you will find yourself the target of some law enforcement action very quickly. Also, watch out for direct reflections such as windows, and shiny steel surfaces. The chance of a direct reflection is greatly reduced as the distance from the reflective object increases from your position however. The lasernoculars are a great basis for further laser experimentation, and with a little creativity, you may be able to send secret transmission through the air, control far away devices, or even determine the distance from you to the target if you added a second laser. Read on for some other laser experiments that may be of interest, or might provide ideas for modifications.

Project 86—Laser Beam Transmitter

Here is a simple, yet interesting device that will send your voice or any audio transmission through the open air to a distant location using only a beam of silent laser light. Because of the direct path a laser beam takes from its origin to the target location, it would be very hard for anyone to intercept your communication, and even if they did, they would have to know exactly how to decode it. Even if the laser beam was spotted by an outside source, it would most likely not be thought to contain an audio signal; it is after all just a beam of light. Laser light has another advantage over radio waves or direct audio in the fact that it takes only a few milliwatts of power to send a laser beam many hundreds of feet, something a radio transmitter could not accomplish easily. Encoding a laser beam with a source of audio information is a very simple task to achieve, as you can see by viewing the schematic in Figure 14-6. If you include the actual laser pointer, there are only three components to make the unit function—the laser pointer, a small transformer and a variable resistor to control modulation level.

The circuit allows the transmission of an audio signal through the laser beam in the following way: the laser is powered via some external DC 4.5-volt source placed in series with the windings on a small low impedance transformer; the other side of the transformer is fed an audio signal at a level strong enough to drive a speaker, such as that from a radio or portable recording device; and, when the audio is fed through the transformer, it induces a small current flow and change in the impedance at the other side of the transformer where the laser is connected, thus creating direct modulation of the laser due to its fluctuating power source.

Basically, the small fluctuations in the laser power supply induced by the audio source into the transformer cause the laser beam to carry the information contained in the original audio source. The key component besides the laser pointer is the transformer, a cube-shaped device that contains two separate coils of wire wound around a common steel core. The perfect transformer for this project will be one that was actually doing a similar job in the device that you will remove it from, changing or coupling an audio signal to some other device. Telephones, answering machines, older tape recorders, fax machines, are all good sources of low impedance transformers for this project. Yes, you could actually use the large AC transformer from a wall wart or from the inside of a portable appliance, but that would result in a large final project. The perfect transformer will measure no more than an inch squared, and will look like the one shown in Figure 14-7.

The transformer will have no less than four wires connected to it, and could have as many as six or more. We will only be using four of them, two wires per side. Measure the two wires or pins

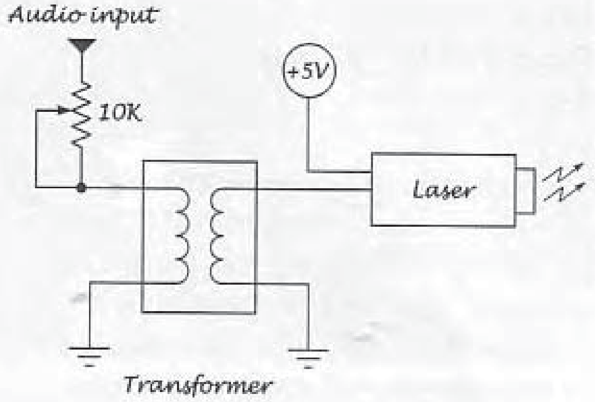

Figure 14-6 *The laser beam transmitter is a very simple project to build.*

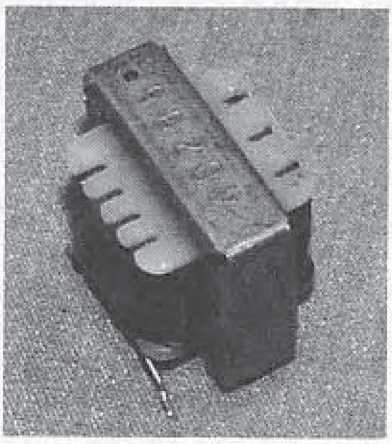

Figure 14-7 *A small audio transformer salvaged from a dead answering machine.*

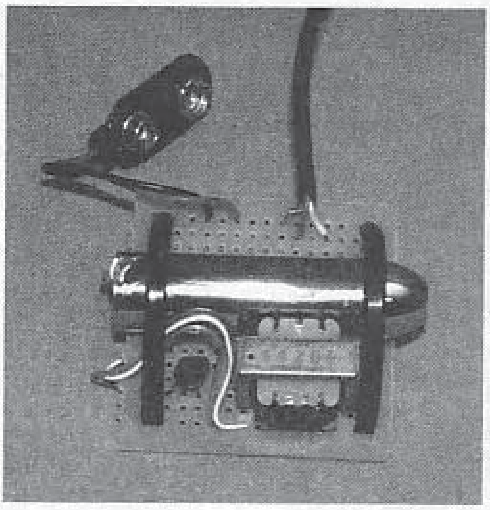

Figure 14-8 *The laser beam transmitter built on a small square bit of perf board.*

on each side of the transformer with an ohmmeter and make note of the impedance. If there are more than two wires on a side, measure across the two outermost wires to get a reading. If there is no reading, try random pairs until you get the lowest reading. One side of the transformer may have a lower resistance than the other—4 to 16 ohms would be optimal, and this side will be the "laser" side. The other side of the transformer might be equal, which would be good, but most likely it will have an impedance of 20 to several hundred ohms. This will be the "audio" side. The laser side of the transformer is the circuit that connects the laser pointer in series with its power supply through the transformer's winding as shown in the schematic Figure 14-6, and the audio side is the circuit between the audio input, potentiometer and transformer's other winding. As for powering the laser pointer, some type of external 4.5-volt DC power source will be needed such as a series of three AAA batteries or a 9-volt battery connected through a 4.5-volt regulator. It is critical that the power supply does not exceed 4.5-volts, as this will instantly destroy the laser pointer. Two wires must be soldered to the laser pointer—one to the negative spring inside the shell, and another to the positive shell itself. If you don't think you can get the soldering iron tip into the shell for the negative spring connection, just hook it with a stiff copper wire and bend the exposed copper around the spring with a pair of needle nosed pliers being careful not to allow the copper wire to short with the positive pointer shell. The input connector used to feed the audio signal into the audio side of the transformer is up to you, whichever is most convenient. The final unit, as shown in Figure 14-8, will be no larger than a few square inches if you found a suitable transformer. The 4.5-volt regulator is also shown on my unit, as I chose to power it from a 9-volt battery.

The unit cannot be tested at this point, as you do not have a laser beam receiver. Where do you find such a device you ask? Read on.

Project 87—Laser Beam Receiver

This is the device you will need to decode the secret information traveling through the air on a laser beam if you have built the device from the previous section. This device is a little more complicated than the actual transmitter, but still remains a basic and easy-to-build device with only a handful of common parts. Have a quick look at the schematic diagram in Figure 14-9, and see if you can figure out how the modulated laser beam is converted back into an audio signal.

The circuit must operate in reverse to the laser beam transmitter, turning the modulated laser light back into an audio signal, which will be fed to an amplifier. The key to this circuit is the NPN phototransistor, a device that uses a light source to switch on the collector and emitter junction, and this is the reason why there are only two leads on the device (the base lead is not necessary). When any amount of light strikes the light sensitive area of the device, it causes a certain level of conductivity between the emitter and collector, thus creating an analog amplifier. Because the laser light coming from the transmitter is modulated by the audio signal, the voltage from the phototransistor will represent the original analog signal and can simply be amplified to re-create the original audio.

The LM386 IC is a basic 1-watt audio amplifier chip that needs nothing more than two capacitors and a power source to operate, which is why it was chosen for this project. As you can see in the schematic shown in Figure 14-9, the output voltage from the phototransistor is fed directly into the input of the LM386 amplifier IC for direct amplification. The variable resistor controls the amplifier's volume by varying the voltage level coming from the phototransistor. Although this receiver is very simple, and requires only a few

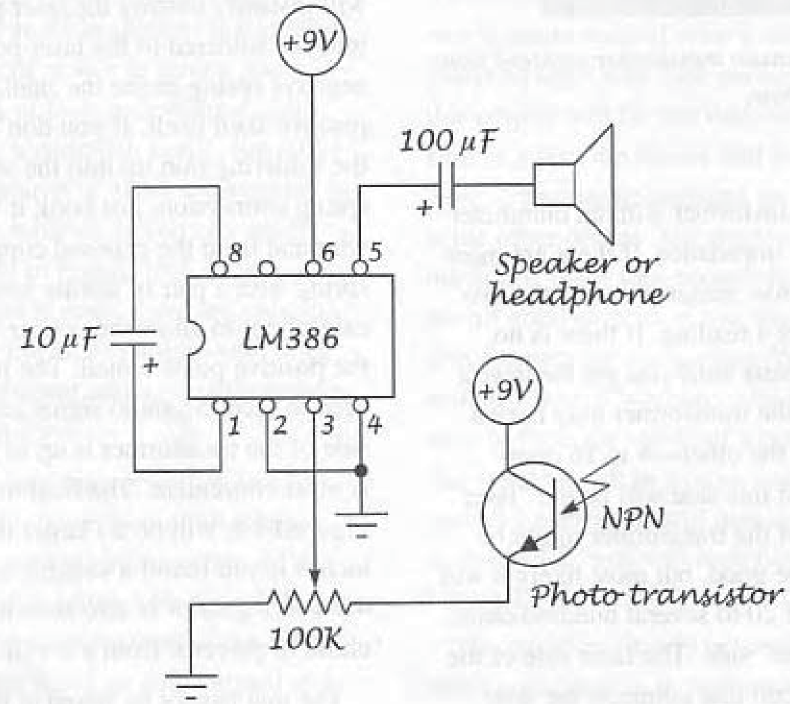

Figure 14-9 *The laser beam receiver schematic.*

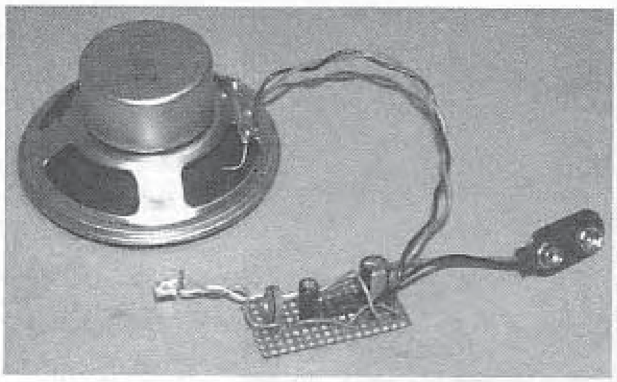

Figure 14-10 *The completed laser beam receiver powering a 3-inch speaker.*

components, its resulting audio level is comparable with any small transistor radio. An old transistor radio cabinet with the circuit board removed would in fact make a great project case for the final unit, as you could utilize the internal speaker, battery compartment, and headphone jack. The completed unit does not take up much room at all, and can be powered for many hours from a 9-volt battery as shown in Figure 14-10.

There are many styles of phototransistors to choose from due to the multiple configurations of lens styles which affect focal range, field of view and wavelength. But, you will not need to worry about this because the laser has such an intense focus that any of the phototransistor types will work perfectly. In fact, the phototransistor is so sensitive to light, that the laser beam can easily saturate the base to 100 per cent, which is why the resulting audio signal is much louder if the beam strikes the phototransistor's input window slightly offset, or from a much greater distance than just a few feet. With proper alignment this transmitter and receiver pair are easily capable of transmitting your secret audio signal thousands of feet away, well out of your visual range. Before you start beaming your top-secret information across secured borders, you should put the unit together on a bit of perf board and start by doing some short-range tests to make sure everything is in operation correctly. Find a type of continuous audio source with an output level high enough to drive a small speaker or set of headphones and input this into your laser transmitter. A small microrecorder or transistor radio is a good choice. The receiver should be placed a few inches or feet away from the transmitter so you can visually align the beam into the window of the phototransistor, and instantly the audio should be heard from the receiver's output speaker. As shown in Figure 14-11, there is no visible connection between my laser transmitter shown on the left and the laser receiver shown on the right, but I am able to hear the output from the small microrecorder on the receiver's speaker as though it were powered directly by the microrecorder. The output from the receiver's LM386 amplifier IC actually produces a louder output than the original audio source.

Once you can verify the short-range operation of your laser transmitter and receiver pair, you can put both units into some type of cabinet for proper mounting, and set your secret information free. With a simple tripod to mount the transmitter to, and a pair of binoculars, it was easy to align the transmitter with the receiver placed at a distant location many blocks away. The only thing that affects the resulting transmission will be interruption of line-of-sight, or movement at the transmitter, which is why sturdy mounting is important for long distances. If you want to become ultra stealthy with your laser transmission system, install an infrared laser module in place of the original visible red laser pointer and use a video camera or second visible red laser for alignment. The phototransistor is sensitive to just about any wavelength of light including infrared, so the choice of laser beam color is completely up to you. Also, to increase range you may be tempted to install a lens at the receiver to magnify the incoming signal as it is done in many infrared beam switches utilizing infrared LEDs for the actual beam. Adding a lens to this device will not make it function any better, as the laser beam is already as focused as possible from its origin, and you will only distort the beam rather than making it any brighter. It is truly amazing how far this

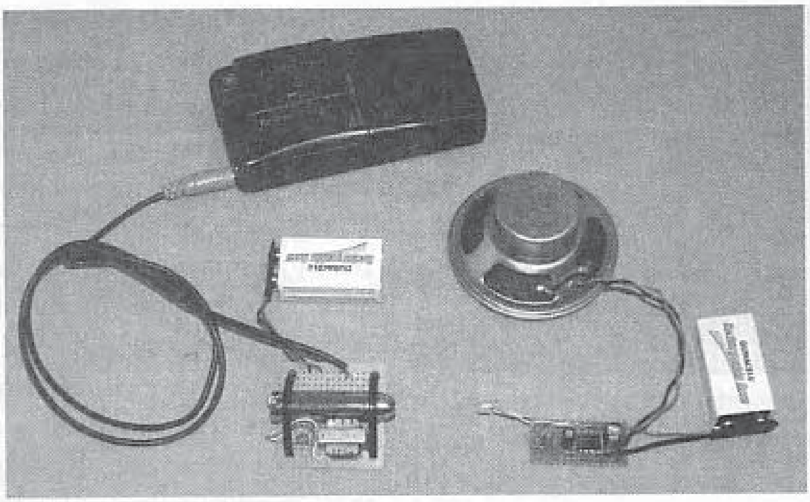

Figure 14-11 *Short-range testing. Transmitter shown on the left, and receiver on the right.*

device can function if properly aligned, and besides using a high quality laser module with focus adjustment, the actual weak link will not be in the distance possible, but your ability to strike the phototransistor.

Well, I hope you had fun sending your top secret information at light speed to a remote location, and if laser beam experimentation is your kind of thing, read on, because it's going to get much more interesting and devious!

Project 88—Laser Microphone Experiment

The laser microphone has to be one of my all-time favorite high-tech laser spy devices, and it has been around for many years, popping up on just about every spy forum under names such as Laser Listener, Laser Bug, Laser Snooper, to name a few. The information presented on this device is rarely complete, and mostly incorrect, so it makes you wonder if the device actually works at all, or is it just another nerd myth such as the "over unity machine" or UFO engine? I am going to settle this question once and for all by first explaining how the laser microphone actually works, and by showing you how to create your own working model from easy-to-find parts. Once you have a basic working model, you can decide how far you want to take this technology, or make your own modifications to create an entirely new style laser bug.

Before we dig into the electronic part of this device, let's have a look at how the device supposedly works. When I spent a night working my favorite search engine on the subject of "laser bugs," and "laser listener," I came up with the same few designs and a couple of ready-made kits and plans, each describing how the laser light is bounced off a target window, modulated by the sound waves inside the room, and then decoded by the receiver in almost the same way our laser receiver from the previous section works. After thinking about this and creating a few working prototypes, I now realize that this information is not correct.

Modulation occurs when a continuous signal or wave is altered by an input signal of varying levels. If you look back in this section to our laser transmitter and receiver projects, then you will remember that the steady beam from the laser pointer (continuous signal) was modulated by the microrecorder's audio output (varied signal) to create a laser beam that would carry the audio signal in a modulated format to the receiver. In that system, modulation does indeed occur because the impedance of the transformer that was placed in series with the laser pointer power supply was varied directly by the audio signal, creating a resulting amplitude modulated laser beam. This is the same way that almost all light based communication systems work including infrared remote controls, cordless headphones using infrared LEDs and even some distance measuring devices. The laser microphone, on the other hand, does not use modulation in this way, as it is just not possible. The popular theory is that the small vibrations in the target window caused by noise such as conversation in a room will modulate the laser beam that you have bounced off the glass, and because of this will be able to decode this modulation back into an audio signal in a way very similar to our laser receiver from the previous section. The problem with this theory is that to create modulation in the laser beam, the level or intensity of the beam would have to be varied according to the audio signal in the room, but it is not. Because the laser beam originates from our location, bounces off a target window then returns to the receiver at our same location, there would be no way for the target to modulate our source beam, and it does indeed return to its original location as a non-modulated continuous source of light. OK, if this is the case, then how can a system like this actually function, and how does it really work?

The real magic behind this device is not modulation at all—it is alignment due to vibration. If you bounce a laser beam off a window that is being vibrated slightly by the audio source behind it, this will indeed affect it, but not due to modulation of its intensity, it will in fact be moving. Although the vibrations of the window from the weak sound within a room may equate to only a few thousandths of an inch, this can create a much larger motion of the reflected laser beam due to the distance and angles between the source and target, and this change in motion will have a great affect on a phototransistor, much as it did with the actual modulated laser beam from our laser transmission system. Knowing this, we now realize what many others did when building this type of device—the unit always works much better when the received laser beam does not directly strike the phototransistor. If we let the vibrations from the window move the laser in and out of the path of the phototransistor, then the receiver circuitry actually works as if it were decoding a modulated signal. However, in reality it is working much more like the vibrating needle on a record player. Armed with this information, it was not hard at all to build a working prototype capable of targeting a window across the street. There are indeed other issues that need to be overcome in such a sensitive and alignment critical device like the laser microphone, but we will discuss this in more detail as we build the simple prototype.

Before you even think about creating the receiver, it is highly recommended that you build the simple "window simulator" unit as shown in Figure 14-12. Without this simple device, I would not have been able to create the working laser microphone.

As you can see from Figure 14-12, the window simulator is nothing more than a small speaker with a little bit of reflective material glued to the center cone. I snapped the corner of a broken glass mirror using pliers then secured it in place with a hot glue gun. When there is any slight vibration of the speaker from a source such as the small microrecorder I have attached, then there will be movement of the mirror, much like what would occur to a window from sound from inside a room. To simulate a vibrating window as much as possible, the audio level of the micro recorder is

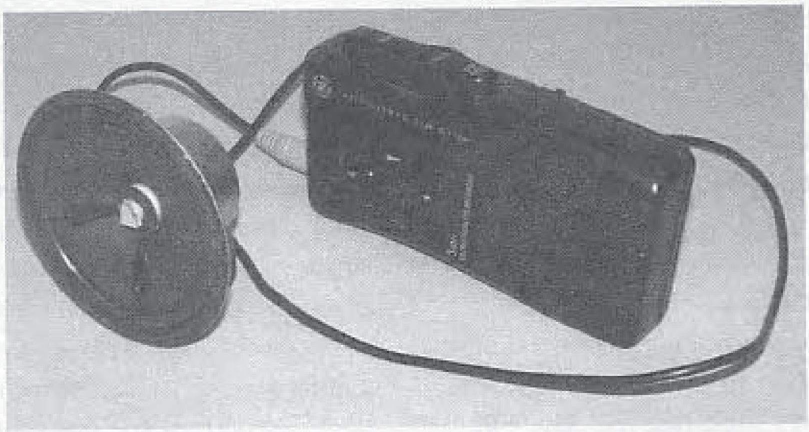

Figure 14-12 *The window simulator will make prototyping a lot easier.*

set to a level so low that you have to press the speaker up to your ear to ascertain that it is even working. The reflective surface does not have to be a mirror, just find something that will reflect the laser beam for testing purposes.

Now that we know the resulting laser beam will be moving rather than modulated, it should be very easy to make this rig functional, especially when you can use your window simulation device rather than your neighbor's window for testing purposes. A real laser microphone will use an invisible infrared laser rather than the visible red we will be using, but for now, this makes things much easier to align and test. A visible laser will not only kill all hopes of using the laser microphone covertly, but could get your target very nervous; after all, a red laser bouncing into your personal space usually means some evil device is targeting you. Have a look at the schematic for the laser microphone shown in Figure 14-13, and you might recognize certain parts from the laser receiver presented earlier.

The operation of the laser microphone receiver is much like the laser receiver, with the addition of a high-gain amplifier. The signal from the phototransistor was fed directly into an LM386 audio amplifier in the previous laser receiver, but this time goes to the high-gain amplifier based on the LM358 operational amplifier first. Because we are not dealing with a modulated laser beam, but rather a beam with a very slight movement, we are going to need some serious amplification in order to change the slight voltage variances detected by the phototransistor back into an audible audio signal. The LM358 is set up as a non-inverting amplifier with a very large amount of gain, adjustable by a variable resistor. This amplified signal is then fed to the LM386 audio amplifier, which will directly power a set of headphones or recording device. Although this receiver circuit is very basic, and could be greatly improved, it did actually seem to function better than the other two I built based on the much more complicated versions floating around on the Internet. You should build the circuit on a proto board first, and verify its operation before hard-wiring the components or making a circuit board, an easy task to accomplish using the window simulator. Although the simple circuit presented here is indeed a working unit, you may want to look into additional filter circuits to deal with 60 Hz hum, or hum from street lights at night. I decided to build the working unit as simple as possible, and then test it in the real world first to come up with ways to improve the unit and make it easier to set up and give it the ability to work at greater distances.

My working unit shown in Figure 14-14 is based on the simple circuit and hand wired to a bit of perf board for easy modification. I found hand wiring to be fine, as all the noise intruded into the

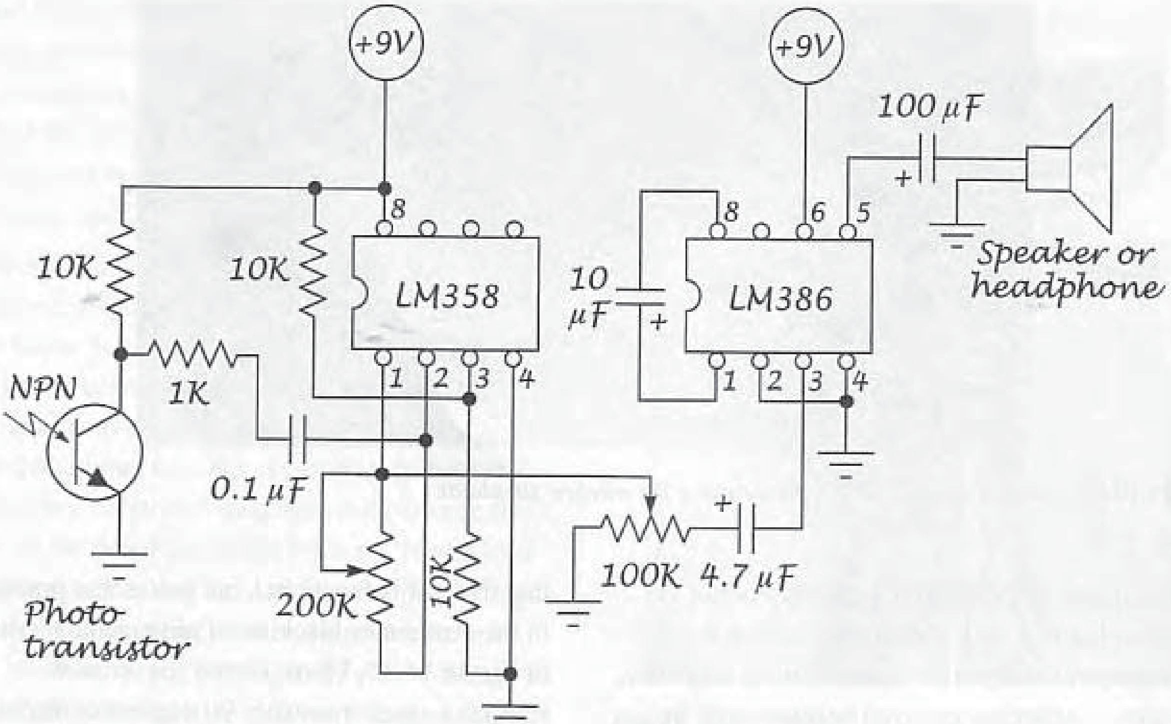

Figure 14-13 *Schematic for the laser microphone receiver.*

unit was from external sources such as AC hum and ambient light sources, not the circuitry itself.

The phototransistor is not critical, and any shape will work just fine since the laser spot will be very directional and focused directly into the input window of the device. I mounted my phototransistor on a length of wire so that I could experiment with different mounting systems and light attenuators to help block out unwanted AC lighting causing hum. The best system for mounting the phototransistor was a simple black tube that would stop some of the ambient light from saturating the base. A bit of drinking straw painted black fits nicely over many of the standard phototransistor cases. Originally, I thought that the phototransistor would be the most critical part of the device; after all, it has to detect the extremely small changes in the laser position to recreate the analog voltage for the audio amplifier.

I tried several phototransistors, a PIN diode, and even a new light sensor IC with incredible sensitivity, but in the end, the old phototransistor salvaged from a 1980's television remote control receiver worked best. After a bit of thinking, it made sense as to why the worst light sensor achieved the best results. The laser beam is always going to be way too much light for the phototransistor, which is why the beam must be offset from the phototransistor's input window.

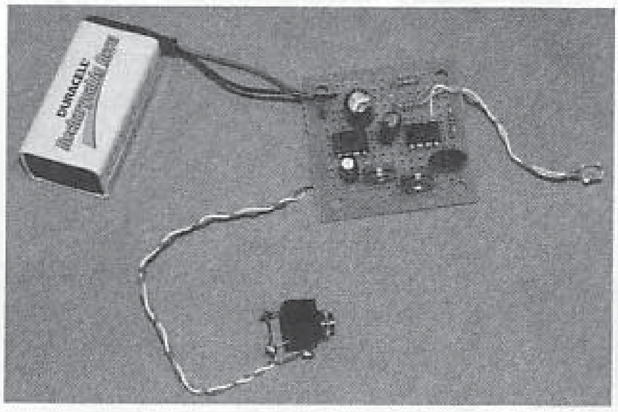

Figure 14-14 *The original laser microphone circuit hand wired on a bit of perf board.*

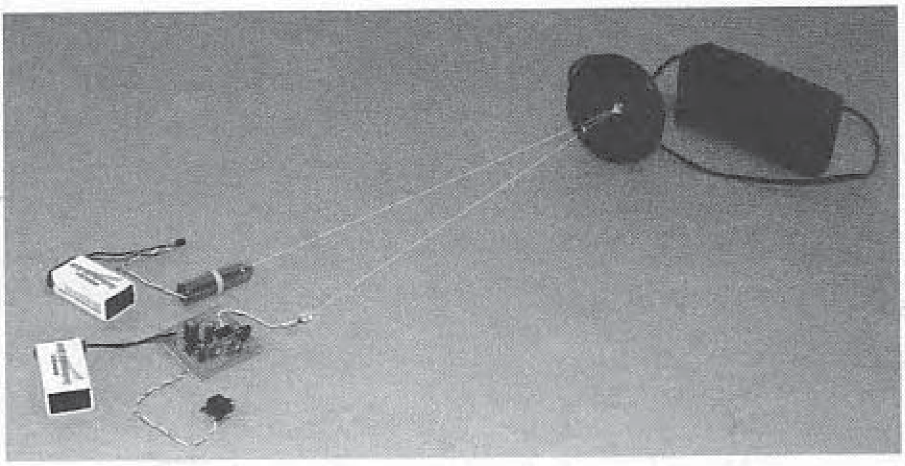

Figure 14-15 *Testing the laser microphone using the window simulator.*

Detecting a laser beam with a phototransistor is like listening to a rock concert by holding a stethoscope directly to the speaker on an amplifier, so we must offset the received beam so only its edge hits the input window. Varying the gain potentiometer can reduce some of this over saturation, but in reality, this just reduces the fidelity of the audio signal. You will see exactly what I am talking about when you set up your test unit using the window simulator. You are almost ready for testing the laser microphone, but first, you need a laser to be used as your source. As shown in Figure 14-15, I have connected a garden variety red laser pointer to a 9-volt battery using a 4.5-volt regulator.

The laser could be run from the original button cells as well, but due to the steady use, they would be drained in only a few minutes. With a 9-volt battery, or three AAA cells, the run duration will be several hours. I would avoid using an AC adapter to run the source laser, as this could introduce hum into the receiver if there was even the slightest ripple in the regulation circuitry, a common problem with most AC adapters. If you are worried about long duration run time, then three D size batteries powering the laser will yield more than a full day of operation.

Before you get deep into the covert operations, it is a good idea to practice a few alignments using the window simulator so you can not only verify that the unit is functional, but gain some practice in the sometimes black art of alignment. As shown in Figure 14-15, I have placed the window simulator speaker roughly 90 degrees to the bench so that the reflected beam would be easily captured by the receiver's phototransistor. The small microrecorder is playing a bit of recorded music at a volume level so slight that I can just barely hear it on the speaker if my ear was pressed against it. Although the laser beam is only simulated in the photo, it is indeed working, and at this distance of only a few inches, alignment was a very simple task. Working with the unit across the room is quite a bit more challenging, and takes a fair amount of trial and error to get things aligned properly. I would first shine the laser directly at the little mirror on the speaker, and then look to see where on the wall behind me the reflected beam was ending up, and depending on the angle of the mirror to the source, this could be several inches to many feet from the origin. As you will have found out really quickly, there will be almost zero chance of the receiver and source laser being in the same spot during operation, as you have very little control over the orientation of the reflective surface at the target. If you ever see a so-called "laser spy" device for sale that combines the source laser with the receiver, then most certainly it will be nothing more than a short range toy, functional only in the most controlled test bench environment. Bouncing a laser beam off of a window across the street is entirely possible as long as the alignment between your position and the target window is not so far off that the returning beam misses your location, a problem that is multiplied as the distance between the source and target increases.

You should be able to make the unit function no matter where you place the window simulator in your house, but as you might have already found out, your receiver may be on the opposite side of the room from the source beam, or even worse, many feet higher or lower depending on both the vertical and horizontal misalignment between the angle of the beam and target reflector. If you look out your window and see nothing except buildings full of windows aligned in the same manner as your window, then it's going to be easy hunting. But if this is not the case, you may have to choose your setup location in order to catch the received beam. Once you have the knack of aligning the laser microphone in your test area using the window simulator, go ahead and try a real test using your own window. If you cannot spot a window from your test bench, then some type of proper mounting of the source laser and receiver will be necessary as I have done in Figures 14-16 and 14-17. Figure 14-16 shows the receiver built into a small project box to contain all of the electronics and batteries. The box is then mounted to a bit of plastic that can be attached to any standard tripod used for video or still photography.

You will also notice that there is a gun sight placed directly in front of the receiver's phototransistor in Figure 14-16, and although this does little to increase the range of the unit, it does allow the use of a video camera during alignment at large distances. Since you would never want to look through a gun sight when attempting to spot the reflected laser beam, a small black and white video camera can be swapped for the receiver and viewed safely on a monitor while you attempt to position the source beam and receiver's tripod. Because of the sensitivity of the low lux black and white camera, it is easy to see the general direction of the reflecting beam even if it is not yet hitting the receiver. Once the reflected beam is within visible range (shown as a spot on your wall), you can then remove the camera and replace it with the receiver box for final alignment. Although this method did work well for me, even when experimenting with an infrared laser, it is definitely not the only answer to alignment, and with a little creativity, you will most likely be able to invent a much faster and more reliable method. Figure 14-17 shows the source laser contained in a small plastic box with its external battery source and a power switch. Using batteries as a power source eliminates any induce hum from AC noise, a problem that can easily drown out the usable audio signal. This experiment does indeed prove that the laser microphone is a working device, but not like many of the spy stores claim with their "point and shoot" ready to operate units. Distance targeting requires a lot of patience in finding the proper location of your source beam and receiver, and there are many factors that can easily render the signal unusable.

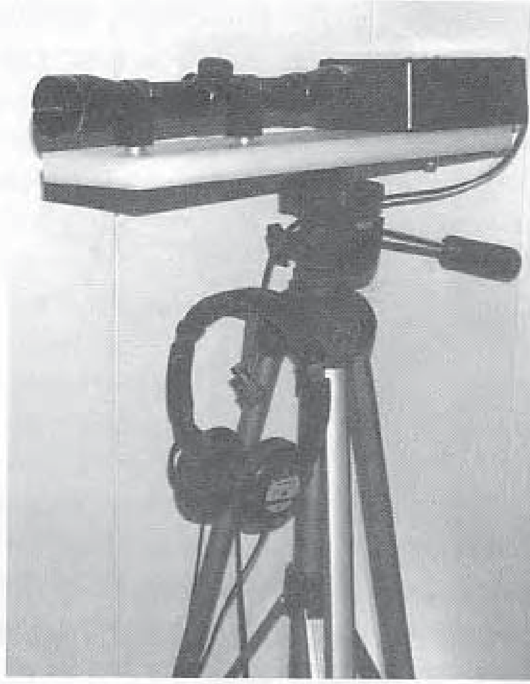

Figure 14-16 *The receiver unit is mounted to a tripod for easy alignment.*

Figure 14-17 *The source laser is powered by battery and mounted to a tripod.*

There should be no reason at all that the laser microphone would fail when experimenting with the window simulator, even at great distances, although alignment may have been a bit of a chore. When bouncing the beam off real world objects, a lot can hamper the ability of the unit to collect a usable source. Some of these factors include: the inability to bounce the source back to your location due to extreme angles; dirty surfaces reflecting a very reduced beam; multiple panes of glass causing a dampening of sound; extreme hum from a nearby street light; sound levels much too weak in the target area; ambient noise levels in the target room too high; and, countermeasures such as white noise or infrared modulation in use.

So, there you have it—the good, the bad, and the ugly on the mythical laser microphone device. I hope I didn't turn you off from building an experimental unit, as the device does indeed work if the conditions are in your favor. I was able to record a conversation of moderate levels from a location across the street from my source laser and receiver, and although this was a controlled experiment with optimal position of the two buildings, often these conditions will arise right outside your own window. If you plan on building the device into a portable hand-held unit that you can aim at any window, instantly eavesdropping on any sound in the room, then you will be greatly disappointed, and no, those cheap devices that claim to do this rarely work well at all. The laser microphone is a device for the truly dedicated spy who does not mind hiding in the darkness tweaking electronics and pushing the envelope of possibilities to the maximum. I do intend to study this technology much further to improve on not only the usable range of the device, but also the filtering and enhancing of the received audio signal. With enough patience and understanding, it may even be possible to create a device that can shoot a laser at a distant window and instead of attempting to catch the reflected beam, directly decode the slight variations of the exact spot where the laser point is hitting the target. Yes, this would take an extremely sensitive receiving system with state of the art long-range optics, but you just never know what the Evil Genius could accomplish with the proper motivation. Are you up to the task?

Project 89—Laser Perimeter Alarm

In most high-tech crime or spy movies there is a scene in which the hero or villain will find him/herself traversing a secure room jam packed with laser beams bouncing all over the place, and if even one beam is crossed, the alarm will sound, foiling his/her evil plans. Well, how would you like to have that exact system installed in your home or office, built from nothing more than a cheap laser