Welcome to the 1st Annual (?) 1296/2304 MHz. Conference. We hope you will enjoy the program of activities and your visit to Estes Park. It is a pleasure for me to provide this conference for you and to provide you with the most up-to-date information in this field. I want to thank all the speakers for the time and effort they have put into their presentations and to those who have provided valuable material to include in this book. I know that the publishing of this material will be helpful to us all.

I would also like to thank my wife, Norma, for organizing the mailing list, sending out the many mailings, reproducing the presentations and putting together this book, and for organizing the Ladies Program.

Enjoy!

73

Don Hilliard, WØPW

1985 ESTES PARK 1296/2304 MHz. CONFERENCE SCHEDULE
Holiday Inn - Estes Park, CO
Columbine and Lakes Estes Meeting Rooms

THURSDAY, 19 September 1985

07:00-09:00 pm	• Flea Market • "Show and Tell" • Noise figure measuring	

FRIDAY, 20 September 1985

08:00-08:10 am	Welcome and Introduction...............	Don Hilliard, WØPW Bill McCaa, KØRZ
08:10-08:40	"Transponder Intermodulation"	Gordon Hardman, KE3D Jan King, W3GEY
08:40-09:40	"Getting Started on 13 and 23 cm"........	Joe Reisert, W1JR
09:40-11:40	Antenna gain measuring	
11:30-01:00	L U N C H	
01:00-02:00 pm	"Using Monolithic Microwave IC's in 1296, 2304 and 3456 MHz Transverters"......	Al Ward, WB5LUA
02:15-03:15	"Clean Local Oscillators"	Richard Campbell, KK7B
03:15-03:45	B R E A K	
03:45-04:45	"13/23 cm in the AMSAT Phase 3 Program".................................	Bill McCaa, KØRZ
04:45-07:00	F R E E T I M E / D I N N E R	

SATURDAY, 21 September 1985

09:00-12:00	BUS TOUR OF ROCKY MOUNTAIN NATIONAL PARK	
12:00-01:00 pm	L U N C H	
01:00-01:45	"23 and 13 cm Activity, Operation and Equipment in the U.K."	Angus McKenzie, G3OSS
01:45-02:30	"The Care and Feeding of a 7 Foot Dish"	Gerald Handley, WA5DBY
02:30-03:15	"Designing Loop Yagis for 13 and 23 cm"	Joe Reisert, W1JR
03:15-03:45	B R E A K	
03:45-04:45	"Linear Amplifiers Using Power GaAs FET's"	Richard Campbell, KK7B
06:45-09:45	Dinner/Country Music Show at Barleen Country Music Theater	

SUNDAY, 22 September 1985

08:15-09:15 am	"2304 Transverter Design"	Al Ward, WB5LUA
09:30-10:30	"24 GHz Record"	Lauren Libby, KXØO
NOON	Conference ends	

Thank you for attending this conference. We hope you enjoyed the presentations, the area and other activities. Hope to see you next year!

HAVE A SAFE TRIP HOME

PRIZES WILL BE DRAWN!

WOMEN'S ACTIVITY SCHEDULE

1985 ESTES PARK 1296/2304 MHz. CONFERENCE

Holiday Inn - Estes Park CO

THURSDAY - 19 September 1985

7:30 pm	Presentation on an exciting new food for tomorrow to meet the needs of today. [Held in "The Bridge" overlooking the pool]

FRIDAY - 20 September 1985

10:30-11:30	Tour of the historical Stanley Hotel ($1.00)
01:00-01:45	Tour of the Peuter factory (Free)
02:00-03:00	Estes Park Historical Museum (Free)

- Slide presentation on the Estes Park Flood of 1982
- Treasure Hunt

SATURDAY - 21 September 1985

09:00-12:00	Bus tour through Rocky Mountain National Park ($12.00)

- Bear Lake Tour, or
- Tour over Trail Ridge Road

[The men's schedule allows them to join us!]

01:00- ?	Shopping Spree - downtown Estes Park
06:45-09:45	Barleen Country Music Dinner Theater

Thank you for spending these few days with us in Estes Park. We hope you enjoyed the area and the activities which we planned for you. Hope to see you next year!

HAVE A SAFE TRIP HOME

TABLE OF CONTENTS

DESIGNING LOOP YAGIS FOR 13 and 23 cm

by

Joe Reisert, W1JR

First Annual 1296/2304 mHz Conference, Estes Park, Colorado, 19-22 Sept. 1985

"Getting Started on 13 and 23-CM" by Joe Reisert, W1JR

The recent activity on the 13 and 23-cm microwave bands has been very encouraging. However, there are still many other interested Amateurs who need information on the microwave bands. Typically they ask what are the prime frequencies and modes of operation. The next questions seem to center around propagation, recommended receivers, transmitters and antennas. With this in mind, let's examine these question areas and then review some of the preferred equipment for these frequencies.

Frequencies of interest: Most of the early work on 23-cm was done on cw using multipliers, typically from 144 or 432 mHz. This was even carried through to EME (ref. 1). However, present day operation is primarily on cw and ssb, especially on OSCAR and weak signal operation. Some FM and FM repeaters are also gaining popularity but they are hardly the mode for weak signal operation. Let's keep them out of the weak signal portions of the band!

OSCAR 10 operation is almost entirely centered around the uplink frequency of 1269 mHz. Most of the weak signal operation is conducted between 1296.000 and 1296.150 mHz with EME between 1296.000 and 1296.050 mHz and the terrestrial work centered around the calling frequency, 1296.100 mHz.

13-cm is now a fragmented band. Before WARC '79 most of the world had the full 2300 to 2450 mHz band. However, soon after WARC '79 the band started to to be segmented. In Europe several countries removed the spectrum below 2320 mHz while in November 1984 the FCC removed 2310 to 2390 mHz from USA Amateurs. This makes it tough for those using "polaplexer" types of setups with 30 mHz IFs unless they stay in the top portion of the band or use 88-108 mHz IF's (ref. 2). The EME'ers who schedule Europe have had to resort to crossband operation from 2304.000 to 2320.150 mHz.

In the USA most of the 13-cm weak signal operation is conducted between 2304.000 and 2304.150 mHz. EME operation is primarily conducted between 2304.000 and 2304.050 mHz. 2304.1 mHz is the recommended terrestrial calling frequency. It probably will take some time to move everyone to a common calling frequency of 2304.1 mHz since many of the older transmitters use multiplier schemes that are centered on 2304.0 mHz. However, in the long run it will be worthwhile since there will be no conflict with EME operation and the USSR satellites that have been monitored near 2304.0 mHz.

Propagation: Radio propagation on the 13 and 23-cm bands is quite similar to 70-cm. However, the typical antenna beamwidths are narrower, transmitter power is often low (1-10 watts) at the present time and feedline loss becomes a real limiting factor. As a result, these microwave bands are perceived as different or more difficult to conquer.

One of the most noticeable problems on the microwave bands is foliage attenuation (including evergreens!). Foliage can cause terrific attenuation of signals. You can wait until the leaves fall (if they're not evergreens) but the propagation during the fall and winter is typically at its poorest point.

However, on the plus side, aircraft scatter and scatter in general are very noticeable on the microwave bands and are big propagation contributors when conditions are poor (ref. 3). It is recommended that if you set up schedules over an obstructed path that both stations aim their antennas at some common scattering medium such as a tall building, hill or mountain top and take advantage of the scatter so prevalent on the microwave bands.

Finally, it has been speculated that the optimum frequency for long haul tropo and ducting is near 1500 mHz (ref. 3). What this means is that there is more likelihood of long DX via tropospheric propagation on 13 and 23-cm than at the lower UHF/VHF Amateur bands. Furthermore, static, noise, and other objectionable VHF phenomenon are almost nonexistent at microwaves so it is more pleasurable place to operate. I think that these microwave bands are really where the greatest advances will occur in the next few years. All we need is time to develop the bands, better gear (especially with higher power), and an increase in the activity level.

Receiving Equipment: Since cw and ssb are the most popular modes for weak signal operation, the following recommendations will concentrate on this type of gear. More specifically, we will concentrate on receive type down-converters, transmitter up-converters, and transverters.

A basic receive type down-converter is shown on figure 1. There is nothing new on this block diagram. However, the components necessary at microwave frequencies are quite different from those used on VHF/UHF. Technology has come a long way of late and is still improving at a rapid rate. Therefore the modular approach is strongly recommended so that new improved designs can be substituted as they become available (ref. 4).

Inexpensive bipolars such as the NE64535 work great as a preamplifier or postamplifier through 4000 mHz (ref. 5). There are now many modular amplifiers available. At the present time the least expensive are the Avantek "MSA" series MMIC's (microwave monolithic IC's). More on this later. While these MMIC's may not have state-of-the-art noise figures for the input preamplifier, they can still easily deliver 5-6 dB noise figures. Siemens, NEC, and others are now offering broadband GaAs FET versions of the same. The noise figures on the broadband matched types of GaAs FET preamplifiers are typically 4 dB with 18-20 dB of gain! Expect the noise figures to drop.

Likewise, there are many low-cost GaAs FETs now available (refs. 6, 7 & 8). Simple PI-network or tuned tank circuits still work well on these bands for input/output matching with either bipolars or GaAs FETs. There is no longer any excuse for a high noise figure (over 2 dB) on any Amateur band below 2450 mHz!

If the modular approach is used, new improved preamplifier designs can be easily added later. HMETs (high mobility electron transistor) may soon be available to Amateurs (ref. 9). They promise to have lower noise figures than GaAs FETs with a higher cutoff frequency!

Bandpass filters are highly recommended to remove general crud as well as the image frequency especially if a 28 or 50 mHz IF is used. If a 2 meter IF is used with a tuned preamplifier(s), a bandpass filter may not be necessary.

The heart of any high-performance converter, be it receive or transmit, is the mixer and local oscillator (LO). Trough line mixers of the K6AXN/W1OOP type used to be very popular (ref. 10). In recent years the W2CQH interdigital type of mixer has become very popular (ref. 11). More recently the anti-parallel harmonically-pumped mixer is gaining popularity (refs. 12 and 13). It is simple to build and only requires the LO to be at one 1/2 the normal frequency!

However, the mixer type most recommended is the balanced type (ref. 14). Better yet I recommend the double-balanced-mixer (DBM) type (ref. 15). DBMs used to be very expensive but with recent improvements in technology and the low-cost TVRO market, they are dropping to very affordable prices.

Also, if two DBMs are configured with the proper hybrids, an image-rejection mixer can be configured per figure 2. This scheme has the advantage of not requiring special filtering for image rejection even when a low frequency IF (eg. 28 mHz) is used. It also can be used in the transmitter as we shall shortly see.

Let's not forget the LO. It must not only be stable but must be clean of spurious frequencies and should be relatively clean of harmonics of the basic crystal oscillator. Recommended LO schemes are shown on figure 3. As shown, the most popular LO frequencies for 23-cm are 1268 mHz (from a 105.666 mHz crystal oscillator) for a 28 mHz IF and 1152 mHz (from a 96 mHz oscillator) for a 144 mHz IF. The most popular LO frequencies for 13-cm are 2276 mHz (derived from a 94.8333 mHz oscillator) for a 28 mHz IF and 2160 mHz (from a 90 mHz oscillator) for a 144 mHz IF. Properly implemented, the LO output should be at least 30 dB above any other generated products.

The lowest recommended frequency for the crystal oscillator in a microwave receiver is 90 mHz. Frequency multipliers in a LO chain should be limited to doublers and triplers using the recommended multiplication scheme shown on figure 3. Triplers have lower efficiency than doublers and require more complex filtering than most Amateurs are willing to employ! Therefore, I recommend that triplers only be employed up to 350 mHz on the output.

Finally, the crystal oscillator should be a 5th overtone colpitts type with the crystal in the feedback path between the collector and emitter per reference 4. A recommended overtone crystal oscillator circuit is shown on figure 4. Overtone oscillators with the crystal from the base to ground should be avoided at all cost since they will have poorer frequency stability and greater phase noise (ref. 4).

Transmitters: The transmitter design is primarily a function of the type of emission desired. As described earlier, until recently most of the operation on the 13 and 23-cm bands has been with cw and multipliers. Often an 8 mHz oscillator was multiplied all the way up to the final output frequency. In the more sophisticated setups, an upconverter was used to mix to some intermediate frequency before multiplying the final step to 13 or-23 cm.

One popular scheme used in Europe (that has also been used by some contest stations in the USA) is to build a stable 1152 mHz LO from a 96 mHz crystal oscillator and then multiply it to the desired band (ref. 16). 1152 mHz is a unique frequency since 2, 3, 5 and 9 times 1152 is 2304, 3456, 5760 and 10,368 mHz respectively, all falling in our assigned microwave bands. Furthermore, if 1152 mHz is mixed with 144 mHz, we obtain 1296 mHz.

By far the most popular transmitter scheme of late is the transverter. If a common IF such as 28 or 144 mHz is used, only one LO has to be built for each microwave band as shown on figure 5. Hence the LO (such as the receiver LO just discussed) does double duty. This scheme allows cw as well as ssb operation with more than adequate frequency stability. The image reject mixer shown on figure 2 is strongly recommended for a transverter since it will reduce filtering requirements.

Tube upconverter/mixers such as the 2C39 family have also been used but I personally recommend the low-level upconverter approach with a DBM since it is clean and easy to construct. If the modular approach is used, you can add or change stages as they are built or upgraded. Also solid state devices don't require high voltages and filament voltages not to mention the warmup and tuning drift.

It used to be difficult to obtain the required gain and power for low-level upconverters but that is no longer true. The low cost (less than $3.00) Avantek MMIC's mentioned earlier yield 8-15 dB of gain (ref. 17). Furthermore, NEC (NEL1300 and NEL2300 series), Acrian, SSM, TRW etc. all have available linear bipolars that will deliver up to 20 watts on 23-cm and 3-6 watts of linear power on 13-cm at reasonable prices. Medium power (1 watt) GaAs Fets are also quite available and power levels increasing to 10 watts reported. For higher solid state power, devices can be combined either directly with matching networks or by using hybrid power splitter/combiners.

If only cw is desired at higher power levels, there are numerous solid state devices up through at least 15 watts on 13-cm. WA3AXV, WA3JUF and W3HQT have successfully used ssb with some of the higher powered class C transistors by employing a slight amount of forward bias. However, this technique is only recommended on selected devices (ref. 18).

Some Amateurs have supposedly run class C devices on ssb with reasonable linearity. The trick is to inject a small amount of carrier by unbalancing your balanced modulator. I haven't tried this method personally and would appreciate information from any one who has.

Admittedly there is still an RF power generation problem on the microwave bands. The ubiquitous 2C39/7289 vacuum tube is still king for the up to 50 or so watts per tube and more if abused (ref. 19)! Single and two tube amplifiers are in use on both 13 and 23-cm (refs. 19, 20, 21, and 22).

For real high power there are presently only a few designs available. A few lucky Amateurs have managed to obtain surplus klystrons such as the Varian VA-802 for 13-cm and its complement on 23-cm. The UPX4 is probably the most widely used high-power amplifier on 23-cm (ref. 23). Hans Rasmussen, OZ9CR, has been producing a copy of this amplifier for interested parties as his time permits. Recently Buzz Miklos, WA4GPM, gave a paper on a high-power 23-cm amplifier using the new Eimac Y846 planar triode (ref. 24).

On 13-cm some 2C39/7289 designs have emerged (Ref. 25). A real catch, if you're lucky, is the AN/TRC-29 surplus amplifier which uses a single 7289 and can easily deliver 25-50 watts of output at 13-cm. However, these amplifiers seem to all be hidden away by Amateurs who someday hope to get on 13-cm and probably never will!

Recently Hans Rasmussen, OZ9CR, has produced single and two tube designs for 13-cm. Gain is about 6-8 dB depending on drive and power level. The two tube amplifier, if really pushed, will deliver about 100 watts output at 25% efficiency with 5-6 dB gain (ref. 26).

Finally, many bits and pieces of information about designing and operating UHF amplifiers has been written but not always gathered together. An effort to do this was conducted in two of my recent Ham Radio "VHF/UHF World" columns (ref. 27 and 28). Other circuits have appeared in some popular VHF/UHF journals (ref. 29).

Summary: The material in this paper is not complete. However, most of the missing material can be found in the references. Reference 1 is particularly recommended reading before undertaking either of the designs in figures 1 and 2. In the designs on the figures, I have taken the liberty of showing all dimensions without alternatives since nowadays most Amateurs do not really have the time or inclination to go through the effort required to redesign or second-guess an author on a complicated design.

I hope the material presented is useful and will help populate the microwave bands. High gain antennas must be duplicated exactly if good performance is expected. The loop Yagi is one type of antenna that is easy to duplicate with predictable performance.!

References:

1. Joe Reisert, W1JR, "VHF/UHF World-Designing and Building Loop Yagis", Ham Radio, September 1985, Pg. 56.
2. Joe Reisert, W1JR, "VHF/UHF World-Stacking Antennas: Part 1", Ham Radio, April 1985, Pg. 129.
3. Joe Reisert, W1JR, "VHF/UHF World-Stacking Antennas: Part 2", Ham Radio, May 1985, Pg. 95.
4. Gunter Hoch, DL6WU, "Extremely Long Yagi Antennas", VHF Communications, 1982, summer issue, Pg. 130.
5. Joe Reisert, W1JR, "VHF/UHF World-Transmission Lines", to be published in Ham Radio, Oct. 1985 issue.
6. Joe Reisert, W1JR, "VHF/UHF World-Determining VHF/UHF Antenna Performance", Ham Radio, May 1984, pg. 110.

Table 1: Specifications and stacking information for the available loop Yagi antenna designs. Equivalent dish diameters are shown for 23 and 13-cm.

Design	Boomlength* in λ	Gain* (dBi)	Equiv. dish diameter**	Beamwidth* (degrees)	Stacking distance* in λ E and	H planes
28 element	9.0	19.0	36/20"	18.0	2.50	2.30
38 element	13.2	20.0	39/22"	16.5	2.75	2.55
45 element	15.7	20.5	42/24"	15.0	3.00	2.75
52 element	18.7	21.0	45/25"	14.0	3.40	3.00

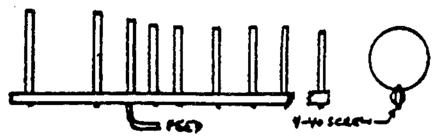
* Approximate. The wavelengths of 23 and 13-cm are 9.1" and 5.12" respectively.
** 23/13-cm respectively.

Figure 1.

W1JR 23-cm 45 Element Loop Yagi

Freq:	1265-1300 mHz
Gain:	20.5 dBi approx.
Boomlength:	12 feet
Beamwidth E:	15-17 degrees
Beamwidth H:	16-18 degrees
Front to back ratio:	20 dB
Side lobes:	13-15 dB down

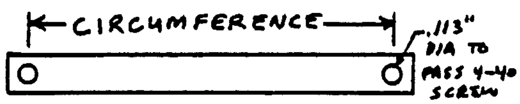
Recommended stacking distance:
  E plane: 27 inches (3.00)
  H plane: 24 inches (2.75)



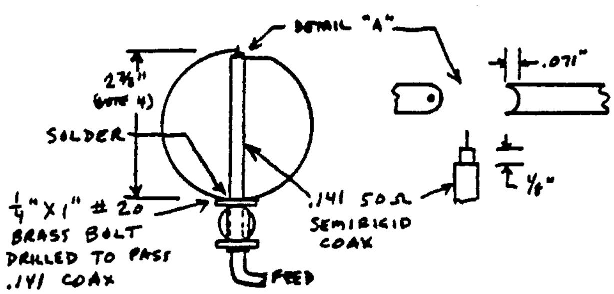
Element	Spacing (note 2)	Circum. (note 3)
Ref. 2	1.00"	9.735"
Ref. 1	4.10"	9.735"
Dr. El.	5.05"	9.292"
Dir. 1	6.17"	8.305"
Dir. 2	7.00"	
Dir. 3	8.78"	
Dir. 4	10.56"	
Dir. 5	11.81"	
Dir. 6	14.12"	
Dir. 7	17.68"	
Dir. 8	21.24"	
Dir. 9	24.80"	
Dir. 10	28.36"	
Dir. 11	31.92"	8.305"
Dir. 12	35.48"	8.054"
Dir. 13	39.04"	
Dir. 14	42.60"	
Dir. 15	46.16"	
Dir. 16	49.72"	
Dir. 17	53.28"	8.054"
Dir. 18	56.84"	7.800"
Dir. 19	60.40"	
Dir. 20	63.96"	
Dir. 21	67.52"	
Dir. 22	71.08"	
Dir. 23	74.64"	7.800"
Dir. 24	78.20"	7.700"
Dir. 25	81.76"	
Dir. 26	85.32"	
Dir. 27	88.88"	
Dir. 28	92.44"	
Dir. 29	96.00"	
Dir. 30	99.56"	
Dir. 31	103.12"	
Dir. 32	106.68"	
Dir. 33	110.24"	
Dir. 34	113.80"	
Dir. 35	117.36"	7.700"
Dir. 36	120.92"	7.600"
Dir. 37	124.48"	
Dir. 38	128.04"	
Dir. 39	131.60"	
Dir. 40	135.16"	
Dir. 41	138.72"	
Dir. 42	142.28"	7.600"

Notes:

1. All dimensional tolerances should be kept to +/-.01" with +/-.025" max.
2. Reference all spacings from the rear of the boom to prevent tolerance buildup.
3. Loop length should be approximately 0.500" longer than circumference dimension shown to allow approximately 0.25" overlap on each end. The circumference shown is the exact distance between the holes in the loop (see sketch below on how to measure). The dimensions are based on using soft aluminum loops that are 0.25" wide and 0.032" thick. Any changes will cause the dimensions to be re-scaled.



4. The driven element is made from a piece of brass 0.25" wide and 0.032" thick. See detail below (and note 3 above) for the measurement of dimensions. First prepare the brass bolt as shown. Then insert the .141 diameter semirigid coax cable and set the driven element height to the dimension shown on the sketch below. Next check the VSWR. If the VSWR is above 1.2:1, move the first director and/or reflector slightly closer or further from the driven element to minimize VSWR. Then adjust the height of the loop up or down to decrease VSWR. When the VSWR is minimum, solder the junction where the loop, .141 coax, and bolt join as shown on the sketch.



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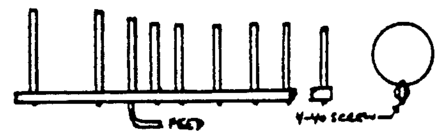


Figure 2

W1JR 13-cm 45/52 Element Loop Yagi

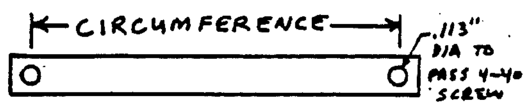
Freq:	2300-2325 mHz
Gain:	20.5-21.0 dBi approx.
Boomlength:	8 feet
Beamwidth E:	15-17 degrees
Beamwidth H:	17-19 degrees
Front to back ratio:	>20 dB
Side lobes:	13-15 dB down

Recommended stacking distance:
E plane: 17.5 inches (3.4 λ)
H plane: 15.5 inches (3.0 λ)

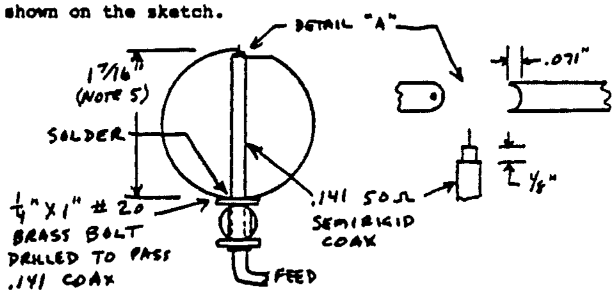
Element	Spacing (note 2)	Circum. (note 3)
Ref. 2	1.000"	5.480"
Ref. 1	2.744"	5.480"
Dr. El.	3.278"	5.125"
Dir. 1	3.908"	4.676"
Dir. 2	4.375"	
Dir. 3	5.376"	
Dir. 4	6.378"	
Dir. 5	7.081"	
Dir. 6	8.380"	
Dir. 7	10.383"	
Dir. 8	12.385"	
Dir. 9	14.388"	
Dir. 10	16.390"	
Dir. 11	18.393"	4.676"
Dir. 12	20.395"	4.534"
Dir. 13	22.398"	
Dir. 14	24.400"	
Dir. 15	26.403"	
Dir. 16	28.405"	
Dir. 17	30.408"	4.534"
Dir. 18	32.410"	4.392"
Dir. 19	34.413"	
Dir. 20	36.415"	
Dir. 21	38.418"	
Dir. 22	40.420"	
Dir. 23	42.423"	4.392"
Dir. 24	44.425"	4.335"
Dir. 25	46.428"	
Dir. 26	48.430"	
Dir. 27	50.433"	
Dir. 28	52.435"	
Dir. 29	54.438"	
Dir. 30	56.440"	
Dir. 31	58.443"	
Dir. 32	60.445"	
Dir. 33	62.448"	
Dir. 34	64.450"	
Dir. 35	66.453"	4.335"
Dir. 36	68.455"	4.279"
Dir. 37	70.458"	
Dir. 38	72.460"	
Dir. 39	74.463"	
Dir. 40	76.465"	
Dir. 41	78.468"	
Dir. 42	80.470"	4.279"
Dir. 43	82.473"	4.229"
Dir. 44	84.475"	
Dir. 45	86.478"	
Dir. 46	88.480"	
Dir. 47	90.483"	
Dir. 48	92.485"	
Dir. 49	94.488"	4.229"

Notes:

1. All dimensional tolerances should be kept to +/-.005" with +/-.01" max.
2. Reference all spacings from the rear of the boom to prevent tolerance buildup.
3. Loop length should be approximately 0.375" longer than circumference dimensions shown to allow approximately 0.188" overlap on each end. The circumference shown is the exact distance between the holes in the loop. The dimensions are based on using a soft aluminum loops that are 0.25" wide and 0.032" thick. Any changes will cause the dimensions to be re-scaled. See sketch below on how to measure.



4. Director 42 completes the original 45 element model patterned after the 23-cm loop Yagi. Extending the boom to 8 feet and adding 7 more directors will increase the gain by about 0.5 dB.
5. The driven element is made from a piece of brass 0.25" wide and 0.032" thick. See detail below (and note 3 above) for the measurement of dimensions. First prepare the brass bolt as shown. Then insert the .141 semirigid coax cable and set the driven element height to the dimension shown on the sketch below. Next check the VSWR. If the VSWR is above 1.2:1, move the first director and/or the reflector slightly closer or further from the driven element to minimize VSWR. Then adjust the height of the loop up or down to decrease VSWR. When the VSWR is minimum, solder the junction where the loop, .141 coax and bolt join as shown on the sketch.



2304 MHz - 45 ELEMENT LOOP YAGI

(Very preliminary information by W1JR

Revised by Chip Angle, N6CA

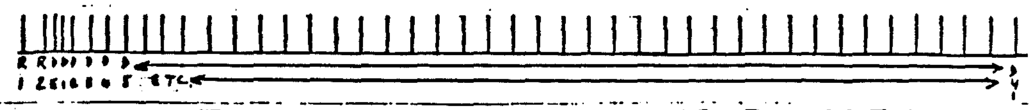
VERY PRELIMINARY INFORMATION REV 3-15-83

W1JR - 2304 MHz - 45 ELEMENT LOOP YAGI (NOTE 1) J H Reisert

GAIN ≈ 21dBi F/B RATIO ≈ 20dB RECOMMENDED STACKING

BW (E) ≈ 18° SIDELOBES ≥ -15dB E (HORIZ) PLANE ≈ 15"

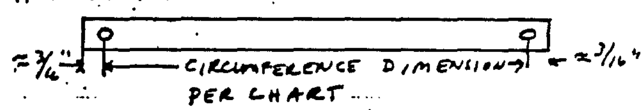
BW (H) ≈ 20° BOOM: 1/2" OD X 80 1/2" H (VERT) PLANE ≈ 13"



Element	Spacing (note 3)	Circum. (note 4)
Refl. 2	0.500"	5.480"
Refl. 1	2.244"	5.480"
Dr. El.	2.728"	5.125"
Dir. 1	3.408"	4.676"
Dir. 2	3.875"	
Dir. 3	4.876"	
Dir. 4	5.878"	
Dir. 5	6.581"	
Dir. 6	7.880"	
Dir. 7	9.883"	
Dir. 8	11.885"	
Dir. 9	13.888"	
Dir. 10	15.890"	
Dir. 11	17.893"	
Dir. 12	19.895"	4.676"
Dir. 13	21.898"	4.534"
Dir. 14	23.900"	
Dir. 15	25.903"	
Dir. 16	27.905"	
Dir. 17	29.908"	4.534"
Dir. 18	31.910"	4.392"
Dir. 19	33.913"	
Dir. 20	35.915"	
Dir. 21	37.918"	
Dir. 22	39.920"	
Dir. 23	41.923"	4.392"
Dir. 24	43.925"	4.335"
Dir. 25	45.928"	
Dir. 26	47.930"	
Dir. 27	49.933"	
Dir. 28	51.935"	
Dir. 29	53.938"	
Dir. 30	55.940"	
Dir. 31	57.943"	
Dir. 32	59.945"	
Dir. 33	61.948"	
Dir. 34	63.950"	
Dir. 35	65.953"	4.335"
Dir. 36	67.955"	4.279"
Dir. 37	69.958"	
Dir. 38	71.960"	
Dir. 39	73.963"	
Dir. 40	75.965"	
Dir. 41	77.968"	
Dir. 42	79.970"	4.279"

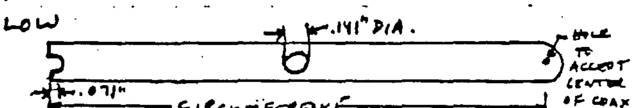
2.744 1.744 .680 .467 1.001 1.002 .703 1.299 2.0025 SPACING

1. BASED ON WORK DONE BY G3JVL
2. DIMENSIONAL TOLERANCES SHOULD BE KEPT TO ±.005" WITH ±.01" MAXIMUM
3. REFERENCE ALL SPACINGS FROM END OF BOOM TO PREVENT TOLERANCE BUILDUP
4. LOOP LENGTH SHOULD BE APPROXIMATELY 3/8" LONGER THAN CIRCUMFERENCE SHOWN TO ALLOW ≈ 3/16" OVERLAP. THE CIRCUMFERENCE DIMENSION IS THE DISTANCE BETWEEN HOLES. SEE SKETCH BELOW:

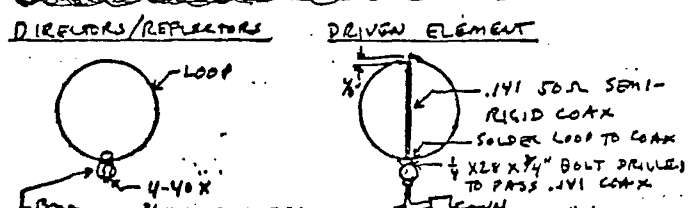


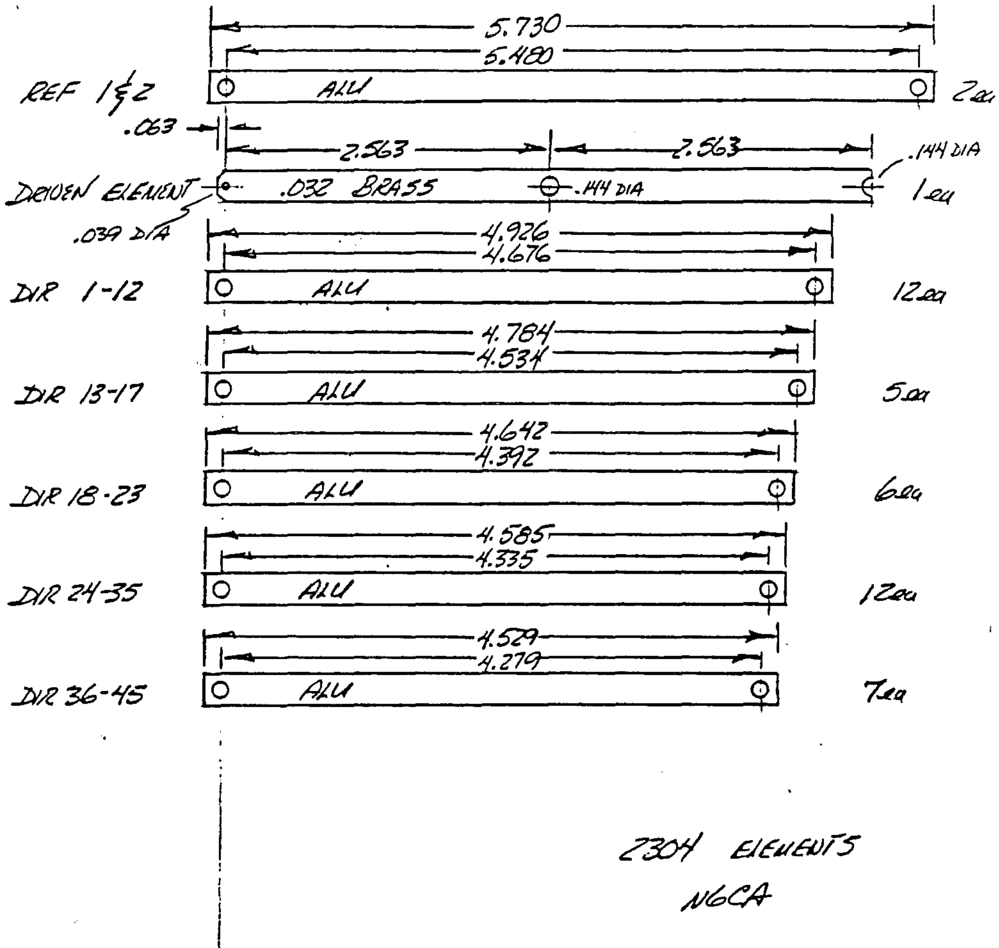
ALL LOOPS ARE MADE FROM SOFT ALUMINUM 0.250" WIDE AND 0.032" THICK. ANY DEVIATIONS FROM ABOVE MUST BE COMPENSATED OR PERFORMANCE WILL DETERIORATE. SEE SKETCH BELOW FOR MOUNTING.

5. DRIVEN ELEMENT MADE FROM 0.250" WIDE X .032" THICK BRASS AS SHOWN BELOW



~~[illegible]~~



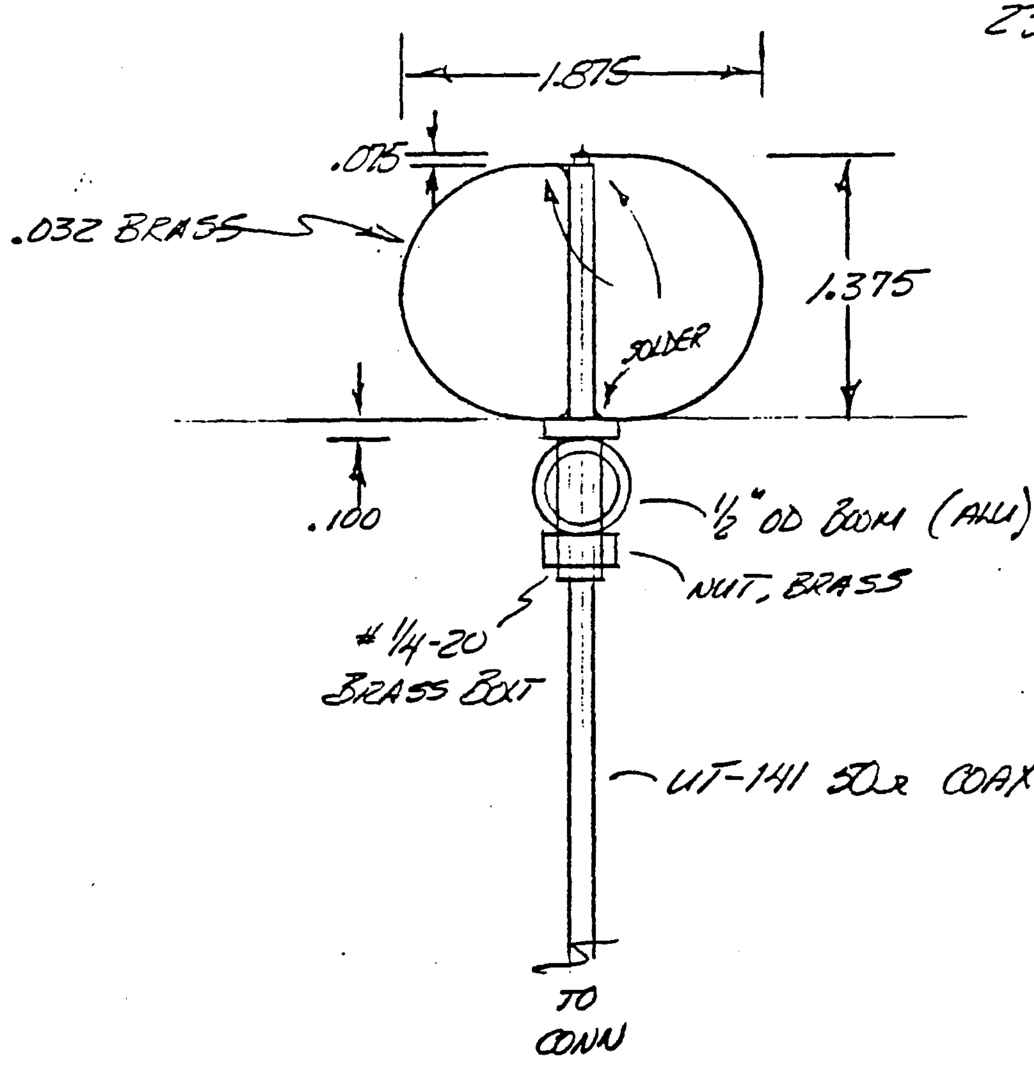


2304 ELEMENTS
N6CA

PER G3JVL / W1JR

DRIVEN ELEMENT
2304 LOOP 4/8/91

N6CA

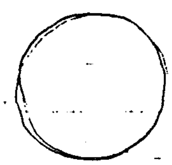


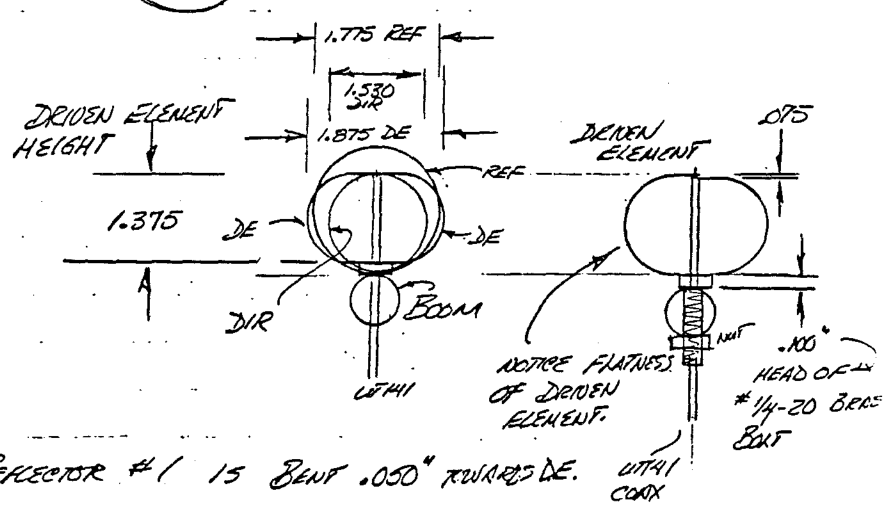
6-22-85
N6CA

D.E. → 1.875 O DIM ←

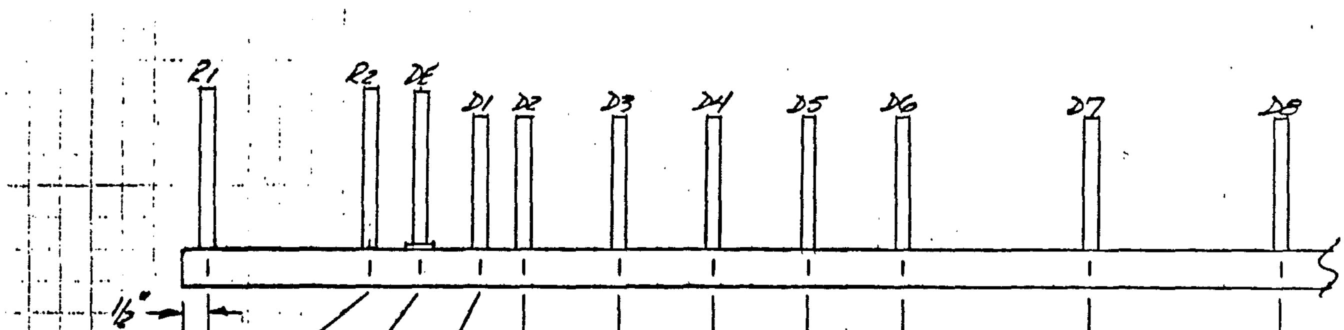
REF → 1.775 O DIM ←

DIR 1 → 1.530 O DIM ←





- REFLECTOR #1 IS BENT .050" TOWARDS DE.
- THESE DIMENSIONS RESULTED IN A 30 dB RTN LOSS AT 2304 & ± 10 MHz >20 dB RTN LOSS
- GAIN PEAK OF GAIN PASS BAND WAS AT 2304.



1296	3.050	1.180 ~~[illegible]~~	1.120	.830	1.780	1.780	1.780	1.780	3.560	3.560
1283	3.090	1.193 ~~[illegible]~~	1.135	.841	1.804	1.804	1.804	1.804	3.607	3.607
1270	3.122	1.202 ~~[illegible]~~	1.146	.850	1.822	1.822	1.822	1.822	3.644	3.644
FREQ										

ELEMENT SPACING (INCHES)

→ SPACING REMAINS CONSTANT FOR ALL ELEMENTS FROM D6 UP

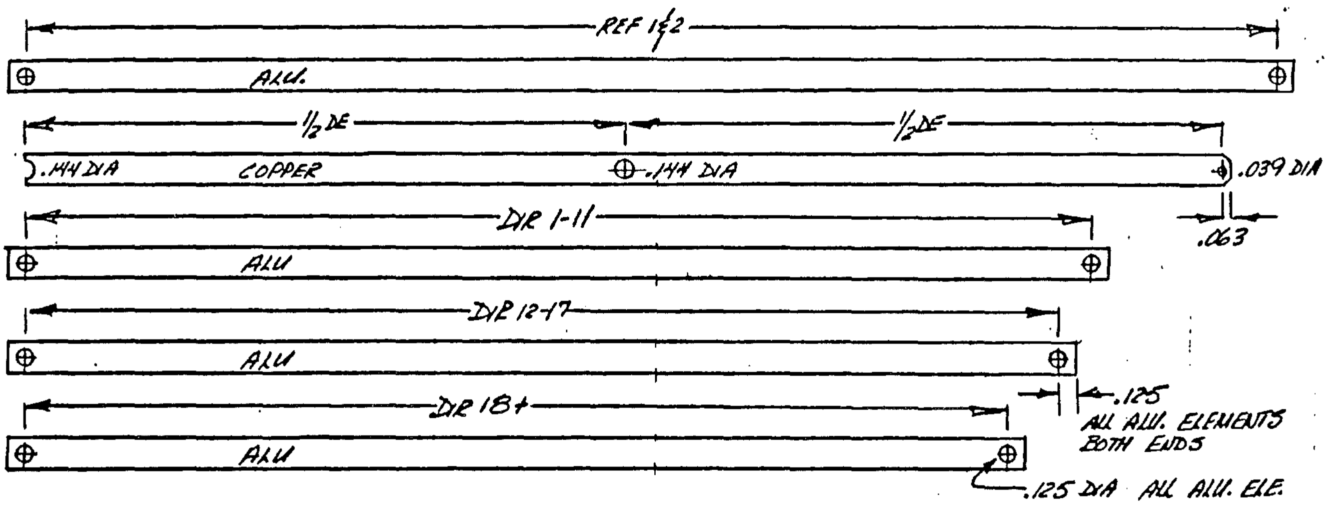
GAIN IS TYPICALLY -2 dB AT ± 30 MHz FROM DESIGN FREQ, HOWEVER VSWR DETERIORATES RAPIDLY ON LOW SIDE. MODE L & FM USERS SHOULD USE 1270 DIMENSIONS. THE 1283 DIMENSIONS ARE FOR UPPER BAND USE ONLY AND WILL GIVE LESS 1 dB GAIN VARIATION FROM 1280 TO 1300 MHz. THE 1296 DIMENSIONS ALLOW USE ONLY FROM 1290 TO 1300.

TYPICAL RESULTS FROM VARIOUS GAIN TESTS THROUGHOUT THE COUNTRY INDICATE A 12' YAGI WILL YIELD 20.5 dBi AND A 6' YAGI ABOUT 18 dBi.

REFER TO THE RSGB VHF/UHF HANDBOOK FOR ADDITIONAL INFORMATION.

SOURCE OF ORIGINAL DIMENSIONS: G3JVL
W1JR

REV



FREQ	1270	1283	1296
REF 1&2	9.929	9.829	9.700
1/2 DE	4.752	4.704	4.643
DIR 1-11	8.445	8.359	8.250
DIR 12-17	8.189	8.106	8.000
DIR 18+	7.882	7.802	7.700

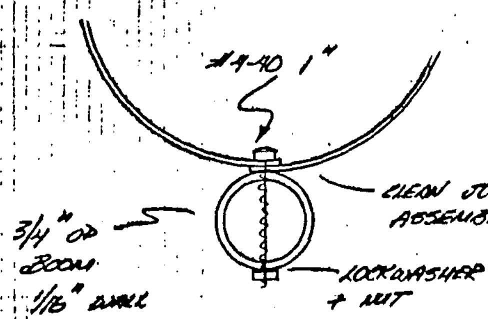
ELEMENT LENGTHS (INCHES)
(HOLE TO HOLE)

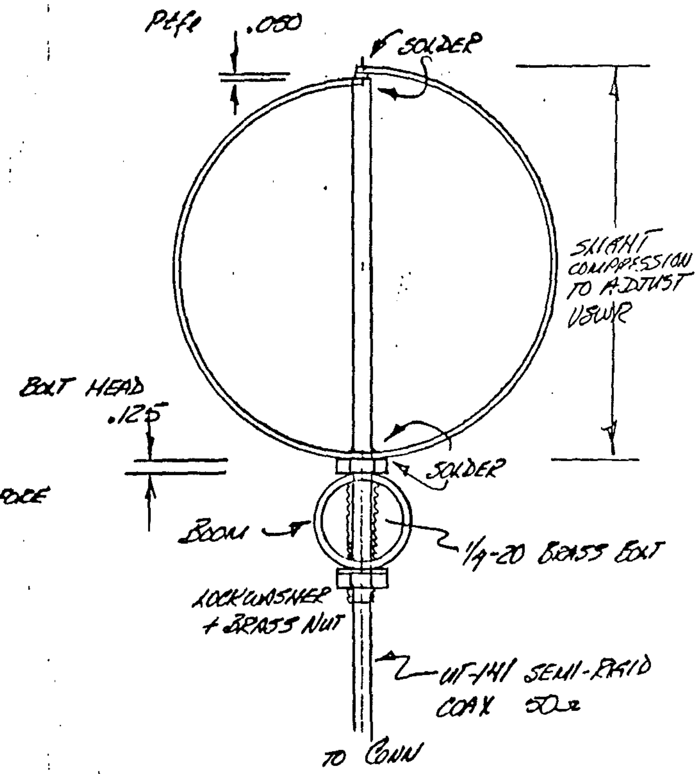
THESE DIMENSIONS APPLY ONLY TO:

.250 ELEMENT WIDTH
.0325 ELEMENT THICKNESS
.750 DIAMETER BOOM

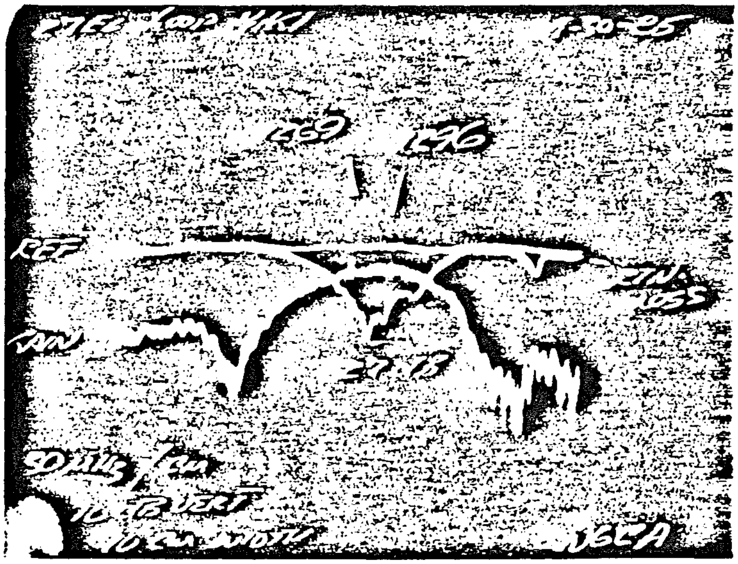
REV
N6CA 4-30-85

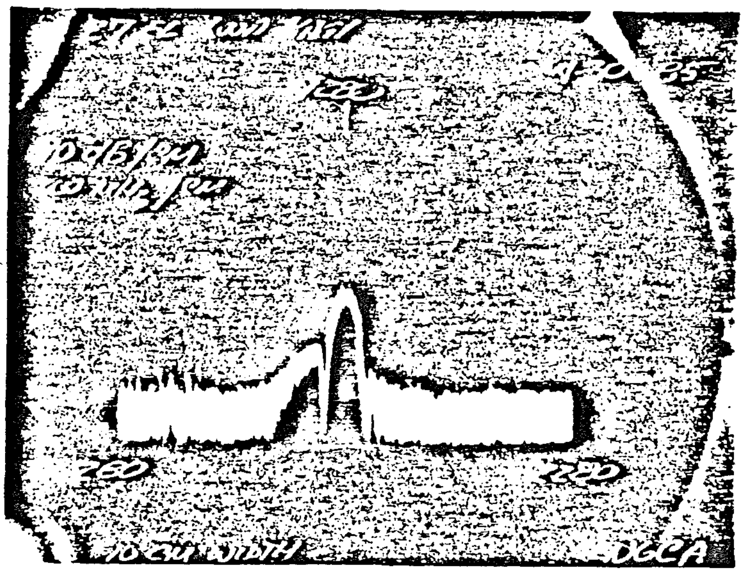
TYPICAL ELEMENT ATTACHMENT





DRIVEN ELEMENT ASSEMBLY


REF
10 dB VERT


10 cm WIDTH

GETTING STARTED ON 13 AND 23 CM

by

Joe Reisert, W1JR

First Annual 1296/2304 mHz Conference, Estes Park, Colorado, 19-22 Sept. 1985

"Getting Started on 13 and 23-CM" by Joe Reisert, W1JR

The recent activity on the 13 and 23-cm microwave bands has been very encouraging. However, there are still many other interested Amateurs who need information on the microwave bands. Typically they ask what are the prime frequencies and modes of operation. The next questions seem to center around propagation, recommended receivers, transmitters and antennas. With this in mind, let's examine these question areas and then review some of the preferred equipment for these frequencies.

Frequencies of interest: Most of the early work on 23-cm was done on cw using multipliers, typically from 144 or 432 mHz. This was even carried through to EME (ref. 1). However, present day operation is primarily on cw and ssb, especially on OSCAR and weak signal operation. Some FM and FM repeaters are also gaining popularity but they are hardly the mode for weak signal operation. Let's keep them out of the weak signal portions of the band!

OSCAR 10 operation is almost entirely centered around the uplink frequency of 1269 mHz. Most of the weak signal operation is conducted between 1296.000 and 1296.150 mHz with EME between 1296.000 and 1296.050 mHz and the terrestrial work centered around the calling frequency, 1296.100 mHz.

13-cm is now a fragmented band. Before WARC '79 most of the world had the full 2300 to 2450 mHz band. However, soon after WARC '79 the band started to to be segmented. In Europe several countries removed the spectrum below 2320 mHz while in November 1984 the FCC removed 2310 to 2390 mHz from USA Amateurs. This makes it tough for those using "polaplexer" types of setups with 30 mHz IFs unless they stay in the top portion of the band or use 88-108 mHz IF's (ref. 2). The EME'ers who schedule Europe have had to resort to crossband operation from 2304.000 to 2320.150 mHz.

In the USA most of the 13-cm weak signal operation is conducted between 2304.000 and 2304.150 mHz. EME operation is primarily conducted between 2304.000 and 2304.050 mHz. 2304.1 mHz is the recommended terrestrial calling frequency. It probably will take some time to move everyone to a common calling frequency of 2304.1 mHz since many of the older transmitters use multiplier schemes that are centered on 2304.0 mHz. However, in the long run it will be worthwhile since there will be no conflict with EME operation and the USSR satellites that have been monitored near 2304.0 mHz.

Propagation: Radio propagation on the 13 and 23-cm bands is quite similar to 70-cm. However, the typical antenna beamwidths are narrower, transmitter power is often low (1-10 watts) at the present time and feedline loss becomes a real limiting factor. As a result, these microwave bands are perceived as different or more difficult to conquer.

One of the most noticeable problems on the microwave bands is foliage attenuation (including evergreens!). Foliage can cause terrific attenuation of signals. You can wait until the leaves fall (if they're not evergreens) but the propagation during the fall and winter is typically at its poorest point.

However, on the plus side, aircraft scatter and scatter in general are very noticeable on the microwave bands and are big propagation contributors when conditions are poor (ref. 3). It is recommended that if you set up schedules over an obstructed path that both stations aim their antennas at some common scattering medium such as a tall building, hill or mountain top and take advantage of the scatter so prevalent on the microwave bands.

Finally, it has been speculated that the optimum frequency for long haul tropo and ducting is near 1500 mHz (ref. 3). What this means is that there is more likelihood of long DX via tropospheric propagation on 13 and 23-cm than at the lower UHF/VHF Amateur bands. Furthermore, static, noise, and other objectionable VHF phenomenon are almost nonexistent at microwaves so it is more pleasurable place to operate. I think that these microwave bands are really where the greatest advances will occur in the next few years. All we need is time to develop the bands, better gear (especially with higher power), and an increase in the activity level.

Receiving Equipment: Since cw and ssb are the most popular modes for weak signal operation, the following recommendations will concentrate on this type of gear. More specifically, we will concentrate on receive type down-converters, transmitter up-converters, and transverters.

A basic receive type down-converter is shown on figure 1. There is nothing new on this block diagram. However, the components necessary at microwave frequencies are quite different from those used on VHF/UHF. Technology has come a long way of late and is still improving at a rapid rate. Therefore the modular approach is strongly recommended so that new improved designs can be substituted as they become available (ref. 4).

Inexpensive bipolars such as the NE64535 work great as a preamplifier or postamplifier through 4000 mHz (ref. 5). There are now many modular amplifiers available. At the present time the least expensive are the Avantek "MSA" series MMIC's (microwave monolithic IC's). More on this later. While these MMIC's may not have state-of-the-art noise figures for the input preamplifier, they can still easily deliver 5-6 dB noise figures. Siemens, NEC, and others are now offering broadband GaAs FET versions of the same. The noise figures on the broadband matched types of GaAs FET preamplifiers are typically 4 dB with 18-20 dB of gain! Expect the noise figures to drop.

Likewise, there are many low-cost GaAs FETs now available (refs. 6, 7 & 8). Simple PI-network or tuned tank circuits still work well on these bands for input/output matching with either bipolars or GaAs FETs. There is no longer any excuse for a high noise figure (over 2 dB) on any Amateur band below 2450 mHz!

If the modular approach is used, new improved preamplifier designs can be easily added later. HMETs (high mobility electron transistor) may soon be available to Amateurs (ref. 9). They promise to have lower noise figures than GaAs FETs with a higher cutoff frequency!

Bandpass filters are highly recommended to remove general crud as well as the image frequency especially if a 28 or 50 mHz IF is used. If a 2 meter IF is used with a tuned preamplifier(s), a bandpass filter may not be necessary.

The heart of any high-performance converter, be it receive or transmit, is the mixer and local oscillator (LO). Trough line mixers of the K6AXN/W1OOP type used to be very popular (ref. 10). In recent years the W2CQH interdigital type of mixer has become very popular (ref. 11). More recently the anti-parallel harmonically-pumped mixer is gaining popularity (refs. 12 and 13). It is simple to build and only requires the LO to be at one 1/2 the normal frequency!

However, the mixer type most recommended is the balanced type (ref. 14). Better yet I recommend the double-balanced-mixer (DBM) type (ref. 15). DBMs used to be very expensive but with recent improvements in technology and the low-cost TVRO market, they are dropping to very affordable prices.

Also, if two DBMs are configured with the proper hybrids, an image-rejection mixer can be configured per figure 2. This scheme has the advantage of not requiring special filtering for image rejection even when a low frequency IF (eg. 28 mHz) is used. It also can be used in the transmitter as we shall shortly see.

Let's not forget the LO. It must not only be stable but must be clean of spurious frequencies and should be relatively clean of harmonics of the basic crystal oscillator. Recommended LO schemes are shown on figure 3. As shown, the most popular LO frequencies for 23-cm are 1268 mHz (from a 105.666 mHz crystal oscillator) for a 28 mHz IF and 1152 mHz (from a 96 mHz oscillator) for a 144 mHz IF. The most popular LO frequencies for 13-cm are 2276 mHz (derived from a 94.8333 mHz oscillator) for a 28 mHz IF and 2160 mHz (from a 90 mHz oscillator) for a 144 mHz IF. Properly implemented, the LO output should be at least 30 dB above any other generated products.

The lowest recommended frequency for the crystal oscillator in a microwave receiver is 90 mHz. Frequency multipliers in a LO chain should be limited to doublers and triplers using the recommended multiplication scheme shown on figure 3. Triplers have lower efficiency than doublers and require more complex filtering than most Amateurs are willing to employ! Therefore, I recommend that triplers only be employed up to 350 mHz on the output.

Finally, the crystal oscillator should be a 5th overtone colpitts type with the crystal in the feedback path between the collector and emitter per reference 4. A recommended overtone crystal oscillator circuit is shown on figure 4. Overtone oscillators with the crystal from the base to ground should be avoided at all cost since they will have poorer frequency stability and greater phase noise (ref. 4).

Transmitters: The transmitter design is primarily a function of the type of emission desired. As described earlier, until recently most of the operation on the 13 and 23-cm bands has been with cw and multipliers. Often an 8 mHz oscillator was multiplied all the way up to the final output frequency. In the more sophisticated setups, an upconverter was used to mix to some intermediate frequency before multiplying the final step to 13 or-23 cm.

One popular scheme used in Europe (that has also been used by some contest stations in the USA) is to build a stable 1152 mHz LO from a 96 mHz crystal oscillator and then multiply it to the desired band (ref. 16). 1152 mHz is a unique frequency since 2, 3, 5 and 9 times 1152 is 2304, 3456, 5760 and 10,368 mHz respectively, all falling in our assigned microwave bands. Furthermore, if 1152 mHz is mixed with 144 mHz, we obtain 1296 mHz.

By far the most popular transmitter scheme of late is the transverter. If a common IF such as 28 or 144 mHz is used, only one LO has to be built for each microwave band as shown on figure 5. Hence the LO (such as the receiver LO just discussed) does double duty. This scheme allows cw as well as ssb operation with more than adequate frequency stability. The image reject mixer shown on figure 2 is strongly recommended for a transverter since it will reduce filtering requirements.

Tube upconverter/mixers such as the 2C39 family have also been used but I personally recommend the low-level upconverter approach with a DBM since it is clean and easy to construct. If the modular approach is used, you can add or change stages as they are built or upgraded. Also solid state devices don't require high voltages and filament voltages not to mention the warmup and tuning drift.

It used to be difficult to obtain the required gain and power for low-level upconverters but that is no longer true. The low cost (less than $3.00) Avantek MMIC's mentioned earlier yield 8-15 dB of gain (ref. 17). Furthermore, NEC (NEL1300 and NEL2300 series), Acrian, SSM, TRW etc. all have available linear bipolars that will deliver up to 20 watts on 23-cm and 3-6 watts of linear power on 13-cm at reasonable prices. Medium power (1 watt) GaAs Fets are also quite available and power levels increasing to 10 watts reported. For higher solid state power, devices can be combined either directly with matching networks or by using hybrid power splitter/combiners.

If only cw is desired at higher power levels, there are numerous solid state devices up through at least 15 watts on 13-cm. WA3AXV, WA3JUF and W3HQT have successfully used ssb with some of the higher powered class C transistors by employing a slight amount of forward bias. However, this technique is only recommended on selected devices (ref. 18).

Some Amateurs have supposedly run class C devices on ssb with reasonable linearity. The trick is to inject a small amount of carrier by unbalancing your balanced modulator. I haven't tried this method personally and would appreciate information from any one who has.

Admittedly there is still an RF power generation problem on the microwave bands. The ubiquitous 2C39/7289 vacuum tube is still king for the up to 50 or so watts per tube and more if abused (ref. 19)! Single and two tube amplifiers are in use on both 13 and 23-cm (refs. 19, 20, 21, and 22).

For real high power there are presently only a few designs available. A few lucky Amateurs have managed to obtain surplus klystrons such as the Varian VA-802 for 13-cm and its complement on 23-cm. The UPX4 is probably the most widely used high-power amplifier on 23-cm (ref. 23). Hans Rasmussen, OZ9CR, has been producing a copy of this amplifier for interested parties as his time permits. Recently Buzz Miklos, WA4GPM, gave a paper on a high-power 23-cm amplifier using the new Eimac Y846 planar triode (ref. 24).

On 13-cm some 2C39/7289 designs have emerged (Ref. 25). A real catch, if you're lucky, is the AN/TRC-29 surplus amplifier which uses a single 7289 and can easily deliver 25-50 watts of output at 13-cm. However, these amplifiers seem to all be hidden away by Amateurs who someday hope to get on 13-cm and probably never will!

Recently Hans Rasmussen, OZ9CR, has produced single and two tube designs for 13-cm. Gain is about 6-8 dB depending on drive and power level. The two tube amplifier, if really pushed, will deliver about 100 watts output at 25% efficiency with 5-6 dB gain (ref. 26).

Finally, many bits and pieces of information about designing and operating UHF amplifiers has been written but not always gathered together. An effort to do this was conducted in two of my recent Ham Radio "VHF/UHF World" columns (ref. 27 and 28). Other circuits have appeared in some popular VHF/UHF journals (ref. 29).

Antennas: Until recently the parabolic dish has been the most popular antenna on both 23 and 13-cm. The six to eight footers have been most common on 23-cm, often made from a refurbished UHF TV dish. This size dish is capable of about 25-28 dBi of gain. Most 13-cm operation has likewise used dishes with the three to four footers being most popular. Properly illuminated they will deliver about 24-27 dBi of gain. A six footer at 13-cm can yield up to 30 dBi of gain but only has a 5 degree beamwidth!

Lately the "Loop Yagi" has been taking over on both 13 and 23-cm especially where wind, ice and snow are common (ref. 30). It surely has a lower profile. The main problem with the loop Yagi is that the present designs available are gain limited. At 23-cm the longest design presently available has a twelve foot boom and will deliver about 20.5 dBi of gain. Therefore, stacking with its associated problems is needed for higher gains.

Regardless of its shortcomings, the loop Yagi is getting many Amateurs on the 23 and 13-cm bands and is now available commercially (more on this later). Designing loop Yagis especially on 13-cm will be a subject of a later talk at this conference (ref. 31).

Feedlines: No talk on microwaves would be complete without a few words on feedlines. At microwave frequencies, unless you have a clear and elevated QTH, you will need a feedline that will undoubtedly be your most serious station limitation.

Heliax (TM of Andrew Corp.) and hardline are the recommended feedlines for Amateurs operating on the lower microwave bands. They are expensive, but then again, so is the price of generating power or signal strength at these frequencies. The recommended transmission line for the price and performance is the 7/8" air dielectric Heliax which is often available at flea markets. It has a loss of about 4 dB per 100 feet at 23-cm and 6 dB per 100 feet at 13-cm, quite low for these frequencies.

Hardline with its aluminum outer conductor and foam dielectric has considerably more loss than Heliax but is lower loss than any of the commonly available flexible types of line. The "G" Line is also a strong underused possibility. These and other suggested feedlines are described in detail in reference 32 so I will not dwell on them further at this time.

One closing remark on feedlines. Any transmission line loss is a two way street so you lose both on receive and transmit. Hence a 4 dB feedline loss will cost you 8 dB in system performance! Therefore, it is often a good idea to at least consider mounting your preamplifier at the antenna to obtain all the signal you can receive! I'm convinced that feedline loss is the single most important contributor to poor performance on the microwave bands.

Miscellany: As I mentioned before, there's lots of construction information pertaining to the microwave bands but it seems to be tucked away or scattered without any real way to pull it together. Many articles are available in the popular journals and books mentioned in reference 29. Also there are a few microwave bibliographies that are available. Undoubtedly I'll miss some but those I have on file are listed in references 33 thru 37.

Commercial Equipment: Finally, for those who just don't have the patience or time to build, there is now more than enough gear available to get on the microwave bands without "rolling your own". The following information in no way implies that any of the information is accurate or that I personally in any way endorse any of the products or companies about to be mentioned. My apologies to those I may have missed. Please bring them to my attention so they may be listed in future articles.

Companies Producing Microwave Gear (not listed in any particular order):
1. Microwave Modules of England: Transverters, receive converters and preamplifiers.
2. SSB Electronics of W. Germany (represented in the USA by The VHF Shop): Transverters, receive converters, preamplifiers, solid state low power amplifiers.
3. Down East Microwave, W3HQT: Loop Yagis and solid state power amplifiers.
4. Tonna Antennes (F9FT): 23-cm Yagi antennas and power splitters.
5. HI-SPEC: Ott Fiebel, W4WSR, 23-cm tube type power amplifiers.
6. VE3CRU: Loop Yagis for 23-cm, Microwave Modules and SSB Electronics gear.
7. Maki-Denki (Spectrum West): 23 and 13-cm transceivers.
8. ICOM: 23-cm transceivers.
9. Parabolic (SM6CKU): 23-cm transverters, tube type 23-cm power amplifiers, and dishes.

Summary: This wasn't a highly sophisticated paper. In fact, most of you that read or heard this material will already be familiar with most of this information. However, perhaps there are some scraps of information that will be of value. Also I hope that you will spread the word and distribute all or part of this information to interested parties in an effort to activate the microwave bands. The sooner we get activity, the sooner we will get real growth. As mentioned earlier, any worthwhile information not in this paper and brought to my attention will be greatly appreciated and added to future presentations.

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3. Joe Reisert, W1JR, "VHF/UHF World-The VHF/UHF Primer: An Introduction to Propagation", Ham Radio, July 1984, Pg. 14.
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5. Bob Atkins, KA1GT, "The New Frontier-A 2304 mHz Preamplifier", QST, August 1981, Pg. 65.
6. Joe Reisert, W1JR, "VHF/UHF World-Low-Noise GaAs FET Technology", Ham Radio, December 1984, Pg. 99.
7. Geoff Krauss, WA2GFP, "A Low-Noise Preamplifier for 2304 mHz", Ham Radio, February 1983, Pg. 12.
8. Bob Sutherland, W6PO, "GaAsFET Preamplifiers for 902 MHz and 1296 MHz", Eimac Amateur Service Note 49-36.
9. Jack Browne "Looking Forward to the Promise of the HMET", Microwaves and RF, March 1985, Pg. 17.
10. Mike Krivolavik, K6AXN, and Henry Cross, W1OOP, both developed 1296 trough line receive converters which appeared in many ARRL Handbooks and CQ magazine in the 1960's.
11. R. E. Fisher, W2CQH, "Interdigital Converters for 1296 and 2304 mHz", QST, January 1974, Pg. 11.
12. M. V. Schneider and W. W. Snell, Jr., "Stripline Downconverter With Subharmonic Pump", Bell System Technical Journal, July-Aug. 1974, Pg. 1179.

13. Jim Dietrich, WA0RDX, "Twin-Diode Mixer-a New Microwave Mixer", Ham Radio, October 1978, Pg. 84.
14. H. Paul Shuch, WA6UAM, "Easy-to-build SSB Transceiver for 1296 mHz", Ham Radio, September 1974, Pg. 8.
15. Joe Reisert, W1JR, "VHF/UHF World-VHF/UHF Exciters", Ham Radio, April 1984, Pg. 84.
16. RSGB Microwave Committee, "A High-quality UHF Source for Microwave Applications", Radio Communications, Oct. 1981, Pg. 906. Reprinted with errors in QST in February 1983.
17. Al Ward, WB5LUA, Presentations at various VHF/UHF conferences. Write Al direct.
18. Ron Whitsel, WA3AXV, Bill Olson, W3HQT, and Dave Mascaro, WA3JUF. Talks at several "Mid-Atlantic States VHF/UHF Conferences". Write each one separately.
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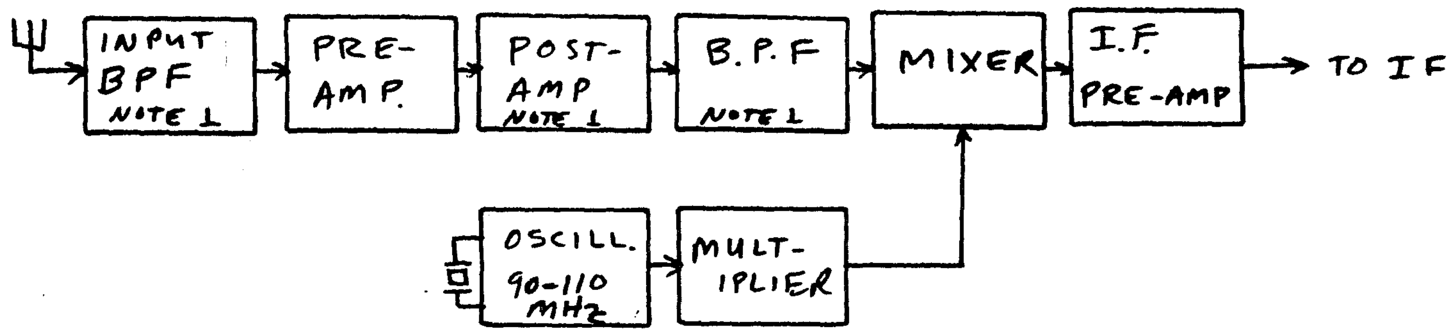
21. Crawford Hill VHF Club, W2NFA, "A Water Cooled Power Amplifier for 1296 mc/s", Technical Note #6. Request from W2IMU.
22. Roger Blackwell, G4PMK, and Ian White, G3SEK, "More Gain from 1.3GHz Power Amplifiers", Radio Communication (RSGB), June 1983, Pg. 500.
23. Crawford Hill VHF Club, W2NFA, "A Kilowatt Power Amplifier for 1296 mc/s", Technical Note #13. Request from W2IMU.
24. Buzz Miklos, WA4GPM, "Coaxial Cavity Amplifiers", Proceedings of the 1985 Central States VHF Society, proceedings copies available for $7.50 from WORRY/5.
25. Norman J. Foot, WA9HUV, "2304-MHz Power Amplifier", Ham Radio, February 1975, Pg. 8.
26. Details of the 13-cm OZ9CR designs are scheduled to be part of the Proceedings of the First Annual 1296/2304 Conference, Estes Park, CO, 9/85.
27. Joe Reisert, W1JR, "VHF/UHF World-High Power Amplifiers: Part 1", Ham Radio, Jan. 1985, Pg. 97.
28. Joe Reisert, W1JR, "VHF/UHF World-High Power Amplifiers: Part 2", Ham Radio, Feb. 1985, Pg. 38.
29. VHF Communications, DUBUS, Radio Communications (RSGB), The Microwave Newsletter Technical Collection (RSGB), VHF UHF Manual (RSGB), and The UHF-Compendium Part 1 and 2 (See Joe Reisert, W1JR, "VHF/UHF World-Keeping VHF/UHFers up-to-date", Ham Radio, Mar. 1985, Pg. 126 for further info on how to obtain these and other publications which are in the field of interest).
30. Joe Reisert, W1JR, "VHF/UHF World-Designing and Building Loop Yagis", Ham Radio, Sept. 1985, Pg. 56.
31. Joe Reisert, W1JR, "Designing Loop Yagis for 13 and 23-cm", Proceedings of the First Annual 1296/2304 Conference, Estes Park, CO, Sept. 21, 1985.
32. Joe Reisert, W1JR, "VHF/UHF World-Transmission Lines", Ham Radio, to be published in Oct. 1985 issue.
33. Bob Atkins, KA1GT, "The New Horizon-1296-MHZ Bibliography", QST, August 1985, Pg. 68.
34. Richard L. Frey, WA2AAU, "2304 mHz construction Ideas", presented at Dayton Hamvention, April 1983. Write WA2AAU directly for copies.
35. Cliff Buttschardt, W6HDO, "Microwave Bibliography", Ham Radio, January 1978, Pg. 68.
36. Al Ward, WB5LUA, "Getting Started on 1296 mHz", 7-17-81. Write Al direct.
37. Richard J. Rosen, K2RR, "From Beverages Thru OSCAR, A Bibliography" and "Addendum: 1979-1981", Contact K2RR directly.

"GETTING STARTED ON 13 AND 23-CM" J. REISERT, W1JR 9/85

FIGURE 1 - BLOCK DIAGRAM OF A TYPICAL RECEIVE-TYPE DOWN-CONVERTER.



NOTE 1 - IF NEEDED. SEE TEXT

FIGURE 2 IMAGE-REJECT MIXER FOR UP/DOWN CONVERTER.

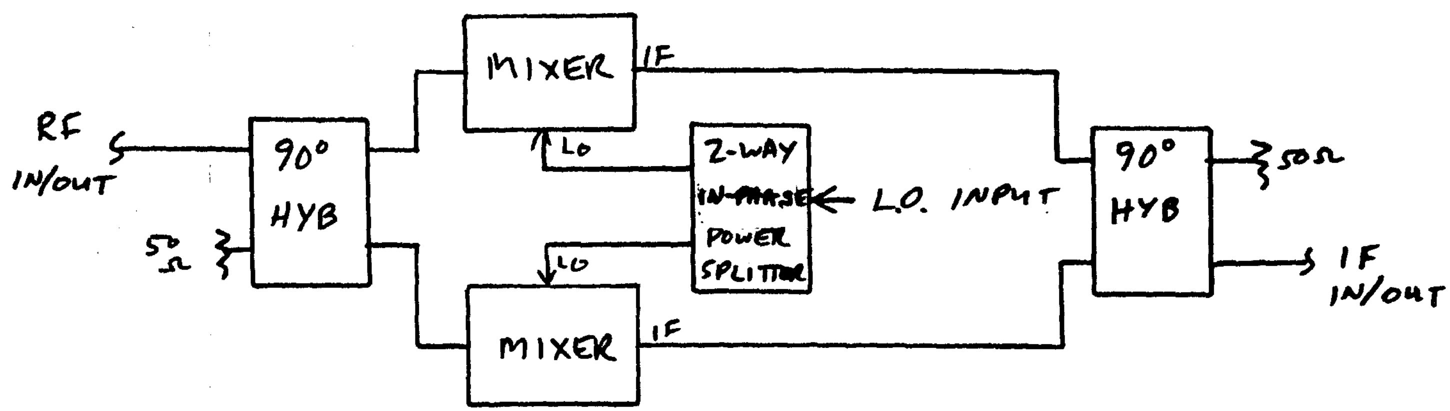


FIGURE 3 LOCAL OSCILLATOR/MULTIPLIER SCHEMES FOR 13/23-CM

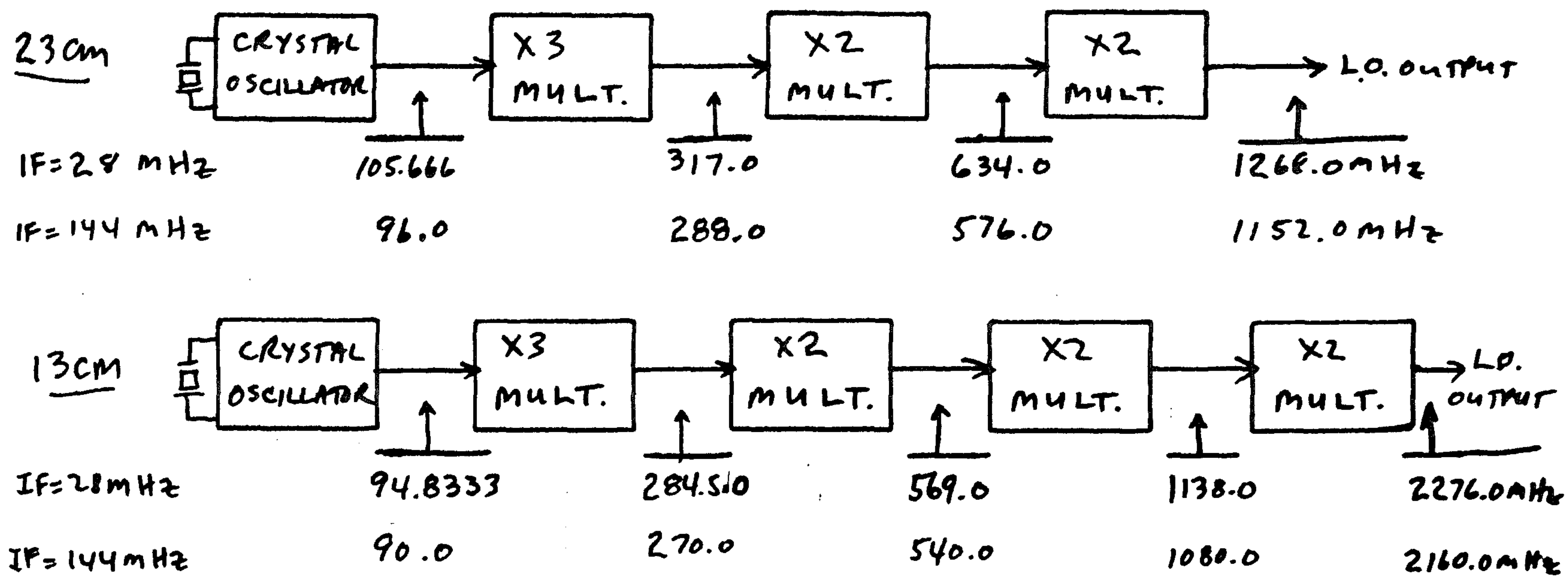
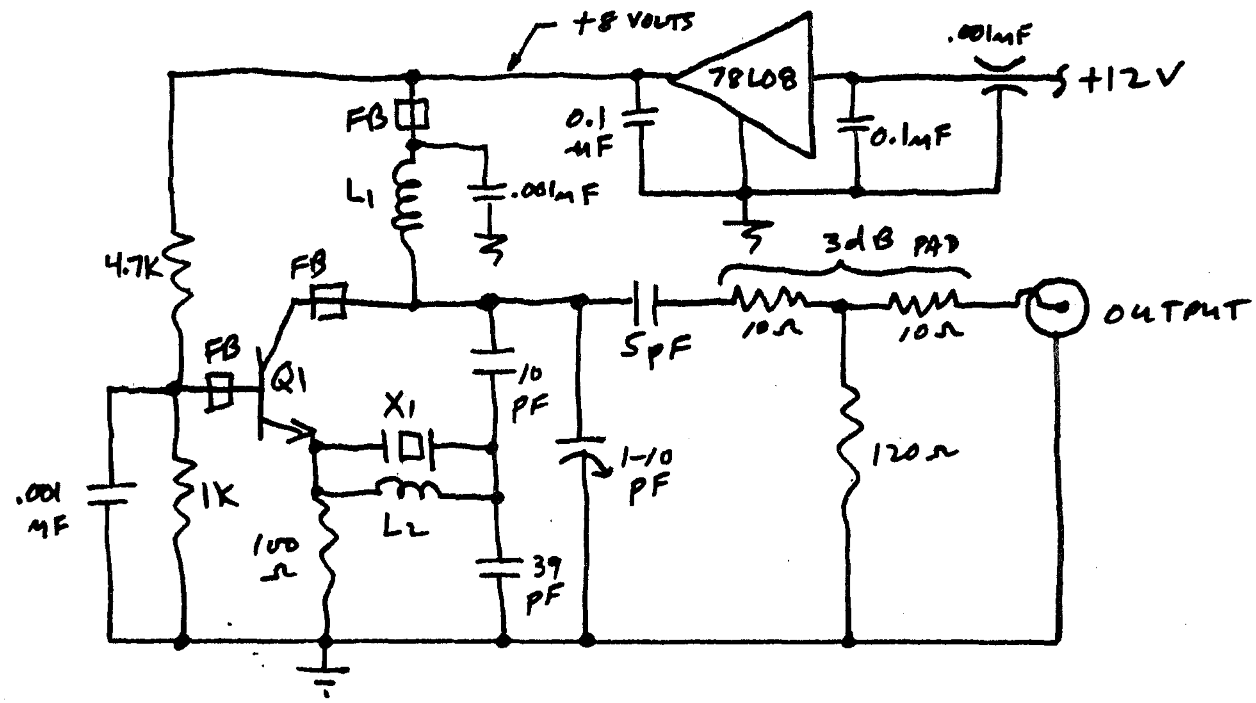


FIG 4. RECOMMENDED 90-110 MHz FIFTH OVERTONE CRYSTAL OSCILLATOR CIRCUIT. POWER OUTPUT APPROX. 10 MW.



FB - FERRITE BEAD, TYPE NOT CRITICAL

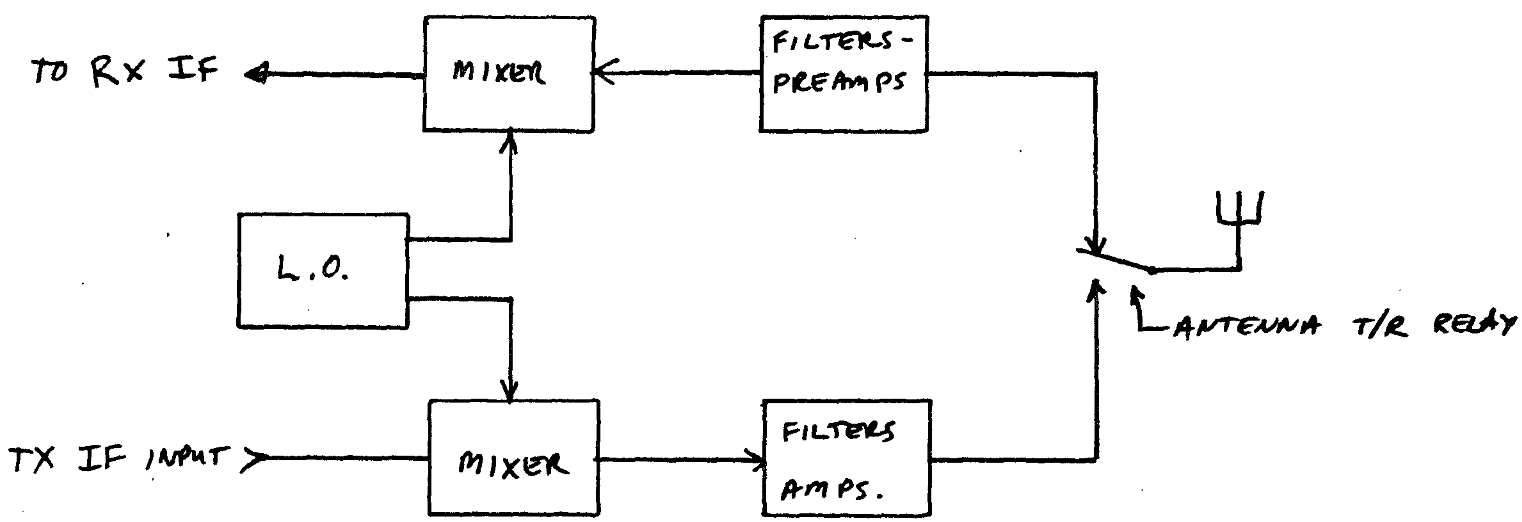
L1 - 10 TURNS # 24 CLOSE WOUND 1/8" ID (PULL APART TURNS SLIGHTLY FOR UPPER FREQ. RANGE)

L2 - 0.39 μh RF CHOKE OR 11 T #28 T-25-6 TOROID

Q1 - NE 73432B, 2N5179 etc

X1 - 5th OVERTONE SERIES MODE CRYSTAL AT CORRECT FREQUENCY

FIGURE 5. TYPICAL TRANSVERTER UP/DOWN CONVERTER



MONOLITHIC MICROWAVE INTEGRATED CIRCUITS

BY

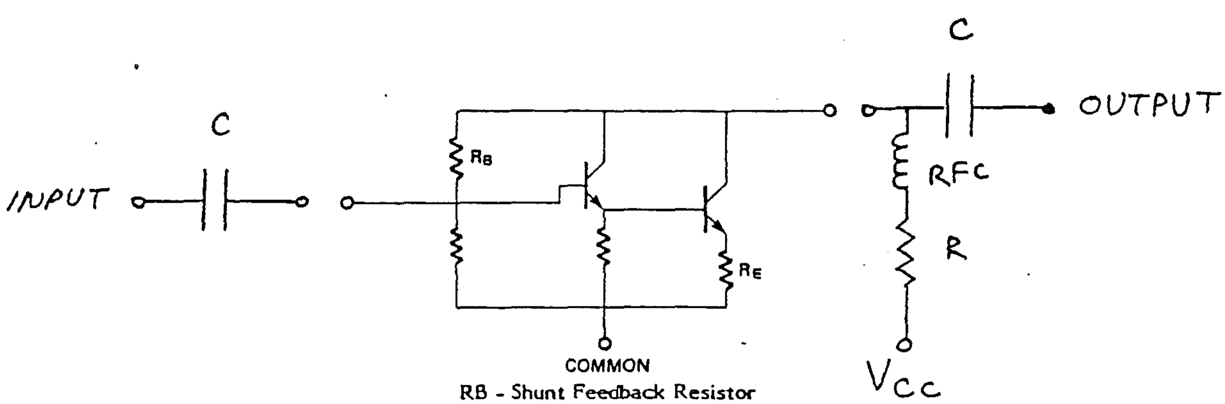
AL WARD

WB5LUA

SEPTEMBER 9,1985

AVANTEK
MONOLITHIC MICROWAVE INTEGRATED CIRCUITS
(MMIC)

* 50 OHM GAIN BLOCK
* BROADBAND DC TO 4GHZ.
* DARLINGTON CONNECTED TRANSISTOR PAIR
* INTERNAL BIASING
* INTERNAL FEEDBACK ENSURES STABILITY
* EASY TO CASCADE



RB - Shunt Feedback Resistor
RE - Series Feedback Resistor

OTHER ADVANTAGES

* LOW COST
* SMALL SIZE
* REPRODUCIBLE PERFORMANCE
* HIGH RELIABILITY
* EASY TO USE

MMIC
MANUFACTURING PROCESSES

* MMIC CHIP MANUFACTURING SIMILAR TO TRANSISTORS
* NITRIDE SELF-ALIGNMENT ION IMPLANTATION TECHNIQUES ARE USED FOR PRECISE CONTROL OF DOPING AND NITRIDE PASSIVATION
* RESISTORS ARE FABRICATED DIRECTLY ON SUBSTRATE
* DESIGNING MASKS IS EXPENSIVE
* DESIGN ITERATIONS REQUIRED BUT COSTLY
* DEVELOPING A FACILITY IS EXPENSIVE
* NEED A HIGH VOLUME MARKET TO MAKE PRODUCTION COST EFFECTIVE

MMIC
PACKAGING

* 100 MIL METAL/CERAMIC "MICRO-X" PACKAGE
* 70 MIL CERAMIC PACKAGE
* 200 MIL CERAMIC PACKAGE
* TO-8 AND TO-12 PACKAGE
* PLASTIC PACKAGE

MMIC
APPLICATIONS

* RECEIVERS   RF/IF
  - TV
  - TVRO
  - DBS
  - COMMUNICATIONS
* RF POWER AMPLIFIERS
* TEST EQUIPMENT
* ELECTRONIC DEFENSE SYSTEMS
* COMMERCIAL MARKET

MANUFACTURERS

* AVANTEK
* ALPHA
* TEXAS INSTRUMENTS
* SIEMANS
* CALIFORNIA EASTERN LABORATORIES
* PLESSEY
* PLUS OTHERS

AVANTEK MONOLITHIC AMPLIFIER PERFORMANCE SUMMARY

TYPICAL GAIN/COMPRESSION VERSUS FREQUENCY

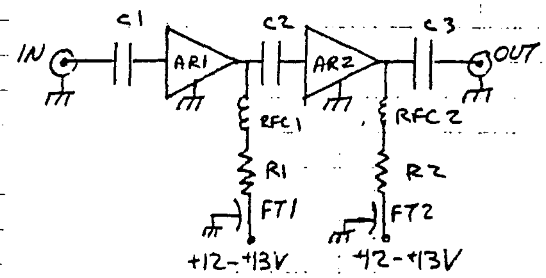
MSA-	30	50	144	220	432	902	1296	2304	3300	MHz.
0104	19	19	19	18	17	14	12	9	6	dB
	+8	+8	+7	+6	+4	**	**	**	**	dBm
0204	13	13	13	13	12	11	10	8	6	dB
	>+7	>+7	>+7	>+7	+7	+5	+4	+2	**	dBm
0304	13	13	13	13	12	11	10	8	6	dB
	>+13	>+13	>+13	>+13	+13	+11	+10	+5	**	dBm
0404	8	8	8	8	8	8	7	6	5	dB
	>+13	>+13	>+13	>+13	>+13	+13	+13	+13	**	dBm
4-0404	>+19	>+19	>+19	>+19	>+19	+19	+19	+19	**	dBm
02/03 *	26	26	26	26	24	22	20	16	12	dB
	>+13	>+13	>+13	>+13	+13	+11	+10	+5	**	dBm
02/03/04 *	34	34	34	34	32	30	28	x	17	dB
	>+13	>+13	>+13	>+13	+13	+13	+13	x	**	dBm
03/04/04 *	-	-	-	-	-	-	-	22	16	dB
	-	-	-	-	-	-	-	+13	**	dBm

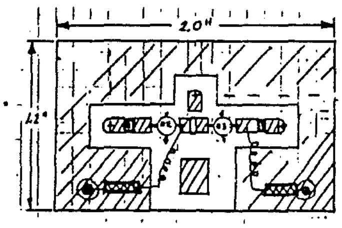
* Devices are from the __04 family
** Not specified
x Combination not desired for 2304 MHz. due to compression of 03 stage
\- Not analyzed

Data obtained from Avantek data sheets

A.J. WARD
WB5LUA
JULY 18, 1985
REV.B, 9-9-85

MMIC AMPLIFIER LAYOUT





COMPONENT LAYOUT

C1-C3 50-100pf CHIP CAP.
RFC1,2 4 TURNS #28GA. ENAMEL WIRE 1/8" I.D. S.W.D.
R1,R2 BIAS RESISTORS-SEE TABLE
FT1,FT2 470-1000pf FEEDTHROUGH
AR1,AR2 AVANTEK MMIC

- SLASHED AREA IS COPPER
- 50Ω LINEWIDTHS ARE .100"
- DIELECTRIC IS .062" G-10

DEVICE	I_C * (mA)	BIAS RESISTOR OHMS	BIAS RESISTOR WATTS (DISS.) FOR Vcc=13V	COST (SINGLE QTY'S)
MSA 0104	30	267	.24	$ 2.75
MSA 0204	30	267	.24	$ 2.90
MSA 0304	40	200	.32	$ 3.00
MSA 0404	50	150	.38	$ 3.25

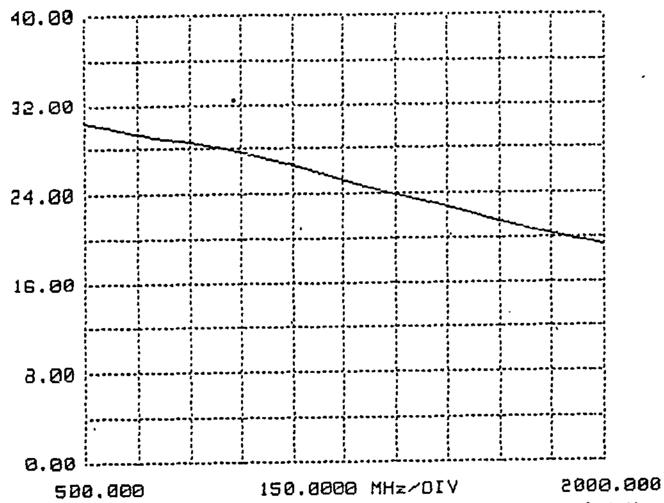
* RECOMMENDED I_C FOR CONTINUOUS OPERATION

MICRO-X (35 STYLE PACKAGE) VERSIONS AVAILABLE AT COST ≈ $ 9.00 EACH. OFFER SLIGHTLY GREATER GAIN (≈2dB) AT 1-2GHz. SHOULD BE EVEN BETTER AT 3-4GHz.

A.J. WARD
WB5LUA
9-8-85

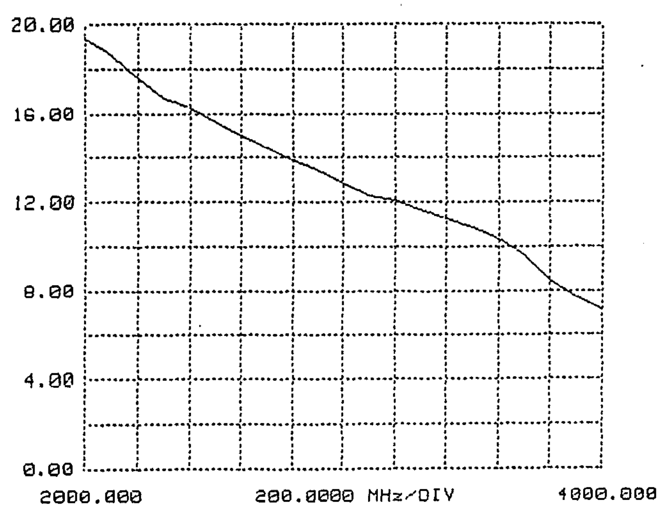
GAIN

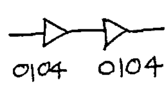
MHz	S21 DB	S21 ANG
500.0000	30.42	-130.5
600.0000	29.64	-147.8
700.0000	29.07	-164.9
800.0000	28.56	176.3
900.0000	28.07	157.1
1000.0000	27.39	139.4
1100.0000	26.50	122.2
1200.0000	25.65	106.1
1300.0000	24.75	91.0
1400.0000	23.88	76.7
1500.0000	23.10	62.4
1600.0000	22.35	47.2
1700.0000	21.34	33.6
1800.0000	20.72	21.1
1900.0000	20.00	6.8
2000.0000	19.26	-6.9



GAIN

MHz	S21 DB	S21 ANG
2000.0000	19.40	-70.0
2100.0000	18.59	-86.2
2200.0000	17.55	-102.0
2300.0000	16.65	-112.6
2400.0000	16.26	-129.2
2500.0000	15.60	-146.1
2600.0000	15.00	-161.8
2700.0000	14.45	-176.9
2800.0000	13.85	168.9
2900.0000	13.44	153.4
3000.0000	12.82	137.2
3100.0000	12.30	123.2
3200.0000	12.10	109.4
3300.0000	11.65	94.8
3400.0000	11.25	80.6
3500.0000	10.85	64.6
3600.0000	10.35	47.0
3700.0000	9.60	28.0
3800.0000	8.45	15.8
3900.0000	7.72	2.0
4000.0000	7.15	-7.9





NF=4.7dB@1.3GHz
NF=5.3dB@2.3GHz
6

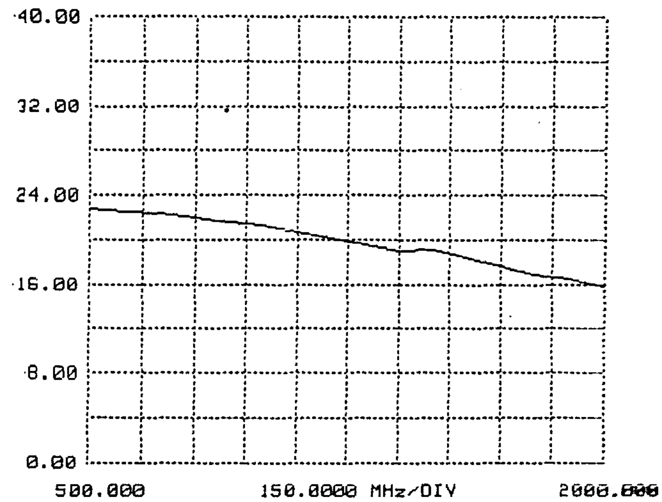
CASCADE MSA 0104
MMIC
AMPLIFIER

AJWARD

GAIN

S21

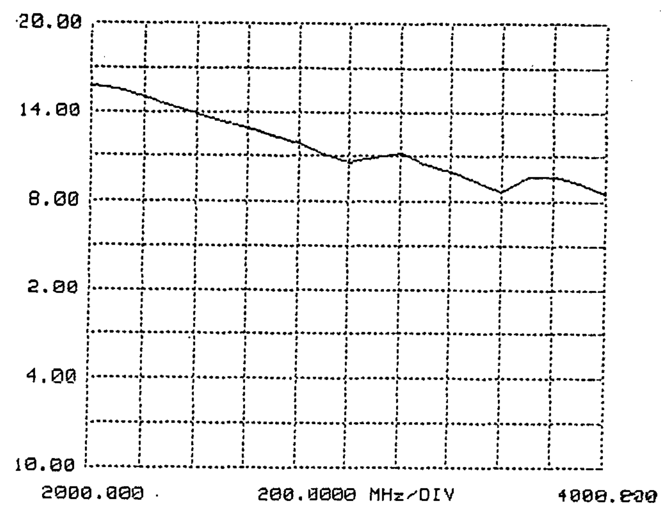
MHz	DB	ANG
500.0000	22.70	-89.4
600.0000	22.50	-107.5
700.0000	22.28	-126.2
800.0000	21.96	-142.4
900.0000	21.52	-161.2
1000.0000	21.15	-178.7
1100.0000	20.65	163.9
1200.0000	20.15	147.6
1300.0000	19.50	132.1
1400.0000	19.04	119.2
1500.0000	19.15	99.6
1600.0000	18.44	82.3
1700.0000	17.60	66.7
1800.0000	16.85	53.8
1900.0000	16.50	36.0
2000.0000	15.76	27.5

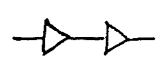


GAIN

S21

MHz	DB	ANG
2000.0000	15.75	27.1
2100.0000	15.48	11.4
2200.0000	14.95	-2.7
2300.0000	14.40	-17.6
2400.0000	13.85	-31.5
2500.0000	13.30	-43.6
2600.0000	12.90	-55.7
2700.0000	12.42	-68.0
2800.0000	11.85	-81.4
2900.0000	11.15	-95.2
3000.0000	10.64	-104.9
3100.0000	10.95	-112.7
3200.0000	11.24	-128.1
3300.0000	10.52	-142.8
3400.0000	10.00	-156.3
3500.0000	9.40	-170.1
3600.0000	8.65	179.7
3700.0000	9.69	169.9
3800.0000	9.66	149.1
3900.0000	9.30	128.2
4000.0000	8.49	104.2





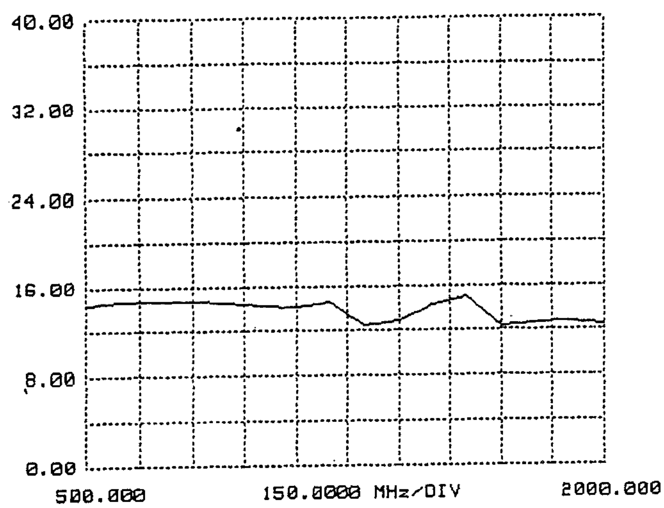
0204 0304

CASCADE MSA0204/0304
MMIC
AMPLIFIER

AJWARD
9-5-85

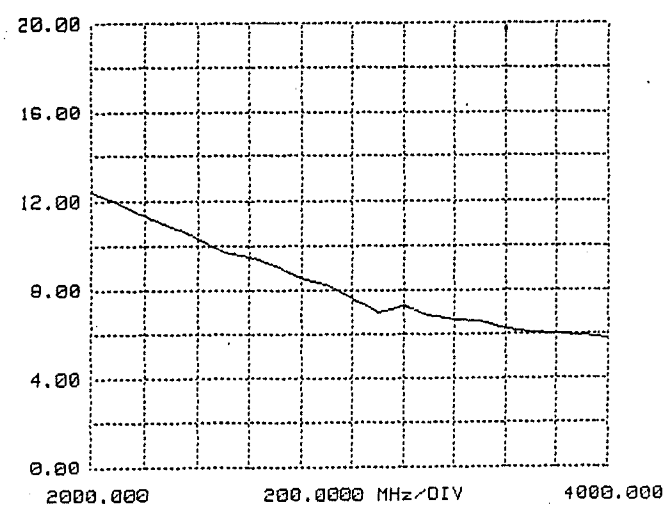
GAIN

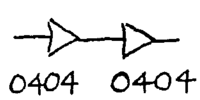
MHz	S21 DB	S21 ANG
500.0000	14.45	-68.7
600.0000	14.65	-86.5
700.0000	14.74	-104.4
800.0000	14.67	-122.3
900.0000	14.48	-139.3
1000.0000	14.19	-155.8
1100.0000	14.10	-169.4
1200.0000	14.60	171.6
1300.0000	12.46	151.5
1400.0000	12.84	151.5
1500.0000	-14.20	135.3
1600.0000	-14.94	114.8
1700.0000	12.25	79.1
1800.0000	12.55	80.9
1900.0000	12.67	65.3
2000.0000	12.46	48.6



GAIN

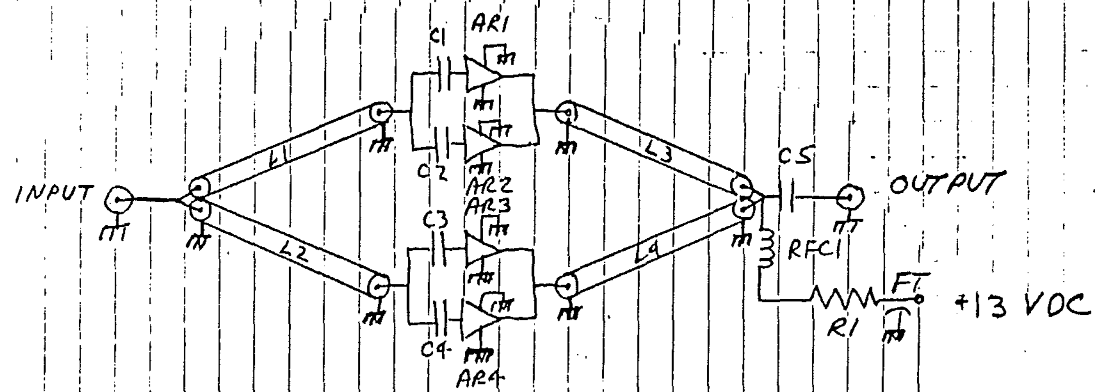
MHz	S21 DB	S21 ANG
2000.0000	12.45	46.2
2100.0000	11.93	30.2
2200.0000	11.30	16.6
2300.0000	10.80	3.4
2400.0000	10.35	-10.7
2500.0000	9.70	-23.9
2600.0000	9.50	-34.7
2700.0000	9.07	-47.7
2800.0000	3.55	-60.0
2900.0000	3.25	-73.6
3000.0000	7.65	-87.7
3100.0000	7.00	-96.1
3200.0000	7.29	-104.7
3300.0000	6.82	-117.5
3400.0000	6.65	-126.7
3500.0000	6.60	-140.6
3600.0000	6.25	-154.0
3700.0000	5.09	-165.8
3800.0000	6.00	-177.7
3900.0000	5.95	168.8
4000.0000	5.79	153.8





CASCADE MSA 0404
MMIC
AMPLIFIER

AJWARD
9-5-85



AR1-AR4	MSA-0404 AVANTEK MMIC
C1-C5	100-820pf BLOCKING CAPACITOR - VALUE NOT CRITICAL
L1-L4	QUARTER WAVE (3/4) 50 OHM SEMI-RIGID CABLE 1.6" LONG SHIELD TO SHIELD
RFC1	6 TURNS #24 GAUGE WIRE, .125" I.D. S.W.D.
R1	40 OHMS AT 2 WATTS - MODIFY AS NECESSARY TO LIMIT CURRENT TO 200mA MAX.
FT	470-1000 pf FEEDTHROUGH CAPACITOR

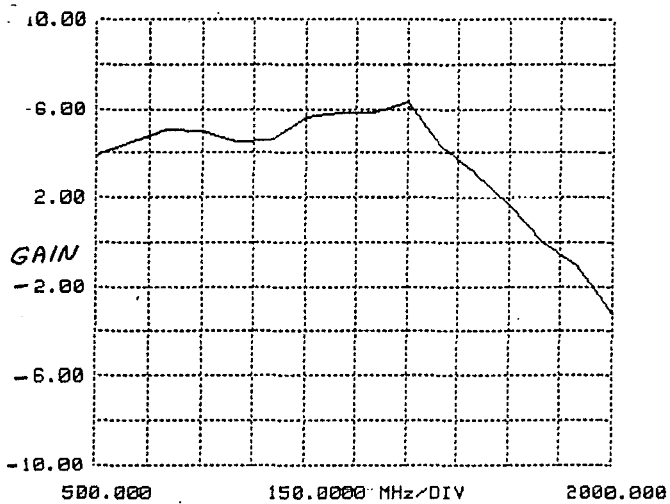
GAIN = 5.5 to 6.0 dB
P_{OUT} (1dB) = +19 dBm
P_{OUT} (SAT) ≥ +20 dBm

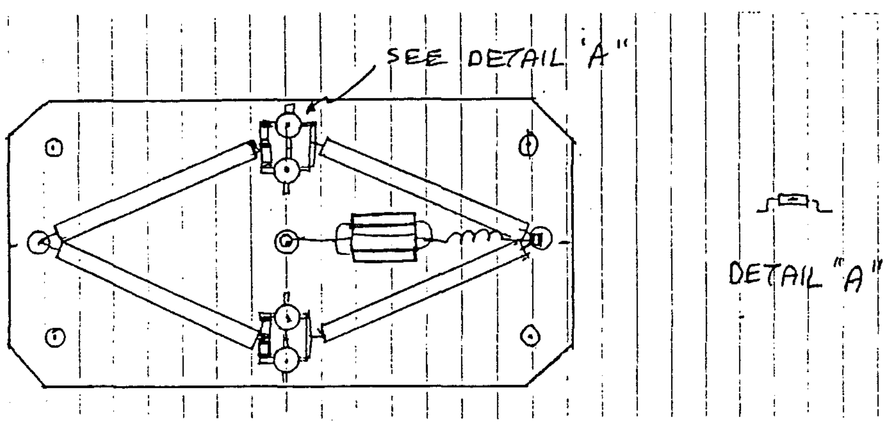
80 mW AMPLIFIER
1296 MHz
FIGURE 14

AJWARD
WB5LUA
5-28-85

GAIN

MHz	S21 DB	S21 ANG
500.0000	3.90	79.7
600.0000	4.50	54.7
700.0000	5.03	28.0
800.0000	4.96	-1.9
900.0000	4.47	-15.8
1000.0000	4.60	-46.9
1100.0000	5.60	-72.6
1200.0000	5.85	-102.0
1300.0000	5.80	-130.3
1400.0000	6.29	-167.5
1500.0000	4.30	166.7
1600.0000	3.09	140.3
1700.0000	1.65	113.8
1800.0000	- .04	88.1
1900.0000	-1.06	64.0
2000.0000	-3.23	26.3





80 mw 1296 MHz
AMPLIFIER

AJWARD
WB5LUA
9-8-85

SIGNAL TO NOISE RATIO

An amateur radio operator makes a sun noise measurement on his 2304 MHz system. The 5 ft dish plus the 3 dB coax loss connected to the 1 dB noise figure preamplifier receives 2 dB of sun noise. Assuming 55% efficiency, the gain of the dish is 28.6 dBi . He decides to take the 5 ft dish down and replace it with a 7 ft. dish with a gain of 31.6 dBi. He now expects to receive 5 dB of sun noise (due to a 3 dB gain increase), but initially is very upset when all he receives is 3.3 dB of sun noise, an increase of only 1.3 dB. What has happened?

Simply, our "S" meter reads signal plus noise to noise ratio.

$$\frac{S+N}{N}$$

When a desired signal , be it either a cw signal or sun noise, is very near the receiver noise level, i.e. less than 10 dB, the "S" meter reads signal plus receiver noise. If we are interested in knowing how much we have improved the signal level , the signal to noise ratio must be calculated. The equation is calculated as follows;

$$\frac{S+N}{N} = \frac{S}{N} + \frac{N}{N}$$

$$= \frac{S}{N} + 1$$

$$\text{THEREFORE} \quad \frac{S}{N} = \frac{S+N}{N} - 1$$

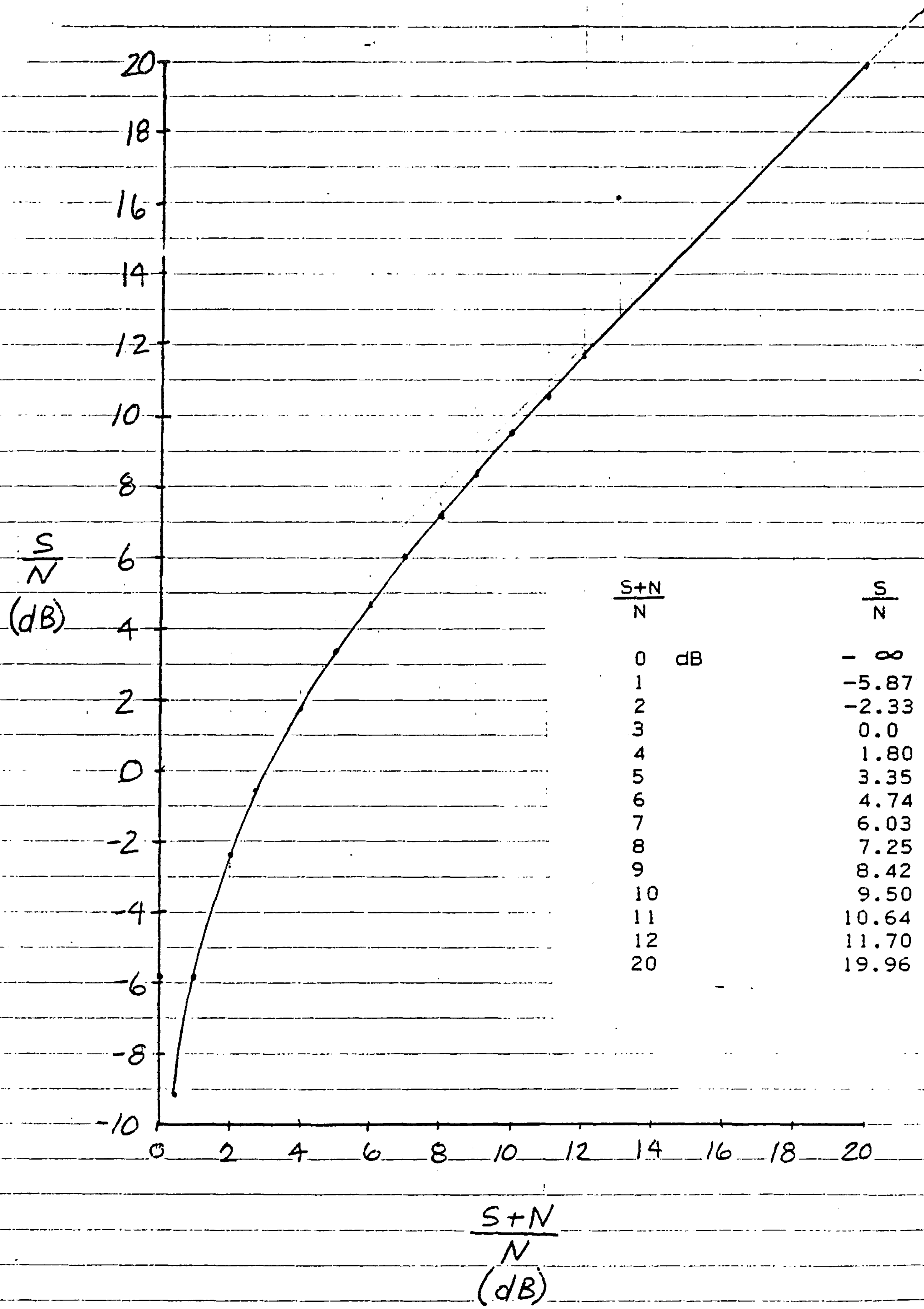
WHEN THE QUANTITIES ARE CONVERTED FROM dB TO RATIOS

A conversion table and graph are shown on the following page. The difference between 3.3 dB and 2 dB signal plus noise to noise ratio is now .56 - (-2.33) dB = 2.89 dB signal to noise ratio improvement. Expressing the equation in a form that allows a calculator to perform the math yields the following :

Let $A = \frac{S+N}{N}$ in dB

Then $\frac{S}{N}$ (dB) $= 10 \log(\log^{-1}(A/10)-1)$

A.J. WARD
9-4-85

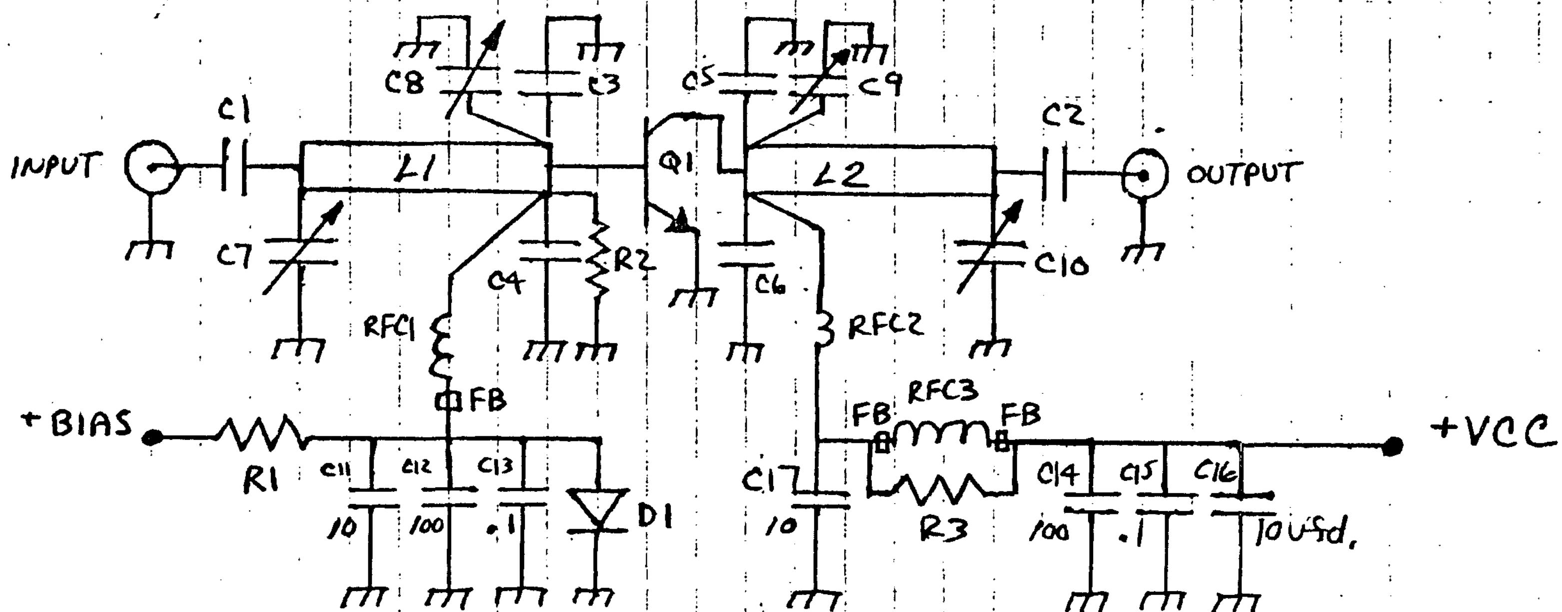


(S+N)/N	S/N
0 dB	- ∞ dB
1	-5.87
2	-2.33
3	0.0
4	1.80
5	3.35
6	4.74
7	6.03
8	7.25
9	8.42
10	9.50
11	10.64
12	11.70
20	19.96

$\frac{S+N}{N}$ TO $\frac{S}{N}$ RATIO CONVERSION

A.J. WARD
9-4-85

NEL1300 SERIES 1296MHz AMPLIFIERS



Device	NEL130681-12	NEL132081-12
Pout (1dBC.P.)	7 watts	18 watts
Gain (1dBC.P.)	6 dB typ.	5 dB typ.
Collector EFF.	40-50%	40-50%
Idling Current	50mA	150mA
Ic @ 1dBC.P.	1.1 Amps	3.0 Amps
Vcc	13.5V	13.5V
Power Input	14.9 watts	40.5 watts

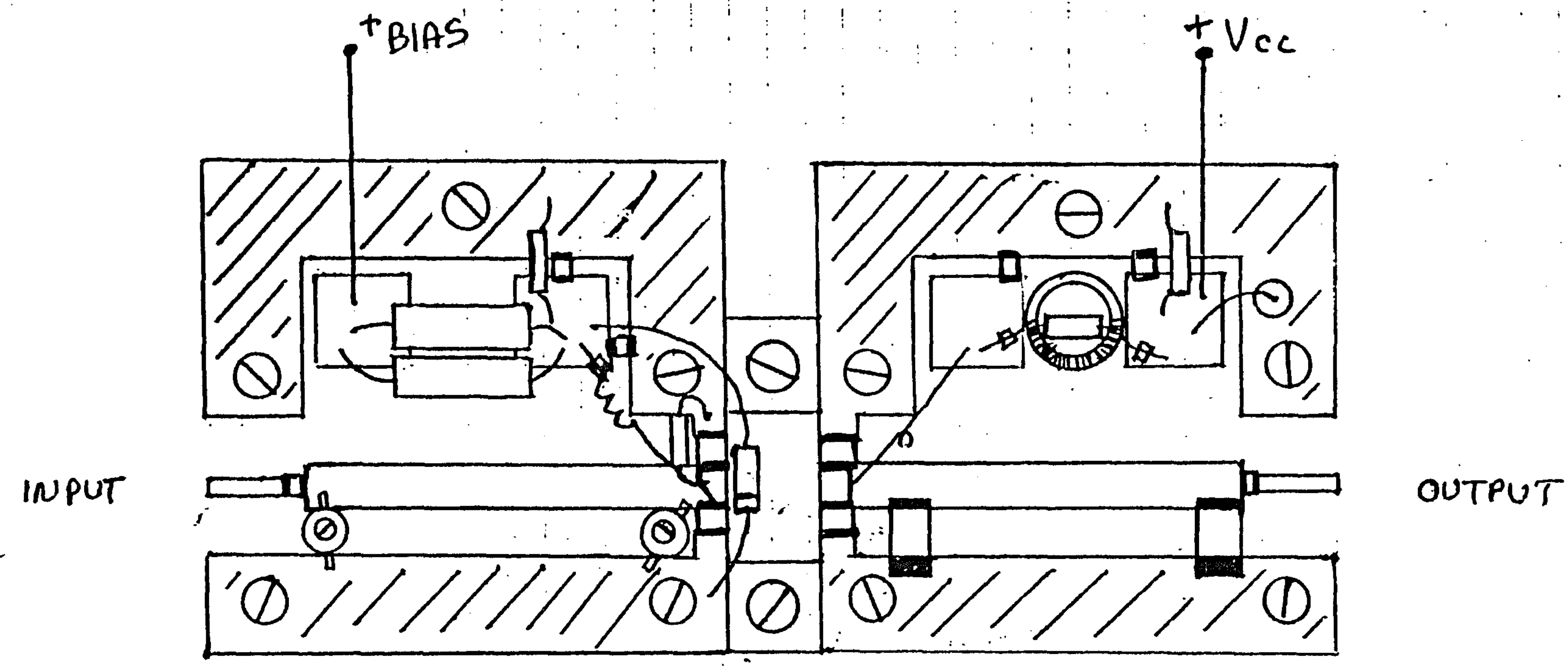
TABLE 1

A.J. WARD
WB5LUA

Q1	NEL130681-12/NEL132081-12 POWER TRANSISTOR (C.E.L.)
D1	1N4007
RFC1	3 TURNS #24 GUAGE WIRE, .125" DIA S.W.D.
RFC2	TURNS #24 GUAGE WIRE, .125" DIA S.W.D.
RFC3	1 uH RF CHOKE, 18 TURNS #24 GUAGE ENAMEL WIRE CLOSE SPACED WOUND ON T50-10 TOROID
C1, C2, C11, C17	10 pf CHIP CAPACITOR
C3, C4, C5, C6	3.6 - 5.0 pf CHIP CAPACITOR
C7, C8	1.8 to 6.0 pf MINIATURE VARIABLE CAPACITOR (MOUSER ELECT. P.N. 24AA070)
C9, C10	.8-10 pf PISTON TRIMMER FOR NEL1320 (JOHANSON 5221 or 8053) SAME AS C7, C8 FOR NEL1306 (SEE TEXT)
C12, C14	100 pf CHIP CAPACITOR
C13, C15	.1 ufd DISC CAPACITOR
C16	10 ufd ELECTROLYTIC CAPACITOR
FB	FERRITE BEAD
L1, L2	30 OHM MICROSTRIPLINE - QUARTER WAVE LONG
R1	82-100 OHM ATLEAST 2 WATT - VARY RESISTOR VALUE FOR SPECIFIED IDLING CURRENT
R2	10 OHM 1/4 WATT CARBON RESISTOR
R3	15 OHM 1 WATT CARBON RESISTOR

FIGURE 1

A.J. WARD
WB5LUA
5-28-85



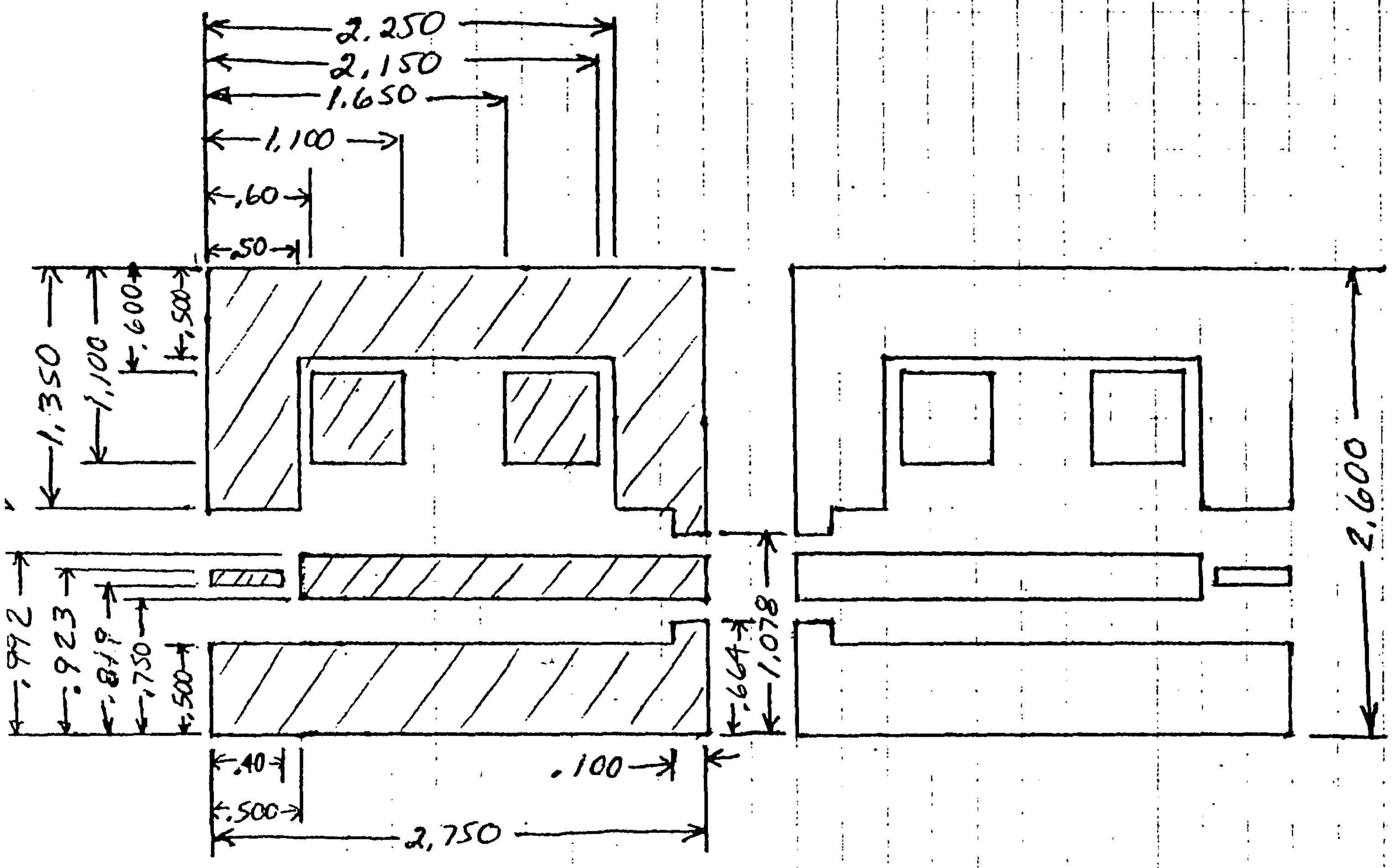
NEL1320 LAYOUT

2X SIZE

FIGURE 4

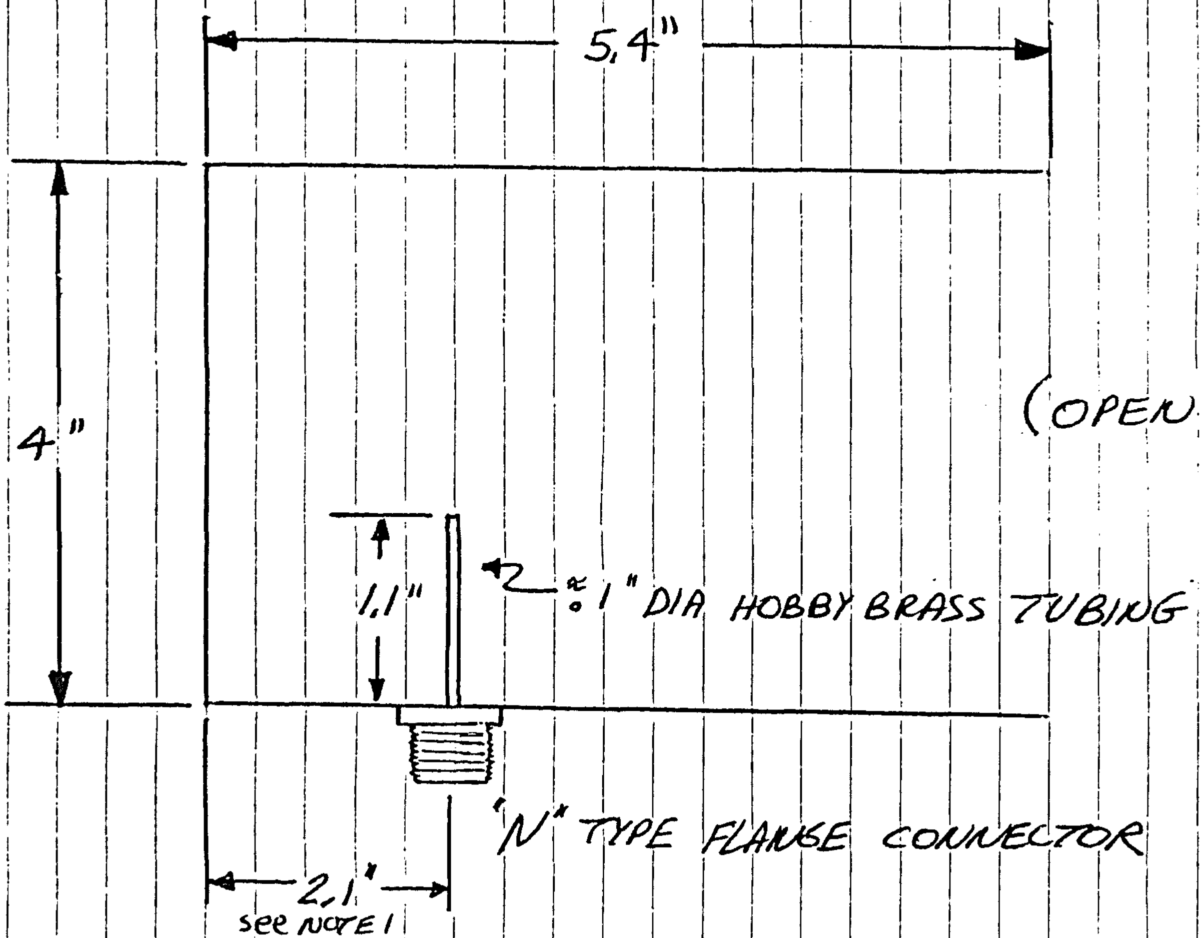
NOTE: NEL1306 LAYOUT UTILIZES SAME SHUNT VARIABLE CAPACITOR ON OUTPUT CIRCUIT AS ON INPUT CIRCUIT

A.J. WARD
WB5LUA
5-28-85



NOTES: 1. DIMENSIONS ARE 2X
2. DIMENSIONS ARE IN INCHES
3. RIGHT SIDE IS MIRROR IMAGE OF LEFT SIDE.
4. SLASHED AREA IS COPPER

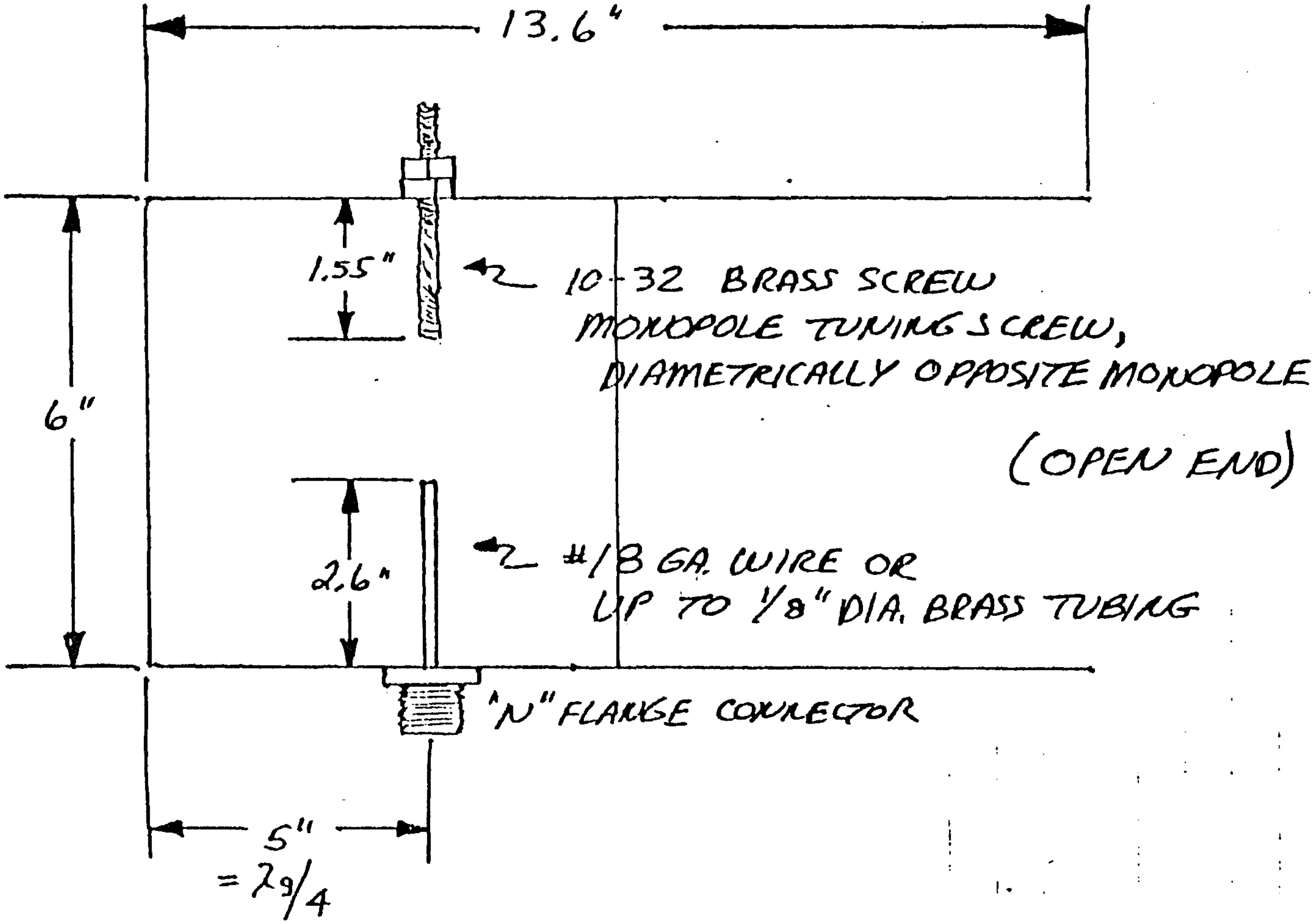
NEL 1300
1296 mHz
POWER AMPLIFIER
Er = 5.0
H = .031"
A.J. WARD
JAN 3, 1984



NOTES

1. DIMENSION (2.1") IS MEASURED FROM OUTSIDE EDGE OF COFFEE CAN.
2. HORN CONSTRUCTED FROM 1 lb. COFFEE CAN
3. RETURN LOSS ≈ 20dB AT RESONANCE (VSWR = 1.22:1 MAX)
4. REF GAIN → 9dBi

2304 MHz. STANDARD GAIN COFFEE CAN HORN



NOTES
1. HORN CONSTRUCTED FROM 2 - 3lb COFFEE CANS SOLDERED TOGETHER
2. RETURN LOSS ≥ 30dB AT RESONANCE VSWR ≤ 1.06:1 MAXIMUM
3. MEASURED GAIN IS 7.5 dBi

1296 MHz STANDARD GAIN COFFEE CAN HORN

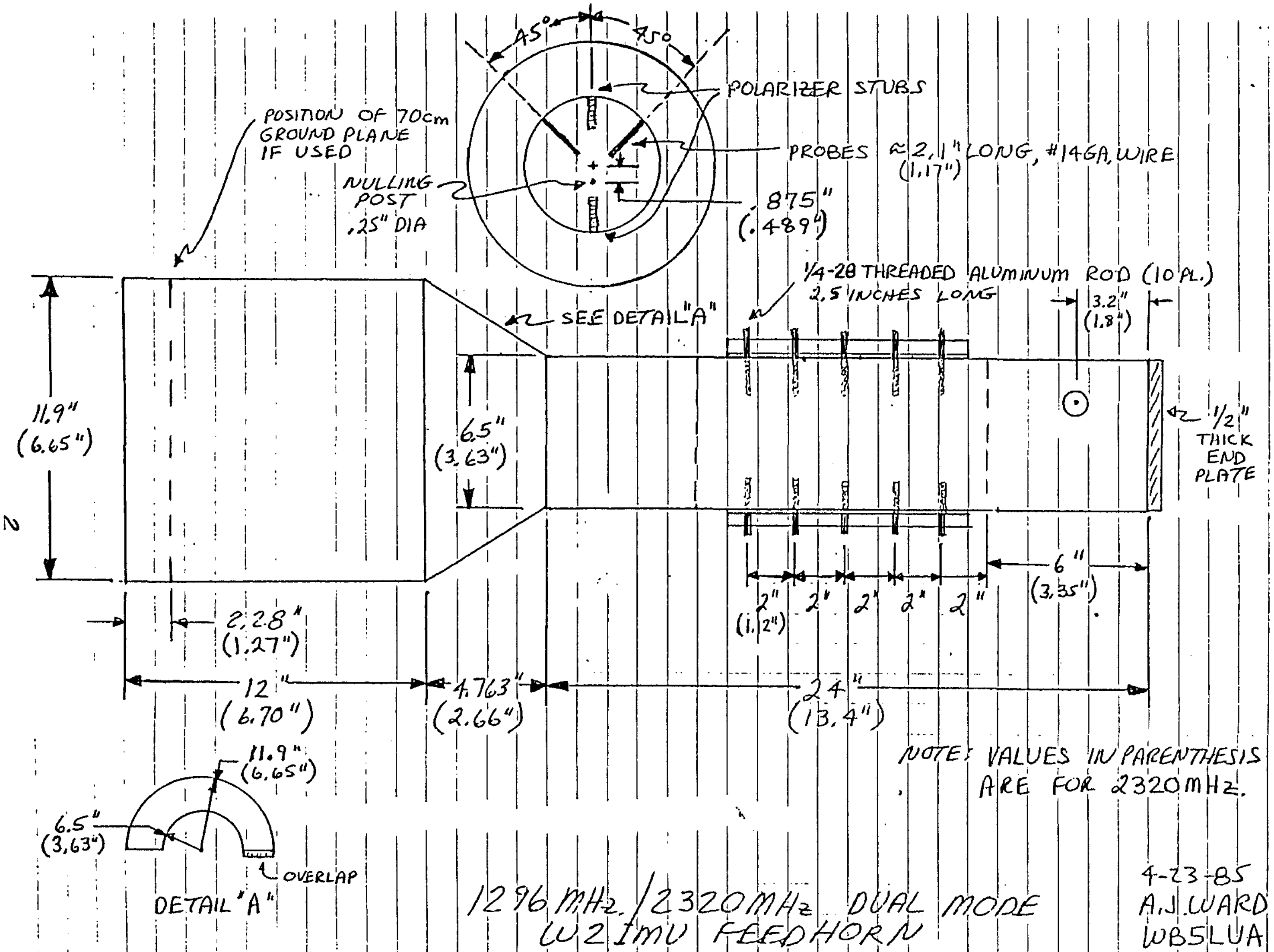
A.J. WARD
9-19-82

PARABOLIC REFLECTOR FEED SYSTEMS

NOTES COMPILED
BY

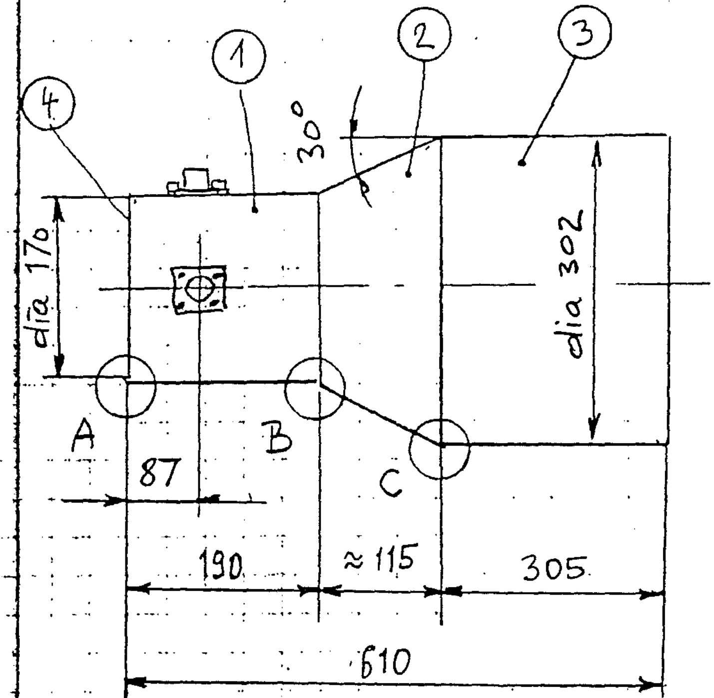
AL WARD
WB5LUA

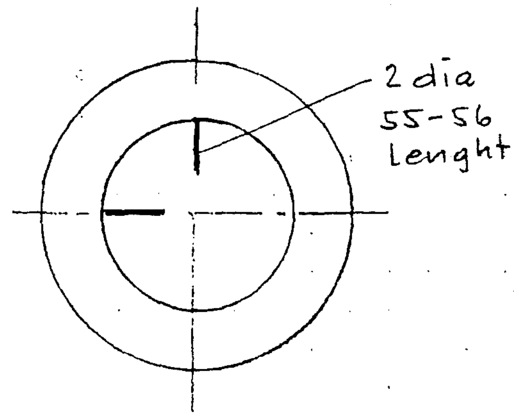
4-23-85


45°
45°
POLARIZER STUBS
POSITION OF 70cm GROUND PLANE IF USED
PROBES ≈ 2.1" LONG, #14GA. WIRE
(1.17")
NULLING POST .25" DIA
.875"
(.489")
1/4-28 THREADED ALUMINUM ROD (10 PL.)
2.5 INCHES LONG
3.2"
(1.8")
SEE DETAIL "A"
11.9"
(6.65")
6.5"
(3.63")
1/2" THICK END PLATE
2"
(1.12")
2"
2"
2"
2"
6"
(3.35")
2.28"
(1.27")
12"
(6.70")
4.763"
(2.66")
24"
(13.4")
11.9"
(6.65")
6.5"
(3.63")
OVERLAP
DETAIL "A"
NOTE: VALUES IN PARENTHESIS ARE FOR 2320MHz.
1296 MHz./2320MHz DUAL MODE
W2IMU FEEDHORN
4-23-85
A.J. WARD
WB5LUA

Dual mode horn
1296 MHz (W2IMU shortened)

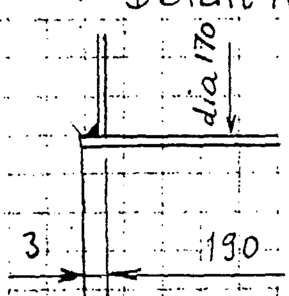
OE9PMJ Apr. 84



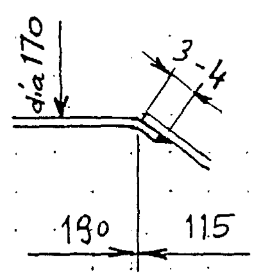


Dimension inside
in mm

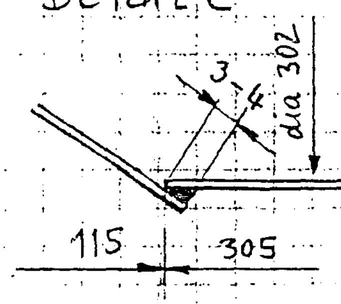
Detail A



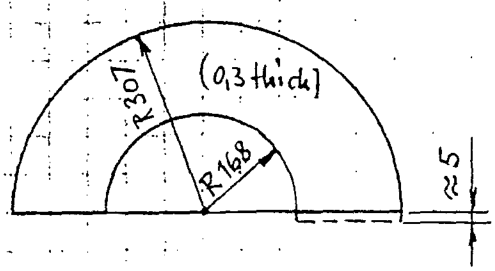
Detail B



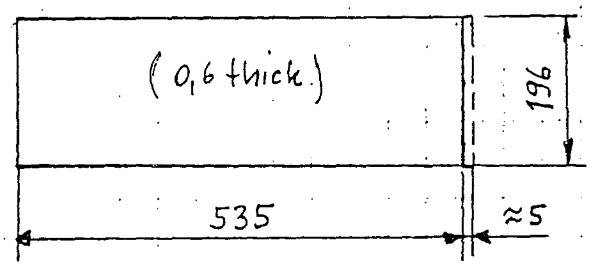
Detail C



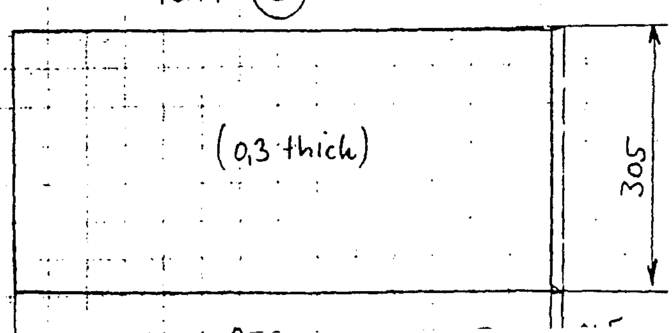
Part 2



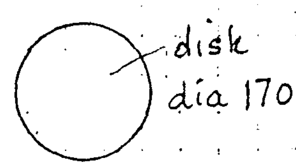
Part 1



Part 3

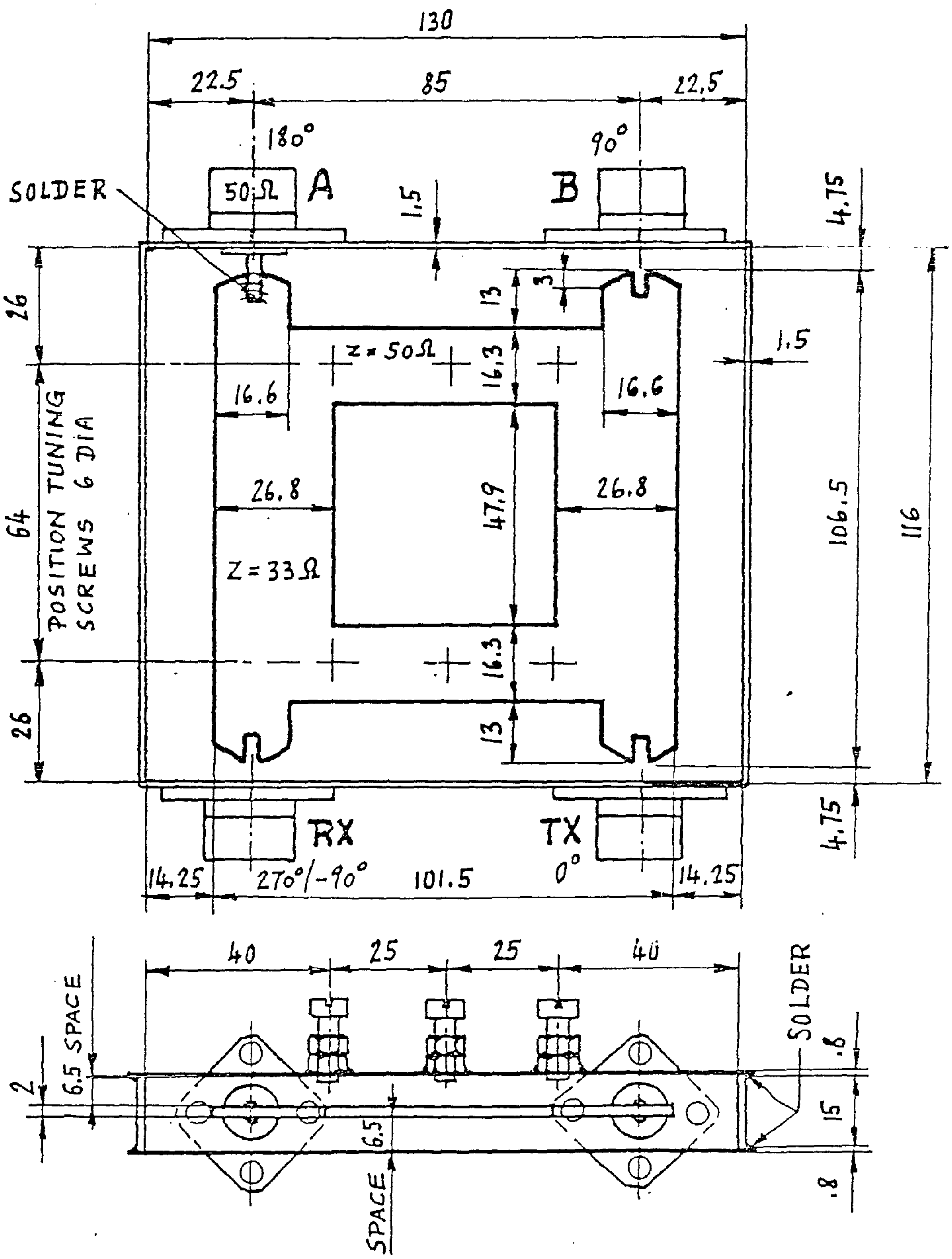


Part 4



Material brass - or

A MODIFIED VERSION OF DL7YC's HIGH POWER 1296 MC QUAD HYBRID COUPLER BY OE9PMJ

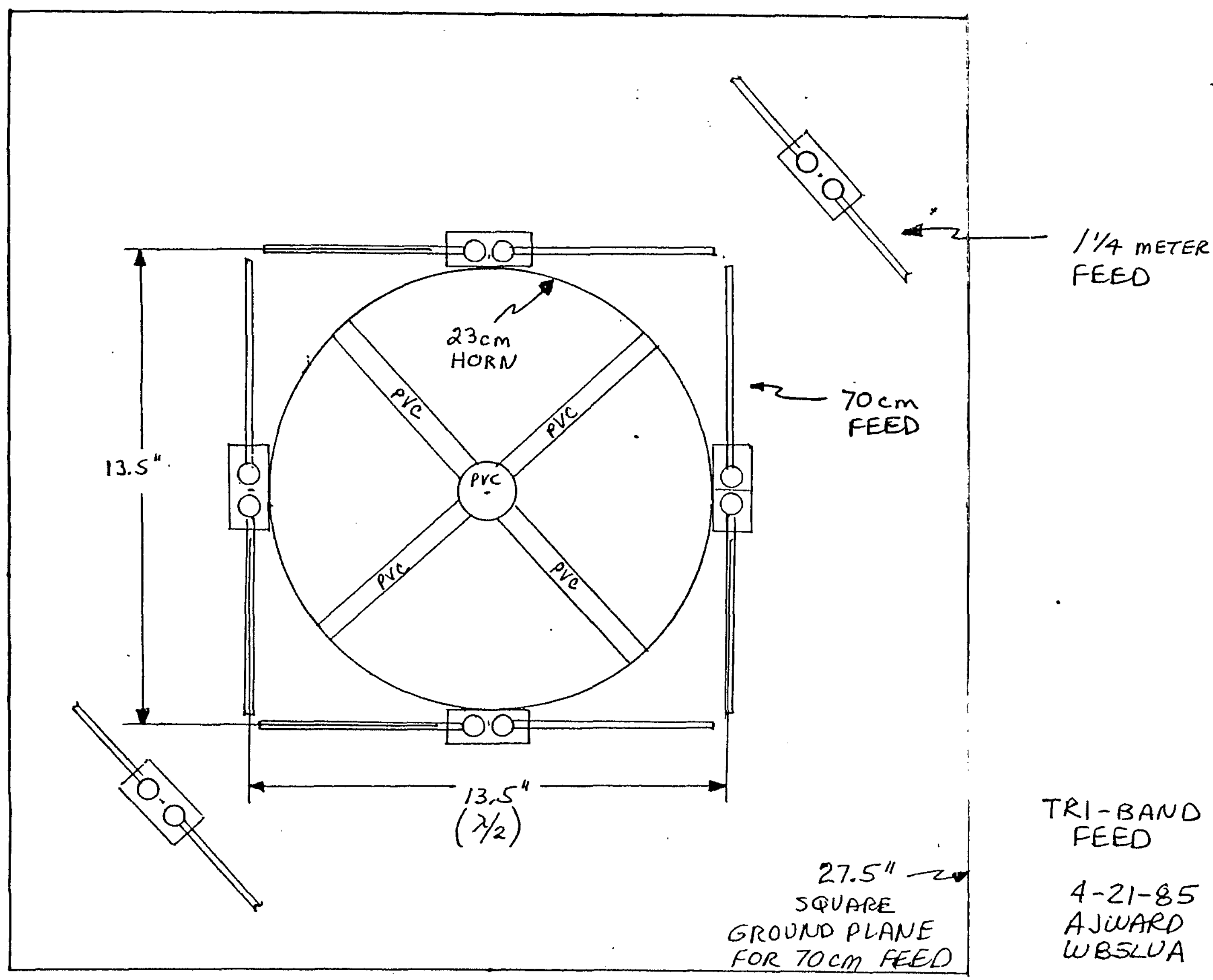


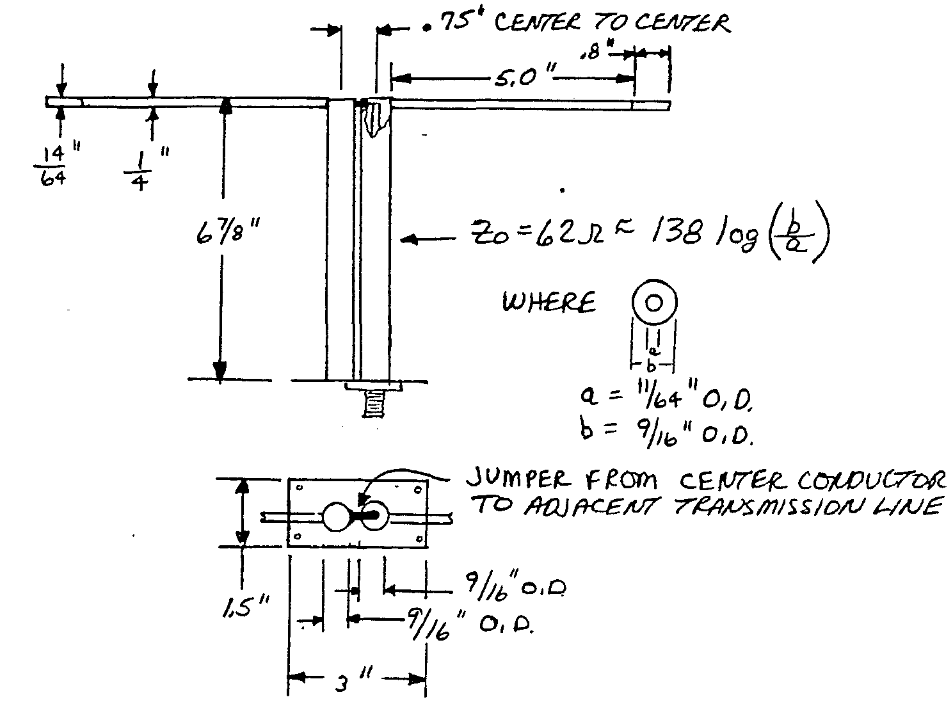
DIMENSIONS IN MILLIMETER (1 INCH = 25.4 MM)

STRIPLINE SYSTEM - COPPER SHEET POLISHED
CASE - COMPLETE CLOSED, BRASS SHEET
TUNING SCREWS ADJUSTED FOR BEST POWER SYMMETRY AND ISOLATION (PORT RX-TX)

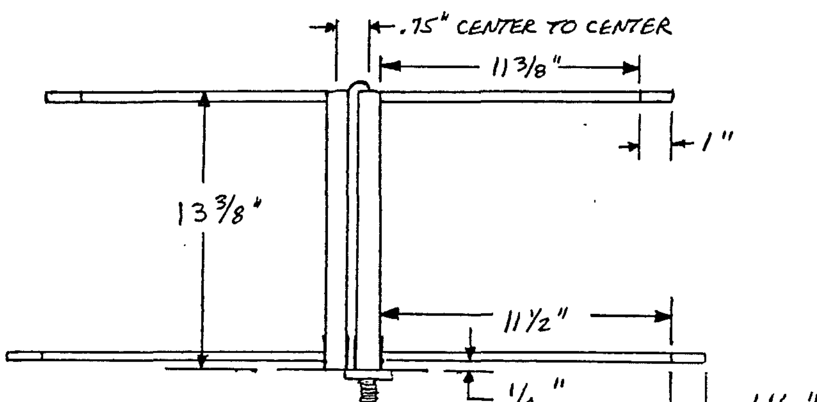
3-84 OE9PMJ

SCREWS REQUIRED TO EQUALIZE MECHANICAL INACCURACY


1 1/4 METER FEED
70cm FEED
23cm HORN
PVC
PVC
PVC
PVC
PVC
13.5"
13.5" (λ/2)
27.5" SQUARE GROUND PLANE FOR 70cm FEED
TRI-BAND FEED
4-21-85
AJWARD
WB5LUA



70 cm DIPOLE FEED



MATERIALS SAME AS 70cm FEED

4-22-85
A.J. WARD
WB5LUA

1 1/4 METER DIPOLE FEED

W2IMU HORN SPECIFICATIONS @ 1296 MHz.

• RETURN LOSS RECEIVE PORT	19dB	(1.24:1 VSWR)
TRANSMIT PORT	18.5dB	(1.26:1 VSWR)
• CROSS COUPLING	26dB	
• CIRCULARITY	1dB	
• NULLING POST DEPTH	* 1.15"	(SPEC 1.31")
DIAMETER	.25"	(SPEC 7/16")
• POLARIZER STUB DEPTH INTO HORN	** 1.60"	(SPEC 1.50")
• OPTIMUM F/D RATIO	.4-.6	

* SUGGEST .64" FOR 2320MHz

** SUGGEST .89" FOR 2320MHz.

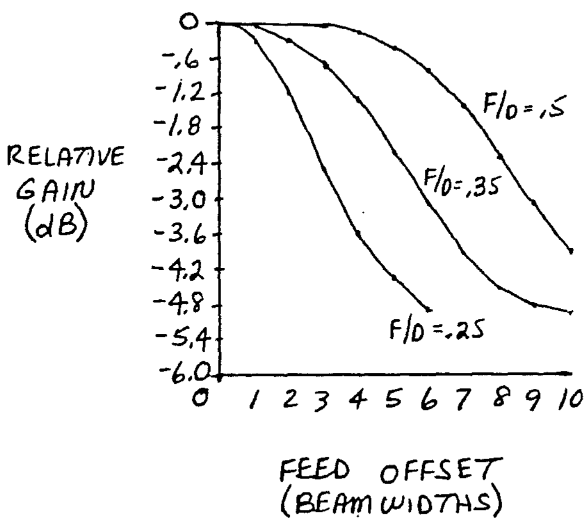
DUAL DIPOLE FEED FOR 432 MHz.

• RETURN LOSS	19-20dB	(1.24:1 VSWR)
• CROSS COUPLING (VERT. TO HORIZ.)	35dB	
• OPTIMUM F/D RATIO	.4-.5	

DUAL DIPOLE FEED FOR 220 MHz

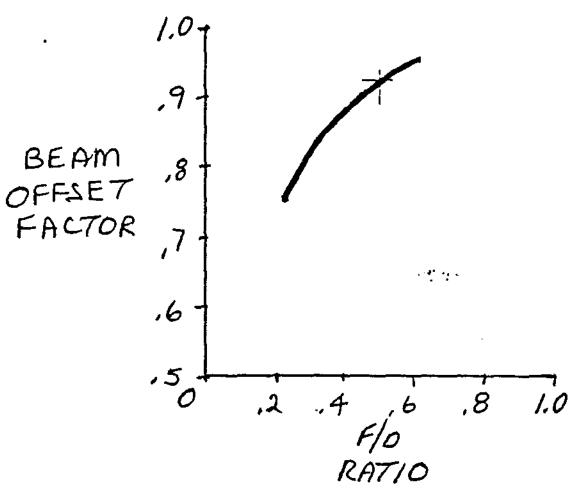
• RETURN LOSS	20dB	(1.2:1 VSWR)

4-22-85
AJWARD



FREQ. (mHz)	B.W. (DEG.)	OFFSET FOR 1dB GAIN RED.
432	6.5	51"
1296	2.2	17"
2304	1.3	10"

ASSUMPTIONS $F/D = .5$
DIA = 24 FT.
55% EFF.

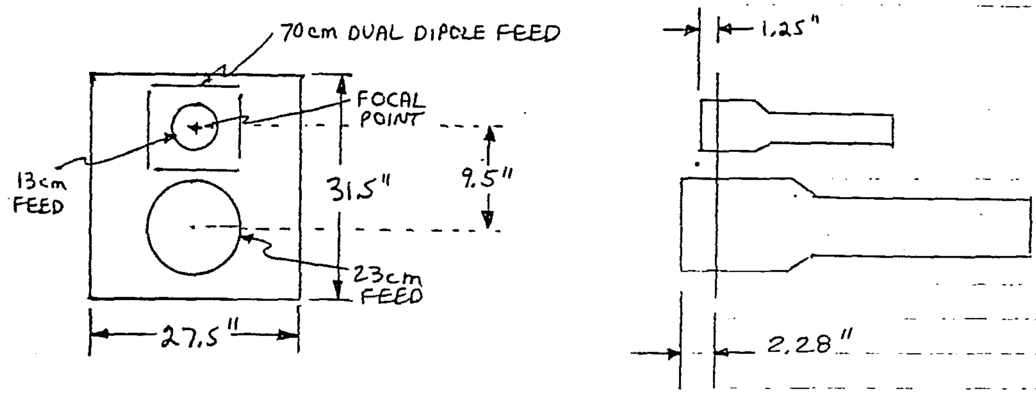


- BEAM OFFSET FACTOR = $\phi_{BEAM} / \phi_{FEED\ OFFSET}$
- FOR $F/D = .5$, OFFSET FACTOR ≈ .92

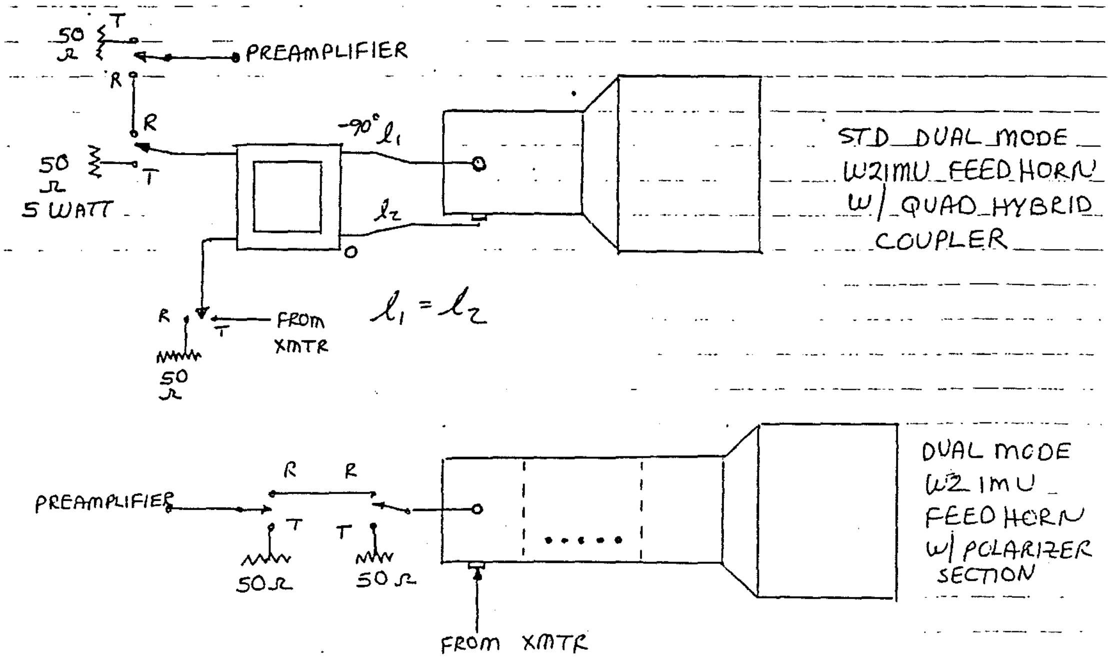
4-22-85
A J WARD
WB5LVA

REFERENCE:
SILVER
MIT RAD. LAB
1949

OFFSET FEEDS



LX1DB 70/23/13 cm FEED

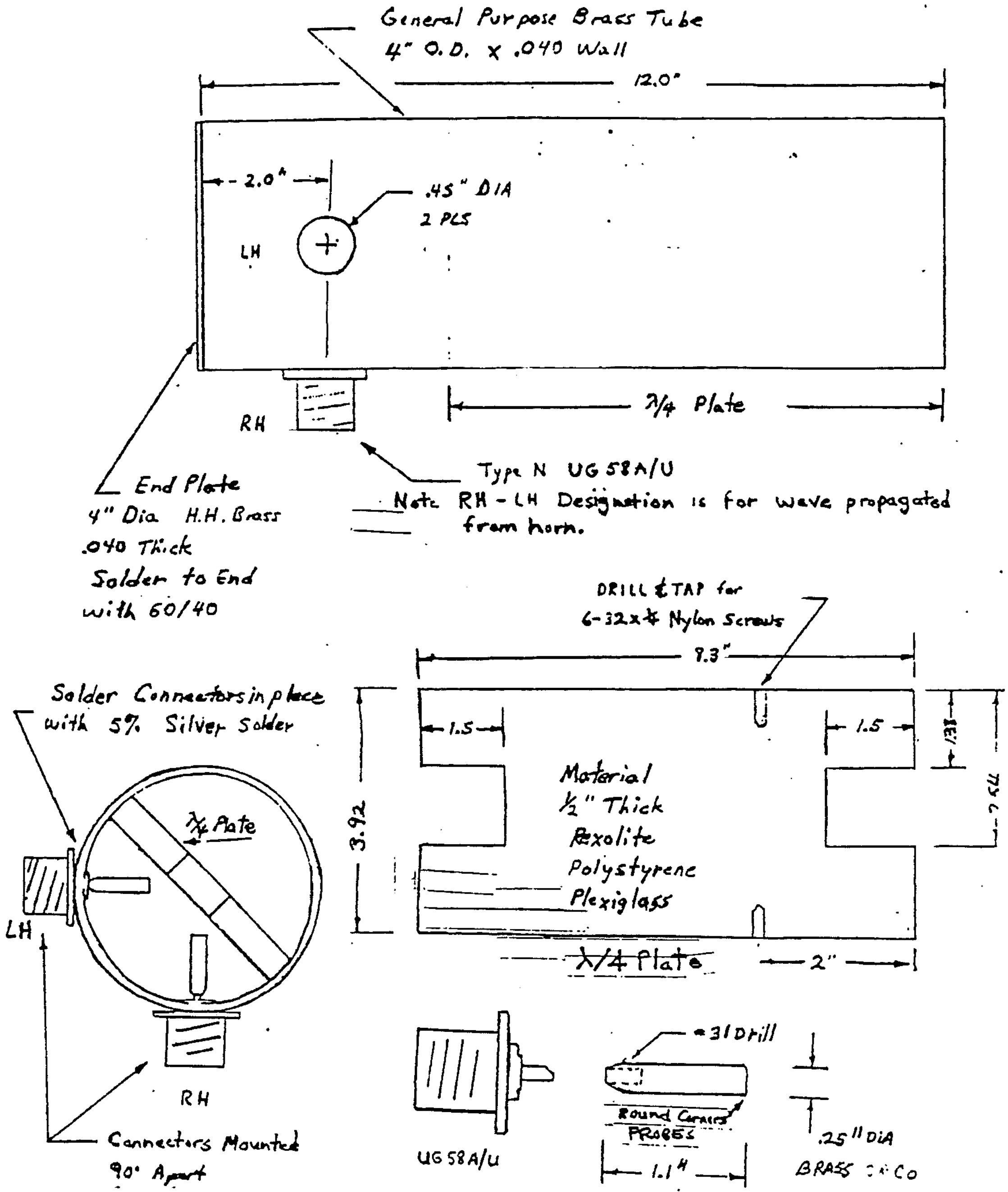


DISH XMIT RCP ∴ FEED XMIT LCP
RCVE LCP RCVE RCP

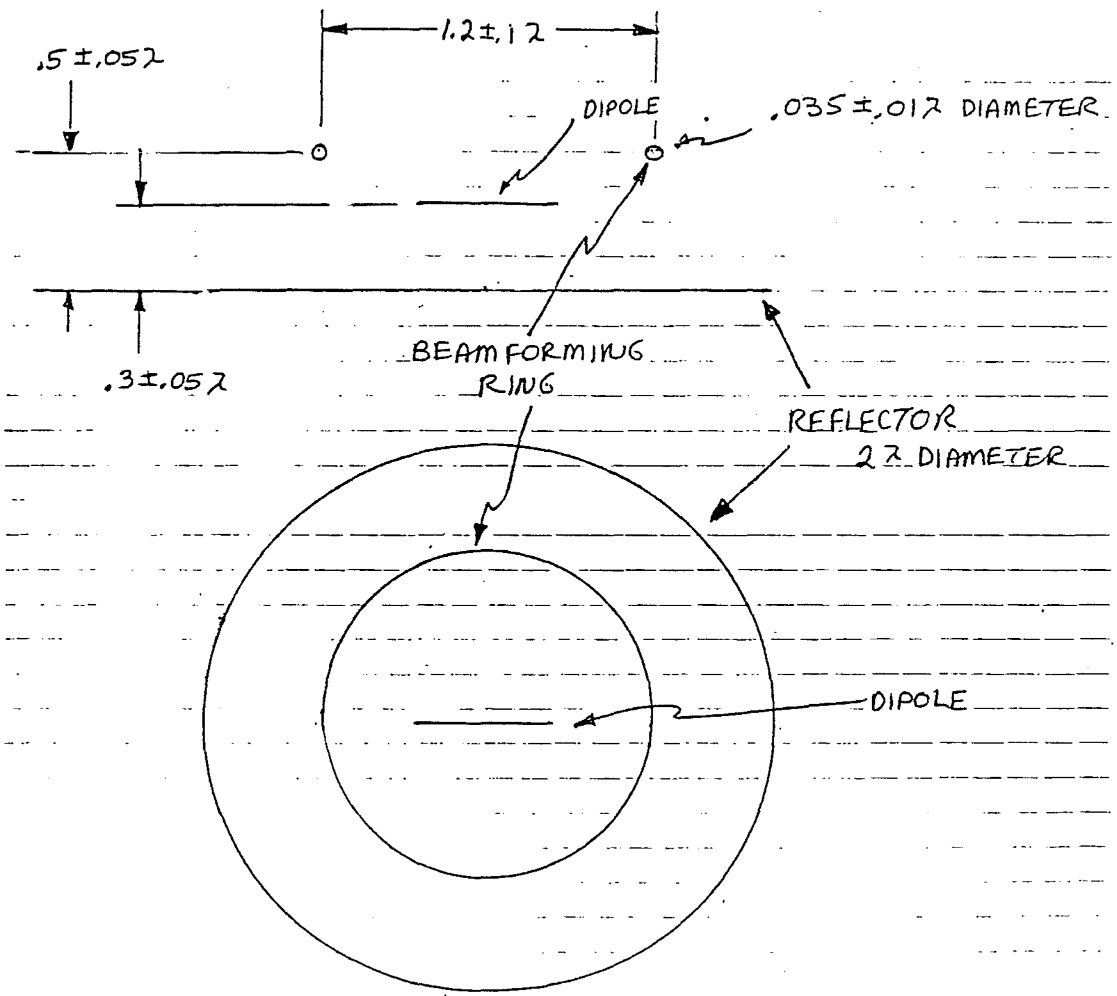
4-23-85
A. J. WARD
WB5LUA

IARU POLARIZATION STANDARD ABOVE 1GHz

2304 MHz CIRCULAR POLARIZED FEED (f/D = .375)



FROM 432 AND ABOVE EME NEWS
JANUARY 1985 VOL 13 #1
EDITOR: K2UYH



NOTES
- OPTIMUM FOR F/D BELOW .4
- EQUAL "E" AND "H" PLANE BEAMWIDTHS ≈ 110° @ 10dB POINTS
- DIPOLE CAN BE ANY POLARITY OR CROSSED DIPOLES FED BY 90° HYBRID FOR CIRC. POL.

4-22-85
A.J. WARD
WB5LUA

REFERENCE:
IEEE ANT. + PROP.
VOL. AP-30, No 4
JULY 1982 pg. 529

KILDAL AND SKYTTEMYR
DIPOLE DISK ANTENNA

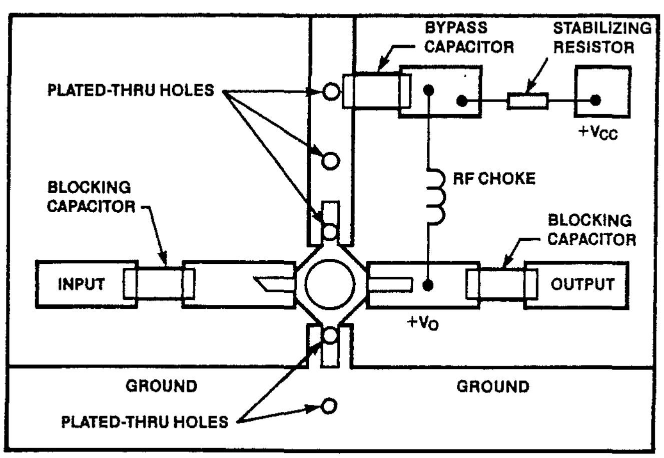
Recommended Mounting Procedures

1. **PC Board Material:**
   a. G-10 glass epoxy board clad with 1 oz. copper on both sides is acceptable for frequencies below 1 GHz.
   b. .015 inch thick Duroid is recommended for maximum gain flatness at frequencies above 1 GHz.
2. **Grounding:**
   It is important that the amplifier package be well grounded to achieve maximum gain flatness. Plated thru holes on both sides of the package are recommended. They should be as close to the package edge as possible.
3. **Biasing:**
   The -21 and -22 models of the amplifiers require $+V_O$ to be supplied at the output lead. The guaranteed gain is achieved by using an RF choke with a series bias stabilizing resistor. The resistor is required for temperature stabilization. ¼ watt carbon composition resistors can be connected directly to the output but the gain will be reduced by 0.5-1 dB. ¼ watt resistors should be paralleled for higher power dissipation if a choke is not used. (-11/12 models only require $V_{CC} = +12V$ at lead 4.)

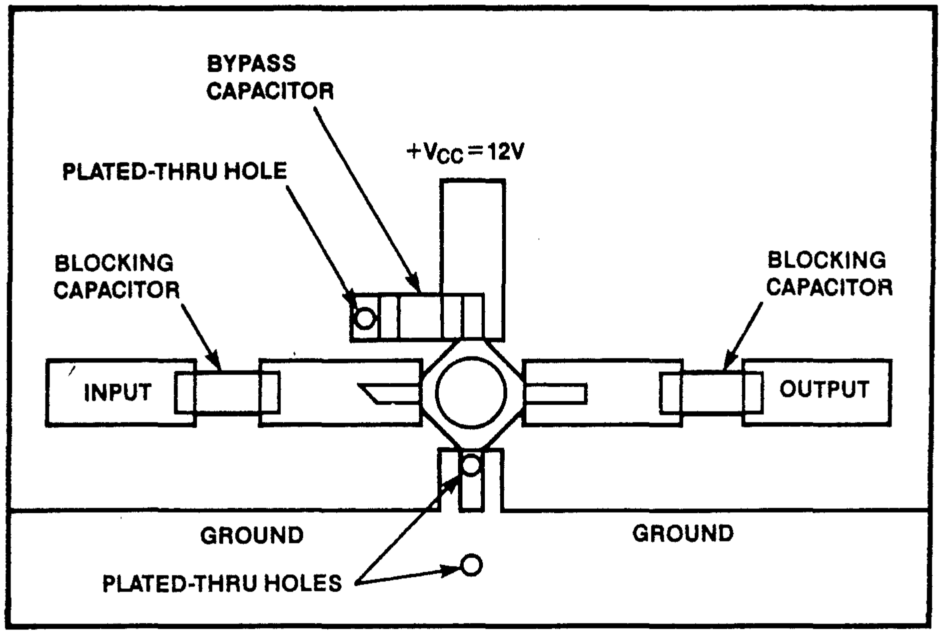
Amplifier	Bias Current	Bias Voltage	Approximate Bias Resistor (Ohms)			Resistor Dissipation (Watts)
	I_B (mA)	$+V_O$	+9V	+12V	+15V	$+V_{CC} = 12V$
MSA-01XX	17	~5	235	412	588	.12
MSA-02XX	25	~5	160	280	400	.18
MSA-03XX	35	~5	114	200	286	.25
MSA-04XX	50/90	~6	60/33	120/67	180/100	.30/.54

4. **Cascading:**
   An external ceramic DC blocking capacitor is required at the output of the amplifiers. An external capacitor is also required at the input unless the amplifiers are supplied with an optional 45 pF internal capacitor. If amplifiers are cascaded, then only one capacitor is needed between stages.

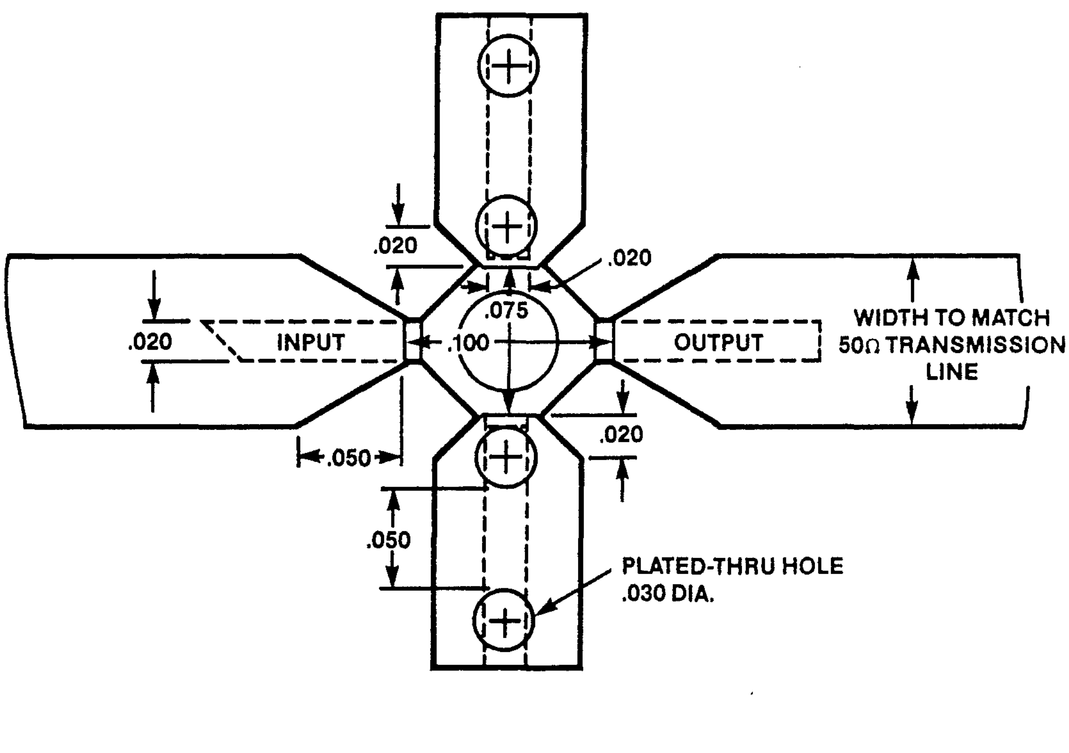
TYPICAL -21 AND -22 MODEL MOUNTING CONFIGURATION



TYPICAL -11 AND -12 MODEL MOUNTING CONFIGURATION



RECOMMENDED PC BOARD DETAIL FOR -21 AND -22 MODELS



Avantek APPLICATION INFORMATION

Paralleling & Unilateralization of MODAMP™ Silicon MMIC Amplifiers

The Avantek MODAMP™ MMIC is a silicon monolithic microwave integrated circuit that is best categorized as a 50-ohm gain block. Its applications in the 50-ohm microstrip environment are virtually unlimited, and it can be extremely useful in other circuit impedances as well.

Some of the advantages of the MODAMP MMIC include:

1. Minimized circuit design time
2. Unconditional Stability
3. Broadband operation: DC to beyond 4 GHz
4. Near 50-ohm input and output impedance
5. Flat gain through 3 GHz
6. Easy to cascade
7. Low group delay
8. Internally-biased
9. Good reverse isolation
10. Extremely compact

The electrical equivalent circuit of the MODAMP MMIC is shown in figure 1. These amplifiers are available with two bias options, for operation at +5V or at +12VDC. With the 12-volt units, the temperature compensating resistor is a part of the monolithic circuit, and connected in series with the power supply line. In the 5-volt version, the temperature compensation is provided by the user with an external resistor. In either case, the MODAMP amplifier is typically biased through a user-supplied resistor or inductor to provide isolation from the power supply bus. An example of a typical bias network is shown in figure 3. Note that DC blocking capacitors are also shown at the input of each module, to isolate the inputs from each other and from the source.

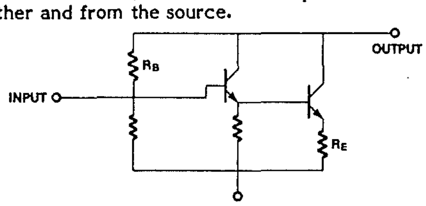


Fig. 1 RB - Shunt Feedback Resistor
RE - Series Feedback Resistor

The circuit of the MODAMP MMIC is basically a Darlington-connected transistor pair with internal feedback. A simplified A.C. equivalent circuit appears in figure 2.

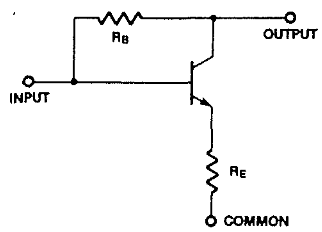
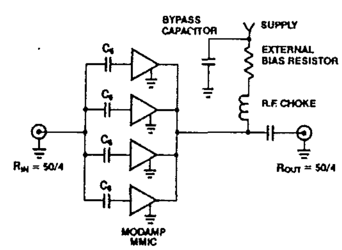


Fig. 2

This is a relatively standard broadband amplifier circuit. Its major advantage comes from monolithic fabrication, which means that the reactive values associated with the feedback elements are very small, for enhanced stability and greater bandwidth.

Since they are unconditionally stable, MODAMP MMIC's may be easily paralleled for increased output power capabilities (fig. 3). Fortunately, the input and output impedances of paralleled MODAMP amplifiers fall within the range that conveniently terminates standard 4:1, 9:1 and 16:1 broadband transformer configurations.

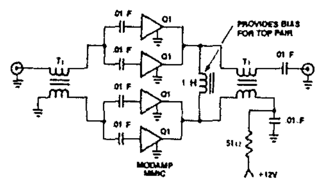


C_B = BLOCKING CAPACITORS

Fig. 3

The bandwidth of the resulting multi-MMIC circuit will be limited by the bandwidths of the impedance matching elements. In figure 4, for example, the bandwidth would be limited by the 4:1 impedance transformers.

Fig. 4



In applications not calling for the maximum possible bandwidth, there are many appropriate impedance matching and combining techiques, such as quarter-wave transmission lines and Wilkinson n-way divider/combiners. The choices for impedance matching and transformation over octave and multi-octave bandwidths are more limited. Some of the techniques are discussed in reference 1.

Again as a result of their unconditional stability, MODAMP MMICs may also be connected in push-pull (fig. 4). The advantages of push-pull over straight paralleling are that most of the good attributes such as stability and gain of the MODAMP MMIC are retained, even-order harmonics tend to be cancelled and, of course, the push-pull circuit shown in the figure provides four times the power output of a single device.

In the circuit of figure 4, the input and output transformers are of the type that are generally called baluns (for BALanced to UNbalanced). A balun provides two signals at the balanced output which are 180 degrees out of phase, but equal in magnitude with respect to ground. This establishes the necessary conditions for push-pull operation.

For those unfamiliar with the concept of a balun, we can begin by showing a conventional RF transformer with a 1:1 turns ratio and a coupling coefficient of 1 (fig. 5). This same transformer becomes a balun when connected as shown in figure 6 (note the polarity of the windings).

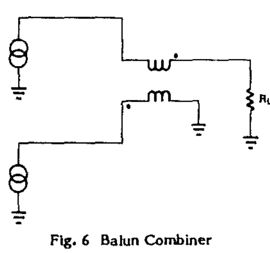


Fig. 6 Balun Combiner

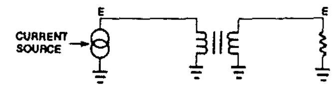


Fig. 5 Single Ended

To more easily understand the combining effects of the balun, examine figure 7, which is actually an alternate connection of an ordinary 1:1 transformer that will also provide the balanced to unbalanced effect. Note that the currents produced by the generators are assumed to be 180° out of phase with each other. The current from each generator results in a voltage drop across R_L which is equal to that of the other in magnitude but opposite in phase. The net result is that the total voltage across R_L is always the sum of the two voltages, or 2E at any given moment. Since the transformer in figure 7 is defined as having a coupling coefficient of 1, a turns ratio of 1:1 and no phase reversal, it may simply be replaced with a short circuit. The net result is shown in figure 8. This circuit shows the two generators to be in series, with the total current being I. The value of the current may be doubled by placing an additional current source in parallel with each of the original sources, as shown in figure 9. Thus the voltage produced across R_L becomes 2E, with 2I flowing through it. The effective power is then 2E x 2I or 4EI--four times the power of a single-ended device. In the case of the MODAMP MMICs, the current sources are shunted by 50 ohms due to internal feedback. Conveniently, this properly terminates the balun, with 50 ohms on each side.

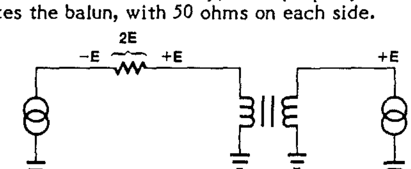
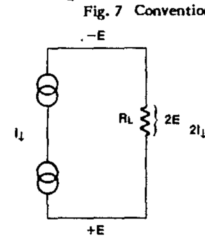


Fig. 7 Conventional Transformer Configuration



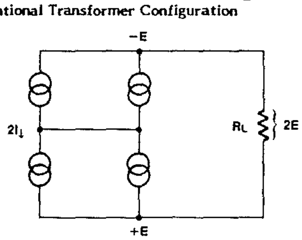


Fig. 8 Electrical Equivalent without Transformer

Fig. 9 Adding Two Current Sources to Double the Current

In the push-pull connection, even-order harmonic cancellation occurs because the output currents of even-order harmonics appear across the load resistor in phase with each other and, assuming that each is a perfect replica of the other, their sum is therefore zero at all times.

Note that the gain of the amplifier in the push-pull configuration, is still the same as the gain of a single single-ended amplifier channel. Thus, to get four times the output power, the resulting push-pull amplifier must be driven with four times the input power.

A push-pull pair of MODAMP MMICs also lends itself to neutralization, a circuit design technique which has almost disappeared except among designers of high-powered tube-type RF amplifiers, and to the even more worthwhile design concept of true unilateralization.

Unilateralization is a circuit technique in which the imaginary as well as the real term of the feedback elements are cancelled. This creates an amplifier with a large degree of isolation between the input and the output.

At first glance, unilateralization might appear to be the same as neutralization as a means of stabilizing an amplifier. In neutralization, though, only the imaginary terms of the feedback reactances are canceled because the necesary inverse feedback is provided through an inductor (or capacitor), which does not track the reactance of the capacitive (or inductive) feedback over frequency. Consequently the conventionally-neutralized amplifier is stable only over a small frequency range (figure 10).

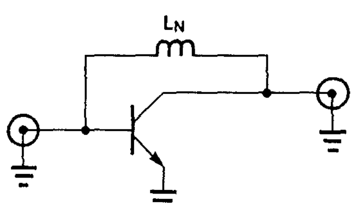


Fig. 10 AC Equivalent Circuit Neutralized Device

What is really needed is not an inductor or a capacitor, but a circuit element which is always equal in magnitude but opposite in sign to the positive feedback reactance of the device; including all parasitic elements of the device itself, its package and the circuit in which it is installed.

Such a negative element can best be simulated with a duplicate active device. In the case of the push-pull configuration, it may be obtained by cross-coupling between the input of one of the two amplifier devices and the output of the other, and vice-versa. In figure 11, this condition is provided, with the input transformers serving the dual purpose of 4:1 impedance transformation and balun.

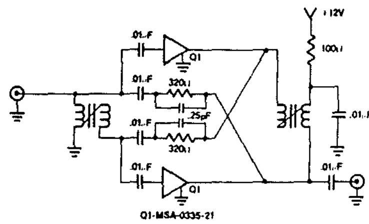


Fig. 11 Unilateralized Push-Pull Circuit

The reason that the MODAMP amplifier is so easily unilateralized is that its internal feedback network is of very low Q compared to that of conventional amplifiers. In other words, in conventional amplifier devices the feedback elements tend to be more reactive than resistive, while the feedback in the MODAMP MMIC is predominantly resistive.

Unilateralization of a push-pull pair of MMIC amplifiers would appear to negate some of the advantages of the basic amplifier itself. In general, this is true. Unilateralization is only useful in providing slightly higher gain or substantially more isolation.

To determine the necessary component values for unilateralization, the s-parameters of the device should be converted to y parameters. The real part of the feedback element is equal to $-1/g_{12}$, and the imaginary part is equal to $-1/b_{12}$. The addendum shows an example of this calculation.

After an amplifier has been unilateralized, the load impedance will no longer affect the input impedance and vice-versa, but unilateralization often increases the effective input and output impedance of the amplifier. This is the mechanism which actually increases the gain. Again, this is shown in the example in the addendum. Careful attention must be paid to the effects of unilateralization on the input and output match.

Practical application of the MODAMP amplifier

The paralleling techniques we have discussed were tested in single-ended (as shown in figure 4) and push-pull (as shown in figure 11) experimental amplifiers. The two amplifiers were built with little effort toward optimizing board layout, and with standard components such as carbon composition resistors and chip capacitors. To optimize performance, microwave printed circuit layout techniques and microwave components would be preferable.

AVANTEK
3175 Bowers Avenue
Santa Clara, California 95051
(408) 727-0700

Figures 12 and 13 show the measured harmonic performance of the two amplifiers.

Configuration	Frequency (MHz)	Gain (dB)	P_{-1dB} (dBm)	2nd Harmonic @ P_{-1dB} (dB below carrier)
Single-ended	100	12	+10	-15
Push-pull (Unilateralized)	100	15	+13.5	-26
Push-pull	100	12	+17	-34

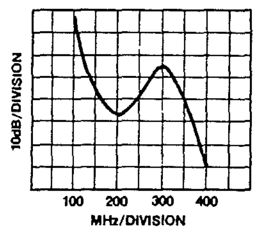


Fig. 12 Harmonic Performance of the Circuit Shown in Figure 4 at 1 dB Gain Compression

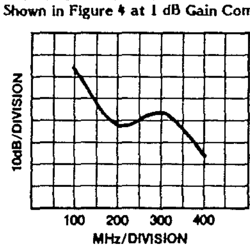


Fig. 13 Harmonic Performance of the Circuit Shown in Figure 11 at 1 dB Gain Compression

Figures 14 and 15 demonstrate the calculated performance of the two amplifier configurations, assuming that ideal components were used. Actually, the "idealness" of components and circuit layouts in microwave amplifiers are mainly a function of how much you are willing to pay.

Fig. 14

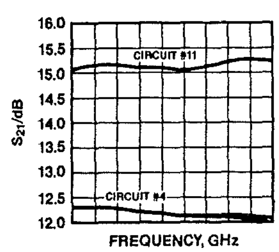
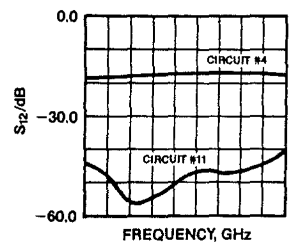


Fig. 15



The calculated design was analyzed with CADEC™, a computer-aided design program available from Communications Consulting Corporation of New Jersey. The push-pull transformers were implemented using the MCI and INS code, along with the nodal analysis routine available in the program.

Addendum:

$$y_{11} = \left[\frac{(1+S_{22})(1-S_{11}) + S_{12}S_{21}}{(1+S_{11})(1+S_{22}) - S_{12}S_{21}}\right]\frac{1}{Z_0}$$

$$y_{12} = \left[\frac{-2S_{12}}{(1+S_{11})(1+S_{22}) - S_{12}S_{21}}\right]\frac{1}{Z_0}$$

$$y_{21} = \left[\frac{-2S_{21}}{(1+S_{11})(1+S_{22}) - S_{12}S_{21}}\right]\frac{1}{Z_0}$$

$$y_{22} = \left[\frac{(1+S_{11})(1-S_{22}) + S_{12}S_{21}}{(1+S_{22})(1+S_{11}) - S_{12}S_{21}}\right]\frac{1}{Z_0}$$

where Z_0 equals the characteristic impedance.

$$S_{11} = \frac{(1+y_{22})(1-y_{11}) + y_{12}y_{21}}{(1+y_{11})(1+y_{22}) - y_{12}y_{21}}$$

$$S_{12} = \frac{-2y_{12}}{(1+y_{11})(1+y_{22}) - y_{12}y_{21}}$$

$$S_{21} = \frac{-2y_{21}}{(1+y_{11})(1+y_{22}) - y_{12}y_{21}}$$

$$S_{22} = \frac{(1+y_{11})(1-y_{22}) + y_{12}y_{21}}{(1+y_{22})(1+y_{11}) - y_{12}y_{21}}$$

References:

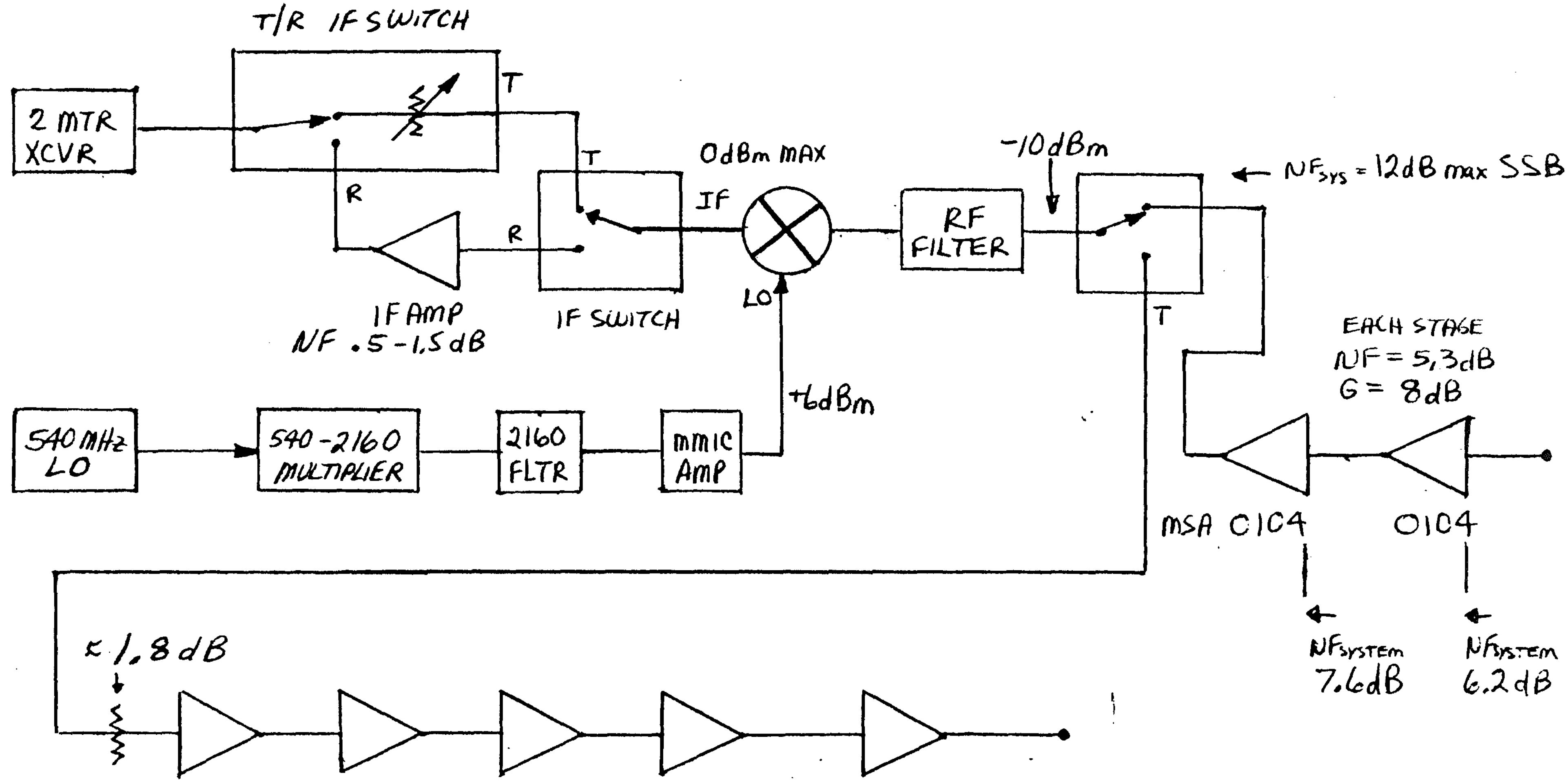
1. Herbert L. Krauss, Charles W. Bostian and Frederick H. Raab; Solid State Radio Engineering, John Wiley & Sons, New York, 1980.

2. Ralph S. Carson, High Frequency Amplifiers, John Wiley & Sons, New York, 1975.

2304 TRANSVERTER DESIGN

by

Al Ward, WB5LUA



MSA	0204	0304	0404	0404	4-0404
G	7 dB	7 dB	5.4 dB	4.4 dB	4-5 dB
P_{OUT}	-4.8 dBm	+2.2 dBm	+7.6 dBm	+12 dBm	> +16 dBm (40 mw)

2304 MHz TRANSVERTER BLOCK DIAGRAM

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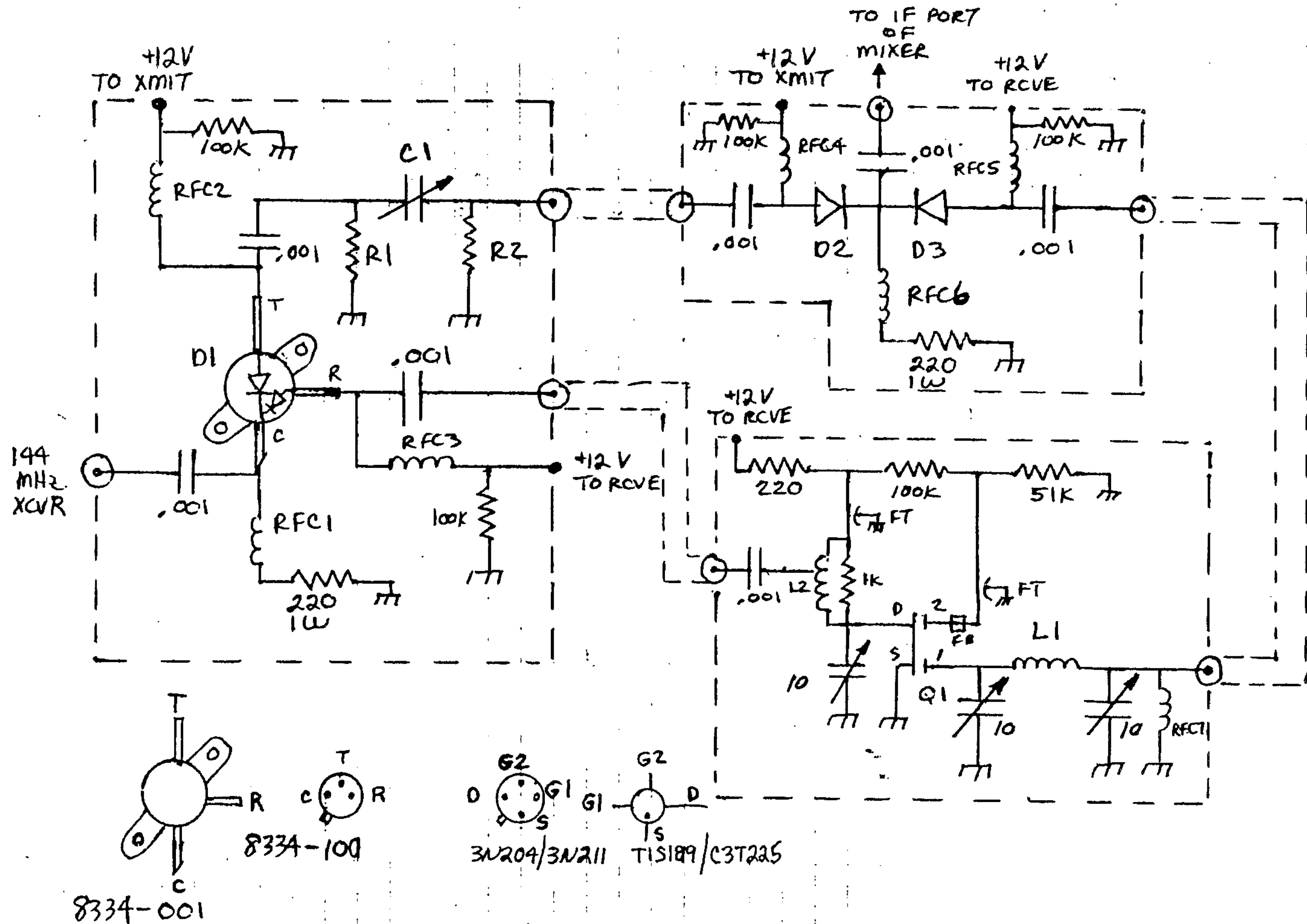

TRANSMIT /RECEIVE IF SWITCH /IF AMPLIFIER
FIGURE 4

AJWARD
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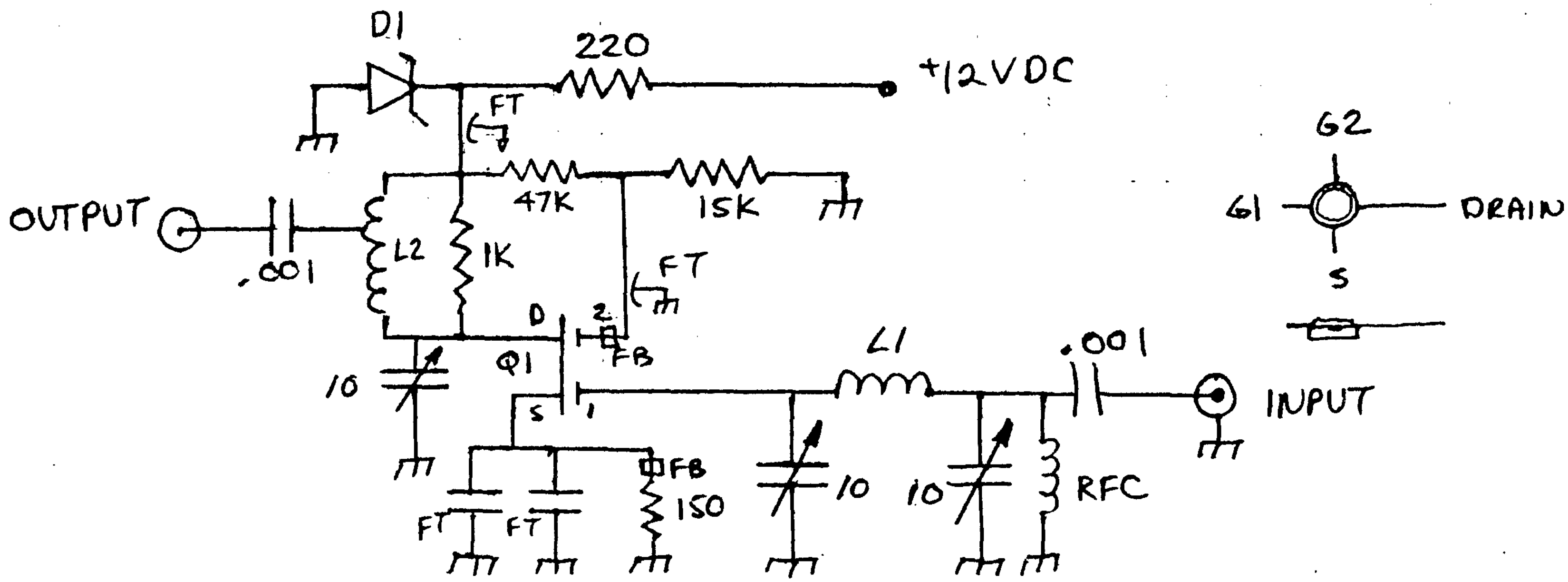
5-28-85

Q1	TIS189, 3N204, 3N211 DUAL GATE FET
D1	MA8334 T/R SWITCH SERIES (-100 is 10W version and -001 is 100W)
D2, D3	MA 47047, 47110, 47123 PIN SWITCHING DIODE or HP 5082-3379
RFC1-RFC7	1 uH MINIATURE RF CHOKE
R1	50Ω 10W NONINDUCTIVE RESISTOR
R2	51Ω 1/2W CARBON RESISTOR
C1	1-2 pf ADJUST FOR DESIRED DRIVE LEVEL AT DBM
FB	FERRITE BEAD
L1	6 TURNS #18 GUAGE .25" I.D. SPACED WIRE DIAMETER
L2	5 TURNS #18 GUAGE .25" I.D. S.W.D., TAP 1 TURN FROM COLD END
FT	470-1000 pf FEEDTHROUGH CAPACITOR

- UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE 1/4 WATT CARBON
- UNLESS OTHERWISE SPECIFIED ALL CAPACITORS ARE DIPPED SILVER MICA

T/R IF SWITCH/IF AMPLIFIER

AJWARD



Q1	NE41137 GaAs DUAL GATE MESFET (CALIFORNIA EASTERN LABORATORIES)
L1	6 TURNS #24 GUAGE WIRE .25" I.D. S.W.D.
L2	5 TURNS #24 GUAGE WIRE .25" I.D. SWD TAPPED 1 TURN FROM COLD END.
D1	1N752 ZENER DIODE (5.6 VOLT)
FT	470-1000 pf FEED THROUGH / BYPASS CAPACITOR
FB	FERRITE BEAD
RFC	1uH MINIATURE RF CHOKE

ALL RESISTORS ARE 1/4 WATT CARBON
ALL CAPACITORS ARE DISC OR S.M. UNLESS OTHERWISE SPECIFIED

NF = .5 - 1.0 dB $\quad V_{DS} \approx 4V \quad V_{G2S} \approx .5V$

G = 24 dB TYP $\quad I_D \approx 6\text{-}10\,mA$

NE411 I.F. AMPLIFIER
FIGURE 5

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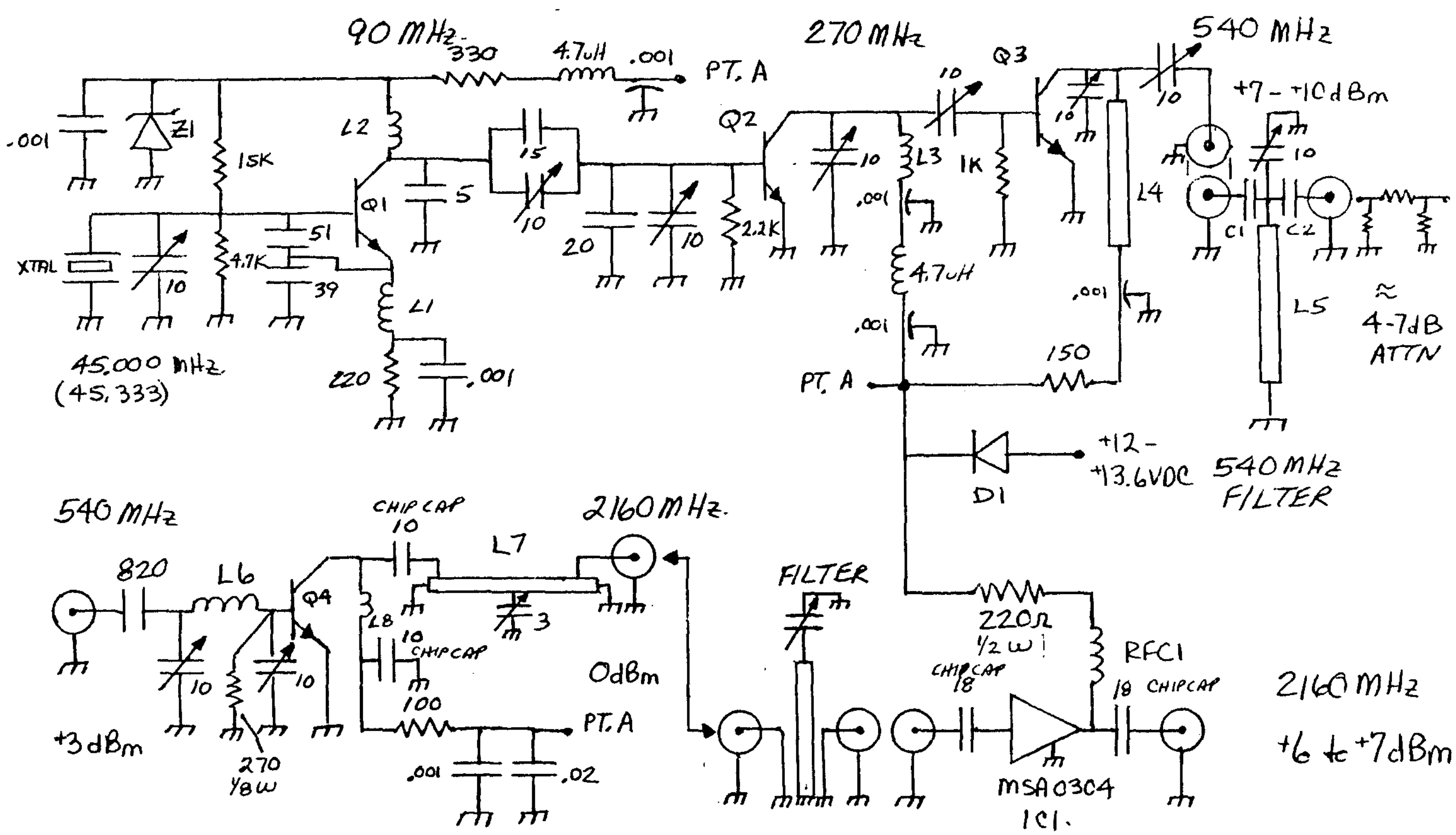
5-28-85



- HARMONICS DOWN -28dBc @ ±45 MHz FROM 2160 MHz
  ALL OTHERS > -40dBc
  SUGGEST 90 MHz OSC. TO REMOVE ±45 MHz HARMONICS
- 540-2160 MULTIPLIER w/o EXT. FILTER
  +3dBm IN → 0dBm OUT
  1620 MHz SIGNAL -10dBc.

2160 MHz LO

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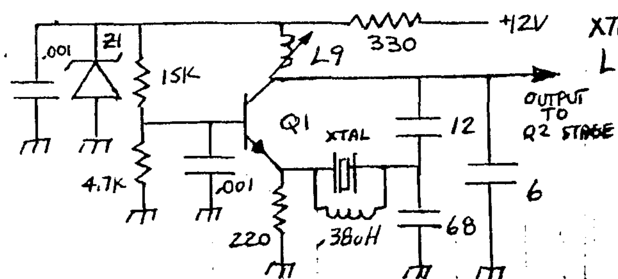
9-15-85

PARTS LIST

L1	10T #24 WOUND ON .25" COIL FORM (GRN SLUG)
L2	6T #24 WOUND ON .25" COILFORM (WH. SLUG)
L3	2 1/4 T #24, .3" I.D., .2" LONG AIR WOUND
L4	1.4" LONG MICROSTRIPLINE .5" WIDE BY .125" ABOVE GROUNDPLANE
L5	1.75" LONG MICROSTRIPLINE LIKE L4
L6	2 T #24, .125" I.D. S.W.D
L7	2.3" LONG MICROSTRIPLINE .25" WIDE SUSPENDED .1" ABOVE GROUNDPLANE GROUNDED AT EACH END. TAP 10pf CAP .25" FROM GROUND AND TAP OUTPUT CONNECTOR .1" FROM GROUND.
L8	1 T #28 .1" I.D.
Q1, Q2	MPS 3563, 2N918
Q3	2N3866
Q4	HEWLETT PACKARD HXTR3101 ($4.00 EA.)
IC1	AVANTEK MMIC MSA 0304 ($3.00 EA.)
Z1	9V ZENER 1N757
D1	1N4007
C1, C2	VARIABLE CAP USED IN PROTOTYPE - COULD REPLACE WITH 2.7pf S.M. CAP
RFC1	4 T. #28 .125" I.D. S.W.D

SUGGESTED 90 MHz OSCILLATOR



XTAL 90 MHz OVERTONE
L9 4 T. #24 .25" COIL FORM

2160 MHz LO

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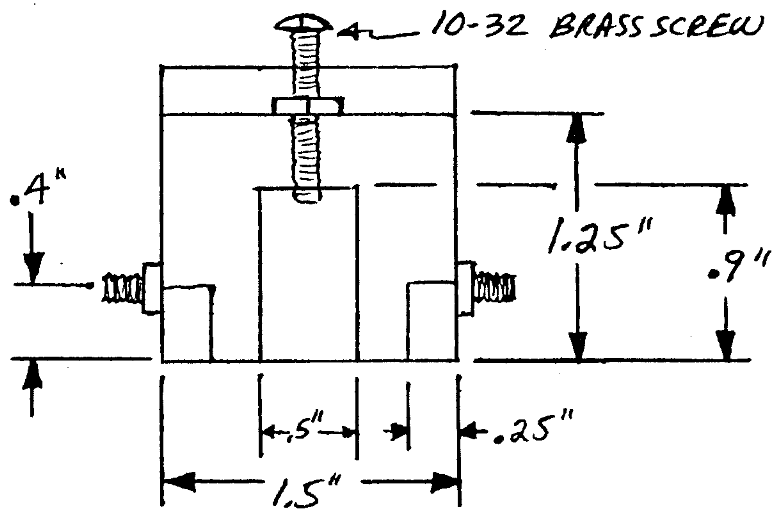
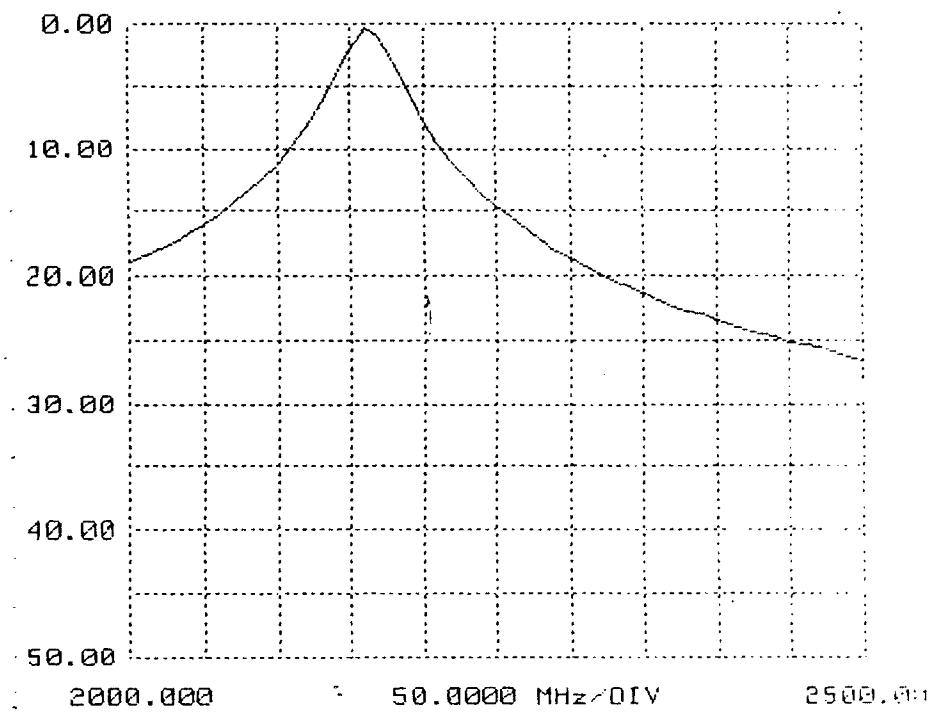
9-15-85

λ/4 CAVITY FILTER FOR 2160 MHz



- LOSS .5 dB
- 3dB B.W. 32 MHz
- VSWR LESS THAN 1.1 : 1



- TUNES 2160 MHz WHEN SCREW PENETRATES ≈ .030" INSIDE TUBE

2304 MHz. DOUBLE BALANCE MIXER

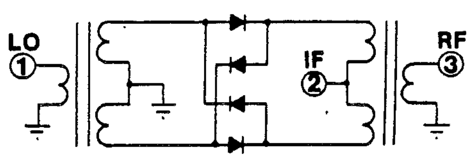
- TELETECH MT-57 \$26.00 SINGLE QTY'S (HP QUAD DIODE)

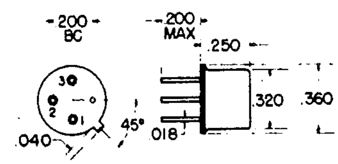
  MT-47 \$8.00 SINGLE QTYS (NEC QUAD DIODE)
- SPECIFIED AS A BLOCK DOWNCONVERTER DBM

  RF 900-1400 MHz

  LO HIGH SIDE INJECTION (UP TO 2GHz.)

  +7 dBm
- TO-5 PACKAGE





- MEASURED PERFORMANCE

  RF 2304 MHz

  LO 2160 MHz @ +6 dBm

  IF 144 MHz

  CONVERSION LOSS (SSB) ⇒ 9.5 dB

  LO-IF ISOLATION ⇒ 25 dB

  LO-RF ISOLATION ⇒ 22 dB

- MANUFACTURE

TELETECH
2050 FAIRWAY DRIVE
BOX 1827
BOZEMAN, MT 59715
(406) 586-0291

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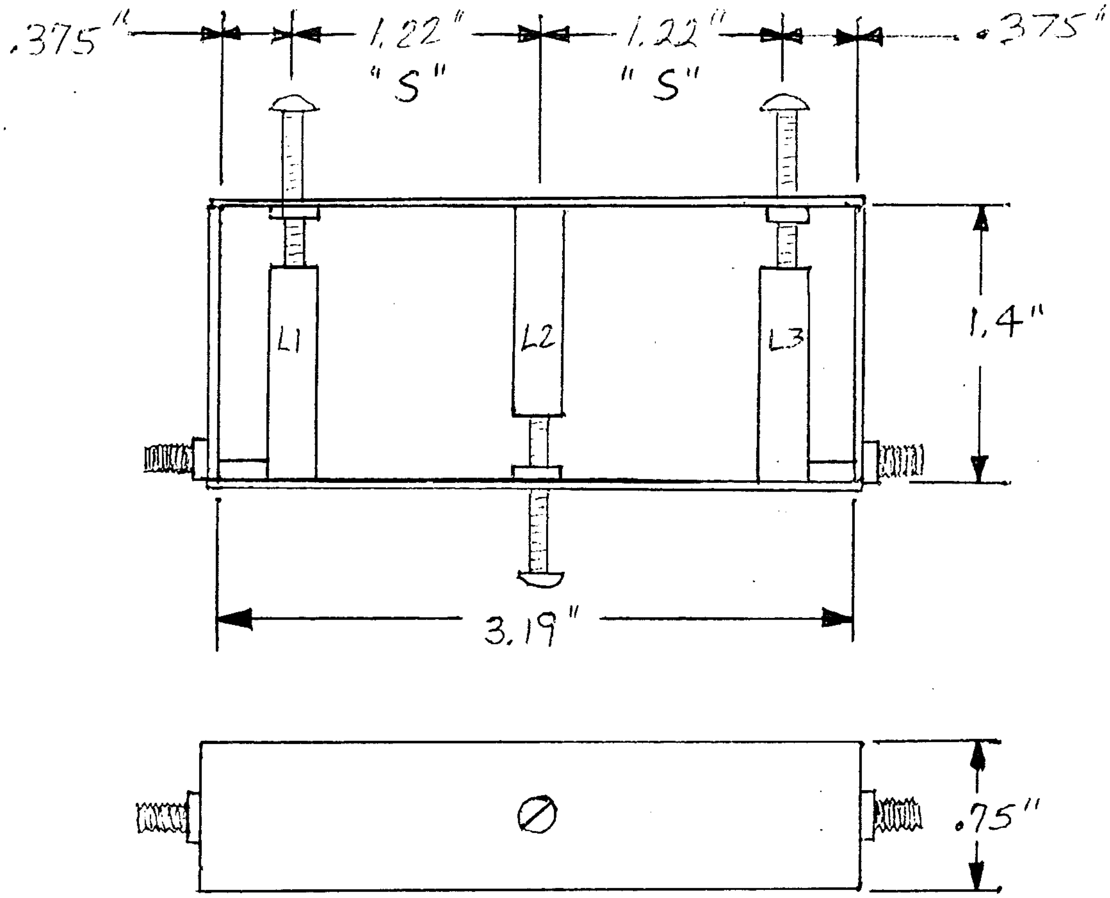
9-14-85

2304 MHz. INTERDIGITAL FILTER.



L1, L3 .25" DIA BY 1.1" LONG, TAPPED AT .070" FROM SHORTED END.

L2 .25" DIA BY 1.08" LONG.

- TUNING SCREWS ARE 4-40 BRASS WITH NUTS SOLDERED TO INSIDE WALL.
- BOX MADE FROM .062" G-10 - ALL DIMENSIONS ARE INSIDE BOX MEASUREMENTS.
- DESIGN PARAMETERS OBTAINED FROM COMPUTER PROGRAM WRITTEN BY JERRY HINSHAW, N6JH AND FEATURED IN "HAM RADIO MAGAZINE" JANUARY 1985

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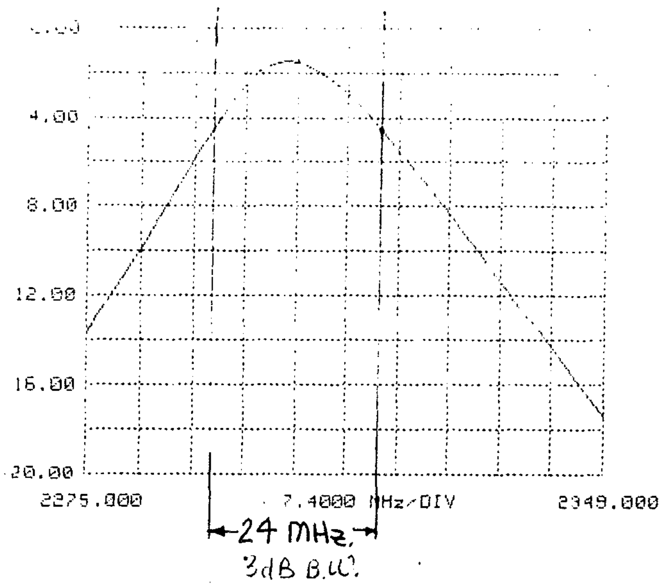
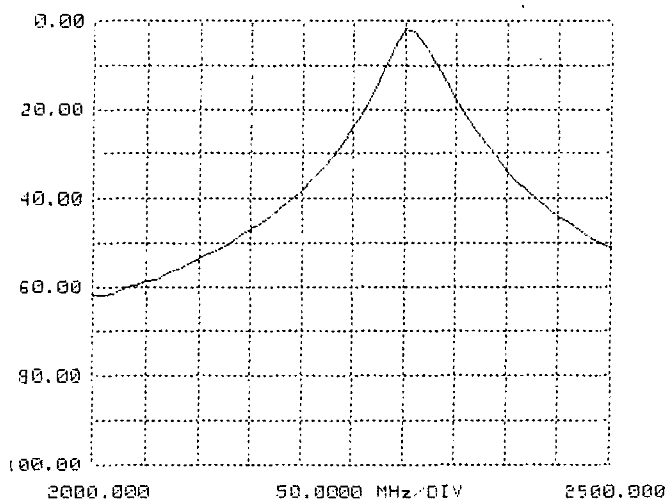
2304 MHz INTERDIGITAL FILTER





PERFORMANCE

- LOSS IS 1.5dB WHEN TUNED FOR MAXIMUM 3dB BANDWIDTH OF 24MHz
- 61 dB ATTENUATION AT 2016 MHz IMAGE FREQUENCY
- 45dB ATTENUATION AT 2160 MHz LO FREQUENCY
- WHEN TUNED FOR MINIMUM LOSS AT 2304MHz, LOSS = 0.5dB

- TO DOUBLE BANDWIDTH OF FILTER, DECREASE SPACING "S" FROM 1.22" TO 1.05" AND TAP .1" FROM SHORTED END. OUT OF BAND REJECTION WILL DECREASE

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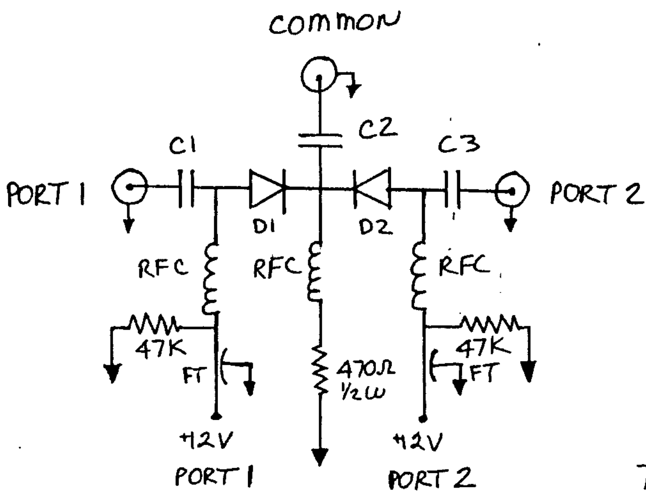
9-15-85

SPDT RF SWITCH

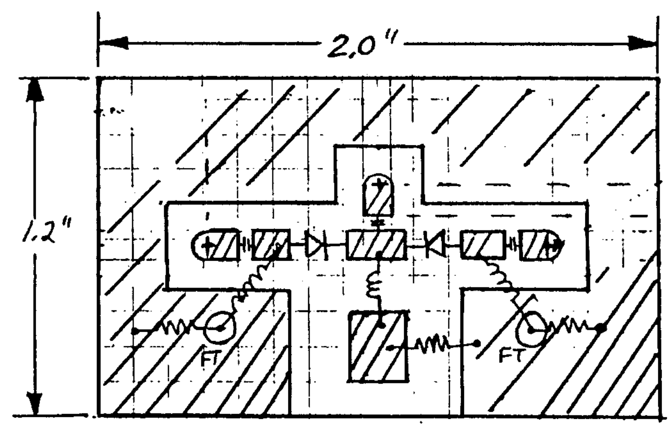


	1296 MHz	2304 MHz
C1, C2, C3	100pf CHIP	22pf CHIP
RFC	6T #24 1/8" I.D. CLOSEWOUND	4T #28 1/8" SPACED WIRE DIA.
D1, D2	5082-3379	5082-3379
FT	100-470pf	30pf

DIODES ARE MANUFACTURED BY HEWLETT PACKARD. COST 1$/6¢ EACH.

ELECTRICAL PARAMETERS

	1296 MHz	2304 MHz
LOSS	.5dB	.6dB
ISOLATION	21dB	15.4dB
"ON" CURRENT	≈25mA	≈25mA



50Ω LINE WIDTHS ARE .10" WIDE
DIMENSIONS ARE 1X
DRAWING IS 2X
SLASHED AREA IS COPPER
PWB IS .062" G-10

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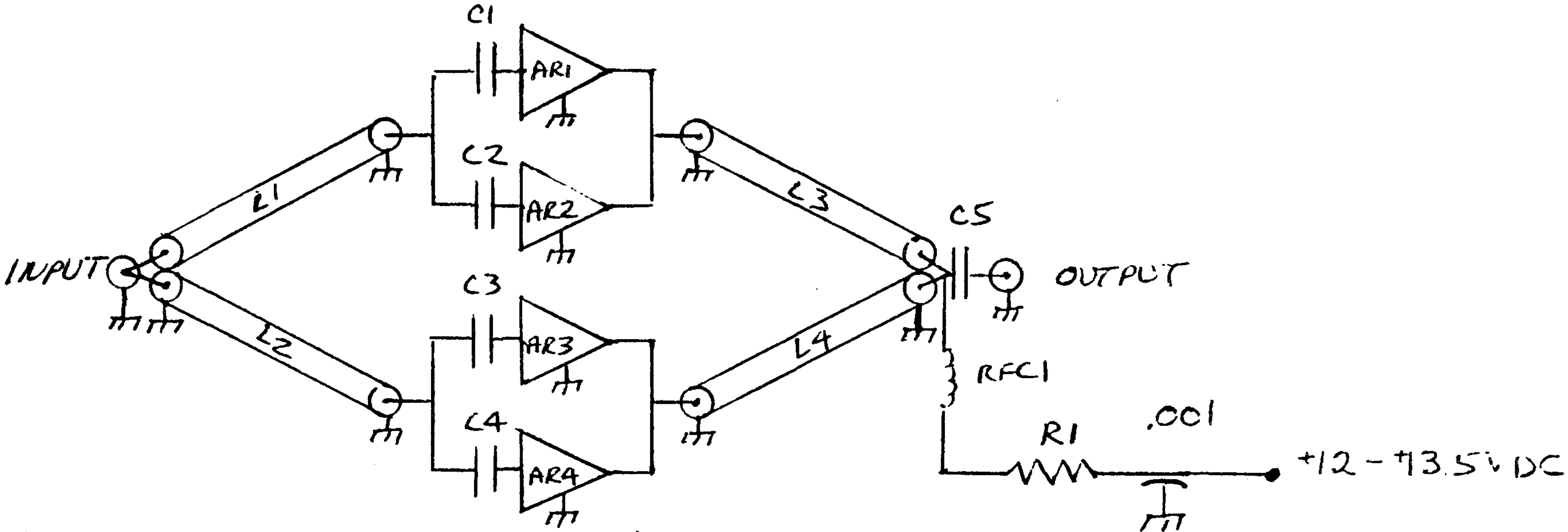
4-17-84



AR1-AR4 AVANTEK MMIC MSA-0404
C1-C5 100 pf CHIP CAP.
L1-L4 QUARTER WAVE 50Ω SEMI-RIGID CABLE .141" DIAMETER
FOR 2.3GHz, EACH CABLE IS .8" LONG SHIELD TO SHIELD
FOR 2.05GHz, EACH CABLE IS .9" LONG SHIELD TO SHIELD
RFC1 6 TURNS #28 GA. WIRE .125" I.D. SCWD
R1 30 OHMS AT 2 WATTS

1dB COMPRESSION POINT +17dBm (50mw)
GAIN 4-5 dB
CURRENT CONSUMPTION 240 mA TOTAL

50 mw MMIC AMPLIFIER FOR 2.3GHz

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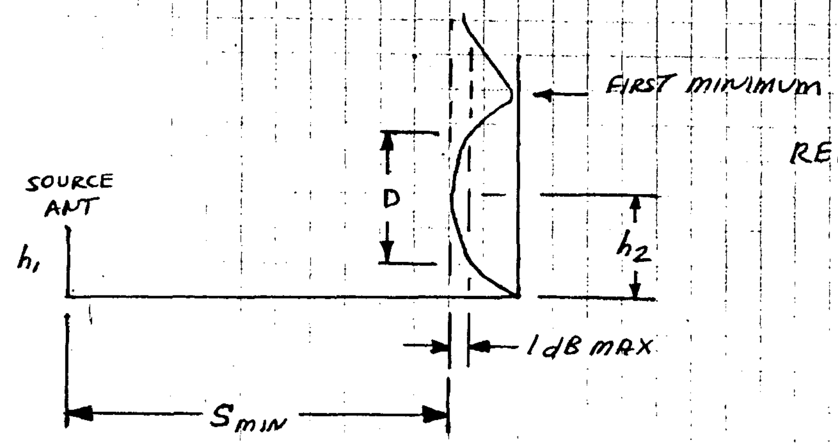
ANTENNA GAIN MEASUREMENT USING GROUND REFLECTION



$G = \dfrac{4\pi A_E}{\lambda^2}$

REF: ARRL ANTENNA BOOK ©1974 pg 317-320

$S_{MIN} = G\dfrac{2\lambda}{\pi^2}$ FOR BEST ILLUMINATION (Less than 30° phase error and 1dB gain variation)

$h_1 = N \cdot \dfrac{\lambda}{4} \cdot \dfrac{S}{h_2}$ where $N = 2$ for first min. above ground and $h_2 = 3.0$ defines the location of the first minimum

$h_2 = N \cdot \dfrac{\lambda}{4} \cdot \dfrac{S}{h_1}$ where $N = 1$ for first maximum above ground

FREQUENCY (MHz)	MAX GAIN (dBi)	S_{MIN} (feet)	h_1 (feet)	h_2 (feet)
1296	25	48	1.4	6.5
1296	30	154	2.5	11.7
2304	30	86	1.4	6.6
2304	32	137	1.8	8.1

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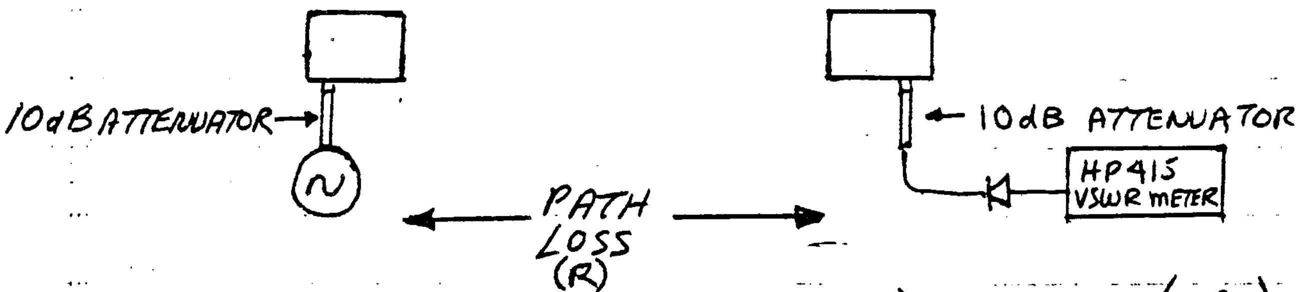
ANTENNA GAIN MEASUREMENT OF 2 IDENTICAL ANTENNAS



$$G(A) + G(B) = 20\log_{10}\left(\frac{4\pi R}{\lambda}\right) + 10\log_{10}\left(\frac{P_r}{P_T}\right)$$

- ANTENNAS UNDER TEST MUST BE SEPARATED BY A DISTANCE GREATER THAN $\frac{2D^2}{\lambda}$
- ANTENNAS UNDER TEST MUST BE HIGH ENOUGH ABOVE GROUND SO THAT GROUND REFLECTION IS NOT A FACTOR
- CALIBRATE BY REMOVING FEED HORNS FROM 10dB ATTENUATORS AND MAKE THROUGH CONNECTION WITH ATTENUATORS. DETERMINE $\left(\frac{P_r}{P_T}\right)$
- MEASURE DISTANCE (R) AND CALCULATE PATH LOSS.
- GAIN MEASUREMENT AT 1296 MHz USING TWO IDENTICAL DUAL 3 lb. COFFEE CANS.

RANGE #1 $2G = 38.52\text{dB} - 23.6\text{dB}$

$G = 7.46\text{dBi}$

RANGE #2 $2G = 42.36\text{dB} - 27.3\text{dB}$

$G = 7.53\text{dBi}$

AVG = 7.50 dBi GAIN

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A.J. WARD
9-16-85

A Clean Microwave Local Oscillator

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Department of Electrical Engineering
Michigan Technological University
Houghton, MI 49931

A Clean Microwave Local Oscillator

Richard L. Campbell KK7B
Department of Electrical Engineering
Michigan Technological University
Houghton, MI 49931

Crystal controlled local oscillators of exceptional spectral purity have been constructed for 1152 MHz and 2160 MHz. The block diagram of a complete LO is shown in Figure 1.

Clean Local Oscillator Example -- 2160 MHz

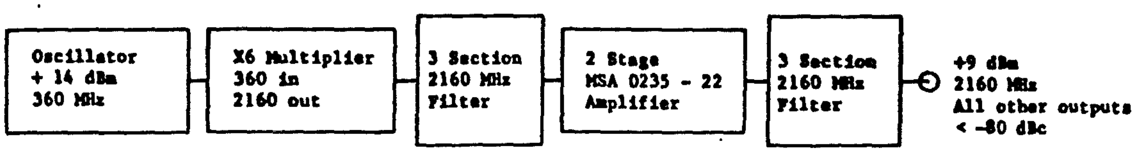


Figure 1

The 360 MHz circuitry is conventional, but the later stages employ two recent developments: computer designed interdigital filters and inexpensive monolithic silicon (MSA) amplifiers. The filters are designed with multiple resonators for good skirt selectivity, but with broad bandwidths so that they do not have to be adjusted if constructed to reasonable tolerances. The MSAs have moderate gain and output power, and provide proper terminations for the filters over a wide bandwidth with no tuning. There are no microwave adjustments to make. The availability of inexpensive gain and custom designed filters makes it practical to use high order multiplication instead of many bipolar doubler or tripler stages. It is also possible to sacrifice multiplier efficiency for stability, repeatability and graceful tuning characteristics. Step recovery diode multipliers, although excellent performers is a properly designed and tuned circuit, have a tendency to become parametric amplifiers or oscillators with improper matching or thermal design, component aging, temperature fluctuations, drive level variations or load variations. They are also very expensive in leadless versions suitable for microwave work, especially considering the necessity of microwave tuning elements at both the input and the output. The Schottky diode harmonic generator used here has about 17 dB more loss than a Step recovery diode harmonic generator, but tunes very broadly, has a minimum number of components, and is very inexpensive. The 17 dB loss is easily made up with 2 inexpensive ($6.60 current price) Avantek MSA 0235-22 amplifier stages. A disadvantage of using broadband amplifiers at the LO output is that they also amplify noise at the signal frequency, which is then injected into the

LO port of the mixer. This should not be a problem when using a balanced mixer and signal preamplifier, but the conservative approach is to use a second LO noise filter after the amplifier, as shown in Figure 1. With the second filter in place, all spurious outputs of the 2160 MHz LO are more than 80 dB below the 2160 MHz output. With a single filter at the input to the MSA amplifiers, the 1800 MHz and 2520 MHz spurious outputs are -45 dB relative to the 2160 MHz output. The +9 dBm output level is convenient for use with an attenuator pad and standard level Double Balanced Mixer, or to feed a Wilkinson divider for separate transmit and receive mixers. Performance is greatly enhanced by completely enclosing each stage in a seam soldered box and using SMA connectors for interconnections. In particular the harmonic generator should be completely shielded, as all harmonics from the fundamental through about the 20th are present at various levels. Also note that the connection between the harmonic generator and the first filter should be short (preferably a male-female SMA panel mount pair) as the source impedance is probably not 50 ohms.

The following figures and tables may be used to construct LOs and filters for a number of frequencies of interest to amateurs. Figure 2 is a swept response of a 2160 MHz and 2304 MHz filter, illustrating the isolation between the signal and LO filters used with a mixer in a 13 cm amateur transverter. Figure 3 is a drawing of the basic filter design. Filters are constructed of G-10 board, .141 semi rigid coax (the center conductor is removed, but is used to align the rods during soldering) and 0.015" thick brass sheet (available at hobby shops and hardware stores). The brass is cut with sharp scissors, and the .141" coax is cut by rolling it under a sharp pocket knife. Final dimensions were obtained to approximately 0.01" tolerances with a steel scale and a set of small files. Table 1 is a list of useful filter designs. The bandwidths were chosen so that 0.01" mechanical tolerances would not greatly affect filter performance. Theoretical losses for the filters in table 1 are on the order of half a dB. In practice, measured losses are about 1 dB and passband ripple is about 1 dB for the seven filters constructed to date. Figure 4 is the 360 MHz driver, with considerable credit due to Joe Reisert, W1JR. Figure 5 is the 192 MHz driver. Either of these may be easily tuned to other frequencies. Figure 6 is the Schottky diode harmonic generator. Half a dozen of these have been built, and all performed within a dB or so of each other. Sufficient information is given to cover output frequencies from 758 to 3456 MHz. Figure 7 is the MSA amplifier schematic. R1 and R2 are carbon film 1/4 watt resistors with sufficient inductance that no other RF chokes are needed.

Three Resonator Interdigital Filters

Measured Response

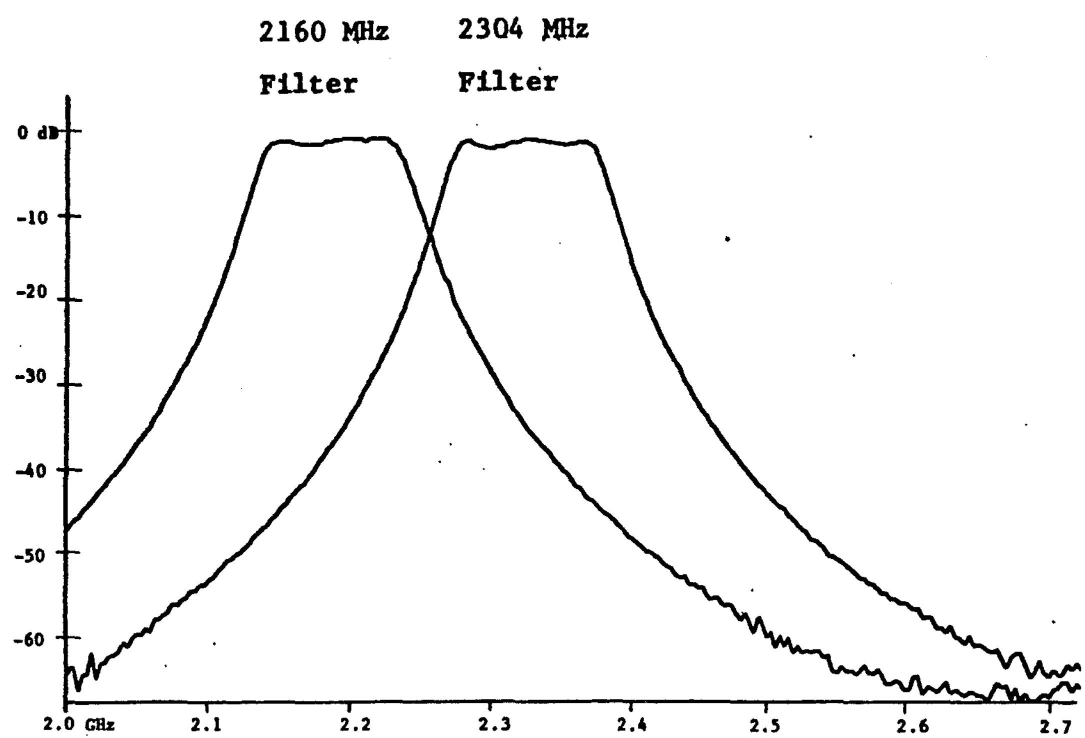


Figure 2

Three Resonator Interdigital Filter

Mechanical Details

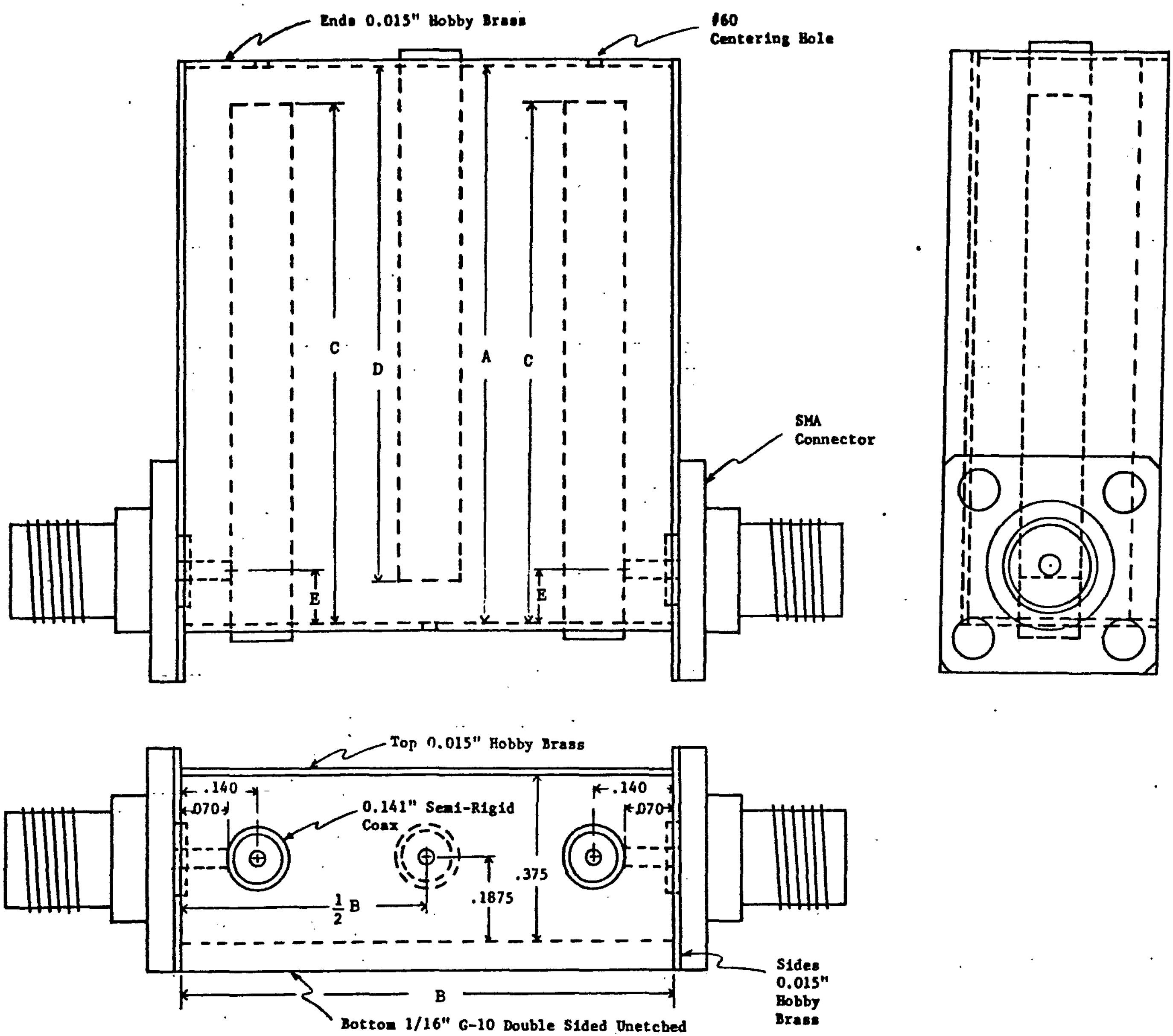


Figure 3

3rd Order Chebychev 0.1 dB Ripple Interdigital Filters

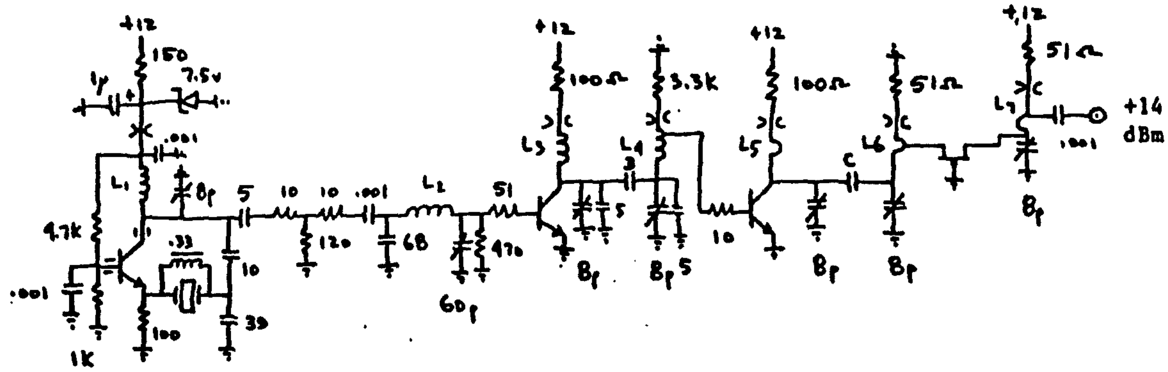
Richard L. Campbell KK7B
September 11 1985

Center Frequency MHz	Ripple Bandwidth MHz	Dimensions in Inches A	B	C	D	E
758	20	3.893	1.318	3.815	3.792	.317
850	20	3.471	1.345	3.390	3.369	.267
874	20	3.376	1.352	3.294	3.273	.256
902	20	3.271	1.359	3.188	3.168	.244
1080	30	2.732	1.305	2.647	2.626	.229
1126	30	2.621	1.315	2.534	2.514	.215
1138	30	2.593	1.318	2.506	2.486	.211
1152	30	2.561	1.321	2.474	2.454	.207
1244	30	2.372	1.339	2.283	2.264	.185
1268	30	2.327	1.344	2.238	2.218	.180
1270	60	2.323	1.179	2.240	2.215	.254
1280	40	2.305	1.277	2.217	2.197	.205
1296	40	2.277	1.280	2.189	2.168	.201
1296	30	2.277	1.349	2.188	2.168	.174
1512	50	1.952	1.264	1.861	1.841	.178
1656	50	1.782	1.285	1.689	1.671	.155
1702	50	1.734	1.292	1.641	1.622	.149
1872	60	1.576	1.271	1.482	1.464	.142
2160	80	1.366	1.237	1.272	1.254	.132
2252	60	1.310	1.315	1.214	1.198	.107
2276	40	1.296	1.415	1.200	1.185	.086
2304	80	1.281	1.252	1.186	1.169	.120
2420	80	1.219	1.264	1.124	1.108	.111
3024	200	.976	1.098	.884	.866	.126
3312	100	.891	1.285	.796	.782	.078
3400	200	.868	1.126	.776	.759	.106
3456	300	.854	1.034	.764	.745	.127

Dimensions were calculated using the BASIC program in J. Hinshaw and S. Menemzadeh, "Computer-Aided Interdigital Bandpass Filter Design," Ham Radio, Volume 18, number 1, January, 1985, pp 12 - 26.

Table 1

360 MHz Local Oscillator To Drive X6 Multiplier



Q1 2N5179 Q2 2N5179 Q3 2N5179 . Q4 U310

L1 9t 0.1" Dia
#28 closewound

L2 10t 0.1" Dia
#28 closewound

L3 5t 0.1" Dia #24
space 1 wire Dia

L4 6t 0.1" Dia #24
space 1 wire Dia
Tap 1t from FT

L5 0.75" straight #24

L6 0.75" straingt #24
Tap 0.1" from FT

L7 0.75" straight #24
Tap 0.1" from FT

C 0.5 pF gimmick

Construction Sketch

Actual Size

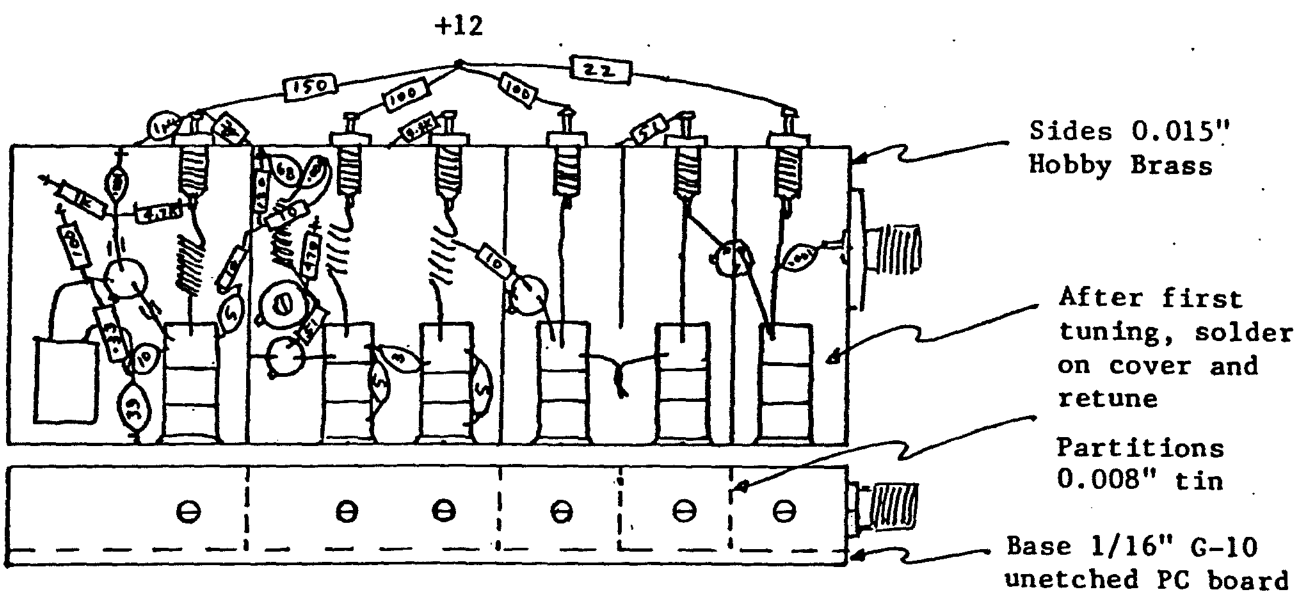
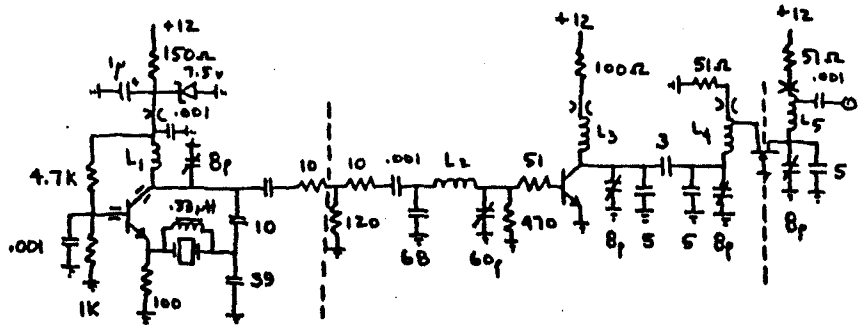


Figure 4

192 MHz Local Oscillator To Drive X6 Multiplier



Q1 2N5179

Q2 2N5179

Q3 U310

L1 9t 0.1" Dia
#28 closewound

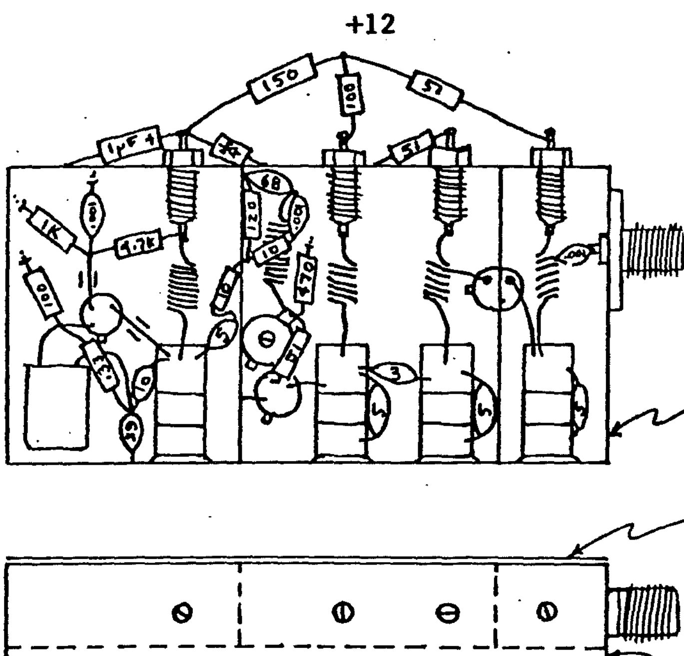
L2 10t 0.1" Dia
#28 closewound

L3 6t 0.1" Dia
#24 bare - space 1 wire Dia

L4 6t 0.1" Dia
#24 bare
space 1 wire Dia
tap 1t from FT

L5 6t 0.1" Dia
#24 bare
space 1 wire Dia
tap 1t from FT

All Feedthroughs
0.001 µF



Construction Sketch
Actual Size

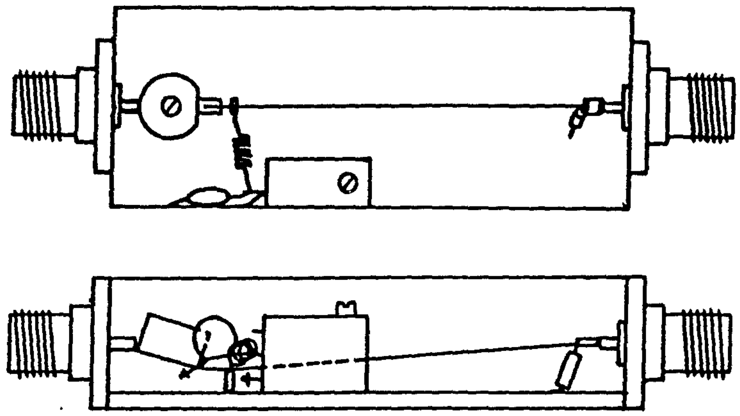
Box 0.015 Hobby Brass

Solder on Tin Cover after preliminary tuning

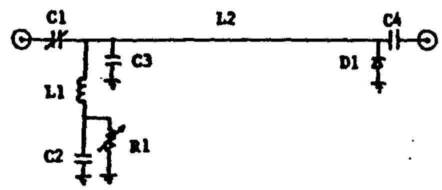
Bottom 1/16" unetched G-10 PC board

Figure 5

XN Schottky Diode Multiplier



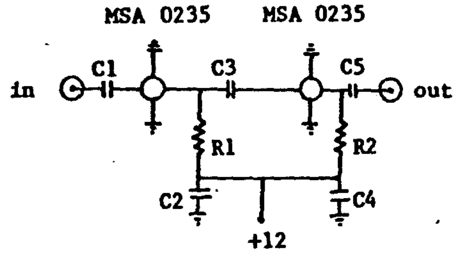
Typical Performance: +14 dBm in at 360 MHz
-8 dBm out at 2160 MHz through filter



C1 20 or 60 pF variable -- resonates with L2 at input freq.
C2 0.001 μF ceramic disk
C3 5 pF Chip
C4 5 pF Chip
L1 resonates with C3 at input freq.
L2 either: ¼λ at output #24 wire 0.1" above ground plane
or: X_L about 100 Ω at input freq.

R1 1k Trimpot
D1 HP5082 - 2835 Schottky Diode

Figure 6



R1 270 Ω (or as appropriate for other MSA types)

C1, C3, C5 10 pF chip

C2, C4 0.001 μF chip

Figure 7

A M S A T PHASE 3C ENGINEERING

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AMSAT MODE-S TRANSPONDER DEVELOPMENT

by

William D. McCaa, Jr., KØRZ

A M S A T Phase 3C Engineering

AMSAT MODE-S TRANSPONDER DEVELOPMENT

by
WILLIAM D. McCAA Jr., KØRZ
August 7, 1985

Introduction

The S-band output transponder described here is being developed for flight in the AMSAT Phase-3C satellite which is scheduled for launch in June, 1986. Since this transponder is an add on to a Phase-3 type satellite, the power consumption and space must be held to the constraints of the satellite's origional design. Thus power efficiency and size become major design consideration.

Link Calculations at 2.4 GHz.

Transmitter output power at antenna	+3 dBW
Spacecraft antenna gain (8 turn helix)	+14 dBic
Spacecraft EIRP	+17 dBW
Free space path loss (40,000 km @ 2.4 GHz.)	-192 dB
Signal level at receive antenna	-175 dBW
Receive antenna gain (1 meter dish @ 50%)	+25 dBic
Signal level at receiver	-150 dBW
Receiver sensitivity (75K, 20 kHz.BW)	-160 dBW
Received signal to noise ratio	+10 dB

Implementation in the Phase-3C Satellite

The S band transponder uses a portion of the mode-B transponder's receiver. A buffered output at 53 MHz. is provided by the mode-B receiver's first mixer. The transponder will be operated only when the mode-B receiver is active.

The following details the frequencies used in the S band transponder.

Input frequency to the S band transponder	435.21 MHz.
Input frequency from Mode-B transponder	53.25 MHz.
Local crystal controlled oscillator (LO)	41.93 MHz.
IF frequency including filter (IF)	11.32 MHz.
IF filter bandwidth	20 kHz.
Beacon injection oscillator	11.25 MHz.
1st upconversion frequency (FI=3XLO+IF)	137.11 MHz.
2nd upconversion frequency (Fout=54XLO+FI)	2401.33 MHz.
Output frequency from the S band transponder	2401.33 MHz.
Beacon output frequency	2401.26 MHz.

The spacecraft antenna is planned to be a left hand circular 8 turn helix that will be counter wound around the omni antenna and inside the 1269 helix.

The power drain at 14 volts should be less than 10 Watts overall and should provide at least two watts of 2401 MHz. output.

All transponder electronics must function to specification over the temperature range -25C to +55C.

The functional block diagram for the S-Band transponder is shown in the attached drawing.

Mechanical Packaging

Mounted at arm end next to Mode-B receiver.
Package length = 10.0" max
Package width = 2.23" max
Package heigth = 3.00" max

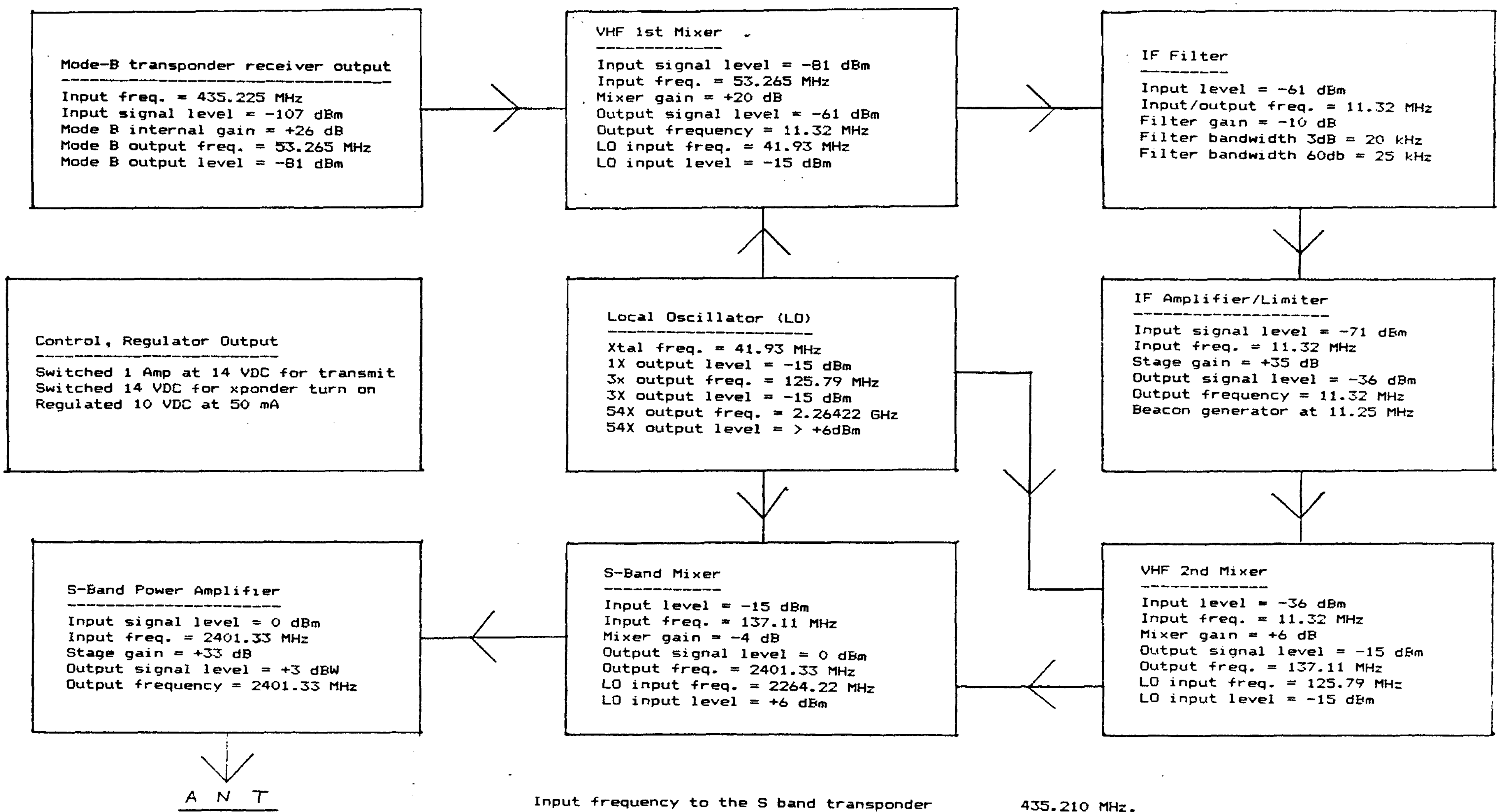
S-Band Mixer, LO Multiplier (18X)	2 X 1.5 X 5.5
Local Oscillator, LO Multiplier (3X)	2 X 1.5 X 2.5
VHF section, Control, Regulator	2 X 1.5 X 7
S-Band RF Amplifier	2 X 1.5 X 4.0

External connections will be on one of the 3 X 2 sides only. Two compartments 2 X 1.5 X 10 will be placed back to back. One housing the VHF Converter, LO, and Control and the second housing the 18X Multiplier and S-Band Mixer and Amp.

Modulation

The transponder will be a soft limiting type that will be suitable for use by one NBFM signal or four simultaneous SSB signals. The nonlinearity introduced by the amplifier and limiter does not limit its usefulness to CW or FM only. Since the received signal to noise ratio will be less than 20 dB, SSB can be used thru the transponder as the intermod products are generally below 20 dB and thus below the received noise level. This technique is being used sucessfully in the Mode-L transponder on OSCAR-10.

TASK AREA	RESPONSIBLE PERSONS	
Project Coordination	Bill, McCaa,	K0RZ
S-Band Mixer	Brad Bradley	KD0WM
Housings, Construction, and Test	Ray Uberecken,	AA0L
S-Band Miltiplier Chain	Steve Ernst,	WB0WED
Local Oscillator and 3X Mulitplier	Chuck Hill,	KY0S
VHF Mixers, IF Amp, Control,	Gordon Hardman,	KE3D
Placement in Spacecraft	Jan King,	W3GEY
S-Band RF Amplifier	George Noyes,	W1XE
S-Band RF Techniques	Ken Zurawski,	WB9QDL



Input frequency to the S band transponder	435.210 MHz.
Input frequency from Mode-B transponder	53.250 MHz.
Local crystal controlled oscillator (LO)	41.930 MHz.
IF frequency including filter (IF)	11.32 MHz.
IF filter bandwidth	20 kHz.
1st upconversion frequency (FI=3XLO+IF)	137.11 MHz.
2nd upconversion frequency (Fout=54XLO+FI)	2401.33 MHz.
Output frequency from the S band transponder	2401.33 MHz.

Telemetry Monitor Points

Package temperature
Output power

AMSAT

S-BAND TRANSPONDER
(MODE - S)

by W. McCAA, K0RZ
6/18/85

THE 23 AND 13cm AMATEUR BANDS IN THE UK

by

Angus McKenzie, G3OSS

Synopsis of lecture to be given by Angus McKenzie, G3OSS

The 23 and 13cm Amateur Bands in the UK

The 23cm band has become very popular in recent years throughout the UK, and in England in particular there are several hundred stations active. Most stations have good antenna systems, and whilst a few run very low power, the majority have amplifiers with outputs from 20 to 200W, with just a handful of stations running higher power still. 13cm is beginning to become more popular, and about 100 stations are equipped, most using at least a 1M dish. Whilst the area of the UK is of course very small by US standards, the country is extremely hilly, and very few stations indeed are more than a few hundred feet above sea level, and so this has become quite a challenge to DX operation. The lecturer will outline the spread of equipment used, including the performance of typical antennas, mast head pre-amplifiers, power amplifiers, transverters and transceivers, and will describe the various transmission and propagation modes used, as well as discussing the DX potential of the bands in Europe. G3OSS has been active on 23cm for around 12 years, but has only fairly recently become very active on 13cm.

TWO TUBE AMPLIFIER FOR 2304 MHz.

by

Hans Lohmann Rasmussen, OZ9CR

TWO TUBE AMPLIFIER FOR 2304 MHz.

Hans Lohmann Rasmussen, OZ9CR

This amplifier is mainly built up from 2.5 mm brass plate. It is all soldered together and only a few parts require threading. 3 mm screws are used, but of course 1/8" screws will do as well.

Partition plate

The plate between the anode cavity and the cathod chamber we can call it the partition plate. This plate is cut from 2.5 mm brass plate and should measure 85 x 90 mm. As seen on drawing 1, the two holes are marked off and bored to 21 mm size. The small 3.5 mm hole is bored and later used for a ground lug.

Cathode chamber

The cathode chamber is formed as a somewhat deformed ring, as seen on drawing. It is made of a strip of brass 1.5 mm thick and 17 mm wide and 117 mm long. The holes are then marked off and bored before the strip is bent into the form shown. The butt ends should be soldered together.

Finger stock. Mounting cathode chamber.

Finger stock contact rings can now be fitted in the holes bored in the partition plate. The topside of the rings should be flush with the top-side of the partition plate. The soldering should be done from the under side. The Cathod chamber ring is placed on the underside of the partition plate and centered equally with the two contact rings. A few spots are soldered on the cathode ring to hold it in place while it is being pre-heated, and then soldered to the partition plate. The cathode chamber is to be orientated with the 8 mm hole to the side of this unit where the tuning piston will be located.

Tuning piston

The tuning piston can be made of a solid piece of brass or built up from three layers of 2.5 mm brass plate which are held together by two rivets, as shown on drawing number 5.

The tuning piston should measure 36 x 26 mm, the thickness 7.5 mm. Two grooves should be cut in the long side of the piston where finger stock is to be soldered in. These grooves can be cut with a hacksaw. On the opposite side of the piston, a hole is bored in the middle of the piston, a 4.3 mm hole, which is tapped to 5 mm thread. This hole should go deep into the piston to give full movement in the tuning. Later the finger stock should be soldered into the two grooves.

Cavity strips

The cavity is formed by two strips of brass, 2.5 mm thick and 9.8 mm wide and each 95 mm long. A notch is filed 57 mm from one end, as shown on drawing number 4. This notch makes it easy to bend the strip at a sharp angle, before the curved bend is done in a vice, round a one inch mandrel.

On the drawing, the shape of these strips can be checked. The tuning piston should be palced between the two straight parts, and a small clamp put on to hold the position while the butt ends of the strips are soldered together. The strips that form the cavity serve also as guide for the tuning piston, and now the jointed strips can be placed on the topside of the partijtion plate, where the two holes with fingerstock should be centered in the curves of the cavity strips. With a large soldering iron a few spots of solder applied to the cavity and partition plate. This should hold the whole unit in position while it is being pre-heated. When heated, the cavity strip is soldered all along the outside.

Cavity top plate

The cavity top plate is also made of 2.5 mm brass plate 90 x 85 mm square. The two large convering hoiles can either be sawed out, or by drilling holes close together all along the marking and then breaking out the center part after which the hoile is filed to size. Four small holes are bored as shown on the drawing.

Anode capacitor plate

A piece of 2.5 mm brass plate is cut to 82 x 50 mm square. Two large holes and four smaller are marked off, as shown on drawing number 7. The two large holes can be cut out with a special cutter, or by drilling small holes along the circumference, and then break out the center part and file the hole to right size. The four 6.5 mm holes should not be bored to size in the first place but only bored to 2.5 mm in order to mark off the position later. Then two rings should be made in a lathe. The rings should be 31 mm inside and about 35 to 36 mm on the outside. The height should be 8 mm. These rings can also be made by bending a strip round a mandrel in a vice, and then solder the butt ends together. As seen on the drawing, these two rings are to be placed very close together on the capacitor plate and for this reason a flat side must be filed on each ring. These must be filed until the rings barely hang together. The rings should be placed 32 mm between centers.

The rings and the capacitor plate is pre-heated, and then the rings are aligned with the large holes in the plate and then soldered.

Finger stock

A suitable grade of finger stock should be fitted inside the two rings. The finger stock should extend 2 mm above the top of the rings and then after preheating, the rings are soldered from the underside, or with care from the top side. Now the fingerstock can be worked with a tapered mandrel until a loose fit on the 2C39 tube is obtained. Then with a pair of pointed pliers the fingerstock is adjusted to give a tight fit on the 2C39 tubes.

Soldering the cavity top plate

The anode capacitor plate is now placed on the top cavity plate (number 2) and aligned with the large oblong hole in order to make off the four screw holes. These holes should be bored to 2.5 mm and tapped to 3 mm thread. The four holes in the capacitor plate should be enlarged to 3 mm. The capacitor plate can now be screwed to the top cavity plate and this plate is now placed to form the top of the cavity. Two old tubes are placed in the sockets in order to align the top plate for soldering. The whole unit must be pre-heated for soldering of the cavity plate. A flatened soldering iron must be used to get into the narrow space between the partition plate and the top cavity plate.

Cathode top plate

This plate is cut from 2.5 mm brass plate and should measure 75 mm x 65 mm square. The position of the three large holes is marked off and bored. The three small holes should be bored later. While the 2C39 tubes are in the sockets, the two 14 mm holes should be centered with the cathode parts of the tubes. In this position the plate should be clamped down while being soldered. It will be necessary with some pre-heating. It is important that the cathode back plate be turned with the . . . . of the unit.

Cathode capacitor plates

From 2.5 mm plates are made two shapes as shown on the drawing. The position of the holes are marked off and bored. The small holes should be bored to only 3 mm for the time being while the 12 mm holes are bored to size. The underside of the plates should be planed and smooth.

Cathode stem

From 12 mm copper tubing are cut two lengths of 40 mm. The tubing should be 10 mm inside, the ends squared off and rounded slightly, then finger stock contact rings fitted on the tubes and tied with wire while the soldering is done. Then the finger stock is worked with a small mandrel to get a snug fit on the cathode part of the tubes.

Soldering cathode stems

With the 2C39 tubes in the sockets, the copper cathode stems are pushed down on the cathode parts of the tubes. The capacitor plates are slid down on the copper stems and the position of the screw holes are marked off on the cathode top plate. 2.5 mm holes are bored and tapped to 3 mm thread. The cathode plates should be tinned round the 12 mm hole and the copper stems rubbed with emry cloth in order to ease the soldering. Then the copper stems are pushed in place on the cathode part of the 2C39 tubes. The capacitor plates are slid down on the copper stems and screwed down with the 3 mm screws. With a larges soldering iron, the copper stems are soldered to the capacitor plates. At the same time a small lug is soldered to the side of the cathode stem. This lug is to be used for connection of the cathode resistor and heater current.

Mounting the cathode capacitors

The three holes in the capacitor plates can now be bored to 6 mm and small teflon collar bushings (beads) must be made in a turning lathe. Then with the beads placed in the holes a piece of sheet teflon is marked off and cut out to shape that extends 2 to 3 mm beyond the shape of the capacitor plates. The 12 mm hole in the dielectric sheet should fit tight on the copper stem. Also the 12 mm holes in the cathode chamber top should be chamfered with a large drill. Now the capacitor plates with the cathode stems all mounted with contact pins and dielectric in place, the capacitors can be screwed to the top plate of the cathode chamber.

Dielectric

The four holes in the anode capacitor should be enlarged to 6.5 mm and teflon collar bushings (beads) should be made in a turning lathe. A dielectric, or gasket, is cut out from 0.25 mm sheet teflon. The capacitor plate is placed on the sheet and the shape and the holes are marked off and cut out. The large holes for the tubes should be cut to measure 24 mm and the screw holes for 3 mm screws. The dielectric should extend 5 mm beyond the size of the capacitor plate. Before the capacitor is screwed onto the cavity, the surface should be polished with emery cloth, to be sure that no small burs or irregularities are maring the surface. A small chip can in time cut through the dielectric and cause a short.

Contact pins for heater current

The contact pins for the heater current can be made in different ways. One is to turn down from a brass rod to the shape shown on the drawing. These pins are mounted in teflon bushings in the cathode stems. On the drawing can be seen how the top bushing is locked in position by filing a small notch in the copper stem and then with a center punch make a deep nick into the copper. The contact pins are placed in the teflon bushings and a small lug is soldered to the lower end of the pin.

Cathode tuning capacitor

The cathode tuning is done with a disc capacitor. A shaft of 5 mm brass rod should be 75 mm long. On this rod a 5 mm thread is cut to a length of 30 mm. In a turning lathe, a brass disc is made with a 5 mm hole and the diameter should be 11 mm. As seen on the drawing, a small hub is made on one side. This disc is placed on the end of the shaft and soldered. A piece of 8 mm brass tubing is cut to a length of 40 mm, the inside of the tubing should be 6 m. Now the ends of this tubing is sliced into 6 contact fingers. These fingers can be cut with a hacksaw and filed to a pointed shape, as seen on drawing number 14. These fingers are bent with a pair of pointed pliers in order to make a tight fit on the shaft. In a turning lathe, a bushing is made from solid brass. The dimensions can be seen on the drawing. The flange is filed to a nearly triangular shape in order to be placed between the two cathode capacitors. Either 2.6 mm or 3 mm screws are used. The slitted tubing is placed in the hole and should protrude 5 mm from the flange bushing. Then the hub of the flange-bushing is soldered to the slitted tube. The shaft is placed in the slitted tube and a nut is screwed onto the shaft and positioned as shown on the drawing. Then two strips of brass are soldered to the nut and the hub of the flange bushing. These strips can be of 1 mm plate and the width about 6 mm. The two angle bends are to give a slight spring effect.

Input and output links

The input link tube is a piece of 8 mm brass tubing with a 1 mm wall. The tube should be 65 mm long and a notch is filed at one end. It should be 3 x 3 mm and here the link is soldered in later on. A piece of copper wire 2 mm thick and 65 mm long. The end of the wire should be filed to a slant which should be fitted to the center pin of a BNC coax connector and soldered on a teflon bead with a 2 mm hole and fitted to be pushed into the brass tube where the notch is filed. The copper wire is inserted in the brass tube and extended through the teflon bead. The BNC connector is now soldered to the brass tube. The link proper is made of a copper strip 3 mm wide and 0.5 mm thick and about 36 mm long. A 2 mm hole is bored near the end of the strip.

On the drawing one can see how the link should be shaped. The copper link is then placed with the 2 mm wire in the hole and soldered in place. The loose end of the copper strip is cut off and the strip fitted into the notch in the brass tube where it is soldered fast.

The output link

The output link is nearly identical to the input link. The main difference is the mounting of a type N coax connector. It requires a bushing with an 8 mm hole in order to make the 8 mm brass tube fit to the N connector. (see drawing) The copper link should be about 4 mm wide.

No guide bushings for links

The input and output links are held in place by two bushings on the anode cavity and the cathode chamber respectively. Two pieces of copper tubing 12 mm diameter and 10 mm inside are cut to 35 mm length. In the turning lathe are made two flanges 24 mm diameter and with a 12 mm hole in the center. Two more flanges are made but with an 8 mm hole. The two copper tubes are put into the flanges with the 12 mm holes. The ends should square with the flanges. This is now soldered together. One of these flange bushings should be placed on the cathode chamber and centered with the 8 mm hole in the chamber wall. Here the bushing should be soldered on, but it should be noted that the bushing should be filed down on the sides in order to pass inbetween the top cavity plate and the partition plate. Here it should be centered with the same hole in the cavity wall, and then soldered in place. It is very important that the link tube get a good contact with the cavity wall at this point. Poor contact here may cause instability in the amplifier. So the hole in the cavity wall should center well with the flange bushing and the hole in the cavity wall is enlarged to 8 mm. Then the edges of this hole is chamfered, as later the clamp bushing should seat on this chamfer. Screw holes are to be bored in the flanges and threads cut in the holes for 3 mm screws -- as seen on the drawing.

Air shroud

For aircooling of the 2C39 tubes, or 7289 for higher ouput:

A special shroud can be made for more efficient cooling. The shroud is made of 1 mm plate. A piece of 85 x 72 mm is bent at the edges on both sides. (see the drawing). A 40 mm hole is cut in the plate and here is soldered on a piece of 41 mm tube. This tube is cut off at an angle of about 15 degrees and then arranged on the plate as seen on the drawing. Two 10 mm holes are bored in the tube for some small air ducts. In the bent up edge of the plate should be bored two holes for screws. These holes should match two threaded holes in the cavity top plate on the output side. The shroud is screwed on and two copper tubes are fitted to go from the two small chambers on the anode cavity and the cathode chamber into the two 10 mm holes bored in the large air intake tube. The copper tubes should be formed like a small scoop to catch some air for cooling the lower part of the 2C39 tubes.

From plexiglass a small enclosure is formed. This is to be mounted on the air shroud which is mounted on the amplifier unit. This enclosure has the purpose to lead the cooling air on to the 2C39 tubes for better cooling. From 5 mm thick plexiglass is cut a piece that measures 75 mm x 50 mm. Two screw holes are bored 50 mm apart and 8 mm from the edge of the long side. The holes are tapped to 4 mm thread. The plexiglass is screwed onto the edge of the shroud with mm screws. Two small end pieces are fitted to the irregular openings above and below the two tubes and glued to the ends of the plexiglass already screwed on. Rubber cement can be used for the gluing.

Tuning up

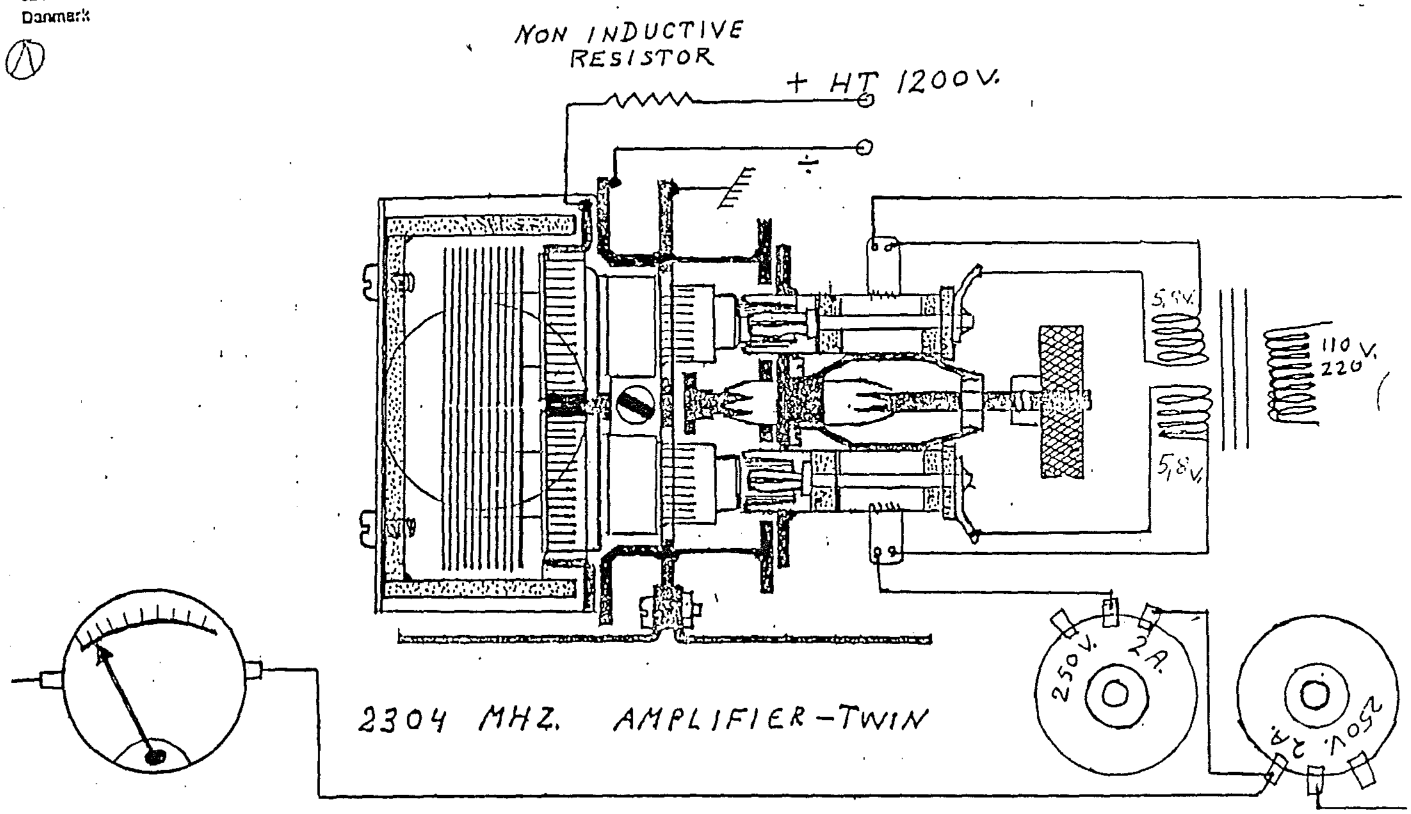
It is of some importance to use two tubes which are about equal in efficiency. To regular the cathode current it is handy to have two potmeters which can carry 2 Amp. For preliminary test two 50 ohm resistors can be used, connected from cathode stems to ground. Heater current should be 5.8 volts and each tube should have its separate coil on the transformer. A micro amperemeter with a diode and a wire loop (called an HF meter) is used to measure for resonance. The wire loop is made narrow enough to be put into the cathode chamber through one of the air holes.

Drive current can now be applied to the input link connector. Then the cathode disc capacitor is screwed all the way in till it touches bottom and then backed off about 3 to 4 turns. At this position there should be noted some response. If only slight response is noted, the input link should be pushed in as far as it can go and then pulled out again about 5 mm. Then the disc capacitor is adjusted and the input link turned until a position is found for maximum resonance.

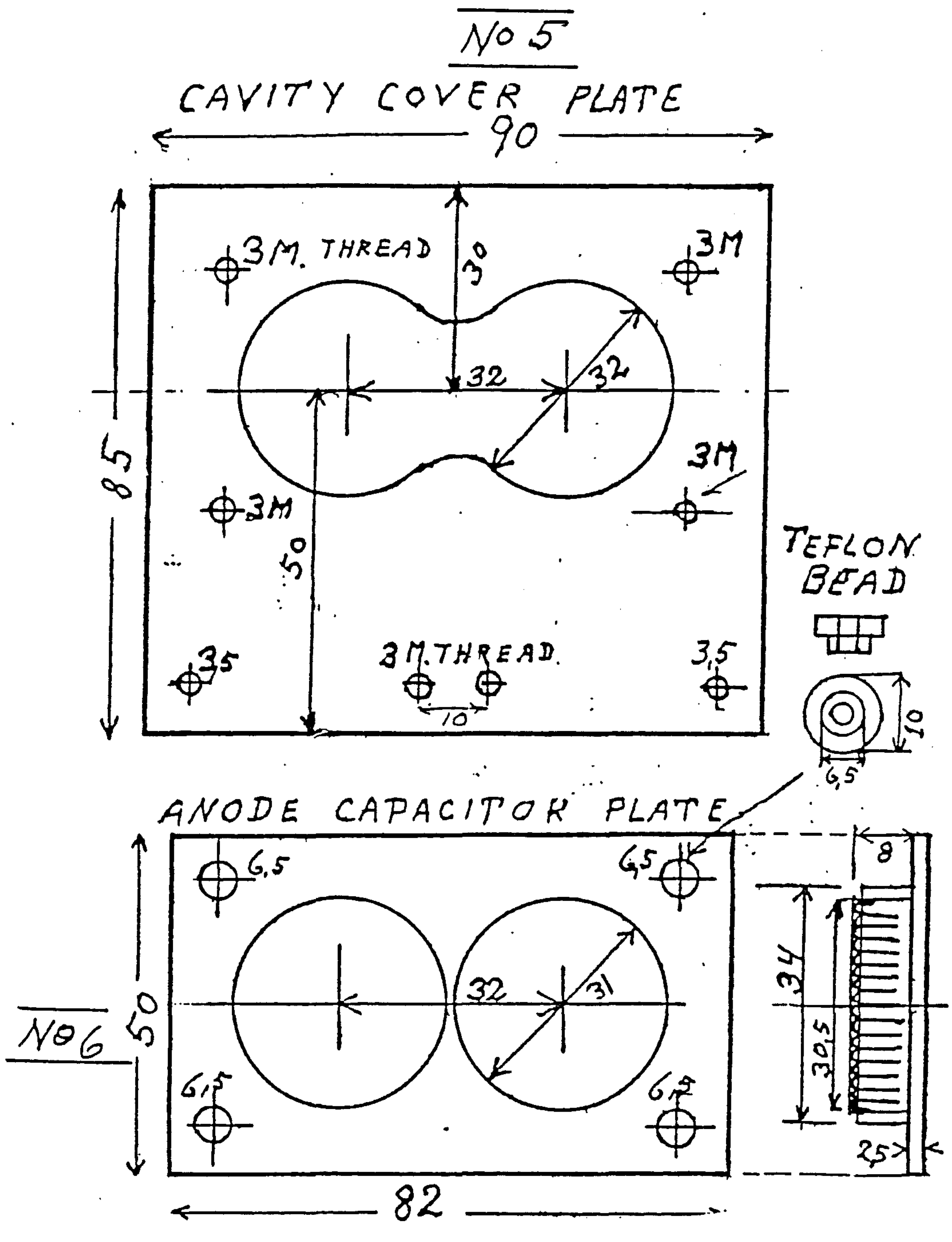
A load must be connected to the amplifier when power is on. A simple means for a good antenna can be made from an empty tin coffee can. About 60 mm from the bottom of the can, a hole is made where a BNC coax connector is soldered in. A small dipole is soldered to the center pin of the connector. The dipole should be 35 mm long. The alternative is a dummy load, but the can gives a good protection against dangerous radiation. Don't look into the can when the power is on. With the can placed a yard from the amplifier, and the HF meter about 10 inches from the can, it can be seen when resonance is achieved. 400 to 500 volt plate current can now be applied to the small tab located at the lower part of the anode capacitor plate. The minus lead should be connected to a ground tab. An extra ground wire is a good thing to have for safety. With power on and drive applied, the tuning piston is moved back and forth and there should be some response on the HF meter. The output link should be turned and pulled in and out of the cavity for maximum output position. Also the cathode tuning should be fine adjusted. If all seems to work satisfactory, it should be tried to pull the tubes out of the sockets about 3 millimeters and the tuning procedure is repeated all over. If the output is increased by pulling the tubes, then some rings can be made of wire and placed on the tubes to keep the position. However, different makes of tubes have different maximum positions.

Before running full power test, a non-inductive resistor should be connected in the H.T. lead and close to the tubes. It is not critical, but a number of 5 W. carbon resistors, perhaps a dozen, could be coupled together and mounted in some enclosure. 1200 V on the plates is suited for average operation, but for maximum output 1500 V is okay. For low power runs, any small blower will do, but if the amplifier heats up excessively, perhaps it is not tuned right, or perhaps it would be good with a "slug tuner" at the output connector. For full power runs, a good sized blower is a must. Also, for full power output it is necessary with more drive than a varactor can give. A one tube amplifier will be indispensable. When all works right, there should be 75 watts output.

Hans Lohmann Rasmussen
Aasum Bygade 3
5240 Odense NØ
Danmark



2304 MHZ. AMPLIFIER-TWIN

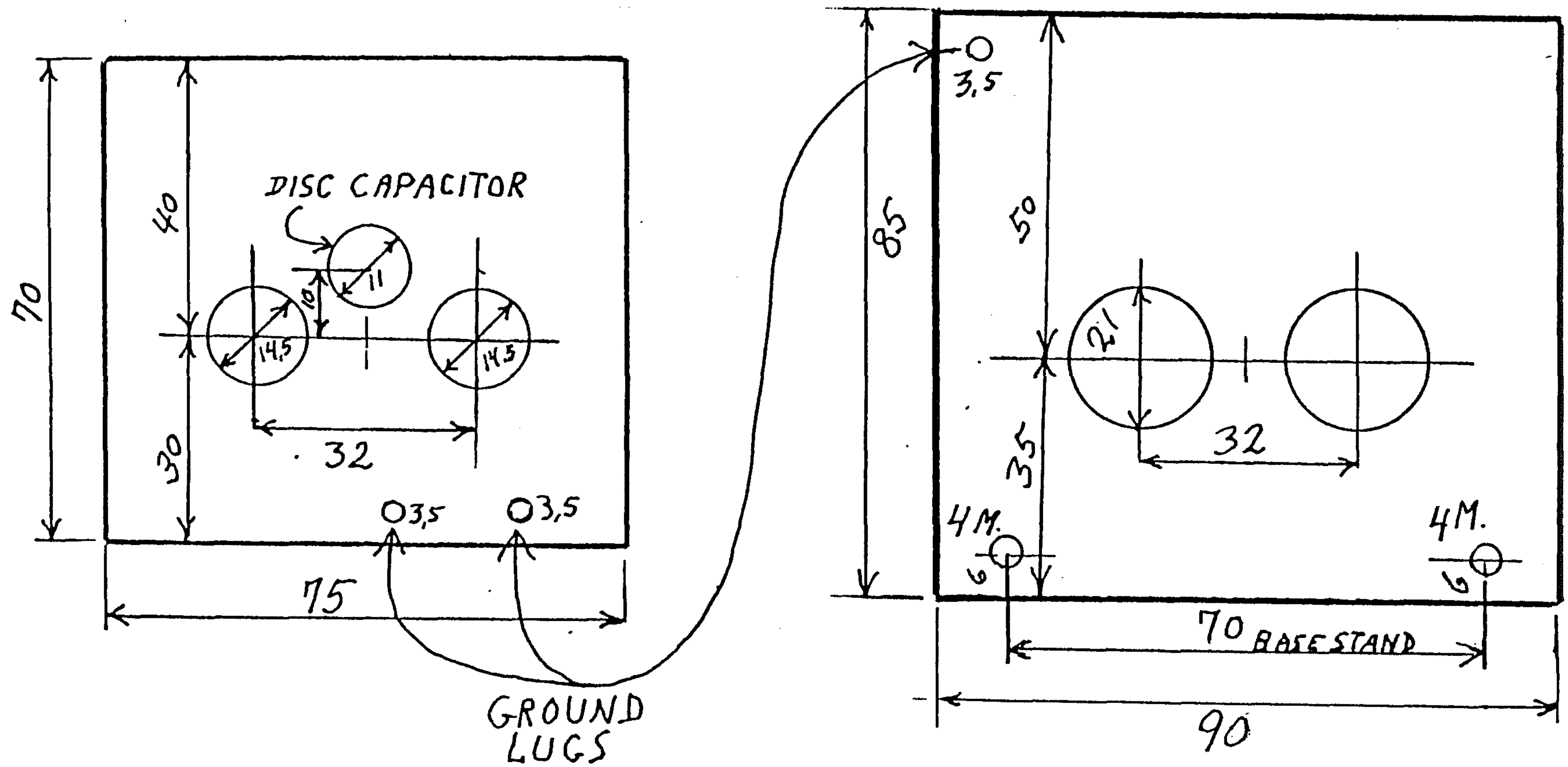

No 5
CAVITY COVER PLATE
90
85
30
3M. THREAD
3M
32
32
3M
3M
50
35
3M.THREAD.
3,5
10
TEFLON BEAD
10
6,5
ANODE CAPACITOR PLATE
6,5
6,5
32
31
No6
50
6,5
6,5
82
8
34
30,5
2,5

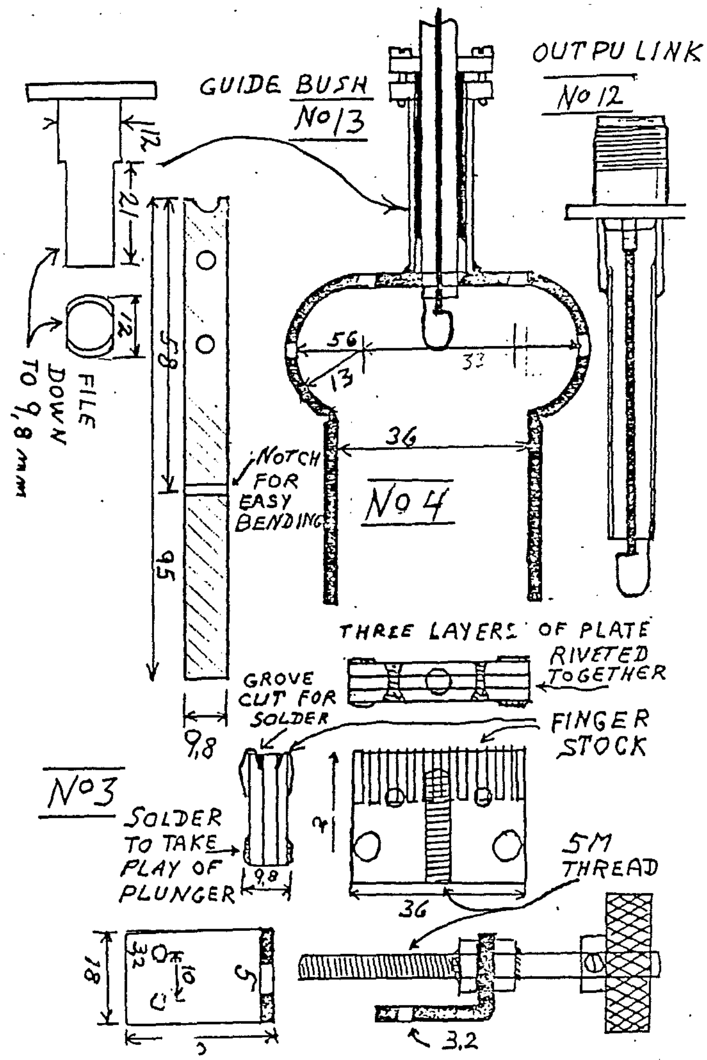
No 7

CATHODE CHAMBER TOP PLATE

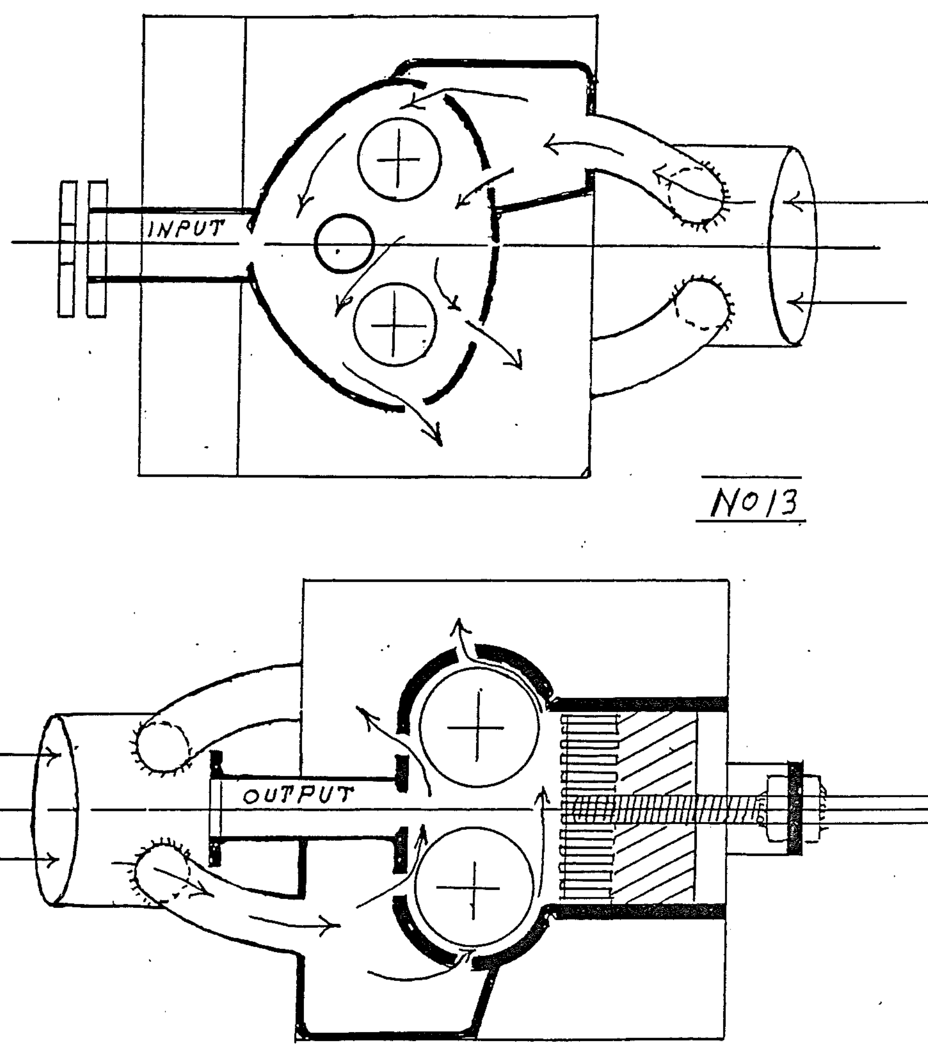
No 1

PARTITION PLATE

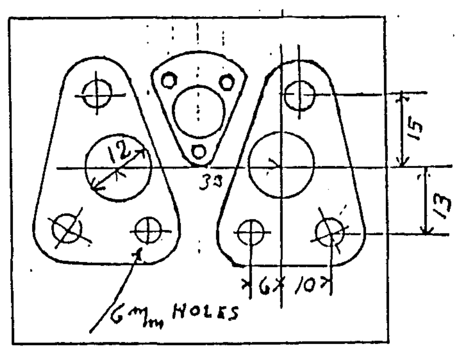



GUIDE BUSH
No 13
OUTPU LINK
No 12
12
21
12
58
FILE DOWN TO 9,8 mm
56
13
33
36
NOTCH FOR EASY BENDING
No 4
95
9,8
THREE LAYERS OF PLATE RIVETED TOGETHER
GROVE CUT FOR SOLDER
FINGER STOCK
No 3
SOLDER TO TAKE PLAY OF PLUNGER
9,8
36
5M THREAD
18
3,2
10
5
3,2

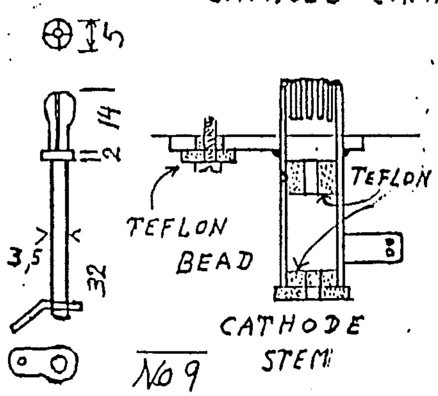
DUCTS FOR COOLING AIR



No 8

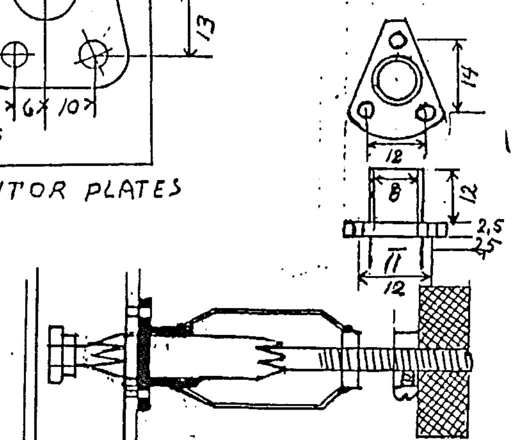


CATHODE CAPACITOR PLATES



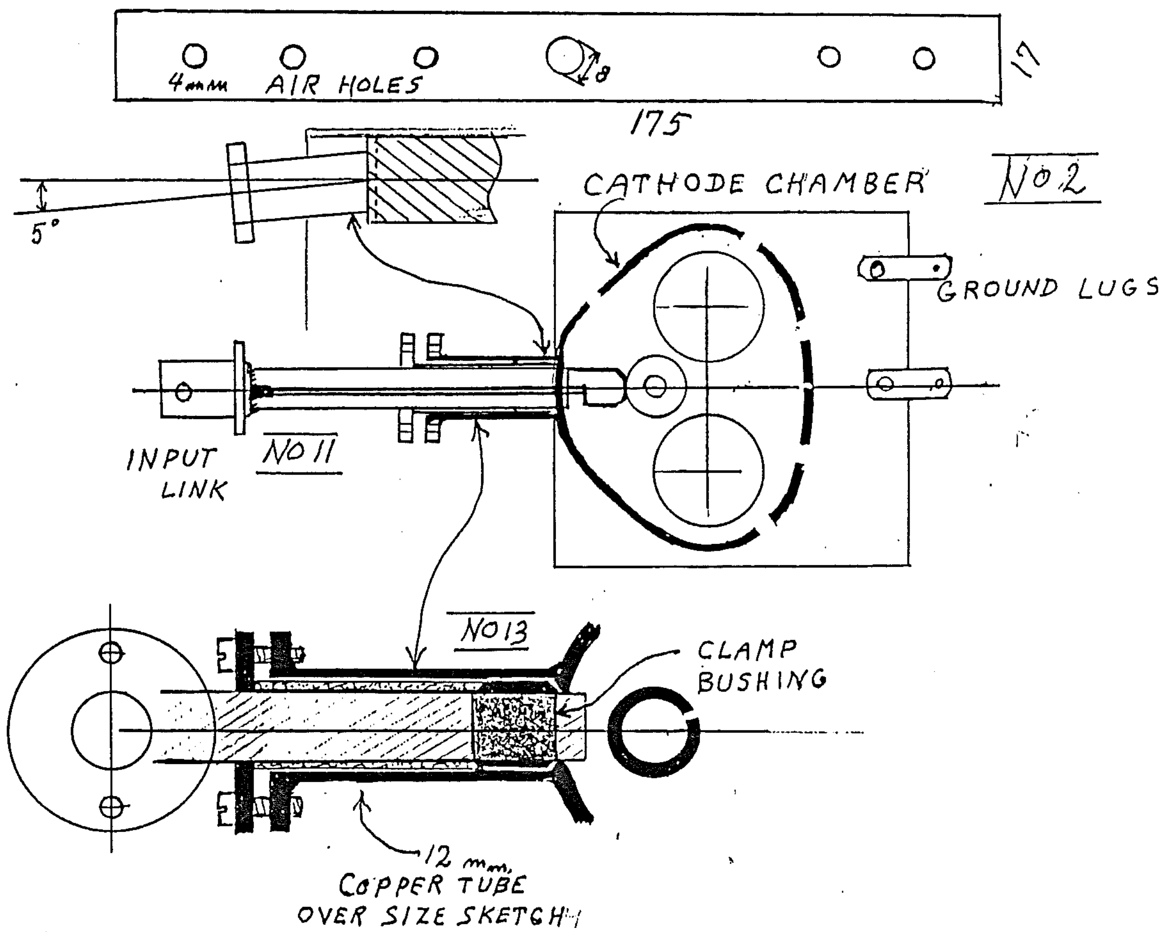
CATHODE STEM

No 9

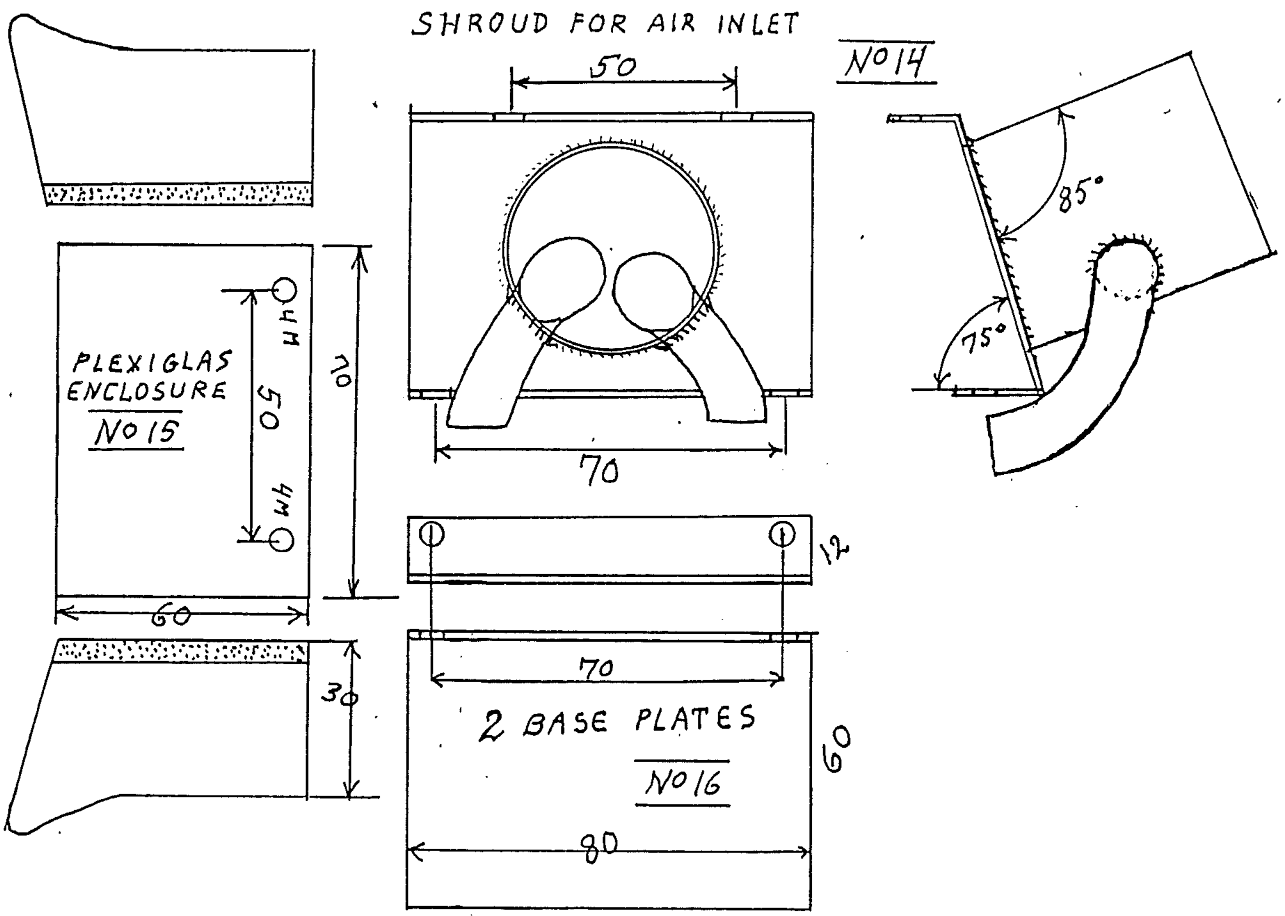


DISC CAPACITOR FOR CATHODE TUNING

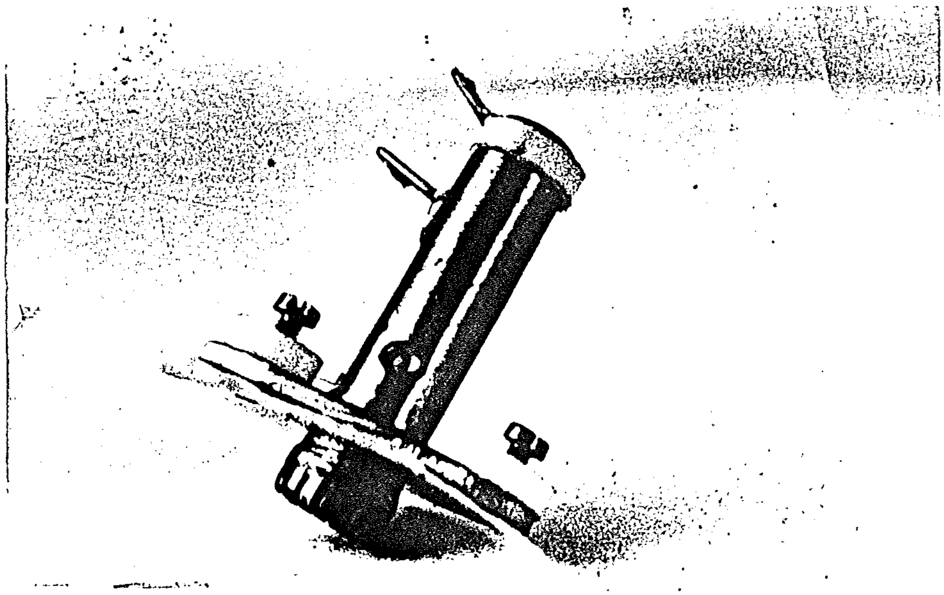
No 10

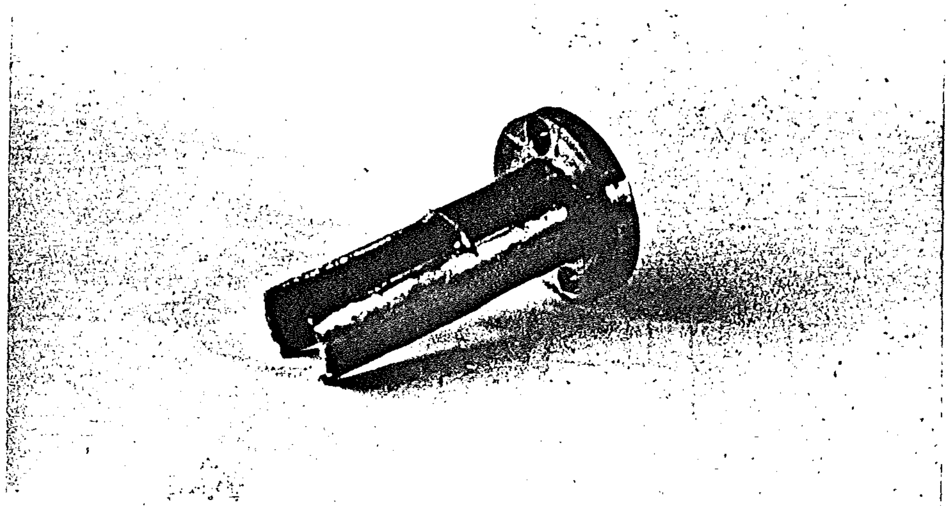


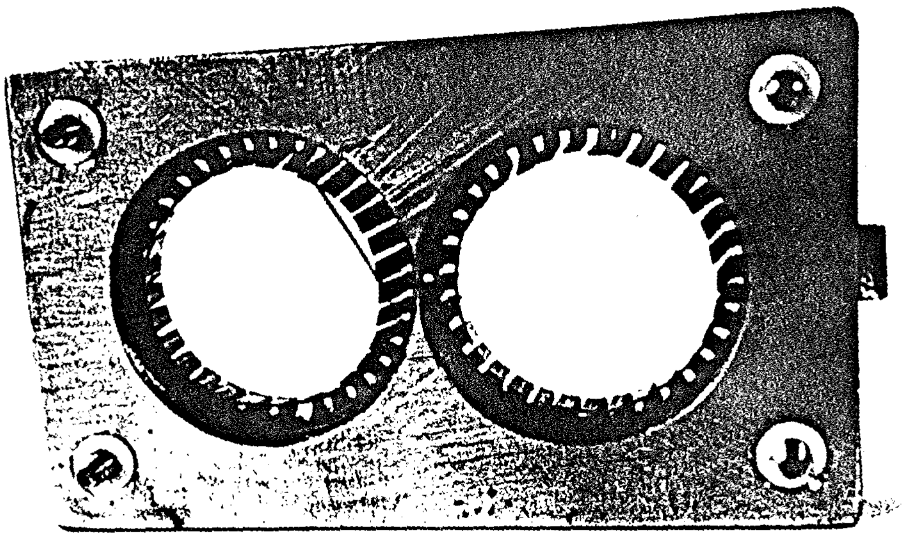
4mm
AIR HOLES
8
17
175
5°
CATHODE CHAMBER
NO 2
GROUND LUGS
INPUT
LINK
NO 11
NO 13
CLAMP
BUSHING
12 mm
COPPER TUBE
OVER SIZE SKETCH

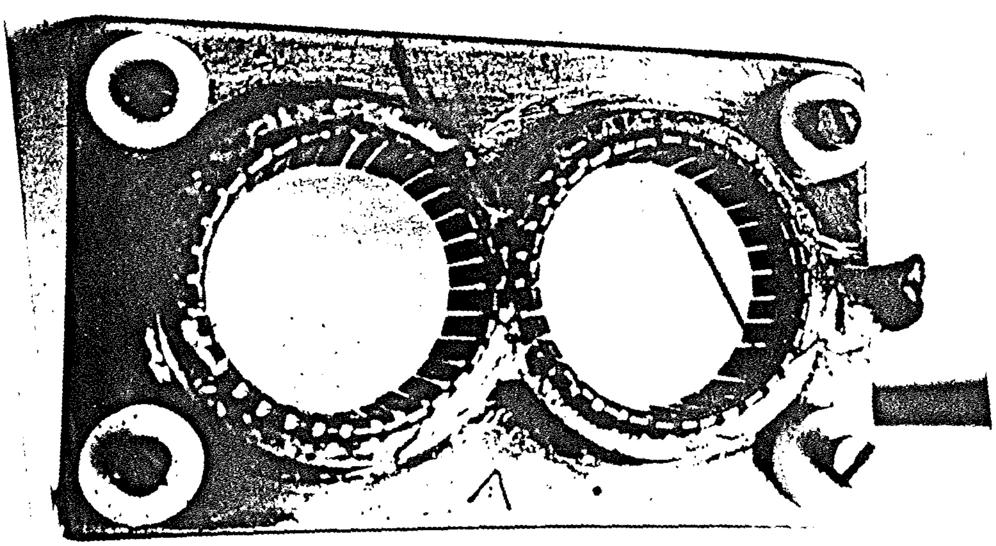


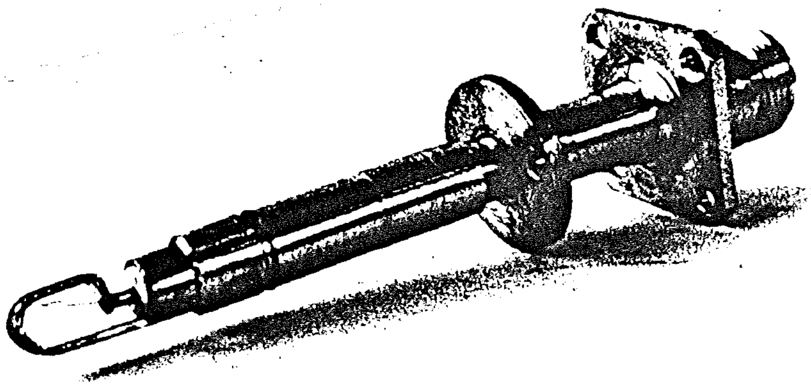
SHROUD FOR AIR INLET
No 14
50
70
85°
75°
PLEXIGLAS
ENCLOSURE
No 15
4M
50
4M
70
60
30
12
70
2 BASE PLATES
No 16
60
80

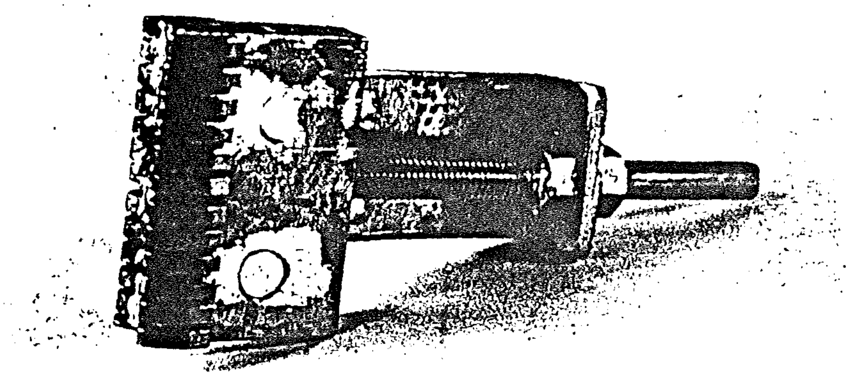


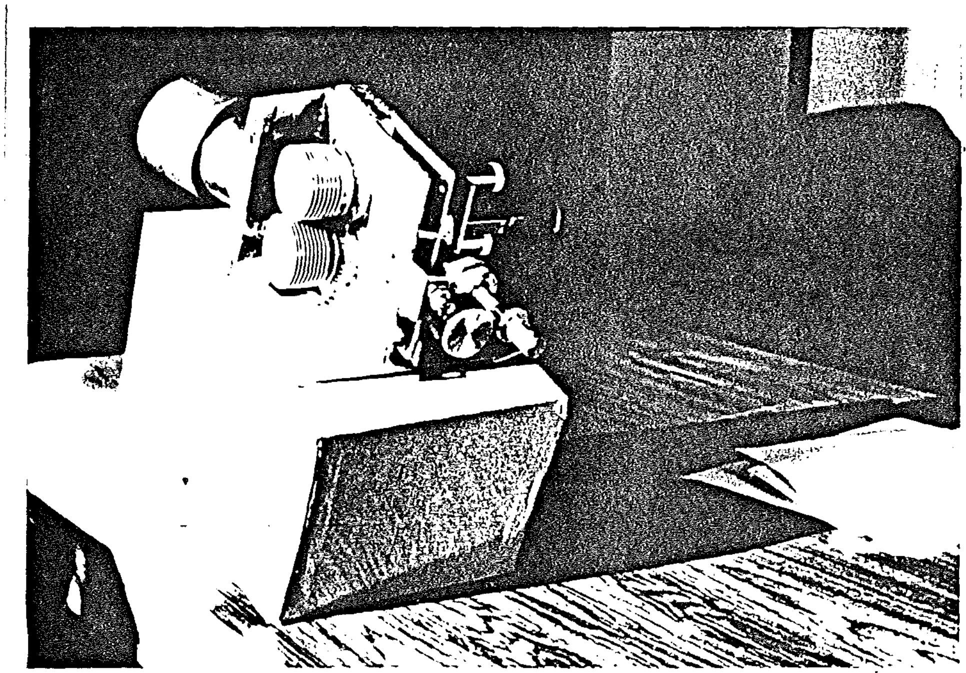


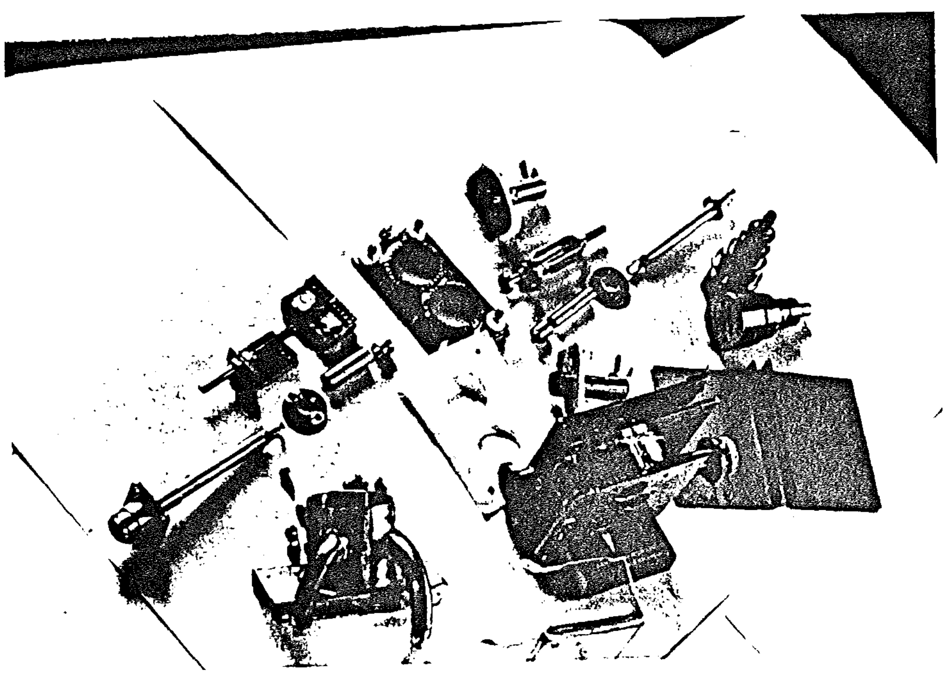


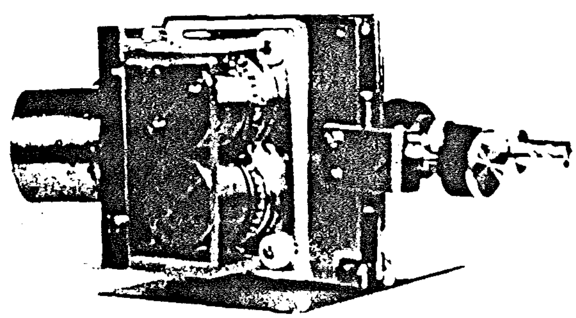


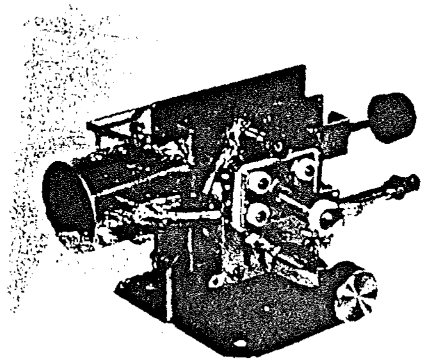


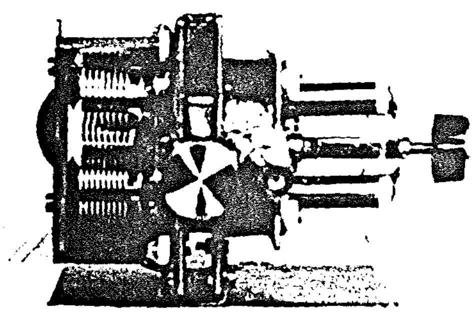












INFORMATION ON 1296 MC and 23 MHz

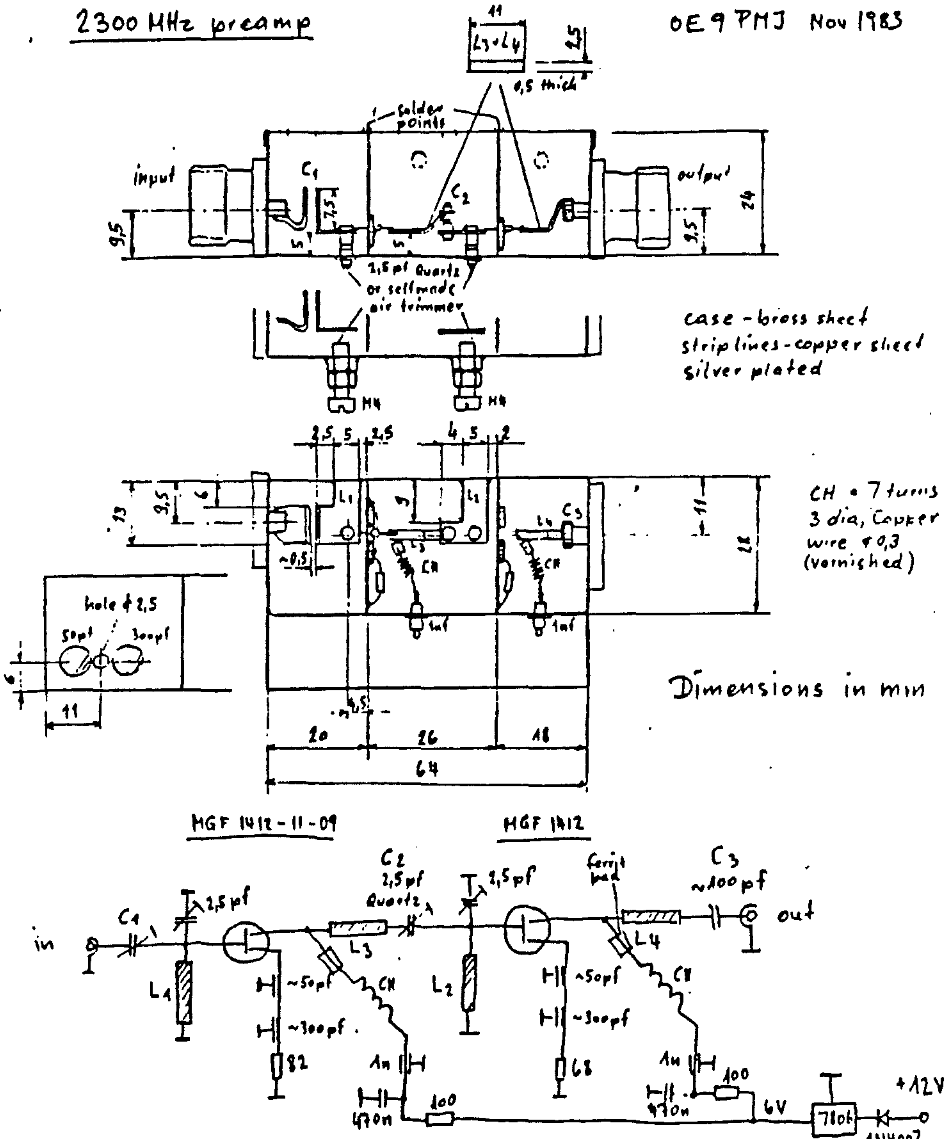
from

"432 Newsletter"

K2UYH

2300 MHz preamp

OE9PMJ Nov 1983

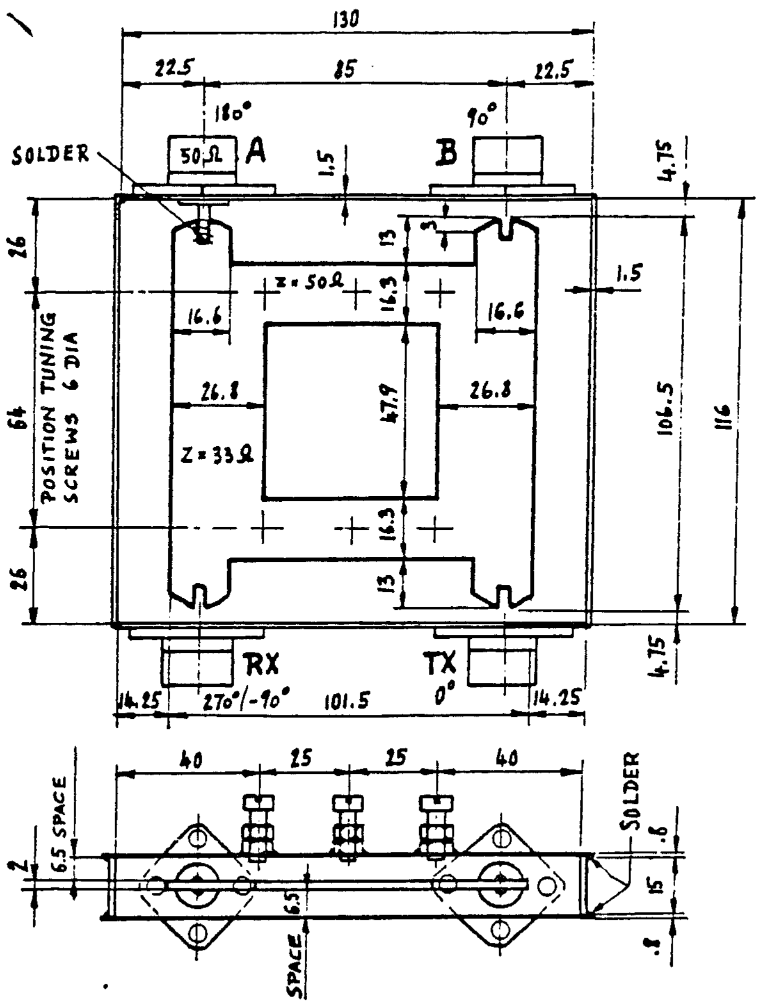


Masurements: NF < 0,6 dB , 2300 MHz , gain 32 dB

1296 Mhz — 02/23/84

STATION	GRID SQUARE	EME CONTACTS	EME COUNTRIES	EME STATES	LAST UPDATE
OE9XXI	JN47UL	36	16	6	02/23/84
K2UYH	FN20	36	17		01/26/84
G3LTF		31	15	7	02/23/84
OK1KIR	JN79DU	29			01/26/84
VE7BBG		29	15		06/14/83
Z25JJ		26	13		11/06/83
WB5LUA	EM13	26	14	6	01/26/84
SM6CKU		25			02/04/83
K4QIF		21			10/04/83
OE5JFL	JN68RL	20	13		01/26/84
DF0EME		16	11		12/14/83
GW3XYW		15	10	4	11/06/83
SM4DHN		14			02/04/83
WA8NLC					

A MODIFIED VERSION OF DL7YC's HIGH POWER
1296MC QUAD HYBRID COUPLER BY OE9PMJ



DIMENSIONS IN MILLIMETER (1 INCH = 25.4 MM)

STRIPLINE SYSTEM - COPPER SHEET POLISHED
CASE - COMPLETE CLOSED, BRASS SHEET
TUNING SCREWS ADJUSTED FOR BEST POWER SYMMETRY
AND ISOLATION (PORT RX-TX)

3-84 OE9PMJ

N6CA

Combiner

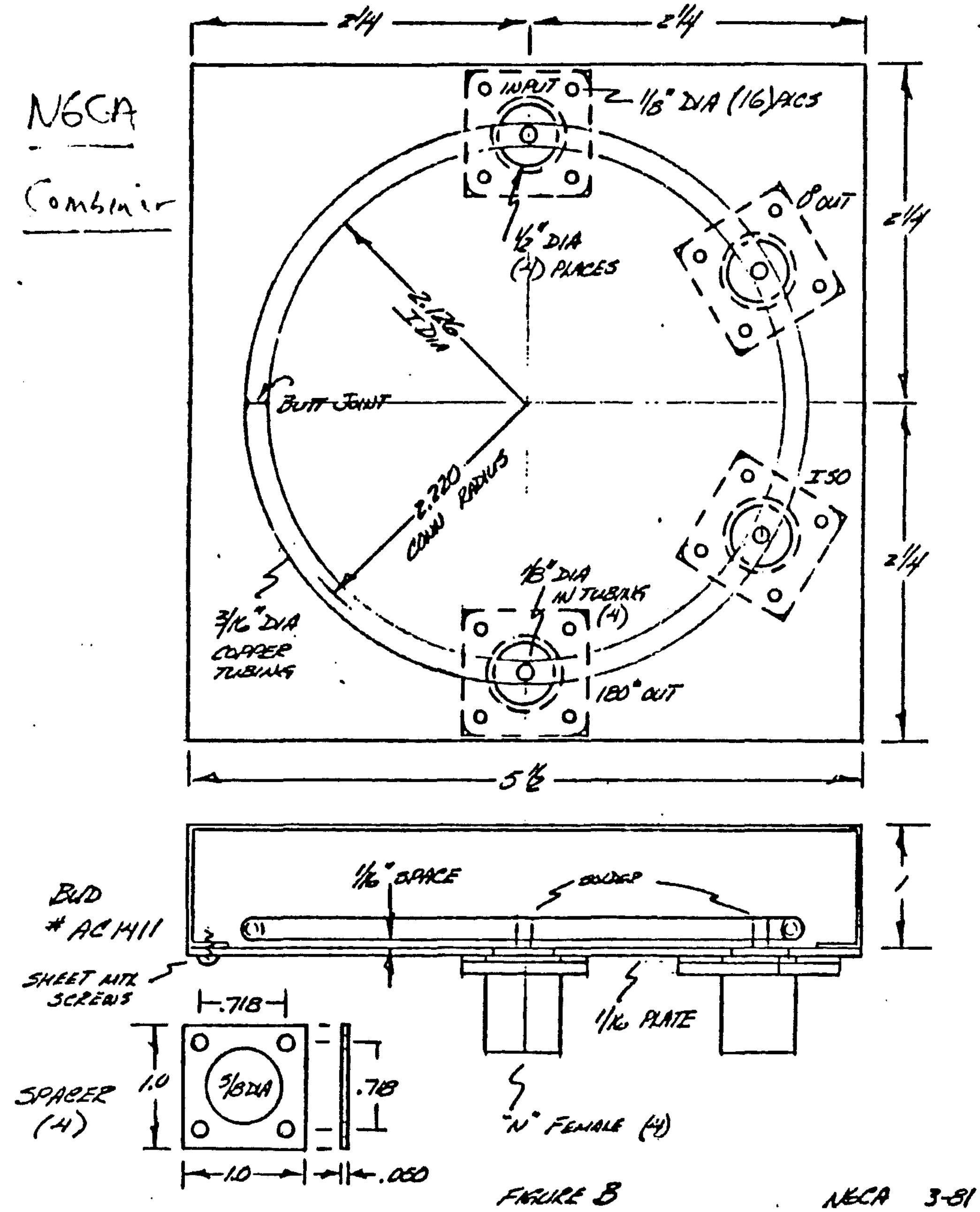


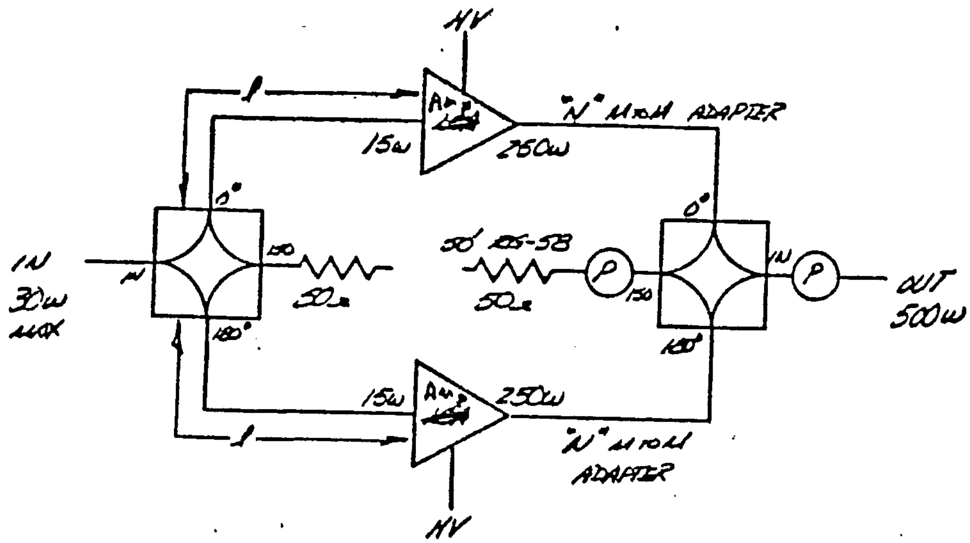
FIGURE 8

N6CA 3-81

Principles

Basically, when a signal is applied to the input port, two equal in amplitude but opposite in phase signals will be produced at output ports 0° and 180°. The isolated port will essentially be the imbalance between the two outputs. The isolated port should be terminated in a known good 50Ω load.

The electrical diameter of the ring is 6/4 wavelengths. Figure A shows the basic splitting and combining scheme.



Construction

Refer to Figure B. A 3/16" diameter copper tubing is rolled around a 4¼ inch diameter form. This ring must be as circular as possible. If necessary, make a wooden cylinder on a lathe for bending the tubing. Tightly wrap the tubing while on the form. Wind several turns of tubing on the form and secure so it won't unwind. With a file, mark a line across all the turns of tubing. This will accurately set the length.

Now cut the tubing into individual rings. Chamfer the ends as they will be butt-joined and soldered. Carefully remove the pitch and "spring-out" of the rings by bending. Check diameter and circularity by placing back on form. The rings must also be flat. After this is done then solder the butt-joint of each ring.

Mounting Plate

As accurately as possible using a compass, mark the cover plate for your selected enclosure. This will serve as a template. Drill all 1/8" holes only. Position the copper ring with tape to the inside of the plate and mark the connector center pin positions on the ring (four places). Accurately center-punch the ring at these four places and drill the 1/8" holes through the ring. Now the connector holes can be opened up on the plate to 1/2" diameter.

Assembly

Once all parts are made, check alignment before soldering. Mount spacers and connectors to enclosure. Position ring on the connector center pins. Clean and tin all parts. Temporarily install 1/16" spacers under the ring to set ring height above the ground plane. Install "N" male adapters on all female connectors to assure good alignment of the center pins. Now solder all ring-pin joints. Remove 1/16" spacers and clean all solder joints. Install cover on box. The unit is ready for testing.

MISCELLANEOUS INFORMATION ON 1296 MC AND 2300 MHz

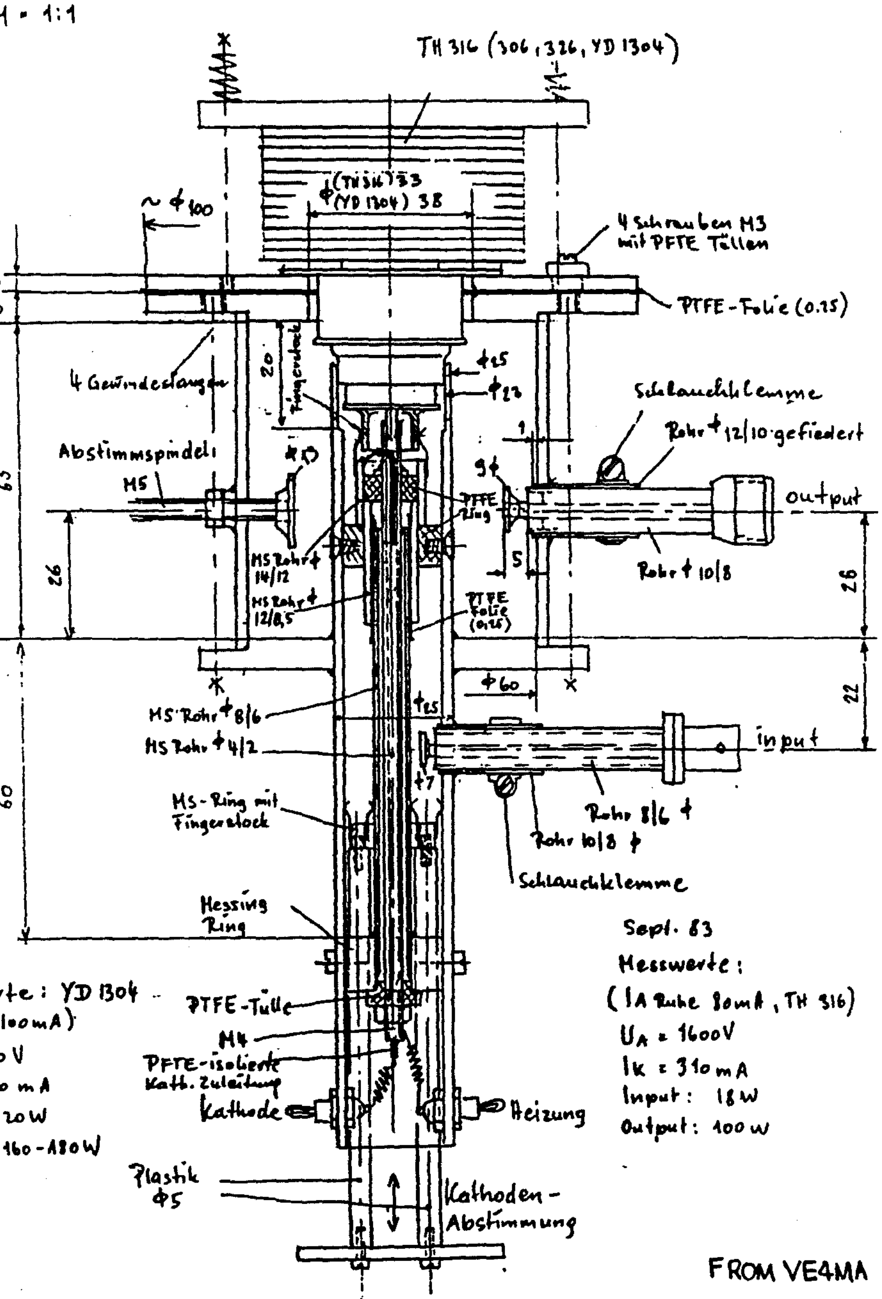
from

VE4MA

2300 MHz PA

OE9PMJ Nov 1983

M = 1:1



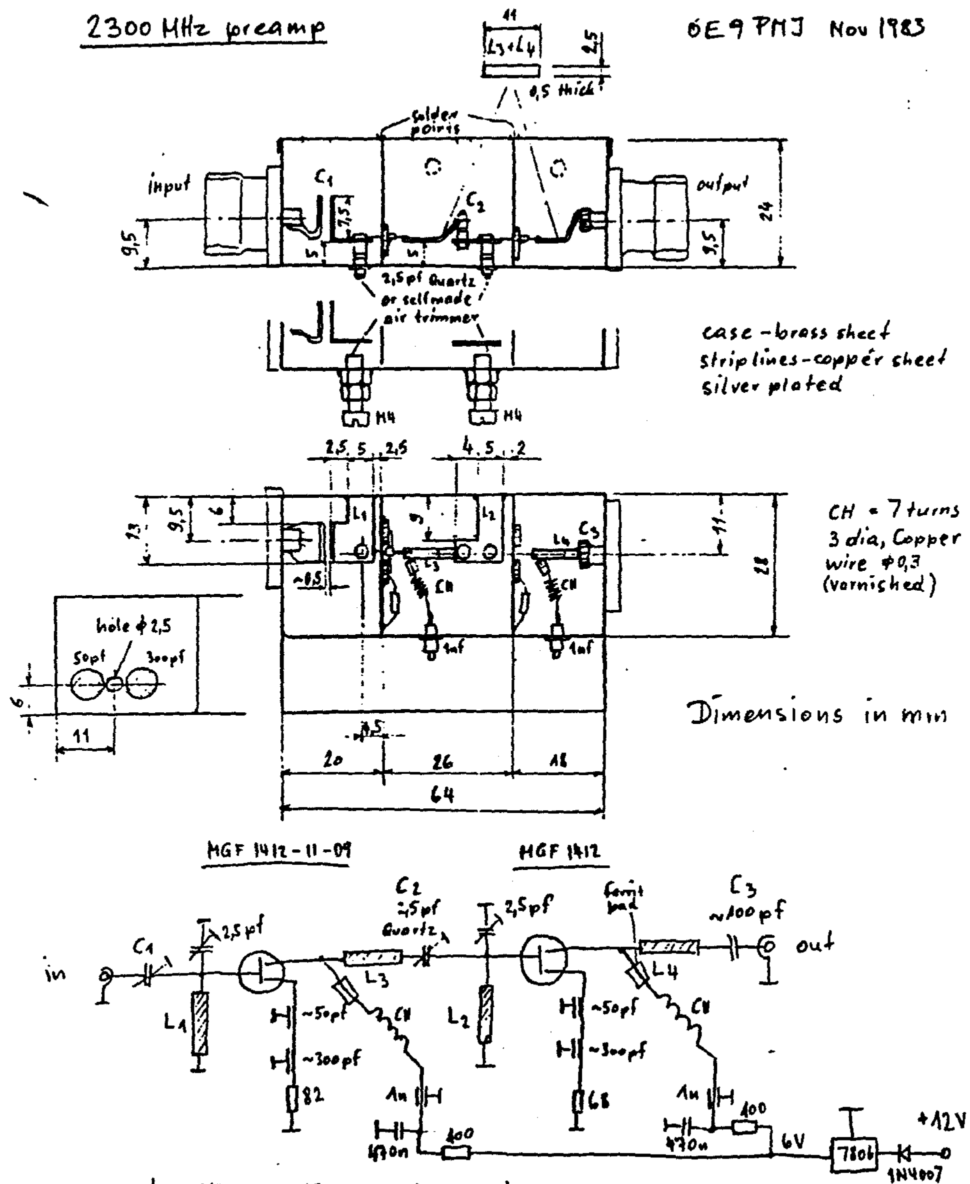
·z. 83
·sswerte: YD 1304
: Ruhe 100 mA)
A = 1700 V
< = 320 mA
·put: 20 W
·put: 160-180 W

Sept. 83
Messwerte:
(IA Ruhe 80 mA, TH 316)
U_A = 1600 V
I_K = 310 mA
Input: 18 W
Output: 100 W

FROM VE4MA

2300 MHz preamp

OE9PMJ Nov 1983



case - brass sheet
strip lines - copper sheet
silver plated

CH = 7 turns
3 dia, Copper
wire ϕ0,3
(varnished)

Dimensions in mm

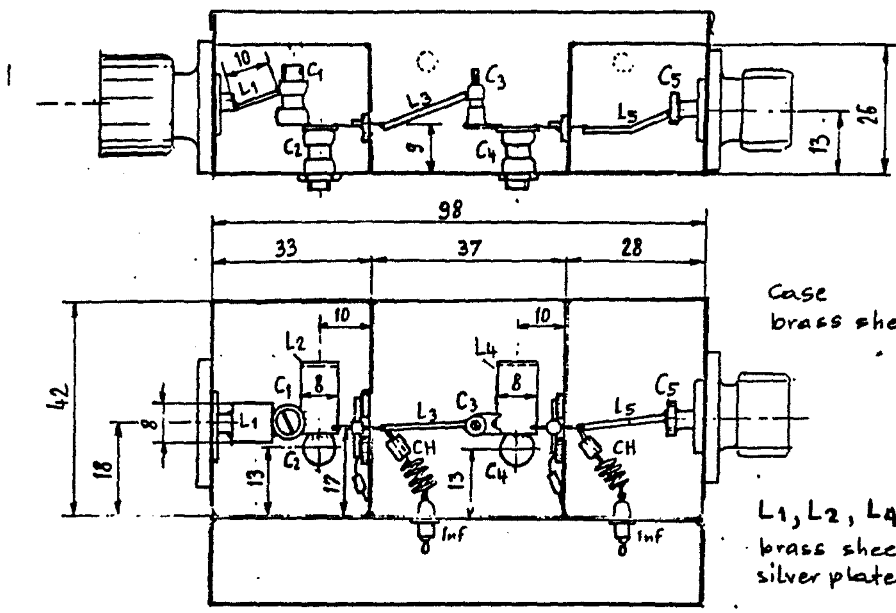
Measurements: NF < 0,6 dB, 2300 MHz, gain 32 dB

FROM VE4MA

1296 MHz preamp

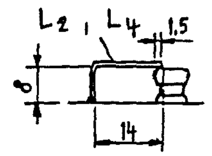
OE9PMJ April 84

Dimensions in mm

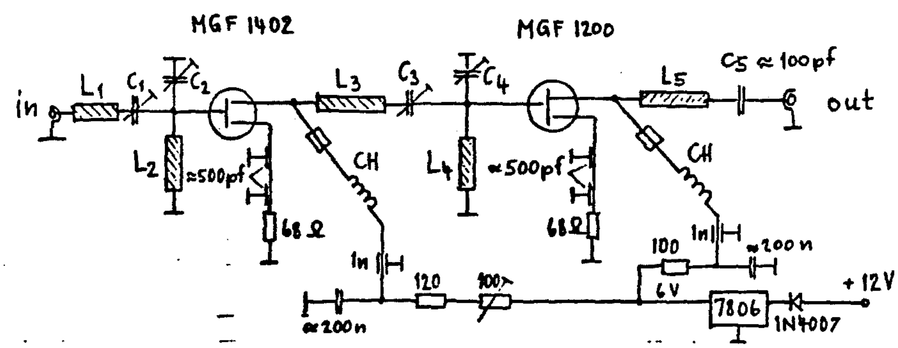


Case brass sheet

L1, L2, L4 brass sheet silver plated



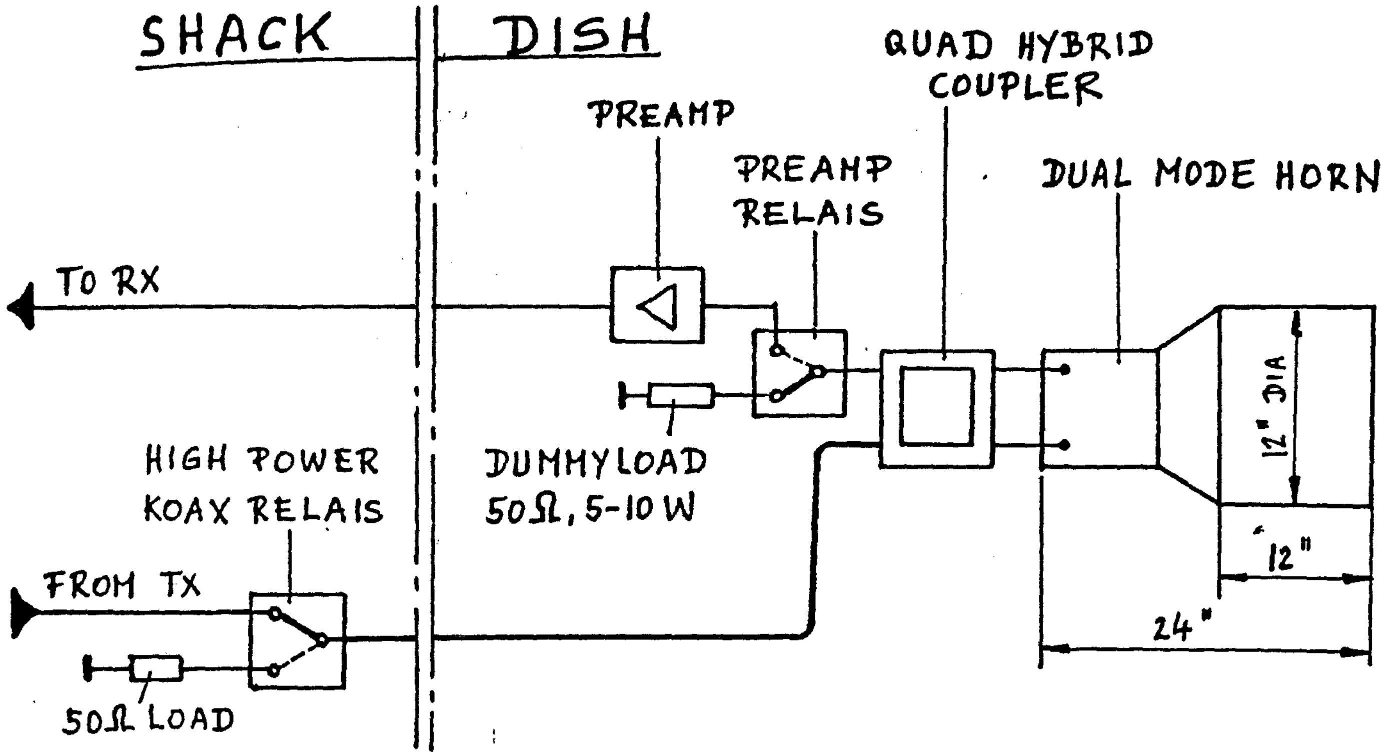
C1, C2, C4 = 0,5-6pf High Q air trimmer
C3 = 3pf ceramic trimmer
L3, L5 = Copper wire 1 dia, length 18 mm
CH = 5 turns, 4 dia, + ferrit bead



Measurements: NF < 0,6dB, gain 35 dB

FROM VE4MA

OE9XXI's 1296 MC CIRCULAR POLARIZED DISH FEED SYSTEM USING A QUAD HYBRID COUPLER

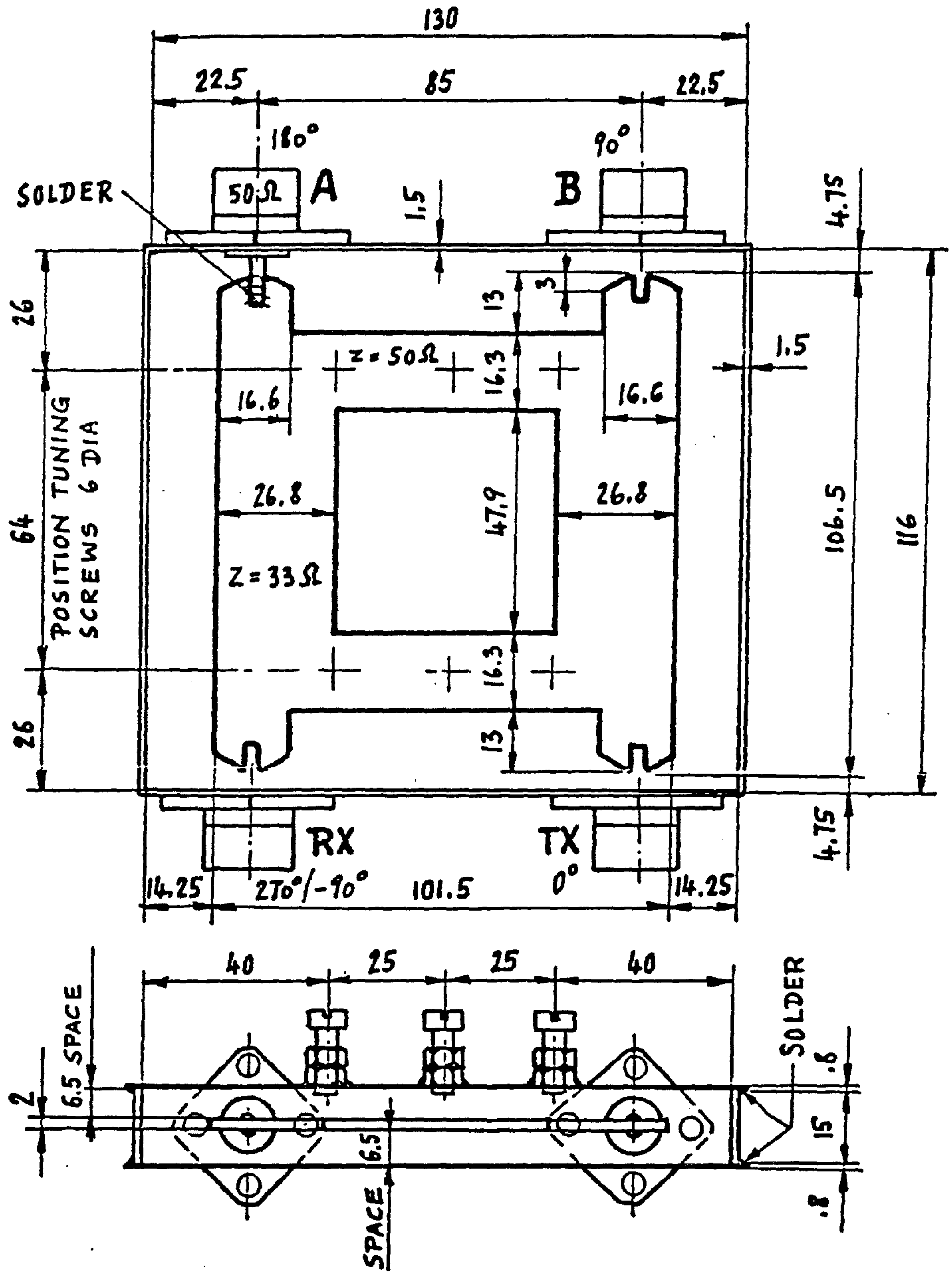


NOTE THAT IT IS NECESSARY TO PUT 50 Ω AT ALL PORTS OF THE HYBRID COUPLER FOR A CORRECT WORK OF THIS SYSTEM AND EXACTLY POLARISATION.

3-84 OE9PMJ

FROM VE4MA

A MODIFIED VERSION OF DL7YC'S HIGH POWER 1296MC QUAD HYBRID COUPLER BY OE9PMJ



DIMENSIONS IN MILLIMETER (1 INCH = 25.4 MM)

STRIPLINE SYSTEM - COPPER SHEET POLISHED
CASE - COMPLETE CLOSED, BRASS SHEET
TUNING SCREWS ADJUSTED FOR BEST POWER SYMMETRY AND ISOLATION (PORT RX-TX)

3-84 OE9PMJ

FROM VE

COMPUTER AIDED DESIGN (CAD) INTERDIGITAL FILTERS

by

Ray Uberecken, AAØL

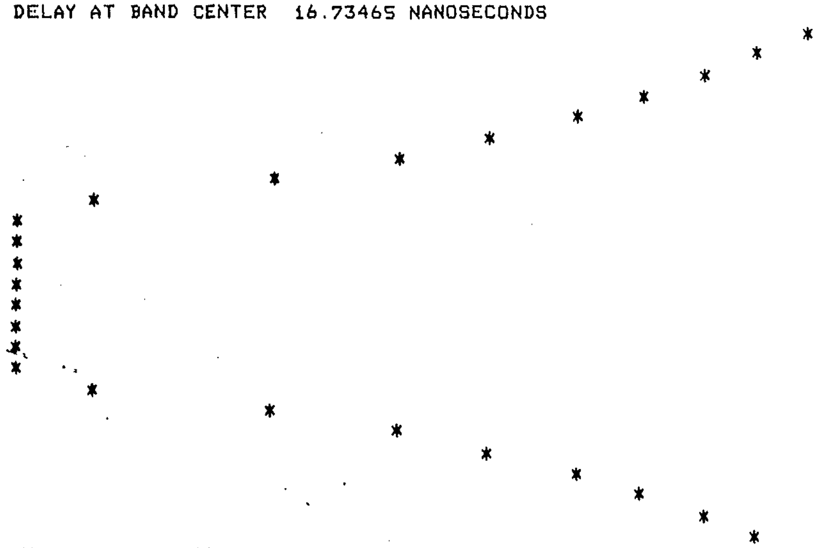
```
DESIGN DATA FOR 5 POLE INTERDIGITAL FILTER. BAND PASS RIPPLE .5 DB
CENTER FREQ.  .435 GHZ
CUTOFF FREQ.  .415  (GHZ) AND  .455   GHZ
RIPPLE BW.    4.000002E-02 GHZ
3 DB BW.      4.237039E-02 GHZ
FRACTIONAL BW. 9.195408E-02
FILTER Q   10.2666
EST QU     1451
LOSS BASED ON THIS QU   .2736136   DB
DELAY AT BAND CENTER  33.46925 NANOSECONDS
                                                             *   373      63
                                                         *       378      59
                                                     *           383      55
                                                *                388      50
                                           *                     392      45
                                     *                           398      39
                              *                                  403      31
                    *                                            408      21
      *                                                          413      7
*                                                                418      0
*                                                                423      0
*                                                                428      0
*                                                                433      0
*                                                                438      0
*                                                                443      0
*                                                                448      0
*                                                                453      0
      *                                                          458      7
                    *                                            463      21
                              *                                  468      31
                                     *                           473      39
                                           *                     478      45
                                                *                483      50
                                                     *           488      55
                                                         *       493      59
QUARTER WAVELENGTH = 6.783219 INCHES
THE LENGTH OF INTERIOR ELEMENTS = 6.49727  INCHES
LENGTH OF END ELEMENTS = 6.553323  INCHES
GROUND-PLANE SPACE = 1        INCHES
ROD DIAMETER  = .375  INCHES
END PLATES .5  INCHES FROM C/L OF END ROD
TAP EXTERNAL LINES UP  .7653194  INCHES FROM SHORTED END
LINE IMPEDANCES: END ROD 68.10758  ,OTHER  73.2929  , EXT. LINES  50 OHM
EL. NO.       END TO C      C TO C      G(K)         Q/COUP
0                                       1             0
1               .5                      1.705822      .6518494
                           1.092273
 2              1.592273                1.22961       .5340992
                           1.167327
 3              2.7596                  2.540881      .5340993
                           1.167327
 4              3.926928                1.22961       .6518493
                           1.092273
 5              5.019201                1.705822      1.806907
 6                                      1
                5.519201
```

```
DESIGN DATA FOR 5 POLE INTERDIGITAL FILTER. BAND PASS RIPPLE .5 DB
CENTER FREQ.  .915 GHZ
CUTOFF FREQ.  .895  (GHZ) AND  .935   GHZ
RIPPLE BW.    4.000002E-02 GHZ
3 DB BW.      4.237039E-02 GHZ
FRACTIONAL BW. 4.371587E-02
FILTER Q    21.59527
EST QU      2104.424
LOSS BASED ON THIS QU   .3968291   DB
DELAY AT BAND CENTER  33.46925 NANOSECONDS
                                                                 * 790       94
                                                                 * 800       91
                                                                 * 810       87
                                                                 * 820       82
                                                                 * 830       77
                                                                 * 840       72
                                                                 * 850       65
                                                         *        860       57
                                               *                  870       48
                                  *                               880       35
              *                                                   890       15
*                                                                 900       0
*                                                                 910       0
*                                                                 920       0
*                                                                 930       0
              *                                                   940       15
                                  *                               950       35
                                               *                  960       48
                                                         *        970       57
                                                                 * 980       65
                                                                 * 990       72
                                                                 * 1000      77
                                                                 * 1010      82
                                                                 * 1020      87
                                                                 * 1030      91
```

QUARTER WAVELENGTH = 3.224809 INCHES
THE LENGTH OF INTERIOR ELEMENTS = 2.927792 INCHES
LENGTH OF END ELEMENTS = 2.948765 INCHES
GROUND-PLANE SPACE = 1   INCHES
ROD DIAMETER = .375 INCHES
END PLATES .5 INCHES FROM C/L OF END ROD
TAP EXTERNAL LINES UP .2501753 INCHES FROM SHORTED END
LINE IMPEDANCES: END ROD 68.10758 ,OTHER 73.2929 , EXT. LINES 50 OHM

EL. NO.	END TO C	C TO C	G(K)	Q/COUP
0			1	0
1	.5		1.705822	.6518494
		1.328875		
2	1.828875		1.22961	.5340992
		1.403962		
3	3.232837		2.540881	.5340993
		1.403962		
4	4.636799		1.22961	.6518493
		1.328875		
5	5.965675		1.705822	1.806907
6			1	
	6.465675			

DESIGN DATA FOR 5 POLE INTERDIGITAL FILTER. BAND PASS RIPPLE .5 DB
CENTER FREQ. 1.27 GHZ
CUTOFF FREQ. 1.23 (GHZ) AND 1.31 GHZ
RIPPLE BW. 7.999993E-02 GHZ
3 DB BW. 8.474066E-02 GHZ
FRACTIONAL BW. 6.299207E-02
FILTER Q 14.9869
EST QU 2479.274
LOSS BASED ON THIS QU .2337575 DB
DELAY AT BAND CENTER 16.73465 NANOSECONDS

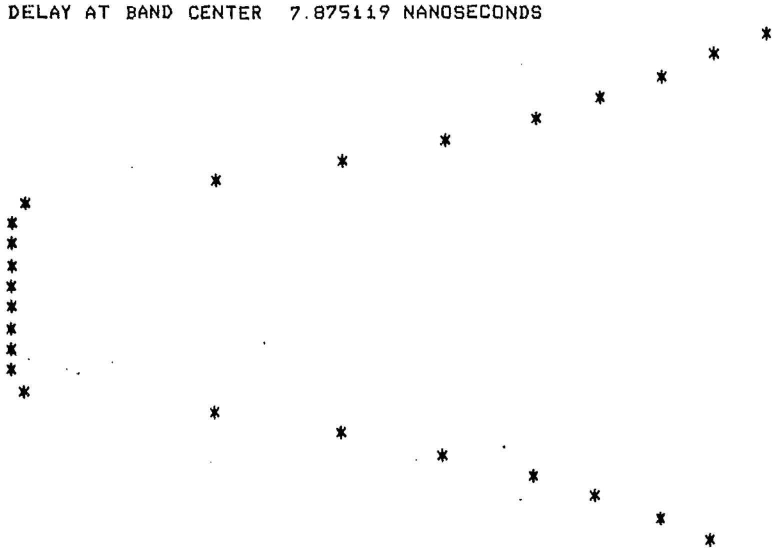


1145	63
1155	59
1165	55
1175	50
1185	45
1195	39
1205	31
1215	21
1225	7
1235	0
1245	0
1255	0
1265	0
1275	0
1285	0
1295	0
1305	0
1315	7
1325	21
1335	31
1345	39
1355	45
1365	50
1375	55
1385	59

QUARTER WAVELENGTH = 2.323386 INCHES
THE LENGTH OF INTERIOR ELEMENTS = 2.033717 INCHES
LENGTH OF END ELEMENTS = 2.054541 INCHES
GROUND-PLANE SPACE = 1 INCHES
ROD DIAMETER = .375 INCHES
END PLATES .5 INCHES FROM C/L OF END ROD
TAP EXTERNAL LINES UP .2166024 INCHES FROM SHORTED END
LINE IMPEDANCES: END ROD 68.10758 ,OTHER 73.2929 , EXT. LINES 50 OHM

EL. NO.	END TO C	C TO C	G(K)	Q/COUP
0			1	0
1	.5		1.705822	.6518494
		1.212625		
2	1.712625		1.22961	.5340992
		1.287701		
3	3.000326		2.540881	.5340993
		1.287701		
4	4.288027		1.22961	.6518493
		1.212625		
5	5.500652		1.705822	1.806907
6			1	
	6.000652			

```
DESIGN DATA FOR 5 POLE INTERDIGITAL FILTER. BAND PASS RIPPLE .5 DB
CENTER FREQ.  2.375 GHZ
CUTOFF FREQ.  2.29  (GHZ) AND  2.46   GHZ
RIPPLE BW.     .1700001 GHZ
3 DB BW.       .1800741 GHZ
FRACTIONAL BW. 7.157898E-02
FILTER Q    13.18901
EST QU      3390.428
LOSS BASED ON THIS QU   .1504305   DB
DELAY AT BAND CENTER  7.875119 NANOSECONDS
```

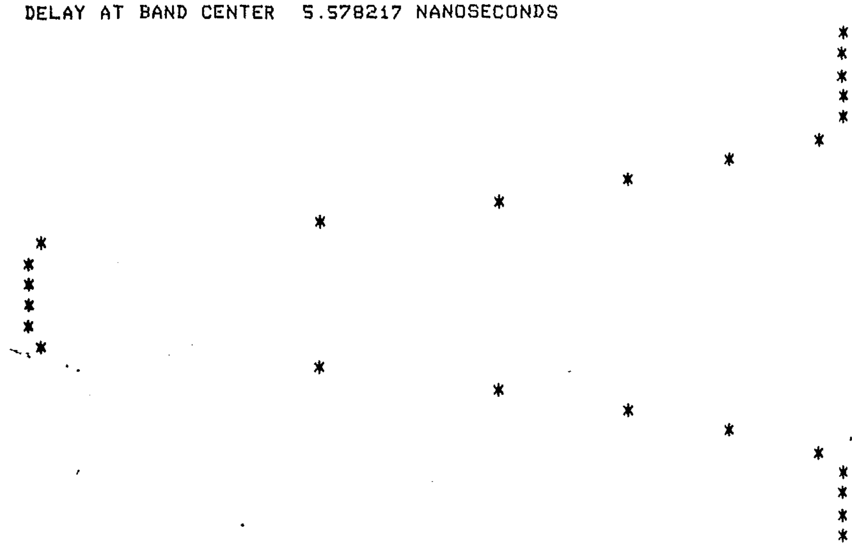


2125	60
2145	57
2165	52
2185	48
2205	42
2225	36
2245	28
2265	17
2285	3
2305	0
2325	0
2345	0
2365	0
2385	0
2405	0
2425	0
2445	0
2465	3
2485	17
2505	28
2525	36
2545	42
2565	48
2585	52
2605	57

```
QUARTER WAVELENGTH = 1.2424 INCHES
THE LENGTH OF INTERIOR ELEMENTS = .9582302  INCHES
LENGTH OF END ELEMENTS = .9785439  INCHES
GROUND-PLANE SPACE = 1        INCHES
ROD DIAMETER  = .375  INCHES
END PLATES .5  INCHES FROM C/L OF END ROD
TAP EXTERNAL LINES UP  .1235284  INCHES FROM SHORTED END
LINE IMPEDANCES: END ROD 68.10758  ,OTHER  73.2929  , EXT. LINES  50 OHM
```

EL. NO.	END TO C	C TO C	G(K)	Q/COUP
0			1	0
1	.5		1.705822	.6518494
		1.171962		
2	1.671962		1.22961	.5340992
		1.247032		
3	2.918994		2.540881	.5340993
		1.247032		
4	4.166026		1.22961	.6518493
		1.171962		
5	5.337988		1.705822	1.806907
6			1	
	5.837988			

DESIGN DATA FOR 5 POLE INTERDIGITAL FILTER. BAND PASS RIPPLE .5 DB
CENTER FREQ. 3.4 GHZ
CUTOFF FREQ. 3.28 (GHZ) AND 3.52 GHZ
RIPPLE BW. .2399998 GHZ
3 DB BW. .254222 GHZ
FRACTIONAL BW. 7.058816E-02
FILTER Q 13.37414
EST QU 4056.6
LOSS BASED ON THIS QU .1274917 DB
DELAY AT BAND CENTER 5.578217 NANOSECONDS



2775	86
2825	83
2875	78
2925	74
2975	69
3025	63
3075	57
3125	49
3175	39
3225	25
3275	2
3325	0
3375	0
3425	0
3475	0
3525	2
3575	25
3625	39
3675	49
3725	57
3775	63
3825	69
3875	74
3925	78
3975	83

QUARTER WAVELENGTH = .8678529 INCHES
THE LENGTH OF INTERIOR ELEMENTS = .5933372 INCHES
LENGTH OF END ELEMENTS = .6094436 INCHES
GROUND-PLANE SPACE = 1 INCHES
ROD DIAMETER = .375 INCHES
END PLATES .5 INCHES FROM C/L OF END ROD
TAP EXTERNAL LINES UP 8.568404E-02 INCHES FROM SHORTED END
LINE IMPEDANCES: END ROD 68.10758 ,OTHER 73.2929 , EXT. LINES 50 OHM

EL. NO.	END TO C	C TO C	G(K)	Q/COUP
0			1	0
1	.5		1.705822	.6518494
		1.176397		
2	1.676397		1.22961	.5340992
		1.251468		
3	2.927866		2.540881	.5340993
		1.251468		
4	4.179334		1.22961	.6518493
		1.176397		
5	5.355731		1.705822	1.806907
6			1	
	5.855731			

BIASING IDEAS FOR 2C39 TUBES

by

Don Hilliard, WØPW

BIASING IDEAS FOR 2C39 TUBES

by

Don Hilliard WØPW

Amplifiers using 2C39 tubes or variants of this tube are frequently used at 902, 1296 or 2304 MHz. Frequently articles written about these amplifiers have little to say about bias circuits.

Some years ago I built a 2-stage amplifier for 1296 MHz. using 2C39 cavities from surplus DME equipment, one tube driving the other. Without giving much thought to what I was doing, I hooked the cathode circuits up as shown in Figure 1. It worked, or at least I thought it did, at the time. I could get 60-70 watts output with 1100 volts on the anodes. A couple of years ago KØRZ made some comments on how he was biasing his 2-tube 1296 amplifier that really started me thinking about how poor resistive bias is for amplifiers of this type. To shorten the story, I changed to the circuit shown in Figure 4. I made no other changes and my output doubled from 60 to 120 watts, this from a single 2C39 running 300 ma. at 1100 volts (70 ma. resting current).

The desired objective is to hold the bias voltage very stable at whatever level you require. The circuit in Figure 1 is perhaps the worst possible from this standpoint. Let's assume the R1 value has been chosen to give 50 ma. with no drive applied. When you apply drive, the amplifier may then draw 100-300 ma. Of course the cathode (bias) voltage increases by several volts; exactly what should be avoided. The tube will try to cut itself off while you are trying to get every watt you can from it. Do not use this circuit.

Let's look at the circuit in Figure 2. This circuit will do exactly what we want, but with some limitations. To obtain the bias voltage you desire, you may have to try several different 10 watt zeners. (2C39 tubes vary greatly as to the bias required for set operating conditions. If operated at 300 volts or so, the cathode circuit can be returned to ground. But usually one tries to get lots of power output and therefore uses 1000 to 1500 volts or more on the anode). Once you have selected the zener you want,

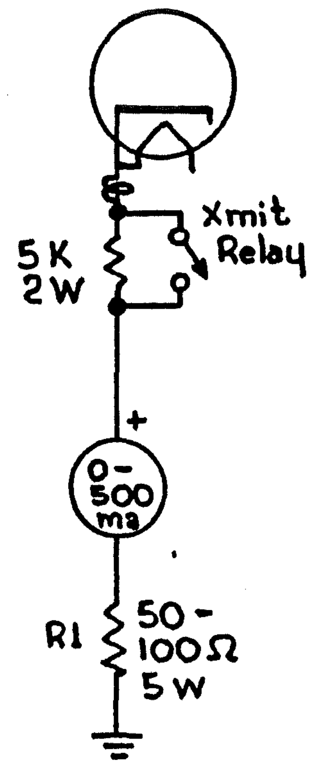


Figure 1

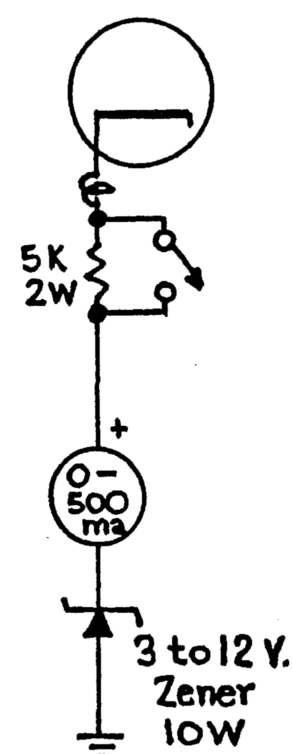


Figure 2

you are stuck with that voltage. Figure 3 details how the bias voltage can be changed in .6 volt steps using the inherent .6 volt drop in a silicon diode. Switch in a diode and the bias increases by .6 volts. In fact, one can use several diodes instead of using a zener plus a few diodes. However, since 12 volts or more may be required to bias your amplifier, 20 or more diodes may be required.

The circuits described in Figures 4, 5 and 6 use a 2N2955 which is a PNP power transistor in a TO-3 package. Since the collector is case, it can be mounted directly to the chassis without the use of a mica insulator as would be required if using the common 2N3055 which is NPN. A PNP TO-220 packaged device can be used also. I selected the 2N2955 because it is one of the more common transistors available at a low price. Such a device is readily available as of early 1985 at Radio Shack. It is their number 276-2027 and sells for $1.49. As with the 2N2955 the collector, which is the tab, should be mounted directly to chassis ground.

The circuit in Figure 4 will not hold the bias voltage to any value very well. From resting current to full current, it may vary by a couple of volts. Do not use this circuit.

The circuit in Figure 5 really does a good job. Typically the variation in cathode current will cause a change of only a couple tenths of a volt at most. However, one disadvantage is that a fixed voltage is available due to the use of a zener diode in the base of the 2N2955.

The circuit I use in most of my 2C39-type amplifiers is Figure 6. The LM317LZ is an adjustable positive 3-terminal low power regulator available from many sources. It is reasonably priced and in a T092 package. With the circuit values shown, the bias can be varied from 16.5 to 3.7 volts. This assumes an input to the regulator of approximately 25.5 volts from the relay supply.

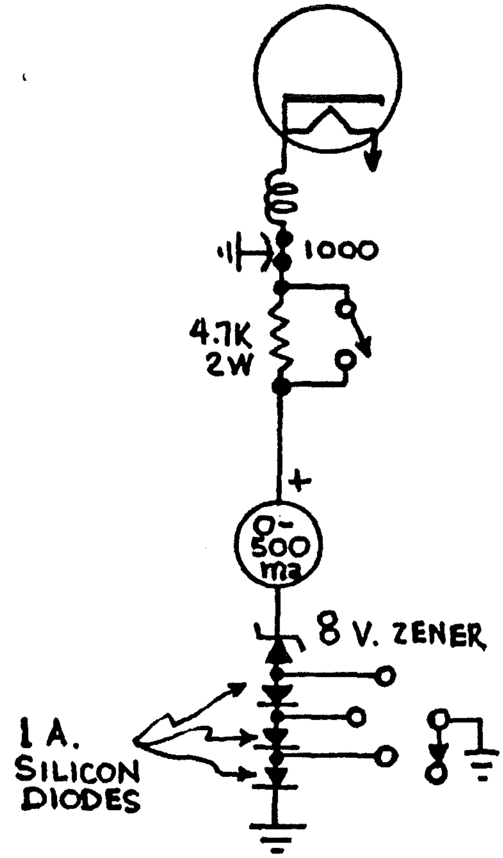


Figure 3

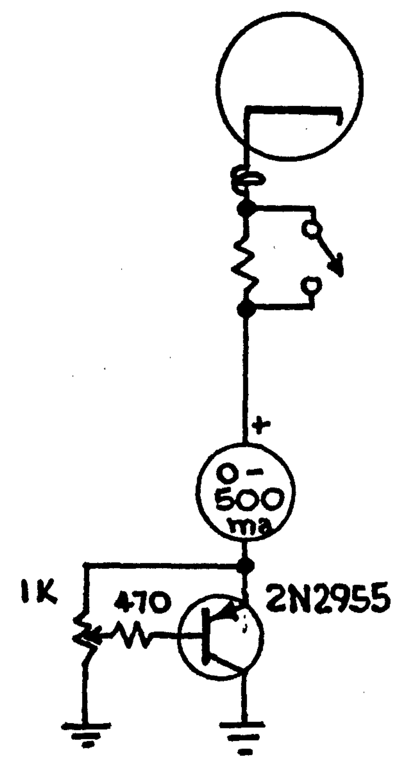


Figure 4

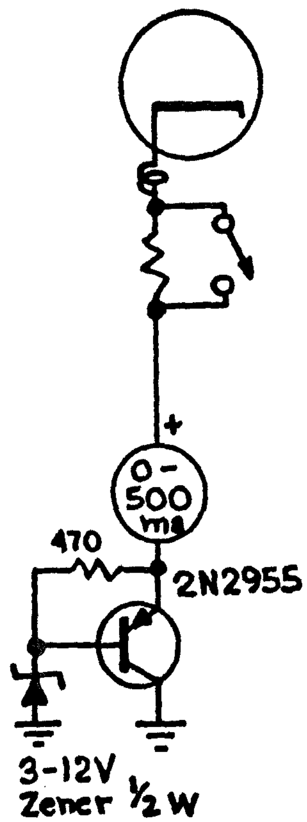


Figure 5

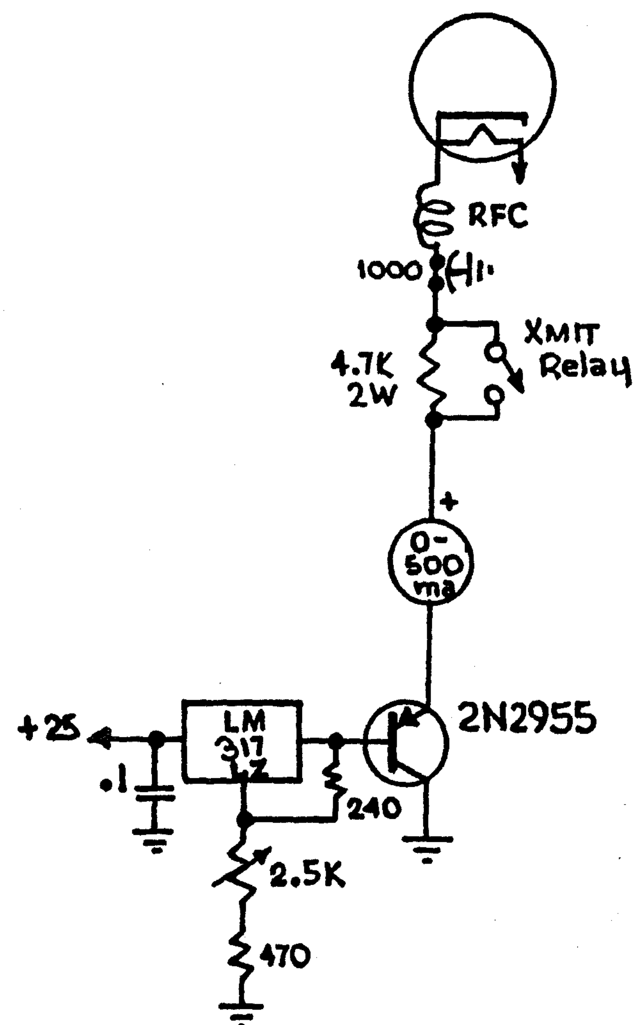


Figure 6

This range of bias voltage usually allows you to vary the cathode current from cutoff to about 150 ma. or so. The reason I use this circuit frequently is that I have a supply of 2N2955 transistors.

Perhaps one of the best biasing circuits is shown in Figure 7. It uses the readily available LM327T device. One of the older LM317K (TO-3) devices will work equally well. The LM317T is available at Radio Shack stores for $2.79 as of early 1985.

The circuit of Figure 8 can be used if the control circuit is a grounding one rather than a separate isolated switch. With R1 set to zero ohms and with R2 shorted, the output voltage will be approximately 3.7 and with R2 unshorted (1500 ohms) the output will be approximately 12 volts. With R1 set at 2500 ohms and with R2 shorted, the output will be approximately 16.5 volts and with R2 unshorted (1500 ohms) it will be approximately 24 volts.

Figures 6, 7 and 8 show a +24 input to the 3 terminal regulator. I have a 24 volt d.c. supply built into all my power amplifier to power antenna and control relays. It also is convenient to use this source for the bias regulators.

Figure 9 details one way to obtain a good meter (500 ma) for use wherever one might be needed. The 50μa. Radio Shack panel meter can be easily shunted to become a 500 ma. meter. Radio Shack also sells small spools of number 30 enameled wire. Twenty inches of No. 30 wire shunting the 50μa. meter does the job. The manufacturing tolerances (electrical) for these meters are good enough so that they always are very close to reading correctly, without the necessity of checking each one individually.

CONCLUSION:

Several circuits have been shown describing different biasing arrangements for 2C39 amplifiers. The advantages and disadvantages of these various circuits have been discussed.

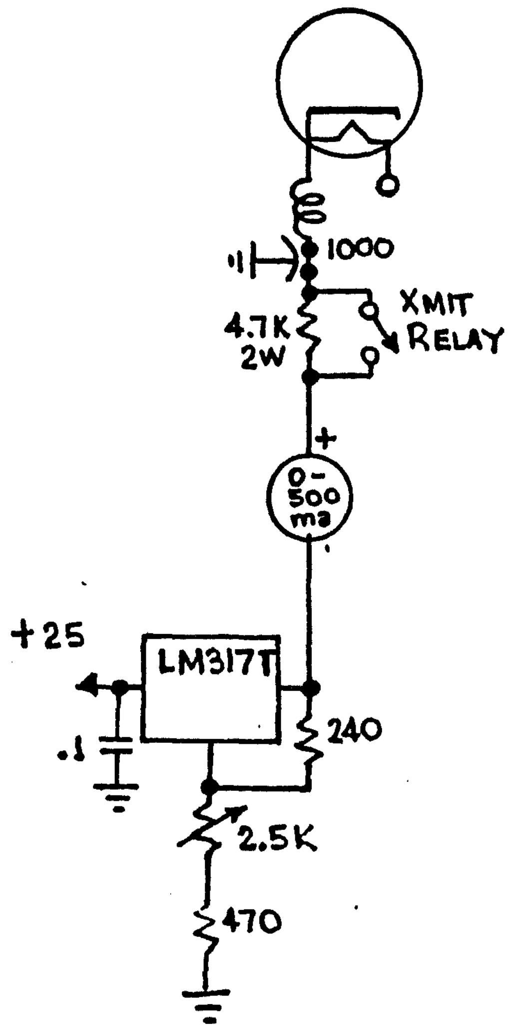


Figure 7

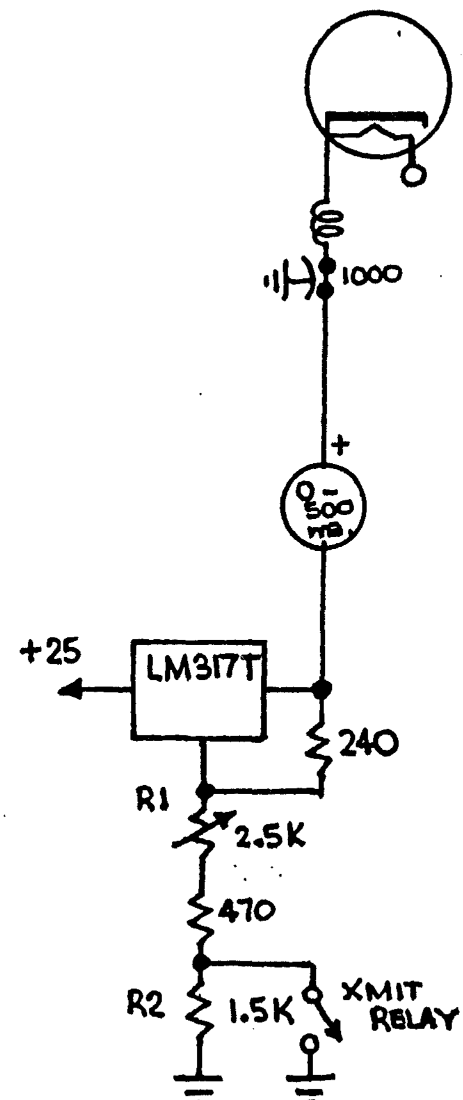


Figure 8

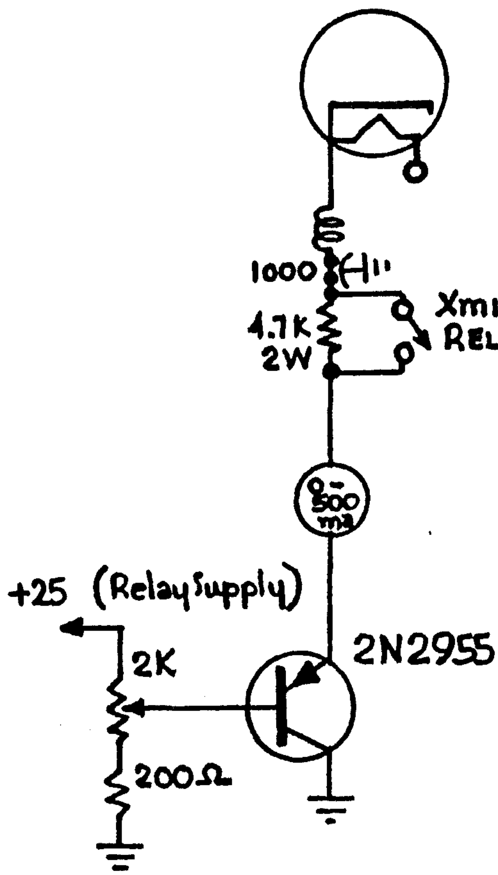


Figure 9

500ma. meter

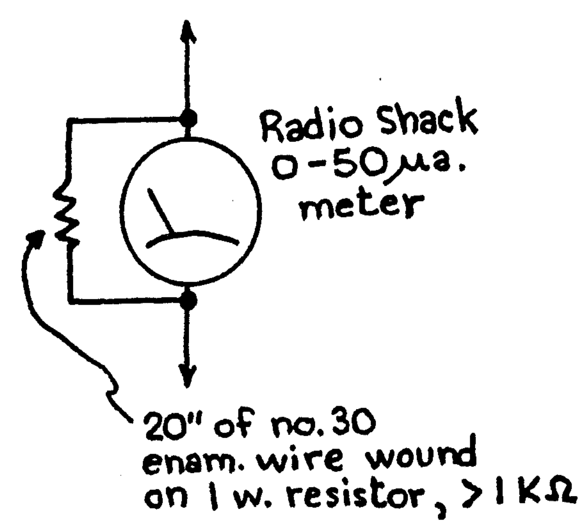


Figure 10

INTERDIGITAL FILTER FOR 2304 MHz

by

Don Hilliard, WØPW

INTERDIGITAL FILTER FOR 2304 MHz.

Donald L. Hilliard, WØPW

In QST for March 1968, pages 32 and 33, Reed Fisher, W2CQH, describes an easy to build filter for 1296 MHz. I have built two of these filters and they perform as described. I have also built some of the lower frequency versions for 606 and 540 MHz. They also work well. In the article, Reed mentions that the design can be scaled for other frequencies. Needing a low loss filter for 2304 MHz, I decided to try this design. The 606 and 540 MHz filters required some resonator length adjustment. In other words, there are apparently some of the strays that cause the scaling formula to change, such as "fringing capacitance".

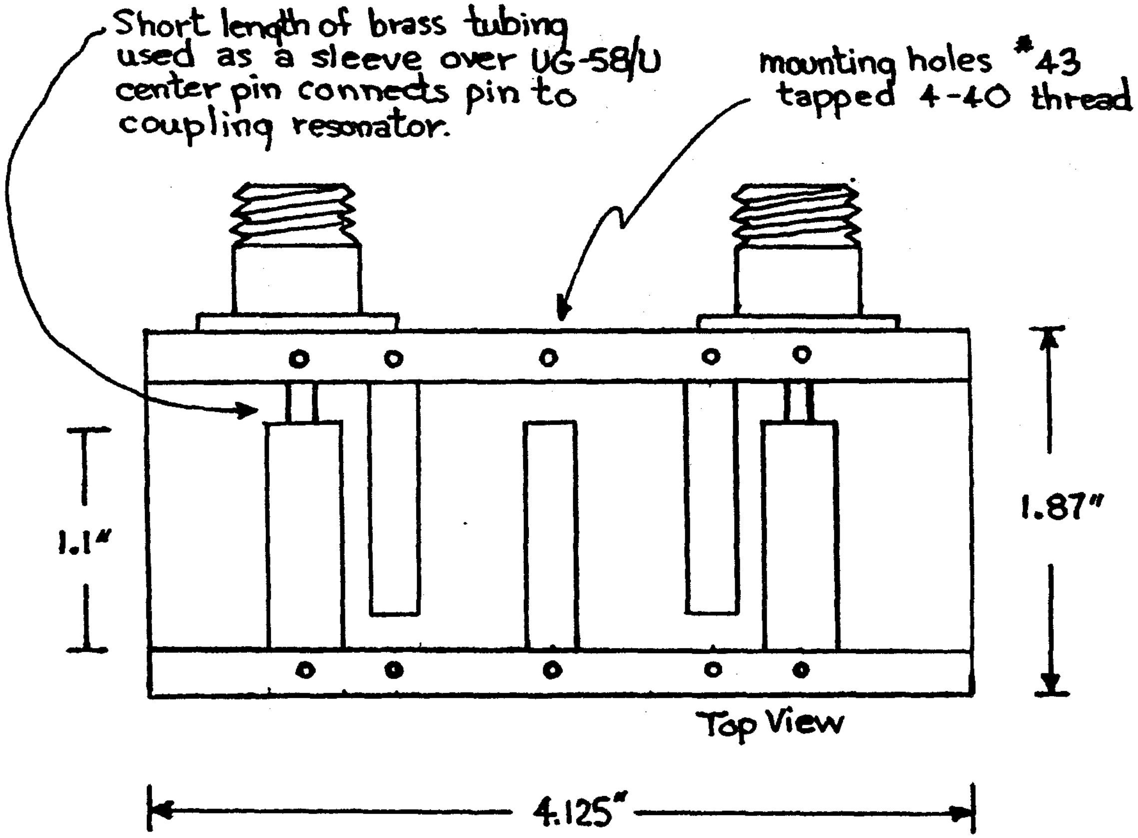
The article calls for resonator lengths of 2.1" at 1296. This would produce the following equation, $L \text{ (inches)} = \frac{2721.6}{f(\text{MHz})}$. At 2304 MHz, the required length would then be 1.181". I made up the filter using resonators 1.187" long and checked the resonant frequency of the filter. It was approximately 2090 MHz. Using this result to correct the equation, I now came up with $L = \frac{2481}{f(\text{MHz}}$. This indicated the length should be approximately 1.076".

Not wanting to make the resonators too short, I changed the length to 1.1". This resonator length produced a filter that peaked at 2324 MHz., again indicating the equation needed correcting. $\left(L = \frac{2556}{f(\text{MHz})}\right)$ However, the loss at 2304 was what I considered acceptable, just less than .3 db Figure 3 shows a plot of loss/frequency. If desired, toning screws could be added to lower the resonant frequency of the three ¼" diameter rods. The loss measured at 2324 appeared to be only about .1 db. This low value appears to be questionable, but it is what was measured three times.

The original article should be consulted before attempting to build the filter. Figures 1 and 2 give some of the details of the construction methods I used.

I used UG1094/U connectors (BNC) which I would strongly recommend be changed to type N, C or TNC. The use of BNC connectors at 1296 and 2304 and higher should be avoided if at all possible.

FIG. 1



Resonator rods are ¼" dia. brass (round)
Coupling rods are ⅜" dia. brass (round)
All are 1.1" long (2320 MHz) Mounting ends are drilled no. 36 and tapped 6-32, ¼" deep.

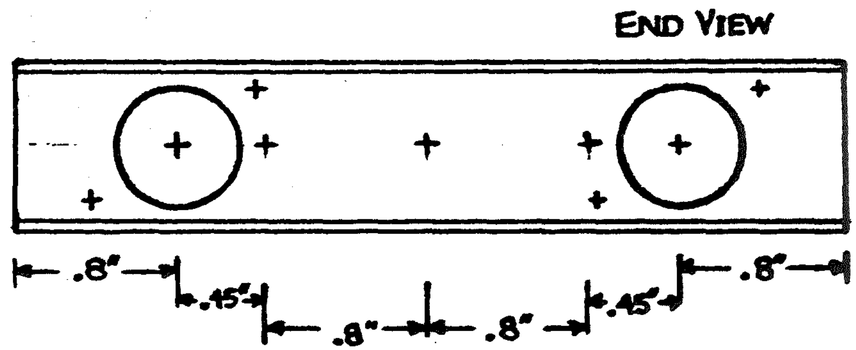
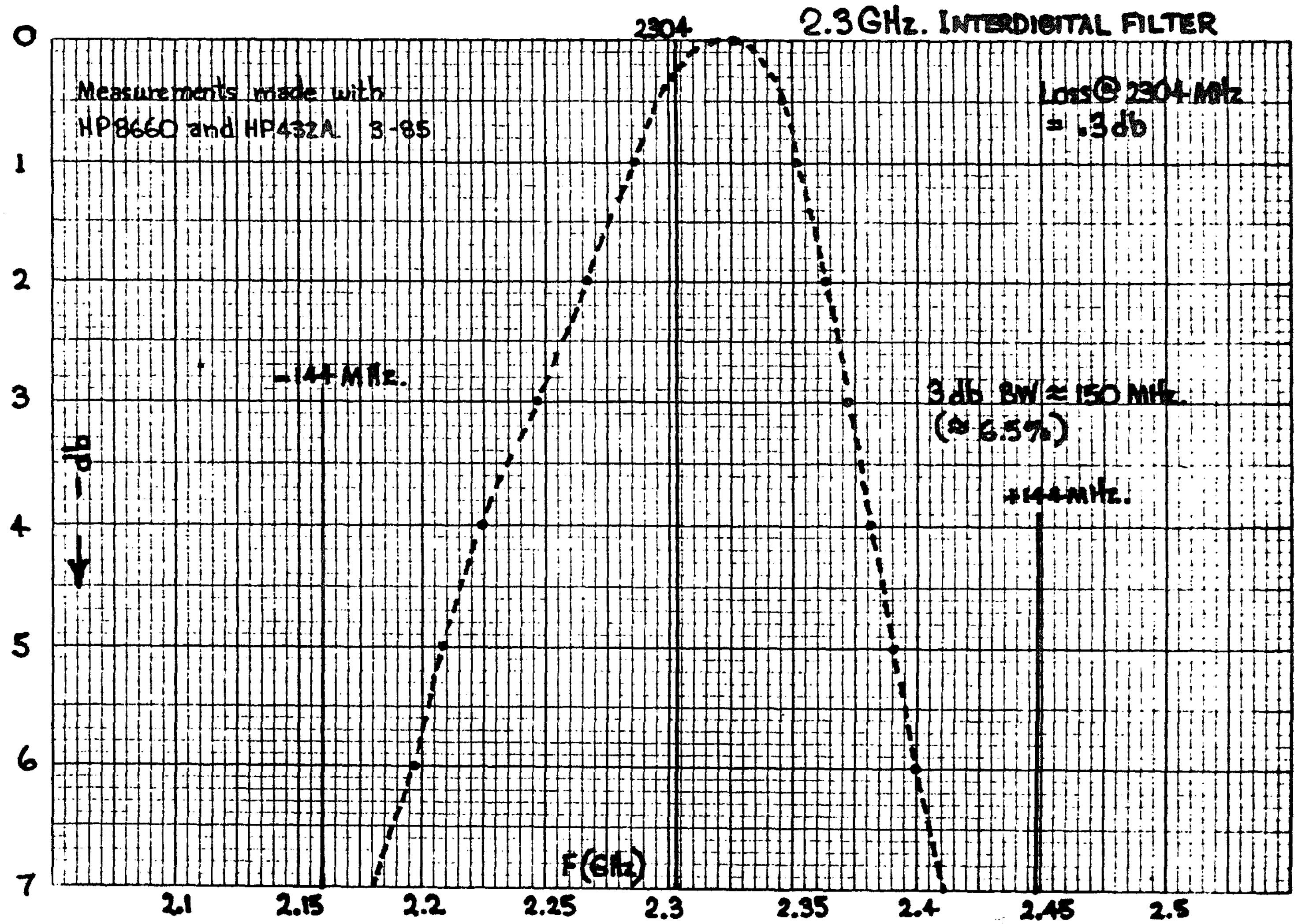


FIG. 2

2.3 GHz. Interdigital Filter
For complete construction details see
QST March, 1968, page 32

D. Hilliard, WØPW, 3-8



2.3 GHz. INTERDIGITAL FILTER
Measurements made with
HP8660 and HP432A 3-85
Loss @ 2304 MHz
≈ .3 db
2304
-144 MHz.
3 db BW ≈ 150 MHz.
(≈ 6.5%)
+144 MHz.
db
F (GHz)
0
1
2
3
4
5
6
7
2.1
2.15
2.2
2.25
2.3
2.35
2.4
2.45
2.5

FIGURE 3

A TEMPERATURE CONTROLLER FOR UHF OSCILLATORS

by

Don Hilliard, WØPW

A TEMPERATURE CONTROLLER FOR UHF OSCILLATORS

Donald L. Hilliard, WØPW

One of the real problems confronting microwave amateurs today is one of drift in oscillators. Assuming the oscillator is of good design and quality components have been used in its construction, the primary cause of drift is change in ambient temperature in the area around the oscillator. Most commerical transverters have not been designed with this problem addressed, nor have most amateur constructed units. Typical frequency excursions may be from a few kHz to a few tens of kHz, for a few degrees change in temperature.

The solution to this problem may be quite simple, depending on available room in the vicinity of the oscillator circuit.

The described circuit uses but few parts, can be built in a relatively small area, but if thermally isolated with insulation, it should hold the temperature of your oscillator circuit to a stability of less than a tenth of a degree.

The heart of the circuit is the thermistor that senses the change in temperature. It is readily available from Newark Electronics and other electronic parts vendors. The device is made by Fenwal Electronics and is listed in Newark catalog number 107 on page 202. The manufacturer's type number is JA35J1, a 5k ohm unit. It's price, $1.56.

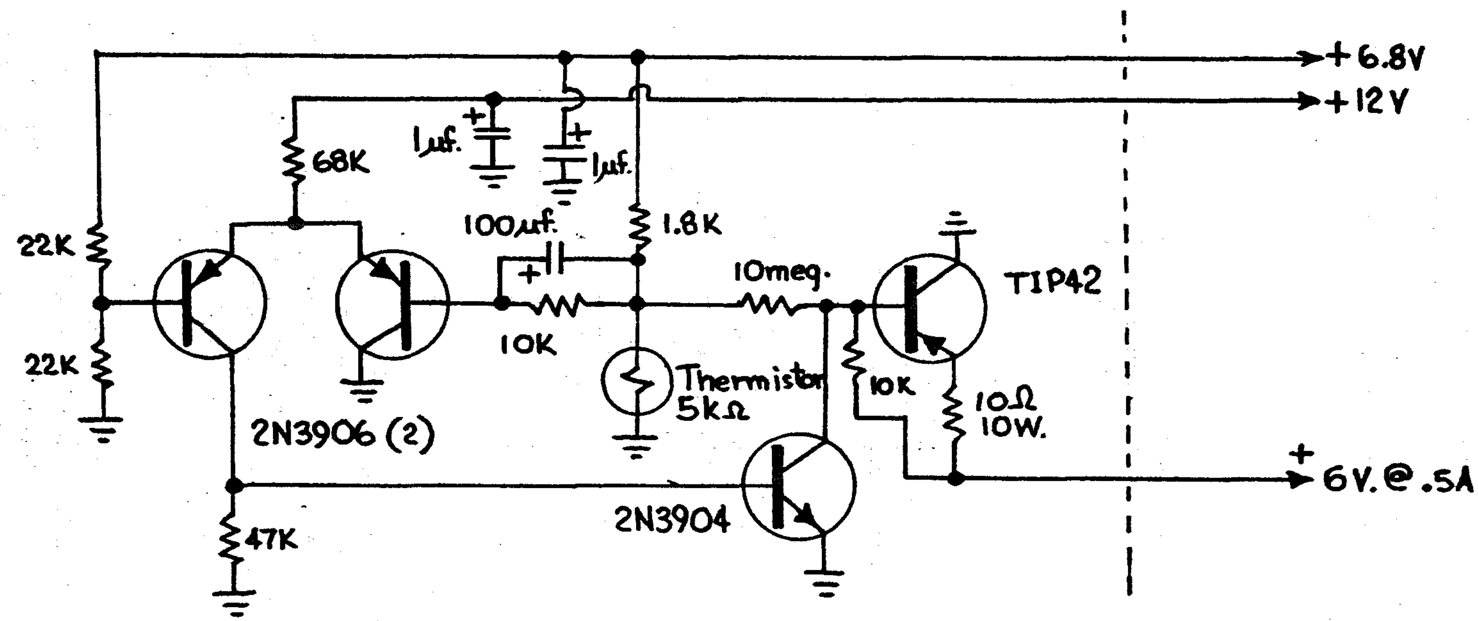
Good thermal isolation is required. A good way to achieve this is to build the oscillator, and multiplier circuits too, if there is adequate room, on a small copper plate or piece of copper plated circuit board. Also leave room near the oscillator circuit for the controller circuit. This unit should be of a size that, when wrapped with a layer or two of 1" fiberglass insulation, may be inserted into a widemouth Thermos bottle. In the case of commercially made units, this may not be possible. However, with some ingenuity, it should be possible to adapt this circuit to your particular unit. The less adequate the thermal insulation, the more current the heater circuit will use.

A few words on parts placement. Place the thermistor near the crystal. It should be held in place with good thermal contact to the copper plate or circuit board. A drop or two of 5 minute epoxy may be used to secure it in place. The heater resistor (10 ohm) should be an inch or so away. It should also be in good thermal contact with the circuit plate. Epoxy seems to be adequate. The TIP42 should be mounted to the plate also. Any power PNP device can probably be used. The TIP42 was chosen because it is readily available at Radio Shack.

Operation

After the unit has been thermally insulated (thermos bottle), power may be applied. A current meter should be placed in the 6 volt heater supply lead. The initial heater current will be approximately half an amp. After a few minutes, during which time the unit is heating up, the current will drop down to 50 mils or so and then start increasing to half an amp again. For several minutes, it will slowly cycle. When the operating temperature has stabilized, the current will settle, usually between 50 and 150 ma. depending on how well you have insulated the unit. This is a proportional controller.

After the unit has operated for an hour or so, check the oscillator stability. You will be pleased. No longer will temperature changes affect your oscillator stability.



TEMPERATURE CONTROLLER

A LOW LEVEL SIGNAL SOURCE FOR 2304 MHz.

by

Don Hilliard, WØPW

A LOW LEVEL SIGNAL SOURCE FOR 2304 MHz.

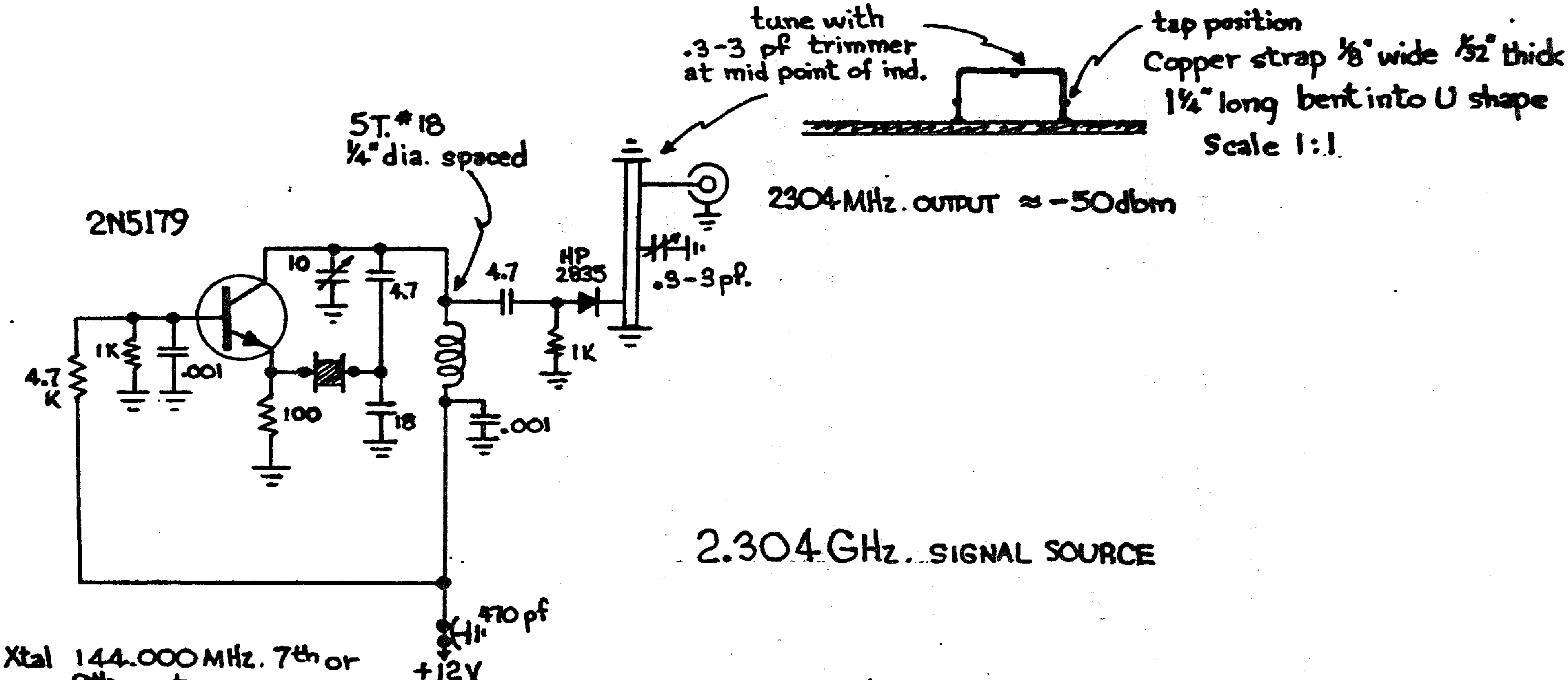
Donald L. Hilliard, WØPW

Often the 2304 enthusiast will need a signal source for various reasons. Described is a crystal controlled source that will deliver a -50 dbm. signal. The 144 MHz. overtone oscillator drives a diode multiplier. The halfwave tuned circuit at the output selects the 2304 MHz. harmonic.

By lengthening the output filter inductance, the circuit could be resonated to 1296 MHz.

Adding one or more Avantek MSA-0104 MMIC amplifiers would allow the level to be increased by 20 to 30 db or more. Being wide band amplifiers, all the spurious signal levels would also be built up so additional filtering of the desired signal might be desirable.

Spurious levels are typically down only a few db.



2.304 GHz. SIGNAL SOURCE

Xtal 144.000 MHz. 7th or
9th overtone

or 102.857 MHz.
5th overtone

or 80.000 MHz
5th overtone

D. Hilliard.
5-85

A 1296 MHz. DUAL DIPOLE/REFLECTOR FEED

by

Don Hilliard, WØPW

A 1296 MHz. DUAL DIPOLE/REFLECTOR FEED

Donald L. Hilliard, WØPW

Described is an efficient feed for parabolic reflectors with an f/D of approximately .45. This antenna has a -10 db beamwidth of approximately 120° in both E and H planes, which is thought to be about the optimum illumination taper for .43 f/D relfectors.

The so-called "coffee can" feeds described by Norm Foot[1] are easy and cheap to construct, but suffer from unequal E and H patterns and an illumination taper that is not ideal for f/D ratios of approxiamtely .45. The choke ring described, again by Foot[2], corrects some of these problems.

The "dual dipole" feed described is a scaled version of one I used for some years on 432 MHz.

It uses a one wavelength square aluminum plate reflector and short pieces of "hobby shop" brass tubing for the rest of the assembly.

The drawings detail the dimensions and show construction details.

The antenna if duplicated carefully, should have a VSWR less than 1.5/1.

---

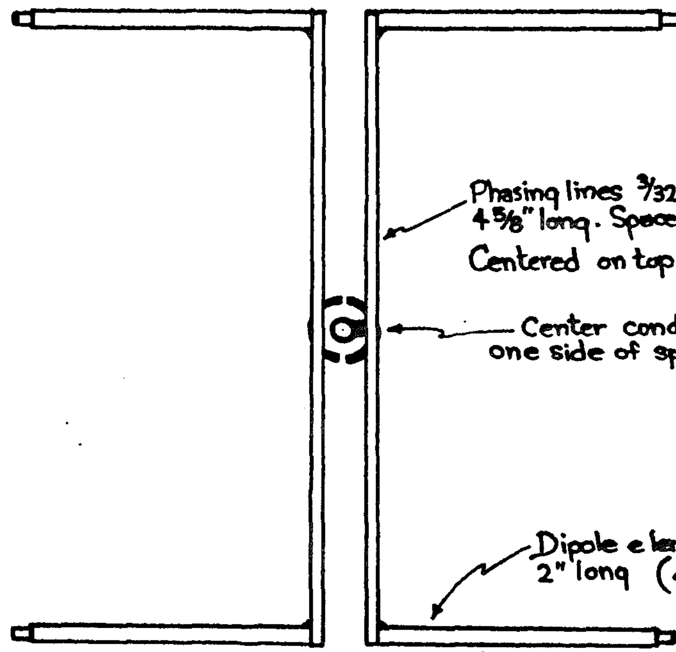
[1] Norman Foot, WA9HUV, "Cylindrical Feed Horns for Parabolic Reflectors", Ham Radio, May, 1976, p. 16.

[2] Norman Foot, WA9HUB, "Second Generation Cylindrical Feedhorns", Ham Radio, May, 1982, p. 31.

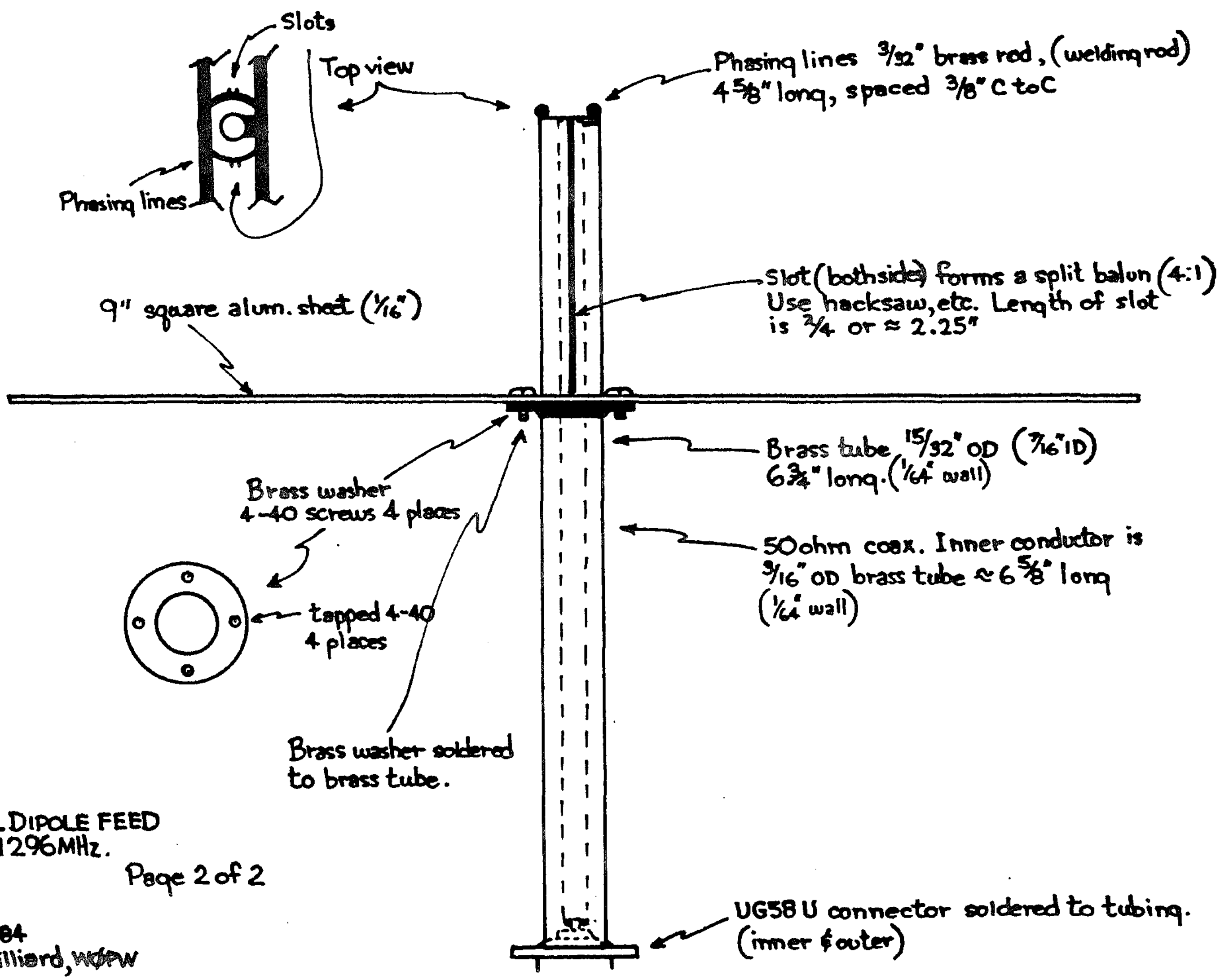
DUAL DIPOLE FEED FOR .4 to .5 F/D REFLECTORS
10db Beamwidth 120°

1296 MHz.

Page 1 of 2



10-84
Don Hilliard WØPW



DUAL DIPOLE FEED
1296MHz.

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10-84
Don Hilliard, WØPW

A 1296 MHz. DUAL DIPOLE/REFLECTOR FEED

by

Don Hilliard, WØPW

A 1296 MHz. DUAL DIPOLE/REFLECTOR FEED

Donald L. Hilliard, WØPW

Described is an efficient feed for parabolic reflectors with an f/D of approximately .45. This antenna has a -10 db beamwidth of approximately 120° in both E and H planes, which is thought to be about the optimum illumination taper for .43 f/D relfectors.

The so-called "coffee can" feeds described by Norm Foot[1] are easy and cheap to construct, but suffer from unequal E and H patterns and an illumination taper that is not ideal for f/D ratios of approxiamtely .45. The choke ring described, again by Foot[2], corrects some of these problems.

The "dual dipole" feed described is a scaled version of one I used for some years on 432 MHz.

It uses a one wavelength square aluminum plate reflector and short pieces of "hobby shop" brass tubing for the rest of the assembly.

The drawings detail the dimensions and show construction details.

The antenna if duplicated carefully, should have a VSWR less than 1.5/1.

---

[1] Norman Foot, WA9HUV, "Cylindrical Feed Horns for Parabolic Reflectors", Ham Radio, May, 1976, p. 16.

[2] Norman Foot, WA9HUB, "Second Generation Cylindrical Feedhorns", Ham Radio, May, 1982, p. 31.

DUAL DIPOLE FEED FOR .4 to .5 F/D REFLECTORS

10db Beamwidth 120°

1296 MHz.

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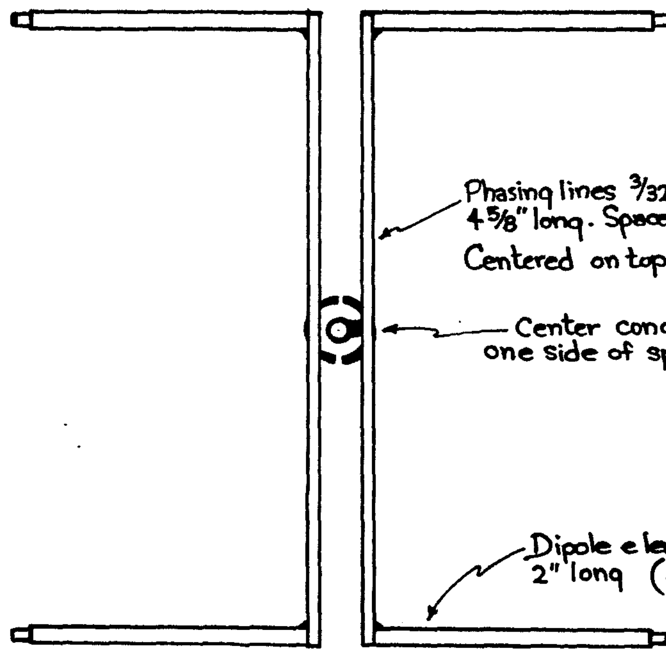

Length adjusters
1/2" length 3/32" brass rod
protrudes ≈ 1/8".
Soldered in place.

Phasing lines 3/32" brass rod
4 5/8" long. Spaced 3/8" center to Center
Centered on top of balun and soldered in place.

Center conductor connected to
one side of split balun as shown.

Dipole elements 1/8" OD brass tube
2" long (4 each) soldered to phasing lines.

Length could probably be made
2 1/8" and extenders left out.

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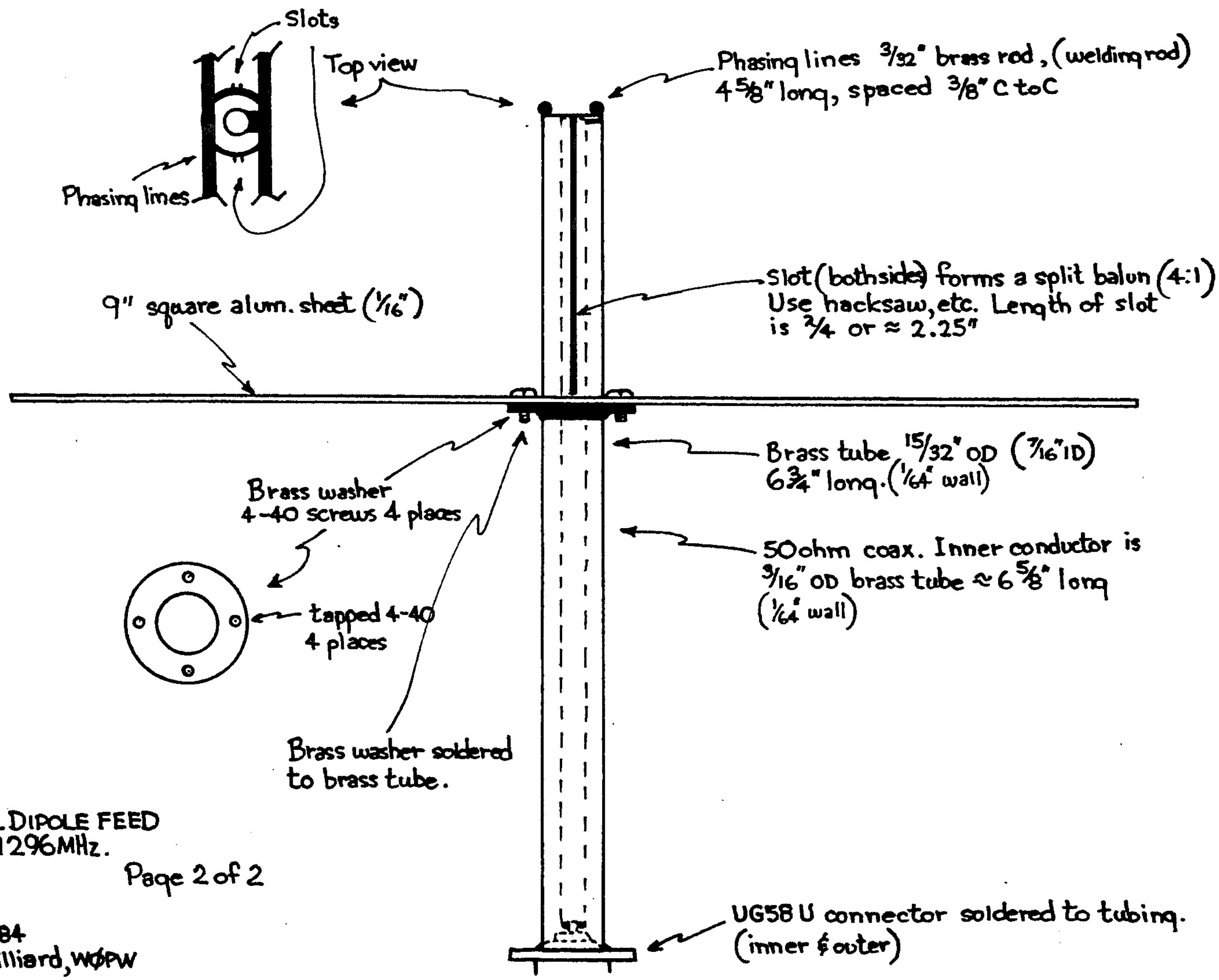
Don Hilliard WØPW



DUAL DIPOLE FEED
1296 MHz.

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10-84
Don Hilliard, WØPW

A 32 ELEMENT LOOP YAGI FOR 1296 MHz

by

Don Hilliard, WØPW

A 32 ELEMENT LOOP YAGI FOR 1296 MHz.

The following design is an adaptation of the G3JVL/W1JR loop Yagi.

The G3JYL design was a 27 element one and the W1JR was a 38 element one.

Design modifications have occurred over the years and this 32 element design incorporates most of them. The loop Yagi has a relatively broad frequency response and though designed for 1296 MHz, it performs nearly as well on 1269 MHz.

The boom is a standard 8 foot length of 3/4 inch O.D. aluminum tubing that is generally available in hardware and building supply stores for about $6.50 at this time (1984). Since the element loading is rather small, the finished antenna is strong mechanically.

Using a tape measure attached to one end, the following element mounting positions should be marked on the boom:

R1	1/4"	D9	24 3/32"	D20	63 7/32"
R2	3 3/8"	D10	27 21/32"	D21	66 25/32"
Dip.	4 11/32"	D11	31 7/32"	D22	70 11/32"
D1	5 15/32"	D12	34 25/32"	D23	73 29/32"
D2	6 11/32"	D13	38 5/16"	D24	77 15/32
D3	8 1/8"	D14	41 7/8"	D25	81 1/32"
D4	9 7/8"	D15	45 7/16"	D26	84 9/16"
D5	11 5/8"	D16	48 31/32"	D27	88 1/8"
D6	13 3/8"	D17	52 17/32"	D28	91 23/32"
D7	16 31/32"	D18	56 3/32"	D29	95 9/32"
D8	20 17/32"	D19	49 21/32"		

The boom may then be drilled using a jig device to hold the boom so hole alignment is achieved. Such a device is described in Figure 1. A drill press must be used as alignment cannot be easily achieved otherwise.

Drill all the element mounting holes using a number 32 drill, except the dipole mounting hole which should be drill 1/4" Also the holes for mounting a gussett plate should be drilled number 11 for 10-32 hardware. Of course, these are drilled 90° from the plane of the element mounting holes and approximately 3 1/2 feet from the reflector end of the boom. Figure 5 shows a suitable gussett plate.

The reflectors and directors are 1/4" wide straps sheared from 1/32" thick aluminum sheet. Lengths are given in Figure 2. The length plus overlap is the length to cut the strap to. A number 32 hole is drilled 1/4" in from each end of each strap, except the dipole strap. Deburr the holes.

Figure 3 details how the elements are mounted. Of course all elements must be formed on a round former before mounting. I use a spray paint can approximately 2 1/2" diameter as a former.

Figure 4 details the dipole element assembly.

After the loop Yagi is completed, a feedline must be attached. At this frequency, it is very desireable to use a minimum number of RF connectors. Therefore, a type N connector designed for use with .141 coax is recommended. Such a connector is a model PE 4006 from Pasternack Enterprises, P.O. Box 16759, Irvine, CA 92713. Another recommended connector series is the TNC.

If 2 or 4 Yagis are to be stacked, it is desireable to use a length of .141 coax from the feedpoint to the power divider. A suitable power divider is described in Figure 6. A single loop Yagi constructed as described may be all right to use at the 100-150 watt level (at the antenna). For higher power levels of say 400-500 watts, one should use 4 or more antennas so that the power at the feedpoint of the individual Yagi is not high enough to cause problems.

Also, of course, the Yagis must be phased correctly when stacked. This means that the outer of the feeders should go on the same side of all driven elements. Also, an H frame should be used and <u>not</u> an H frame turned 90°. There should be a minimum of horizontal members in the framework. Recommended stacking distances are 20-24".

The boom may be lengthened out to at least 12 feet if desired. The W1JR version is 10 feet long and the WB5LUA version is 12 feet long. The additional directors are all spaced 3.56" and remain at same length as D29 or 7.75".

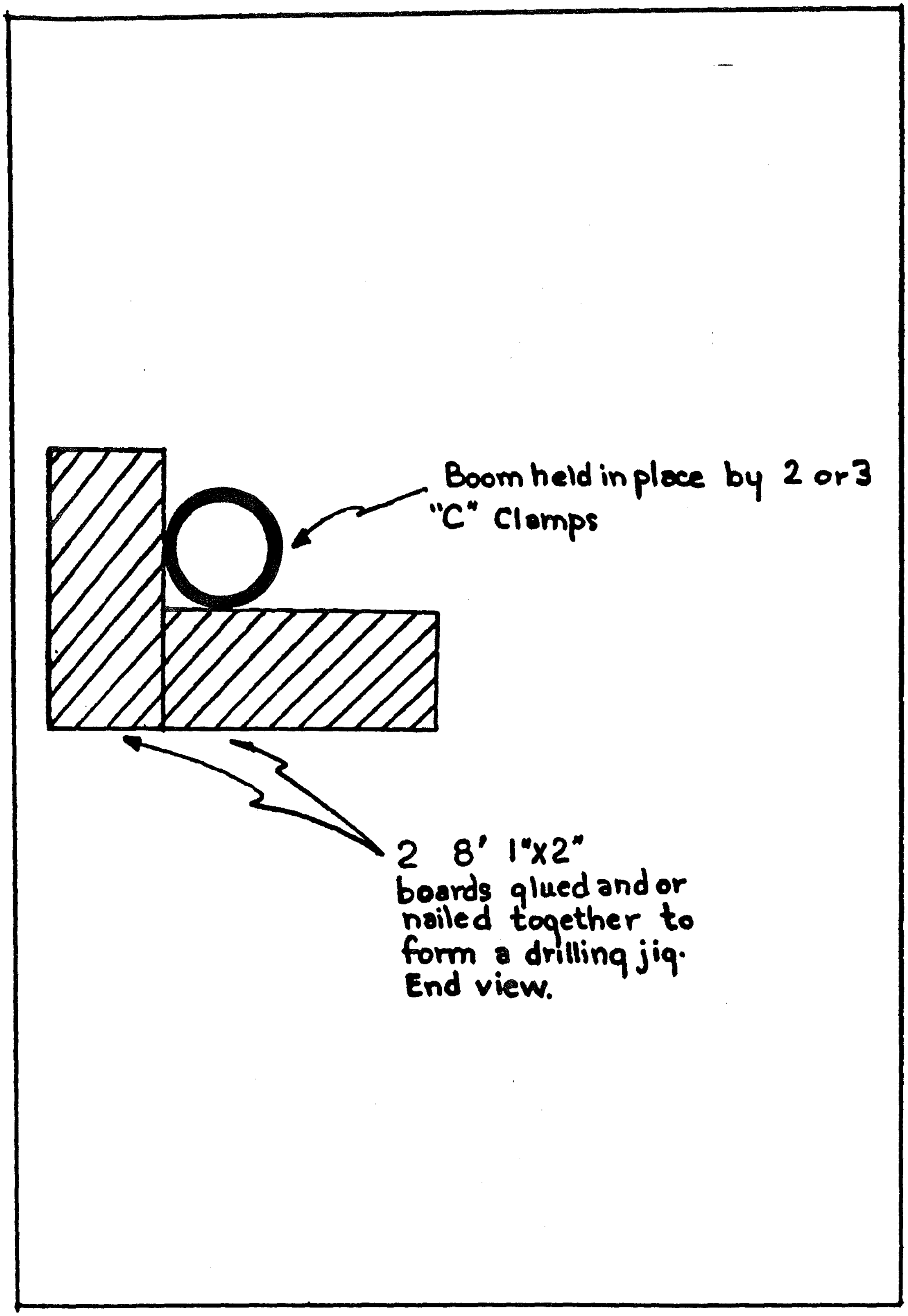

Figure 1 - Jig for drilling boom

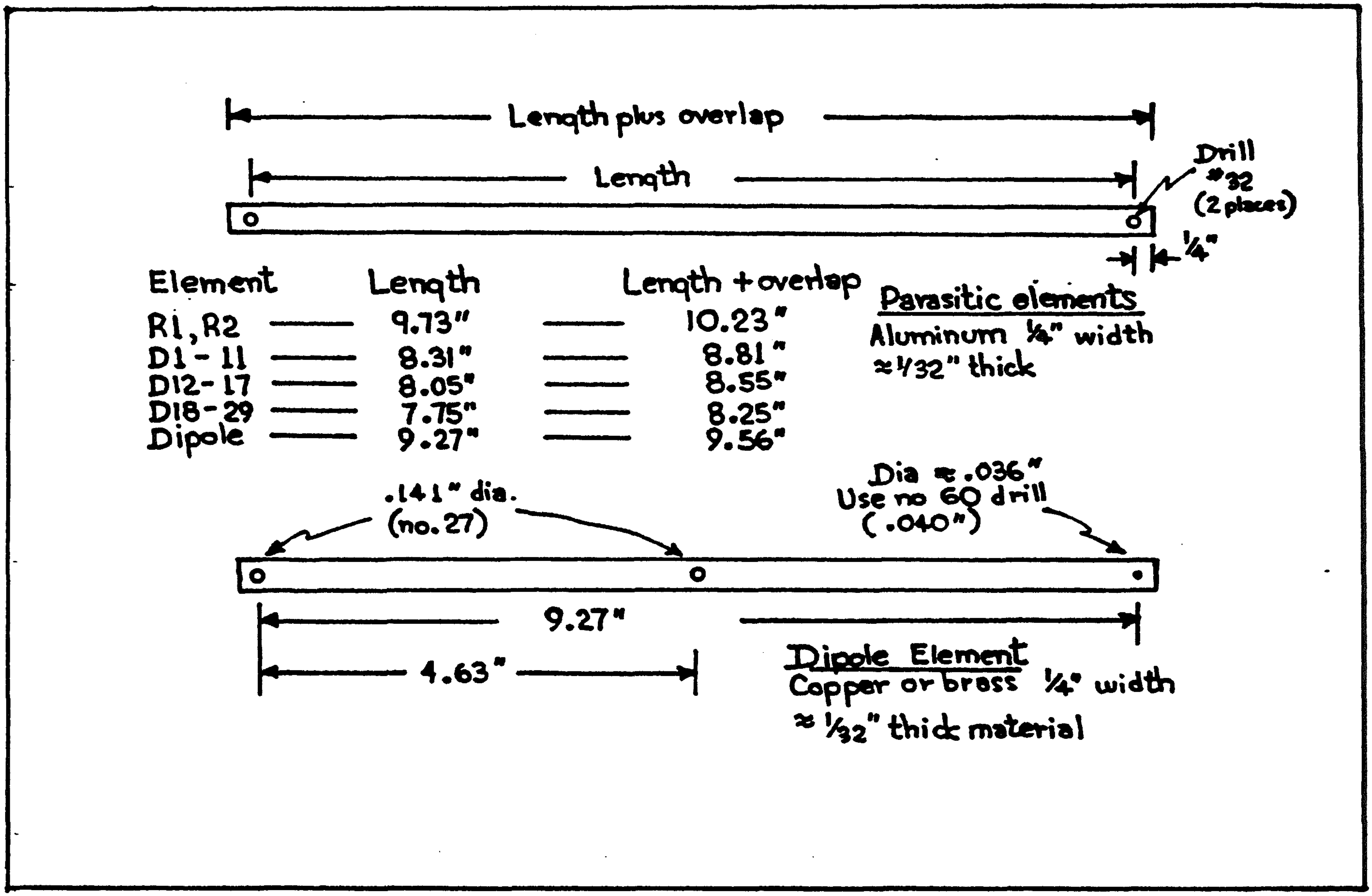

Figure 2 - Elements

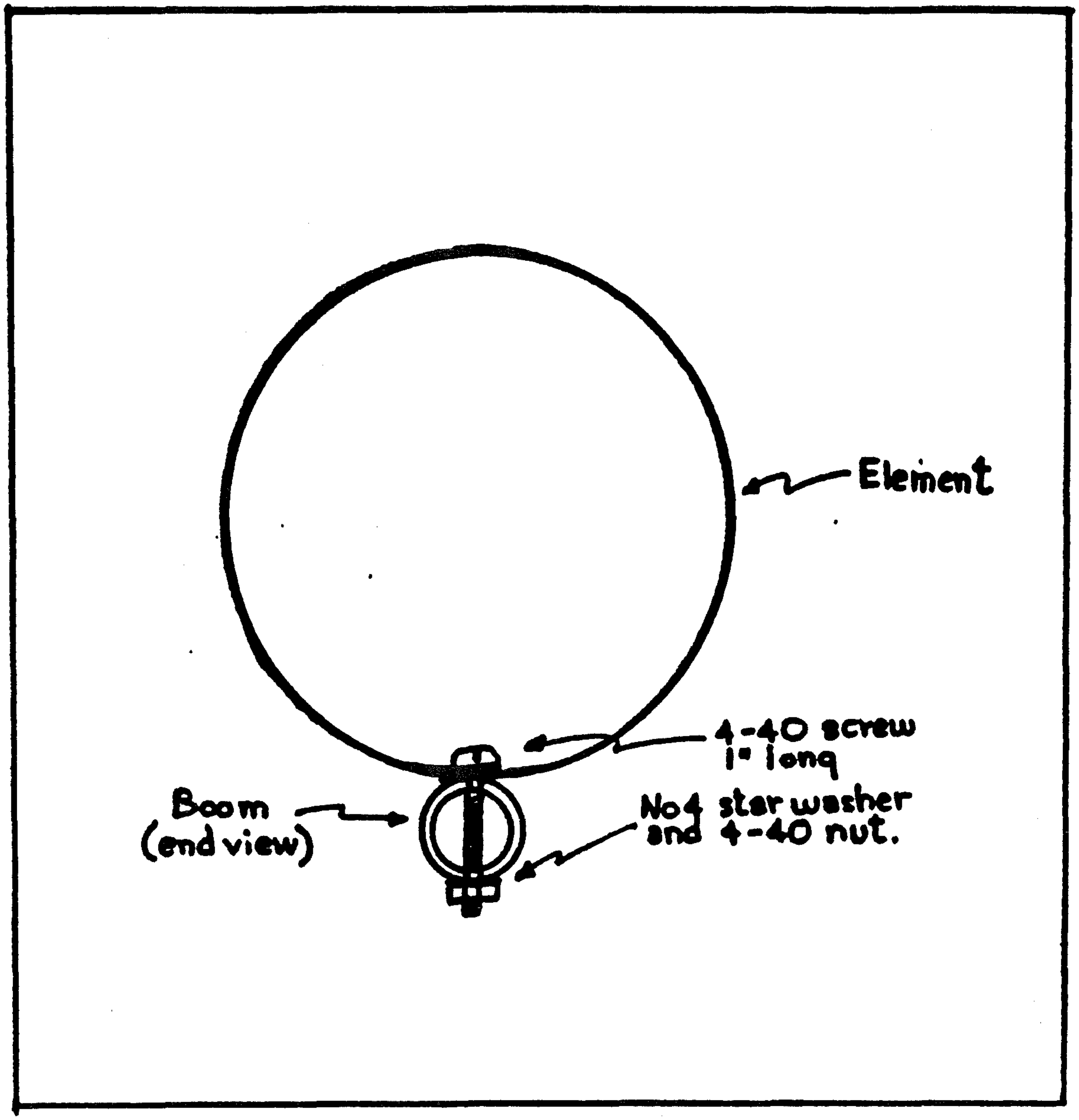

Figure 3 - How the elements are mounted

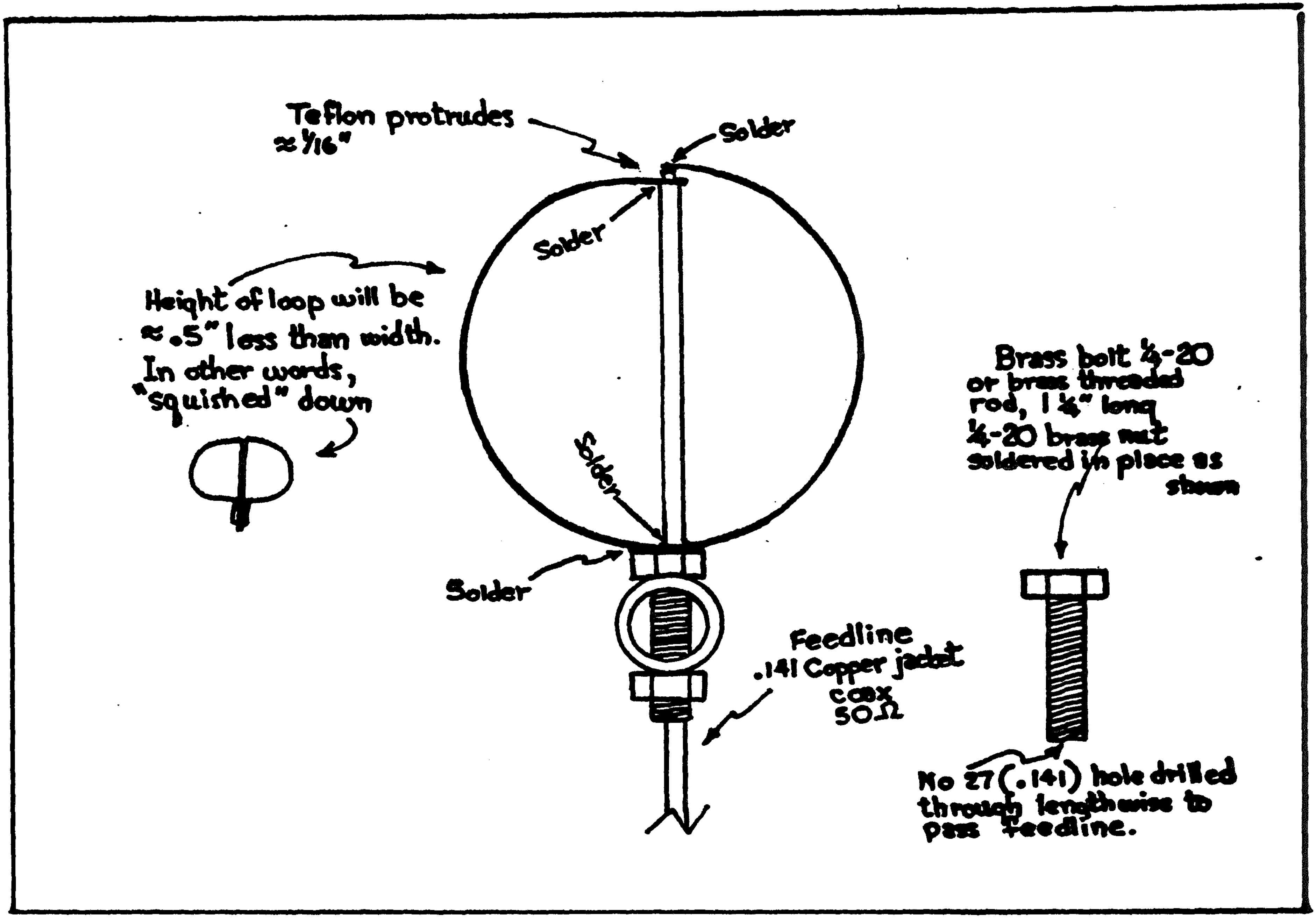

Figure 4 - Dipole element assembly

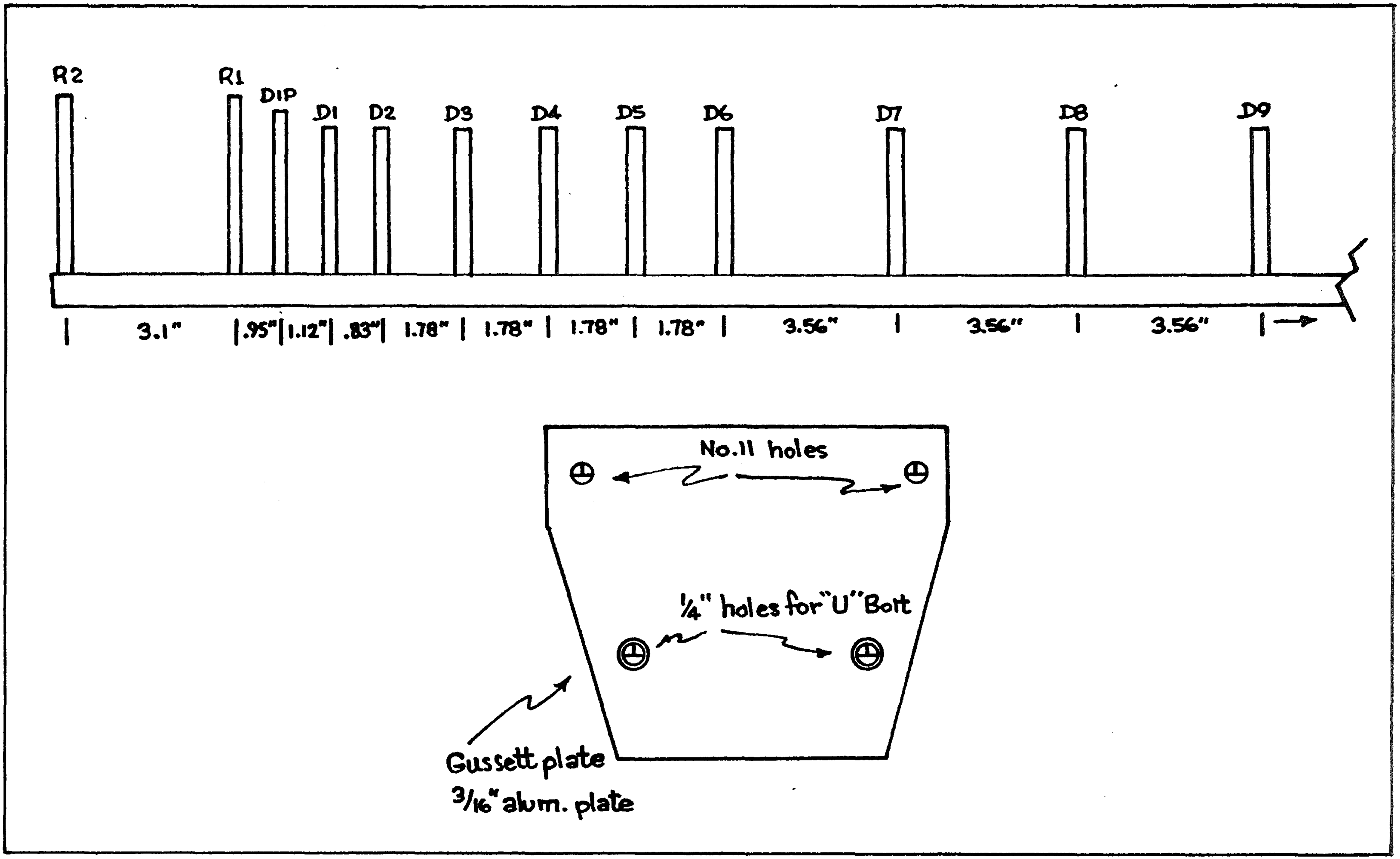

Figure 5 - Element Loop Yagi for 1296 MHz - Spacing drawing

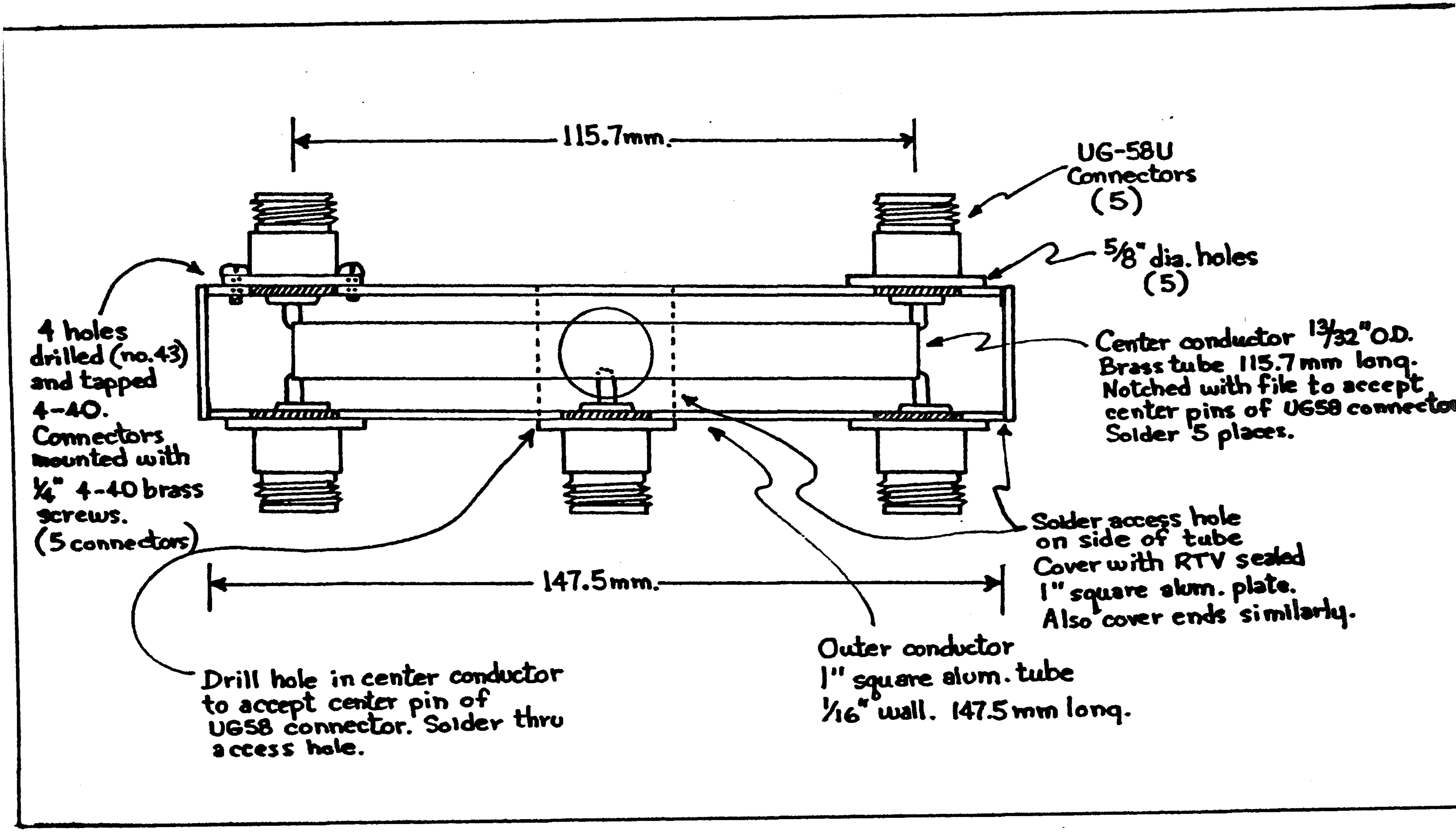

Figure 6 - 4 Port 50 Ohm Power Divider for 23 cm (1296 MHz.)

THE CARE AND FEEDING OF A 7 FOOT DISH

by

Gerald Handley, WA5DBY

THE CARE AND FEEDING OF A 7 FOOT DISH

by
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INTRODUCTION

Dishes always seem to demonstrate impressive performance on the microwave amateur bands, even when compared to a loop yagi of equal gain. One possible reason for this is the capture area of a dish. Figure 1 illustrates the difference in the capture area of a dish and an array of four loop yagis.

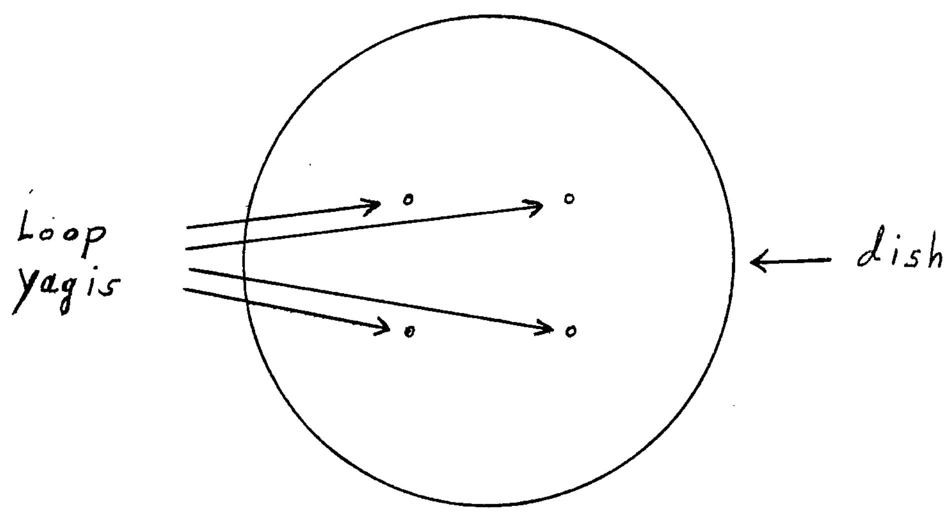


Figure 1

Another reason for the impressive performance of a dish is the absence of the feedline and connectors needed to construct a phasing harness for a high gain loop yagi array.

MODIFICATION OF A 7 FOOT DISH

Channel Master manufactures several different sizes of UHF TV dish antennas. The largest, a 7 foot dish, was selected because it would give the most gain. The price of the dish is:

7 Foot Channel Master UHF TV Dish

Quantity	Price
1	$136.95
2 - 5	$86.21
6 and up	$77.57

The following specifications were measured or calculated after obtaining the dish:

Diameter	--	7 feet	
Depth	--	13 inches	
Focal Length	--	33.9 inches	34.5"
F/D Ratio	--	0.4	.41

The focal length (f) was computed using the formula

$$f = \frac{Diameter^2}{16\ Depth}.$$

The dish comes in two halves that unfold to make two seven foot by 3 1/2 foot pieces. There is a support that attaches to the center of the dish and extends outward to hold the feed. The feed for the dish is a dual bow tie antenna. The dish is made up of horizontal ribs spaced 5 1/4 inches apart. In order for the dish to work satisfactorily in the microwave spectrum, it needs to be covered with hardware cloth. The largest dimension of the mesh should not exceed 1/10 wavelength. This equates to:

1/2 inch for 1296 MHz.
1/4 inch for 2304 MHz.

The dish was covered with 1/4 inch hardware cloth. A four foot wide by 30 foot long piece hardware cloth was sectioned into one foot wide pie sections as shown in Figure 2. The outline of the pies were drawn on the hardware cloth with a permanent ink marker then cut out with tin snips. The pie slices must be formed around the center of the dish and not the feed support, because the

¼" Hardware Cloth

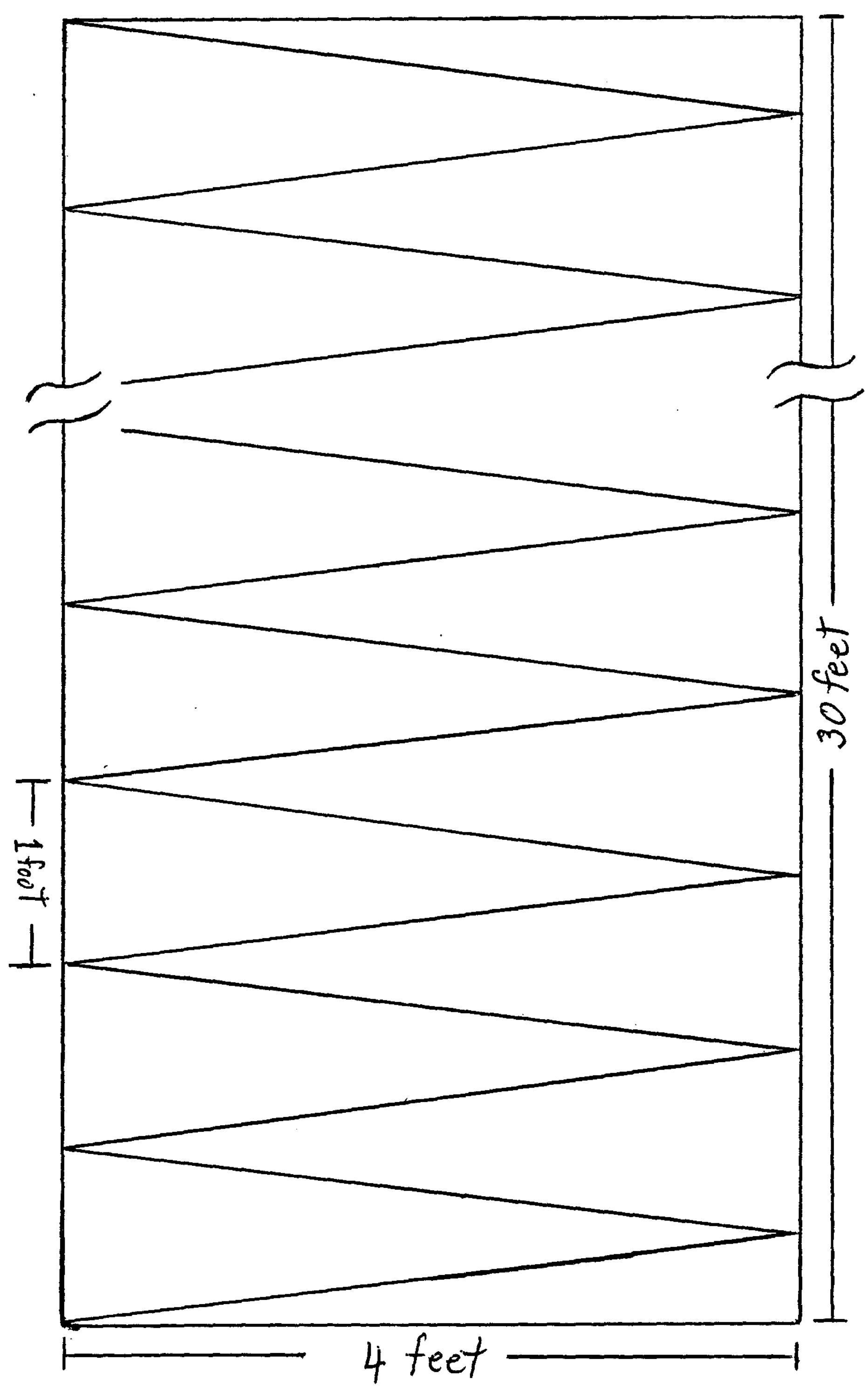


Figure 2

feed support is slightly off center in order for it to be fastened to the mast. The dish should be installed on a mast and formed into its parabolic shape before installing the hardware cloth onto the dish. The pie sections of hardware cloth were tied to the ribs of the dish using single strands of unraveled guy wire. The wire was wrapped around the rib a single time and tied in a square knot on the back side of the dish using two pairs of pliers. The ends of the hardware cloth can be cut with diagonal cutters forming pieces of wire connected to the hardware cloth that can be used to connect the pie sections to each other. The loss from using 1/4 inch hardware cloth over a solid metal dish at 2304 MHz. is about 0.8 dB. The panels of the dish were overlapped 1.25 inches (1/4 wavelength on 2304 MHz.). This will create a low impedance parallel plate transmission line transformer which will reflect a short circuit at the surface gap. All panel overlaps were in the same direction.

The gain of the dish was measured using Al Ward's, WB5LUA, antenna range. The 7 foot dish measured 25.5 dBi on 1296 MHz. and 30 dBi on 2304 MHz. Figure 3 shows the theoretical gain for a 7 foot dish with 50% efficiency is 26 dBi on 1296 and 30 dBi on 2304 MHz. The antennas measured on the range and their respective gains is shown in Table 1.

Antenna	1296	2304
Two 3 lb. coffee cans	7.5 dBi	--
1 lb. coffee can	--	9 dBi
45 element loop yagi	20 dBi	20 dBi
7 foot dish	25.5 dBi	30 dBi

Table 1

The beamwidth of the dish is:

7.5 degrees on 1296 MHz.
4.3 degrees on 2304 MHz.

FEED HORN FABRICATION

The dish was fed with two separate feed horns, one for 1296 and one for 2304. Initially an attempt was made to fabricate a single feed horn which would work on both 1296 and 2304. The advantage of a dual band feed horn is the beam reflected from the dish will radiate straight out of the dish. The dual band feed horn was fabricated using a 3

DISH GAIN

$$\text{Gain (in dbi)} = 10 \log_{10}\left(\eta\left(\frac{\pi D}{\lambda}\right)^2\right)$$

On 2304 MHz

$$\text{Gain} = 10 \log_{10}\left(.50\left(\frac{\pi\,(84\,\text{in})(2.54\,\text{cm}/\text{in})}{13\,\text{cm}}\right)^2\right)$$

$$\text{Gain} = 31\ \text{dBi}$$

On 1296 MHz

$$\text{Gain} = 10 \log_{10}\left(.50\left(\frac{\pi\,(84\,\text{in})(2.54\,\text{cm}/\text{in})}{23\,\text{cm}}\right)^2\right)$$

$$\text{Gain} = 26\ \text{dBi}$$

Figure 3

lb. coffee can and the dimensions shown in Figure 4. The dual band feed horn had 7 dBi of gain on 1296 and 10 dBi of gain on 2304. When the dual band feed horn was used to feed the 7 foot dish, its performance on 1296 was acceptable. However, its performance on 2304 was 5 dBi down from the performance of the 1 lb. coffee can feed horn.

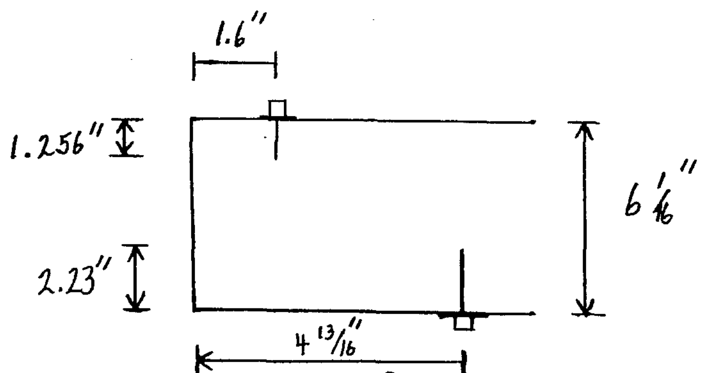
The feed system that provided the highest gain was the use of two separate feed horns. The disadvantage of this system is the beam reflected from the dish will be offset by about the same angle that the feed horn is offset from the center of the dish. The 1296 feed horn was fabricated using two 3 lb. coffee cans and the dimensions shown in Figure 5. Both lids were removed from one of the coffee cans and it was soldered to the other coffee can. The connector is an N connector bolted to the coffee can with the nuts on the outside of the can. The monopole was made from #14 copper wire. The 2304 feed horn was fabricated using a 1 lb. coffee can and the dimensions shown in Figure 6. The connector is an N connector bolted to the coffee can with the nuts on the outside of the can. The monopole is piece of #14 copper wire. The two coffee cans were bolted to the feed support at a distance of 33 inches from the center of the dish. That is the same place that the two bow ties on the bow tie antenna were located. The two coffee cans were mounted opposite of each other with two bolts and washers that went through the front and rear of the 2304 feed horn, through the feed support, and then through the 1296 feed horn. Washers and nuts were installed in the 1296 feed horn to secure the feed horns. The bolts were cut down to the nuts using a bolt cutter.

The loss due to feed horn blockage is shown in Figure 7. When the dish is used on 2304, the blockage due to the 1296 feed horn will result in a loss of -0.038 dB. When the dish is used on 1296, the blockage due to the 2304 feed horn will result in a loss of -0.091 dB. The use of two feed horns results in a relatively small loss in gain. This makes the use of additional feed horns for other bands look very attractive.

PERFORMANCE

The feed horns should be mounted side-by-side to ensure maximum gain. The feed horns were initially mounted one above the other and the performance of the dish checked using local 1296 and 2304 beacons. The dish had to be aimed into the ground for maximum gain on 2304 and up into the sky for maximum gain on 1296. Figure 8 illustrates how the beam will reflect from the dish if the feed horns are

2304/1296 FEED HORN



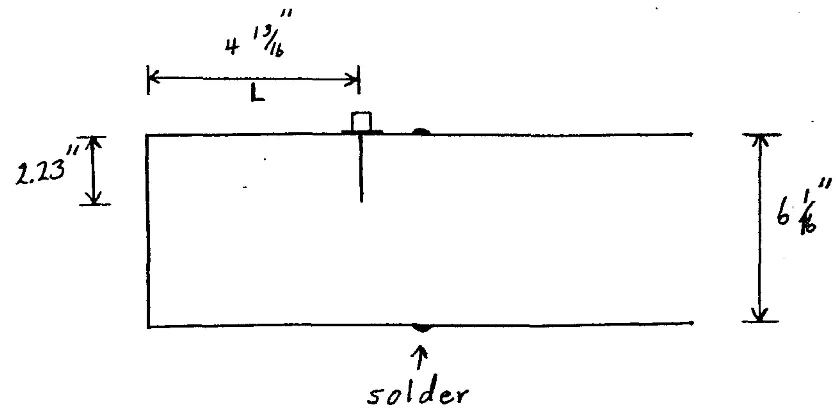
3 lb. coffee can

1296 - 7 dBi
2304 - 10 dBi

Was 5db down on 2304 MHz when used as a dish feed.

Figure 4

1296 FEED HORN



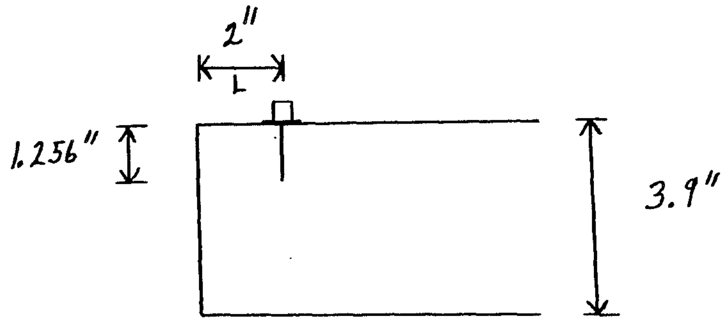
Two 3 lb. coffee cans

7.5 dBi

Horn length should be 2 to 3 times L.

Figure 5

2304 FEED HORN



1 lb. coffee can

9 dBi

Horn length should be 2 to 3 times L.

Figure 6

LOSS (IN DB) DUE TO FEED HORN BLOCKAGE

$$Loss = 10\,Log_{10}\left(1-\left(2\,\frac{A_b}{A_o}\right)\right)^2$$

A_b = blockage area
A_o = aperture area

ON 2304 MHz

$$Loss = 10\,Log_{10}\left(1-\left(\frac{2\pi\,(1.95)^2}{\pi\,(42)^2}\right)\right)^2$$

$$Loss = -0.038\,dB$$

ON 1296 MHz

$$Loss = 10\,Log_{10}\left(1-\left(\frac{2\,\pi\,(3.03125)^2}{\pi\,(42)^2}\right)\right)^2$$

$$Loss = -0.091\,dB$$

Figure 7

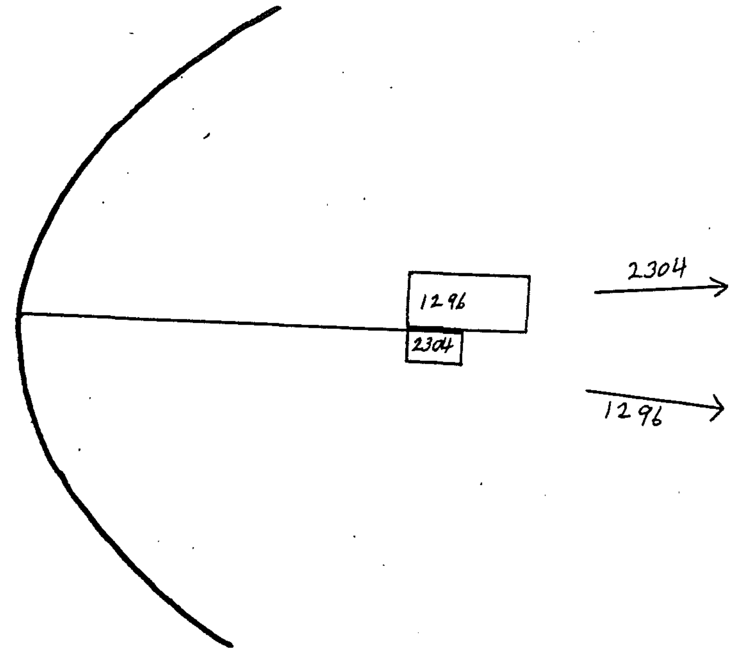


Figure 8

mounted one above the other. The beam reflected from the dish is offset by about the same angle the feed horn is offset from the center of the dish. If the dish is mounted aimed at the horizon, a significant amout of gain will be lost. By mounting the feed horns side-by-side this problem can be overcome and gain will not be lost. However, the 1296 and 2304 beams will not be in the same direction which will create problems when changing from one band to another. In addition, neither the 2304 beam nor the 1296 beam will be in the same direction as yagis mounted in the direction the dish is pointing.

The performance of the dish was outstanding. The dish can easily be handled by one person. The dish has the following advantages:

- INEXPENSIVE
- HIGH GAIN
  25.5 dBi on 1296
  30 dBi on 2304
- LARGE CAPTURE AREA
- MULTIPLE BANDS (JUST ADD FEED HORNS)
- LIGHT WEIGHT
- LOW WIND LOAD FOR A DISH
- WELL CONSTRUCTED
- CAN BE MOUNTED ON CONVENTIONAL TOWERS

In conclusion the modified 7 foot Channel Master UHF TV dish proved to be a superb high gain antenna for the microwave amateur bands.

```
1 PRINT "♥"
2 POKE 53280,10
3 POKE 53281,13
4 PRINT "▣"
5 PRINT "    KAIGT PARAMETRIC DESIGN PROGRAM"
6 PRINT "              FOR LOOP YAGI"
7 PRINT "          WRITTEN BY BOB ATKINS"
8 PRINT:PRINT
9 PRINT "      MODIFIED FOR C-64 BY WA5DBY"
10 PRINT:PRINT:PRINT:PRINT
11 DIM A(38)
20 A(1)=3.1
21 A(2)=4.05
22 A(3)=5.17
23 A(4)=6.0
25 A(5)=7.78
26 A(6)=9.56
27 A(7)=10.81
28 A(8)=13.12
30 FOR X=1 TO 30
40 A(X+8)=13.12+X*3.56
50 NEXT
60 INPUT "FREQUENCY OF USE IN MHZ";F
65 PRINT
70 FC=1296/F
72 FOR X=1 TO 38
75 A(X)=A(X)*FC
77 NEXT
80 R1=9.67
90 DE=9.23
100 DIM B(36)
110 FOR X=1 TO 11
120 B(X)=8.25
130 NEXT
140 INPUT "27 OR 38 ELEMENT VERSION";N
142 IF N<>27 AND N<>38 THEN GOTO 140
150 FOR X=12 TO 18
160 B(X)=8.0
170 NEXT
180 IF N=27 THEN GOSUB 500
190 IF N=38 THEN GOSUB 600
200 FOR X=1 TO 36
210 B(X)=B(X)*FC
215 NEXT
220 R1=R1*FC
230 DE=DE*FC
235 PRINT
240 INPUT "BOOM DIAMETER IN INCHES";B
245 PRINT
250 INPUT "ELEMENT WIDTH IN INCHES";W
255 PRINT
260 INPUT "ELEMENT THICKNESS IN INCHES";T
265 PRINT "♥"
270 B1=B/FC
271 W1=W/FC
272 T1=T/FC
280 IF B1<.5 THEN GOSUB 700
290 IF B1<2.1 THEN GOSUB 700
300 IF T1<.028 THEN GOSUB 750
310 IF T1>.063 THEN GOSUB 750
320 IF W1<.1 THEN GOSUB 800
330 IF W1>.375 THEN GOSUB 800
```

```
340 B2=((B1-.5)+(B1-.5)↑2)*2.88
350 FOR X=1 TO (N-2)
360 B(X)=B(X)+(B(X)/100)*B2
365 NEXT
370 DE=DE+DE*B2/100
380 R1=R1+R1*B2/100
390 W2=(.1875-W1)*4.8
400 FOR X=1 TO (N-2)
410 B(X)=B(X)+(B(X)/100)*W2
420 NEXT
422 DE=DE+DE*W2/100
424 R1=R1+R1*W2/100
430 T2=(T1-.028)*(.6/.031)
440 FOR X=1 TO (N-2)
450 B(X)=B(X)+((B(X)/100)*T2)
460 NEXT
470 DE=DE+DE*T2/100
475 R1=R1+R1*T2/100
480 RA=4.5
481 RB=5.5
485 RA=RA*FC
486 RB=RB*FC
495 GOTO 1000
500 FOR X=19 TO 25
510 B(X)=8.0
520 NEXT
530 RETURN
600 FOR X=19 TO 36
610 B(X)=7.7
620 NEXT
630 RETURN
700 PRINT "BOOM DIAMETER OUTSIDE RANGE OF"
701 PRINT "PARAMETRIC STUDY.  CALCULATION CONTINUES";
702 PRINT "WITH EXTRAPOLATED DATA."
710 RETURN
750 PRINT "MATERIAL THICKNESS OUTSIDE RANGE OF PARAMETRIC STUDY.  ";
751 PRINT "CALCULATION CONTINUES WITH EXTRAPOLATED DATA."
760 RETURN
800 PRINT "ELEMENT WIDTH OUTSIDE RANGE OF PARAMETRIC STUDY.  ";
801 PRINT "CALCULATION CONTINUES WITH EXTRAPOLATED DATA."
810 RETURN
1000 PRINT "J"
1005 PRINT "DATA FOR LOOP YAGI FOR USE AT ";F;" MHZ"
1010 PRINT
1020 PRINT "BOOM DIAMETER ";B;" IN"
1030 PRINT "ELEMENT WIDTH ";W;" IN"
1040 PRINT "ELEMENT THICKNESS ";T;" IN"
1042 PRINT"REFLECTING SCREEN ";INT(RA*1000)/1000;" X ";INT(RB*1000)/1000;" IN"
1043 PRINT:PRINT:PRINT
1044 PRINT "ALL DIMENSIONS ARE IN INCHES"
1045 PRINT:PRINT
1046 PRINT "ELEMENT"," DISTANCE"," LENGTH"
1047 PRINT "NUMBER"," FROM"," (CIRCULAR)"
1048 PRINT "       "," SCREEN"
1049 PRINT "-------"," ------"," ---------"
1050 PRINT
1051 PRINT "R1",(INT(A(1)*1000))/1000,(INT(R1*1000))/1000
1060 PRINT "DE",(INT(A(2)*1000))/1000,(INT(DE*1000))/1000
1070 FOR X=1 TO N-2
1075 L=(INT(B(X)*1000))/1000
1076 L1=(INT(A(X+2)*1000))/1000
1080 PRINT "D";X,L1,L
1090 NEXT
1100 END
```

```
60 PRINT:PRINT:PRINT "LOADING"
70 POKE 53280,8
80 POKE 53281,13
90 PRINT CHR$(31)
100 GOTO 340
101 PRINT "□"
102 PRINT CHR$(147);CHR$(142):PRINT "           MORSE CODE PROGRAM":PRINT
103 PRINT "          FROM  QST MAGAZINE":PRINT
104 PRINT "      MODIFIED FOR C-64 BY WA5DBY":PRINT:PRINT:PRINT
105 PRINT "COUPLE COMPUTER AUDIO INTO MIKE INPUT"
106 PRINT "OF TRANSMITTER TO SEND CODE"
107 PRINT:PRINT:PRINT
110 REM INITIALIZE "SID"
111 S=54272:V=8:FOR I=1 TO 24:POKE S+I,0:NEXT
112 POKE S+1,52:POKE S,110:POKE S+5,16:POKE S+6,240:POKE S+24,V:POKE S+4,17
113 PRINT "PRESS L FOR LOUDER, S FOR SOFTER,":PRINT "PRESS RETURN WHEN DONE."
114 GET A$:IF A$="" GOTO 114
115 IF A$="L" THEN V=V+1:IF V>15 THEN V=15
116 IF A$="S" THEN V=V-1:IF V<0 THEN V=0
117 POKE S+24,V
118 IF A$=CHR$(13) THEN POKE S+4,0:GOTO 120
119 GOTO 114
120 PRINT "□"
130 PRINT " KEYBOARD=1":PRINT:PRINT " CODE PRACTICE=2":PRINT
140 INPUT " YOUR SELECTION";G
150 ON G GOTO 160,1090
160 PRINT "□"
170 INPUT " TIME SET (HHMMSS)";TI$
180 PRINT:INPUT " CODE SPEED";S:T=225/S:PRINT
184 POKE 252,T:TC=0
185 PRINT:PRINT:PRINT"TYPE:":PRINT"<?> FOR MENU"
186 PRINT "<←> FOR TIME"
187 PRINT "<*> FOR CENTIGRADE/FAHRENHEIT CONVERSION";
188 PRINT "<+> FOR TABLE OF AMATEUR FREQUENCIES"
189 PRINT "<£> TO CHANGE CODE SPEED"
190 PRINT "<↑> TO CHANGE SELECTION OF MODE"
191 PRINT "<F1> TO SEND INFO IN LINE 650"
192 PRINT "<F2> TO SEND INFO IN LINE 690"
193 PRINT "<F3> TO SEND INFO IN LINE 660"
194 PRINT "<F4> TO SEND INFO IN LINE 700"
195 PRINT "<F5> TO SEND INFO IN LINE 670"
196 PRINT "<F6> TO SEND INFO IN LINE 710"
197 PRINT "<F7> TO SEND INFO IN LINE 680"
198 PRINT "<F8> TO SEND INFO IN LINE 720"
199 PRINT "HIT INDIVIDUAL KEYS TO SEND THEIR CODE":PRINT:PRINT
200 GET B$: IF B$="" THEN 200
205 IF ASC(B$)=63 THEN GOTO 185
210 IF ASC(B$)=95 THEN GOTO 590
220 IF ASC(B$)=42 THEN GOTO 830
230 IF ASC(B$)=43 THEN GOTO 920
240 IF ASC(B$)=92 THEN GOTO 180
245 IF ASC(B$)=94 THEN GOTO 120
250 IF ASC(B$)>132 AND ASC(B$)<142 THEN 630
260 IF ASC(B$)=58 THEN PRINT " (AR)";:GOTO 310
270 IF ASC(B$)=59 THEN PRINT " (SK)";:GOTO 310
280 IF ASC(B$)=61 THEN PRINT " (KN)";:GPTP 310
290 IF ASC(B$)=45 THEN PRINT " (BT)";:GOTO 310
300 PRINT B$;
310 POKE 1019,ASC(B$):POKE 56579,255
320 SYS 1009
330 GOTO 200
340 M=849
350 READ X$
```

```
360 IF X$="ZZ" THEN 101
370 GOSUB 490
380 POKE M,X
390 DATAC9,20,F0,67,C9,2C,90,4E,C9,5B,B0,4A,AA,BD,96,03,A0,08,84,FB,0A,C6,FB,90
400 DATAFB,85,02,A5,02,0A,85,02,A0,01,90,02,A0,03,A9,11,8D,04,D4,EA,EA,EA,EA,EA
410 DATAEA,EA,EA,EA,EA,EA,EA,EA,A9,01,8D,01,DD,20,A8,03,A9,00,8D,04,D4,8D,01,DD
420 DATAA0,01,20,A8,03,C6,FB,D0,CA,A0,02,20,A8,03,60,98,0A,0A,A8,A5,FC,A2,FA
430 DATACA,D0,FD,38,E9,01,D0,F6,88,D0,F1,60,A0,04,20,A8,03,60,73,31,55,32,3F,2F
440 DATA27,23,21,20,30,38,3C,3E,2A,45,80,36,80,4C,80,05,18,1A,0C,02,12,0E
450 DATA10,04,17,0D,14,07,06,0F,16,1D,0A,08,03,09,11,0B,19,1B,1C
460 DATAAD,FB,03,4C,51,03,ZZ
470 M=M+1
480 GOTO 350
490 X=0
500 IF LEN(X$)=0 THEN 580
510 A1$=LEFT$(X$,1)
520 X1=ASC(A1$)
530 X1=X1-48
540 IF X1>9 THEN X1=(X1)-7
550 X=X*16+X1
560 X$=RIGHT$(X$,LEN(X$)-1)
570 GOTO 500
580 RETURN
590 TH$=LEFT$(TI$,4)
600 PRINT
610 PRINT"------TIME=";TH$;"-------"
620 GOTO 200
630 N=ASC(B$)-132
640 ON N GOTO 650,660,670,680,690,700,710,720
650 AD$=" 73 73 73 ":GOTO 750
660 AD$=" GRID IS ":GOTO 750
670 AD$=" SK ":GOTO 750
680 AD$=" CQ CQ CQ DE WA5DBY WA5DBY WA5DBY K ":GOTO 750
690 AD$=" RST IS ":GOTO 750
700 AD$=" QTH IS ":GOTO 750
710 AD$=" NAME IS GERALD GERALD GERALD":GOTO 750
720 AD$=" RIG HERE IS ":GOTO 750
740 PRINT "⊐"
750 X=1
760 B$=MID$(AD$,X,1)
770 X=X+1
780 IF X=LEN(AD$)+2 THEN GOTO 200
790 POKE 1019,ASC(B$):POKE 56579,255
800 SYS 1009
810 PRINT B$;
820 GOTO 760
830 PRINT "⊐":INPUT" FAR-1,CEL-2";H:PRINT
840 ON H GOTO 850,880
850 INPUT " DEG. FAR";FA:PRINT
860 CE=INT((FA-32)*5/9)
870 PRINT " FAR";FA,"= CEL";CE:PRINT:GOTO 200
880 INPUT " DEG. CEL";CE:PRINT
890 FA=INT (CE*9/5+32)
900 PRINT " CEL";CE,"= FAR";FA:GOTO 200
910 GOTO 200
920 PRINT "⊐"
930 PRINT "FREQ. ALLOC-EXTRA"
940 PRINT
950 PRINT "10 PH.","28500-29700"
960 PRINT "10 CW.","28000-29700"
965 PRINT
970 PRINT "15 PH.","21250-21450"
980 PRINT "15 CW.","21000-21450"
985 PRINT
990 PRINT "20 PH.","14200-14350"
1000 PRINT "20 CW.","14000-14350"
```

```
1005 PRINT
1006 PRINT "30 CW.","10100-10109 AND"
1007 PRINT "            10115-10150"
1008 PRINT
1010 PRINT "40 PH.","7150-7300"
1030 PRINT "40 CW.","7000-7300"
1040 PRINT
1050 PRINT "80 PH.","3775-4000"
1060 PRINT "80 CW.","3500-4000"
1065 PRINT
1066 PRINT "160 PH.","1800-2000"
1067 PRINT "160 CW.","1800-2000"
1068 PRINT
1070 GOTO 200
1080 PRINT "♥":GOTO 200
1090 PRINT "♥"
1100 INPUT " CODE SPEED";CC:PRINT:PRINT
1110 CS=225/CC:POKE 252,CS
1120 PRINT " 1=LTRS,NUMS,PUNCT":PRINT
1130 PRINT " 2=LTRS, NUMS":PRINT
1140 PRINT " 3=LTRS ONLY":PRINT
1150 INPUT " YOUR SELECTION";PS
1160 CT=1:PRINT:PRINT:PRINT
1170 PRINT " 1=RANDOM SPACING":PRINT
1180 PRINT " 2=5 CHAR. GROUPS":PRINT
1190 INPUT " YOUR SELECTION";SS
1200 PRINT "♥"
1205 PRINT "HIT <RUN STOP>":PRINT"THEN TYPE <RUN 120> TO RESTART":PRINT:PRINT
1210 IF SS=1 THEN ZR=INT(RND(0)*10)
1220 IF SS=2 THEN ZR=5
1230 FOR T=1 TO ZR
1240 ON PS GOTO 1250,1280,1310
1250 RN=INT((RND(0)*47)+44)
1260 IF RN>57 AND RN<63 OR RN=64 THEN 1250
1270 GOTO 1320
1280 RN=INT((RND(0)*43)+48)
1290 IF RN>57 AND RN<65 THEN 1280
1300 GOTO 1320
1310 RN=INT((RND(0)*26)+65)
1320 PRINT CHR$(RN);:CT=CT1
1330 POKE 1019,RN
1340 POKE 56579,255
1350 SYS 1009
1360 NEXT T
1370 PRINT " ";:RN=32
1380 POKE 1019,RN
1390 SYS 1009
1400 IF CT>200 THEN 1420
1410 GOTO 1210
1420 PRINT:PRINT:PRINT " 200 CHARACTERS SENT."
1430 PRINT " CHECK YOUR COPY.":PRINT
1440 PRINT " 1=ANOTHER SESSION":PRINT
1450 PRINT " 2=QUIT":PRINT
1460 INPUT " YOUR SELECTION";YQ
1470 ON YQ GOTO 1090,110
1480 END
```

```
10 PRINT CHR$(144):POKE 53280,4:POKE 53281,4
100 DIM A(6)
110 DIM N$(20)
120 DIM O$(20)
150 PRINT CHR$(147)
180 PRINT:PRINT
190 PRINT TAB(7);"MAIDENHEAD LOCATOR CONVERTER"
195 PRINT TAB(7);"MODIFIED FOR C-64 BY  WA5DBY"
200 PRINT:PRINT:PRINT
210 PRINT
220 PRINT"TYPE <E> TO EXIT TO BASIC"
230 PRINT:PRINT
240 PRINT "TYPE <L> FOR LOCATOR TO"
245 PRINT "LATITUDE/LONGITUDE CONVERSION"
250 PRINT:PRINT
260 PRINT "TYPE <D> FOR LATITUDE/LONGITUDE"
265 PRINT "TO LOCATOR CONVERSION"
268 PRINT:PRINT:PRINT
270 PRINT
280 INPUT "WHAT IS YOUR CHOICE";X$
300 IF X$ <> CHR$(69) THEN GOTO 360
350 STOP
360 IF X$="L" THEN GOTO 400
365 IF X$="D" THEN GOTO 940
367 GOTO 270
400 PRINT CHR$(147):PRINT TAB(10);"MAIDENHEAD LOCATOR TO"
405 PRINT TAB(7);"LATITUDE/LONGITUDE CONVERTER"
410 PRINT:PRINT:PRINT
470 PRINT "THE COMPLETE LOCATOR IS SPECIFIED AS"
480 PRINT "'AANNAA', WHERE 'AA' IS COMPRISED OF 2"
490 PRINT "ALPHABETIC CHARACTERS AND 'NN' IS"
495 PRINT "COMPRISED OF 2 DECIMAL DIGITS.":PRINT:PRINT
500 PRINT "'AANNAA' PRODUCES THE CENTER OF THE"
505 PRINT "SUBGRID LOCATION.":PRINT
510 PRINT "'AANN' PRODUCES THE CENTER OF THE GRID"
515 PRINT "SQUARE.":PRINT
520 PRINT "AN <R> RETURNS YOU TO THE MASTER MENU."
525 PRINT "HIT ANY OTHER KEY TO CONTINUE."
530 PRINT:PRINT
550 INPUT "WHAT IS YOUR CHOICE";Z$
555 IF Z$="R" THEN GOTO 150
560 PRINT
660 INPUT "LOCATOR (AANNAA)";A$
670 X$=A$
680 L1=LEN(A$)
690 IF L1<>0 THEN GOTO 710
700 GOTO 200
710 IF L1=2 THEN GOTO 720
711 IF L1=4 THEN GOTO 720
712 IF L1=6 THEN GOTO 720
713 GOTO 660
720 IF L1<4 THEN GOTO A$=A$+"44"
730 IF L1<6 THEN A$=A$+"LL"
740 FOR K=1TO6
750 A(K)=ASC(MID$(A$,K,1))
760 NEXT K
790 L9=-90+(A(2)-65)*10+A(4)-48+(A(6)-64.5)/24
800 L9=L9+.005
810 IF L1<4 THEN L9=L9+.500
820 IF L1<6 THEN L9=L9+.020
840 G9=-180+(A(1)-65)*20+(A(3)-48)*2+(A(5)-64.5)/12
850 G9=(G9+.0005)*(-1)
860 IF L1<4 THEN G9=G9-1.000
```

```
870 IF L1<6 THEN G9=G9-.041
890 A$=A$(1,L1)
900 PRINT:PRINT:PRINT:PRINT
910 PRINT X$;" IS CENTERED":PRINT "AT ";L9;" LATITUDE"
915 PRINT "AND ";G9;" LONGITUDE."
920 PRINT:PRINT:INPUT "HIT ANY KEY TO CONTINUE";X$
930 GOTO 150
940 PRINT:PRINT
960 PRINT CHR$(147):PRINT TAB(10);"LATITUDE/LONGITUDE TO"
965 PRINT TAB(7);"MAIDENHEAD LOCATOR CONVERTER"
1000 PRINT:PRINT:PRINT
1010 PRINT "PRECEDE SOUTH LATITUDE OR EAST LONGITUDE";
1020 PRINT "DEGREES WITH A MINUS SIGN.  ENTER"
1030 PRINT "DEGREES, MINUTES, AND SECONDS FOR"
1040 PRINT "BOTH LATITUDE AND LONGITUDE ENTRIES."
1050 PRINT "TO RETURN TO THE MASTER MENU RESPOND TO"
1055 PRINT "THE ENTER QUERY WITH <R>."
1060 PRINT:PRINT
1150 PRINT "ENTER LOCATION, NAME, OR CALL SIGN":INPUT N$
1155 IF N$="R" THEN GOTO 150
1160 IF N$ <> "" THEN GOTO 1180
1170 GOTO 200
1180 PRINT
1190 INPUT "LATITUDE DEGREES";L$
1200 INPUT "LATITUDE MINUTES";M$
1205 INPUT "LATITUDE SECONDS";S$
1210 IF L$="" THEN L=0
1215 IF L$<>"" THEN L=VAL(L$)
1220 IF M$="" THEN M=0
1225 IF M$<>"" THEN M=VAL(M$)
1230 IF S$="" THEN S=0
1235 IF S$<>"" THEN S=VAL(S$)
1250 PRINT
1270 INPUT "LONGITUDE DEGREES";G$
1280 INPUT "LONGITUDE MINUTES";H$
1290 INPUT "LONGITUDE SECONDS";I$
1300 IF G$="" THEN G=0
1305 IF G$<>"" THEN G=VAL(G$)
1310 IF H$="" THEN H=0
1315 IF H$<>"" THEN H=VAL(H$)
1320 IF I$="" THEN I=0
1325 IF I$=<>"" THEN I=VAL(I$)
1350 L8=L+(M/60)+(S/3600)
1360 G8=G+(H/60)+(I/3600)
1370 L1=L8
1380 G1=G8
1400 G4=(180-G1)/20
1410 C=INT(G4)
1420 M$=CHR$(C+65)
1440 R=(G4-C)*10
1460 C=INT(R)
1480 R$=CHR$(C+48)
1500 M=(R-C)*24
1530 C=INT(M)
1550 V$=CHR$(C+65)
1580 L4=(L1+90)/10
1590 C=INT(L4)
1600 T$=CHR$(C+65)
1620 R=(L4-C)*10
1640 C=INT(R)
1660 F$=CHR$(C+48)
1680 M=(R-C)*24
1700 C=INT(M)
1720 S$=CHR$(C+65)
1730 M$=M$+T$+R$+F$+V$+S$
1740 X=LEN(N$)
```

```
5 REM MODIFIED FOR C-64 BY WA5DBY
10 M=255
20 DIM A$(M)
30 FOR I=1 TO M
31 A$(I)="*"
32 NEXT I
40 INPUT "CALL";I$
50 REM HASH CALL
60 H=0
70 FOR J=1 TO LEN(I$)
80 H=H+ASC(MID$(I$,J))
90 NEXT J
100 H=H-INT(H/M)*M
110 REM DUP CHECK
120 IF A$(H)<>"*" THEN 130
121 A$(H)=I$
122 GOTO 40
130 IF A$(H)=I$ THEN 170
140 H=H+1
150 H=H-INT(H/M)*M
160 GOTO 120
170 PRINT "DUPE CALL"
180 GOTO 40
190 END

READY.
```

```
1750 IF X>19 THEN GOTO 1790
1760 FOR X1=X TO 20
1770 B$=B$+"."
1780 NEXT X1
1785 PRINT:PRINT:PRINT:PRINT
1790 IF P1<>1 THEN 1810
1800 PRINT B$;" LOCATOR IS ";M$:PRINT "AT ";L8;" LATITUDE"
1805 PRINT "AND ";G8;" LONGITUDE"
1810 PRINT N$;" LOCATOR IS ";M$:PRINT "AT ";L8;" LATITUDE"
1812 PRINT "AND ";G8;" LONGITUDE"
1815 PRINT:PRINT
1820 INPUT "HIT ANY KEY TO CONTINUE";X$
1830 GOTO 150
1900 END
```

1296 to X BAND SYSTEM

by

Chip Angle, N6CA

1296 - X BAND SYSTEM

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LOMITA, CA 90717
213-5395395

THE FOLLOWING ARE GENERAL NOTES ON A MULT-BAND SYSTEM FOR CW/SSB ON 1296 THRU 10368 MHz. THE APPROACH TAKEN MINIMIZES BUILDING REQUIREMENTS BY USING AS MUCH COMMONALITY AS POSSIBLE IN THE LOCAL OSCILLATOR CHAIN. TWO SCHEMES ARE SHOWN. THE FIRST IS UNDER CONSTRUCTION AND IS THE MOST VERSATILE AS BANDS CAN BE ADDED EASILY AND OPERATION ON 1296 & 2304 REQUIRE. LESS CONSTRUCTION INITIALLY.

SPLIT FREQ OPERATION AT 2304/2320 IS MOST EASILY ACCOMPLISHED BY ADDING A 304 TO 28.1 CONVERTER. THIS IS OBVIOUSLY MUCH PREFERED OVER BUILDING A NEW 2GHz LO.

OPERATION AT 3312 IS DESIRED DUE TO COMMONALITY WITH LO SCHEME. THERE IS NO REASON TODAY TO STAY ON MULTIPLES OF 144 MHz. 3456 MHz OPERATION IS OK BUT HOW MANY PEOPLE ARE USING 144 MHz MULTIPLIED TO 3456?. THINK ABOUT IT.

GaAs FET MULTIPLIERS A SUPERIOR APPROACH COMPARED TO DIODES. THEY GIVE STABILITIES AN ORDER OF MAGNITUDE OVER ANY OTHER MULTIPLIER. THESE GaAs FET MULTIPLIERS ARE USED ON ALL BANDS

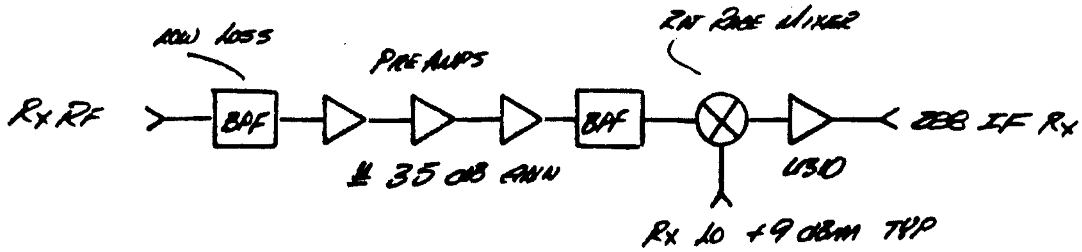
ABOVE 2304. THEY ALSO GIVE SEVERAL dB OF GAIN WHILE MULTIPLYING. THEIR DRIVE LEVELS ARE 0 TO +3dBm ELIMINATING THE NEED FOR HI LEVEL DIODE DRIVERS.

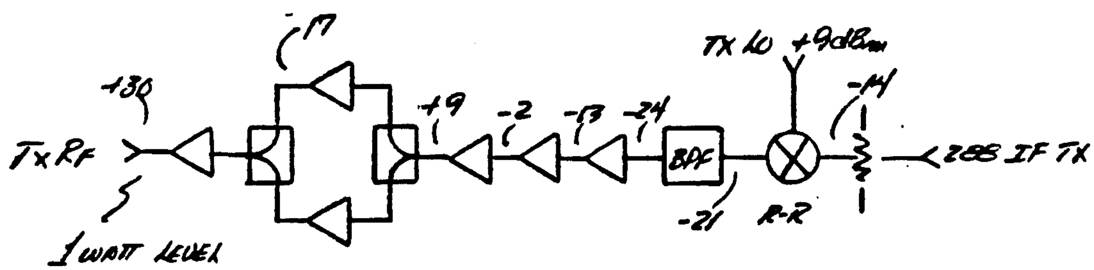
TWO OF THESE SYSTEMS ARE UNDER CONSTRUCTION AND EXACT DESIGN DETAILS WILL BE MADE AVAILABLE TO INTERESTED INDIVIDUALS.

NEW DEVICES ON THE MARKET HAVE MADE LINEAR L & S BAND TRANSMIT AMPS MUCH EASIER TO BUILD. IN PARTICULAR THE MOTOROLA MRF 57/37. IT COSTS $1.38 EA IN SINGLE PIECE PRICE AND GIVES THE FOLLOWING PERFORMANCE:

	GAIN	1dB COMP PT	VSWR IN & OUT
1296	12 dB	+24	< 1.2:1
2304	9 dB	+23	< 1.5:1

THESE WERE MEASURED ON G-10 (FR-4) BOARD. THEY ARE UNCONDITIONALLY STABLE. THEY MAKE SUPER TX AMPS UP TO THE 100 TO 200 MILLIWATT LEVELS. THE $6 VERSION WILL GIVE ABOUT 2½ TO 5 dB MORE GAIN BUT THATS NOT REALLY NECESSARY AT 1296/2304

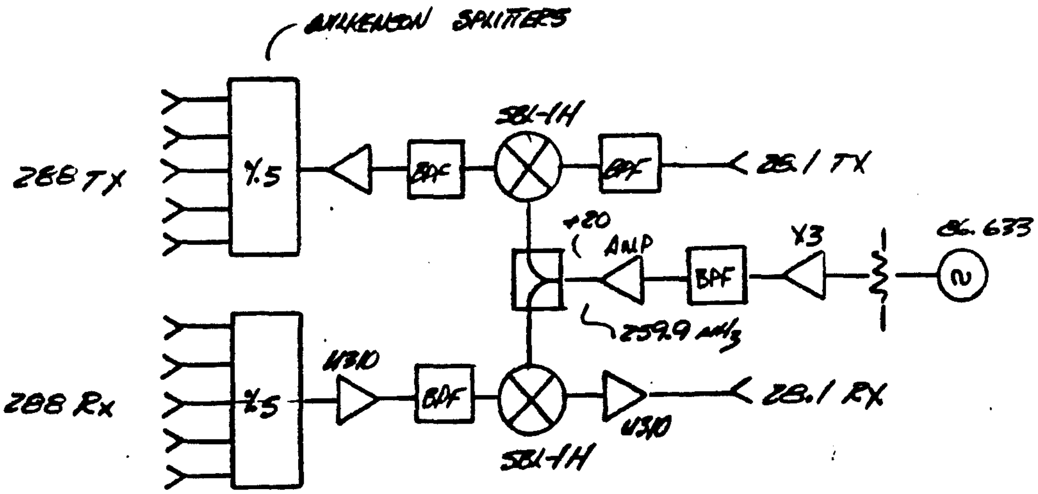




TYPICAL Rx & Tx SCHEMES

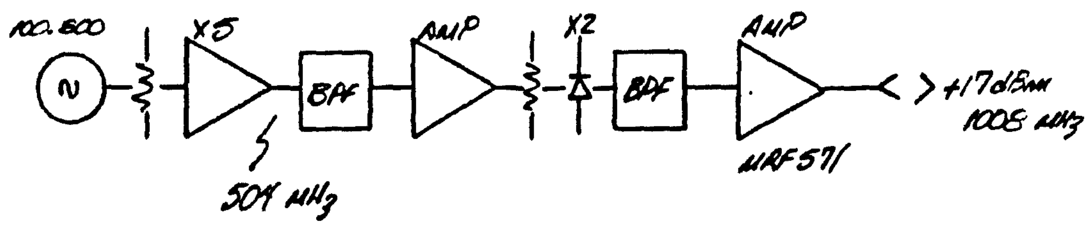
THESE LEVELS HAVE BEEN TESTED AT 1296 & 2304 AND YIELD IMD_3 PRODUCTS AT > -45 dBc AT 1 WATT OUTPUT.

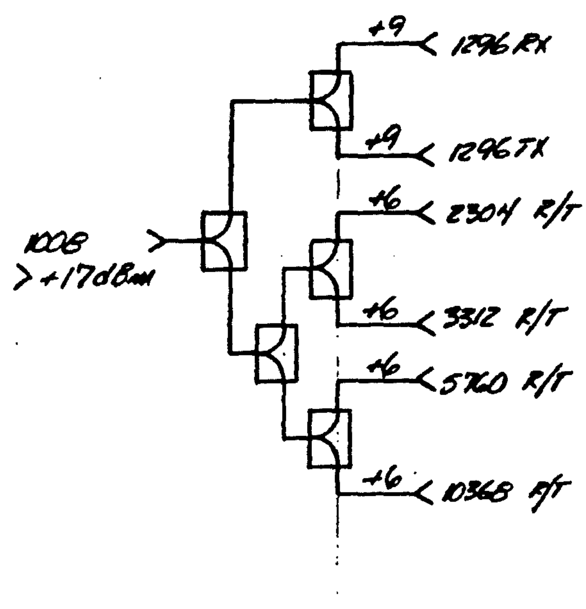
9-15-85 N6CA



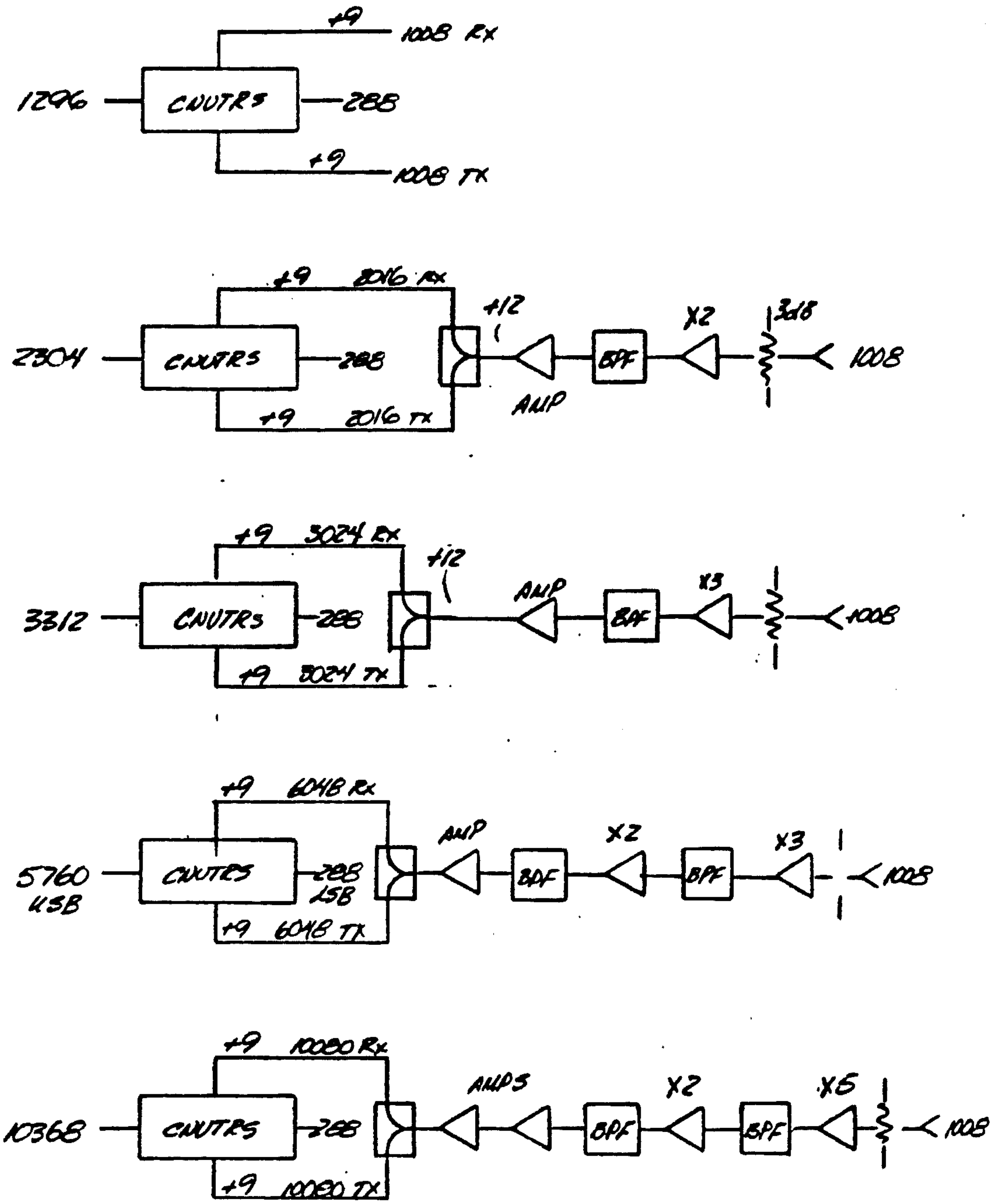
288/28.1 UP & DOWN IF CONVERTER

9-15-85 N6CA

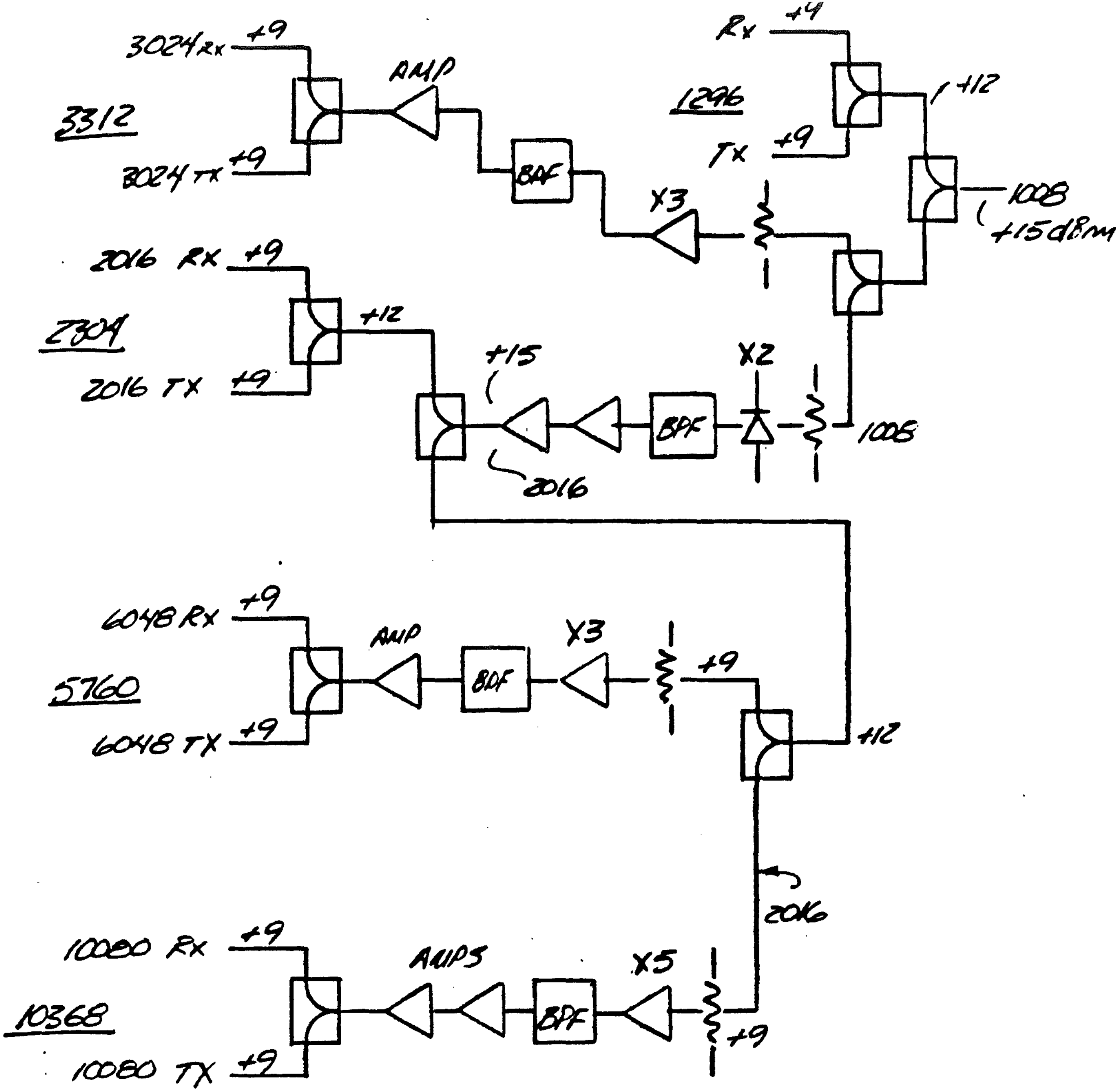

100.800
X5
504 MHz
BPF
AMP
X2
BPF
AMP
MRF571
+17dBm
1008 MHz


1008
+17dBm
+9
1296 RX
+9
1296 TX
+6
2304 R/T
+6
3312 R/T
+6
5760 R/T
+6
10368 R/T

9-15-85 N6CA


+9
1008 RX
1296
CNVTRS
288
+9
1008 TX
+9
2016 RX
+12
X2
3dB
2304
CNVTRS
288
BPF
1008
+9
2016 TX
AMP
+9
3024 RX
+12
AMP
X3
3312
CNVTRS
288
BPF
1008
+9
3024 TX
+9
6048 RX
AMP
X2
X3
5760
USB
CNVTRS
288
LSB
BPF
BPF
1008
+9
6048 TX
+9
10080 RX
AMPS
X2
X5
10368
CNVTRS
288
BPF
BPF
1008
+9
10080 TX

9-15-85 N6CA



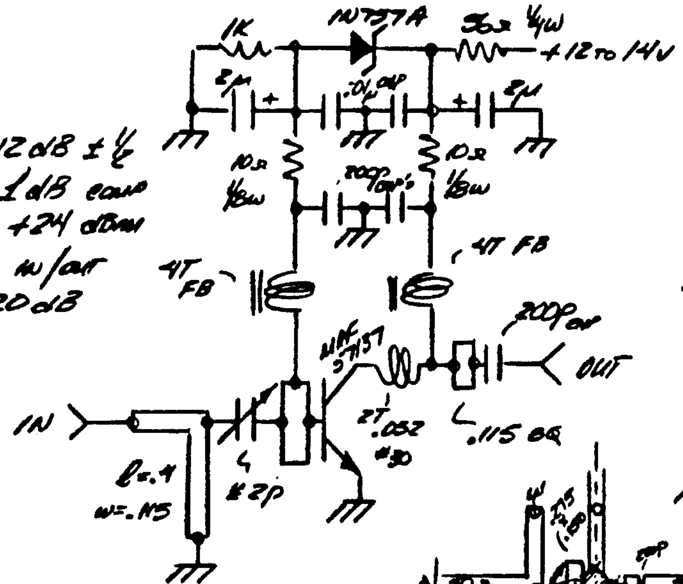
ALTERNATE SCHEME

NOTICE - THERE IS NO REAL ADVANTAGE TO USING THIS SCHEME. THE ADVANTAGE TO THE FIRST APPROACH IS ALL SPLITTING IS DONE AT 1008 INSTEAD OF 2016.

9-15-85 N6CA

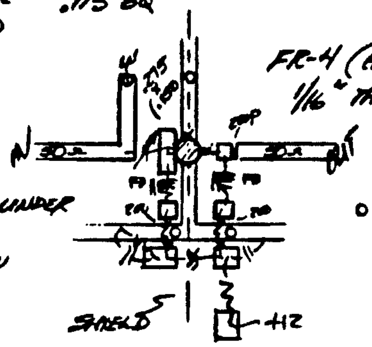
N6CA
9-16-85

GAIN = 12 dB ± ½
OUTPUT 1 dB COMP PT = +24 dBm
RTN LOSS IN/OUT => 20 dB



1296 TX AMP
MRF 57/37
+13V @ 50 TO 60 mA

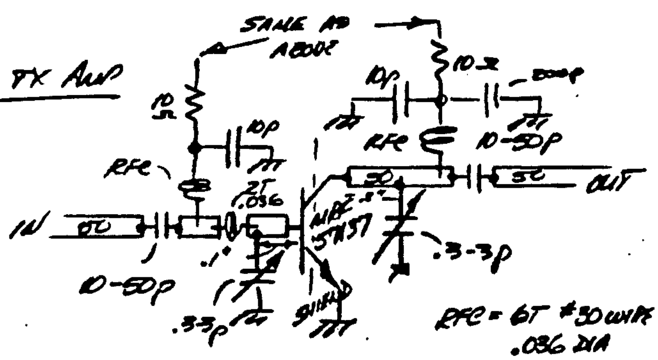
FR-4 (G-10) BOARD
1/16" THK, FULL ground
BK SIDE



O = ground EYELET

- USE COPPER RIBBON UNDER EACH EMITTER LEAD
- TRANSISTOR MOUNTS IN 3/16 DIA HOLE.

2304 TX AMP



RFC = 6T #30 WIRE .036 DIA

ALL 10p, 200p & .01µ ARE CHIP CAPS.

GAIN = 8¾ ± ¼ dB
1 dB COMP PT +23 dB
RTN LOSS IN/OUT >15 dB

SHIELDS ARE REQ'D TO ELIMINATE FEED BACK IN CASCADED STAGES.
3/4" HEIGTH