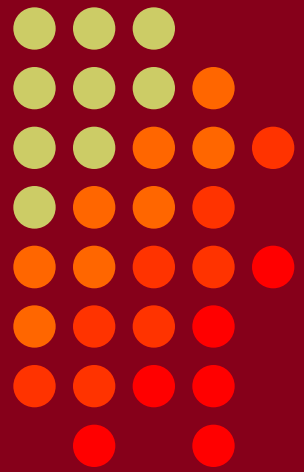
Receiving Antennas

- or -

What happened to the Beverages at K3LR and W3LPL?

- directive antennas for small lots
- higher performance for larger lots
- very high performance for multi-acre lots



Frank Donovan

W3LPL

• CTU •
CONTEST UNIVERSITY

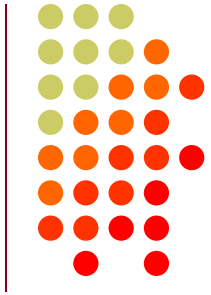
ICOM

Why Receiving Antennas?

- Much better performance than transmitting antennas, especially on 160 and 80 meters
  - greatly reduced footprint
  - greatly reduced height
  - greatly reduced mutual coupling between elements
    - simplifies receiving antenna design
  - greatly reduced need for high efficiency
  - greatly reduced cost
  - large arrays actually perform equivalent to huge multi-element Yagis!
- Combining two antennas with a variable phase controller
- Diversity reception with dual phase locked receivers

All dimensions in this presentation are for 160 meters

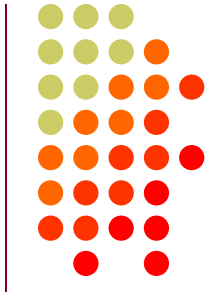
Receiving Directivity Factor (RDF)



- RDF is an accurate, proven measure of receiving antenna performance
  - forward gain at the desired azimuth and elevation angle compared to average gain over the entire hemisphere
- Nearby antennas and power lines degrade actual RDF, **especially high RDFs**
- 4 dB: small diameter loop
- 5 dB: a single vertical antenna (1/4 wavelength vertical and short verticals)
- 4 - 6 dB: 250 - 400 foot Beverages and Beverage on Ground (BOG)
- 6 - 8 dB: array of small loops (flag, pennant, ewe, K9AY, shared apex loop array)
- 9 dB: two element array of short verticals or a triangle array (65 foot spacing)
- 10 dB: 500 - 600 foot Beverage
- 11 dB: two close spaced 500 - 600 ft Beverages staggered 65 feet
- 12 dB: 800-900 foot Beverage
- 12 dB: 4-square array of short verticals only 65 feet on a side (1/10 acre)
- 13-14 dB: 4 short verticals or a steerable 8-circle array of short verticals (1 - 3 acres)
- 14 dB 2 broadside, staggered 800-900 ft Beverages separated 350 ft (8 acres or more)
- 14-16 dB: 3 broadside 800-900 ft Beverages and arrays of 8 short verticals (5 - 20 acres)

Size Matters!

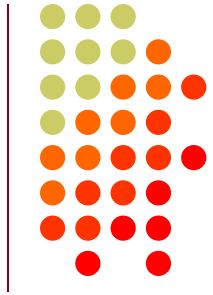
Popular Receiving Antennas



- Loops
  - small diameter loop (“magnetic” loop)
  - fixed unidirectional loop (flag, pennant, ewe, K9AY)
  - mechanically rotatable unidirectional loop (rotatable flag)
  - electrically steerable compact array of loops (K9AY, Shared Apex Loop Array)
- Beverages
  - single wire Beverage
  - Beverage on ground (BOG)
  - two wire bi-directional Beverage
  - two close spaced Beverages, staggered 65 feet
  - phased broadside Beverages spaced 350 feet
  - phased broadside staggered Beverages (350 feet broadside, staggered 65 feet)
- Arrays of short verticals (2 elements to 8 elements or more)
  - active high impedance verticals with amplifiers at the base of each vertical
  - passive low impedance verticals with radials and umbrella wires

Small Diameter Loop Antenna

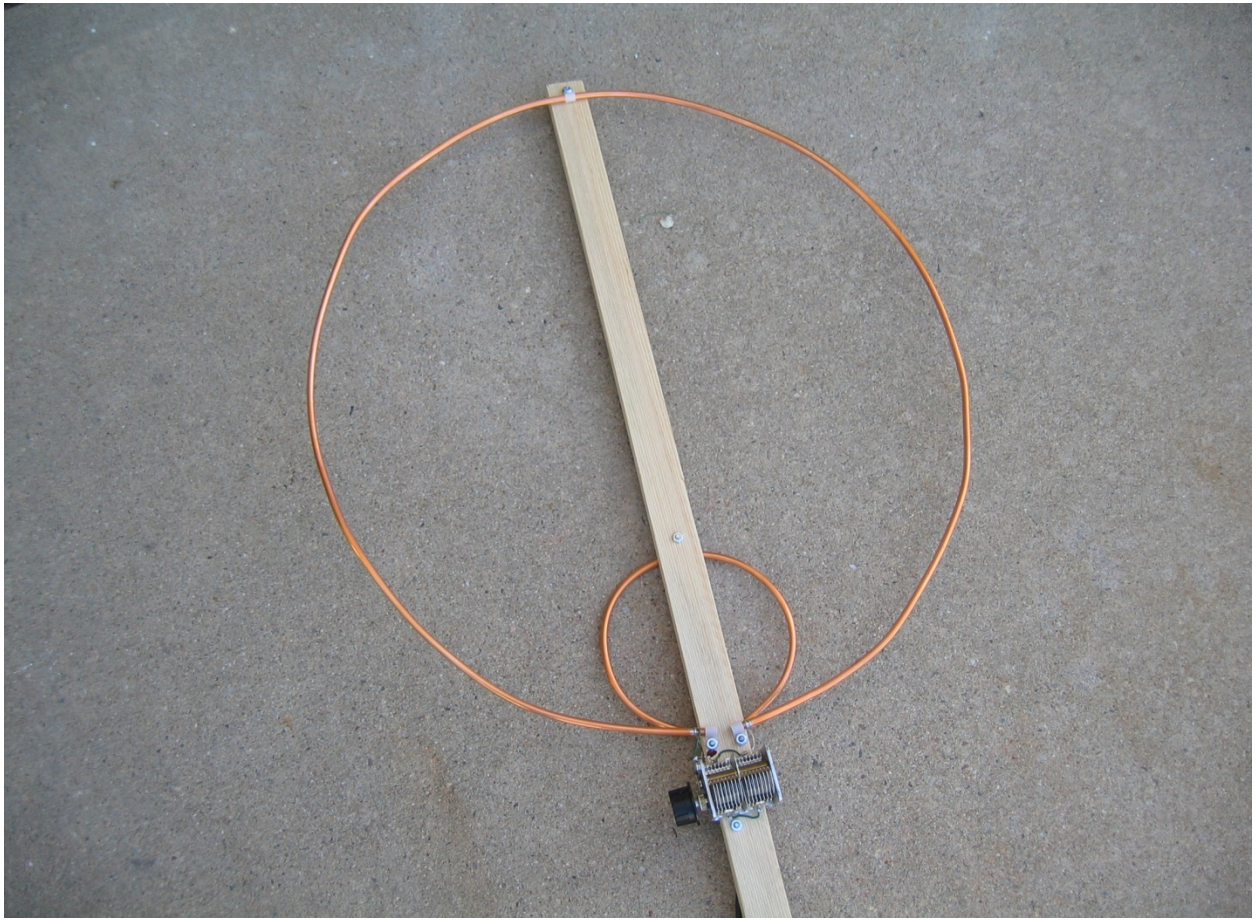
"magnetic" loop



- Excellent for nulling a single RFI source
  - the RFI must be vertically polarized
  - the RFI must be received via ground wave
- Excellent for very accurately locating RFI sources
- Bi-directional figure-8 pattern
- Deep nulls off both ends of the loop
  - mechanically rotate the loop until the single RFI source is nulled
- Loop antennas produce very low signal levels
  - requires a high gain, low noise, high dynamic range preamplifier
  - requires careful attention to isolation of stray pickup from:
    - coaxial feedline
    - control cable
    - bury cables about 12 inches deep for best null depth

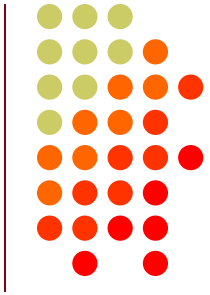
Small Diameter Loop

inexpensive and very easy to build and use
24 - 36 inch diameter
bidirectional 160 degree 3 dB beamwidth
4 dB RDF



http://tomthompson.com/radio/ReceivingLoop/loop.html

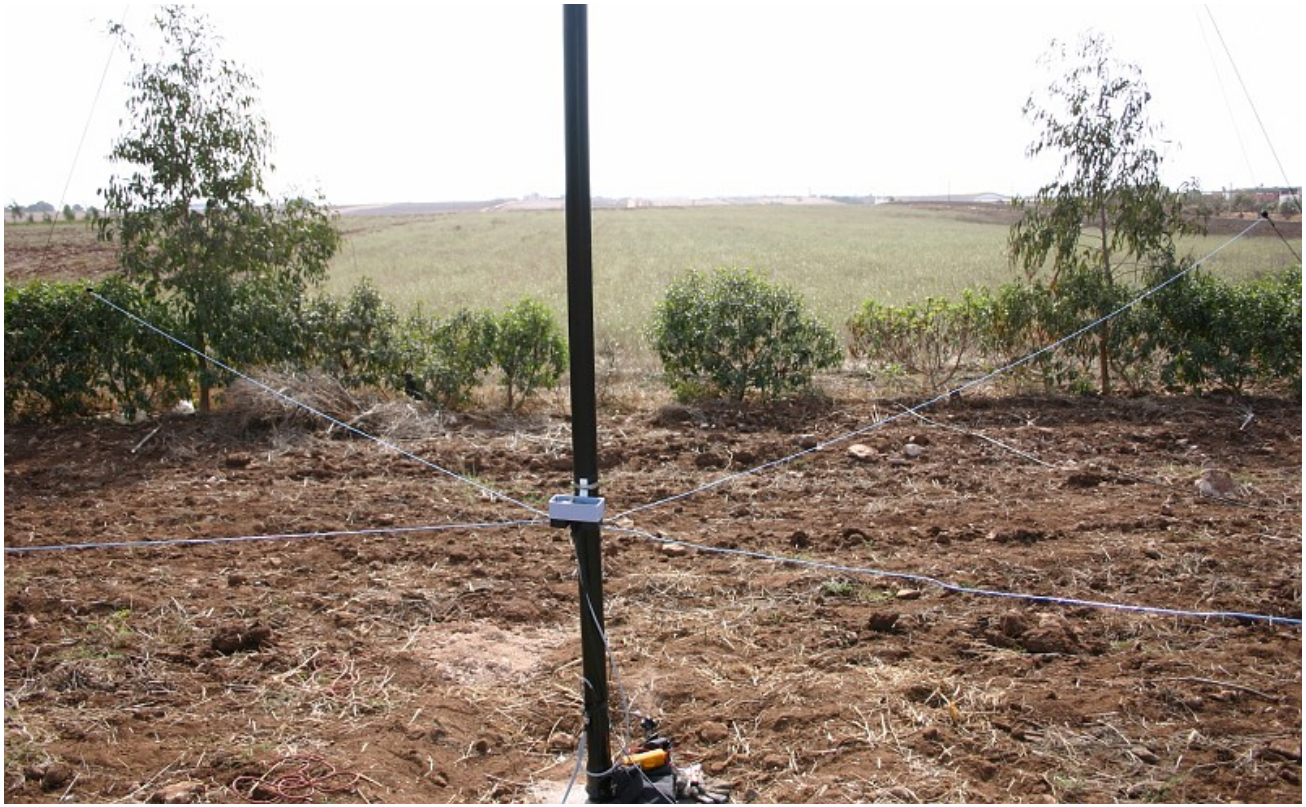
Electrically Steerable Loop Arrays



- Two K9AY Loops
  - switchable in four directions
  - footprint is only 25x25 feet and 25 feet tall
  - 120 degree 3 dB beamwidth
  - 7 dB RDF
- Shared Apex Loop Array
  - switchable in eight directions
  - footprint is only 50x50 feet and 25 feet tall
  - 75 degree 3 dB beamwidth
  - 8 dB RDF
- Loop antennas produce very low signal levels
  - high gain, low noise, high dynamic range preamplifier
  - requires careful attention to isolating stray pickup from:
    - coaxial feedline
    - control cable
    - bury cables about 12 inches deep for best null depth

Two K9AY Loops

25x25 foot square footprint
switchable in four directions
120 degree 3 dB beamwidth
7 dB RDF



www.arraysolutions.com/Products/lowbandrcv.htm

Shared Apex Loop Array

50x50 foot square footprint
switchable in eight directions
75 degree 3 dB beamwidth
8 dB RDF

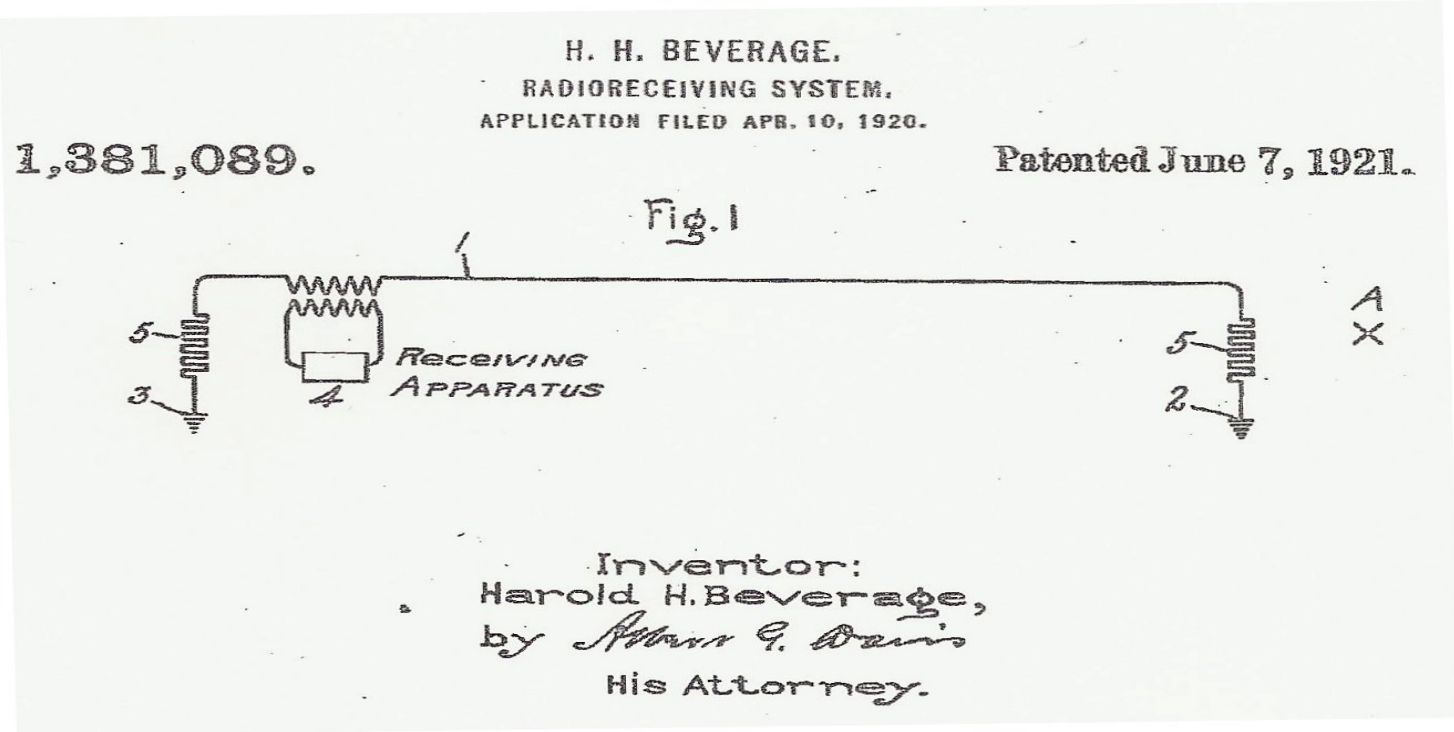
Array Solutions AS-SAL-30

Single Wire Beverage

a very simple and inexpensive antenna

250 - 400 feet long	4 - 6 dB RDF	100 degree beamwidth
500 - 700 feet long	10 dB RDF	70 degree beamwidth
800-900 feet long	12 dB RDF	60 degree beamwidth

longer than 900 feet often results in degraded performance


H. H. BEVERAGE.
RADIORECEIVING SYSTEM.
APPLICATION FILED APR. 10, 1920.

1,381,089. Patented June 7, 1921.

Fig. 1

Inventor:
Harold H. Beverage,
by Albert G. Davis
His Attorney.

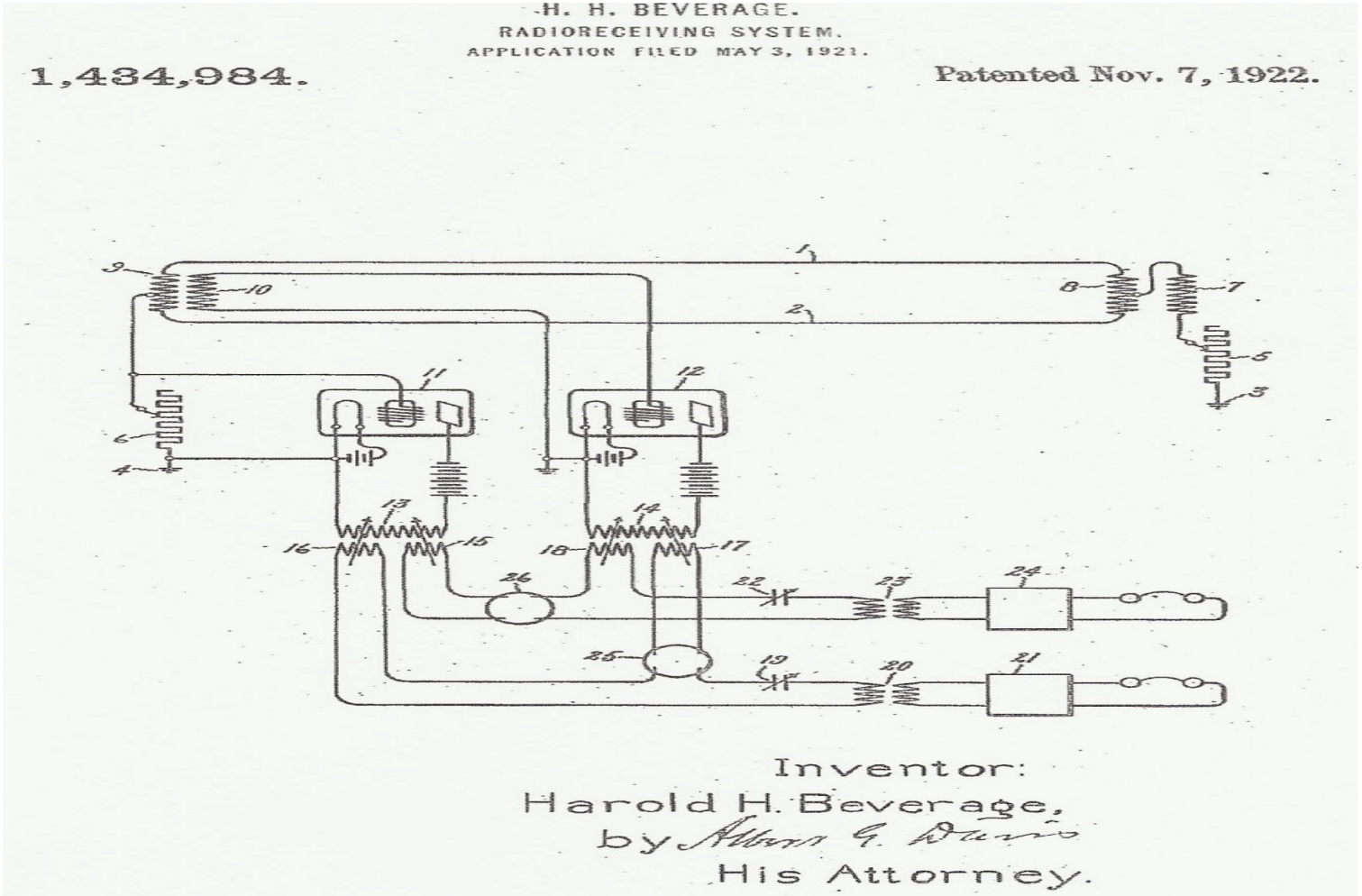
Beverage on Ground

a good choice when stealth is important
about 220 feet long
longer lengths often degrade performance
70 - 100 degree 3 dB beamwidth
6 - 8 dB RDF

http://n4dj.com/Beverage.html

Two Wire Bidirectional Beverage

two directions with full Beverage directivity
simultaneous dual reception or switched



H. H. BEVERAGE.
RADIORECEIVING SYSTEM.
APPLICATION FILED MAY 3, 1921.

1,434,984. Patented Nov. 7, 1922.

Inventor:
Harold H. Beverage,
by Albert G. Davis
His Attorney.

Staggered Pair of Beverages

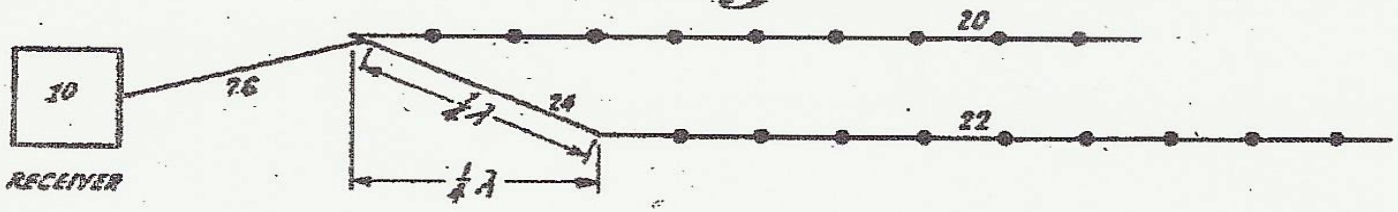
Significantly enhanced front-to-back ratio
compared to a single wire Beverage
The deep rear null can be steered
by a variable phase combiner
11 dB RDF for 500-600 foot Beverages

Sept. 1, 1931. H. O. PETERSON 1,821,402

ANTENNA

Filed Nov. 8, 1927 2 Sheets-Sheet 2

Fig. 7

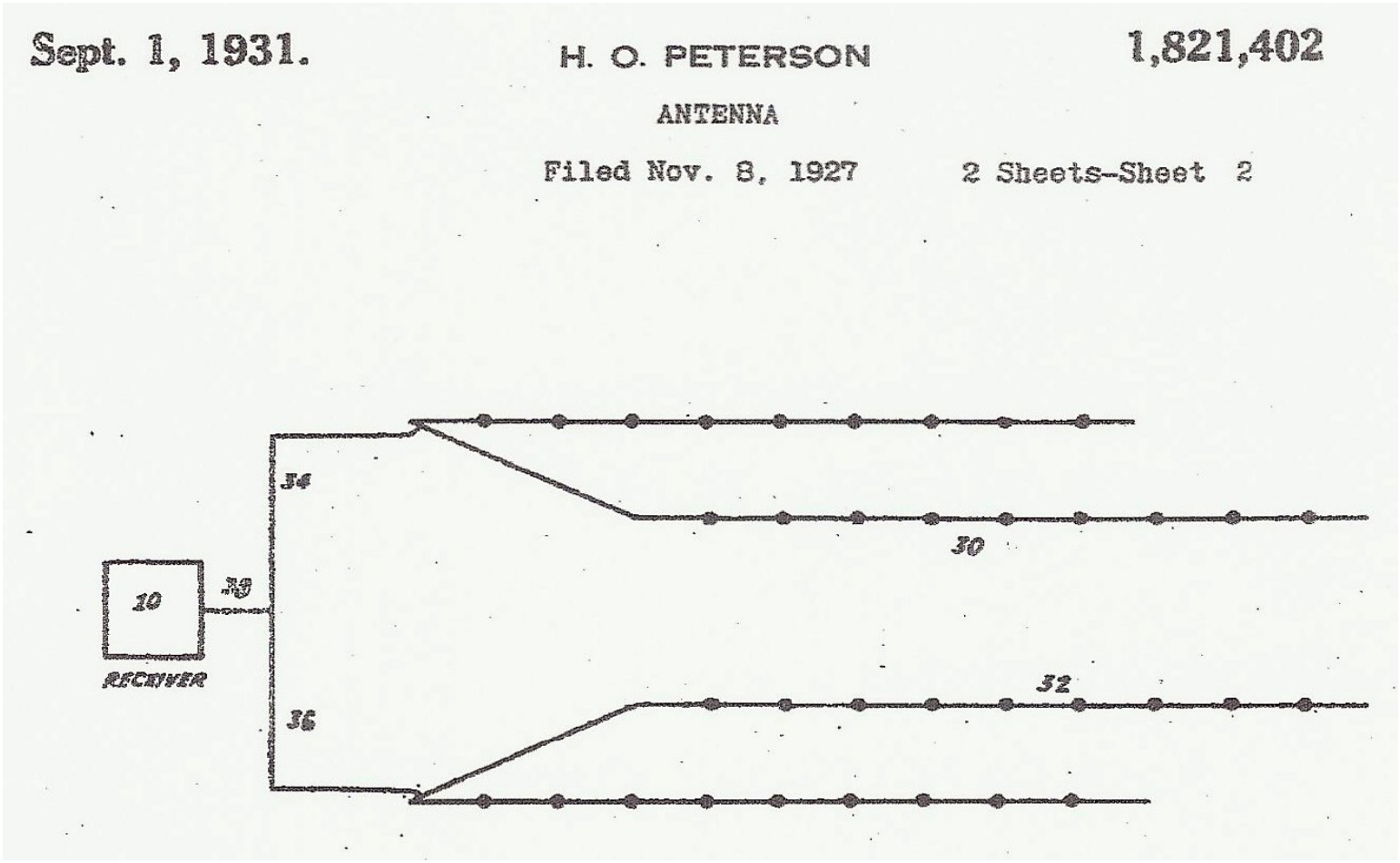


Broadside Pair of Staggered Beverages

800-900 foot Beverages

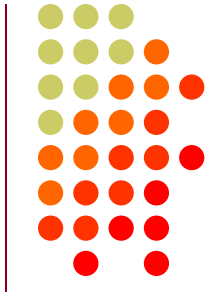
45 degree 3 dB beamwidth

14 dB RDF



Phased Short Verticals

two or more high impedance 24 foot verticals



- No radials
- No umbrella wires
- As little a 65 foot element spacing
  - closer spacing is possible with precise phase and amplitude alignment
- Needs a high gain amplifier at the feed point of each vertical
- Requires careful attention to all construction details
- Switchable in multiple directions
- Cannot be installed within ten feet of nearby objects
  - trees
  - any other conductive or partially conductive structure

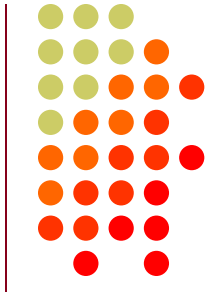
Electrically Steerable 4-Square Vertical Array

four high impedance 24 foot verticals
no umbrella wires, no radials
80x80 foot square footprint
requires a high gain amplifier at the base of each vertical
switchable in four directions
100 degree 3 dB beamwidth
12 dB RDF in a small space

Hi-Z-4-LV2-80

Phased Short Verticals

two or more low impedance 25 foot verticals



- Requires eight 70 foot radials per vertical
  - or sixteen 35 foot radials
  - laid on the ground or shallow buried
- Requires four 25 foot umbrella wires per vertical
  - or four 35 foot verticals with no umbrella wires
- As little a 65 foot element spacing
  - closer spacing is impractical for optimum performance
- No amplifiers are needed at the base of each vertical
- Switchable in multiple directions
- Tolerant of nearby objects
- Easy to homebrew your own antenna
  - large arrays are very tolerant of moderate amplitude and phase errors

Electrically Steerable 4-Square Vertical Array

four low impedance 25 foot umbrella verticals
four 25 foot umbrella wires per vertical
eight 70 foot or sixteen 35 foot radials per vertical
65x65 foot square footprint
switchable in four directions
easy and inexpensive to build
100 degree 3 dB beamwidth
12 dB RDF in a small space

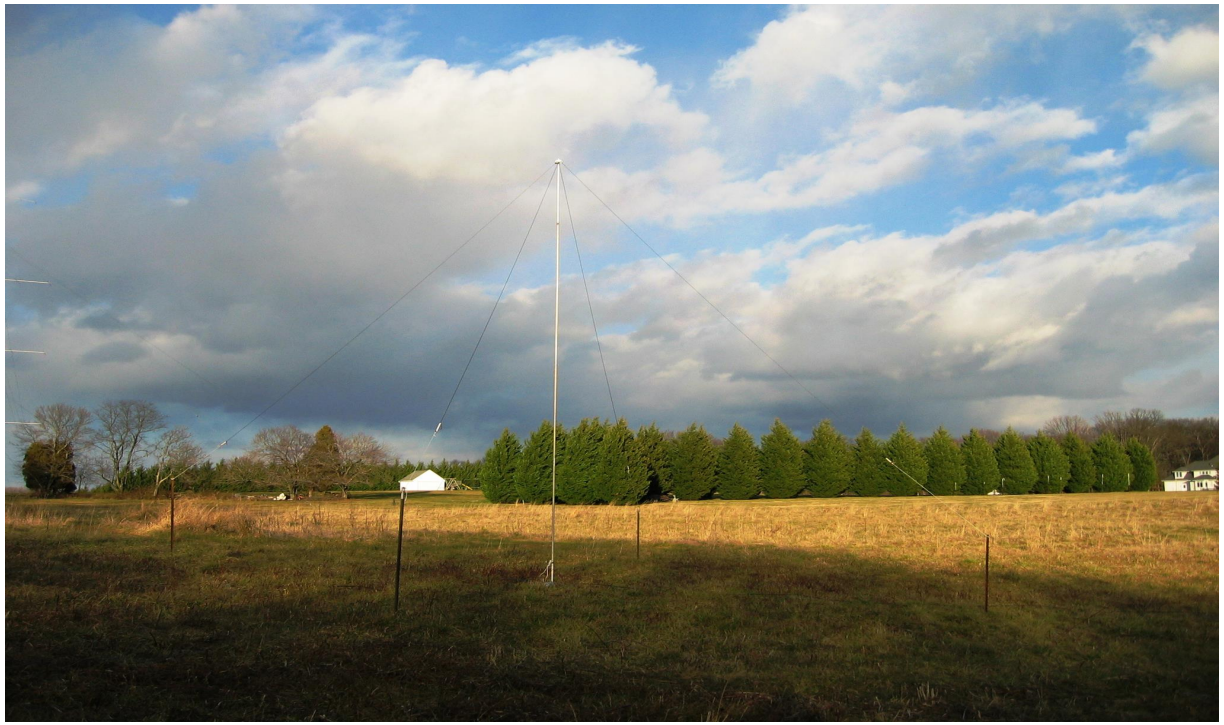
www.iv3prk.it/user/image/site2-rxant.prk_4-square_1.pdf

Electrically Steerable 8-Circle Vertical Array

eight high impedance 24 foot verticals
no umbrella wires, no radials
requires a high gain amplifier at the base of each vertical
200 foot array diameter
switchable in eight directions
45 degree 3 dB beamwidth similar to a 5 element Yagi
14 dB RDF

Electrically Steerable 8-Circle Vertical Array

eight low impedance 25 foot umbrella verticals
four 25 foot umbrella wires per vertical
eight 70 foot or sixteen 35 foot radials per vertical
300 - 350 foot array diameter
switchable in eight directions
easy and inexpensive to build
45 degree 3 dB beamwidth similar to a 5 element Yagi
13 dB RDF



Receive Antenna Variable Phasing Controller

combine two receiving antennas
to create a directional pattern with steerable nulls

Phase Synchronous Diversity Reception

two widely spaced antennas (500-1000+ feet) feeding
two identical full performance phase synchronous receivers

Elecraft K3 with KRX3 subreceiver