CONSTRUCTING A PHASING UNIT

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 Antennas	Chuck Hutton	NRC Reprint A28
Practical Phased Beverages	Chuck Hutton	DX News 17 DEC 1979
Phased Longwires	Mark Connelly/ Nick Hall-Patch	IRCA Reprint A28
More Thoughts about Phased Antennae	Mark Connelly	DX News 21 JAN 1980
Improve your Latin-American DX by Phasing Non-Identical Antennae	Mark Connelly	IRCA Reprint A33, DX News 8 JUN 1981, DX Monitor 13 JUN 1981
Phasing Unit Design Modifications	Mark Connelly	DX News 26 OCT 1981, DX Monitor 24 OCT 1981

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 30 m/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 & 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 in main body of article), ruler/scale, calipers or micrometer, wire stripper, push-pin insertion tool (e. g. Vector P91-DP), vise, solder sucker, 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 realise 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 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. Parts electrically equivalent to those listed, but possibly different from a mechanical standpoint, may certainly be used — as long as the builder adjusts all assembly drawings to reflect component variations, before any actual drilling or assembly is undertaken.

Table 1: Parts List for Phasing Unit

Component Designation(s)	Quantity Required	Description	Manufacturer	Manufacturer Part #	Approx. Price
C1,C2,C3,C4	4	10-365 pF variable capacitor	Calectro	A1-232	$2.70/1
C5,C6	2	47 pF fixed mica capacitor	Sprague	QCP-1171-01	$1.40/1
J1,J2,J3,J4,J5,J6,J7	7	insulated banana jack	H. H. Smith	1463	$2.10/2
L1x,L2x	2	470 uH inductor	Nytronics	WEE-470	$2.75/1
L1y,L2y	2	270 uH inductor	Nytronics	WEE-270	$2.75/1
L1z,L2z	2	120 uH inductor	Nytronics	WEE-120	$2.75/1
R1,R2	2	100K pot w/switch	Radio Shack	271-216	$1.69/1
R3,R4,R7	3	1K pot w/switch	Calectro	B1-660	$1.10/1
R5,R6	2	1K fixed resistor	Radio Shack	271-023	$0.19/2
SW1,SW2	2	SPDT toggle switch, centre-off	Alco or(Radio Shack	MST105E / 275-325	? / $2.39/1
SW3	1	3-pole,4-position switch	G. C. Electronics	35-379	$2.15/1
SW4	1	4-pole,3-position switch	G. C. Electronics	35-380	$2.15/1
SW5,SW6,SW7	3	DPDT toggle switch, no centre position	Radio Shack or Radio Shack or Alco	275-663 / 275-1546 / MST205N	$2.99/1 / $2.69/1 / ?
T1,T2	2	toroidal core	J. W. Miller	T-106-2	$1.50/1
" "	≃25'	#28 solid enamelled magnet wire	Columbia Electronic	10023-13	$2.49/375'
" "	8	push-pins for lead attachment/	Keystone Electronics	1499PK	$2.49/100
" "	4	tie-wraps to secure T1,T2	Waldom "speedy tys"	65001	$3.30/100
(Metal Hardware Assemblies)					
H1,H2,H3,H4,H5	5	6-32 X 1¼" threaded spacer	*	*	*
" " " " "	10	6-32 X 3/8" binder-head screw	*	*	*
" " " " "	9	6-32 internal tooth lockwasher	*	*	*
H5	1	6-32 solder lug	Waldom	KT-197 or KT-194	?/15
(Nylon or Plastic Hardware Assemblies for mounting C1-C2-C3-C4)					
HC1,HC2,HC3,HC4	4	4-40 X 3/8" screw	*	*	*
" " " "	8	4-40 hex nut	*	*	*
(Miscellaneous parts - no designation numbers)					
	1	Vectorboard 4.8" X 8.5" .062" dia. holes on .1" square grid (84 columns X 47 rows = 3948 holes)	Vector	85H48WE DP	$3.30/1
	1	ground plate, 8" X 10" bare metal	LMB	(8 X 10 Cap Cover)	$2.98/1
	1 roll	insulated hookup wire, #22 solid	Columbia Electronic Cables	10010-13	$2.49/ 90'roll
	2	single-line knobs for SW3,SW4	Archer	274-407	$1.29/2
	5	calibrated knobs for R1, R2, R3, R4, R7	Archer	274-413	$1.39/2
(Optional Support Leg Assembly)					
	2	solid metal, wood, G-10, or plastic cylindrical dowel 4½" 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)					
	≃1 m/3.3'	TV Twin-Lead or AC "zip cord"	*	*	*
	2	banana plug	Radio Shack	274-730	$0.99/2
	2	receiver connectors (e. g. spade lugs)	*	*	*
(Unbalanced Cable Assembly, from phasing unit to receiver unbalanced input & rx. ground)					
	≃1 m/3.3'	RG174 coaxial cable	*	*	*
	2	banana plug	Radio Shack	274-730	$0.99/2
	1	receiver input connector (e. g. PL-259, BNC, phono plug, etc.)	*	*	*
(Balanced-Mode Ground Jumper (from phasing unit ground to receiver ground))					
	≃1 m/3.3'	insulated hookup wire, #18 stranded	*	*	*
	1	banana plug	Radio Shack	274-730	$0.99/2
	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. Some small pieces of hardware may be available at the builder's place of employment.

Table 2 Functional Descriptions of User-Adjustable Controls on Figure 1 to follow.

Component Designation	Functional Name	Notes
	CONTROLS ON ANTENNA #1 LINE	
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

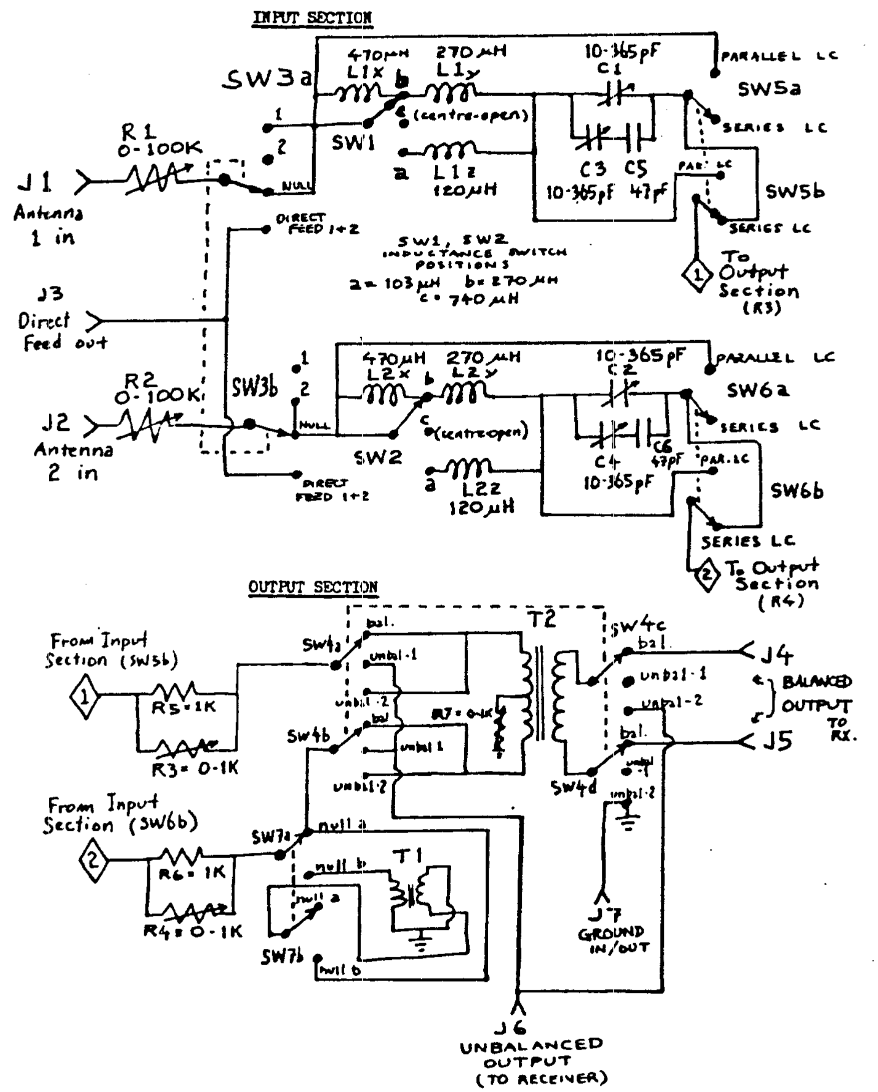
A38 7-2 M>D 2oFT

Table 2 (continued) User-Adjustable Controls

CONTROLS ON ANTENNA #2 LINE

Component Description	Functional Name	Notes
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

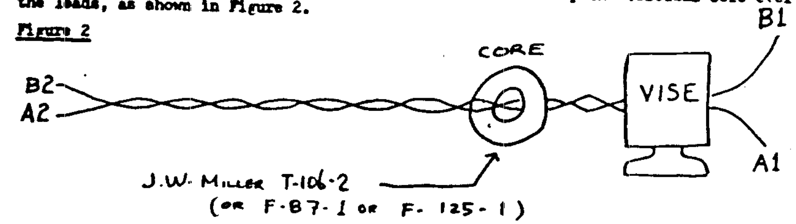
T1 is used as a phase-reversing transformer which yields phase shifting required to establish some nulls.

Cut 2 pieces of #28 enamelled solid magnet wire to a length of approximately 2 metres/6½'. Label one end of one of the wires 'A1'. Label the other end of that wire 'A2'. Label one end of the second wire 'B1' & label its other end "B2".

Tape the 2 wires together 10 cm./4" from the A1 & B1 ends. Insert the taped part of the wires into a bench vise. Stretch the wires out taut and tape the A2 & 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.

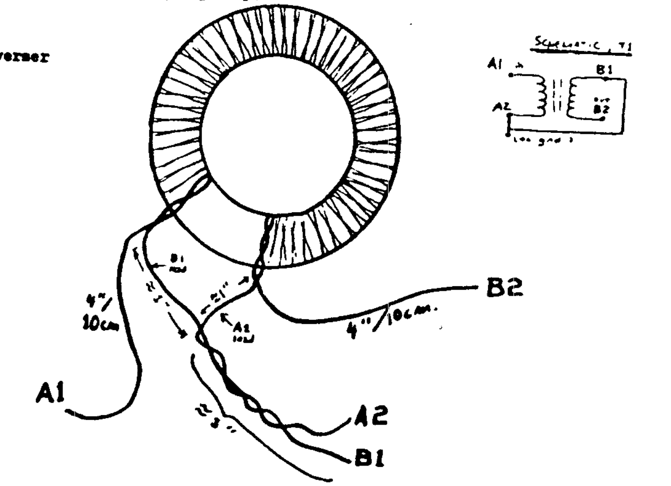
Turn the screwdriver slowly & evenly such that a twisted pair of leads is formed. One or two twists per inch along the entire length of the paired wires is the result desired. Detach the B2 & A2 ends from the screwdriver. Slip the toroidal core over the leads, as shown in Figure 2.

Figure 2



Wind 40 to 50 turns of twisted pair on the core. After that, untwist the wires between the A2 & 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"/10 cm. from the core. Detach the A1 & B1 leads from the bench vise & 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.

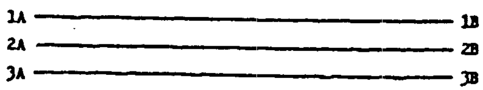
Figure 3
T1, Phase-Reverser



A38-7-3 A38 sort

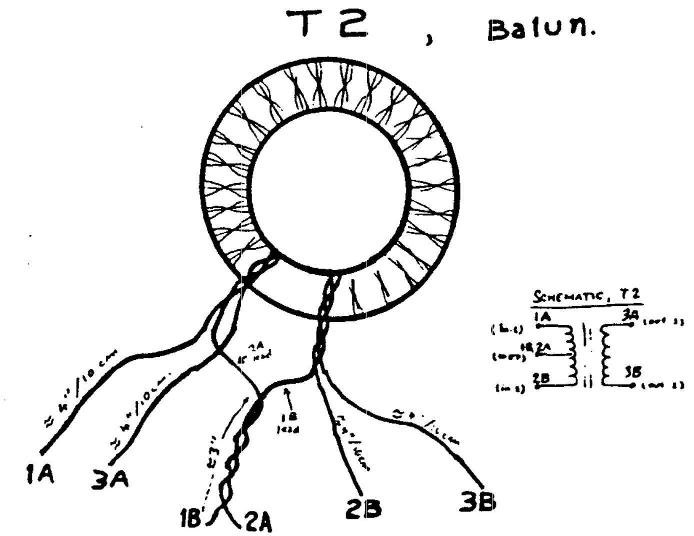
T2 is the balun transformer, necessary to provide balanced outputs. Cut three #28 magnet wire leads to 1-m./3.3' each. Using the practices employed in fabricating T1, label the leads, as in Figure 4.

Figure 4



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"/10 cm. 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



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 and the 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.

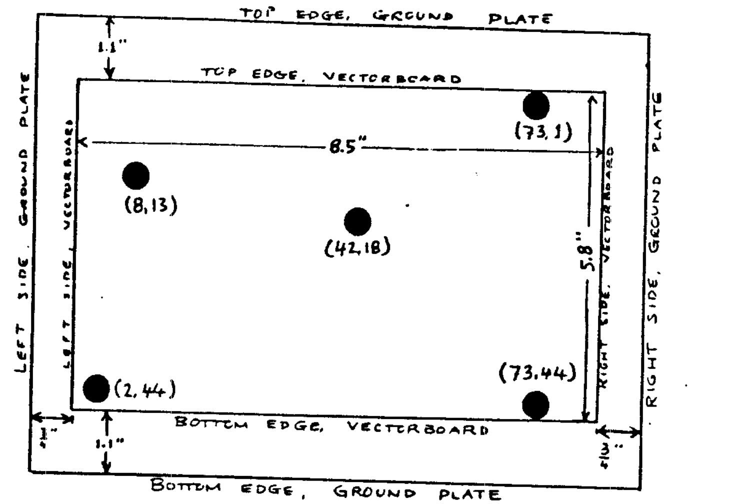
The Vectorboard with the 5 A-series holes will now be used as a template to prepare the ground plate. Other holes shown in Figure 6 will be drilled later, after the ground plate has been completed. (See page 23 for an explanation of why you can't find figure 6....bp)

3. Ground Plate (LMB "8X10 Cap Cover" or equivalent)

The ground plate is an 8" by 10" (20.32 cm. X 25.4 cm.) bare metal sheet of approximately 0.05" to 0.1" thickness. This will eventually be attached 1¼" 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 and the wiring to be built onto the backside of the Vectorboard (3) to reduce the effect of hand capacitance on tuning & nulling.

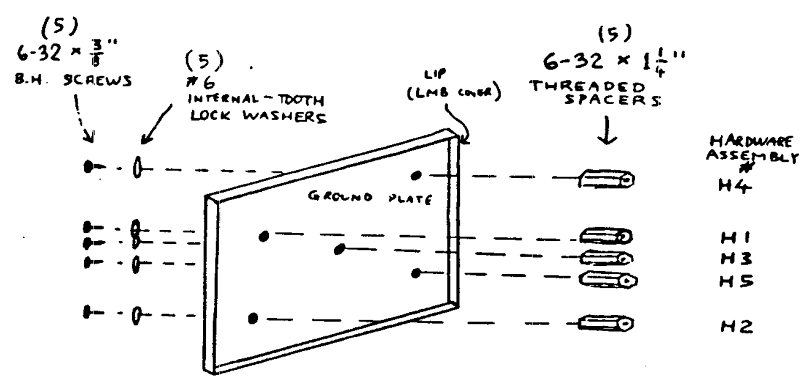
To prepare the ground plate, place the Vectorboard over the 8" X 10" metal plate. The LMB plate has an edge lip projecting ¼" perpendicular to the surface on one side. Consider the side with the lip to be the front side of the ground plate. The Vectorboard (with only "A" series holes drilled) is centred over the front side of the ground plate, in accordance with Figure 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 1¼" threaded metal spacers on the front of the plate, with 6-32 X 3/8" metal screws & #6 lockwashers on the back, as shown in Figure 8.

Figure 8



A38-7-4

4. Support Leg Assembly (optional)

Drill 2 holes in the ground plate, each 4" from the top & bottom edges. One hole is to be 2½" from the left side, the other should be 2½" from the right side. Refer to Figure 9A. Start with two 4½" long, 3/4" diameter solid cylindrical dowels, preferably metal. In the centre of one end of each dowel drill a small pilot hole no more than ½" 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 ½" 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 side (180° 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 back of the ground plate using 6-32 X 3/8" screws & #6 lock-washers on the front. Each of the two legs should appear as in Figure 9B.

FIGURE 9A
VIEW FROM FRONT
GROUND PLATE
SUPPORT LEG HOLES

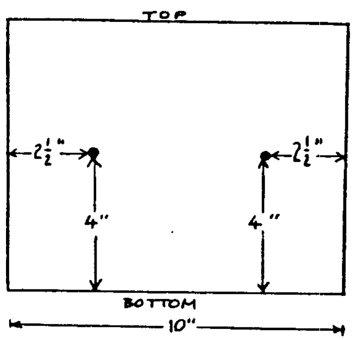
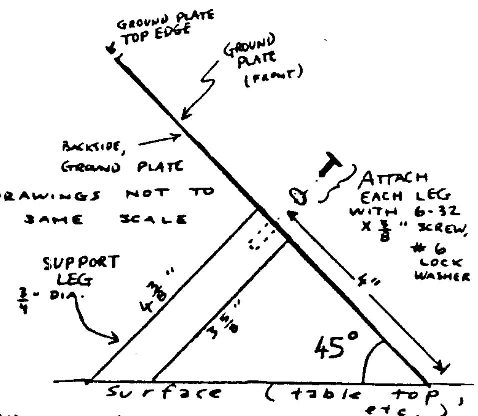


FIGURE 9B
VIEW FROM LEFT SIDE



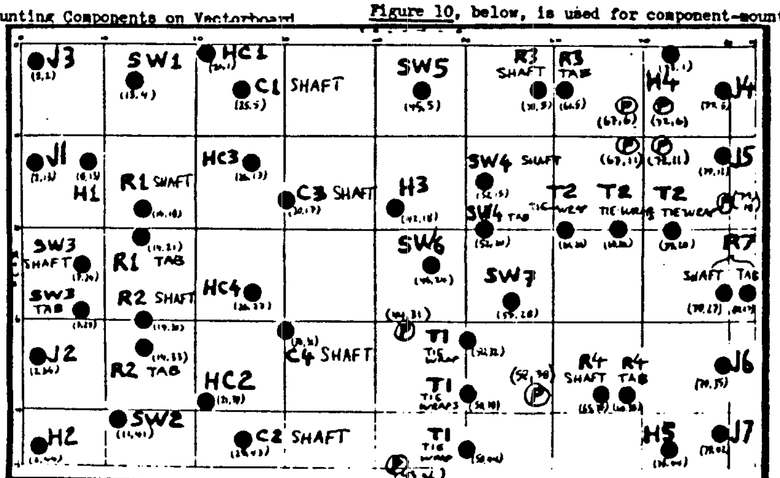
At this time, set aside the ground plate with attached legs and standoff spacers. It will be needed later.

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

Figure 10, below, is used for component-mounting.



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).

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 Ⓟ 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 centre-hole (50,38) is exactly in the centre of the toroid's "doughnut hole". From the front of the board, insert two tie-wraps through that centre-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 centre-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 centre of its "doughnut hole" over the T2 centre-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 centre 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).

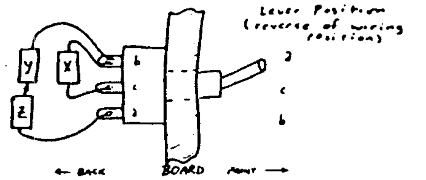
A38-7-5

A38 5 of 7

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



Assembly Drawing Designation	Inductor Value (uH.)	/ Designation (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 & L1z and that of L2y & L2z. Ensure that none of the exposed leads can be pushed into a position which could cause an undesired shorted connection.

Locate pots R3 & 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 approximately 1K with that pot turned totally clockwise. Place a 1K fixed resistor (R5) across the two terminals to be used on R3. Place 1K 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 47-pF mica capacitor (C5) from the stator lug of C1 to that of C3. Connect a 47-pF 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 ¼" long.

Ascertain which two terminals of R1 are to be used: the resistance between the correct terminals should be 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 colours 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)

I N P U T   S E C T I O N

#	From	To
1	J1	R1 in
2	R1 out	arm, SW3a
3	1, SW3a	3 (null), SW3a
4	1, SW3a	c (arm, centre), SW1
5	c (arm,centre), 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/centre, SW5a
10	arm/centre, 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, centre), SW2
17	c (arm,centre), 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/centre, SW6a
22	arm/centre, SW6a	bottom (ser.), SW6b

O U T P U T   S E C T I O N

#	From	To
23	arm/centre, 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/centre, SW6b	R4 in, jct. R6
32	R4 out, jct. R6	arm/centre, SW7a
33	top (null b), SW7a	push-pin (44,31)
34	push-pin (58,38)	J7
35	arm/centre, 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 1½ " 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 (back of board, refer to Table 3)

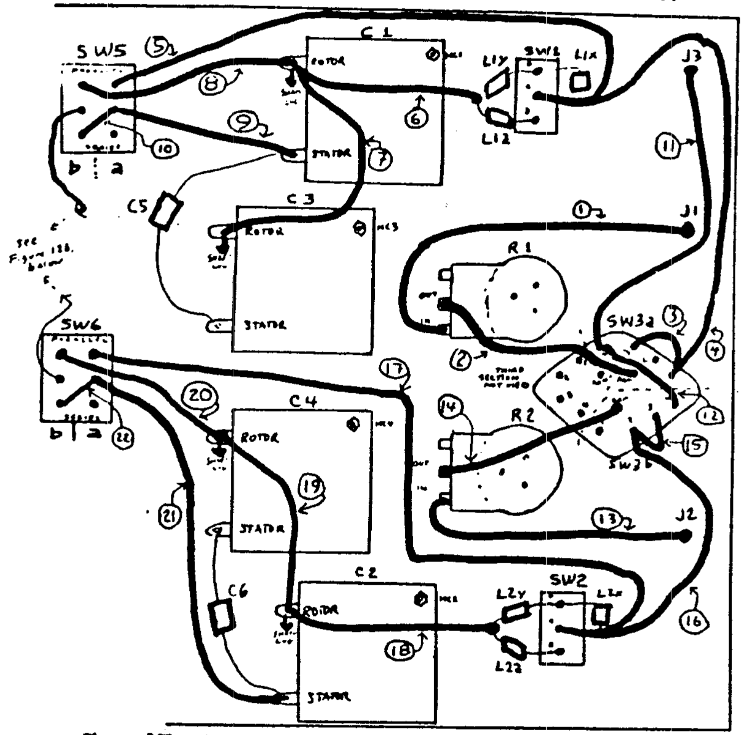
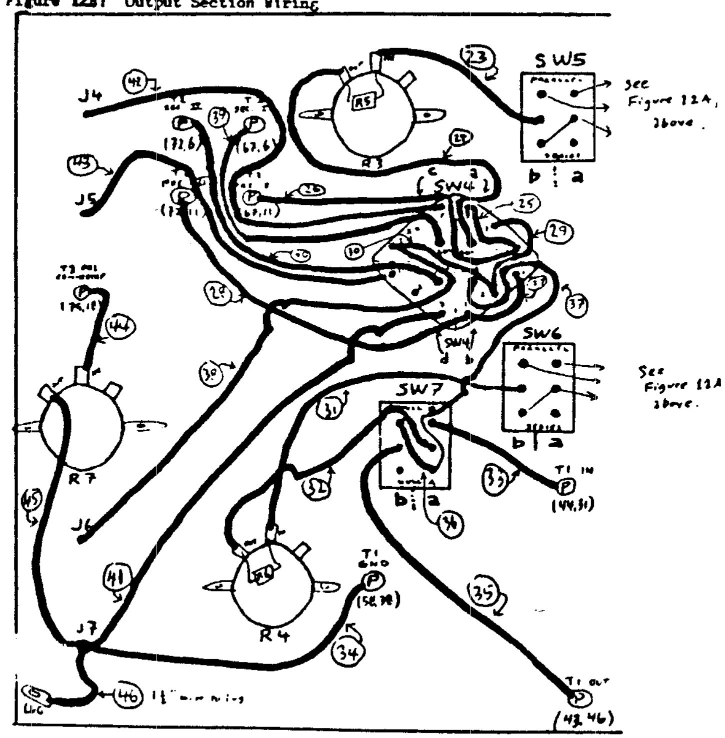


Figure 12B: Output Section Wiring



A38-7-6

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)
"	ground	A2 & B1	(58,38)
"	out	B2	(43,46)
T2	primary-I (in-I)	1A	(67,11)
"	primary-II (in-II)	2B	(72,11)
"	primary centre tap	1B & 2A	(79,18)
"	secondary-I (out-I)	3A	(67,6)
"	secondary-II (out-II)	3B	(72,6)

Cut leads to proper length, consistent with a neat layout and short runs. Strip about ¼" (maximum) of enamel varnish from lead ends & 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 & 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 & a cotton swab or with a commercial de-fluxer.

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); & 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 30 m./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 1 m./3.3' length of coaxial cable (RG-174 or equivalent) from J6 (centre, or 'hot' conductor) & J7 (shield/ground/outer conductor) to the receiver input & to receiver ground. The coaxial cable to be used should be fitted with banana plugs on the end attached to the phasing unit & with the appropriate receiver input connector(s) at the opposite end.

If a receiver with balanced (dual) inputs is to be used, run about 1 m./3.3' of TV Twinlead or "AC zip cord" from J4 & 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 the finished phasing unit, interesting DX should now be possible.

NEXT WEEK: Part 2, in which you find out how to use the phasing unit. In the meantime, you can have fun tweaking the knobs to see what happens, hi. The elusive figure 6 will also appear. This is a drilling layout, which is basically the same layout as figure 10, parts layout, except it shows what sized holes to drill. If you're smart enough to build this thing before you get next week's DXM, then you're smart enough to figure out what sized drills to use to make the holes, hi. --bp

PHASING UNIT CONSTRUCTION

Part II

by Mark Connelly

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 Trans-Atlantic 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 & 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 & 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 balanced if receiver has balanced dual inputs, or to unbal-2 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 initial unbalanced nulling should be done in the unbal-2 condition. This is because unbal-2 condition, using the balun, provides greater isolation between inputs & outputs, hence less stray coupling & 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 & #1 trim pot to zero ohms (fully counterclockwise).
   - (c) #1 trim cap. to centre (halfway between fully meshed plates & 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	" "
3		c , 740 uH	" "
4		a , 103 uH	series LC
5		b , 270 uH	" "
6		c , 740 uH	" "

   When the sharpest, highest gain peak in signal level is found, leave the #1 L & LC switches & 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 & #2 trim pot to zero ohms.
   - (c) #2 trim cap to centre (halfway between fully meshed plates & fully open plates).
   - (d) Play the #2 main cap., the #2 L switch, & the #2 LC switch to open a distinct, good peak signal, in the same fashion as that of step (d) of the "PEAK #1 LC" subroutine. The #2 L & 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 & 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-perceptible 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 by tweaking the #1 & #2 trim caps. & the #1 & #2 trim pots. The ground pot. may also have a favourable effect on obtaining some nulls. If the unbal-2 SW4 position was used up to this point & the desired station left after nulling seems too weak, switch to unbal-1. After a slight retweaking of trim caps. & trim pots, a null of the pest giving a greater wanted-station level may occur in some circumstances.

Nulls should be attainable in about 4 out of 5 situations, using the method above. In cases where sufficient cancellation of an unwanted station does not occur, the above procedure can be re-iterated with the <u>null switch</u> on <u>null mode a</u>. That should assist in obtaining more of the desired nulls. Some nulls may be impossible with a particular pair of wires. It is strongly advised 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 well. TADX is best heard by using the phasing unit to subtract the pest 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 <u>when the wires are shorter than 152 m./500'</u>. 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 vs. 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.

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

DRILL BIT CHART

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

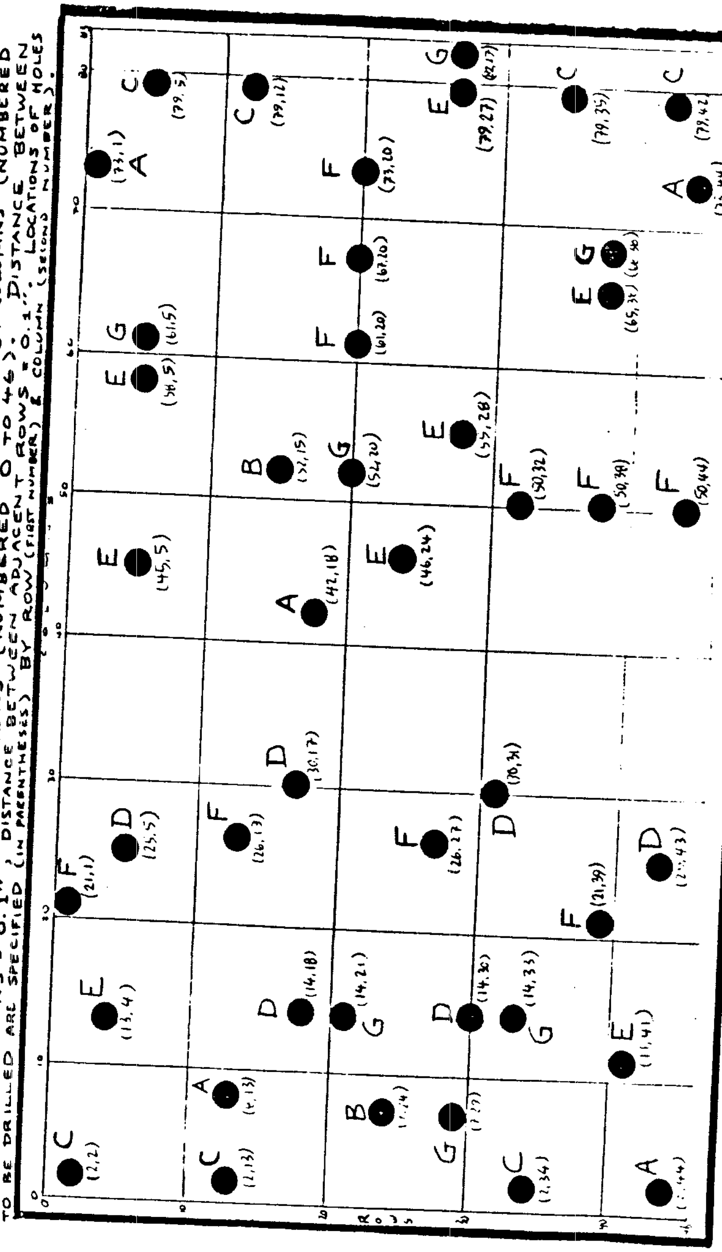
WTNE
TOWN HOUSE OFFICE BLDG.
TRENTON, TENN.
38382

To the left and on <u>the next page:</u>
<u>Figure 6, left out</u>
lastweek due to
space limitations

<u>Below:</u>
<u>From Electronic</u>
<u>Design 8-6-81</u>

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.