Short Wave Radio

A Working Electronic Sculpture Honoring the History of Radio

Please note: This radio picks up short wave stations, but for your best satisfaction it will require a little time and attention, both to learn how to operate it and to appreciate the principles and history that it embodies. You’ll find bare-bones instructions on this page and more details inside the notebook.

To turn the radio on, rotate the volume control clockwise until you hear a click, then set its dial to 3 or 4. If the radio was not already turned on, you’ll have to wait about 30 seconds for its vacuum tubes to warm up.

• Put on the headphones.

• Set the radio’s other controls as follows:

  • RF Gain: Fully clockwise.
  • Preselector: 1
  • Tuning: 20
  • Fine Tuning: 5.0 (This works like a clock, only with ten “hours” instead of 12)
  • Regeneration: 7 (Or advance slowly clockwise from zero until just after the point you hear a louder hiss in the headphones.)
  • Volume: Set to a comfortable level, usually about 4.

Now, slowly adjust the TUNING control back and forth looking for squeals that indicate signals. (The shortwave broadcast band with 31 meter wavelength is located between about 10 and 30 on the dial.) You’ll should find a few unless ionospheric conditions are particularly poor on this day.

Leave the TUNING control set on a loud squeal. Then slowly adjust the FINE TUNING to “zero beat.” (You’ll notice as you move the dial across a signal, it starts with a high-pitched note, moving down to a low-pitched or zero note, then back up to high pitch again. “Zero Beat” is the silent place in the middle.)

Very carefully adjust the regeneration control for best sound quality. This is a touchy adjustment, so go slowly. The regeneration interacts slightly with the TUNING, so you have to fiddle with both controls to get the signal tuned in properly.

Finally, adjust the PRESELECTOR control for best signal. With very strong signals, you may not hear much difference. But on weak ones, proper adjustment of this can make quite a difference. If the signal is VERY loud, turn the RF Gain halfway counter-clockwise or more to improve sound quality.

If you don’t find any loud signals, the 31 meter band may be “dead” due to poor ionospheric conditions. Look inside for more things to try.
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More details of operation

This section covers the nitty-gritty of the receiver’s operation. The following section discusses technical details of what the controls do and how this and other radios, actually work. If you’re not interested in technical matters, and more inclined to ask why, then skip even farther to the philosophical and historical section.

This How-to section doesn’t cover what the controls do, only how to operate them. Check the appendix, all the way at the end, if you get hung up on any of the technical terms in this section.

Oddly enough, once you’ve played with the receiver for awhile, you’ll find it simpler to operate than much of today’s digital equipment. This is because there’s no hidden functions, and no invisible options accessed by pressing combinations of buttons. When your body has gotten a sense of what’s happening with the radio, operating it becomes instinctive. You don’t have to memorize sequences of button presses or decipher icons on a digital readout. It’s a simple matter even to operate it in the dark, once you know which knob does what.

To start with, let’s make sure you have the REGENERATION set correctly. If it’s set too far counterclockwise, not much, if anything, will come through.

With the REGENERATION control set at zero, listen as you rotate it clockwise. The hissing sound in the headphones will get slightly louder until some point after 6 on the dial, when it will abruptly change quality and sharply increase in volume. This is where the regenerative detector starts oscillating (Details about oscillation come later).

At just a hair past the “oscillation point”, receiver sensitivity is greatest. For voice signals (as opposed to morse code signals), once you find one you want to listen to, it usually works best with strong signals to turn the regeneration control a tiny bit back from the oscillation point. You’ll lose a little volume, but the squeal will disappear, which makes tuning easier. However if the signal is fading in and out and becomes distorted as it fades, sometimes it works better to set the detector past the oscillation point and keep the signal tuned to zero beat.

To listen to Morse Code signals (also called CW or Continuous Wave), you’ll need to set the REGENERATION control so that the detector is oscillating (loud hiss, about 7 on the dial), otherwise, they’ll not be audible.

Now you’ve had a lesson in using the regeneration control. You don’t find these on today’s radios, but this radio is partially a history lesson, so bear with me.

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What is “Short Wave?”

Radio signals are transmitted at different vibratory rates, specified by the number of vibrations per second, using the frequency units, “Hertz,” or the equivalent length of their waves, usually spoken in metric units of meters or centimeters. As frequency gets higher, wavelength becomes shorter.

Traditionally, “short” waves were the wavelengths shorter than 200 meters, which is equivalent to 1.5 megahertz (1.5 million cycles per second), the high end of the regular broadcast band on your AM radio.
Suppose you aren’t hearing much going on at 31 meters, then let’s try the 21 meter broadcast band, at about 92 on the tuning dial. (This wavelength amounts to a frequency of about 13.6 Megahertz, or 13,600,000 vibrations per second. Usually we specify a specific frequency in Megahertz [Mhz] and a band of frequencies by its approximate wavelength. This is simply a way of confusing the neophyte short-wave listener, since frequency and wavelength are really just two ways of speaking of the same quantity. The usage is historical convention, and not necessarily logical)

Please note that the numbers on the tuning dial are a “logging scale,” not referring to actual frequencies. The graph on this page allows you convert logging scale numbers to frequencies.

After you adjust the tuning dial to 92, set the PRESELECTOR to about 4.9. Look for signals the same way you did on the 31 meter band. During the day, you’ll sometimes hear signals on this band when the lower frequency (higher wavelength) band is dead, that is, unless both bands are dead. The ionosphere, a conducting layer of gas in the upper atmosphere which bounces signals around the world, is strongly affected by radiation from sunspots and “solar storms.” During times of low sunspots, or conversely, during solar “storms,” the part of the ionosphere responsible for deflecting short wave signals back to earth disappears. Under such “dead” conditions, you’ll hear little or nothing on many of the short wave frequencies.

Look at the frequency chart below and notice the numbers in parenthesis on the left side, labeled PRESELECTOR. Right next to them are the numbers corresponding to those on the TUNING dial. When the tuning dial is set to 60, for example, set the PRESELECTOR to 3. Find the real frequency by following the horizontal line under 60 to the right until you intersect the curve, then drop down vertically to read the frequency, 11.1 Megahertz at the bottom of the graph. The preselector setting should track the tuning setting, as noted on this chart.

When you’ve tuned a signal in, it often helps to tweak the preselector a bit to peak its loudness. On weak
signals, this peak can be quite sharp. In playing with the receiver, you’ll eventually notice that the preselector doesn’t always seem to have much effect on a particular signal, or that the signal gets louder at a preselector setting that is different than indicated above. In this case, you’re listening to an image of a signal on another frequency entirely, which is a kind of phantom signal. These phantoms, called spurious responses, afflict simple receivers, and it takes more circuitry than this one contains to eliminate them. This is a very rudimentary radio and it picks up quite a few spurious signals. But that doesn’t make it any less fun to play with.

Now you should know enough about the receiver’s operation to get around pretty well. You can use the above frequency graph to convert any number on the 0 to 100 “logging scale” on the TUNING dial to frequencies in Megahertz. I inserted a few corresponding wavelengths as well.

The receiver covers three ranges of short-wave broadcasting, 31 meters, 25 meters, and 21 meters and two amateur radio (ham) bands, 30 meters and 20 meters. Thirty meters is all code (CW) operation, so unless you know morse code, you’ll have to be content listening to dits and dahs. Both bands are rather narrow and the signals on them are weaker than the broadcast bands, so they require careful tuning and adjustment of the preselector. You’ll find WWV, the standard time at 10 Mhz, or about 32 on the tuning dial. Note that for the calibration graph to be accurate, the FINE TUNING dial must be set to 5.0 on its clock-like face.

Nearly all voice signals on the 20 meter ham band are Single Sideband modulated. This means that the voice is applied to the signal in a particular, quite efficient way, but it requires very careful tuning with the FINE TUNING control to render it comprehensible. If the signal is not tuned correctly, you’ll hear something akin to Donald Duck talk. You’ll notice, with Single Sideband signals, that there’s no squeal as you tune them. This is because the “carrier” signal characteristic of the usual sort of AM (Amplitude Modulated) broadcast signals is absent. The regenerative detector supplies the missing carrier.

To listen to the upper end of the 20 meter ham band, set the TUNING all the way to 100, then tune up or down with the FINE TUNING control from its central 5 setting. You’ll have to move the TUNING control to 98 or so to catch the bottom, CW segment, of the ham band.

The RF GAIN control is another control that you don’t find nowadays on most radios designed for the lay consumer. It also has been subsumed by automatic circuitry, which is absent in this simple radio. Usually you can leave this control set fully clockwise. But if signals are VERY strong you may have to rotate it counterclockwise to keep them from overloading the detector, which has occurred if you hear serious distortion or other loud, chaotic sounds coming from the receiver. If you turn the RF GAIN down, remember to turn it up again when you’re searching for new signals. Otherwise you won’t be able to hear the weak ones.
How a Receiver Works

I’ll try to make this section as friendly as possible for the uninitiated. You can skip it, but you may want to come back after delving into the section that follows, on philosophy, because it explains some of the technical references that were unavoidable in that section. You’ll find a glossary of technical terms in the appendix, but I’ve tried to define most terms as I go. Usually I explain some process first, then clarify afterwards, so if you don’t understand something immediately, keep reading and it may become clearer as you progress.

Before saying anything about how radio signals are received, let me describe what it takes to get broadcast intelligence into the air. Radio waves aren’t in the air, actually; they travel through what we understand as empty space at the speed of light. Programming rides on a “carrier” signal, a Radio Frequency (RF) Alternating Current (AC).

To get a handle on how a carrier works, consider two people holding a long, loosely-stretched rope between them. . . like a long jump-rope for example. One person, the receiver, holds his end still, while the other, the transmitter, waves his arm up and down at a rapid rate. You’d see a train of waves moving down the rope until they shake the receiving person’s hand. As long as the transmitter shakes the rope at a constant rate, the receiver will know a signal is coming through, but it won’t convey any information. This constant waving is like a radio “carrier.” Look at the illustration on page 5 to help visualize what I’m talking about.

Now suppose the guy on the transmitting end starts and stops his wave-making in the dots and dashes of morse code. The receiving guy now gets a message, if he knows how to interpret the code. First he’ll get a long handshake for a dash, then no signal at all, then a short handshake for a dot.

With a radio signal, the “rope,” which, in this case consists of the medium of “empty” space (science isn’t so sure empty space is actually empty nowadays), gets waved at a much faster carrier frequency. In the case of the 20 meter ham band, it would be waving at about 14 million times per second. A Morse code dot would turn the carrier on for a short time, and a dash for a longer time. This is amplitude modulation with no intermediate amplitudes present. Actually, when we send morse code it’s called “Continuous Wave” or CW modulation. The wave isn’t actually continuous, but turns on and off in dots and dashes.

If we want to send voice or music, we have to be able to adjust the height or amplitude of the carrier continuously from zero to twice its average level. When we do that in step with the individual vibrations of music or voice, then we have Amplitude Modulation, or AM. Your regular AM radio uses this sort of modulation, and so does short wave, long distance, broadcasting.

So, Amplitude Modulation changes the carrier strength at a rate corresponding to the vibrations of a human voice or music. When sending Morse code, we just turn the carrier on and off for varying lengths of time that correspond to Morse code dots and dashes. There are other ways of modulating a carrier, but you aren’t likely to recognize them when tuning around with this receiver because mostly they’re used for transmitting digital data. The other type of modulation, FM, or frequency modulation, is used for transmitting standard high-fidelity stereo broadcasting, but it does not occur on the frequencies tuned by this receiver.

Ok, we’ve transmitted a signal into space by sending it out through an antenna. The details about how a transmitter works is a subject for another day. Let’s just assume we’ve got an Amplitude Modulated carrier wave vibrating through the ethereal fabric of space. When it encounters the conductive wire of a
receiving antenna, the “free electrons” in the wire get excited by its presence. (Free electrons are unattached to atoms so they can move through the wire with little resistance, like water in a stream bed.) They move back and forth through an external circuit, our receiver, in step with the wave coming through space. This back-and-forth movement of electrons is like a tiny tide moving in and out 14 million times per second. To use electronic terms, this ebbing and flooding tide of electrons actually constitutes a tiny Alternating Current, with an amplitude of perhaps a billionth of the current that originally flowed in the transmitting antenna.

Below, you’ll find an illustration of what happens in the transmitter when the Radio Frequency (RF) carrier, on the left, is modulated with audio information, represented in the center panel. The high frequency, modulated RF carrier in the right-hand drawing varies in amplitude at an audio rate. Remember, this could just as well be our jump rope, except this is happening a few million times faster. Don’t forget that this drawing and the jump rope are just useful analogies that help understand the basics of what happens. Radio waves don’t actually “look like” anything, since they’re invisible!

So now we have that tiny ebbing and flooding tide of electrons lapping at the input of our receiver. The first thing this tiny electron tide encounters is the RF GAIN control. This simply a volume control that moderates the influx so that, if the transmitting station happens to be VERY strong, the receiver’s defenses don’t get overwhelmed. The PRESELECTOR control is a tunable circuit, which in most cases consists of the combination of two components hooked together, an inductor and a capacitor.

Inductors are coils of wire, sometimes wound around metallic cores, sometimes having only air in the center. They possess the property that when a current of electrons flow through them, they create a magnetic field that absorbs some of the energy of the moving electrons. If the flow of electrons gets interrupted, or if it’s reversed, the energy waiting in the magnetic field gets released in such a way as to oppose any change in the electron flow. So inductors are a little like a regulating flywheel when current flow changes.

Capacitors consist of two parallel conductive plates, usually metal, that are in close proximity to each other. They have the power to store electrical charge, acting like a reservoir for free electrons. Capacitors do for electrical potential, or voltage (which is equivalent to the pressure of water in a pipe), what inductors do for electron flow (which is equivalent to the current of water moving through a pipe). Capacitors resist sudden changes of voltage or electrical pressure the way inductors resist sudden changes of current, or flow.

A tunable circuit combines an inductor and a capacitor. If you look inside our radio, you’ll see the tuning capacitors, those gadgets with interleaved plates that move when you adjust the PRESELECTOR or TUNING control, and their companion inductors which are those brown cylinders, about 2.5 inches high with the fine reddish wire close-wound around them.

When you hook a capacitor and inductor together like this, it becomes resonant. That is, it shorts out, or eliminates, any frequency that is different than its resonant frequency. When you create a resonant circuit
with an inductor and capacitor, their opposite properties work together. Once you get a current flowing in
the circuit formed by the two components, the inductor resists a change in current, the capacitor resists a
change in voltage, but the there’s delay involved between the recalcitrant behaviors of each component.
The net result is that you get an oscillation of electrons between to two at exactly the resonant frequency.
If the electron tide flowing through from the receiver’s antenna is right at the resonant frequency of the
tuned circuit, then it sloshes right on through. If it’s at a different frequency, it gets derailed and shorted
out.

You can demonstrate for yourself exactly what happens with resonance by filling a two-quart saucepan
halfway with water. Hold it in your hand over the sink and move it at a constant rhythm directly toward
then away from you. Start by moving back and forth very slowly, then gradually move faster and faster.
When you’re moving slowly, the water will keep pace. At increased speed, it can’t keep up and starts to
pile up at one side of the pan when you move in the opposite direction. When you move the pan at a
certain faster rate, the water will start to slosh violently, probably coming right out into the sink. This is
the resonant frequency. If you set the pan down after the water has started sloshing out of it, it will keep
sloshing back and forth for awhile at exactly that resonant frequency. This is precisely what happens with
electrons moving in the resonant circuit formed by an inductor and capacitor. At resonance, it takes very
little energy to keep the sloshing going. If you move faster than the resonant frequency, or slower, the
water responds less… although if you move the pan two, three or more multiples faster than the resonant
frequency, the water will respond with a harmonic motion. Try it and see what that looks like. An
electronic resonant circuit will also respond harmonically under some circumstances.

So, the PRESELECTOR control serves to eliminate (more or less) the signals that are outside the
frequency we want to tune in. Most contemporary consumer radios lack an external preselector or RF
gain control. The functions are still present, but are automated. In sophisticated communications
equipment, these controls often show up because they confer a degree of flexibility needed in some
situations. They are included in this receiver because automating them requires more mechanical and
electrical complexity, and besides, they authentically represent the controls that were available on early
20th century equipment.

There’s actually a bonus associated with having a separate preselector, which is this: in some situations,
it allows the receiver to cover two separate frequencies with one setting of the frequency dial. I won’t go
into detail about this, but if you experiment with preselector settings different than those given on the
chart, you’ll discover this yourself.

After our incoming, oscillating tide of electrons gets filtered through the preselector control, it
encounters its first vacuum tube, which has two functions. The first is to serve as an RF amplifier,
increasing the amplitude or power of the tiny signal coming from the antenna. The second function is to
mix the received frequency with a frequency generated within this tube by a local oscillator.

The TUNING control actually varies the frequency of the local oscillator (LO). When this LO frequency
mixes with the amplified signal coming from the antenna, two frequencies are produced, the
mathematical sum and difference between the local oscillator and the input signal. The difference signal
is called the Intermediate Frequency, or IF. More complex radios than this one will usually have two or
three tubes or transistors serving as IF amplifiers. The Intermediate frequency is always constant. This
means that the IF amplifiers can all be tuned to one frequency, which makes the mechanical design of the
receiver much simpler, and confers a number of other advantages as well.
Our simple receiver has no separate IF amplifier, but applies the IF signal directly to the regenerative detector, which has considerable gain (amplification), and fairly sharp selectivity as well. This means that it can sharply differentiate between signals on closely adjacent frequencies so you don’t hear the both at once.

The modulated RF signal has now been amplified, and converted to a new carrier frequency, the IF or Intermediate Frequency. The modulation is still there, just as it was earlier, but now we have to somehow separate the modulated intelligence or programming from the carrier so we can do the useful work of driving a headphone or speaker with it.

The process of separating modulation from an RF carrier is called detection.

Before we get into regenerative detectors, let’s talk about the simplest form of detector, invented early in the 20th century, the crystal detector. Refer to the illustration on the left for this discussion.

A crystal detector accomplishes its job by using a “rectifier,” an electronic component that lets current flow in one direction but not the other. Let’s return to the water analogy: The “tide” of the modulated carrier signal is ebbing and flooding at the carrier’s frequency. Suppose you install a one-way valve, which is the water equivalent of an electronic rectifier. The rectifying “valve” lets flooding pulses of water come through, but doesn’t let the water ebb. So, when the instantaneous volume of the program material, (voice or music) is high, big pulses come through the valve. When the volume of the program material is low, the flooding pulses of water are smaller.

Now, imagine that the pulses of water coming through our rectifying “valve” are flowing into a pan with a small hole in the bottom. When big pulses come through the valve, the pan fills up faster than the water can drain out. When small pulses come through the valve, water drains out of the pan faster than new pulses fill it. The result is, the level of water in the pan gets high when the carrier modulation level is high, and low when the modulation level is low. Hence, the average water level in the pan follows the modulation.

To get back to electrons, the rectifier keeps out all the “ebbing” pulses. We’ll call these the “negative” pulses. The “flooding” pulses that do make it through the rectifier, we’ll call positive pulses. With only the positive pulses now flowing through the circuit, we have a pulsating current that flows in only one direction, which is called pulsating Direct Current (DC). One positive pulse comes through the circuit with each cycle of the modulated carrier. When the modulation level is high, big pulses come through, when the modulation is low, small pulses come through.
Now we take advantage of the electron storage capabilities of a capacitor. We put a capacitor in the circuit so that each pulse of electrons comes through our rectifier gets stored up in the capacitor. We put a “load” on the capacitor, like a headphone. Electrons from the capacitor slowly trickle off through the headphone load, just as water leaked out of the pan when we used that analogy earlier. Exactly as occurred with the perforated pan, the capacitor bleeds electrons (“charge”) off through the headphone, while it’s simultaneously being replaced by the positive pulses of current from the varying strength carrier signal. When the modulation on the carrier is at a high level, the pulses are larger and the capacitor accumulates charge faster than it bleeds off through the headphone. When the carrier is at a low lever, the capacitor’s charge bleeds off faster than the incoming pulses fill it up, and its charge level drops lower. This means that the current leaking off through the headphone actually follows the average level of charge on the capacitor, which in turn follows the modulation on the carrier. The headphone converts the instantaneous current level through it into the movement of a diaphragm, sending the sound of the carrier’s modulation to your ear.

Our receiving sculpture employs a more complex detector than that describe above. The result is the same, but the implementation is different. This detector, called a regenerative detector, was invented by Edwin Armstrong in 1912. It was made possible by the earlier invention by Lee De Forest of the amplifying triode vacuum tube, the “audion.”

The regenerative detector amplifies the RF (IF, in this case) carrier signal then feeds some of it back into its own input, so that it gets amplified over and over again. This increases the detector’s gain and “selectivity,” meaning its ability to separate closely spaced signals. The REGENERATION control on our receiver controls the amount of feedback in the detector. When you increase it to a critical point, the detector oscillates, creating the consequential hiss (or squeal, when a received signal is present) you hear in your headphones.

If you experiment with the regeneration control, you can hear how the gain or loudness of the signal increases to an optimum right as the detector starts to oscillate. Just before the oscillation, you’ll notice that the selectivity of the detector gets sharper, as evidenced by a sort of hollow, resonant sound, sweeping from high to lower pitch, as you tune a signal in. This happens because the high selectivity of the detector filters out some of the audio frequencies generating that characteristic sound. As you advance the control more, oscillation starts and you hear a squealing “heterodyne,” caused by the RF carrier of the input signal mixing with the oscillation of the detector.

Don’t confuse the heterodyning that went on earlier when we generated the Intermediate Frequency with the heterodyning that occurs in the detector when it oscillates. They are both exactly the same process, but in the detector, the mathematical difference between the carrier frequency and the frequency of the oscillating detector is in the audible range. It’s actually that squeal that you hear as you tune through a carrier signal. When you tune to “zero beat,” and the squeal disappears, you’ve effectively converted the IF carrier to zero, leaving just the audio modulation, which you hear in headphones or speaker. If the detector feedback is set below the point of oscillation, the carrier simply gets filtered out by a capacitor acting together with an inductor. There’s no squeal, but the audio modulation comes through, though more weakly.

Once the audio has been demodulated from the carrier, all that remains is to amplify it again in order to
Older vacuum tube in a receiver probably built in the 1940s by a hobbyist. Spark Museum exhibit.

The audio amplifier in this radio, making a concession to modernity, is an integrated circuit, employed, I blush to admit, out of sheer lazy reluctance to devise a vacuum tube amplifier for the purpose.

A word about the vacuum tubes you see through the window atop this receiver, marked by the characteristic glowing red-hot dots of their heaters: Normally vacuum tubes require two voltages for their operation, a high voltage for the different operating electrodes of the tube, and a low voltage to run those red-hot filaments that boil out the free electrons that flow through the tube making it amplify. These particular tubes were designed in the fifties for car radios, just before transistors appeared on the scene, rendering them obsolete. These are unique in that they only require 12 volts for their operation, both to heat the filaments and to excite their plates and other electrodes. They are a good choice for this application because they eliminate the need for high voltage and its attendant shock hazard.

Vacuum tubes hailing from earlier in the 20th century, like the one on the left, were physically larger “bottles,” than the one in our receiver. Regardless of the size, nearly all vacuum tubes work on the same principle: A hot filament (or cathode), glowing in an evacuated bulb, generates free electrons that are attracted toward a “plate” electrode operating at a positive potential (or voltage) with respect to the cathode. An electrode, called the “grid” is inserted between the plate and hot cathode. Varying voltage applied to the grid controls the flow of electrons passing from the cathode to the plate. Since the current flowing between cathode and plate is relatively large, and the change in grid voltage needed to control this electron flow is small, the tube amplifies the signal on its grid.

In all but the very earliest vacuum tubes (or “valves,” as the British aptly call them), the elements are arranged concentrically around the central heated cathode, with the grids (some tubes have more than one) in the middle and the plate on the outside. When you look at a vacuum tube in operation, you can typically see the orange-glowing filament in the center and the cylindrical sleeve of the plate electrode on the outside, just under the glass. The grid(s) are difficult to see since they’re hidden in the middle.

If you’ve made it this far, you deserve a medal. Congratulations! Onwards to philosophy and history.

Technology and Meaning

At the beginning, I referred to this receiver as a “Working Electronic Sculpture.” My reason for this has to do with my personal history with technology, and how I’ve come to view it as an expression of meaning, rather than simply a neutral tool with which to accomplish some task. Exploring the meaning of technology has become somewhat of an obsession with me as I’ve become more consciously aware of the effect it has on my life, and conversely the way my beliefs are expressed through technologically based artifacts I’ve designed and built myself. I’m convinced that if we do not maintain conscious awareness of technology’s meaning and how it structures our lives, we unwittingly become its slaves instead of its masters.

Some people seem to believe that technology, and its handmaidens, science and math, serve an indispensable “practical” function, while art is more or less optional, providing merely decoration or entertainment. They advocate a school curriculum devoid of education in the humanities, since art is “play,” and, to them a trivial endeavor, rather than a subject worthy of formal education. I’d counter that argument by pointing out that various forms of artistic expression have been constants of human
existence from the beginning, so must be more fundamental to basic survival than the “practical”
functions of all the technologies that have come and gone over the history of humankind. I’d be the last
to argue against education in science and math, but to teach them to the exclusion of humanities is a
grave error. For one thing, we can derive essential insights as to how technology can be most
productively used by studying humanities. To neglect the arts and what they teach us is to leave ourselves
open to becoming victims of technology run rampant. Some of us like to believe technology is a neutral
tool with no political implications. But to believe that is naive. Technology is a powerful force that
leaves us at the mercy of our unexamined cultural assumptions and which also structures our lives,
usually in unexpected ways. We ignore that truth at our peril.

Throughout history, our use of technology has reflected the unconscious societal attitudes and
assumptions prevalent at any given moment. In other words, technology has been a form of expression,
just as a sculpture is an expression of the conscious or unconscious psyche of its creator. Consider the
early twentieth century, when the uses of radio technology expressed something quite different than what
they do today. At that time, radio was an exciting possibility, and those who devoted themselves to its
development were driven by motivations more in the realm of spiritual quest, involving the improvement
of mankind’s lot, and with plumbing the unknown laws of the physical universe. Nowadays, radio, and its
offspring TV, as technologies, are more or less taken for granted. They’ve been relegated to the status of
megaphones devoted to social control and product sales. In Marshall McLuhan’s terms, our focus is now
on the message instead of the medium. Sadly, nearly every new technology that becomes available is
lauded as a great boon to the future of humankind, and nearly always they end up being twisted primarily
to the purpose of lining pockets.

My purpose in building this radio and presenting it as a “sculpture,” has been to lift a technological
artifact, radio, out of its mundane context, where it has become invisible and taken for granted, then to
re-introduce it in the context of “functional” sculpture assembled from physical components that together
have the rather curious power to collect “radio broadcasts” out of empty space and project that
intelligence into your ear. Its operation depends on the properties of invisible and inscrutable “particles”
(that can just as easily present as waves) and their interaction with conductors, semi-conductors, non-
conductors, vacuum tubes, and components we call “inductors” and “capacitors,” the latter two having
the power to store “electrical energy” for short periods of time. In addition to radio’s identity as a kinetic
physical contrivance, it’s one with meaning, association, and history, all wrapped inseparably with its
technical function.

In what follows, I’ll devote attention to the history of radio, both in general and from the perspective of
my own association with it. Seeing this radio from a wider perspective will possibly restore it to the
status of an intriguing and still slightly mysterious device, reminding us of aspects of our universe that
are less well understood than commonly believed. It may become more apparent as you read on, how
radio, or any other technology, expresses much about cultural assumptions and beliefs, and that choices
we make about the “practical” uses to which we put our knowledge of the physical universe are more
arbitrary than you might have thought.

Radio, Then and Now

One of my favorite places to visit in Bellingham is the Spark Museum of Electrical Invention, right
around the corner (north) of Mindport. The place is a nostalgia trip for me since most of the items
exhibited there date from the forty or fifty years previous to my birth in 1944. I started becoming
fascinated with science when I was about seven, and my early learning on the subject was gleaned from
science textbooks dating from the early part of the 20th century. I grew up taking apart vacuum tube
radios salvaged from that earlier era, since a reasonably-priced junction transistor did not appear on the market until 1955, six years after its invention. In fact the first radio I owned was a crystal set that had been my father’s as a boy in the 1920s. It used a galena crystal detector, which was really the first “solid state” electronic device, and a tuning coil with a slider contact for changing stations. It required a long piece of wire for an antenna, a good ground connection and careful adjustment of the “cat’s whisker” on the galena detector in order to hear stations. (If you skipped the previous technical section, you’ll find more information about detection and other details there.)

Here’s an early crystal radio on display at the Spark Museum, a much more upscale version than the one I owned. You can see the cylindrical galena detector in the left rear corner and the “cat’s whisker” adjustment, which is that ball in a bracket from which a fine wire protrudes, contacting the galena (lead sulfide) crystal. You use the fine point of the cat whisker to search around on the surface of the galena until you find a “hot spot” where the contact rectifies, that is, conducts current in one direction more easily than the other. This was one of the earliest methods of “demodulating” radio signals, which means separating the audio information from the radio frequency “carrier” on which it rides. The crystal radio in this picture was tuned by a switch connected to taps on a coil of wire, rather than the more crude slider employed by my own radio. Mine was mounted in a tin box instead of an attractive wooden cabinet. See the appendix for other pictures of crystal radios.

You can imagine that the power of an incongruous device like this to actually bring in radio stations was intriguing to a seven-year-old. It was fascinating that a conductor hanging between two trees, a coil of wire, and this little crystal of lead sulfide could actually pluck radio broadcasts out of the air.

My choice to build a receiver employing such ancient technology as vacuum tubes and a regenerative detector hearkens back to my associations with that crystal radio. It had a lot to do inspiring my growing interest in radio and electronics. For our radio sculpture, I could have used modern transistors that take up so little space and use almost no power, compared to their grandparent vacuum tubes, but transistors are pea-sized objects whose inner workings are not visible. And I wanted to use a regenerative detector because it’s a circuit that revolutionized radio in its day. It teaches the user a number of lessons about radio’s technical aspects that are lost with modern detectors requiring no operator adjustments. I built the radio this way partly for nostalgia sake, because I’ve built a great deal of electronic equipment in my life, but nothing with vacuum tubes since about 1960. The older technology also provides a useful contrast to the modern versions, being just plain bigger and hence more visible. It makes the differences between the technological meanings of then and now so much more obvious.

Invisibility is an unfortunate aspect of today’s technology, at least when it comes to teaching anyone about it or provoking their interest. If you take apart your TV or your cell phone, or any other modern piece of electronic equipment, all you see are nearly microscopic little squares on a printed circuit board. Those little squares, which a friend of mine used to refer to as “integrated secrets,” are just that: secrets, at least as far as the lay observer is concerned. Each one of the caterpillars (as I’ve been known to call them) contains anywhere from scores to millions of individual transistors and other components arranged in highly complex circuits etched on microscopic slabs of silicon. In the case of computers, they’re unimaginably complex. As an electronic designer, I often don’t know exactly what the circuit in an IC (Integrated Circuit) consists of, only what signals should go into and come out of it.
You now may begin to understand why I harbor an attachment to old technology, where you can see every component and describe its individual function in the circuit, not to speak of actually being able to grasp it in your hand. If you look through the window in the top of our receiving sculpture, you can see the vacuum tubes that amplify the signals, those glass things, each with a faintly glowing orange filament, or “heater” at the top, the tuning capacitors, with interleaving parallel plates that move when you turn the PRESELECTOR or TUNING controls, the coils of fine wire that “resonate” with the capacitors to form the “tuned circuits” allowing the receiver to separate one signal from another. All the other components you can see here (with two exceptions) are discrete components, each with a single, clearly identifiable function.

It saddens me that nowadays, when a curious youngster tears apart a piece of electronic equipment, there’s nothing recognizable to see or explore. The parts are too small and inscrutable to invite experimentation, hence no opportunity is provided to learn anything about how the device works. Tuning capacitors, for example, are now tiny solid state devices, rather than interesting-looking gadgets with rotating, interleaved plates. In my radio sculpture, by the way, I confess that I cheated against vintage technological purity by using one of these solid-state capacitors in this circuit to accomplish the fine tuning. My excuse is that I didn’t have the proper component available, and because, if I had, fitting it in would have been difficult. The modern component, a varistor, is actually not a complex device, consisting only of a reverse-biased silicon diode, not really qualifying it as an integrated circuit. These have actually been in use since the 1960s, or earlier.

The other place I cheated on vintage purity in this radio was with the audio amplifier, which is a true integrated circuit, but a relatively simple one. I used it because I built the radio from a design by another radio amateur, Ron D’Eau Claire, call sign AC7AC, whose article describing it appeared in November, 2003 QST magazine. I didn’t want to take the time to design a tube-based audio amplifier to replace the amplifier IC in Ron’s circuit. I rationalized, in a radio serving partly as a history lesson, why not include the whole 20th century? I modified Ron’s original circuit in order to change its operating frequency, and to include fine-tuning appropriate to a receiver covering a larger frequency range than did the original. The mechanical design is entirely my own, since it was destined for a much different use than his version.

Our receiver uses another principle that Edwin Armstrong first incorporated into a receiver a few years after he invented the regenerative detector. This is heterodyning, a technique now employed in nearly all receivers of any sort. In the “superheterodyne” or “superhet” receiver a signal, generated by a tunable “local oscillator,” is mixed with the signal from the antenna. This generates signals at the mathematical sum and difference of the two frequencies. One of them, normally the difference signal, is amplified by a very high gain and high selectivity “intermediate frequency” (IF) amplifier before it is detected. In the case of our receiver, its regenerative detector serves simultaneously as an IF amplifier, providing much of the gain that a normal IF amplifier would, while using fewer components.

Unfortunately, regenerative detectors have a number of flaws, namely a tendency toward instability, when signals are too strong, and limited selectivity. They also generate an oscillation whose harmonics can mix with the local oscillator, creating phantom “spurious responses,” interfering signals that are generated within the receiver itself, and others that are picked up from parts of the spectrum where the receiver is not actually tuned. But the regenerative detector works well, considering its simplicity. For the purposes of a radio “sculpture,” the flaws are not a critical problem.

As I said earlier, two controls on this receiver, the preselector and the regeneration control, have, since the time such technology was current, either been automated or their need eliminated. Such simplification is common as technological devices are redesigned to accommodate mass marketing to lay
people who may not be interested in the more esoteric aspects of a particular technology. It’s natural
enough that this should occur, but for me it inevitably culminates in a loss of the intrigue I found in
equipment from an earlier age.

Older technologies, such as those in our receiver, typically demand for their operation a distinctly
different style of knowledge and skill than is required to operate, say, a modern push-button controlled
short-wave receiver. This receiver, for example, asks that you acquire just a little knowledge of the
principles of its operation, and it teaches you something, even if only unconsciously or intuitively, about
physical properties connected with amplifiers, oscillators, and resonance, to name three. You can liken it
exactly to the sort of physical knowledge required to operate the stick shift of a car with manual
transmission. Once you’ve learned to shift manually, the car teaches you something about momentum,
friction, gear ratios, braking, and so-on. You may not know exactly how a car with a manual shift works,
but you’ve internalized a great deal more intuitive knowledge about physics than does someone who has
never driven one. And so it is operating this receiver.

In other words, as technology becomes more automated and sophisticated, it tends to abstract the user
more from the intuitive, physically-based world. Operating machinery becomes dependent on rote
memory, rather than an intuitive body knowledge. For example, compare the process of manual drafting
to that of CAD (computer aided drafting). The latter forces you to intellectually memorize how to
accomplish simple acts like drawing a line, deleting it, erasing, etc, whereas when you draw by hand,
these tasks are elementary and intuitive. Furthermore, once you learn manual drafting, you don’t forget
how to do it over the next year or ten, even if you haven’t kept practicing.

For similar reasons, I find operating such “obsolete” technology as our receiving sculpture more intuitive
and more entertaining than, say, my high-tech digitally-tuned ham radio transceiver. When operating the
modern equipment, I still must consult the instruction manual at times to implement the operation of
some obscure function whose button-press sequence I’ve forgotten. Contrast that to the intuitive
knowledge, acquired at age 14, about how to operate a regeneration control. It’s not something I’d forget
any more than I’ve forgotten how to ride a bicycle. It’s the same story with a manual camera compared to
my modern digital one. Details of operating the latter are always subject to forgetfulness, while the older
camera is, ironically, simpler to use, even though it doesn’t automatically produce a good image without
a little basic real-world knowledge on the part of its operator.

The Dubious Benefits of “Progress”

If I’ve seemed to belabor these differences between old and new technology, it’s in order to bolster my
assertion that societal beliefs are deeply entwined with the way we apply technology, and that those
applications, in turn, tend to structure our lives in ways we rarely anticipate. An illustration of this is the
assumption we often make that automating equipment functions improves the equipment. It’s true that it
may simplify its operation, but the side-effect is often to eliminate operator skills and understanding that
might be better left intact. We so frequently focus our attention on what’s getting better with the
machinery rather than what’s getting worse about the lives of people using it.

Computers are a good example. Much ballyhoo is made about how computers increase our productivity,
yet studies indicate that we spend as much time fussing with the machinery as we used to spend getting
the tasks done that they supposedly help us with. I’m typing this material on a computer, of course,
inserting pictures that I shot myself with a digital camera, and illustrations drafted on another computer
program. All very nice, I think, unless I take into account the huge amount of time I’ve spent and the
expense I’ve incurred over fifteen years in order to assemble this system and learn enough to keep it
operating.
Forty years ago, I would have typed this by hand, or had a secretary (whose job has been eliminated) do so. Someone would have had to do the drafting of illustrations and shoot the pictures, process, print, and retouch them. Another person would have done a paste-up to include the pictures with the text, and then a printer would have had to print everything. Yes, I can do all that now myself, much faster. But jobs for at least four other people have been eliminated. Meanwhile, I’ve spent hours dealing with computers and software, etc, instead of developing more exhibits for Mindport. Personally, I find being self-sufficient this way satisfying, but I haven’t much enjoyed the 50% of my time spent in troubleshooting computers.

Of course, there’s always the option of hiring someone to deal with the computers, software, etc. But isn’t a society that provides jobs for skilled draftsmen, photographers, secretaries and printers richer and better off than one where many people’s lives are devoted to computer jobs, which are now being outsourced to foreign countries? I think it probably is. I’m sure the photographers, secretaries, and printers that are now unemployed or hustling fries at McDonald’s would agree.

So, lifestyle and belief determines the uses to which technology is put, and the technology, in turn, influences belief and lifestyle. As the traditional jobs disappear, and the skills are rolled into one rather dull skill, namely, operating a computer, the question arises, are we better off with company stockholders richer because the companies don’t have to “waste” money on things like employee benefits? When those workers end up on the street, have we really increased “efficiency?” Maybe human values should be factored into the efficiency equation. So far our unconscious assumption seems to be that any acknowledgment of workers’ needs or the importance of societal diversity is extraneous. Compared to the importance of corporate money-making efficiency, concessions to human values appears to be our last consideration. Technology, instead of living up to its glowing potential to improve the lot of humankind, seems inevitably to serve a minority of humans while it increasingly oppresses the rest.

From this one begins to ask whether most of our technological innovation is all it’s cracked up to be. Ostensibly, we’re saving time while increasing “productivity.” As I’ve argued, that’s questionable. If we’ve indeed saved time, what have we saved it for? Debugging computer viruses, playing video games, and watching TV, as too many people and their children do today? We rationalize our technology as being incredibly important, and it seems so obvious the gadgets confer wonderful advantages. But do they really? Are we having more fun now? Or was it more fun to string a wire up in a tree and listen at night to the home-built crystal radio set hidden under the bed? I’m biased, but I think video games and TV are deadly boring next to building things. And if it’s true that video games teach the skills necessary to soldiers fighting the automated wars of the future, then tell me, does skill at waging war confer more advantage to the world than the skill of building things? I don’t think so. Why aren’t we developing alternative power sources rather than fighting a war over oil? I have little doubt that we’d be far happier now if we’d somehow arrested all technical innovation in 1949, before TV became commercially viable, and had instead devoted our resources to the arts and to humanitarian causes, including social research.

Ham Radio- A Personal Technological Perspective

Having slyly slipped into a demonstration of technology’s political aspect, let me now back away from such complex and controversial subject matter and devote a few paragraphs to an area of radio endeavor I’ve myself been sporadically involved with since age 14, Amateur “Ham” Radio. It’s an avocation where the meanings associated with the use of technical equipment, ostensibly designed for efficient communication, are especially obvious, since those who use that equipment are forbidden by law to receive any compensation for their activities.

I’ll start with a slightly tongue-in-cheek observation having to do with the way some of us use technology: Since well before I first obtained my amateur radio license in 1958, communications
equipment has become more and more sophisticated. We’ve gone from receivers on the technical level you’re looking at here, which were operated in conjunction with a separate, often home-built transmitter, to lovely contemporary $10,000 transceivers, where both transmit and receive functions are rolled into one box. At the most extreme end, a transceiver of the several thousand dollar variety might have fifty or sixty buttons on its panel, a computer screen, and more functions than you can memorize in a lifetime.

Now, you might think that with such financial resources being plowed into incredibly sophisticated communication systems, hams would be talking over the air about some pretty important stuff. But, you know what? It’s seldom that you can get a ham to talk about anything but his equipment, your signal report, the weather at his location, and then . . . goodbye. Some hams take fifteen minutes to get through that last part. So what’s the point of a $10,000 transceiver? Love of gadgetry? Status?

I’ve puzzled about this. Some hams are definitely status conscious, and a transceiver like this can certainly be a status symbol. But there’s more to it than that. When I look deeply into some of my own past love of gadgetry for gadgetry’s sake, I realize that playing with intricate technology has something in common with playing video games. It’s a proxy relationship with the ghost of the gadget’s designer, inherent within the gadget’s design. There are transceivers available for a little over a thousand dollars that will allow you to communicate with virtually anyone that this one will. What they lack, though, are enough buttons. Each button and its accompanying function is a challenge provided by the designer. Your job is to struggle along until you’re completely fluent with all the buttons. Then you sell the gadget and buy one with a different ghost to struggle with. It makes you realize how many computer hackers are drawn to their craft out of a desire to pit themselves against Darth Vader Gates, the ghost in the Windows Operating System. It’s a game.

On the serious side, my personal interest in ham radio resurrected itself a couple years ago, after a twenty five year hiatus, brought about partly by sheer boredom with the mindlessness of on-the-air interactions. My interest was reawakened by an itch to play again with analog equipment, like receivers and transmitters. Twenty years of mucking about with computers and the Internet had made me appreciate how immediate worldwide radio communication seemed, compared to Internet access, where you’re at the mercy of Microsoft, Internet service providers, and accelerating obsolescence. The latter problem is hardly a factor with amateur radio equipment. You can still work the world with home-built radios fifty years old, and with a modicum of skill, you can do it just as well as you can with one of those $10,000 transceivers I mentioned earlier. In fact, some of the “vintage” equipment is worth more than it was when it was new.

In my ham radio activities, I’ve returned to the use of morse code (CW), which is a skill I find inherently satisfying to maintain. Sending and receiving code over the air induces a relaxed, meditative state. It’s a refreshingly simple activity, compared to combing through email spam in order to glean a few legitimate messages. A week ago I was tickled to read about a national TV show where experienced morse operators were pitted in speed against instant messaging cell phone enthusiasts. The CW ops won hands down!

Another ham activity of mine is operating very low power portable stations from remote locations. There’s a thrill that comes with contacting a station two thousand miles away with half the amount of power that it takes to light a night-light, while transmitting via an antenna consisting of a length of hookup wire thrown over a tree limb. Pretty efficient communication: 572 miles per watt. You can’t do that with a computer and email. It takes ten times that just to light the screen, not to speak of all the kilowatts that supply the servers through which your email passes.

I still find romantic pleasure in hearing weak signals coming from far-away places. The sound of a
distant CW signal takes on a characteristic quavery note that it gets from bouncing repeatedly through the layers of the ionosphere. Hearing this sound reminds me of getting up at 4 AM when I was fourteen years old, and shivering in front of my WWII surplus aircraft radio transmitter in order to make a few European contacts. Ham radio is a way of feeling in touch with an invisible, echoing physical space, quite unlike the manmade construct that we call “cyberspace.” Ham talk is still tedious much of the time, but occasionally, if you have the patience to do a lot of listening, you run across the rare character who is willing to “rag chew” for an hour or two.

Since my patience level is considerably higher than it was 27 years ago, when I commenced my leave of absence from Ham Radio, I’m more prone to forgive the bores and appreciate the aspects of the hobby that I still enjoy. Despite ways in which the avocation has been trivialized, there’s still a strong core of ham operators who devote themselves to public service and technical experimentation. It was amateurs who were responsible for a majority of the experimentation that made radio a viable form of communication in the first place, and who have made numerous technical contributions all along. One of these days, terrorist hackers, natural disaster, or simply an excess of corporate greed may hamper access to the Internet, and we’ll be reminded of how unwise we’ve been to become exclusively dependent on such a complex and vulnerable infrastructure. One catastrophic event that threatened its integrity would cast semi-neglected and less sophisticated technologies, like vintage-style radio communication, and traditional skills, not mediated by computers, into a new light.

You might consider the recent tsunami in Asia as a relatively short-lived catastrophe where modern hi-tech communication was eclipsed by older technology. After the event, much emergency radio traffic was passed by radio amateurs, and a great deal of it was sent in morse code, which can get through when conditions are too poor for voice communication. This calls into question the wisdom of lowering the code speed requirement for amateur licensing exams, as has occurred over the years. Some countries have eliminated the code requirement altogether, which has been proposed repeatedly in the US. This is just another instance where we seem to be forgetting that sometimes no-tech or low-tech is better than high-tech, and that certain human skills, now gradually being replaced by automation, could, under easily imaginable circumstances, turn out to be essential to our survival.

The Loss of Wonder

My recounting of personal radio history will hint at how this receiver/sculpture project has served to recapture for me a little of the magic radio and electronics had for me when I was a youngster. My temporary abandonment of ham radio was spurred in part by the novel distraction of solid-state electronics when they came on the scene in the late 50s. As integrated circuits came into vogue in the 60s, I was entranced by the power they conferred to create electronic systems of immense complexity and perfection, compared to what was possible with the large discrete components of the vacuum tube era. Next to that, ham radio lost its allure for a time. But years of immersion in digital circuitry, with its sameness and technical perfection, compounded by the constraints of practicing electronic craft for remuneration began to dampen my enthusiasm for sophisticated solid state electronics. It made me feel out of touch with those fundamental properties of electronics and physics that are inherent in basic macro-sized analog circuitry, not to speak of their esthetic associations, which had attracted me to the field in the first place.

It often seems to me that the world-at-large has undergone a parallel loss of wonder for the traditional attraction of science, math, and technology. You see it in the lackluster response of many young students to these subjects. The pioneers of radio and electronics, men like Edison, Tesla, De Forest, Armstrong, and Marconi were first drawn to the field by its inherent fascination, just as I was at age seven. Later, as the technology became mastered, elaborated, and ultimately commercialized, it was put to uses that had
nothing to do with the fascinations that attracted either me or its discoverers.

While many of those pioneers, notably Edison, embraced the profit that could be derived from their inventions, it’s clear that their initial dedication to their work was not driven by a craving for financial gain. In Edison’s case, his profit was turned largely to the purpose of developing more technology. Since those exciting days, the “mysteries” of radio waves echoing through space have been drummed out of our awareness, subverted to the purpose of propagating manipulative advertising messages to the ears of young listeners. It’s no surprise that the youngsters find the message far more intriguing than the medium. Which is to say, the idea of tearing apart a modern miniaturized TV has become far less attractive to them than soaking up the glitzy provocations flashing across its screen. This loss of enchantment is one of the unanticipated consequences of unhampered and mindless commercial exploitation of a technology that once promised much more.

Speaking of the “mystery” of radio waves, their propagation... and of space itself, I’m reminded of a scientist friend who hates to hear that word, “mystery” applied to aspects of the physical universe. Another scientist said something like this: “There are no mysteries, only principles that have yet to be explained.” I disagree. I fervently hope we never manage to explain everything, and I’m fairly certain that we won’t, at least not while thinking within our current belief system. I maintain that, for all we’ve learned of physics, we still don’t know exactly what electrons are, what radio waves are, or even what space is. I was drawn to my life-long interest in science by my early curiosity over the attraction and repulsion of magnets. The invisibility of the force between them implied the existence of an invisible universe full of surprises, of which I craved and still crave to know more. The physical world, whether we acknowledge it or not, is still a mystery, and, as much as anything, I regard the electronic sculpture before you as a shrine to that mystery.

While we’re speaking of shrines, take a look at this radio from the Spark Museum. I don’t believe its cathedral shape was an accident, but suspect it was an expression of the reverence people felt for this novel device that put them in touch with the outside world. At least it was an expression of how the designer of the radio wanted them to view it. In any case, I feel an empathy with that sentiment in recalling another early experience of mine, tuning the short-wave bands on my grandfather’s radio, an ornate four-foot high console that projected a similar aura to the one on the left.

My construction of our sculpture/radio also re-kindled a half-forgotten interest in foreign short-wave broadcasting. In the process of getting the radio to work properly I had occasion to do more listening to the international short-wave bands than I’d done in years. I was reminded that short-wave listening is a means to hear news of the world that has not been filtered through the censoring mechanism of our domestic, corporately-controlled media. Short wave listening is not plagued by all the technological impediments associated with the Internet. With simple equipment, you can listen to broadcasts that include opinions from much different perspectives than you commonly hear on local radio, especially if you are fortunate enough to be fluent in a foreign language.

During the past few pages I’ve touched on some of the general ways in which technical function is inextricably associated with meaning. You may have begun to see that this radio/sculpture is an artifact rich with personal meaning and association beyond its technical function. It receives short-wave stations, but it also calls attention to radio as a unique materialization brought about by the intersection between a
physical and a social universe.

The photos I’ve included of antique radio equipment should make it clear how physically “functional” equipment betrays much about the esthetics and beliefs current at the time of its creation. The shape of the vacuum tube in the transmitter pictured to the left (also from The Spark Museum) identifies its era, within a few years. The neatness and rectilinear style of construction tells you something about the painstaking character of the person, doubtless a man, who built it, and the fact that he had a certain reverence toward the idea of transmitting radio waves into the ether. Contrast it to the picture of the one-tube regenerative receiver on page 10. The latter was built at time when radio was much more taken for granted, and probably by someone more interested in conventional function than in esthetics, as would have been true of many radio hobbyists during that period of history. These are functional devices, but clearly esthetic statements as well.

The radio in the adjacent picture is an ultimate expression of how function, meaning, and esthetics are intertwined, and the kind of statement they make about the era in which they are created. To my eye, it’s one of the homeliest looking pieces of technology I’ve ever seen, especially next to most of the antique equipment whose photos have accompanied it. But I’m speaking from the point of view of someone who admires handmade craftsmanship and the clean, functional esthetic of scientific instrumentation over equipment glitzed up to fit some manipulative commercial idea of “cool.” The image of this Motorola table model radio was downloaded from the website of Camil Mujaber, a builder and collector of radio receivers from Lebanon. It’s well worth visiting Mr. Mujaber’s site, www.midcenturyradios.com, to see his radio collection, along with pictures of some of the fine receivers he’s built himself.
Appendix

More antique radios from the American Museum of Radio and Electricity in Bellingham:

An assortment of crystal radio receivers

De Forest experimental crystal radio, 1922

More sophisticated crystal radios

A beautifully made Atwater Kent radio, vintage 1922
Glossary, including Abbreviations

Alternating Current (AC)- A current that continuously reverses itself, flowing back and forth through the circuit. The wall sockets in your house supply AC current.

Amplification- Increasing the strength (amplitude) of a signal. Sometimes referred to as Gain.

Amplifier- a circuit or device that provides amplification.

Antenna- A wire conductor suspended in the air for the purpose of transmitting or receiving radio waves.

Audio Frequency (AF)- Refers to alternating current that reverses itself at an audible rate, between 20 and 20,000 Hz

Bias- The voltage applied to the elements of a transistor or vacuum tube.

Capacitor- An electronic device consisting of parallel plates with an insulator (sometimes air) between them that has the ability to store electronic charge. Signified by the symbol C.

Carrier- The RF signal radiated from an antenna that carries intelligence through space.

Conductor- A material that allows the passage of electricity.

Crystal Radio- An early radio that used a semiconducting crystal of galena (lead sulfide) or silica to demodulate a Radio Frequency carrier.

Current- A flow of electrons. Similar to a water current.

Detection, also called Demodulation- The process of separating intelligence from an RF carrier and restoring it to a useable form.

Diode- A two terminal device, which can be either solid-state or vacuum tube, that usually serves as a rectifier, but may be employed for other functions, such as a voltage-controlled capacitor.

Direct Current (DC)- A current that flows in one direction only, like your car battery or a flashlight battery.

Electron- The most fundamental, negatively charged particle of electricity that forms an electric current when it moves through a conductor, semiconductor, or vacuum tube.

Frequency- The number of times per second that an Alternating Current reverses itself. Measured in Hertz, Kilohertz, Megahertz, Gigahertz. Respectively, 1, 1000, 1 million, 1000 million times per second. Abbreviation Hz, Khz, Mhz, Ghz.

Galena- Lead sulfide, used in crystal detectors.

Ground- A connection to the earth, usually to provide an electrical counterbalance to an antenna.

Heterodyne. Superheterodyne. Heterodyning is the process of mixing two frequencies in order to generate sum and difference frequencies of the two. A Superheterodyne is a receiver that makes use of
the heterodyne principle.

Inductor- An electronic device consisting of a coil of wire that stores electrical energy in the form of a magnetic field. An inductance is signified by the symbol L.

Integrated Circuit (IC)- A device in which many transistors and other components are etched onto tiny silicon wafers so that they form complete self-contained circuits.

Intermediate Frequency (IF). Used in reference to an Intermediate Frequency (IF) amplifier, which normally amplifies the difference signal from the mixing process in a Superheterodyne receiver.

Modulation- The process of impressing intelligence, such as Audio Frequency voice or music onto an RF carrier.

Oscillation- A condition that occurs in an amplifying system when enough signal from its output becomes coupled to its input to cause a self-sustaining pulsation in its external circuit. The “squawk” that you hear when the volume of a public address system is turned up so high that feedback occurs through its microphone is a form of oscillation.

Oscillator- A circuit specifically designed to oscillate, usually providing the signal source for a transmitter, or heterodyning signal for a receiver.

Preselector- A control that operates a tuned circuit at the input of a radio receiver. Also may refer to a Radio Frequency amplifier which serves as the first stage of a receiver.

Radio Frequency (RF)- Refers to alternating current that reverses itself at a rate well above audio. Generally anything above 30 Khz is considered to be RF.

Rectifier, rectification. A device that allows current to flow through it in only one direction. Rectification is using a rectifier to change Alternating Current to Direct Current. Detection involves rectification of an RF signal.

Regeneration- A process whereby a portion of an amplified signal is reapplied to the amplifier input, resulting in a great increase of amplification, and oscillation if the feedback is great enough.

Resistor- An electronic component the resists the flow of current.

Resonate, Resonance. Resonance means that a system is vibrating in lock step with an outside frequency source. When a receiver is tuned to resonance with a transmitter, it can accept the signals being transmitted. When two systems vibrate in lock step, they resonate with each other.

Semiconductor- A material, often formed of silica, that conducts electricity under select circumstances.

Signal- Any sort of electronically mediated intelligence to be conveyed or processed by electronic circuitry, or via a wireless system. This can be an audio signal, an RF signal, a carrier signal, a video signal, etc.

Solid State- A generic term applied to any semiconducting electronic device or circuit not depending on vacuum tubes for its operation.
Transistor- A device, usually composed of silicon, that can provide amplification.

Tuning- The process of adjusting a circuit to resonate at a certain frequency, thereby augmenting signals from that frequency and eliminating signals from other frequencies.

Tuned Circuit- A circuit, usually consisting of a capacitor operating in conjunction with an inductor that selectively allows a single band of frequencies to pass, while blocking others. Tuned circuits can also block one frequency while passing the rest.

Single Sideband (SSB)- A type of Amplitude Modulation in which the carrier and one “sideband” are eliminated. This allows about four voice signals to occupy the spectrum space normally taken up by one standard AM signal. To demodulate SSB, the carrier is reinserted at the receiver.

Vacuum Tube- An active (opposite of “passive” devices like resistors, inductors, or capacitors) electronic device widely in use previous to 1970. It uses a heated cathode emitting electrons that flow through a vacuum toward a positively charged electrode called the “plate.” Intervening “grid” electrodes control the flow of electrons, providing amplification. Vacuum tubes can perform a number of other functions beside amplification, such as rectification, and regulation.

Variable capacitor- A capacitor with adjustable, interleaving plates used to adjust the frequency of a tuned circuit.

Wavelength- The distance between two “peaks” of a Radio Frequency signal radiating through space. Divide 300 by the wavelength in meters to get approximate frequency in Megahertz, Divide 300 by the frequency in Megahertz to get the approximate wavelength in meters.