# NATIONAL RADIO CLUB
# ANTENNA REFERENCE MANUAL
# VOLUME TWO

This is the second in our series of reprint reference manuals on the subject of antennas. Most of the articles herein appeared originally in DX NEWS from 1974 through 1982, and were subsequently put into NRC Reprints. Updates have been made where necessary, especially as to parts availability. Every effort has been made to include the most popular and the most generally useful articles herein, although with this book, we break with tradition somewhat in that we have included two articles on antenna phasing units which never officially were incorporated into the NRC reprints. This is done with the knowledge that this subject matter is an important new development which will likely be of increasing interest in the years to come. We wish to thank the following authors whose works go to make up this manual (alphabetically): Mark Connelly, WA1ION; Russell J. Edmunds, WB2BJH; James V. Hagan, WA4GHK; Chuck Hutton, WD4ELO; Mike Maloney; Harley Steward; John Tull; &Charles A. Wolff, jr.

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# ② A WHIP ANTENNA COUPLER FOR USE WITH PORTABLE RECEIVERS

J. HAGAN

Several years ago I purchased one of those multiband portable receivers covering LW-MW-SW and FM. It had a built-in ferrite rod antenna for LW and MW. On the short wave bands from 1.5 MHz to 27 MHz, a 48" collapsible whip was provided. This was also used on FM.

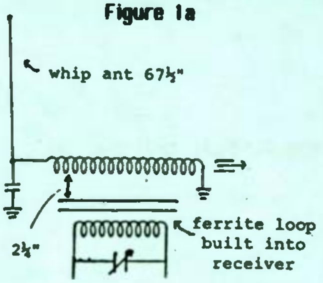
After using the receiver for some time, it was noticed that MW stations between 1500 and 1600 KHz, when tuned in on the low end of the lowest SW band, were somewhat stronger than when tuned in on the high end of the MW band. It was also obvious that the only difference had to be the antenna that was used, the 48" whip being in use on the SW band, and the ferrite rod being used on the BCB. A little experimentation with a few clip leads and variable inductors of the loop-stick variety proved that this was indeed the case and also pointed the way to vastly improving the DX capabilities of the receiver on BCB and LW. The experiments showed that the 48" whip, when properly resonated and coupled to the set, had at least 25 db more signal pick-up than the ferrite rod built into the receiver's handle. (Note: The same principle applies to receivers where the ferrite rod is located inside the cabinet.)

Since this receiver was fairly expensive and exceptionally well built set, the main problem was to decide how to incorporate the new circuitry into the receiver without serious modifications to the receiver itself. After thinking about the problem for a few days, I decided to build all the additional circuitry into a small wooden box that would fit over the handle on the receiver and inductively couple the signal into the ferrite rod. A two band tuner was built, covering both the BCB and LW bands. Many DX'ers own similar receivers, and practically none of these have provisions to use the whip antenna for BC reception. The purpose of this article is to describe some of the details of my tuner. Since a tuner of this type must of necessity be "tailored" to the receiver it is to be used with, it can not be duplicated exactly in every case, but the principle involved can be used with any comparable receiver.

Figure 1 shows schematics of two versions of the tuner. In my tuner the whip that came with the set was used, contact with the tuner circuitry being established by means of a spring clip salvaged from a fuse holder. Contact with the receiver chassis ground (metal cabinet) was made with a small phosphor bronze spring. Since use of the actual whip contained in any given receiver will depend on just how the whip is wired into the set internally, it may not be possible to use this whip without some receiver modification. It is strongly suggested that the Lafayettte whip specified be use, if the existing whip proves unsatisfactory. This is a CB walkie-talkie replacement antenna and is somewhat longer and therefore better than the whips built into most receivers.

The inductively tuned version is a little more difficult to arrange mechanically, because of the need to slide the slug in and out of the coil for tuning. It is, however, a much better performer on the low end of the band from about 800 KHz on down and is highly recommended. If this one can't be conveniently worked out, the capacitively tuned model will do a very good job also.

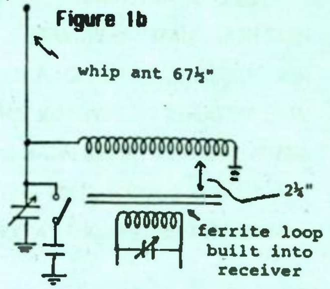
**Figure 1a**




Inductively Tuned Tuner

L1 (MW) - Miller 2007
(LW) - Miller 9004
C1 - approx 68pF
Whip - 48' length

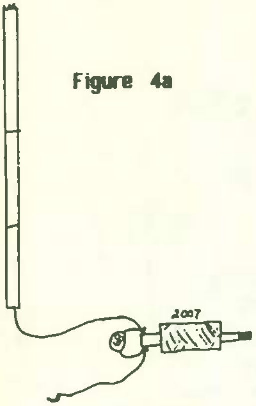
**Figure 1b**




Variable Capacitor Tuned Tuner

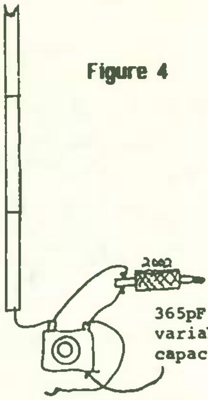
L1 - Miller 2002
C1 - 365pF miniature variable
S1 - SPST switch
C2 - 47pF (range extension)
Whip - 48' length

Figure 4a




Pictorial Wiring Diagram
(Inductive Tuning)

Figure 4




Pictorial Wiring Diagram
(Variable Capacitor Tuning)

NOTE: Mounting clips that come in the end of the coils are removed to allow slugs to slide freely in coils.

NOTE: No adjustment is required for the inductively tuned model. In the variable capacitor tuned version tune to the high end of the band, set the capacitor to minimum and adjust coil slug for signal peak. Slug is now glued in this position, and all tuning is done with the variable capacitor.

As mentioned before, the above construction cannot be duplicated exactly unless you have the same receiver, an Airline GEN 1477-A. If the set does not have the ferrite rod in the handle, it will be found in the back of the set, usually near the top, and construction details will have to change accordingly. Chassis ground connection may be difficult to arrange in some cases but is absolutely essential. In fact chassis ground is sometimes not enough, and additional ground plane must be provided by holding the receiver or setting it on top of an automobile or metal table. If none of these is available, a 6 - 10' wire can be attached to the set's chassis and laid out on the ground.

In operation the receiver is tuned to the desired frequency, and then the tuner is peaked to that frequency. If the signal is a weak one, it will increase in strength enormously as the tuner is tuned through it. Many signals will not even be audible without the tuner. The antenna is completely nondirectional, but what can you expect for this kind of performance and portability? Using this tuner and the 48" whip that came with my set, I can hear WABC-770 in daytime during the winter from Florida. This is about 1100 miles. Not bad for a portable. Also heard are WWL-870, 4VEH-1035 and Radio Belize-834.

At night stations like KSL-1160 and KFI-640 are easily copied with good signals. TICAL-525, a weak one, is also fairly easy and a good test. On long wave the New Orleans weather station GNI-236 is copied loud, and Galveston weather GLS-206 is copied fair. GNI is only barely audible without the tuner, and GLS is completely inaudible. At night, conditions permitting, Donebach-151, Brasov-155, Allouis-164, and Europa#1-180 are easy copy.

Short tuned antennas such as used here are excellent performers if used out in the clear. If the location is not a clear outside location, performance will be degraded accordingly. In heavily wooded areas there is some degradation but generally not severe. Inside a house performance will be noticeably poorer than in a clear outside location due to the distortion of the wave fronts by wiring in the walls of the house and any metal used in construction, such as steel reinforcing rods or aluminum siding and foil insulation. The third floor of a wood frame house would probably be an excellent location, being above all these obstacles. A basement or concrete block location may so seriously degrade performance that the ferrite rod antenna already in the set may be equal or superior to the whip. City locations on streets with high buildings (like New York) or overhead will be bad also.

One great advantage of this system is that it provides a portable receiving system of high sensitivity that can be located to a quiet location if local noise levels are high. My location is impossibly noisy at times, and nearly all the time on the lower frequencies. LW reception is impossible. But by relocating just one block to a church parking lot, quiet reception is obtained. All of my long wave loggings are done this way, and the CPC DX tests of WYLO-540 and Radio Anguilla-1505 were saved from the line noise by this method.

I have taken the NRC A-A loop with me for tough ones, but its size makes for great inconvenience, and it is impossible to take on vacation trips. The whip antenna is about equal to it in signal pick-up but of course lacks nulling capability and is no problem in a suitcase. Try building one of these, and see if you don't agree.

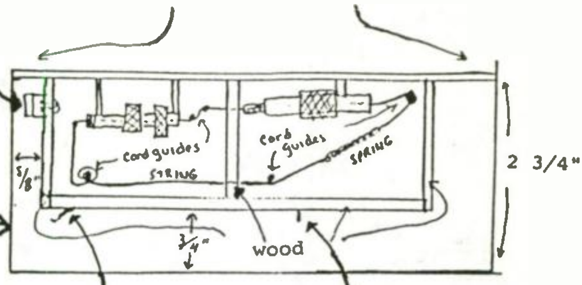
**Figure 2A**

9 1/2" (masonite)

Fuse Clip
Whip Antenna snaps into this. Depending on the type of antenna used, you may require two of these.

Oversize masonite side cover

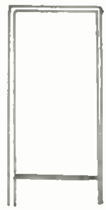
Ground spring clip (Makes contact with screw in handle to chassis ground)*




Pin Guide (Fits small hole in handle properly to locate tuner with respect to ferrite rod**

*Note: Many receivers have no such screw. It will then be necessary to arrange a useable grounding point. If one can be easily reached by the clip, the problem is simply solved. If not, it will be necessary to run a wire to a chassis screwwhich is grounded.

My tuner was built into a home made box of masonite paneling and some 7/16" thick (1/2 inch is OK also) lumber left over from another project. The box must be made of insulating materials so as not to interfere with the magnetic coupling between coil in the box and the ferrite rod in the receiver. Details are as shown above.



← Figure 2b End View (Covers on)
NOTE: All joints are glued. One side is held on with screws so unit may be opened if needed. Wiring not shown. This is two band model. LW coil on left; MW coil on right.

The receiver the tuner mates with is shown below for reference.

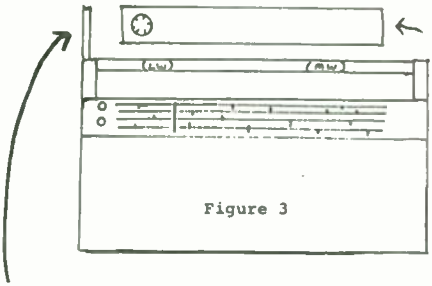



Figure 3

Tuner – fits down over handle and to left, making contact with whip and screw in handle.**

LW antenna is located in position (LW).

MW antenna is located in position (MW).

Whip Antenna (collapses into set)

**NOTE: Again, this will vary with the type of receiver in use, since most will not have this hole. It may be best to add simple guide markings on box and receiver chassis.

The BC and LW coils in the tuner must be located directly over the BC and LW coils on the ferrite rod in the receiver. In addition they must be spaced away from these coils by an amount best determined by experiment. In my case the BCB coil is 2 3/8" center to center from the ferrite rod, and the LW coil is spaced 2". This distance is determined before final assembly by tuning in a weak station, holding the coil about 3" away from the ferrite rod, and tuning the tuner for maximum signal. The coil is then slowly moved closer to the ferrite rod until signal is strongest. If coils are then moved closer together, signal level will actually decrease and tuning will be broad. Determine the spacing for several points in the band, and make a compromise. It will vary somewhat with frequency. It is probably better to be spaced a little apart than too close. Once the spacing is determined, supports for the coil can be made from masonite and everything glued in place. Use epoxy type glue.

# RADIO WEST LOOP(R) VS. THE SM-2(R)



Mark Connelly, WA1ION

This is a comparison of the new MW-1 loop against the popular, older design SM2. Considerations of interest to the DXer are the following:

1. Sensitivity
2. Frequency range covered
3. Nulling
4. Tuning sharpness/selectivity of the preamplifier
5. Ease of operation/physical construction of loop.

Now on to the tests:

1. Sensitivity was checked using my R390A receiver and 5 selected local stations. The signal was peaked up on the SM2 & receiver antenna trimmer. The RF gain was then set for a mid-scale (50 db. over zero, or an "S9" reading). Then the MW1 was peaked (after removing the SM2 & connecting the MW1, of course) and the trimmer retweaked for peak level. The meter reading with the peaked MW1 was noted against the normalized 50 db. level for the SM2. Here are the results:

| | | |
|---|---|---|
| WEEI | - 590 | MW-1 3 db over SM2 |
| WHDH | - 850 | MW-1 3 db over SM2 |
| WBZ | -1030 | outputs equal |
| WEZE | -1260 | SM2 5 db over MW-1 |
| WITS | -1510 | SM2 12 db over MW-1 |

A usable-sensitivity test, taking into account desired signal versus noise and off-frequency splatter, was done by tuning in Italy on 1332 around 0530 GMT after local WHET had gone off. The signal was S9+10 on the SM2 peaks and S9 on the MW-1, receiver RF gain up to full. THe SM2 had slightly more hiss, also splatter seemed to be a little worse. The MW-1, overall had a slight edge in desired-signal audio clarity.

2. The frequency range covered by the SM2 is the American broadcast band only. With the MW coil, my MW-1 could cover 360 - 540 kHz. on the "Low" frequency switch position and about 500 -2000 kHz. on the "HIGH" position. I used a Westinghouse RBM3 LW receiver for this test.

3. On nulling it was hard to judge which was better. Both antennas could achieve nulls of considerable depth on groundwave and long-skip signals. Both were relatively ineffective on powerful high-angle short-skip stations like WPTR - 1540 & CKLM - 1570. The MW1 should be held by the end of the ferrite rod when tilting in a vertical plane; a null may change then the hand is removed. This hand-effect is really no worse that that experienced when using the SM2, however.

4. Tuning sharpness - a measure of how much adjacent stations will be down at a retune of the loop to the desired station. I used a Palomar Engineers crystal calibrator to inject signals every 5 kHz. into the antenna. The calibrator was positioned in the lobe of antenna pickup, about a foot from the loop. The "desired station" was peaked at 50 db with the R390A RF gain about mid-position. Then carriers on +- 5kHz. (a typical split) and the center frequency signal when peaked on its own frequency versus its strength when peaked on the aforementioned adjacent carriers.

| Frequency | Db differences | | | | |
|---|---|---|---|---|---|
| | -5 kHz | +5 kHz | -20 kHz | +20 kHz | |
| 600 | 15 | 17 | 38 | 42 | MW1 |
| | 13 | 15 | 38 | 40 | SM2 |
| 800 | 10 | 12 | 37 | 40 | MW1 |
| | 6 | 9 | 29 | 30 | SM2 |
| 1000 | 3 | 8 | 19 | 20 | MW1 |
| | 6 | 8 | 23 | 24 | SM2 |
| 1200 | 2 | 3 | 10 | 8 | MW1 |
| | 10 | 9 | 23 | 24 | SM2 |
| 1400 | 2 | 3 | 5 | 8 | MW1 |
| | 3 | 4 | 23 | 24 | SM2 |
| 1600 | 1 | 1 | 3 | 3 | MW1 |
| | 5 | 2 | 18 | 19 | SM2 |

The above figures give the SM2 the edge in sharpness from 1000 kHz up; below 1000 kHz the MW1 has a slight edge. Taking this result plus the sensitivity test into account, it is evident that the MW1 is a better low-band performer and the SM2 does better above 1000 kHz.

5. Other considerations: The battery clip on the MW1 may not always hold the battery in place - a bottom plate under the battery would remedy this. The MW1's wooden base is convenient for mounting a good compass (Silva or other types). You might want to epoxy a piece of wood or G-10 epoxy glass to one end of the MW1 ferrite rod so you can tilt the loop without touching the rod. SM2 owners may also find that if they epoxy wooden extensions on the shielded case, hand effects on nulling can be significantly reduced. Nulling ability of the SM2 is not greatly effected by the surface upon which it is placed; however, the MW1 does not null well if it is placed on a metal surface - I found it necessary to use a wooden table for the SM2 versus MW1 tests. Radio West make it clear in their instructions that the MW1 should be placed away from large metal objects.

In conclusion, the differences between the two loops are fairly subtle; each has its own advantages and disadvantages. This analysis may help to sway DXers to one antenna or the other; which one is selected will be based on personal requirements. You pay a little more for the MW1, but for this you get the capability to change coils and cover down to 150 kHz and up to 5 mHz. For another opinion on commercially available ferrite loops, consult Mike Sapp's recent article in the **IRCA DX Monitor***. Please keep the following in mind: these tests were done with just one MW1 and one SM2. Characteristics of the antennas are not deemed to be held to such a tight military style consistency that tests run with other MW1's and SM2's could be expected, a priority, to yield the same results. What is needed would be further testing by other DXers, so overall patterns could be discerned.

*DX MONITOR, June 10, 1978, pages 517-518

# THE WEDGE

THE WEDGE is a broadcast band loop antenna which began life as an experiment in loop shape. I'm sure it's not the first time it's been tried, but it does work, and, as I had never seen the idea in print before. I thought other DXers would like to know about it.

These plans describe the construction of my own 4 1/2" Wedge. You may wish to change certain phases of the construction. However, these plans are intended to give you a working, sturdy loop.

1. The Materials List

125' of #14 or #16 insulated wire
2 tuning capacitors: variable, 365pf
wing nut with bolt
6' insulated one-conductor coax cable
1" dowel, 2' long

6' of 1 x 3 pine
6' of 1 x 1 pine
6' of 1 x 2 pine
nails, solder, tools,etc
2 plastic knobs (for capacitors)

2. Cutting the Wood

These three pieces will be cut further during construction

1 x 1 pine

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7" a | 7" b | 8" c | 8" d | 8" e | 12" f | 12" g | 10" h |

1 x 2 pine

| | |
|---|---|
| 1 1/2" i | 4 1/2" j |

1 x 3 pine

| | | | | |
|---|---|---|---|---|
| 18" k | 18" l | 12" m | 12" n | 12" o |

3. Drilling Holes

parts a & b, 1 x 1, 7"

| 1" | eleven holes, 1/2" spacing | 1" |

part o, 1x3, 12"

| 2" |

part c, 1 x 1, 8"

| 1" | thirteen holes, 1/2" spacing | 1" |

part j, 1 x 2, 4 1/2" long

| 1 1/2' (=18") |

HOLES in parts a, b, and c, should be drilled so wire can pass thru them. HOLES in parts j and o should be large enough for wing nut/ bolt assembly.

4. Construction of the Antenna Stand

Materials Needed:

wood parts f, g, h, k, l, m, n, o
dowel, 1", 2' long
wing nut
nails, tools

## 5. Construction of Antenna Frame

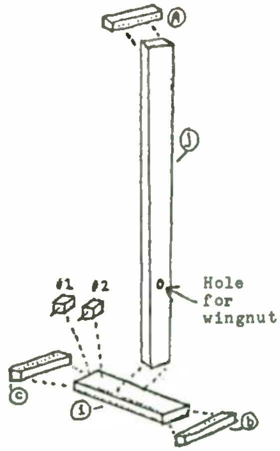
Materials Needed:

wood parts a , b , c , i , j
nails, tools
tuning capacitors

Step 1: Attach part j (vertical) to part i (horizontal) at the center of i , to make an inverted "T" shape. Use three or four nails, make it firm. Be careful that the hole in part j is closer to the bottom of the loop.

Step 2: Mount the wire "looms", parts a , b , and c , as indicated. Be careful to get the holes lined up the way they are in the drawing; holes in b and c should face up and down, holes in a should be parallel to the ground. Mount the looms about 1/3 of the way back; see detail.

Step 3: Mount the tuning capacitors, shown in the drawing as small boxes #1 and #2. The shafts should extend towards the front of the loop. Many tuning capacitors are difficult to mount; contact cement will work, if you follow directions closely and give it plenty of time to work. Mount the capacitors as close as possible to part c the 13-hole loom, on part i , so as to get the shortest possible leads from the tank winding to the capacitors.




DETAIL:
mounting of looms is slightly offset, so

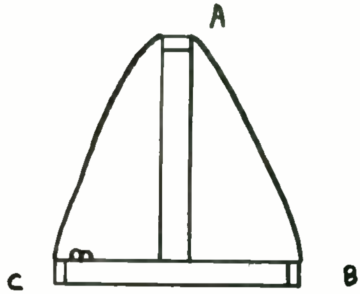
that loop frame is closer to the front

## 6. Winding the Loop Antenna

Materials Needed:

125' of #14 or #16 insulated wire
loop frame (completed)
wood parts d and e

To begin, let's review which corner of the loop is which: All the windings begin and end at C. The coax lead to the receiver will also attach at this point.



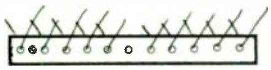

Step 1: Take one end of the wire and pull it through the hole at the front of C. Pull through about six inches (enough to reach one of the tuning capacitors) and tie a knot to hold the wire in place. The knot is tied in the six-inch section, right where it comes through the loom (part C).

Step 2: Take the other end of the wire and begin going around the loop, pulling the wire through the holes in the looms. It doesn't matter whether you go clockwise or counter-clockwise, as long as you do all the winding in the same direction. Continue around the loop until you have wound **five** complete turns. The end of the wire from the end of the fifth turn goes through the **seventh** hole in loom C; hole #6 is left open.

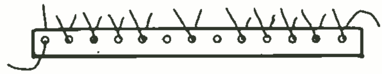
Step 3: Continue around the loop, skipping the sixth hole in looms A & B, and the eight hole in loom C.

After passing the wire through hole #9 in loom C, you should have four open holes in each loom, plus the #6 holes and #8 hole you left open. Compare with the drawing below.

Step 4: After checking that you're ok so far, continue around the loop and finish the winding. The very last open hole you come to should be in loom C. As you did at the start, tie a knot in the loose end of the wire. However, do not cut off the extra wire at this point. If you have correctly wound the loop to this point, your three looms should look like this:



LOOMS A & B 11 HOLES, #6 EMPTY



LOOM C 13 HOLES, #6 & #8 EMPTY

Either end of the loom may be considered "hole #1"; you will get the same results counting either way.

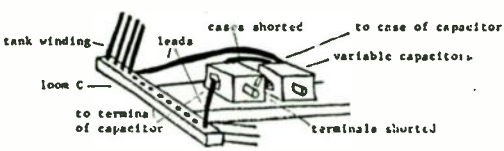
Step 5: TIGHTENING THE LOOP Even if you had a friend help you with the winding of the loop, the wires are probably still rather slack, and they must be tightened. Begin with the end of the wire you began the winding with, and go around, side by side, and pull the loop tight; each time you pull a side tight (by pulling it out away fromthe frame of the loop), pull through all the accumulated slack. By the time you've worked your way around ten turns of the loop, you should have five or six inches of extra wire, or more, depending on how tightly it was originally wound. Tie a new knot in the end of the wire, to keep the slack from pulling back through the loom. It's usually worth going through this whole process two or three times, so that the loop is tight enough that the wires don't droop visibly. If the 1 x 2's start to bend, that's too tight.

Step 6: After you have the loop tightened up, cut off the excess wire fromthe end of the ten-turn "tank" winding. This extra wire should be enough to make one more full turn around the loop - about eleven feet long - with a little extra at each end. Be sure, however, that you leave enough of a lead on the end of the tank winding to reach the capacitors.

Step 7: Take the lead from one end of the tank winding and attach it to the case of one of the variable capacitors. Take the lead from the other end of the tank winding & attach it to the terminal (either terminal) of the other variable capacitor. For some reason I have not been able to figure out this is important. I don't know why, it just has to be done to make both capacitors work in the circuit.

Step 8: Short the terminals of the two capacitors together, and short the cases of the two capacitors together. This should give you a setup that looks like the diagram below.

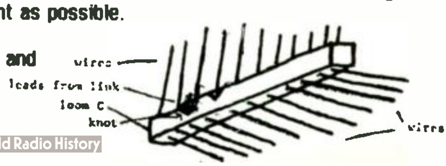
DIAGRAM: Correct Wiring of Variable Capacitors




Step 9: Take the remaining 11 or so feet of wire. This wire is used to make a one-turn link winding, using the open holes in the looms. If you wound the tank winding clockwise, do the link winding clockwise. If you did the tank winding counterclockwise, do the link winding counterclockwise. The way to make sure you did this correctly is that the tank winding and the link winding should not cross at any point.

Attach the wire the same way you attached the tank winding - leave leads of about 4" at each end, and tie knots in the wire to keep it from pulling out. Not much can be done to tighten up this one-turn winding, but try to keep it as tight as possible.

Step 10: Take the two leads from the link winding and tie them together with a simple knot:



Step 11: Attach your coax lead to the link winding at the point where the wires are tied together. One wire goes to the shield of the coax (which hooks to the ground terminal on your receiver); the other wire goes to the inner conductor of the coax, (which hooks to the antenna terminal on your receiver). Mount the plastic knobs on the capacitors.

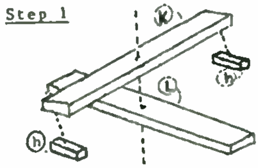
7. Putting the whole thing together....

....is fairly simple. The first thing to do is to put the spacers in place. The spacers are meant to tighten up the windings a little more. The drawing on the last page of this article should show where to put the spacers, betwen the wires on the bottom side of the Wedge and the horizontal frame member. Insert them near the center and slide them toward the edges, until things seem tight.

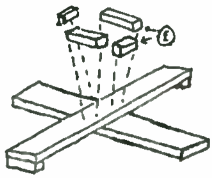
Finally, attach the loop frame and windings to the stand by means of the wingnut; again, see the last page for details. Attach the coax to your receiver (see step 11 - if you have A1, A2, and Ground terminals, attach the center wire to A1, and the shield to Ground, which is then shorted with A2).

Step 1: Cut part h into sections as long as the width of one of the 18" 1x3s. Attach pieces K and L at right angles at their centers, and mount the pieces of h to create a flat base.

Step 1

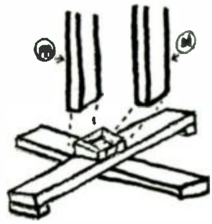



Step 2

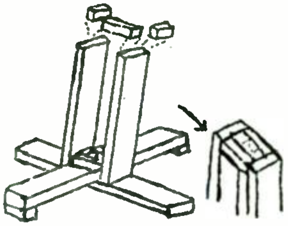



Step 2: Take part f and cut it up to build a square which will hold the 1" dowel snugly in place, and mount to the base.

Step 3: Attach parts m and n, the 12" sections of 1x3 pine, vertically to the base. To see how these parts hook on, see the drawing for Step 4. Just use one or two nails for each of the vertical supports at this point; after completing step 4, add extra nails to firm things up.

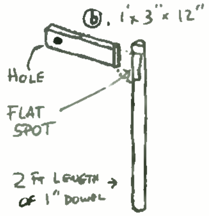



part g (one of the sections of g is not shown)



Step 4: Hopefully, your stand will come out a little straighter than this drawing... anyway, the next step is to take part g , a 12" section of 1x1 and use the pieces to create a square to hold the 1" dowel like you did at Step 2 this time, it's mounted at the top of the vertical supports. After adding the square at the top, you should add extra nails to the vertical supports where they join the base of the stand, to firm things up.

Step 5: Attach part o , a 12" long 1x3 with a hole drilled in it, to the 2' length of 1" dowel. HINT: At the point where the board mounts to the dowel, it makes things a lot easier to file a flat spot on the dowel at the junction point, as in the drawing. This makes for a firmer stand, and also makes it easier to drive nails into the dowel. These two parts need to be very strongly attached.

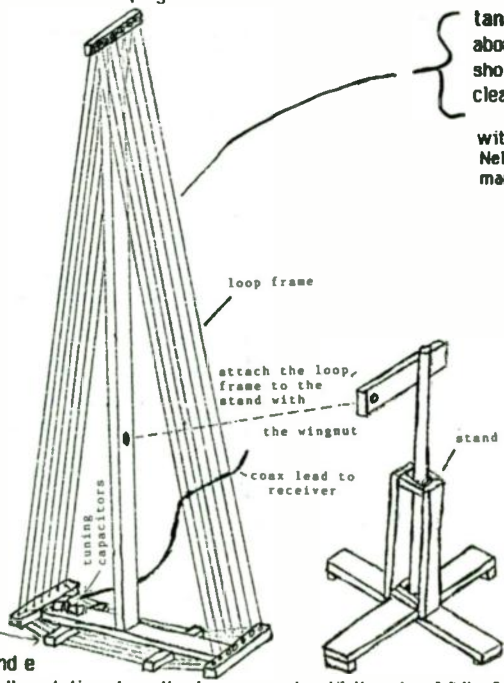



FINALLY, insert the dowel through the two supports. It should rotate freely, without being sloppy. If it's too tight, use a file on the 1x2's to open the hole a little more. If it's too loose, try shimming things up with a couple sections of popsicle stick or something similar.
Insert the wingnut in the hole for safe keeping.

The Finished Wedge

tank and link coils: only about half the wires are shown here, to keep things clear

with thanks to Sanserino, Nelson, Heald, and many, many others .....




note position of spacers

wood parts d and e

Operating the Wedge: To null a station, turn the loop around until the signal "dips". By centering in on the place where the dip is the deepest, and experimenting with various degrees of tilting the loop, you should be able to knock out a noticeable amount of signal from any station. The tuning capacitors are meant to peak the antenna to certain frequencies. The further clockwise you turn the capacitors, the higher the frequency you'll tune. Both capacitors fully clockwise puts you at the top end of the band (1600 KHz); both capacitors fully counterclockwise puts you at the bottom (540 KHz). A little experimenting should make their operation obvious.

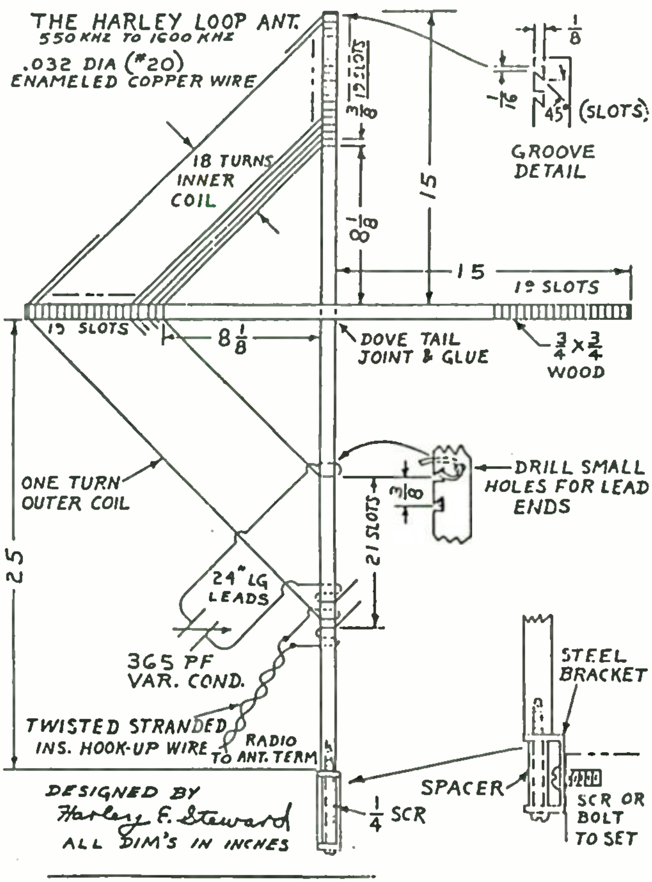
*** END ***

# 'HARLEY' LOOP ANTENNA

by Harley Steward

Points that might mot be clear in the diagram will be discussed here in detail. The 3/4 X 3/4 wood strips should be strong, dry wood that does not easily splinter. We used western pine. The center joint is made by cutting a 3/4 wide by 3/8 deep notch in each piece then glue, clamp and let dry. The slots shown in the groove detail are whittled out by using a hack saw. First hold the saw vertical and cut to a depth of 1/32". Then tilt the saw to a 45 degree angle and work back and forth until a depth of 1/8 " is reached. Notice that the 45 degree angles all run in the direction of the center of the frame. Make lead holes as small as possible so the wire is held tight. Test this and the grooves with a small piece of wire as you go along. When winding the wire, clamp to the corner of the workbench at the glued joint. Then proceed to wind. This will use about 110 feet of wire. Splices may be made but should be good sound splices and soldered. This means cleaning all enamel off the ends of the wire. The 365 pf capacitor, if of the old, heavy type, may just rest on a board on top of the receiver. If a small capacitor is used it may be mounted on an insulated or metal panel attached to the lower end of the wood leg.

This antenna is very directive and will loop out unwanted stations and noise. It has gain equivalent to the average longwire antenna and has been used by me to pick up stations from all 48 contiguous states.



## AN AC POWER SUPPLY FOR THE FET LOOP AMPLIFIER



J. Hagan and R. Edmunds

**[ NOTE: These authors, the NRC or its subsidaries are NOT reponsible for damage to you or your property or someone elses property. In other words, if you don't know what you are doing DO NOT attempt this project.]**

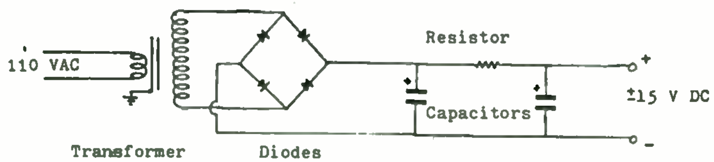
Many active Dx'ers discover as they use their NRC Altazimuth Loops that they encounter relatively short battery life and high expense for battery power for their FET amplifiers. In addition, those DX'ers using the remote-tape method for DX TESTS are forced to run the amplifier all night, thus further depleting the batteries unnecessarily. While a relay system could be used to eliminate this problem, we present here a simple and inexpensive power supply which will power the loop amplifier from an AC source, which can then be served by a timer switch along with the remote tape recorder. This supply is both easy to build and inexpensive to construct.

The FET plans call for a power for a power source of approximately 18 volts DC at an optimum current drain of about 8 mA. The source detailed here will provide about 15 volts at up to 1 ampere, which is quite sufficient for our use. The difference in voltage has proven to be almost negligible in practice, and the current rating is due to the consideration of inexpensive and ready parts availability. Actually, a current rating of .25 - .5 ampere is also suitable.

All of the parts should be available either right in your parts box, or at a local Radio Shack or electronic parts outlet. You will meed 4 diodes rated at 50 PIV at 1 ampere or more; one 100 ohm 1/2 watt resistor; a transformer with a 110 VAC primary and a 20 V, .25-1 amp AC secondary (The value for transformer secondary voltage is not higher owing to the scarcity and cost of such items); and two 200 uf electrolytic capacitors rated at 20+ volts.

Wiring is not critical and the only precaution to be taken is to be sure to ground the core of the transformer to minimize any potential hum generation. The circuit diagram appears below. When placing the unit in operation, be sure to set the current drain control on the amplifier to its minimum setting, and then slowly increase it. (It should be noted here that operation in excess of 9 mA will reduce the operating voltage of the unit).

Radio Shack, as well as other outlets, have units similar to this already built. A 12VDC filtered supply, similar to Radio Shack 22-120 or 22-127 (p.133 1989 Radio Shack Catalog).



# AN FET LOOP AMPLIFIER WITH COAXIAL OUTPUT

When I decided to build the NRC Alt-Az loop antenna, it was obvious that I would have to modify the preamp for unbalanced output, or modify my receiver for balanced input. Many of the best receivers on the market today have only coaxial input with no provisions for a balanced input such as required for the A-A loop. My receiver, a Galaxy R-530, is one of these.

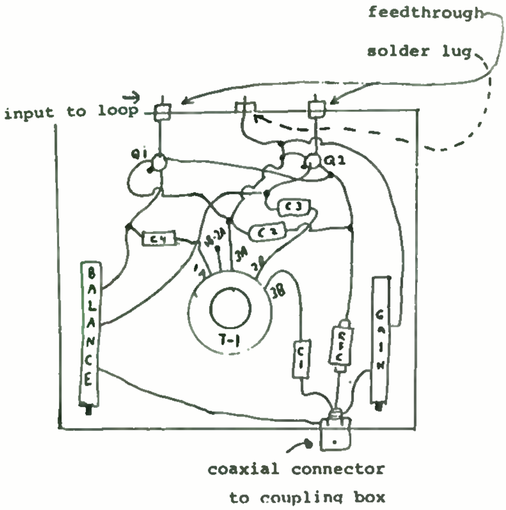
It was decided before construction was begun to redesign the FET preamp for coaxial (unbalanced) output rather than attempt modification of the receiver. Coaxial output has the additional advantage of getting inherently better shielded than a balanced system and also permits the use of standard readily available coaxial connectors. These connectors can be quickly connected or disconnected from the receiver when other antennas are also used. The mechanically cumbersome arrangement of the twin shielded transmission line from loop to receiver can be any length, even hundreds of feet if desired with no adverse effect on loop performance. Many of the commercially available TV antenna mounted preamps also use the feedline between the TV set and the preamp to feed DC power to the preamp as will. This feature was also incorporated in the new FET preamp. Power can now be supplied by batteries from the receiver itself, eliminating the necessity of a separate pair of leads to carry DC power to the preamp on the loop. Only a single line leaves the loop preamp, allowing for greater freedom of motion of the loop.

In the original FET preamp a matched pair of 2N4416's was called for. I could not obtain a matched pair for my project, and assume others may have this trouble also. For best loop balance a matched pair would be absolutely essential, so it was decided to incorporate some sort of a balance control into the circuit to allow use of any pair of FET's in the preamp, matched or not. Also since the output of the preamp is going to feed the low impedance. The rest of the impedance drop is accomplished in the 4:1 balun transformer. The source follower circuit is degenerative, therefore doing away with the requirement that the amplifier be neutralized, simplifying amplifier adjustment.

A small box is required at the receiver to couple DC power into the transmission line. Power can be obtained from batteries or directly from the receiver as in my case, and the box fastened to the back of the receive cabinet with two small sheet metal screws. The range of the preamp gain control was found to be quite small, so additional attenuation was built into this coupling box in the form of two switchable attenuators of 10 and 20 db each, allowing for attenuations on 0, 10, 20, or 30 db. In my system the preamp gain is set at 10 db (near minimum position) ad left there. Ten db is generally switched in at the coupling box, completely wiping out the gain produced by the preamp, the preamp merely acting as a balance-to-unbalance converter and impedance matching device. This choice is left to the operator, however, as the preamp is capable of a power gain of over 20 db. This extra gain has never been needed by me, and I prefer to see essentially the same signal level as the loop provides to the preamp input, at the receiver.

This preamp requires a few more parts that the original FET preamp and may be a little more complicated, but the results are well worth the extra effort.

The preamp is built in a 2 3/4" x 2 1/8" x 1 5/8" aluminum minibox obtained from Lafayette or Radio Shack. All parts except the input terminals and output connector are mounted on perfboard cut to fit the box. The board can be mounted in the box on standoffs, or supported by stiff soldered leads if desired. A small PC board could be fabricated in place of the perfboard for a neater installation, if the builder feels industrious. If not, flea clips are used on the perfboard to hold components in place and make connections. Small feedthroughs (press in or stud mounted types), Cambion 570-1795-01-01-00 or 571-4176-01-05-19 or equivalent types, are used for loop input terminations. These are available from Newark but may be hard to find in small quantities, so some improvisation may be needed here. The only requirements are that whatever is used, the connection must by mechanically solid and have low electrical capacitance to the minibox. A phono pin plug can be used for the output coaxial connector, but a UG-1094/U or UG-625/U connector is a much better arrangement. RG-58 fitted with the mating connectors or RG-174 cable is used to connect to the coupling box. RG-174 is smaller and more flexible, and is probably the better choice if connectors for it are available. It works great with phono plugs.




C1,2,3,4 .1uf 25V ceramic caps

RFC 470uH (Miller 70F474A1)

BALANCE 1000 ohm Bourns Trimpot

GAIN 2500 ohm Boruns Trimpot

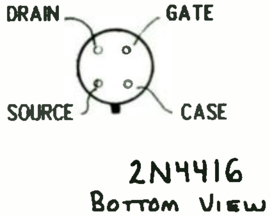
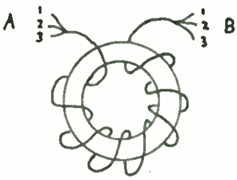



**Figure 1**
Parts are mounted in the box as shown. Part layout and wiring dress are not critical at these relatively low frequencies. The FET gate leads to the input feedthrough insulators should be as short as possible, though. Miniature parts are used throughout. Substitutions are possible as long as the same value part is used.
Q1 and Q2 should be mounted in the sockets to facilitate changing transistors in case of damage. T1 consists of 40 turns of #31 wire trifilar wound on a toroidal core, Amidon T-94-2 or equivalent. (Amidon Associates, 12033 Otsego St., North Hollywood, CA 91607) Cores are also available from Indiana General. A trifilar winding is made by twisting together three equal lengths (about 4') of #31 wire. The twisted triplet is then wound more or less evenly through the core 40 times as shown:

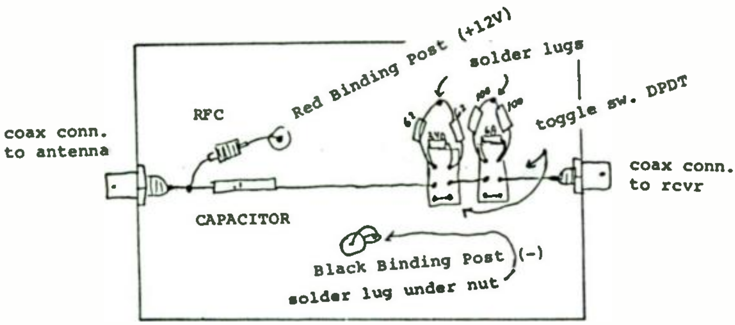



Each of the wires should be marked on each end with pieces of tape to aid in identification after winding. Label one end of the triplet A, and the other B. Solder 1B to 2A. This is the primary centertap and and is later soldered to a tiepoint, but not used. 1A will go to C4, and 2B willgo to C3. 3A goes to ground, and 3B goes to C1.

**Figure 2**

The coupler/attenuator box is assembled next. It is built in the same size minibox as the preamp. Wire as shown:

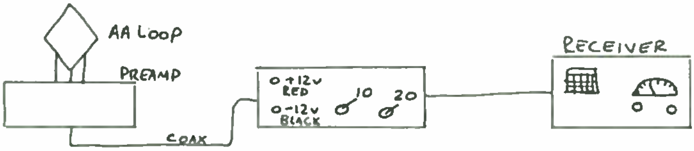
**Figure 3**




all resistors 1/8 W
RFC is 470 uH same as in preamp

This completes construction of the preamp and power coupler/attenuator box. Connect to receiver as shown:

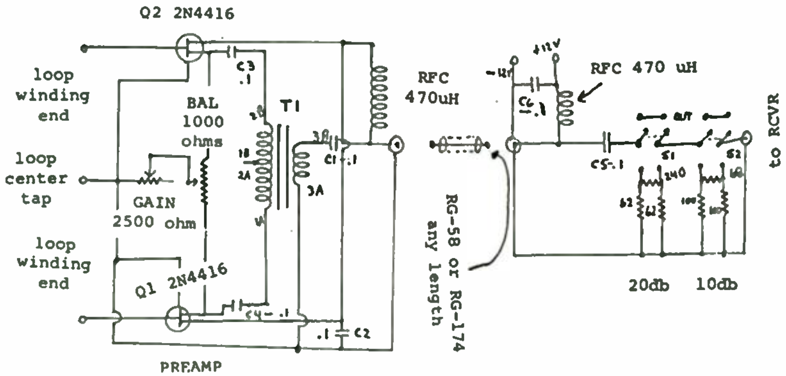
**Figure 4**




Adjustment of the balance control is accomplished by tuning in the strongest local in your area, the stronger the better. Temporarily connect the two input feedthrough insulators (ends of loop winding) together with a short length of hookup wire. This will reduce the signal strength drastically if everything is working OK. If the receiver has a BFO, it should be turned on. Slowly rotate the balance control for null position (minimum signal.) The null will be quite sharp, and the signal will probably disappear altogether. Remove the short length of hookup wire. The preamp is now balanced, and this control will not require further adjustment unless Q1 or Q2 is changed. Preamp gain is set wherever the operator desires, although with most of the better receivers, not much gain is required. I prefer the minimum setting. This corresponds to about 10db gain. The attenuator box controls allow various attenuation to be set in. With either the 10 ot 20 db switch in, the attenuation will be 10 or 20 db respectively. With both the 10 and 20 switches in, the total attenuation will be 30 db. With both our the attenuation is 0.

Results using this preamp have been excellent. The loop balance is as good as ever, as evidenced by the extremely sharp nulls characteristic of the AA loop. The loop tuning is very sharp, just as before. In fact the AA loop is about the sharpest tuning circuit I have ever experienced at MW frequencies, the loop by itself when used with an FET preamp having more selectivity than the usual transistor pocket receiver. There is a complete absence of regenerative effect or oscillation of any kind. Extremely strong locals do not exist in this area as they do in the larger cities, but there is a 1kw local less than 4 miles away on 1240 kHz. The presence of this signal does not impair reception of signals on 1230 and 1250 kHz, so the overload problem cannot be serious. At the same time, my 1240 local can be nulled to provide daytime reception of ZNS-2.

**Figure 5 Power Coupler/Attenuator**



# A GOOD LOOP IS EASY (AND CHEAP) TO MAKE

John Tull

This is not a complete construction article article but rather a guide to a new idea for making a simple loop antenna.

I wanted to be able to make a loop antenna without the need for metal parts (braces, screws, etc.) or the need for any expensive tools to be used in its construction. I wanted great performance at the lowest cost and the minimum in construction difficulty.

The basic parts of this loop can be purchased at a good hardware store. You will need eight 5/8 inch dowels 36 inches long. These dowels are already cut, so you need only select the straightest ones. The eight corners are 90 degree elbows for 1/2 inch plastic water pipe. The dowels will fit the plastic elbows because the 1/2 inch water pipe has a 5/8 inch outside diameter. A good glue to use is a vinyl plastic product with the trade name "DAP".

The base of the antenna is made from plastic water pipe (1/2 inch) and plastic 90 degree elbows. It is made large enough to support the loop and small enough to fit on top of my receiver. A hacksaw blade will work fine to cut the pipe. The loop sides are spaced with 6 inch sections of 1/4 inch dowel. They fit into 1/4 inch holes drilled into the plastic elbows. Drill the holes before starting construction of the loop sides. If you drill the holes in the same place in all eight elbows, the dowels can be used without the vector board for the corners of the loop. My holes were not quite in the same place on some of he elbows and I used Vector board to true the corners before winding the loop.

The base of the loop is attached to the loop with monofilament fishing line. This can be coated with DAP to protect the fishing line from abrasion.

Plain, unclad Vector board is used as a mount for the loop amplifier and miniature 365 pF tuning capacitor. To support the Vector board I used 1/4" pine wood. You can find it at most hobby shops. I used DAP to hold it together.

The coax used from the loop windings to the tuning capacitor and from the tuning capacitor to the amplifier is not grounded. It is not connected to anything. Only the Center wire is used. The shield is just to prevent unwanted pickup of received signal by the inside wire. (Ed note: Pickup unwanted signal will not be reduced unless the shield is grounded. Shielding may alter tuning of the loop because of capacitance to ground.) The loop amplifier represents the best of many I have made over the last few years. It has a very high impedance input along with high gain, and requires no neutralization. The gain pot will come in handy to prevent overloading of your receiver when listening to local stations.

The interstage shield may not be needed. It was the result of earlier amplifier experimentation. The Vector Board inside the minibox is copper clad on one side. I have used many different types of N-FETs in different amplifiers, and it seems to make little difference what ones you use as far as noise levels go. I would recommend you do not use MOSFETS. (They are susceptible to static electricity, i.e. lightening.) A good way to protect the FETs from static electricity during construction is to dip them in water. This will short out static charges that may be on your hands or soldering iron.

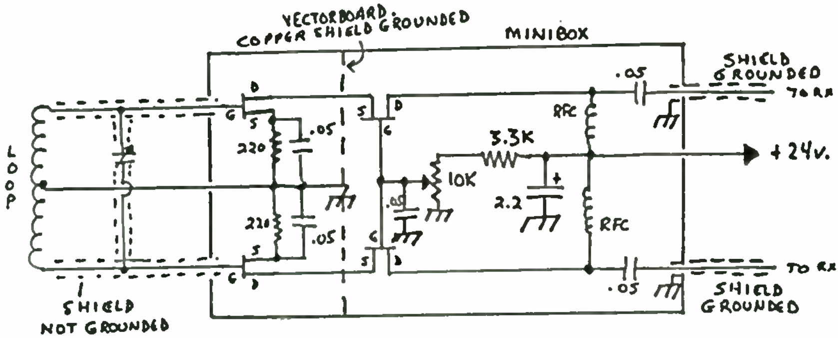
The supply voltage used for this amplifier is from a voltage divider added inside the receiver. I used 25 volts but have used up to 50 volts. 25 volts is best all around, though. The amplifier will work will with 12 volts, however if your receiver uses a 12 volt supply.

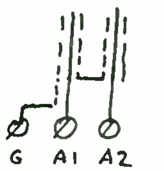
If you need to tilt the antenna to null out a station, you can use a paperback book under one side of the base. Use more or fewer pager for more or less tilt. How's that for low cost?

I made this antenna as a low cost project. It beats any other antenna I have made, and that includes a 36 inch Ferrite loopstick with a similar FET preamp. I think most of our members can make this loop without a large cash investment or a carpenter's toolchest.

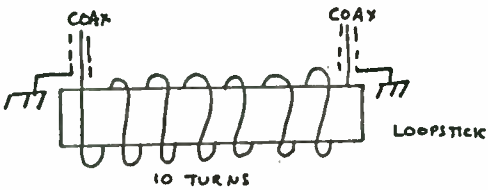
If you use a small receiver with a ferrite antenna, just place your receiver within six inches or so of the loop windings. You will not need the amplifier. The signal level increase will surprise you. You may have a hard time nulling unwanted stations, however.

I hope the loop can be used to increase your DXing totals and enjoyment.



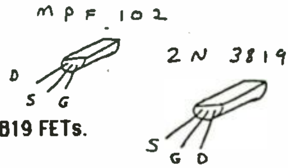

RX ANT. TERMS




RX W/ LOOPSTICK ANTENNA.

loop wire - Belden indoor antenna wire #8014
You will need 120 feet (10 turns)
coax - Belden 8218 Subminax
RFC - 3.9 mH, Miller #70F393A1
gain pot - 10,000 ohm Mallory MLC14L 1/8 shaft linear taper
resistors - 1/4 watt
capacitors - 100 volt dipped Mylar

minibox, solder, solder iron, etc.




You may wish to use MPF-102 or 2N3819 FETs.
Both work fine and are inexpensive.

# A STURDY AND EFFECTIVE FLOOR STAND AND MOUNTING ARRANGEMENT FOR LOOP ANTENNAS

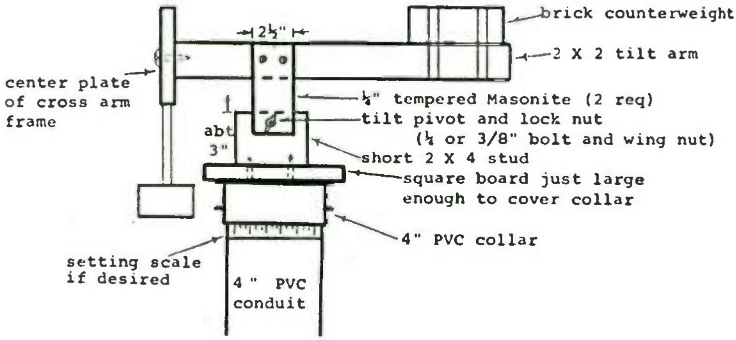
**Mike Maloney**

This is not a detailed step-by-step construction project but contains rather a general outline and description of an effective method for a floor stand and mount for loop antennas with a few construction tips tossed in.

My base consists of two pieces of 16" x 16" x 3/4 inch particle board glued together. A 28" length of 4 inch PVC plastic conduit pipe was securely fastened to the center of the base with two 4" diameter x 3/4" pine wood plugs cut with a 4" hole saw, some wood screws and lots of glue. One could alternatively use some small angle brackets and screws to secure the pipe to the base.

A 4" PVC all plastic collar (type used to prevent electrical wires from scraping sharp edge of conduit) was obtained. The collar slips very nicely over the outside diameter of the pipe. There is enough lip on the collar to mount a square board with some small #8 self-tapping screws. The board is large enough to accommodate the stand off base of my loop, which is made of 1" PVC pipe and elbows and packed with dry cement for weight. The rest of the loop was made in a similar fashion to John Tull's loop. (Article found previous to this one) The 4" PVC collar makes a very smooth bearing upon which the loop can be rotated a full 360 degrees on and around the fixed 4" conduit and base.

An additional arrangement can easily be incorporated for those who have loops constructed in crossmember fashion with a center plate such as my first loop was. The diagram should illustrate:




Two equal size pieces of 1/4" tempered Masonite are securely glued and/or screwed to opposite sides of the 2" x 2" (1 1/2" x 1 1/2" actual size) tilt arm which is in turn securely fastened to the center of the crossarm center plate. The Masonite pieces are then fitted over the 2" x 4" stud and a hold drilled clear through for the pivot bolt and lock wing-nut. This arrangement makes for a stable "fork" type mount which can tilt a full 90 degrees and rotate a full 360 degrees. If one makes the rear end of the tilt arm several inches longer than the front part (fastened to the center plate), a heavy brick can be used as a counterweight to balance the loop and tilt arm directly above the tilt pivot point above the center of the PVC conduit. Once the balance is found, the brick can be secured to the tilt arm with rubber bands and tape. Thus you will have a mechanically balanced loop.

I loaded the 4" PVC pipe with dry cement to within 4" or so of the top. (Sand could also be used but would not be so heavy.) My base and stand together weigh a solid 35 pounds, so you can see why I call it sturdy!

The stand was covered with a walnut grained self adhesive vinyl paper for a finished appearance, but it can be painted or just left plain and still look good. A most effective glue for securing PVC pipe to wood or Masonite is the PVC solvent cement which can be purchased at larger electrical or plumbing supply houses that handle PVC pipe and accessories. For those who do not like to use metal bolts, screws, nuts washers, etc. in loop construction, I have found Elmer's general purpose white glue to be very effective for gluing wood to wood to Masonite when used above 60$^0$F. It will not, however, glue PVC or Plexiglass.

It is hoped that the loop stand and mount described will improve your Dxing enjoyment and effectiveness.

# PRACTICAL PHASED BEVERAGES

by Chuck Hutton

The two-wire phased Beverage is a design that combines the great directivity of the Beverage antenna with the sharp null of a loop antenna. In practice the null of a Beverage is actually superior to that of a loop because in addition to discriminating on the basis of compass direction, it discriminates by arrival angle also. This allows the user to null one TA and hear another of almost identical bearing, or null of US station and hear a Latin on much the same angle but much further away.

This time around theory will be ignored and practical construction details featured.

Figure One is a simplified diagram of a two wire phased Beverage and the associated control box. One wire is termed "F" and the other "G"; "F" is the floating wire and "G" is the grounded wire. $C_g$, $L_g$, and $R_g$ are in the "G" leg. The same system of nomenclature will be used in all succeeding diagrams.

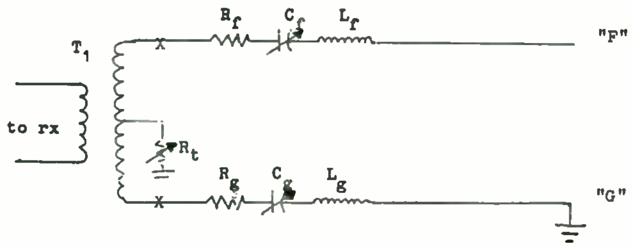



FIGURE ONE

In this, as well as all other diagrams to follow, the two variable capacitors are standard 365 pf units, the coils are 250 uH (preferably shielded in aluminum cans - the Miller A320A is an excellent choice), and all potentiometers are 1000 ohms. For $T_1$ see Figure Two.

The procedure for creating a null is: (1) turn each pot to minimum resistance. Start with "F" and adjust $C_f$ for maximum meter reading. (2) adjust $C_g$ for maximum reading. (3) adjust either $C_f$ or $C_g$ until a null is seen on the S-meter or the offending station is reduced on strength. This generally will involve only a slight movement of the capacitor from the position where signals peaked. (4) adjust whichever capacitor was not used in #3 until the null is deepened. (5) adjust $R_g$ slowly and observe to see whether the null deepens. (6) if #5 yielded no improvement, slowly try the same procedure with $R_f$. (7) slowly rotate $R_t$ and observe for any possible deepening of the null. (8) repeat the process, making fine adjustments as long as improvement is noted.

At the points marked "X" in Figure One (which is identical to the unit Mark Connelly uses to phase his two 37 meter longwires) Mark has inserted a DPDT switch; in one position it grounds that antenna leg and in the other position it connects that antenna leg to the transformer. Mark's procedure for nulling is: (1) switch in "F" with "G" grounded. Set pot $R_f$ at minimum resistance. Tweak $C_f$ for peak signal; note S-meter reading. (2) switch in "G" with "F" now grounded. Set pot $R_g$ at minimum resistance. Tweak $C_g$ for peak signal. Note if S-meter reading is higher or lower than peaked $C_f$ reading. (3) if "F" reading is higher than "G" reading, adjust $R_f$ to equalize the readings. If the "G" reading is higher, adjust $R_g$ for equal readings. (4) flip both switches to connect both "F" and "G" to the balun coil. Carefully adjust the pot just used to equalize signals to reduce the strength of the undesired station. If no null is obtained, re-equalize strengths (step 3). Adjust the other pot with both "F" and "G" connected for a null. Touching up the capacitors slightly will deepen the null. Continue adjusting $R_f$ and $R_g$ plus $C_f$ and $C_g$ to obtain the best null.

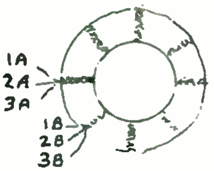



FIGURE TWO

To wind the balun, obtain about three feet of enameled or insulated wire and cut it into identical sections each a foot long. Either twist the wires by hand or put one bunch of ends in a vise and the other bunch of ends in a drill and use the drill to twist. Wind the coil as pictured, being careful to mark each lead before starting. Solder 1B to 2A and also solder a short piece of wire to this junction. This is the center tap of the transformer; the short piece of wire will connect to $R_t$. Wires 1A and 2B are the wires to which the "F" and "G" legs will be attached. Wires 3A and 3B are the receiver connection wires. After winding and soldering are completed, fix the windings in place with coil dope, epoxy glue, or silicon rubber sealant.

This balun has worked very well for me. I can not compare it with the coil used by Connelly and Bailey because they are using a "black box" balun of non-commercial origin.

Figure Three is a slightly more elaborate phasing unit. The basic idea is the same. $T_2$ is a toroid core of 84 turns of approximately #28 enameled wire with a center tap that is grounded. The small value capacitors and potentiometers added are for use in finding a very deep and sharp null, which sometimes proves difficult with the basic setup; the positioning is too critical. The ganged switch is an operating convenience that reduces the number of manipulations that must be made. $C_g$, $C_f$, $R_g$, $R_f$, $L_g$, and $L_f$ are the same as before.

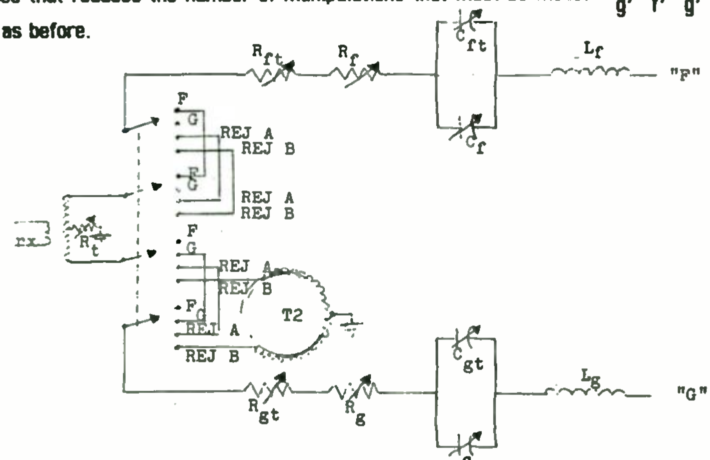



FIGURE THREE

$C_{gt}$ and $C_{ft}$ should be small trimmers of perhaps 15 pf or so. $R_{ft}$ and $R_{gt}$ should be 10-50 ohms. Neither value needs to be exact; anything with a low value compared to the main components will suffice. "REJ A" is the standard null position. In "REJ B" the toroid T2 is in the circuit; T2 is a phase reversing transformer.

In nulling procedure is the same as with the simpler unit. One may; either resonate each wire separately by putting the switch in "F" and "G" and then adjusting for the null, or simply putting the switch in "REJ A" or "REJ B" and adjusting for the null without bothering to resonate the wires. With a little experience one can tell quickly where the nulls will be in terms of capacitor settings, and the resonating step can be eliminated.

Connection of the Beverages to the phasing box can be accomplished with coax, open-wire transmission line, or simply running the Beverage wire directly to the unit. The impedance mismatch between the antenna and RG58 does not seem to affect matters very much. If open wire line is used, each line will have to run into a balanced transformer in order to neutralize transmission line non-directional pickup. A slight bending of the antenna wires in order to bring them directly to the phasing box will probably not affect matters too much.

Some Questions and Answers that may be encountered ----->

# PRACTICAL PHASED BEVERAGES - Questions

Some questions that may be encountered:

(1) Q: I can null OK but nulls sometimes last a few minutes-sometimes only a few seconds. Why?

A: This is probably not due to your antenna or phasing box, but rather changes in ionospheric conditions. This situation is identical to that seem when you use your loop; skywave signals will often drift a bit, requiring re-positioning of the loop.

(2) Q: I still say my nulls aren't steady enough, requiring constant readjustment of the controls.

A: If the fault is to be in the antenna system, the only possibility is that the two wires are spaced too far apart. If this is the case, **diversity reception** is occurring; your wires are not "seeing" the same skywave signal due to their physical separation. While appreciable diversity effect is usually found only at a minimum of 1/4 wavelength separation, enough diversity effect is encountered at 100 feet for the effects to be slightly noticeable.

(3) Q: I can null stations WXXX or WYYY fine but station WZZZ won't null at all. Why?

A: Almost all stations should be nulled to a substantial degree. Unfortunately, there will be a few which prove impossible to null. Generally, these stations are from 60 to $90^0$ off the front or rear of the antenna and the L-C circuit can not provide enough phase alteration to create the necessary $180^0$ out-of-phase current. While the theoretical limits of the phase adjustment by the L-C circuit are +- $90^0$, this is limited in reality to a slightly lower figure by the losses in the circuit. Switching toroid $T_2$ into the circuit should help on some stations. However, there are likely to be a few stations that will not null satisfactorally. There should only be a few of these on the entire band.

(4) Q: I can't null at all. Why?

A: Don't go looking at the wires and wondering if that slight bend is responsible. The phasing system is very forgiving of such imperfection. The problem is in either the wiring of the phasing controls or the transformer $T_1$. Check to make sure that everything is exactly per the diagrams; even with sloppy construction of the antenna and unit decent nulls should be obtained.

(5) Q: My nulls are only 10 or 15 dB. Why?

A: If this is the case for all stations on the band, check $T_1$. If you have wound your own transformer on an air core, consider obtaining the toroid is likely to be better balanced electrically and will have self shielding properties that should minimize pickup from undesired sources

(6) Q: What design considerations are important in construction of the phasing control box?

A: Very little is critical. The toroid should be mounted at least one inch from metallic surfaces. The windings should be coated with coil dope, epoxy glue, or a silicon rubber sealant. The input wires should be kept as short was possible and separated from the output. Ground the case of the minibox to the station ground.

(7) Q: I note the differences between operation procedures for the different phasing systems. Why the difference?

A: In the systems where each leg is resonated individually & then adjusted for a null, the end result is the same as in the one-step procedure. The resonant peak is quite easily noted on the receiver in the one step procedure, even though both antennas are connected. The difference becomes less important when you take into account that the position of $C_g$ and $C_f$ when peaking "G" and "F" respectively are almost always not the position where the null is encountered. The position where the null is encountered should be very near the peak position; this makes location of the peak advantageous in the nulling process.

(8) Q: I just don't have the (wire/time/land) to put up another wire parallel and of equal length to the first wire, so that I can null stations using the two-wire phasing technique. Is there anything that I can do?

A: Most definitely. The stipulation that the wires be parallel and of equal length is made in order to assure optimum performance. As the basic requirement is that we have a source of current which can be phased against the first wire, this current can actually be derived from any source. Beverages of different length & direction, longwires, verticals, dipoles, rhombics, bedsprings, anything can be used and will provide adequate nulling in most instances. Beware, however, that you are introducing signal pickup into the system which may well partially defeat the tremendous directionality of a Beverage. This is the one and only reason why the system is described as two equal length, parallel wires!

(9) Q: I am pleased with the performance of my system and its nulls. Sometimes when I try to deepen nulls further by adjusting $C_g$ or $C_f$, I succeed only to have the deep null lessened when I remove my hand. Why?

A: The cause is hand capacitance, which is sufficient to disturb a deep null. As the variable capacitors are insulated from the chassis (not grounded on one side as is usually the case), your body capacitance will be added to the system. The best remedy is to mount the capacitors on a panel behind the front panel of the minibox and epoxy plastic extension shafts onto each.

(10) Q: I am using posts to support my Beverage as no trees are available. Rather than be forced to install another set of posts 10 feet away for the second wire, can I mount it on the post along with the first wire?

A: Yes and no. Yes, if you can keep it a least a foot away from the first wire. No, if it is closer, because undesirable re-radiation from the first wire will couple into the second wire.

(11) Q: I live in a part of the country where the ground isn't very conductive. In addition, I don't want to spend a small fortune on ground rods. Do I need to invest a large amount of time and money establishing a "perfect" ground for one wire?

A: Not really. The purpose of the ground is not really to ground the wire, but to reverse the phase of the current on that wire. While a decent ground is desirable, experience shows that an excellent ground is not necessary to operation of the system.

(12) Q: I read elsewhere that a ground counterpoise wire run underneath the wire will improve performance. That is an awful lot of trouble, and could prove hazardous to persons walking in the area. Is it worth it?

A: It doesn't seem to be. The purpose of the wire is to reduce ground losses, and by doing so, eliminate alterations of phase relationships created by losses in the antenna. The L-C circuits can compensate for this condition. The improvement in loss characteristics of the antenna does not seem to be worthwhile. Also, the wave velocity of the Beverage will be increased by a ground counterpoise. This is important in only two situation: when running extremely long Beverages (on the order of a mile at MW frequencies) or when operating a Beverage at the upper frequency limits of its practical operation (5-10 MHz).

(13) Q: I have never wound a toroidal core transformer and will therefore have some trouble. What are some tips on construction?

A: No need to worry. Toroids are pretty forgiving devices, and this circuit is non-critical. It doesn't matter whether the windings are evenly spaced around the core or whether one turn doesn't sit completely flat against the surface of the core. Also, the center tap does not need to be positioned with anything more than a normal degree of exactitude.

(14) Q: Sometimes I notice nulls in signal level ( of very good deepness) but this does not bring out the DX underneath; rather it seems to only weaken everything on the channel. Why?

A: The cause is unknown. Usually a null that allows the DX to surface can be found by moving one variable capacitor slightly and re-adjusting the other for a new null. These "false nulls" are semi-frequent occurrences but usually can be corrected for as above.

(15) Q: I am phasing wires that run in different directions. Sometimes I have a very difficult time finding nulls; this is not the case when I phase wires that run in the same direction. What is the cause?

A: The reason seems to be that since signal levels for station WZZZ are likely to be much different on two non-parallel wires, the phasing controls can be properly adjusted to create the $180^0$ phase difference but no null will be created because of the extreme difference in magnitude of the current. The solution is to adjust the capacitors to the peak position and then try alternately $R_f$ and $R_g$ at a mid-scale value while twiddling the capacitors to create a null.

(16) Q: What about $R_t$? When should it be adjusted?

A: While this is not usually a critical adjustment, it is always best to rotate it slowly after adjusting the other controls. Sometimes it will be possible to further deepen the nulls. In very rare instances, no null or little null will be noticed until $R_t$ is adjusted to the proper position.

My thanks to Bill Bailey and Mark Connelly for forwarding their set-ups. Bill introduced me to the practical details which led to me setting up by first phased Beverage in 1977; Mark has sent along much information on the electrical properties of the toroid and balun he uses, along with his set-up for phasing longwires.

++ END ++

# MORE THOUGHTS ON PHASED ANTENNAS

Mark Connelly

As a phasing-unit user, I thought that I could add a few more questions, answers, and comments to Chuck Hutton's fine "Practical Phased Beverages" article.

Regarding question #8 in Hutton's article: If the wires to be phased are not of equal length, the gain/sensitivity of the shorter wire will determine the overall antenna system gain. If you have a 1000 foot Beverage and a 100 foot longwire, you will have to crank in much more resistance on the Beverage leg of the phasing box to get the amplitudes of the two incoming signals roughly equal. This is necessary as it is impossible to phase-cancel 2 signals of different amplitudes: a 10 v p-p signal phased against a 5 v p-p signal will give you a minimum of 5 v p-p if the signals are $180^0$ out of phase, 11.2 v p-p if $90^0/270^0$ out of phase, and 15 v p-p if they are in phase ($0^0$ shift). It should be obvious that, in the case of weak signal reception, that it's a waste of time to phase a Beverage against a much shorter wire. Your Beverage might be giving you USSR - 765 at 10 dB over the noise masked by Dakar at 60 dB over the noise. Your bedspring, shortwave or whatever gives you Dakar at 30 dB over the noise, but USSR is 20 dB under the noise. To even begin to phase out Dakar with this configuration, you would have to crank in enough resistance on the Beverage leg to knock Dakar down to 30 dB over the noise. Nulling out Dakar will leave USSR at 20 dB (see note below) under the noise: this was a fruitless exploit and a waste of valuable DX time. It behooves the DXer to lay out his aerial farm to accommodate the two longest equal-length wires that can be installed, even if they are only a few feet apart. If you have to run the wires in different directions, so be it. You'll still realize a good deal of phasing capability

## Questions and Answers

1. Q. I can only run one good wire of reasonable length because I live in an apartment building not allowing antennae. There's a big spruce tree about 60' from my window and if I'm sneaky I can run some "invisible" #28 magnet wire out to it sometime when no one is looking. Is there anyway I can phase this wire?

   A. Yes. Use an amplified loop antenna on the other leg of the phasing unit. In most steel-frame apartment buildings, loops alone are ineffective: everything peaks with the loop pressed against the window; nulling one station usually nulls all others. If you phase the peaked loop next to the window (ant.#1) against the "invisible longwire" (ant.#2), real nulling becomes achievable for the apartment dweller. You can not only null pest stations, but you can also put a dent in pesky TV birdies and man-made electrical noise.

2. Q. I null a local station down, but it doesn't seem to reduce the splash on adjacent channels. How do I get rid of this slop?

   A. If the splatter is actually present at the adjacent channel frequency as it comes from the transmitter (not generated in the receiver by overloading), you will have to null the pest station carrier on its frequency first and then finely re-tweak to null the slop while you are tuned to the desired adjacent channel station. Loop antenna users are familiar with this technique: it is not merely sufficient to null the pest station on its own frequency to eliminate splatter; a fine repositioning of the loop is required to minimize the slop on an adjacent channel of DX interest.

Note: In the first discussion, USSR might be more than 20 dB under the noise if totally nulling Dakar-765 also partially nulled USSR.

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# MORE THOUGHTS ON BEVERAGE ANTENNAS

Chuck Hutton

A few more comments on Beverage antennas are in order, by one who has used Beverages for years and had 4 Beverages up permanently for the last year. In addition I have accumulated notebooks of information on Beverages from research laboratories and the commercial press. NRC'er Bill Bailey has been playing with these antennas for longer than Clements and myself put together and probably knows more practical details than anybody else.

First, the matter of length. The optimum length is dictated by the velocity of the current on the antenna, which is always less than that of the Space Wave. This leads to increasing phase differences between the currents induced in various sections of the wires. Analysis of the equations shows the point at which the currents are more than $90^0$ out of phase and resultant loss of signal takes place. For example, an average Beverage constructed over average earth will have an antenna velocity of between 80 and 90% which limits the maximum practical length to right at 2 wavelengths-about 1300 feet at the top of the band and 3600 feet at the bottom. That is why you rarely see very long Beverages used by those with much experience in the field.

Secondly, termination. The resistor at the far end is designed to match the surge impedance "discontinuity" and travel thru the resistor to ground. This takes place no matter what the length of the antenna in wavelengths, making the system unidirectional. What Beverage is saying in this article is that the antenna will have no pickup directly off the back end or some pickup dependent on the antenna length velocity. As for the variation in the exact terminating resistance required, the change is only of a small order of magnitude, say 50 ohms. The antenna will not stay perfectly terminated, but a slight error is still greatly preferable to no termination. One point mentioned by Clements that is important is that a long Beverage begins to assume significant unidirectional qualities. This is due to the rather high transmission line losses that any signal must suffer that is propagated to the far end of the antenna and then reflected to the receiver end. Such losses will run at least 25% and make a Beverage much less useful off the back side. My experience with a 1600' Beverage on a $250^0$ bearing used all this season was that it is almost useless for TA's off the back end. As for how necessary the termination is on a Beverage, I have tried the 1900" Beverages I have running $150^0$ with and without the resistance and the difference is very great if you have the right resistance. I started off with 470 ohm resistors and found that did not do the job. 560 ohms was the next value and that must be close to perfect - you are welcome to hear my tapes of Dobleve 840 with little or no WHAS (who is at a commercial listening quality usually), and the Cuban R. Guama outlets on 990, 1000, 1010, 1020, and 1030. The R. Guama outlets are all covered by domestics when the antenna is ungrounded, although 1020 can be heard thru KDKA.

Construction- past 5 or 10 feet off the ground there is little to be gained by raising the antenna. Chances of you getting it 1/2 wavelength off the ground (essentially in free space as far as the antenna is concerned) are minimal. Beverages simply stretched on the ground will indeed work, but will have somewhat lower signal levels due to the extremely high attenuation and the high degree of earth losses in these closely coupled antennas. The Beverage is actually a very inefficient antenna, averaging about 10% of the efficiency of a vertical. This is due to the high ground losses, and can be dramatically rectified by the use of a second wire parallel to the first, with more wires bringing an even further decrease in near field losses. I have found that a second wire yielded an 88% increase in signal delivered to the receiver. Increases of up to 300% are possible according to some studies dome by research laboratories for the Department of Defense. Going back to Beverages stretched on the ground, the extra attenuation and slower wave velocity can be plugged into equations of Beverage performance. The results show slight but appreciable blunting of the characteristics. The only practical experience I have had with ground Beverages was at the Louisville Convention, where I had 1500' parallel to the LPC Beverage that was up on poles. The space between the antennas was about 20 feet. The good DX heard that night was not quite as loud or quite as free from QRM as on the main Beverage, but we heard every station they heard, I believe.

Frank Dailey once published a brief note on what he called loaded Beverages winding wires on coils every hundred feet or so in order to have the full length of wire in less space. Unknowingly, he was close to doing something that will indeed yield full Beverage directionality in reduced space. The directionality of the antenna depends on the length of the wire and also on the wave velocity, ignoring other minor effects.

By reducing the wave velocity to half of the normal value, you can get an antenna that is as directional as an antenna twice as long. Series inductance or shunt capacitance will produce the proper phase delay, but I have never taken the time to derive exact values. Beverage used series capacitance in order to obtain phase advance and keep the wave velocity (effective) at a high value when using super long Beverages (on order of 17 miles!) for one low frequency Beverage.

Lastly, phased Beverages are perhaps the most amazing of all the Beverages. They are touched upon briefly in the original article on the Wave antenna by Beverage. His system used two wires with $180^0$ phase difference once the phase difference is created it is a simple matter to combine the two currents and produce a null in any direction off of the back of the antenna. Unfortunately it is necessary to leave the far end open for one antenna and grounded for the other in order to produce the out of phase currents. This situation means that some reflection will take place from both wires and there will be a degree of pickup off the back end. The phasing controls then allow you to move the null to any location and remove whatever pickup there was. Nulls of 30-40 db can be created on nighttime pests. You will notice that this system (state of the art in amateur and BCB Beverage user's circles) allows users to null only pickup off of the rear of the antenna. So far I have had some success using a system of 2 almost parallel Beverages that are both grounded at the far end, and accomplishing phasing with the use of a passive phasing circuit.

Sometime in the near future I hope to write up a full report on my experiences with Beverages, including the phased systems. My personal observations plus some data from several research labs has led to some new conclusions, some of which contradict accepted ideas that many of us have held.

One item that also deserves attention. Beverages perform <u>well</u> at BCB frequencies regardless of the ground over which they are erected. The difference in the ground determines the value for the tilt angle (ratio of horizontal to vertical gradient) of the incoming wavefront. The tilt angle also is affected by the frequency; in early days when Beverages were used for TA communications on frequencies like 60 kHz, ground was all important as the antenna was almost useless over ground with a high soil conductivity. The British PO abandoned several sites in north England because of the ground characteristics. At BCB freqs, the worry is needless, as there is plenty of wave tilt from both the ground and the arrival angle of the signal. Of course, antennas will deliver somewhat more signal over a desert than over swamps. As to the question of whether water in the soil will cause the surrounding area to be too conductive for a Beverage to operate correctly, Beverage addressed this question in his epic and proved there was no effect with surface streams. Ground water is so far below the surface that it has little effect on the Beverage performance. I think it still very true that the best antenna would indeed be one over a desert, terminated in a swamp. Further, parts of all of my 4 Beverages are over mushy swamps (or lose to it) and I think the results certainly show that they have been excellent antennas, as good or better than any I have ever used. I think logging a Columbian on 1490 indicates a pretty fair antenna.
*****

# Improve your Latin American DX by Phasing Non-Identical Antenna

by Mark Connelly

As a preface to this article, the reader should become familiar with phasing units and techniques: this can be done by reading "Practical Phased Beverages" by Chuck Hutton (found in this booklet).

Some recent experimentation at the "DX Lab" in West Yarmouth, MA. has involved phasing aerials of similar length but having different skip-angle reception properties. In particular, one of the aerials used in the phasing was a wire laying on the ground; this was tied to a ground rod at the far end. The second aerial used for phasing was of similar length (about 37 m) but at a height of 10 metres.

One might initially think that the antenna on the ground would have much less overall pickup than the wire 10 m. in the air, but it actually produced domestic skip signals of levels comparable to those of the other longwire. It should be noted that the ground at the site is somewhat lousy, being deep sand similar to that of Long Island and eastern New Jersey, but unlike Conn., Mass. west of Boston, or Rhode Island.

Before commencing actual phasing, just flipping between the two wires yielded considerable differences on Latin American (LA) stations. The wire on the ground was obviously more short-skip oriented: domestics from the Eastern and Central time zones were very strong; long-skip domestics and all foreign stations were poor. On the aerial mounted 10 m. off the ground, Caribbean/Latin American stations were much more evident.

For the following discussion, we'll refer to the aerial 10 m. above the ground as Antenna A and the longwire on the ground as Antenna B. Previous phasing experience has usually involved two parallel equal-length, equal-height wires producing very similar receptions as they were switched back and forth. Very often it was found that, as phasing was attempted on a channel with a domestic (e.g. WLS-890) and a co-channel LA (e.g. HJCE) of comparable strength, the LA would get phased out much more readily than the domestic arriving at a higher skip angle. Obviously, the desired goal was not being achieved. The concept of using the wire on the ground (Antenna B) came about when I noticed that a wire wrapped around a cold-water pipe in the cellar produced good short-skip reception, but was lousy for TA & LA DX. I reasoned that if you have a "good" antenna that produces WLS-890 at S9 + 30 dB and HJCE-890 at S9 + 20 dB and a "bad" antenna (the ground-longwire) giving WLS at S9 + 30 dB and negligible HJCE (maybe S6 or so, but utterly buried under WLS), phasing these two wires against each other will likely cause cancellation of WLS, but not of HJCE. In previous discussions of phasing it was noted that the signal to be nulled should be about equal on Antenna A and Antenna B. By extending that logic based upon the subtractive nature of phasing, a signal <u>not to be nulled</u> should <u>not</u> be at the same level on both antennae.

With two "good" antennae phased against each other, it is theoretically possible to phase out either WLS or HJCE. As there is greater vertical skip-angle variation (shifting) on a short-skip station, however, the null on WLS is harder to hold than that on HJCE. With a "good" LA antenna phased against a "bad" LA antenna, HJCE cannot be easily nulled: in the worst case, the S6 Antenna B signal subtracted from the S9 + 20 dB Antenna A signal would still leave about S6-7 worth of the Colombian, assuming 6 dB per S-unit.

The testing was conducted in May, a month known for relatively poor foreign conditions. Short-skip was very dominant at the time, even on Antenna A. Even with skip-angle variation, WLS can be nulled well below S6 most of the time. Using two normal longwires, HJCE may have also been reduced drastically at the same phasing unit control settings as those with nulled WLS. This is not the case when the "good" 10 meters - high wire is worked against the "bad" wire on the ground: here on Cape Cod, HJCE (and/or HIPJ, YV etc.) are copyable for an hour or more at a time without having to re-adjust phasing controls - even on nights when WLS has a good signal. Using this scheme, skip angle shifting tends to reach insurmountable proportions only if the domestic to be nulled is closer than 300 miles/ 500 km.

WBAL-1090 can quite readily be nulled to yield YVSZ/HJBX; WHAM-1180 can be knocked out to get a Reloj Cuban/ VOA Fl./ YVNU and others. WCAU-1210 is on the close-in border of easy nulling. It can sometimes be "dumped" for 3 to 5 minutes without phasing-unit retweaking, usually revealing 2 YV's, a Haitian, and a Cuban.

On the other hand, New York City stations arriving on strong short skip with residual groundwave are nearly impossible to null. In this case, auroral conditions are needed to dispose of the high-angle skywave. This leaves groundwave which, although still strong, can be easily nulled. Groundwave nulling is best done with two "good" antennae. The wire on the ground discriminates against low-angle signals, including domestic groundwave as well as desirable foreign DX. It would be more difficult to get equal level groundwave signals for the nulling process if the ground-longwire and the wire 10 meters in the air were used instead of dual 10 meters high wires.

Over the past year, more international DXers have been building and using phasing units. It seems to be an appropriate time to address the question "Will phasing longwires or Beverages really get me more

DX than I'm presently hearing with my loop?" This is a question that cannot be answered in general terms. Neil Kazaross has been using a phasing unit on his coastal Beverage installation in Narragansett, RI: sometimes the phased-Bev's bring up DX not heard on the Sanserino loop, on other occasions the loop offers unique loggings. Bill Bailey in Holden, MA - again using full-length Beverages - has probably logged more East European stations behind the Iron Curtain than any other US DXer in recent history. I have seen using two much shorter wires (each about 37 m. long) in my phasing scheme at W. Yarmouth,MA. The main advantages I have noted there are (1) you can null out an undesired station in the same direction as a desired station at a different distance, leaving the desired station relatively in the clear. Also, during AU CX when domestic skip is not a problem, one LA can often be nulled to get another co-channel LA. (2) nulls of short/ medium skip domestics are longer-term and steadier than those possible with SM2 or MW-1 ferrite loops. (3) phasing of outdoor wires can be one in a cellar, in a steel-frame building, or in a car/van/trailer where use of a loop would be doomed to failure.

Reception diversity seems to offer the greatest range of DX possibilities. There are times when TA and eastern LA signals show earlier sunset-period fade-in times on phased longwire system; on other occasions, the loop yields earlier fade-in times. Atmospheric noise problems vary similarly: tolerable reception on one system, impossible static crashes on the other. Nulling WJR-760 on the loop might yield HJAJ/YVQQ whilst, at the same instant, nulling WJR by phasing the longwires might produce Guyana, the Reloj Cuban, or something else.

One interesting instance (of practical concern): the house across the street (Trowbridge Path, W. Yarmouth) has an obnoxious light dimmer. As luck and Murphy's Law would have it, the offending dimmer is to the east. On the SM2, effectively nulling the noise kills all interesting sunset-period DX including TA's and far-east LA's (e.g. Windward Islands, Surinam, Guyana, north coast Brazil). The phasing unit produces a superior null on the noise to start with; in addition, although weakened considerably, Africans on 765, 1349, & 1404 and several Surinam stations still make it through at sunset. ZBVI-780, St. Kitts-825, and the usual bunch of Venezuelans quickly follow. Looping dimmer noise, TV QRM, & the like is more difficult than phasing with noise arriving from several different directions simultaneously. The phased longwires, being outdoors, "see" the manmade noise as emanating more from a single point source than the indoor loop ever could.

The loop has earned its keep by being consistently better on European sunrise/ local midnight period highband TA DX than the phased 37 m. wires.

From the above discussion, the serious foreign DXer should go into the DX battle armed with one or more good loops, a phased parallel-longwire arrangement. By doing this, the DXer should have configurations at his disposal to deal with such varied band conditions as short-skip conditions, aurora, and good TA nights.

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# PHASING UNIT CONSTRUCTION AND USE

by Mark Connelly, WA1ION

This article is presented to describe the actual construction of a versatile phasing unit and to delineate methods of using the unit to produce nulls of unwanted stations or noise signals, allowing desired DX to be heard. The following works should be read as a preface to this article:

| | | |
|---|---|---|
| Analysis of Beverage Antenna | Chuck Hutton | Beverage & Longwire Ant.Book |
| Practical Phased Beverages | Chuck Hutton | This booklet |
| Phased Longwires | Mark Connelly/Nick Hall-Patch | IRCA Reprint A28 |
| More Thoughts about Phased Antenna | Mark Connelly | This booklet |
| Improve your Latin-American DX by Phasing Non-Identical Antenna | Mark Connelly | This booklet |
| Phasing Unit Design Modifications | Mark Connelly | This booklet |

The construction article to follow is the first article to actually outline a step-by-step procedure to build a versatile phasing unit which can be used by itself to phase wires of 30m/98' length (or greater) or, when fed to an RF amp., to phase wires as short as 5m/16'. The amplified shortwire concept will be covered in the next article of this series. The phasing unit to be built incorporates several recent improvements such as flexible LC module design.

## Starting the Project

The prospective builder should have rudimentary tools and shop accessories such as a soldering pencil, rosin core solder, screwdriver and nutdriver sets, 6-32 tapping tool, longnose pliers, diagonal cutters, regular 'gas' pliers, hacksaw or jigsaw, drill with a reasonably good assortment of bits (see Figure 6, further into this article), ruler/scale, calipers or micrometer, wire stripper, push-pin insertion tool (e.g. Vector P91-DP), vise, solder sucker (de-solder wick), file, and X-Acto (or similar) knife set. The author does not like wire-wrapping for RF work, but some would rather wrap than solder.
A volt-ohmmeter comes in handy for verifying switch connections and wiring runs. A well-stocked hardware cabinet is useful. A candle will be used to dribble wax over the two toroidal transformers when they have been assembled. Glue or rubber cement applied to the toggle switches will hold them into place more securely than the manufacturer-supplied nut & lockwasher arrangements could do alone.
When the builder has marshalled all of the necessary tools & accessory items together into a suitable work area, parts acquisition is the next phase. At the outset, you must realize that 'Radio Shack' won't have many of the needed parts. Electronic parts retail stores must be located. In the Boston area, You-Do-It Electronics in Needham Heights, MA. has many (but not all) of the necessary components. Those in rural areas will have to shop by mail. Consult QST magazine and other hobby publications for parts suppliers. When you buy components new, you are paying 'top buck'. Ham auctions & 'flea markets' are a much cheaper way to obtain necessary parts.

IMPORTANT NOTE: The drilling drawing, component layout drawing, and wiring drawing are laid out for the specific parts listed herein. Parts electrically equivalent to those listed, but possibly different from a mechanical standpoint, may certainly be used -- as long as you, the builder, adjusts all assembly drawings to reflect component variations, before any actual drilling or assembly is undertaken.
.pm0

**Table 1: Parts List for Phasing Unit**

| Component Designation(s) | Quantity Required | Description | Manufacturer | Manufacturer Part # |
|---|---|---|---|---|
| C1,C2,C3,C4 | 4 | 10-365pf variable capacitor | Calectro | A1-232 |
| C5,C6 | 2 | 47 pf fixed mica capacitor | Sprague | QCP-1171-01 |
| J1 thru J7 | 7 | insulated banana jack | H.H.Smith | 1463 |
| L1x,L2x | 2 | 470 uH inductor | Nytronics | WEE-470 |
| L1y,L2y | 2 | 270 uH inductor | Nytronics | WEE-270 |
| L1z,L2z | 2 | 120 uH inductor | Nytronics | WEE-120 |

| Component Designation(s) | Quantity Required | Description | Manufacturer | Manufacturer Part # |
|---|---|---|---|---|
| R1,R2 | 2 | 100K pot w/switch | Radio Shack | 271-216 |
| R3,R4,R7 | 3 | 1K pot w/switch | Calectro | B1-660 |
| R5,R6 | 2 | 1K fixed resistor | Radio Shack | 271-023 |
| SW1,SW2 | 2 | SPDT toggle switch, center-off | Alco or Radio Shack | MST105E 275-325 |
| SW3 | 1 | 3-pole,4-position switch | G.C.Electronics | 35-379 |
| SW4 | 1 | 4-pole,3-position switch | G.C.Electronics | 35-380 |
| SW5,SW6,SW7 | 3 | DPDT toggle switch no center position | Radio Shack or Alco | 275-663 MST205N |
| T1,T2 | 2 | toroidal core | J.W.Miller | T-106-2 |
| - - | 25' | #28 solid enamelled magnet wire | Columbia Electronic | 10023-13 |
| - - | 8 | push-pins for lead attachment | Keystone Electronics | 1499PK |
| - - | 4 | tie-wraps to secure T1, T2 | Waldom | 65001 |

**(Metal Hardware Assemblies)**

| Component Designation(s) | Quantity Required | Description | Manufacturer | Manufacturer Part # |
|---|---|---|---|---|
| H1 thru H5 | 5 | 6-32 x 1 1/4" threaded spacer | * | |
| - - | 10 | 6-32 x 3/8" binder-head screw | * | |
| - - | 9 | 6-32 internal tooth lockwasher | * | |
| H5 | 1 | 6-32 solder lug | Waldon | KT-197 or KT-194 |

**(Nylon or Plastic Hardware Assemblies for mounting C1 thru C4)**

| Component Designation(s) | Quantity Required | Description | Manufacturer | Manufacturer Part # |
|---|---|---|---|---|
| HC1 thru HC4 | 4 | 4-40 x 3/8" screw | * | |
| | 8 | 4-40 hex nut | * | |

**(Miscellaneous parts - no designation numbers)**

| Component Designation(s) | Quantity Required | Description | Manufacturer | Manufacturer Part # |
|---|---|---|---|---|
| | 1 | Vectorboard 4.8" x 8.5" .062" dia. holes on .1" (84 columns x 47 rows = 3948 holes) | Vector | 85H48WE |
| | 1 | ground plate, 8" x 10" bare metal | LMB | (8 x 10 Cap Cover) |
| | 1 roll | insulated hook up wire, #22 solid wire | Columbia Electronic Cables | 90' roll |
| | 2 | single-line knobs for SW3,SW4 | Radio Shack | 274-407 |
| | 5 | Calibrated knobs for R1,R2,R3,R4,R7 | Radio Shack | 274-413 |

**(Optional Support Leg Assembly)**

| Component Designation(s) | Quantity Required | Description | Manufacturer | Manufacturer Part # |
|---|---|---|---|---|
| | 2 | solid metal, wood, G-10, or plastic cylindrical dowel 4 1/2" long x 3/4" dia. | * | |
| | 2 | 6-32 x 3/8" binder-head metal screw | * | |
| | 2 | 6-32 internal-tooth lockwasher | * | |

**(Balanced Cable Assembly, from phasing unit to receiver balanced inputs)**

| | | | |
|---|---|---|---|
| 1m/3.3' | TV Twin-lead or AC "zip-cord" | * | |
| 2 | banana plug | Radio shack | 274-730 |
| 2 | receiver connectors (e.g. spade lugs) | * | |

**(Unbalanced Cable Assembly, from phasing unit to receiver unbalanced input and receiver ground**

| | | | |
|---|---|---|---|
| 1m/3.3' | RG174 coaxial cable | * | |
| 2 | banana plug | Radio shack | 274-730 |
| 1 | receiver input connector (e.g. PL-259,BNC,phono plug,etc.) | * | |

**(Balanced-Mode Ground Jumper (from phasing unit ground to receiver ground))**

| | | | |
|---|---|---|---|
| 1m/3.3' | insulated hookup wire,#18 stranded | * | |
| 1 | banana plug | Radio Shack | 274-730 |
| 1 | alligator clip or spade lug (to rx.) | * | |

NOTE: Asterisk (*) indicates that there are many different suppliers of this product at varying prices. Consult local hardware stores and electronic parts outlets for availability.

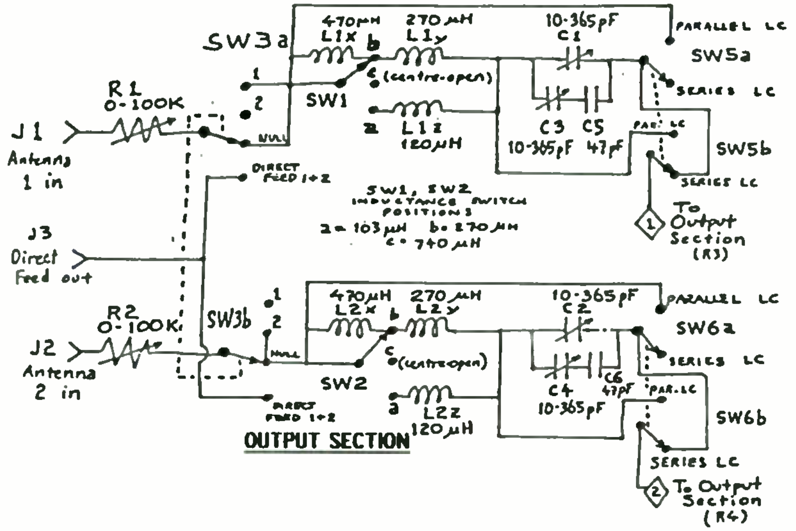
**Table 2**

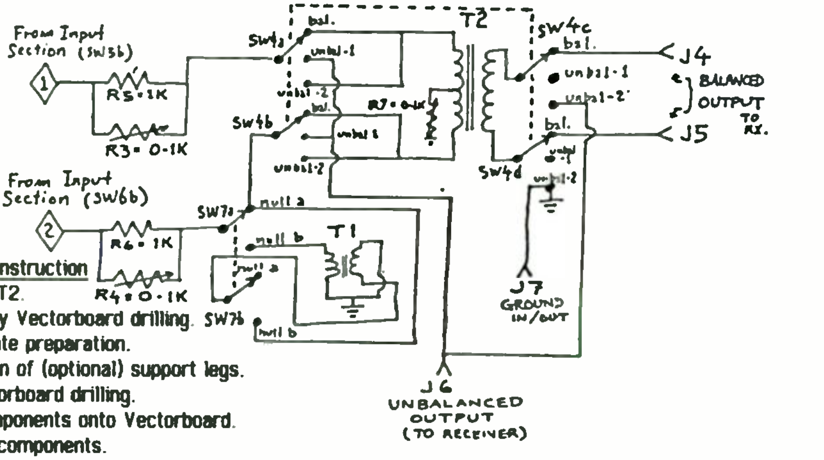
**Functional Descriptions of User-Adjustable Controls on Figure 1 to follow:**

CONTROLS OF ANTENNA #1 LINE

| Component Designation | Function Name | Notes |
|---|---|---|
| R1 | #1 main (level) pot. | adjust signal level from Antenna 1 |
| SW1 | #1 L switch | 3 possible inductances (e.g. 103,270,or 740 uH) |
| SW5 | #1 LC switch | choose series or parallel LC |
| C1 | #1 main tune cap. | |
| C3 | #1 trim cap. (a.k.a. vernier cap, fine-tune cap.) | |
| R3 | #1 trim pot. | |
| | CONTROLS ON ANTENNA #2 LINE | |
| R2 | #2 main pot. | adjust signal level from Antenna 2 |
| SW2 | #2 L switch | choose one of 3 inductance values (as done with SW1) |
| SW6 | #2 LC switch | choose series or parallel LC |
| C2 | #2 main tune cap. | |
| C4 | #2 trim cap. | |
| R4 | #2 trim pot. | |
| SW7 | Null-mode switch | switches phase-reversing transformer, T1, in or out of Antenna #2 line. |
| | CONTROLS SIMULTANEOUSLY EFFECTING BOTH ANTENNA LINES | |
| SW3 | antenna switch | choose Ant. 1 only, Ant. 2 only, both, or none |
| SW4 | bal./Unbal. switch | select balanced output or one of two unbalanced output configurations (unbalanced with balun (unbal-2) or unbalanced without balun (unbal-1)) |
| R7 | ground pot. | used for fine-nulling in balanced or unbal-2 output modes. |

**FIGURE 1: Schematic Diagram of "MWDX-1" Phasing Unit**




Outline for Construction

1. Wind T1, T2.
2. Preliminary Vectorboard drilling.
3. Ground plate preparation.
4. Preparation of (optional) support legs.
5. Final Vectorboard drilling.
6. Mount components onto Vectorboard.
7. Wiring of components.
8. Inspection of completed wiring, checking of switch connections.
9. Final mechanical assembly: attach Vectorboard to spacers on ground plate.
10. Connect appropriate antennae to completed unit. Run cable from phasing unit to receiver.
11. Commence DXing.

1. Wind T1, T2

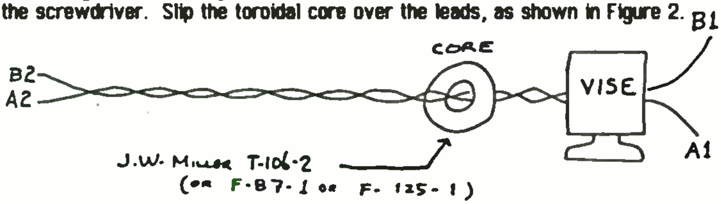
T1 is used as a phase-reversing transformer which yields phase shifting required to establish some nulls.

Cut 2 pieces of #28 enamelled solid magnet wire to a length of approximately 2 meters/6 1/2'. Label one end of one of the wires 'A1'. Label the other end of that wire 'A2'. Label one of the second wire 'B1' and label its other end 'B2'.

Tape the 2 wires together 10 cm./4" from the A1 and B1 ends. Insert the taped part of the wires into a bench vise. Stretch the wires out taut and tape the A2 and B2 ends to the blade of a large screwdriver. Ensure that the labels do not become detached from the wires! If the gummed label method is too clumsy, other ways to differentiate the 'A' wire from the 'B' wire may be devised: these include knotting each end of one wire, leaving the other wire unknotted; or, stripping enamel varnish from each end of one of the wires and not stripping the other.

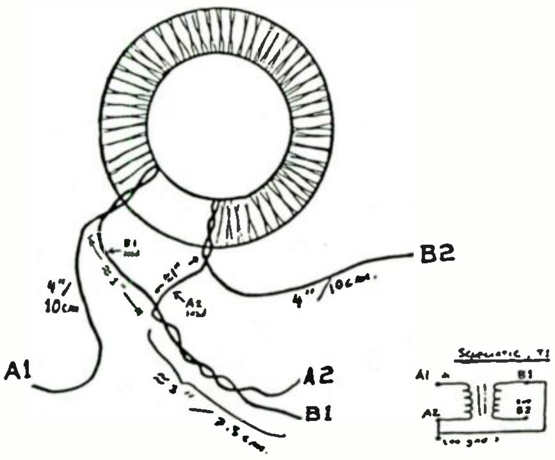
Turn the screwdriver slowly and evenly such that a twisted pair of leads is formed. One or two twists per inch along the entire length of the paired wires is the result desired. Detach the B2 and A2 ends from the screwdriver. Slip the toroidal core over the leads, as shown in Figure 2.

**Figure 2**




Wind 40 to 50 turns of twisted pair on the core. After that, untwist the wires between the A2 and B2 ends and the toroid. Re-label the B wire such that B2 is now 4" from the toroidal core. Cut off B wire more than 4" from the core. Similarly, re-label the A wire so that A2 is now 4"/10cm. from the core. Detach the A1 and B1 leads from the bench vise and untape them. Twist lead A2 with lead B1. Temporarily retain all labels on lead ends. Drip candle wax over final T1 toroidal coil assembly. The T1 assembly should resemble Figure 3.

**Figure 3 T1, Phase-Reverser**




T2 is the balun transformer, necessary to provide balanced outputs. Cut three #28 magnet wire leads to 1m./3.3' each. Using the practices employed in fabricating T1, label the leads, as in Figure 4.

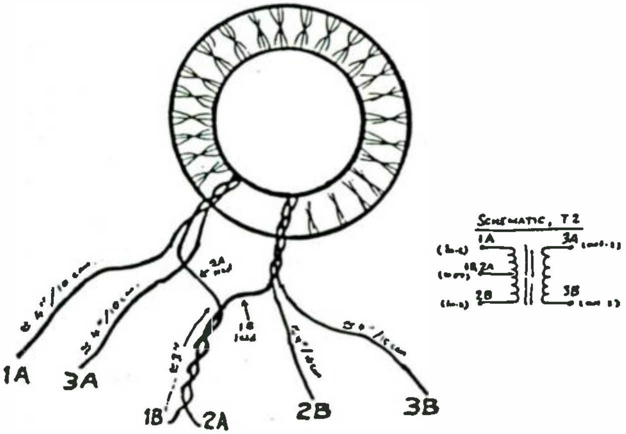
**Figure 4**

```
1A ------------------------------------- 1B
2A ------------------------------------- 2B
3A ------------------------------------- 3B
```

Tape the 3 leads together, 10cm./4" from the 1B/2B/3B ends. Insert this taped section into a bench vise. Tape the 1A/2A/3A ends to the blade of a large screwdriver. Stretch the wires straight & taut, then turn the screwdriver slowly & steadily to twist the leads. Wind 25 turns of twisted triple wire onto a J.W. Miller T-106-2 (or F-87-1 or F-125-1) toroidal core. Untwist the leads between ends 1A/2A/3A and the core. Move the three labels (1A,2A,3A) in towards the core along their respective leads such that each label is 4"/10cm. from the core. Cut off wires greater than 4" from the core. Release the 1B/2B/3B ends from the bench vise. Twist the 2A lead and the 1B lead together. Leave labels on all leads for now. The T2 assembly should resemble Figure 5.

Drip candle wax over final T2 coil assembly.

Figure 5 T2, Balun




Completed T1 & T2 assemblies may now be set aside until they are required later.

2. Preliminary Vectorboard drilling

Observe the drilling master, Figure 6. The .062" diameter holes on the Vectorboard are arranged in an 84 column by 47 row array. Consider the left-most, or first, column on the board to be Column #0 (zero). The right-most, or last, column will be considered Column #83. Similarly, the top, or first, row is Row #0 and the bottom, or last, row is Row #46. The distance between any two adjacent columns is 0.1"; the distance between any two adjacent rows is also 0.1". There is 0.1" of board material between the edges of the board an closest end row or column.

Use a felt-tipped marker to make vertical lines on the Vectorboard at columns 0, 10, 20, 30, 40, 50, 60, 70, 80, & 83. Make horizontal lines at rows 0, 10, 20, 30, 40, & 46. These lines will aid in locating holes to be drilled. Note that all holes on the drilling master are specified by two numbers in parentheses: (column # first, row # second). Mark the five 'A' series holes shown on Figure 6. Locations are (2,44); (8,13); 42,18); (73,1); and (73,44). Drill these out, using one of the bits prescribed in the table accompanying the drilling master.

The Vectorboard with the 5 A-series holes will now be used as a template to prepare the ground plate. Other holes shown in Figure 6 will be drilled later, after the ground plate has been completed.

Figure 6 located on the next page.

3. Ground Plate (LMB 8 x 10 Cap Cover or equivalent)

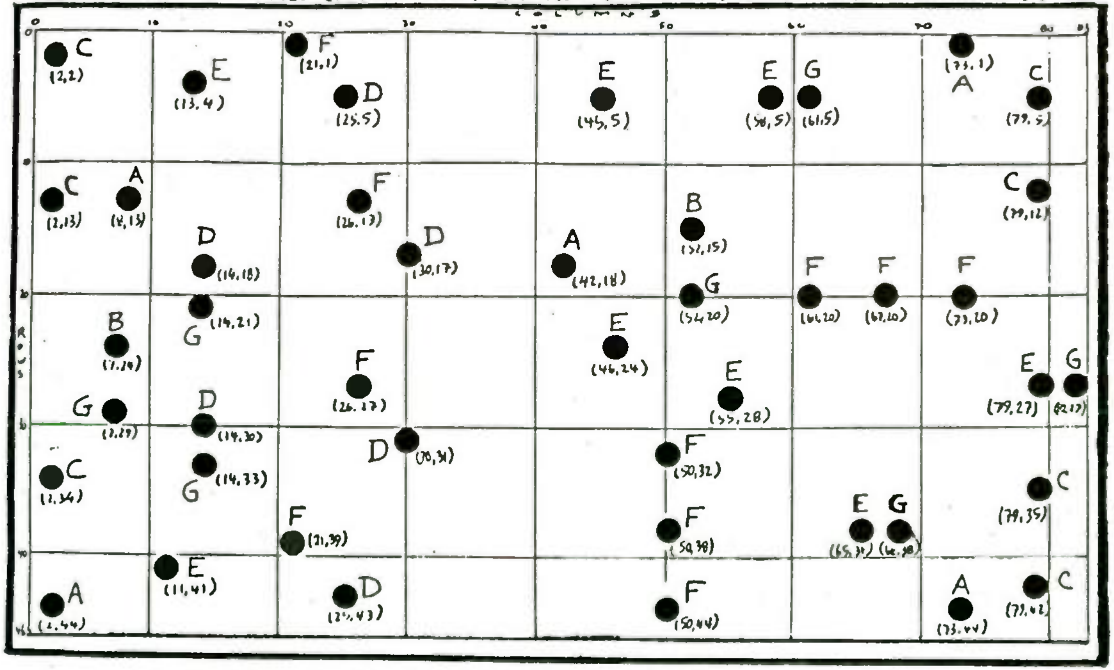
The ground plate is an 8" x 10" (20.32 cm. x 25.4 cm.) bare metal sheet of approximately 0.05" to 0.1" thickness. This will eventually be attached 1 1/4" behind the circuit board by means of hardware assemblies H1 through H5. The ground plate serves 3 purposes:

(1) to make a mechanically stable assembly
(2) to protect the components & the wiring to be built onto the backside of the Vectorboard
(3) to reduce the effect of hand capacitance on tuning & nulling.

To prepare the ground plate, place the Vectorboard over the 8 x 10" metal plate. The LMB plate has an edge lip projecting 1/4" perpendicular to the surface on one side. Consider the side with the lip to be the front side of the ground plate. The Vectorboard (with only 'A' series holes drilled) is centered over the front side of the ground plate, in accordance with Figure 7.

## FIGURE 6: DRILLING MASTER

OVERALL BOARD DIMENSIONS: 8.5"/21.59 CM. WIDE BY 4.8"/12.19 CM. HIGH. VECTORBOARD HAS 3948 HOLES (EACH OF .062" DIA.) ARRANGED IN 84 COLUMNS (NUMBERED 0 TO 83 ON THIS DRAWING) AND 47 ROWS (NUMBERED 0 TO 46). DISTANCE BETWEEN ADJACENT COLUMNS = 0.1", DISTANCE BETWEEN ADJACENT ROWS = 0.1". LOCATIONS OF HOLES TO BE DRILLED ARE SPECIFIED (IN PARENTHESES) BY ROW (FIRST NUMBER) & COLUMN (SECOND NUMBER).



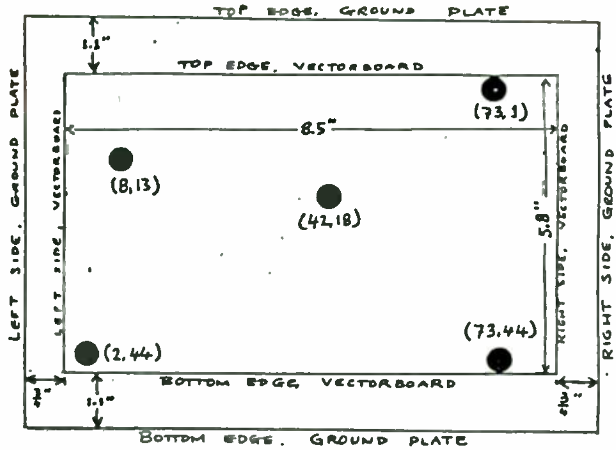

DRILL 'A' SERIES HOLES (5 TOTAL) FIRST; THESE ARE ALSO TO BE DRILLED ON GROUND PLATE.

LETTER (A THROUGH G) INDICATES DRILLING SEQUENCE — "A" FIRST, "G" LAST.

### DRILL BIT CHART

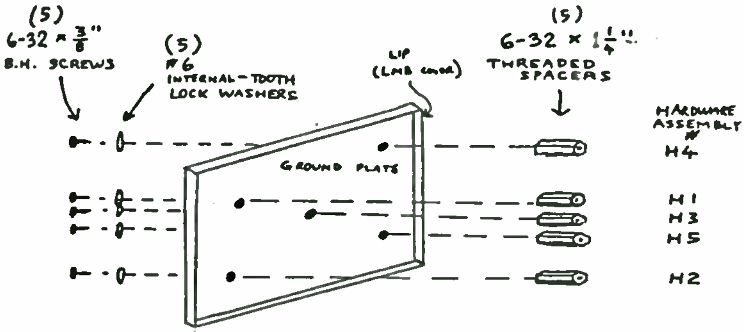
| LETTER ON DRAWING | DRILL BIT SIZE | NO. OF HOLES |
|---|---|---|
| A | $\frac{9}{64}$ (.1406") or #28 (.1405") or 3.6 MM | 5 |
| B | $\frac{11}{32}$ (.3438") or #S (.348") or 8.75 MM | 2 |
| C | $\frac{5}{16}$ (.3125") or #0 (.3160") or 8.0 MM | 7 |
| D | $\frac{9}{32}$ (.2812") or #K (.2810") or 7.2 MM | 6 |
| E | $\frac{1}{4}$/#E (.250") or 6.4 MM | 8 |
| F | $\frac{1}{8}$ (.1250") or #30 (.1285") or 3.2 MM | 10 |
| G | $\frac{7}{64}$ (.1094") or #35 (.1100") or 2.8 MM | 7 |

**Figure 7:**




Hold the Vectorboard in place with Scotch tape. Use a pencil to mark the 5 A-series holes onto the ground plate. Then, remove the Vectorboard. Drill the 5 pencil-marked points on the ground plate: use the same drill bit as that which was used to drill the A-series holes on the Vectorboard. Using the holes just drilled, mount five 6-32 x 1 1/4" threaded metal spacers on the <u>front</u> of the plate, with 6-32 x 3/8" metal screws & #6 lockwashers on the back, as shown in Figure 8.

**Figure 8**




4. <u>Support Leg Assembly</u> (Optional)

Drill 2 holes in the ground plate, each 4" from the top & bottom edges. One hole is to be 2 1/2" from the left side, the other should be 2 1/2" from the right side. Refer to Figure 9A. Start with two 4 1/2" long, 3/4" diameter solid cylindrical dowels, preferably metal. In the center of one end of each dowel drill a small pilot hole no more than 1/4" deep (drill bit size same as that used for A-series board holes). Insert a 6-32 tapper into each pilot hole to produce 6-32 threaded holes at least 1/2" deep. At the end of each dowel opposite to that which was tapped, mark a point 3 5/8" from the tapped end. On the exact opposite <u>side</u> (180 degrees around) from the point just marked, mark a point 4-3/8" from the tapped end. Stretch a thin string around the untapped end of each dowel, so that both of the marked points are on the string. Use a pencil to scribe a line around the dowel connecting the points, by following the string. Use a hacksaw or jigsaw to cut each dowel along the lines just drawn. Mount the legs on the <u>back</u> of the ground plate using 6-32 x 3/8" screws & #6 lockwashers on the <u>front</u>. Each of the two legs should appear as in Figure 9B.

**Figure 9A**
**View from Front**

**Ground plate support leg holes**

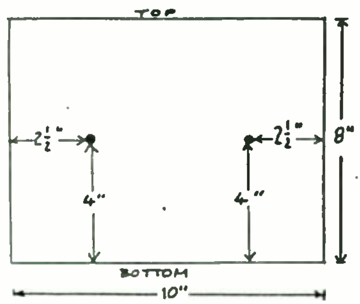
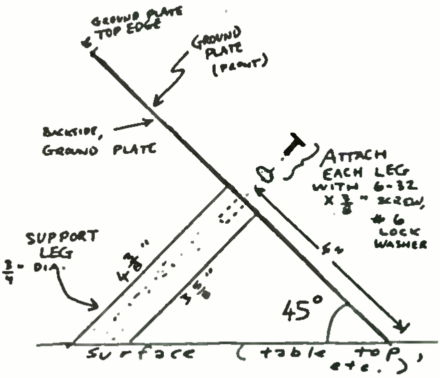



**Figure 9B**
**View from Left Side**




**Drawings not to Same Scale**

At this time, set aside the ground plate with attached legs & standoff spacers. It will be needed later.

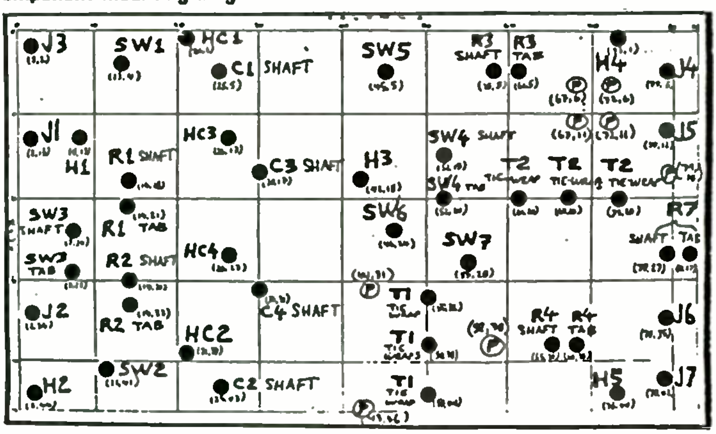
5. Final Vectorboard Drilling

Observe Figure 6, the drilling master. Use a felt-tipped marker or pencil to mark all B-series holes on the Vectorboard. Drill B-series holes with one of the prescribed bits listed in the table on Figure 6. Mark, then drill, C-series holes with an appropriate bit. Mark, then drill, D-series holes. Mark, then drill, E-series holes. Mark, then drill, F-series holes. Mark, then drill, G-series holes. This completes all of the necessary drilling.

6. Mounting Components on Vectorboard

Throughout the following component-loading sequence, it will be necessary to refer repeatedly to the component-location front-of-board "roadmap" drawing (Figure 10) and to the parts list (Table 1, beginning of article).

**Figure 10 Component mounting diagram**



From the front side of the board, load a 4-40 x 3/8" nylon screw into each of the "HC" holes: HC1 (21,1); HC2 (21,39); HC3 (26,13); & HC4 (26,27). On the back of the board, attach & tighten a nylon 4-40 hexnut to each of these 4 screws.

Remove tuning knobs, manufacturer-supplied solder lugs, and nuts from the C1, C2, C3, & C4 shafts at this time. Load the four variable capacitors from the back of the board. Shafts should go into the holes specified by Figure 10. The small mounting holes on the capacitor bodies should go over the protruding nylon screws on the back of the board. Attach a 4-40 nylon nut to each of the nylon screws to hold the capacitors in place. There should now be 2 nylon nuts on each 4-40 screw. Place a manufacturer-supplied internal-tooth solder lug over each of the threaded sections of the capacitor shafts on the front of the board. Attach, then tighten, the metal nuts supplied with each capacitor, over each of the shaft solder lugs. Do not attach the capacitor tuning knobs at this time. Strip a piece of #22 hookup wire to produce four bare lengths, each about 3"/7.6 cm. long. Save the stripped-off insulation for possible later use.

Solder one end of one bare wire to each variable capacitor shaft solder lug (front of board). Push these wires through convenient Vectorboard holes to the back side. Locate the rotor lug on the back of each capacitor: this lug should measure zero ohms to the wire just soldered to the corresponding shaft lug. The stator lug, the other lug on the back of the capacitor, should measure nearly infinite resistance to the shaft lug wire. After establishing which lugs are rotor lugs, fish each bare wire through the small hole in its corresponding rotor lug. At each rotor lug, solder the wire just attached. Cut off excessive length. The rotor lug to shaft lug connections are necessary because the rotor lug makes a rather tentative connection to the rotor, one which tends to deteriorate with frequent capacitor adjustment and with age. The rotor makes a much better connection to the shaft lug. At this time, the tuning knobs may be installed on the capacitors by using the manufacturer-supplied hardware.

Load the seven banana jacks with manufacturer-supplied hardware - jack openings on the front of the board, solder pins on the back: these are J1 (2,13); J2 (2,34); J3 (2,2); J4 (79,5); J5 (79,12); J6(79,35); & J7 (79,42). Load the rotary switches and potentiometers, observing proper shaft and tab locations. Nuts & lockwashers supplied with these parts are to be used to secure the parts to the front of the Vectorboard. Shafts should protrude out of the front of the board at the following locations: SW3 (7,24); SW4 (52,15); R1 (14,18); R2 (14,30); R3 (58,5); R4 (65,38); & R7 (79,27). After these pots & rotary switches are firmly mounted, knobs may be attached to their shafts. Use a hacksaw to remove excessive shaft length. SW3 & SW4 get single-line knobs; R1, R2, R3, R4, & R7 get calibrated knobs.

With a push-pin insertion tool, insert Keystone 1499PK or Vector T28-DP push-pins at points designated P on Figure 10. These are loaded from the front of the board at locations (44,31); (43,46); (58,38); (67,6); (67,11); (72,6); (72,11); & (79,18). These will eventually be used as tie points for toroidal transformer leads.

Load the toggle switches with manufacturer-supplied nuts & lockwashers. Electrical connection blocks are to be on the back of the board, switch levers on the front of the board. Levers should go up & down, not right to left. The toggle switches of concern and their respective locations are SW1 (13,4); SW2 (11,41); SW5 (45,5); SW6 (46,24); & SW7 (55,28). Ensure, by checking parts list, that proper switch types have been installed at each of the 5 locations. Put a few drops of rubber cement or glue over nuts to improve mechanical stability.

Place T1 on the front of the Vectorboard such that the T1 center-hole (50,38) is exactly in the center of the toroid's "doughnut hole". From the front of the board, insert two tie-wraps through that center-hole. Run the end of one of the tie-wraps along the back of the board to the T1 top hole (50,32). Fish it through that hole back to the front of the board and pull it through the eyelet on the opposite end of the same tie-wrap until the tie-wrap holds T1 tightly to the board. Similarly, route the other tie-wrap from the front of the board through the T1 center-hole (50,38), along the back of the board to the T1 bottom hole (50,44), back to the front, & through the eyelet on that tie-wrap's opposite end. Pull the tie-wrap tight: it will hold the side of T1 opposite to that held by the first tie-wrap. Cut off excessive tie-wrap portions protruding beyond the eyelets.

Place T2 on the front of the board by positioning the center of its "doughnut hole" over the T2 center-hole (67,20). Affix T2 to the board using 2 tie-wraps in the same manner as undertaken to attach T1. One T2 tie-wrap goes through the T2 left hole (61,20); one goes through the T2 right hole (73,20);

the ends of both are brought through the center hole at (67,20).

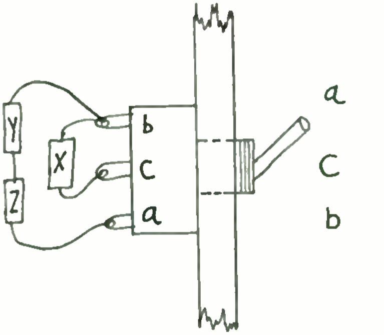
This completes the mounting of all front-side components. Screws & miscellaneous hardware are to go in the H1, H2, H3, H4, & H5 holes at a later step in the procedure. Mounting of additional back-side components C5, C6, L1x, L1y, L1z, L2x, L2y, L2z, R5, & R6 will be done as a preliminary part of the wiring section.

Turn the board to the back side while keeping the same vertical orientation (e.g. T1 at bottom, J3 at top).

7. Wiring (back side of board)

Assemble the two inductance switches, SW1 & SW2 with appropriate inductors as in Figure 11.

**Figure 11** Installation of L1x/L1y/L1z on SW1; L2x/L2y/L2z on SW2




<------- Back Board Front ------>

| Assembly Drawing Designation | Inductor Value/Designation (uH.) | (SW1) | (SW2) |
|---|---|---|---|
| x | 470 | L1x | L2x |
| y | 270 | L1y | L2y |
| z | 120 | L1z | L2z |

Solder all leads to switch pins indicated. Solder the junction of L1y and L1z and that of L2y and L2z. Ensure that none of the exposed leads can be pushed into a position which could cause an undesired shorted connection.

Located pots R3 and R4. On each pot, ascertain which two terminals are those to be used: do this by checking for zero ohms on a volt-ohmmeter with that pot turned fully counter-clockwise (as observed from the front of the board) and by checking for appoximately 1K with that pot turned totally clockwise. Place a 1000 ohm fixed resistor (R6) across the two terminals to be used on R4. Solder these in place after slipping plastic insulation over the leads (or after making leads sufficiently short to prevent adjacent undesired connections). cut off excessive fixed resistor leads.

On the back side of the board, connect a 47pF mica capacitor (C5) from the stator lug of C1 to that of C3. Connect a 47pF mica capacitor (C6) from the stator of C2 to that of C4. Put plastic insulation stripped from hookup wire over any mica capacitor lead greater than 1/4" long.

Ascertain which two terminals of R1 are tob e used: the resistance between the correct terminals should nbe zero ohms with the pot adjusted fully counterclockwise as observed from the front; the resistance should be about 100K with the pot fully clockwise. Determine the two terminals of R2 to be used by the same method. Establish which two terminals on R5 are to be used: resistance between the proper terminals should be zero ohms with its knob adjusted fully counterclockwise as viewed from the front; the resistance becomes 1K with the knob set fully clockwise.

Use the wiring run list (Table 3), the schematic (Figure 1), and the backside wiring drawings (Figures 12A & 12B) to wire the components together, using #22 insulated hookup wire of the shortest length consistent with neat layout & ease of servicing. Ends to be connected should have about 3/16" of insulation stripped away. Good solder joints should be made at every connection point.

If different colors of wire are available, a coding scheme may be useful for later troubleshooting - e.g. wire runs 1 to 5 black, 6 to 10 brown, 11 to 15 red, 16 to 20 orange, 21 to 25 yellow, 26 to 30 green, 31 to 35 blue, 36 to 40 violet, and 41 to 46 grey.

Table 3: Wiring Runs (number given corresponds to sequence of installation)

## INPUT SECTION

| # | FROM | TO |
|---|---|---|
| 1 | J1 | R1 in |
| 2 | R1 out | arm, SW3a |
| 3 | 1, SW3a | 3 (null), SW3a |
| 4 | 1, SW3a | c (arm, center), SW1 |
| 5 | c (arm, center), SW1 | top (par.), SW5a |
| 6 | jct. L1y/L1z | C1 rotor |
| 7 | C1 rotor | C3 rotor |
| 8 | C1 rotor | top (par.), SW5b |
| 9 | C1 stator, jct. C5 | arm/center, SW5a |
| 10 | arm/center,SW5a | bottom (ser.), SW5b |
| 11 | J3 | 4 (dir.), SW3a |
| 12 | 4 (dir.), SW3a | 4 (dir.), SW3b |
| 13 | J2 | R2 in |
| 14 | R2 out | arm, SW3b |
| 15 | 2, SW3b | 3 (null), SW3b |
| 16 | 2, SW3b | c (arm, center), SW2 |
| 17 | c (arm, center), SW2 | top (par.), SW6a |
| 18 | jct. L2y/L2z | C2 rotor |
| 19 | C2 rotor | C4 rotor |
| 20 | C4 rotor | top (par.), SW6b |
| 21 | C2 stator, jct. C6 | arm/center, SW6a |
| 22 | arm/center, SW6a | bottom (ser.), SW6b |

## OUTPUT SECTION

| | | |
|---|---|---|
| 23 | arm/center, SW5b | R3 in, jct. R5 |
| 24 | R3 out, jct. R5 | arm, SW4a |
| 25 | 1 (bal.), SW4a | 3 (unbal.-2), SW4a |
| 26 | 1 (bal.), SW4a | push-pin (67,11) |
| 27 | 1 (bal.), SW4b | 3 (unbal.-2), SW4b |
| 28 | 1 (bal.), SW4b | push-pin (72,11) |
| 29 | 2 (unbal.-1), SW4a | 2 (unbal.-1), SW4b |
| 30 | 2 (unbal.-1), SW4b | 3 (unbal.-2), SW4c |
| 31 | arm/center, SW6b | R4 in, jct. R6 |
| 32 | R4 out, jct. R6 | arm/center, SW7a |
| 33 | top (null b), SW7a | push-pin (44,31) |
| 34 | push-pin (58,38) | J7 |
| 35 | arm/center, SW7b | push-pin (43,46) |
| 36 | bottom (null a), SW7a | top (null b), SW7b |
| 37 | bottom (null a), SW7a | arm, SW4b |
| 38 | J6 | 3 (unbal.-2), SW4c |
| 39 | arm SW4c | push-pin (67,6) |
| 40 | arm SW4d | push-pin (72,6) |
| 41 | 3 (unbal-2), SW4d | J7 |
| 42 | J4 | 1 (bal.), SW4c |
| 43 | J5 | 1 (bal.), SW4d |
| 44 | R7 in | push-pin (79,18) |
| 45 | R7 out | J7 |

The final backside wire to be attached is wire-run #46. This consists of a 1 1/2" lead with one end soldered to J7. The other end should be soldered to a #6 internal-tooth solder lug. The lug will be attached to hardware assembly H5 at hole (73,44) later.

**Figure 12A: Input Section Wiring**

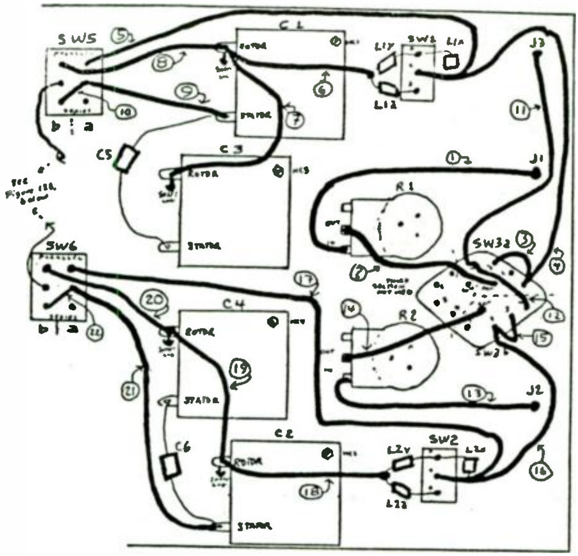
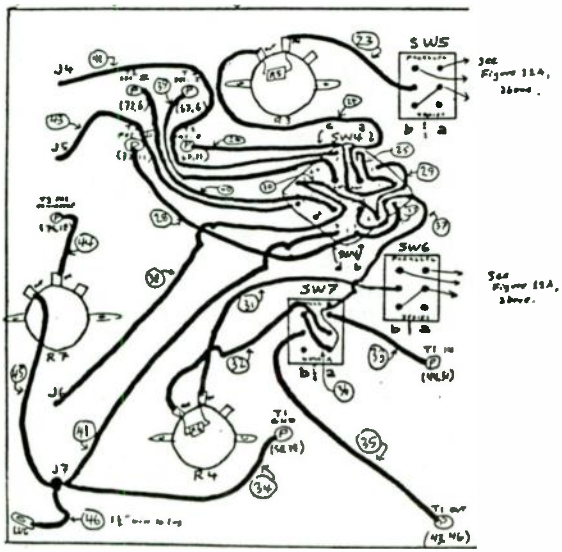


**Figure 12B: Output Section Wiring**



After the 46 wiring runs have been completed, the T1 & T2 leads may be connected on the front of the board to the push-pins to which leads have already been affixed on the back of the board.

These are connected in accordance with Table 4.

Table 4: Connections between push-pins (front side) and T1/T2 leads



| Toroidal Transformer | Lead Name | Lead(s) * Figures 3 & 5 | To push-pin at Hole * |
|---|---|---|---|
| T1 | in | A1 | (44,31) |
| T1 | ground | A2 & B1 | (58,38) |
| T1 | out | B2 | (43,46) |
| T2 | primary-I (in-I) | 1A | (67,11) |
| T2 | primary-II (in-II) | 2B | (72,11) |
| T2 | primary center tap | 1B & 2A | (79,18) |
| T2 | secondary-I (out-I) | 3A | (67,6) |
| T2 | secondary-II (out-II) | 3B | (72,6) |

Cut leads to proper length, consistent with a neat layout and short runs. Strip about 1/4 inch (maximum) of enamel varnish from lead ends and solder bared toroid lead ends to the appropriate Table 4 push pins. Soldering should be done quickly so as not to loosen the push pin leads which were connected on the back of the board. This completes phasing unit wiring.

8. Inspection of wiring, checking switches, etc.

Reference actual physical assembly to appropriate drawings. Visually inspect each component to ensure correctness of assembly. Check wiring runs visually and with an ohmmeter. Verify proper potentiometer and switch connections with an ohmmeter. Ensure that there are no unwanted connections (such as two adjacent pins on a switch accidentally touching). Flux may be cleaned from solder joints with alcohol and a cotton swab or with a commercial defluxer.

9. Final Mechanical Assembly

Refer to Figures 7/10 for hardware assembly hole locations. From the front of the Vectorboard, load a 6-32 X 3/8" metal screw with a #6 internal tooth lockwasher on it through each of the following holes: H1 (8,13); H2(2,44); H3(42,18); and H4 (73,1). Place the #6 internal tooth solder lug, attached by wire run #46 to J7, over the end of a 6-32 X 3/8" metal screw. From the front of the Vectorboard, load this screw with attached lug to the H5 hole (73,44). Place the back of the Vectorboard upon the spacers on the front of the ground plate so that each of the 5 screws protruding from the back of the Vectorboard may be screwed into its corresponding ground plate spacer. Turn all screws such that tight fits are made with the spacers.

**PHASING UNIT IS NOW COMPLETED!!!**

10. Connect Phasing Unit to Receiver, Antennae

The following discussion applies to use of the phasing unit in a "stand alone", or unamplified, configuration. Solder banana plugs to the input leads of two longwire aerials, preferably of similar length. Each wire should be at least 30m./98' long for optimal performance. Nulls can be produced with shorter wires, but signal strengths of wanted stations tend to be quite low by the time pest nulling is completed, if the phasing unit output is not amplified. Plug one longwire into J1; the other into J2.

If a receiver with unbalanced (single ended) input is to be used, run an approximate 1m./3.3' length of coaxial cable (RG-174) from J6 (center, or 'hot' conductor) and J7 (shield/ground/outer conductor) to the receiver input and to receiver ground. The coaxial cable to be used should be fitted with banana plugs on the end attached to the phasing unit and with the appropriate receiver input connector(s) at the opposite end.

If a receiver with balanced (dual) inputs is to be used, run about 1m./3.3' of TV Twinlead or "AC zip cord" from J4 and J5 of the phasing unit to the appropriate balanced inputs of the receiver. The phasing unit end of the cable should be fitted with banana plugs; the other end should have the proper receiver input connector(s). If the balanced cable is used, a wire tying phasing unit ground to receiver ground is also necessary. Once all connections have been made to finish phasing unit, interesting DX should now be possible.

## USING THE PHASING UNIT

This section describes the manipulation of phasing unit controls necessary to produce nulls of dominant 'pest' stations, allowing weaker co-channel or adjacent-channel stations to be heard. A station to be nulled can be in the exact opposite direction from a desired signal; this is the situation frequently encountered in TA DX situations. A loop is generally incapable of nulling a station to the southwest for instance, without simultaneously killing signals from the northeast. From the Boston/Cape Cod region, a loop can handily dump WBAL-1090 to the southwest to allow southeastern signals from YVSZ and HJBC through. To get BBC-1089 however, from the northeast, phased longwires will outperform the loop after WBAL is nulled. This article will briefly outline some phasing techniques to get the user started; each DXer will then evolve personal techniques best suited to a particular antenna/receiver/type of DX combination.

As nulling is discussed, the reader is advised to refer to Table 2, the list of adjustable controls (at the beginning of this article).

After the DXer has properly connected two longwire aerials to the phasing unit input and has made the necessary phasing unit to receiver connections, nulling may commence. The following procedure is just one of several possible nulling schemes.

1. Set balanced/unbalanced output switch (SW4) to <u>balanced</u> if receiver has balanced dual inputs, or to <u>unbalance-2</u> if receiver has single ended, unbalanced input. The unbal-1 position may work better for shorter wires on some receivers, notably the TRF; but all <u>initial</u> unbalanced nulling should be done in the unbal-2 condition. This is because unbal-2 condition, using the balun, provides greater isolation between inputs and outputs, hence less stray coupling and greater tuning accuracy. Switching to unbal-1 should be done towards the end of the procedure.

2. Null switch to null mode b. This includes the phase reverser (T1) in the Antenna 2 line.

3. "Peak #1 LC" subroutine

   a. **Antenna switch** to Ant. #1
   b. **#1 main pot** and **#1 trim pot** to zero ohms (fully counterclockwise).
   c. **#1 trim cap.** to center (halfway between fully meshed plates and fully open plates).
   d. Sweep the **#1 main cap.** through its range on each of the following LC#1 module modes:

| LC module mode | #1 L switch | #1 LC switch |
|---|---|---|
| 1 | a, 103 uH | parallel LC |
| 2 | b, 270 uH | parallel LC |
| 3 | c, 740 uH | parallel LC |
| 4 | a, 103 uH | series LC |
| 5 | b, 270 uH | series LC |
| 6 | c, 740 uH | series LC |

When the sharpest, highest gain peak in signal level is found, leave the #1 L and LC switches and the #1 main tuning cap. in the positions which produced that peak.

4. "Peak #2 LC" subroutine

   a. **Antenna switch** to Ant. 2
   b. **#2 main pot** and **#2 trim pot** to zero ohms
   c. **#2 trim cap** to center (halfway between fully meshed plates and fully open plates)
   d. Play the **#2 main cap.**, the **#2 L switch**, and the **#2 LC switch** to open a distinct, good peak signal, in the same fashion as that of step d of the "Peak #1LC" subroutine. The #2 L and LC switches can initially be set at the positions corresponding to those of the #1 switches; if the longwires are electrically similar, the positions of controls yielding a peak on the #2 line will be very similar to the positions of the #1 line LC controls yielding a peak on the #1 line.

5. Switch the **Antenna switch** between Ant. 1 and Ant. 2 repeatedly and note which antenna line is producing the stronger unwanted station signal.

6. **Antenna switch** to null.

7. Adjust the **main pot** on the line which had yielded the stronger signal in step 5. A "**dip**", defined as a point within the moving range of a control (not at an end setting) at which a readily perceptibly minimum signal occurs with greater level as the control is adjusted either clockwise or counterclockwise from that point, should occur. If there is no well defined dip, return that pot. to zero ohms.

8. Carefully off tune the **main tune cap**. on the line which had produced the greater level in Step 5. If a dip occurs, leave that cap. at the dip-yielding setting. Improve the null be tweaking the #1 and #2 trim caps, and the #1 and #2 trim pots. The **ground pot** may also have a favorable effect on obtaining some nulls. If the unbal-2 SW4 position was used up to this point and the desired station left after nulling seems too weak, switch to unbal-1. After a slight retweaking of trim caps and trim pots, a null of the pest giving a greater wanted station level may occur in some circumstances.

Nulls should be obtainable in about 4 out of 5 stations, using the method above. In cases where sufficient cancellation of an unwanted station does not occur, the above procedure can be reiterated with the null switch on **null mode a**. That should assist in obtaining more of the desired nulls. Some nulls may be impossible with a particular pair of wires. It is strongly suggested that the DXer have 3 longwires, each separated by a horizontal angle of 120°. In the New England region, longwires aimed at 50° for TA DX, 170° for LA DX, and 290° as a pest station aerial should work will. TA DX is best heard by using the phasing unit to subtract the rest signals arriving best on the 290° longwire against desired stations on the longwire aimed 50°. LADX is best heard by subtracting the 290° wire pest signals from the desired signals heard best on the wire pointed at a bearing of 170°. The concept of phasing wires running in different directions seems to work better than the parallel wire concept when the wires are shorter than 152m./500'. There are many different antenna pairs which may be presented to the input of the phasing unit, each with unique properties; examples include 2 parallel longwires, 2 longwires running in opposite directions, 2 longwires separated by a 90° horizontal angle, one horizontal longwire vs. a vertical longwire, a horizontal longwire high above the ground via a horizontal longwire lying on the ground in either the same or in a different direction from the high wire, or two phased verticals.

A future article on Amplified Phased Shortwires will address some of the null producing possibilities of various wire combinations as well as dealing with the "LSCA" concept of working a loop against a longwire (or shortwire) to obtain single direction nulls. Additional phasing unit control manipulation procedures will also be explored.

It is sincerely hoped that this construction article will stimulate others to experiment with phased wire systems and to come forth with both technical articles and analyses of DX loggings obtained through use of phasing units.

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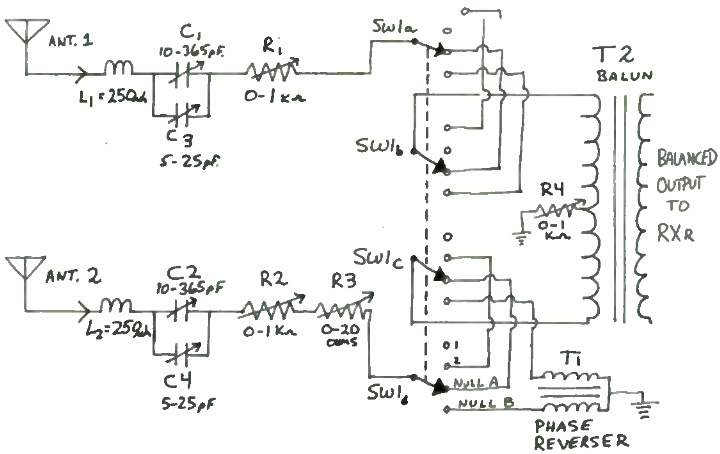
# PHASING UNIT DESIGN MODIFICATIONS

by Mark Connelly, WA1ION

This article is presented for two purposes: (1) to improve upon existing designs of phasing units presently in use by several active international DXers. (2) to serve as a prelude to an upcoming phasing unit construction article. The construction article to be released soon will also deal with a new concept: Amplified Phased Shortwires.

DXers who have used phasing units in recent years include Chuck Hutton, Nick Hall-Patch, Bill Bailey, Neil Kazaross, Gordon Nelson, and Mark Connelly. Most of the units in use have a schematic similar to that of Figure 1.

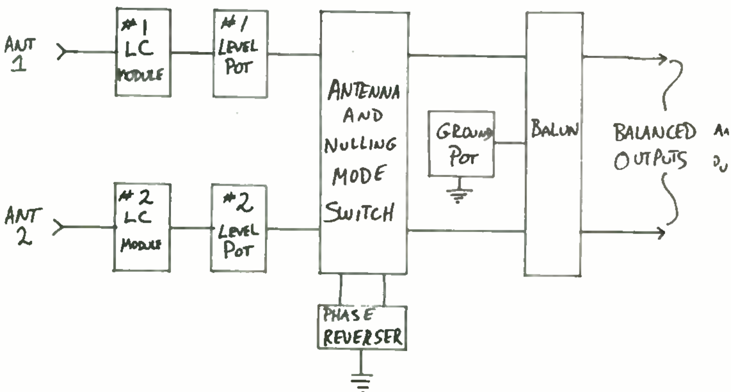
**Figure 1 a conventional phasing unit**




The phase reversing transformer and the balun are wound on toroidal cores such as J.W. Miller #F-125-1 or T-106-2.

Coil windings will be supplied in a subsequent construction article.

**Figure 2 Block diagram of conventional phasing unit**



Nulling (using the unit of Figures 1 & 2) is accomplished by the following procedure: 1. initialize by setting all pots to zero ohms. 2. with antenna 1 switched in, peak the antenna 1 main tuning capacitor, C1, for maximum composite signal on the frequency of interest. 3. with antenna 2 switched in, peak the antenna 2 main tuning capacitor, C2, for maximum composite signal. 4. switch between antenna 1 and antenna 2; note which switch position produces the strongest level of the undesired (interfering) station. 5. switch to "null a" mode. 6. adjust the series potentiometer on the line which had produced the stronger "pest station" signal. 7. if a dip, or point on the pot where a distinct drop in signal occurs with a rise in level on either side of that point, is attainable, set the pot at that dip point and finely tune the main and vernier capacitors (C1, C2, C3, C4) and the ground resistor R4 for further dipping until the best null is achieved. 8. if satisfactory nulling could not be obtained in steps 6 and 7, reiterate steps 1 through 4 and then switch to "null B" redo steps 6 and 7 (in "null B" mode).

**Some shortcomings of conventional phasing unit design**

(a) The series L-C " modules" each consisting of a 250 uH inductor in series with the parallel main (10-365 pf.) and trim (5-25 pf.) capacitors seem inadequate to peak tune wires with lengths less than 30 meters. This problem is most acute on the lower frequencies, 520-900 kHz.

A two pronged approach to this problem turned out to be most advantageous. The first step is to make a switchable 3-value inductance unit for each antenna line. Three inductors and a SPDT (center open position) switch are used in each of the two L-units.

Figure 3 three value inductance unit

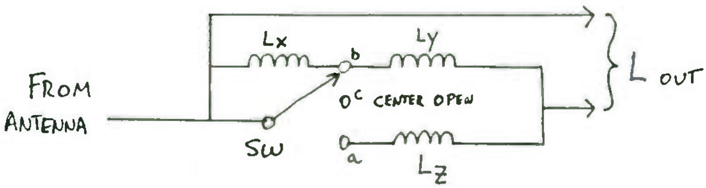



Table 1 L out values*Y

Nytronics "Wee" inductors used

| L values, uH | | | L out, uH | | |
|---|---|---|---|---|---|
| | | | switch pos.: a | b | c |
| Lx | Ly | Lz | Lz (Lx+Ly) | Ly | Lx+Ly |
| 390 | 220 | 100 | 86 | 220 | 610 |
| 470 | 270 | 120 | 103 | 270 | 740 |
| 560 | 270 | 120 | 105 | 270 | 830 |

J.W. Miller video-peaking type inductors used

| L values, uH | | | L out, uH | | |
|---|---|---|---|---|---|
| | | | switch pos.: a | b | c |
| Lx | Ly | Lz | Lz (lx+Ly) | Ly | Lx+Ly |
| 420 | 200 | 100 | 86 | 200 | 620 |
| 470 | 250 | 120 | 103 | 250 | 720 |
| 550 | 275 | 120 | 105 | 275 | 825 |

J.W. Miller Part #'s

| L, uH | # |
|---|---|
| 100 | 6112 |
| 120 | 6153 |
| 200 | 6154 |
| 250 | 6173 |
| 275 | 6130 |
| 420 | 6136 |
| 470 | 6138 |
| 550 | 6144 |

The Q of the coils listed in Table 1 is somewhat below that of the shielded can-type antenna coils used by Gordon Nelson and Chuck Hutton, but only a very slight decrease in tuning sharpness and signal transfer occurs. The small size job the coils used makes them ideal to be connected in a switch multiple L-value arrangement. The phasing unit's tuning range is extended considerably by this scheme.

The author recommends that two separate SPDT switches for each antenna line L-unit should be utilized. If a DPDT switch were used to switch the inductance in the Antenna 1 leg and that in the Antenna 2 leg simutaneously, stray coupling from the Antenna 1 coils to those for Antenna 2 (and vice versa) could occur. The Antenna 1 L-unit should be located at least 10 cm./4" from the Antenna 2 L-unit.

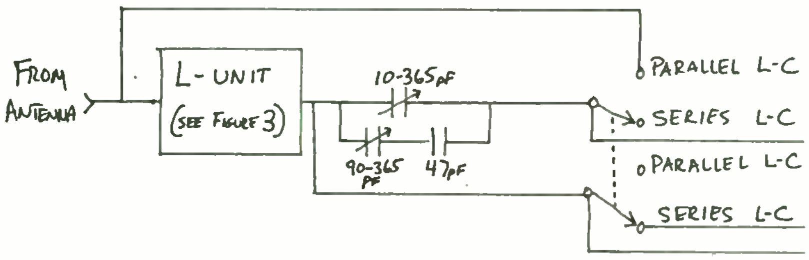
The switchable inductance scheme has indeed extended the usefulness of the phasing unit in working with wires shorter than those commonly phased.

The second concept applied to extend the tuning capabilities further is the ability to switch between series L-C (as in the conventional phasing unit of Figure 1) and parallel L-C. Parallel L-C tuning seems to work will with shortwires, esp. in the lower half of the band.

We shall incorporate the inductance-unit and switchable series/parallel L-C concepts in a subsection of the phasing unit to be referred to hereafter as the "LC Module". Each antenna line has an LC module: the Antenna 1 LC module should be isolated from the Antenna 2 LC module by at least 10 cm. to prevent stray coupling or 'crosstalk'.

Figure 4 Schematic of LC module (2 per phasing unit)

Figure 4 Schematic of LC module (2 per phasing unit)




(b) The 10-365 pf. capacitors used are the cheap miniature variety (e.g. Calectro/ GC Electronics # A1-232, priced at about $2.70 each). The trim capacitor section, 10-365 pf. in series with 47 pf., is effectively a 8-42 pf. trimmer. The expensive air variable capacitors used in previous phasing units can be dispensed with.

Even before switching to null, it is noticed that tweaking the controls for Antenna 2 effect the Antenna 1 control settings (and vice versa).

This indicates inadequate isolation within the phasing unit. Stray capacitance between the LC modules, between wires on the mode switch, and directly from the antenna to the output of the phasing unit may be the contributing factor.

Reconfiguring the antenna-line (mode) switch such that antennae are connected or disconnected directly at their inputs is the logical way to attack this problem. As a side benefit, this eliminates the need for the clumsy, expensive 4-pole 4-position switch used in previous phasers. That "kluge" is replaced by a 2-pole 3-position switch and a DPDT toggle switch (see Figure 5). The Antenna 2 line can be peaked with the phase-reverser in line if desired (null mode b): any peak-skewing effects of the phase-reverser can thereby be compensated out prior to the initiation of the actual nulling sequence.

Figure 5 Antenna mode/null mode switching to improve isolation/reduce crosstalk

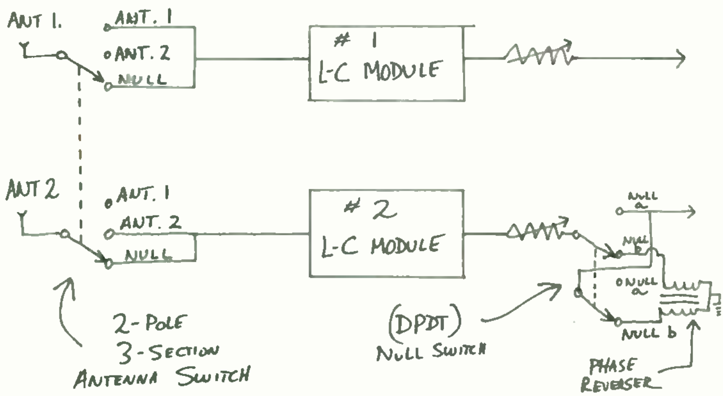
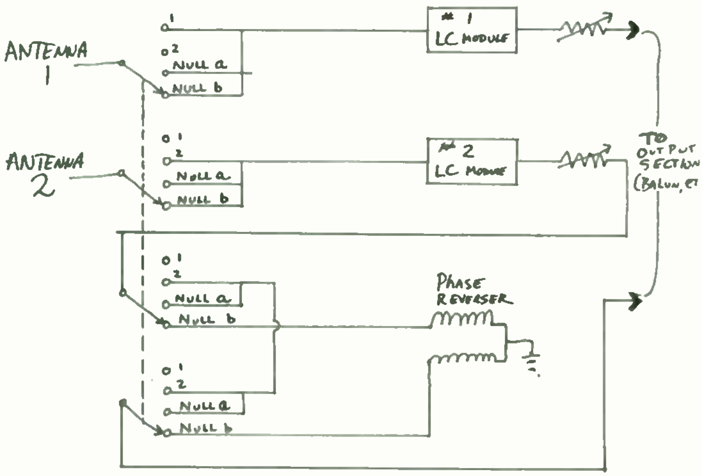


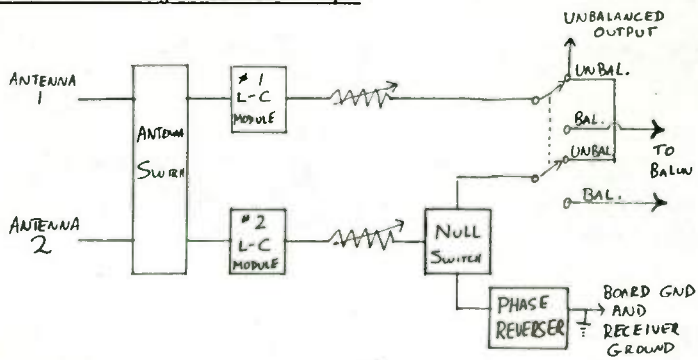

Figure 6 Single antenna/null mode switch configured to reduce crosstalk




(c) Conventional phasing unit has no provision for unbalanced output.

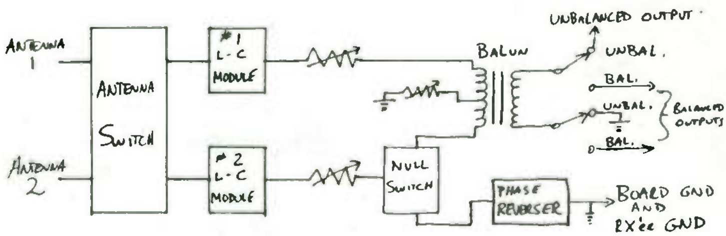
There are two philosophies regarding the provision of an unbalanced output. One is to disconnect the two tuned lines from the balun primary, short these together, and feed them out to an unbalanced output jack, as in figure 7.

Figure 7 one method of obtaining an unbalanced output



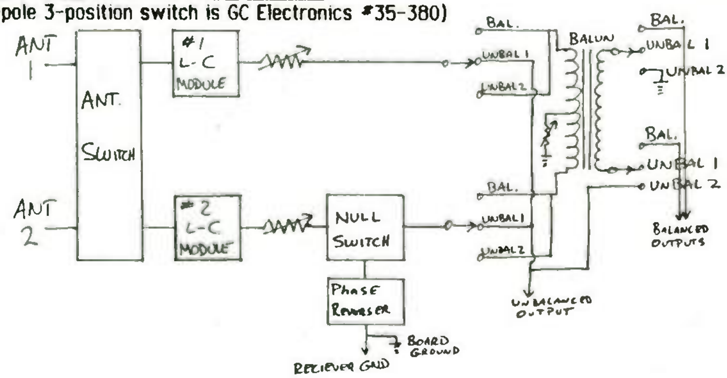

An alternative method is to leave the balun in the operating system and to connect one side of the balun output to ground/the other balun output to the unbalanced output jack, as in Figure 8.

Figure 8 an alternate method to obtain an unbalanced output




Perhaps the best solution to obtain unbalanced output is to build both approaches into the output section of the phasing unit, as in Figure 9.

Figure 9 versatile approach to unbalanced output
(NOTE: the 4-pole 3-position switch is GC Electronics *35-380)



(d) Metal case is expensive; isolating the tuning capacitors and other components from case ground requires much mechanical layout work.

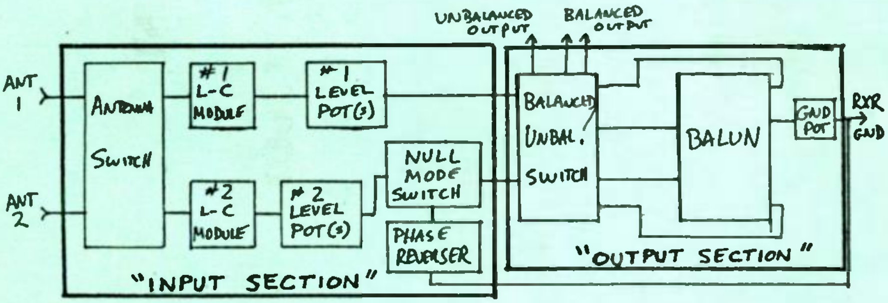
Worry not....you can build the phasing unit on a standard epoxy-glass vectorboard; this will be discussed in a soon to be released construction article.

(e) The 1K series pots don't always effect the signal levels on their respective antenna lines. Two reasons are postulated for this: 1. in some cases 1K may be too low a maximum resistance value to have any meaningful attenuating effect. One remedy may be the use of a higher resistance pots in series with the 1K pots. The 1K pots would then become more finely tuned pots. 2. leakage capacitance across pots negates the effect of their resistances. Several schemes may be initiated to remedy this: (a) pots could be placed right at the antenna inputs (between jacks and antenna switch, ahead of LC modules) (b) try a different brand of pot. (c) keep all leads short to minimize stray pickup.

**Summary - The modular approach to phasing unit design**

In this article several operator conveniences and tuning aids were discussed. A phasing unit need not have all of these "bells and whistles". The block diagram below (Figure 10) points out the modular concept of phasing unit development; actual contents of modules will be determined by the user's particular needs.

Figure 10 Modules of a phasing unit




If only true longwires or Beverages are to be used, the LC modules can be reduced to the simple single-L-value (e.g. 250 uH) in series with 10-365 pf. The balun might be omitted if only an unbalanced output is desired, although this might decrease some null capability. Others may retain the balun, but they'll eliminate the phase-reversing toroid - again, nulling flexibility may be decreased slightly. In my experience, you have to have either the phase-reverser or the balun to have even minimal nulling power; having both, obviously, is the optimal situation.

The author believes that as phasing units come into more general use, they will take their place alongside loops as worthy weapons in the DXer's arsenal to combat both interference from "pest stations" and that from nonbroadcast sources such as light-dimmers, TV sync. oscillators, power lines and the like.

The serious DXer should evenly blend the use of a good amplified loop with the use of a phased wire system. Each setup may offer unique DX possibilities; the experienced DXer will soon learn which setup to use to "milk" a specific type of opening or to hunt for specific target stations. The ability of the phased wire system to produce unidirectional nulls may open up new DX possibilities for many. Similarly, a loop might catch some DX not possible with a particular phased wire setup. With ever increasing levels of interference plaguing the DX efforts of us all, it seems wise to have as much antenna (and receiver) diversity as possible at our disposal.

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