How to Use a Laser to Eavesdrop On Anyone

A long time ago in a galaxy far, far away...

In 1948 the clever Russians, following Lee's first law of bugging (give it as a gift) had a bunch of shiny-scrubbed school children present our Ambassador in Moscow a very nice, shopping network level, Great Seal Of The United States including a very nice carved wooden eagle.

The gift was so nice, and given in the name of peace and cooperation, that it was immediately hung directly above the Ambassador's desk.

Some time later the CIA began to suspect that facts were leaking directly from the same Ambassador's office. Electronic counter measures people "swept" the room but could find no conventional RF signals indicating a bug was in place.

At some point, some GS - 12 genius decided to take apart the Great Seal itself and, lo and behold, upon close examination up popped a small cavity with a spring loaded support rig. There were no batteries, microphone, or other traditional electronic components.

We couldn't figure out how it worked so we sent it to our good friends the English who possessed a finer working knowledge of microwave technology than we did (having, after all, invented radar).

The English promptly demonstrated how a tightly focused beam of several hundreds watts of microwave energy could be aimed at the hidden chamber where it would be modulated by the mechanical make up of the resonant chamber.

A portion of this modulated energy would bounce back towards the listener where it was subsequently picked up by a microwave receiver and directional antena.

The Modern Civilian Equivalent

Once again our friends the Brits have taken the microwave bit directly in their teeth and designed a system that will flood an area with high frequency RF where it is modulated and a small portion aimed back towards the Listening Post.

This time the unit is made by civilians and sold to same...

While this unit does contain a microphone, amplifier and batteries it still has several advantages over conventional area bugs:

- The tiny in-area transponder will run for a full year on its internal batteries
- The system is designed for long term surveillance and can be installed at the target location months or even years before the eavesdropping is set to begin

- Very low electronic profile to counter measures is presented
- Can be turned off during and TSCM sweep activity

And finally one would presume coming from England this unit would be sold to anyone with the capability of conducting a bank transfer.

On the other hand it appears to be obviously illegal to use or probably even possess this nice system on this side of the pond.

Somewhere around the same time that the Russians were micro-waving our Ambassador, the CIA and/or its minions, discovered a similar way to eavesdrop on conversations taking place in closed rooms without actually entering the room. By focusing a beam of concentrated laser light (usually infrared wave length) on a window of the target room and catching a tiny portion of the reflected beam with nice optics they found it was possible to demodulate the sound from the minute window vibrations.

This opened a whole new world to the aural voyeur; friends, foes; professionals and talented amateurs started using the laser at a prodigious rate.

Many still do.

Several civilian corporations started offering acceptable (assuming $25,000 falls within your realm of the term acceptable) laser eavesdropping units over the counter.

The most (in)famous was Micro and Security in Germany who enclosed their system in two Nikon-like camera housings.

A good choice from both engineering as well as an ergonomic standpoint as the camera lens focused the light, the units could be tripod mounted and aroused very little suspicion in most applications.

Micro and Security went out of biz a couple of years ago, but a bunch of their laser systems are still floating around loose.

The next great advance came from an English firm who kicked the technology into overdrive by offering a four beam unit – three of the beams were used as noise canceling, out-of-phase counterpoints, to the main beam providing the clearest audio yet.

Customs, bless their hearts, grabbed several of these units as they were being shipped into the U.S. (also in the $25K range) and an arrest or two was forthcoming.

Said firm is also no longer around, but again a few units are floating on the ocean of used goodies.

Since that time a couple of moderately well known American "surveillance enthusiasts" have experimented with the idea of bringing the laser back into the marketplace.

The idea was fostered when a number of firms begin importing truck loads of cheap first to second generation Russian night vision gear. Because the performance of these units was marginal at best, many came with separate IR laser boosters.

These boosters were often powered at 5-10 times the legal US limit for salable lasers, giving a new, cheap source of very powerful coherent IR light.

Aim said light at a window, grab the reflection(s) back, run it over a simple photo diode, add a cheap equalizer to help clean up the result and you have a very usable, very sophisticated eavesdropping system.

The Americans in question were (at least somewhat) involved with the great round of spy shop busts and, probably wisely, decided selling a few laser surveillance systems were not worth the joint or living out their lives in a small third world country, and shelved the project.

It's coming back out of the closet as we speak…

Reinaert Electronics markets a proprietary laser listening system also contained in camera bodies that utilizes an infrared beam for surveillance purposes.

Reinaert also carries a wide mixture of night vision equipment, audio and video surveillance devices and so on.

When I spoke to their manager he confided that they weren't paying as much attention to the sales of other people's gear because They "were selling so many of the laser monitors it was taking up most of their time"…

Price on request, which means not cheap…

So the news is that this concept is still in use today. At least two overseas companies sell a compete system with the laser, power supply focusing lens as well the receiver and its lenses/electronics into a pair of 35mm camera bodies.

The advantages to this concept are many and multi – cameras reside on steady tripods, don't look out of place in most settings and allow for the placement of an enhancing lens system.

These systems check in at about $25,000 and are considered Title III, or worse in the U.S. A number of people have been busted trying to import such a device.

Do the damn things work?

Well, I happen to be in an unusual position to breech this particular gap; I got the chance to be teamed up with a couple of top notch electronic engineers (much better than I was) and cut loose with some money and a Ferrari 546.

Okay, actually it was one white Ford van, but it really jazzes the story substitute a Ferrari or two…

We drove hither, we drove yonder, we drove over a traffic cop's foot, (another story), searching for errant signals. We kept certain rules and regulations in mind:

- Watch the high ambient noise
- Avoid double pane windows (in California, no sweat)
- Plan on set up and aiming time
- Don't go thru any extraneous glass (such as a window in your vehicle)
- Filter hard and be ready to adjust for change

And yeah, it worked.

To some degree…

Use the best optics possible, jam it on with a slammin' laser, throw in some active, parametric (or now, software based filters) and even you can hear the vice president of Standard Oil discuss private matters in the security of his high rise office.

On Market Street, just off Second…

I could tell you he talks a lot about women and golf scores, but that might be construed as, well hell, a bunch of bad stuff.

So I'll just leave it to the darker recesses of your mind.

Where no man has gone before…

Moving Along

Having used more than one IR laser over the years I can tell you that if they are set up properly, possess like my first wife, a great set of collecting lenses and some filtering, they can work.

Unless of course, the target window is being modulated by higher amplitude audio on either side of the glass (stereo inside, truck outside) than the target conversion can manage.

Or the operator hasn't got the first fuck of an idea of how to aim the optics, in which case, one hears the loudest noise available and not much else.

Lower end units are usually little more than simple cons – in fact there is a story with some credibility, still circulating, that claims several custom made laser listeners were sold to an unnamed African country where the pleasant government, ah, agents, were abashed to discover the units where not exactly point and shoot.

Supposedly they immediately put a contract out on the supplier.

As unfair as this appears, I can conjure up times I would have done the same thing to various "merchants" who lived by the slogan, "buyer beware".

The Civilian Answer?

As a matter of fact there are answers to your yet unasked question(s), floating around. Information Unlimited sells a kit using a low powered laser that allows the young scientist to experiment with laser bounce-back.

The IU kit gets around the "designed primarily for surveillance" wording of the Omnibus Crime bill by using a visible laser instead of one in the IR wave length thus making covert surveillance quite difficult.

Unless…

Unless someone were to substitute an "invisible" IR unit for the red laser diode that comes with the project.

Also available from IU.

Our persistent staff built one of the IU units and were pleasantly surprised by a couple of factors about this couple of hundred dollar unit:

- Simple to put together, the receiver is housed in a piece of PCV tubing
- The laser provided is a red diode normally used as a pistol aiming device
- Based on a very simple photo transistor optical reader and amplifier, IT WORKS!

Kind of…

First of all, one needs to purchase the (available) extra lens to have any hope of audio recovery and the legal laser doesn't really provide enough power for any distance.

It's also a matter of trial and error to aim the unit, and the lack of audio filtering does nothing to help the recovered sound.

But the unit does demonstrate the principle in a most acceptable fashion.

I'm sure this kit has been constructed by a number of "spy shops" and resold for 10 times the price.

As easy modification to turbo charge the IU, or any other small laser receiver has been explored by a couple of moderately well known American "surveillance enthusiasts" who have experimented with the idea of bringing the laser back into the marketplace.

But Martha, there was one, there was one unit ("who was the best pilot I ever saw? You're looking at him"–Tom Wofle, *The Right Stuff*) that worked as well or better than the $25K Kraut Kinder.

In the year of 1987 *RADIO–ELECTRONICS* published an article entitled Laser Listener.

An engineer friend of mine, with the same bent sense of adventure as I seem to be cursed with, built the project, and low and behold, it worked as well or better than the $25,000 government level versions.

I'm reprinting the following article in total, with full permission from *RADIO-ELECTRONICS.*

I would point out that this was originally published in a more surveillance friendly era, before dealers and collectors were arrested for possession of $30 electronic kits.

It may easily be illegal to construct or even own and I guarantee it is illegal to use this device for the purposes of surveillance.

But man it worked…

Laser Listener

Use a light beam to listen in to anything anywhere, any time.

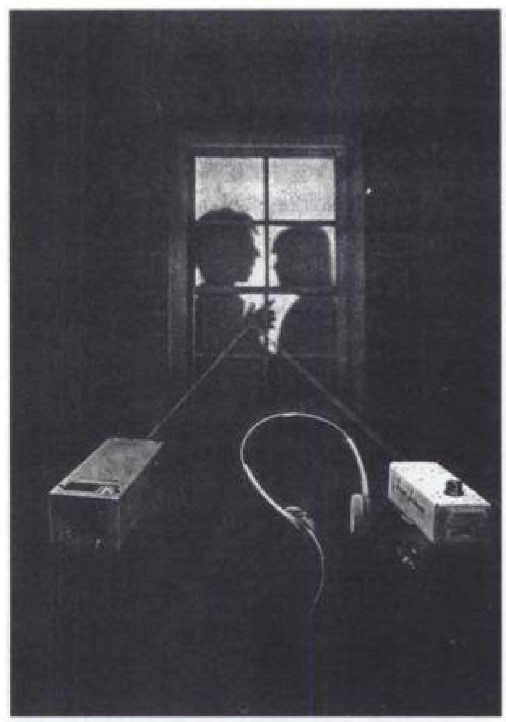
—Richard L. Pearson

Breaking and entering to plant a listening device is one way to "bug" a room. Unfortunately, it can earn someone a long jail time too. A better and safer way to bug a room is to use a laser beam to eavesdrop on a window from across the street.

The sound waves generated by nearby conversation will cause the glass in a window to vibrate very slightly. If a laser beam is bounced off the window, the vibrations will modulate its reflection. All that's needed to hear what is being said is a demodulating device that extracts the audio from the reflected laser beam. That technique is used by sophisticated "surveillance experts," but you can easily duplicate that feat by using a hobbyist's laser and the inexpensive Laser Listener demodulator shown in Fig. 1. If you need something a little more sophisticated, it can be made part of the rifle scope aimed laser-bug system that is shown in Fig. 2.

Early Light-wave Communications

Communication using a modulated beam of light isn't a new idea. In the 1880's, Alexander Graham Bell experimented with something he called a Photophone; a device that modulated a beam of sunlight. It had a mouthpiece that concentrated sound energy on a reflecting diaphragm, which, in turn, modulated a beam of sunlight that was aimed at the diaphragm.



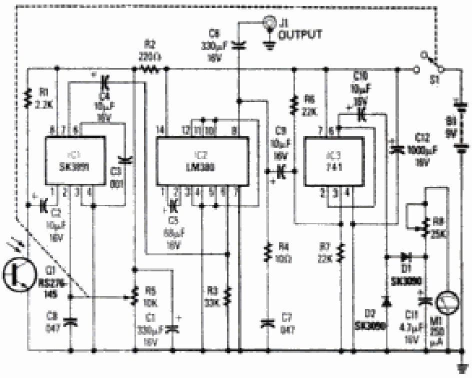


Fig.1 the Laser receiver has extremely high gain, so be sure to keep the wiring of the Q1 and IC1 separated from IC2's output and the connection to J1.

When a remote consisting of a photovoltaic cell and a sensitive earphone was positioned in the beam, the voice could be heard clearly from the receiver. The aiming problems presented by the movement of the sun, and the interruptions due to clouds and night probably prevented the commercial exploitation of the device.

But by using coherent light – such as that produced by a continuous-wave laser- the principles used by Bell's device may again be applied in a meaningful way. After all, terrestrial lasers aren't' influenced in any way by sunlight or clouds. And perhaps more important, unlike acoustic sound-detection devices, lasers aren't usually subject to interference originating between the sound source and the receiver.

For example, remote sound-pickup devices in the form of directional microphones have been available for many years. Unfortunately, any sound generated between the listener and the sound source usually renders the device useless because the interference is heard at the receiver, and it can be even louder than the source. On the other hand, lasers are not sensitive to sound of any kind between the source and the receiver.

However, lasers may be subject to other kinds of interference: For example, AC-powered incandescent lights can produce a hum; gas discharge devices such as fluorescent, mercury, sodium vapor, and neon lights might produce a buzz; and direct sunlight might swamp the laser detector device. Also, where unusually long distances are involved, air currents can add flicker to the laser beam, which on windy days can result in a noise that is similar to that of blowing into a microphone. (But even though sensitive to some kinds of electrically-generated noise, laser-listening devices have an advantage: They can seemingly hear through walls or close windows, and even selectively monitor only one window of a building from several hundred feet away.)

Commercially available laser sound pickups use a laser device having an output in the infrared region. Because infrared is below the visible portion of the light spectrum, it cannot be seen by humans. However, some commercial devices have power output rating as high as 35 milliwatts. At such a power level there is clear potential for eye damage if someone in the target area unknowingly stares into the beam, or if the laser is operated carelessly by the user.

Laser Basics

Although the details underlying the generation of laser light are beyond the scope of this text, an understanding of some of the characteristics of a laser beam as compared to ordinary light will be helpful in assembling a laser-listener system.

Light is considered to be a compromise of packages of energy particles called photons. However, light is also electromagnetic radiation and behaves like radio waves, although at a much higher frequency. The perceived color of visible light is determined by the radiation's wavelength, which is given in micrometers.

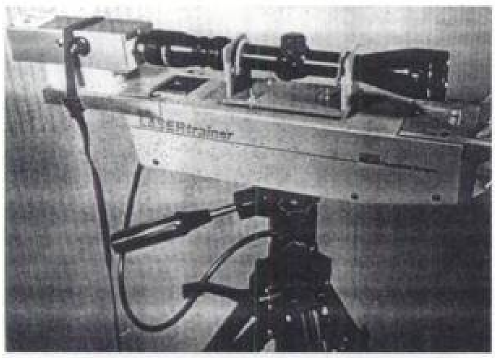


Fig. 2. For long-range use the laser and the receiver should be combined into an integral unit so both are aimed together. The telescopic signal provides precision aiming on the target.

The shorter wavelengths are perceived as violet, the longer wavelengths as red. The spectrum below the visible portion is called infrared; the spectrum above is called ultraviolet.

The light emitted by a conventional incandescent or fluorescent source contains a wide range of frequencies, and the photons are emitted randomly and spontaneously in all directions. On the other hand, in a laser light source the photons are released in one direction, at one frequency, making the laser light highly directional and pure in color. (An analogy would be to liken ordinary light to the white noise, while the laser is likened to a sine wave, a single pure tone.) Since all of the light emitted by a laser is coherent (has the same frequency), constructive or destructive interference occurs when two beams of laser light meet at the same place and time (Fig.3).

As shown in Fig. 3-a, the beams cancel each other when out of phase (destructive interference). As shown in Fig. 3-b, the beams are additive when in-phase (constructive interference). It is the interference between the beams that enables the movement of any reflecting surface to be sensed by a device called an interferometer. An interferometer is a beam splitter- usually a piece of partially-mirrored glass- that deflects only a small part of a beam aimed through the glass. As shown in Fig. 4, it can be used to reflect both the source and reflected laser beams so that their phasing or amplitude can be compared by a receiver.

The major problems with using interferometry for eavesdropping is that only a part of the laser's energy is directed at the target, limiting the working range, and the interferometer is sensitive to the diffusion of the sound target's reflections caused by tremors in the mountings of the interferometer, the laser, and the reflective target.

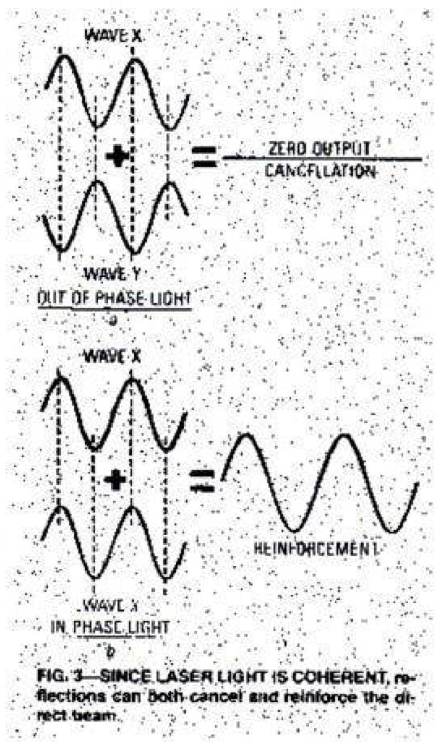


Fig. 3. Since laser light is coherent, reflections can both cancel and reinforce the direct beam.

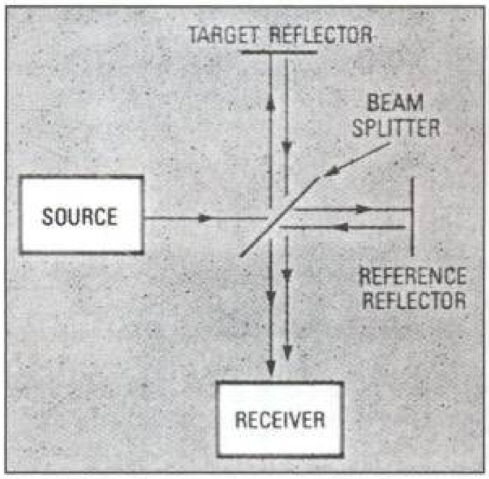


Fig. 4. An Interferometer diverts part of the laser to the target. Its chief advantage is that it can sense any kind of movement at all four points; the source, the reflector, the target, and the receiver.

For super-snooping, a direct reflection from the target is preferred because the collimated nature (parallelism) of laser light also allows modulation of the beam to occur just as Bell's photo-phone modulated the sunlight.

Regardless how we choose to eavesdrop, we must start out with a laser, so we'll cover the prototype laser-bug's laser unit first. It's a Heathkit model ETS-4200 Laser Trainer, a Helium Neon (HeNe) unit having an output power of 0.9 milliwatts. It has beam divergence of 1.64 milliradians, which produces a spot of light 1+ -inches in diameter at a range of 200 feet.

Although 0.9 milliwatts doesn't appear to be much power, it can cause extreme eye damage if allowed to shine or be reflected directly into the eye, or if viewed directly through any optical device such as a telescope, binocular, etc. The beam may be safely viewed only if projected onto a non-reflective surface such as a white sheet of paper.

If you want to keep costs at rock-bottom, or just want the excitement of a complete home-brew project, another alternative is to assemble the helium-neon laser shown in the June 1986 issue of Radio-Electronics. Also, if you want to build a laser from your own design, helium-neon tubes are often available from "surplus" distributors.

The Receiver

The Laser Listener's receiver is relatively easy to build and adjust. It is designed to drive a 4-20 – ohm headphone or speaker, which permits just about any high-fidelity or Walkman-type headphone to be used for monitoring. The circuit show in Fig. 1, uses a photo transistor (Q1) for a sensor, and has a meter (M1) that indicates the relative signal strength of the reflected laser beam. Because the meter responds only to the amplitude modulation of the reflected laser beam, it is unaffected by ambient light and the relative intensity of the laser beam. An adjustable polarizing light filter can be installed in front of Q1 to avoid swamping of the phototransistor by very high ambient light.

Phototransistor Q1 is an inexpensive type usually called an IR detector, which means that it is specifically sensitive to infrared light. Tests comparing the unit specified in the parts list with other less readily-available and more-expensive devices show no measurable differences in performance in the prototype receiver. No base connection is used for Q1 because the reflected laser light controls the collector current.

The audio signal developed across collector load-resistor R1 is coupled by C2 to voltage-controlled attenuator IC1, which has a greater than 30-dB gain variation; It serves as both a preamplifier and as an electronic volume control.

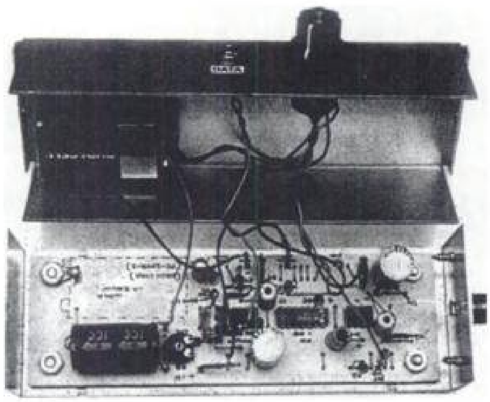


Fig. 5. A component template cemented to the pre-drilled PC board will simplify assembly.

Resistor R2 and capacitor C1 decouple (filter) the power supply voltage to Q1 and IC1. Be sure to take extreme care not to eliminate or accidentally bypass the filter because that will cause unstable operation. The gain of Q1 and IC1 is too great to permit non-de-coupled operation from the power supply.

The output form IC1 is fed through C4 so that the reflected laser beam can be easily seen. The attenuator is built in such a way that the photo transisitor can see the laser beam directly, or thorough a combination of one or two polarizing filters.

When both filters are in place, rotation of the large-diameter filter-mount will cause a gradual decrease in light transmission (to almost 90 o of rotation), which allows the receiver to be used over a wide range of light intensities without swamping the photo detector. Figure 8 shows the installed assembly and the two filters.

The attenuator has an inner filter and an outer filter made from brass telescopic tubing. Each filter consists of two sections; a filter base that is soldered to small mounting plate made from brass sheet (the painted target), and a filter mount that slips over the base.

Polaroid filters cut from neutral-tint polarized sunglasses are cemented to one end of each filter mount to complete the attenuator. When complete, the entire optical attentuator's mounting place is secured on the enclosure over phototransistor Q1.

PARTS LIST

All resistors are 1/4-watt, 5% unless otherwise noted:

R1- 2200 ohms
R2-220 ohms
R3-33000 ohms
R4-10 ohms
R5-10,000 ohms; miniature potentiometer with SPST switch
R6, R7-22,000 ohms
R8-25000 ohms, trimmer potentiometer

Capacitors
C1, C6, C9, C10 uF, 16V volts, electrolytic
C3-0.001 uF, 50 volts, ceramic disc
C5-0.68 UF, 16 Volts, Tantalum
C7, C8-0.047 uF, 50 Volts ceramic discß
C11-4.7 uF, 16 Volts, electrolytic
C12-1000uF, 16 Volts, electrolytic

Semiconductors
1C1-SK-3891 attenuator
1C2-LM380 audio amplifier
1C3-LM741 op-amp
Q1-TIL414, NOP phototransistor (Radio Shack 276-145 or equal)
D1, D2-SK-3090 germanium diode, or equiv.

Other components
B1-90volt transistor-radio type battery
J1- miniature phone jack
M1-250 u Ameter, panel mounting
S1-SPST switch, part of R5

Miscellaneous
Pre-drilled PC board, brass sheet and tubing, wire, solder, etc.

The following is available from Dirijo Corp, Box 212, Lowell, NC 28098. A drilled prototype-board with a component layout overlay in place, model LXVR is also available.

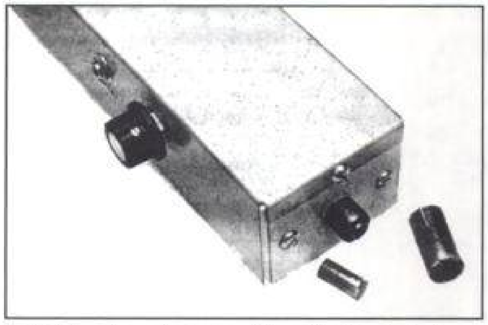


Fig 8. The attenuator's mounting plate is installed directly over photoresistor Q1. The inner and outer filters are slipped into position when needed.

Testing

We advise that a small speaker be used rather than headphones for the initial tests; then, if a wiring error or a defective component has crested an audio oscillator rather than an amplifier, your ears will not be assaulted by a high-level tone or squeal.

With the volume control fully counterclockwise and power-switch S1 set to off, install the battery and connect the speaker. Turn the unit on and point it toward a source of daylight (not direct sun). Advance the volume control to maximum. Correct operation is indicated by a frying noise that sharply diminishes when the light is blocked. The meter-sensitivity control, R8, should then be set so that the meter's pointer just begins to move off the zero calibration. Decrease the gain and point the receiver toward an AC-powered light source, such as an incandescent or fluorescent light, or even an LED driven by an audio oscillator. Those sources should produce a loud hum or tone. Sound will be heard if the LED is driven from an audio amplifier at the correct level.

If everything checks OK, assemble the enclosure.

Remote Sound Detection

To use the receiver as a remote sound pickup, you will need a laser and a reflective surface that sound waves will cause to vibrate the receiver, must be positioned so it can "catch" the direct reflection of the laser beam (Fig. 9). A particularly effective reflector for experimental use is a small piece of mirror cemented to the center of a speaker cone (see Fig. 10). There is no connection made to the speaker. The movement of the speaker cone caused by sound waves is transferred to the mirror-reflector, which in turn modulates the laser beam.

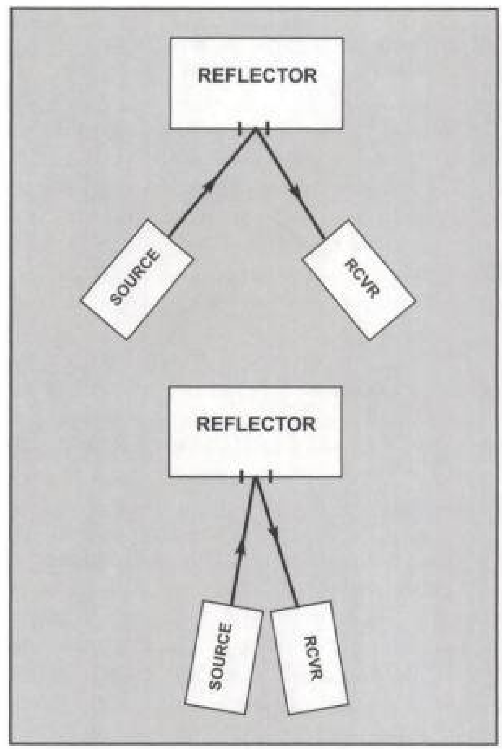


Fig. 9. A wide range of reflection angle is possible. The laser source and the receiver can even be at the same location.

Due to the varying reflectivity and distances of the targets, the intensity of the light falling upon the detector may vary considerably from setup to setup. That will be readily apparent if the collector voltage of O1 is measured while the illumination level on Q1 is adjusted. AT some point of increasing illumination, the collector voltage will fall sharply and the audio output from the receiver will drop or disappear. The small-diameter polarized filter should then place over Q1. If more light attenuation is required, slip the large-diameter filter in position and rotate it for maximum sound output.

The thinner and more responsive to sound the reflective medium is, the greater the "laser bug" sensitivity.

Most window panes will work. Moving the beam to different spots on the glass can make a dramatic difference in the sensitivity.

For testing, no additional optics are needed for the receiver.

Set up an convenient reflector – the mirrored speaker, or even an embroidery hoop holding plastic wrap or Mylar film (see Fig. 10)- aim the laser at the reflector, and then position the reflector so that the beam bounces back to the receiver. If you speak in the room, or play a radio or a tape recorder, the sound will be heard in the receiver's headphones.

Another test can be done by modulating the laser with a 1-kHz tone while having an assistant move the target reflector for maximum tone reception- as indicated by maximum volume in the highest meter reading.

A non-adjustable target, such as a windowpane, requires that the operator select a site where a direct reflection can be caught. That can be done from hundreds of feet away if conditions are right. Use the modulated beam for setup, and then remove the modulation to listen in. Double-pane glass and storm windows tend to greatly reduce sound transmission to the outer glass. It is possible, however to aim through the glass to an object within the room, such as the glass front of a china cabinet or a hanging picture. The returned reflection is usually modulated.

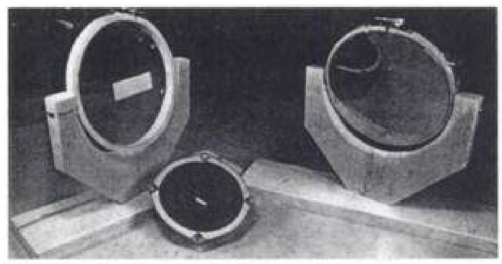


Fig. 10. For experimental use, gluing a small piece of mirror to the center cone of a speaker can make am effective reflector. Also shown are Mylar, at left, and glass, at left, reflectors.

At Long Range...

At ranges greater than 100 feet or so, or when a high ambient light level obscures the reflected beam, a means must be provided to accurately aim the receiver to the reflective laser. As shown in Fig. 11, the receiving unit of our prototype laser-bug system uses a telescopic gun sight; and that assembly is, in turn, mounted directly on the laser housing as shown in Fig. 2 so both the laser and the receiver can be aimed at a single unit.

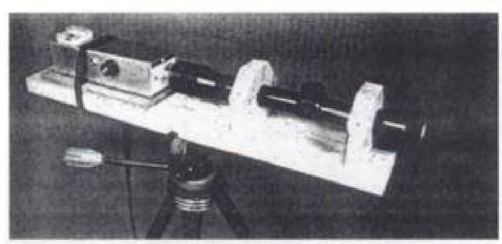


Fig. 11. At long distances, a telescopic gun sight is used to accurately aim the receiver. That assembly is then strapped to the laser, as shown in Fig. 2, so that both units can be aimed together.

The design of a combination receiver and laser mounting bracket will depend on the particular laser and scope that's being used. In general, the mounting bracket should be sturdy and have provisions for coarse elevation and azimuth adjustments; all gun scopes have provisions for fine adjustments.

The adjustment details for the prototype mount are shown in Fig. 12. The scope-to-laser alignment is done in two stages. First, the distance from the center of the laser beam to the center of the scope is measured and used as the spacing for the cross marks of the target shown in Fig. 13, which is made from dull, white cardboard. Then, the target is taped to a wall about 50 feet away from the laser assembly.

Next, with the scope's cross-hair adjustments at the center of their range, position the laser beam at the center of the lower cross. Looking through the scope, adjust the scope's mounting bracket so that its cross-hairs are close to being entered on the target's upper mark. Making sure that the laser beam stays centered on the lower mark, tighten the mounting bracket's nuts and use the scope's fine adjustments for the final alignment.

In this instance, the diffuse reflection of the laser beam from the card should present no eye hazard.

When using the laser/scope assembly, remember that at a range of less than 300 feet you must compensate for the aiming error introduced by the offset between the scope and the laser beam centerlines.

Again, let us stress that under no circumstances should the laser beam or its direct reflection be viewed through optical devices of this type because severe damage to the eye can result.

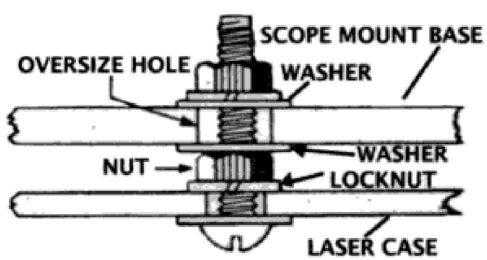


Fig. 12. Detail for the receiver mounting plate. An oversized hole-mounting base allows coarse adjustment of the scope assembly. Use an over sized washer on both sides of the hold, and a lock washer at the laser's case.

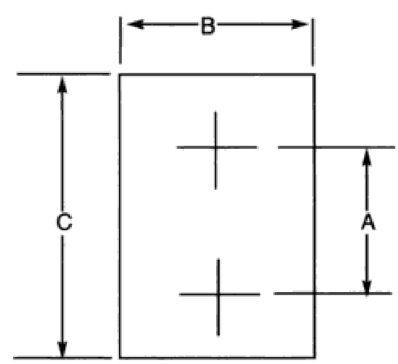


Fig. 13. The aiming target for the scope/laser assembly should be made of dull-finish paper or cardboard. Dimension "A" is the measured distance between the laser beam and the optical center of the scope. Dimensions "B" and "C" are whatever you think will be convenient. The aiming cross-marks should be made with a soft pencil or a medium-point marking pen.