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Build a Weird 2 Band Mobile Antenna

--fantastic parking lot car locater

If you have operated 75 and 40 mobile, you are well aware of the problem of stopping (on a freeway?) to switch resonators on your antenna only to wish you had stayed on the other frequency. Wouldn't it be great if you could switch bands even more conveniently than in your home station . . . no levers, switches, sliders or moving parts?

Here is an electronically switched multiband mobile antenna that can be built with the minimum of parts that are available at the corner home improvement discount house.

I had been anxious for a no-nonsense, non-mechanical multiband mobile antenna for years. The final straw, however, occurred somwhat suddenly one stormy afternoon away from home in our travel trailer. I was talking to a long-time friend across a couple of states and without warning he suggested we shift from 75 to 40 and "click" – he was gone. Normally this would not have been a big deal, but under the circumstances it was downright inconvenient.

This was in 1969, and almost the first person I saw after returning home was Walt W6IJA. He came to our place sporting a three band antenna on his mobile.

Walt had all three of his resonators, 75-40-20, mounted fan fashion on a single base section fed with a single feedline. It was so stupidly simple and practical that I had carbon copies installed on my car and travel trailer within hours. Using just about any resonators available, most of the mobiles in the area were multiband from then on. See Fig. 1.

Not All Roses

Even with the W6IJA multiband antenna, I kept looking for that better mousetrap. Along the way there were plenty of failures. One that I think worth mentioning was what I thought was my greatest pride and joy.

By early 1971 I had a dual bander that looked just like a monobander going down the road. Simply, it was constructed with two insulated top whips laid side by side and held together with shrink tubing. One whip was attached to the top of the coil for 75 and the other brought down to a point where it would resonate on 40 meters (see Fig. 2).

The rig used was a small low powered 75-40 SSB transceiver. The antenna was used mobile for over six months and I was so convinced "this was it" that I submitted a patent disclosure.

Then one weekend I shifted it over to another vehicle with a higher powered rig. After the second syllable – nothing – complete failure. Looking outside toward the antenna, I saw a neat little smoke ring drifting across the canyon! Inspection revealed that the whips had arced through the insulation and they were shorted together at the center. Every type of available insulation was tried, but anytime anything but the little rig was tried . . . fireworks! Back to slaving over a hot soldering iron.

Mother of Invention

Then there was the time I completely demolished my W6IJA dual band antenna with no spare parts for miles around. I did salvage enough for a 75 meter resonator and a couple of top whips, and I was going to be content to get out and short out a few turns to get on 40.

The more I thought of this the less I liked it, having been spoiled by the dual band convenience, so I haywired together a modified version of the earlier "Ol' Smokey." See Fig. 3.

This worked the very first try, and the antenna noise bridge indicated a good match to the 50 Ohm coax on both bands using the old tried and true "Z" match at the base. A surprise bonus was several dB gain in signal strength over the monobanders.

Within a few months this model was cleaned up mechanically, using easy to obtain parts and far fewer of them. Also, the current model described in this article is a little easier on the eye. With a large number of them on the road for the past few years, it has exceeded all expectations. Mechanically it is rugged — none has been reported broken. It has been operated thousands of miles in ice, snow, mud, rain, hot and cold. Everyone has been pleasantly surprised with the performance.

During six months in 1975 the XYL and I traveled 15,000 miles to the four corners of the United States and we never missed our daily 75 meter schedule to the home base in California. Time, 1900 PST; frequency, 3830; rig, TR-3 with the big DK antenna.

No, This Is Not a Broadband Antenna

It may be redundant, but I have to repeat that, like any other good HF mobile antenna, this is not a broadband device. In my travels to clubs last year this was usually the first question that was asked. This appears to be a point that has eluded even a lot of the old-timers. Maybe it is just wishful thinking.

When you are messing with a high Q HF mobile antenna, twiddling the transmitter knobs will not make the antenna work any better. The antenna must be resonant and then matched to the feedline. The more abbreviated the antenna is in relation to the wavelength, the less the usable bandwidth. That's just the way it is! See Fig. 4.

For some of the hard to convince, I have tuned and matched their transmitters to good fifty Ohm dummy loads and then switched it over to the antenna to prove that twisting the transmitter knobs wasn't the secret to get the antenna to take the load. As a matter of fact, this is a very acceptable way to match your antenna to transmitter and feedline. Just switch off from the dummy load and then do all the adjusting to the antenna system to obtain maximum output. The big DK as shown will present a 50 Ohm load at the base on both 75 and 40. The swr will be less than 1.1 to 1.

Preparing the Coil Form

The loading coil is wound on a nineteen inch piece of one inch, schedule 40 PVC pipe. The 1" is the inside dimension. It's a little over an inch and a quarter on the outside. You should be able to bum this much pipe out of your friendly plumber's scrap box. When you cut off the ends, use a pipe cutter if possible to be sure they are square. Don't use too much pressure and crowd the cutter.

With a straightedge, lay a line the full length of the pipe along one side. Measuring from the bottom end, accurately mark points at 1", at 7

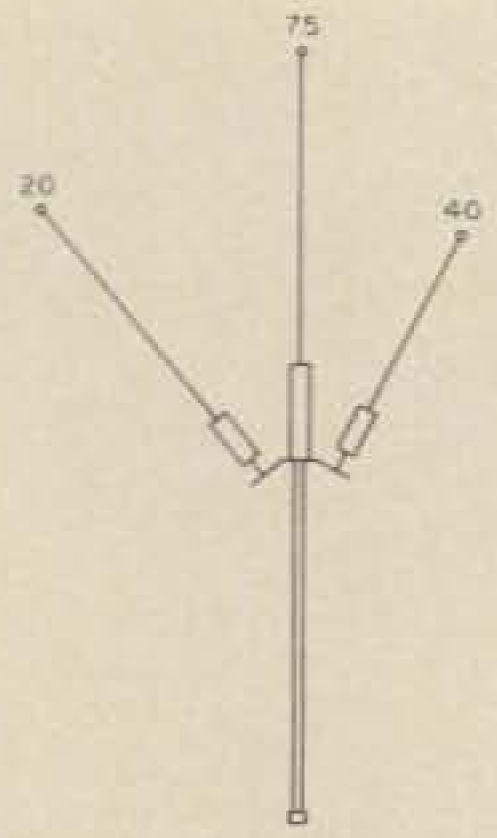

Fig. 1. The 1969 W6IJA special.

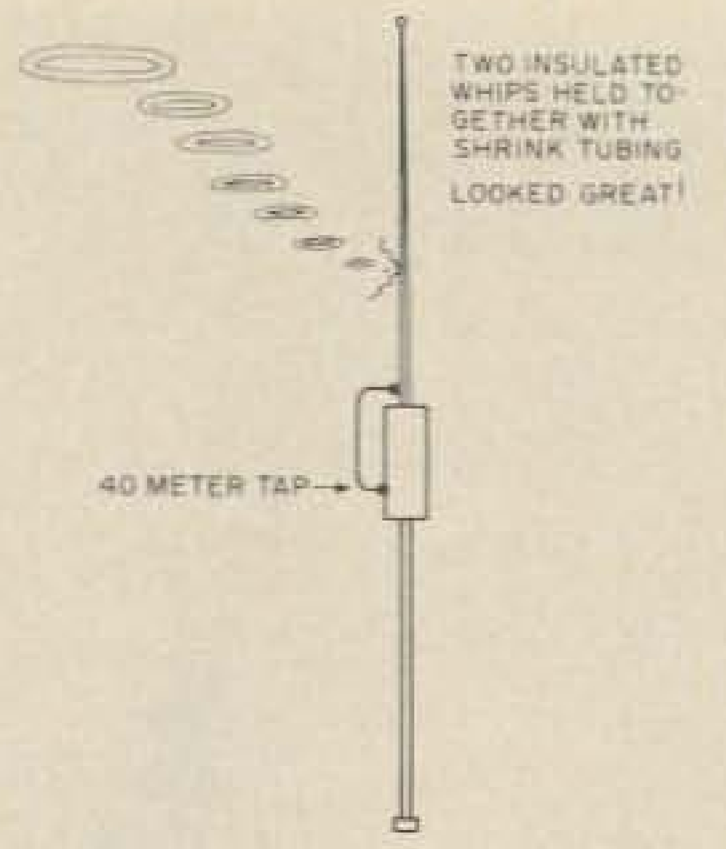

Fig. 2. Ol' Smokey.

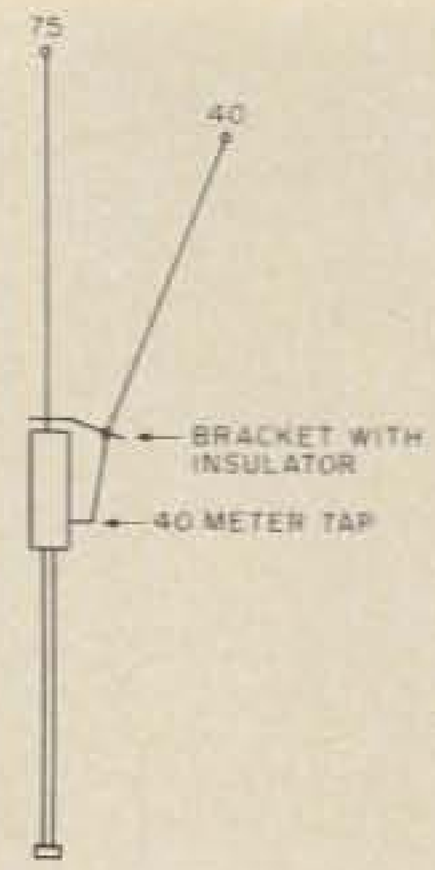

Fig. 3. The 1972 impromptu dual bander.

1/8" and at 17 5/8". Use a number 30 drill and drill holes through the side of the pipe at these points. At the 1" mark only, drill on through both sides of the pipe (see Fig. 5).

The next step is to install the bottom plug to provide the mechanical and electrical connection to the usual 3/8-24 stud that is found on mobile antenna base sections. If you dig around in the plumbing supplies, you can find a regular 3/4" to 1/8" pipe bushing that has a lot of threads both inside and out. The inside 1/8" pipe threads will be tapered and it may be necessary to run a 3/8-24 tap all the way through so it will screw all the way onto the bottom mast section. The cast bushings are not so good, but usually in the same bins there will be ones that appear to be machined and are also plated. A brass bushing would be dandy.

Screw this bushing into the bottom end of the pipe until all the outside threads disappear. Here's where a lathe would be great, because it is important to get this plug in straight so the antenna will stand at attention properly when it is finally mounted on the vehicle.

The pipe bushing will screw in very tightly and makes its own threads as it is turned in. Be sure the pipe is at room temperature so it won't crack. I have never used any glue or cement to hold the bushing in and have never had any reports of any coming loose. Believe it or not, this makes a really rugged mount. I have hit low obstructions with the coil hard enough to break off the bottom mast section with no damage to the coil.

When the bushing is in, drill and tap for an 8-32 screw on the side of the pipe, through the PVC and into the bushing. Do this directly below the 1" point where the number 30 drill came out opposite the penciled line. This screw will be used for the lower coil connection.

Winding the Coil

Winding the coil is really the most difficult part of construction, particularly if a lathe is not available. The coil is wound with 196 turns of #18 solid copper wire space wound to 12 turns per inch. The 40 meter tap will pass over the tap hole at the 71st turn. 85 feet of wire will be sufficient to wind the coil and leave plenty to play with on both ends.

Before you go at it the hard way, check with one of the local adult education classes where someone is taking shop and a lathe is available. Set up the lathe for 12 threads per inch, run the wire through a guide on the tool post, and it will take the operator about one minute to wind the entire coil. Note how the start and finish wire is dressed through the holes in the PVC coil form (see Fig. 6).

Also, if I am winding on a lathe, I spray a thin coat of adhesive on the pipe just ahead of the winding to help keep the wire in place. Sometimes when I am not in a hurry, and can leave it in the lathe for a while, I brush on a generous coat of fiberglass resin or varnish over the windings and let the coil keep turning while the stuff sets up. This makes a very attractive finish and it can even be painted to a color of your choice. Just be sure you are careful about the kind of paint used. No metallic particles, please! I have been that route.

If resin or varnish is used, be sure to put a toothpick or some similar plug in the 40 meter tap hole so it can be cleared later without damaging the wire.

Those of you who have shrink tubing available can go ahead and use it over the coil; it works fine. Also, it is advisable to drill a small drain hole on the side just above the bottom plug. I found this necessary as I unscrewed my coil one day to show it off. The coil holds exactly one coatsleeve full of water!

As I say, if you can get to a lathe, you have it made. I would certainly make every effort to locate one. If not, there are other tedious ways to space-wind coils, but one this size gets to be a problem. Our luck has been that when the XYL and I are very carefully winding one by hand, the phone will ring. The question is who drops what, or do you just start over only to have the whole thing "clunk" together at the very last turn?

A popular way, of course, is to select another piece of wire or a string that will give the correct spacing, and then

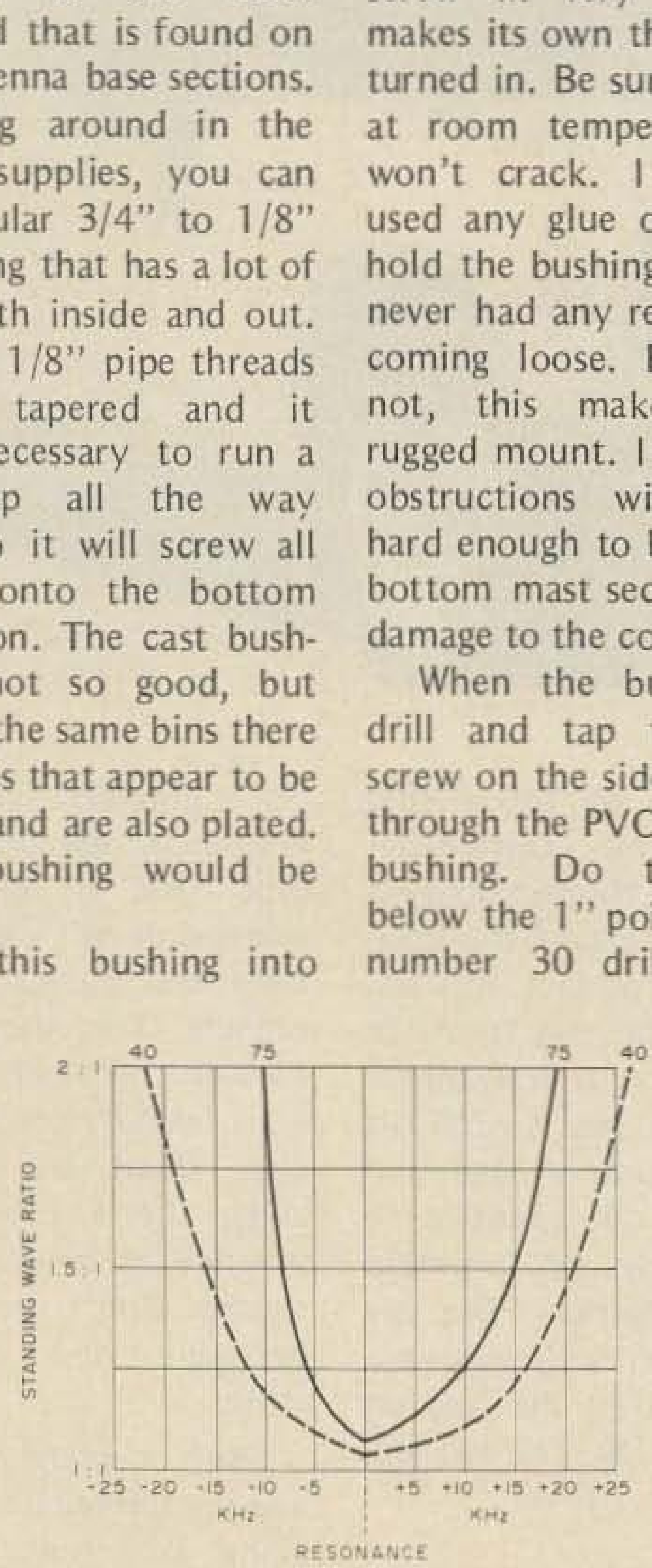

Fig. 4. Swr curves for typical big DK.

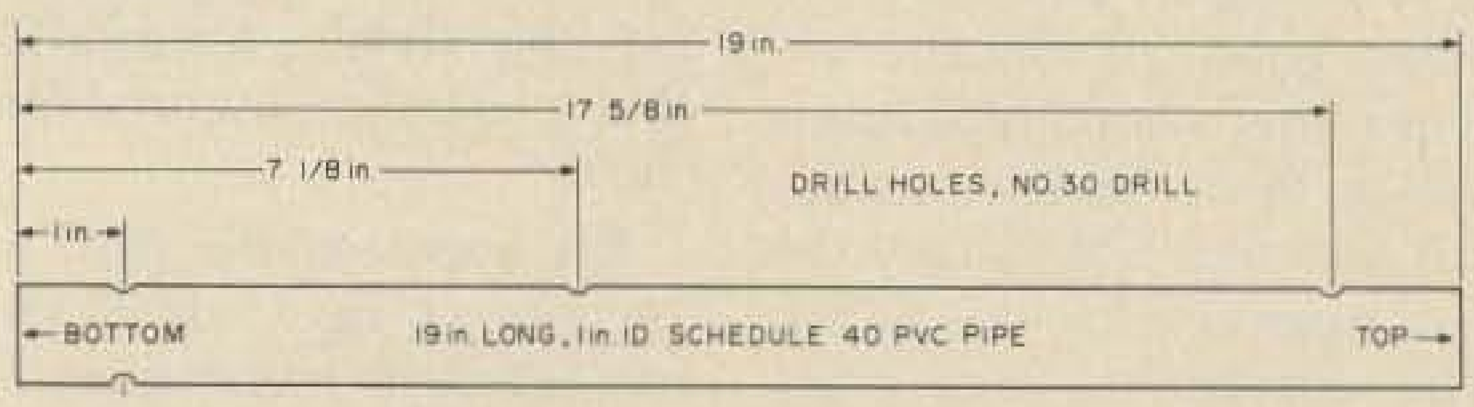

Fig. 5. Preparing the coil form.

wind it side by side with the coil wire. When the winding is completed and secured, the wire or string is carefully removed.

Preparing the Coil Wires

Remove the insulation from the end of the bottom coil wire and place it securely under the 8-32 screw that goes into the side of the 3/4" pipe bushing. I use a brass screw and then a dab of solder to be sure there is a good electrical connection. This is a low voltage point and it is wise to continually inspect all connections from here on down to the feedline to keep the I/R losses to absolute minimum. Dissimilar metals and constant exposure to the elements encourage trouble, causing corrosion in a very short time.

For the 40 meter tap I use an eighteen inch piece of the inner insulated conductor from stripped RG-58U or other similar small coax. Strip the insulation from this inner conductor 2" on one end and 3" on the other. Be sure there are no nicks in the wire.

Remove the insulation from the coil winding that passes directly over the hole drilled for the 40 meter tap (turn 71). Be sure you don't take any insulation off the adjacent windings. Clean out the hole under this wire.

Now shove the wire just prepared down through the inside center of the coil form from the top so that the bare end stripped 2" comes out through the 40 meter tap hole. This is not hard to do. Put a long 90° radius on the bare 2" end and then hold the pipe and wire in such a way that as you shove it down toward the tap hole you have a good chance of it coming out on the first try.

Pull this wire out so the insulation is tight up against the inside of the 40 meter tap hole. Use a small soldering iron and solder this wire to the winding that passes over the hole. Put a little bend or hook in the end of the tap wire to help hold it mechanically. Try applying a little pressure to this connection with the soldering iron, pushing it just below the outside surface of the PVC. Don't push too hard or you'll have a horrible mess. When soldered, carefully trim off the excess wire and examine closely to make sure there are no solder blobs or bitter ends touching the adjacent windings.

Cut off the wire coming out of the coil from the 75 meter hole so the wire extends three inches beyond the top end of the pipe. Remove two inches of insulation from the 75 meter wire. Tin both the 75 and 40 meter wires. Now your masterpiece should look like Fig. 6.

Preparing the Tee

The support for the two whips on top of the coil is a one inch PVC pipe tee that slips on the top of the completed coil. When obtaining this fitting, ask for a "slip-slip-slip" one inch PVC tee for 1" schedule 40 PVC pipe. No threads.

Drill two 5/16" holes, 1 1/4" each side of center, through the top of the tee for mounting the two whips (see Fig. 7).

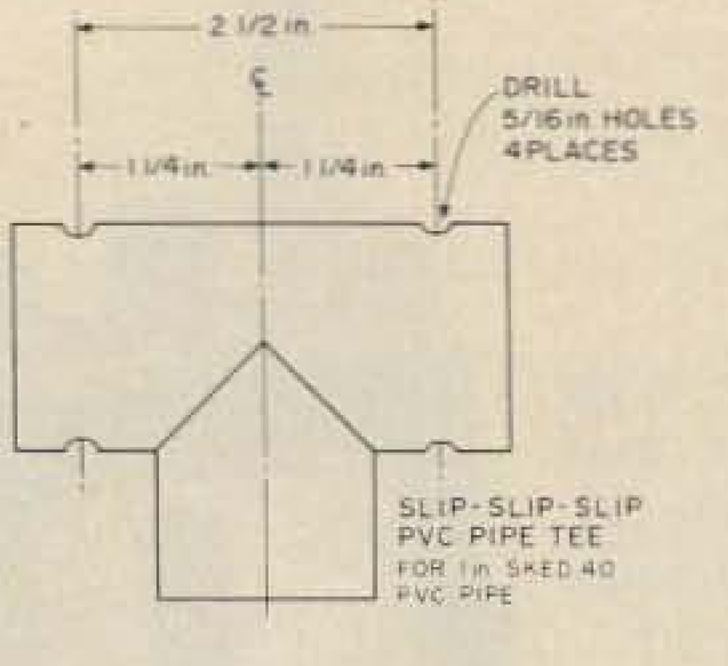

Fig. 7. Preparation of PVC tee for top whips.

It is important that these holes are absolutely parallel to both the sides and ends of the tee. A drill press is a big help here but it can be done with a hand drill if both sides are very accurately marked and caution is used while drilling. Don't let the drill or the tee wobble and make the holes egg-shaped because this will affect the proper installation of the whips. Of course where I drill a large number at a time, I have cheated and fabricated a fixture so if I make a mistake I have a box full of instant surplus!

Installing the Tee

Align one open end of the tee so that it will line up with the hole where the 75 meter wire goes through the side of the pipe. Place the 75 and 40 meter coil wires up into the tee and out their respective ends, and push the tee onto the coil end. Be sure that the open end selected is still lined up with the 75 meter wire hole. This is very important to provide maximum clearance between the 75 and 40 meter connections. Also be positive that the two wires are not crossing over each other inside the coil form or the tee. There are tremendously high voltages here and precautions must be taken to prevent arc-over. When the alignment of the tee is verified, tap it all the way down onto the coil form as far as it will go. I use a rawhide hammer.

Here again I have not found it necessary to use any PVC cement because this slip fitting is plenty tight and, if necessary, it can be driven off again. The coil now looks like Fig. 11.

The Top Whips

The top whips on mobile antennas usually take a pretty good beating from low branches and flourescent bulbs in service stations. They have to be flexible enough to give when an immovable object is struck, but still stiff enough to recover to the original position without taking a set.

The position that a top whip maintains determines the exact resonant frequency. It should not wave around too much while underway. This is why I do not use, nor recommend, a spring mobile mount. The mobile antenna must maintain the same relative position to the vehicle at all times to keep it at resonance. When you see someone tearing down the road with the antenna swinging wildly in the slipstream, you'd better get in contact quick, because by the time he gets down to the next corner he's going to be out of range!

Over the years I have tried various brands and combinations for top whips, but there was always something lacking. Many times the price bothered me. Currently I am using 1/4" diameter solid fiberglass poles covered with copper braid. The best source for these fiberglass poles in small quantities is the six foot bicycle safety flag. Cheap, too; less than a buck.

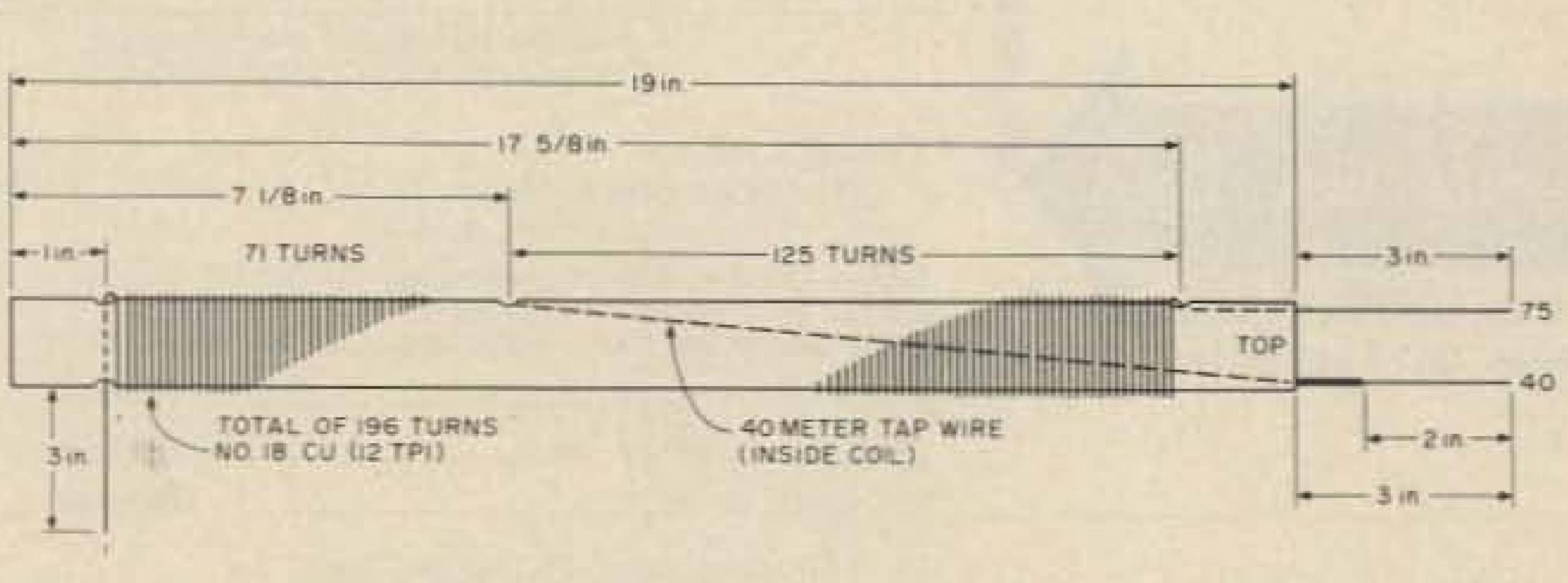

Fig. 6. Big DK loading coil.

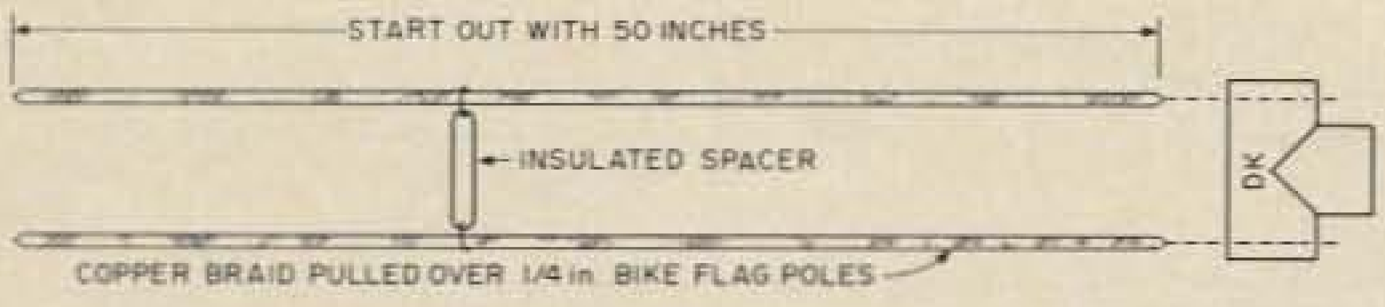

Fig. 8a. Fiberglass whips.

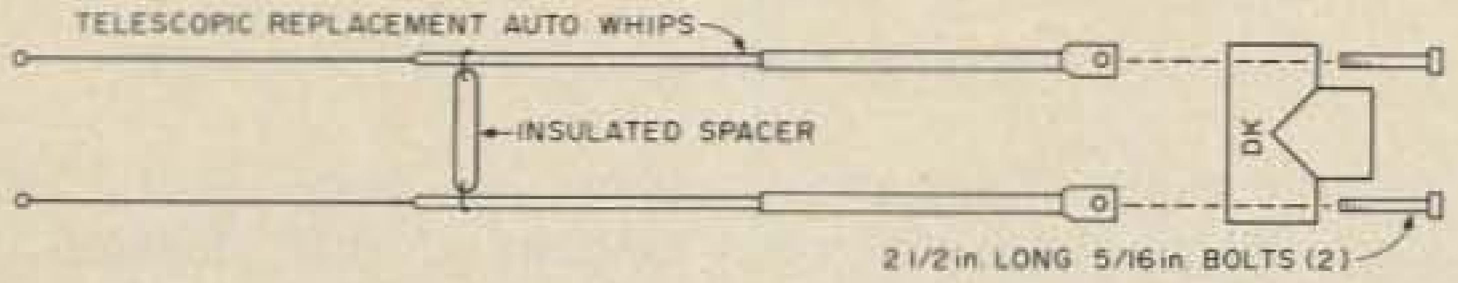

Fig. 8b. Adjustable auto replacement whips.

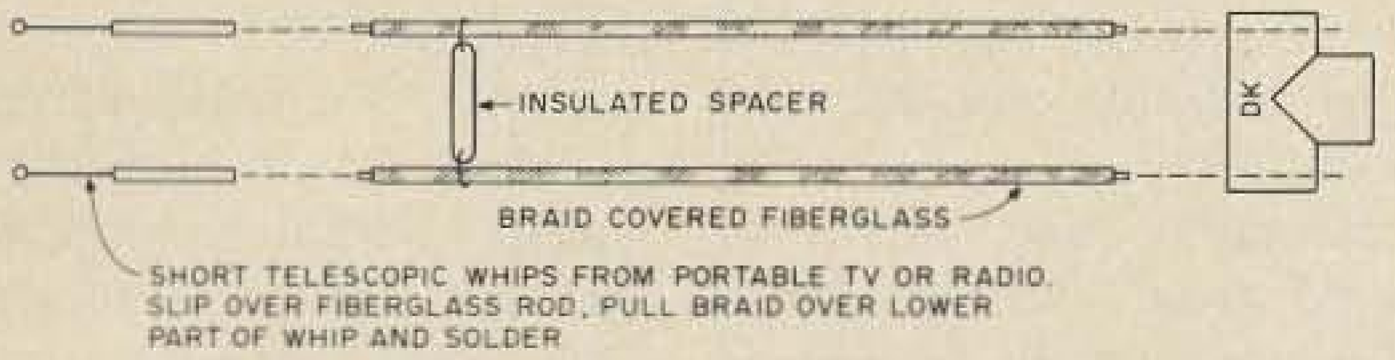

Fig. 8c. Adjustables on fiberglass whips.

Probably the best source for the copper braid to slip over the fiberglass poles is some old scrap coax. I found some old RG-6U and used the silver tinned braid. It looks real classy while it is new.

To make the whips using the fiberglass poles, cut two of them 50" each and slip the copper braid over them. Pull the braid up tight on both ends, give a good twist and cut off the excess (see Fig. 8).

Later on, the whips can be painted, doped or just left as is. My Sunday antenna is striped FAA orange and white. It gets a lot of attention. When the other driver hesitates for the second look, you get the jump on him at the traffic signal.

Alternate Top Whips

You might come up with some alternate top whips which will work as well as the cheapie bicycle flag poles. A couple of the local mobileers have used their retired fiberglass CB whips and just pruned them down to resonance. Another ex-fisherman used two of his old tapered hollow fiberglass fishing poles. For the conductor, he just merely shoved a #12 copper wire up through the center and, when it was trimmed to the proper length, he soldered a neat little corona ball on top.

Automobile Replacement Whips

I have also used a number of the automobile replacement whips (Fig. 8b). These are the type that slip over the 5/16" diameter auto whips that get ripped off. One source is the Ward TCFR-1; another is Radio Shack part #12-1309. These telescopic whips are not really the greatest for mobile use because when they hit something they normally bend and take a set which puts the antenna off resonance.

For the travel trailers and mobile homes and other stationary installations, the replacement whips work out just fine. The advantage, of course, is being able to vary the length easily if you have the urge to move around the band.

Installation of the Top Whips

Installation of the braid-covered fiberglass whips is relatively simple. With the braid pulled tightly over the 1/4" fiberglass poles, they will go into the 5/16" holes in the PVC tee with a very snug fit. Push the whips on through so the bottoms protrude out the bottom holes in the tee about an eighth of an inch (see Fig. 8).

Pull the 75 and 40 meter tinned coil wire leads around their respective whips. Take up all the possible slack from inside the coil form and then solder to the braid on the whips (Fig. 9). Be very careful that the PVC tee doesn't get too hot. It melts very easily. Cut off any excess wire and dress so that sharp ends are pointing toward the outside ends of the tee. If you have some Glyptal, it won't hurt to coat these connections. Don't leave any debris that might encourage corona inside the tee.

Use a piece of the leftover 1/4" fiberglass rod for a spacer to hold the two top whips parallel. Cut the spacer 2 1/4"; drill two small holes crossways close to both ends. Thread a 2" piece of bare wire through each hole. Place this spacer between the whips about 36" up from the tee, wrap the bare wires around the braid and then solder to hold it in place.

Be sure you can identify which whip is which, and then plug up the open ends of the tee. Cap-plugs that are often used to protect pipe threads can be modified to snap in. Maybe you have a couple of spare plastic shot glasses.

Finally glue, dope, epoxy, or what have you around the four holes in the tee where the whips fit.

Bottom Section

The bottom section of the mobile antenna should be installed to place the bottom of the antenna coil a minimum of 6" above the highest part of the vehicle. The length of the bottom section will vary with the location of the base mount on the vehicle. I have installed lower sections with lengths varying from 18" to 6 feet without degrading the efficiency of the antenna. Anytime any part of the loading coil is placed below the highest part of the vehicle, the radiated signal suffers considerably.

Bottom Section Fabrication

A very simple, sturdy and cheap antenna bottom section can be made from a piece of 1/2" EMT – thin wall conduit. Cut off the desired length and then in each end braze a 5/8" by 1/2" long hex-head bolt. Chuck this up in the lathe and drill and tap 3/8-24 both ends (see Fig. 10a).

If a lathe is not available, you'll have to come up with the old "drill a hole in the bolt trick," which could be to sneak it in on one of the local shop teachers while your coil is being wound.

Antenna Mount

While you are at it, you might as well go all the way and make your own base mount. This can be done with a 1" bolt and a few homemade insulating washers.

Dig out a bolt that has no threads within a couple of inches from the head. Make a very square cut and saw off the threaded end and discard. Using the same "drill a hole in the bolt trick," drill and tap a 3/8-24 hole 3/4" deep in each end. Cut out a few washers from some good insulating material and drill the

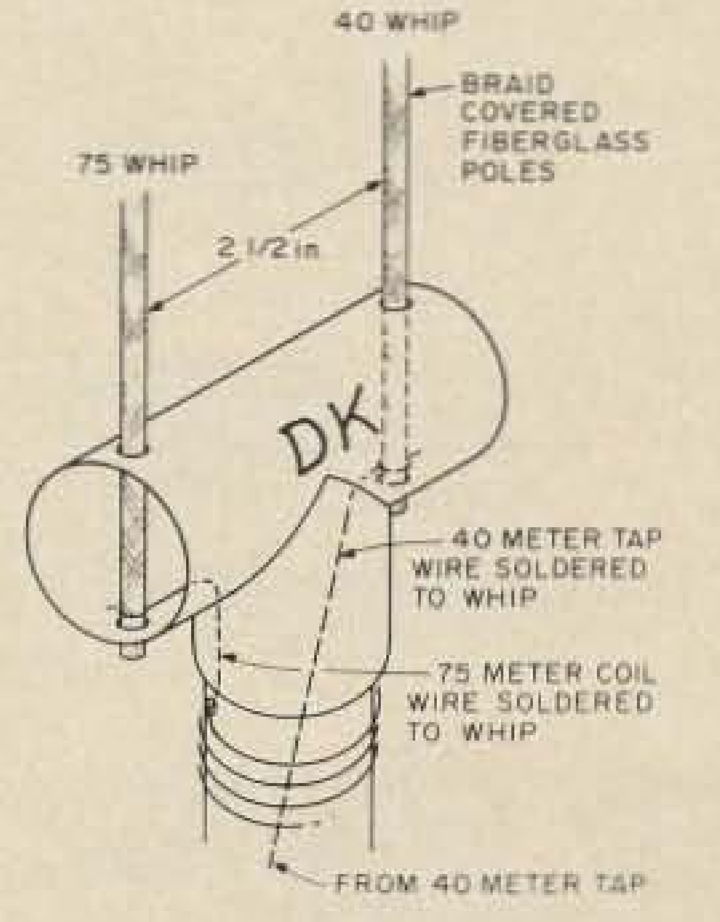

Fig. 9. Detail of coil wires' connection to whips.

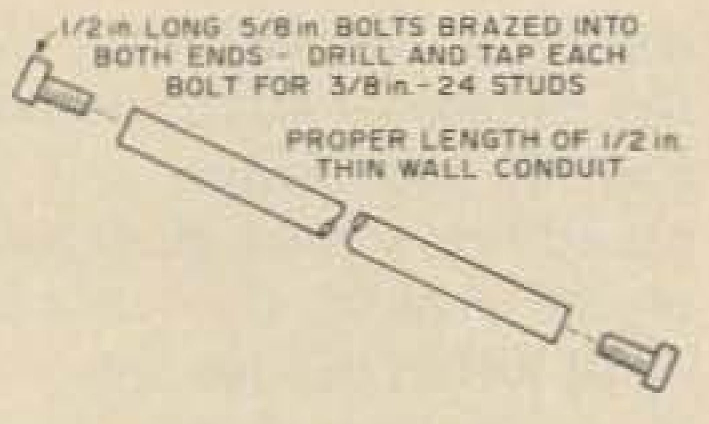

Fig. 10a. Lower mast section.

Fig. 10b. Homemade antenna mount.

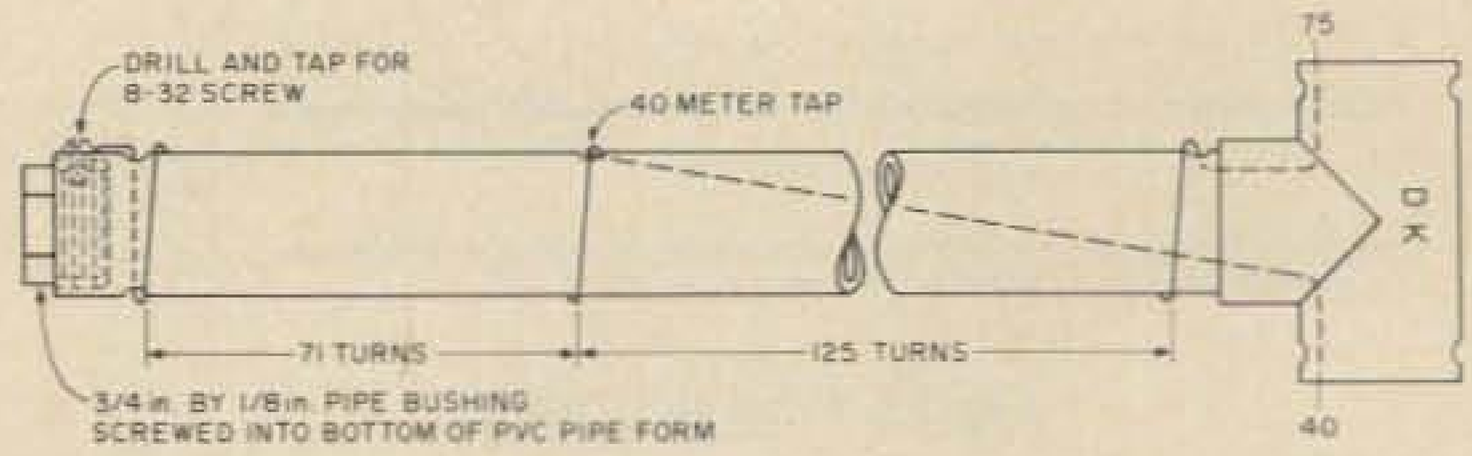

Fig. 11. Completed loading coil ready for whips.

centers of each with 3/8" hole. Assemble as in Fig. 10b.

Matching Capacitor

The capacitor across the antenna end of the feedline preferably should be a variable with a range that goes through 500 pF to 1500 pF. I was able to pick up a few compression screw driver adjusts, Arco part #310. These worked out very well and they could be put right on the money for a good match. The way to adjust the cap is to jump back and forth from one band to the other, readjusting the capacity for the lowest swr on both bands with the same setting. This will affect the resonant frequency of the antenna a small amount, so be sure you have the capacitor in place and adjusted close to the correct value before pruning the whips the last few kHz. See Fig. 12a.

If one of the adjustable trimmers cannot be located, start out with a fixed 820 pF silver mica. It is very possible the 820 pF will give an swr of 1.1:1 or less.

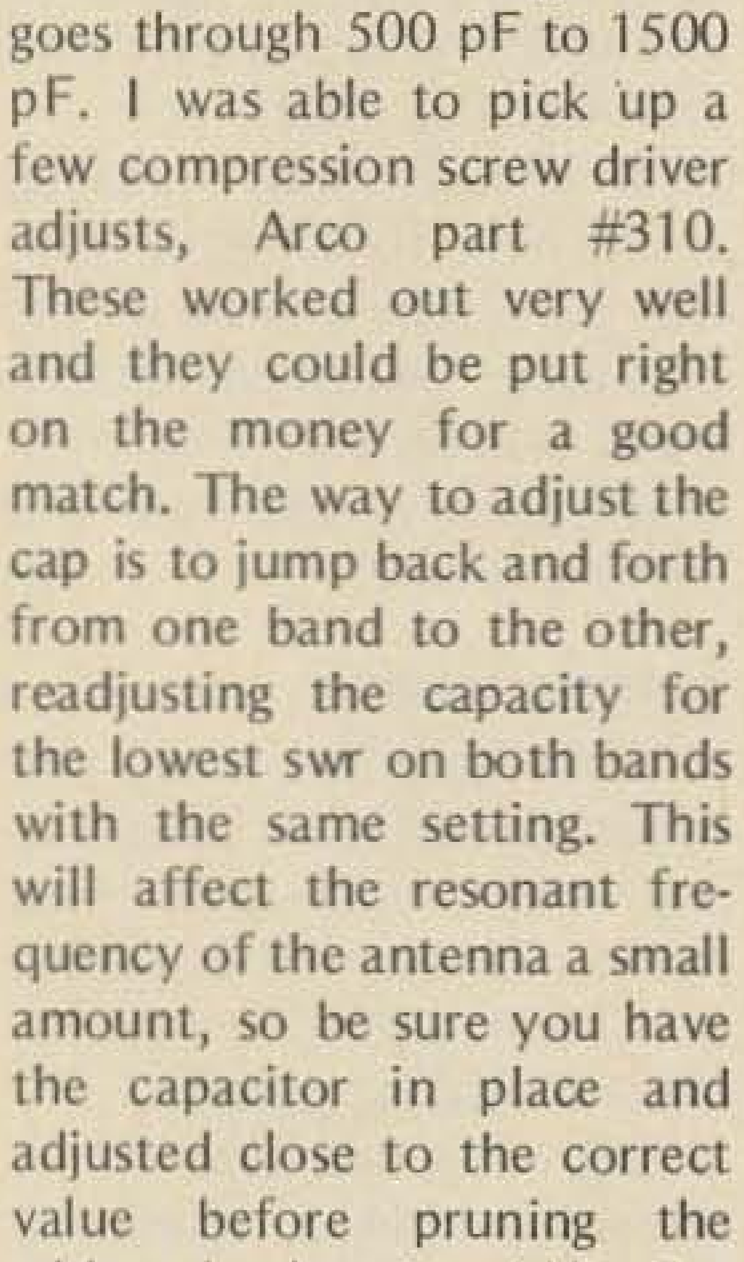

Fig. 12a. Installation.

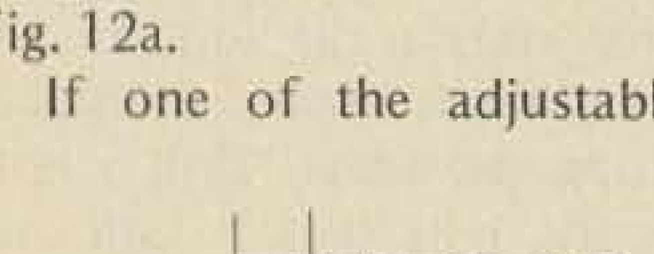

Fig. 12b. Installation of variable inductor.

Pruning the Top Whips

With the assembly installed on the vehicle as in Fig. 12, connect the antenna noise bridge in the line and look for the resonant point on both bands. Using the braid-covered bike whips, each 50" long, will place the antenna quite low on both bands. Thinner whips, however, will require lengths up to twenty percent longer.

First of all, if you are using a variable inductor at the base, as in Fig. 12b, be sure it is set at the minimum inductance before you start pruning and tuning.

If resonance cannot be located starting with the 50" whips, don't overlook the fact it may be so low that it is at a point below the frequency range of the receiver.

Slide the braid down on the whips, saw off one inch of the fiberglass, pull the braid back up tight, give it a twist and cut off the excess. Continue this, cutting off shorter and shorter pieces until the desired resonant point is reached. It is very doubtful that the whips will be much shorter than 46" each when the antenna is completed. Don't get confused; be sure the proper whip is being trimmed, because it gets embarrassing when one of the whips keeps getting shorter and the frequency does not change. After the last and final prune, pull the braid up tight again, give it a twist, put a bit of solder over the end and trim off smoothly.

Normally one inch removed from the 40 meter whip will raise the frequency 50 kHz. One inch removed from the 75 meter whip will raise the frequency 25 kHz.

Using the telescoping types of top whips will make tuning a lot easier, but you are not going to be happy with them mobile unless you have some of the exceptionally good ones made particularly for this type of service.

Random Info

This antenna has been developed in various other directions: 160 and 75 meters; some three banders, 160-75-40 and 75-40-20; two whips on the same band, permitting CW and phone band without retuning the antenna; MARS and amateur.

On mobile homes and travel trailers, a base section of approximately 14 feet, plus or minus a little, will permit operation on 20 in addition to 75 and 40 by just using the two whips. The big DK on the top appears as a top hat on the 20 meter 1/4 wave vertical.

With the antenna mounted on the rear of the vehicle, the resonant frequency on 75 will go down as much as 30 kHz when a travel trailer is hooked on behind. Likewise, if you have the antenna installed on a travel trailer and then connect the tow vehicle — zip — down the band it goes again. The amount of shift depends on the location of the antenna in relation to the added vehicle.

Don't expect any directivity from 75 or 40 mobile antennas. The pattern around a vehicle on a properly installed 75-40 meter antenna is very symmetrical. If someone says "I'm headed toward you now and I should be louder," — don't get sucked into agreeing with him.

A properly matched antenna presents a 50 Ohm load at the base, and the length of coax feedline has no effect on the resonant frequency of the antenna. Of course I would not recommend a couple of hundred feet under the front seat; it gets sort of lumpy.

It may be noticed that I did not mention "roller" inductors for the QSY variable coil at the base. There are other ways to produce a variable inductor, probably right out of the scrap box. Think about it.

Another way to lower the frequency of a fixed whip is to alligator clip a "stinger" on the whip right above the tee and let it trail aft (see Fig. 13). A clip and a piece of wire with an overall length of 8" will move the 75 meter resonant frequency down about 30 kHz.

One owner mounted a tiny telescopic antenna out of the 75 meter end of the tee. He can reach this adjustable whip out of the pickup window while underway. We call him "Hot Fingers Ralph."

Another mobileer starts out early in the morning, checking into a weather net, and then drops 25 kHz down the band. He installed his spacer at the very top of the whips. At the center he wedges in a 4" plastic spacer to bow the whips out from one another in the center. This four inch plastic temporary spacer is attached to a fishline leading into the car window. After he checks out of the weather net he jerks the spacer out and pulls it in the car. Presto! He's 25 kHz down the band. The next morning the spacer goes back in. This illustrates how important it is to keep the two whips in the same relation to each other at all times.

The bicycle poles with the braid covering are also doubling around Wireless Hill as 2 meter verticals, VHF and UHF beam elements. Uses around the station are limited only to the number of bicycles ripped off.

It is best to orient the tee on the antenna crossways to the vehicle. This allows for better fore and aft flexibility. Also it has been found that, with the tee aligned fore and aft, the turbulence from the leading whip creates a severe flutter to the trailing whip which causes the whole assembly to vibrate.

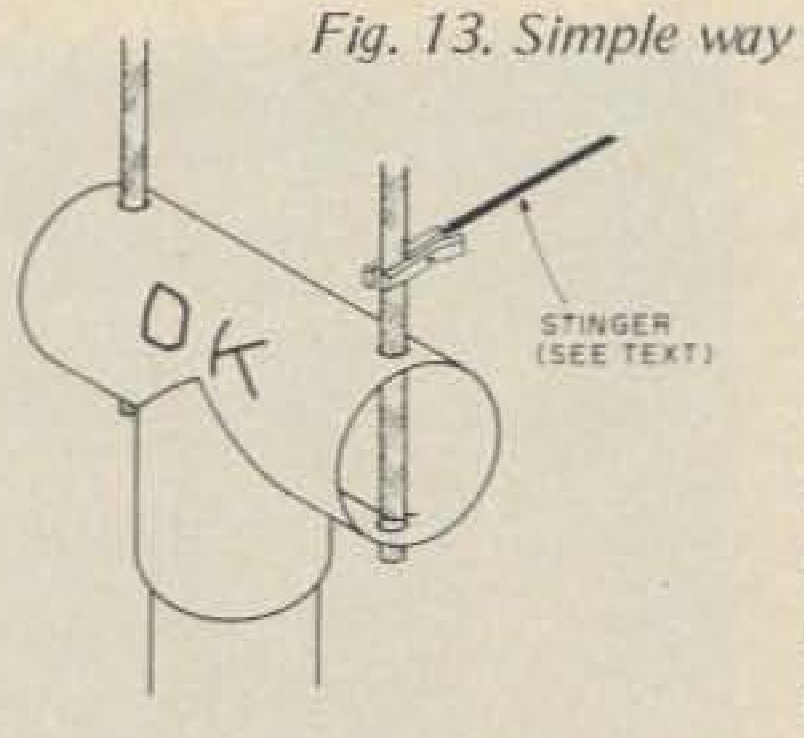

Fig. 13. Simple way to lower frequency in a pinch.

Acknowledgements

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New Products

HOW ELECTRONICS GOT FASTER AND EASIER TO WORK WITH THANKS TO MODERN SOLDERLESS BREADBOARDS

A P Products Incorporated of Painesville, Ohio, originated the modern solderless breadboard in 1968. Since then, tens of thousands of solderless breadboards have been used each month by electronics experimenters and designers in a wide variety of fields.

But just what is a solderless breadboard? How does it work? What advantages does it offer? Where can it be used? And how?

Before the era of modern solderless breadboards, designing and testing any given electronic circuit was an aggravating, tedious, time-consuming task. First a circuit would have to be designed on paper. Then the schematic diagram of the circuit would have to be translated into a circuit board parts layout for either point-to-point or printed circuit wiring. If a printed circuit were to be used, as was most often the case, the circuit layout would have to be transferred to a copper-clad board, the copper selectively etched, holes drilled, and components soldered in place. Then, if a component proved the wrong value, it would have to be desoldered and a new one soldered in place. If the printed pattern were in error, a whole new board would have to be laid out, etched, drilled, filled and soldered. A lot of time, a lot of work.

Then A P Products came up with the idea of arranging a breadboard with a matrix of interconnected holes. The interconnections are made by conductive spring clips that grip each component lead firmly to establish a good electrical connection without soldering. The matrix of holes was laid out in a tenth-inch spacing pattern to conform with standard component lead spacing.

The interconnection pattern was designed to provide ample access to each lead of each component, especially with modern transistor and integrated circuitry in mind. And distribution strips were designed to provide power and signal lines where needed.

Circuit designing now becomes plug-in-easy. ICs and/or discrete components plug into the solderless breadboard and ordinary 22 gauge solid wire jumpers are used to interconnect them.

A given circuit can now be prototyped in minutes rather than hours or days. Many designers work directly with component specification sheets, many with schematic diagrams. Changes in parts values are as easy as pulling out one part and plugging in another. And the geometry of the modern solderless breadboard translates into a printed circuit layout readily, once the circuit is ready to commit to hardware.

In addition, solderless breadboards can serve as a basis for semi-permanent circuits in applications where the need for a given circuit requires reliability but does not require longevity.

Applications for modern solderless breadboards are as wide as all of electronics. There are professional applications in machine control, data processing, test and measurement, device testing, prototyping and equipment adjunctive aids. There are hobby applications ranging from communications to photography to automotives to biofeedback to music to model railroading and more.

And, of course, solderless breadboards are perfect for educational and instructional applications.

Solderless breadboards and breadboarding aids come in many sizes and prices, capable of circuits as simple as you like or as complicated as a small computer.

A P Products continues to be a pioneer in the development and application of modern solderless breadboards. If you have questions about what solderless breadboards can do, how much they cost, or what's available, contact A P Products at Box 110, 72 Corwin Drive, Painesville OH 44077. A P Products has available a free catalog of their ACE All Circuit Evaluator solderless breadboards, Super Strips™, Terminal and Distribution Strips, IC Test Clips and accessories.

For more information, contact Robert J. Gabor, A P Products Incorporated, Box 110-P, Painesville OH 44077. Phone: (216)-354-2101; TWX: 810-435-2250. Direct all inquiries to Rita Mercer.

DRAKE RCS-4

Checked the price of RG8-U lately? Want to beat that price and clean up the unsightly mess of coax running down your tower? The boys at Drake have a real winning number for you.

The RCS-4 is a remote controlled switch that will switch 5 antennas from 1 feedline, ground those not in use – and will ground them all when not in use. Cheap lightning protection, right?

This unit will take full legal power, and operates up through 2 meters like a champ. Only 24 volts dc to motor – and has rain hat construction to prevent moisture damage.

This jewel works like a dream, with swr less than 1.5 to 1 even on 146.94. At $120.00 this has to be one of the top buys. We aren't easily impressed, but this got our attention. Switch 3 beams and a couple of inverted vees, all with only 1 up lead. Fantastic! Available at your dealers.