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Micro-MWDX-4A Loop-vs.- Wire Phaser

Mark Connelly - WA1ION - 15 MAR 1989

Phasing a loop against a longwire or a vertical to establish a cardioid pattern continues to be a popular concept in the DX press. Over the years, numerous schemes have evolved: Dallas Lankford, Paul Swain, Ron Schatz, and others have done articles on this specific issue. My previous phasing unit articles accentuated two-wire phasing, but loop-vs.-wire and loop-vs.-loop possibilities have been addressed.

The units used to establish the null between the loop (oriented for maximum pickup of the station to be nulled) and the sense antenna (most often a vertical or other nearly-omnidirectional aerial) take several forms. Units that merely resistively-sum the wire's contribution with that of the loop, with no tuning of the wire at all, are difficult to use; nulls are pretty much hit-or-miss. Of greater value are designs that use a tuned circuit to couple in the RF contribution from the wire. Dallas Lankford's LIL-1 ("DX News", 27 FEB 1989) operates on such a principle. A possible drawback in that design is that no Q-spoiling is being employed either on the loop's L-C tank or on the tank circuit used for the wire (sense) aerial. Not spoiling the Q results in a very narrow-band null: as both Dallas and I have noted, you can null the carrier deeply without nulling the sidebands anywhere near as much. This is even worse if the two tank Q's aren't fairly closely matched. Real QRM-killing, therefore, is limited with such a scheme. Null "touchiness" with arrival-angle / hop-mode variation on skywave signals is also made worse by employing high-Q tanks. My experimentation indicates that a resistor of between 10K and 50K should be put across each L-C tank (loop and wire-tuner). This will widen the bandwidth and improve the steadiness of the null. Better than a fixed resistor is a "Q-skewing" pot of 50K (linear, non-reactive) - normally set to mid-range (25K) - across each tank. When "closing in" on a null, tweaking one Q-skewing pot and/or the other can "finish off" the pest station. When the Q's / frequency-response curves of the two tanks are fairly close, null bandwidth improves. The pots help to match tank Q's as well as providing controlled Q-reduction. The trade-offs with Q-spoiling are (1) the amount of phase shift for a given amount of tank capacitor detuning is lessened and (2) system sensitivity is lower. The way around problem (1) is to put a switchable (0/180 degree) phase-reversal transformer in one of the two signal lines (e. g. the loop line) enroute to the summation point that feeds the receiver. This allows a capacitor-detuning phase shift of +/- 90 degrees to do the work that previously required a +/- 180 degree detuning-created shift. Problem (2), sensitivity reduction, is easily solved by amplification. Gain is cheap below 30 MHz. Amplifier noise is seldom as limiting a factor as the amplifier's strong-signal handling ability. Amplification may be broadband, using a circuit similar to that in my "BBA" unit (NRC/IRCA reprint) or like that in Gerry Thomas's "Phase One". In strong signal areas, tuned amplification is preferable. When using Q-spoiled tanks, received bandwidth is relatively wide; therefore, a broadband amplifier after the phasing unit could get "creamed" by off-frequency locals: mix spurs / "inter-mod" could result. Even in the "boondocks", a broadband amplifier may get bothered by strong shortwave broadcast and utility signals coupled in from the longwire: mix spurs of RTTY, FAX, and other unwanted garbage could show up. Tuned (especially high-Q / regenerative) amplification after the phasing unit's summation point is definitely the way to go when DX signal levels after pest-nulling are low. Ken Cornell has published a schematic for such a tuned amp. in "Monitoring Times" and NRC/IRCA have reprints of my "MWT-1" unit. "MWT-2", under development, combines the best features of MWT-1 and Ken Cornell's tuner-amp. Commercially-made active tuner-preamps. by MFJ, Grove, Arcomm, et al could be used as well. If a really good receiver (e. g. R-71A, R390A, HQ180A) is used, amplification is seldom necessary. With a Sony ICF-2010, on the other hand, you'll need it.

Another criticism that I have of some of the other loop-vs.-wire designs (and other tuner and phaser designs, in general) is an apparent fixation with clumsy homemade coils. Commercially-available inductors from Mouser, Digi-Key, and oth[illegible] fine. Capacitive-coupling of the longwire to the tank gets rid of the need to use link-coupling. Once that requirement goes away, there's little need for homebrew coils. When small moulded inductors (resembling resistors) are used, bandswitching becomes easier. Rules-of-thumb ("heuristics" for you AI types) employed are that (1) The ratio of maximum tuning capacitance to input coupling capacitance should be about 6 to 1: 56 or 62 pF to couple to a tank that has a 10 to 365 pF variable cap. is about right for "average" wire aerials and (2) The ratio between the inductor that goes from the tank "high-Z" point (tuning capacitor stator) to the "tap" point (for low-Z output) should be about 5 times greater in value than the inductor which goes from the "tap" point to ground: e. g. 220 uH (high-Z to tap) and 47 (or 39) uH (tap to ground). In a phasing system, the Q of the coils used is of little importance: the Q-spoiling pot (set to 25K until null-finalization) is the main determining factor in tank Q.

ON 27 JAN 1986, I published an article entitled "The Micro-MWDX-4 Phasing Unit: A Small, Cheap, and Simple Approach". The article appeared shortly thereafter in "DX News" & "DX Monitor". The unit was presented as both a wire-vs.-wire and a loop-vs.-wire phaser. Its nulling performance as a two-wire phaser was not as good as phasing units employing a separate tank circuit for each wire. As a loop-vs.-wire unit, however, it worked quite well. A problem noted was signal loss because of the 100-ohm resistors in each signal line and because of the relatively-low coupling capacitor (39 pF) chosen to couple the longwire to the tank. The fixed 27K Q-spoiling resistor was adjudged to be less worthwhile than a 50K Q-skew pot across the wire-aerial tuning tank. If the pot could be squeezed into the box somehow, it would be. With all of these ideas in mind, I set about to create the Micro-MWDX-4A, a replacement for its predecessor. Furthermore, this newer unit was designed to be a loop-vs.-wire phasing unit <u>only</u>. Good two-wire phasing requires two L-C tanks, or (perhaps) delay-line techniques à la Gerry Thomas. (The jury's still out on that design.)

<u>Micro-MWDX-4A: Relevant design features</u>

* A "1-2-Null" function switch (S2) is used. This is standard on my newer phasing units. This feature is important because it allows isolation of each line, enabling independent peaking and level-setting prior to nulling.
* As on the earlier unit, a three-position bandswitch (S1) allows the wire-tuning tank to cover 500 to 1800 kHz without a great deal of influence by the length of wire connected.
* The coupling capacitor (C2), 62 pF, is a good compromise value between maximum achievable signal level and maximum tuning bandwidth. A higher value might couple in a bit more signal but the tuning and phase-shifting range would decrease. A lower value would give more phase-shifting and band-coverage capability, but with poorer signal-coupling efficiency.
* Two 500-ohm level pots (R1, R2) are used. With each pot set for maximum signal, the 500 ohm resistance of each pot to ground causes minimal signal loss when the phaser's output is "playing" into 50 ohms. These pots are available commercially for less than $2 each.
* The phase-reversal transformer (T1: Mini-Circuits part number T1-6) as previously mentioned, permits nulls with less capacitor-detuning required. Because this is now a loop-vs.-wire unit, S3 is now used with T1, rather than to swap the two inputs.
* The 50K Q-skewing pot (R3) has been found to be very useful in nulling out the last few dB of a "pest" station or electrical noise.
* A Mouser 45KN100 vernier knob is used on C1. It costs about $6, a good deal less than some of the other vernier drives people have been using lately.

<u>Micro-MWDX-4A: Loop-vs.-Wire Phasing Procedure</u>

Figure 1, which follows in this article, is the schematic of the Micro-MWDX-4A. Please refer to it during this discussion of phasing procedure.

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The desired effect of loop-vs.-wire phasing is to receive stations in the opposite direction of the station to be nulled out: this is something a loop, on its own, generally cannot do. The loop should be physically positioned for maximum signal from the direction of the desired station, regardless of the direction of the station to be nulled. When the desired station is in the opposite direction of the "pest", the loop will also be positioned for maximum "pest" station pickup.

The loop to be used may be either passive or active as long as the signal fed by it to the phasing unit is of a low impedance suitable to feed to a receiver's input. This low impedance signal, in the passive loop case, would come from a coupling link relatively loosely-coupled to the loop's high-Z LC tank. For active loops, the loop amplifier's output is, of course, used. For best phasing results the loop should be "Q-spoiled" somewhat by clipping in a fixed resistor of about 15K, or (preferably) a non-inductive, linear-taper 50K pot normally set to center (25K). This resistance is to be connected in parallel with the loop's parallel inductance / tuning capacitance. Of course, the connection should be easily removable for use of the loop in high-Q, non-phasing applications.

In the following procedure, the use of a 50K pot shunting the loop's LC tank will be assumed. This pot will be referred to as "Loop-R". The loop's tuning capacitor will be referred to as "Loop-C".

1.0 Phasing Steps

1.1 Connect longwire to J1. Connect loop output coaxial cable to J2. Connect earth ground, if available, to J3. Connect phaser's output (J4), via coaxial cable, to the input of the receiver to be used, or to an RF amplifier between phaser and receiver.

1.2 Set level pots R1 and R2 to fully counterclockwise (CCW) (maximum resistance arm to ground). Set longwire-Q pot R3 and Loop-R to mechanical center (approx. 25K each).

1.3 Set frequency-range switch S1 to the correct range for the frequency of operation (see Table 1). Set function switch S2 to 1 (wire). Null-mode switch S3 may be put in either position: it doesn't matter yet.

1.4 Tune Line 1 (signal from longwire) by peaking desired-frequency signal strength with C1. At this time, leave C1 at its peaked-signal position.

1.5 Set S2 to 2 (loop). Use Loop-C to peak the desired-frequency coming from the loop.

1.6 Switch S2 back and forth between 1 and 2. If "1" is stronger than "2", adjust R1 until the levels are equal. If "2" is stronger than "1", adjust R2 until the levels are equal. Once this has been done, set S2 to Null.

1.7 Switch S3 back and forth between Null-a and Null-b positions. Leave S3 on the position yielding the weaker level (more cancellation) of the dominant station (or electrical noise) to be nulled. Subdominant signals, if present, should become more apparent if the proper S3 null position has been chosen.

1.8 Try to enhance the null by adjusting the pot set in step 1.6. If the best null is with that pot fully CCW, leave it there. Try to enhance the null by adjusting the opposite line's pot (R2 if you previously adjusted R1 or vice versa). If the best null is with that pot fully CCW, leave it there.

1.9 Adjust C1 to get a null of the dominant station. If a null doesn't occur, set S2 to 1, re-peak C1, then set S2 to Null and adjust Loop-C for a null.

1.10 Make successive adjustments of the capacitor which provided null improvement in step 1.9 and the pot that provided null improvement in step 1.8. After several of these successive adjustments, a fairly good null should be obtained. To finalize the null, try slight adjustments of R3 and Loop-R blended into the previous cycle of two-control tweaking. Slight physical re-positioning of the loop may also help.

This guide to loop-vs.-wire phasing is a starting point. Often it takes experience to get the correct "feel" for a given nulling situation: experience that will allow the minimum number of control manipulations and the quickest route to the desired null.

Building the Micro-MWDX-4A

Construction details given here are the schematic (Figure 1), the parts list, the hole-drilling list, and pictorials to assist in mounting the vernier knob for C1 and a perfboard on which T1 is mounted. Given these pieces of information, most people with even modest homebrewing experience should have no trouble. Wire runs should be as short as practicable.

FIGURE 1 : SCHEMATIC

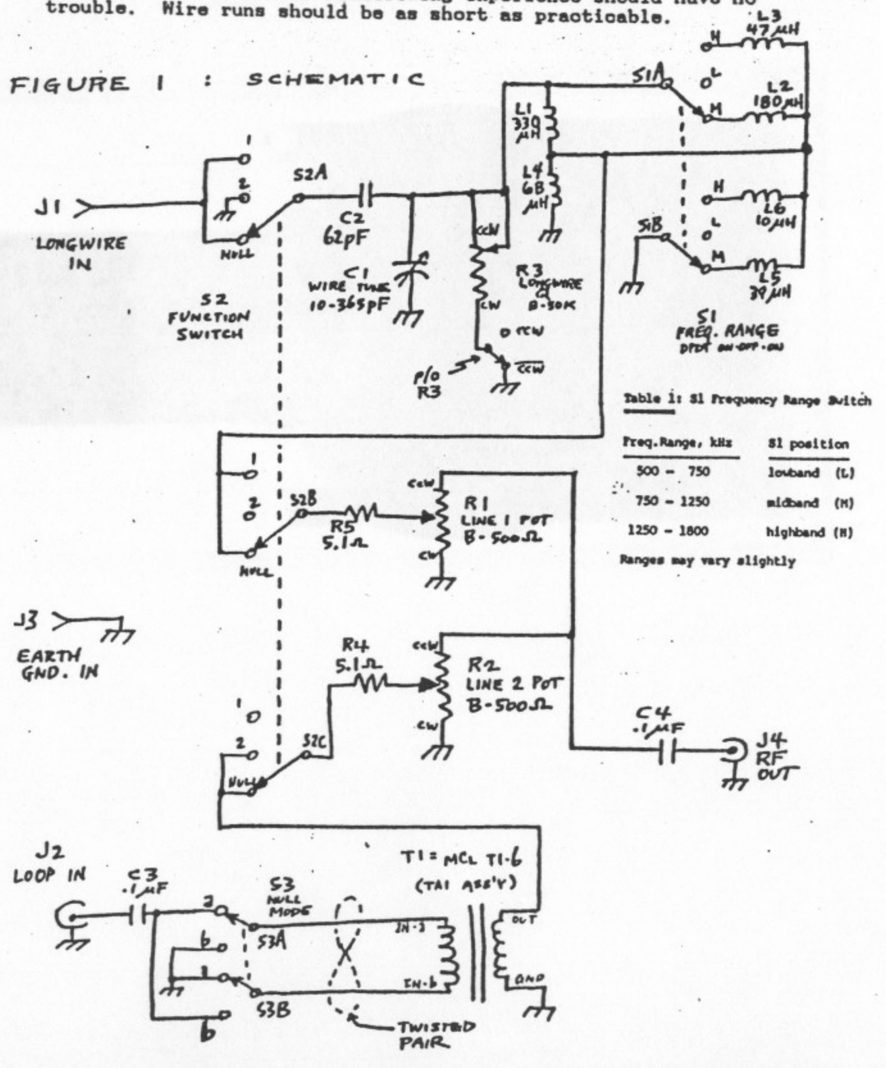

Table 1: S1 Frequency Range Switch

Freq.Range, kHz	S1 position
500 – 750	lowband (L)
750 – 1250	midband (M)
1250 – 1800	highband (H)

Ranges may vary slightly

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CONSTRUCTION-DATA APPENDIX TO MICRO-MWDX-4A ARTICLE
(Includes parts list, notes, hole list, pictorials)

Parts List for the Micro-MWDX-4A

An asterisk (*) next to item number indicates that notes follow.

A plus-sign (+) next to QTY indicates that the minimum purchasable quantity is greater than the number of pieces required.

Vendor codes:
RS = Radio Shack / Many locations worldwide
MOU = Mouser Electronics / 11433 Woodside Ave. / Santee, CA 92071
MCL = Mini-Circuits Lab. / 2625 E. 14th St. / Brooklyn, NY 11235

Item	Designator	Description/Value	Vendor	Vendor Stock #	QTY
1 *	-	chassis box	RS	270-238	1
2	(for R1,R2,R3,S2)	knob	RS	274-415	4
3 *	-	screw, 4-40X.375	MOU	572-01881	2 +
4	(for C1)	vernier knob	MOU	45KN100	1
5 *	-	screw, 4-40X.25"	MOU	572-01880	8 +
6 *	-	hex spacer, 4-40X.5"	MOU	534-1450A	4
7 *	-	split lockwasher,#4	MOU	572-00649	7 +
8	(for C1)	screw, 6-32X.25"	MOU	572-01888	2 +
9	(for C1)	split lockwasher,#6	MOU	572-00650	4 +
10 *	-	solder lug, #4	MOU	534-903	3 +
11 *	-	hex nut, 4-40	MOU	572-00484	2 +
12 *	(for TA1)	perfboard	RS	276-1394	1
13	(for TA1)	"flea clip" terminal	MOU	574-T42-1/100	4 +
14	T1 (p/oTA1)	RF transformer(1:1)	MCL	T1-6	1
15	C1	variable cap.,10-365pF	MOU	524-A1-227	1
16	C2	capacitor, 62 pF	MOU	21CB062	1
17 *	C3,C4	capacitor, 0.1 uF	RS	272-109	2
18	J1	red banana jack	RS	274-662	1
19 *	J2,J4	BNC jack	RS	278-105	2
20	J3	black banana jack	RS	274-662	1
21	L1	inductor, 330 uH	MOU	43LR334	1
22	L2	inductor, 180 uH	MOU	43LR184	1
23	L3	inductor, 47 uH	MOU	43LR475	1
24	L4	inductor, 68 uH	MOU	43LR685	1
25	L5	inductor, 39 uH	MOU	43LR395	1
26	L6	inductor, 10 uH	MOU	43LR105	1
27 *	R1,R2	pot.,500 ohm, linear	MOU	31CR205	2
28	R3	pot., 50K, linear	MOU	31CT405	1
29 *	R4,R5	resistor, 5.1 ohms	MOU	30BJ250-5.1	2
30	S1	switch,DPDT,center-off	RS	275-664	1
31	S2	switch/4pole/3pos. rotary	MOU	10YX043	1
32	S3	switch,DPDT,on-on toggle	RS	275-636	1
33	-	solder	RS	64-005	(as req'd)+
34	-	wire, bus	RS	278-1341	(as req'd)+
35	-	wire, #22 insulated	RS	278-1296	(as req'd)+
36 *	-	wire, twisted pair	[fabricate from Item 35]		1

Notes, by item number

1: Box size is 5.2" X 2.92" X 2.125" (13.2 X 7.4 X 5.4 cm.).
3: 2 pieces for vernier knob mounting
5: 2 pieces for vernier knob mounting, 1 piece for G1 ground, 1 piece for G2 ground, 4 pieces for TA1 assembly
6: 2 pieces for vernier knob mounting, 2 pieces for TA1 ass'y
7: 4 pieces for vernier knob mounting, 3 pieces for TA1 ass'y
10: 1 piece for G1, 1 piece for G2, 1 piece for TA1
11: 1 piece for G1, 1 piece for G2
12: Cut perfboard to 0.6" X 1.2" (see TA1 pictorial).
17, 19, 27, 29: One piece for each designator listed
36: Twisted pair is used from S3 to T1, per schematic.

Hole-drilling list for Micro-MWDX-4A

X = Horizontal distance, in inches, from the vertical centerline (VCL) on the side observed. Negative values of X are left of VCL, positive values of X are right of VCL.

Y = Vertical distance, in inches, from the bottom horizontal edge of the side observed.

D = Hole diameter in inches.

Hole loci are first marked on the box with a scriber and are then drilled with a .125" bit. Subsequently, as required, the holes are enlarged to the proper size by using progressively larger bits up to that corresponding to the final desired diameter.

LEFT SIDE

Hole #	Comp. Desig.	Description	X	Y	D
1	J1	Wire 1 In - banana jack	-0.75	0.5	0.3125
2	J3	Earth GND In - banana jack	0.0	0.5	0.3125
3	G1	GND H/W - internal lug	0.0	1.125	0.125
4	J2	Loop In - BNC jack	0.75	0.5	0.375

TOP SIDE

Hole #	Comp. Desig.	Description	X	Y	D
1	S3	Null-mode switch - tab	-2.125	2.375	0.125
2	S3	Null-mode switch - shaft	-2.125	2.125	0.25
3	S1	Freq. Range switch - shaft	-2.125	0.75	0.25
4	S1	Freq. Range switch - tab	-2.125	0.5	0.125
5	C1	Tuning cap. - mounting H/W 1	-1.088	1.625	0.144
6	C1	Tuning cap. - shaft	-0.625	1.375	0.5
7	C1	Tuning cap. - mounting H/W 2	-0.162	1.625	0.144
8	-	C1's vernier knob - H/W 1	-1.265	0.75	0.125
9	-	C1's vernier knob - H/W 2	0.015	0.75	0.125
10	G2	GND H/W - internal lug	0.25	2.375	0.125
11	R1	Line 1 pot. - shaft	0.8125	2.125	0.3125
12	R1	Line 1 pot. - tab	1.125	2.125	0.144
13	R2	Line 2 pot. - shaft	0.8125	0.625	0.3125
14	R2	Line 2 pot. - tab	1.125	0.625	0.144
15	S2	Function switch - shaft	1.875	2.125	0.375
16	S2	Function switch - tab	1.875	1.625	0.144
17	R3	Longwire Q pot. - shaft	1.875	1.0	0.3125
18	R3	Longwire Q pot. - tab	2.125	1.0	0.144

RIGHT SIDE

Hole #	Comp. Desig.	Description	X	Y	D
1	TA1	Phase Rev. Card - H/W 1	-0.875	1.25	0.125
2	TA1	Phase Rev. Card - H/W 2	-0.875	0.45	0.125
3	J4	RF out - BNC jack	0.0	0.5	0.375

G1, G2 GROUNDING HARDWARE - EXPLODED VIEW

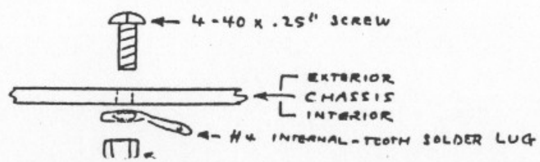

FIGURE 2 : TA1 PHASE-REVERSING TRANSFORMER ASSEMBLY

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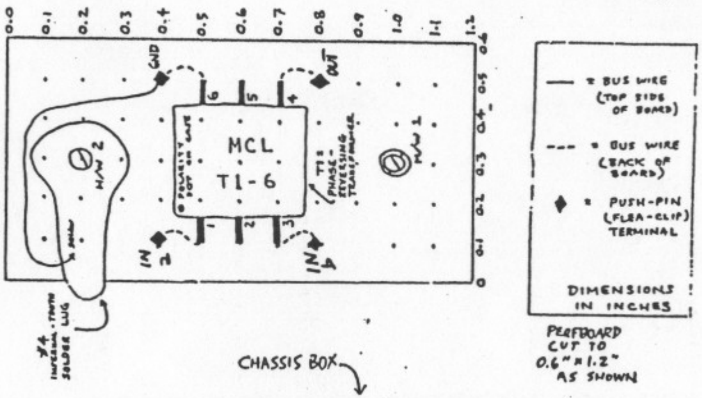


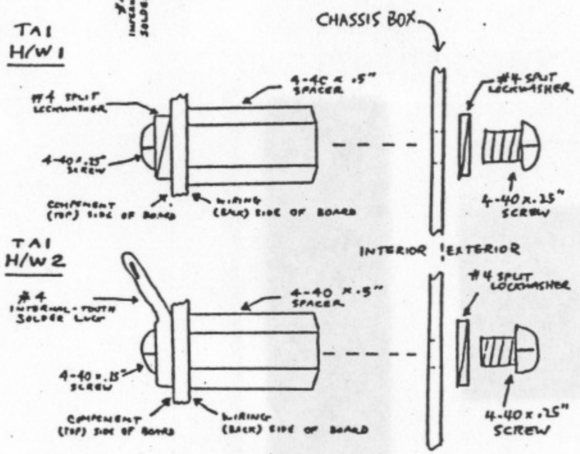
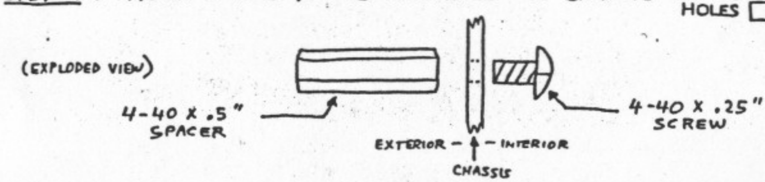
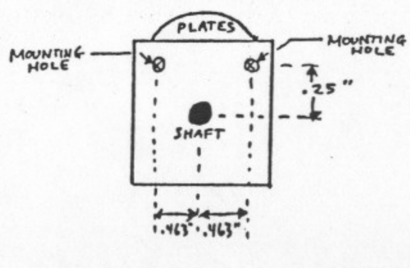


FIGURE 3 : VARIABLE CAPACITOR/VERNIER KNOB MOUNTING

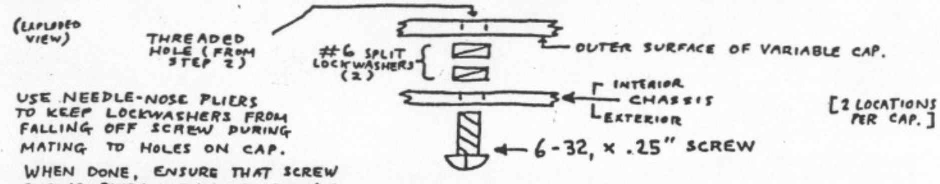
STEP 1 : MOUNT SPACERS FOR VERNIER KNOB TO CHASSIS AT TOP SIDE HOLES 8, 9



STEP 2 : TAP MOUNTING HOLES ON VARIABLE CAPACITOR TO 6-32 THREADS



STEP 3 : MOUNT VARIABLE CAPACITOR IN ACCORDANCE WITH HOLE LIST



USE NEEDLE-NOSE PLIERS TO KEEP LOCKWASHERS FROM FALLING OFF SCREW DURING MATING TO HOLES ON CAP.

WHEN DONE, ENSURE THAT SCREW END IS FLUSH WITH INNER SURFACE OF CAP. : SCREW END SHOULD NOT TOUCH MOVING PLATES (ROTOR).

STEP 4 : MOUNT VERNIER KNOB ON SPACERS INSTALLED IN STEP 1 AND ON SHAFT OF TUNING CAP. INITIALLY, KNOB SETSCREW WILL HAVE TO BE LOOSENED.