

Installing DCC Decoders with Sound in Steam Locomotives

by

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- **Today, many steam locomotives are available with factory-installed DCC sound decoders**
- **Manufacturers select the engines they will manufacture with DCC sound decoders based on expected sales**
- **Models of many locomotives that were unique to smaller railroads are not profitable to manufacture and market today, based on costs and a limited market**
- **However, back in the 1960's and 1970's, there were many manufacturers of brass locomotives, and models of a wide variety of steam locomotives were available**

- **Most of these older models are still in existence, and can often be found and purchased at model train shows or auction sites like eBay**
- **However, these older models usually do not have DCC decoders installed in them (sound or otherwise)**
- **In order to run these older locomotives on our layouts that are powered and controlled by Digital Command Control (DCC), we must install decoders in them**

- **Many of us probably shudder at the thought of taking apart an older locomotive!**
- **And panic may set in at the thought of trying to figure out how to install a sound decoder!**
- **The purpose of this clinic is to de-mystify the process of installing a sound decoder in an older steam locomotive**
- **It is not that difficult!**

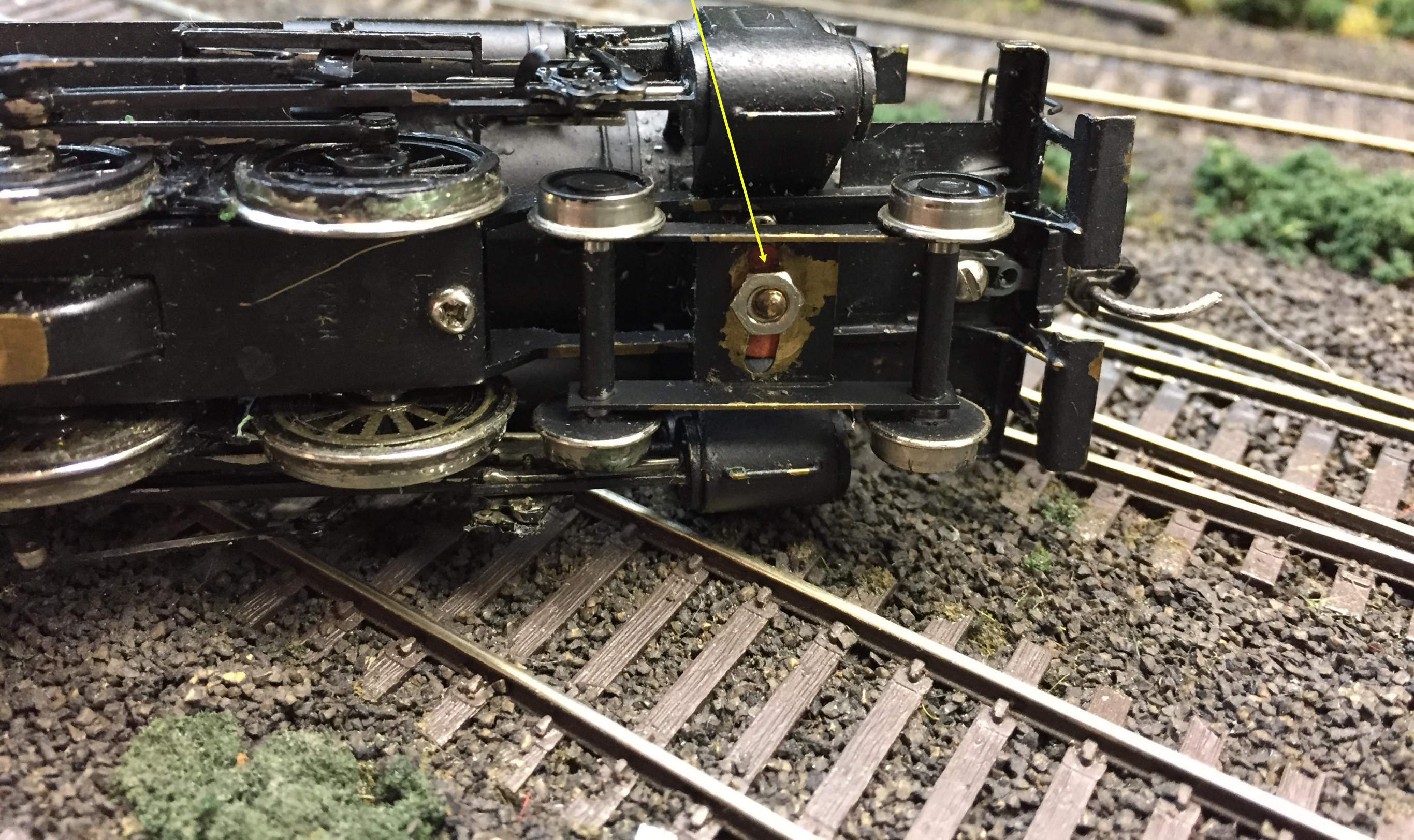
Some Explanation of Terms

- **Decoder** - this is a small integrated circuit board that usually mounts in the tender of a steam locomotive
- **Speaker** - If you are installing a decoder that has sound, you must install a speaker
- **Keep Alive** - also called a Current Keeper, it is series of electrical capacitors that connects to the decoder. A capacitor has the capability to store an electric charge. If the locomotive hits a dead spot and loses electrical contact with the rails, the Keep Alive capacitors will discharge, sending current to the motor for a few seconds so it will continue to run and hopefully move your engine off of the dead spot
- **DC** - direct current
- **DCC** - digital command control

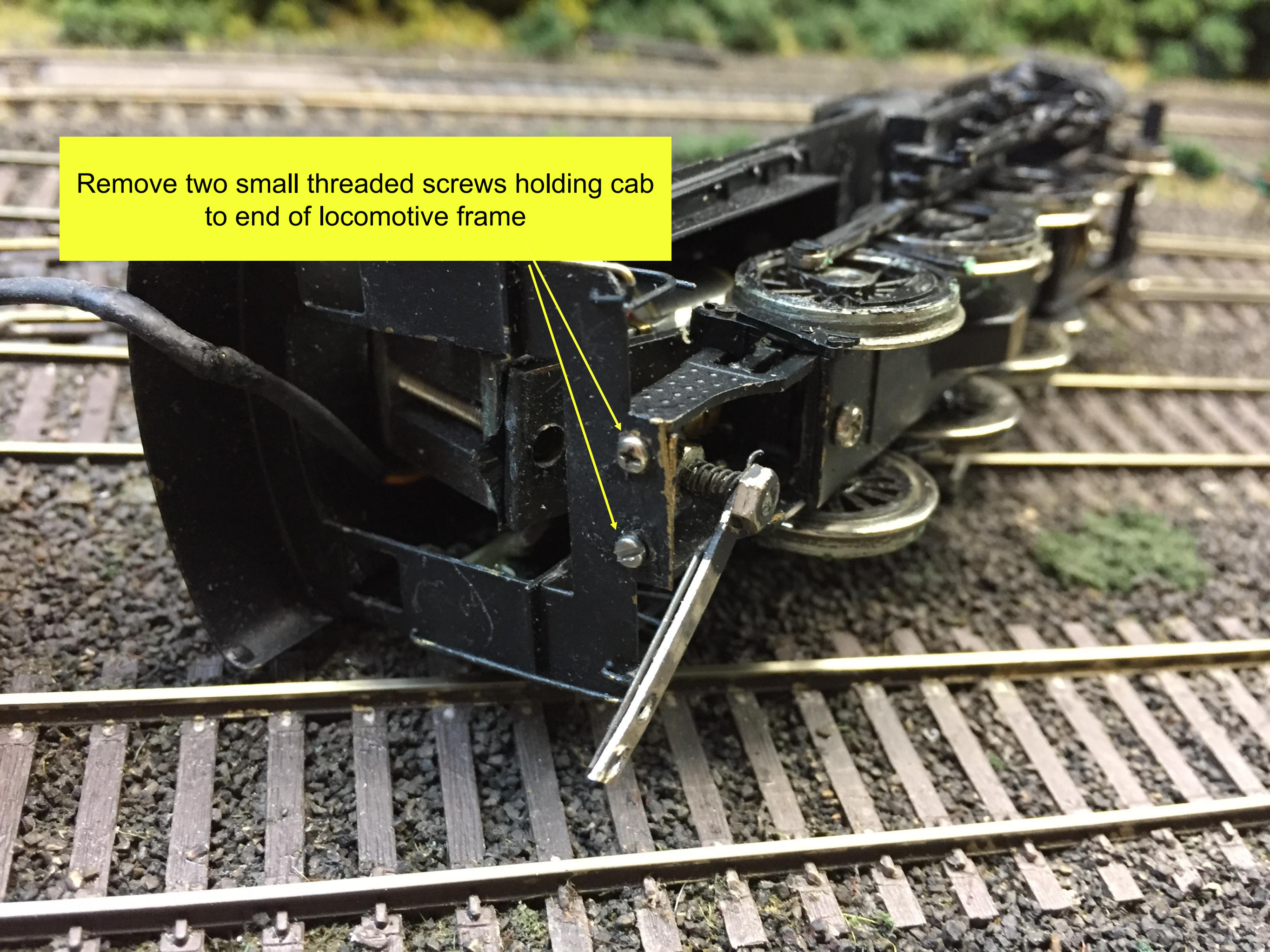
Removing the Boiler from the Frame to Access the Motor

- Most older brass locomotive boiler/cab assemblies are connected to the frame at two points
- A threaded fastener that holds the front trucks on usually extends through the frame and threads into the boiler
- Two small threaded fasteners usually connect the back of the cab to the frame
- Removing these fasteners will usually allow the boiler to lift off of the frame

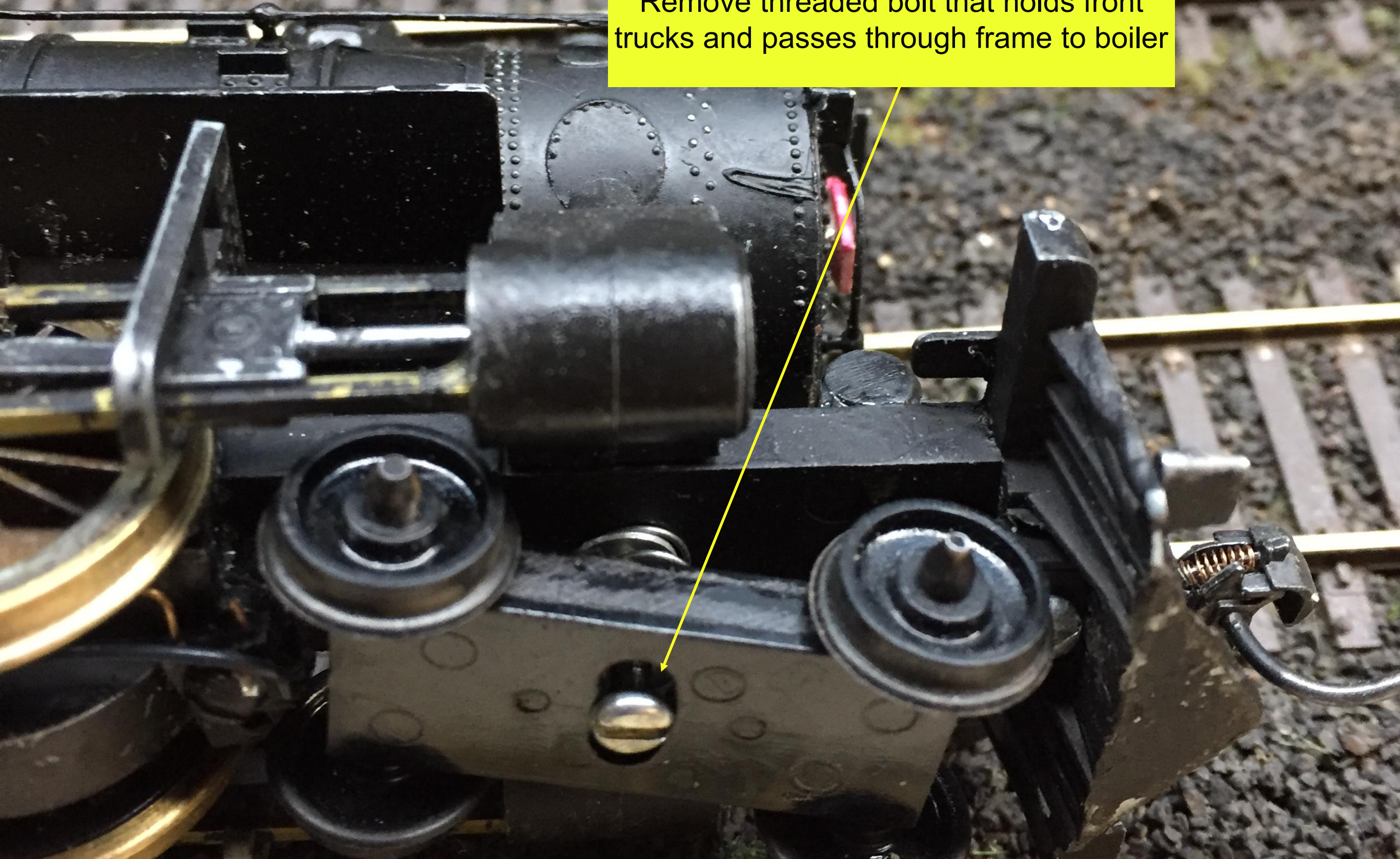
Threaded rod with threads on
both ends



Remove two small threaded screws holding cab
to end of locomotive frame



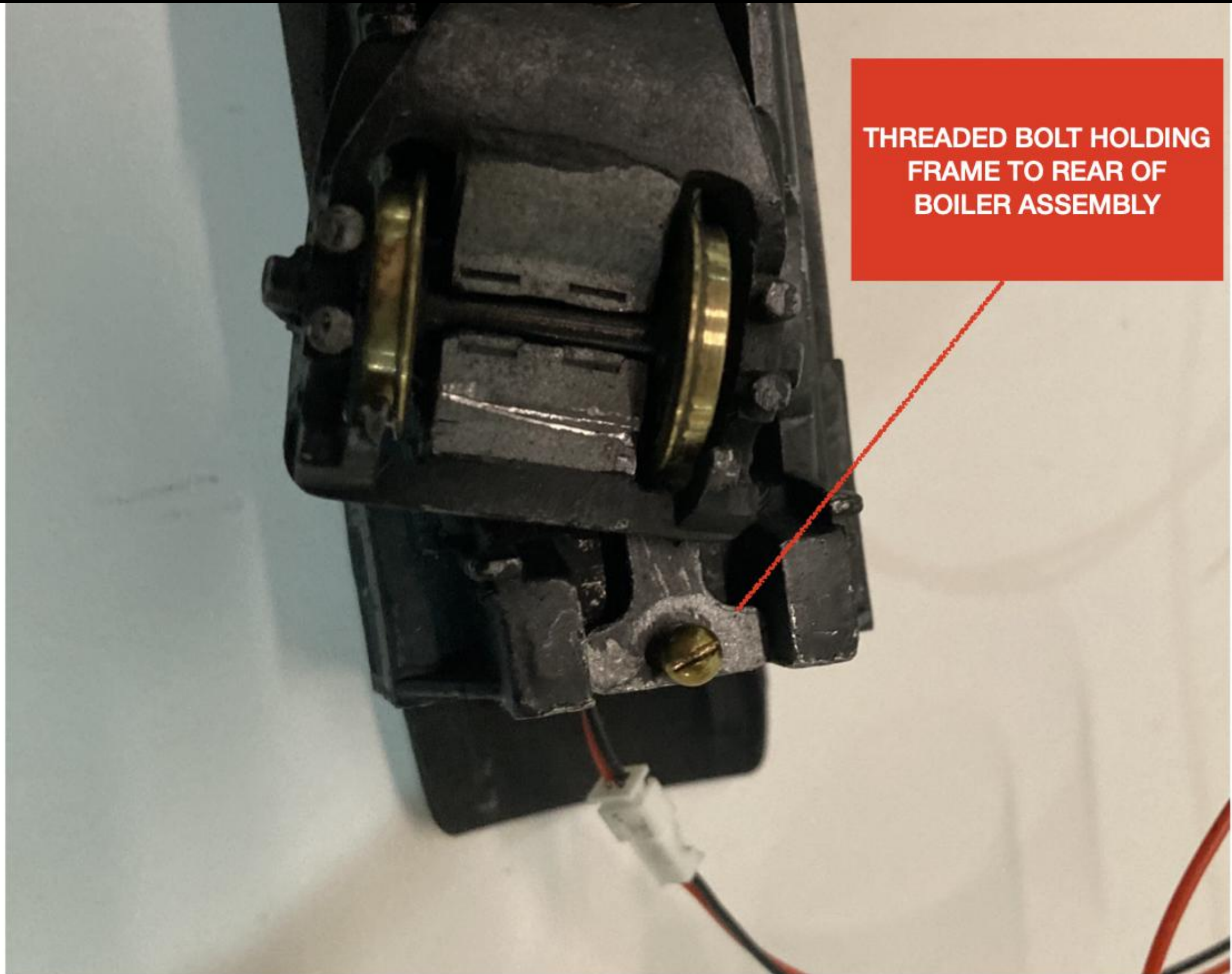
Remove threaded bolt that holds front trucks and passes through frame to boiler



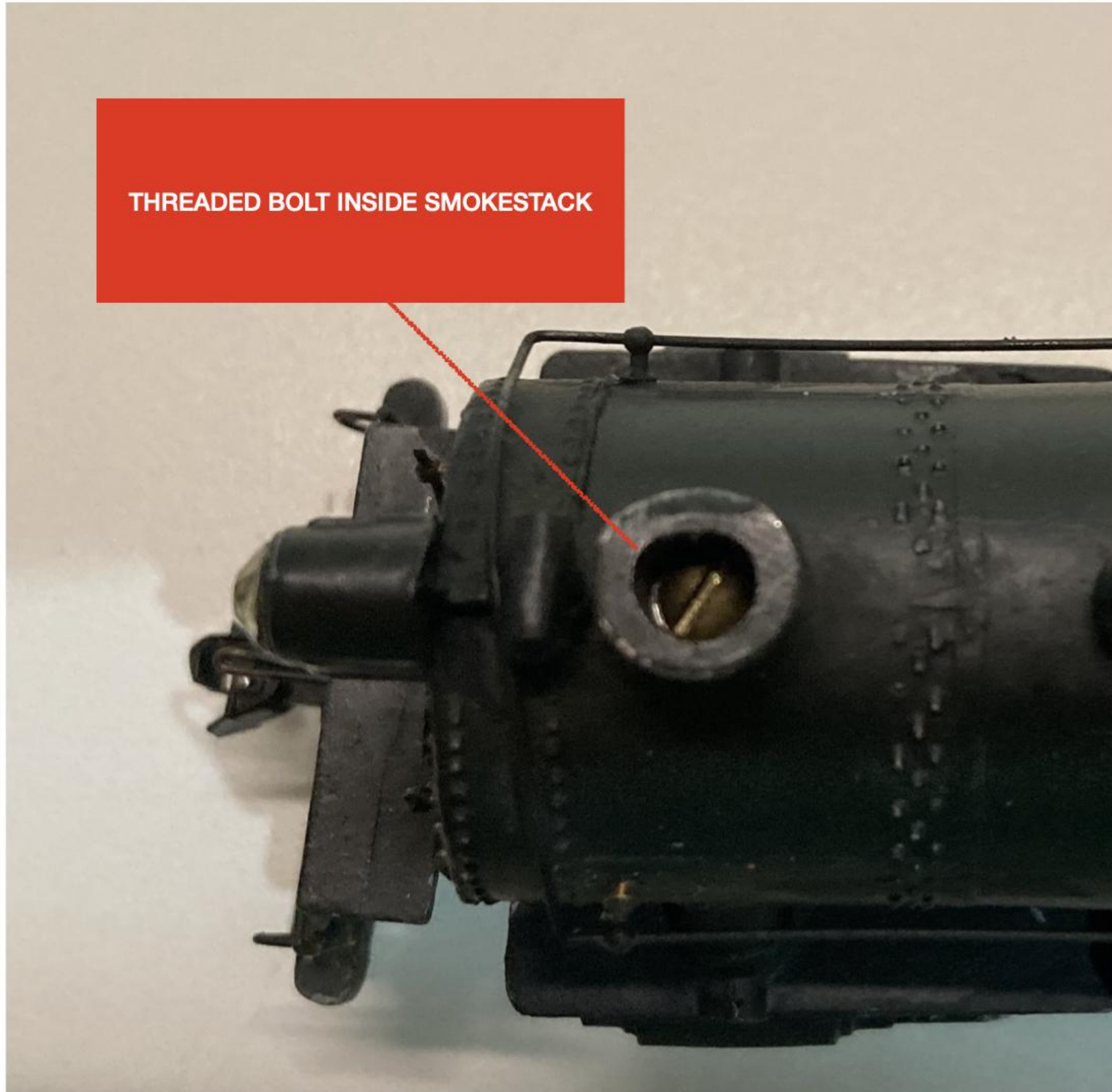
REMOVING BOILERS ON OLDER ENGINES (BOWSER, PENN LINE, MANTUA)

- **BOILER IS USUALLY ATTACHED TO THE FRAME WITH TWO THREADED BOLTS. ONE IN THE BACK UNDER THE CAB, AND THE OTHER IN THE SMOKESTACK**

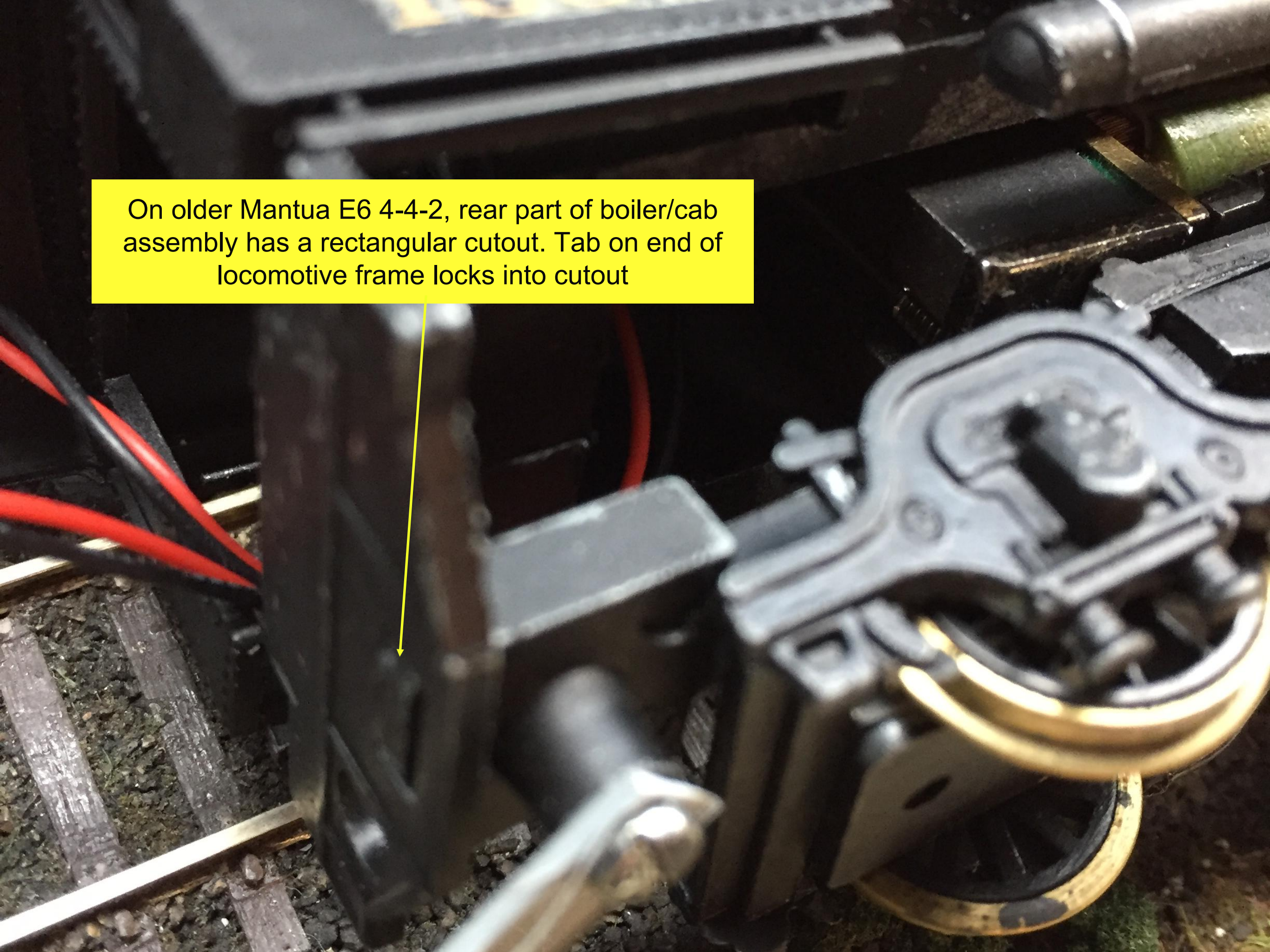
**THREADED BOLT HOLDING
FRAME TO REAR OF
BOILER ASSEMBLY**



THREADED BOLT INSIDE SMOKESTACK

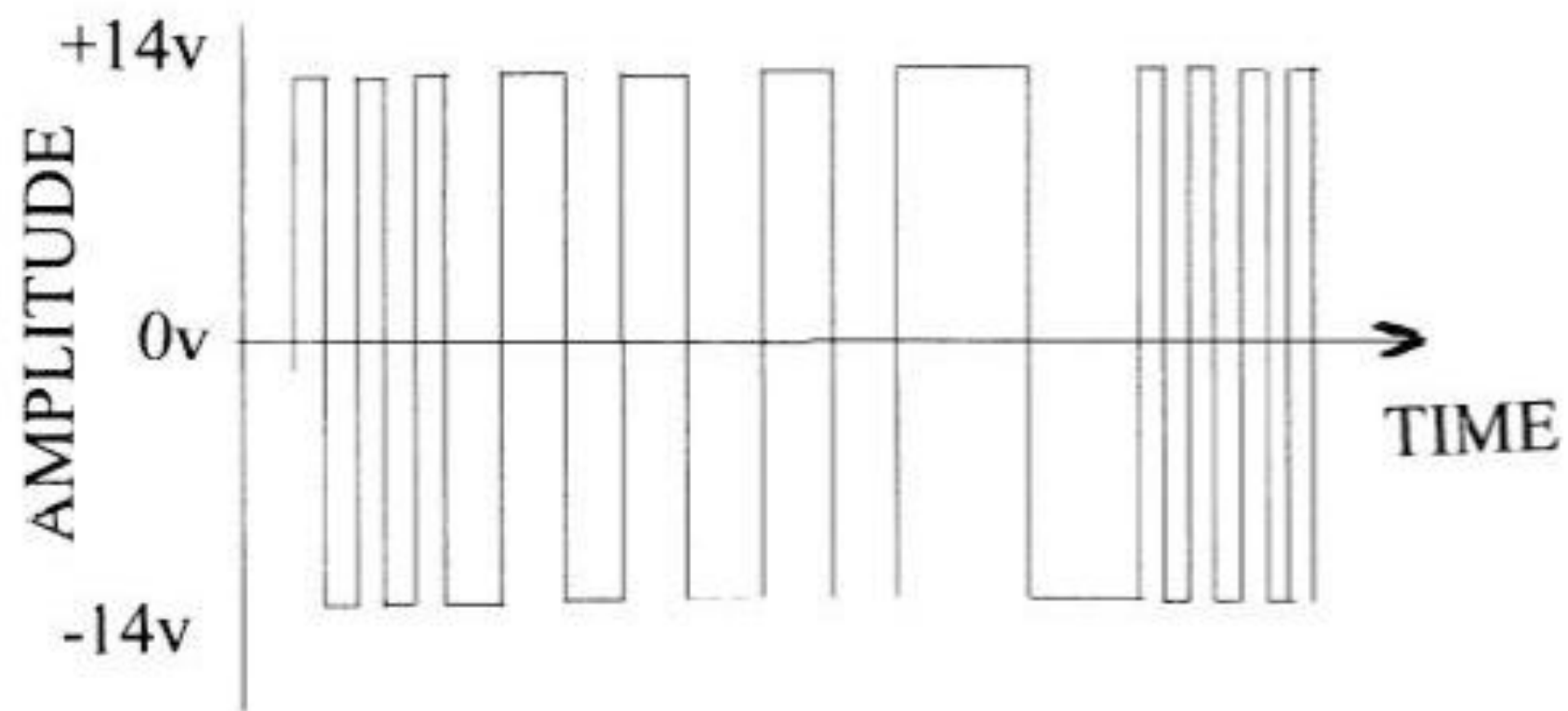


On older Mantua E6 4-4-2, rear part of boiler/cab assembly has a rectangular cutout. Tab on end of locomotive frame locks into cutout



So What is the Difference with DCC?

- **On a conventional DC-powered model railroad, the power to the engine is supplied by connecting a DC voltage to the rails, + to one rail, and - to the other rail**
- **With DCC, the DCC signal on the rails is a +/- 14 volt alternating current signal with a digital square waveform**
- **DC motors cannot run on alternating current and voltage to engine must be converted to a DC signal**
- **The motor must be connected to the decoder, NOT to the rails**



Typical DCC waveform sent to locomotive via the rails

- **When you are using your DCC throttle, and you key in commands, such as speed up, slow down, blow the whistle, etc., you are sending a digital signal over the rails to the decoder in the locomotive**
- **The decoder processes the digital signals. For signals that tell the motor to speed up or slow down, the decoder converts them to the appropriate DC voltage that is connected to the motor terminals**

What are the Main Concerns with Installing a Sound Decoder in an Older Steam Engine?

- **Is there room for the decoder, speaker (and Keep Alive) in the tender?**
- **Can the motor be electrically isolated (i.e., not in electrical contact with the rails)?**

- **Most steam engines with a separate tender will have room in the tender compartment to hold at least a decoder and speaker and perhaps a Keep Alive**
- **For engines with an integral tender, such as shays and climaxes, there may or may not be room for a decoder.**

- **Speaker technology has vastly improved and speaker size has vastly shrunk!**
- **Today you can buy a high quality speaker that is about the size of a dime and no thicker than two dimes for about \$6 (a cell phone speaker)**
- **Depending upon the room available, installing sound in an HO scale shay or climax is possible**

- **Remove the tender base from the tender shell and see how much room is available**
- **Note that a Keep Alive or Current Keeper can add about \$20 to the cost of a decoder, so make sure it will fit in the tender before your buy it!**

- **Some tenders may have internal panels, perhaps so the tender's coal bin can be modeled half empty**
- **If you need more space, and you feel confident, remove the panels to make space, and model the tender's coal bin as full**

**- the tender from a
NJCB G-53sd 4-6-0**

- Internal brass panels were removed**
- 0.040" styrene plastic was cut to size and glued in place to gain room for a decoder, speaker, and Keep Alive and serve as a false bottom for coal**



Top View of Tender with Plastic Insert

**Coal Load Will Be
Glued On Top**



Making Sure the Motor is Electrically Isolated

- **The motor will not run on AC**
- **AC at the motor terminals will also be connected to the decoder output, and can damage the decoder!**

- Therefore, we want the electrical signal picked up by the engine and/or the tender wheels to be electrically isolated from the motor terminals
- The only electrical signal that the motor terminals should receive is from the decoder output.
- Our goal is to pick up the electrical signal from the rails and connect it to the input of the decoder
- The decoder will process the signal and convert it to an appropriate DC voltage and current that then goes to the motor terminals

How Can I Tell if my Motor is Electrically Isolated from the DCC Signal on the Rails?

- You will need a Volt-Ohm-Ammeter (commonly termed a Multimeter)
- You can buy inexpensive ones in any hardware store for around \$10
- When you turn the dial on the meter to “Resistance,” or “Ohms”, you are reading the electrical resistance that is between whatever the two probe ends are touching
- If you touch the probe ends together, the meter needle should show zero ohms (a short circuit). Thus, whenever the needle goes to zero, you have a good electrical connection between whatever the probe ends are touching

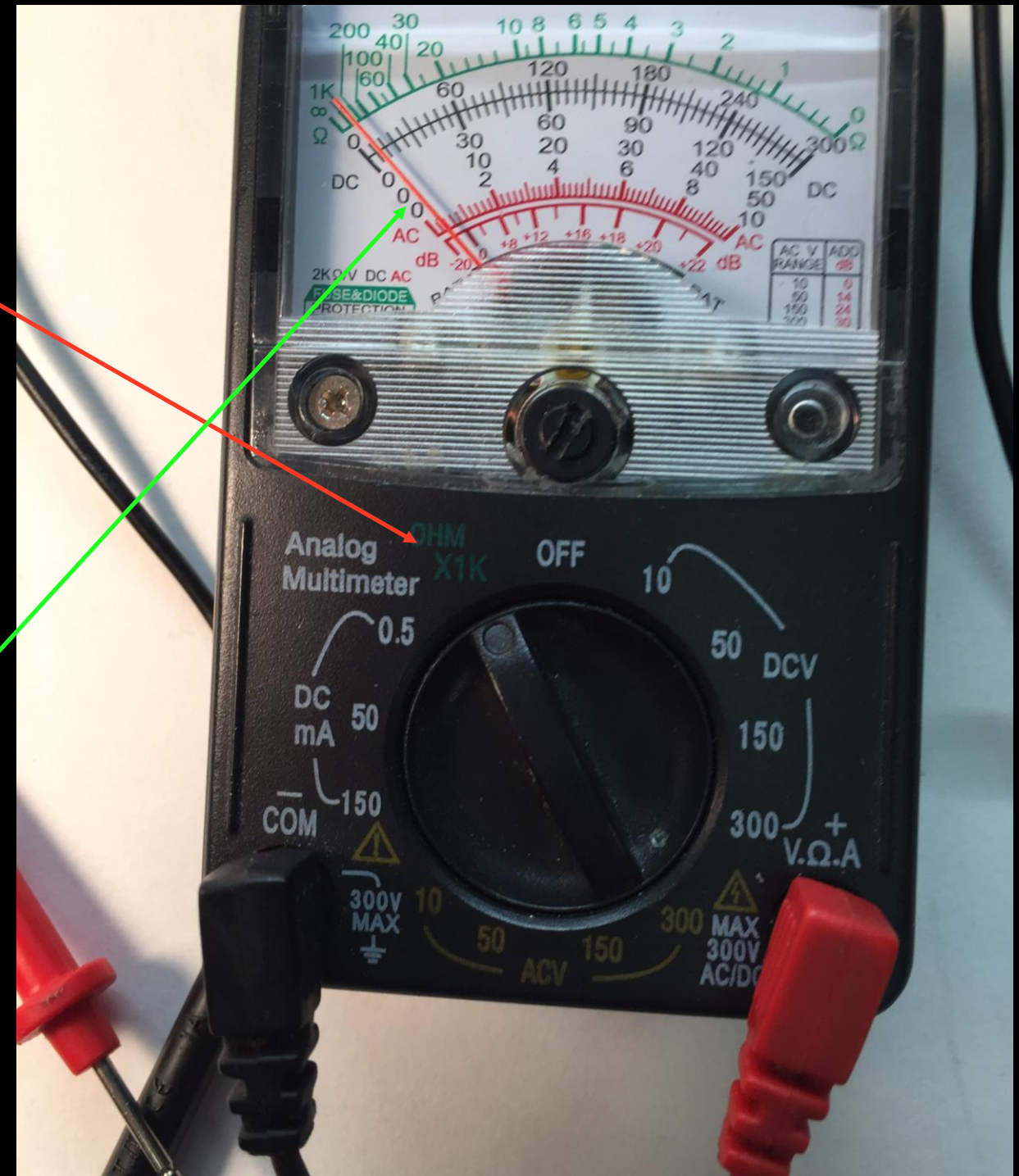
Typical Inexpensive Multimeter (analog)



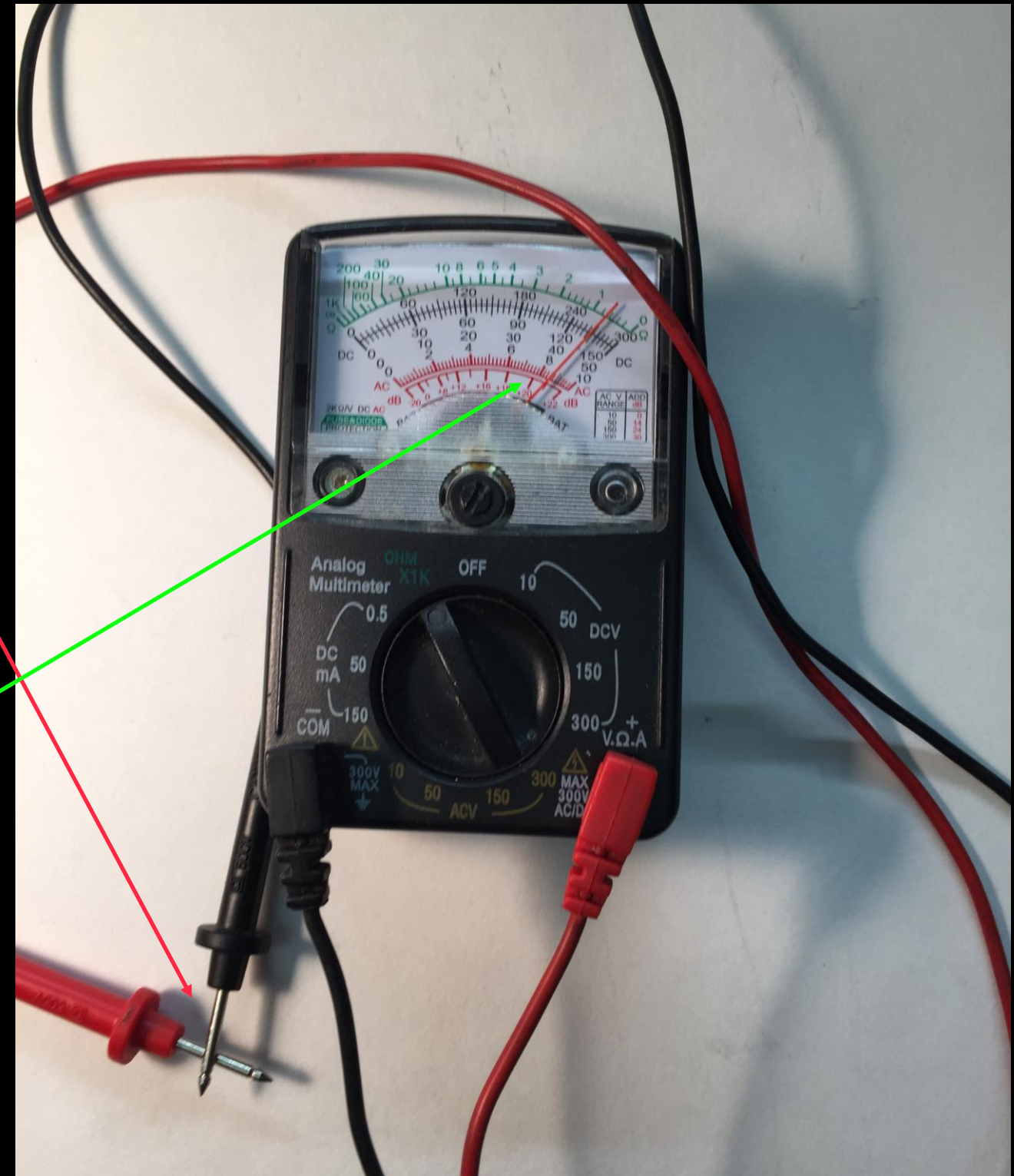
Typical Inexpensive Digital Multimeter



- **Multimeter with selector switch set to measure ohms (electrical resistance)**
- **When probes are not touching, resistance between probes is infinite**
- **Needle is to the left of the dial, showing very high electrical resistance**

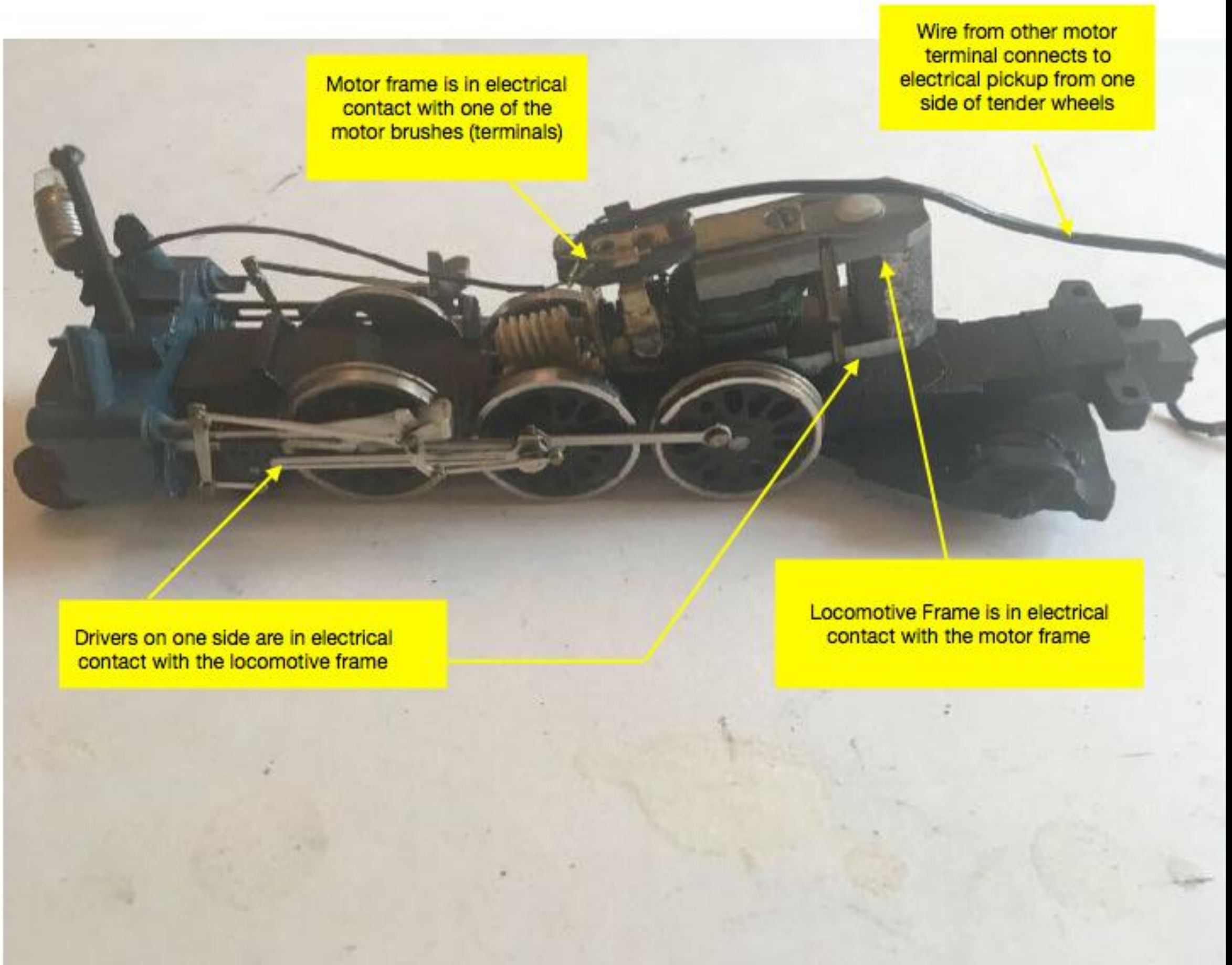


- When probes are touching, electrical resistance between the probes is zero
- Needle on the meter is pegged to the right, reading zero ohms



- **When the locomotive is on the track, the drivers are in electrical contact with the rails**
- **To see if the motor terminals are electrically isolated from the rails, we therefore need to make sure they are electrically isolated from the driver wheels**
- **On all model locomotives, each side of the drivers are electrically isolated from the other side (otherwise they would short-circuit the two rails).**
- **The drivers on one side are usually used to pick up the DC signal from one side of the rails, and are in electrical contact with the locomotive's frame and motor**

- **The motor frame is usually mounted on the locomotive frame and attached with one or two threaded metal fasteners, so the motor frame is therefore electrically connected to one side of the drivers**
- **One of the motor terminals is usually connected to the motor frame**
- **The other motor terminal is isolated from the motor frame. A wire from that terminal usually leads to a pickup in the tender that connects to the tender wheels on the side opposite the locomotive drivers that are connected to the motor**



Motor frame is in electrical contact with one of the motor brushes (terminals)

Wire from other motor terminal connects to electrical pickup from one side of tender wheels

Drivers on one side are in electrical contact with the locomotive frame

Locomotive Frame is in electrical contact with the motor frame

- **To see if your motor is isolated or not, simply put one probe of the ohmmeter on a part of the locomotive frame with bare metal (to assure good electrical contact)**
- **Touch the other probe on the motor terminals. If both terminals show an open circuit, then the motor is electrically isolated from the frame**
- **If a short circuit is indicated (the ohmmeter reads zero ohms) when you touch the probe to one of the motor terminals, then that terminal is NOT electrically isolated**

How Can I Isolate the Motor?

- **There are two solutions**
- **One way is to isolate the motor terminal that is in electrical contact with the frame**
- **This can be done in several ways**
- **by inserting a piece of insulating material (e.g, electrician's tape, flexible, thin plastic) between the brush bar and the wire spring holding the brush bar in place**

- **Different manufacturers of motors often have different spring arrangements to hold the brush bars in contact with the commutator**
- **You need to examine the motor and the brush bars and determine if a brush that is in contact with the motor frame can be electrically isolated from the frame**

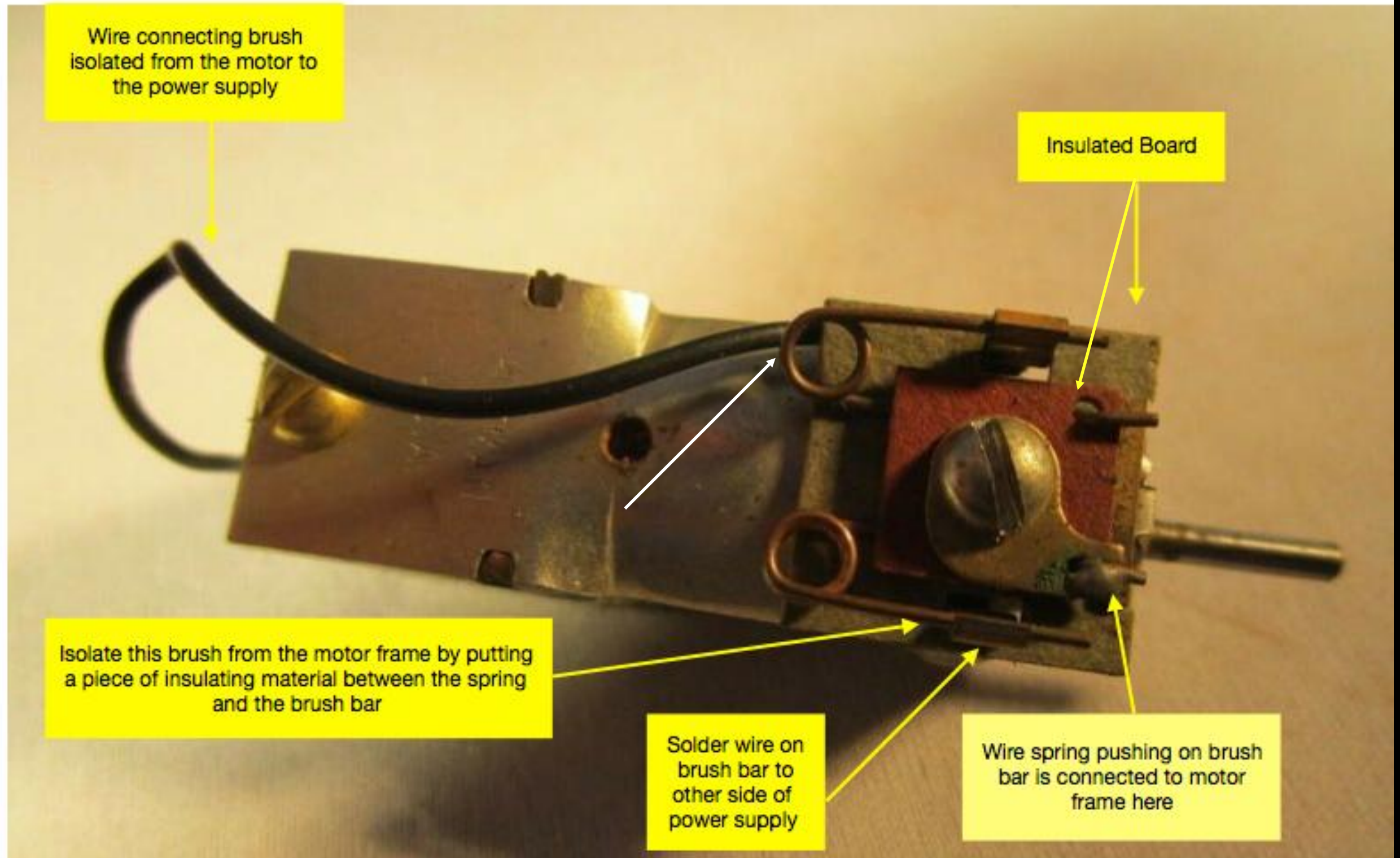
Wire connecting brush
isolated from the motor to
the power supply

Insulated Board

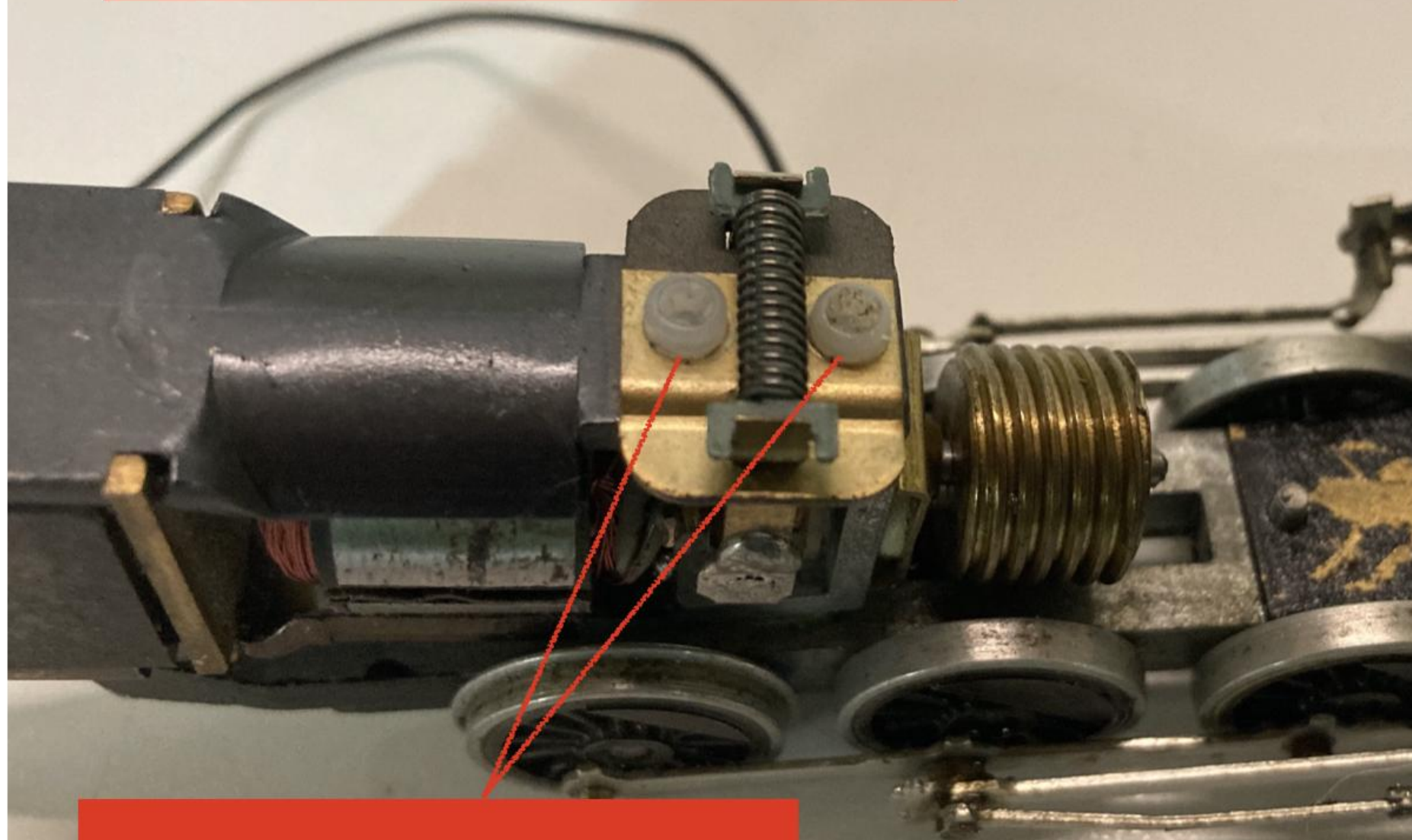
Isolate this brush from the motor frame by putting
a piece of insulating material between the spring
and the brush bar

Solder wire on
brush bar to
other side of
power supply

Wire spring pushing on brush
bar is connected to motor
frame here

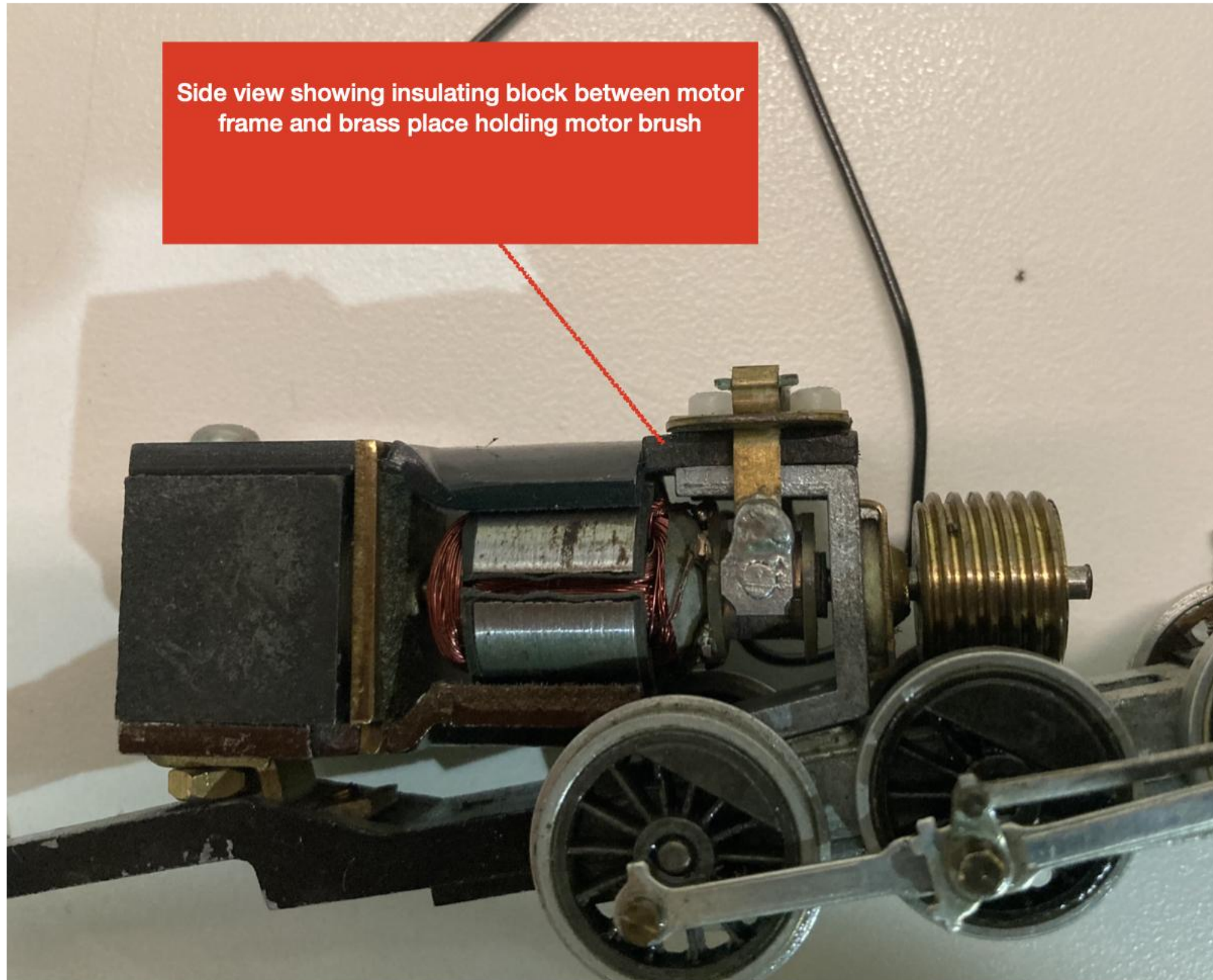


Motor brush at bottom was in direct contact with motor frame
with two metal threaded bolts holding brass plate to motor
frame



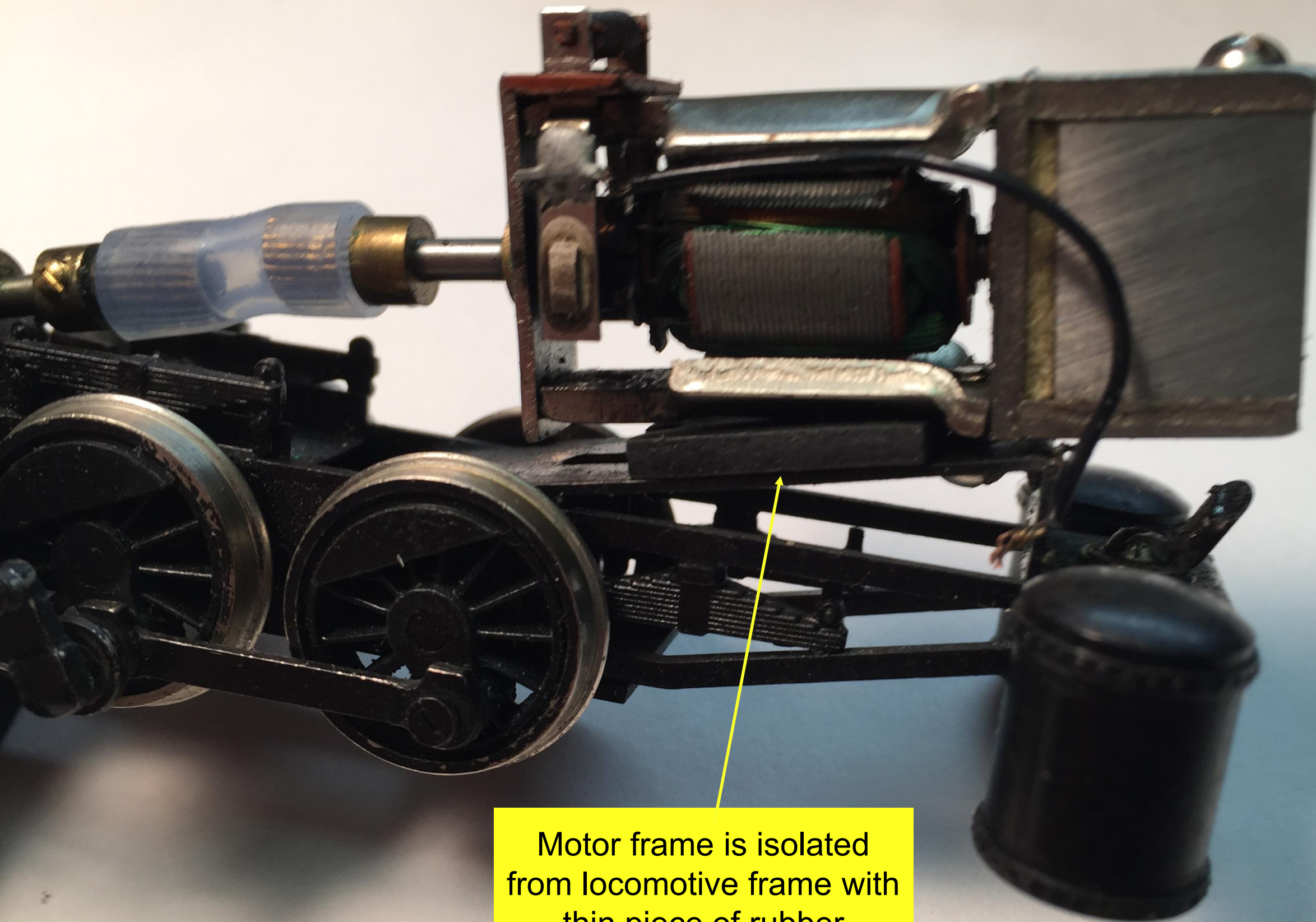
Motor brush is electrically isolated by replacing metal
threaded bolts with plastic threaded fasteners

Side view showing insulating block between motor frame and brass plate holding motor brush



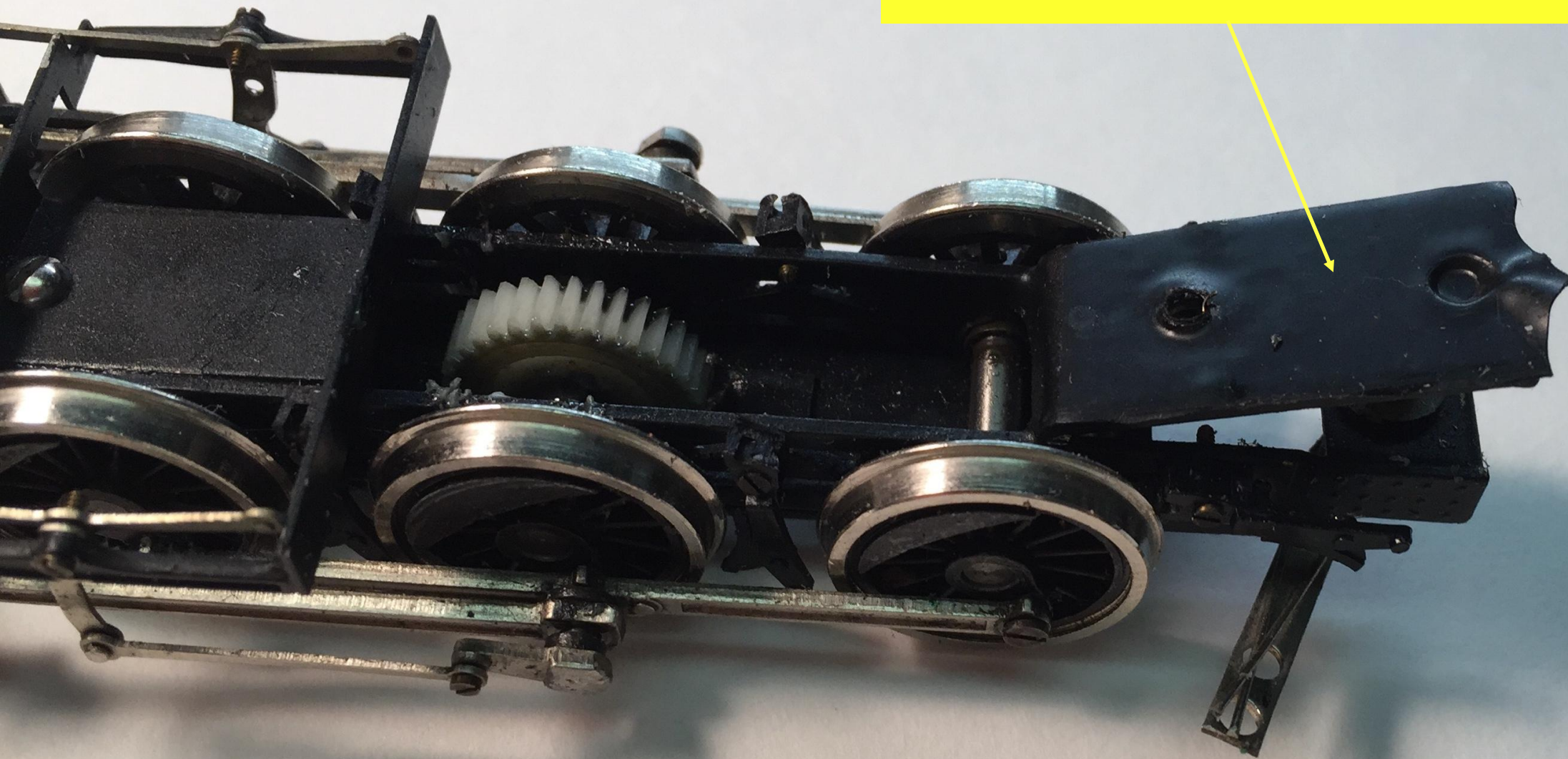
What if I Cannot Isolate the Brushes from the Motor Frame?

- **If you cannot isolate the brushes from the motor frame, then try to isolate the motor frame from the locomotive frame**
- **Most open frame electric motors attach to the locomotive frame with one or two threaded fasteners**
- **Put an electrically insulating piece of material (e.g., electrical tape) between the motor and the locomotive frame to electrically isolate the motor frame from the locomotive frame**



Motor frame is isolated
from locomotive frame with
thin piece of rubber

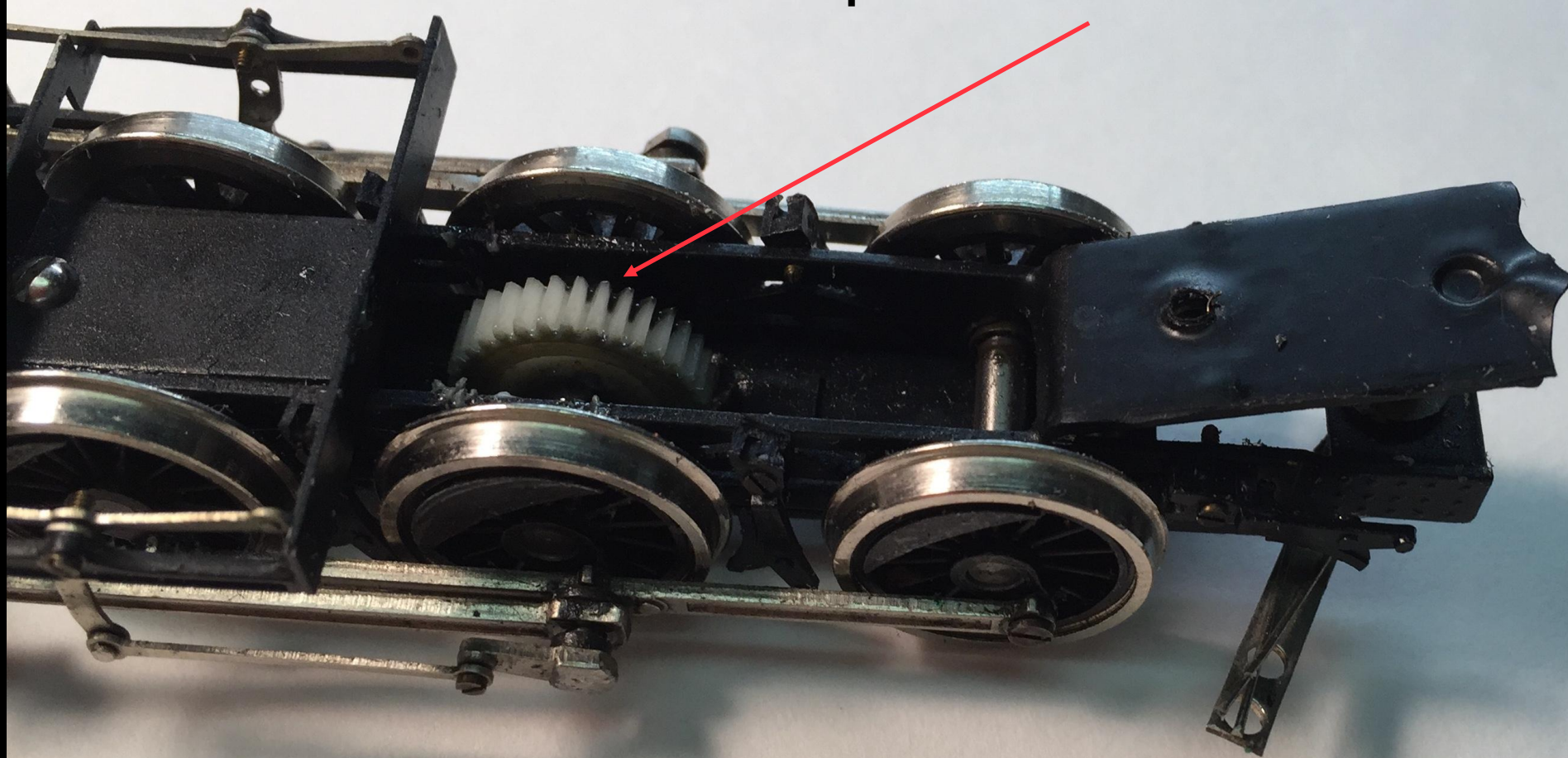
Piece of black electrical tape cut to size
and glued onto locomotive frame where
motor attaches



- **The threaded fastener that holds the motor to the frame can be a source of a short circuit because it is metal**
- **If you have a non-conductive fastener (e.g, nylon or plastic), use it to replace the metal fastener(s) that hold the motor to the frame.**
- **If you do not have plastic or nylon fasteners, put an insulating washer on the fastener and make sure the hole that the fastener passes through on the locomotive frame is big enough so the fastener threads don't touch it.**
- **Also, when you poke a hole through the isolating tape on the frame, push it into the hole to help prevent the motor fastener from touching the frame**

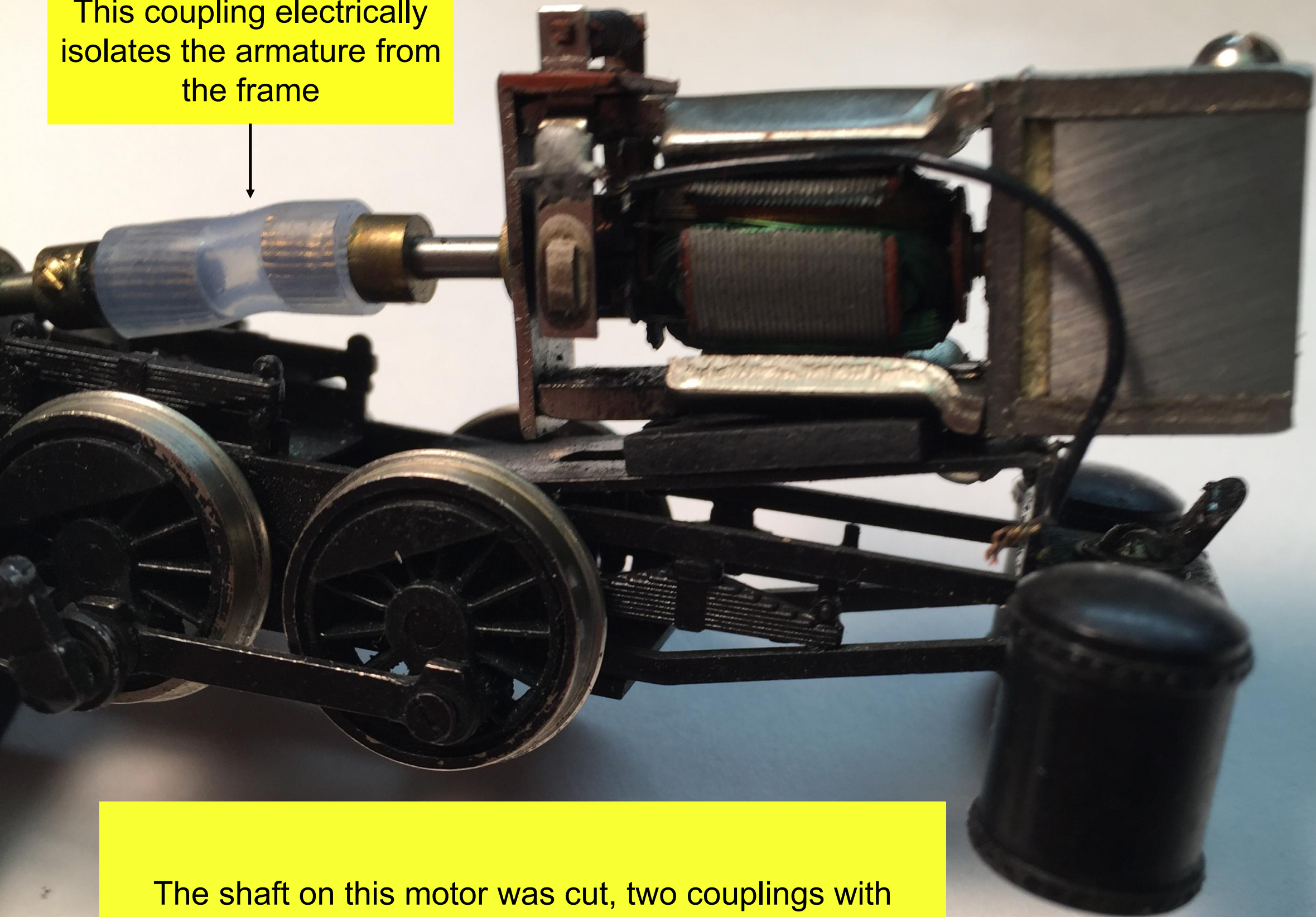
- **There is one other potential source of a short between the locomotive frame and the motor frame**
- **On some older motors, the motor shaft is in electrical contact with the motor frame (shaft bearings are not insulated from the motor frame) and drivers (because the main gear on driver axle that engages worm gear on the motor shaft is metal)**
- **The armature shaft has a worm gear on one end and drives a main gear that is attached to a driver axle**
- **If the main gear is plastic, then the gear will isolate the armature shaft from the axle and drivers**

**Main drive gear is nylon or
plastic on this locomotive**



- **If the gear is metal and the armature is electrically in contact with the motor frame, then the motor frame will be electrically in contact with the driver wheels**
- **Isolating the motor from the locomotive frame at the motor mount won't prevent the short caused by this path**
- **Isolating the brush bar will solve this short circuit path**
- **If you cannot isolate the brush bar from the motor frame, as a last resort you can cut the motor shaft and put a non-conductive coupling to reconnect the two halves of the armature shaft**

This coupling electrically isolates the armature from the frame



The shaft on this motor was cut, two couplings with knurled ends were installed, and a plastic tube coupler was attached

The motor is Isolated, Now What?

- **Before you re-install the boiler and cab assembly, can you put a headlight on the front of the boiler? Do you want to?**
- **If so, mount the headlight and feed the two wires through the boiler assembly.**
- **Note that the decoder output for a light is usually 12VDC, so if you use an LED light, be sure to include a dropping resistor**
- **Do you want to put pickups on the drivers?**

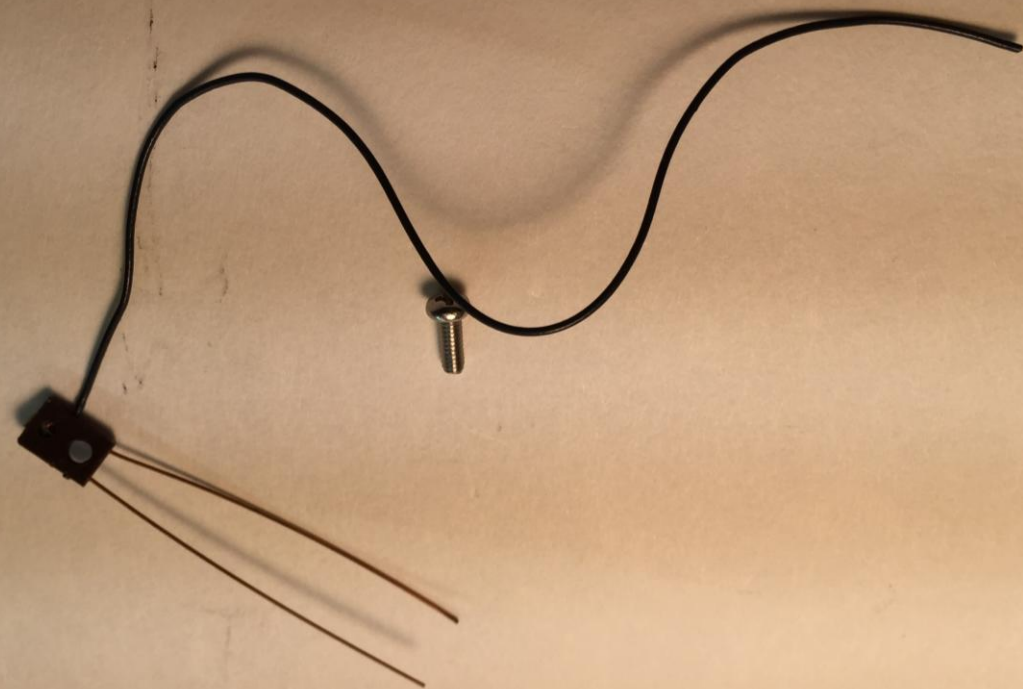
- **You have several options for picking up the DCC signal from the rails**
- **You can install wiper-style pickups on the locomotive**
- **You can install wiper-style pickups on the tender**
- **You can install wiper-style pickups on both the locomotive and the tender**
- **The more pickups you have, the smoother your engine will run (reduced stalling on dead spots, unpowered frogs, etc.)**

Installing Pickups on the Drivers

- One side of the drivers is connected to the locomotive frame, so a wire connected to the frame will pick up one side of the rails
- Install a wiper on the drivers that are isolated from the rails
- Grandt Line makes a wiper (part #7005) that is easy to install



**Grandt Line #7005
Electrical Pickup
Wiper**





Grandt Line Wiper Installed on a Mantua E6 4-4-2

Note wipers are rubbing against the two drivers. Make sure they are bent such that they will not snag on turnouts , crossings, etc.

- **Depending upon how many wires are connecting between the engine and the tender (potentially 6: two from the motor terminals, two from the rail pickups, and two from a headlight), purchase a micro-connector with the required number of connectors**
- **Train Control Systems (TCS) sells 2, 4, and 6 pin micro-connectors, and Miniaturonics sells 2,3, and 4 pin connectors**
- **Others may be available from other manufacturers**
- **Connect the wires from the locomotive to the micro-connector wires. Use shrink tubing or liquid tape around the soldered connections.**

Miniatronics 2-pin
connectors



TCS 4-pin connector



TCS 6-pin connector



Typical heat-shrink electrical insulation

Diameter before heat is applied

Diameter after heat is applied



TYPICAL CAN OF LIQUID
ELECTRICAL TAPE



- **At this point, if you have removed the electric motor in order to insulate it, and then reinstalled it, it is a good idea to test it**
- **If the motor is not aligned correctly, it could bind**
- **I strongly suggest that during various stages of the process, you periodically test the motor with a DC power source and make sure it runs freely and that the drivers and drive mechanisms all move freely**
- **Test it after you reinstall the boiler/cab assembly. The boiler/cab assembly is often cast metal on older locomotives, such as Mantua's and Bowser's.**

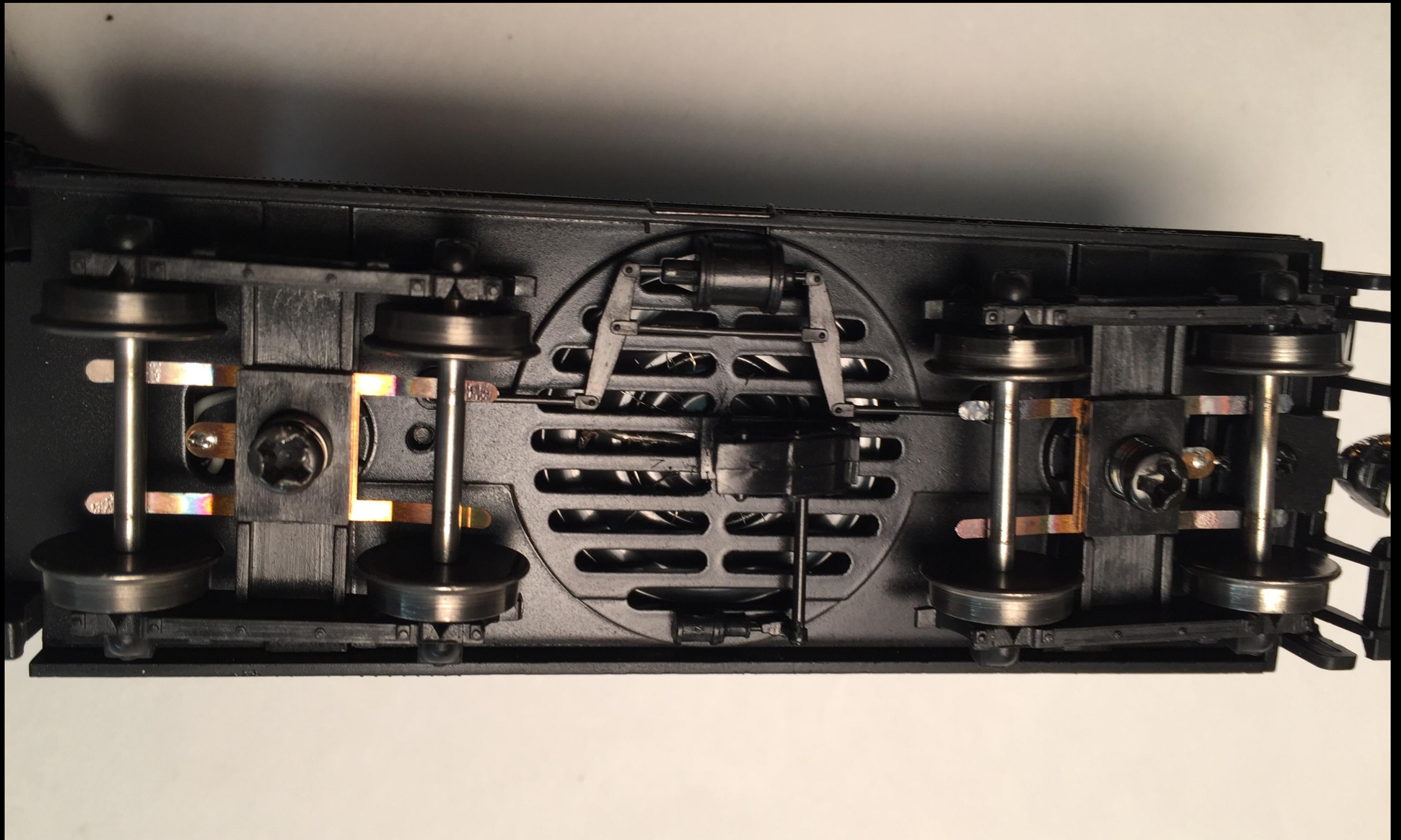
- **If the metal boiler/cab somehow touches either of the brush bars, it will electrically connect the motor directly to the rails**
- **Also, the boiler/cab assembly cab can push on the motor if not installed correctly, causing the motor to bind.**
- **Once the boiler/cab assembly is replaced, plug in the other end of the micro connector to the microconnector coming from the engine and connect the motor leads to a DC power supply**
- **Ensure that the engine runs smooth with no binding**

Now Let's Work on the Tender

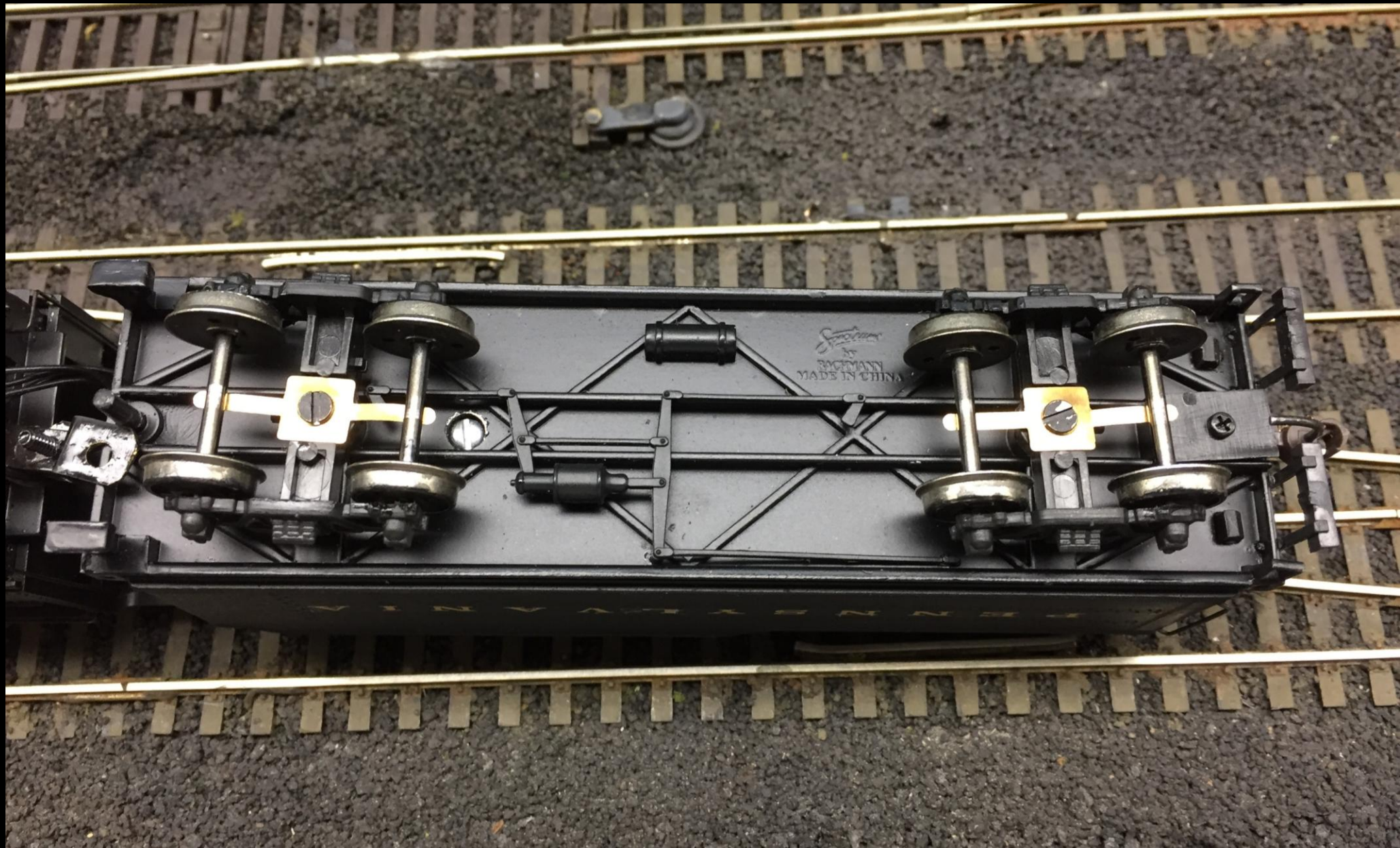
- Pickups on just the locomotive drivers may result in stalling on turnouts, crossings, etc.
- Pickups in the tender truck wheels will improve reliability and reduce stalling
- There are three options for installing pickups in the tender. Each option has its pros and cons
 - Mount wipers that rub on the axles of the wheels. One truck will pick up one rail, and the other truck will pick up the other rail
 - Use metal frame trucks to contact axles (wipers not needed)
 - Use Athearn freight car trucks with all-wheel pickup

Wipers that rub on the Axles

- **These can mount on the threaded fastener that holds the truck to the tender base**
- **Wipers rub on axles of wheels. Both wheels on one side of axle will pick up signal from one rail**
- **One truck will contact one rail, the other truck will contact the other rail**



Wipers on a HO Scale BLI H10



**Wipers on a Bachmann
K4 Tender**

- **PRO:**

- Provides pickup on each rail from two wheels on tender

- **CON:**

- Can be tricky to install so wipers are making good contact with axles
- Must be electrically isolated from a tender with a metal base, such as brass locomotives

Use Metal Frame Trucks to Contact Axles

- **A metal axle with metal wheels (one wheel is insulated from the axle) will contact a metal truck frame at the ends of the axle**
- **The metal truck frame can contact the metal tender frame and the entire tender frame will now be in contact with one rail**
- **You can do the same with the other truck but the tender wheels will only be picking up the power from one rail**
- **You can electrically isolate the other truck from the frame, and solder a wire to the truck, so it can now pick up the signal from the other rail**

- **PRO:**

- You only have to electrically isolate one truck

- **CON:**

- Entire tender frame is in contact with one rail with higher potential from inadvertent short circuits

Use Athearn Freight Trucks

- **Athearn makes freight car trucks with electrical pickups**
- **The wheels on one side of the truck pick up one rail, and the wheels on the other side of the truck pick up the other rail**

- **PRO:**

- Easy to install (truck frames are plastic similar to a non-pickup Athearn truck)
- You do not have to worry about electrically isolating them from a metal tender frame
- Installing two Athearn trucks on a tender means that four wheels will be picking up the signal from one rail, and four wheels will be picking up the signal from the other rail
- All-wheel pickup essentially eliminates the need to install wipers on the locomotive, and the benefit of needing a Keep Alive is reduced as well

- **CON:**

- Side frames on truck are not prototypic tender trucks

- **Each option has its pros and cons**
- **Decision is up to the modeler which option they prefer or feel most comfortable with**
- **My preference is to use the Athearn Trucks**
- **I feel benefits of ease of installation, elimination of potential shorting concerns, and getting all wheel pickup on the tender outweigh having a non-prototypic tender trucks**
- **I found no need for installing wipers on the locomotive drivers with the Athearn trucks on the tender**



AS CLOSE TO REAL AS IT GETS.™

ATHG61382

100-Ton Truck
w/ Electrical Pickup
1 Pair per Pack



Made in China
Rev 10.17.14-200 (D04)



Brass G-53sd with Athearn Trucks on Tender

Now That We've Figured Out How to Pick Up the Power Signal from the Rails, Lets Install a Decoder, Speaker, and Keep Alive

- **Most decoders come with a standardized color coding on the wiring harness**
- **The wiring harness is usually separate from the actual decoder, so it can be wired separately and the decoder plugged in after the wiring is complete**
- **All decoders also come with a wiring diagram showing the wiring colors and where they connect**

Typical Wiring Diagram

This is the
wiring diagram
for a TCS WOW
101-KA Sound
Decoder

WARRANTY PROCEDURE: All decoders are covered by a one year goof proof, no questions asked warranty. Please return in a small box.

You MUST register the failed decoder on our web site at www.tcsdcc.com.

Follow the instructions on the web site before returning any decoders to TCS.

Important: For maximum enjoyment of the dynamic proto chuff feature of this decoder we highly recommend that you calibrate the decoder using Audio Assist. This is one of the most important features of this decoder! You will love the results. See the video tutorial on the TCS web site!

WIRING DIAGRAM

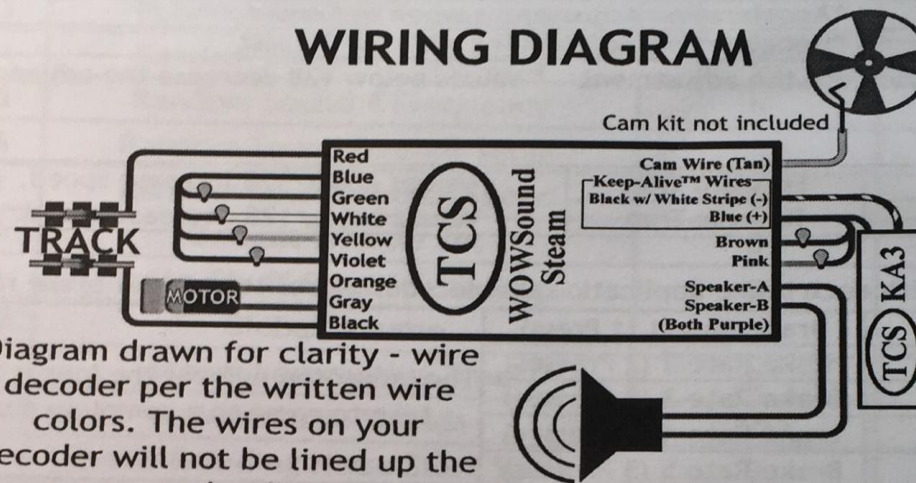


Diagram drawn for clarity - wire decoder per the written wire colors. The wires on your decoder will not be lined up the same as the diagram.

This decoder is Patriotic compliant, use the Additional Options menu in Audio Assist™ to find out more.

Speaker Selection

- 1W minimum power rating
- Speaker enclosures greatly increase speaker performance

WOWSound Upgrade

Older versions of WOWSound can be upgraded to the current version. Visit www.tcsdcc.com for more information

Video Tutorials

Important! First time users should view our instructional videos in the WOWSound section of the TCS website for a full range of information on using this decoder.

Compatible with NMRA DCC standards.

Made by TCS in the USA.

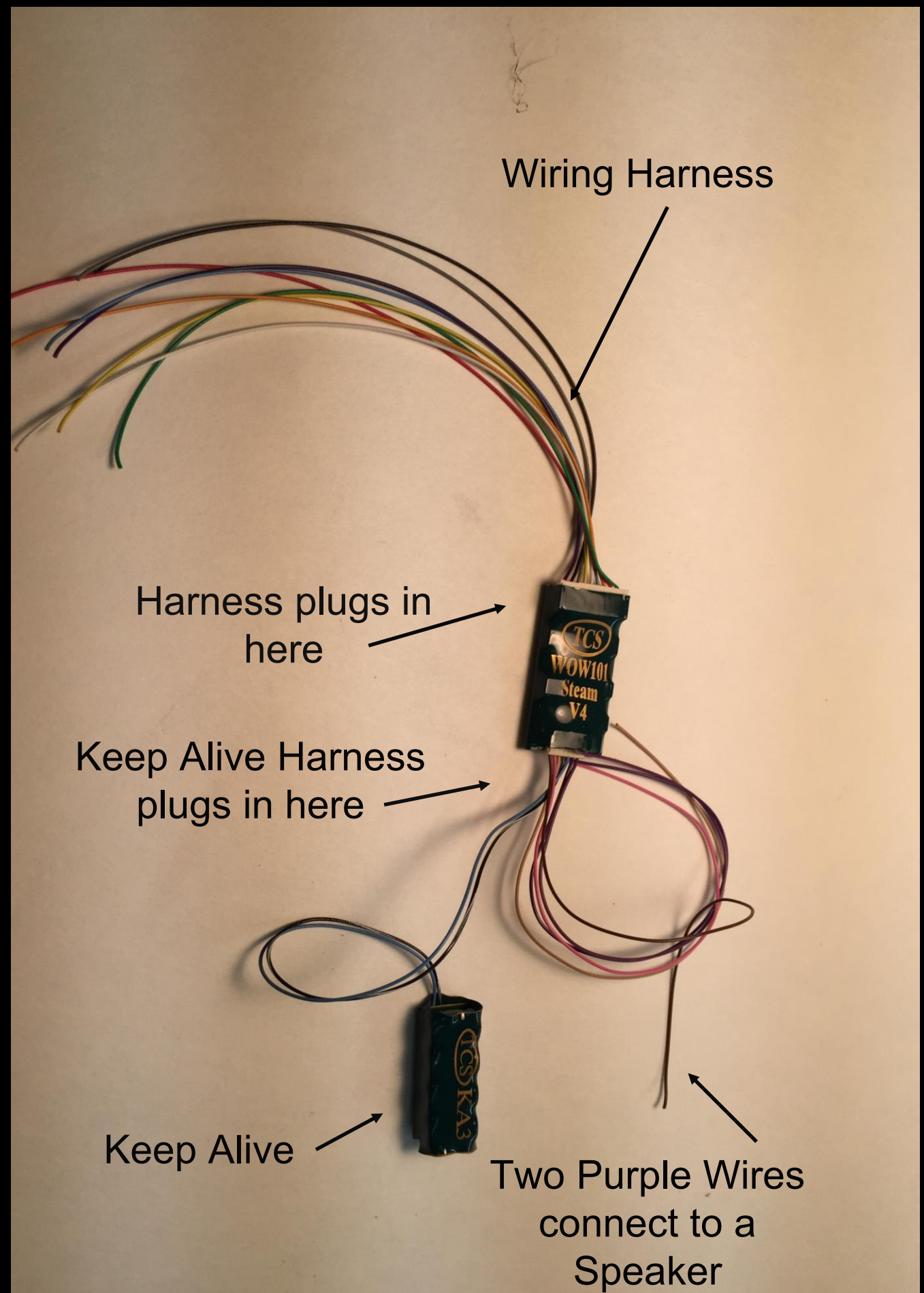
Train Control Systems
P.O. Box 341
845 Blooming Glen Rd.
Blooming Glen, PA 18911



Phone 215-453-9145
Fax 215-257-0735
Email tcs@tcsdcc.com
Web www.tcsdcc.com

Typical Sound Decoder as it Comes Out of the Package

This is a TCS WOW
101-KA Sound
decoder



Connecting the Decoder, Speaker, and Keep Alive

- The red wire and the black wire on the decoder harness connect to all the electrical pickups from the rails. Black connects to one side and red to the other
- Simply follow the wiring diagram that comes with the decoder
- Use an ohmmeter and frequently check to make sure you have all polarities correct
- The orange and gray wires connect to the motor. These should be soldered to the other end of the micro-connector you attached to the motor leads in the locomotive
- If you have a headlight, tender light, or even a firebox glow light, connect up those wires per the wiring diagram to a micro-connector

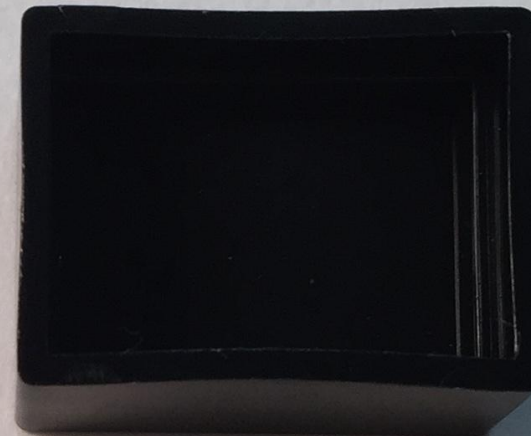
Speakers

- **There are a number of speakers available for installation in locomotives**
- **Ideally, what you want is the smallest speaker with the loudest and clearest sound**
- **Tony's Train Exchange recommended the TDS Supersonic Minispeaker and enclosure**

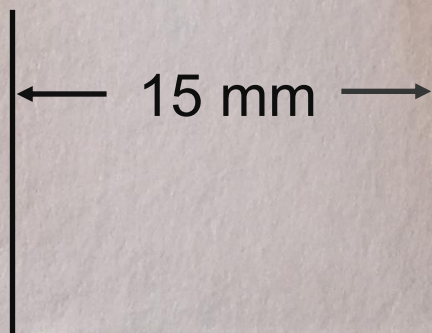
Baffle Enclosure
Extension



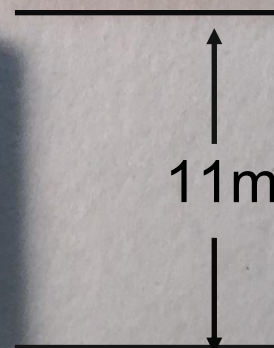
Baffle Enclosure



TDS Supersonic Mini-speaker



15 mm

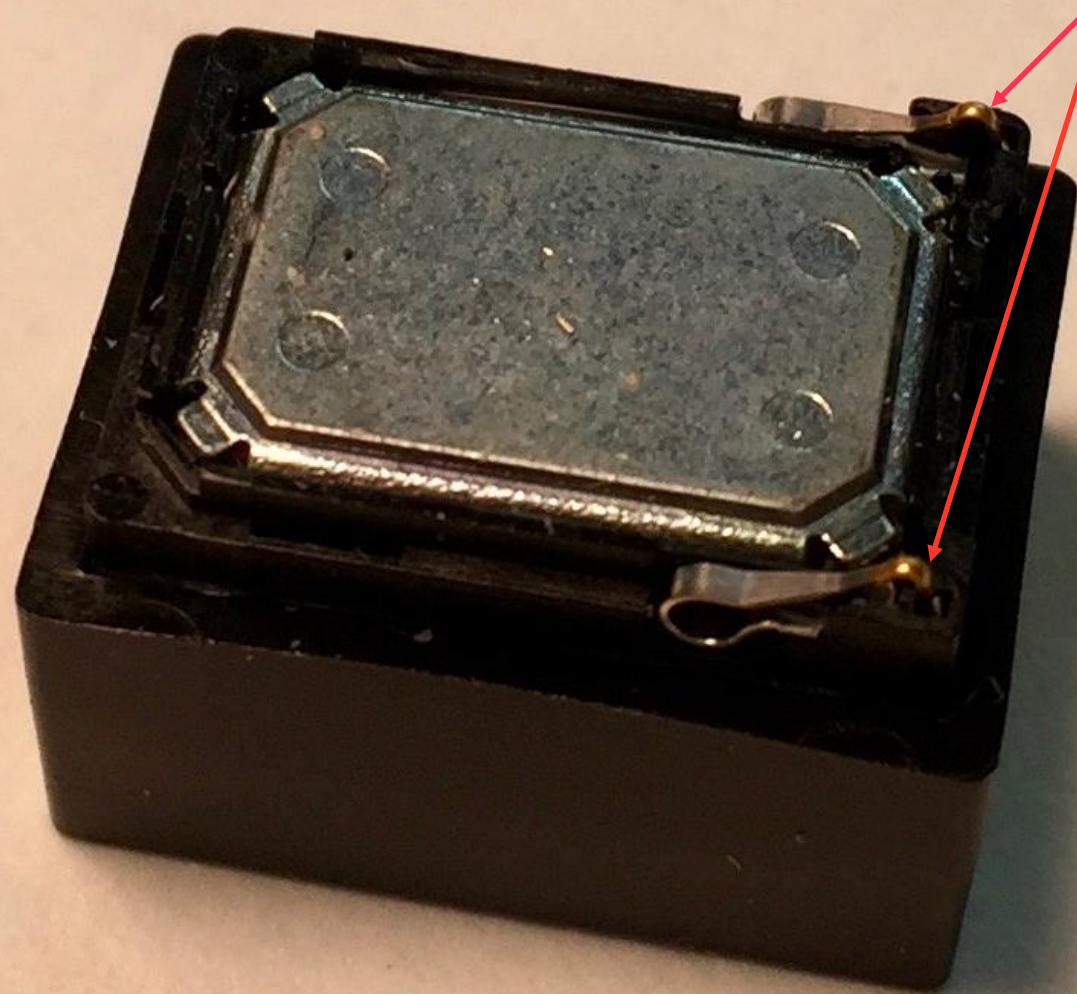


11mm

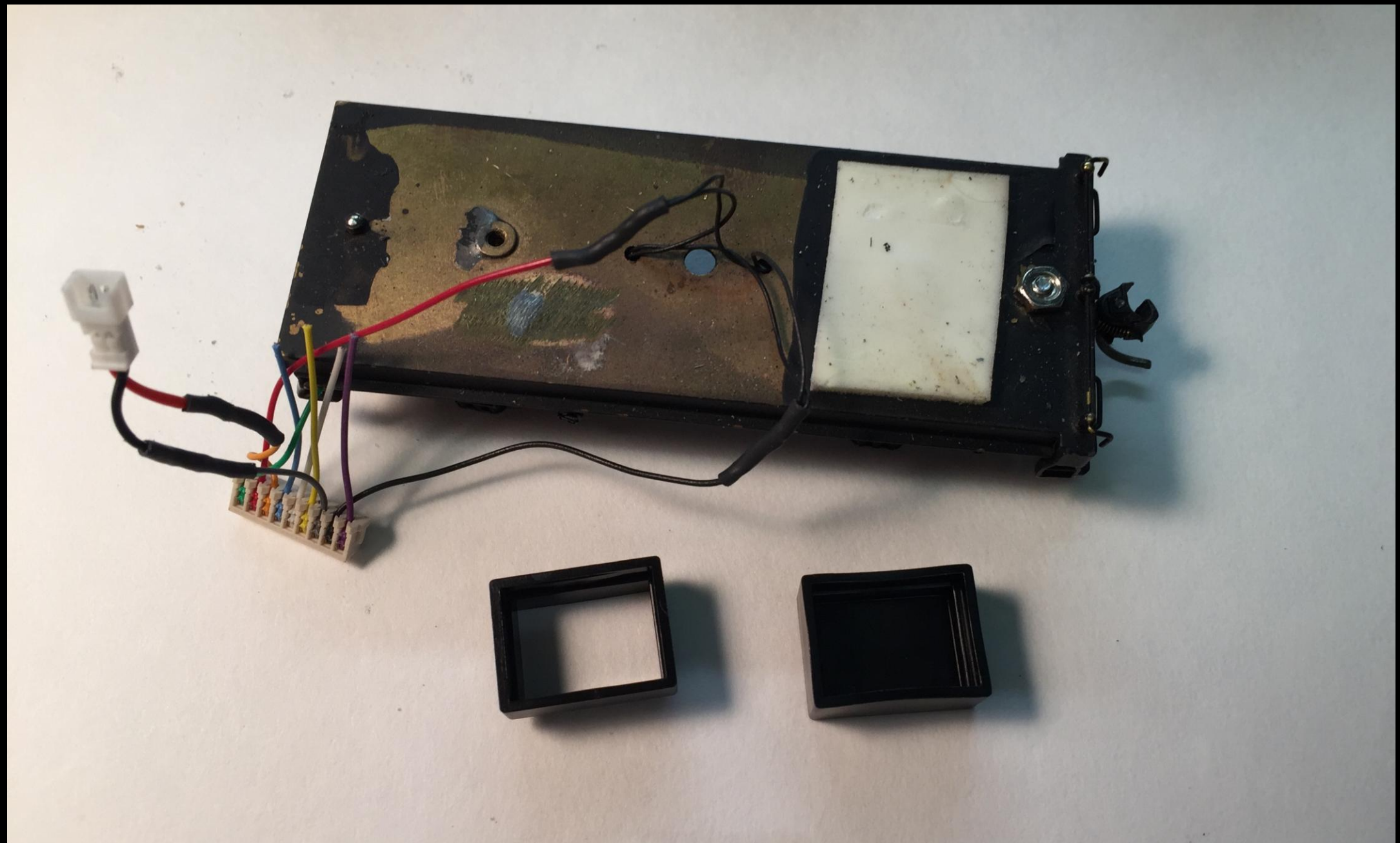
3.6 mm thick

- **This is basically a cell phone speaker**
- **It is loud! I did not have to drill holes in the base of the tender for the sound to come out loud and clear**
- **Very Inexpensive (about \$6 for the speaker and \$10 for the enclosure)**

Solder speaker wires to these
two terminals



**Supersonic Mini-Speaker Mounted in
the Baffle Enclosure**



Tender base with Ring Engineering truck leads soldered to red and black wires of harness and orange and gray leads that go to the motor soldered to a microconnector



Tender Shell with Decoder, Keep Alive, and Speaker Installed

Note that speaker, decoder, and KeepAlive all held in place with double-sided tape. Wires on decoder harness not in use were cut short



**1970's Vintage NJCB HO Scale G53sd
4-6-0 Locomotive with Sound Decoder,
Speaker, and Keep Alive Installed**



**G53sd with Decoder and
Coal Load Installed**

- **Note: if you installed either a headlight, tender light, or both, and the headlight comes on when the engine is reversed, simply switch the wires to the motor**

Total Cost (Approximate)

- **TCS WOW 101-KA Decoder with Keep Alive (~\$110)**
- **TDS Supersonic Minispeaker (~\$6)**
- **TDS Supersonic Minispeaker Enclosure (~\$10)**
- **Micro-connector (~\$1 - \$8)**
- **Two Athearn Power Pickup Trucks (~\$25-\$30)**
- **Total ~ \$150 - \$160**
- **Plus solder, shrink tubing, electrical tape, etc.**

- **Once the decoder is installed and you test out the engine, you will have to set the CVs the same way you would have to on a steam locomotive with factory-installed sound**
- **Most decoder manufacturers have a web site with decoder manuals that provide extensive information on CV settings, such a chuff rate, whistle type, volumes, etc.**

Thank You for Your Attention

- This clinic is posted on the Potomac Division web site (<http://potomac-nmra.org>). Follow the link to “**Modeling Ideas, Clinics, Articles,**” then “**Clinics and Library,**” and then “**Installing Sound Decoders in Steam Locomotives**”
- Any Questions?