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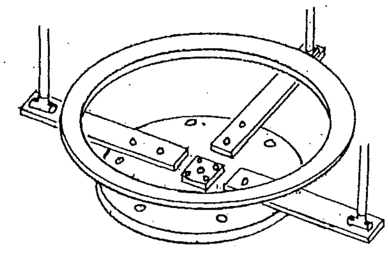
Newton and Lionel - Newton's 3rd Law of Motion is demonstrated in limitless ways because it is so common. In 1950, if not before, someone came up with the idea of using a bicycle wheel, some circular toy track, and an electric toy locomotive to illustrate "action and reaction". If all of the elements are constructed correctly, the demo is dramatic, and the law is verified.

Embedded in the 3rd Law, of course, is the Law of Conservation of Momentum, in this case, specifically Angular Momentum. It must be considered if the demo is to succeed, namely that the angular momentum of the running locomotive forward is equal to the angular momentum of the wheel and track rotating backward. It is imperative that the mass of the wheel and track and the friction involved be kept to a minimum as this design attempts to do. The wooden frame of the apparatus, without the spoked wheel, is pictured at the right.



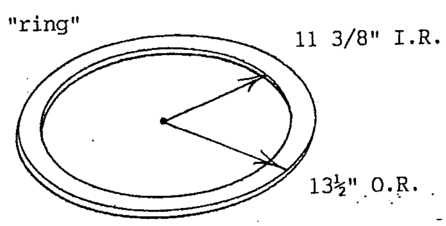
Considerations: The construction of this demo is very demanding. You may decide that the result is not worth the time, effort, and expense. Also, its storage requires a lot of space you may not have.

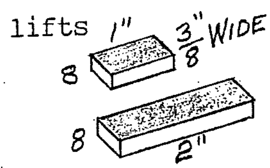
My 1978 design was based on two different versions that I had witnessed earlier; I chose the best ideas from each. You are free to improve the design. One of my "improvements" was to "bank" the track with 1/8" lifts under the outside rail; this provides extra safety to keep the locomotive on the track at higher speeds.

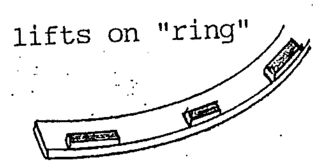
The construction of this apparatus is in three parts: mechanical, electrical, and stability.

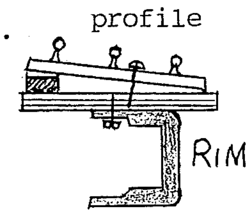
Part I - Mechanical. Follow the diagrams; nothing is drawn to scale.

Materials: a 26" bicycle wheel, a 3/8" plywood "ring", a 4" sq. x ½" steel plate, 3/4" plywood base, 6 thumb screws, 8 sections of 027 gauge curved track, 1/8" masonite lifts, #4 x ½" RH wood screws, 14mm and 9/16" thin bicycle wrenches

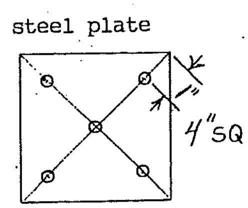
1. 

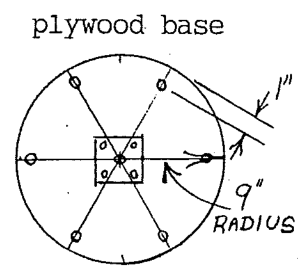

2. 


3. 


4. 


Construction: Using 3/8" plywood, cut out a "ring" as a base for the track (1.). Using 1/8" masonite, cut out 8 single-tie lifts and 8 double-tie lifts (2.). Assemble the curved track as tight as possible in a circle and center it on the "ring". Mark the positions of the lifts and glue them on (Elmer's?) (3.). Drill 8 equally spaced 1/8" holes in the wheel's rim for the #4 screws that will attach it to the "ring" (4.). Look to an "iron works" for the steel plate (5.). Drill the 17/64" dia. "axle" hole in the center and thread it with a 5/16" x 24 tap. Drill four 5/16" dia. holes in the corners of the plate for 5/16" x 18 x 1¼" stove bolts. Using 3/4" plywood, cut out a base 18" in dia. to hold the steel plate and six equally spaced holes for 5/16" x 18 x 1½" thumb (leveling) screws (6.). Center the plate and drill all five 5/16" holes through the plywood base; also, drill the six thumb screw holes with a 9/32" bit so the thumb screws can self-thread. (Tap part way if necessary with a 5/16" x 18 tap.) Put a finish (paint, varnish, etc.) on the "ring" and base plywoods.

5. 

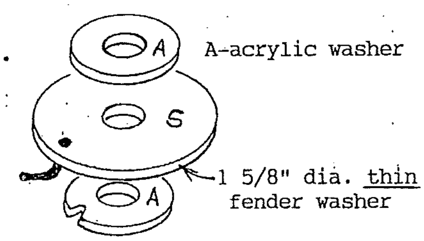

6. 

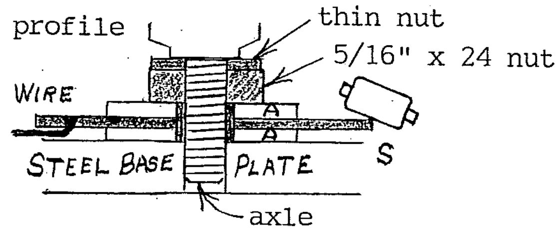

Part II - Electrical. Follow the diagrams.

The electrical connections or circuit are the most difficult part of the project. Current passes from the transformer to an insulated fender washer; a roller contacts the washer and carries the current up to a lockon connected to the track's center rail. After the current passes through the locomotive's motor, it travels to an outside wheel contacting an outside rail which connects to the lockon. From there, the current passes to a small lug and screw in the bicycle wheel's rim. From the rim, the current travels down a spoke, to the axle and the base plate. A lug under a corner bolt carries the current back to the transformer. Since it's only a 14 volt circuit, insulation is minimal; even the plywood is a good insulator at this low voltage.

Construction: Cut out two 1/8" acrylic "washers", 1 1/8" and 1 3/8" in dia. on a jig saw. Drill an 11/32" dia. hole in the acrylic and fender washers. Drill a 1/16" dia. hole off-center in the fender washer; solder the end of a wire in this hole. Cut a notch in the lower acrylic washer for the wire to pass. The washers are going to stack up on the base plate around the axle (7.).

7.

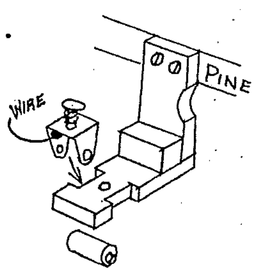



Assembly: Bolt (four) the steel base plate to the plywood base. For best electrical contact, use a "dry" bearing (no oil) in the axle. Wrap a layer or two of plastic tape around the axle that "faces" the washers only. Stack the washers on the base plate and screw the axle, through the washers, into the steel base; tighten everything down with the thin bicycle wrenches. Attach the track to the "ring" and the "ring" to the wheel's rim (4.).

The last step is constructing the "roller pick-up" that transfers the current from the fender washer's edge to the lockon. Some systems use a "wiper", a thin copper/brass strip that slides across the rim of the washer. I chose a roller for less friction and sparking (oxidation). The roller pick-up can be cannibalized from a "junk" toy car or purchased inexpensively from a Lionel parts store, usually by mail. You have to make an insulated bracket to hold the pick-up; I chose 1/8" acrylic (8.). Follow the diagram; recommended, make a cardboard pattern first. The bracket is fastened to a simple "clamp" made of pine and masonite that attaches to the spokes (9.). Wrap the insulated wire around a spoke from the pick-up to the lockon.

8.

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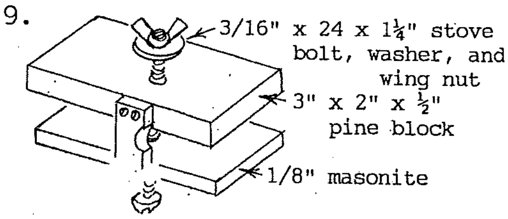
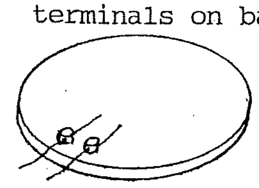



10. terminals on base

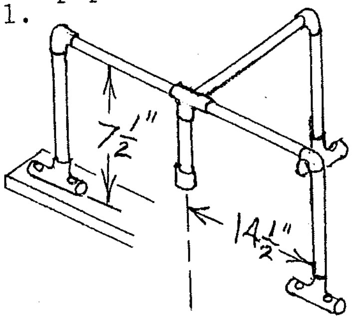


I also added a bubble level to the plywood base; adjust the thumb (leveling) screws. With all of the wires connected, especially to the two terminals on the base (10.), and the loco on the track, give the demo a try.

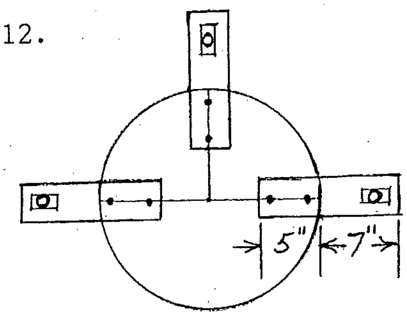
Part III - Stability. Follow the diagrams.

In my experience, I found that a heavier locomotive will "spring" (tilt) the axle wherever it is located on the track and affects the result; thus, an outside frame is necessary to stabilize the axle. I chose the use of rigid ½" copper pipe and brackets on one side of the apparatus leaving the other side "open" for display (11.).

11. pipe frame




12.

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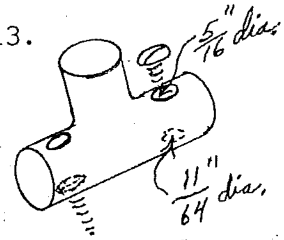


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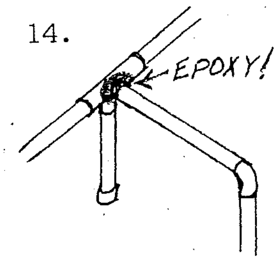


Construction: Plan on enough clearance for the loco. Cut three 2½" x 12" sticks from 3/4" pine or plywood; paint (?) and screw them down to the plywood base (12.). If brackets aren't available, make them from T's by drilling the necessary screw holes (13.) for #8 x 3/4" PH screws.

Carefully measure, cut, and fit the pipe, elbows, and T's together for the front of the frame. The "axle" pipe has an end cap with a 5/16" hole drilled in it to fit over the axle; sweat solder everything together. Center the frame over the axle and screw it down to the two sticks.

Measure, cut, and fit the back part of the frame. The connection (14.) to the central T is accomplished by making a paper pattern and shaping the end of that pipe with a grinder and a round file. The final attachment is made with epoxy putty after the sweat soldering is completed; screw this last bracket down. Test the system.

Good "used" electric toy train pieces may be donated by interested people or purchased inexpensively at train stores or shows. Semi-scale locos from the 1950's are ideal and are still available. I use a 2-6-2 steamer without its tender. You want as few non-powered wheels as possible to lessen drag (slowing the bicycle wheel and track). A 2-8-0 would be best but wasn't produced until recently.

A very convincing ending to this demo is the use of two matched No. 50 section gang cars aimed at each other on opposite sides of the track (circle). They meet head-on, collide, and reverse their direction. During all of this activity, the wheel and track doesn't move (rotate); thus, angular momentum is vividly conserved. Good physics and fun!