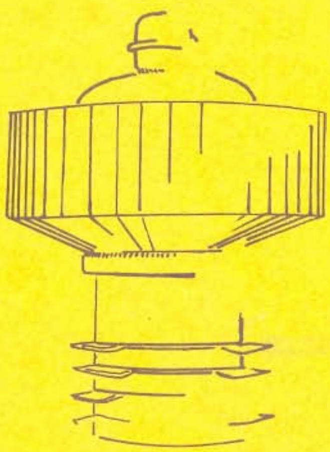
amateur service newsletters

WILLIAM I. ORR

W6SAI



EIMAC

DIVISION OF VARIAN

301 Industrial Way
San Carlos, California

amateur service newsletters

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USE OF TRIODE CONNECTED TETRODES AS GROUNDED GRID AMPLIFIERS

The tetrode tube may be connected for hi-mu triode operation by placing the grid and screen elements at the same d.c. and signal potential (figure 1). Low-mu triode operation may be approximated with the same tube by connecting the screen to the plate (figure 2). This connection is not recommended for grounded-grid operation, as the tube amplification factor is extremely low.

Hi-mu triode connection, however, offers several advantages for sideband operation. First, no grid bias or screen power supplies are needed. In addition, the drive level of the grounded grid stage is compatable with the power output level of the modern sideband exciters. Finally, neutralization is not required in a properly designed amplifier employing modern tubes.

Certain tetrodes do not perform well when connected in the grounded grid configuration of figure 1. These tubes are characterized by high perveance, together with extremely small spacing between the grid bars, and between the grid structure and the cathode. Thus, while performing in excellent fashion as high gain tetrodes, this family of tubes are unsuited for grounded grid operation. Tubes of the 4-65A, 4X150A/7034, 4CX250B and 4CX1000A type are in this class.

For proper operation of the tetrode the screen requires much larger voltages than the control grid. When these electrodes of these high perveance tubes are tied together the control grid tends to draw tremendous currents and there is grave risk of destroying it. For example, in the following table, the control grid current of the 4X150A is 1.3 amperes at the positive peak of the driving cycle and the screen current is about 0.5 amperes. At the same instant, the plate current is only about 0.8 amperes. In other words, the plate is getting only a third of the current emitted by the cathode instead of nearly all the current! By any standards, such a triode is unsatisfactory. Observe that the grid dissipation is one thousand times as great for the high-mu connected tetrode as it is for the tetrode-biased tube.

4X150A Tetrode Comparison of Tetrode Biased and High-mu Triode Operation of Driven Cathode Amplifiers

	Hi-mu (Not recommended)	Tetrode Biased	
D-C Plate Voltage	2000	2000	volts
D-C Screen Voltage	0	250	volts
D-C Grid Voltage	0	- 50	volts
D-C Plate Current	250	250	ma
D-C Screen Current	105	20	ma
D-C Grid Current	305	3	ma
Plate Dissipation	145	145	watts
Screen Dissipation	5.7	6.3	watts
Grid Dissipation	18	0.02	watts
Plate Power Output	355	355	watts
Plate Power Input	500	500	watts
Driving Power	38	13.0	watts
Stage Gain	10	28	
Cathode Impedance	86	120	ohms

By far the best way to operate tetrodes such as the 4X150A, 4X250B or 4CX300A in a cathode driven linear amplifier is to ground the grid and screen through bypass capacitors and to operate them at their rated d.c. voltages, as shown in figure 3. The grid dissipation reduces to little or nothing when this is done and the stage gain is greatly increased. The screen dissipation is nearly the same as in the tetrode connection. Greater stage gain can be obtained with this circuit because the driver does not have to supply large screen and grid losses. If it is desired to dissipate some excess of driving power, it should be expended in a resistive load (figure 4).

Tetrodes such as the 4-125A, 4-250A, 4-400A and the 4-1000A are suitable for connection as grounded grid tetrodes because of their more favorable current division characteristic. In the case of the smaller tubes, the maximum power capability is limited by maximum grid dissipation.

The following ratings apply to these tubes for triode connected, grounded grid service.

OPERATING CHARACTERISTICS, EIMAC TETRODES, GROUNDED GRID CONFIGURATION

4-125A

D-C Plate Voltage	2000	2500	3000	volts
O-signal D-C Plate Current	10	15	20	ma
Single-Tone D-C Plate Current	105	110	115	ma
Single-Tone D-C Screen Current	30	30	30	ma
Single-Tone D-C Grid Current	55	55	55	ma
Single-Tone Driving Power	16	16	16	watts
Driving Impedance	340	340	340	ohms
Load Impedance	10,500	13,500	15,700	ohms
Plate Input Power	210	275	345	watts
Plate Output Power	145	190	240	watts

4-400A

(ratings apply to 4-250A, within plate dissipation rating of 4-250A)

D-C Plate Voltage	2000	2500	3000	volts
Zero-Signal d.c. Plate Current	60	65	70	ma
Single-Tone d.c. Plate Current	265	270	330	ma
Single-Tone d.c. Screen Current	55	55	55	ma
Single-Tone d.c. Grid Current	100	100	100	ma
Single-Tone Driving Power	38	39	40	watts
Driving Impedance	160	150	140	ohms
Load Impedance	3950	4500	5000	ohms
Plate Input Power	530	675	990	watts
Plate Output Power	325	435	600	watts

4-1000A

D-C Plate Voltage	3000	4000	5000	volts
Zero-Signal d.c. Plate Current	100	120	150	ma
Single-Tone d.c. Plate Current	700	675	540	ma
Single-Tone d.c. Screen Current	105	80	55	ma
Single-Tone d.c. Grid Current	170	150	115	ma
Single-Tone Driving Power	130	105	70	watts
Driving Impedance	104	106	110	ohms
Load Impedance	2450	3450	5550	ohms
Plate Input Power	2100	2700	2700	watts
Plate Output Power	1475	1870	1900	watts

In all cases, grid current should be monitored. This may be accomplished by grounding the control grid through a 1-ohm composition resistor, bypassed by a .01 µfd disc ceramic capacitor (figure 5). The R-C combination serves to hold the control grid very near to ground potential. Grid current is monitored by measuring the voltage drop across the resistor. The indicating meter is calibrated in terms of grid current. For example, to have a meter range of 100 milliamperes, the series resistor plus the internal meter resistance should equal 100 ohms.

For voice operation, the plate or grid current (as read on the meter) will reach some peak value less than the single tone meter reading. Under average conditions, the "voice" current peaks should be approximately one-half the indicated single tone current. For example, a single tone plate current of 300 ma is approximated by voice meter peaks of 150 ma. Driving the indicated voice meter peaks to equal the value of single tone current will result in severe overload distortion.

Use of a high-C tuned cathode circuit in any grounded grid amplifier is mandatory if maximum efficiency and lowest intermodulation products are desired. The circuit need have only a Q of 2 or so.

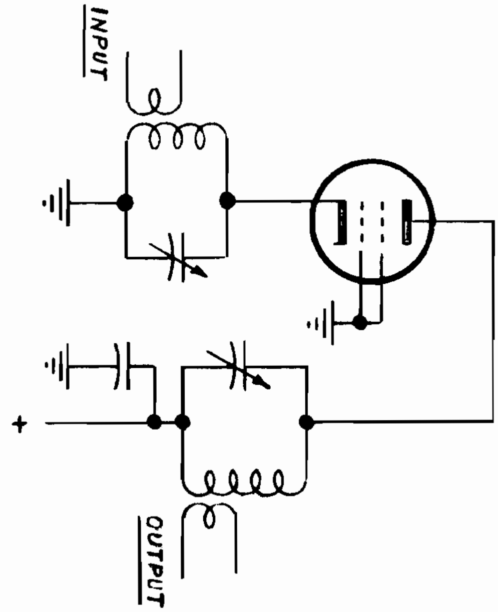


FIGURE 1

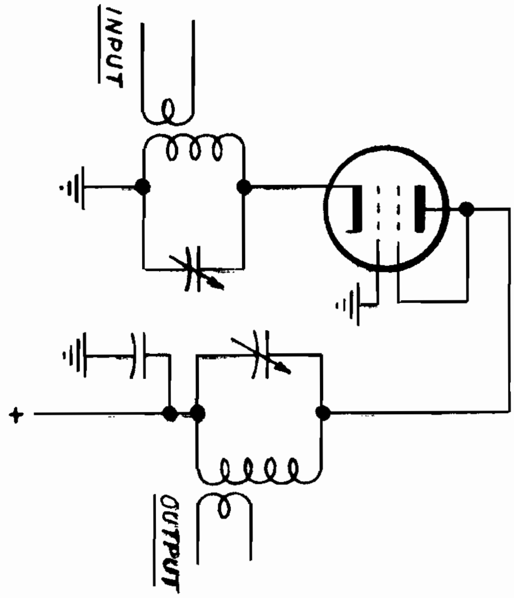


FIGURE 2

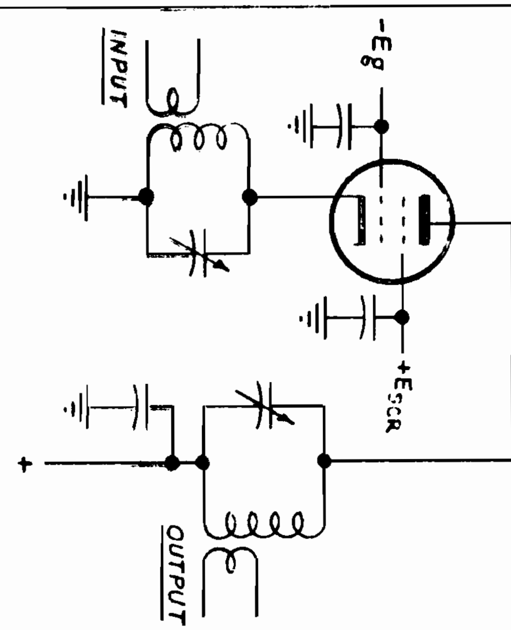


FIGURE 3

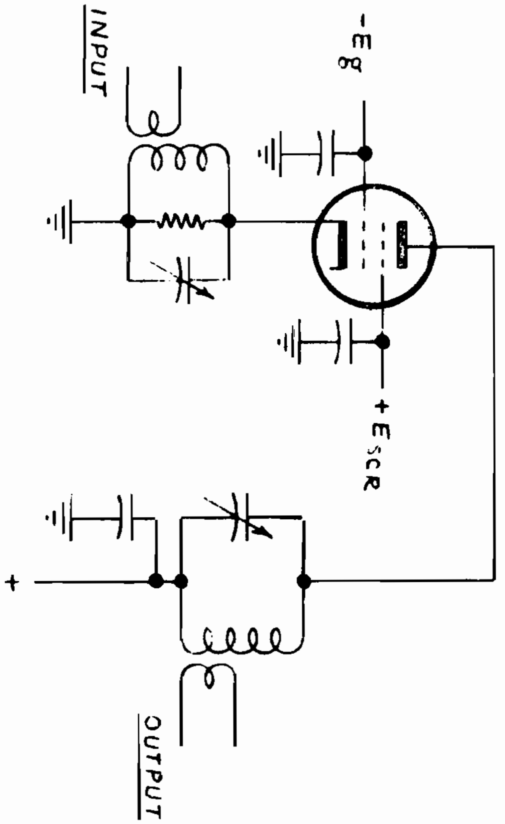


FIGURE 4

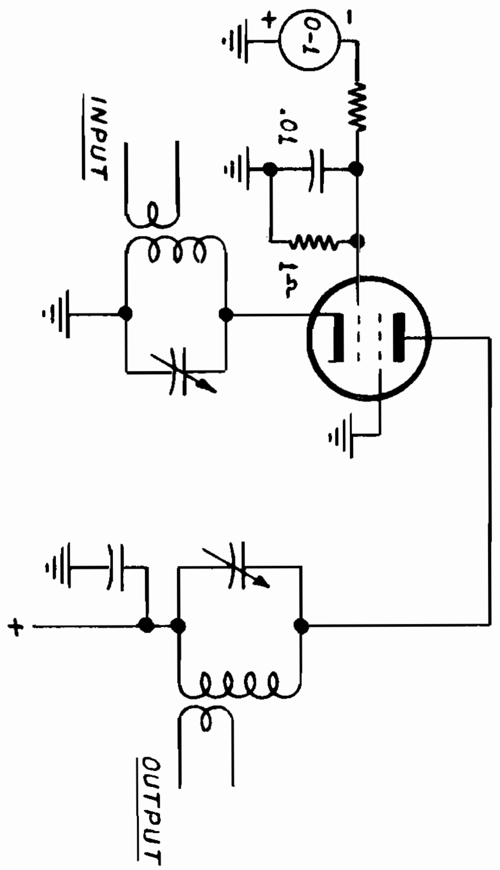


FIGURE 5

The 4-1000A in Grounded Grid

Fig. 1—K9LKA's kilowatt 4-1000A grounded-grid amplifier. Meters across the top of the panel are, from left to right, for plate voltage, relative r.f. output, plate current and grid current. The band-switch control is in the center, flanked by the plate tuning control and capacitor switch S_2 on the left, and the output loading control on the right. Along the bottom are the filament switch, panel lamp and fuse; r.f.-indicator sensitivity control, and the input tuning control.

Most high-power triodes available at surplus prices do not have a sufficiently high amplification factor to permit zero-bias operation. Tetrodes may be converted to high-μ triodes by connecting the screen to the control grid. However, in the case of most tetrodes, this connection results in excessive control-grid dissipation at the driving-power level required to obtain normal rated output. The 4-1000A is one of the few exceptions to this rule[1] and is also one that is available in usable condition at relatively low cost from a number of sources. The triode connection results in considerable circuit simplification, especially in grounded-grid operation, since regulated bias and screen supplies are eliminated and neutralization is not required.

Zero-Bias Triode Operation in a 1-Kw. Linear

By LARRY KLEBER,* K9LKA

Many construction articles describe radio gear that is almost impossible to duplicate with facilities available to the ordinary ham because of unusual mechanical requirements. Complicated gearing, chain drives or special metal shapes that require power tools found only in machine shops sometimes cause an otherwise excellent article to be passed by. In addition to the mechanical problems, cost is frequently completely out of reach for the would-be constructor.

Here is a kilowatt linear amplifier covering 10 through 80 meters that has several features to recommend it to the fellow who wants to increase power. First of all is the cost. Using all new parts, except the meters which are readily available from used- or surplus-equipment sources, the total expenditure will be less than \$150 plus the cost of the tube. If you are willing to do some horse trading, scrounging and junk-box raiding, you can do it for considerably less. Type 4-1000As from broadcast or police radio transmitters are readily available at prices from \$20 to \$50. Surplus JAN tubes are listed by several *QST* advertisers, and they are regularly offered in Ham-Ads. Remember, the Eimac 4-1000A is built like a Mack truck and, once you have acquired one of these tubes in good condition, you can expect years of satisfactory service if you don't abuse it by overdriving the grid. That is why a grid-current meter is mandatory.

Secondly, construction is extremely simple. All mechanical work can be performed with ordinary hand tools. An electric drill will cut the con-

* 922 Whitney Blvd., Belvidere, Illinois.

[1] The Eimac data sheet on the 4-1000A as a grounded-grid triode qualifies this by adding, ". . . if a plate voltage of at least 3000 volts is used." — Editor.

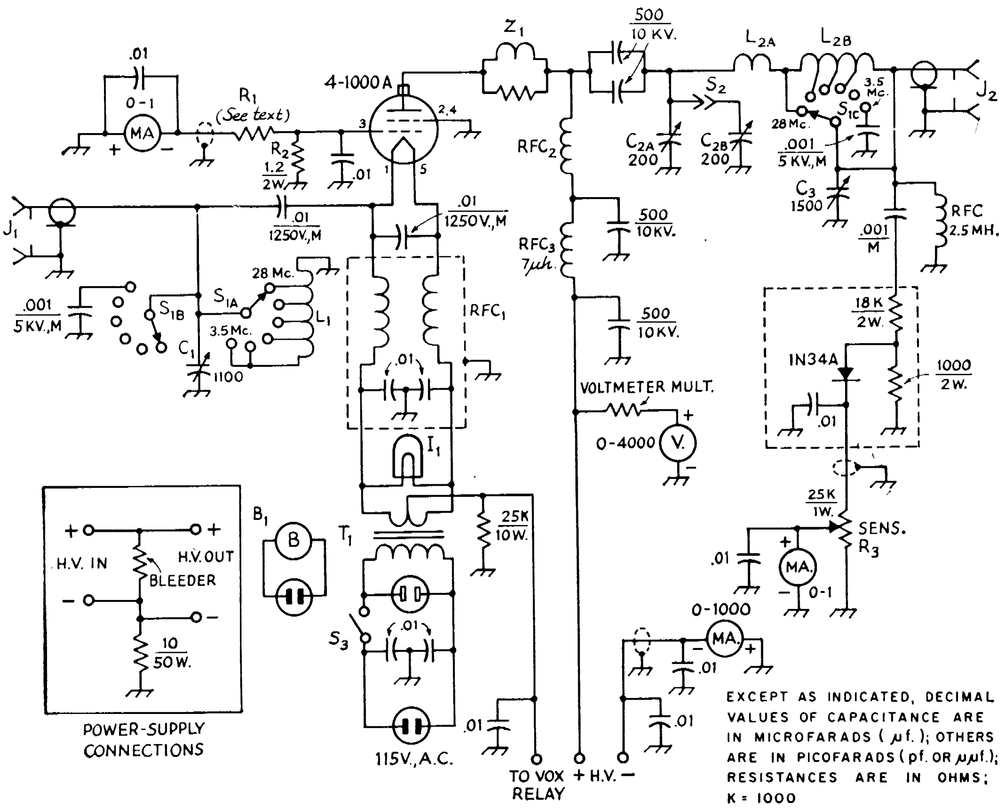


Fig. 2—Circuit of the 4-1000A grounded-grid amplifier. The 500-pf. 10-kv. fixed capacitors are TV doorknob type; others are 1-kv. disk ceramic, except M indicates mica.

B_1—Centrifugal blower, 60 c.f.m. at 0.6-inch static pressure (Ripley 8472).

C_1—Triple-section broadcast-replacement-type variable, 365 pf. or more per section, sections connected in parallel.

C_2—Dual air variable, 200 pf. per section, 7000 volts (Johnson 152-503/200CD70).

C_3—Air variable, 0.03-inch plate spacing (Cardwell PL-8013 or B & W 51241).*

I_1—6–8-volt panel lamp.

J_1, J_2—Chassis-mounting coaxial receptacle (SO-239).

L_1—6 turns No. 10, 1½-inch diam., 1½ inches long, tapped at 1¼, 1⅞, 2½, and 4⅛ turns from ground end.

L_2—Approximately 14 µh., tapped at 7, 3.5, 2.5 and 1.75 µh. (Barker & Williamson 850A bandswitching inductor).

R_1—Approx. 27 ohms; see text.

R_2—Made up of four 4.7-ohm ½-watt carbon resistors in parallel.

R_3—Linear control.

RFC_1—30-amp. bifilar filament choke (B & W FC30A).

RFC_2—Solenoid r.f. choke (B & W 800).

RFC_3—Solenoid r.f. choke (Ohmite Z-50).

S_{1A-B}—Single-section double-pole six-position ceramic rotary switch, 60-degree index (CRL 2551).

S_{1C}—Heavy-duty single-pole six-position rotary switch (part of L_2 coil assembly, modified as described in the text).

S_2—See text.

S_3—S.p.s.t. toggle switch.

T_1—7.5-volt, c.t., 21-amp. filament transformer (Stancor P-6457, Chicago F-725).

Z_1—2 turns No. 8, ½-inch diam., shunted by three 150-ohm 1-watt carbon resistors in parallel.

* The Cardwell capacitor is listed in the 1963 Allied catalog. The B & W capacitor, which is identical, is not stocked by B & W as a retail item, and may or may not be available at any particular time, depending on manufacturing needs. It is advisable to check with B & W before ordering from this source.

struction time considerably, but it is not an absolute necessity. The meter holes can be cut with a bit brace, or with a hand drill and file. Best of all, every single component is standard merchandise and is readily available. Your favorite ham supplier may not have every item in stock, but he should be able to get any of them for you in a hurry.

Triode Operation

The 4-1000A may be connected for high-µ triode operation by placing the grid and screen elements at the same d.c. and signal potentials; in this case, both are grounded. This connection offers several advantages for sideband operation. First, no grid-bias or screen-voltage power supplies are needed. In addition, the drive level of this grounded-grid stage is compatible with the power-output level of modern sideband exciters. Finally, neutralization is not required.

The Circuit

The circuit of the amplifier is shown in Fig. 2. Excitation is fed to the filament through a 0.01-µf. 1250-volt (working) mica capacitor. A ceramic capacitor is not suitable for coupling since it will not stand the current. The cathode coupler, consisting of C_1 and L_1, does an excellent job of input matching. RFC_1 is the new B & W FC-30A bifilar filament choke which is more efficient than the earlier type FC-30. With the center tap of the filament transformer returned to ground through an extra pair of contacts on the VOX or antenna relay, the no-signal resting current will be approximately 60 ma. with 3000 volts on the plate. With the relay contacts open on standby, the 25K bias resistor drops the plate current to a negligible value.

A B & W type 850-A coil-switching unit is used in the pi-network output circuit. The type 852, incidentally, is not suitable for use with the 4-1000A, since it is designed for a much lower plate load impedance. Its use would not only require much higher input and output capacitances, but would also result in an abnormally high-Q circuit in this amplifier. Instead of an expensive vacuum variable for the tank capacitor, C_2 is a split-stator air unit with 0.175-inch plate spacing. To reduce the minimum circuit capacitance on the higher-frequency bands, one section of the dual capacitor is used for 10, 15, and 20 meters; the second section is switched in parallel with the first for the lower frequencies.

The variable output capacitor C_3 is a 1500-pf. unit with 0.03-inch plate spacing. This provides sufficient capacitance for the phone end of the 80-meter band. However, more capacitance will usually be required for the low-frequency end of this band, and this is provided by connecting a fixed 0.001-μf. mica capacitor in parallel with C_3 in the last position of S_{1C}.

Parasitic Suppression

Several different makes of chokes were tried at RFC_2 in conjunction with many different resistance-inductance combinations in the v.h.f. suppressor Z_1. However, it was found practically impossible to completely eliminate parasitic oscillation on all bands until the B & W type 800 choke was tried.

Metering

Grid current is monitored very simply. The control grid is grounded through four 4.7-ohm ½-watt composition resistors in parallel, by-passed by a 0.01-μf. disk ceramic capacitor. The RC combination serves to hold the control grid very close to ground potential. Grid current is monitored by measuring the voltage drop across the resistors with the 1-ma. grid meter, calibrated 0-300 ma. full scale, and a series resistor.

A simple way to determine the value of the series resistor R_1 is to place a regular milliammeter with a scale of 200 ma. or more from the VOX relay terminal to ground. Apply excitation, and substitute resistors at R_1 until both meters have the same deflection at 150 ma. As an example, the Weston Model 301, 1-ma. meter requires a 27-ohm series resistor.

Plate current is measured by a 0-1-amp. d.c. meter shunted across a 10-ohm resistor in the negative high-voltage lead. This resistor is incorporated in the power supply, not in the amplifier itself. The 50-watt rating gives an ample safety factor, since the power dissipation would not exceed a few watts should the ammeter open up. Notice that the negative terminal of the supply must not be grounded except through the 10-ohm resistor.

A plate voltmeter has a definite place in this amplifier, or in any other amplifier where the d.c. input runs 900 watts or more, since it is required by FCC regulations. Even if you run less than 900 watts, it is reassuring to know exactly what your input is at all times.

To continuously monitor the r.f. output level of the amplifier and to aid in efficient tuning, a simple r.f. voltmeter has been incorporated in the circuit. Absolute readings are not necessary, so provision has been made for varying the sensitivity by adjustment of R_3.

Component Modification

Some of the components require minor modification before mounting. The last rotor plate and the last stator plate of the rear section of the tank capacitor C_2 are removed. This is section C_{2A} in the diagram, which is used alone on the higher frequencies. The operation is simple and requires no special tools. The alteration reduces the minimum capacitance to permit a more favorable Q on 10 meters. To further reduce the minimum circuit capacitance, the stators of C_2 are moved farther away from the chassis by mounting the capacitor in an inverted position; that is,

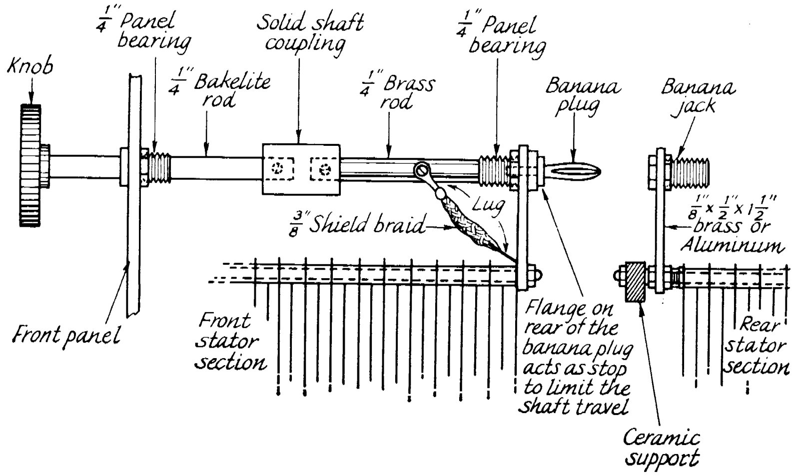


Fig. 3—Sketch showing details of the tuning-capacitor switch, S_2. The stator sections are connected in parallel when the panel control knob is pushed to engage the plug in the jack.

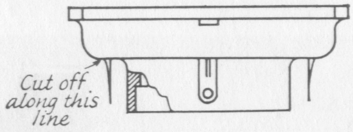


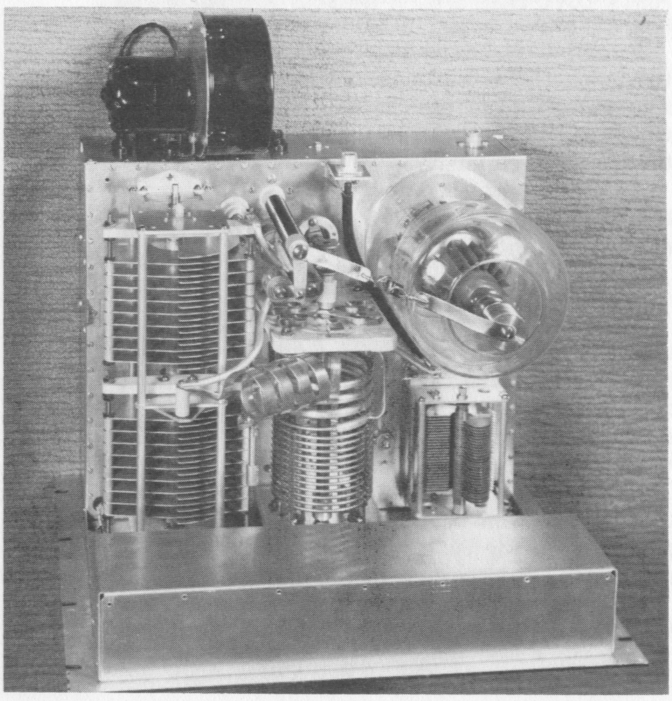
Fig. 4—Sketch showing how the lower portion of the tube socket is cut off.

with the stators on top. The mounting feet of the Johnson capacitor are easily moved to permit mounting in this manner, since the capacitor frame has duplicate mounting holes.

Fig. 3 shows the device used for S_2. Similar metal brackets are attached to adjacent ends of the stator-assembly rods of the dual capacitor. The bracket on the rear end of the front capacitor section (C_{2B}) carries a ¼-inch panel bearing through which a 3-inch length of ¼-inch brass rod slides. One end of this rod is drilled and tapped to accept the threaded shank of a banana plug. The other end of the brass rod is coupled to a 3⅛-inch length of ¼-inch bakelite rod which passes through another bearing in the panel to the control knob. The shaft coupler should be of the rigid type, either metal or ceramic. To assure good contact between the stator of C_{2B} and the banana plug, a piece of ⅜-inch flexible copper braid is used to connect the two directly, rather than to depend on the sliding contact at the bearing.

The banana jack is mounted on the other bracket. Be sure that the two brackets are drilled identically so that the plug and jack may be lined up accurately.

One other slight modification was made in the capacitor before mounting. A small triangular bracket was mounted inside the rear frame plate, that is, between the capacitor sections. This was fastened in place using the same screws which hold the ceramic stator bar against the frame plate. The upper point of the triangle extends sufficiently above the frame plate to allow mounting a 1-inch ceramic pillar. After the components were mounted on the chassis, the open end of the 10-meter section of L_3 was removed from the coil assembly, turned end for end, and fastened



between the ceramic end plate and the ceramic pillar. A short length of ¼-inch copper tubing, also fastened to the ceramic pillar, connects the coil to one side of the blocking capacitors. Another short length of tubing connects the rear stator terminal of C_{2A} to the same point.

It will be noted that the 0.001-μf. fixed output capacitor requires an additional switch position. Fortunately, this is not difficult to provide, since there is already a hole for an extra stationary contact in the ceramic end plate of the B & W coil unit. All that is necessary is to obtain a switch contact from B & W [2] for one dollar (or make a reasonable facsimile) and mount it in the spare hole.

The socket for the 4-1000A is Eimac's new plastic type SK-510 (amateur net $6.50). It is designed primarily for duct connection to a blower. For the pressurized-chassis ventilating system used here, you can improve the air flow by cutting off the "nose" of the socket with a hacksaw, as shown in Fig. 4. Remove the socket contacts while this operation is performed, to avoid damaging them. Use extreme care in sawing. Although the socket is made of a tough plastic, unusual stress or strain may cause it to break.

You will note that the socket has slots next to the pins, right in the side of the molded fixture. To ground the two screen leads, pass a ¼-inch copper ground strap through the slot and solder it to the bottom of the screen contact inside the socket; then ground the strap to the chassis at the point where it emerges from the socket. The grid bypass capacitor should be installed in the same manner. One lead passes through the slot and is soldered to the bottom of the grid contact, while the other lead is grounded to the chassis. The leads should be only ¼-inch long.

Construction

The 14 × 17 × 4-inch chassis is made up of a pair of SeeZak [3] R414 rails (4 by 14 inches), a pair of R417 rails (4 by 17 inches), and two P1417 panels (14 by 17 inches). Standard 13 × 17×4-inch chassis are readily available, of course, but the extra inch of depth provided by the SeeZak units is necessary to accommodate C_2 which has a length of 13$\frac{1}{16}$ inches. Machining of the front and rear chassis walls and the top deck is greatly simplified by using these handy rails and panels. No more trying to get big fingers and tools into small corners. You can do all of the drilling and cutting on flat plates, and then assemble your chassis.

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[2] Barker & Williamson, Bristol, Penna. Mention 850A type number when ordering.

[3] SeeZak products are available from Radio Shack Corp., 730 Commonwealth Ave., Boston 17, Mass., Terminal Hudson Electronics, 236 West 17th St., New York, N. Y., and California Electronics Supply, Los Angeles, among others.

Fig. 5—Plan view of the 4-1000A grounded-grid amplifier. This view shows how the position of the 10-meter section of L_2 is changed.

Cathode Coupler

Place S_1, L_1, and C_1 close to the tube socket, as shown in Fig. 6. In this amplifier, Millen type 39005 universal-joint couplings were used between the shaft of C_1 and the front panel to allow the control to be placed symmetrically in respect to others on the panel. Even though the shaft and rotor of C_1 are at ground potential, use an insulated shaft coupling to couple the indicator dial to avoid the possibility of setting up a spurious tuned circuit. If you don't gang the input and output band switches, as described presently, use an extension shaft on the input switch so that the switch can be placed close to the tube socket.

Ganging the Switches

It is not difficult to gang S_{1A-B} and S_{1C} to provide single control. This can be accomplished by means of a National type RAD geared right-angle shaft coupler. A Johnson rigid ceramic shaft coupler (type 104-252) is attached to the tail shaft of the B & W coil unit. A short length of ¼-inch brass rod couples the gear end of the right-angle drive to the ceramic coupler. S_{1A-B} is mounted below deck with its shaft extending through a clearance hole in the chassis so that the shaft can be lined up with the shaft of the right-angle drive. The two shafts are coupled together by means of a ceramic semiflexible coupler (Johnson 104-262). Since the switch on the B & W coil unit has 60-degree indexing, S_{1A-B} must have the same indexing, rather than the more common 30-degree indexing. The 60-degree switch is, however, a standard item in the manufacturer's catalog. A 30-degree switch may be used, of course, if ganging is dispensed with.

Wiring

As the photographs indicate, very little actual wiring is required. The positive high-voltage lead enters the rear of the chassis through a Millen high-voltage connector where it immediately connects to the first 500-pf. bypass capacitor. RFC_3 is mounted between this capacitor and a feedthrough insulator which is connected to one side of the voltmeter multiplying resistor. The feedthrough carries the high voltage through to the top of the chassis where it connects to the second 500-pf. capacitor mounted on the chassis, and to the bottom end of RFC_2. A tapped ceramic pillar insulator threads onto the top terminal of this capacitor. The two blocking capacitors are suspended from a short copper strap fastened across the top end of the insulator, and a second strap connects them to the top of the r.f. choke. The parasitic suppressor Z_1 is inserted at the center of a copper strap connecting the top of RFC_2 to the plate cap of the tube.

Since the high-C input circuit carries considerable current, the r.f. wiring should be done with reasonably heavy wire (I used No. 10). This includes the short between the 80-meter contacts of S_{1A}.

A lead attached to the stator of C_3 passes down through the chassis via a second feed-through insulator to the box below containing the r.f. output-indicator components. A short section of RB-8/U connects the stator of C_3 to J_2. Be sure to ground both ends of the outer conductor.

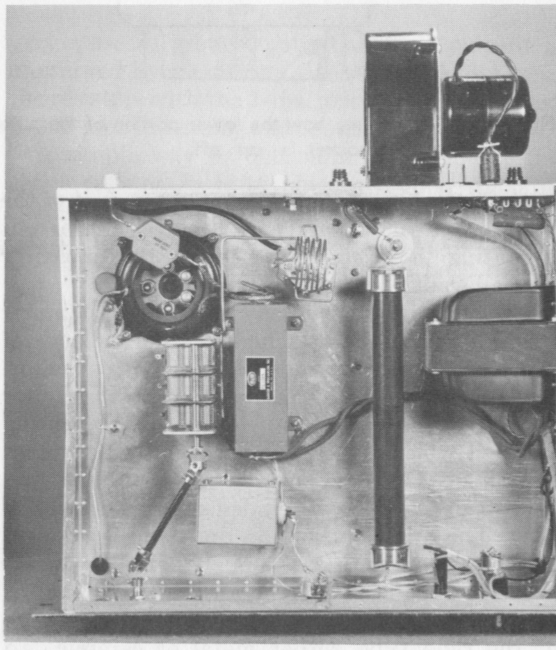

Fig. 6—Bottom view of the 4-1000A amplifier. The filament transformer and voltmeter multiplier resistor are to the right. The input coil, L_1, is at top center, supported on S_{1AB} by its leads. Input capacitor C_1 is operated through a pair of universal-joint shaft couplers so that the capacitor may be placed close to the tube socket without upsetting panel-layout symmetry. The small shielding box (2¾ × 2⅛ × 1⅝-inch Minibox), below the bifilar filament choke, houses the r.f. output-indicator diode and associated components.

Blower Mounting

Don't compromise on the blower. The 4-1000A requires 60 c.f.m. at 0.6 inch of static pressure. Some so-called 60-c.f.m. blowers aren't worth their salt when you try to pressurize the chassis. The blower suggested does an excellent job in this respect, and is priced quite reasonably.

Be sure to place the blower well away from the tube socket. If it is placed too close, it will create a pressure wall across the bottom of the socket which will tend to restrict the flow of air through the base and chimney.

An a.c. receptacle is set in the rear apron of the chassis and a short cord from the blower motor plugs into it.

The Panel

The panel is a standard 15¾ × 19 × ⅛-inch unit of aluminum. The four meters are in line across the top. A 4 × 17 × 3-inch aluminum chassis fits over the back of the line of meters to shield them from r.f. fields. It is held in place by eight No. 6 sheet-metal screws inserted from the front. Shielded meter leads (Belden 8882 wire) are brought up from below chassis through rubber grommets in the chassis and in notches filed in the bottom front corners of the meter enclosure.

The panel is fitted with chrome handles (Bud type H9113) for lifting the amplifier in and out of the rack mounting. They also serve to protect the controls if it becomes necessary to place the unit face down on your workbench for service.

The lettering was done with Tekni-Cals, and the engraved plates are obtainable from Central Engravers [4] at 5 cents per letter.

The Shielding Enclosure

The two ends and the back of the shielding enclosure are made of 0.51-inch solid sheet aluminum, while the top is made of perforated sheet of the same weight. One of the SeeZak P1417 panels is used for the bottom cover. Aluminum angle stock, ½ inch by ½ inch, is used to join the pieces with the help of ¼-inch No. 6 sheet-metal screws spaced every two inches. All of the above pieces, including the angle stock, may be obtained cut to size if desired.[5]

Adjustment

After checking out the filament circuit and grounding the center tap of T_1, reduce the sensitivity control of the r.f. voltmeter to near minimum. Select the proper band with S_1 and apply excitation. Adjust C_1 for a grid current of approximately 150 ma. Apply plate voltage and load, and resonate the output circuit with C_2. With a plate voltage of 3000 and grid current of 160 to 170 ma., alternately adjust C_3 and C_2 to increase the plate current to 300 ma. or slightly over. In observing the r.f. voltmeter, you will note that maximum output does not always occur at the point of resonance as indicated by the dip in the plate current.

The amplifier may be checked for linearity as described in the *Radio Amateur's Handbook*.

I am very grateful for the technical advice and suggestions of Bill Orr, W6SAI, and George Stinson, W9KDK. Their analysis of the problems encountered, as well as their suggestions for changes during construction, made this a much better amplifier, and a pleasure to build. Operating at an input of 1 kw. or less, this amplifier actually "coasts" and will give you years of trouble-free service. QST

[4] 529 South State, Belvidere, Illinois.

[5] From Dick's, 62 Cherry Ave., Tiffin, Ohio.

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MORE ON THE MOONBOUNCE UNIVERSAL WINDOW FOR 144 MHz

Eimac®
DIVISION OF VARIAN
301 Industrial Way
San Carlos, California

AS-49-3

4142

PROPOSAL FOR A UNIVERSAL EME MOONBOUNCE WINDOW

By: Ken Tentarelli, W1FZA

In much the same way that "calling frequencies" are useful in promoting activity on some VHF propagation modes, a "universal window" could be of great value in promoting EME (earth-moon-earth) activity. The phrase "universal window" is used here to mean a selected area of the sky which the community of EME enthusiasts agree to use as a primary target for aiming their antenna arrays. First let us explore what could result from such an agreement by EME operators and then let us consider which particular area of the sky should be selected.

For EME to be enjoyed by the greatest number of interested operators, those stations with the facilities for erecting vast, high-gain, arrays should be encouraged to build the largest possible antennas. These stations could then furnish EME contacts to stations with much smaller arrays. Unfortunately, at the present time anyone who builds a large fixed, or partially steerable, EME array might find that his window is not shared by many other EME stations. With such a limited prospect of success, only the most courageous among us have invested their time and money in massive EME antenna construction projects. On the other hand, the existence of a universal window would give confidence to stations building large fixed arrays that their efforts would be rewarded by access to all other EME stations. Another advantage of a universal window is the simplification of moon tracking problems; in fact, any practical antenna could be oriented in a fixed position within the window and yield several moon-days per month.

Now let us consider which point in the sky should be chosen for the universal window. The window which is now used for European EME schedules (see AS-49-2) has been suggested by Bob Sutherland, W6PO, as a window which offers several advantages over other choices:

1. It is now being used for regular schedules by several stations which implies that anyone who constructs an antenna aimed at this window can expect some measure of success almost immediately.

2. The window corresponds to a meridian crossing near the middle of the North American continent. This means that all stations in the continental United States would have high antenna elevations when aiming at the window. High elevation angles ease the problem caused by ground-level obstructions (trees, hills, etc.), reduce interference from local stations, minimize TVI, and enable antennas to be mounted near ground level to keep feedline losses low.

3. The window includes the region of maximum northerly lunar declination. Since the moon changes declination in sinusoidal fashion it remains near its maximum declination for several days; thus this window optimizes the number of moon-days per month available to fixed position antennas.

4. The window is designed such that even very high gain antennas need only azimuth steering to further extend the number of available moon-days.

5. Stations on all continents except Asia and Australia can access this window (no single window is accessible from all continents).

Obviously, no window could be truly universal and meet everyone's needs. Therefore, it is proposed only that this window be a primary target; that is, every EME station should insure that his array can be aimed at this window in addition to any other window he might desire to use. If the concept of a universal window is accepted by a majority of EME stations it should not be too long before those fortunate stations with massive arrays have the WAS award within their grasp, while VHF city dwellers with small antennas will be able to enjoy the thrill of communication via the moon.

Explanation of Figures

Figure 1 is a diagram of the proposed universal window in declination and Greenwich hour angle coordinates. The moon is within this window approximately one hour per day for about five days per month. Also shown in this figure are AZ-EL coordinates which bound the window for three geographic locations across the United States.

Figure 2 is diagramed similar to Figure 1. Shown in this figure are the 3 dB beamwidths of two antennas which are fixed in position and aimed at the midpoint of the window. One antenna is a 320-element collinear, and the other is a single 24-element Yagi.

Figure 3 provides AZ-EL coordinates of the midpoint of the window as a function of station location. This data may be interpolated with good accuracy.

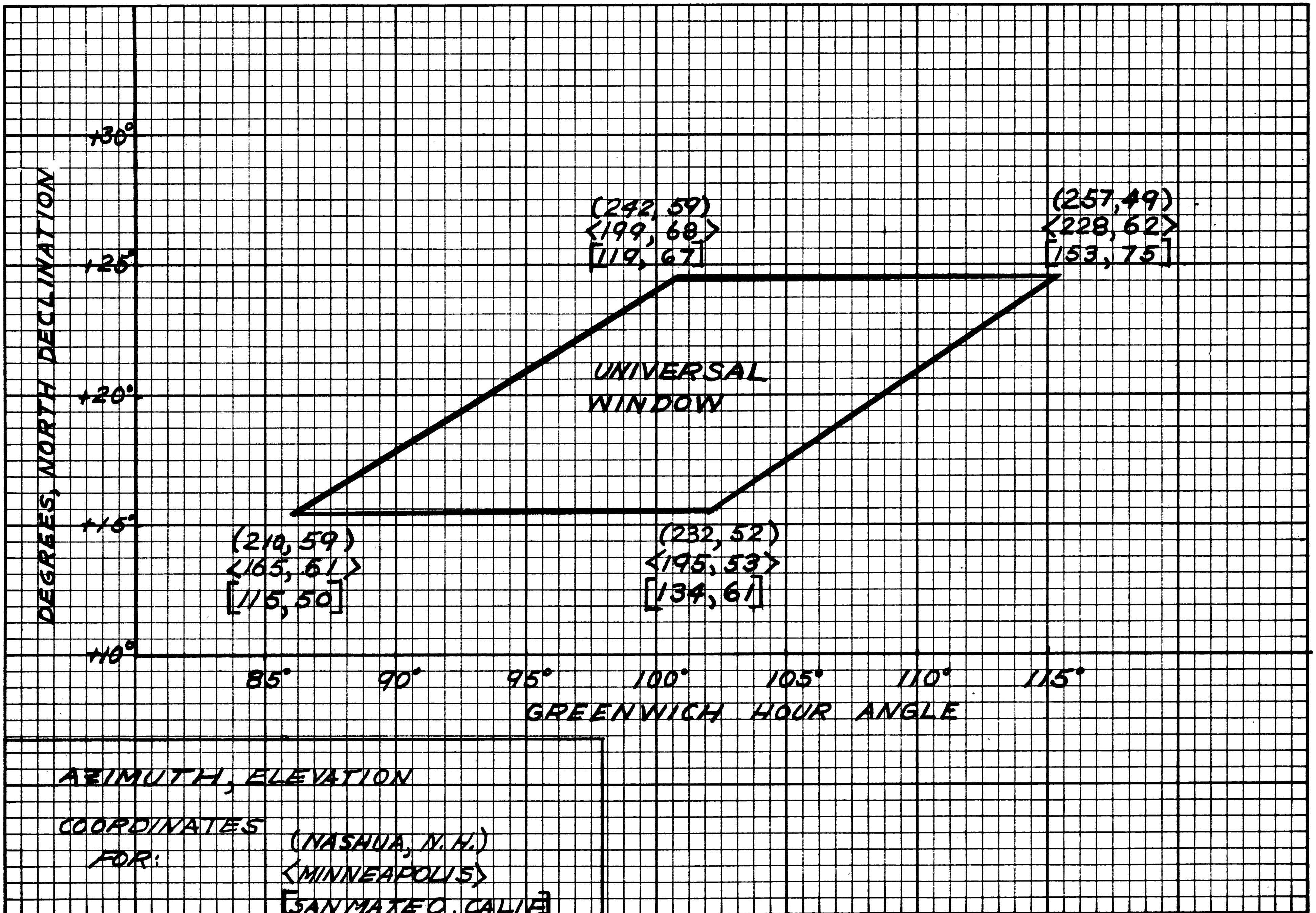

FIGURE 1

W1FZA

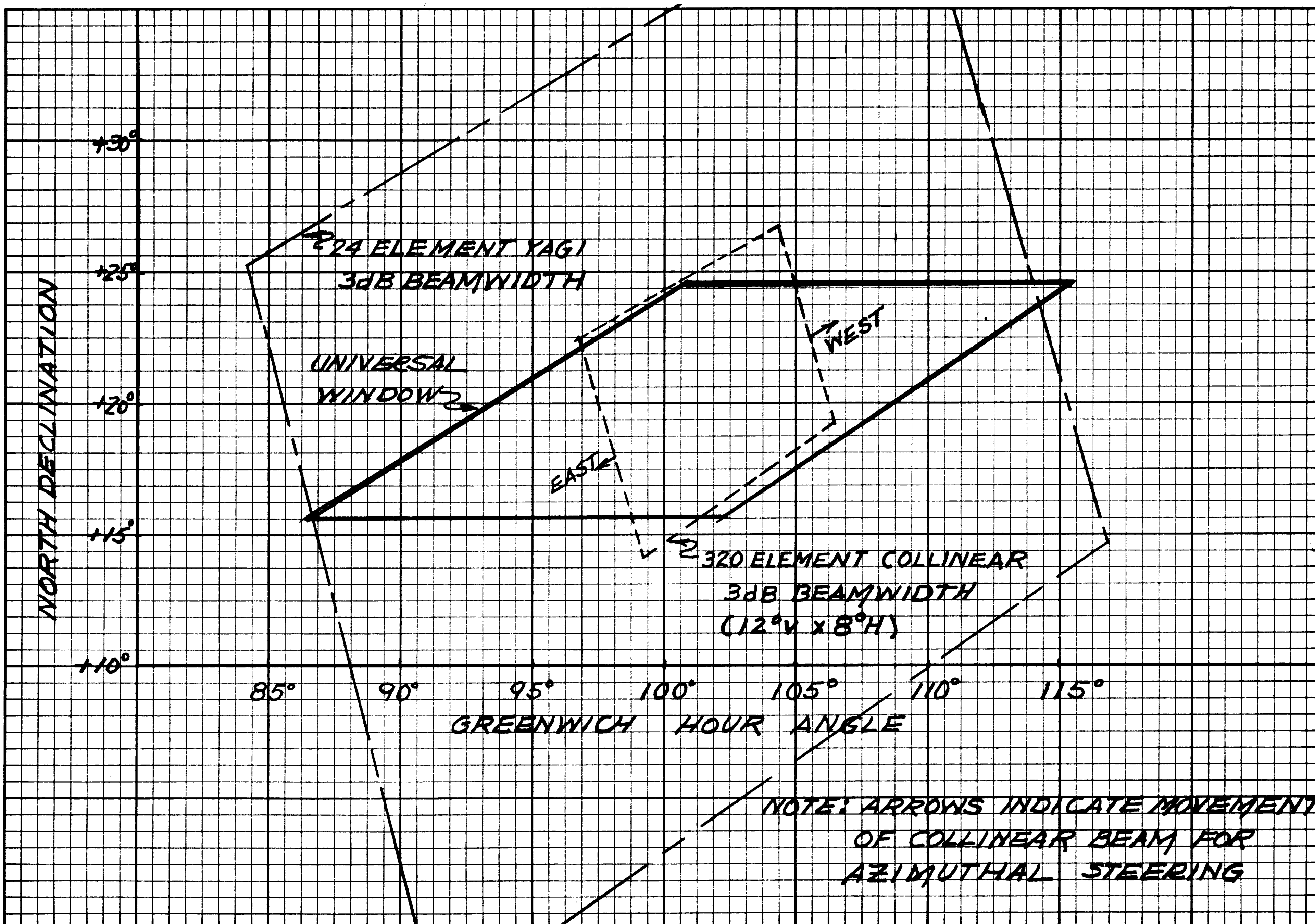

FIGURE 2

W1FZA

ELEVATION-AZIMUTH COORDINATES VS LOCATION
FOR MIDPOINT OF UNIVERSAL WINDOW
(GHA = 102^{o}, DEC = 20^{o}N)

NORTH LATITUDE / WEST LONGITUDE	25^{o}		30^{o}		35^{o}		40^{o}		45^{o}	
	El	Az	El	Az	El	Az	El	Az	El	Az
70^{o}	60.1	266.9	59.4	258.4	58.1	250.4	56.1	243.3	53.6	237.1
75^{o}	64.6	264.1	63.7	254.0	61.9	244.9	59.5	237.1	56.5	230.6
80^{o}	69.1	260.6	67.8	248.4	65.5	238.0	62.5	229.7	59.1	223.2
85^{o}	73.5	255.7	71.7	240.9	68.8	229.4	65.3	221.0	61.3	214.9
90^{o}	77.8	248.1	75.2	230.1	71.6	218.3	67.5	210.7	63.1	205.6
95^{o}	81.8	233.7	78.2	213.9	73.8	204.2	69.1	198.7	64.3	195.3
100^{o}	84.7	200.7	79.8	190.7	74.9	187.2	69.9	185.5	64.9	184.4
105^{o}	84.3	150.4	79.6	164.1	74.8	169.2	69.8	171.8	64.9	173.3
110^{o}	81.1	122.5	77.7	142.3	73.4	152.7	68.9	158.7	64.1	162.6
115^{o}	77.0	110.0	74.6	127.4	71.1	139.2	67.1	147.1	62.8	152.5
120^{o}	72.7	103.1	70.9	117.4	68.2	128.7	64.7	137.1	60.9	143.3
125^{o}	68.2	98.6	66.9	110.4	64.8	120.5	61.9	128.7	58.6	135.2

FIG. 3

SUCCESSFUL 144 MHz

EME ANTENNAS

DIVISION OF VARIAN
301 Industrial Way
San Carlos, California

AS-49-5

4144

SUCCESSFUL 144 MHż EME ANTENNAS

One of the most important decisions that an amateur planning a moonbounce system must make is the choice of antenna. There are many variables that enter into the decision as there are both practical and technical topics to consider. In the practical category are:

1. What will the system cost?
2. What is the availability of the materials?
3. What is the available real estate?
4. What are the esthetics as judged by the neighbors and the wife?
5. What are the electrical and mechanical abilities of the amateur and his helpers?

In the technical category some of the considerations are listed below. Quite often the technical desires must give-in to some of the previously listed practical considerations.

1. What system gain should be sought after?
2. Should the array be fully steerable, partially steerable, or fixed?
3. Should the array be on a high tower, or on the ground?
4. Is the array for EME only, or is it to be used for other propagation modes?
5. If the array is to be steerable, should an AZ-EL mount or a Polar mount be used?
6. What kind of feedline should be used?
7. Should the preamplifier be mounted at the antenna?
8. What kind of transmission line should be used in the phasing lines?
9. Should power dividers be used?
10. What type of antenna should be used? (Probably the hardest decision is the choice of antenna type.)

Amateurs tend to become quite emotional when discussing the relative merits of collinears, yagis, log-periodic yagis, rhombics, and dishes. All of the antennas mentioned have been used successfully in EME systems. The relative merits of each antenna probably change as the discussion moves from band to band. For example, the dish is quite acceptable on 432 MHz, but is too big to be practical on 144 MHz.

Included in this EME Note are pictures of successful 144 MHz antennas. Pictures of antennas for other bands are not available at this time but as pictures are collected they will appear in subsequent issues of the EME Notes.

When deciding whether to use a collinear, a yagi or a log-periodic yagi, the capability of the amateur must be considered. The lower the "Q" of the antenna, the better the chances of operational success. It is difficult to fail with a low-Q collinear array. The log-periodic yagi is a band-pass type of antenna of medium-Q and is therefore easy to assemble into an array. Short yagi antennas are a little more critical. The long and very long high-Q yagis are even more critical to assemble into an array. Also, their performance is optimum only over a narrow part of the two meter band.

It is very important to be certain that your chosen yagi design has been carefully checked out before building eight or sixteen identical antennas. If this is not done, a lot of time and money can be spent on an array with inadequate gain for EME work. With proper antenna-to-antenna spacing, the yagi and log-periodic yagi tend to have a cleaner pattern than other types. The cleaner the pattern, the better the antenna will perform for receiving.

The main idea to keep in mind when thinking about the antenna array to put up is the minimum system requirement as pointed out in earlier issues of these Notes. For two stations each running 500 watts output with a system noise figure below 2 dB, the minimum antenna gain each station should strive for is 20 dB. Actually what is required is a "round trip" gain of 40 dB. That is to say, if one station has 17 dB antenna gain and the other station has 23 dB gain, their total gain is 40 dB round trip. Therefore, if the two stations schedule each other often enough, they will be successful in completing a contact. Two stations with 17 dB antenna gain would probably not be able to make contact very often, if at all. If the constraints on your antenna project relegate you to something under 20 dB, you still can work those stations having an extra amount of antenna gain. There are several 144 MHz stations with antenna gain in the 23 to 24 dB range. There are even some having close to 30 dB gain.

Remember that the previous discussion on system requirements is for 144 MHz. As EME activity and interest increase, there will be bigger and better arrays built.

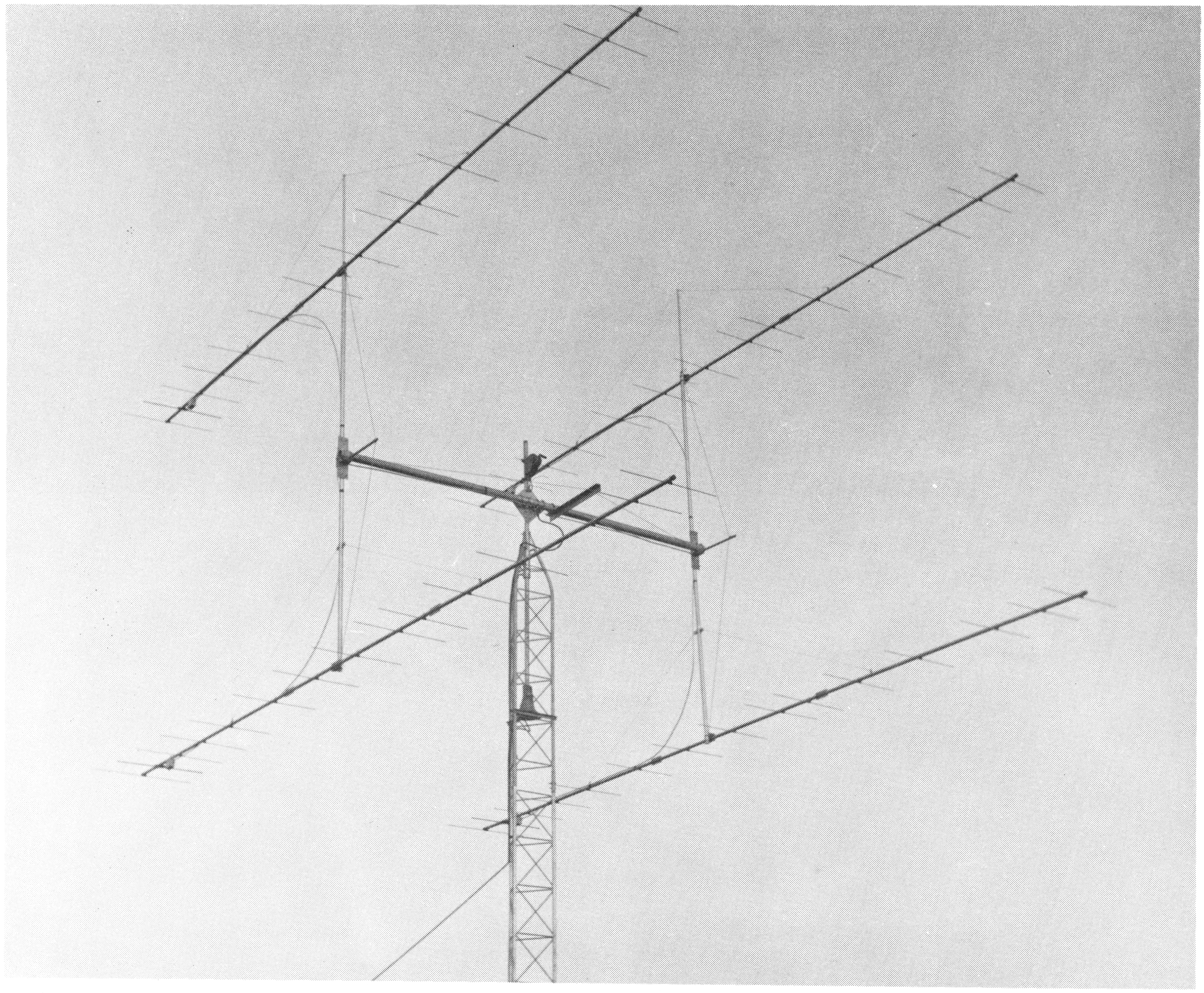

Figure 1

The array of John Allen, WAØCHK consisting of four Hy-Gain 15 element Yagis. The antennas have been modified as per the instruction from K6MYC. As the antennas come all of the parasitic elements appear to be one inch too long. The "H" frame is made from a 14 foot length of three inch diameter 6061-T6 aluminum pipe with an eighth inch wall thickness. The vertical members are made from two pieces of 1.59 inch diameter 6061-T6 aluminum pipe 13' long with a .140 inch wall thickness. The gusset plates are quarter inch 6061-T6 aluminum. The clamps are muffler clamps and electrical conduit "U" bolts. Small antenna tuners are mounted 6 1/2 inches away from each feed point and are tuned for 50 ohms. The phasing lines are 75 ohm .412 O.D. surplus CATV aluminum coax. The antenna is mounted on a 25' Rohn #45 tower. The boat winch mounted above the center of the "H" frame is for lifting the antenna up and down the tower for maintenance. The antenna is elevated manually by loosening the four muffler clamps on the "H" frame center gusset plate and twisting the three inch pipe and antennas to the desired elevation angle.

The rotor shown in the photos is a CDE TR-44. Struts are made from quarter inch polypropolyene rope to keep the antennas aligned when elevated. The gain of this antenna array is probably around 19 to 20 dB.