Antennas – The Last Frontier

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WS8B

Space: The final frontier

*These are the voyages of the Starship, Enterprise.

*Its 5 year mission
To explore strange new worlds.

*To seek out new life and new civilizations.

*To boldly go where no man has gone before.

Introduction

- Rules for the Forum
- Antenna Safety
- Dipole
- 2-4-6-8
- Fooling Mother Nature
- Build your own

Frank J. Beafore
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Comments on Antenna Installation Safety

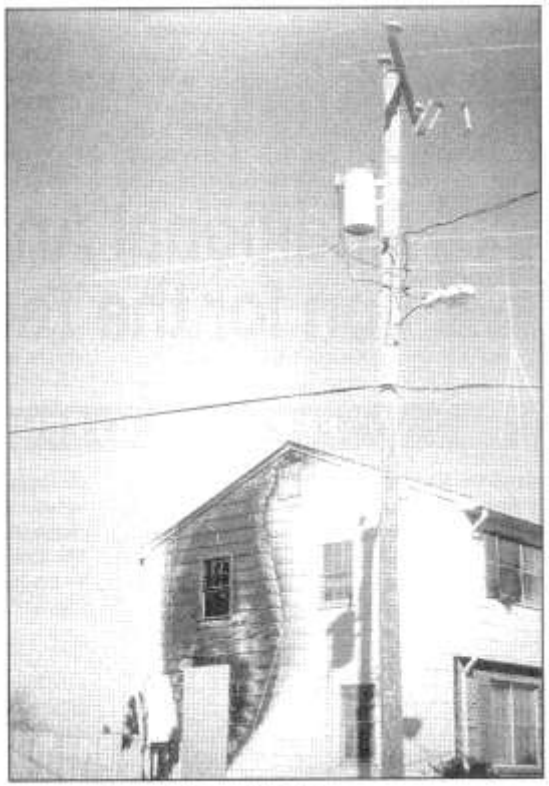


Photo by Charles Stokes, WB4PVT

Antenna Safety

- Near-by Objects
- Lightning & EMP Protection
- Physical Installation
- Radiation Hazards
- Grounding
- Height
- Safety Belts
- Lock-Out, Tag-Out

Antenna Definition

- “The antenna launches energy from a transmitter into space or pulls it in from a passing wave for a receiver. Without a suitable, properly installed antenna, the best transmitter and receiver are useless”.

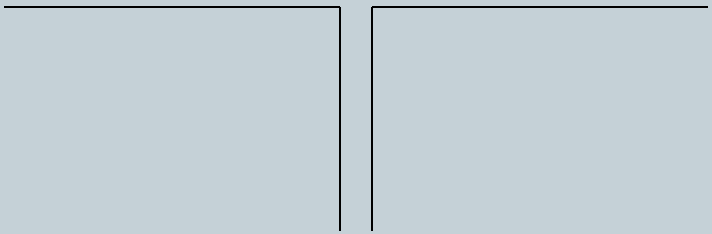
Quote: Dr, John Kraus-W8JK, Professor Emeritus,
The Ohio State University (Beat Michigan)
Columbus, Ohio

Wave formation

- Waves are the result of energizing a “balanced” dipole system.
- This can be demonstrated by “waving” a rope, plucking a banjo string or striking a piano key.

Radio Waves

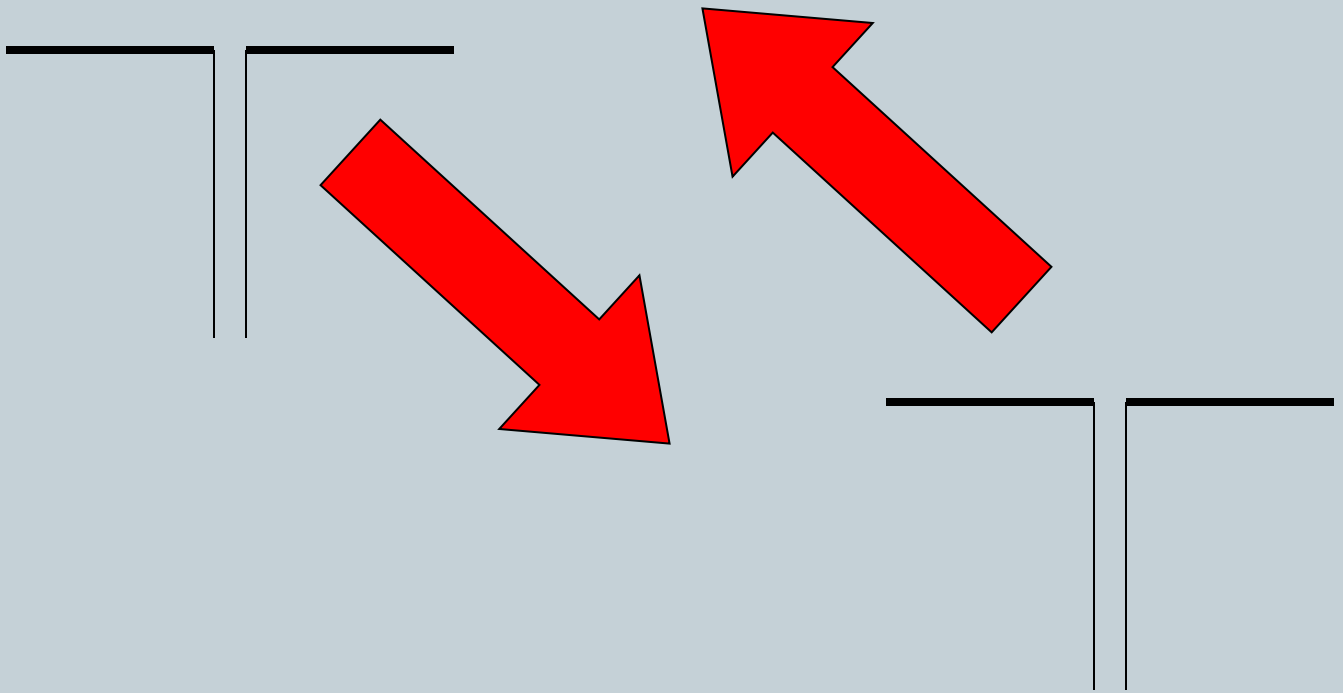
- Radio waves are formed by energizing a “dipole”
- (di meaning to cut or dissect and pole is a pole is a pole).
- The dipole or antenna is a specific length relating to the energizing frequency.



Transmission and Reception

- Radio waves are emitted by an oscillating dipole and escape into electromagnetic space much like music from guitar string, that moves the air near it.
- The radio receiver detects the radio wave in a manner similar to the human ear detecting a note from a guitar.

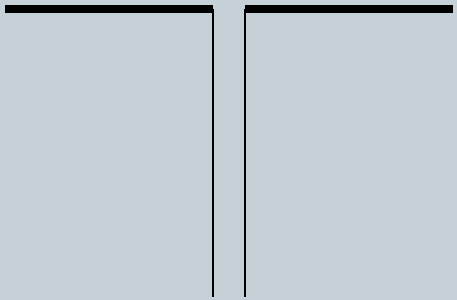
Transmission / Reception



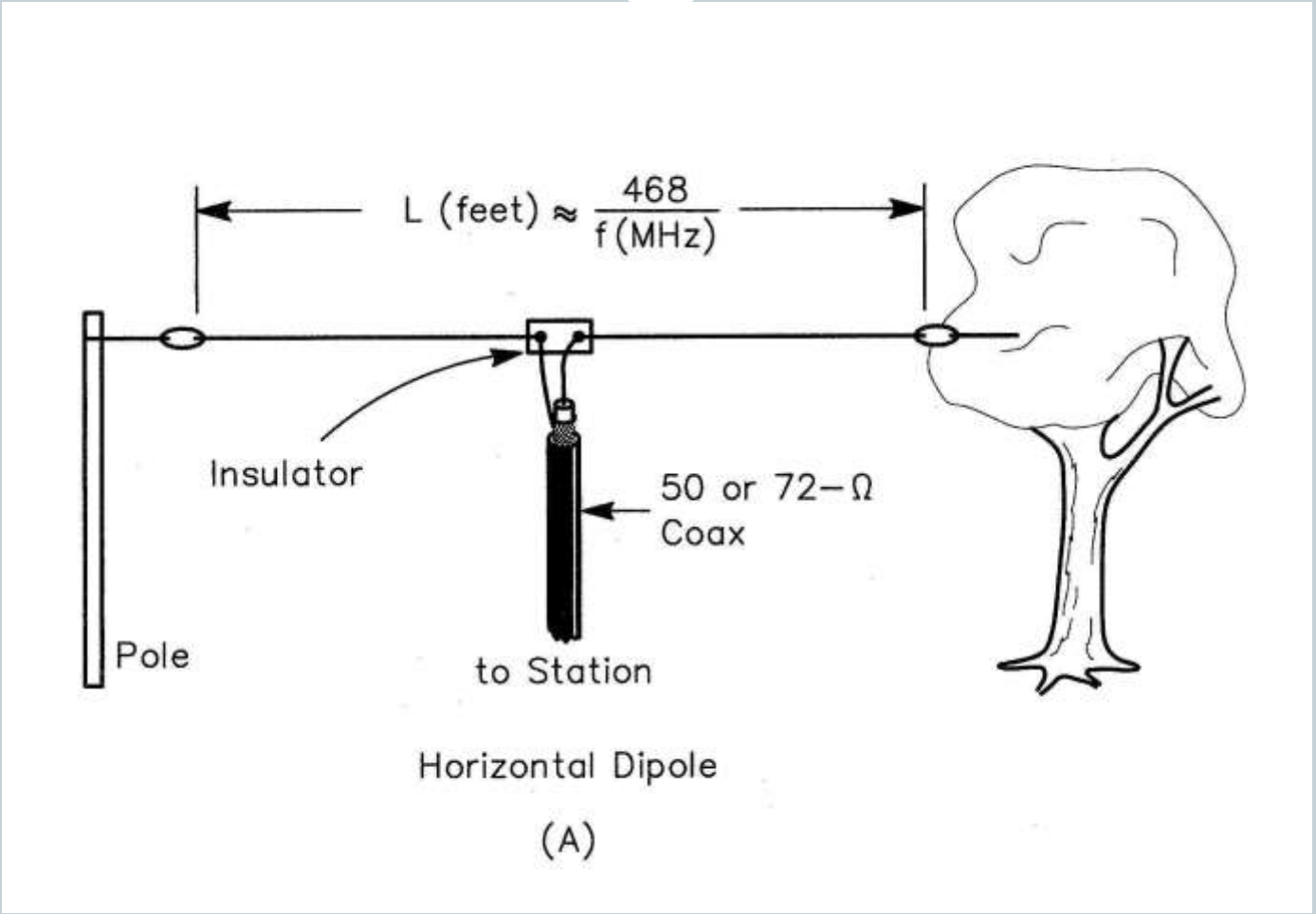
The Dipole

- The dipole is the fundamental antenna. It is found freely in nature. Consisting of 2 equal length poles, the energy oscillates… it oscillates (moves back and fourth) in two directions.

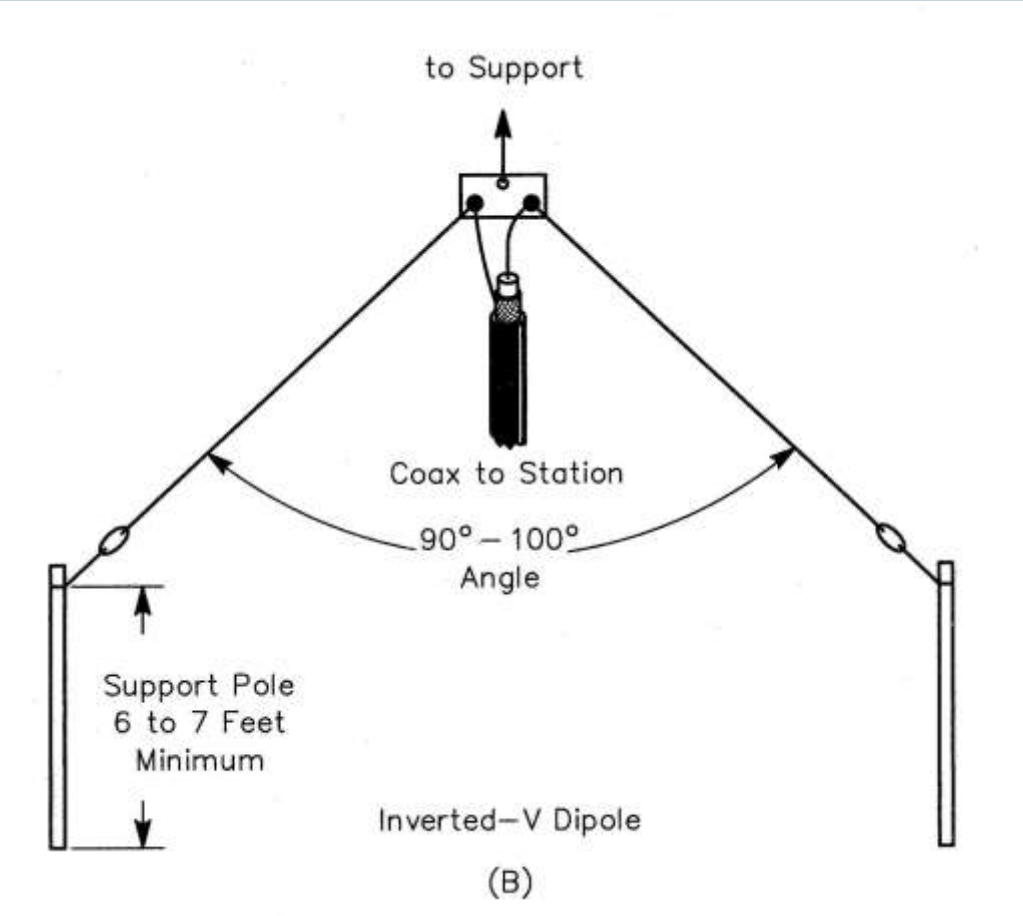
- Isotropic Dipole
- Dipole in Space
- Dipole Near The Earth
  - Horizontal
  - Vertical



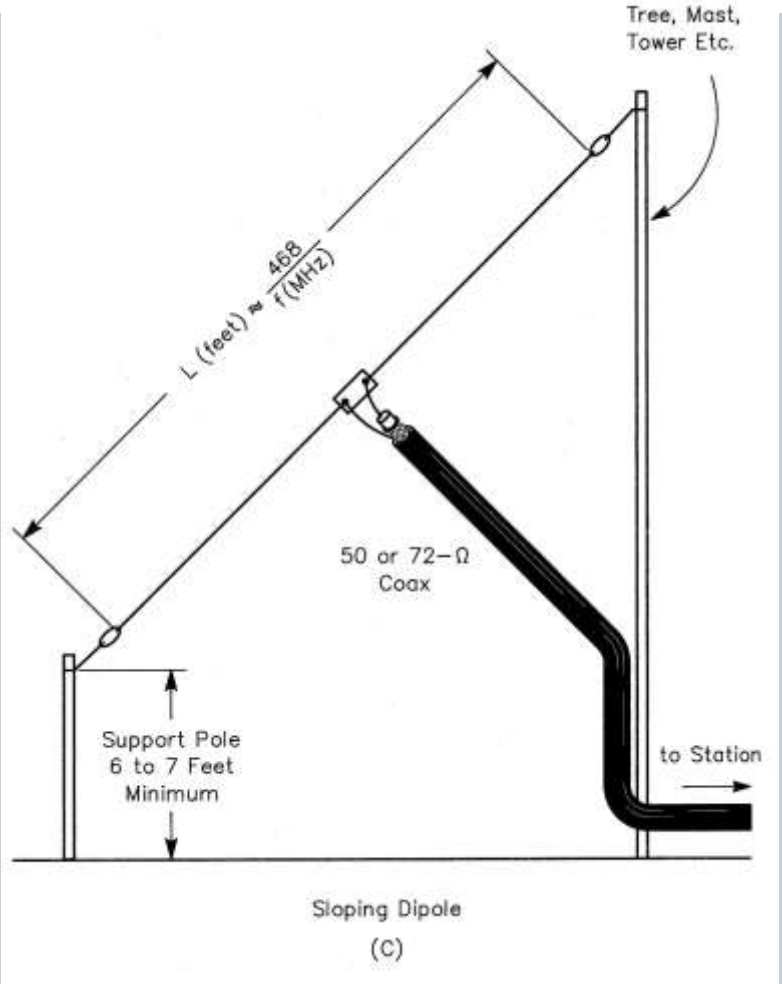
Simple Antenna Dipole



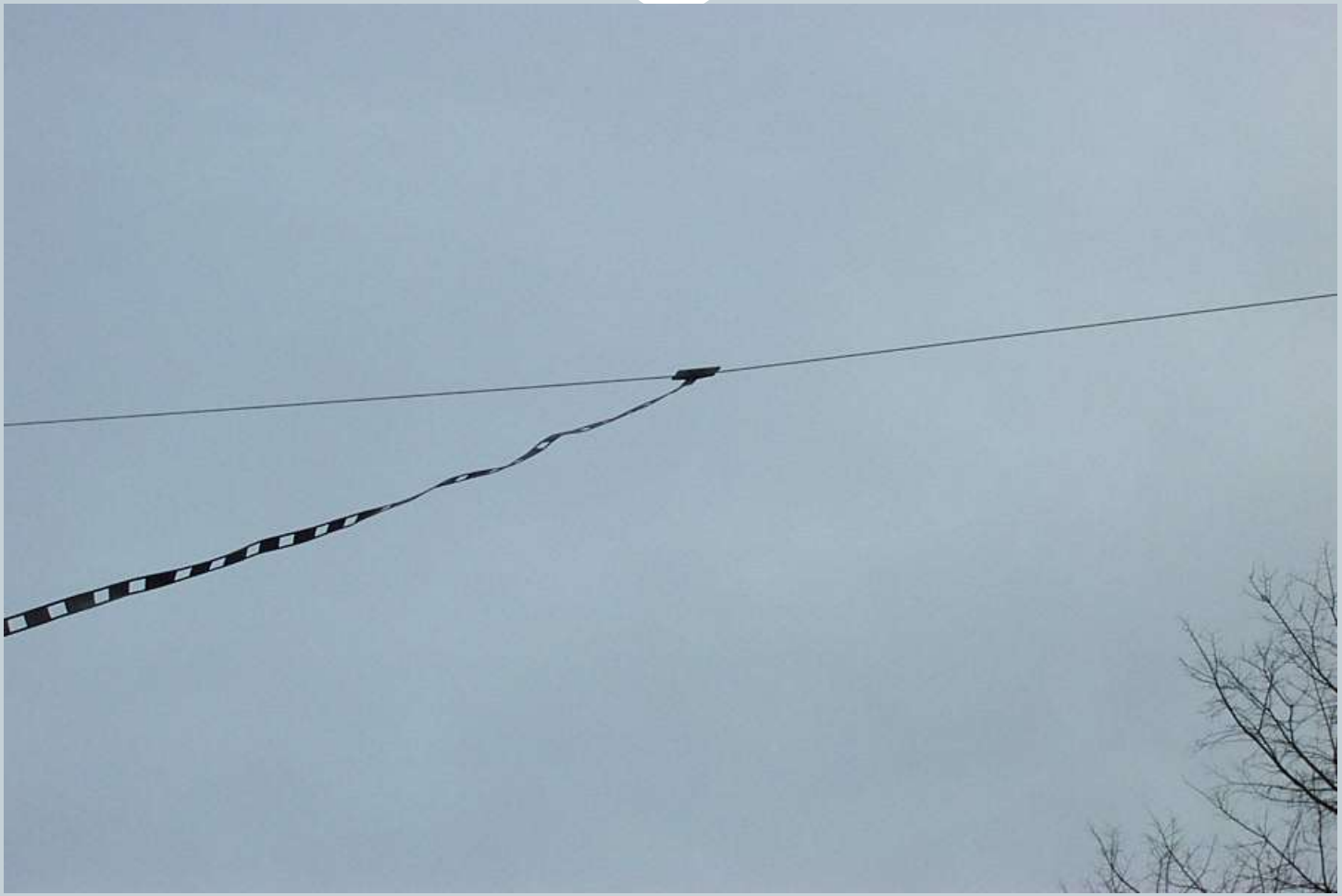
Inverted “Vee”



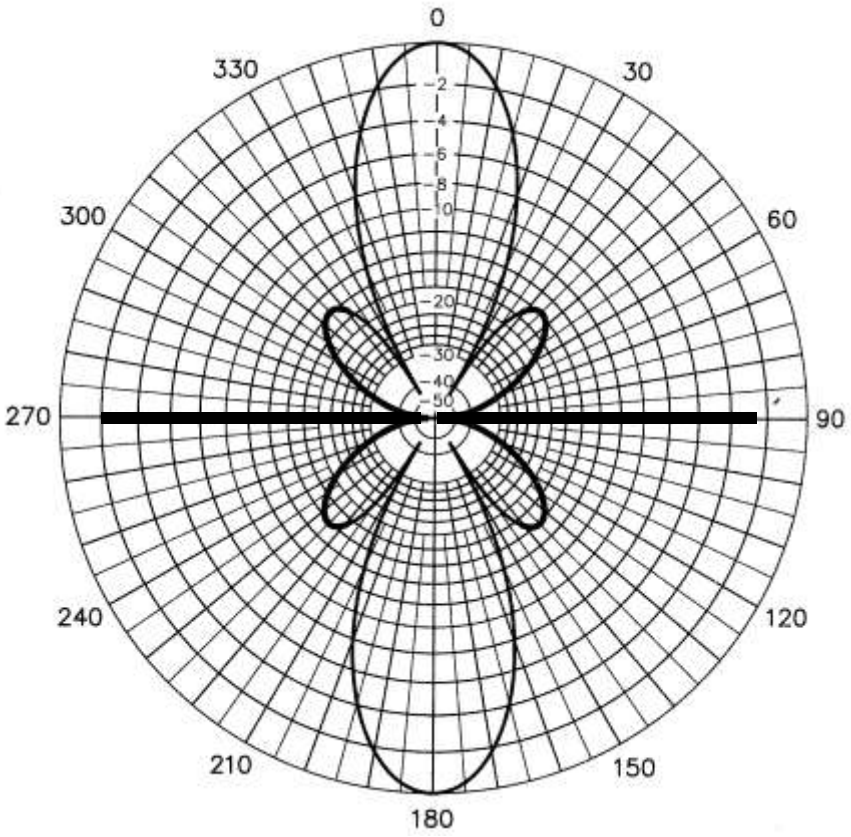
Sloper



Double Extended Zepp



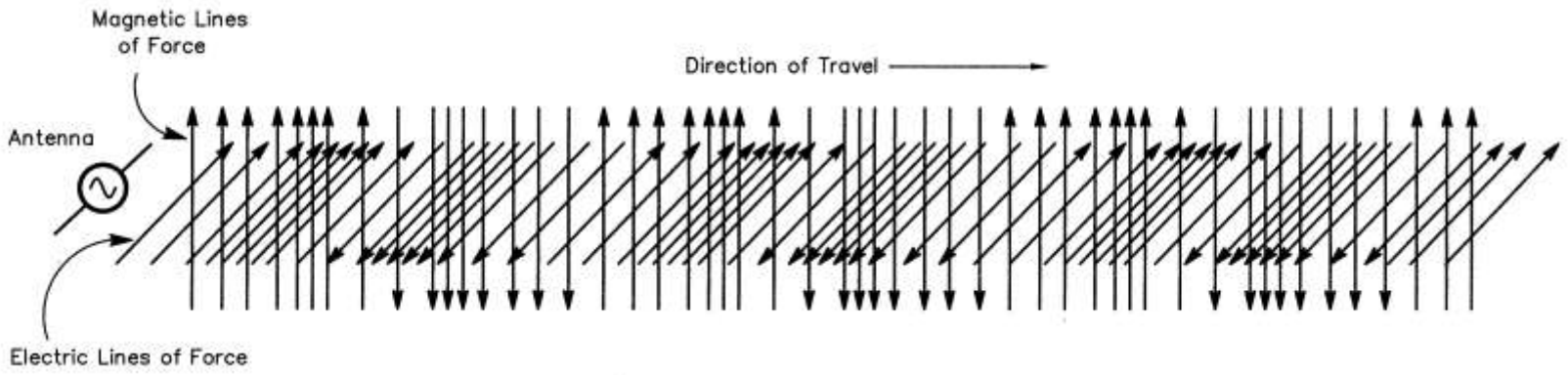
Double Extended “Zepp” Emission Pattern



Antenna Polarization

- Horizontal
- Vertical
- Circular

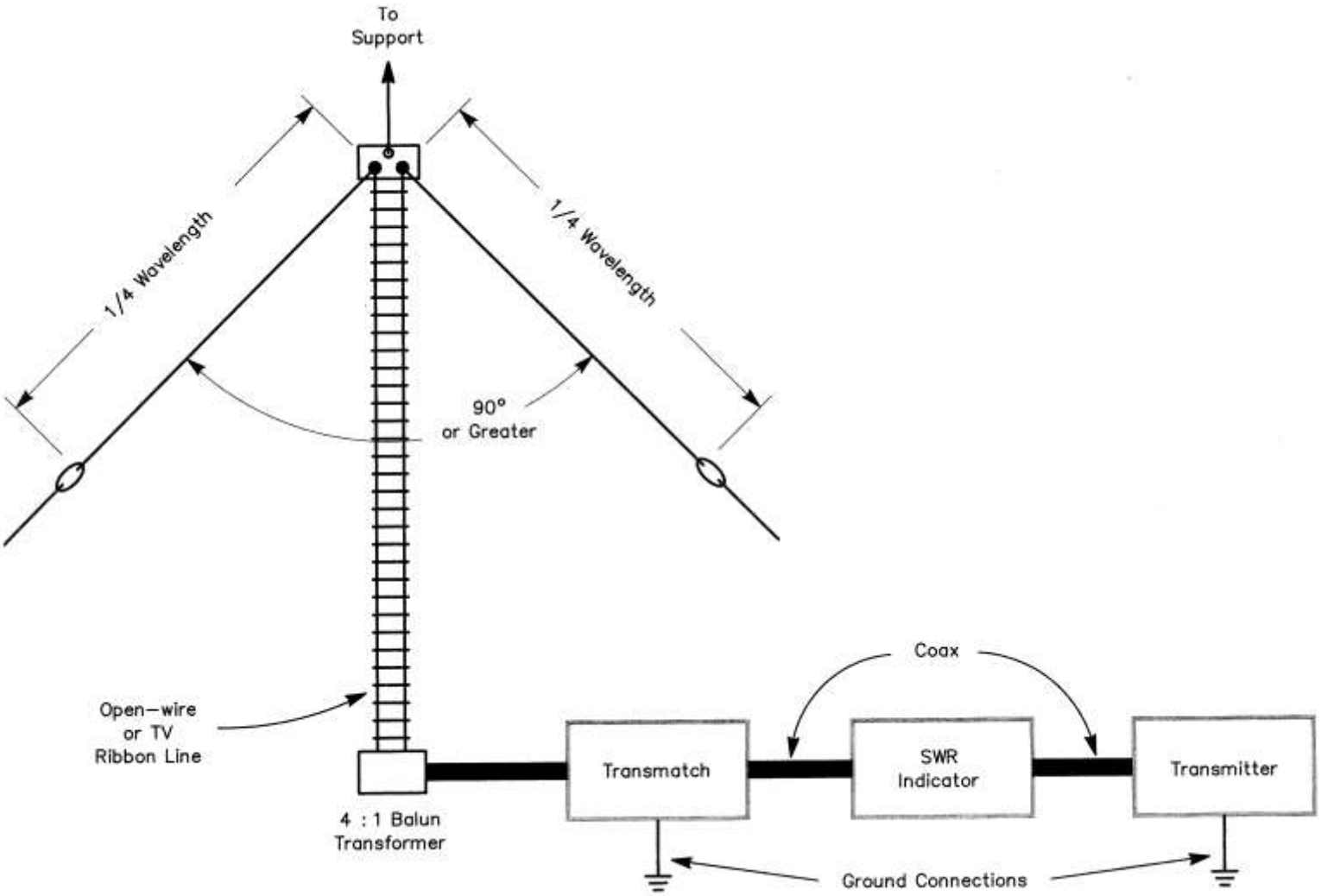
Elements of a Radio Wave



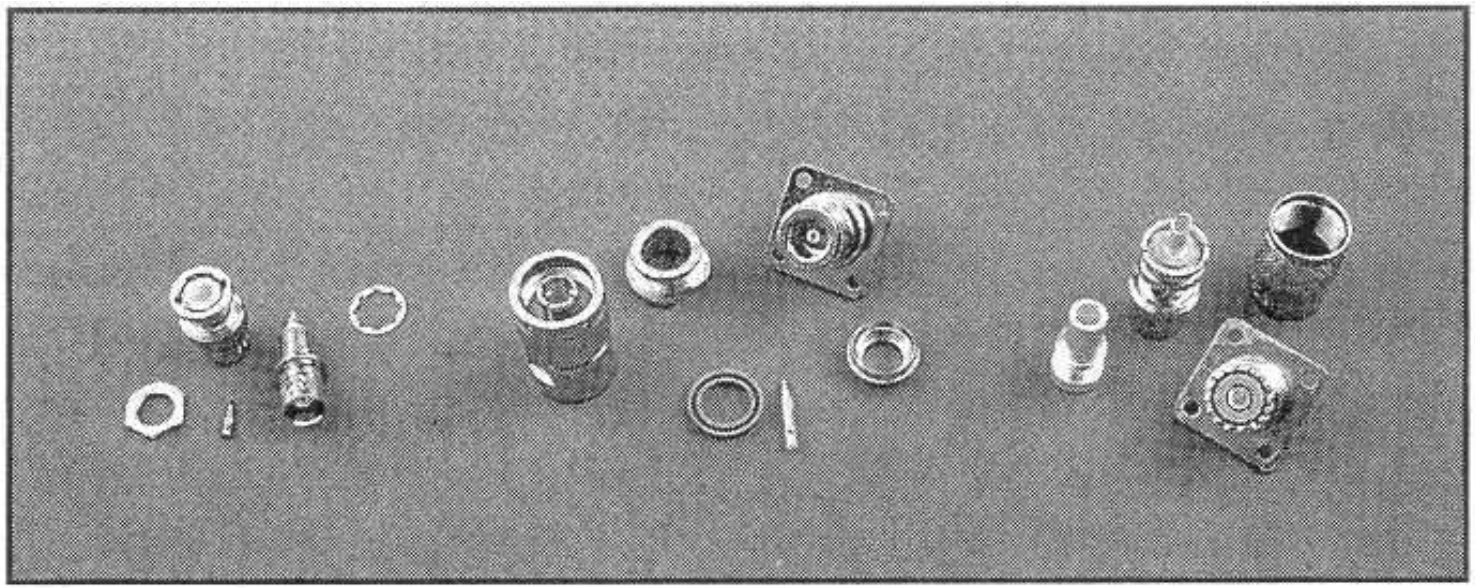
The Antenna System

- Transceiver connections
- Accessories connections
- Feed line
- Balun connections
- Antenna connections
- Matching system
- The antenna
- Ground

A Typical Antenna System



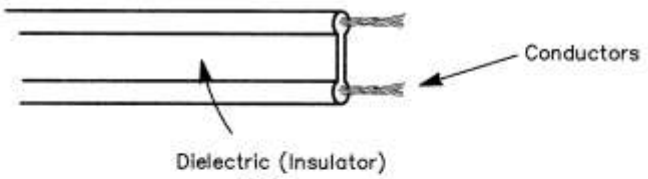
Various Types of Connectors



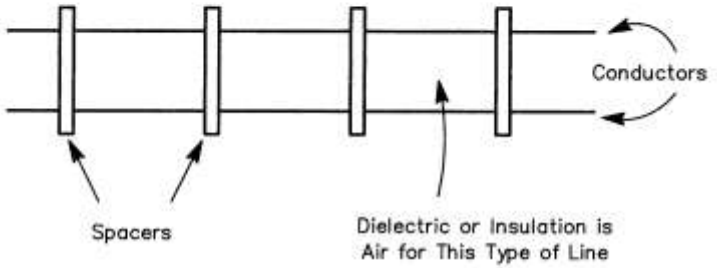
(A) (B) (C)

RF Connectors

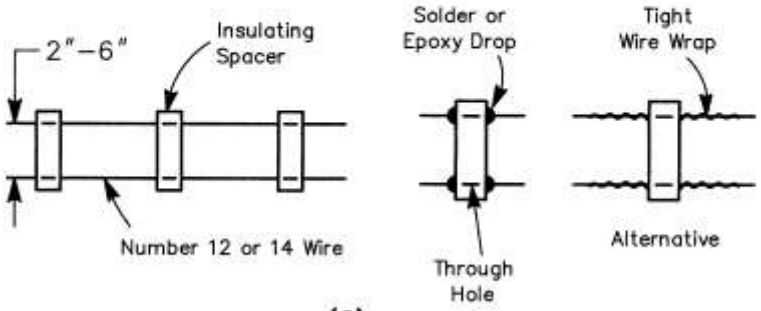
Twin Line



(A)

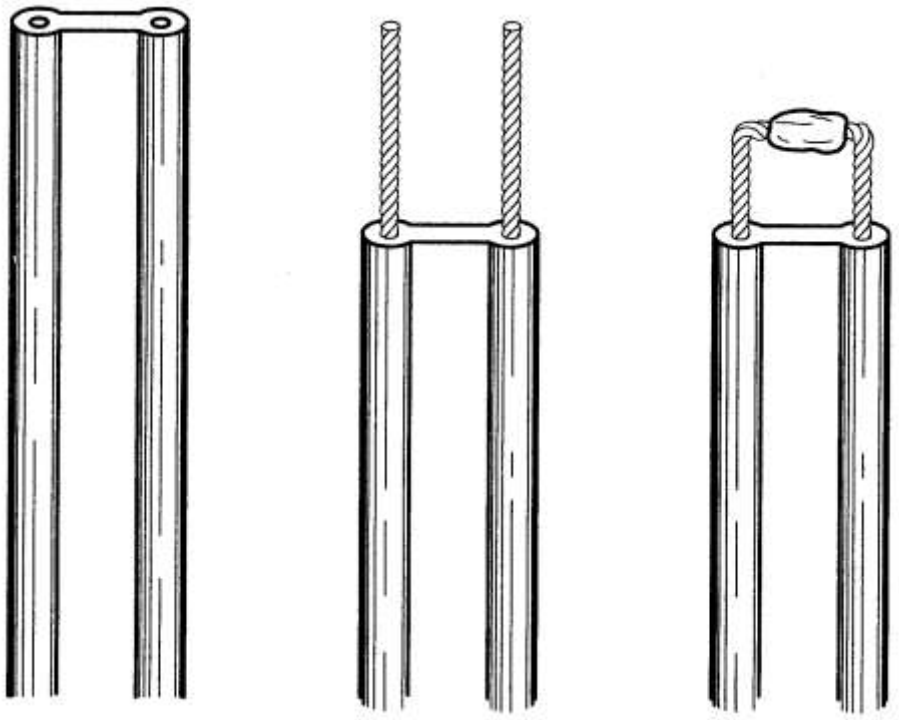


(B)

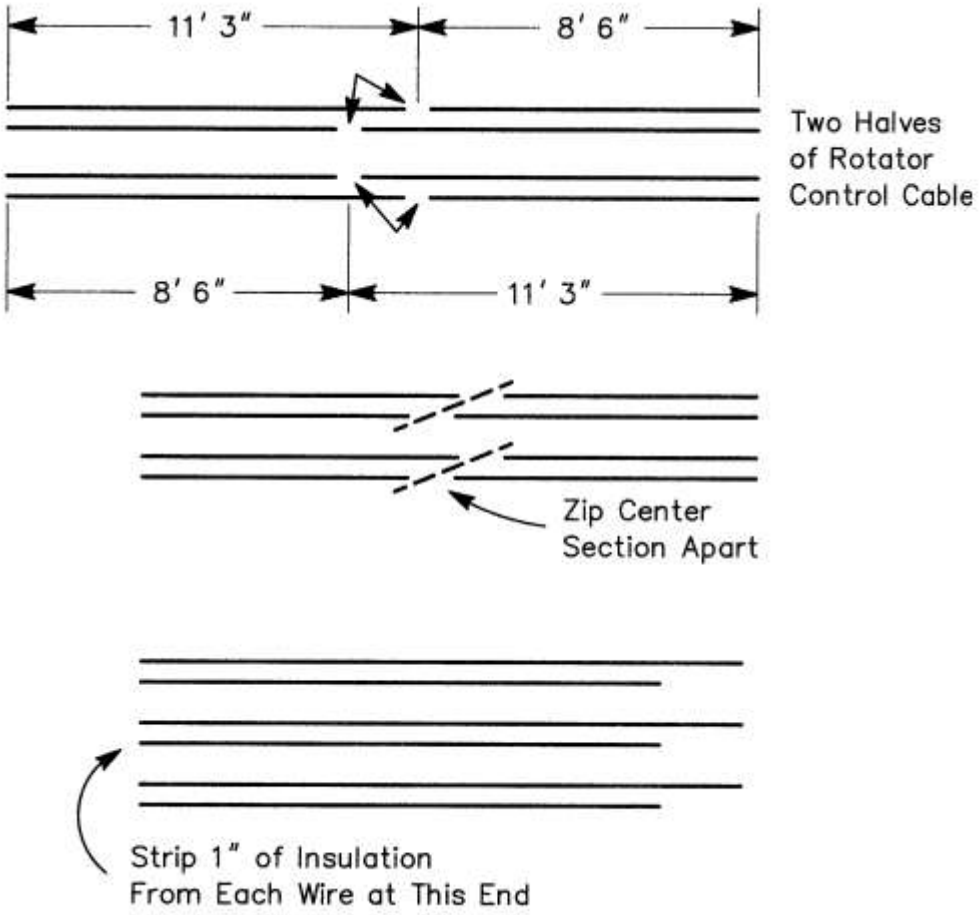


(C)

Termination of Twin Line



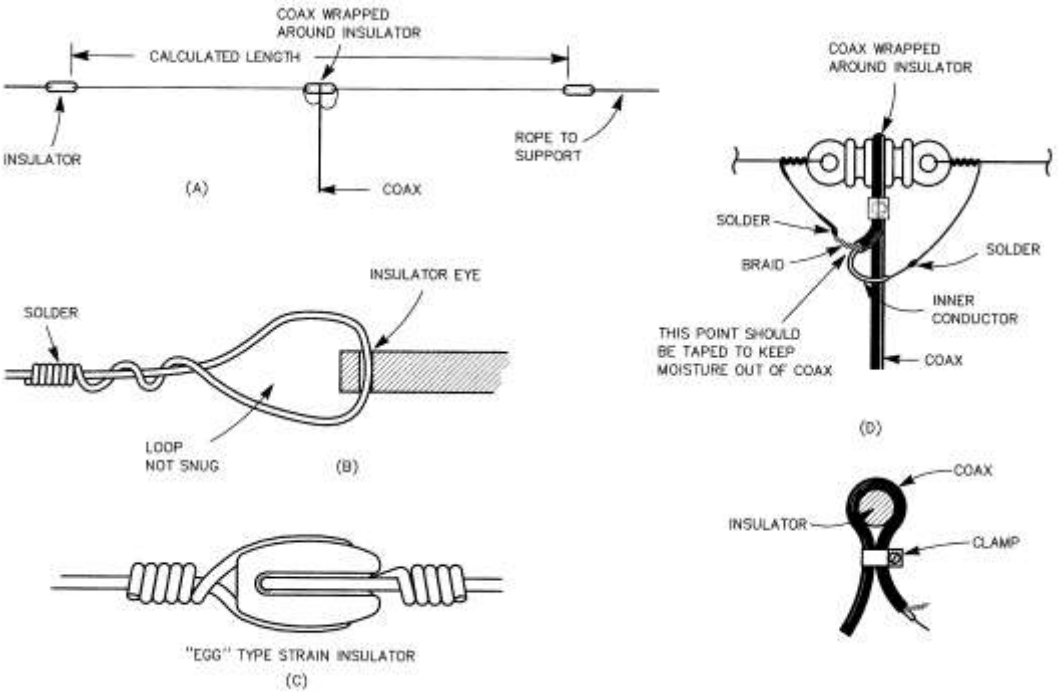
Proper Splicing of Rotor Line



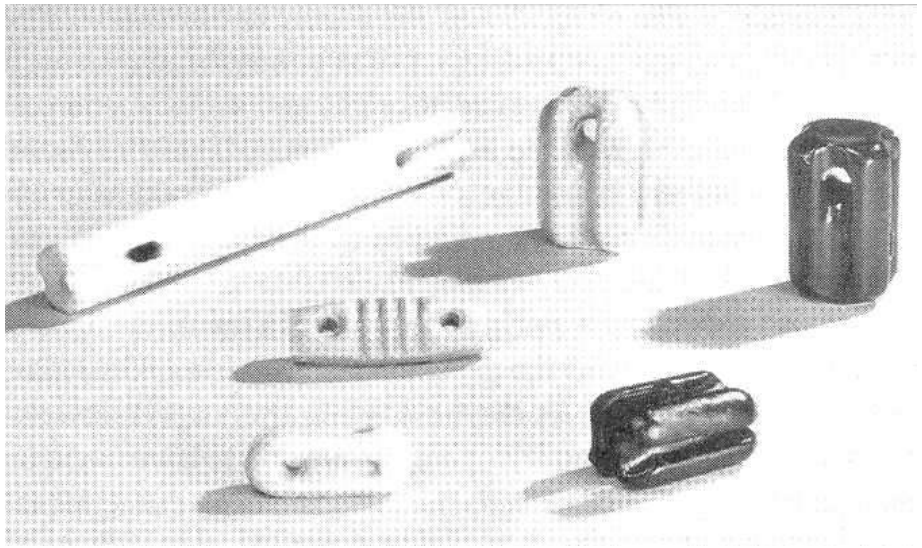
Construction of a Dipole

- Radiating Elements
- End Insulators
- Center Insulator
- Feed line Coupling

Construction Methods for Homemade dipoles

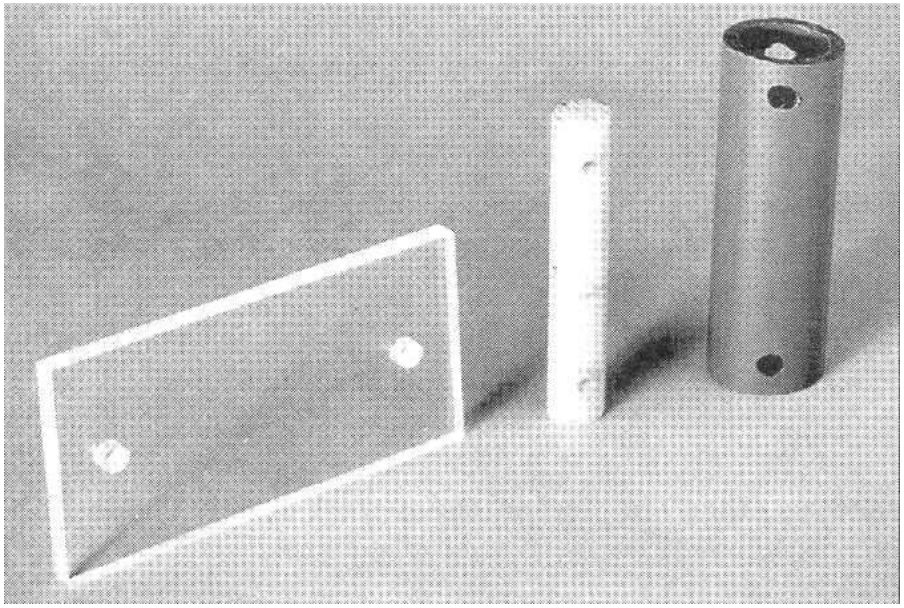


Examples of Commercial Insulators

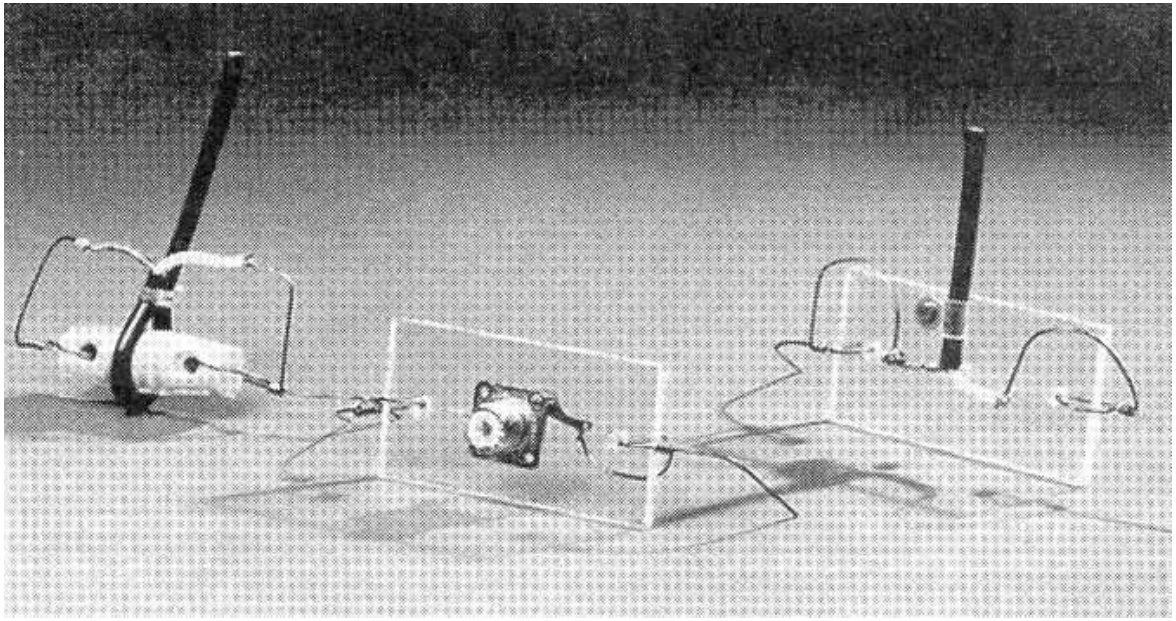


? What makes an insulator insulate???

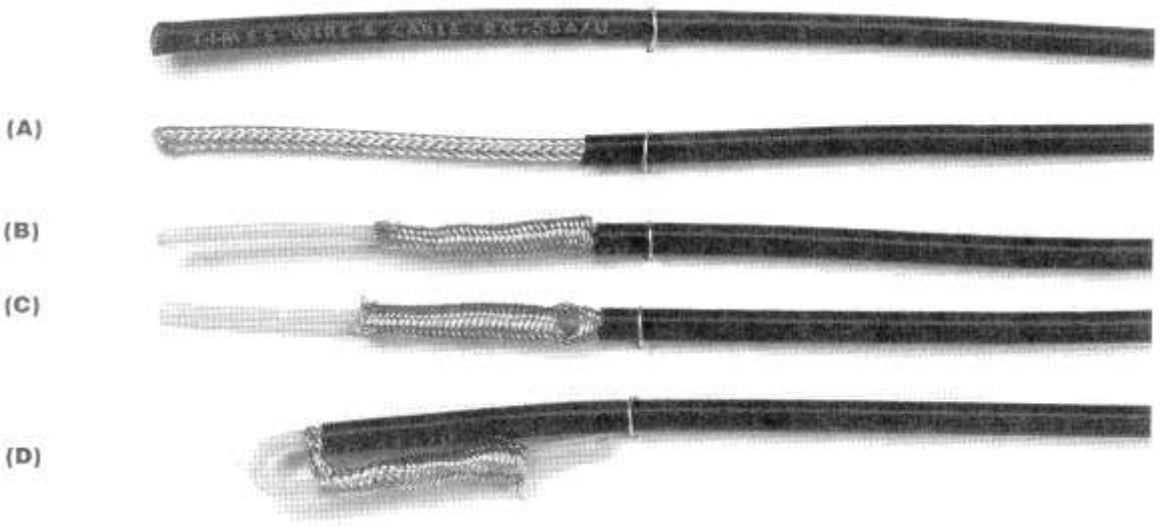
Examples of Homemade Insulators



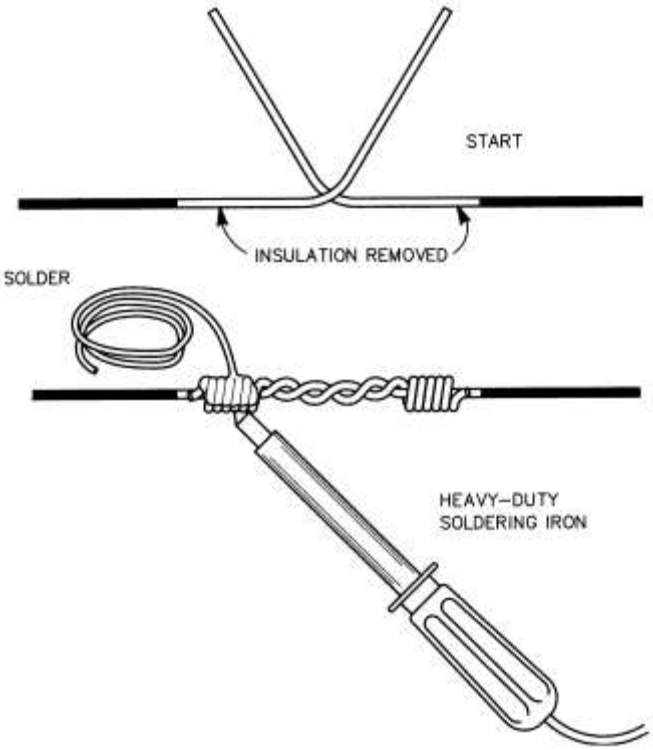
Various Examples of Homemade Center Insulators



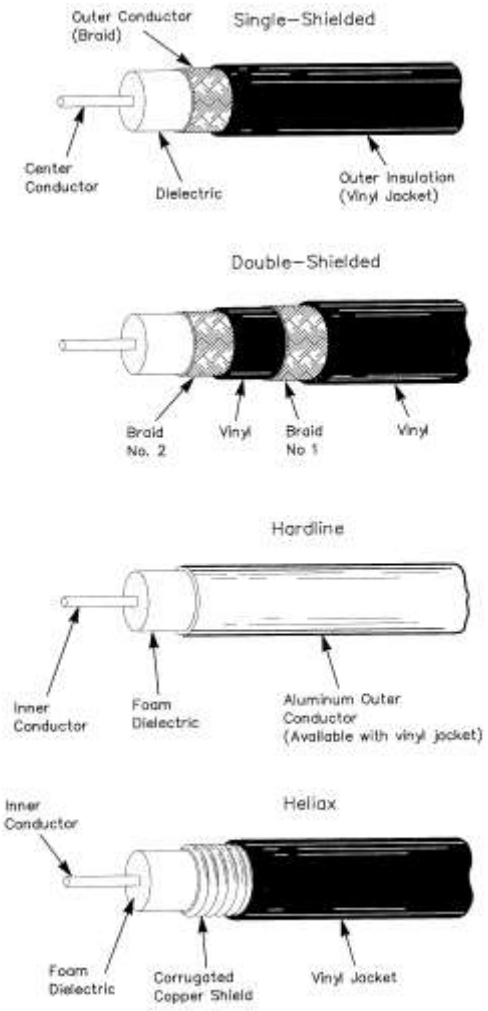
Separating Coax Shield



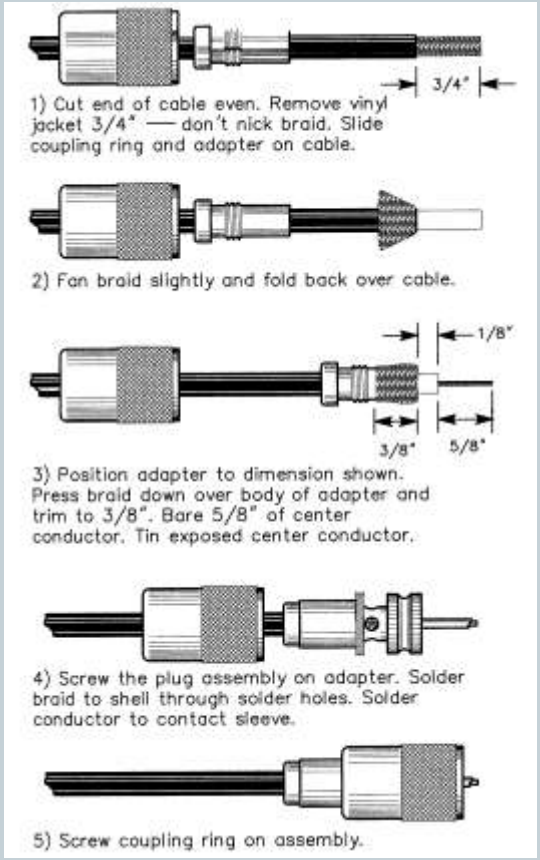
Proper Soldering of a Wire Antenna



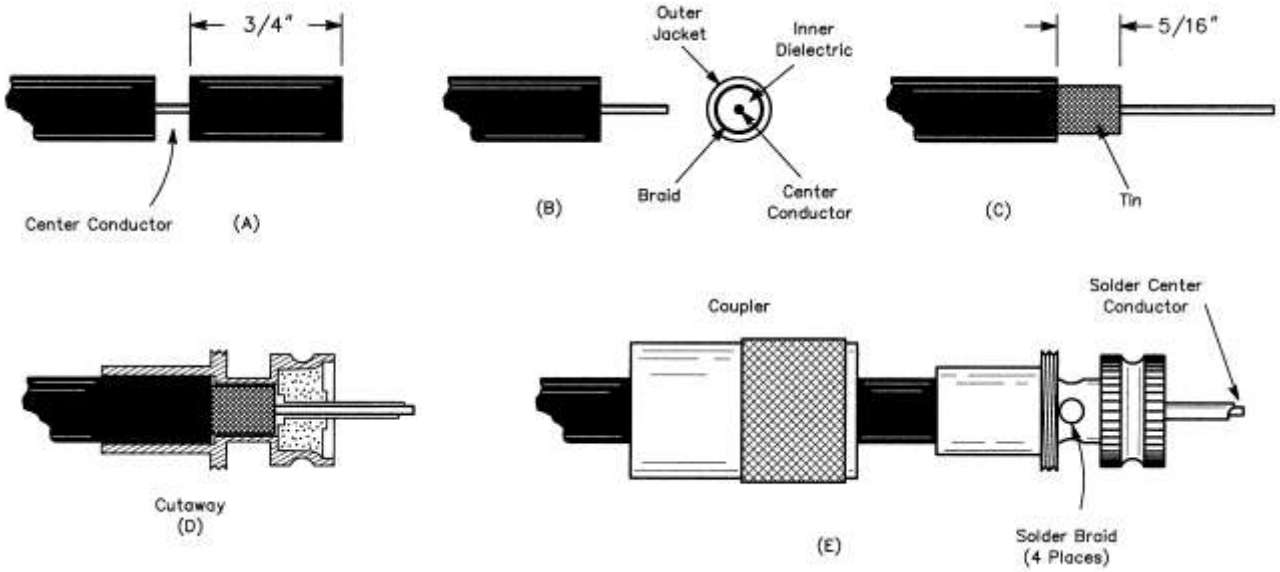
Coax Examples



Coax Connector Construction



Assembling RG-8 or other larger diameter coax.



Grounding

- True Ground
- Artificial Ground
- Ground Loops

Lets do some Physics !!!!

Radio Wave Speed

- Same as the speed of light !!!

- Lets prove this -

Radio Wave Speed:

$$\mathbf{A}' = \mathbf{A} + \nabla\lambda$$

$$V' = V - \frac{\partial\lambda}{\partial t}\nabla\cdot\mathbf{A}' = -\mu_0\varepsilon_0\frac{\partial V'}{\partial t}$$

$$F^{\mu\nu} = \begin{vmatrix} 0 & -\frac{E_x}{c} & -\frac{E_y}{c} & -\frac{E_z}{c} \\ \frac{E_x}{c} & 0 & -B_z & B_y \\ \frac{E_y}{c} & B_z & 0 & -B_x \\ \frac{E_z}{c} & -B_y & B_x & 0 \end{vmatrix}$$

$$\left(\nabla^2\mathbf{A} - \mu_0\varepsilon_0\frac{\partial^2\mathbf{A}}{\partial t^2}\right) - \nabla\left(\nabla\cdot\mathbf{A} + \mu_0\varepsilon_0\frac{\partial V}{\partial t}\right) = -\mu_0\mathbf{J}\nabla^2\lambda - \mu_0\varepsilon_0\frac{\partial^2\lambda}{\partial t^2} = -\nabla\cdot\mathbf{A} - \mu_0\varepsilon_0\frac{\partial V}{\partial t}$$

$$\nabla^2 V + \frac{\partial}{\partial t}(\nabla\cdot\mathbf{A}) = -\frac{\rho}{\varepsilon_0}$$

$$J^\alpha = \begin{pmatrix} c\rho & J_x & J_y & J_z \end{pmatrix}$$

$$F^{\alpha\beta}{}_{,\alpha} = \frac{\partial F^{\alpha\beta}}{\partial x^\alpha} = \mu_0 J^\beta G^{\alpha\beta}{}_{,\alpha} = \frac{\partial G^{\alpha\beta}}{\partial x^\alpha} = 0$$

$$\nabla^2 V' - \mu_0\varepsilon_0\frac{\partial^2 V'}{\partial t^2} = \Box^2 V' = -\frac{\rho}{\varepsilon_0}\nabla^2\mathbf{A}' - \mu_0\varepsilon_0\frac{\partial^2\mathbf{A}'}{\partial t^2} = \Box^2\mathbf{A}' = -\mu_0\mathbf{J}$$

(Gauss's Law for electrostatics)
(Ampère-Maxwell Law)

Radio Wave Speed:

YEAh !!!

Too Cool……..

WaveLength

- Speed of Light/Frequency

The Secret Numbers (20 meters)

- 299,794,458
- 14,250,000
- 3.2808399
- 69.02299
- 17.25575

The Secret Numbers

- 299,794,458 – Speed of Light
- 14,250,000 – Frequency in HZ
- 3.2808399 – Feet / Meter
- 69.02299 – Full Wave in Feet
- 17.25575 - ¼ Wave in Feet

Most Important Formula

- Relationship between Frequency and Length
- Length of a half wave dipole = 486 / Frequency in Megahertz
- L=468/f (easy to remember with a safety factor)

Let's do one for "2 meters"

- 468/F(Mhz)
- 468/146.52 =
- 3.194103194103 Feet
- Divide above by 2 = 1.59 feet
- Multiply by 12 inches in a foot = 19.08 inches (19.5 to be safe)

Relationship of Frequency and Wavelength

Band (Meters)	Freq (Mhz) (Mhz)	1/2 Wave (Feet)	1/4 Wave (Feet)
80m	3.5625	131.3684	65.68421
40m	7.1250	65.68421	32.84211
20m	14.2500	32.84211	16.42105
10m	28.5000	16.42105	8.210526
6m	52.525	8.910043	4.455021
2m	146.52	3.194103	1.597052

Important Factors

- Length
- Width
- Height above average terrain
- Surrounding Objects
- Grounding

Effects of The Local Environment

- Type of Support Structure
- Other Antennas
- Height above Ground
- Ground Conductivity
- Nearby Objects
- Transmission Line
- Terrain

Radiated Signal Factors

- Directivity
- Pattern
- Gain
- Bandwidth
- Launch Angle

Choosing an Antenna

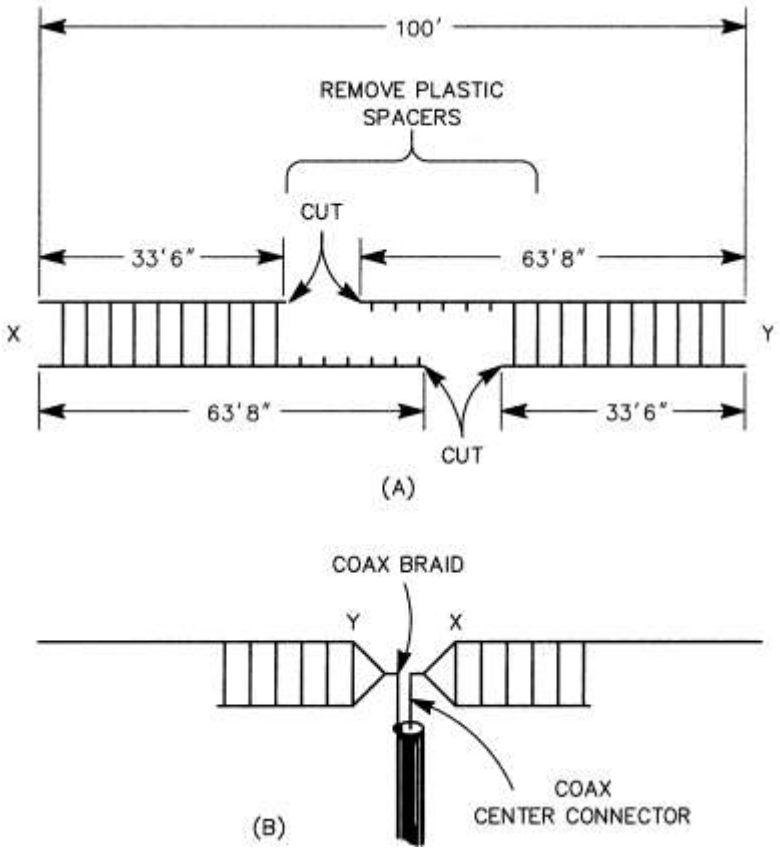
Practical Antennas

- The Half Wave Dipole
- Most Important Formula
- Tuning The Antenna
- Multiband Dipole Operation
- The Quarter Wave Vertical
- The Ground Plane Antenna
- Full Wave Loops

Practical Antennas (Cont.)

- Trapped Verticals
- Hand Held Antennas
- Verticals for 146,222 and 440
- A simple 10 and 15 Meter Vertical

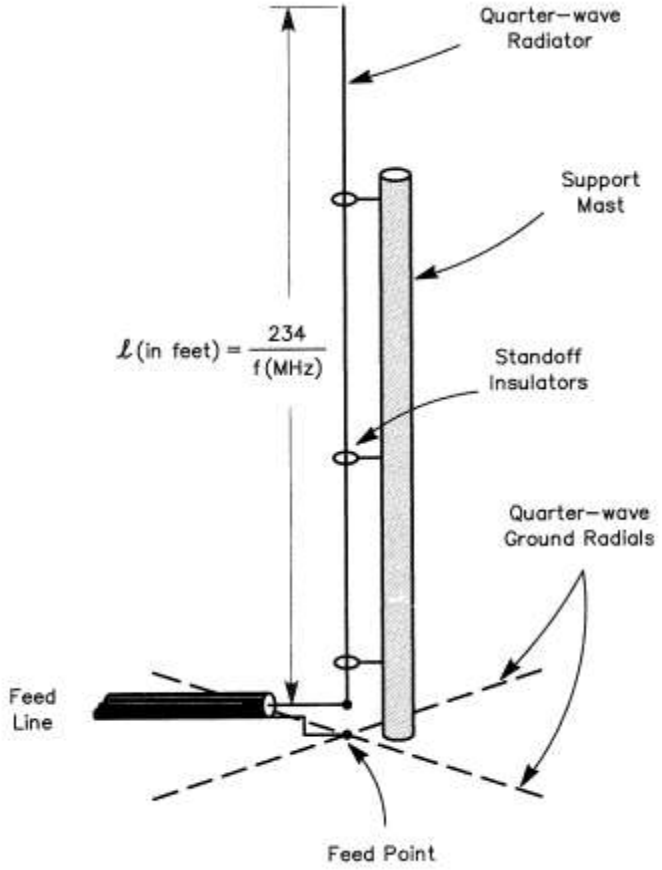
Construction of a Dual Band Antenna



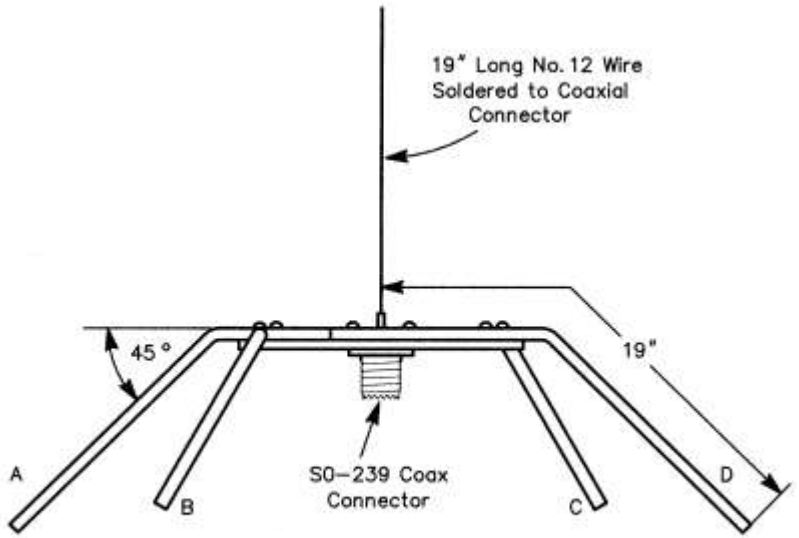
Commercial Multiband Vertical Antenna

Short Antennas for HT's

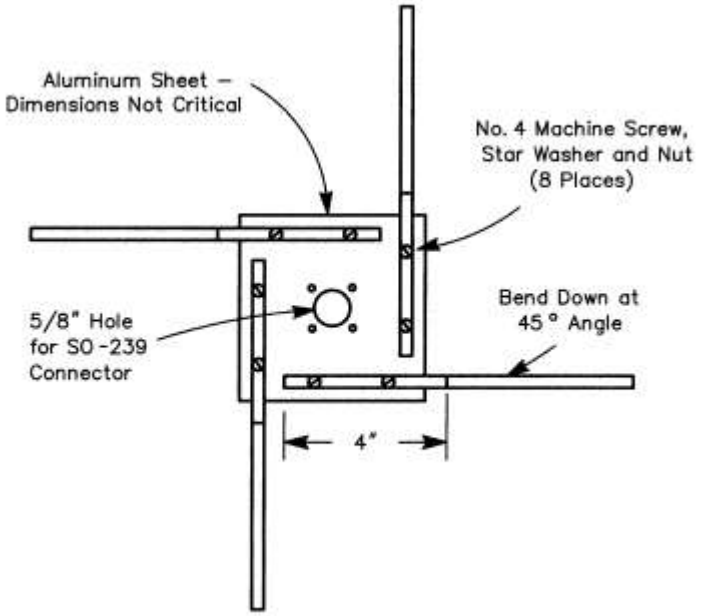
Home-Brew Ground Plane



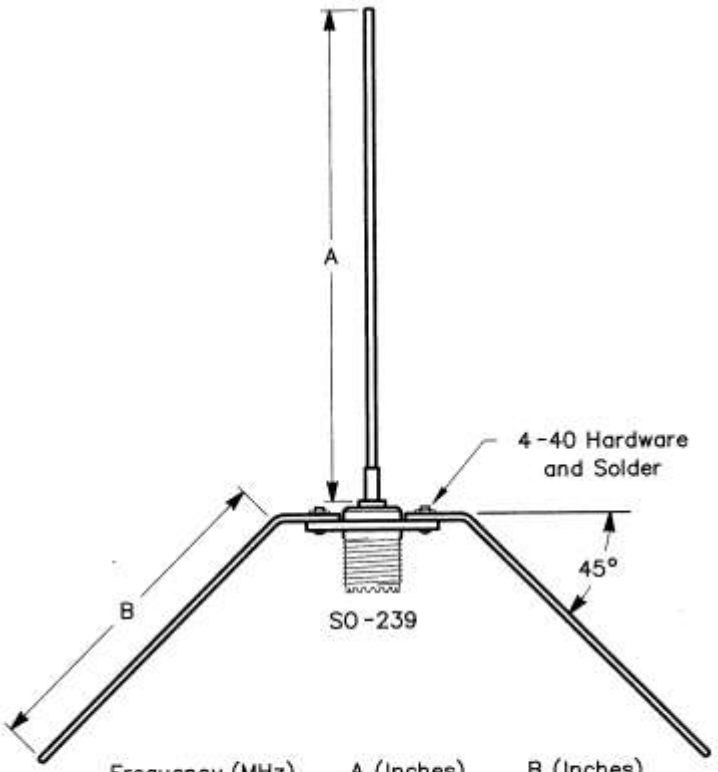
Homemade Ground Plane



A,B,C,D – 19" Lengths of 3/16" Aluminum
Rod Bent Down at 45° Angle

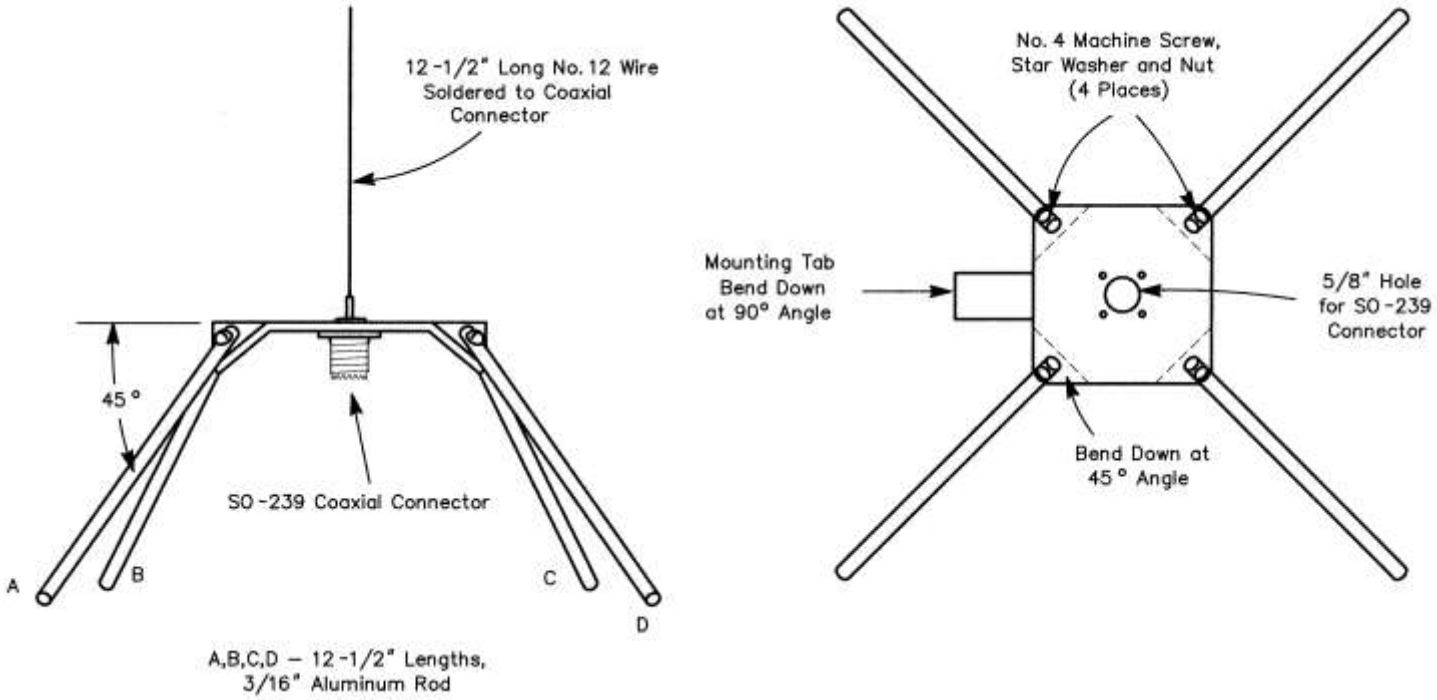


Homemade Ground Plane Dimensions

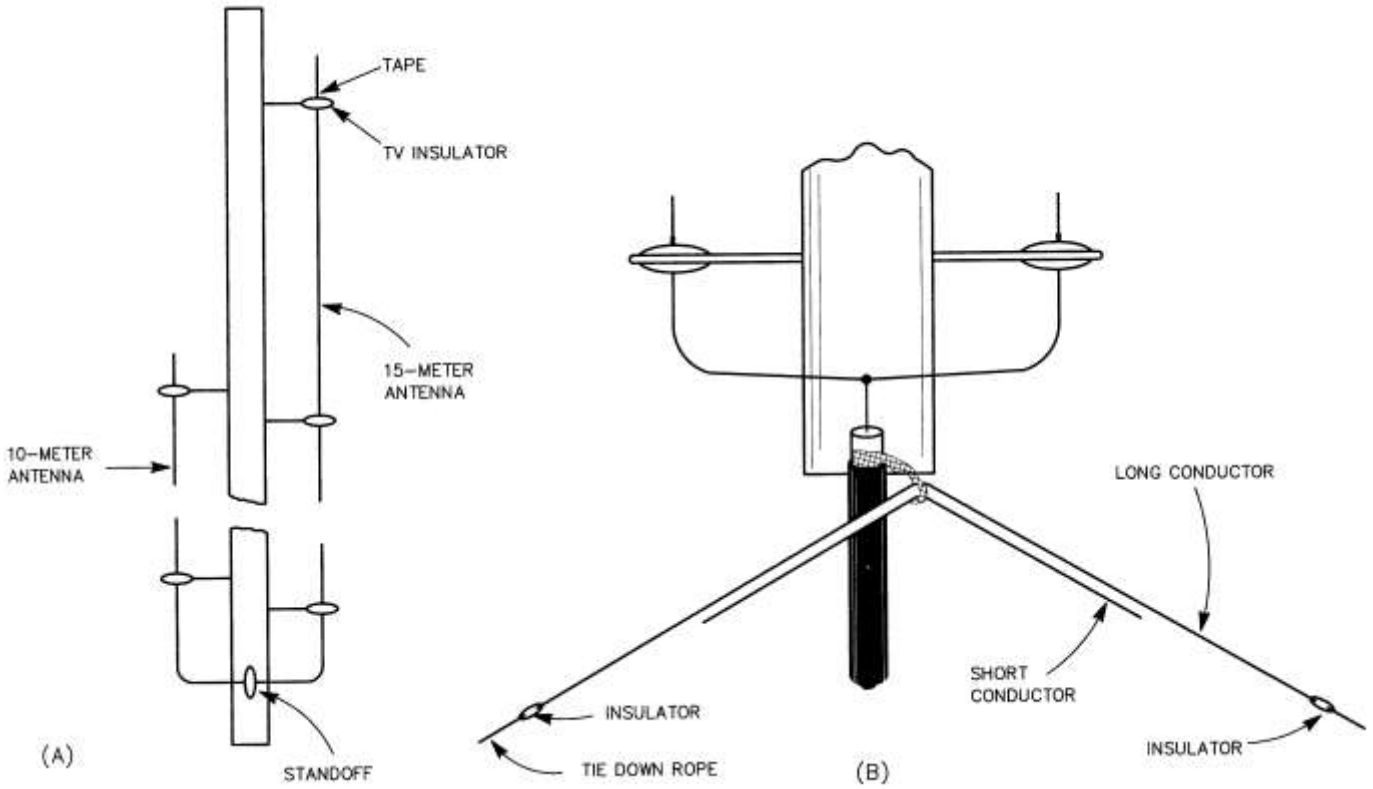


Frequency (MHz)	A (Inches)	B (Inches)
146	19-5/16"	18-11/16"
225	12-5/8"	12"
445	6-3/8"	5-3/4"

Homemade Ground Plane

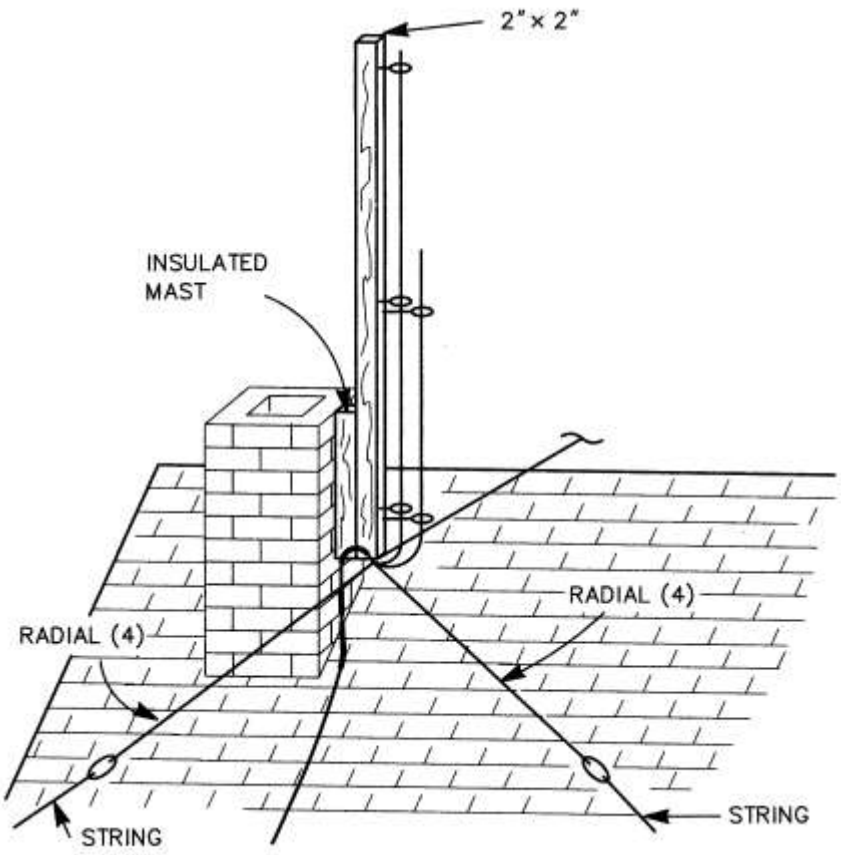


Homemade Vertical

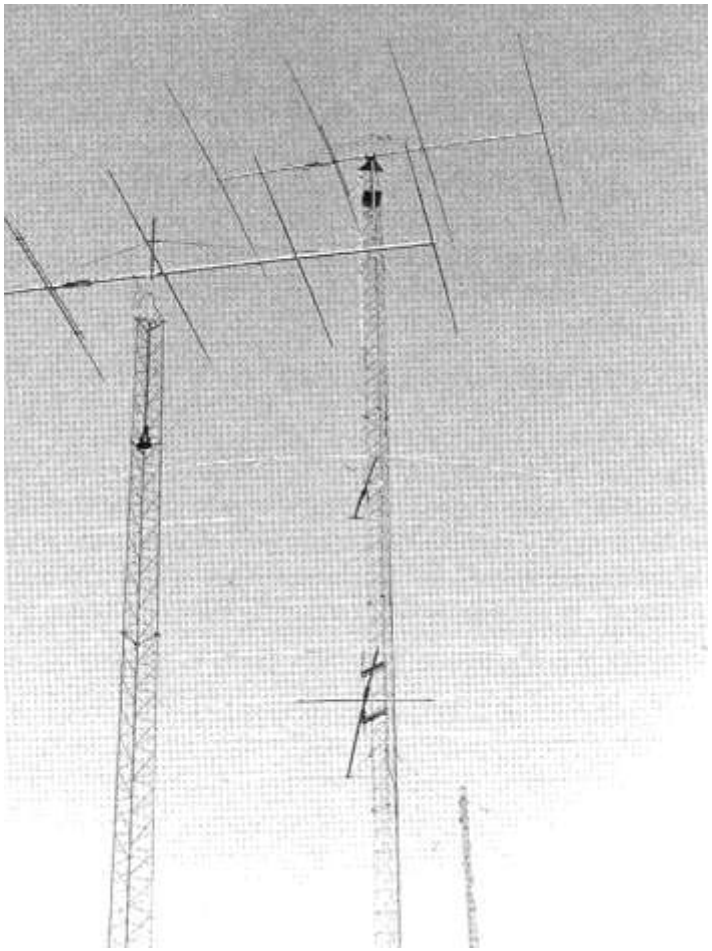


Homemade Wire Ground Plane

Homemade Roof-Mounted Vertical



Yagi Beams



The Parasitic Antennas

- The name is derived from:
- Parasite
- This means to “live off another”

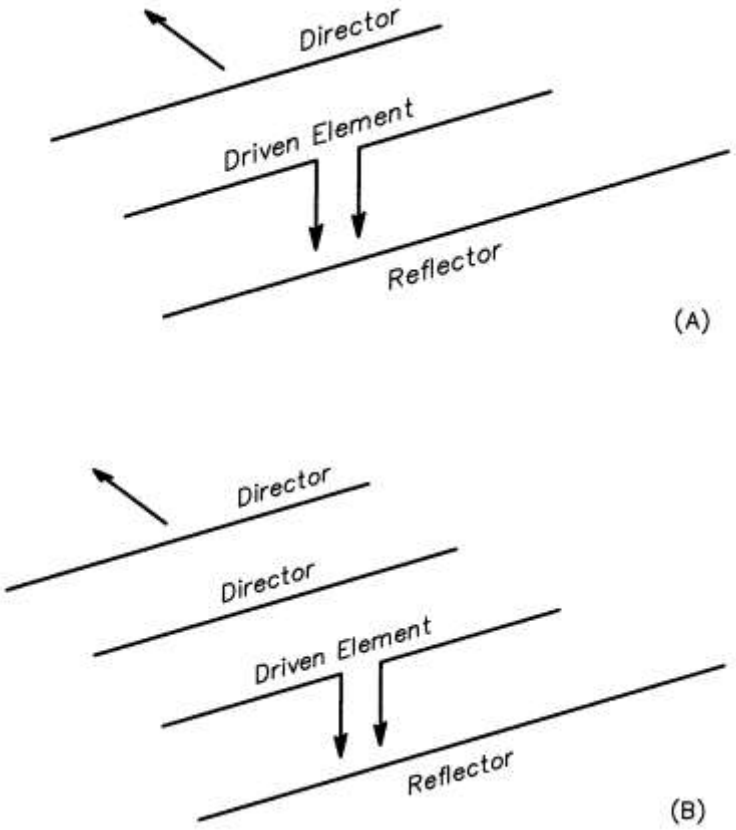
Types of Parasitic Antennas

- The Yagi (Uda)
- Log Periodic
- Cubical Quad
- Delta Loop

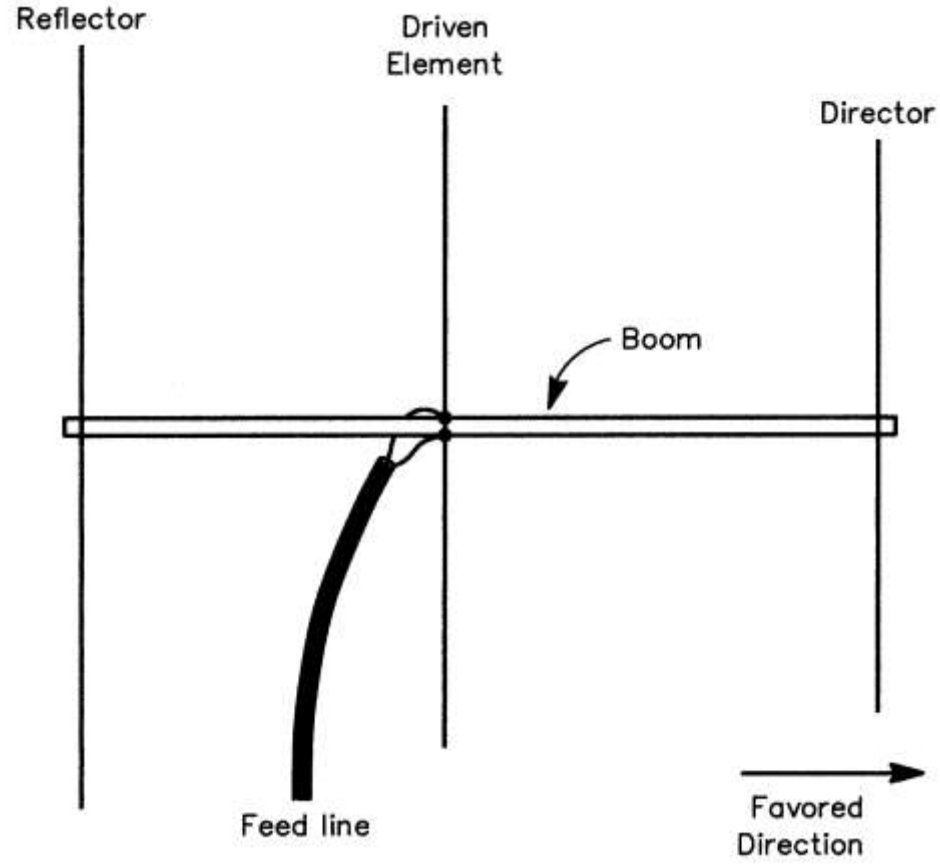
Elements of a Beam Antenna

- Driven Element (Dipole)
- Reflector(s)
- Director(s)
- Mast

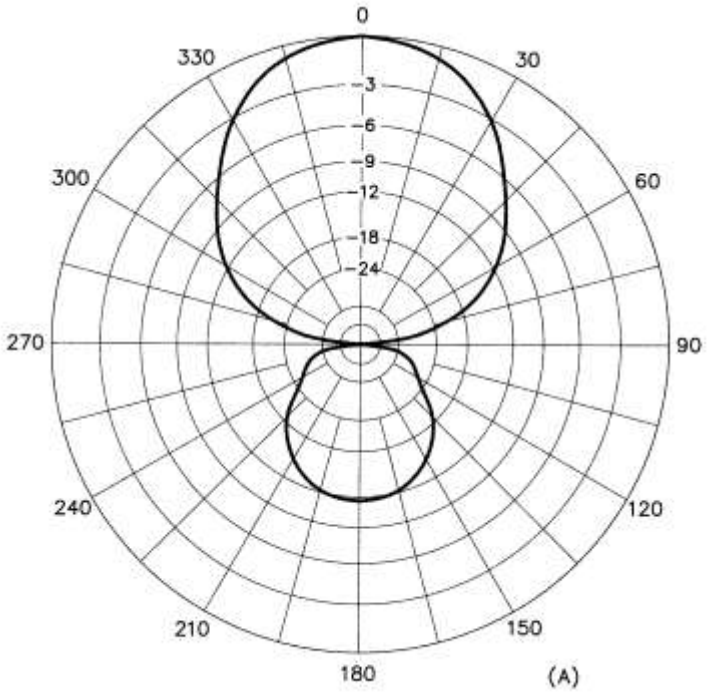
Elements of a Beam

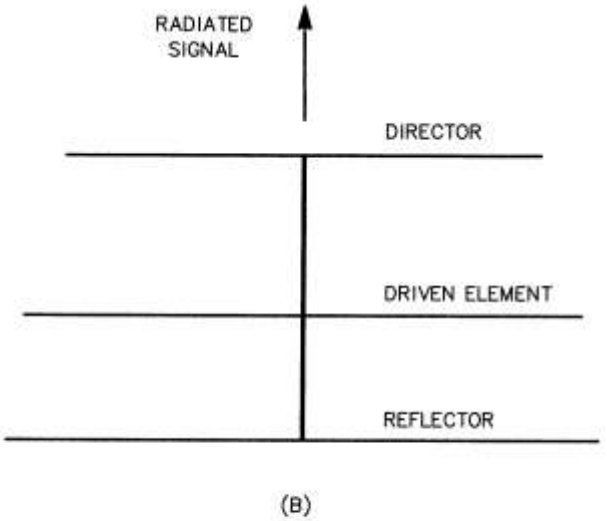


3 Element Beam Construction

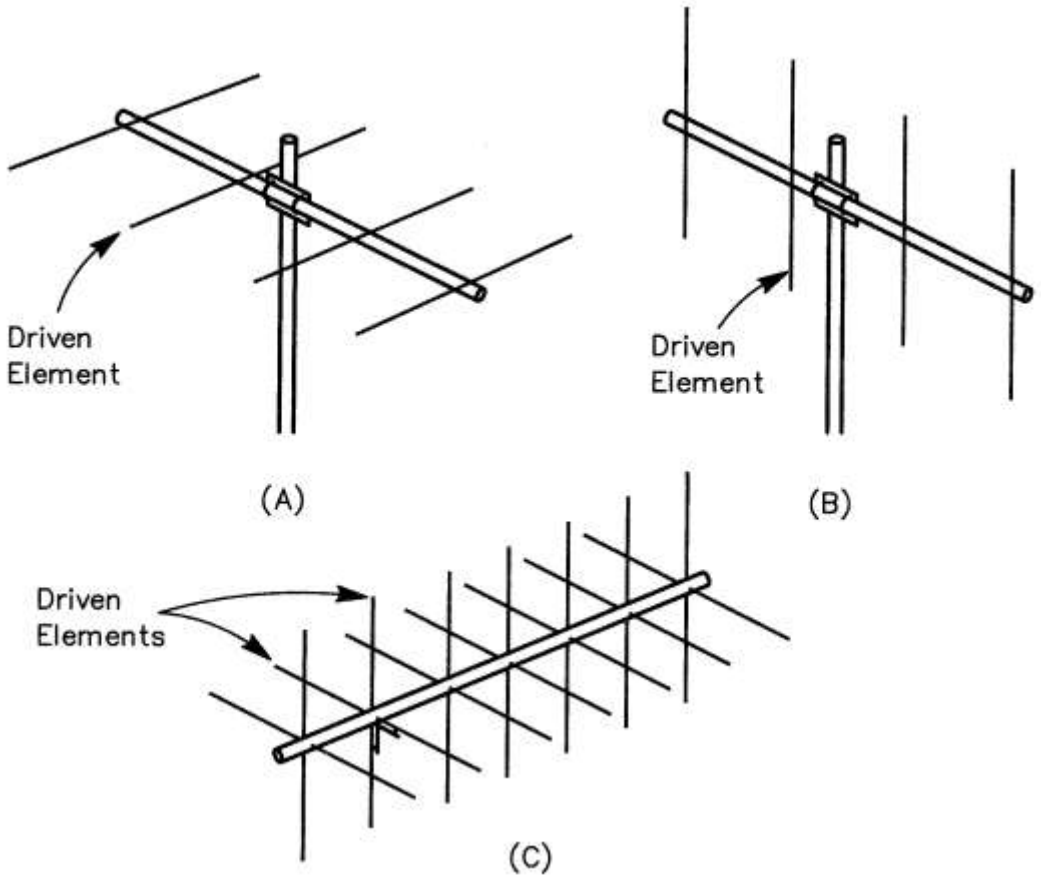


Beam Radiation Pattern

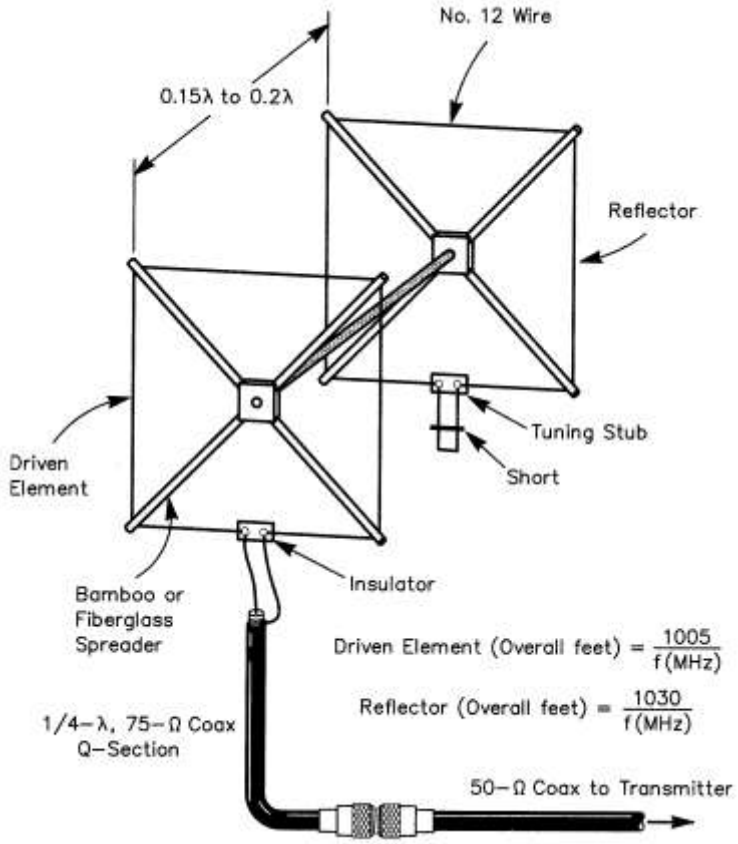




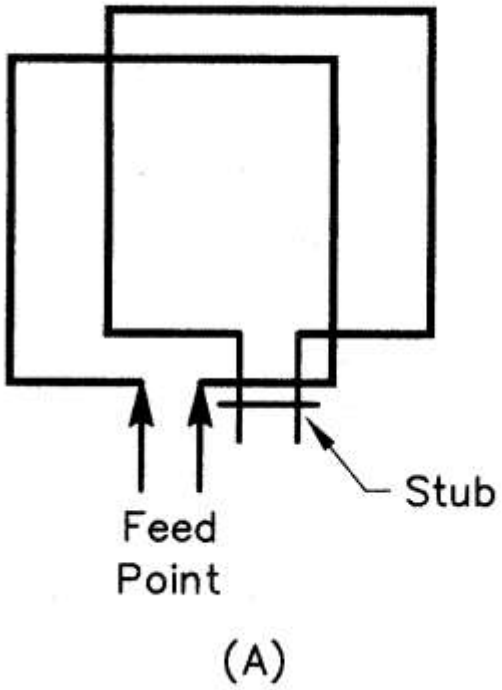
Variations of Beam Construction

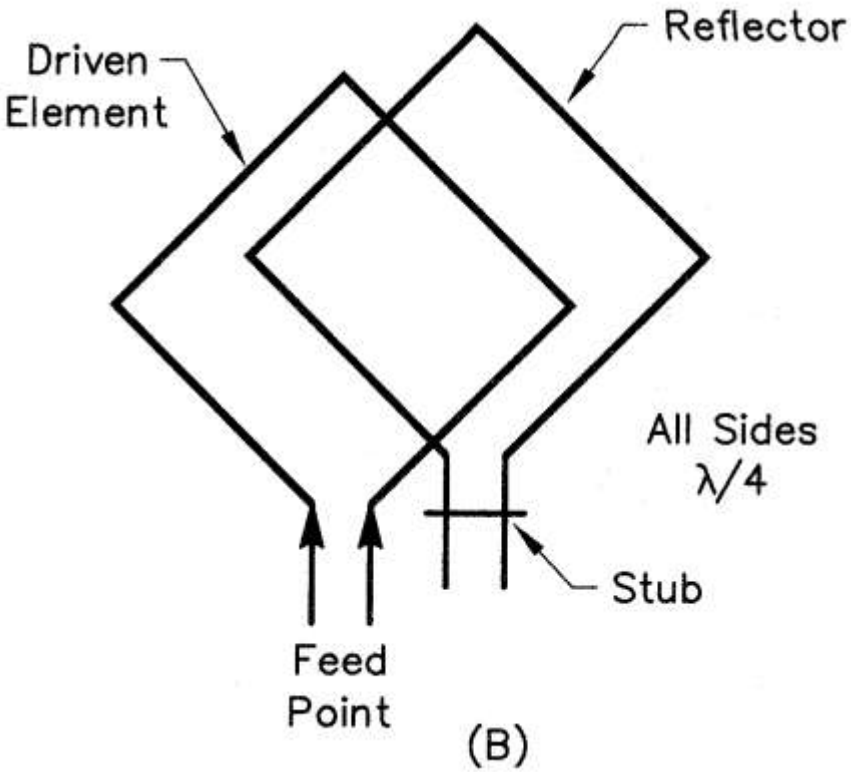


“Quagie” Configuration

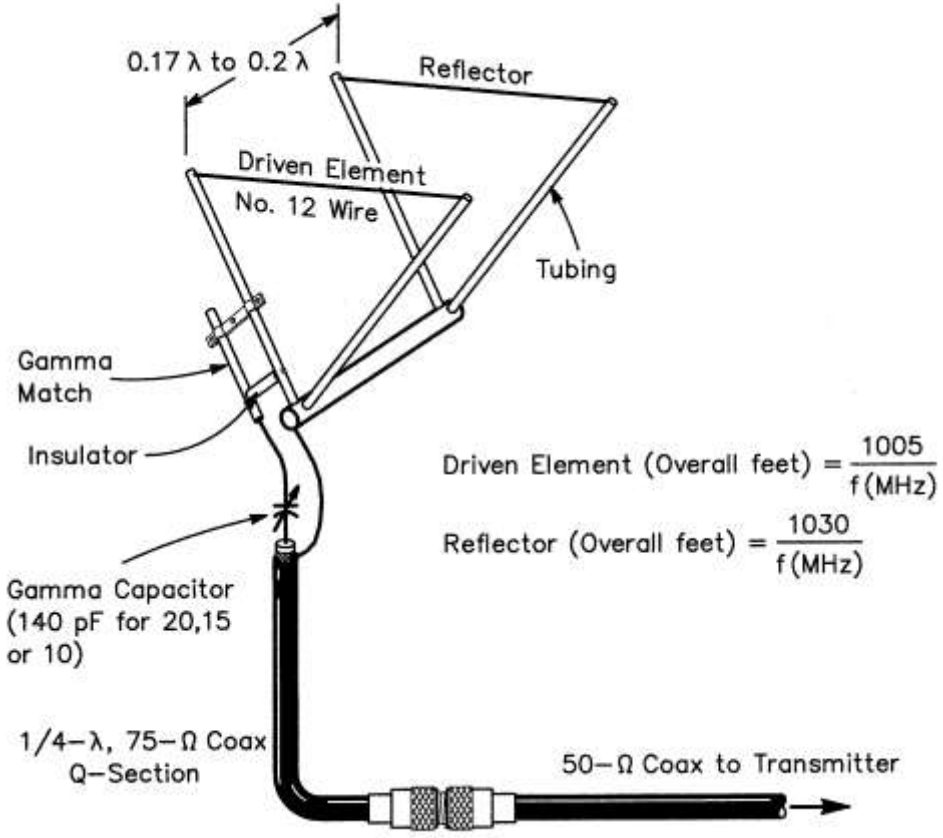


The Cubical Quad Antenna





Delta Loop Beam



Fooling Mother Nature

- Inductors
- Capacitors
- L/C circuits
- Ground systems

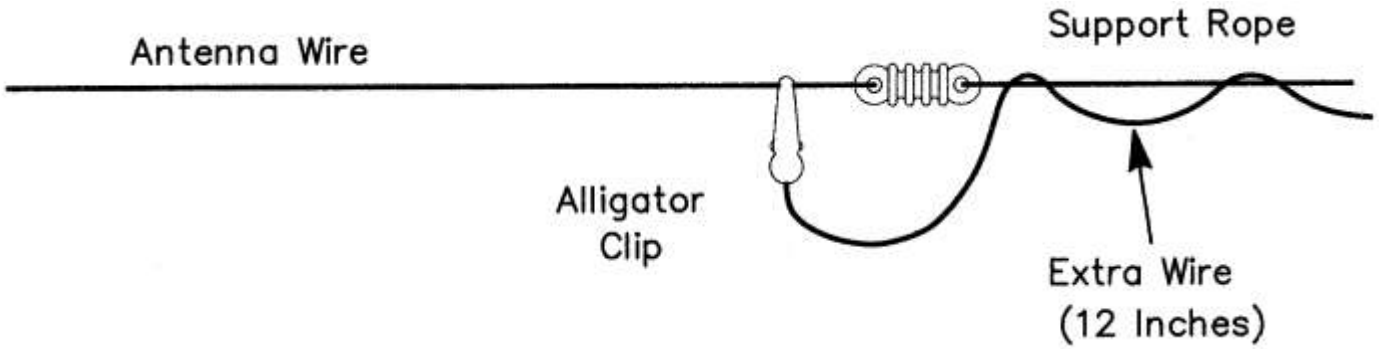
Impedance Matching Devices

- Transformers
- Balun's
- Transmatches
- Tuners

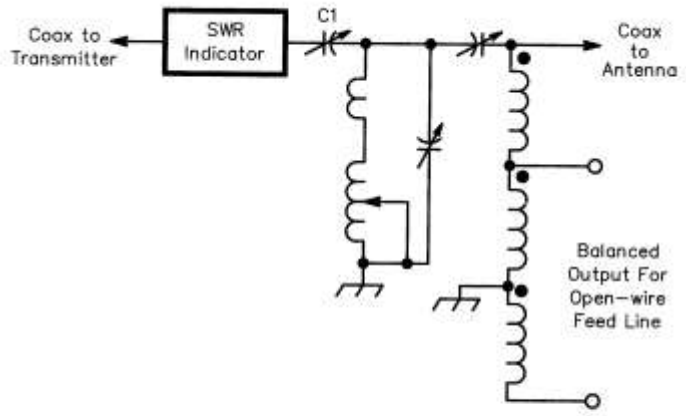
Coupling

- Direct
- Capacitance
  - Delta Match
  - Gamma Match

Tuning a Wire Antenna



Details of a Transmatch



(B)

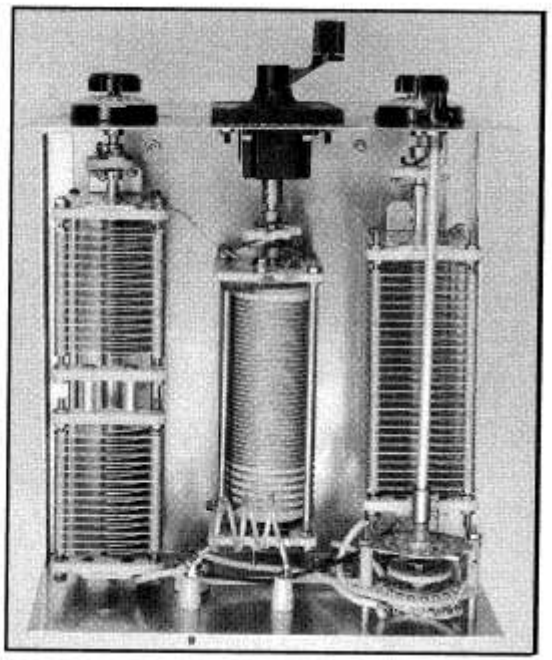
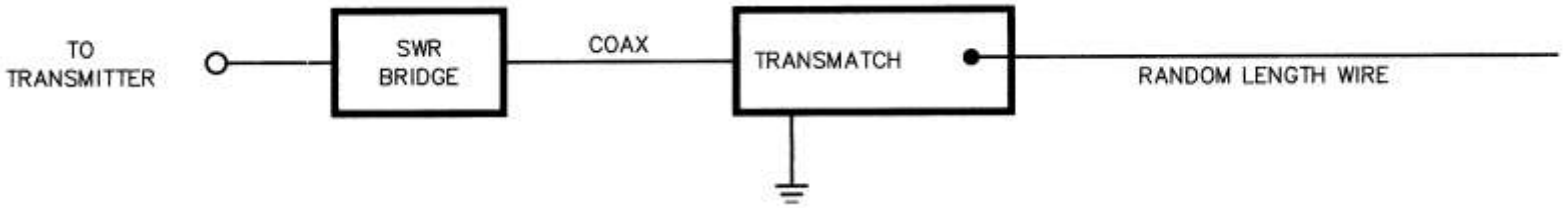
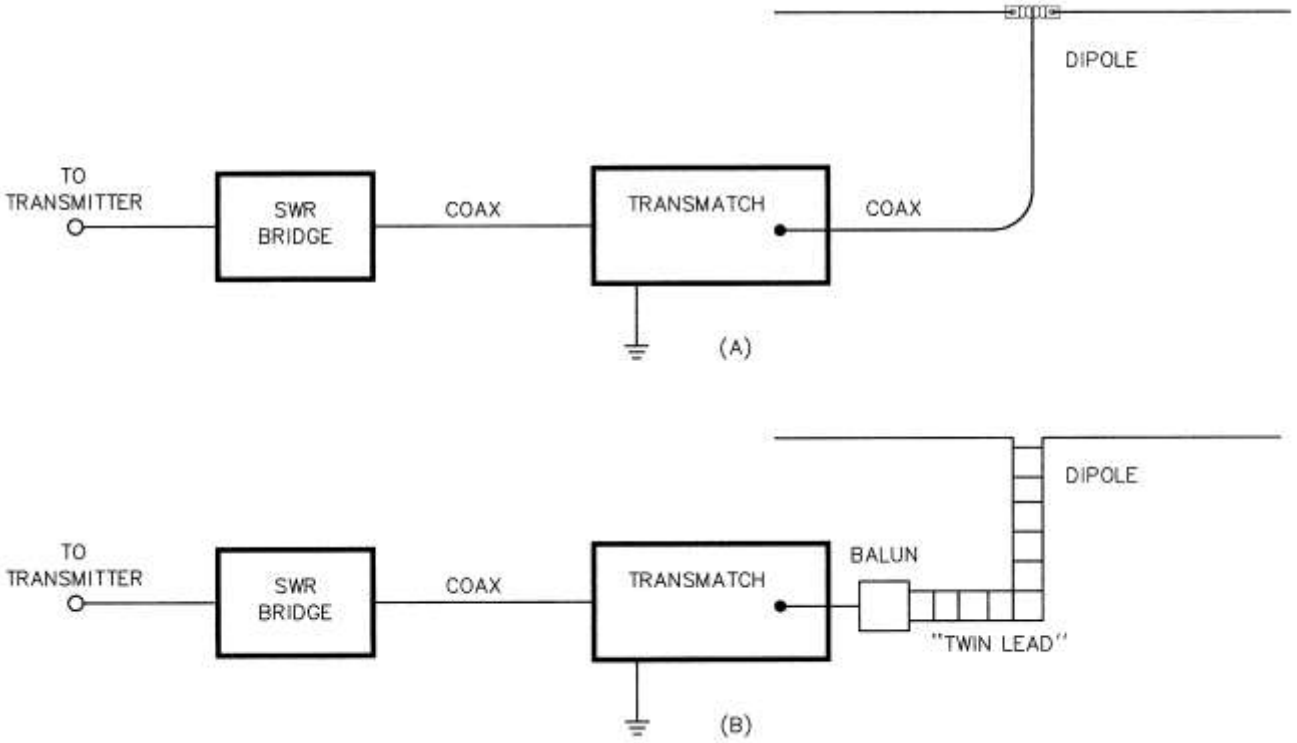


Figure 9-4—At A, the schematic diagram for a versatile Transmatch circuit. B shows a homemade Transmatch constructed from the circuit of A.

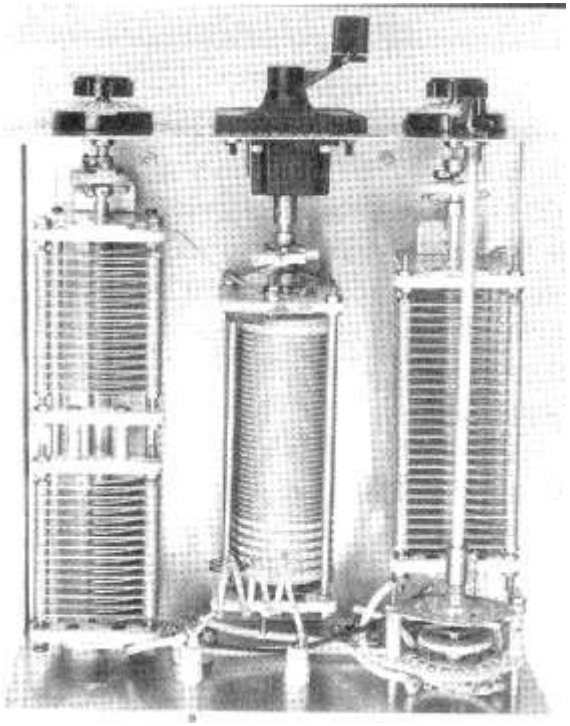
Using a Transmatch



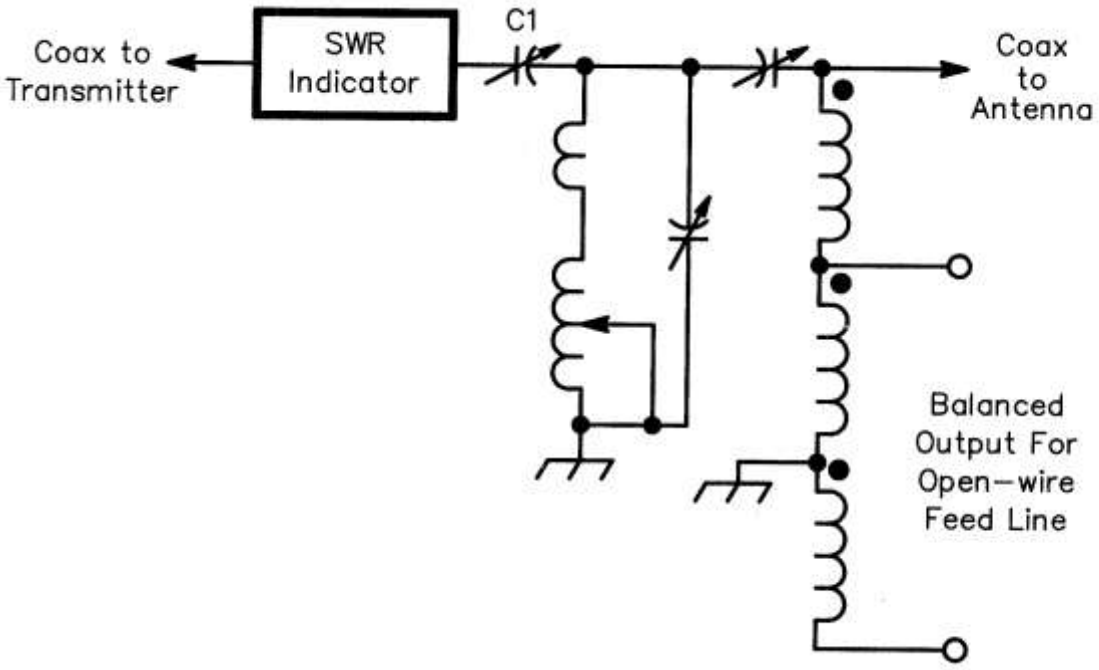
Using the Transmatch



Transmatch Configuration



Components of a Transmatch



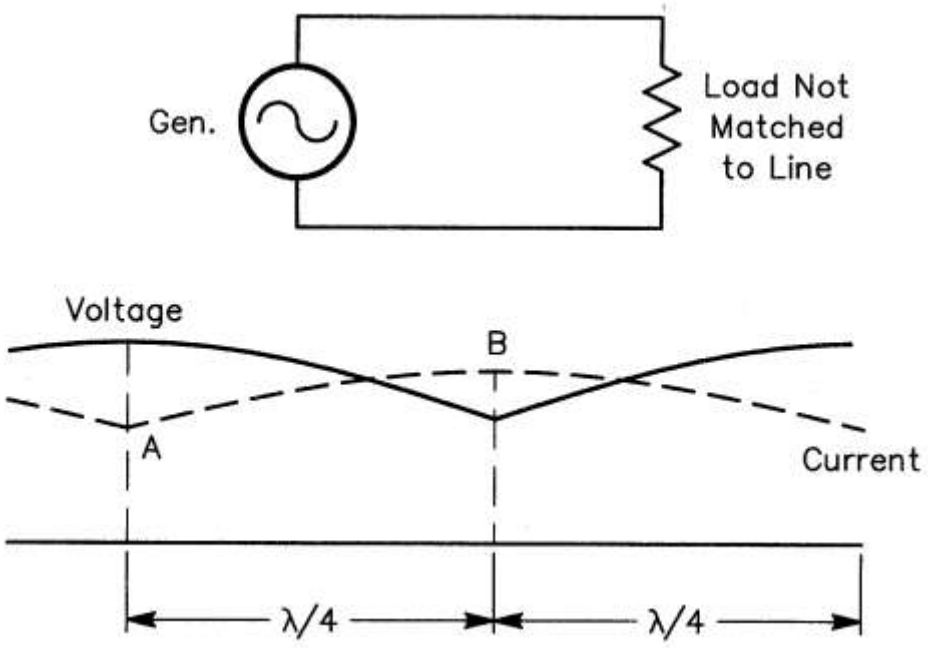
VSWR

- Voltage Standing Wave Ratio

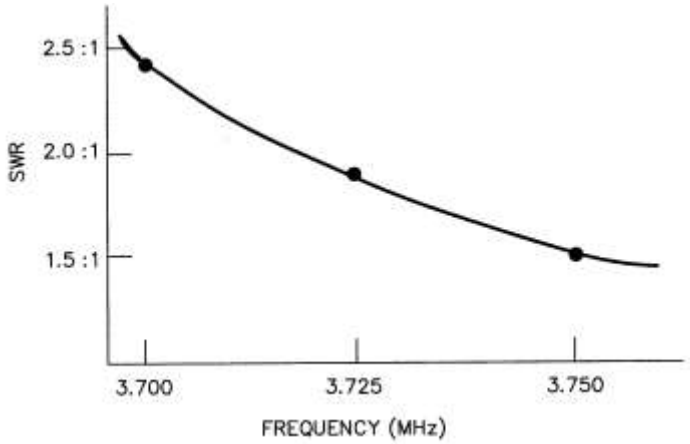
$$VSWR = |V(max)| / |V(min)|$$

- Or – the ratio of what goes out v. what is reflected back down the coax.
- High is Bad +3:1
- Low is Good- 3:1
- I.5:1 is VG

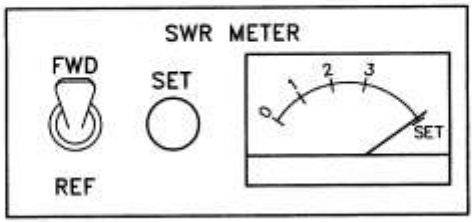
Concept of SWR



Reading SWR

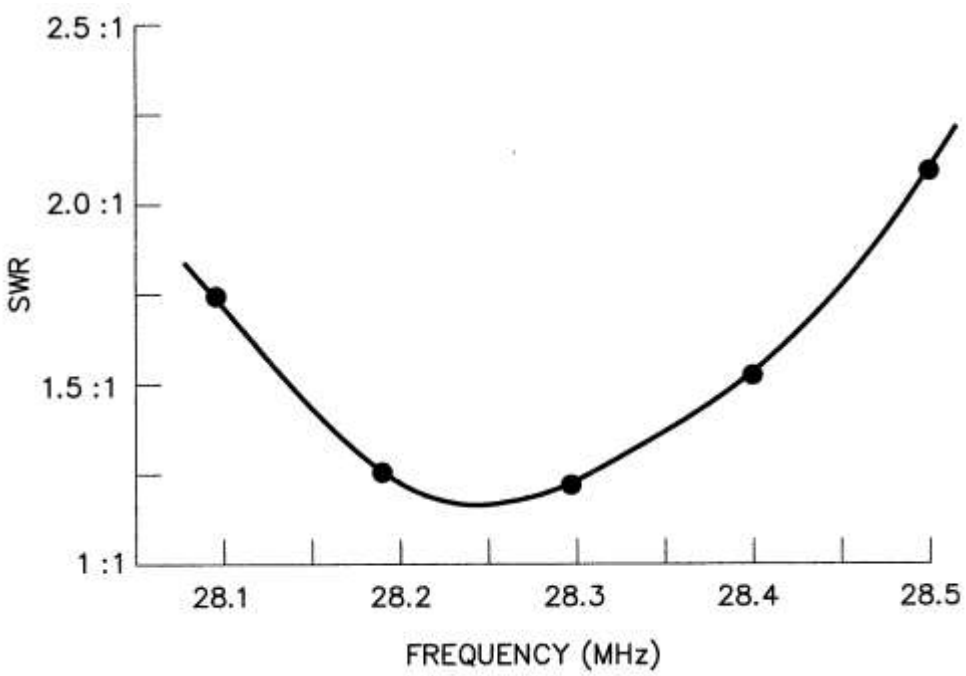


(A)



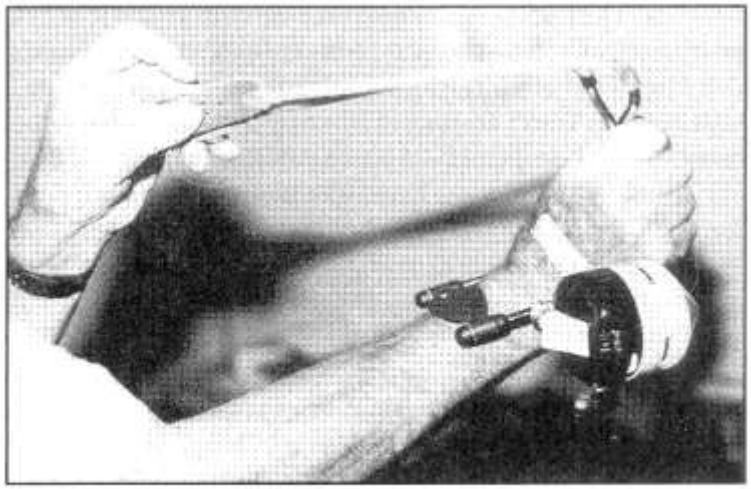
(B)

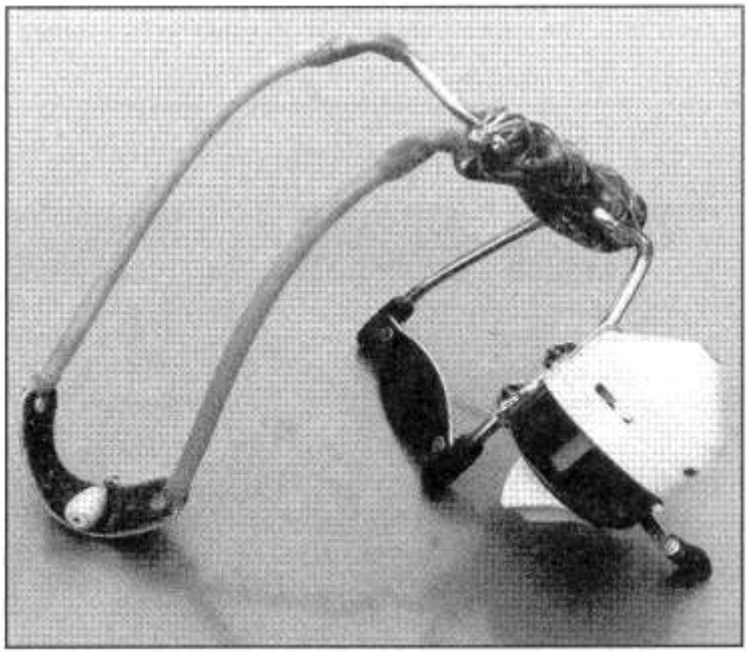
SWR Curve



Installation Photos

“Launching a Dipole”

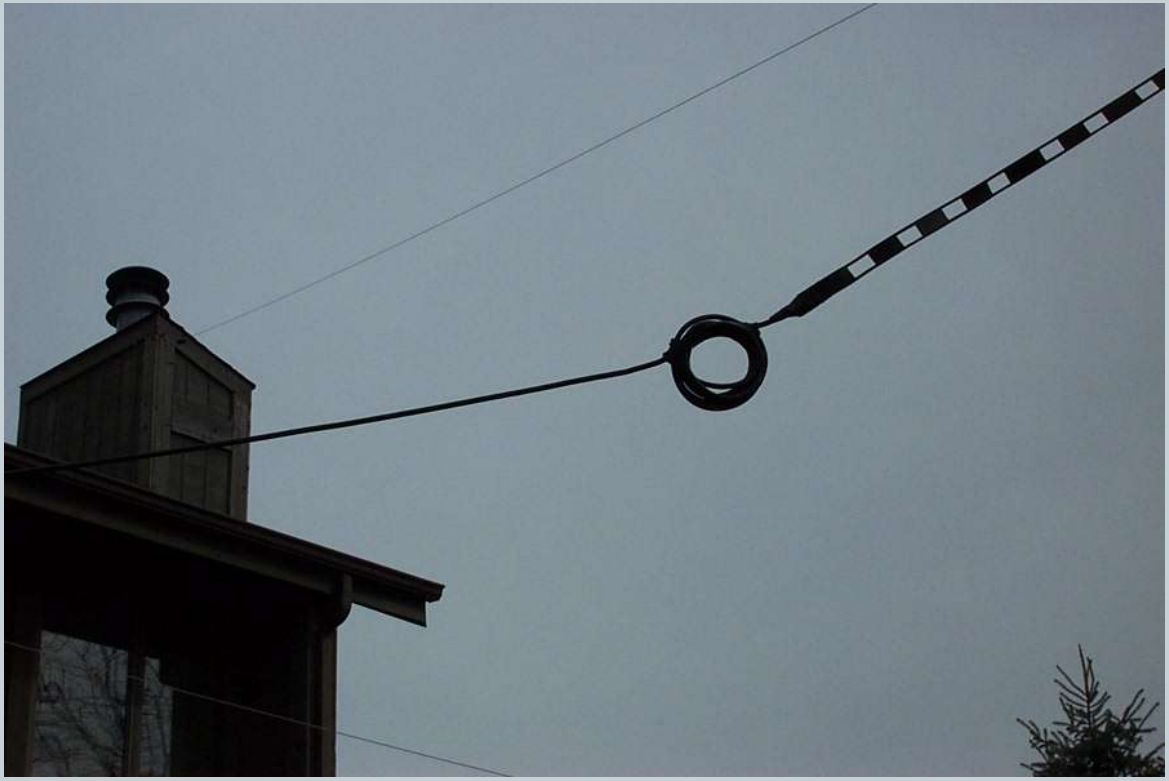




Fishing Reel Launcher

Central Insulator - Choke

RF Choke



Central Connections

Feed Thru

Mobile Antenna System

Fixed Station Grounding

Test Equipment – Antennas

- Multimeter
- SWR Meter
- Antenna Analyzer
- Noise Bridge
- Field Strength Meter
- Dummy Load
- Frequency Counter

VHF SWR Meter

HF SWR Meter

Antenna Bridge

Frequency Counter

“Grid-Dip” Meter

Automatic Height Adjustment

Adjustments

Antenna Experimentation – The Last Frontier

Summary

- Di-Pole
- 2-4-6-8 (468/F(Mhz)
- You can fool Mother Nature
- Have lot’s of fun building your own antenna.

Conclusion

- Antennas have always been the radio frontier. From Marconi to the present, Antenna technology remains an opportunity for innovation. Please enjoy your newfound knowledge.