

Antenne di piccole dimensioni

$$\begin{aligned}\vec{N} &= \int_v \underbrace{e^{jk\vec{u}_r \cdot \vec{r}'}}_{1 + jk\vec{u}_r \cdot \vec{r}' + \dots} \vec{J}(\vec{r}') dv' \\ &= j\omega \vec{m}_e + \frac{j\omega}{c} \vec{m}_m \times \vec{u}_r - \frac{\omega^2}{c} \vec{Q}_e \cdot \vec{u}_r\end{aligned}$$

momento di dipolo elettrico

$$\vec{m}_e = \frac{1}{j\omega} \int_v \vec{J}(\vec{r}') dv' = \int_v \vec{r}' \rho(\vec{r}') dv'$$

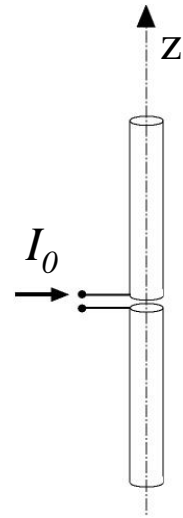
momento di dipolo magnetico

$$\vec{m}_m = \frac{1}{2} \int_v \vec{r}' \times \vec{J}(\vec{r}') dv'$$

tensore quadrupolare elettrico

$$\begin{aligned}\vec{Q}_e &= \frac{1}{2j\omega} \int_v (\vec{r}' \vec{J}(\vec{r}') + \vec{J}(\vec{r}') \vec{r}') dv' \\ &= \int_v \vec{r}' \vec{r}' \rho(\vec{r}') dv'\end{aligned}$$

dipoli corti



$$\vec{N} = \int_v \underbrace{e^{jk\vec{u}_r \cdot \vec{r}'}}_{\approx 1} \vec{J}(\vec{r}') dv \approx \vec{u}_z I_0 L_{eq}$$

$$L_{eq} = \int \frac{I(z)}{I_0} dz$$

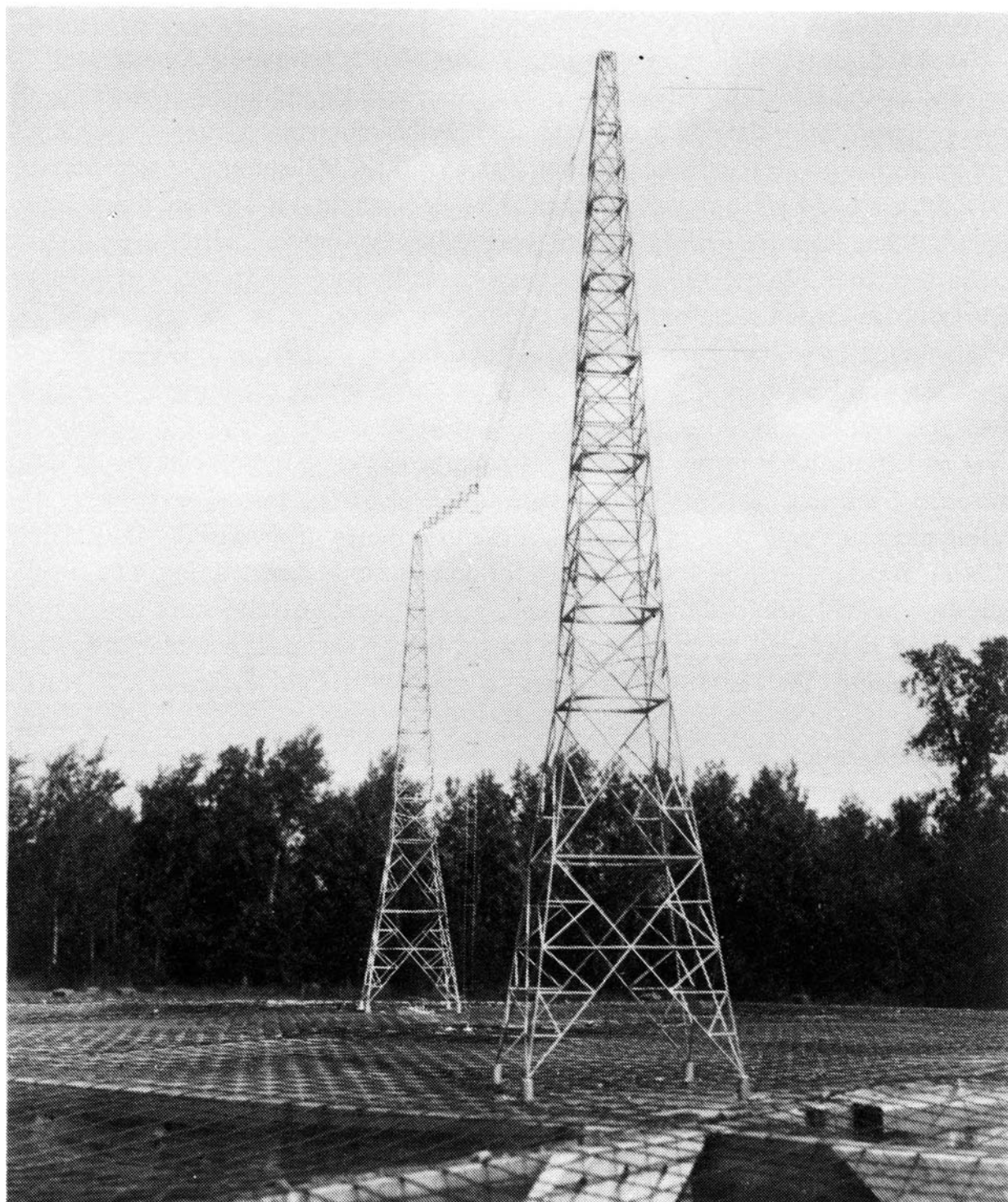
$$K = \frac{\eta}{8\lambda^2} (I_0 L_{eq})^2 \sin^2 \theta$$

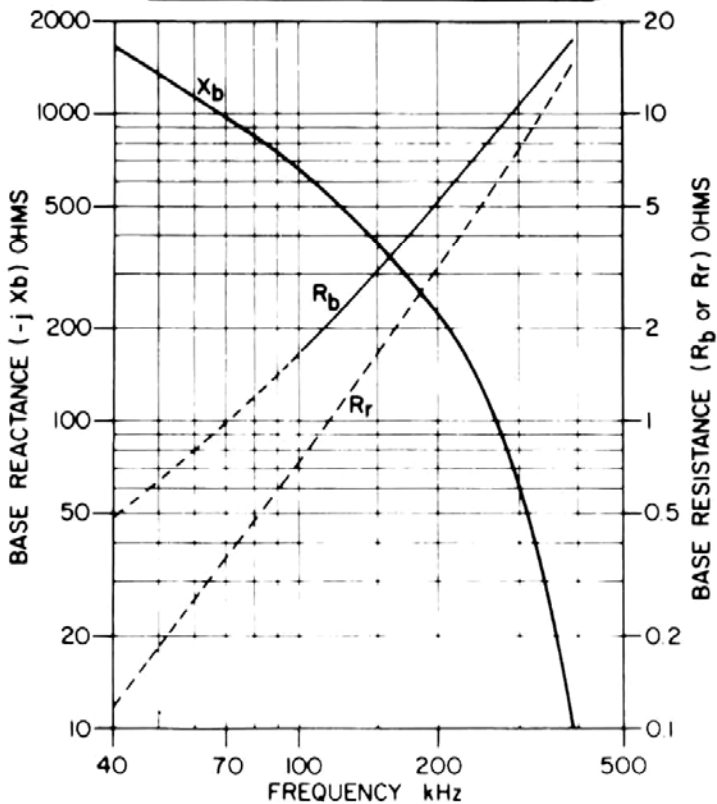
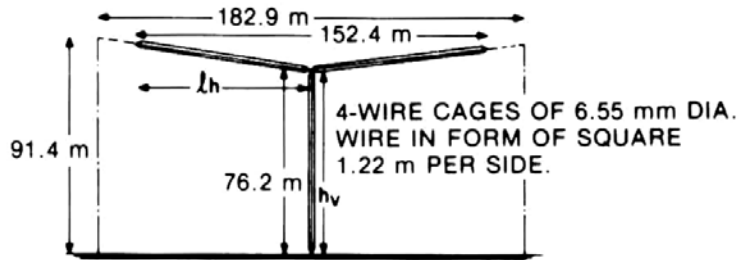
$$P_{irr} = \frac{\eta\pi}{3} \left(\frac{I_0 L_{eq}}{\lambda} \right)^2$$

$$D = \frac{3}{2} \sin^2 \theta$$

$$R_{rad} = \frac{2\eta\pi}{3} \left(\frac{L_{eq}}{\lambda} \right)^2$$

antenna a T

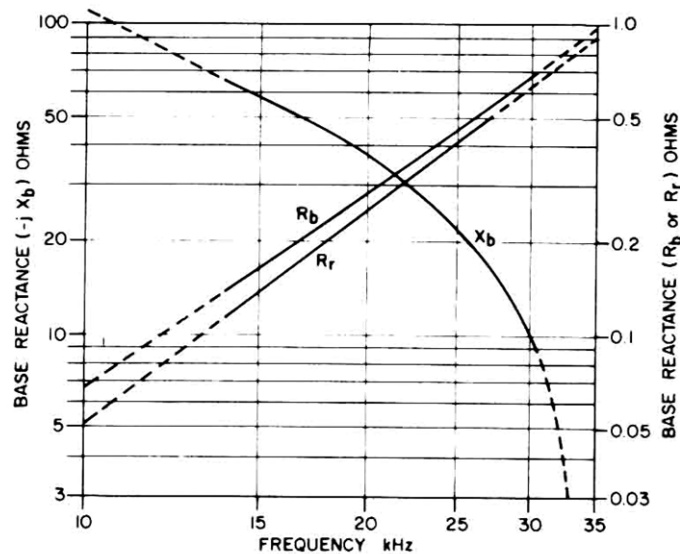
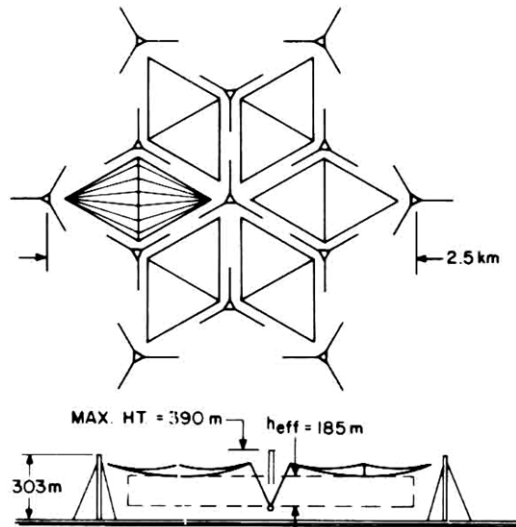




frequenza di funzionamento	100 kHz
larghezza di banda	0.84 kHz
efficienza	30 %
alimentazione:	
potenza	25 kW
tensione	56 kV
corrente	106 A

antenna a diamante

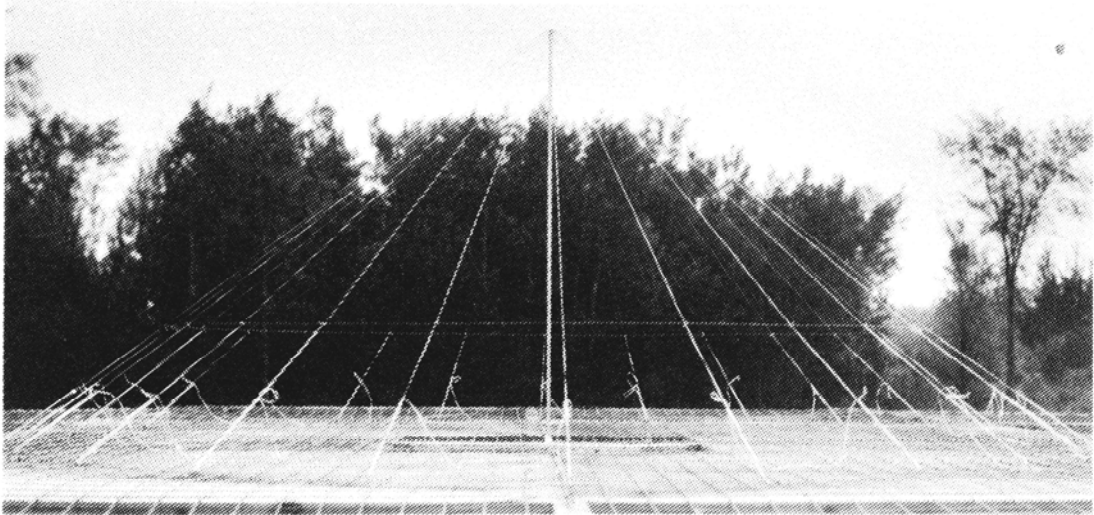
(Capo Nord-Ovest, Australia)



frequenza di funzionamento	15 kHz
larghezza di banda	110 Hz
efficienza	67 %
alimentazione:	
potenza	2 MW
tensione	177 kV
corrente	3098 A

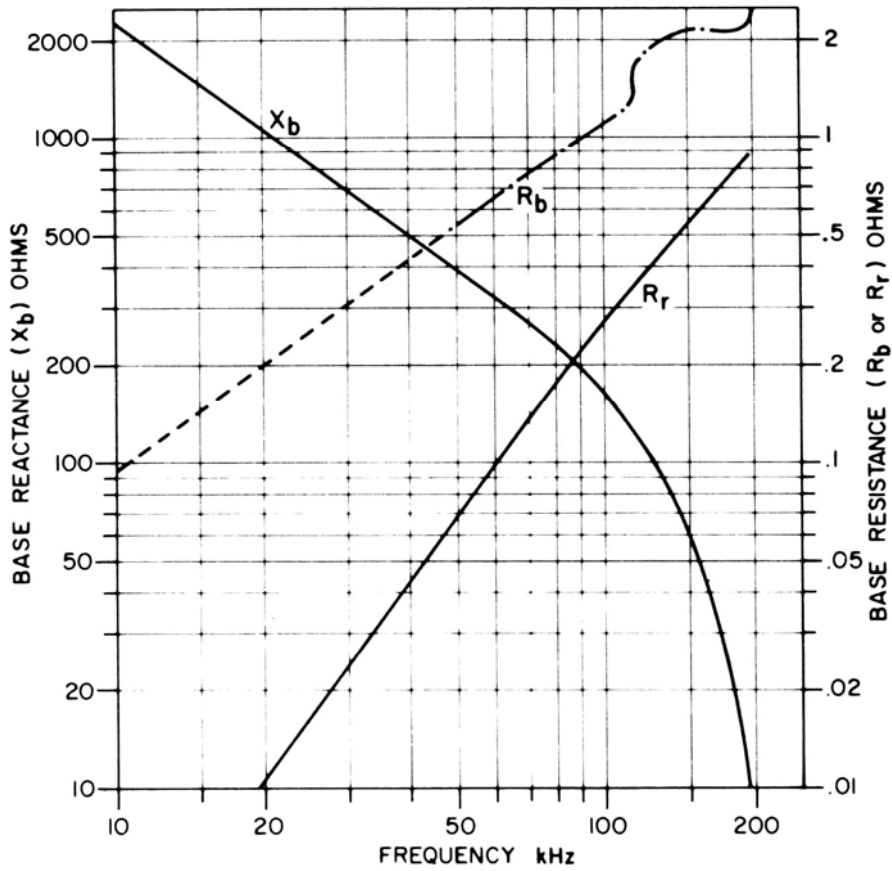
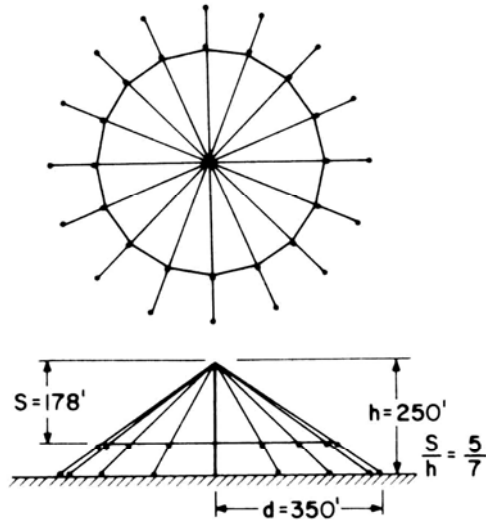
antenna ad ombrello

per trasmissioni OMEGA, Tsushima, Giappone

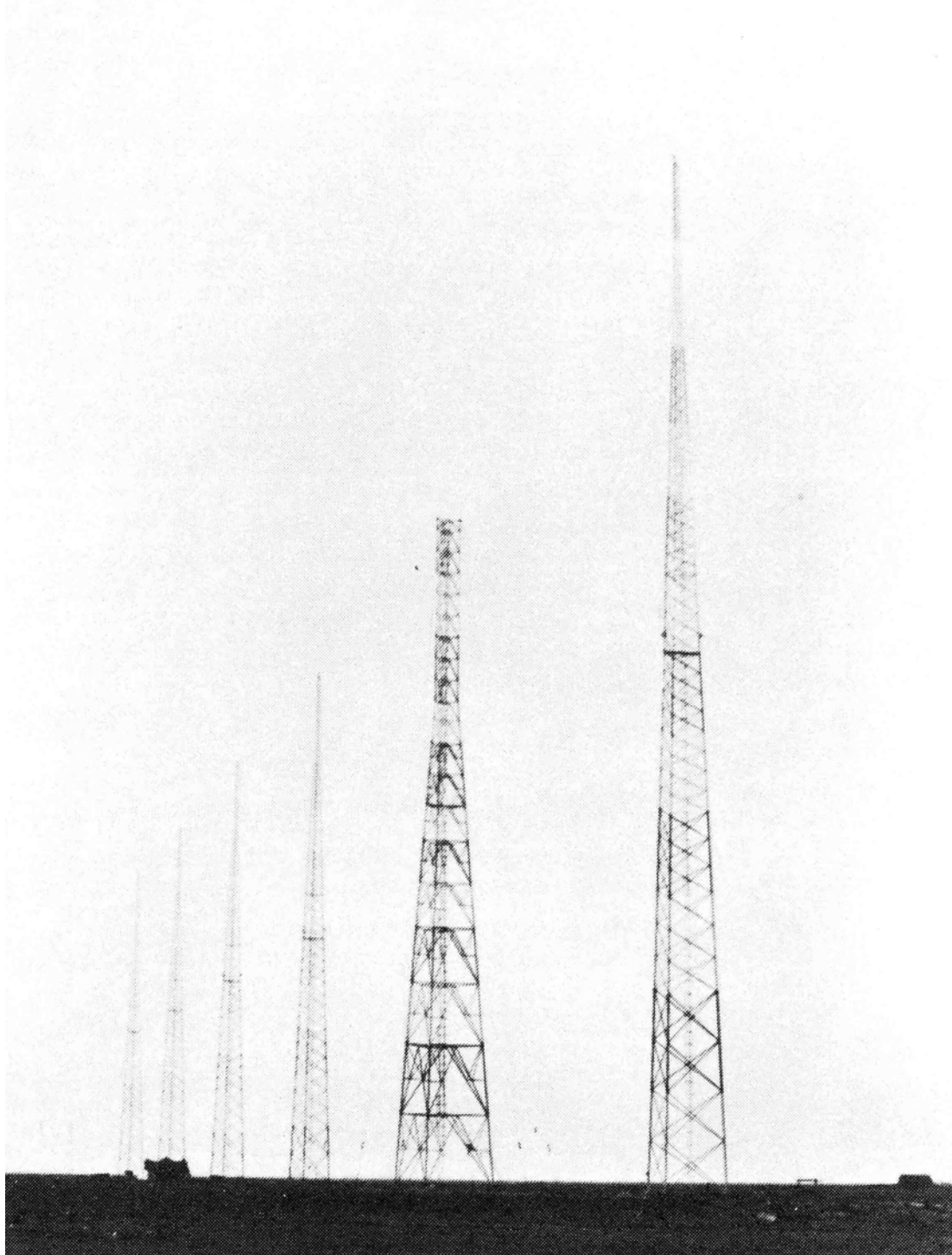


Altezza		450 m
frequenza di funzionamento		10.2 kHz
larghezza di banda		15 Hz
efficienza		12 %
alimentazione:	potenza	88 kW
	tensione	160 kV
	corrente	345 A
sistema di terra:		90 conduttori radiali di 200 m

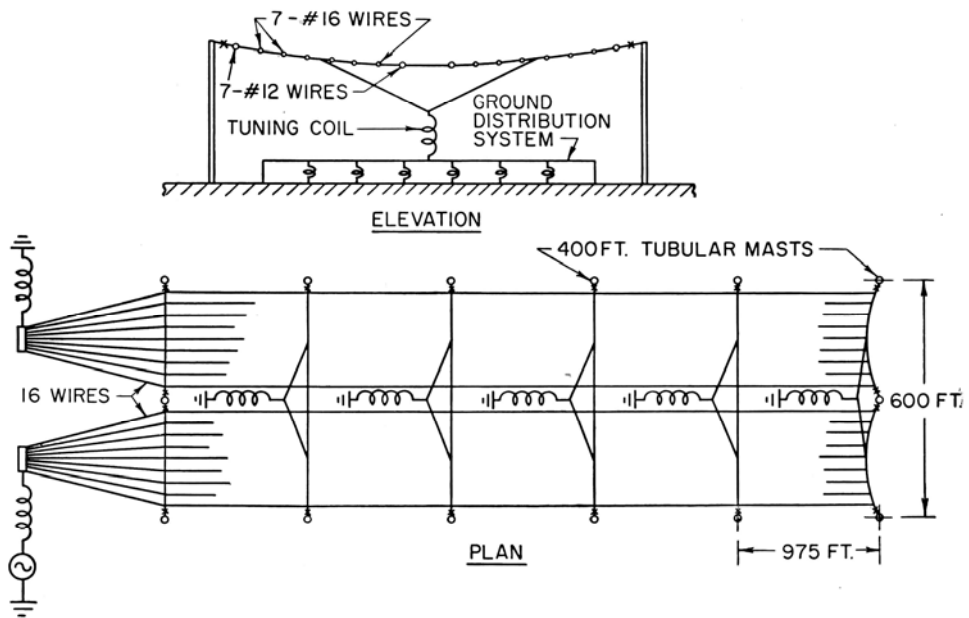
modello



antenna a schiera di semidipoli, tipo Yagi-Uda, per radiodiffusione (Qatar)

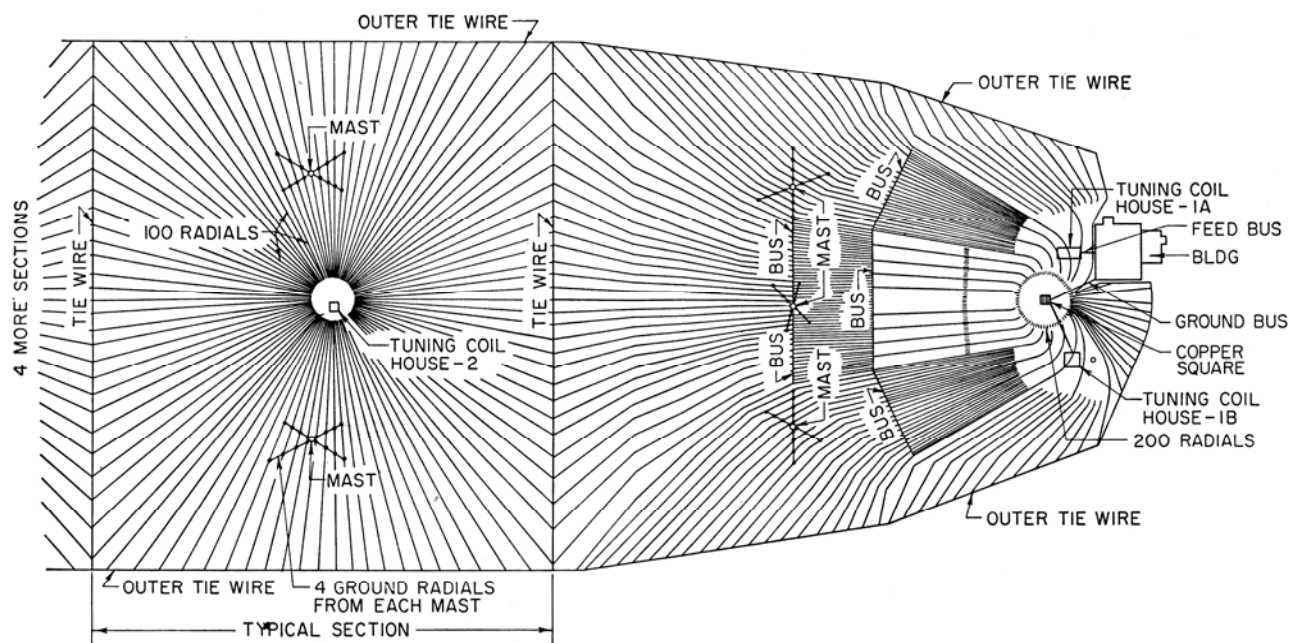


Roky Point, N.Y., USA

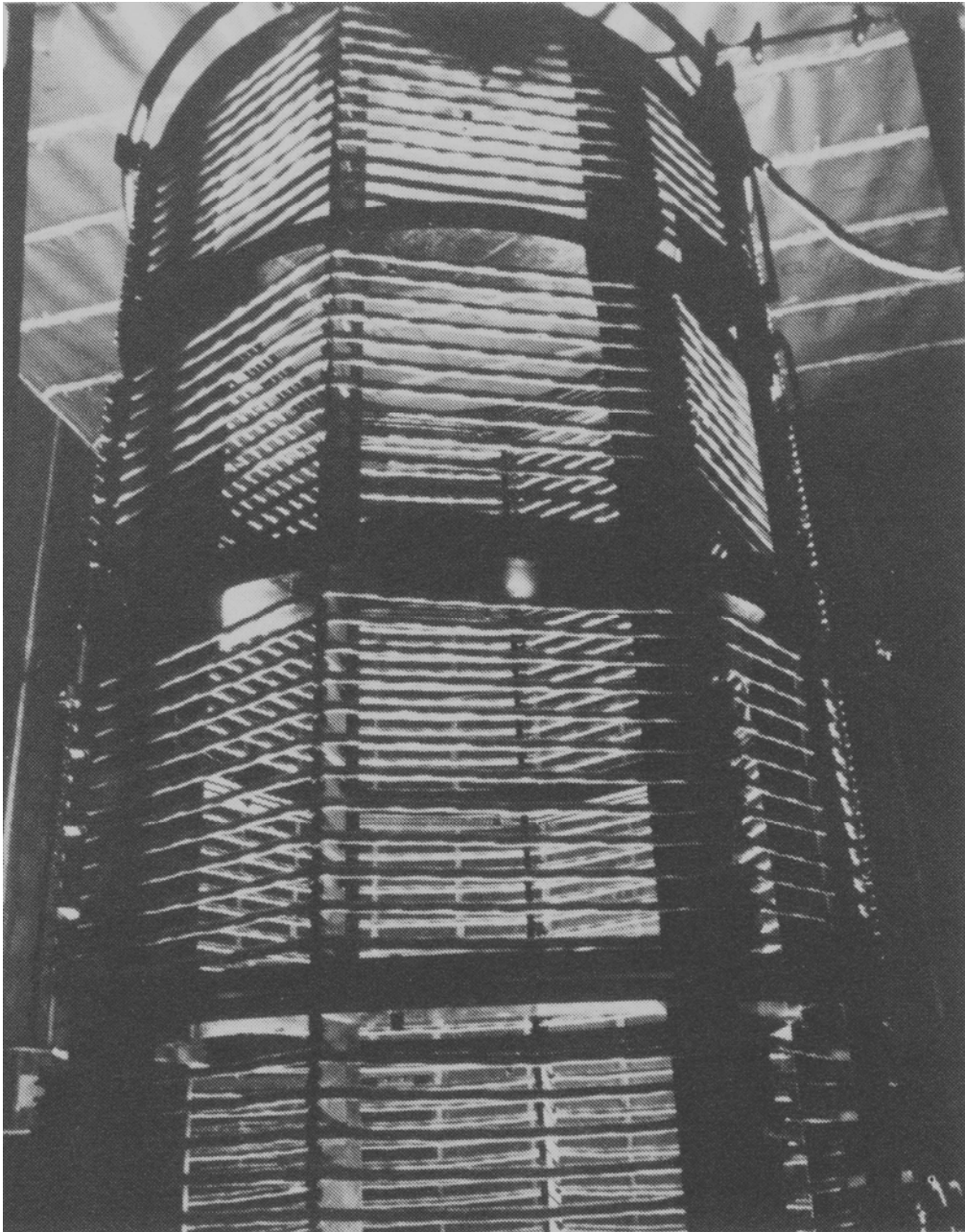


frequenza di funzionamento	18.22 kHz
altezza equivalente	223 m
capacità	0.050 μF
efficienza	10 %
alimentazione:	150 kV

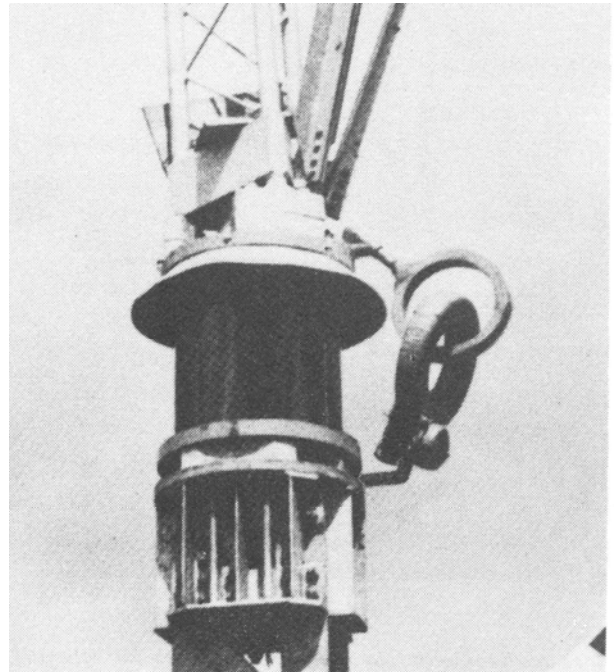
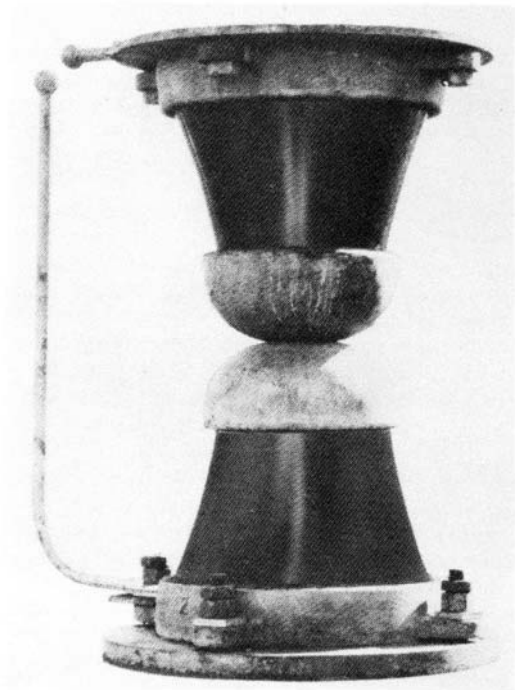
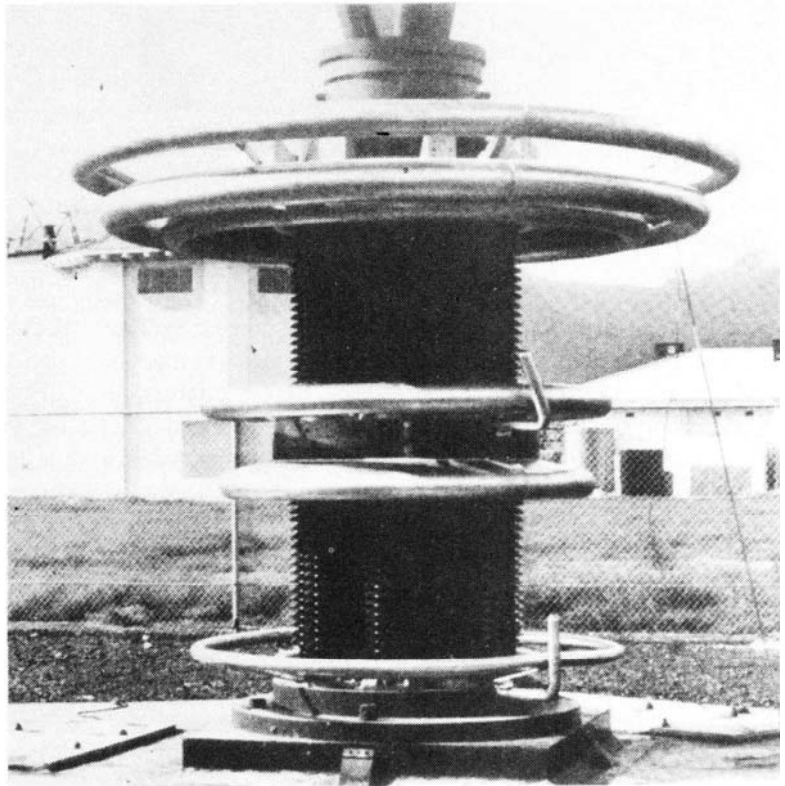
particolare del sistema di cavi di terra



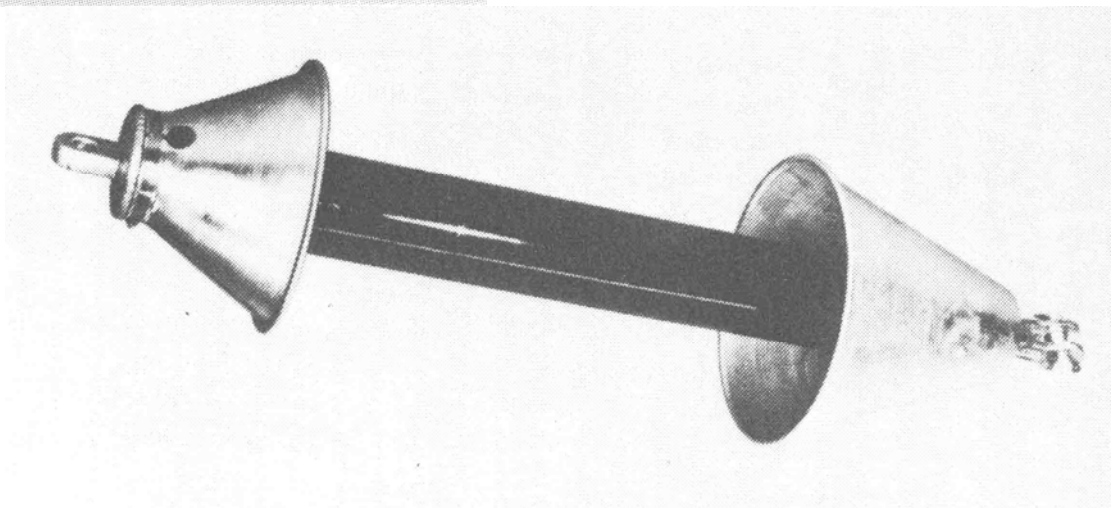
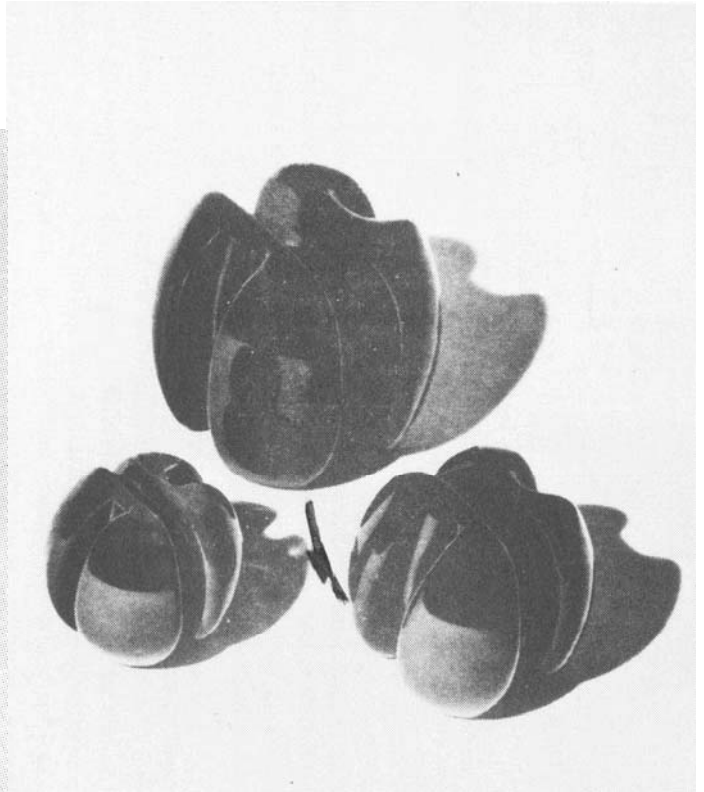
induttore di adattamento per antenna LF alimentata con 100 KW



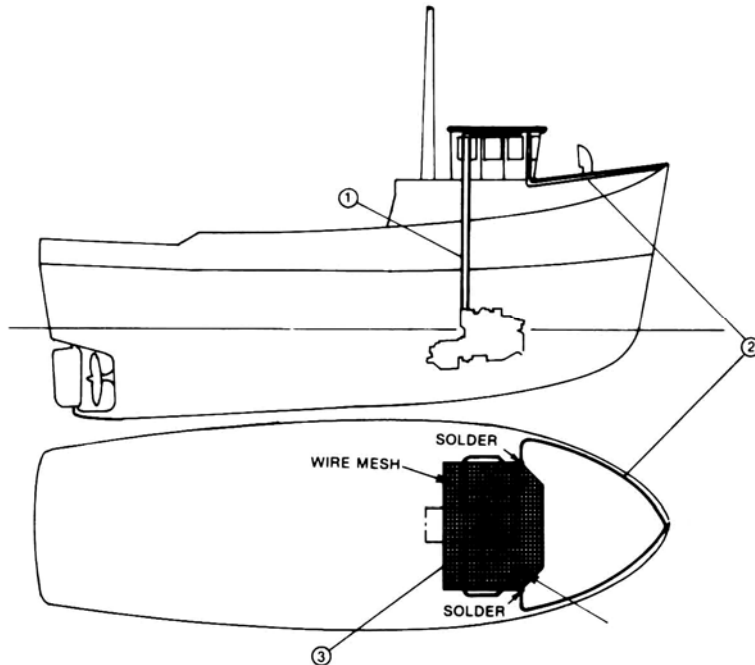
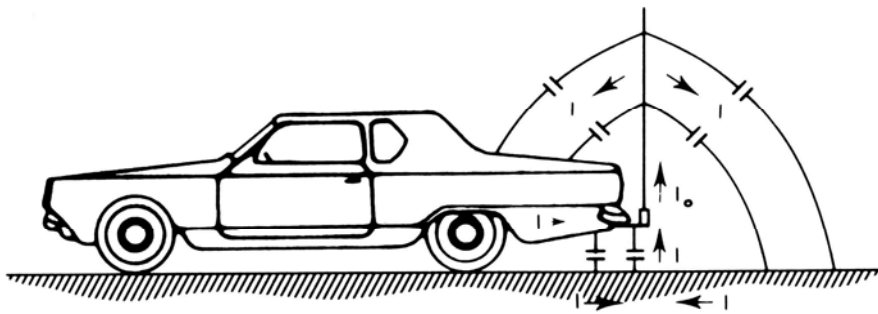
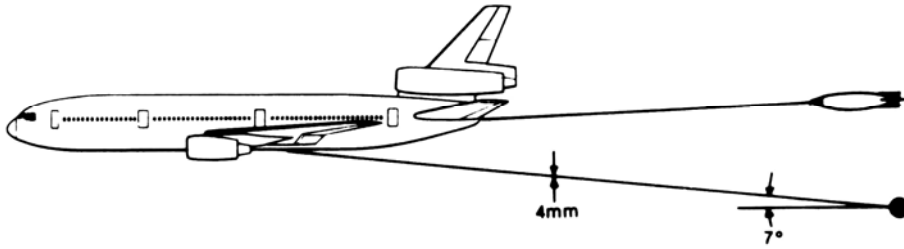
isolatori



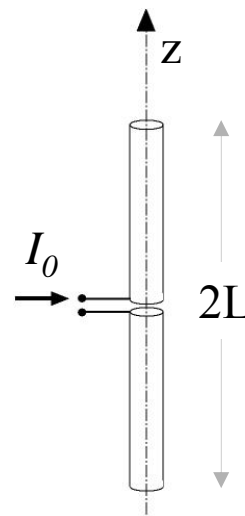
isolatori per funi



dipoli asimmetrici - semidipoli



dipoli sottili



$$\vec{N} = \int_v e^{jk\vec{u}_r \cdot \vec{r}'} \vec{J}(\vec{r}') dv =$$

$$= 2\vec{u}_z I_0 \frac{\cos(kL \cos \theta) - \cos(kL)}{k \sin^2 \theta}$$

$$K = \frac{\eta}{8\pi^2} |I_0|^2 \left(\frac{\cos(kL \cos \theta) - \cos(kL)}{\sin \theta} \right)^2$$

$$P_{irr} = \frac{\eta}{4\pi} |I_0|^2 \left[\gamma + \ln(2kL) - Ci(2kL) + \right.$$

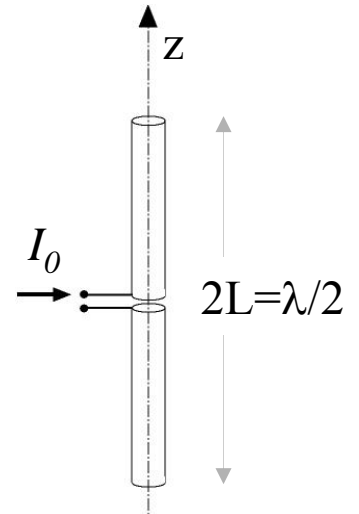
$$\left. + \frac{1}{2} \sin(2kL) (Si(4kL) - 2Si(2kL)) + \frac{1}{2} \cos(2kL) (\gamma + \ln(kL) + Ci(4kL) - 2Ci(2kL)) \right]$$

$$Si(x) = \int_0^x \frac{\sin \xi}{\xi} d\xi$$

$$Ci(x) = -\int_x^\infty \frac{\cos \xi}{\xi} d\xi$$

$\gamma = 0.5772$ costante di Eulero

dipoli sottili risonanti



$$\vec{N} = 2\vec{u}_z I_0 \frac{\cos(\pi/2 \cos \theta)}{k \sin^2 \theta}$$

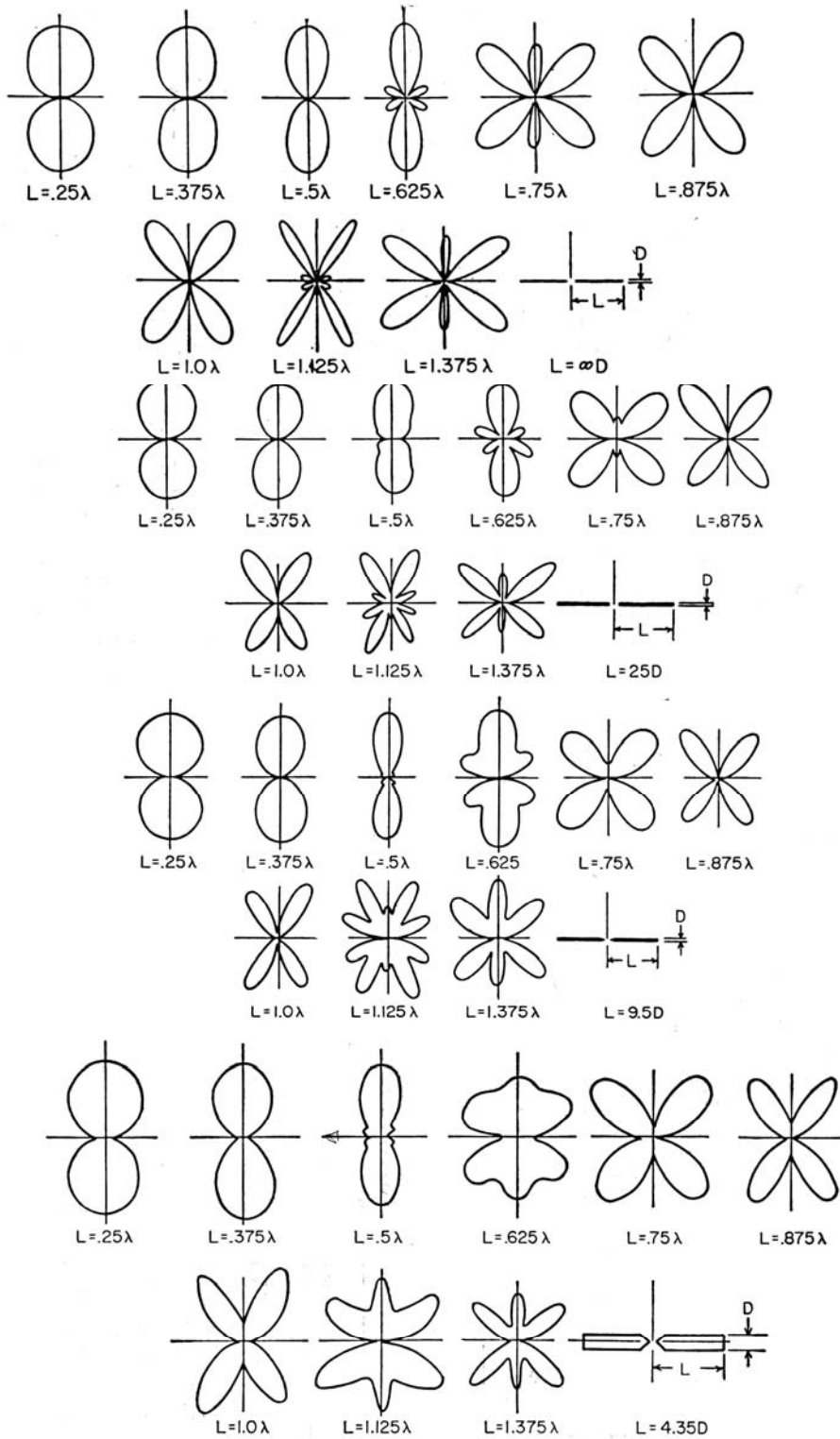
$$K = \frac{\eta}{8\pi^2} |I_0|^2 \left(\frac{\cos(\pi/2 \cos \theta)}{\sin \theta} \right)^2$$

$$P_{irr} = \frac{\eta}{8\pi} |I_0|^2 [\gamma + \ln(2\pi) - Ci(2\pi)] = 2.44 \frac{\eta}{8\pi} |I_0|^2$$

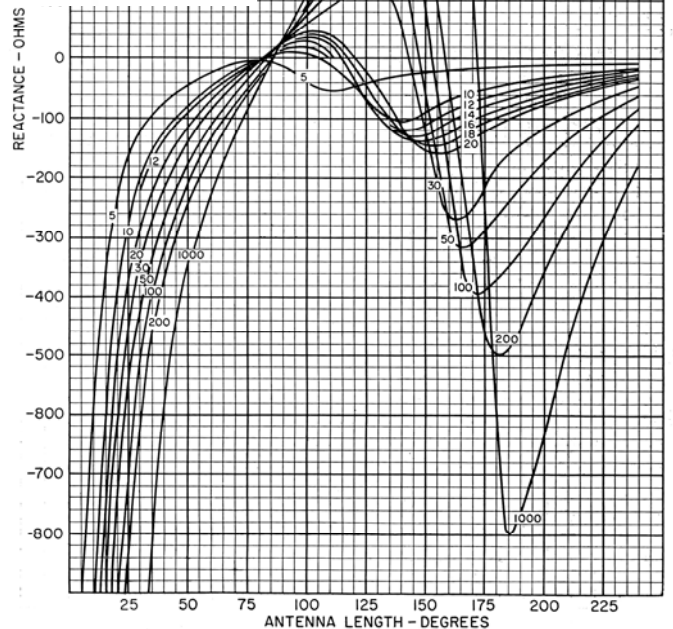
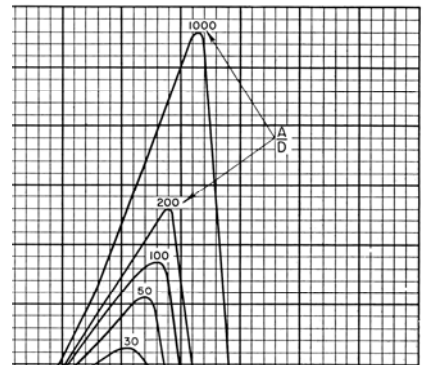
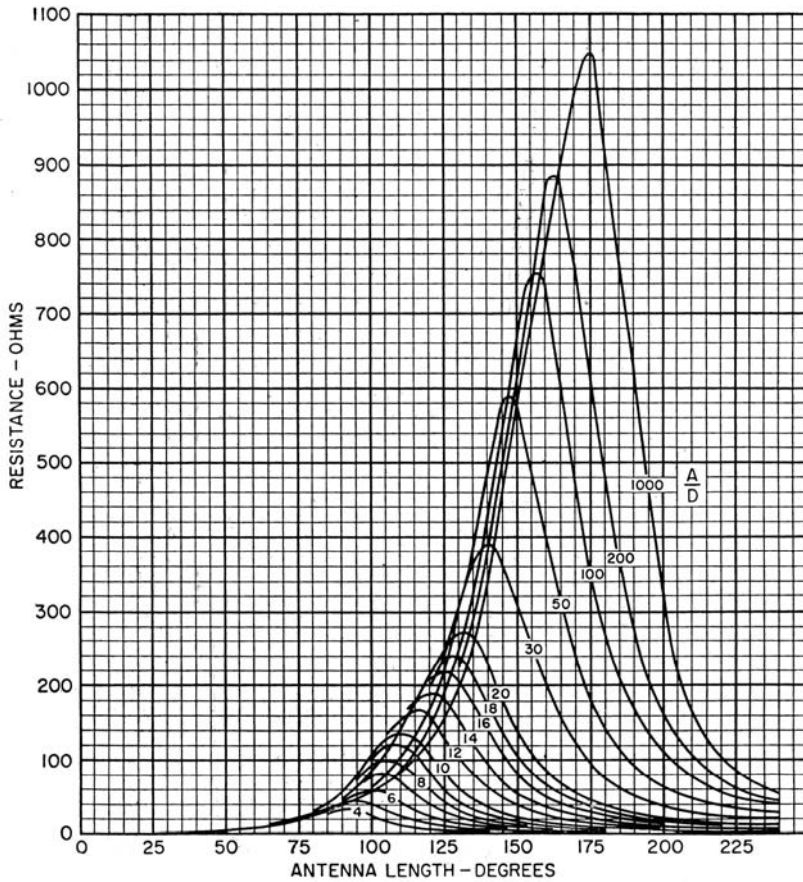
$$D = 1.64 \left(\frac{\cos(\pi/2 \cos \theta)}{\sin \theta} \right)^2$$

$$R_{rad} = 73.1 \quad \Omega$$

diagrammi di radiazione di dipoli cilindrici per diversi valori di lunghezza (L) e diametro (D)



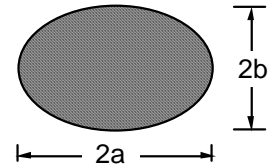
impedenza d'ingresso di dipoli cilindrici per diversi valori di lunghezza (L) e diametro (D)



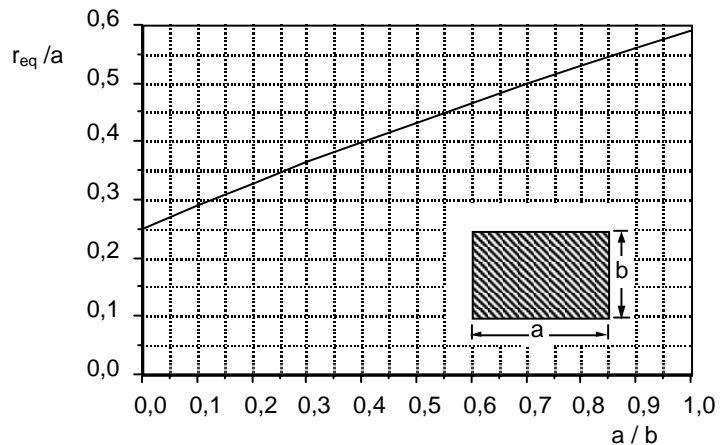
raggio equivalente di dipoli cilindrici non circolari

dipolo a sezione ellittica

$$r_{eq} = \frac{a + b}{2}$$



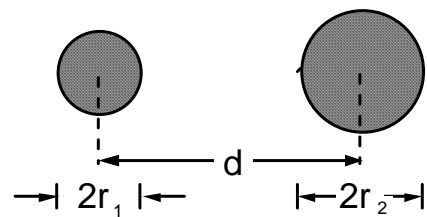
dipolo a sezione rettangolare



dipolo composto

$$\ln r_{eq} = \ln r_1 + \frac{\mu}{(1 + \mu)^2} (\mu \ln \mu + 2 \ln \nu)$$

$$\mu = \frac{r_2}{r_1} \quad \nu = \frac{d}{r_1}$$



dipolo a sezione di poligono regolare

n. lati	3	4	5	6
r_{eq} / a	0.4214	0.5903	0.7563	0.9200

a = raggio del cerchio circoscritto

componente simmetrica e antisimmetrica

$$V_1 = Z_{11}I_1 + Z_{12}I_2$$

$$V_2 = Z_{21}I_1 + Z_{22}I_2$$

Componente simmetrica

$$V_1 = V_2 \Rightarrow \frac{I_2}{I_1} = \alpha = \frac{Z_{21} - Z_{11}}{Z_{12} - Z_{22}}$$

Componente antisimmetrica

$$I_1 = -I_2 \Rightarrow \frac{V_1}{V_2} = -\alpha$$

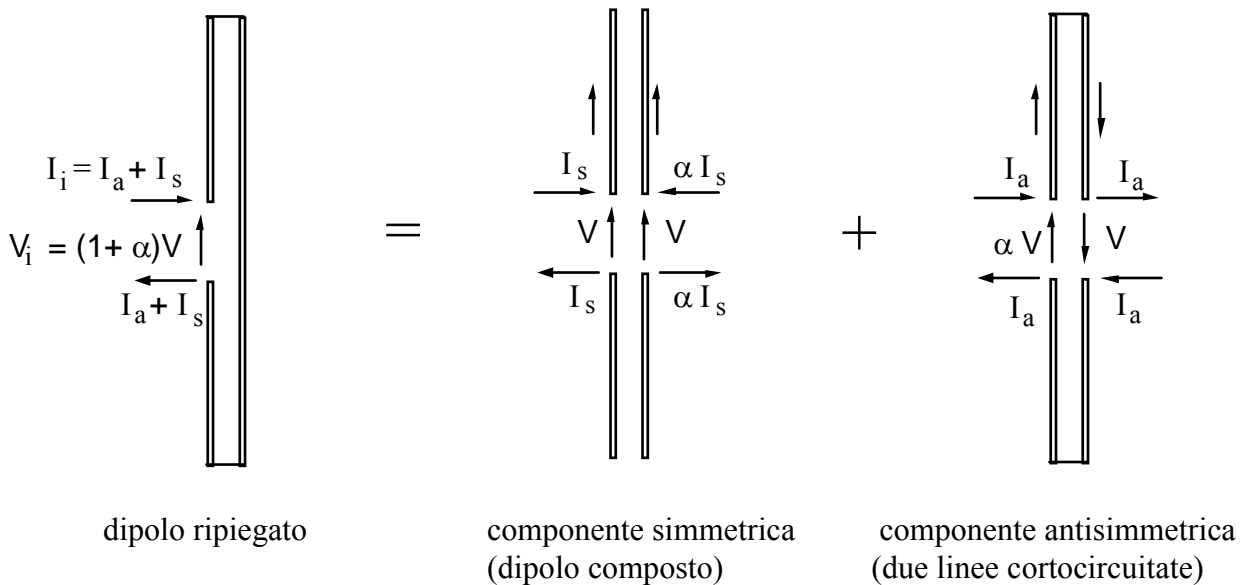
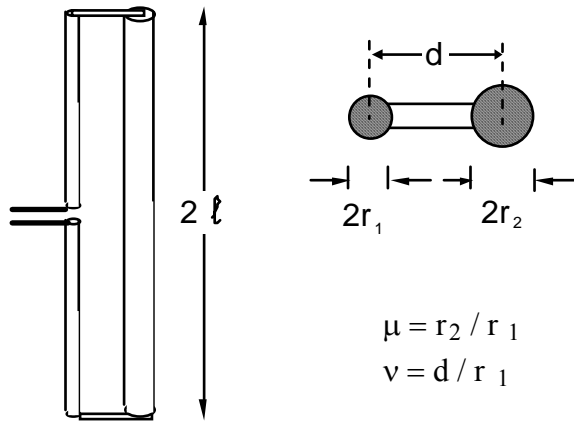
$$I_1 = I_s + I_a \quad I_s = \frac{I_1 + I_2}{1 + \alpha}$$

$$I_2 = \alpha I_s - I_a \quad I_a = \frac{\alpha I_1 - I_2}{1 + \alpha}$$

$$V_1 = V_s - \alpha V_a \quad V_s = (Z_{11} + \alpha Z_{12})I_s = (Z_{21} + \alpha Z_{22})I_s$$

$$V_2 = V_s + V_a \quad V_a = (Z_{21} - Z_{22})I_a$$

dipolo ripiegato

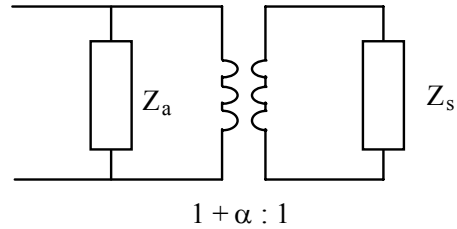


Espressione quasi statica del rapporto di eccitazione dei due modi :

$$\alpha = \frac{\cosh^{-1} \frac{\nu^2 - \mu^2 + 1}{2\nu}}{\cosh^{-1} \frac{\nu^2 + \mu^2 - 1}{2\mu\nu}} \approx \ln \frac{\ln \nu}{\ln \nu - \ln \mu} \quad \text{per } d \gg r_1, r_2$$

impedenza d'ingresso del dipolo ripiegato

$$Z_i = \frac{2(1+\alpha)^2 Z_s Z_a}{(1+\alpha)^2 Z_s + 2Z_a}$$



dove

$$Z_s = \frac{V}{(1+\alpha)I_s}$$

impedenza d'ingresso del dipolo composto

$$Z_a = \frac{(1+\alpha)V}{2I_a} = jZ_0 \tan kl$$

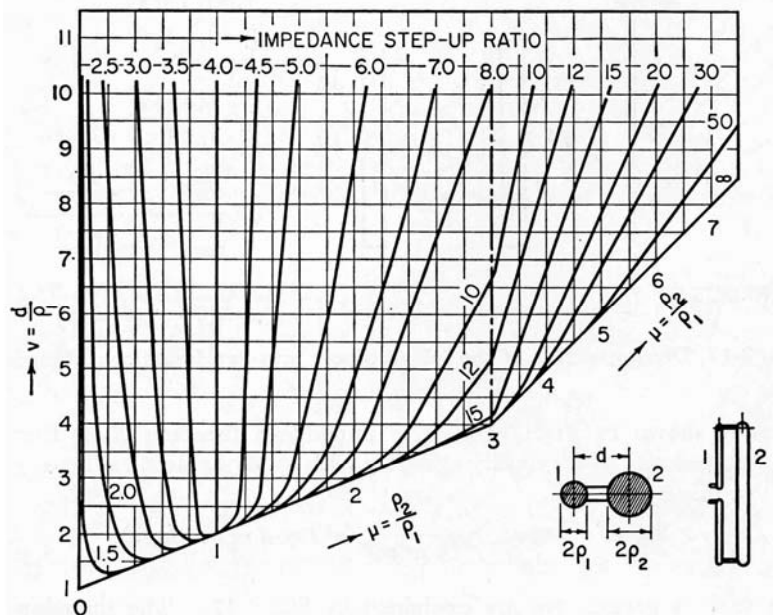
impedenza d'ingresso della linea bifilare cortocircuitata

rapporto di eccitazione (approssimazione quasi-statica)

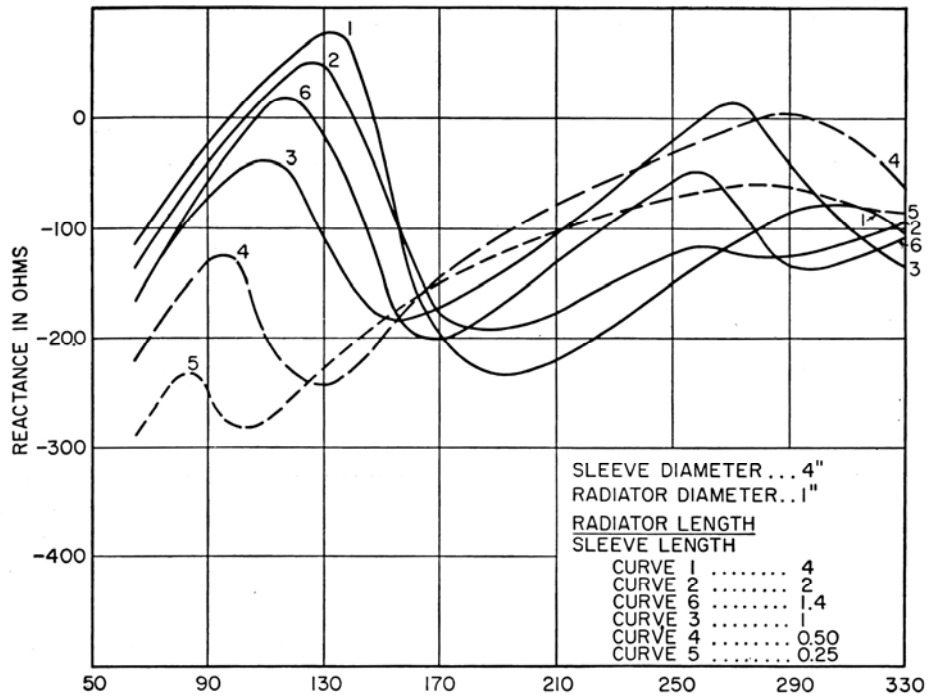
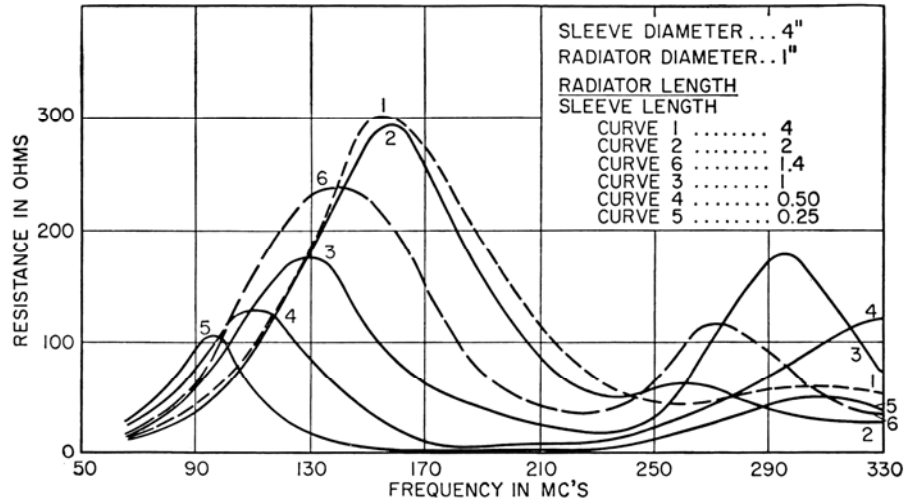
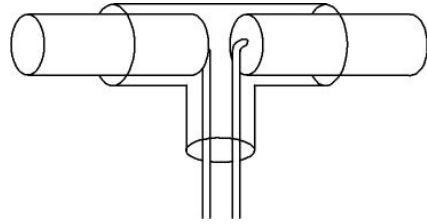
$$\alpha = \frac{\cosh^{-1} \frac{v^2 - \mu^2 + 1}{2v}}{\cosh^{-1} \frac{v^2 + \mu^2 - 1}{2\mu v}}$$

$$\approx \ln \frac{\ln v}{\ln v - \ln \mu} \quad d \gg r_1, r_2$$

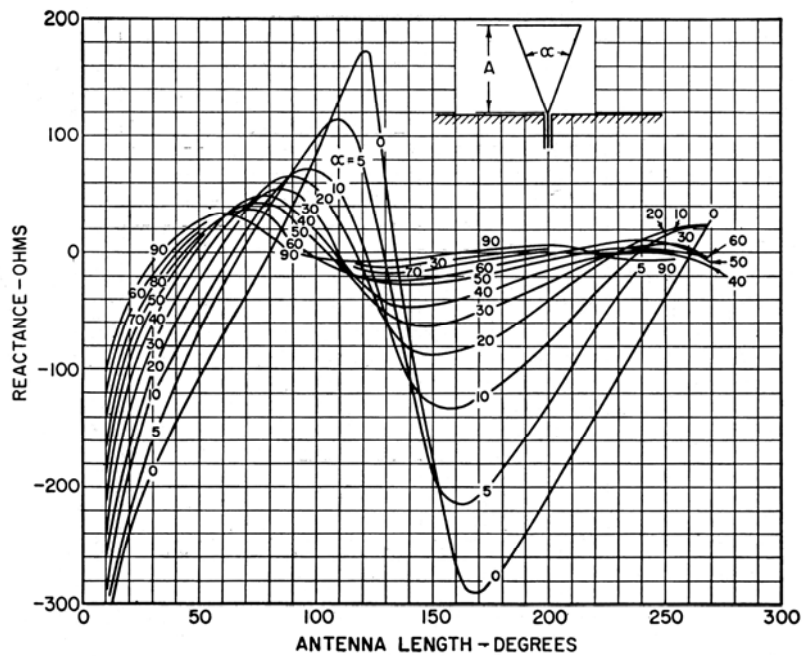
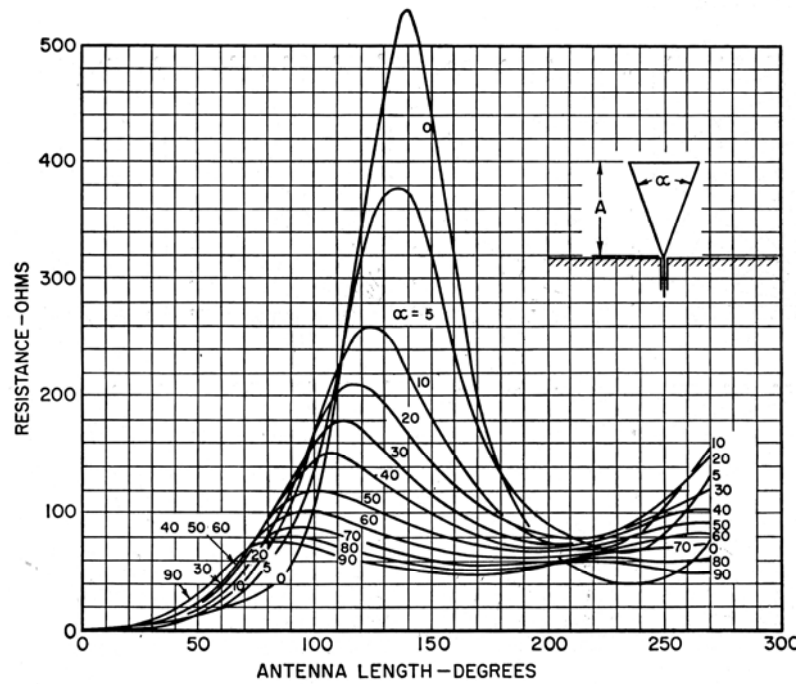
$$Z_0 = \frac{\eta}{\pi} \cosh^{-1} \frac{v}{\sqrt{\mu}}$$

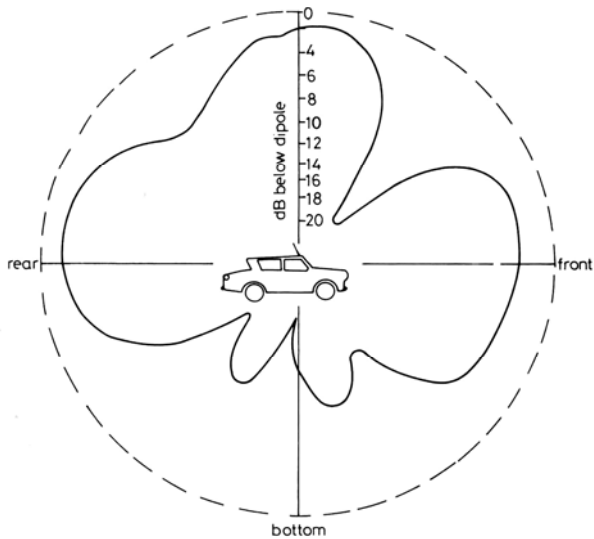
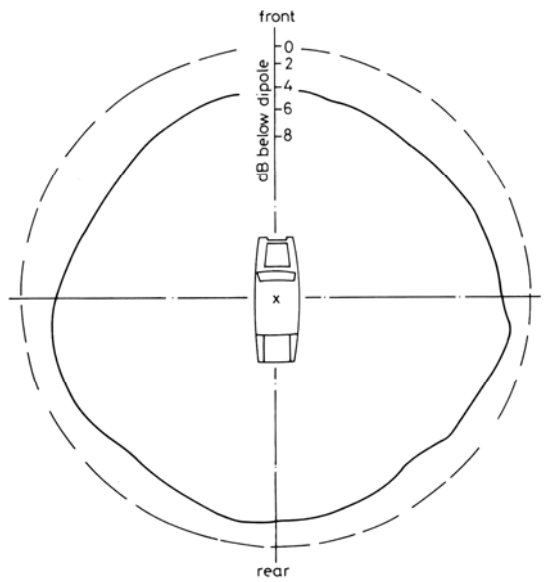
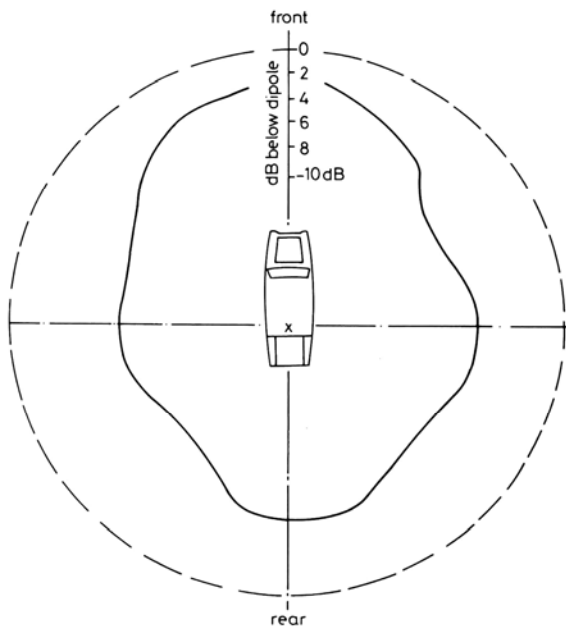


dipolo sleeve

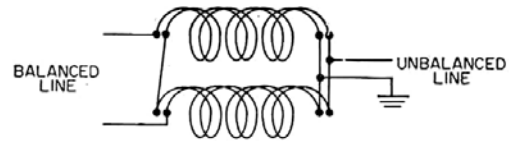


semidipolo conico

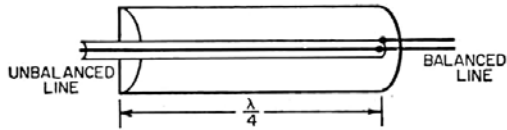




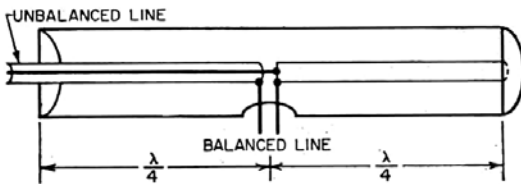
baluns



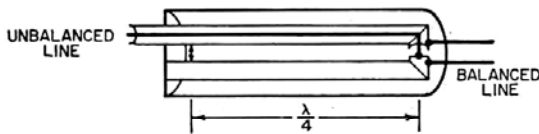
TYPE 6 BIFILAR-COIL OR ELEVATOR BALUN



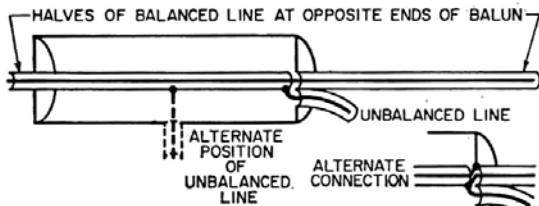
TYPE 1 BAZOOKA BALUN



TYPE 2 COLINEAR BALUN

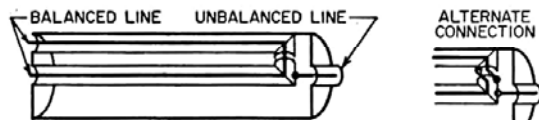


TYPE 3 FOLDED BALUN



TYPE 4a

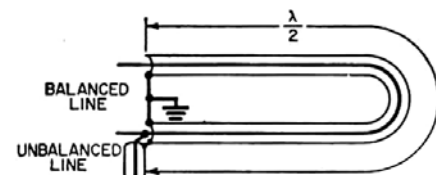
TYPE 4b



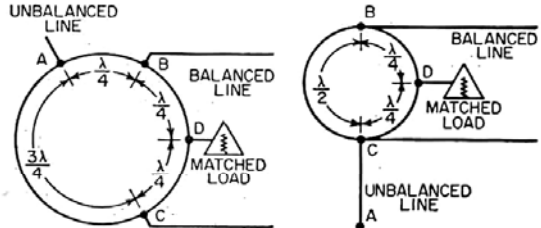
TYPE 4c

TYPE 4 INVERTED BALUNS

TYPE 4d



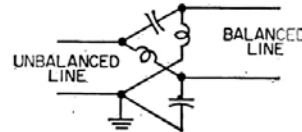
TYPE 5 HALF-WAVE-LINE BALUN



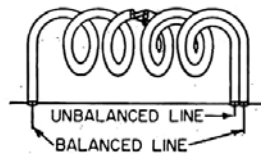
TYPE 7a

TYPE 7 HYBRID RING

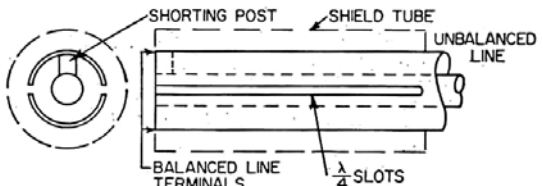
TYPE 7b



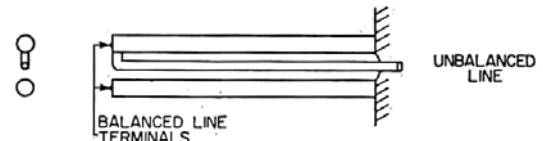
TYPE 8 LATTICE



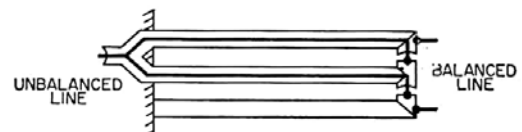
TYPE 9 COILED-CABLE BALUN



TYPE 10a SPLIT-TUBE BALUN

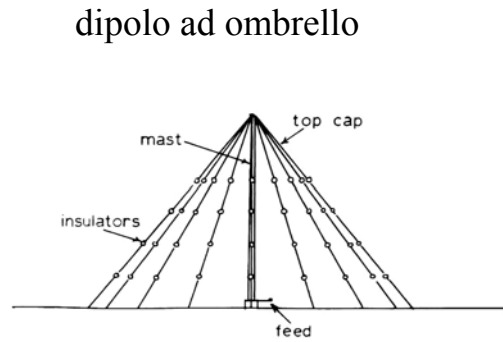
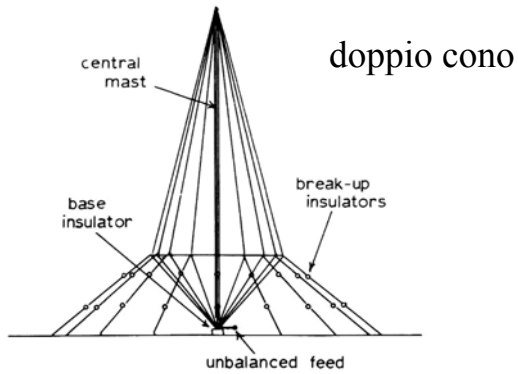


TYPE 10b THREE-WIRE BALUN

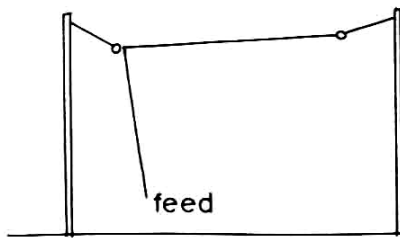


TYPE 11

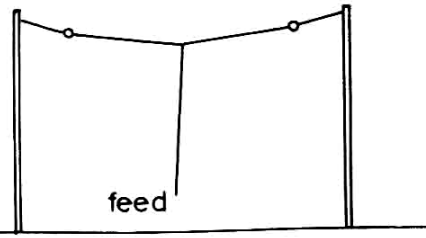
semidipoli e dipoli



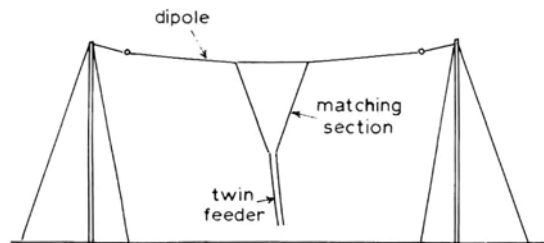
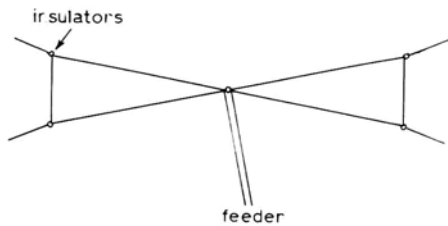
dipolo a L rovesciato



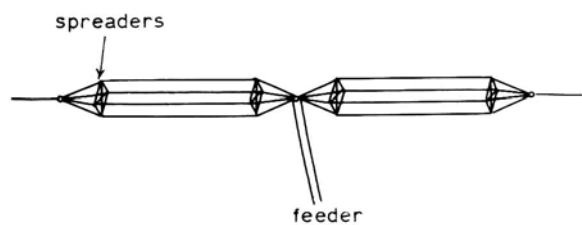
dipolo a T



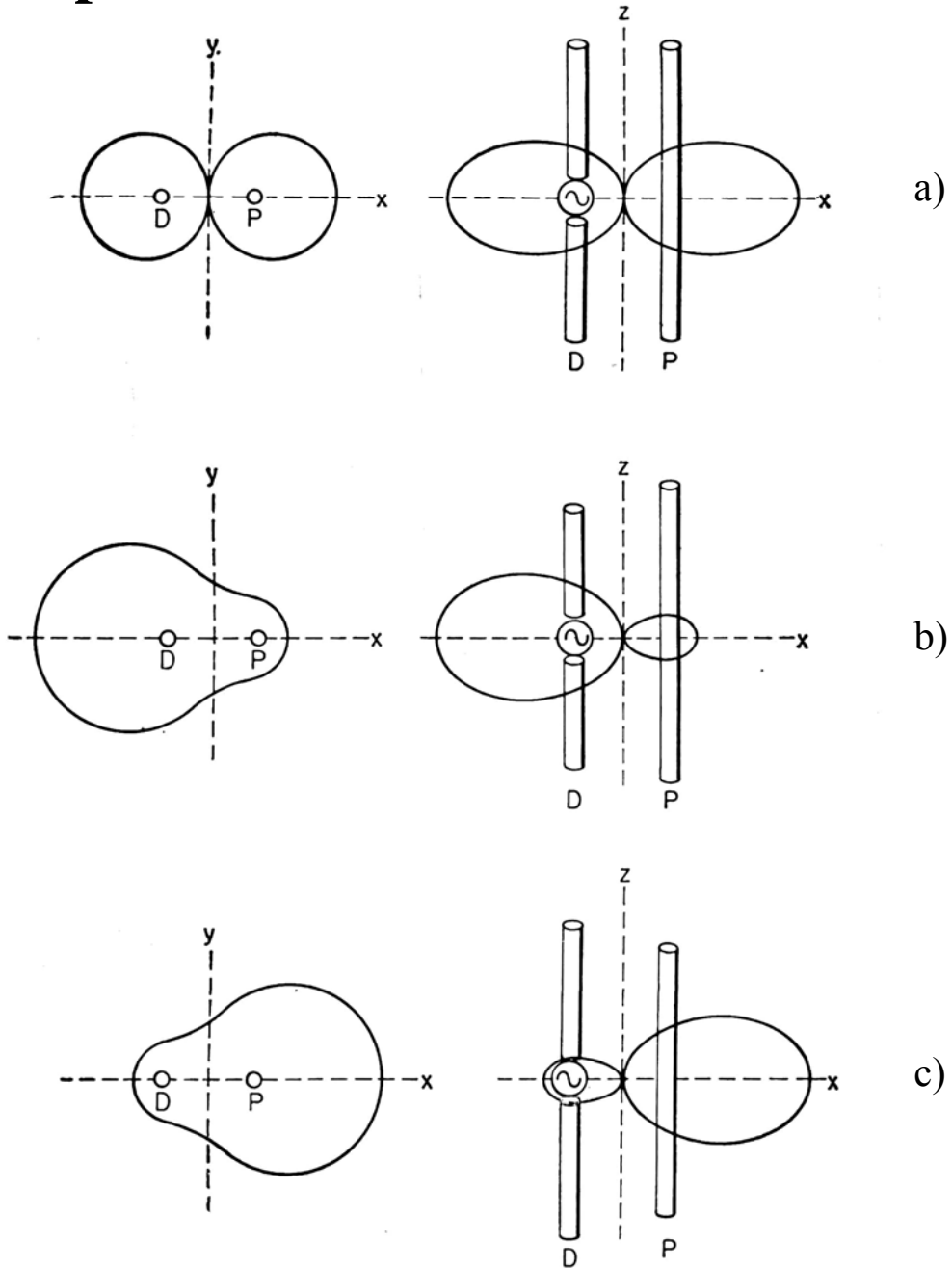
dipolo a farfalla



dipolo a gabbia



dipoli parassiti



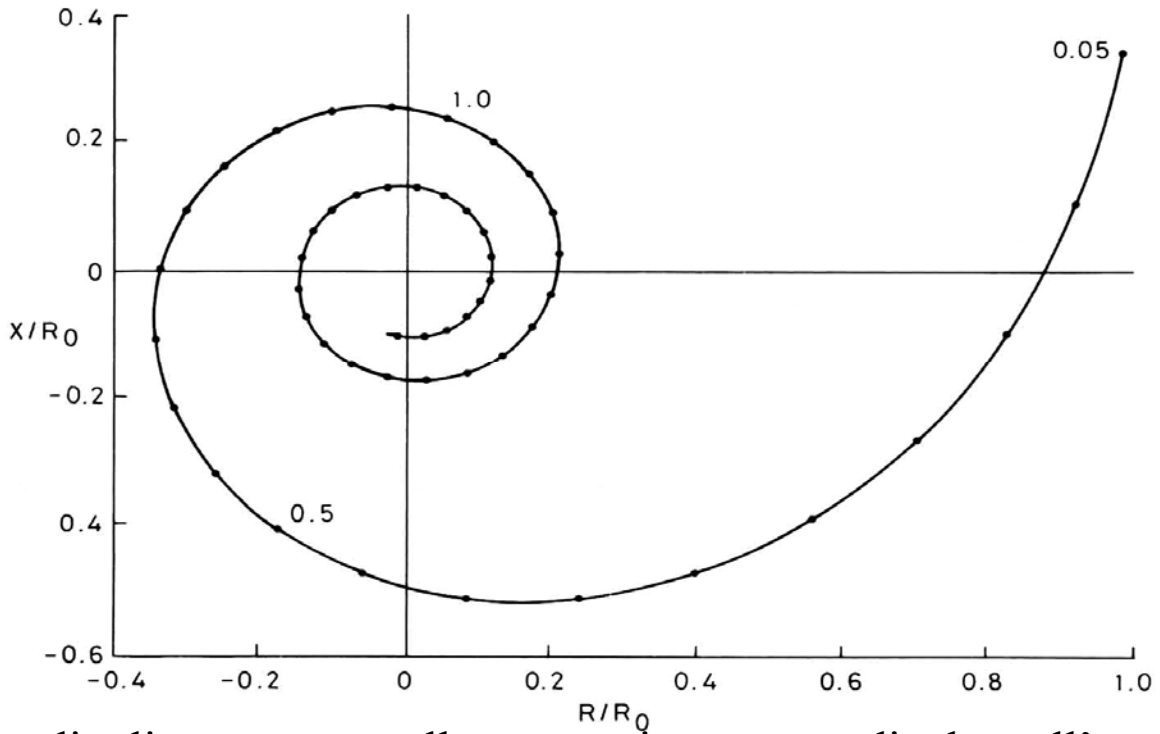
diagrammi di radiazione (indicativi) di un dipolo alimentato in presenza di un dipolo parassita molto vicino (0.04λ) :

a) i due dipoli sono risonanti;

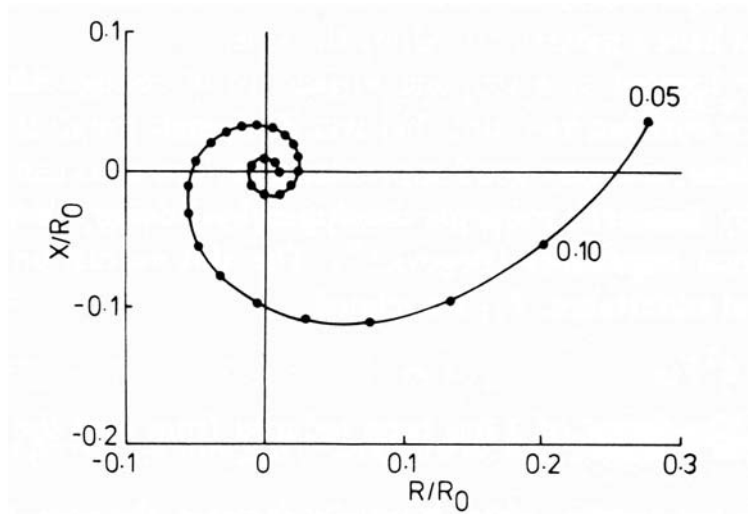
b) il dipolo parassita è allungato del 5% per fungere da riflettore;

c) il dipolo parassita è accorciato del 5% per fungere da direttore.

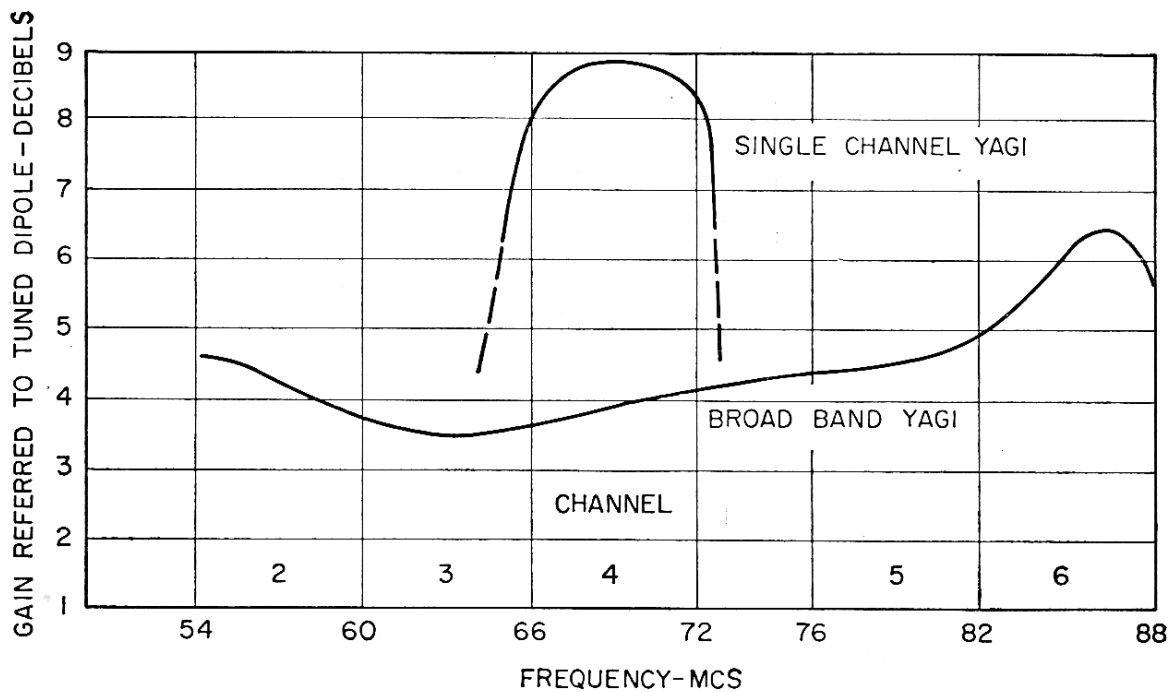
impedenza mutua, normalizzata, tra dipoli paralleli in $\lambda/2$ al variare della distanza
 (la curva è punteggiata per differenze di distanza di 0.05λ)



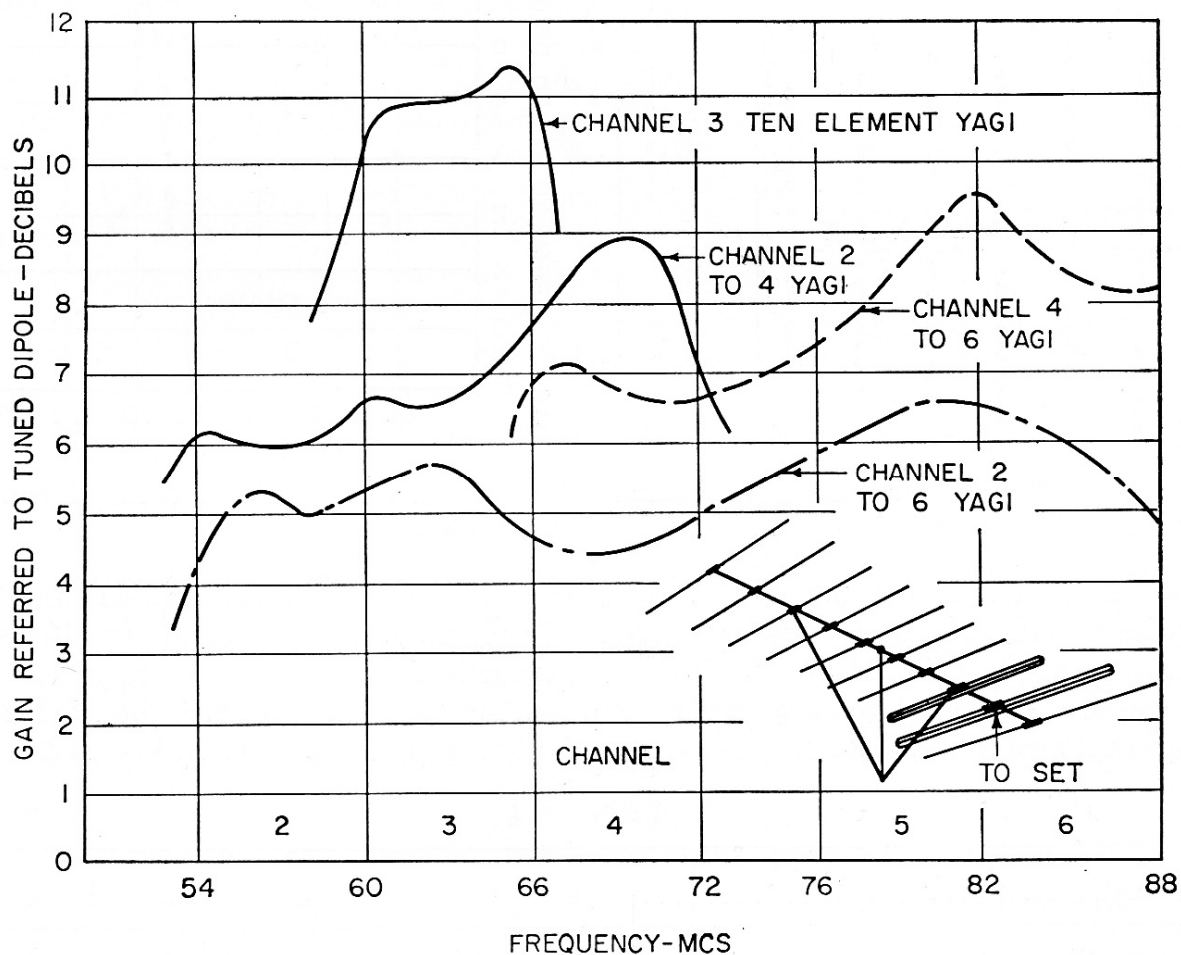
dipoli con centro sullo stesso piano perpendicolare all'asse



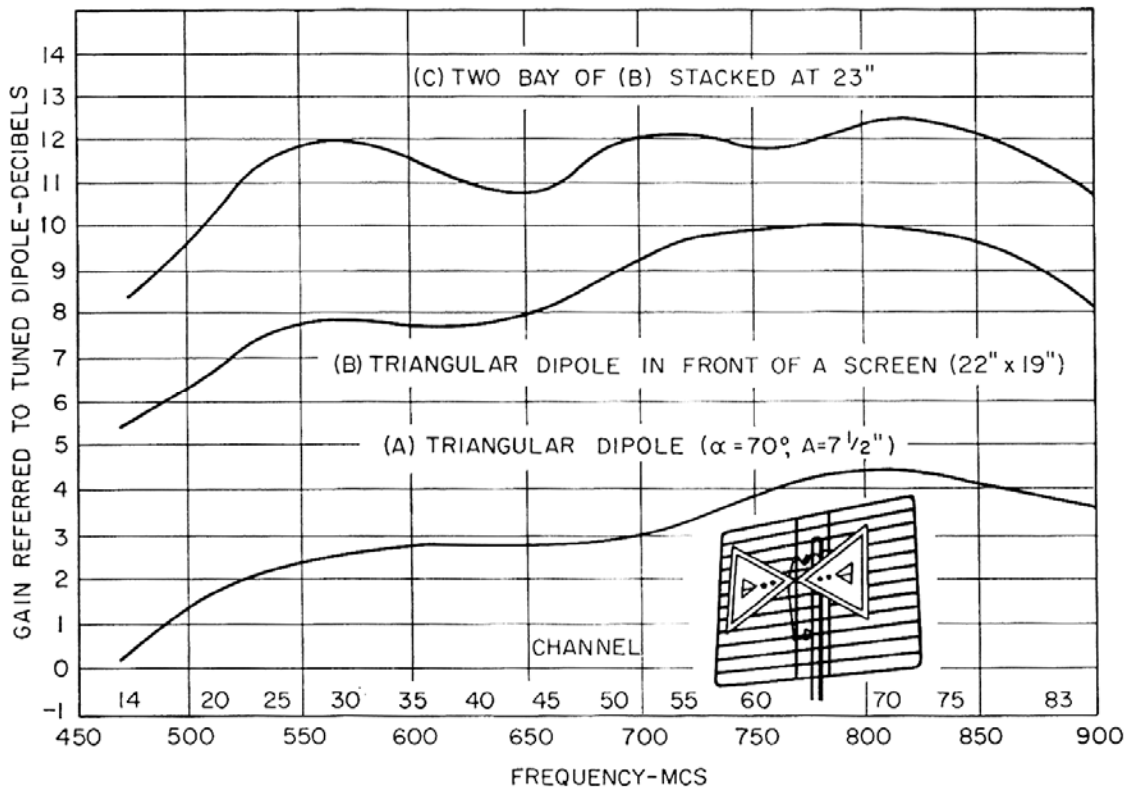
dipoli collineari



guadagno misurato di antenne Yagi-Uda di 5 elementi per singolo canale e a larga banda.

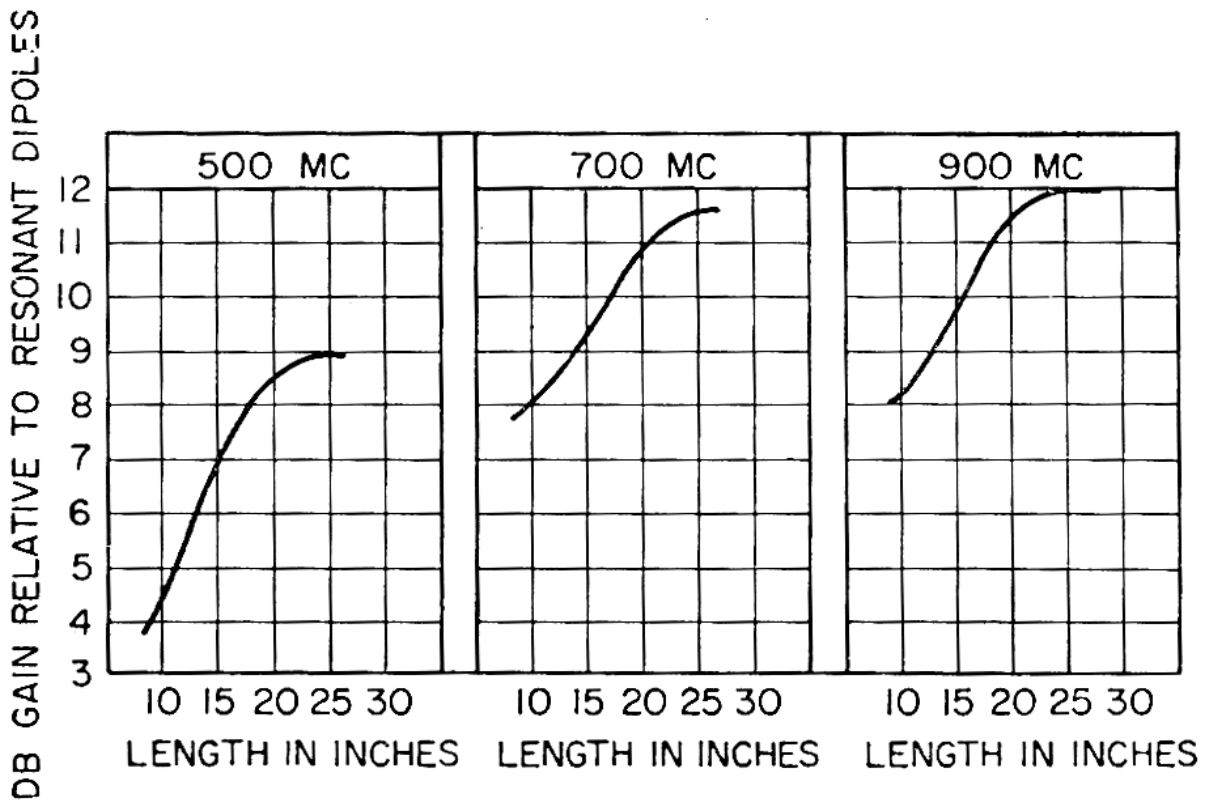
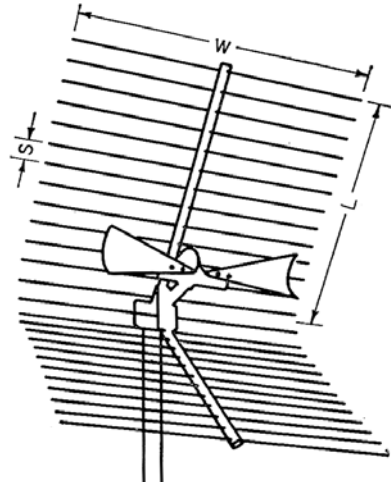


guadagno misurato di tre antenne Yagi-Uda di 10 elementi, le antenne multicanale hanno due elementi alimentati per allargare la banda.



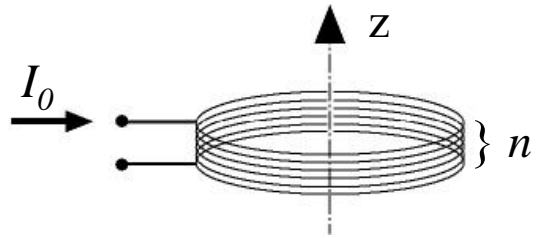
caratteristiche di guadagno (misurato) di:

- un dipolo triangolare,
- di un dipolo triangolare con riflettore piano,
- di una coppia di dipoli con riflettore piano.



caratteristiche di guadagno misurate in funzione della lunghezza L del riflettore a diedro

Antenna a spira



$$\vec{N} = jk \vec{m}_m \times \vec{u}_r$$

$$\vec{m}_m = \frac{1}{2} \int_v \vec{r} \times \vec{J}(\vec{r}) dv = \vec{u}_z I_0 S n$$

$$K = \frac{\eta}{8\lambda^2} (k n I_0 S)^2 \sin^2 \theta$$

$$P_{irr} = \frac{\eta\pi}{3} \left(\frac{k n I_0 S}{\lambda} \right)^2$$

$$D = \frac{3}{2} \sin^2 \theta$$

$$R_{rad} = \frac{2\eta\pi}{3} \left(\frac{k S n}{\lambda} \right)^2$$

Antenna a spira con nucleo magnetico

