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THE SCREWDRIVER MOBILE ANTENNA

The following material was extracted from earlier editions. Figure and Equation sequence references are those from the 21st edition of *The ARRL Antenna Book*

Imagine QSYing from the bottom of 80 meters to the top of 10 meters, right from the driver's seat. With this antenna you will enjoy a very high Q antenna that has no taps or external adjustments, and that exhibits an SWR under 1.5:1 on all bands. Max Bloodworth, KO4TV, described this antenna in *The ARRL Antenna Compendium, Vol 7*.

The Screwdriver type of antenna was the brainchild of Don Johnson, W6AAQ, who developed it after many years of experimenting with mobile antennas. **Fig 23** is a photo of the completed antenna mounted on KO4TV's truck.

Fig 23—The completed Screwdriver antenna mounted on KO4TV's truck rear bumper. (*Photo courtesy of Gary Pearce, KN4AQ.*)

THE LOADING COIL

The general concept for the Screwdriver is that of a center-loaded antenna with an adjustable loading coil. This is an old idea; however, most previous multi-band antennas required multiple coil taps and an adjustable top whip section, as well as an impedance-matching unit at the base.

The problem of tapping a coil is well known. If you leave one end of the coil open, you have a miniature Tesla Coil, which can cause corona discharge and arcing. If you short the turns, the Q of the loading coil usually drops drastically. The Screwdriver is remarkable in that it does not have any coil taps and yet it can cover a wide range of frequencies with very high Q.

The secret is in the manner of adjusting the coil. It simply slides up or down into a metal tube (the base section), and makes contact with the top of the tube by means of "finger stock," which is made of spring-like Beryllium Copper. The coil is pushed up or down by an ordinary cordless screwdriver; hence the name, Screwdriver. This turns a section of threaded rod and moves the coil form up or down. The section of coil above the finger stock is the active loading coil, and the part of the coil just below the finger stock simply "disappears" into the base tube and is totally out of the circuit. No taps, no loose ends—just a high-Q coil in the middle of two solid metal tubes. Although this antenna is available ready-made from several commercial sources, making one is well within the capabilities of any ham who is relatively handy with ordinary hand tools, and who has access to either a small lathe or a common $1^{1}/_{4}$-inch pipe die.

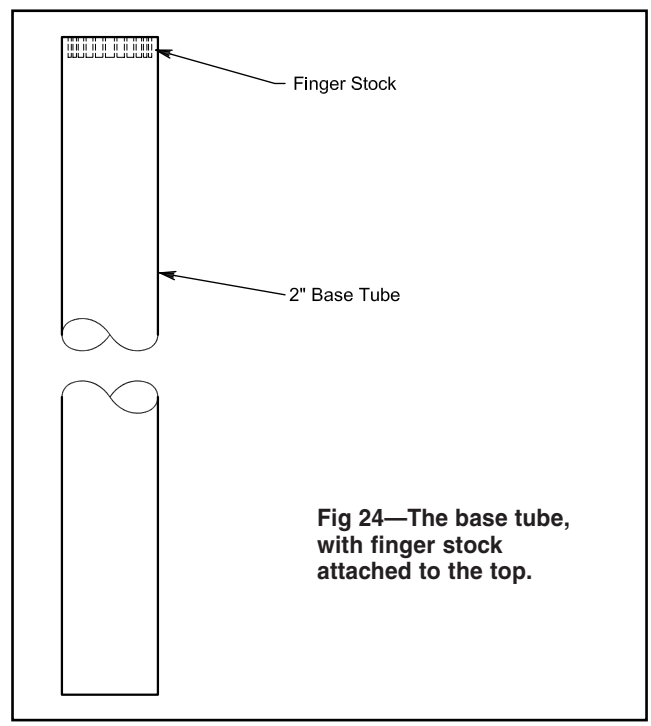

Fig 24—The base tube, with finger stock attached to the top.

CONSTRUCTING YOUR SCREWDRIVER ANTENNA

Construction begins by locating a 2-inch inside-diameter tube, about 3 to 3 1/2 feet long. See **Fig 24**. The author had used such diverse materials as:

- Aluminum irrigation pipe
- Schedule-20 copper tubing
- A stainless-steel hydraulic cylinder
- A section of aluminum from a 6-meter beam that was damaged by a tornado
- And even a brass bedpost salvaged from the local garbage dump.

The brass bedpost looked especially good on his vehicle, which was Burgundy with gold trim. Whatever material you use for the bottom tube, you can either leave it unfinished or painted to your taste.

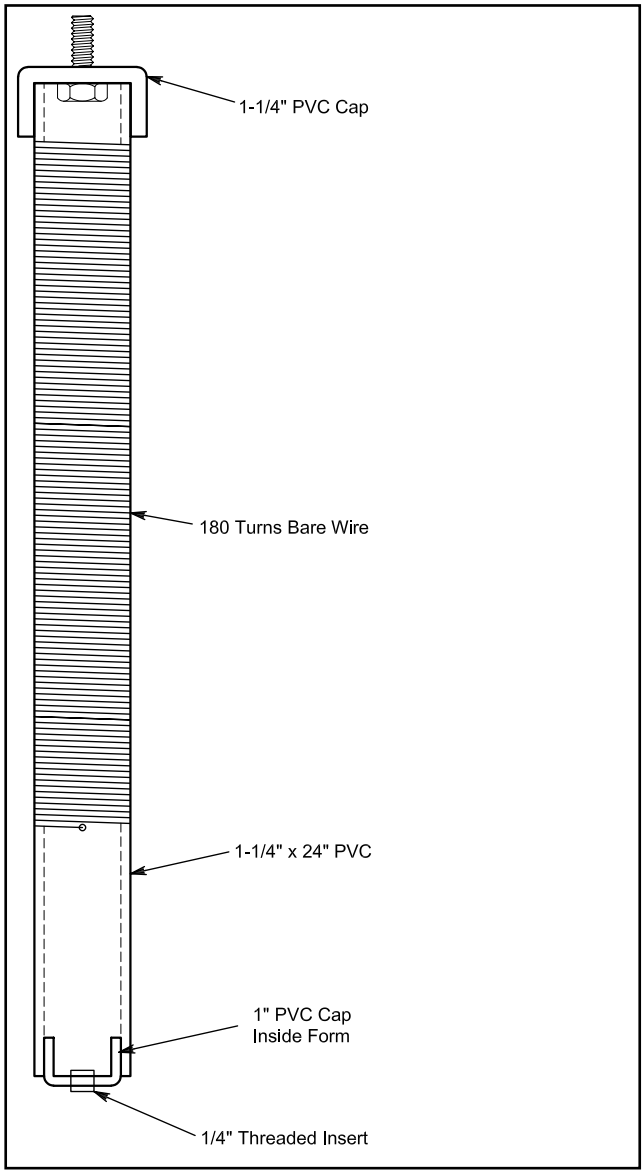

Fig 25—The coil form, with a threaded insert inserted into the bottom PVC cap inside the coil form.

The other essential item is a cordless screwdriver, minus its batteries and switch. You can often find one at yard sales or flea markets for a dollar or so, usually with dead batteries, since it is often just as cheap to buy another one new as it is to buy new batteries. So long as it will fit snugly inside the base tube, the brand name is immaterial. KO4TV has used Skil, Black & Decker, or even a Wal-Mart $8 special, all with equal success. The most difficult part of the job will be making the coil form and winding the loading coil, but with a little patience you should be able to do this satisfactorily.

Bear in mind that it is *not* a "Heathkit" type project, and it will require some innovation and ingenuity on your part. Next, obtain a 2-foot long piece of 1 1/4-inch PVC pipe (*not* CPVC, which is vulnerable to ultraviolet rays from the sun). With either a lathe or a pipe die, thread approximately 20 inches from one end, at 10 to 12 threads per inch (See **Fig 25**). If you use a pipe die, it helps to loosen the cutters slightly, to make the grooves shallower.

When using a lathe, temporarily insert a piece of 1-inch water pipe inside the coil form to hold it steady in the lathe. The grooves should be just deep enough to comfortably hold the wire in place when it is wound. The choice of coil wire is up to you. The author has used #16 or #18 tinned copper, bare copper, or best yet, 17-gauge aluminum electric fence wire. This is available from any

Fig 26—Photo of the top of the loading coil. (*Photo courtesy of Gary Pearce, KN4AQ.*)

farm supply store at a very reasonable cost. It will take about 65 to 70 feet of wire.

Begin by drilling a 1/16-inch hole through the PVC pipe at the bottom end of the threaded portion. Slip the end of the wire through this hole and tie a knot in it to serve as a stop. You could also insert a nut and bolt through a loop in the wire. Then carefully wind the coil to within an inch of the end of the threaded portion. The preferred method of winding is to put a stick or pipe through the holes of the wire reel and hold it between your feet and the floor, to provide the necessary tension to allow tight winding.

About an inch below the top of the coil, drill a 1/16-inch hole and thread about 6 or 8 inches of wire through it. This will be the top connection from the coil to the whip. The bottom of the coil has no electrical connection.

The method of attaching the whip to the top of the coil form is up to you. I usually drill a 3/8-inch hole through a 1 1/4-inch PVC pipe cap and place a 3/8 × 1 1/2-inch SAE bolt through the hole, with a matching washer and nut on top. The bolt can be drilled and tapped for mounting the whip, which should be about 5 to 6 feet long. (It will be pruned for resonance later.) See **Fig 26**, a photo showing the top of the coil.

A more elegant way of connecting the whip is to obtain a swivel or quick-disconnect antenna fitting from your nearest truck stop. These are widely available for use with CB antennas and are threaded 3/8-inch SAE. Do not attach the cap to the coil form until after the coil is inserted in the base tube.

Now that you have a coil form and a base tube, the next step will be to plug the bottom of the PVC coil form with a 1-inch PVC pipe cap, which fits snugly inside the coil form. Drill a hole directly in the center of this cap, and install a 1/4-20 threaded insert, available at most hardware stores for about 25 or 30 cents. These are commonly used in wooden furniture to provide a thread for attaching bolts to wood. See **Fig 27**.

It is imperative that you install this insert squarely. The best method is to screw a short bolt into it and chuck the bolt in a drill press, placing the pipe cap

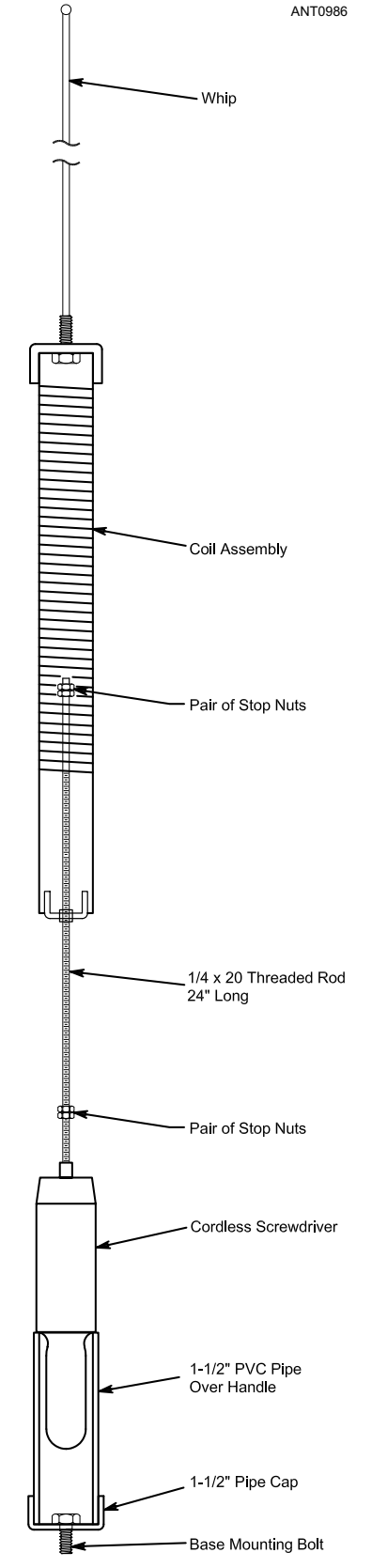

Fig 27—The coil assembly and cordless screwdriver drive assembly.

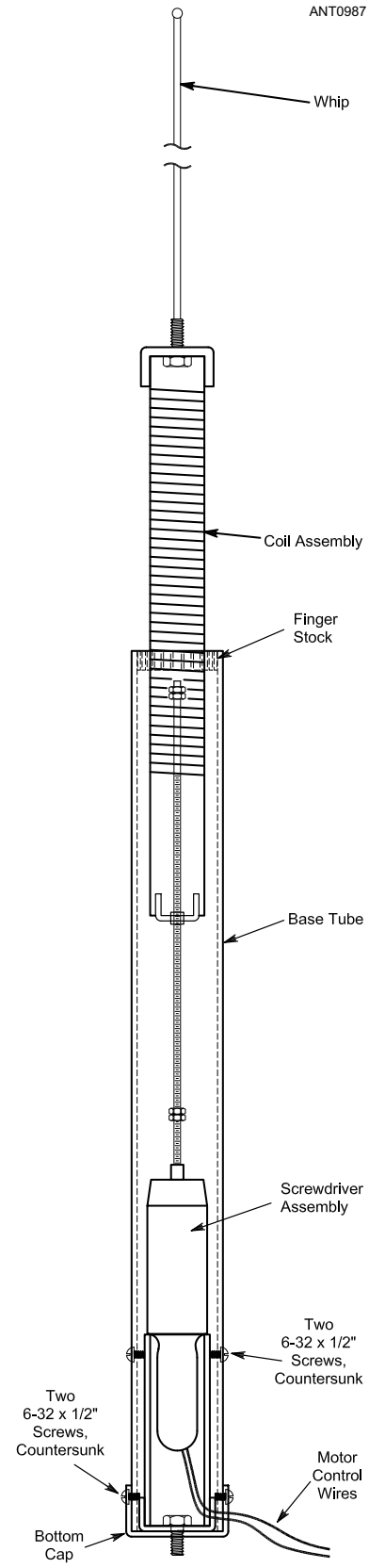

Fig 28—The complete antenna assembly.

squarely on the drill press table. Carefully turn the drill chuck by hand until the insert is properly seated.

The Motor

Now prepare the cordless drill by removing the dead batteries and the switch. Install a pair of 1 or 1.5-Ω, 10-W resistors in series with each motor lead. Connect a 0.1 μF 50-V disc ceramic capacitor across the motor leads to suppress motor noise.

Connect a pair of wires, about a foot long, to the other ends of the resistors. These will power the screwdriver from your car's 12-V system. Next, procure a 20-inch long piece of 1/4-20 threaded rod (also called "all-thread"). Insert one end of this into the cordless screwdriver chuck, and drill a 1/16-inch or 3/32-inch hole through both the chuck and the rod. Secure the rod in place with either a roll or cotter pin, and install a pair of 1/4-inch nuts on the rod near the screwdriver chuck. This will be the lower stop for the coil travel and will be adjusted later.

Thread the rod into the threaded insert at the bottom of the coil form, and install another pair of stop nuts on the top side of the rod. It will be easier to do this before attaching the bottom plug to the coil form. Again, these nuts will be adjusted later for proper coil travel.

Place the bottom plug into the coil form, drill a couple of holes through the form and the plug and tap them for 6-32 flat head bolts. Countersink the form so that the heads will be flush with the outside. Again, see **Fig 27**.

Finger Stock

Now, let's go back to the base tube. You must install a circle of finger-stock strip on the top of the tube to make contact with the coil, as shown in Fig 24. This can either be soldered or riveted, depending on your choice of tube material. Next, insert the coil and screwdriver assembly through the bottom of the tube, making sure that the coil clears the finger stock without deforming or bending it.

The best method I have found for attaching the screwdriver to the bottom tube is to fit a piece of 1 1/2-inch PVC pipe, about 8 or 10 inches long, over the handle of the screwdriver and attach it with a couple of flat-head 6-32 bolts. You may have to either grind some material off the handle or wrap it with some duct tape to make a snug fit inside the 1 1/2-inch PVC pipe, which should slip snugly into the base tube.

Place a matching 1 1/2-inch PVC pipe cap on the bottom of the pipe, and secure it with a couple of 6-32 screws. Drill a 1/4-inch hole through one side of the cap, which will serve to pass the wires from the screwdriver motor. Drill a 3/8-inch hole directly in the center of this cap for the base mount. See **Fig 28**, which is a drawing of the completed antenna assembly.

MOUNTING THE ANTENNA

At this point you must determine exactly how you wish to mount the antenna on your vehicle. You could fasten it to a standard mobile antenna mount, but *do not* use a spring! I prefer to fasten the assembly to a thick metal plate about 6 × 18 inches in size. I mount this to the frame of the car, protruding about 4 or 5 inches from the lower car body, just behind the rear wheel. You could also fasten such a plate to the lower fender sheet metal with large sheet-metal screws. The SO-239 connector is mounted to this plate also. See **Fig 29**.

An upper bracket, made from Plexiglas or similar insulating material, can be mounted from the trunk lip with an L-angle and used to support the top of the lower tube. See **Fig 30**. With a Plexiglas bracket about 4-inches wide, a 2-inch hole can be drilled in it to pass the tube. This will make a snug and rigid fit at the top. Under no circumstances use a metal band around the tube, as this will form a shorted turn and drastically lower the antenna Q.

With a little care, this type of mounting will leave no visible holes in the vehicle, which will likely enhance its trade-in value. If you mount the antenna on a pickup truck, it can be mounted directly on the rear safety bumper with a 1 1/2 inch pipe floor flange and matching adaptor on the bottom of the tube.

Electrical Connections

After mounting the base, your next job is to connect the wires from the screwdriver to a DPDT, spring-return center-off switch, mounted in a convenient location in your car. See the schematic in **Fig 31**. Connect the coax from the radio to the base tube, with the center conductor going to the base tube and the shield connected to ground at the base of the antenna.

If you like, you could install a simple base-matching network to give a perfect match on the lower bands. Even with no matching unit, SWR is usually under 2:1 on all

Fig 29—Base-mounting plate for Screw-driver installation on KO4TV's truck. Note the quick-disconnect dc motor con-nections and the SO-239 coax connector.

Fig 30—The support Plexiglas plate. (*Photo courtesy of Gary Pearce, KN4AQ.*)

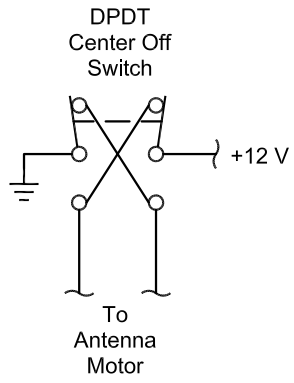

Fig 31—The DPDT center-off spring-loaded switch used to control the screwdriver motor.

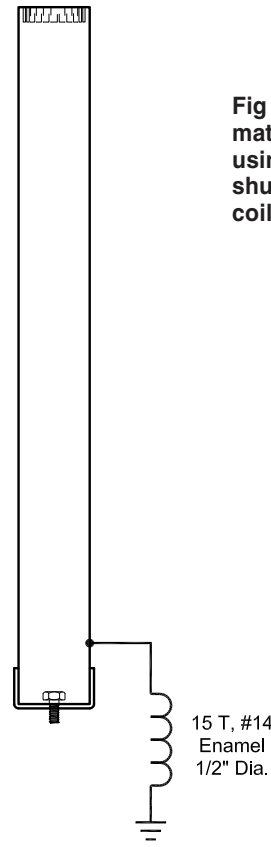

Fig 33—Alternative matching scheme using a single shunt matching coil.

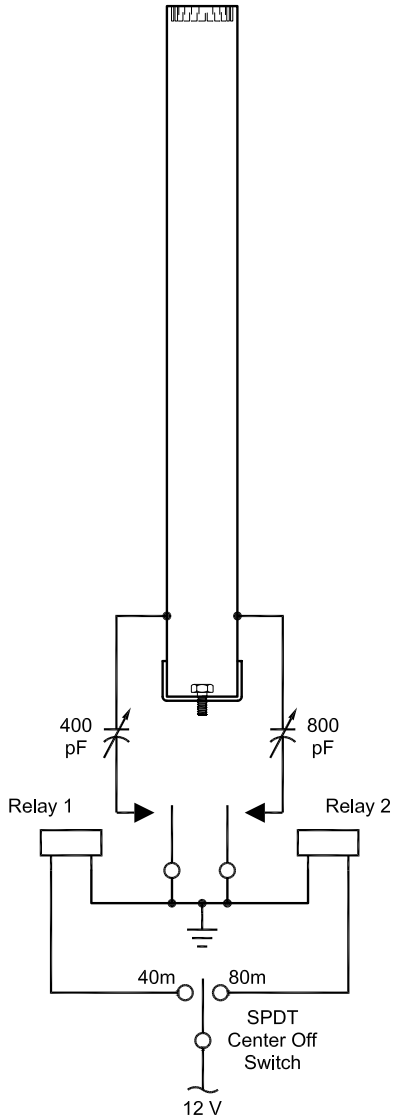

Fig 32—Relay-switched matching capacitors for 40 and 80 meters.

bands. See **Fig 32**. One matching network consists of a couple of trimmer capacitors switched from the bottom of the base tube to ground using a pair of small relays. For 80 meters, approximately 800 pF is required, and for 40 meters about 400 pF. No matching is required for 30 meters or higher.

An alternative matching method is to install a 15-turn coil made from #14 enamel wire, about 1/2 inch diameter, from the base to ground. See **Fig 33**. In either case, adjust the whip length for proper resonance at both ends of the HF spectrum over the range of movement of your coil.

This antenna may have different matching requirements, depending on the vehicle type and mounting location, so you may need to do some experimentation to obtain optimum results. If it doesn't work exactly right at first, be prepared to do a little experimenting.

A COIL COVER

Most builders will want to provide a coil cover, both for protection and appearance. KO4TV's favorite cover is made from a plastic mailing tube, about 24 to 30 inches long and about 1/2 inches in diameter. You can find these at an office supply store. They have a screw-on cap on one end, which can be mounted to the top of the loading coil.

Fig 34—Remote control by the rear-view mirror—tuning by the stripes! (*Photo courtesy of Gary Pearce, KN4AQ.*)

You trim the bottom of the cover to the proper length to allow the coil to be fully retracted into the base tube while still clearing the top bracket. Other builders have used such diverse materials as:

- Several 1-liter soft drink bottles cut off, swaged and glued together
- Sections of Schedule 20 PVC pipe with matching cap
- Empty beef jerky tubes (usually available for the asking at convenience stores)
- Wands from a shop vacuum cleaner, fitted with the cap from an aerosol spray can.

Just let your imagination run wild and you may be surprised at your own ingenuity. Whatever material you do use, paint it to match your vehicle. Just be sure to use non-metallic paint.

TUNING BY THE STRIPES

The author used different colored vinyl tapes to mark the tuning points for the amateur bands along the tuning coil. The lower edge of the supporting Plexiglas middle support acts as a pointer, which he can spot from his rear-view mirror. See **Fig 34**. This may be low-tech tuning method, but it works!

THE PROOF IS IN THE PUDDING

Now, you are ready to enjoy some real mobile communications on all bands, without even stopping the vehicle to QSY. KO4TV's antenna has contacted over 100 DX countries, from as far away as Tasmania and Japan from the East Coast. He enjoys regular contacts with Israel and other stations in the Mid-East, running 100 W or less.