (x axis/pot 0), bx (y axis/pot 1), cx (pot 2), and dx (pot 3) registers. These are *raw, uncalibrated*, pot readings whose values will differ from machine to machine and vary depending upon the game I/O card in use. This call is provided for compatibility with the existing BIOS joystick routines. To read the pots you should use the ReadPot, Read4, or ReadRaw routines described in the next several sections.

24.5.4 ReadPot

Inputs: ah=84h, dh=1, dl=Pot number.

This reads the specified pot and returns a *normalized* pot value in the range 0..255 in the al register. This routine also sets ah to zero. Although the SGDI standard provides for up to 255 different pots, most adapters only support pots zero, one, two, and three. If you attempt to read any nonsupported pot this function returns zero in ax. Since the values are normalized, this call returns comparable values for a given game control setting regardless of machine, clock frequency, or game I/O card in use. For example, a reading of 128 corresponds (roughly) to the center setting on almost any machine. To properly produce normalized results, you must *calibrate* a given pot before making this call. See the CalibratePot routine for more details.

24.5.5 Read4:

Inputs: ah = 84h, al = pot mask, dx=0200h

This routine reads the four pots on the game adapter card, just like the BIOS call (Read4Pots). However, it returns normalized values in al (x axis/pot 0), ah (y axis/pot 1), dl (pot 2), and dh (pot 3). Since this routine returns normalized values between zero and 255, you must calibrate the pots before calling this code. The al register contains a “pot mask” value. The L.O. four bits of al determine if this routine will actually read each pot. If bit zero, one, two, or three is one, then this function will read the corresponding pot; if the bits are zero, this routine will not read the corresponding pot and will return zero in the corresponding register.

24.5.6 CalibratePot

Inputs: ah=84h, dh=3, dl=pot #, al=minimum value, bx=maximum value, cx=centered value.

Before you attempt to read a pot with the ReadPot or Read4 routines, you need to calibrate that pot. If you read a pot without first calibrating it, the SGDI driver will return only zero for that pot reading. To calibrate a pot you will need to read raw values for the pot in a minimum position, maximum position, and a centered position[6]. *These must be raw pot readings.* Use readings obtained by the Read4Pots routine. In theory, you need only calibrate a pot once after loading the SGDI driver. However, temperature fluctuations and analog circuitry drift may decalibrate a pot after considerable use. Therefore, you should recalibrate the pots you intend to read each time the user runs your application. Furthermore, you should give the user the option of recalibrating the pots at any time within your program.

24.5.7 TestPotCalibration

Inputs: ah= 84h, dh=4 , dl = pot #.

This routine returns zero or one in ax denoting *not calibrated* or *calibrated*, respectively. You can use the call to see if the pots you intend to use have already been calibrated and you can skip the calibration phase. Please, however, note the comments about drift in the previous paragraph.

6. Many programmers compute the centered value as the arithmetic mean of the minimum and maximum values.

24.5.8 ReadRaw

Inputs: ah = 84h, dh = 5, dl = pot #

Reads the specified pot and returns a raw (not calibrated) value in ax. You can use this routine to obtain minimum, centered, and maximum values for use when calling the calibrate routine.

24.5.9 ReadSwitch

Inputs: ah= 84h, dh = 8, dl = switch #

This routine reads the specified switch and returns zero in ax if the switch is *not* depressed. It returns one if the switch is depressed. Note that this value is opposite the bit settings the Read4Sw function returns.

If you attempt to read a switch number for an input that is not available on the current device, the SGDI driver will return zero (switch up). Standard game devices only support switches zero through three and most joysticks only provide two switches. Therefore, unless you are willing to tie your application to a specific device, you shouldn't use any switches other than zero or one.

24.5.10 Read16Sw

Inputs: ah = 84h, dh = 9

This SGDI routine reads up to sixteen switches with a single call. It returns a bit vector in the ax register with bit 0 corresponding to switch zero, bit one corresponding to switch one, etc. Ones denote switch depressed and zeros denote switches not depressed. Since the standard game adapter only supports four switches, only bits zero through three of al contain meaningful data (for those devices). All other bits will always contain zero. SGDI drivers for the CH Product's Flightstick Pro and Thrustmaster joysticks will return bits for the entire set of switches available on those devices.

24.5.11 Remove

Inputs: ah= 84h, dh= 80h

This call will attempt to remove the SGDI driver from memory. Generally, only the SGDI.EXE code itself would invoke this routine. You should use the TestPresence routine (described next) to see if the driver was actually removed from memory by this call.

24.5.12 TestPresence

Inputs: ah=84h, dh=81h

If an SGDI driver is present in memory, this routine return ax=0 and a pointer to an identification string in es:bx. If an SGDI driver is not present, this call will return ax unchanged.

24.5.13 An SGDI Driver for the Standard Game Adapter Card

If you write your program to make SGDI calls, you will discover that the TestPresence call will probably return "not present" when your program searches for a resident SGDI driver in memory. This is because few manufacturers provide SGDI drivers at this point and even fewer standard game adapter companies ship any software at all with their products, much less an SGDI driver. Gee, what kind of standard is this if no one uses it? Well, the purpose of this section is to rectify that problem.

The assembly code that appears at the end of this section provides a fully functional, public domain, SGDI driver for the standard game adapter card (the next section present an SGDI driver for the CH Products' Flightstick Pro). This allows you to write your application making only SGDI calls. By supplying the SGDI TSR with your product, your customers can use your software with all standard joysticks. Later, if they purchase a specialized device with its own SGDI driver, your software will automatically work with that driver with no changes to your software[7].

If you do not like the idea of having a user run a TSR before your application, you can always include the following code within your program's code space and activate it if the SGDI TestPresence call determines that no other SGDI driver is present in memory when you start your program.

Here's the complete code for the standard game adapter SGDI driver:

```
              .286
              page      58, 132
              name      SGDI
              title     SGDI Driver for Standard Game Adapter Card
              subttl    This Program is Public Domain Material.

; SGDI.EXE
;
;       Usage:
;             SDGI
;
; This program loads a TSR which patches INT 15 so arbitrary game programs
; can read the joystick in a portable fashion.
;
;
; We need to load cseg in memory before any other segments!

cseg          segment   para public 'code'
cseg          ends


; Initialization code, which we do not need except upon initial load,
; goes in the following segment:

Initialize    segment   para public 'INIT'
Initialize    ends

; UCR Standard Library routines which get dumped later on.

              .xlist
              include       stdlib.a
              includelib stdlib.lib
              .list

sseg          segment   para stack 'stack'
sseg          ends

zzzzzzseg     segment   para public 'zzzzzzseg'
zzzzzzseg     ends



CSEG          segment   para public 'CODE'
              assume    cs:cseg, ds:nothing

wp            equ       <word ptr>
byp           equ       <byte ptr>

Int15Vect     dword     0

PSP           word      ?
```

7. Of course, your software may not take advantage of extra features, like additional switches and pots, but at least your software will support the standard set of features on that device.

```
; Port addresses for a typical joystick card:

JoyPort         equ         201h
JoyTrigger      equ         201h

; Data structure to hold information about each pot.
; (mainly for calibration and normalization purposes).

Pot             struc
PotMask         byte        0                   ;Pot mask for hardware.
DidCal          byte        0                   ;Is this pot calibrated?
min             word        5000                ;Minimum pot value
max             word        0                   ;Max pot value
center          word        0                   ;Pot value in the middle
Pot             ends

; Variables for each of the pots. Must initialize the masks so they
; mask out all the bits except the incomming bit for each pot.

Pot0            Pot         <1>
Pot1            Pot         <2>
Pot2            Pot         <4>
Pot3            Pot         <8>



; The IDstring address gets passed back to the caller on a testpresence
; call. The four bytes before the IDstring must contain the serial number
; and current driver number.

SerialNumber    byte        0,0,0
IDNumber        byte        0
IDString        byte        “Standard SGDI Driver”,0
                byte        “Public Domain Driver Written by Randall L. Hyde”,0


;============================================================================
;
; ReadPots-     AH contains a bit mask to determine which pots we should read.
;                Bit 0 is one if we should read pot 0, bit 1 is one if we should
;                read pot 1, bit 2 is one if we should read pot 2, bit 3 is one
;                if we should read pot 3. All other bits will be zero.
;
;        This code returns the pot values in SI, BX, BP, and DI for Pot 0, 1,
;        2, & 3.
;

ReadPots        proc        near
                sub         bp, bp
                mov         si, bp
                mov         di, bp
                mov         bx, bp

; Wait for any previous signals to finish up before trying to read this
; guy. It is possible that the last pot we read was very short. However,
; the trigger signal starts timers running for all four pots. This code
; terminates as soon as the current pot times out. If the user immediately
; reads another pot, it is quite possible that the new pot’s timer has
; not yet expired from the previous read. The following loop makes sure we
; aren’t measuring the time from the previous read.

                mov         dx, JoyPort
                mov         cx, 400h
Wait4Clean:     in          al, dx
                and         al, 0Fh
                loopnz      Wait4Clean

; Okay, read the pots. The following code triggers the 558 timer chip
; and then sits in a loop until all four pot bits (masked with the pot mask
; in AL) become zero. Each time through this loop that one or more of these
; bits contain zero, this loop increments the corresponding register(s).

                mov         dx, JoyTrigger
```

```
                out       dx, al          ;Trigger pots
                mov       dx, JoyPort
                mov       cx, 1000h       ;Don't let this go on forever.
PotReadLoop:    in        al, dx
                and       al, ah
                jz        PotReadDone
                shr       al, 1
                adc       si, 0           ;Increment SI if pot 0 still active.
                shr       al, 1
                adc       bx, 0       ;Increment BX if pot 1 still active.
                shr       al, 1
                adc       bp, 0       ;Increment BP if pot 2 still active.
                shr       al, 1
                adc       di, 0       ;Increment DI if pot 3 still active.
                loop      PotReadLoop ;Stop, eventually, if funny hardware.

                and       si, 0FFFh   ;If we drop through to this point,
                and       bx, 0FFFh   ; one or more pots timed out (usually
                and       bp, 0FFFh   ; because they are not connected).
                and       di, 0FFFh   ; The reg contains 4000h, set it to 0.
PotReadDone:    ret
ReadPots        endp


;----------------------------------------------------------------------------
;
; Normalize-    BX contains a pointer to a pot structure, AX contains
;               a pot value. Normalize that value according to the
;               calibrated pot.
;
; Note: DS must point at cseg before calling this routine.


                assume    ds:cseg
Normalize       proc      near
                push      cx

; Sanity check to make sure the calibration process went okay.

                cmp       [bx].Pot.DidCal, 0 ;Is this pot calibrated?
                je        BadNorm         ;If not, quit.

                mov       dx, [bx].Pot.Center ;Do a sanity check on the
                cmp       dx, [bx].Pot.Min  ; min, center, and max
                jbe       BadNorm         ; values to make sure
                cmp       dx, [bx].Pot.Max  ; min < center < max.
                jae       BadNorm

; Clip the value if it is out of range.

                cmp       ax, [bx].Pot.Min  ;If the value is less than
                ja        MinOkay         ; the minimum value, set it
                mov       ax, [bx].Pot.Min  ; to the minimum value.
MinOkay:

                cmp       ax, [bx].Pot.Max  ;If the value is greater than
                jb        MaxOkay         ; the maximum value, set it
                mov       ax, [bx].Pot.Max  ; to the maximum value.
MaxOkay:

; Scale this guy around the center:

                cmp       ax, [bx].Pot.Center ;See if less than or greater
                jb        Lower128        ; than centered value.

; Okay, current reading is greater than the centered value, scale the reading
; into the range 128..255 here:

                sub       ax, [bx].Pot.Center
                mov       dl, ah          ;Multiply by 128
                mov       ah, al
                mov       dh, 0
                mov       al, dh
```

```
                shr         dl, 1
                rcr         ax, 1
                mov         cx, [bx].Pot.Max
                sub         cx, [bx].Pot.Center
                jz          BadNorm             ;Prevent division by zero.
                div         cx                  ;Compute normalized value.
                add         ax, 128             ;Scale to range 128..255.
                cmp         ah, 0
                je          NormDone
                mov         ax, 0ffh            ;Result must fit in 8 bits!
                jmp         NormDone

; If the reading is below the centered value, scale it into the range
; 0..127 here:

Lower128:       sub         ax, [bx].Pot.Min
                mov         dl, ah
                mov         ah, al
                mov         dh, 0
                mov         al, dh
                shr         dl, 1
                rcr         ax, 1
                mov         cx, [bx].Pot.Center
                sub         cx, [bx].Pot.Min
                jz          BadNorm
                div         cx
                cmp         ah, 0
                je          NormDone
                mov         ax, 0ffh
                jmp         NormDone

; If something went wrong, return zero as the normalized value.

BadNorm:        sub         ax, ax

NormDone:       pop         cx
                ret
Normalize       endp
                assume      ds:nothing

;============================================================================
; INT 15h handler functions.
;============================================================================
;
; Although these are defined as near procs, they are not really procedures.
; The MyInt15 code jumps to each of these with BX, a far return address, and
; the flags sitting on the stack. Each of these routines must handle the
; stack appropriately.
;
;----------------------------------------------------------------------------
; BIOS-  Handles the two BIOS calls, DL=0 to read the switches, DL=1 to
;        read the pots. For the BIOS routines, we'll ignore the cooley
;        switch (the hat) and simply read the other four switches.

BIOS            proc        near
                cmp         dl, 1               ;See if switch or pot routine.
                jb          Read4Sw
                je          ReadBIOSPots

; If not a valid BIOS call, jump to the original INT 15 handler and
; let it take care of this call.

                pop         bx
                jmp         cs:Int15Vect        ;Let someone else handle it!

; BIOS read switches function.

Read4Sw:        push        dx
                mov         dx, JoyPort
                in          al, dx
                and         al, 0F0h            ;Return only switch values.
                pop         dx
                pop         bx
                iret
```

```
; BIOS read pots function.

ReadBIOSPots:	pop	bx			;Return a value in BX!
		push	si
		push	di
		push	bp
		mov	ah, 0Fh			;Read all four pots.
		call	ReadPots
		mov	ax, si
		mov	cx, bp			;BX already contains pot 1 reading.
		mov	dx, di
		pop	bp
		pop	di
		pop	si
		iret
BIOS		endp

;----------------------------------------------------------------------------
;
; ReadPot-	On entry, DL contains a pot number to read.
;		Read and normalize that pot and return the result in AL.

		assume	ds:cseg
ReadPot		proc	near
;;;;;;;;;;	push	bx			;Already on stack.
		push	ds
		push	cx
		push	dx
		push	si
		push	di
		push	bp

		mov	bx, cseg
		mov	ds, bx

; If dl = 0, read and normalize the value for pot 0, if not, try some
; other pot.

		cmp	dl, 0
		jne	Try1
		mov	ah, Pot0.PotMask	;Get bit for this pot.
		call	ReadPots		;Read pot 0.
		lea	bx, Pot0		;Pointer to pot data.
		mov	ax, si			;Get pot 0 reading.
		call	Normalize		;Normalize to 0..FFh.
		jmp	GotPot			;Return to caller.

; Test for DL=1 here (read and normalize pot 1).

Try1:		cmp	dl, 1
		jne	Try2
		mov	ah, Pot1.PotMask
		call	ReadPots
		mov	ax, bx
		lea	bx, Pot1
		call	Normalize
		jmp	GotPot

; Test for DL=2 here (read and normalize pot 2).

Try2:		cmp	dl, 2
		jne	Try3
		mov	ah, Pot2.PotMask
		call	ReadPots
		lea	bx, Pot2
		mov	ax, bp
		call	Normalize
		jmp	GotPot

; Test for DL=3 here (read and normalize pot 3).

Try3:		cmp	dl, 3
		jne	BadPot
```

```
                mov     ah, Pot3.PotMask
                call    ReadPots
                lea     bx, Pot3
                mov     ax, di
                call    Normalize
                jmp     GotPot

; Bad value in DL if we drop to this point. The standard game card
; only supports four pots.

BadPot:         sub     ax, ax          ;Pot not available, return zero.
GotPot:         pop     bp
                pop     di
                pop     si
                pop     dx
                pop     cx
                pop     ds
                pop     bx
                iret
ReadPot         endp
                assume  ds:nothing


;----------------------------------------------------------------------------
;
; ReadRaw-      On entry, DL contains a pot number to read.
;               Read that pot and return the unnormalized result in AX.

                assume  ds:cseg
ReadRaw         proc    near
;;;;;;;;;;      push    bx              ;Already on stack.
                push    ds
                push    cx
                push    dx
                push    si
                push    di
                push    bp

                mov     bx, cseg
                mov     ds, bx

; This code is almost identical to the ReadPot code. The only difference
; is that we don't bother normalizing the result and (of course) we return
; the value in AX rather than AL.

                cmp     dl, 0
                jne     Try1
                mov     ah, Pot0.PotMask
                call    ReadPots
                mov     ax, si
                jmp     GotPot

Try1:           cmp     dl, 1
                jne     Try2
                mov     ah, Pot1.PotMask
                call    ReadPots
                mov     ax, bx
                jmp     GotPot

Try2:           cmp     dl, 2
                jne     Try3
                mov     ah, Pot2.PotMask
                call    ReadPots
                mov     ax, bp
                jmp     GotPot

Try3:           cmp     dl, 3
                jne     BadPot
                mov     ah, Pot3.PotMask
                call    ReadPots
                mov     ax, di
                jmp     GotPot

BadPot:         sub     ax, ax          ;Pot not available, return zero.
```

```
GotPot:         pop         bp
                pop         di
                pop         si
                pop         dx
                pop         cx
                pop         ds
                pop         bx
                iret
ReadRaw         endp
                assume      ds:nothing


;----------------------------------------------------------------------------
; Read4Pots-    Reads pots zero, one, two, and three returning their
;               values in AL, AH, DL, and DH.
;
;               On entry, AL contains the pot mask to select which pots
;               we should read (bit 0=1 for pot 0, bit 1=1 for pot 1, etc).

Read4Pots       proc        near
;;;;;;;;;;;     push        bx                  ;Already on stack
                push        ds
                push        cx
                push        si
                push        di
                push        bp

                mov         dx, cseg
                mov         ds, dx

                mov         ah, al
                call        ReadPots

                push        bx                  ;Save pot 1 reading.
                mov         ax, si              ;Get pot 0 reading.
                lea         bx, Pot0            ;Point bx at pot0 vars.
                call        Normalize           ;Normalize.
                mov         cl, al              ;Save for later.

                pop         ax                  ;Retreive pot 1 reading.
                lea         bx, Pot1
                call        Normalize
                mov         ch, al              ;Save normalized value.

                mov         ax, bp
                lea         bx, Pot2
                call        Normalize
                mov         dl, al              ;Pot 2 value.

                mov         ax, di
                lea         bx, Pot3
                call        Normalize
                mov         dh, al              ;Pot 3 value.
                mov         ax, cx              ;Pots 0 and 1.

                pop         bp
                pop         di
                pop         si
                pop         cx
                pop         ds
                pop         bx
                iret
Read4Pots       endp



;----------------------------------------------------------------------------
; CalPot-       Calibrate the pot specified by DL. On entry, AL contains
;               the minimum pot value (it better be less than 256!), BX
;               contains the maximum pot value, and CX contains the centered
;               pot value.

                assume      ds:cseg
```

```
CalPot          proc        near
                pop         bx                  ;Retrieve maximum value
                push        ds
                push        si
                mov         si, cseg
                mov         ds, si

; Sanity check on parameters, sort them in ascending order:

                mov         ah, 0
                cmp         bx, cx              ;Make sure center < max
                ja          GoodMax
                xchg        bx, cx
GoodMax:        cmp         ax, cx              ;Make sure min < center.
                jb          GoodMin             ; (note: may make center<max).
                xchg        ax, cx
GoodMin:        cmp         cx, bx              ;Again, be sure center < max.
                jb          GoodCenter
                xchg        cx, bx
GoodCenter:


; Okay, figure out who were supposed to calibrate:

                lea         si, Pot0
                cmp         dl, 1
                jb          DoCal               ;Branch if this is pot 0
                lea         si, Pot1
                je          DoCal               ;Branch if this is pot 1
                lea         si, Pot2
                cmp         dl, 3
                jb          DoCal               ;Branch if this is pot 2
                jne         CalDone             ;Branch if not pot 3
                lea         si, Pot3

DoCal:          mov         [si].Pot.min, ax  ;Store away the minimum,
                mov         [si].Pot.max, bx  ; maximum, and
                mov         [si].Pot.center, cx ; centered values.
                mov         [si].Pot.DidCal, 1  ;Note we've cal'd this pot.
CalDone:        pop         si
                pop         ds
                iret
CalPot          endp
                assume      ds:nothing


;----------------------------------------------------------------------------
; TestCal-      Just checks to see if the pot specified by DL has already
;               been calibrated.

                assume      ds:cseg
TestCal         proc        near
;;;;;;;;        push        bx              ;Already on stack
                push        ds
                mov         bx, cseg
                mov         ds, bx

                sub         ax, ax          ;Assume no calibration (also zeros AH)
                lea         bx, Pot0        ;Get the address of the specified
                cmp         dl, 1           ; pot's data structure into the
                jb          GetCal          ; BX register.
                lea         bx, Pot1
                je          GetCal
                lea         bx, Pot2
                cmp         dl, 3
                jb          GetCal
                jne         BadCal
                lea         bx, Pot3

GetCal:         mov         al, [bx].Pot.DidCal
BadCal:         pop         ds
                pop         bx
                iret
TestCal         endp
```

```
                assume     ds:nothing


;----------------------------------------------------------------------------
;
; ReadSw-       Reads the switch whose switch number appears in DL.

ReadSw          proc       near
;;;;;;;         push       bx                  ;Already on stack
                push       cx

                sub        ax, ax          ;Assume no such switch.
                cmp        dl, 3           ;Return if the switch number is
                ja         NotDown         ; greater than three.

                mov        cl, dl          ;Save switch to read.
                add        cl, 4           ;Move from position four down to zero.
                mov        dx, JoyPort
                in         al, dx          ;Read the switches.
                shr        al, cl          ;Move desired switch bit into bit 0.
                xor        al, 1           ;Invert so sw down=1.
                and        ax, 1           ;Remove other junk bits.
NotDown:        pop        cx
                pop        bx
                iret
ReadSw          endp


;----------------------------------------------------------------------------
;
; Read16Sw-     Reads all four switches and returns their values in AX.

Read16Sw        proc       near
;;;;;;;;        push       bx                  ;Already on stack
                mov        dx, JoyPort
                in         al, dx
                shr        al, 4
                xor        al, 0Fh             ;Invert all switches.
                and        ax, 0Fh             ;Set other bits to zero.
                pop        bx
                iret
Read16Sw        endp


;****************************************************************************
;
; MyInt15-      Patch for the BIOS INT 15 routine to control reading the
;               joystick.

MyInt15         proc       far
                push       bx
                cmp        ah, 84h             ;Joystick code?
                je         DoJoystick
OtherInt15:     pop        bx
                jmp        cs:Int15Vect

DoJoystick:     mov        bh, 0
                mov        bl, dh
                cmp        bl, 80h
                jae        VendorCalls
                cmp        bx, JmpSize
                jae        OtherInt15
                shl        bx, 1
                jmp        wp cs:jmptable[bx]

jmptable        word       BIOS
                word       ReadPot, Read4Pots, CalPot, TestCal
                word       ReadRaw, OtherInt15, OtherInt15
                word       ReadSw, Read16Sw
JmpSize         =          ($-jmptable)/2


; Handle vendor specific calls here.
```

```
VendorCalls:    je          RemoveDriver
                cmp         bl, 81h
                je          TestPresence
                pop         bx
                jmp         cs:Int15Vect


; TestPresence- Returns zero in AX and a pointer to the ID string in ES:BX

TestPresence:   pop         bx                  ;Get old value off stack.
                sub         ax, ax
                mov         bx, cseg
                mov         es, bx
                lea         bx, IDString
                iret

; RemoveDriver-If there are no other drivers loaded after this one in
;               memory, disconnect it and remove it from memory.

RemoveDriver:
                push        ds
                push        es
                push        ax
                push        dx

                mov         dx, cseg
                mov         ds, dx

; See if we’re the last routine patched into INT 15h

                mov         ax, 3515h
                int         21h
                cmp         bx, offset MyInt15
                jne         CantRemove
                mov         bx, es
                cmp         bx, wp seg MyInt15
                jne         CantRemove

                mov         ax, PSP             ;Free the memory we’re in
                mov         es, ax
                push        es
                mov         ax, es:[2ch]        ;First, free env block.
                mov         es, ax
                mov         ah, 49h
                int         21h

                pop         es                  ;Now free program space.
                mov         ah, 49h
                int         21h

                lds         dx, Int15Vect       ;Restore previous int vect.
                mov         ax, 2515h
                int         21h

CantRemove:     pop         dx
                pop         ax
                pop         es
                pop         ds
                pop         bx
                iret
MyInt15         endp
cseg            ends



Initialize      segment     para public ‘INIT’
                assume      cs:Initialize, ds:cseg
Main            proc
                mov         ax, cseg            ;Get ptr to vars segment
                mov         es, ax
                mov         es:PSP, ds          ;Save PSP value away
                mov         ds, ax

                mov         ax, zzzzzzseg
```

```
                mov     es, ax
                mov     cx, 100h
                meminit2

                print
                byte    " Standard Game Device Interface driver",cr,lf
                byte    " PC Compatible Game Adapter Cards",cr,lf
                byte    " Written by Randall Hyde",cr,lf
                byte    cr,lf
                byte    cr,lf
                byte    "'SGDI REMOVE' removes the driver from memory",cr,lf
                byte    lf
                byte    0

                mov     ax, 1
                argv                    ;If no parameters, empty str.
                stricmpl
                byte    "REMOVE",0
                jne     NoRmv

                mov     dh, 81h         ;Remove opcode.
                mov     ax, 84ffh
                int     15h             ;See if we're already loaded.
                test    ax, ax          ;Get a zero back?
                jz      Installed
                print
                byte    "SGDI driver is not present in memory, REMOVE "
                byte    "command ignored.",cr,lf,0
                mov     ax, 4c01h;Exit to DOS.
                int     21h

Installed:      mov     ax, 8400h
                mov     dh, 80h         ;Remove call
                int     15h
                mov     ax, 8400h
                mov     dh, 81h         ;TestPresence call
                int     15h
                cmp     ax, 0
                je      NotRemoved
                print
                byte    "Successfully removed SGDI driver from memory."
                byte    cr,lf,0
                mov     ax, 4c01h       ;Exit to DOS.
                int     21h

NotRemoved:     print
                byte    "SGDI driver is still present in memory.",cr,lf,0
                mov     ax, 4c01h       ;Exit to DOS.
                int     21h



; Okay, Patch INT 15 and go TSR at this point.

NoRmv:
                mov     ax, 3515h
                int     21h
                mov     wp Int15Vect, bx
                mov     wp Int15Vect+2, es

                mov     dx, cseg
                mov     ds, dx
                mov     dx, offset MyInt15
                mov     ax, 2515h
                int     21h

                mov     dx, cseg
                mov     ds, dx
                mov     dx, seg Initialize
                sub     dx, ds:psp
                add     dx, 2
                mov     ax, 3100h       ;Do TSR
```

```
                int     21h
Main            endp

Initialize      ends


sseg            segment para stack 'stack'
                word    128 dup (0)
endstk          word    ?
sseg            ends


zzzzzzseg       segment para public 'zzzzzzseg'
                byte    16 dup (0)
zzzzzzseg       ends
                end     Main
```

The following program makes several different types of calls to an SGDI driver. You can use this code to test out an SGDI TSR:

```
                .xlist
                include    stdlib.a
                includelib stdlib.lib
                .list


cseg            segment para public 'code'
                assume  cs:cseg, ds:nothing

MinVal0         word    ?
MinVal1         word    ?
MaxVal0         word    ?
MaxVal1         word    ?


; Wait4Button- Waits until the user presses and releases a button.

Wait4Button     proc    near
                push    ax
                push    dx
                push    cx

W4BLp:          mov     ah, 84h
                mov     dx, 900h        ;Read the L.O. 16 buttons.
                int     15h
                cmp     ax, 0           ;Any button down? If not,
                je      W4BLp           ; loop until this is so.

                xor     cx, cx          ;Debouncing delay loop.
Delay:          loop    Delay

W4nBLp:         mov     ah, 84h         ;Now wait until the user releases
                mov     dx, 900h        ; all buttons
                int     15h
                cmp     ax, 0
                jne     W4nBLp

Delay2:         loop    Delay2

                pop     cx
                pop     dx
                pop     ax
                ret
Wait4Button     endp

Main            proc

                print
                byte    "SGDI Test Program.",cr,lf
```

```
                byte    “Written by Randall Hyde”,cr,lf,lf
                byte    “Press any key to continue”,cr,lf,0

                getc

                mov     ah, 84h
                mov     dh, 4               ;Test presence call.
                int     15h
                cmp     ax, 0               ;See if there
                je      MainLoop0
                print
                byte    “No SGDI driver present in memory.”,cr,lf,0
                jmp     Quit

MainLoop0:print
                byte    “BIOS: “,0

; Okay, read the switches and raw pot values using the BIOS compatible calls.

                mov     ah, 84h
                mov     dx, 0               ;BIOS compat. read switches.
                int     15h
                puth                        ;Output switch values.
                mov     al, ‘ ‘
                putc

                mov     ah, 84h             ;BIOS compat. read pots.
                mov     dx, 1
                int     15h
                putw
                mov     al, ‘ ‘
                putc
                mov     ax, bx
                putw
                mov     al, ‘ ‘
                putc
                mov     ax, cx
                putw
                mov     al, ‘ ‘
                putc
                mov     ax, dx
                putw

                putcr
                mov     ah, 1               ;Repeat until key press.
                int     16h
                je      MainLoop0
                getc


; Read the minimum and maximum values for each pot from the user so we
; can calibrate the pots.

                print
                byte    cr,lf,lf,lf
                byte    “Move joystick to upper left corner and press “
                byte    “any button.”,cr,lf,0

                call    Wait4Button
                mov     ah, 84h
                mov     dx, 1               ;Read Raw Values
                int     15h
                mov     MinVal0, ax
                mov     MinVal1, bx

                print
                byte    cr,lf
                byte    “Move the joystick to the lower right corner “
                byte    “and press any button”,cr,lf,0

                call    Wait4Button
                mov     ah, 84h
                mov     dx, 1               ;Read Raw Values
                int     15h
```

```
                mov         MaxVal0, ax
                mov         MaxVal1, bx

; Calibrate the pots.

                mov         ax, MinVal0;Will be eight bits or less.
                mov         bx, MaxVal0
                mov         cx, bx            ;Compute centered value as the
                add         cx, ax            ; average of these two (this is
                shr         cx, 1             ; dangerous, but usually works!)
                mov         ah, 84h
                mov         dx, 300h;Calibrate pot 0
                int         15h

                mov         ax, MinVal1;Will be eight bits or less.
                mov         bx, MaxVal1
                mov         cx, bx            ;Compute centered value as the
                add         cx, ax            ; average of these two (this is
                shr         cx, 1             ; dangerous, but usually works!)
                mov         ah, 84h
                mov         dx, 301h          ;Calibrate pot 1
                int         15h

MainLoop1:      print
                byte        “ReadSw: “,0

; Okay, read the switches and raw pot values using the BIOS compatible calls.

                mov         ah, 84h
                mov         dx, 800h          ;Read switch zero.
                int         15h
                or          al, ‘0’
                putc

                mov         ah, 84h
                mov         dx, 801h          ;Read switch one.
                int         15h
                or          al, ‘0’
                putc

                mov         ah, 84h
                mov         dx, 802h          ;Read switch two.
                int         15h
                or          al, ‘0’
                putc

                mov         ah, 84h
                mov         dx, 803h          ;Read switch three.
                int         15h
                or          al, ‘0’
                putc

                mov         ah, 84h
                mov         dx, 804h          ;Read switch four
                int         15h
                or          al, ‘0’
                putc

                mov         ah, 84h
                mov         dx, 805h          ;Read switch five.
                int         15h
                or          al, ‘0’
                putc

                mov         ah, 84h
                mov         dx, 806h          ;Read switch six.
                int         15h
                or          al, ‘0’
                putc

                mov         ah, 84h
                mov         dx, 807h          ;Read switch seven.
                int         15h               ;We won’t bother with
                or          al, ‘0’           ; any more switches.
```

```
                putc
                mov     al, ' '
                putc

                mov     ah, 84h
                mov     dh, 9           ;Read all 16 switches.
                int     15h
                putw

                print
                byte    " Pots: ",0
                mov     ax, 8403h       ;Read joystick pots.
                mov     dx, 200h        ;Read four pots.
                int     15h
                puth
                mov     al, ' '
                putc
                mov     al, ah
                puth
                mov     al, ' '
                putc

                mov     ah, 84h
                mov     dx, 503h        ;Raw read, pot 3.
                int     15h
                putw

                putcr
                mov     ah, 1           ;Repeat until key press.
                int     16h
                je      MainLoop1
                getc


Quit:           ExitPgm                 ;DOS macro to quit program.
Main            endp

cseg            ends

sseg            segment para stack 'stack'
stk             byte    1024 dup ("stack ")
sseg            ends

zzzzzzseg       segment para public 'zzzzzz'
LastBytes       byte    16 dup (?)
zzzzzzseg       ends
                end     Main
```

24.6 An SGDI Driver for the CH Products' Flight Stick Pro™

The CH Product's FlightStick Pro joystick is a good example of a specialized product for which the SGDI driver is a perfect solution. The FlightStick Pro provides three pots and five switches, the fifth switch being a special five-position *cooley switch*. Although the pots on the FlightStick Pro map to three of the analog inputs on the standard game adapter card (pots zero, one, and three), there are insufficient digital inputs to handle the eight inputs necessary for the FlightStick Pro's four buttons and cooley switch.

The FlightStick Pro (FSP) uses some electronic circuitry to map these eight switch positions to four input bits. To do so, they place one restriction on the use of the FSP switches – you can only press one of them at a time. If you hold down two or more switches at the same time, the FSP hardware selects one of the switches and reports that value; it ignores the other switches until you release the button. Since only one switch can be read at a time, the FSP hardware generates a four bit value that determines the current state of the switches. It returns these four bits as the switch values on the standard game adapter card. The following table lists the values for each of the switches:

Table 88: FlightStick Pro Switch Return Values

Value (binary)	Priority	Switch Position
0000	Highest	Up position on the cooley switch.
0100	7	Right position on the cooley switch.
1000	6	Down position on the cooley switch.
1100	5	Left position on the cooley switch.
1110	4	Trigger on the joystick.
1101	3	Leftmost button on the joystick.
1011	2	Rightmost button on the joystick.
0111	Lowest	Middle button on the joystick.
1111		No buttons currently down.

Note that the buttons look just like a single button press. The cooley switch positions contain a position value in bits six and seven; bits four and five always contain zero when the cooley switch is active.

The SGDI driver for the FlightStick Pro is very similar to the standard game adapter card SGDI driver. Since the FlightStick Pro only provides three pots, this code doesn't bother trying to read pot 2 (which is non-existent). Of course, the switches on the FlightStick Pro are quite a bit different than those on standard joysticks, so the FSP SGDI driver maps the FPS switches to eight of the SGDI *logical* switches. By reading switches zero through seven, you can test the following conditions on the FSP:

Table 89: Flight Stick Pro SGDI Switch Mapping

This SGDI Switch number:	Maps to this FSP Switch:
0	Trigger on joystick.
1	Left button on joystick.
2	Middle button on joystick.
3	Right button on joystick.
4	Cooley up position.
5	Cooley left position.
6	Cooley right position.
7	Cooley down position.

The FSP SGDI driver contains one other novel feature, it will allow the user to swap the functions of the left and right switches on the joystick. Many games often assign important functions to the trigger and left button since they are easiest to press (right handed players can easily press the left button with their thumb). By typing "LEFT" on the command line, the FSP SGDI driver will swap the functions of the left and right buttons so left handed players can easily activate this function with their thumb as well.

The following code provides the complete listing for the FSPSGDI driver. Note that you can use the same test program from the previous section to test this driver.

```
              .286
              page      58, 132
              name      FSPSGDI
              title     FSPSGDI (CH Products Standard Game Device Interface).

; FSPSGDI.EXE
```

```
;
;       Usage:
;               FSPSDGI    {LEFT}
;
; This program loads a TSR which patches INT 15 so arbitrary game programs
; can read the CH Products FlightStick Pro joystick in a portable fashion.


wp              equ        <word ptr>
byp             equu       <byte ptr>



; We need to load cseg in memory before any other segments!

cseg            segment    para public 'code'
cseg            ends


; Initialization code, which we do not need except upon initial load,
; goes in the following segment:

Initialize      segment    para public 'INIT'
Initialize      ends

; UCR Standard Library routines which get dumped later on.

                .xlist
                include       stdlib.a
                includelib stdlib.lib
                .list

sseg            segment    para stack 'stack'
sseg            ends

zzzzzzseg       segment    para public 'zzzzzzseg'
zzzzzzseg       ends



CSEG            segment    para public 'CODE'
                assume     cs:cseg, ds:nothing

Int15Vect       dword      0

PSP             word       ?

; Port addresses for a typical joystick card:

JoyPort         equ        201h
JoyTrigger      equ        201h


CurrentReading word        0

Pot             struc
PotMask         byte       0                  ;Pot mask for hardware.
DidCal          byte       0                  ;Is this pot calibrated?
min             word       5000               ;Minimum pot value
max             word       0                  ;Max pot value
center          word       0                  ;Pot value in the middle
Pot             ends

Pot0            Pot        <1>
Pot1            Pot        <2>
Pot3            Pot        <8>


; SwapButtons- 0 if we should use normal flightstick pro buttons,
;               1 if we should swap the left and right buttons.

SwapButtons     byte       0

; SwBits- the four bit input value from the Flightstick Pro selects one
```

```
;        of the following bit patterns for a given switch position.

SwBits          byte      10h           ;Sw4
                byte      0             ;NA
                byte      0             ;NA
                byte      0             ;NA
                byte      40h           ;Sw6
                byte      0             ;NA
                byte      0             ;NA
                byte      4             ;Sw 2

                byte      80h           ;Sw 7
                byte      0             ;NA
                byte      0             ;NA
                byte      8             ;Sw 3
                byte      20h           ;Sw 5
                byte      2             ;Sw 1
                byte      1             ;Sw 0
                byte      0             ;NA

SwBitsL         byte      10h           ;Sw4
                byte      0             ;NA
                byte      0             ;NA
                byte      0             ;NA
                byte      40h           ;Sw6
                byte      0             ;NA
                byte      0             ;NA
                byte      4             ;Sw 2

                byte      80h           ;Sw 7
                byte      0             ;NA
                byte      0             ;NA
                byte      2             ;Sw 3
                byte      20h           ;Sw 5
                byte      8             ;Sw 1
                byte      1             ;Sw 0
                byte      0             ;NA


; The IDstring address gets passed back to the caller on a testpresence
; call. The four bytes before the IDstring must contain the serial number
; and current driver number.

SerialNumber    byte      0,0,0
IDNumber        byte      0
IDString        byte      “CH Products:Flightstick Pro”,0
                byte      “Written by Randall Hyde”,0


;=============================================================================
;
; ReadPots-     AH contains a bit mask to determine which pots we should read.
;               Bit 0 is one if we should read pot 0, bit 1 is one if we should
;               read pot 1, bit 3 is one if we should read pot 3. All other bits
;               will be zero.
;
;       This code returns the pot values in SI, BX, BP, and DI for Pot 0, 1,
;       2, & 3.
;

ReadPots        proc      near
                sub       bp, bp
                mov       si, bp
                mov       di, bp
                mov       bx, bp

; Wait for pots to finish any past junk:

                mov       dx, JoyPort
                out       dx, al              ;Trigger pots
                mov       cx, 400h
Wait4Pots:      in        al, dx
                and       al, 0Fh
```

```
                loopnz      Wait4Pots

; Okay, read the pots:

                mov         dx, JoyTrigger
                out         dx, al              ;Trigger pots
                mov         dx, JoyPort
                mov         cx, 8000h           ;Don’t let this go on forever.
PotReadLoop:    in          al, dx
                and         al, ah
                jz          PotReadDone
                shr         al, 1
                adc         si, 0
                shr         al, 1
                adc         bp, 0
                shr         al, 2
                adc         di, 0
                loop        PotReadLoop
PotReadDone:
                ret
ReadPots        endp

;----------------------------------------------------------------------------
;
; Normalize-    BX contains a pointer to a pot structure, AX contains
;               a pot value. Normalize that value according to the
;               calibrated pot.
;
; Note: DS must point at cseg before calling this routine.


                assume      ds:cseg
Normalize       proc        near
                push        cx

; Sanity check to make sure the calibration process went okay.

                cmp         [bx].Pot.DidCal, 0
                je          BadNorm
                mov         dx, [bx].Pot.Center
                cmp         dx, [bx].Pot.Min
                jbe         BadNorm
                cmp         dx, [bx].Pot.Max
                jae         BadNorm

; Clip the value if it is out of range.

                cmp         ax, [bx].Pot.Min
                ja          MinOkay
                mov         ax, [bx].Pot.Min
MinOkay:

                cmp         ax, [bx].Pot.Max
                jb          MaxOkay
                mov         ax, [bx].Pot.Max
MaxOkay:

; Scale this guy around the center:

                cmp         ax, [bx].Pot.Center
                jb          Lower128

; Scale in the range 128..255 here:

                sub         ax, [bx].Pot.Center
                mov         dl, ah              ;Multiply by 128
                mov         ah, al
                mov         dh, 0
                mov         al, dh
                shr         dl, 1
                rcr         ax, 1
                mov         cx, [bx].Pot.Max
                sub         cx, [bx].Pot.Center
                jz          BadNorm             ;Prevent division by zero.
```

```
                div     cx                  ;Compute normalized value.
                add     ax, 128             ;Scale to range 128..255.
                cmp     ah, 0
                je      NormDone
                mov     ax, 0ffh            ;Result must fit in 8 bits!
                jmp     NormDone

; Scale in the range 0..127 here:

Lower128:       sub     ax, [bx].Pot.Min
                mov     dl, ah              ;Multiply by 128
                mov     ah, al
                mov     dh, 0
                mov     al, dh
                shr     dl, 1
                rcr     ax, 1
                mov     cx, [bx].Pot.Center
                sub     cx, [bx].Pot.Min
                jz      BadNorm
                div     cx                  ;Compute normalized value.
                cmp     ah, 0
                je      NormDone
                mov     ax, 0ffh            ;Result must fit in 8 bits!
                jmp     NormDone

BadNorm:        sub     ax, ax
NormDone:       pop     cx
                ret
Normalize       endp
                assume  ds:nothing

;============================================================================
; INT 15h handler functions.
;============================================================================
;
; Although these are defined as near procs, they are not really procedures.
; The MyInt15 code jumps to each of these with BX, a far return address, and
; the flags sitting on the stack. Each of these routines must handle the
; stack appropriately.
;
;----------------------------------------------------------------------------
; BIOS- Handles the two BIOS calls, DL=0 to read the switches, DL=1 to
;       read the pots. For the BIOS routines, we'll ignore the cooley
;       switch (the hat) and simply read the other four switches.

BIOS            proc    near
                cmp     dl, 1               ;See if switch or pot routine.
                jb      Read4Sw
                je      ReadBIOSPots
                pop     bx
                jmp     cs:Int15Vect        ;Let someone else handle it!

Read4Sw:        push    dx
                mov     dx, JoyPort
                in      al, dx
                shr     al, 4
                mov     bl, al
                mov     bh, 0
                cmp     cs:SwapButtons, 0
                je      DoLeft2
                mov     al, cs:SwBitsL[bx]
                jmp     SBDone

DoLeft2:        mov     al, cs:SwBits[bx]
SBDone:         rol     al, 4           ;Put Sw0..3 in upper bits and make
                not     al              ; 0=switch down, just like game card.
                pop     dx
                pop     bx
                iret

ReadBIOSPots:   pop     bx              ;Return a value in BX!
                push    si
                push    di
                push    bp
```

```
                mov     ah, 0bh
                call    ReadPots
                mov     ax, si
                mov     bx, bp
                mov     dx, di
                sub     cx, cx
                pop     bp
                pop     di
                pop     si
                iret
BIOS            endp


;----------------------------------------------------------------------------
;
; ReadPot-      On entry, DL contains a pot number to read.
;               Read and normalize that pot and return the result in AL.

                assume  ds:cseg
ReadPot         proc    near
;;;;;;;;;;      push    bx                      ;Already on stack.
                push    ds
                push    cx
                push    dx
                push    si
                push    di
                push    bp

                mov     bx, cseg
                mov     ds, bx

                cmp     dl, 0
                jne     Try1
                mov     ah, Pot0.PotMask
                call    ReadPots
                lea     bx, Pot0
                mov     ax, si
                call    Normalize
                jmp     GotPot

Try1:           cmp     dl, 1
                jne     Try3
                mov     ah, Pot1.PotMask
                call    ReadPots
                lea     bx, Pot1
                mov     ax, bp
                call    Normalize
                jmp     GotPot

Try3:           cmp     dl, 3
                jne     BadPot
                mov     ah, Pot3.PotMask
                call    ReadPots
                lea     bx, Pot3
                mov     ax, di
                call    Normalize
                jmp     GotPot

BadPot:         sub     ax, ax                  ;Question: Should we pass this on
                                                ; or just return zero?
GotPot:         pop     bp
                pop     di
                pop     si
                pop     dx
                pop     cx
                pop     ds
                pop     bx
                iret
ReadPot         endp
                assume  ds:nothing


;----------------------------------------------------------------------------
;
```

```
; ReadRaw-      On entry, DL contains a pot number to read.
;               Read that pot and return the unnormalized result in AL.

                assume    ds:cseg
ReadRaw         proc      near
;;;;;;;;;;      push      bx                  ;Already on stack.
                push      ds
                push      cx
                push      dx
                push      si
                push      di
                push      bp

                mov       bx, cseg
                mov       ds, bx

                cmp       dl, 0
                jne       Try1
                mov       ah, Pot0.PotMask
                call      ReadPots
                mov       ax, si
                jmp       GotPot

Try1:           cmp       dl, 1
                jne       Try3
                mov       ah, Pot1.PotMask
                call      ReadPots
                mov       ax, bp
                jmp       GotPot

Try3:           cmp       dl, 3
                jne       BadPot
                mov       ah, Pot3.PotMask
                call      ReadPots
                mov       ax, di
                jmp       GotPot

BadPot:         sub       ax, ax              ;Just return zero.
GotPot:         pop       bp
                pop       di
                pop       si
                pop       dx
                pop       cx
                pop       ds
                pop       bx
                iret
ReadRaw         endp
                assume    ds:nothing


;----------------------------------------------------------------------------
; Read4Pots-Reads pots zero, one, two, and three returning their
;               values in AL, AH, DL, and DH. Since the flightstick
;               Pro doesn't have a pot 2 installed, return zero for
;               that guy.

Read4Pots       proc      near
;;;;;;;;;;;     push      bx                  ;Already on stack
                push      ds
                push      cx
                push      si
                push      di
                push      bp

                mov       dx, cseg
                mov       ds, dx

                mov       ah, 0bh             ;Read pots 0, 1, and 3.
                call      ReadPots

                mov       ax, si
                lea       bx, Pot0
                call      Normalize
                mov       cl, al
```

```
                mov     ax, bp
                lea     bx, Pot1
                call    Normalize
                mov     ch, al

                mov     ax, di
                lea     bx, Pot3
                call    Normalize
                mov     dh, al                  ;Pot 3 value.
                mov     ax, cx                  ;Pots 0 and 1.
                mov     dl, 0                   ;Pot 2 is non-existant.

                pop     bp
                pop     di
                pop     si
                pop     cx
                pop     ds
                pop     bx
                iret
Read4Pots       endp



;----------------------------------------------------------------------------
; CalPot-       Calibrate the pot specified by DL. On entry, AL contains
;               the minimum pot value (it better be less than 256!), BX
;               contains the maximum pot value, and CX contains the centered
;               pot value.

                assume  ds:cseg
CalPot          proc    near
                pop     bx                      ;Retrieve maximum value
                push    ds
                push    si
                mov     si, cseg
                mov     ds, si

; Sanity check on parameters, sort them in ascending order:

                mov     ah, 0
                cmp     bx, cx
                ja      GoodMax
                xchg    bx, cx
GoodMax:        cmp     ax, cx
                jb      GoodMin
                xchg    ax, cx
GoodMin:        cmp     cx, bx
                jb      GoodCenter
                xchg    cx, bx
GoodCenter:


; Okay, figure out who were supposed to calibrate:

                lea     si, Pot0
                cmp     dl, 1
                jb      DoCal
                lea     si, Pot1
                je      DoCal
                cmp     dl, 3
                jne     CalDone
                lea     si, Pot3

DoCal:          mov     [si].Pot.min, ax
                mov     [si].Pot.max, bx
                mov     [si].Pot.center, cx
                mov     [si].Pot.DidCal, 1
CalDone:        pop     si
                pop     ds
                iret
CalPot          endp
                assume  ds:nothing
```

```
;----------------------------------------------------------------------
; TestCal-      Just checks to see if the pot specified by DL has already
;               been calibrated.

                assume  ds:cseg
TestCal         proc    near
;;;;;;;;        push    bx                      ;Already on stack
                push    ds
                mov     bx, cseg
                mov     ds, bx

                sub     ax, ax                  ;Assume no calibration
                lea     bx, Pot0
                cmp     dl, 1
                jb      GetCal
                lea     bx, Pot1
                je      GetCal
                cmp     dl, 3
                jne     BadCal
                lea     bx, Pot3

GetCal:         mov     al, [bx].Pot.DidCal
                mov     ah, 0
BadCal:         pop     ds
                pop     bx
                iret
TestCal         endp
                assume  ds:nothing


;----------------------------------------------------------------------
;
; ReadSw-       Reads the switch whose switch number appears in DL.

SwTable         byte    11100000b, 11010000b, 01110000b, 10110000b
                byte    00000000b, 11000000b, 01000000b, 10000000b

SwTableL        byte    11100000b, 10110000b, 01110000b, 11010000b
                byte    00000000b, 11000000b, 01000000b, 10000000b

ReadSw          proc    near
;;;;;;;         push    bx                      ;Already on stack
                mov     bl, dl                  ;Save switch to read.
                mov     bh, 0
                mov     dx, JoyPort
                in      al, dx
                and     al, 0f0h
                cmp     cs:SwapButtons, 0
                je      DoLeft0
                cmp     al, cs:SwTableL[bx]
                jne     NotDown
                jmp     IsDown

DoLeft0:        cmp     al, cs:SwTable[bx]
                jne     NotDown

IsDown:         mov     ax, 1
                pop     bx
                iret

NotDown:        sub     ax, ax
                pop     bx
                iret
ReadSw          endp


;----------------------------------------------------------------------
;
; Read16Sw-     Reads all eight switches and returns their values in AX.

Read16Sw        proc    near
;;;;;;;;        push    bx                      ;Already on stack
```

```
                mov     ah, 0               ;Switches 8-15 are non-existant.
                mov     dx, JoyPort
                in      al, dx
                shr     al, 4
                mov     bl, al
                mov     bh, 0
                cmp     cs:SwapButtons, 0
                je      DoLeft1
                mov     al, cs:SwBitsL[bx]
                jmp     R8Done

DoLeft1:        mov     al, cs:SwBits[bx]
R8Done:         pop     bx
                iret
Read16Sw        endp


;****************************************************************************
;
; MyInt15-      Patch for the BIOS INT 15 routine to control reading the
;               joystick.

MyInt15         proc    far
                push    bx
                cmp     ah, 84h             ;Joystick code?
                je      DoJoystick
OtherInt15:     pop     bx
                jmp     cs:Int15Vect

DoJoystick:     mov     bh, 0
                mov     bl, dh
                cmp     bl, 80h
                jae     VendorCalls
                cmp     bx, JmpSize
                jae     OtherInt15
                shl     bx, 1
                jmp     wp cs:jmptable[bx]

jmptable        word    BIOS
                word    ReadPot, Read4Pots, CalPot, TestCal
                word    ReadRaw, OtherInt15, OtherInt15
                word    ReadSw, Read16Sw
JmpSize         =       ($-jmptable)/2


; Handle vendor specific calls here.

VendorCalls:    je      RemoveDriver
                cmp     bl, 81h
                je      TestPresence
                pop     bx
                jmp     cs:Int15Vect

; TestPresence- Returns zero in AX and a pointer to the ID string in ES:BX

TestPresence:   pop     bx                  ;Get old value off stack.
                sub     ax, ax
                mov     bx, cseg
                mov     es, bx
                lea     bx, IDString
                iret

; RemoveDriver-If there are no other drivers loaded after this one in
;               memory, disconnect it and remove it from memory.

RemoveDriver:
                push    ds
                push    es
                push    ax
                push    dx

                mov     dx, cseg
                mov     ds, dx
```

```
; See if we're the last routine patched into INT 15h

                mov     ax, 3515h
                int     21h
                cmp     bx, offset MyInt15
                jne     CantRemove
                mov     bx, es
                cmp     bx, wp seg MyInt15
                jne     CantRemove

                mov     ax, PSP                 ;Free the memory we're in
                mov     es, ax
                push    es
                mov     ax, es:[2ch]            ;First, free env block.
                mov     es, ax
                mov     ah, 49h
                int     21h
;
                pop     es                      ;Now free program space.
                mov     ah, 49h
                int     21h

                lds     dx, Int15Vect           ;Restore previous int vect.
                mov     ax, 2515h
                int     21h

CantRemove:     pop     dx
                pop     ax
                pop     es
                pop     ds
                pop     bx
                iret
MyInt15         endp
cseg            ends


; The following segment is tossed when this code goes resident.

Initialize      segment para public 'INIT'
                assume  cs:Initialize, ds:cseg
Main            proc
                mov     ax, cseg                ;Get ptr to vars segment
                mov     es, ax
                mov     es:PSP, ds              ;Save PSP value away
                mov     ds, ax

                mov     ax, zzzzzzseg
                mov     es, ax
                mov     cx, 100h
                meminit2

                print
                byte    "Standard Game Device Interface driver",cr,lf
                byte    "CH Products Flightstick Pro",cr,lf
                byte    "Written by Randall Hyde",cr,lf
                byte    cr,lf
                byte    "'FSPSGDI LEFT' swaps the left and right buttons for "
                byte    "left handed players",cr,lf
                byte    "'FSPSGDI REMOVE' removes the driver from memory"
                byte    cr, lf, lf
                byte    0

                mov     ax, 1
                argv                            ;If no parameters, empty str.
                stricmpl
                byte    "LEFT",0
                jne     NoLEFT
                mov     SwapButtons, 1
                print
                byte    "Left and right buttons swapped",cr,lf,0
                jmp     SwappedLeft

NoLEFT:         stricmpl
```

```
                byte        "REMOVE",0
                jne         NoRmv
                mov         dh, 81h
                mov         ax, 84ffh
                int         15h             ;See if we're already loaded.
                test        ax, ax          ;Get a zero back?
                jz          Installed
                print
                byte        "SGDI driver is not present in memory, REMOVE "
                byte        "command ignored.",cr,lf,0
                mov         ax, 4c01h;Exit to DOS.
                int         21h

Installed:      mov         ax, 8400h
                mov         dh, 80h             ;Remove call
                int         15h
                mov         ax, 8400h
                mov         dh, 81h             ;TestPresence call
                int         15h
                cmp         ax, 0
                je          NotRemoved
                print
                byte        "Successfully removed SGDI driver from memory."
                byte        cr,lf,0
                mov         ax, 4c01h       ;Exit to DOS.
                int         21h

NotRemoved:     print
                byte        "SGDI driver is still present in memory.",cr,lf,0
                mov         ax, 4c01h;Exit to DOS.
                int         21h


NoRmv:


; Okay, Patch INT 15 and go TSR at this point.

SwappedLeft:    mov         ax, 3515h
                int         21h
                mov         wp Int15Vect, bx
                mov         wp Int15Vect+2, es

                mov         dx, cseg
                mov         ds, dx
                mov         dx, offset MyInt15
                mov         ax, 2515h
                int         21h

                mov         dx, cseg
                mov         ds, dx
                mov         dx, seg Initialize
                sub         dx, ds:psp
                add         dx, 2
                mov         ax, 3100h           ;Do TSR
                int         21h
Main            endp

Initialize      ends

sseg            segment     para stack 'stack'
                word        128 dup (0)
endstk          word        ?
sseg            ends

zzzzzzseg       segment     para public 'zzzzzzseg'
                byte        16 dup (0)
zzzzzzseg       ends
                end         Main
```

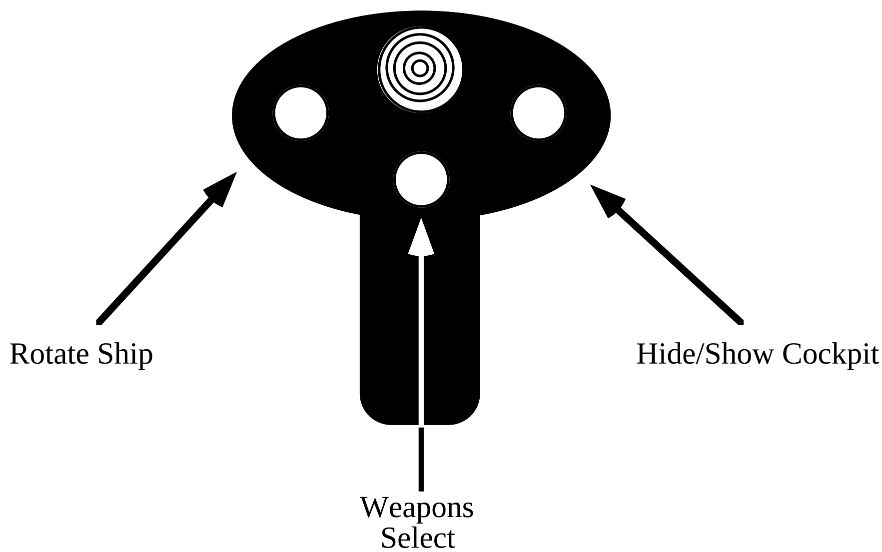
24.7 Patching Existing Games

Maybe you're not quite ready to write the next million dollar game. Perhaps you'd like to get a little more enjoyment out of the games you already own. Well, this section will provide a practical application of a semiresident program that patches the Lucas Arts' XWing (Star Wars simulation) game. This program patches the XWing game to take advantage of the special features found on the CH Products' FlightStick Pro. In particular, it lets you use the throttle pot on the FSP to control the speed of the spacecraft. It also lets you program each of the buttons with up to four strings of eight characters each.

To describe how you can patch an existing game, a short description of how this patch was developed is in order. The FSPXW patch was developed by using the Soft-ICE™debugging tool. This program lets you set a breakpoint whenever an 80386 or later processor accesses a specific I/O port[8]. Setting a breakpoint at I/O address 201h while running the xwing.exe file stopped the XWing program when it decided to read the analog and switch inputs. Disassembly of the surrounding code produced complete joystick and button read routines. After locating these routines, it was easy enough to write a program to search through memory for the code and patch in jumps to code in the FSPXW patch program.

Note that the original joystick code inside XWing works perfectly fine with the FPS. The only reason for patching into the joystick code is so our code can read the throttle every how and then and take appropriate action.

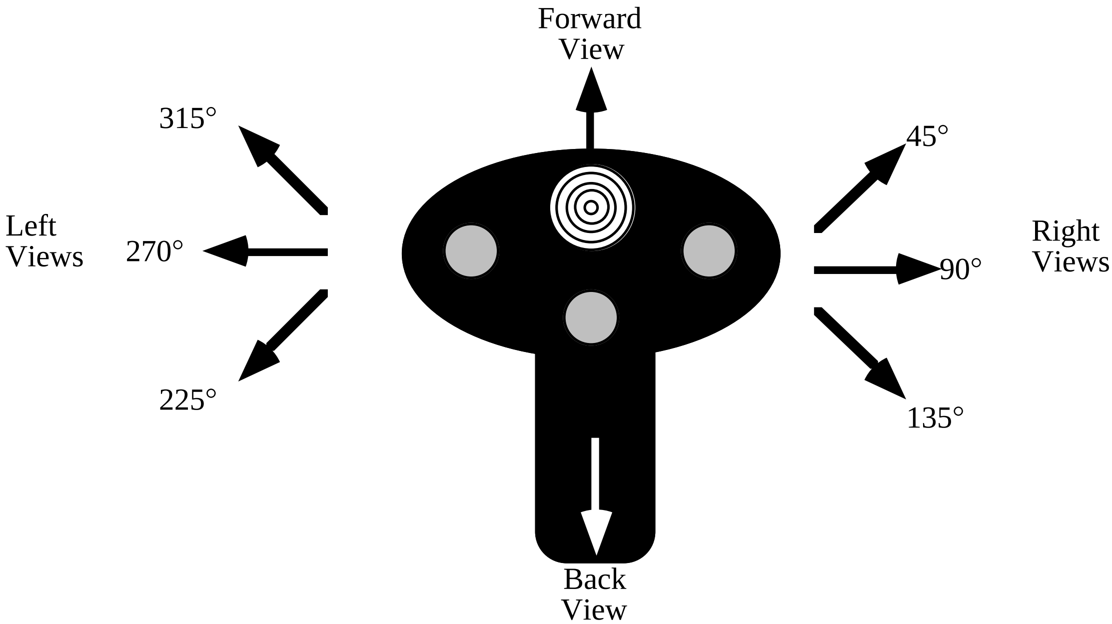
The button routines were another story altogether. The FSPXW patch needs to take control of XWing's button routines because the user of FSPXW might want to redefine a button recognized by XWing for some other purpose. Therefore, whenever XWing calls its button routine, control transfers to the button routine inside FSPXW that decides whether to pass real button information back to XWing or to fake buttons in the up position because those buttons are redefined to other functions. By default (unless you change the source code, the buttons have the following programming:



The programming of the cooley switch demonstrates an interesting feature of the FSPXW patch: you can program up to four different strings on each button. The first time you press a button, FSPXW emits the first string, the second time you press a button it emits the second string, then the third, and finally the fourth. If the string is empty, the FSPXW string skips it. The FSPXW patch uses the cooley switch to select the cockpit views. Pressing the cooley switch forward displays the forward view. Pulling the cooley switch backwards presents the rear view. However, the XWing game provides *three* left and right views. Pushing the cooley switch to the left or right once displays the 45 degree view. Pressing it a second time presents

8. This feature is not specific to Soft-ICE, many 80386 debuggers will let you do this.

the 90 degree view. Pressing it to the left or right a third time provides the 135 degree view. The following diagram shows the default programming on the cooley switch:



One word of caution concerning this patch: it only works with the basic XWing game. It does not support the add-on modules (Imperial Pursuit, B-Wing, Tie Fighter, etc.). Furthermore, this patch assumes that the basic XWing code has not changed over the years. It could be that a recent release of the XWing game uses new joystick routines and the code associated with this application will not be able to locate or patch those new routines. This patch will detect such a situation and will not patch XWing if this is the case. You must have sufficient free RAM for this patch, XWing, and anything else you have loaded into memory at the same time (the exact amount of RAM XWing needs depends upon the features you've installed, a fully installed system requires slightly more than 610K free).

Without further ado, here's the FSPXW code:

```
              .286
              page      58, 132
              name      FSPXW
              title     FSPXW (Flightstick Pro driver for XWING).
              subttl    Copyright (C) 1994 Randall Hyde.


; FSPXW.EXE
;
;       Usage:
;             FSPXW
;
; This program executes the XWING.EXE program and patches it to use the
; Flightstick Pro.


byp           textequ   <byte ptr>
wp            textequ   <word ptr>


cseg          segment para public 'CODE'
cseg          ends

sseg          segment   para stack 'STACK'
sseg          ends

zzzzzzseg     segment   para public 'zzzzzzseg'
zzzzzzseg     ends
```

```
                include         stdlib.a
                includelib stdlib.lib
                matchfuncs

                ifndef      debug
Installation    segment     para public 'Install'
Installation    ends
                endif

CSEG            segment     para public 'CODE'
                assume      cs:cseg, ds:nothing

; Timer interrupt vector

Int1CVect       dword       ?


; PSP-   Program Segment Prefix. Needed to free up memory before running
;        the real application program.

PSP             word        0



; Program Loading data structures (for DOS).

ExecStruct      word        0                   ;Use parent's Environment blk.
                dword       CmdLine             ;For the cmd ln parms.
                dword       DfltFCB
                dword       DfltFCB
LoadSSSP        dword       ?
LoadCSIP        dword       ?
PgmName         dword       Pgm


; Variables for the throttle pot.
; LastThrottle contains the character last sent (so we only send one copy).
; ThrtlCntDn counts the number of times the throttle routine gets called.

LastThrottle    byte        0
ThrtlCntDn      byte        10


; Button Mask- Used to mask out the programmed buttons when the game
; reads the real buttons.

ButtonMask      byte        0f0h


; The following variables allow the user to reprogram the buttons.

KeyRdf          struct
Ptrs            word        ?               ;The PTRx fields point at the
ptr2            word        ?               ; four possible strings of 8 chars
ptr3            word        ?               ; each. Each button press cycles
ptr4            word        ?               ; through these strings.
Index           word        ?               ;Index to next string to output.
Cnt             word        ?
Pgmd            word        ?               ;Flag = 0 if not redefined.
KeyRdf          ends


; Left codes are output if the cooley switch is pressed to the left.
; Note that the strings ares actually zero terminated strings of words.

Left            KeyRdf      <Left1, Left2, Left3, Left4, 0, 6, 1>
Left1           word        '7', 0
Left2           word        '4', 0
Left3           word        '1', 0
Left4           word        0

; Right codes are output if the cooley switch is pressed to the Right.
```

```
Right           KeyRdf     <Right1, Right2, Right3, Right4, 0, 6, 1>
Right1          word       '9', 0
Right2          word       '6', 0
Right3          word       '3', 0
Right4          word       0

; Up codes are output if the cooley switch is pressed Up.

Up              KeyRdf     <Up1, Up2, Up3, Up4, 0, 2, 1>
Up1             word       '8', 0
Up2             word       0
Up3             word       0
Up4             word       0

; DownKey codes are output if the cooley switch is pressed Down.

Down            KeyRdf     <Down1, Down2, Down3, Down4, 0, 2, 1>
Down1           word       '2', 0
Down2           word       0
Down3           word       0
Down4           word       0

; Sw0 codes are output if the user pulls the trigger.(This switch is not
; redefined.)

Sw0             KeyRdf     <Sw01, Sw02, Sw03, Sw04, 0, 0, 0>
Sw01            word       0
Sw02            word       0
Sw03            word       0
Sw04            word       0


; Sw1 codes are output if the user presses Sw1 (the left button
; if the user hasn't swapped the left and right buttons). Not Redefined.

Sw1             KeyRdf     <Sw11, Sw12, Sw13, Sw14, 0, 0, 0>
Sw11            word       0
Sw12            word       0
Sw13            word       0
Sw14            word       0

; Sw2 codes are output if the user presses Sw2 (the middle button).

Sw2             KeyRdf     <Sw21, Sw22, Sw23, Sw24, 0, 2, 1>
Sw21            word       'w', 0
Sw22            word       0
Sw23            word       0
Sw24            word       0

; Sw3 codes are output if the user presses Sw3 (the right button
; if the user hasn't swapped the left and right buttons).

Sw3             KeyRdf     <Sw31, Sw32, Sw33, Sw34, 0, 0, 0>
Sw31            word       0
Sw32            word       0
Sw33            word       0
Sw34            word       0

; Switch status buttons:

CurSw           byte       0
LastSw          byte       0


;****************************************************************************
; FSPXW patch begins here. This is the memory resident part. Only put code
; which which has to be present at run-time or needs to be resident after
; freeing up memory.
;****************************************************************************

Main            proc
                mov        cs:PSP, ds
                mov        ax, cseg        ;Get ptr to vars segment
                mov        ds, ax
```

```
; Get the current INT 1Ch interrupt vector:

                mov     ax, 351ch
                int     21h
                mov     wp Int1CVect, bx
                mov     wp Int1CVect+2, es

; The following call to MEMINIT assumes no error occurs. If it does,
; we're hosed anyway.

                mov     ax, zzzzzzseg
                mov     es, ax
                mov     cx, 1024/16
                meminit2


; Do some initialization before running the game. These are calls to the
; initialization code which gets dumped before actually running XWING.

                call    far ptr ChkBIOS15
                call    far ptr Identify
                call    far ptr Calibrate

; If any switches were programmed, remove those switches from the
; ButtonMask:

                mov     al, 0f0h        ;Assume all buttons are okay.
                cmp     sw0.pgmd, 0
                je      Sw0NotPgmd
                and     al, 0e0h        ;Remove sw0 from contention.
Sw0NotPgmd:

                cmp     sw1.pgmd, 0
                je      Sw1NotPgmd
                and     al, 0d0h        ;Remove Sw1 from contention.
Sw1NotPgmd:

                cmp     sw2.pgmd, 0
                je      Sw2NotPgmd
                and     al, 0b0h        ;Remove Sw2 from contention.
Sw2NotPgmd:

                cmp     sw3.pgmd, 0
                je      Sw3NotPgmd
                and     al, 070h        ;Remove Sw3 from contention.
Sw3NotPgmd:
                mov     ButtonMask, al  ;Save result as button mask

; Now, free up memory from ZZZZZZSEG on to make room for XWING.
; Note: Absolutely no calls to UCR Standard Library routines from
; this point forward! (ExitPgm is okay, it's just a macro which calls DOS.)
; Note that after the execution of this code, none of the code & data
; from zzzzzzseg on is valid.

                mov     bx, zzzzzzseg
                sub     bx, PSP
                inc     bx
                mov     es, PSP
                mov     ah, 4ah
                int     21h
                jnc     GoodRealloc
                print
                byte    "Memory allocation error."
                byte    cr,lf,0
                jmp     Quit

GoodRealloc:

; Now load the XWING program into memory:

                mov     bx, seg ExecStruct
                mov     es, bx
```

```
                mov     bx, offset ExecStruc ;Ptr to program record.
                lds     dx, PgmName
                mov     ax, 4b01h           ;Load, do not exec, pgm
                int     21h
                jc      Quit                ;If error loading file.

; Search for the joystick code in memory:

                mov     si, zzzzzzseg
                mov     ds, si
                xor     si, si

                mov     di, cs
                mov     es, di
                mov     di, offset JoyStickCode
                mov     cx, JoyLength
                call    FindCode
                jc      Quit                ;If didn't find joystick code.


; Patch the XWING joystick code here

                mov     byp ds:[si], 09ah               ;Far call
                mov     wp ds:[si+1], offset ReadGame
                mov     wp ds:[si+3], cs

; Find the Button code here.

                mov     si, zzzzzzseg
                mov     ds, si
                xor     si, si

                mov     di, cs
                mov     es, di
                mov     di, offset ReadSwCode
                mov     cx, ButtonLength
                call    FindCode
                jc      Quit

; Patch the button code here.

                mov     byp ds:[si], 9ah
                mov     wp ds:[si+1], offset ReadButtons
                mov     wp ds:[si+3], cs
                mov     byp ds:[si+5], 90h              ;NOP.


; Patch in our timer interrupt handler:

                mov     ax, 251ch
                mov     dx, seg MyInt1C
                mov     ds, dx
                mov     dx, offset MyInt1C
                int     21h


; Okay, start the XWING.EXE program running

                mov     ah, 62h             ;Get PSP
                int     21h
                mov     ds, bx
                mov     es, bx
                mov     wp ds:[10], offset Quit
                mov     wp ds:[12], cs
                mov     ss, wp cseg:LoadSSSP+2
                mov     sp, wp cseg:LoadSSSP
                jmp     dword ptr cseg:LoadCSIP


Quit:           lds     dx, cs:Int1CVect  ;Restore timer vector.
                mov     ax, 251ch
                int     21h
                ExitPgm
```

```
Main            endp

;****************************************************************************
;
; ReadGame-     This routine gets called whenever XWing reads the joystick.
;               On every 10th call it will read the throttle pot and send
;               appropriate characters to the type ahead buffer, if
;               necessary.

                assume  ds:nothing
ReadGame        proc    far
                dec     cs:ThrtlCntDn     ;Only do this each 10th time
                jne     SkipThrottle      ; XWING calls the joystick
                mov     cs:ThrtlCntDn, 10 ; routine.

                push    ax
                push    bx                ;No need to save bp, dx, or cx as
                push    di                ; XWING preserves these.

                mov     ah, 84h
                mov     dx, 103h          ;Read the throttle pot
                int     15h

; Convert the value returned by the pot routine into the four characters
; 0..63:"\", 64..127:"[", 128..191:"]", 192..255:<bs>, to denote zero, 1/3,
; 2/3, and full power, respectively.

                mov     dl, al
                mov     ax, "\"           ;Zero power
                cmp     dl, 192
                jae     SetPower
                mov     ax, "["           ;1/3 power.
                cmp     dl, 128
                jae     SetPower
                mov     ax, "]"           ;2/3 power.
                cmp     dl, 64
                jae     SetPower
                mov     ax, 8             ;BS, full power.
SetPower:       cmp     al, cs:LastThrottle
                je      SkipPIB
                mov     cs:LastThrottle, al
                call    PutInBuffer

SkipPIB:        pop     di
                pop     bx
                pop     ax
SkipThrottle:   neg     bx             ;XWING returns data in these registers.
                neg     di             ;We patched the NEG and STI instrs
                sti                    ; so do that here.
                ret
ReadGame        endp

                assume  ds:nothing
ReadButtons     proc    far
                mov     ah, 84h
                mov     dx, 0
                int     15h
                not     al
                and     al, ButtonMask    ;Turn off pgmd buttons.
                ret
ReadButtons     endp


; MyInt1C- Called every 1/18th second. Reads switches and decides if it
; should shove some characters into the type ahead buffer.

                assume  ds:cseg
MyInt1c         proc    far
                push    ds
                push    ax
                push    bx
                push    dx
                mov     ax, cseg
```

```
                mov     ds, ax

                mov     al, CurSw
                mov     LastSw, al

                mov     dx, 900h            ;Read the 8 switches.
                mov     ah, 84h
                int     15h

                mov     CurSw, al
                xor     al, LastSw          ;See if any changes
                jz      NoChanges
                and     al, CurSw           ;See if sw just went down.
                jz      NoChanges


; If a switch has just gone down, output an appropriate set of scan codes
; for it, if that key is active. Note that pressing *any* key will reset
; all the other key indexes.

                test    al, 1               ;See if Sw0 (trigger) was pulled.
                jz      NoSw0
                cmp     Sw0.Pgmd, 0
                je      NoChanges
                mov     ax, 0
                mov     Left.Index, ax      ;Reset the key indexes for all keys
                mov     Right.Index, ax     ; except SW0.
                mov     Up.Index, ax
                mov     Down.Index, ax
                mov     Sw1.Index, ax
                mov     Sw2.Index, ax
                mov     Sw3.Index, ax
                mov     bx, Sw0.Index
                mov     ax, Sw0.Index
                mov     bx, Sw0.Ptrs[bx]
                add     ax, 2
                cmp     ax, Sw0.Cnt
                jb      SetSw0
                mov     ax, 0
SetSw0:         mov     Sw0.Index, ax
                call    PutStrInBuf
                jmp     NoChanges



NoSw0:          test    al, 2               ;See if Sw1 (left sw) was pressed.
                jz      NoSw1
                cmp     Sw1.Pgmd, 0
                je      NoChanges
                mov     ax, 0
                mov     Left.Index, ax      ;Reset the key indexes for all keys
                mov     Right.Index, ax     ; except Sw1.
                mov     Up.Index, ax
                mov     Down.Index, ax
                mov     Sw0.Index, ax
                mov     Sw2.Index, ax
                mov     Sw3.Index, ax
                mov     bx, Sw1.Index
                mov     ax, Sw1.Index
                mov     bx, Sw1.Ptrs[bx]
                add     ax, 2
                cmp     ax, Sw1.Cnt
                jb      SetSw1
                mov     ax, 0
SetSw1:         mov     Sw1.Index, ax
                call    PutStrInBuf
                jmp     NoChanges


NoSw1:          test    al, 4               ;See if Sw2 (middle sw) was pressed.
                jz      NoSw2
                cmp     Sw2.Pgmd, 0
                je      NoChanges
                mov     ax, 0
```

```
                mov     Left.Index, ax      ;Reset the key indexes for all keys
                mov     Right.Index, ax     ; except Sw2.
                mov     Up.Index, ax
                mov     Down.Index, ax
                mov     Sw0.Index, ax
                mov     Sw1.Index, ax
                mov     Sw3.Index, ax
                mov     bx, Sw2.Index
                mov     ax, Sw2.Index
                mov     bx, Sw2.Ptrs[bx]
                add     ax, 2
                cmp     ax, Sw2.Cnt
                jb      SetSw2
                mov     ax, 0
SetSw2:         mov     Sw2.Index, ax
                call    PutStrInBuf
                jmp     NoChanges


NoSw2:          test    al, 8               ;See if Sw3 (right sw) was pressed.
                jz      NoSw3
                cmp     Sw3.Pgmd, 0
                je      NoChanges
                mov     ax, 0
                mov     Left.Index, ax      ;Reset the key indexes for all keys
                mov     Right.Index, ax     ; except Sw3.
                mov     Up.Index, ax
                mov     Down.Index, ax
                mov     Sw0.Index, ax
                mov     Sw1.Index, ax
                mov     Sw2.Index, ax
                mov     bx, Sw3.Index
                mov     ax, Sw3.Index
                mov     bx, Sw3.Ptrs[bx]
                add     ax, 2
                cmp     ax, Sw3.Cnt
                jb      SetSw3
                mov     ax, 0
SetSw3:         mov     Sw3.Index, ax
                call    PutStrInBuf
                jmp     NoChanges


NoSw3:          test    al, 10h             ;See if Cooly was pressed upwards.
                jz      NoUp
                cmp     Up.Pgmd, 0
                je      NoChanges
                mov     ax, 0
                mov     Right.Index, ax     ;Reset all but Up.
                mov     Left.Index, ax
                mov     Down.Index, ax
                mov     Sw0.Index, ax
                mov     Sw1.Index, ax
                mov     Sw2.Index, ax
                mov     Sw3.Index, ax
                mov     bx, Up.Index
                mov     ax, Up.Index
                mov     bx, Up.Ptrs[bx]
                add     ax, 2
                cmp     ax, Up.Cnt
                jb      SetUp
                mov     ax, 0
SetUp:          mov     Up.Index, ax
                call    PutStrInBuf
                jmp     NoChanges


NoUp:           test    al, 20h             ;See if Cooley was pressed left.
                jz      NoLeft
                cmp     Left.Pgmd, 0
                je      NoChanges
                mov     ax, 0
                mov     Right.Index, ax     ;Reset all but Left.
                mov     Up.Index, ax
```

```
                mov     Down.Index, ax
                mov     Sw0.Index, ax
                mov     Sw1.Index, ax
                mov     Sw2.Index, ax
                mov     Sw3.Index, ax
                mov     bx, Left.Index
                mov     ax, Left.Index
                mov     bx, Left.Ptrs[bx]
                add     ax, 2
                cmp     ax, Left.Cnt
                jb      SetLeft
                mov     ax, 0
SetLeft:        mov     Left.Index, ax
                call    PutStrInBuf
                jmp     NoChanges


NoLeft:         test    al, 40h         ;See if Cooley was pressed Right
                jz      NoRight
                cmp     Right.Pgmd, 0
                je      NoChanges
                mov     ax, 0
                mov     Left.Index, ax  ;Reset all but Right.
                mov     Up.Index, ax
                mov     Down.Index, ax
                mov     Sw0.Index, ax
                mov     Sw1.Index, ax
                mov     Sw2.Index, ax
                mov     Sw3.Index, ax
                mov     bx, Right.Index
                mov     ax, Right.Index
                mov     bx, Right.Ptrs[bx]
                add     ax, 2
                cmp     ax, Right.Cnt
                jb      SetRight
                mov     ax, 0
SetRight:       mov     Right.Index, ax
                call    PutStrInBuf
                jmp     NoChanges


NoRight:        test    al, 80h         ;See if Cooly was pressed Downward.
                jz      NoChanges
                cmp     Down.Pgmd, 0
                je      NoChanges
                mov     ax, 0
                mov     Left.Index, ax  ;Reset all but Down.
                mov     Up.Index, ax
                mov     Right.Index, ax
                mov     Sw0.Index, ax
                mov     Sw1.Index, ax
                mov     Sw2.Index, ax
                mov     Sw3.Index, ax
                mov     bx, Down.Index
                mov     ax, Down.Index
                mov     bx, Down.Ptrs[bx]
                add     ax, 2
                cmp     ax, Down.Cnt
                jb      SetDown
                mov     ax, 0
SetDown:        mov     Down.Index, ax
                call    PutStrInBuf

NoChanges:      pop     dx
                pop     bx
                pop     ax
                pop     ds
                jmp     cs:Int1CVect
MyInt1c         endp
                assume  ds:nothing

; PutStrInBuf- BX points at a zero terminated string of words.
;               Output each word by calling PutInBuffer.
```

```
PutStrInBuf   proc      near
              push      ax
              push      bx
PutLoop:      mov       ax, [bx]
              test      ax, ax
              jz        PutDone
              call      PutInBuffer
              add       bx, 2
              jmp       PutLoop

PutDone:      pop       bx
              pop       ax
              ret
PutStrInBuf   endp

; PutInBuffer- Outputs character and scan code in AX to the type ahead
; buffer.

              assume    ds:nothing
KbdHead       equ       word ptr ds:[1ah]
KbdTail       equ       word ptr ds:[1ch]
KbdBuffer     equ       word ptr ds:[1eh]
EndKbd        equ       3eh
Buffer        equ       1eh

PutInBuffer   proc      near
              push      ds
              push      bx
              mov       bx, 40h
              mov       ds, bx
              pushf
              cli                         ;This is a critical region!
              mov       bx, KbdTail       ;Get ptr to end of type
              inc       bx                ; ahead buffer and make room
              inc       bx                ; for this character.
              cmp       bx, buffer+32     ;At physical end of buffer?
              jb        NoWrap
              mov       bx, buffer        ;Wrap back to 1eH if at end.
;
NoWrap:       cmp       bx, KbdHead       ;Buffer overrun?
              je        PIBDone
              xchg      KbdTail, bx       ;Set new, get old, ptrs.
              mov       ds:[bx], ax       ;Output AX to old location.
PIBDone:      popf                        ;Restore interrupts
              pop       bx
              pop       ds
              ret
PutInBuffer   endp


;****************************************************************************
;
; FindCode: On entry, ES:DI points at some code in *this* program which
;         appears in the ATP game. DS:SI points at a block of memory
;         in the XWing game. FindCode searches through memory to find the
;         suspect piece of code and returns DS:SI pointing at the start of
;         that code. This code assumes that it *will* find the code!
;         It returns the carry clear if it finds it, set if it doesn't.

FindCode      proc      near
              push      ax
              push      bx
              push      dx

DoCmp:        mov       dx, 1000h
CmpLoop:      push      di                ;Save ptr to compare code.
              push      si                ;Save ptr to start of string.
              push      cx                ;Save count.
        repe  cmpsb
              pop       cx
              pop       si
              pop       di
              je        FoundCode
```

```
                inc     si
                dec     dx
                jne     CmpLoop
                sub     si, 1000h
                mov     ax, ds
                inc     ah
                mov     ds, ax
                cmp     ax, 9000h
                jb      DoCmp

                pop     dx
                pop     bx
                pop     ax
                stc
                ret

FoundCode:      pop     dx
                pop     bx
                pop     ax
                clc
                ret
FindCode        endp


;****************************************************************************
;
; Joystick and button routines which appear in XWing game. This code is
; really data as the INT 21h patch code searches through memory for this code
; after loading a file from disk.



JoyStickCode    proc    near
                sti
                neg     bx
                neg     di
                pop     bp
                pop     dx
                pop     cx
                ret
                mov     bp, bx
                in      al, dx
                mov     bl, al
                not     al
                and     al, ah
                jnz     $+11h
                in      al, dx
JoyStickCode    endp
EndJSC:

JoyLength       =       EndJSC-JoyStickCode

ReadSwCode      proc
                mov     dx, 201h
                in      al, dx
                xor     al, 0ffh
                and     ax, 0f0h
ReadSwCode      endp
EndRSC:

ButtonLength    =       EndRSC-ReadSwCode

cseg            ends


Installation    segment

; Move these things here so they do not consume too much space in the
; resident part of the patch.

DfltFCB         byte    3,” “,0,0,0,0,0
CmdLine         byte    2, “ “, 0dh, 126 dup (“ “)      ;Cmd line for program
Pgm             byte    “XWING.EXE”,0
                byte    128 dup (?)                     ;For user’s name
```

```
; ChkBIOS15- Checks to see if the INT 15 driver for FSPro is present in memory.

ChkBIOS15       proc        far
                mov         ah, 84h
                mov         dx, 8100h
                int         15h
                mov         di, bx
                strcmpl
                byte        “CH Products:Flightstick Pro”,0
                jne         NoDriverLoaded
                ret

NoDriverLoaded:
                print
                byte        “CH Products SGDI driver for Flightstick Pro is not “
                byte        “loaded into memory.”,cr,lf
                byte        “Please run FSPSGDI before running this program.”
                byte        cr,lf,0
                exitpgm

ChkBIOS15       endp


;****************************************************************************
;
;
; Identify-     Prints a sign-on message.

                assume      ds:nothing
Identify        proc        far

; Print a welcome string. Note that the string “VersionStr” will be
; modified by the “version.exe” program each time you assemble this code.

                print
                byte        cr,lf,lf
                byte        “X W I N G P A T C H”,cr,lf
                byte        “CH Products Flightstick Pro”,cr,lf
                byte        “Copyright 1994, Randall Hyde”,cr,lf
                byte        lf
                byte        0

                ret
Identify        endp

;****************************************************************************
;
;
; Calibrate the throttle down here:

                assume      ds:nothing
Calibrate       proc        far
                print
                byte        cr,lf,lf
                byte        “Calibration:”,cr,lf,lf
                byte        “Move the throttle to one extreme and press any “
                byte        “button:”,0

                call        Wait4Button
                mov         ah, 84h
                mov         dx, 1h
                int         15h
                push        dx              ;Save pot 3 reading.

                print
                byte        cr,lf
                byte        “Move the throttle to the other extreme and press “
                byte        “any button:”,0

                call        Wait4Button
                mov         ah, 84h
                mov         dx, 1
                int         15h
                pop         bx
```

```
                mov     ax, dx
                cmp     ax, bx
                jb      RangeOkay
                xchg    ax, bx
RangeOkay:      mov     cx, bx          ;Compute a centered value.
                sub     cx, ax
                shr     cx, 1
                add     cx, ax
                mov     ah, 84h
                mov     dx, 303h        ;Calibrate pot three.
                int     15h
                ret
Calibrate       endp


Wait4Button     proc    near
                mov     ah, 84h         ;First, wait for all buttons
                mov     dx, 0           ; to be released.
                int     15h
                and     al, 0F0h
                cmp     al, 0F0h
                jne     Wait4Button

                mov     cx, 0
Delay:          loop    Delay

Wait4Press:     mov     ah, 1           ;Eat any characters from the
                int     16h             ; keyboard which come along, and
                je      NoKbd           ; handle ctrl-C as appropriate.
                getc

NoKbd:          mov     ah, 84h         ;Now wait for any button to be
                mov     dx, 0           ; pressed.
                int     15h
                and     al, 0F0h
                cmp     al, 0F0h
                je      Wait4Press

                ret
Wait4Button     endp
Installation    ends

sseg            segment para stack 'STACK'
                word    256 dup (0)
endstk          word    ?
sseg            ends

zzzzzzseg       segment para public 'zzzzzzseg'
Heap            byte    1024 dup (0)
zzzzzzseg       ends
                end     Main
```

24.8 Summary

The PC's game adapter card lets you connect a wide variety of game related input devices to your PC. Such devices include digital joysticks, paddles, analog joysticks, steering wheels, yokes, and more. Paddle input devices provide one degree of freedom, joysticks provide two degrees of freedom along an (X,Y) axis pair. Steering wheels and yokes also provide two degrees of freedom, though they are designed for different types of games. For more information on these input devices, see

- "Typical Game Devices" on page 1255

Most game input devices connect to the PC through the game adapter card. This device provides for up to four digital (switch) inputs and four analog (resistive) inputs. This device appears as a single I/O location in the PC's I/O address space. Four of the bits at this port correspond to the four switches, four of the inputs provide the status of the timer pulses from the 558 chip for the analog inputs. The switches you can read directly from the port; to read the analog inputs, you must create a timing loop to count how long it takes for the pulse associated with a particular device to go from high to low. For more information on the game adapter hardware, see:

- "The Game Adapter Hardware" on page 1257

Programming the game adapter would be a simple task except that you will get different readings for the same relative pot position with different game adapter cards, game input devices, computer systems, and software. The real trick to programming the game adapter is to produce consistent results, regardless of the actual hardware in use. If you can live with raw input values, the BIOS provides two functions to read the switches and the analog inputs. However, if you need normalized values, you will probably have to write your own code. Still, writing such code is very easy if you remember some basic high school algebra. So see how this is done, check out

- "Using BIOS' Game I/O Functions" on page 1259
- "Writing Your Own Game I/O Routines" on page 1260

As with the other devices on the PC, there is a problem with accessing the game adapter hardware directly, such code will not work with game input hardware that doesn't adhere strictly to the original PC's design criteria. Fancy game input devices like the Thrustmaster joystick and the CH Product's FlightStick Pro will require you to write special software drivers. Furthermore, your basic joystick code may not even work with future devices, even if they provide a minimal set of features compatible with standard game input devices. Unfortunately, the BIOS services are very slow and not very good, so few programmers make BIOS calls, allowing third party developers to provide replacement device drivers for their game devices. To help alleviate this problem, this chapter presents the Standard Game Device Input application programmer's interface – a set of functions specifically designed to provide an extensible, portable, system for game input device programmers. The current specification provides for up to 256 digital and 256 analog input devices and is easily extended to handle output devices and other input devices as well. For the details, see

- "The Standard Game Device Interface (SGDI)" on page 1262
- "Application Programmer's Interface (API)" on page 1262

Since this chapter introduces the SGDI driver, there aren't many SGDI drivers provided by game adapter manufacturers at this point. So if you write software that makes SGDI driver calls, you will find that there are few machines that will have an SGDI TSR in memory. Therefore, this chapter provides SGDI drivers for the standard game adapter card and the standard input devices. It also provides an SGDI driver for the CH Products' FlightStick Pro joystick. To obtain these freely distributable drivers, see

- "An SGDI Driver for the Standard Game Adapter Card" on page 1265
- "An SGDI Driver for the CH Products' Flight Stick Pro™" on page 1280

This chapter concludes with an example of a semiresident program that makes SGDI calls. This program, that patches the popular XWing game, provides full support for the CH Product's FlightStick Pro in XWing. This program demonstrates many of the features of an SGDI driver as well as providing and example of how to patch a commercially available game. For the explanation and the source code, see

- "Patching Existing Games" on page 1293