is constructed out of several layers of spring material and backed up with a heavy brass or plated-steel armature for the switch contact rotary section. This type of switch is typical of a surplus heavy-duty RF switch removed from older military surplus. Usually it is so heavy it must be mounted on a panel in order to operate the manual switch from one position to the other. It switches into position with a loud "snap" sound, making very evident it switched.

I would hesitate to use this type of switch above 20 MHz and rate it iffy at best near that frequency. An improvement would be to mount the rotary switch in a metal box and fix connectors for each switch contact. As you look inside the metal box of such a switch and its wiring, you can see that there is a certain amount of coupling between each section of the switch. In other words, there is still some coupling (poor isolation) between sections of the switch that are in proximity to each other. Think of the operation as coupling between a tangle of clip leads scattered on your workbench.

To test this isolation, you just run a test signal through the closed contact path and test at the open contact to see how much of the signal leaks through to here and its connecting leads (see **Fig. 2**). What you want to see is lots of isolation and very little signal leaking through. The measure of the loss is the rating of isolation, usually expressed as dB isolation. In this simple switch loss is low, giving it a poor rating above 20 MHz because of poor isolation as frequency is increased above a point. Operation at lower frequencies is quite proper.

The reason you want high loss between the switch contacts is that a transmit path might have 100 watts of power going to the antenna. The open contact is the receiver, and if the isolation is poor, an appreciable amount of power will be coupled into the front end of the receiver. This is not what we want to happen. With a receiver sensitive to minus 100 dB and transmitters with output powers in the 100 watt category (+50 dB), it is safe to assume that a great switch would have isolation in the 50 dB or better range to protect the equipment (receiver) it is switching.

Coupling (poor isolation) is the bane of any coaxial relay circuit. If the frequency is low, the extraneous wiring can be tolerated because the wavelength at these lower frequencies is quite lengthy and short hookup wiring techniques are tolerated. As the frequency rises, shorter wiring methods must be used to limit excess wiring and its associated coupling. All is not lost, as there are switch layouts that help to minimize coupling between switch elements and make them virtually invisible to each other.

What layout can we use to provide low coupling or high loss between adjacent elements of the switch? Well, when we think it out, it can be shown that the best switch would duplicate as best it could a manual coaxial connection. The switch would look in this scenario like a manual coaxial switch panel. The switch panel is one that is entirely made up of coaxial connectors and one patch cord (coaxial). When you wanted to select a new port, you would have to unscrew the connector and move the cord to the new port connector. Not very practical, but very efficient in minimizing coupling and effecting very high isolation, which is excellent.

What is needed is a mechanical contrivance that duplicates this action to obtain the very best in isolation and at the same time maintain almost zero coupling between ports—just like the previous coaxial connector-and-cord scenario. I am not dreaming, as some of you might suspect by now, but rather I am just trying to make you aware of what is going on and how important isolation can be.

The switch that conforms to this design principle is made by Transco. Its operation is exactly what was previously described in a manual-patch cord scenario. The switch I tested has manual operation and six possible output ports. It exhibits all the quality of the coaxial connector-and-cord operation in a very compact rotary coaxial switch. It uses a spring contactor coaxial hairpin, allowing contact in a coaxial environment with only one contact between the selected main input/output connector. To switch it to another position by manual rotary action, it has a cam action to unseat connections before reseating into the new selected position.

There is virtually no coupling between the main and unselected switch ports, due to the excellent shielding between master and selected rotary contact all done in a coaxial environment. This minimum coupling is accomplished by this cam-operated coaxial hairpin internal to the switch. In all respects this hairpin is just like unscrewing a connector and transferring it to another connector.

As far as isolation goes, the other connectors might as well be in the junk box as you cannot see them with this type of mechanical contact switching. The other unused connectors are out of the picture, electrically speaking. The selected path and its connector are totally coaxial and shielded from everybody else.

The Transco switch is quite robust; I have used it to 450 MHz with no problem. This switch must be bolted to something sturdy, as it does require a few pounds of pull to rotate the switch. You need this hard mounting in order to turn the switch by hand. It has quite a stiff cam action and produces a sharp "snap" sound (of the kind mentioned earlier) when the coaxial hairpin is reseated.

The relay that I show in **Fig. 1** and use at 10 GHz is quite small and uses miniature SMA coaxial connectors. The coax cable that is used has Teflon™ insulation and relatively low loss at these frequencies. As you can see in **Fig. 1**, when the relay has current flowing through the coil it attracts the armature to the pole piece on the coil. This activates the armature in a teeter-totter type of function and uses insulated push rods that raise one end and lower the other end of the switch contacts.

The unused switch contact is pulled toward the top of the switch's enclosed chamber and grounds out on top of the switch compartment. The other element is pushed into contact with the previously open contact and the center main contact. The process reverses when relay current is removed. The internal compartment where this switching action takes place is much like a very short section of air dielectric coaxial cable with the exception that its internal dimensions are square and the impedance is 50 ohms. The impedance is determined by the ratio of inner to outer conductors.

Think of this inner-to-outer ratio as quite similar to the ratio between coaxial cable and its inner and outer conductor. The action is quite the same. When the switch duplicates as closely as it can the coaxial environment and the internal elements are a fraction of a wavelength at the frequency of interest, it will function well. 73

Number 84 on your Feedback card

HOMING IN

Radio Direction Finding

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Low-cost monitor for the NorthScope

"Is that radar in your car?" I'm not surprised when visitors to the starting point of our hidden transmitter hunts (T-hunts) ask that question. The lingering yellow glow of the lines on my cathode-ray tube (CRT) display are reminiscent of radar scopes in pre-computer times. But these lines are signal bearings, not aircraft tracks.

Continued

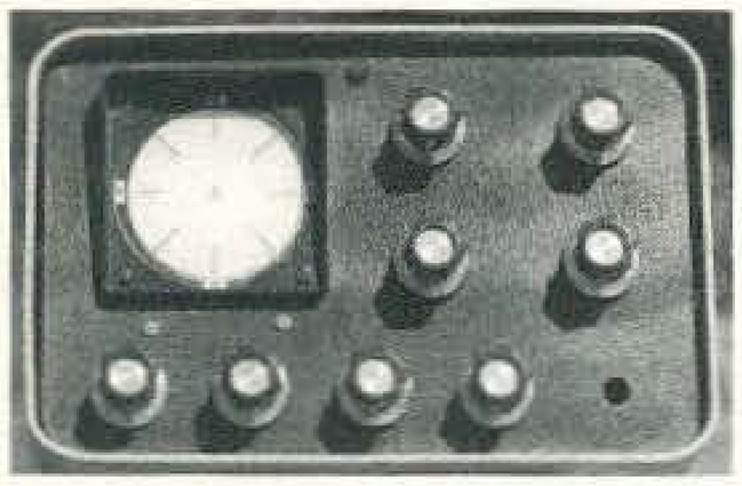

Photo A. The Heathkit Scanalyzer after repainting the front panel and replacing the grid screen under the CRT bezel with a transparent compass overlay. Next comes labeling. The hole at lower right will be filled by a future control.

This month's "Homing In" is the final installment of a series on north-referenced bearing readouts for radio direction finding (RDF). July's column covered remote heading sensor technology. An inexpensive fluxgate compass module gives you a dashboard indication of your mobile antenna mast position with respect to true north. With it, you can quickly tell if the bearing to a hidden T is steady or shifting as you drive on winding roads in the dark.

"Homing In" for August described an analog multiplier circuit that combines fluxgate compass and receiver S-meter signals to produce a "north-up" display of signal strength versus direction. I call it the NorthScope. Its polar plot simplifies the task of separating the direct signal from multiple reflections (multipath) in urban and hilly areas.

Like a radar scope, a north-up display must have persistence of several seconds so that the operator can "stack up" traces. That makes it possible to tell the difference between fluttering reflections and more stable direct signals. Ordinary oscilloscopes and computer monitors are not suitable because their persistence is only a few milliseconds. Surplus waveform storage oscilloscopes and medical monitors make fine readouts, but they require 110-volt AC power and are somewhat expensive.

A recycled boat anchor

I was searching the swap meets for parts to build a home-brew display when I discovered a '60s-vintage Heathkit SB-620 Scanalyzer. There, in one case, were all the hard-to-find items I needed—including the long-persistence CRT, mounting hardware, mu-metal magnetic shield, socket, panel, bezel, high voltage supply, and beam controls. What's more, the cabinet had plenty of room for the interface circuit with its front-panel controls.

Constructing a CRT display from scratch is possible. I built a bigger one for my high school science fair years ago, but surplus scope parts were much easier to find then. Nowadays, the modified Scanalyzer approach is far simpler and cheaper. They show up regularly in estate sales and at the three computer/electronics swap meets in my area. A recent issue of *Amateur Radio Trader* magazine had an SB-620 listed at $75. This appears to be a typical "street price." Be sure to get the manual, too.

The Scanalyzer need not be in full working condition, but the high voltage supply, CRT and beam controls (INTENSITY, FOCUS and ASTIGMATISM) should be functional before you begin the modifications. There are Internet mailing lists and Web pages devoted to "boat anchor" equipment and Heathkits that can help you locate an SB-620 and repair it if necessary. You will find links to these resources at the "Homing In" Web site. My site also has information on CRT sources and high voltage supply schematics for those who choose to build a monitor from the ground up.

The SB-620 has a 3RP7 high-persistence CRT with a 2-5/8-inch-diameter face (**Photo A**). This is quite suitable for a mobile display. I had considered the next size larger CRTs for the project, but electrostatically focused five-inch tubes are about 17 inches long, necessitating a deep enclosure. They also require much higher acceleration and deflection voltages than the 3RP7.

WARNING: Use extreme caution when working on your monitor. Voltages high enough to cause serious injury or death are present in the power supply, beam and deflection circuits. There is no substitute for caution, prudence and clear thinking when working with high voltage. Mount all circuits inside a grounded metal enclosure so that high voltage points are never exposed to the user during normal operation.

Turn off all power and wait for capacitors to discharge fully before removing the cover. With power off, short all capacitor terminals in the high voltage supply to ground with the metal shaft of an insulated screwdriver before touching any circuits. Observe all safety precautions including keeping one hand in your pocket when making adjustments and measurements with the cover removed. Do not work on HV circuits when fatigued or under the influence of medication or intoxicants. Measure high voltages only with instruments and probes designed for this purpose.

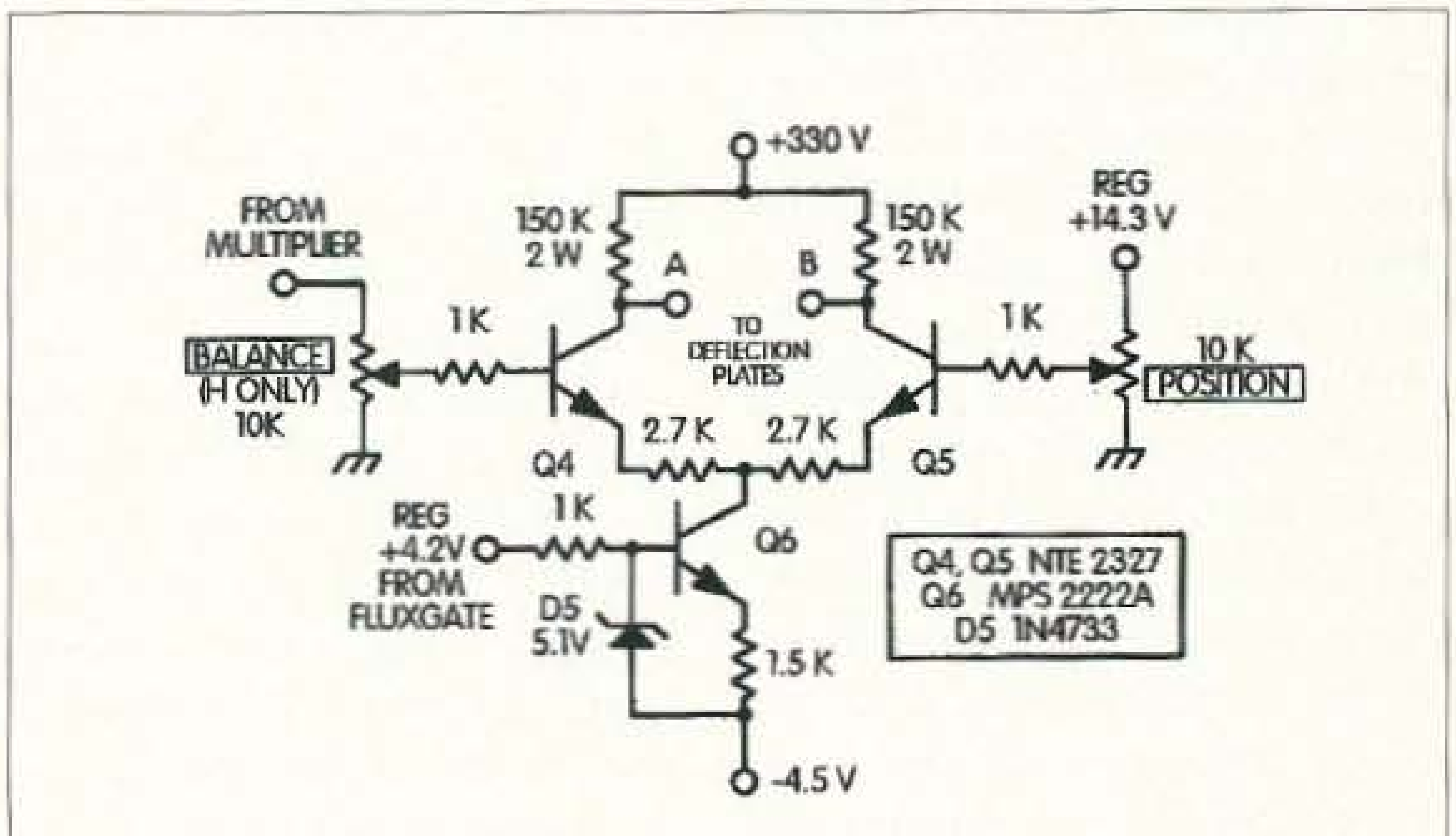

Fig. 1. Schematic of the new deflection circuits. Two are required, each with a spot positioning potentiometer on the front panel. A and B outputs of the horizontal (X) circuit go to the orange and yellow CRT socket wires, respectively. A and B outputs of the vertical (Y) circuit go to white and violet socket wires.

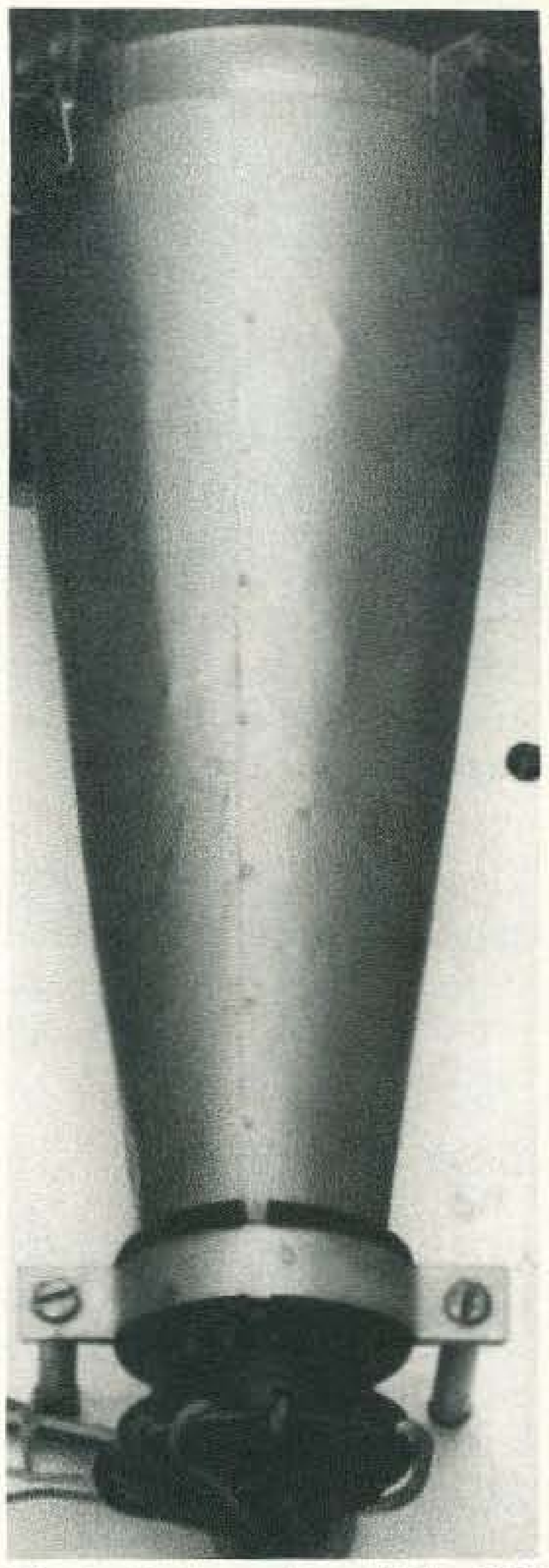

Photo B. Rear view of the CRT inside its mu-metal magnetic shield, with socket. Leave the shield on the CRT to prevent spurious deflection due to magnetic fields from the transformers.

Use care when handling a CRT due to its high vacuum. Do not

Photo C. Components in the CRT cathode supply are as originally described in the SB-620 manual. Note the long insulated bushing on the INTENSITY control. The piggyback switch is rewired for +12 volts.

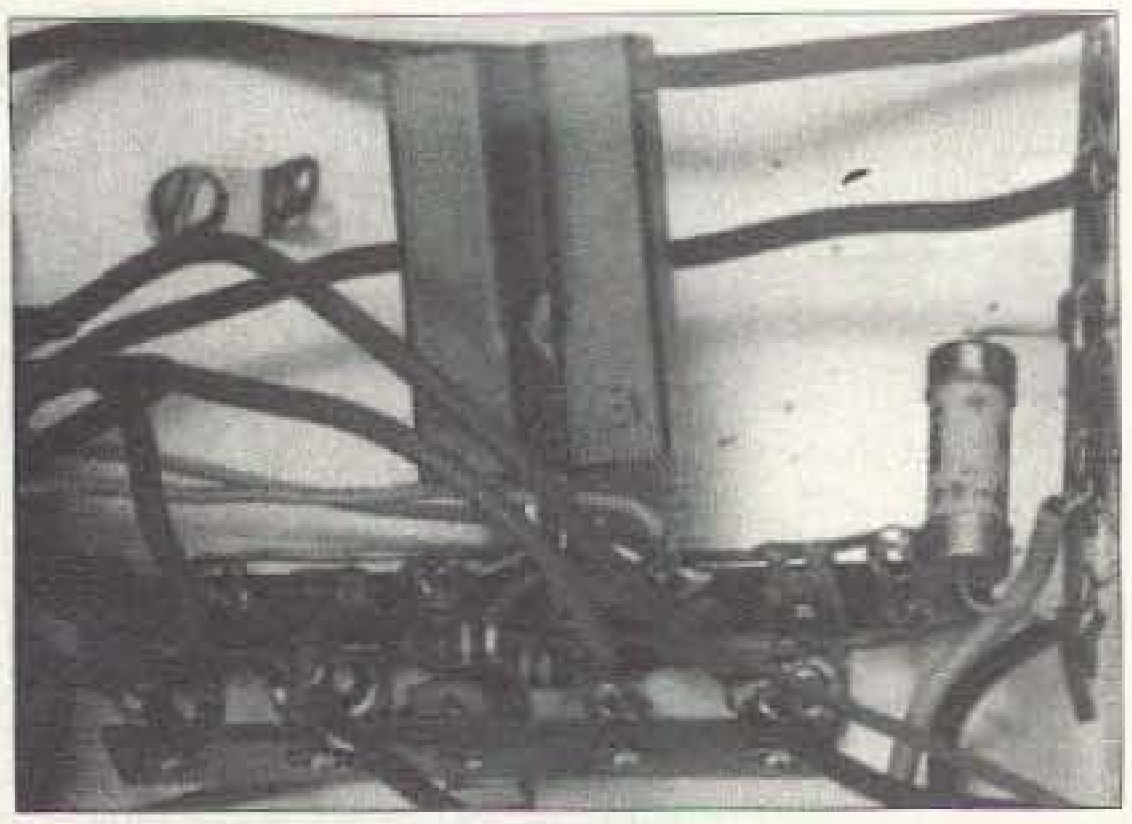

Photo D. This series regulator stabilizes the acceleration electrode and deflection supply voltages to prevent spot movement as vehicle voltage fluctuates.

strike, scratch or subject the CRT to more than moderate pressure at any time. A fracture of the glass could result in an implosion capable of causing injury.

Tubes out, ICs in

The first step in the SB-620 conversion is to remove all of the RF circuits, tubes, tube sockets and associated components, except for the CRT of course. The INTENSITY and FOCUS potentiometers are used as is. All other front panel controls are no longer needed. Replace and rewire them with switches and potentiometers for the new INPUT, BALANCE, HORIZONTAL POSITION, VERTICAL POSITION, SIZE and OFFSET controls.

Disconnect the violet, orange, white and yellow CRT socket wires at the chassis end, leaving the other socket wires connected to the supply (**Photo B**). Leave all power supply components and wiring intact for now. Note that the INTENSITY control has an extended insulated shaft and bushing. For high-voltage safety, be sure this is assembled per the construction manual and **Photo C**.

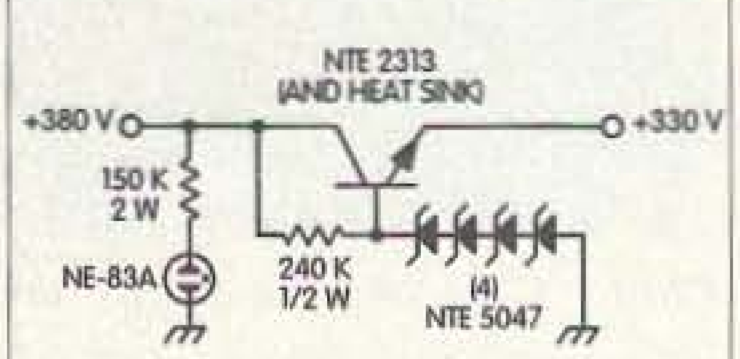

Fig. 2. Schematic of the +330-volt regulator. The NE-83A indicator and 33k resistor are on the original SB-620 front panel.

Build and install new X and Y deflection circuits per **Fig. 1**. A perfboard photo is in last month's "Homing In." The previously disconnected CRT socket deflection wires connect to these circuits. Except as noted, added resistors are quarter-watt. Higher wattage resistors must be used in some places for their greater voltage standoff capabilities.

There is only one BALANCE control, used in the horizontal deflection amplifier. It equalizes the X and Y path gains, compensating for the slightly higher horizontal deflection plate sensitivity in the CRT. When performing the alignment described last month, adjust the BALANCE control to obtain a perfect circle trace instead of a horizontal or vertical ellipse.

Only a few changes are required to the rest of the power supply and beam circuits. Rewire the on/off switch and main fuse to open the vehicle's DC input instead of the main transformer primary. The DC fuse should be two amperes fast-blow. Negative supply (-4.5 V) for the LM324 comes from the original DC heater source (D8-D11 and C54).

Deflection supply and CRT astigmatism (Anode #2) supply voltages are regulated for mobile operation. The +330-volt regulator circuit is in **Fig. 2** and **Photo D**. I built it on an added eight-terminal strip next to the five-terminal strip at position E on the chassis. Be sure to provide heat-sinking for the transistor, but do not ground the sink. Remove the wire from the top of the astigmatism control (lug #3, farthest from the power input grommet) to the positive end of C53-C in the power supply. Connect the regulator input to the positive end of C51. The regulator output goes to lug #3 of the astigmatism control and the common point of the four

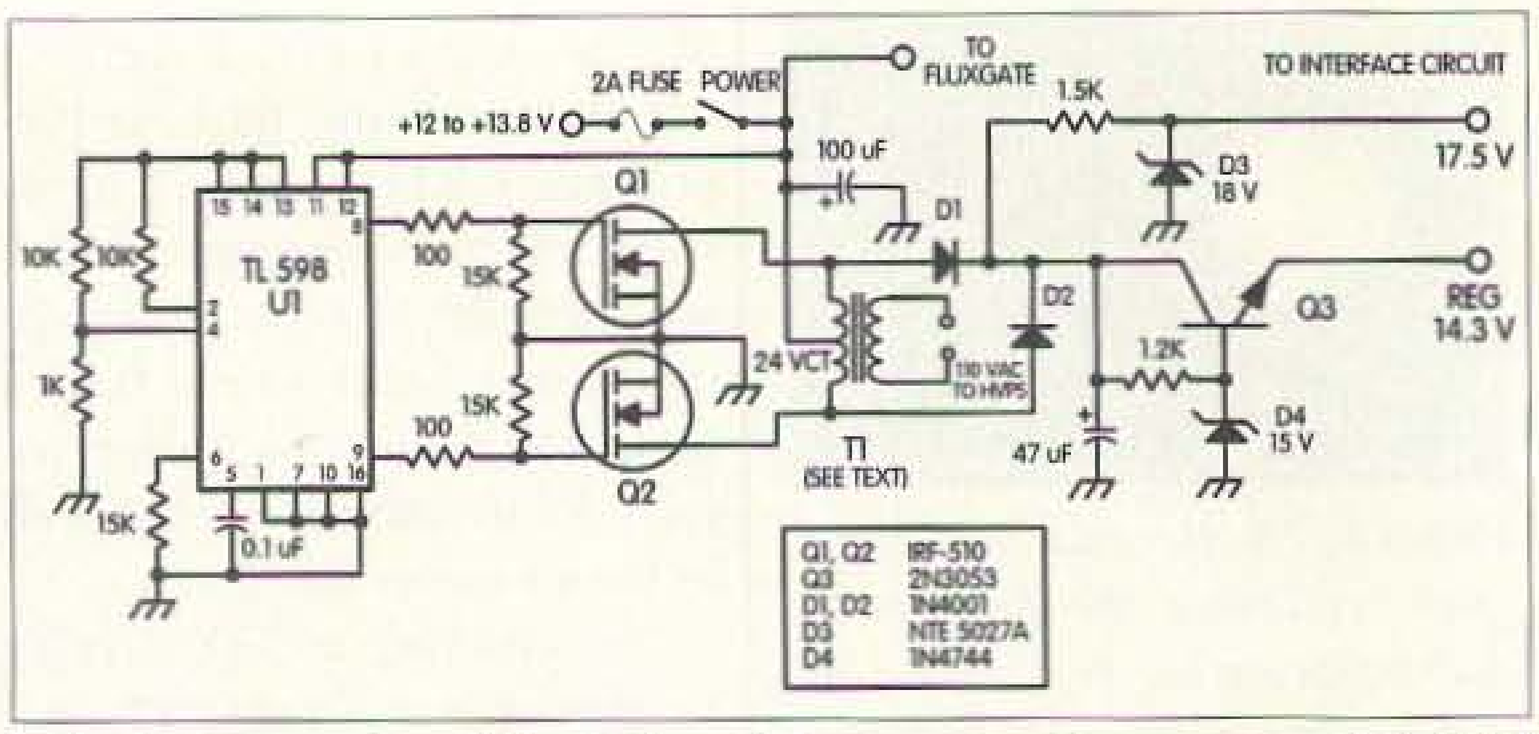

Fig. 3. Schematic of the DC-to-AC converter. Outputs are 110 VAC square-wave for the high voltage supply and positive DC for the analog multiplier circuits.

150k collector resistors in the deflection circuits.

Powering the scope from a car battery is easy with the circuit of **Fig. 3** and **Photo E**. The TL598 converter IC is available from distributors of Texas Instruments™ semiconductors. It generates alternating pulses at 500 Hz to drive the two switching transistors. Although the TL598 has provisions for voltage and current feedback, I found it to be unnecessary in this application.

Mount the transistors to the chassis with supplied insulating hardware. The transformer (Triad F-45X) is connected "backwards." Its 24-volt center-tapped secondary connects to the transistor drain pins. Output at the primary is 110 volts square wave. If you can't find the Triad transformer, you can substitute Radio Shack™ 273-1512, but output voltages will be about 5% lower.

There is no problem feeding the square-wave chopper output into the main transformer primary to operate the scope instead of a sine wave. The RMS voltage at the CRT heater is very close to the wall power value with normal +13.8-volt input. The capacitor-input high voltage supply filters produce about 35% lower voltages, compared to AC power. This is an advantage because it lowers the CRT deflection voltage requirements such that solid-state drivers of **Fig. 1** are practical. Spot brightness is more than adequate at night, but add a sunshield for daytime hunts. You can set the INTENSITY control to maximum without burning the CRT phosphors.

Except for the special components mentioned above and the NTE semiconductors, all of the new parts should be available at your local Radio Shack. NTE transistors and diodes are sold by local parts distributors nationally. My junk box played a large role in parts selection for this project. Experienced experimenters should feel free to make appropriate substitutions.

With modifications completed and the analog multiplier circuits installed, your NorthScope should be ready to align and operate. Be sure to check your work thoroughly before the first "smoke test." Warm-up time of the CRT is about 20 seconds. DC supply current is 600 milliamperes in normal operation, not including the fluxgate compass. Follow the alignment procedures given last month for the fluxgate-to-CRT interface.

Better than a Doppler?

Fans of Doppler RDF units may argue that their method is

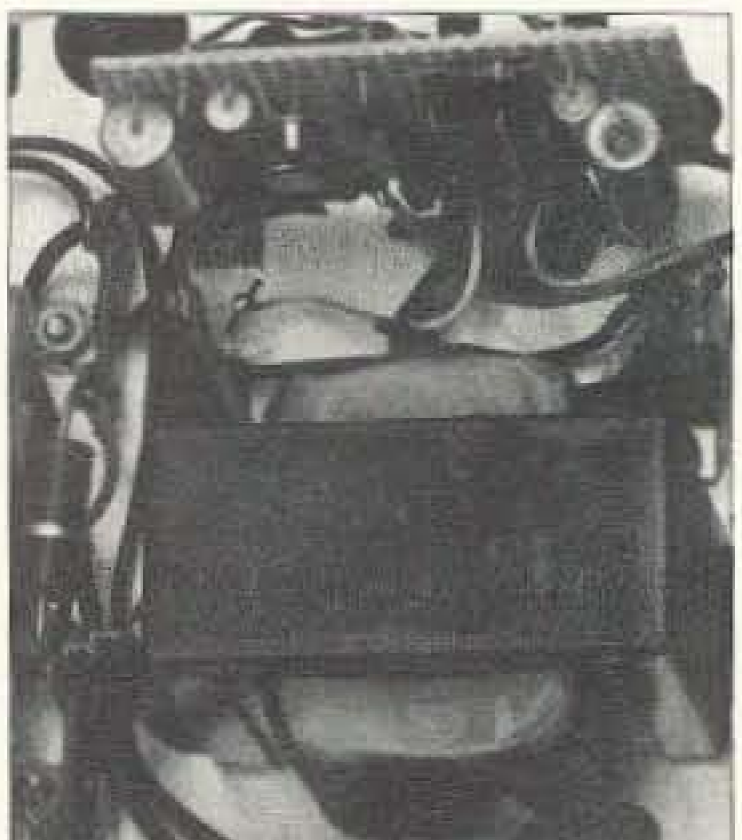

Photo E. The DC-to-AC converter circuit includes a step-up transformer, two field-effect transistors bolted to the chassis and a 2-1/2- x 1-1/2-inch perfboard with the IC and associated components.

Number 87 on your Feedback card

PROPAGATION

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The most disappointing days (VP) for DX propagation are expected to occur during the first and last two weeks of this month, particularly the 4th, 20th, 26th, and 27th, with the occasional appearance of minor to major magnetic storms in the ionosphere. Other severe geophysical upsets may also accompany these days, and an unsettled-to-active ionosphere (P) is likely as well *surrounding* these days (see calendar).

Try to use the 10-day period between the 8th and 18th to your best advantage, but always remember that propagation is where and when you find it. Forecasts made for the period between two sunspot cycles, as now, are always uncertain and subject to sudden increases in solar flux values, particularly surrounding VP days on your calendar. Stay alert and *listen*. We're overdue for some DX surprises.

10–12 meters

Generally Poor, except for occasional transequatorial propagation with F2 openings on the best days—most likely South and Central America.

15–17 meters

DX to Africa and Latin America on the Good days possible, with short-skip out to about 1,000 miles or so in the US.

20 meters

Your best band for DX openings around the world from dawn to dark, and openings to the Southern Hemisphere after dark in evening hours. You can expect excellent short-skip during the daytime to 2,500 miles or so.

30–40 meters

These bands ought to be open for DX from just before sunset to just after sunrise. Signals from the east should peak until midnight, and after midnight to other areas.

SEPTEMBER 1997						
SUN	MON	TUE	WED	THU	FRI	SAT
	1 F	2 F-P	3 P	4 VP	5 P	6 P-F
7 F	8 F-G	9 G	**10** G	**11** G	**12** G	**13** G
14 G	**15** G	**16** G	**17** G-F	**18** F-P	**19** P	**20** VP
21 P	**22** P	**23** P	**24** P	**25** P-VP	**26** VP	**27** VP
28 VP-P	**29** P	**30** P-F				

Daylight short-skip of about 500 miles will be possible, and nighttime short-skip to 1,500 miles or more will be available.

80 meters

Occasional DX to various areas of the world should be possible between sunset and sunrise when QRN levels permit on Good (G) days (see calendar). Short-skip during darkness to 1,500 miles or more.

160 meters

Following the usual summertime slump, this band ought to begin to come alive again during the hours of darkness when QRN permits. Try the days marked G on the calendar for best results. DX toward the east until midnight, and to other areas afterwards until dawn. Short-skip to 1,500 miles will prevail when the band is quiet.

EASTERN UNITED STATES TO:												
GMT:	00	02	04	06	08	10	12	14	16	18	20	22
ALASKA							20	20				
ARGENTINA								15	15	15	15	15
AUSTRALIA						40	20	20			15	15
CANAL ZONE	20	40	40	40	40		20	15	15	15	15	20
ENGLAND	40	40	40				20	20	20	20		
HAWAII		20			40	40	20	20				15
INDIA							20	20				
JAPAN							20	20				
MEXICO		40	40	40	40		20	15	15	15	15	
PHILIPPINES							20	20				
PUERTO RICO		40	40	40			20	15	15	15	15	
RUSSIA (C.I.S.)							20	20				
SOUTH AFRICA									15	15	15	
WEST COAST			80	80	40	40	40	20	20	20		
CENTRAL UNITED STATES TO:												
ALASKA	20	20						15				
ARGENTINA										15	15	15
AUSTRALIA	15	20				40	20	20				15
CANAL ZONE	20	20	40	40	40	40			15	15	15	20
ENGLAND		40	40					20	20	20	20	
HAWAII	15	20	20	20	40	40	40					15
INDIA								20	20			
JAPAN								20	20			
MEXICO	20	20	40	40	40	40			15	15	15	20
PHILIPPINES								20	20			
PUERTO RICO	20	20	40	40	40	40			15	15	15	20
RUSSIA (C.I.S.)								20	20			
SOUTH AFRICA										15	15	20
WESTERN UNITED STATES TO:												
ALASKA	20	20	20		40	40	40	40				15
ARGENTINA	15	20		40	40	40					15	15
AUSTRALIA		15	20	20			40	40				
CANAL ZONE			20	20	20	20	20	20				15
ENGLAND									20	20		
HAWAII	15	20	20	40	40	40	40					15
INDIA		20	20									
JAPAN	20	20	20			40	40	40			20	20
MEXICO			20	20	20	20	20					15
PHILIPPINES	15						40		20			
PUERTO RICO			20	20	20	20	20	20				15
RUSSIA (C.I.S.)									20			
SOUTH AFRICA										15	15	
EAST COAST		80	80	40	40	40	40	20	20	20		

faster than the NorthScope (hundreds of bearings each second) and that Dopplers latch onto short transmissions with ease. PIN-diode-switched Doppler arrays have no moving parts and are much less conspicuous than a big beam. Dopplers are a bit easier to use in a fast-and-furious T-hunt because they have fewer controls to adjust.

Those claims are true, but a beam/CRT configuration tops Dopplers in other important respects. A high-gain antenna makes it much more sensitive, so you can hunt stations at much greater distances. With a twist of the quad's boom, it can track horizontally polarized foxes with the correct polarization, while Doppler users are always stuck with vertical antennas.

The biggest advantage of a scope is its ability to analyze multipath and multi-signal situations. It separates the directions of direct and reflected signals. On the other hand, a Doppler set must give a single bearing indication for each rotation of its array, no matter how many signal components are present. A polar plot gives a moving picture of the channel that clearly displays multiple stations. The operator can identify each one by ear from the receiver audio as the beam goes around. You'll appreciate this feature when you are jammer hunting, because it becomes easier to separate the jammer's signal from that of the station being jammed.

One more plus for the NorthScope: Multiple overlaid sweeps on the CRT will show bearings of single sideband stations and pulsed noise sources. Dopplers, on the other hand, will not, because they require carrier-type signals. They aren't designed to track emissions with large amplitude variations. 73