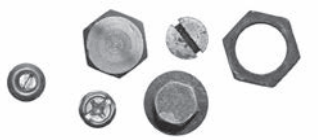
UNSCREWED

Salvage and Reuse Motors, Gears, Switches, and More from Your Old Electronics

Ed Sobey



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To the City of Akron—thank you for launching the National Invention Center and inviting me to be a part of it.

To invent, you need a good imagination and a pile of junk.

—Thomas Alva Edison

This book will help you with the second part.

CONTENTS

ACKNOWLEDGMENTS

Collecting computers and peripherals for dissection is a challenging task in itself. Thanks go to my network of friends who are computer geeks and techno-users. Michael Meyers of Eastside Computer provided me with a treasure trove of components and some good thoughts on how stuff works. Michael also keeps my computers operating so I can write books. Thank you.

Running friend Carl Kadie, a researcher for Microsoft, gave me some unique treasures, too. I think he also regifted me the computer yoke that I had given him the year before. Anyway, Nancy, his wife, is delighted to be rid of some of the stuff crowding their closets. Norbert Geer contributed a monitor for dissection, and Jerry Gardner brought it to our next run. Thanks, guys.

Richard Rundle provided an LCD monitor, and John Dickson gave me his old TiVo. Mark King not only gave me his scanner/fax/printer, he also brought it to me. Seth Leary loaned me one of his metal detectors, but I haven't returned it.

John Weigant contributed several items he rescued from the Portland Goodwill Outlet, where he often shops for yesterday's treasures. He also built the glove/boot/sock dryer pictured in the fan project. Dave Foley with Oregon Community Communications in Roseburg, Oregon, provided technical assistance and component identification. He also answered many of my questions about circuitry and components. Thanks, Dave.

George Gerpheide was generous with his time in recounting to me the history of his invention, the touchpad.

INTRODUCTION

Let's go on a treasure hunt—let's plunder old gizmos and gadgets for the good parts inside! The hunt will take us deep into the dark recesses where only engineers usually venture as we search for useable components, understanding, and techno-entertainment. If you are curious, if you want to know what's on the inside of that plastic or metal case, if you like to know how things work, this hunt is for you.

What might you find when you open up some piece of inoperative technology? You might discover component parts that you can use: motors, switches, magnets, gears, shafts, pulleys, belts, lenses, and lots of screws. Some of the parts will have no immediate utility but might inspire creative thinking on your part. Your curiosity and creativity, empowered by a pile of parts, might equal something new and cool. Totally Edison!

Operating on a broken device may lead you to find out why the gizmo isn't working, and then maybe you will be able to return it to serviceable duty. For sure, you will find things you didn't expect to find, and you'll uncover things that you can't identify. Like any good treasure hunt, you can't predict exactly what you'll find or exactly how you'll get there.

But better than an X on a map or MapQuest directions, this book will guide you to the treasures. It will steer you away from danger and help you overcome the obstacles of the engineered world.

Rules of the Hunt

In over 30 years of teaching reverse engineering, I have come up with important guidelines to ensure a safe process. All of the rules have stories behind them that I won't tell. Trust me—these rules are good ones to follow.

- **Make sure the device owner agrees to your treasure hunt.** Make no promises to fix the device or even return it in as good a condition as it was delivered to you. If the owner doesn't agree, don't accept the device.

- **Cut off any power cords.** Mistakes with power cords can be serious. Remove cords and bend the prongs outward so that the plugs cannot be inserted into outlets. Toss the cords into the trash where kids won't find them.
- **Protect your eyes.** Your eyes are your most vulnerable components. Springs jump, bits of metal and plastic fly, and tools slip. Wear glasses or, better yet, safety goggles.
- **Pry away from you.** Most take-apart accidents occur when someone is pushing very hard on a screwdriver and it slips. It's okay if it slips—as long as it slips away from you and your buddy.
- **Don't torture that VCR!** No hammering. No retribution by sawing. You can almost always get the components out without beating them up. It's a puzzle. If you're stuck, try a different approach. The person who put the device together didn't whack that component into place, so you shouldn't need to whack it out.
- **Watch out for capacitors.** Most are innocuous, but some pack a serious, toss-you-on-the-floor-and-make-you-scream wallop. Cameras, even disposable ones that have strobes, have high-voltage capacitors. Microwave ovens, refrigerators, and blenders also have capacitors to watch out for. Those in televisions and computer monitors (CRTs) can send you to the Big Take-Apart Lab in the Sky—which is why I don't include them here. This book will alert you to potentially dangerous capacitors in the featured devices and will tell you how to render them harmless.
- **Lefty loosens.** Not in every case, but almost always, turning counterclockwise will get the screw loose.
- **Wash your hands.** Mom was right. After messing around with the exotic materials that make up gizmos and gadgets, wash your hands. Whatever is in them doesn't belong in you.
- **If you don't know what it is, don't cut it.** I sometimes do recommend using a rotary cutting tool—but not to explore blindly by cutting stuff up. Nastiness resides inside certain components—such as circuit boards—and you don't want to release nastiness into the air by removing the protective covering.

Tools You'll Want

A few screwdrivers and a pair of needle-nose pliers with wire cutters will handle most of the projects. Phillips screwdrivers are the workhorses of this treasure hunt. One isn't enough. You will want a variety of sizes from the very small to the medium-large.

Here are a few other tools that can help.

- **Magnifying eyeglasses.** Get a pair of 2x magnifying eyeglasses from the drugstore. It's a lot easier to work with small parts when you can see them.
- **A multimeter.** Electronic multimeters are inexpensive, less than $10. They let you test circuits and switches, measure resistance, and measure voltage. Some measure current and test diodes and transistors. Even a cheap meter will be helpful.
- **A Swiss Army knife.** A Swiss Army knife's Phillips screwdriver fits more screw heads than any other driver, and its knife blades are always useful, as are the scissors. If a Swiss Army knife is always in your pocket, you're always ready to take something apart.
- **Two 9-volt batteries and some alligator clip leads.** With these you can quickly test the motors you extract and the LCD screens you find, and you can do some circuit bending on musical instruments.
- **Additional screwdrivers, pliers, and wrenches.** Jeweler's screwdrivers, flat-nose or slip-joint pliers, Vise-Grip pliers, and Allen wrenches help too. Some devices, such as hard drives, have Torx screws. You can get them open without a Torx driver, but it's much more difficult.
- **A rotary cutting tool.** For getting into a molded plastic case, a rotary cutting tool—for example, a Dremel—is a must. It can also cut through that recalcitrant screw that just won't come out. If a

screw head is stripped, you can cut a new notch and then remove the screw with a flathead screwdriver.

- **A digital camera and notepad.** A camera allows you to "remember" the original order of parts, before they got scrambled. A notepad and pen records not only parts numbers to look up on the Internet but also those great ideas you will generate.

The Invention of the Phillips Screw

Phillips screws are everywhere. Who invented them? Henry Phillips of Portland, Oregon, for whom the screws are named, didn't originate or produce them himself, but he took the original design by J. P. Thompson, who held the first patent, and improved upon it. Mr. Phillips's revised design was phenomenally successful, and in six years Phillips screws were made by most American screw manufacturers. The beauty of the screws is that they center and hold the driver in place, not letting it slip, as slotted screws do.

Trash and Treasure

In this modern age, the rate of product turnover is astounding. Thirty years ago your telephone was expected to last a lifetime. Now you replace it every two years when you get a new contract. Your computer is outdated months after you've purchased it. The latest newfangled gadget quickly becomes a historical artifact.

The good side of all this is that there is a lot of stuff being tossed away—and a lot of it is interesting to peer into. So where can you find ammunition for your take-apart hobby? Friends and family probably have old appliances waiting for disposal or thrift stores. Goodwill Outlet stores sell nonworking devices for as little as 99 cents each. Other thrift stores may be willing to hand over the stuff they receive but can't sell. Of course, garage sales and thrift stores will also sell you (hopefully) working appliances, but these are

more expensive and potentially useful for their original purpose. Free or nearly free is best.

Some of the components you remove need special handling. Please dispose of hazardous materials with the environment and local laws in mind. Yes, you can probably sneak them into your garbage can, but when you do, you degrade your own environment and waste useful materials. Batteries, transformers, cathode ray tubes, and computers should be recycled and not put into the waste stream. Check online for the nearest recycling and disposal center that handles each component. For batteries, check out www.ehso.com/ehshome/batteries.php#Summary to guide you in disposal.

Your Guide to the Unscrewed World

Enough chatter. This book is geared to help you do cool stuff. Each item in the book is one I recommend you try to disassemble. Some are more rewarding than others, however, which I indicate with the Unscrewed Value Index, or UVI. The UVI has three elements: value of the parts you can recover, fun/discovery value of taking the device apart, and the negative cost of disposal. If an item requires special handling in disposal, that reduces its UVI.

And one final admonishment: Every part you extract was designed by an engineer and included for a specific purpose. The accountants at the manufacturing facility were probably yelling, "Do we *really* need that part?" But there is a reason it's there. Can you figure it out? As you dig your way through that VCR, appreciate the aesthetics of design, the economy of arrangement, and the manufacturing . . . and be inspired by them!

AUDIOCASSETTE PLAYER

This portable entertainment system was amazing in its day. Sony launched a revolution in 1979 when it introduced the Walkman. The model taken apart here is a later model from a rival company. Today, most cell phones have more audio features than a Walkman, and can play more songs. But one of the wonderful things about this older technology is that it houses so many useable mechanical parts.

Treasure Cache

- DC motor
- Drive belts and pulleys
- Gears
- LCD
- Magnetic tape head
- Piezo speaker
- Rollers/wheels
- Springs

Tools Required

- Flathead screwdriver
- Phillips screwdriver
- Scissors

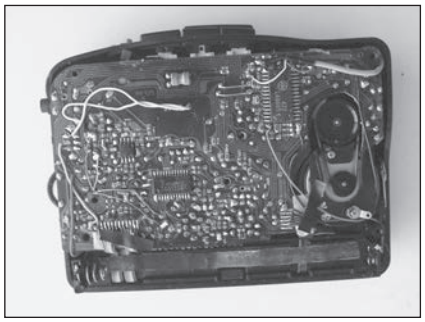
Lefty Loosens

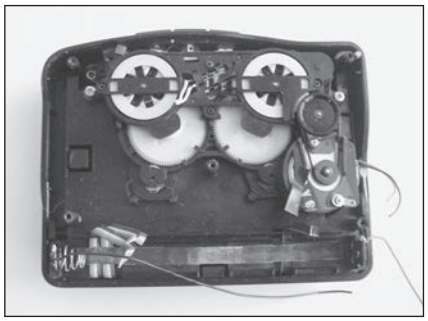
Four Phillips screws hold the back panel to the rest of the player. Underneath the panel is the back of a circuit board; a few screws hold this board to the front frame. On the right are a motor, two pulleys, and a belt.

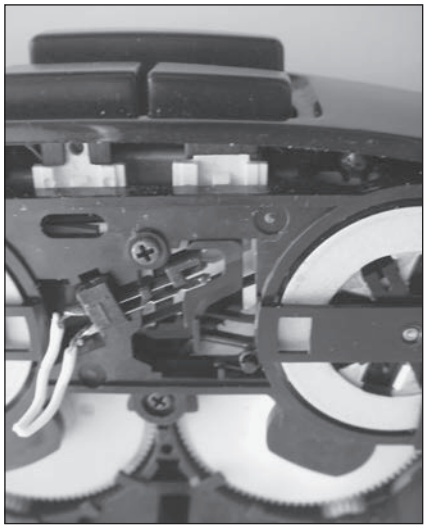
I lifted the circuit board off and cut the several wires connecting it to the rest of the player. In cutting wires it's always good to leave as much wire as possible attached to any components you might want to use later.

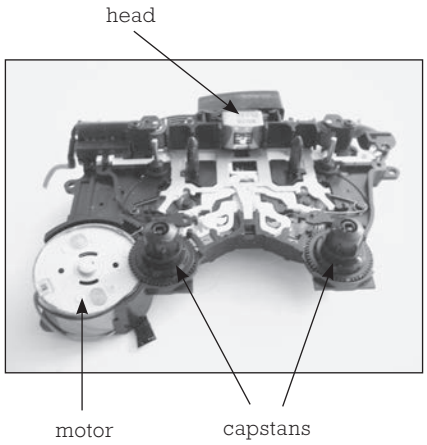
The pulley on the motor shaft belt drives a double pulley above it. This double pulley drives a second belt that powers the two white pulleys. Pressing either the "Fast Forward" or "Reverse" buttons on the top of the player moves one of these white pulleys and its associated white gears. When one of these pulleys moves, it takes up the slack in the large belt, which is how it spins without turning the other white pulley.

Between the two large white pulleys is the switch for the "Reverse" button. Pressing this button pushes together the contacts to power the circuit as well as move the pulley into place.





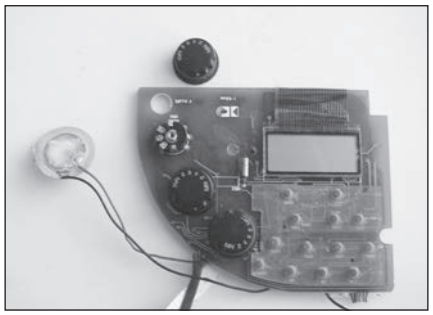




A few screws hold plastic retaining frames over the pulleys and the motor. These come out, freeing the belts, motor, pulleys, and gears. I used a flathead screwdriver to pry them out.

The other side of this assembly is where the tape moves. The magnetic head is here. Depressing the "Play" button moves the head onto the tape so it can read the magnetic fields of the recordings. Guide rollers guide the magnetic tape, and springs apply tension to the tape. The capstans hold the cassette in place and allow the tape to wind and unwind.

The top cover pivots open on plastic hinges so you can drop in a cassette. The plastic housing for the cassette is held to the top cover by a few screws. There is a circuit board in the top that holds the control switches and an LCD screen. Three of the switches, on the left side, are variable resistors. The others are rubber dome contact switches. Wires running from the board go to a piezo speaker that is lightly glued to the inside of the top cover. This can't produce high-quality sounds, so this player is designed to be used with earphones.



What Now?

The plastic case itself could be an interesting container for small parts. You would want to cut out much of the plastic inside to leave as large a space as possible and reassemble the body. You could access the parts stored inside through the hinged top where the cassette would go.

The rollers could become wheels for a tiny vehicle. The motor, which runs on 2 volts, could drive such a vehicle with the belts.

Try messing around with the LCD. Connect various pairs of its leads to a 9-volt battery to see if you can get it to make numbers or letters. It would be interesting to test the heads to see if they put out enough voltage to generate sounds. You would have to pass the signal through an amplifier (Radio Shack sells tiny amplifier/speakers that might work nicely for this). Then run the magnetic strip on your credit card past the head so you can hear your account number.

The piezo speaker could become a pick-up head for a musical instrument, like a homemade electric guitar. Run the leads into an amplifier and try taping the speaker against the bridge of a guitar.

BAR CODE SCANNER

You've used these devices hundreds of times at the checkout stand at the grocery or to identify you as a proper card-holding patron. Now's your chance to open one up and, in the process of scientific discovery, render it impotent.

Treasure Cache

Charge-coupled device (CCD)
Magnetic transducer
Metal weight
Tiny lens and mirror

Tools Required

Phillips screwdriver
Rotary cutting tool

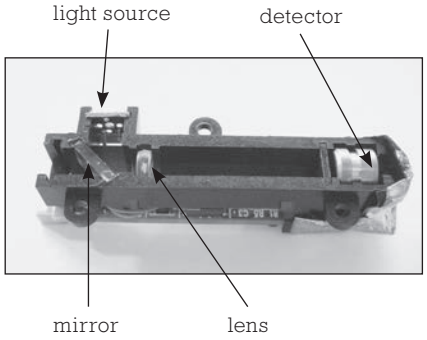
The First Bar Code

A bar code scanner was used for the first time in a store to ring up the sale of a pack of chewing gum at the Marsh Supermarket in Troy, Ohio, in 1974.

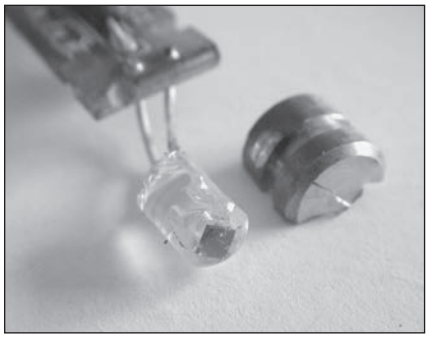
Lefty Loosens

The scanner's plastic bottom comes off with the removal of four screws. This reveals a large metal weight on one side that helps hold the scanner in place on a countertop.

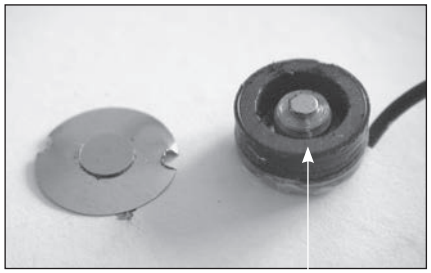
All the action is on the other side of the scan slot. A narrow window in the slot wall allows the light reflected off the bar code to be read inside the case, while keeping ambient light out. Two circuit boards hold the electronics. A circular array of LEDs illuminates the card: they shine through the window and reflect off the white surfaces in the code. The reflected light comes back through the window and through the center of the circular array. It reflects off an angled mirror, through a lens, and onto a detector encased in a brass housing at the far end. The brass housing has a narrow slot to admit only the light from one white bar at a time.



To get to the sensor inside the brass housing, I used a Dremel rotary cutting tool. Inside is a tiny sensor encased in a plastic envelope. The sensor appears to be a charge-coupled device, the same technology used in digital cameras. Other bar code scanners use photo-diodes to read the bars.



This scanner has a small magnetic transducer to signal the user with a sound that a card has been read or not. Inside the transducer is a coil of fine copper wire wrapped around a metallic core. This sits inside a circular or toroid magnet. A metal disk is held in place by the magnet. As electronic pulses pass through the windings, they create a magnetic field that flexes the sound-making metal disk up and down. This movement generates sound waves that tell you, for instance, "Oops, your card didn't get read."



What Do Those Bars Mean?

The bar codes on most items you buy use a numbering system called UPC, for Universal Product Code. Each UPC bar code has 12 digits plus start, end, and middle bit patterns. The first six digits identify the manufacturer, and the second six identify the product. The manufacturer assigns a number for each product, each type of package, and each size using five of the six digits. The last digit is a checksum digit. The computer running the bar code scanner adds up combinations of the code numbers and performs mathematical calculations with them, finally comparing the result with the sixth digit. If the computer doesn't come up with the same digit, it alerts the operator that the code was incorrectly read.

What Now?

If you haven't destroyed it, the magnetic transducer might be fun to experiment with. What sounds can you generate with it? If you wire it into a working electronic keyboard or guitar, does it make sounds like the dynamic speaker?