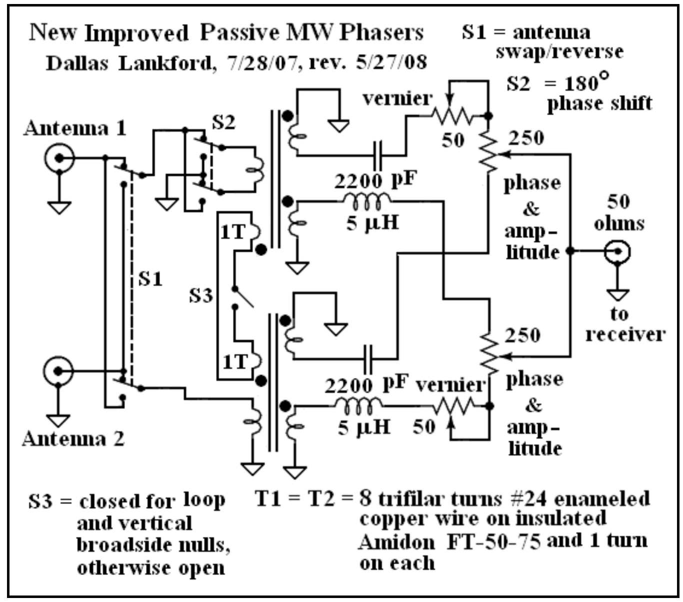
New Improved Passive Phasers

Dallas Lankford, 8/2/07, rev. 7/12/08

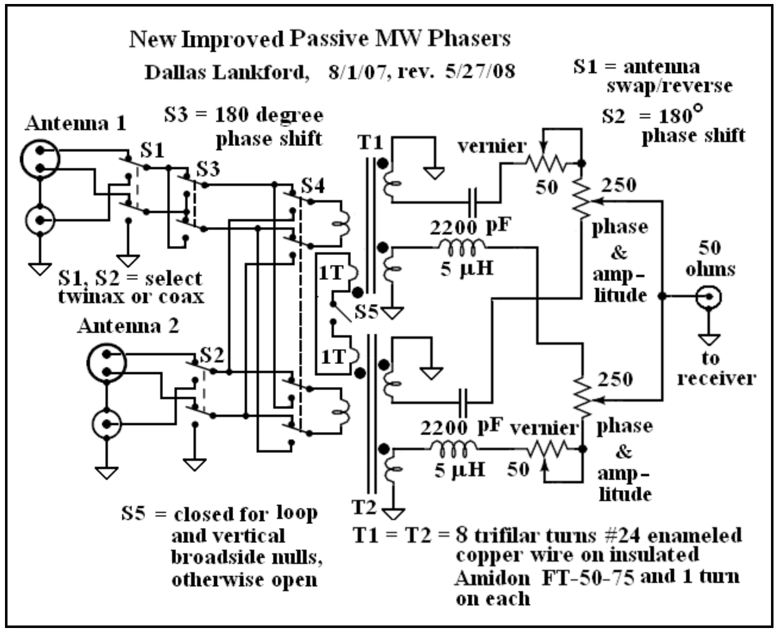


Below are schematics of the 3rd and most versatile versions of my passive phasers. The first schematic is for coax input only. For many daytime ground wave signals and most nighttime sky wave signals the vernier controls are not absolutely necessary, but they are often useful even when not necessary. As with previous designs of mine, the vernier controls should be set to mid range before beginning to null a signal or noise. Like my previous high performance phasers, no amplifier is necessary for these new passive phasers. All of the phasers I have modified or designed, including these new improved passive phasers, should be used with identical antennas spaced 0.1 λ apart at the lowest frequency which is used. If used with other antennas or other spacings, nulls may not be as deep as potentially possible, and in some cases virtually nonexistent. An exception to the 0.1 λ spacing condition is when two of my 15' (amplified) noise reducing vertical antennas or two of my simplified complementary push-pull output active whip antennas are used, in which cases the spacing required for good nulls throughout the MW band (and higher frequencies) is is only 60'. The simplest version above is configured for coax input. A more complex version below is configured for switchable coax or twin lead input, and following that is a still more complex bandswitched version. An amplifier (or 2 or 3) may be beneficial if you use these passive phasers with short antennas, such as 15' noise reducing vertical antennas which are discussed in detail in articles in The Dallas Files. You may use two unamplified noise reducing antennas with an amplifier at the output of the phaser, or two amplified 15' noise reducing vertical antennas with or without an amplifier at the output of the phaser. The difference between these passive phasers and the previous ones is the switched inductive coupling which makes 360 degree null steering practical (without adding attenuation to one or both signal paths) for certain antenna arrays consisting of a vertical and a loop, especially for nulls which are broadside to the loop, and for some µSWA broadside nulls. These are exceptions to the identical antenna condition stated above.

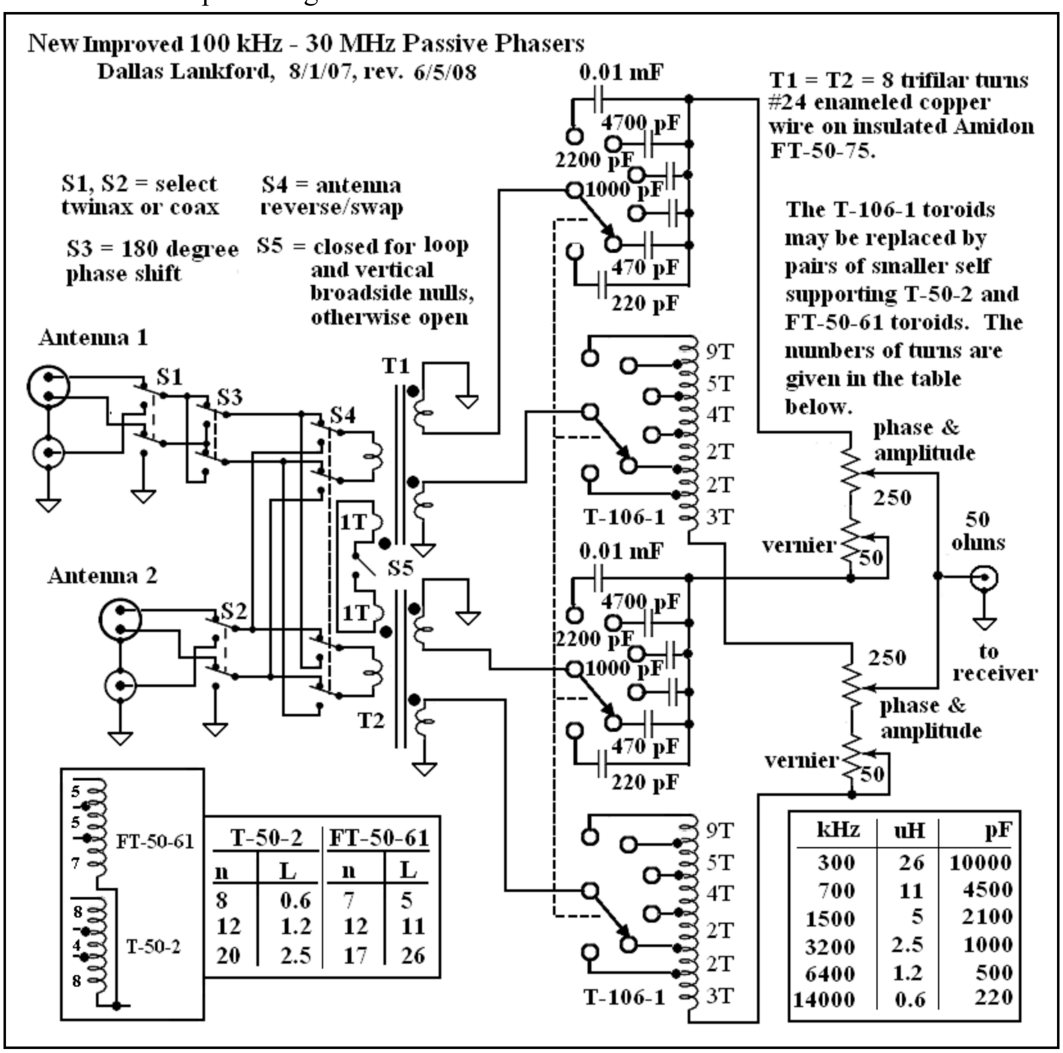
The new improved passive MW phasers above and below have been tested throughout the MW band with a pair of unamplified 15' noise reducing verticals, a pair of amplified 15' noise reducing verticals, a pair of unamplified 45' noise reducing inverted L 's, an amplified 15' noise reducing vertical and an amplified 60' circumference one turn loop (also tested in the NDB), and a 100' µSWA using 450 ohm ladder line. With those antennas the new improved passive phasers work as well as if not better than my modified Misek phasers in the MW band.

Newark Electronics (formerly Newark InOne), the main supplier of the 200 ohm and 50 ohm pots which I normally use, has recently raised the price of their 200 ohm Type J pots (now manufactured by Honeywell, formerly Clarostat, formerly Allen Bradley) to about $50 each, and discontinued their 50 ohm Type J pots. A 100 ohm Type J pot with a fixed 100 ohm resistor in parallel is a suitable substitute for the 50 ohm pot.

These new phasers were motivated by Misek's original design and by earlier passive phasers I designed. Not only was Misek's phase shifter not symmetric, but signal from the inductive phase shifted component was routed to the capacitive phase shifted component. I believe this accounts for the smooth control of null depths exhibited by Misek phasers. The new passive phasers described here are also not symmetric. But the asymmetry is different from the Misek asymmetry; not only is signal from an inductive phase shifted component routed to a capacitive phase shift component, but also signal from a capacitive phase shifted component routed to an inductive phase shifted component.



At right is a more elaborate version of the new phaser for switched twinax or coax input. The 2200 pF capacitors and 5 µH inductors for the MW band only phasers are 50 ohms reactance at approximately 1500 kHz. For theoretically best MW coverage 3300 pF and 8.2 µH might seem more appropriate. But that is not the case because capacitors and inductors which have 50 ohms reactance at 700 kHz do not produce good

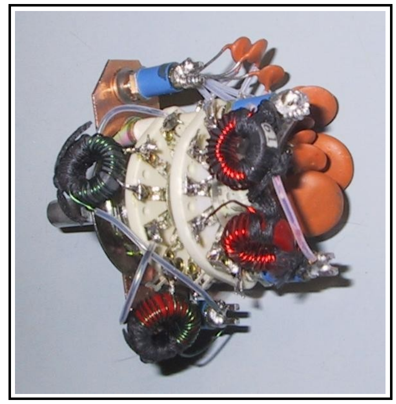


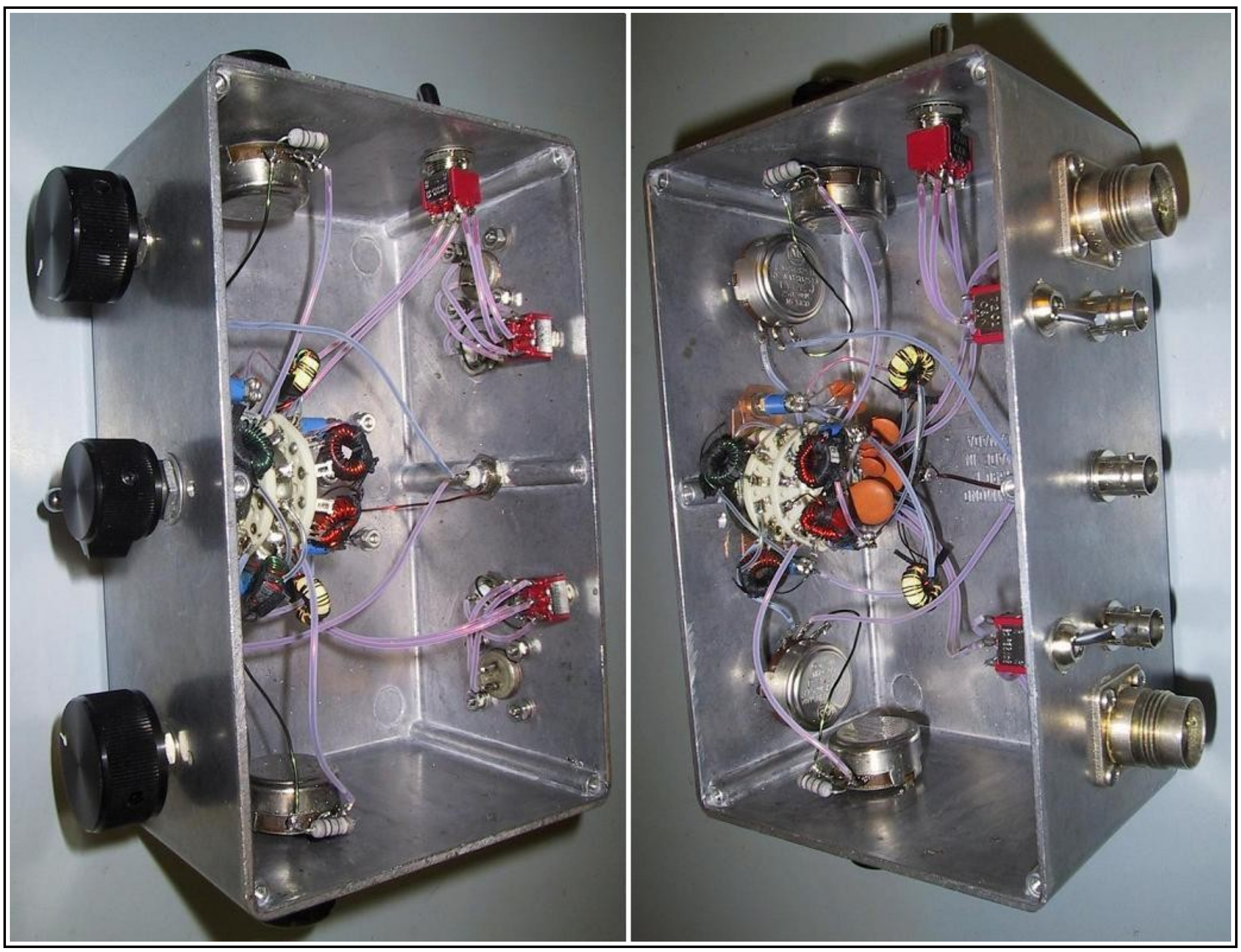
T-50-2		FT-50-61	
n	L	n	L
8	0.6	7	5
12	1.2	12	11
20	2.5	17	26

kHz	uH	pF
300	26	10000
700	11	4500
1500	5	2100
3200	2.5	1000
6400	1.2	500
14000	0.6	220

nulls throughout the entire MW band while those for 1500 kHz do.

Above is a schematic of a 100 kHz – 30 MHz bandswitched version. Instead of T-106-1 toroids specified on the schematic, two pairs of smaller self supporting toroids were used, namely T-50-2 and FT-50-61 toroids. The numbers of turns for the required inductances are given in the table with the schematic. The bandswitched version above was built to determine if this approach works well at VLF and if it is useful for nulling noise at SW frequencies. It does and it is. I made my rotary switch from parts which I had on hand. An Electroswitch D4C0406N, currently available from Newark Electronics, part number 06M4645, for about $60 each, is equivalent. The bandswitched version generates excellent steered nulls in the MW and LW bands when used with a 60' circumference amplified loop antenna described at the end of this article and an amplified 15' noise reducing vertical antenna spaced about 20' apart. Good nulling performance with other non-standard antennas or for other frequencies is not guaranteed. The photo at right shows the bandswitch assembly using four small toroids. The rotary switch was modified with four insulated standoffs and two small hand made brackets mounted to the rotary switch assembly using the two wafer mounting screws which permitted all inductors and capacitors to be mounted directly to the switch assembly.





Above are interior photos of a previous version of the bandswitched 100 kHz – 30 MHz Passive Phaser. The switched inductive coupling enhancement (switch S5) was not implemented in this version. The vernier pots on the sides are 100 ohm in parallel with fixed 100 ohm resistors.

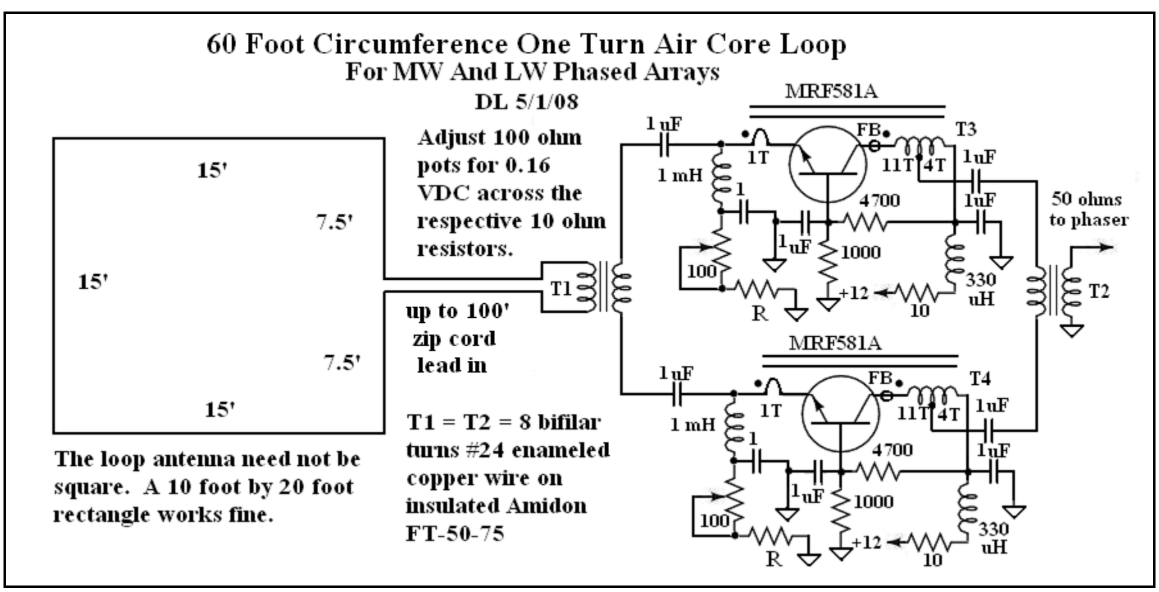
Like my modified Misek phasers, MW Phaser #2, #3, and #4, my passive phasers basically have two controls, the phase controls as I call them (not counting the two additional vernier phase controls and the 180 degree phase shift switch). So operation of my new passive phasers is almost identical to operation of my modified Misek phasers. As Misek said about his phaser, page 74, ***The Beverage Antenna Handbook***, Second Edition, " One of the signal channels is split into two branches... resulting in a net phase shift of 90 degrees between potentiometers P1 and P2 [which I have called the phase controls in previous articles]. ... Because these two outputs [the outputs of P1 and P2] are connected in series, the resulting vectorial combinations can produce any phase shift at zero to maximum amplitude." Consequently no amplitude control (or controls) is (are) required for Misek type phasers when identical antennas spaced 0.1 λ apart at the lowest frequency are used (or 60' apart for short verticals in the MW band). As Misek stated, the two "phase" controls simultaneously vary both the phase and amplitude of one of the signal paths, the path which contains the phasing circuit and the amplifier. There is, however, a minor problem with this approach, namely the signal levels must be "corrected" to obtain full 360 degree nulling. In my modified Misek phasers this was done with toggle switched standard resistive pi attenuators in the unamplified signal path. Alternately, one could put a variable amplitude control in the unamplified signal path, but that does not seem to me to be a good idea because it would make generating nulls more difficult in some cases. My new phasers phasers vary amplitude and phase similar to although somewhat different from the Misek phasers. Because the signal paths of my new phasers are symmetric (ignoring that some path contains inductors and other paths contains capacitors), no amplitude "correction" is needed for one path.

One of the things that makes Misek's phasers and my new passive phasers so much better than other phasers is that they do not have and generally do not need variable amplitude controls provided you use reasonable antennas. The exception is if you use modified Misek phasers or new passive phasers with nonstandard antennas (antennas which are not identical or which are not spaced 0.1 λ apart at the lowest operating frequency, except for the exceptions already mentioned above). As I have said repeatedly over the years, if you use the phasers I have developed with nonstandard antennas, then I do not guarantee their performance. Proceed at your own risk. For example, to get the deepest nulls possible in the NDB band with an amplified 15' noise reducing antenna and a 60' circumference amplified loop antenna, an external 1 dB per step rotary attenuator was required in one signal path for my bandswitched modified Misek phasers. For the new improved passive phasers no attenuator was required when the inductive coupling feature was used as needed. From many hours of hands on experiences with other kinds of phasers, all but one of which used variable gain (amplitude) controls in both signal paths, even if you do use them with identical antennas spaced 0.1 λ apart, you will still have to use their amplitude controls and that makes generating nulls more difficult, and in some cases impossible. And phasers with variable amplitude controls generally have poorer long term null stability compared to my modified Misek phasers and my new passive phasers. Also, a switched (discrete) delay line phaser which I tested had poor null depths in many cases, and poor broadside null depths when used with amplified loops spaced about 40 meters apart as recommended by the designer.

The 180 degree phase shift switch is common to all of the passive phasers above; it is necessary for full 360 degree null steering with overlap. If you get mostly shallow nulls, put the 180 degree phase shift switch in the other position. Deepest nulls for most signals will be obtained with the antenna reverse/swap switch in only one of the two positions, but for a few signals the other position will be needed for deepest nulls. In some cases there may be little difference in maximum null depth between the two positions of the antennas reverse switch.

Before beginning to null a signal, first set the vernier controls to mid range. Next use the phase controls to begin nulling a signal. Adjust one phase control until a dip of the receiver S-meter is observed. It may be helpful to set both phase controls to mid range before adjusting them. An analog S-meter is desirable because some of the null deepening steps may not be indicated by a digital S-meter. If no dip is observed when one phase control is adjusted, then adjust the other phase control until a dip is observed. Alternately adjust the phase controls, first one and then the other, to deepen the null. When the null cannot be deepened further, use the vernier controls to try to deepen the null further. At some point during the nulling process a weaker signal (or tow or three) should be come audible, or if there are no other signals on that frequency, then background noise should become stronger as the signal is nulled. The deepest part of the null can only be adjusted "by ear," not by using the S-meter, and headphones are necessary in many cases to null the stronger signal mostly or completely into the background of the weaker signal(s). The entire process above can be repeated with the antenna reverse/swap switch in its other position to determine if a deeper null is possible. If the maximum null depth is shallow, put the 180 degree phase shift switch in its other position and repeat the entire process above. Except for nearby 50 kW MW signals, you should be able to null any of your daytime ground wave MW signals completely below man made noise at your location. The nulls of daytime ground wave MW signals should have good long term stability except during sunrise and sunset transition. Daytime ground wave nulls of 70 dB or more should be common. For nighttime sky wave MW signals use the same procedure as above to null signals. The nulls generated by the phase controls for nighttime sky wave MW signals are generally broader than for daytime ground wave signals, making it easier to generate nighttime sky wave nulls unless there are numerous weaker signals beneath the signal being nulled. In that case it is difficult to tell when you have nulled the stronger signal as much as possible. Headphones are usually necessary for obtaining the deepest possible nulls for nighttime sky wave signals, especially when there are multiple weaker signals underneath the stronger signal, which is often the case. Many nighttime sky wave nulls are quite stable, some are not. The skywaves of strong nearby MW transmitters generally have less stable nulls than the skywaves of more distant transmitters. For example, 820 WBAP Ft. Worth, TX has a less stable null at my location in Ruston, LA than 750 WSB Atlanta, GA. And 1510 WLAC Nashville, TN has a less stable null than 1530 WSAI Cincinnati, OH. Virtually all MW sky wave nulls are moderately to severely unstable during sunset and sunrise transitions, and when ionospheric propagation is unstable. When MW sky wave propagation is stable, stable sky wave nulls of 50 dB or more are not uncommon.

In the first schematic at the beginning of this article the switch S3 (and in the second and third schematics the switch S5) enables or disables inductive coupling between the two transformers. The inductive coupling is necessary for generating broadside nulls as deep as potentially possible when using a 15 foot amplified vertical and a 60' circumference amplified loop antenna or similar antenna arrays. Such phased arrays obviously do not consist of two identical antennas, in which case, as I have said before, they may not (and generally will not) produce as deep nulls over 360 degrees as when identical antennas are used. Less than maximum null depths are common for a loop and long wire, especially for nulls broadside to the loop. While the switched inductive coupling enhancement of the previous passive phaser circuit produces excellent broadside nulls for appropriate



vertical and loop antenna arrays stated above, I do not guarantee the performance of these improved passive phasers for other nonstandard arrays.

The amplified 60' circumference loop antenna above and an amplified 15' noise reducing vertical antenna are very good for null steering in the NDB band using the new improved passive phaser. They are, of course, not the best choice for null steering in the MW band, and should only be used for that purpose if space constraints prevent the use wider spaced identical antennas. To simplify construction, the loop amplifier can be made from a modified Kiwa Broadband Preamp 2.0. I made my loop head and lead in from a 100' spool of Radio Shack speaker wire (I pulled 30' apart at one end, soldered the two ends, tied a knot where the separation stopped, and hung a 22' by 8' rectangular loop from 0.75" brass cup hooks screwed into the fascia of my roof). If you have an ALA-100 head, that can be used instead. You should not make the loop with multiple turns of 60' of wire.

The new improved passive phasers presented in this article are simpler to build than Misek phasers because they do not require an amplifier as an integral part of the phaser. For this reason I have retired the articles about my modified Misek phasers from The Dallas Files. This does not mean that Misek phasers do not produce as good nulls as passive phasers. As a matter of fact I still use a modified Misek phaser regularly.

Type J Potentiometers

As I have said on many occasions, there is really only one kind of pot you should use to build phasers, namely Allen Bradley Type J. In my and other persons experiences, other types of pots will become scratchy in a day, or week, or month, or other relatively short period of time. Using your favorite anti-scratchy pot chemical on your el chepo pot will probably not change its MTBF by very much. The Allen Bradley Type J pots division was bought by Clarostat more than 12 years ago, and more recently Clarostat was bought by Honeywell. Several recently manufactured Clarostat Type J pots have failed in my phasers after only a few years of light use which suggests that quality control is not as good as it was previously. Two photos at right show the front and rear of AB Type J pots. The Type J front has distinctive circle cutouts in a metal plate over a brown bakelite disc with a sealed metal shell over the rear. Stamped into the rear of the metal shell is the AB logo (or the word Clarostat, and now perhaps Honeywell, although I have not seen any such), with several lines of identifiers below the logo stamped into the metal shell, namely JA1N056S251UA (the 251 denotes 250 ohms and will vary depending on the pot value), RV4NAYSD251A (the mil spec designation), TYPE J (what we want to see!), 250 OHM (which varies, depending on the pot value), V1 (maybe a date code or buyer code, which varies from one batch to another and sometimes is absent), and finally MEXICO (the country where they were made, though USA or some such may appear in earlier AB's). The color difference in the front and rear photos above is due to the lighting required to produce a rear photograph with good contrast. Originally I used 200 Ω Type J's for these passive phasers, but rising cost (mentioned above) caused me to try some 250 ohm Type J's available briefly from Surplus Sales Of Nebraska for $6 each. The 250 ohm Type J's worked just as well as the 200's. Unfortunately the SSNe 250's appear to have been sold out after only a few weeks.

8/5/2011: To the best of my knowledge, Allied Electronics is the only current reliable source of type J pots: 100 ohms type J, 250 ohms type J . The 100 ohm pot is about $25 each; the 250 ohm pot is about $50 each. Paralleling a 100 ohm fixed resistor across the 100 ohm pot (from one end to the wiper) makes an acceptable 50 ohm pot. I suspect that the 100 ohm pot will be discontinued when the current stock is sold out.