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Working cranes in HO scale
Part 2

BY DR. GEOFF BUNZA

Photos by the author

Follow along, step-by-step!

More animated cranes for your layout ...

IN PART 1 I SHOWED YOU HOW TO BUILD THE first two out of four working cranes. This month I will show you how to build the final two mobile crane projects with cranes on caterpillar treads and show how you can put them on your layout using two different control methods: one with in-the-layout wire-guided control, and the other using wireless remote control.

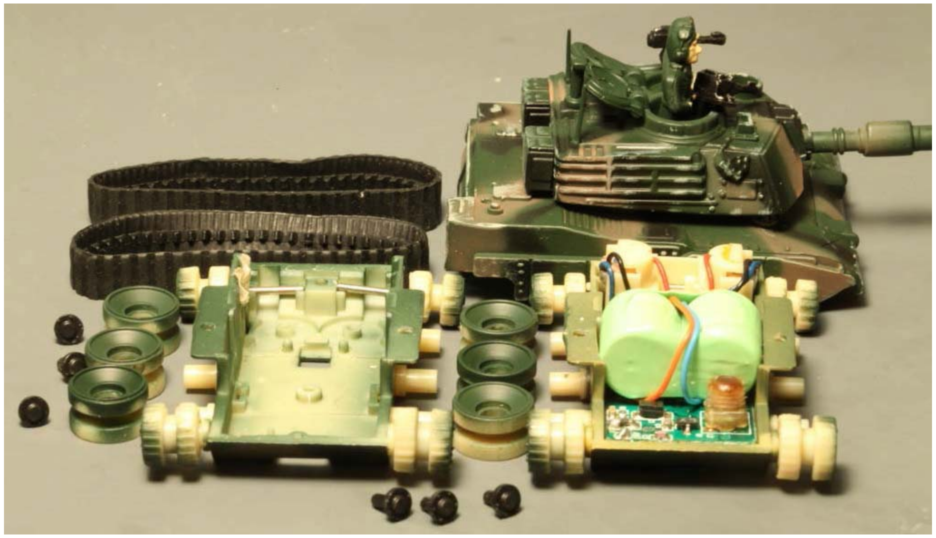
Building a working crawler crane (Crane #2)

While the "simple" truck cranes #18 and #19 work great for gathering attention, I wanted to tackle even more interesting and challenging models – mobile cranes with caterpillar treads.

Click here for reader comments

STEP 1: Gather the parts

54. A stock 25-ton railroad crane.



55. The RC mini-tank used for the chassis of the crane.

For crane #2 (and the next one, crane #3) I used the Walthers/ TrainMiniature/ TrueScale/ AmericanFlyer 25-ton crane cab and boom. I mounted these cranes on a heavily reworked set of caterpillar treads from a remote-controlled (RC) mini-tank (any of several brands will work).

I originally purchased this remote controlled tank years ago locally from Fry's, but they have been available for a long time on eBay. Search for "mini RC tank" identifiable by the 5-wheel tracked drives, less than 3" in length.

I was hoping I could use the motors, geared drives, and perhaps even the RC controller, but I ended up scrapping them all. The RC control was full-on/full-off, and limited to two channels, so I abandoned ideas of using it as built. I also found the gearboxes to be unreliable, so I set those aside also.

STEP 2: Prepare the chassis mechanism

The rollers are too large straight out of the box, so I turned them down on a lathe. If you don't have a lathe, they can also be chucked in a drill and filed or sanded to size. I reduced the middle rollers to about the same size as the end wheels.

This left the tracks with less tension on the rear drive wheel. So I made a cut in the side behind the front sprocket down to the floor without cutting the floor. I bent the front sprocket, axles and side walls forward to make a "V" in the side walls [57]. I cut a piece of 0.010" sheet styrene to fit, and glued each to hold the side wall in place.

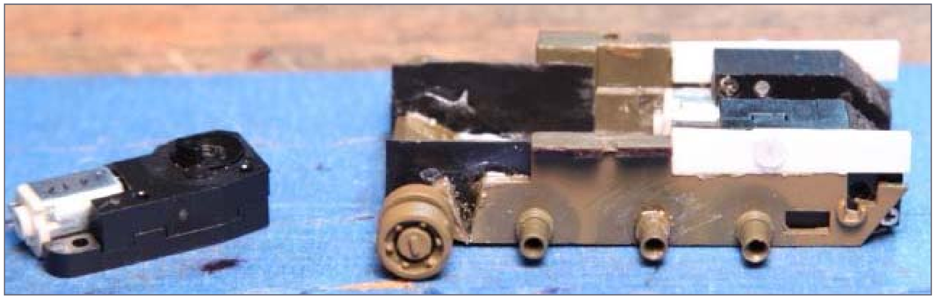
This also leveled the rollers and sprockets for a more realistic look, and allowed for the proper tension for the track drive. The operating rubber caterpillar treads are the only piece of the model that I haven't succeeded in building from scratch to my satisfaction, although I've gotten close with liquid latex and tissue paper.

I built up the sides of the tank with strips of 0.040" plastic to form a level mount for the crane cab. I used the right-hand drive motors on Truck Crane 18 here in pairs.

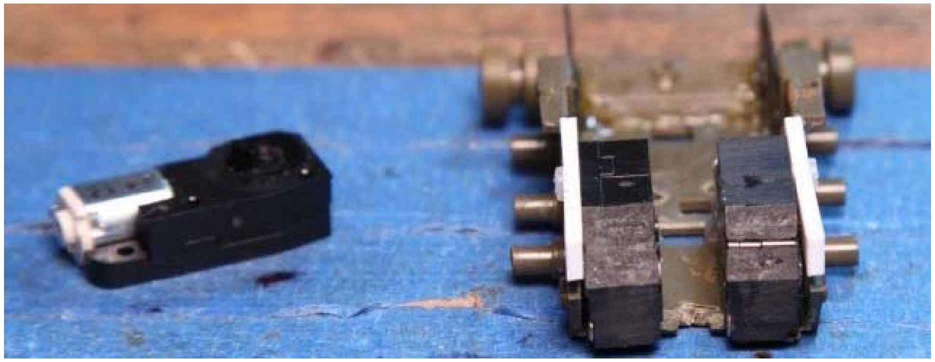
First I cut, trimmed, and sanded the motor gearbox as much as possible, including beveling the corner near the last drive gear. I tried not to destroy the integrity of the case, nor to damage any of the gears. It took several tries for me to finally trim things down to my satisfaction without damaging the case or gears! After shaping the cases, take the gearbox apart.

Warning: That the tiny black screw holding the last drive gear in place is a left-hand screw – to remove it turn it *clockwise.*

56. A stock roller on the left compares to a roller on the right that has been reduced in size.



57. Chassis side-wall preparation for the motor drives.



58. Mount the drives square to the chassis.

STEP 2: PREPARE THE CHASSIS MECHANISM

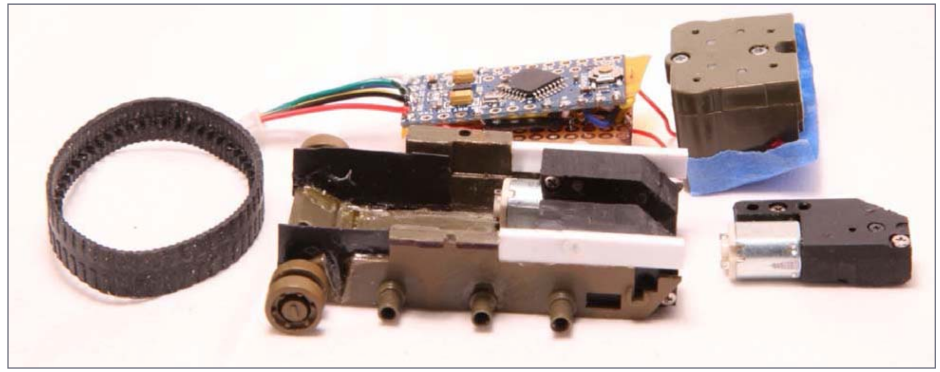
CONTINUED ...

I cleaned off all the grease and re-greased the mechanism with a high-quality lubricant like Nano-Oil (great stuff). The center of the last drive gear needs to be drilled for a friction-fit of the axle to the drive wheel axle for the treads.

Measure the diameter of the axle and use a smaller drill size than your measurement. These axles are not a standard size; mine were 1.5mm, so you will have to make your own measurement. I started with an obviously smaller drill and worked my way up until I got a good fit. Don't insert the axle all the way in yet.

One of the holes can be tapped for a 0-80 screw (mentioned previously) and used to mount each of the drives. I depend on the track and the motor mount to hold the gear and axle in place. It is important that the motor housings be mounted straight and vertical. File and sand the inside floor of the tank, and then reinforce the inside wall with some thin styrene sheet cut to fit.

I recommend attaching the motor wires before installing the motors. Again I used very fine wire—28 gauge or finer. After attaching the motors to the inside wall, I inserted the drive wheels/axles and tested the tracks. Each track should have enough tension to turn easily under power, and remain in place. The roller wheels help keep the tracks in place too. I also spent time correcting any alignment issues; it saved a lot of grief later.



59. Chassis parts.

STEP 3: Mount the cab on the tread chassis

I mounted the crane cab to the track chassis with two flat-head screws through the holes in the chassis tabs next to the motors. I glued thick plastic strips to the bottom of the crane cab and filed them to form an even surface to join to the chassis.

The chassis I used were of differing sizes. I cut and fit until it worked. By now you should be able to mount a cab to the unfinished chassis, with fully tracked caterpillar treads.

60. (Above) Level the cab bottom by filling in the raised portion under the door and window.

61. (Left) The cab has been mounted on the chassis with full caterpillar treads.

STEP 4: Build the guidance system

To understand how this crane travels where intended, you need to understand a great little sensor called a Hall Effect Device.

The Hall Effect sensor is likely known to some, but perhaps not to most modelers. It is a three terminal device. In this case, it is powered by 3.5 Volts. There are two connections: plus (+) and minus (-).

The two types I use are the AH180-PL-A (the one with leads) and the TCS20DLRLF the surface-mount device (SMD). I show both in [63].

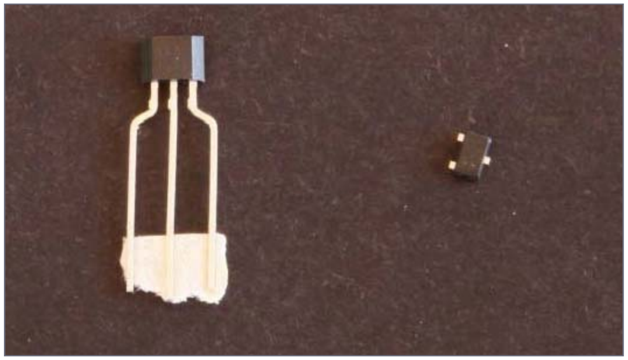
The AH180-PL-A can be powered with 5 Volts. It has a single output pin that will pull the line low (connect it to +3.5 to 5 Volts through a 4.7K resistor) when it detects a magnetic field – so it's a magnetic switch. Big deal you say? Maybe, but consider the possibilities. These switches can be turned on by incredibly small magnets.

Digikey.com and Mouser.com are good sources for all sorts of Hall Effect sensors. Be careful though; there are several variations. Look for the one with an "omnipole" characteristic. This will activate with either the north or south pole of a magnet, which is the kind I used.

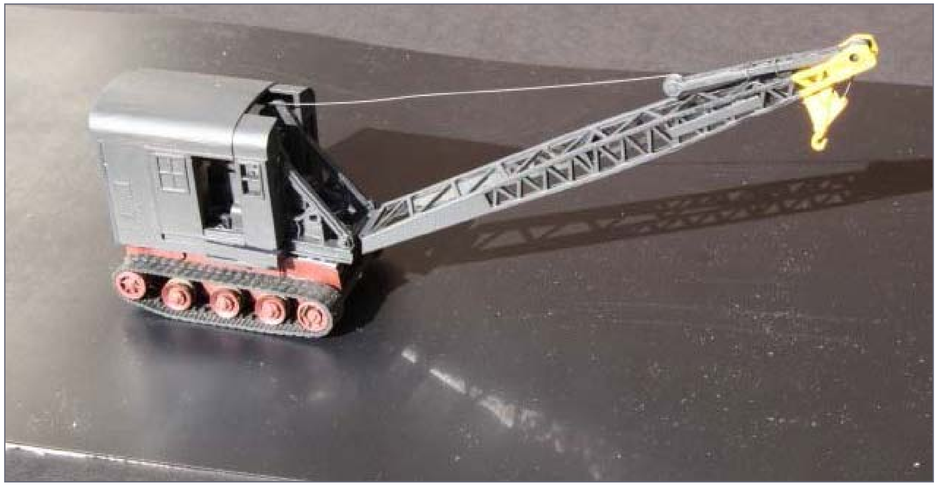
Either of these will react (turn on) in the presence of a magnetic field. They switch on when a magnet is near and switch off when the magnet goes away: very simple. Now for the best part – you can obtain tiny rare earth (incredibly strong) magnets from many sources, including online vendors.

STEP 4: BUILD THE GUIDANCE SYSTEM CONTINUED ...

62. The shoe that guides the crane can be seen between the tracks.



63. AH180-PL-A left and TCS20DL-RLF right.



64. Wire guided crane ready to go to work.

65. Embedded wire in the foamcore base guides the crane on its route.

I insert an iron/steel/ferrous wire along the path of travel I want for the crane, much like the Faller car system (a great innovation in my opinion). I make a cut in the foamcore sub-roadbed I used and inserted the wire just below the surface [65].

STEP 4: Build the guidance system *Continued ...*

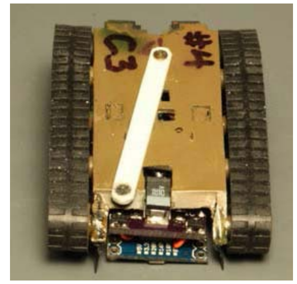
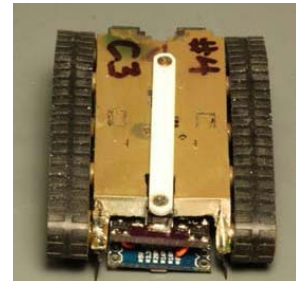
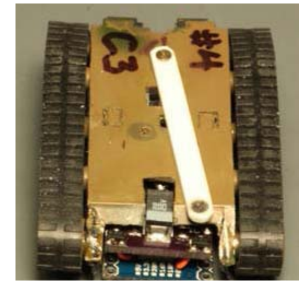
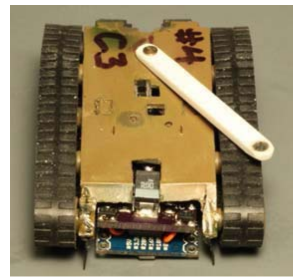
I started with an old wire coat hanger, and it worked great. In the model shipbuilding section of hobby stores, I found black, annealed spools of wire. Be aware some may not be attracted to a magnet, so take a small magnet along with you when you look for them. I found these in 19 gauge, 21 gauge, and 24 gauge. All work, but in this case bigger is better (smaller gauge number).

I made the "shoe" [66] on the bottom of the crane from a small piece of styrene that freely pivots on one end via an 0-80 screw. The shoe is dragged from side to side as the crane moves along the embedded wire under the plastic top. I inserted two brass 0.020" wires as stops to limit the side-to-side travel of the shoe. The magnetic shoe is tapered on the front so it can go over mildly uneven surfaces.

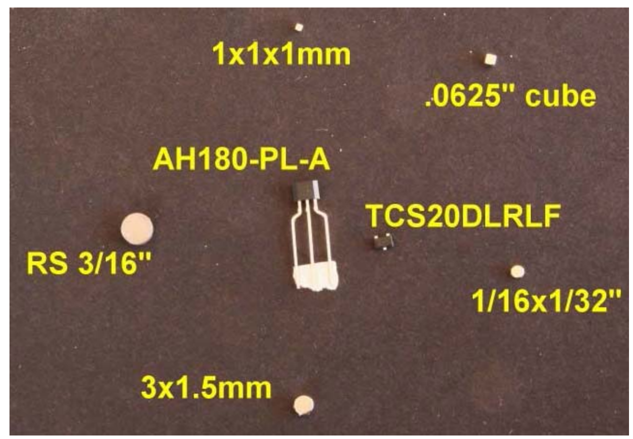
The wire in the roadbed carries no electrical signals, and there are no special markings whatsoever on the surface. But in the crane chassis above the shoe on each left and right side, there are two Hall Effect devices, TCS20DLRLF.

When the crane deviates from the course set by the wire below, the shoe moves under one sensor, the sensor turns on, and the controller in the crane detects the change, and simply drives the treads to turn until the sensor switches off. All very neat and simple.

This is a very simple variation of a "line-following algorithm" used by all kinds of robots.

66a-d. Magnet in shoe on the bottom of the crane.



67. Hall Effect magnetic sensor parts.

68. Magnet sticks used to guide the crane.

STEP 4: Build the guidance system *Continued...*

It should be clear that there is no mechanical linkage as in the Faller car system for steering. A mechanical linkage isn't appropriate for a tracked vehicle anyway.

What happens in turning is really interesting. I laid out the first course as a decreasing-radius spiral following several "wiggles" left and right. This was an attempt to measure how sharp a radius the crane could take. Originally, it turned by stopping one track and driving the other to pivot around the stopped track. This worked, but on the decreasing-radius turn, it eventually went off course.

But a tread crawler can pivot in place by driving one track forward and the other backward – so why not here, too?

This method yields an amazing capability to (almost) make a 90 degree turn following the embedded wire. The modeling intent is to navigate through a forest, city streets, or a quarry. The treads also allow it to climb very easily.

In [68], all of the magnets shown are incredibly small and cheap. Other than the Radio Shack (RS) magnet, I purchased them from different sources like K&J Magnetics (kjmagnetics.com) and eBay. The bigger and stronger the magnet, the greater the distance away from the sensor it can be and still work.

If you have a moving apparatus, say a turntable, you can detect multiple positions with one sensor by secreting tiny magnets at all track alignments, with no mechanical connections or contacts – pretty neat if you think about it. You can glue one of each type magnet to a small stick and use the stick to determine the orientation of the magnet (pole position) and pick up the tiny magnets before they "launch" off your workbench!

STEP 5: INSTALL THE CONTROLLER

The controller in the wire-guided crane is a cheap Arduino Pro Mini controlling the two motors with an SN754410 dual H-Bridge integrated circuit [69]. I originally wired the little board by hand. It took quite a bit of fiddling to get the board to fit with the correct positioning of the tiny Hall Effect sensors.

The sensors must be just above the small (1.5x3mm) magnet in the shoe to work correctly, and as low in the chassis as possible. In the additional materials with this article is a printed circuit board (.brd) file and the accompanying Eagle schematic. With no foreknowledge, you can go online to OSH Park (oshpark.com), create an account, upload the .brd file, and get your own tiny driver board made (three for about $3.15) to save you some effort. This little board needs:

1 - SN754410 Dual H-bridge driver Digikey.com part #296-9911-5-ND
2 - 22 uf SMD capacitors Digikey.com part #399-3781-1-ND

2 - A1202LH Hall Effect sensors Digikey.com part #AH180-WGDIDKR-ND
(This is the surface mount type)

The driver board is laid out with provision for socketing or soldering directly to the Pro Mini. I found cutting and shaping the chassis bottom to be required to fit the pair, but you may prefer the printed circuit board to wiring your own and fiddling with the tiny sensors. Either way, you'll need some custom fitting and filing to make this work. You need to

tack-solder thin wire leads to pins 3 and 6, and 11 and 14 for the motor connections. Use the thinnest wire you can find. I used 30 gauge wire-wrap wire.

Also in the additional materials you will find the Arduino sketch (program) that is ready to load into your wire-guided crane controller. You can find an introductory tutorial on loading your Pro Mini in the November 2014 issue of Model Railroad Hobbyist "Starting from Scratch with an Arduino Pro Mini (or Moteino)." (mrhpub.com/2014-11-nov/land/#83).

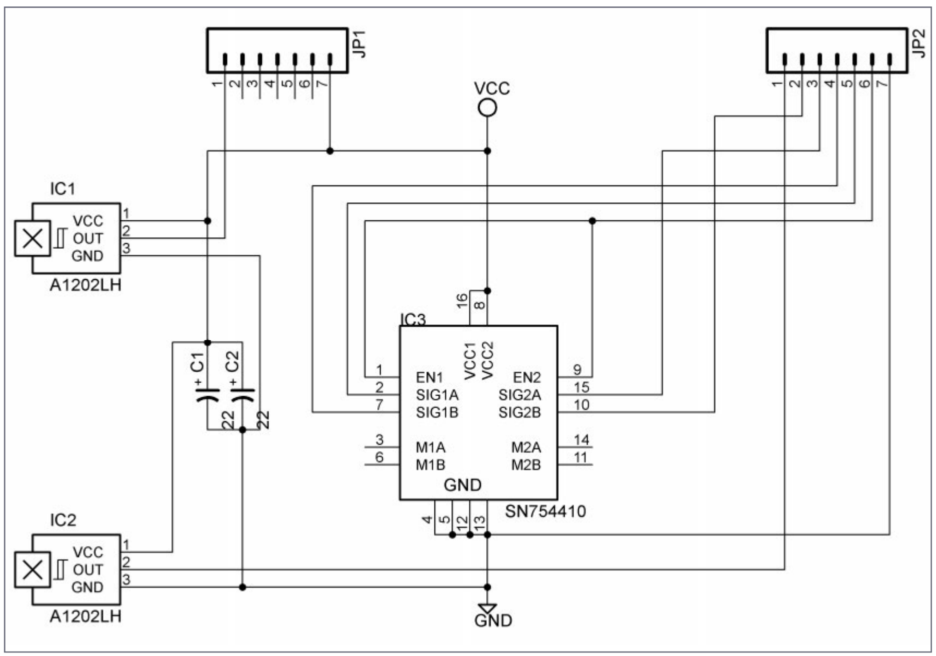
The sketch will move the crane along the wire path and stop every so often at random. In this way the battery life is extended and it makes an interesting animation of its own. This crane ran for several hours by itself on a full battery charge; your mileage may vary!

I used two 240 MAH LiPo batteries, each equipped with its own battery-management board. The batteries are wired in parallel (plus-to-plus, minus-to-minus) and are charged simultaneously only with a compatible LiPo charger. An ElectriFly Triton battery charger is more than capable in this case. The batteries connect directly to a tiny slide switch mounted above a small hole in the bottom of the chassis. You can see it in the rightmost figure [66] of the magnet "shoes."

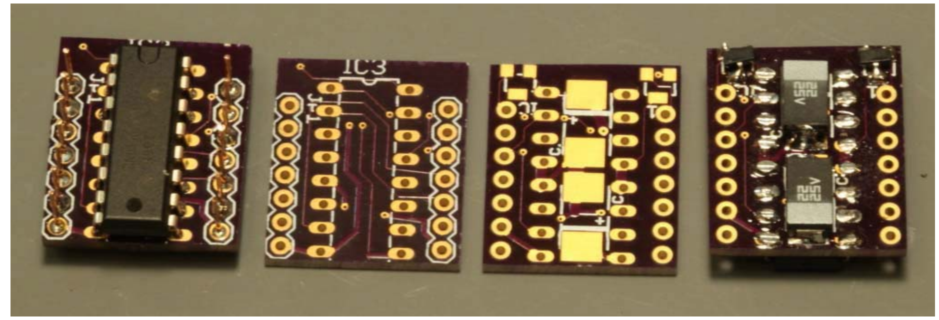
From the switch the power connects directly to VCC or +5V on the Arduino Pro Mini. Originally, I placed two motor drives in the cab for the boom and hook, but never powered them – another project to complete. It will require another

STEP 5: Install the controller *Continued ...*

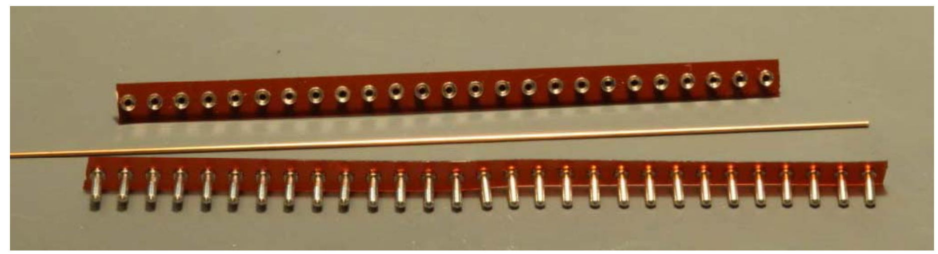
motor drive board, and that would make for a tight fit in the cab. Originally, I had to take the cab off to recharge the batteries, which proved to be a bad idea. I added a tiny connector [80] and cabled it directly to the batteries to allow recharging without disassembly. I switched off the power, and connected the battery charger to the tiny connector for recharging.



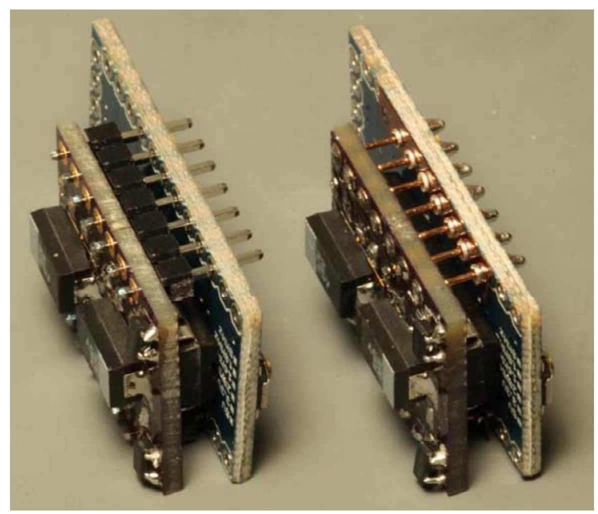
69. Dual motor driver schematic.



70. Dual motor driver PC board.

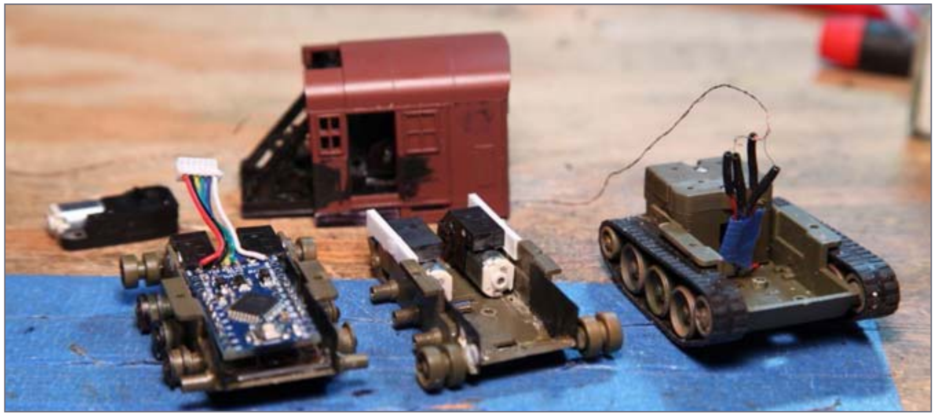


71. Sockets and 0.020" wire.

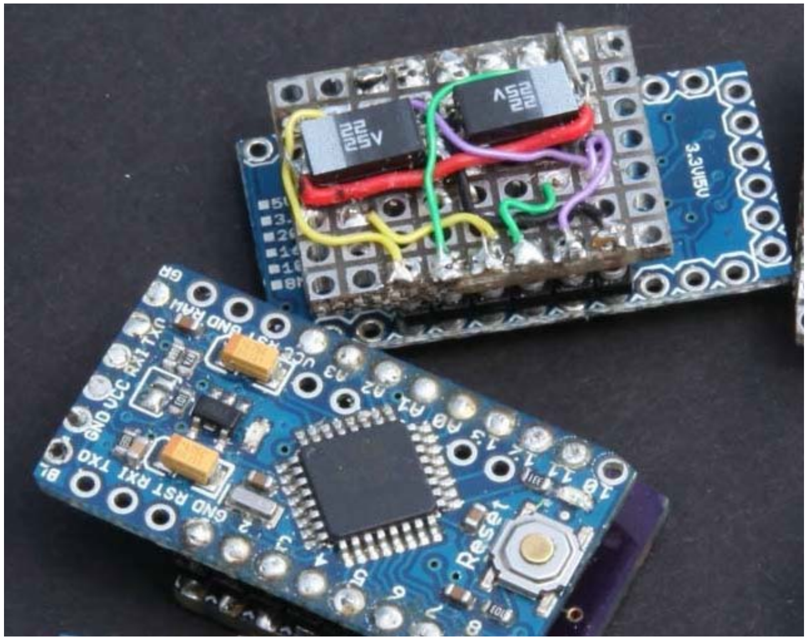


72. Motor driver attachment alternatives.

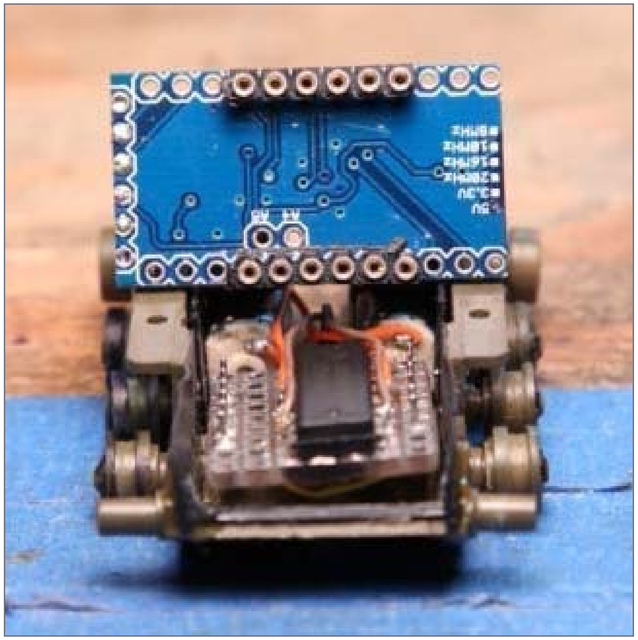
STEP 5: Install the controller *Continued ...*



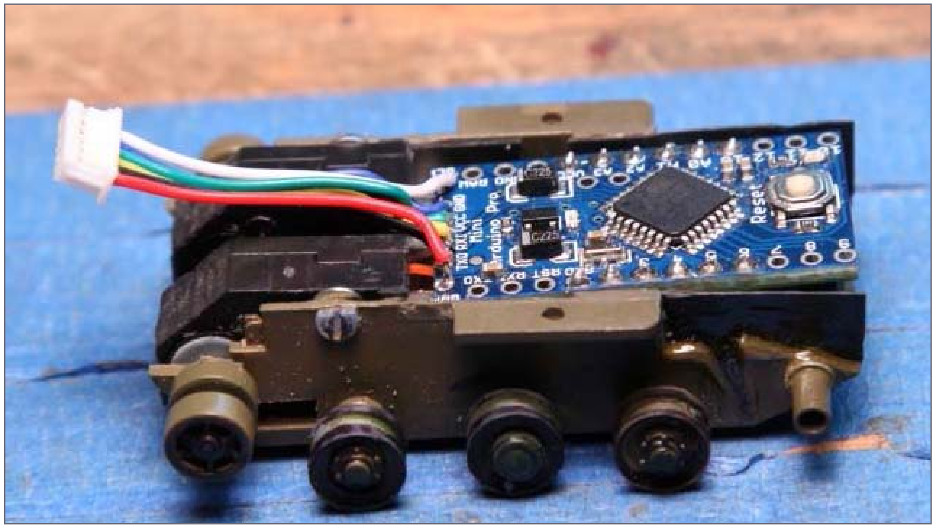
73. Progression of chassis construction.



74. Hand-built driver board.

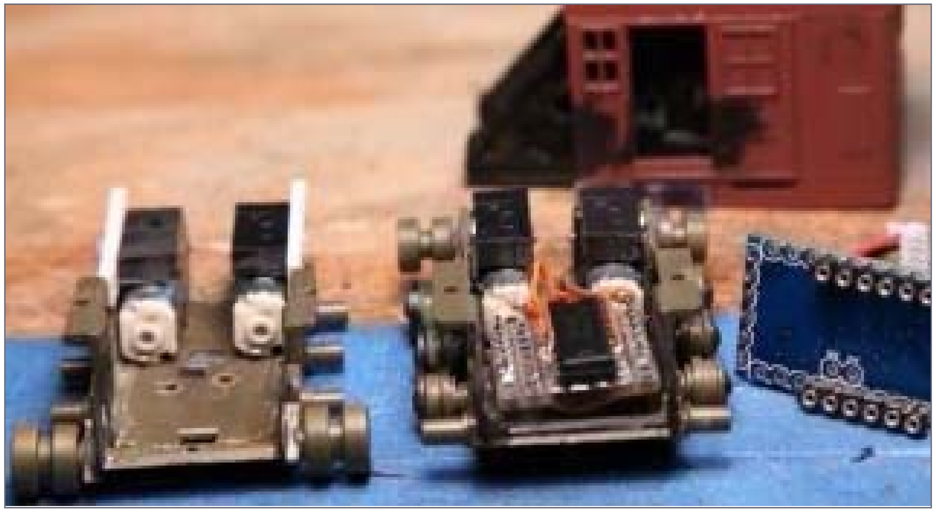


75. Hand-built driver placement in the chassis.

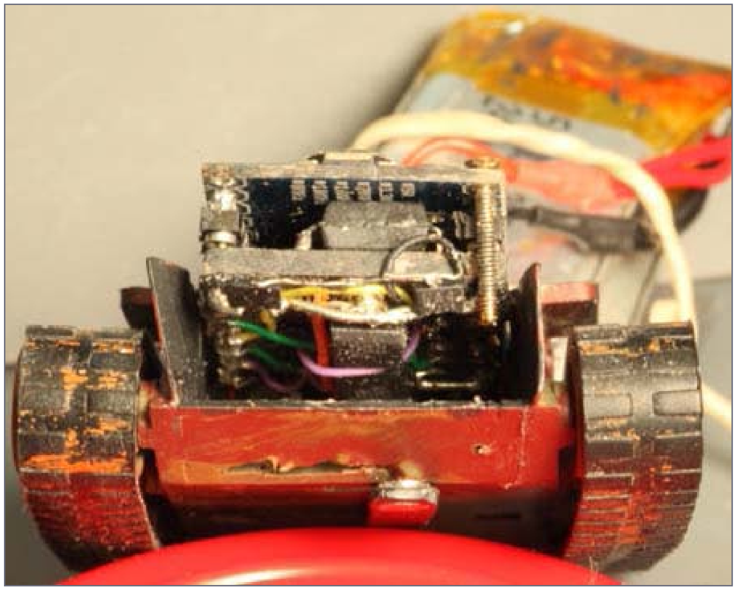


76. Progression of chassis construction.

STEP 5: Install the controller *Continued ...*



77. Assembly steps.

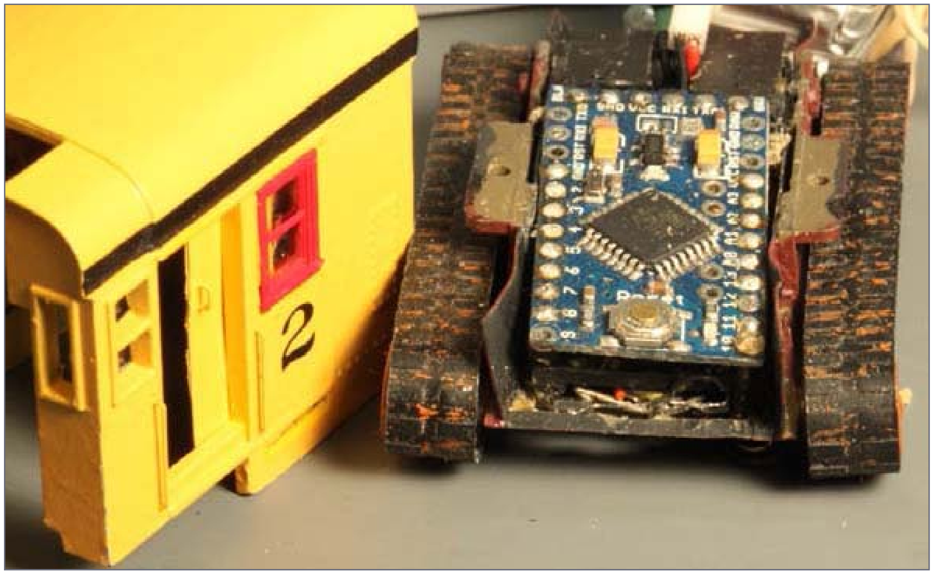


78. Sensors below the board.

STEP 6: Finish crane #2

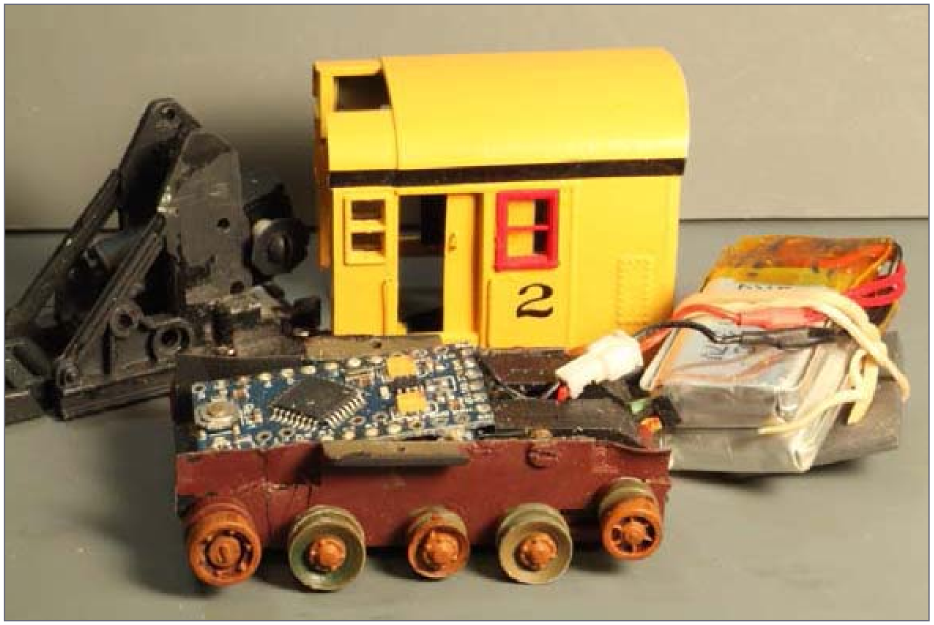
I cut out the rear cab window openings and modified Tichy work car windows that I added and glazed. I also added an inside sliding door in a partly open position along with roof access ladders placed on each side.

I enclosed the chassis front with styrene strips, and placed an air tank in the front. I muddied the caterpillar tread tracks with appropriate colors, but I haven't decided how badly weathered the crane will be yet.



79. Pro Mini and sensor mounting in the chassis.

STEP 6: FINISH CRANE #2 *CONTINUED ...*



80. The cab is ready to be mounted.

81. Finished crawler crane 2.

Building a remote crawler crane (Crane #3)

The last member of my animated crane set is almost identical to the mobile tracked crane #2, but is radio-controlled, and has an operable hook and light. I equipped this crane with a Moteino (lowpowerlab.com/moteino), an Arduino-like controller with a radio transceiver (transmitter-receiver). This is the same device used in the remote-controlled battery locomotives described in the November 2014 Model Railroad Hobbyist (mrhpub.com/2014-11-nov/land/#83).

I followed the same caterpillar tread motor and chassis construction methods from the previous model, crane #2. However, I located all the electronics in the cab, not the chassis.

Because crane #3 construction is so similar to crane #2, I'm only going to focus on the steps in this animated crane project that are unique to building a radio-controlled animated model.

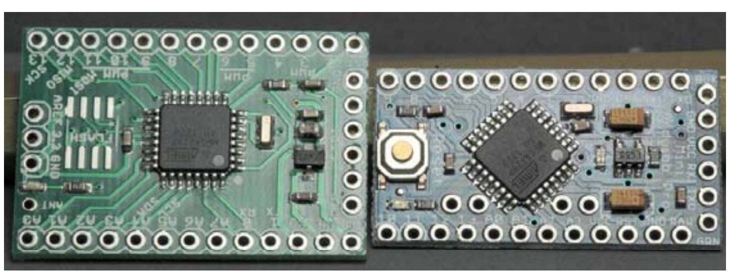
STEP 1: Prepare the electronics

All the electronics are hand-wired on a small perf board incorporating two SN754410 Dual H-bridge drivers. I used Digikey.com part #296- 9911-5-ND to control the three crane motors that provide the animation.

Tiny wire connectors from LedBaron (stores.eBay.com/ledbaron) are used to make assembly/disassembly easier. I used similar connectors for the battery charger connection. I stacked and glued two three-pin connectors to connect to the six programming pins on the Moteino. This makes reprogramming easier.

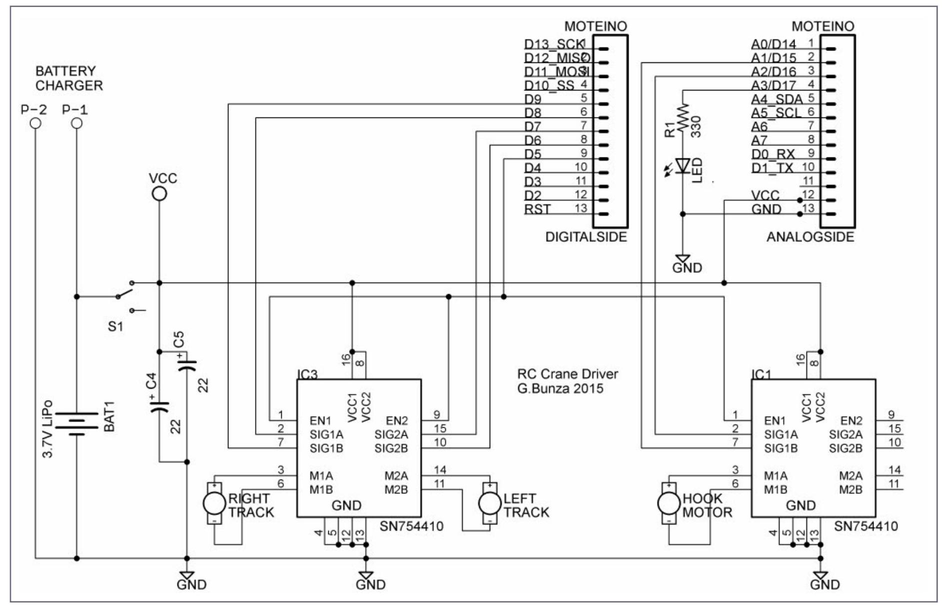
I selected the same LiPo batteries that I used in the previous mobile crane. However, I placed only one hoist drive, using the right-angle drive motor, forward into the cab to move the hook. I equipped this crane with a larger, heavier hook, Athearn part #17017.

I added a work light, an 0603 white LED, to the roof of the cab with a Cal-Scale #190-304 headlight casting. The crane cab has the same paint and detail as the previous crane, but I assigned a different company number. I placed a small "Radio Equipped" sign above the window – sorry, I couldn't resist!



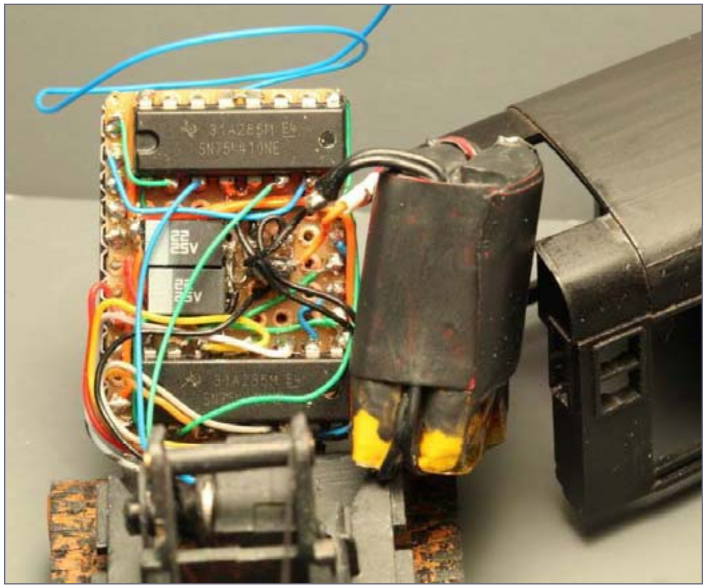
82. Arduino Pro Mini (right) vs. Moteino (left), top view.

83. Arduino Pro Mini (left) vs. Moteino (right), bottom view.

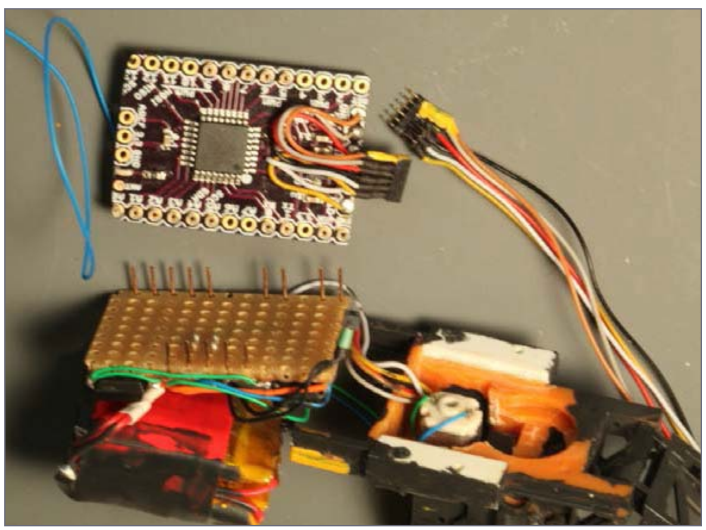


84. Crawler crane schematic.

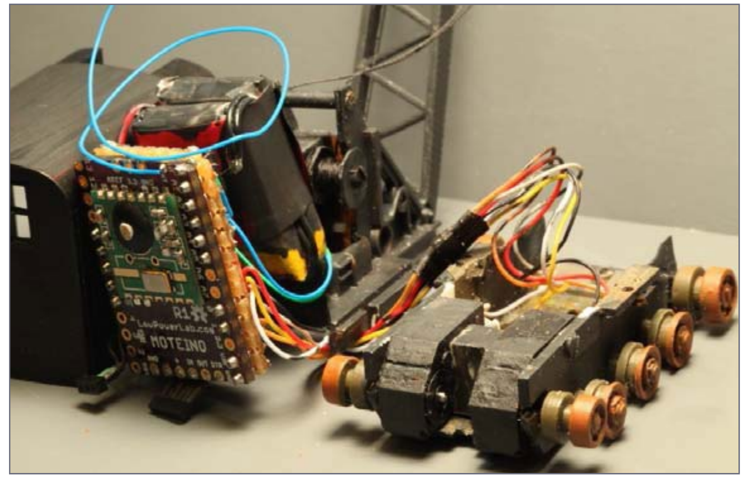
STEP 1: Prepare the electronics *Continued ...*



85. Crawler crane driver.

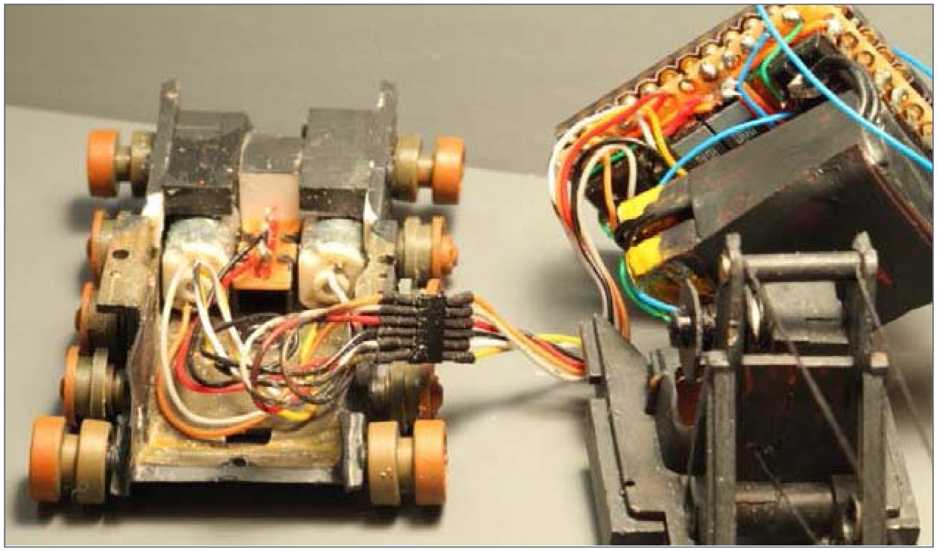


86. Moteino wiring harness.

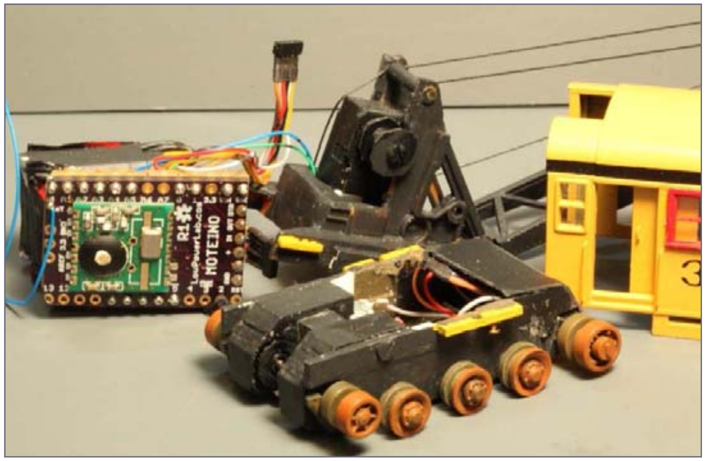


87. Crane 3 internals.

STEP 1: PREPARE THE ELECTRONICS *CONTINUED ...*



88. Crane 3 motors and wiring harness.



89. Crane 3 ready for assembly.

STEP 2: BUILD THE WIRELESS CONTROLLER

The remote control box is essentially another Moteino, some switches and variable resistors, and a 9 Volt alkaline battery. Moteinos can be ordered using different radio frequencies, so check which frequencies are legal in your country. This crane uses the R2 version. The R4 version is available at the time of this writing. You will need to download the appropriate library from http://lowpowerlab.com/moteino to match the one you use. Today there are even more options from other vendors to choose from, but that is beyond the scope of this article.

If you follow both wiring diagrams, you should be able to load the sketches into the Moteinos and operate your remote-controlled crane. You can also consider using the controller to send a series of commands to perform an animated sequence. The commands sent from the controller to the crane are alphabetic characters that are interpreted by the crane:

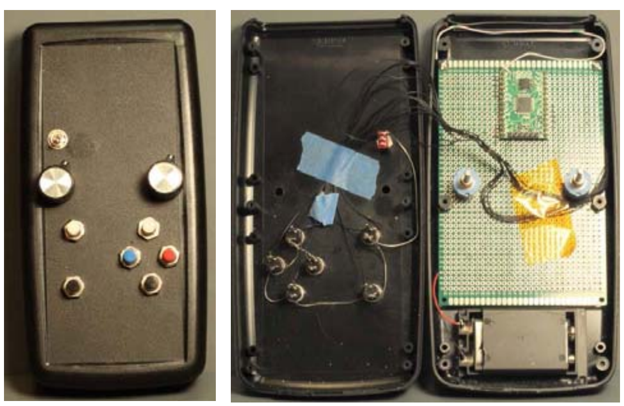
"f": forward tracks
"b": backward tracks
"r": tracks turn right
"l": tracks turn left
"s": tracks stop
"u": hook up
"d": hook down
"p": hook auto down then up
"w": work light On
"x": work light Off

You can make up additional commands if you wish.

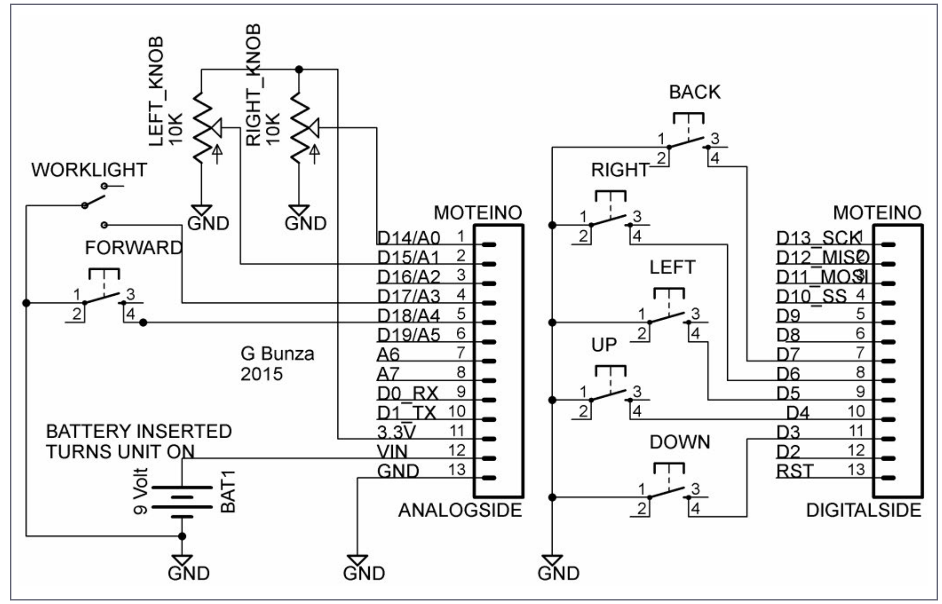
STEP 2: Build the wireless controller *Continued ...*

You can see how each of these cranes performs in the accompanying video, plus a great new capability to put your cranes to work. Check out the video below.

Playback problems? [Click here ...]



90-91. Remote controller front and insides.



92. Remote controller schematic. Knobs are not used here.

93. Finished remote crane 3.

Conclusion

These models represent a variety of animation drives and control methods, from easy to complex. They are offered here to stimulate your imagination, and give you some ideas to develop your own animation projects. Perhaps your own flock of cranes will gather on your layout soon.

Have fun! ☑

Click here for reader comments

94. All of the animated HO scale cranes together. We could call it a "flock of cranes", no?

MOVING CARGO WITH YOUR CRANE

Now that I equipped my HO scale empire with a contingent of operating cranes, it's time to move the goods. But one of the toughest things to tackle is the question of how. For realistic scale model animation, there are several issues to overcome. Let's tackle the basic problem of moving cargo, in this case crates, from one place to another, and of course by crane!

Realistic crates can be built with wood or plastic. A selection of crates can easily be had with crate set #8174 from Tichy Trains. Taking a lead from the old tinplate cranes, I use magnetism to pick up a crate with a small piece of iron or steel embedded or attached. But prototype electromagnets didn't usually lift many crates. However, one of the small rare earth magnets I used with the Hall Effect sensors can do the job.

These are available as small as 1x1x1 millimeter in size. By cutting out the bottom of the Athearn large hook, part #17017 used on tracked crane No.3, I can embed one of these small magnets in the bottom of the hook. An abrasive cutting disk in a Dremel Moto-tool does the job well. See if you can spot the magnet in [96] – it's barely visible. Epoxy or thick ACC will hold it in place. I completely covered the magnet with glue and then painted it.

For the first attempt at modifying crates for pick up, I used 0.001" steel shim stock, glued to the top of the crate. The modified hook easily lifted the crate – success! When glued to the underside of the top of the crate, the gap weakened the grip enough that the crate sometimes fell. A 0.005" piece of styrene substituted for the crate top narrowed the gap to allow the steel shim to be placed

MOVING CARGO WITH YOUR CRANE

Continued ...

inside the crate. I cut a tiny sliver of steel and attached it to the chains mounted across the top of the crate. This also worked well for pickup.

But how do I drop the crate, once the crane has transported it? Magnetism was the obvious answer again.

I placed an electromagnet under a model loading dock, and put a larger piece of steel on the inside bottom of the crate. Once the crane lowered the crate onto the dock, the electromagnet would grab the crate with a force greater than the small magnet in the hook. The crane could then simply pull the hook away, and continue on its way.

This worked, in part. When the crane pulled up and away, the tension applied made the boom act like a trebuchet and rocked the entire crane in an exaggerated manner – not the realistic effect I wanted. The answer came after quite a few engineering trials, resulting in a relatively simple solution.

The key was to use the "problem" described above to my advantage. By increasing the gap between the hook magnet and the crate steel insert, I was able to disconnect the hook. I could open the hook gap simultaneously with grabbing the bottom of the crate. The electromagnet I used was more powerful than the hook magnet by far, so it easily pulled the crate away from the hook. I also helped the electromagnet by making the steel at the bottom of the crate larger than the metal at the crate top.

Quite a few of my attempted mechanisms were poor or intermittent performers. The best solution I came up with is a spring-loaded column with a small steel plate on the top of a brass tube, attached to a larger steel plate on the bottom. The spring raises the column and the top metal pin to the underside of the top of the crate. This allows the hook magnet to grab it at will.

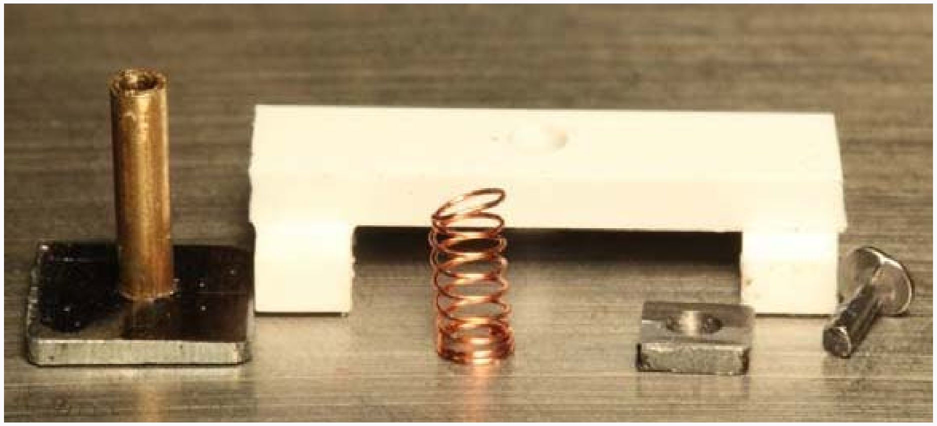
But if the crate is placed on top of a working electromagnet, the magnet grabs the bottom plate and pulls the column down, creating a gap at the top, and dramatically weakening the pull from the hook magnet.

95. Magnet-equipped hooks. The quarter gives you a good idea how small the magnets are.

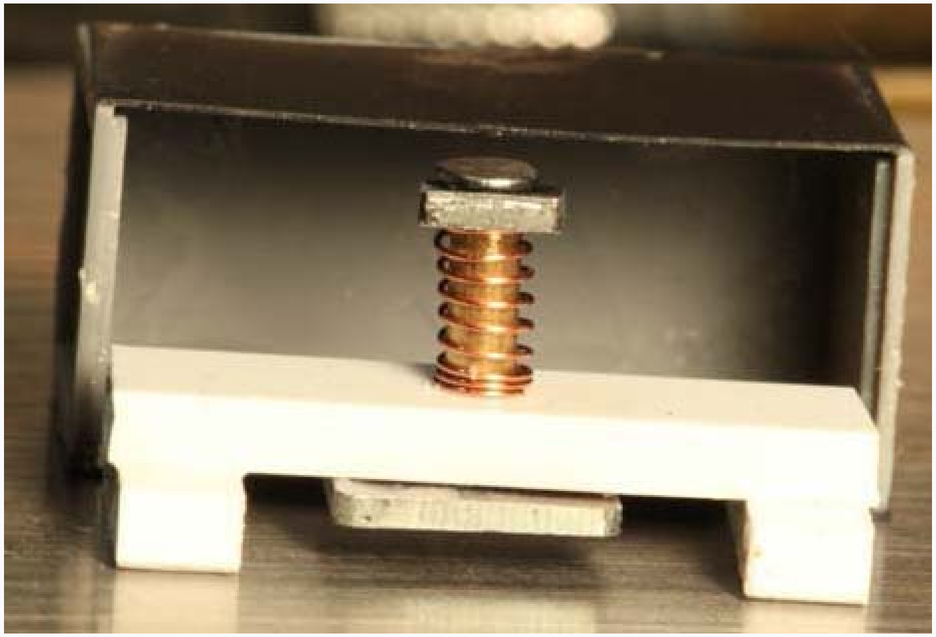
MOVING CARGO WITH YOUR CRANE

Continued ...

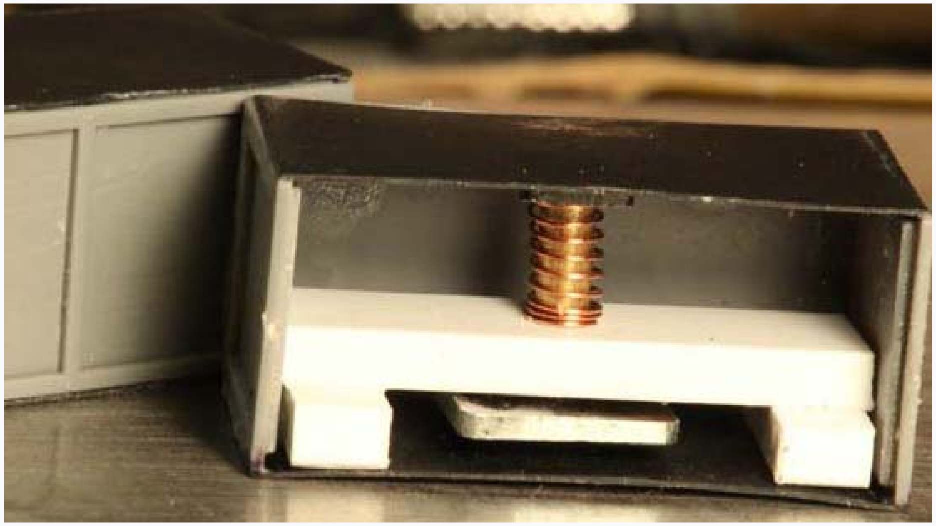
96. The box and its parts.



97. Putting the box together.



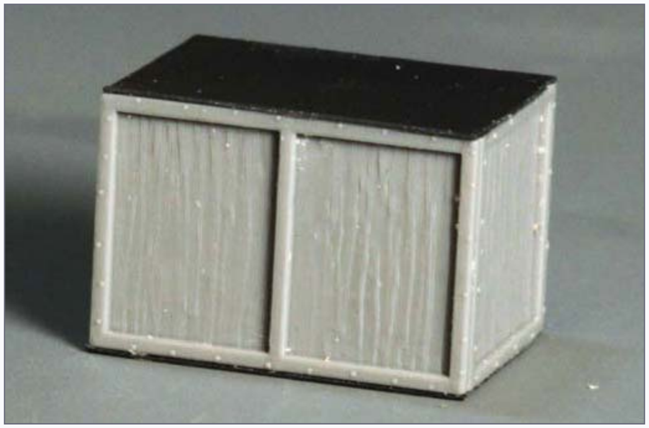
98. The constructed mechanism ready to place inside the box.



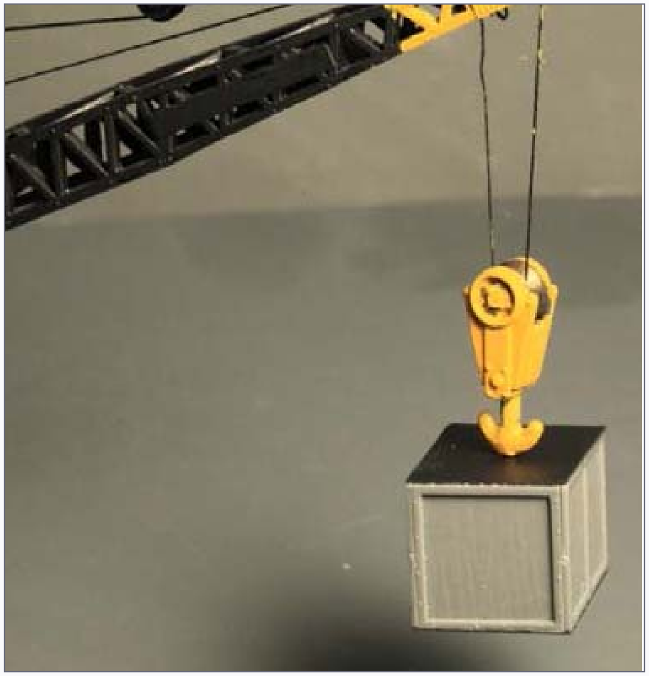
99. Mechanism inside the box.

MOVING CARGO WITH YOUR CRANE

CONTINUED ...

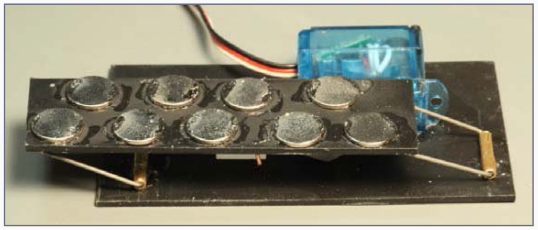


100. The box is ready for transport.

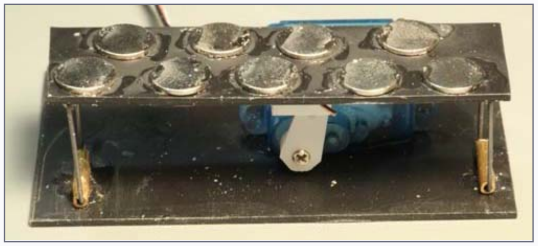


101. Lifting the crate with the crane.

102. The loading dock and crates.



103. Magnet platform in the lowered position.



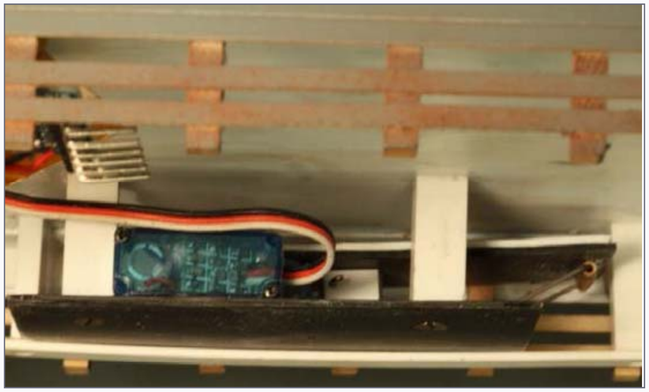
104. Magnet platform in the raised position

This effectively disconnects the hook. After the crane lifts the hook or boom up, the electromagnet can be turned off. Thus, the crate stays in place on the loading dock with no trebuchet effect. The top metal pin is made from a #14 nail/brad. A shortened Kadee #861 G-Scale Centering Spring supports the column. The top and bottom steel pieces are cut from steel key stock obtained at the local Ace Hardware Store. The top and bottom panels of the Tichy box were replaced with black 0.010 sheet styrene.

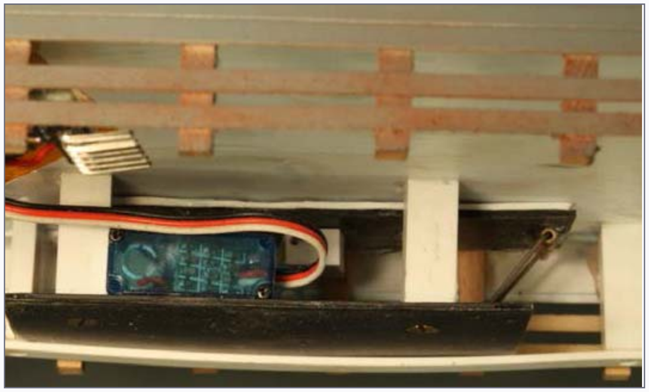
MOVING CARGO WITH YOUR CRANE

CONTINUED ...

The last problem I had dealt with the use of the electromagnet. This solution worked, but the crate needed to be placed on the electromagnet with too much precision. I found this was a bit too limiting and would not permit dropping multiple crates on the same platform without providing an array of electromagnets.



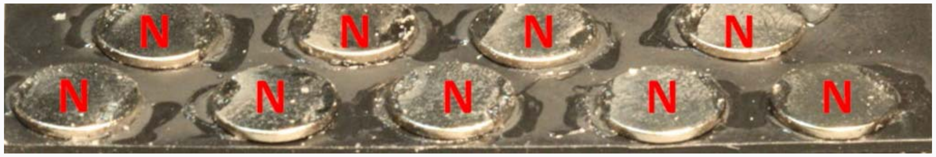
105. The dock platform with the magnets in the lowered position.



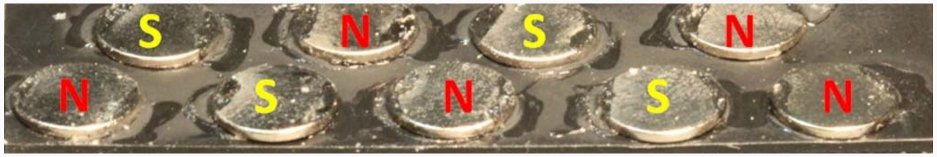
106. The dock platform with the magnets in the raised position.

Again the solution was to forcibly increase the gap mechanically, with a servo motor-driven platform covered with thin rare earth magnets (1/16 x 5/16). You can see the solution in [104 -107]. The "hinges" are made from stiff 0.025" wire (brass, phosphor bronze, or steel) formed into a rectangle and inserted top and bottom into 1/16 brass tubes glued in place.

The servo arm is attached to the underside of the platform and is controlled by an Arduino Pro Mini. I can even use the multifunction Arduino decoder described here: mrhmag.com/node/20739. Now instead of turning an electromagnet on and off, you simply raise or lower the magnet platform under your loading dock.



107. Weak field magnet grouping.



108. Strong field magnet grouping.

109-110. Inside the crate with the magnet in the up position on the right, and in the down position on the left.

MOVING CARGO WITH YOUR CRANE

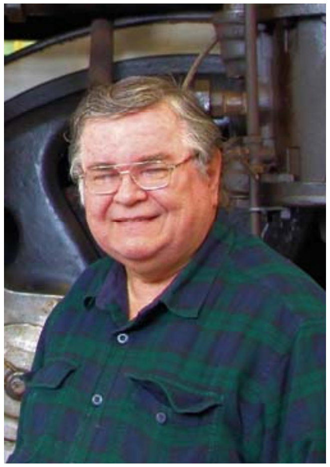
Continued ...

As things would happen, there was one last problem to solve. When I made the first magnet platform, it worked very poorly. This made absolutely no sense until I happened to drop a crate on the edge of the platform and it grabbed the crate like glue. Moving the crate to the obvious middle of the platform had little effect. What was going on? The first platform had an even array of magnets placed so that all were mounted with the same polarization – all with the same pole up.

The resultant magnetic field in the middle of the array had only a weak interaction with the steel in the crate. The solution was to alternate the magnets' orientation in the array – north/south – across the platform. This worked very well. It also enables me to build as large a platform and "landing area" for my crates as I liked, allowing multiple crates to be placed and removed from the loading dock. However, these magnets are quite strong. When I place several crates across a large platform, I need a servo strong enough to pull the magnets down from all the crates above. Some experimentation is needed if you want a large platform capable of receiving many crates simultaneously.

The sequence of events would typically be: 1. Have your crane pick up and carry a crate to the loading dock, 2. Lower the crate onto the dock above the lowered magnet platform, 3. Raise the magnet platform under the loading dock, 4. Lift the hook away from the crate, 5. Lower the magnet platform, leaving the crate in place. The crate is ready to be picked up and moved somewhere else as well. Now you really can realistically move cargo on your layout! ■

Dr. Geoff Bunza



Geoff started as a Model Railroader when he received a Mantua train set for Christmas, at age 6. Interest in the New York Central was cemented when riding on a NYC fan trip to Harmon in November, 1966 behind S-Motor 110. He fed his interests through college becoming a member of the Tech Model Railroad Club (TMRC) at MIT while getting his doctorate and three other degrees in Electrical Engineering.

He models the New York Central Railroad, the Great Northern Railway, and Maine narrow gauge in HOn30. Scale model animation in HO is one of his great interests.

Geoff has authored numerous articles on animation for *Model Railroad Hobbyist,* the *New York Central System Historical Society Modele*r Magazine, and *Railroad Model Craftsman.* He has presented clinics for the NMRA at Division, Regional and National meets, and the National Narrow Gauge Conventions.

He is blessed with his wife, Lin, in marriage for 36 years and their two terrific sons. He is a life member of the NMRA and holds an Extra Class amateur radio license. ■