MIKE — THIS WAS THE FIRST ACCURATE DESCRIPTION OF RHOMBICS FOR TV — 1951 BOB C

RHOMBIC TV ANTENNAS

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Rhombic TV Antennas

Unlike the conventional type of TV antennas which use aluminum tubing and other material that can only be made in a modern factory, this type of antenna uses ordinary copper wire, insulators and poles, and is put up in much the same manner as the ordinary outside radio antenna which has been built by millions of people in the past twenty years. In addition, this type of antenna will have far more pickup, and, although the performance will be slightly better on the channel it is designed for, the performance on all other channels (in either the high or low band depending on which it is built for) will be down only very slightly. The antenna will also practically eliminate all pickup from other stations giving interference from the rear on the same channel.

The ordinary radio antenna consisted of a piece of wire of random lengths stuck up most any place and usually the stations were strong enough or close enough so that good performance resulted. In the case of television, the transmission of pictures demands a much larger signal with less noise for satisfactory operation. This is accomplished by using exact lengths of wire arranged in a specified shape resulting in an antenna that will have far more pickup than the conventional dipole type TV antenna.

CHOOSING THE LOCATION:

The ideal location is one which is in the clear without any objects in line with the antenna to the station. Since this is a condition impossible to obtain in most cases, a choice should be made that as closely as possible approaches this ideal condition. The primary consideration is to attempt to locate it so that as clear a space as possible is to the front of the antenna; that is, so that trees, buildings, and other objects are not in the way. In many cases the antenna can be made tall enough so that it will clear the objects. The second consideration is to locate the supports so that the wires will be as far as possible away from power lines, telephone lines, trees and buildings. The antenna will work even though surrounded by these obstacles; however, the more in the clear, the better the performance. The antenna should be located so that the wire part of the antenna is level. In the case of small humps and small grades this can be done by making the poles of different lengths to compensate for the uneven ground so that the resulting antenna is level on top. The location of traveled roads should be taken into consideration because of the ignition type of interference. Roads to the back of the antenna will have less effect than those to the front or side because of the high directivity of this type of antenna. In many cases it might be better to make the transmission line fifty feet longer in order to get the antenna further away from a road, a high-tension line, or other objects apt to cause interference.

ANTENNA HEIGHTH:

The taller the antenna the greater the pickup will be, and the less will be the effect of interference. In most cases if the antenna can be made of sufficient heighth so that it is ten to fifteen feet above surrounding objects, very good performance will be obtained. In some cases 30 feet will accomplish this, and in other cases a heighth of 45 feet may be necessary. Regardless of heighth the antenna will have pickup, but the taller it is built the better the operation will be, and in areas of weak signals (forty or more miles from the station in most localities) 30 feet and higher will be a requisite for satisfactory performance. The additional heighth will also lessen the effects of fading.

ANTENNA SUPPORTS:

The ideal support is telephone or power poles. In practically all communities poles of all heighths can be purchased. In many cases arrangements can be made with whoever the poles are purchased from to set them in place. People are so used to seeing telephone poles and power poles all over the country that they are taken for granted, and for this reason are not as conspicuous as other type poles might be. They have the further advantage that only a minimum of guying is necessary. In many cases the antenna can be laid out so that one end can be supported by a small pole (2 by 2, or 2 by 3 guyed in place) on top of the house, another one on the garage, the third on the barn, and a pole for the fourth support. In the case of business places it is, in most cases, possible to lay out the entire antenna on the tops of stores and office buildings. Various types of steel and aluminum towers can also be purchased from radio supply houses. Sturdy poles for use up to forty feet can be built using four lengths of two by three timbers for each pole. Two of the lengths should be cut to 18 feet and the other two to 22 feet. The pole is then assembled by placing an 18 foot and a 22 foot length end to end. The other two lengths are laid end to end in the same manner but reversed so that the joints are staggered. The two 40 foot lengths are then bolted together, with the flat sides facing each other, using short pieces of two by threes for spacers. Pieces about six inches long should be used at each end and ten feet from each end. In the center where the joints will occur three foot pieces should be used. The entire pole should be painted two coats using aluminum or white house paint. A pole of this type must be guyed in three places: 3, 15, and 26 feet from the top. There should be three guys at each point — two to the back and one guy to the front. The top guys should be broken up with two strain insulators in each wire. The first spaced 2½ feet from the pole and the second 7½ feet from the pole.

ANTENNA SIZE:

The larger the antenna the greater the pickup will be, and the more directional the antenna becomes. In the case of extreme fringe area reception, the largest possible size that can be put in the available space should be used. Adding the second bay to the antenna will double the power pickup. A two-bay medium size antenna will have about the same pickup as an extra large size single bay antenna. Although not shown, it is possible to go further and add a third bay. In this event the same spacing is used as between the first two bays. The connections are made between the second and third bay the same as between the top two. A transposition block should be used so that the connections are reversed between the two lower bays the same as between the top and middle bay. A three-bay antenna of this type in the extra large size will have a power gain of more than 100 over a conventional dipole antenna. In many localities there will be stations operating on more than one channel. In this case a choice will have to be made as to the channel for which it is to be designed. In making this choice the fact should be considered that a rhombić antenna is inherently very broadband, and will work very satisfactorily over a frequency range as high as two to one. In other words, a rhombic designed for any one channel in the low band will work with very little, if any, loss in pickup over the entire low band. Where there is only one channel involved the antenna should be cut for that channel, and in the case of two or more stations, it should be cut to the channel of the weakest station. In some cases it may be found that where only one channel is received a suitable length or size in the four sizes given will not fit the available space, or on building or supports available. In this case a size for either a channel lower or higher could be used with only negligible loss in pickup. Where stations are received on both low (channels 2, 3, 4, 5, 6) and high (7, 8, 9, 10, 11, 12, 13) bands, because of the wide difference in frequency, it will be necessary to build two antennas. In most cases a high-band antenna could be strung inside the low-band antenna using the same supports. It would be far enough inside so as not to affect the operation of the low band. Rope or some other non-conductor must be used for supports, and of course a separate lead-in would have to be run into the set, and a double pole double throw switch used to connect the set to whichever antenna is desired.

TRANSMISSION LINE:

The conventional type twin lead transmission line has about ten times the loss of an open wire line at the frequencies involved in TV reception. It is for this reason that in the case of long runs an open wire transmission line should be used in order to minimize this loss. As a general rule for runs over 100 feet an open wire line should be used; unless the antenna is located close enough to the station so that considerable loss can be tolerated. There are actual rhombic antenna installations in use with transmission lines of the open type over 1000 feet in length. With the use of a long open line it is possible to locate the antenna in an open field a long way from the buildings or on top of a high hill in order to take advantage of a much better location, or find available space, or to get on the other side of hills, trees, or buildings in line with the stations. The transmission line in all cases should be kept as much as possible away from power lines, roads or other sources of interference.

MATERIALS:

Wire — Each type of antenna wire on the market has certain advantages and disadvantages. Considering all factors, the following types are listed in the order of their preference.

1. Copperweld No. 12 or 14. This type of wire has a steel center to prevent stretching, is copper coated for better conductivity, and usually enamel covered to prevent corrosion.

2. Enameled hard drawn copper preferably No. 12, but 14 can be used in all but the extra large size antenna.

3. Stranded enameled antenna wire. The heavier sizes preferred.

4. Stranded tinned copper antenna wire.

5. Stranded bare copper wire.

6. Enameled soft drawn copper wire. This is commonly called magnet wire. This has the disadvantage of stretching too easily, but can be used if it will support itself.

7. Aluminum clothes line wire.

Insulators — Four inch ceramic type are the best. E. F. Johnson type 104 or similar. Small receiving glass type can be used with the smaller sizes with number 14 wire, but are apt to break under severe weather conditions.

Guy Wire — Galvanized No. 9 steel wire, or preferably stranded steel wire. No. 12 can be used on short light poles such as two by twos.

Pulleys — Small galvanized type commonly called awning pulleys. These should be of a size suitable for ¼ inch manila rope.

Rope — ¼ inch pure manila. Soak in raw linseed oil if maximum weatherproofing is desired.

Feeder Spreaders — There are numerous types on the market — both of the plastic and ceramic type. The plastic type have the advantage of being lighter in weight, but not quite as strong as the ceramic type. In the case of the line between the two bays they should be of the 4 inch size. If used for an open wire transmission line they can be either 2 or 4 inch type. However in the case of a high band antenna, or where the line must pass through a zone of high noise level, the line should be spaced two inches. The plastic type spreaders have a definite advantage for transmission lines because of their light weight.

Terminating Resistors — 390 ohm—1 or 2 watt carbon type. Most resistors of this value are wire wound, so if in doubt break one and make sure. The wire wound type must not be used.

LOCATING ANTENNA:

This type of antenna is highly directional. The directivity increases as the size is made larger. For this reason it is essential that the antenna be properly aimed at the station if best results are to be obtained. This can be done quite simply with the use of a road map. From the map, determine exactly how many miles due east, then how many miles due north you have to go to reach the station or whatever combination of the four directions you live from the station. The direction in miles is then changed to feet and used to obtain the true direction to the station. It is necessary to obtain true North and South or East and West whatever the case may be. This can be done with a compass, and in this case, allowance must be made for magnetic declination. This can be gotten from the city engineer, county engineer, or from a city map. The north star can also be used, and this is true north. In many cases roads, fence lines, and buildings are laid out either true north and south or east and west, and can be used for a reference line. Figure 1 illustrates how an antenna is laid out at Blue Earth, Minn. to receive Minneapolis. If we go straight East from Blue Earth for 40 miles and then straight North for 100 miles we end up in Minneapolis. This information is obtained from a road map. Now to obtain the center line for the antenna, we start from a point at the back pole of the antenna where the lead-in or transmission line comes from. From this point we go straight East for 40 feet and then straight North for 100 feet. A line from where we started and through the point where we ended will be pointed directly at the station and is the center line for the antenna. Now assume we are to build the large antenna for channel 4. The C dimension is 112' 6''. To this we add 6 feet so that we will have three feet of clearance between the poles and the antenna at each end. Along this center line we measure off 118' 6''. The two end poles will be located this distance apart on the center line. Now the distance between the two end poles is divided in half (59' 3'') at the center line another line is run at right angles. From the chart the B dimension is 55' 4''. To this 6 feet is added, making 61' 4''. Half of this is 30' 8''. To obtain the points for the side poles we go 30' 8'' at a right angle each side of the exact center of the distance between the two end poles as shown in figure 1. The layout can be checked by measuring the A dimension between all four poles. It should be within a few inches of being the same in all four places if the layout is correct. This measured B dimension will be sightly longer than the B dimension which is given in the chart because of the six feet added to each of the other dimensions to give clearance between the poles and the antenna.

CONSTRUCTION PROCEDURE:

1. Construct the poles and fasten the pulleys in place. If of the two-bay type, the pulleys should be spaced on the pole the distance S. Put the rope through the pulleys, and make sure all the guy wires and anchors are in place.

2. Raise the poles and fasten the guy wires to the anchors. A level can be used to make sure the poles are vertical.

3. Two pieces of antenna wire, each equal in length, to twice the distance A are needed for each bay. In the exact center of each piece fasten the side insulators as shown in the side pole detail. Fasten the two pieces together using two insulators at each end. Solder two 390 ohm resistors across the end pointing to the station as shown in terminating pole detail. If a single bay antenna, connect the 300 ohm line (or open wire line if used) across the other end. If constructing the two bay type, connect the two bays together using two wires — each cut to the length S. Place the transposition block in the center so that one wire goes from the inside top to the outside bottom, and the other wire goes from the outside top

to the inside bottom. The transmission line is then connected to the bottom bay at the same points that the wire connecting the two bays together is attached.

4. Raise the antenna into position tightening each rope in turn until the antenna is positioned symetrical between the poles and with very little sag. For maximum performance the wires must be kept taut. This can be done by attaching a two gallon oil can filled with tamped sand at the terminating end pole. This will keep the wires at exactly the same tension regardless of the expansion of the wire due to temperature changes or stretching of the rope.

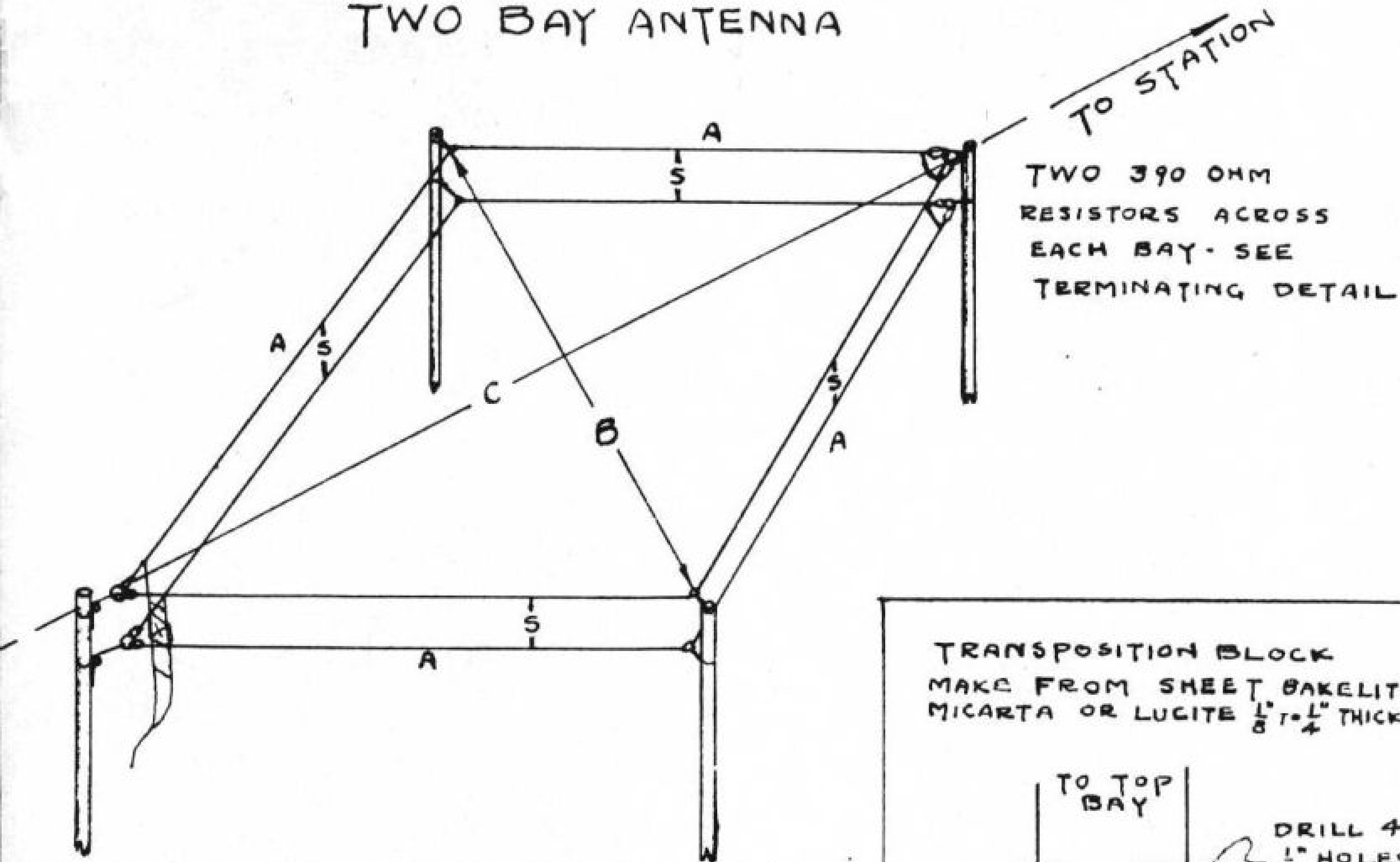
5. Run the transmission line into the house supporting it at necessary intervals to prevent undue strain or excessive sag.

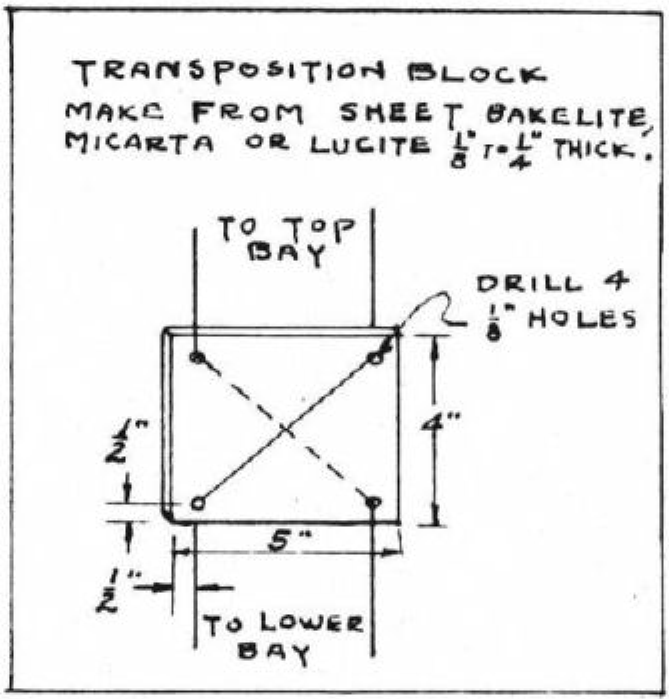
6. Attach a lightning arrestor of the type approved for twin lead at the point where it enters the building. Be sure a good ground is used.

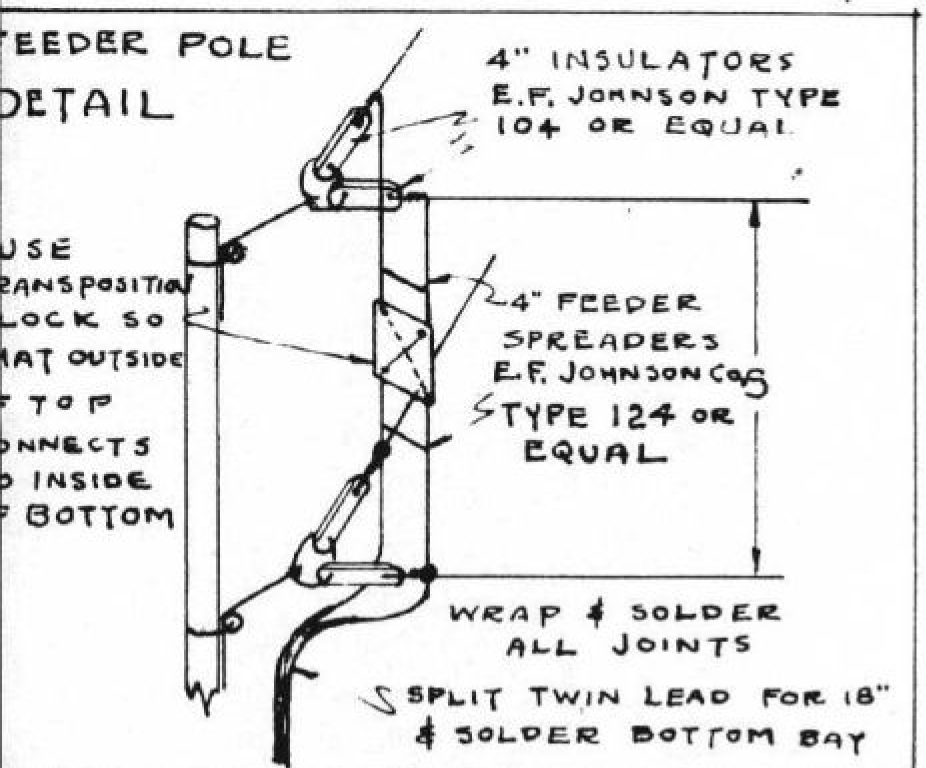
7. If intereference is experienced from stations to the rear on the same channel, the attenuation to the back can be varied by using different values of terminating resistors. Since the ordinary carbon resistor has an accuracy of 10 or 20 percent, different ones of the same marked value can be tried until the interference is at a minimum. The rhombic antenna has a very high front to back ratio, and it will be found that this type of interference will be much less than with the conventional di-pole type antenna.

Typical Two bay Rhombic TV antenna at Lakota, Iowa 117 airline Miles from WTCN TV KSTP TV Minneapolis St Paul Minn.

TWO BAY ANTENNA



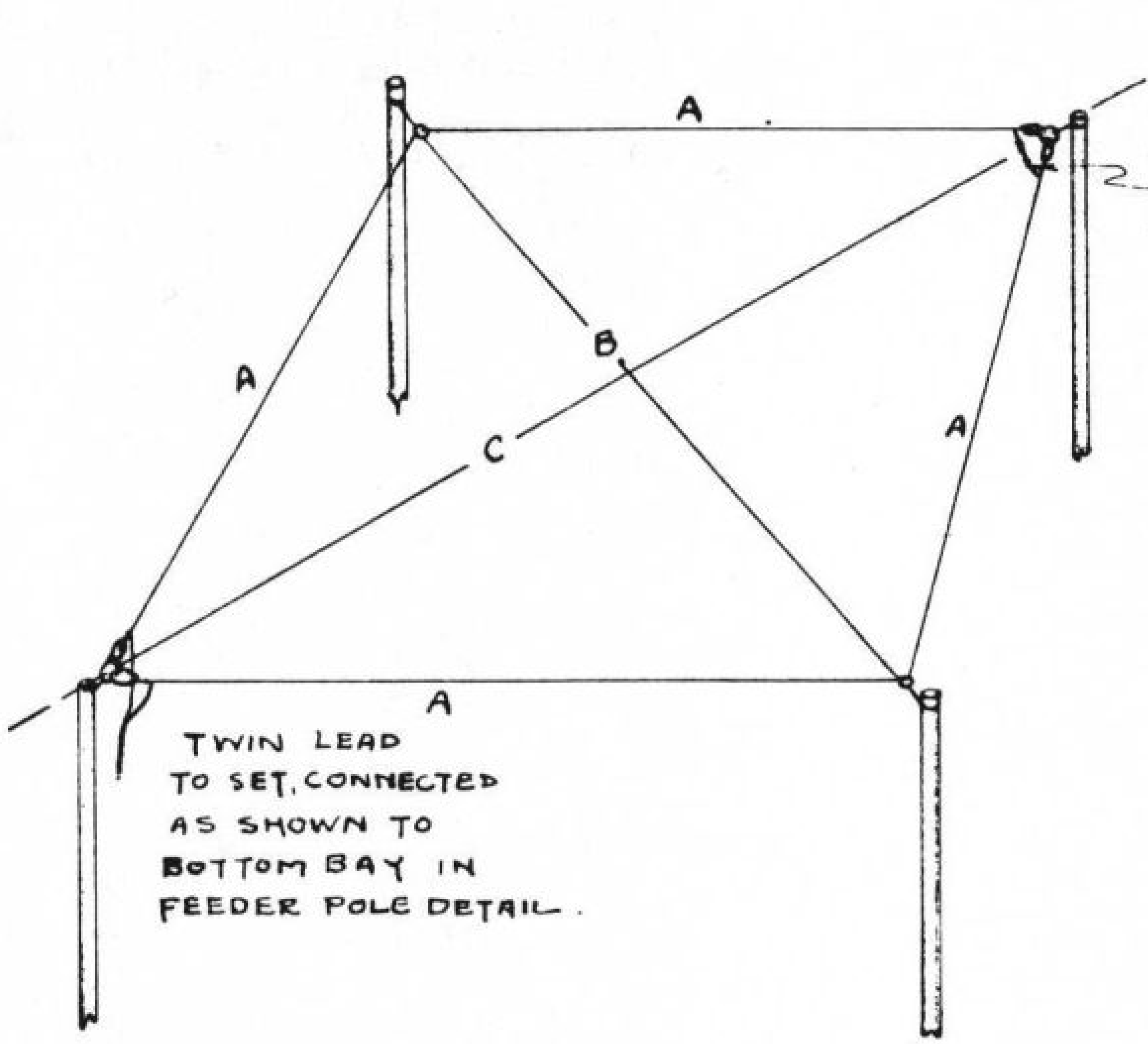




NOTE! SPACING 'S' DOES NOT VARY WITH SIZE OF ANTENNA

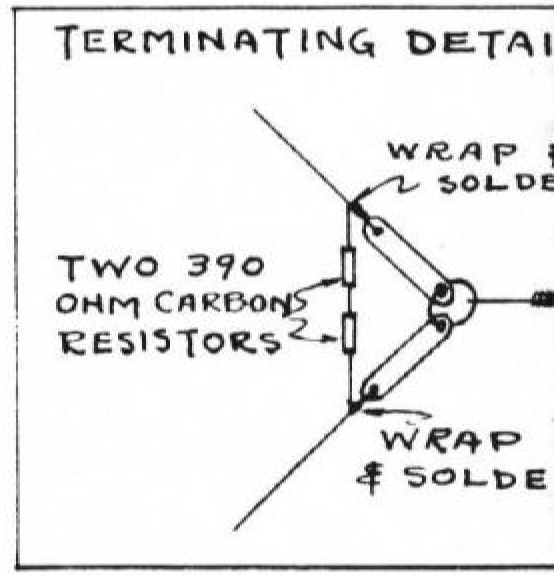
CHANNEL	S
2	107"
3	96½"
4	88"
5	76½"
6	71"
HIGH BAND	30½"

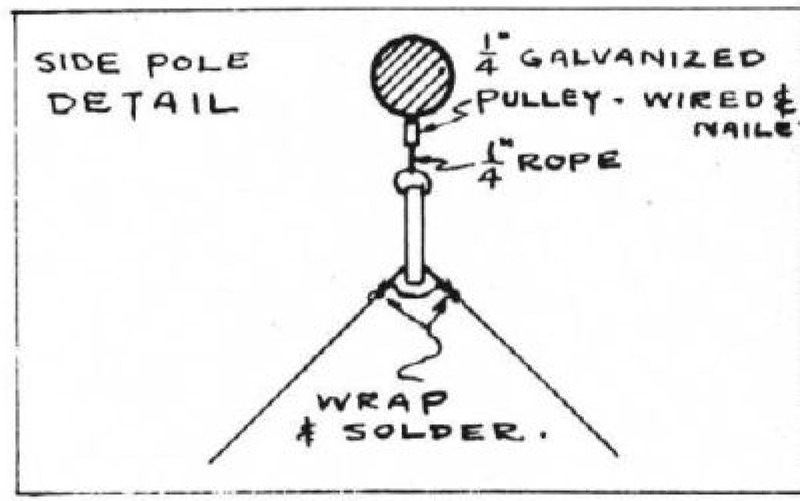
SIZE	CHANNEL 2			3			4			5			6			HIGH BAND		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
SMALL	31'-6"	42'-5"	47'	28'-3"	38'-3"	42'-3"	25'-9"	34'-8"	38'-6"	22'-3"	30'-2"	33'-6"	20'-8"	28'	31'-2"	8'-11"	11'-11"	13'-4"
MEDIUM	49'-3"	54'-9"	82'-9"	44'-5"	48'-3"	74'-8"	40'-5"	44'	68'	35'-2"	38'-4"	59'-2"	32'-7"	35'-6"	54'-11"	14'	15'-4"	23'-7"
LARGE	76'	67'-5"	137'	68'-6"	60'-8"	123'-6"	62'-5"	55'-4"	112'-6"	54'-4"	49'	98'-2"	50'-4"	44'-8"	91'	21'-8"	19'-2"	39'
EXTRA LARGE	101'-8"	80'	188'	91'-9"	72'	169'	83'-5"	65'-6"	154	72'-6"	57'	133'	67'-5"	53'	124'-5"	29'-4"	22'-11"	53'

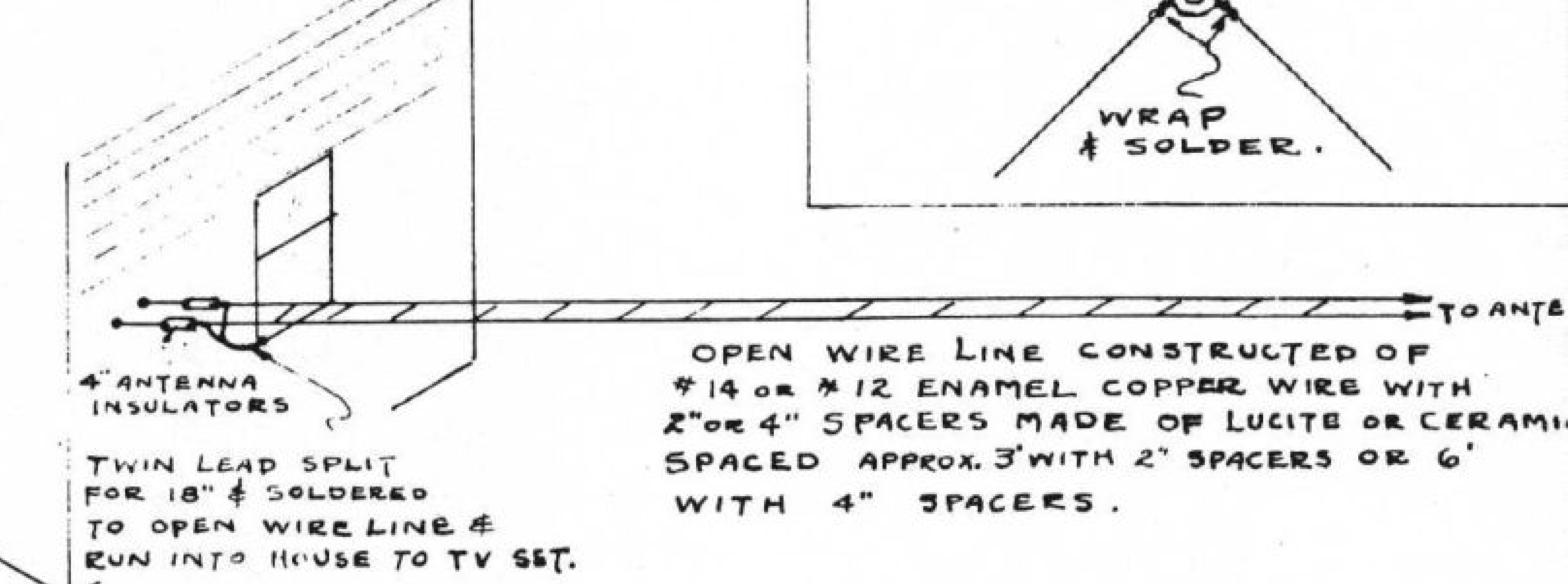


SINGLE BAY ANTENNA

NOTE: A, B, C. DIMENSIONS SAME AS FOR TWO BAY







OPEN WIRE LINE CONSTRUCTED OF #14 OR #12 ENAMEL COPPER WIRE WITH 2" OR 4" SPACERS MADE OF LUCITE OR CERAMI SPACED APPROX. 3' WITH 2" SPACERS OR 6' WITH 4" SPACERS.

OPEN WIRE LINE DETAIL USED IN PLACE OF TWIN LEAD IN CASE OF RUNS OVER 100'

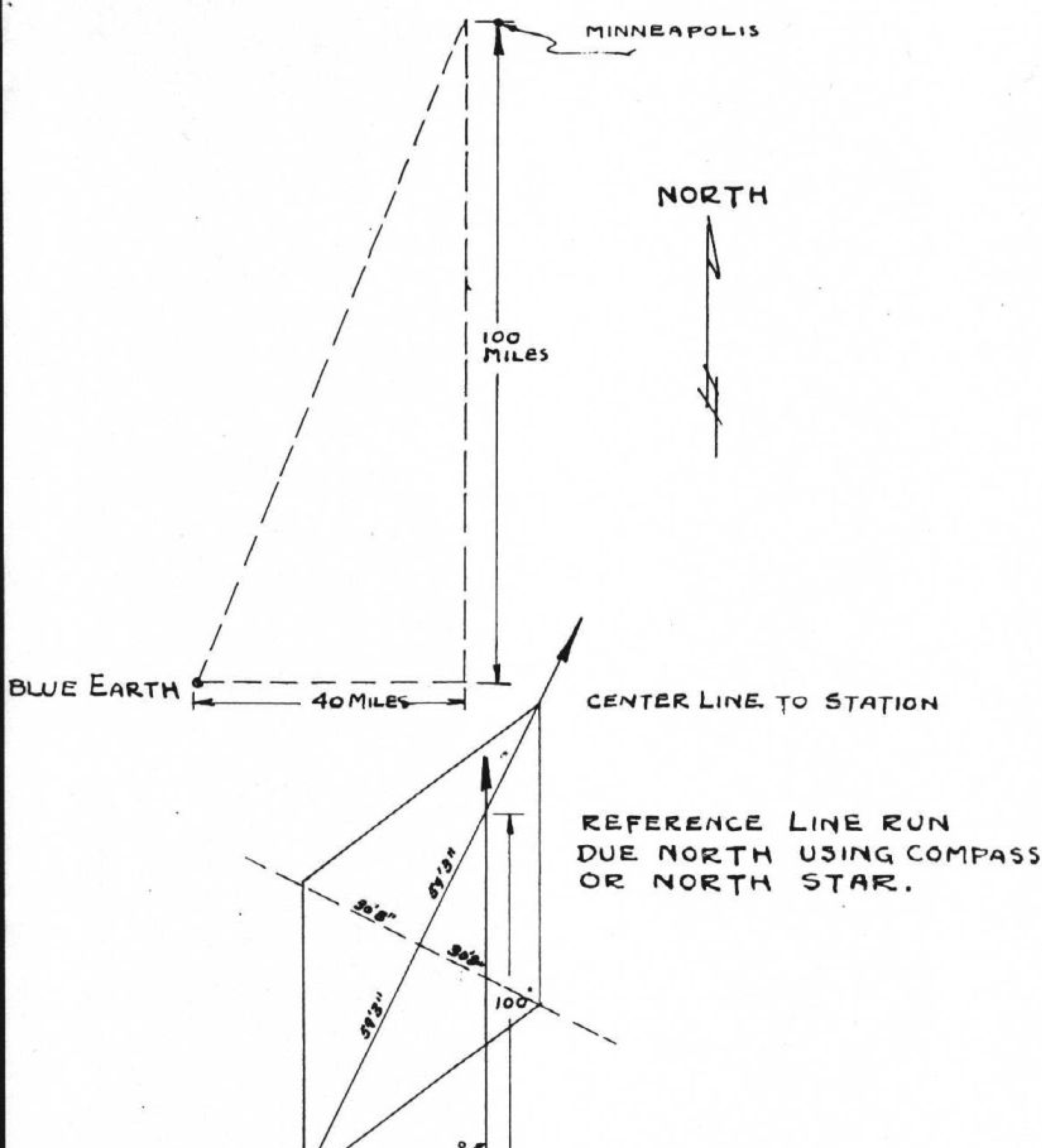


FIGURE 1. EXAMPLE LOCATING ANTENNA TO POINT AT STATION.

SMALL RHOMBICS

There has appeared on the market a Rhombic type TV antenna which is factory made and of a size small enough so that by using wood cross arms an antenna can be built with one support, or even turned with a suitable rotator. Although it uses two elements it is not a stacked Rhombic in any sense. The two wires are hooked in parallel and fanned out so that they are separated on the sides at the point of support then, tapering down so that it meets the other wire at the point of termination. This second wire does add to the gain slightly (about 1 db) whereas stacking adds three db, and the antenna impedance is lowered resulting in a somewhat better match to 300 ohm ribbon line. The gain of these antennas because of their small size does not have any more gain than some type yagi arrays which can be purchased factory made, but they do have the advantage of being broad band so that they will work over all four low channels with almost equal response, and on the high channels even though designed for a specific low channel or vice versa. Where only one channel is to be received, it should be designed for that channel, and in the case it is desired to cover all low channels design figures for channel four should be used. Design dimensions for small sized Rhombic are shown in fig. 1. These small sized antennas can be stacked exactly the same as shown in the two bay antenna detail using the same spacing (s) as shown in the chart.

OPEN WIRE LINE

When the antenna is located a considerable distance from the TV set the use of open wire line will reduce the line loss about 85%. Open wire line can be constructed to a definite impedance value as shown in figure 2, or can be purchased factory made. This factory made line has an impedance of approximately 450 ohms, and can be connected directly to either a single or two bay rhombic antenna. The mismatch in either case will be so slight that the additional loss caused by the mismatch will be negligible. The input impedance of a single bay Rhombic is 800 ohms, and a two bay about 400 ohms. In the event an exact match is desired a ¼ wave matching section can be connected between the line and the antenna. A ¼ wave matching section can be made by building a section of open wire line of the correct length and impedance value. This section of line is then connected between the line and the receiver, or the line and the antenna depending on which is to be matched to the line, or both if necessary. The chart in fig. 2 gives the impedance values of this section for commonly used lines. The length of these sections is given in fig. 3, and the material and spacings in fig. 4. As an example suppose it is desired to connect a 500 ohm open wire line (#14 wire spaced 2") to a 300 ohm antenna. Referring to fig. 4 a 390 ohm section is required. Referring to fig. 2 this can be constructed of #8 wire spaced 1.6 inches and from fig. 3 is should be 37 inches long for channel 5. This same ¼ wave section can be used to connect the 500 ohm line to the 300 ohm input of a TV receiver. The loss caused by a mismatch of open wire line in most cases is so little that the cost or effort in including it is not warranted, unless necessary to eliminate a ghost caused by the standing waves. As an example the loss of a 500 ohm open wire line on the low channels 1000 feet in length is 1.5 db. Connecting this same line to a 300 ohm antenna will increase the loss to 1.7 db. - .2 db. difference which is negligible even by the most critical standards. In the event of long lengths of ribbon line with considerable mismatch the situation changes and in some cases may warrant an exact match. For example consider 200 feet of 300 ohm line. When used on the high channels the loss when perfectly matched is 6 db. Connecting this same line to a 72 ohm antenna (mismatch 4 to 1) will increase the loss to 7.8 db. - or an increase of 1.8 db. which is a noticeable difference.

Dimensions of Small Sized Rhombic Antennas
(Figure 1)

CHANNEL	Dimensions A	B	C
2	17'9"	29'2"	20'2"
3	16'	26'4"	18'3"
4	14'8"	24'	16'6"
5	12'8"	20'11"	14'5"
6	11'10"	19'5"	13'5"
High Band	10'2"	12'10"	15'7"
High Band Small	5'1"	8'5"	5'9"

Open Wire Line Data
(Figure 2)

Impedance Ohms	Spacing Inches	Material
150	.8	1/2" tubing
180	.8	3/8" tubing
190	1.0	3/8" tubing
208	1.25	3/8" tubing
240	1.0	1/4" tubing
370	1.5	#8 wire
390	1.6	#8 wire
420	1.75	#10 wire
475	1.75	#14 wire
500	2.00	#14 wire
510	1.75	#16 wire
540	2.5	#16 wire
580	4.0	#14 wire
600	3.0	#18 wire
635	4.0	#18 wire
680	6.0	#18 wire

(Figure 3)

Channel	2	3	4	5	6	High Band
Length of ¼ Wave	52''	47''	43''	37''	34''	15''

¼ Wave Impedance Matching Chart
(Figure 4)

Impedance Ohms	Impedance to be Matched	Impedance of ¼ Wave Section Reqd.
72	300	150
	450	180
	500	190
	580	208
	800	240
300	72	150
	500	390
	450	370
	580	420
	800	500
450	72	180
	300	390
	500	475
	580	510
	800	600
500	72	190
	300	390
	450	475
	580	540
	800	634
580	72	208
	300	420
	500	540
	450	510
	800	680

RHOMBIC DIMENSIONS FOR UHF CHANNELS

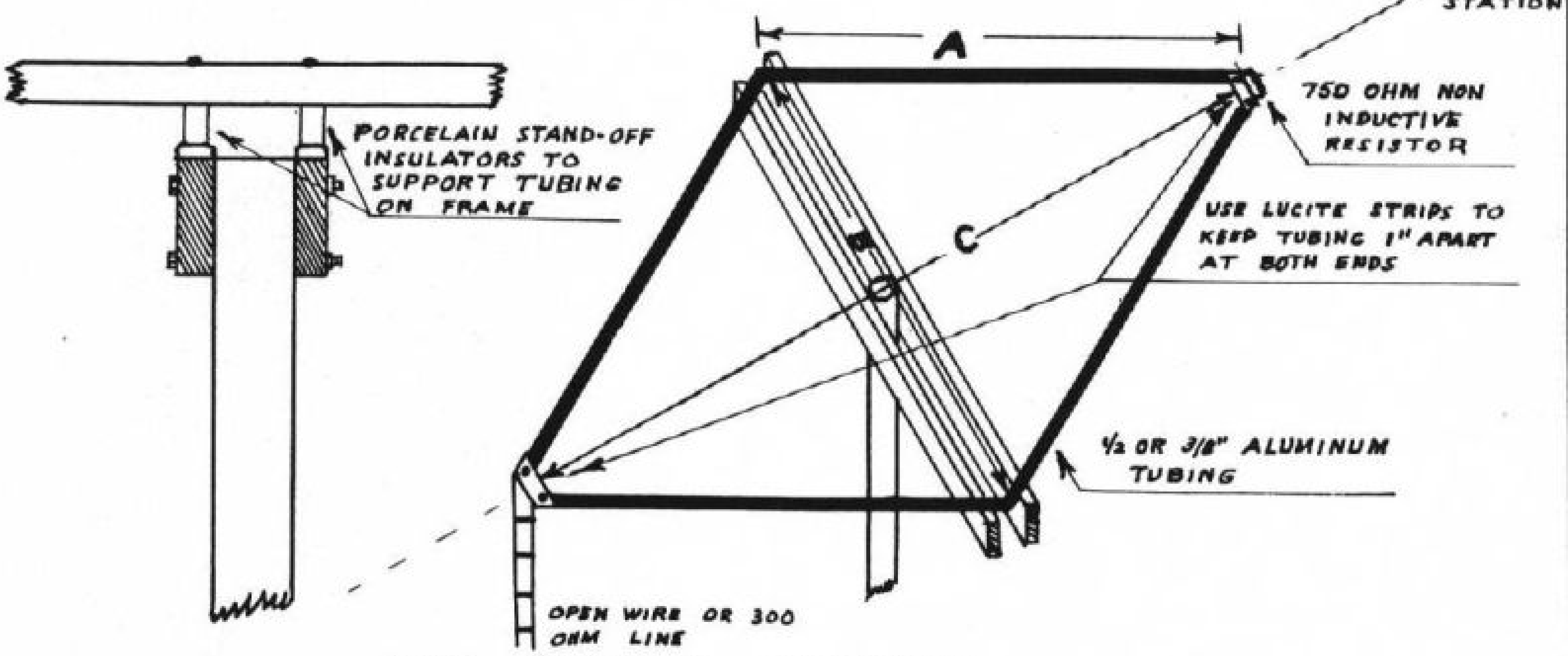
CHANNEL	14 - 29			30 - 54			55 - 83		
	A	B	C	A	B	C	A	B	C
Small	31½''	44½''	44½''	27½''	39''	39''	24''	34''	34''
Medium	63''	68''	106½''	55''	59''	93''	48''	52''	81''
Large	84''	76''	150''	73''	66½''	130''	64''	58''	114''
Extra Large	127''	98''	235''	109''	84''	202''	96''	73''	178''
Stacking Spacing (S) ..	10½''			9''			8''		

RHOMBIC DIMENSIONS FOR FM BAND

	A	B	C
Medium	10'	17'4''	10'
Small	20'	26'5''	30'
Large	30'	33''	50'
Extra Large	50'	43'6''	90'

Stacking Distance (S) 59''

A Rhombic is inherently a broad band antenna and one designed for the middle channels (30-54) will cover the entire UHF band with but little loss in pickup on the higher or lower channels. However if the antenna is to be built for a definite channel, a size should be chosen that includes that channel. Because of the higher frequencies of the UHF band the size of a Rhombic becomes small enough so that rotatable roof size antennas become practical. Furthermore, aluminum tubing can be used in place of wire making it possible to design a compact self supporting antenna. When choosing the size to build it should be remembered that the larger the size the more pickup the antenna will have. The smallest size will have as much pickup as a well built cut for channel Yagi and in addition will cover a frequency range 2 to 1. The extra large size in a stacked model will have a gain of at least 17 db. over a resonant dipole.



UHF RHOMBIC ANTENNA