

Parametri relativi alle antenne trasmettenti

$$\vec{E} = \sqrt{\frac{\eta P_{in}}{2\pi}} \frac{e^{-jkr}}{r} \sqrt{g(\vartheta, \varphi)} \vec{p}(\vartheta, \varphi) e^{-j(\psi(\vartheta, \varphi) + \pi/2)}$$

$$\vec{H} = \sqrt{\frac{P_{in}}{2\pi\eta}} \frac{e^{-jkr}}{r} \sqrt{g(\vartheta, \varphi)} \vec{u}_r \times \vec{p}(\vartheta, \varphi) e^{-j(\psi(\vartheta, \varphi) + \pi/2)}$$

P_{in}		potenza in ingresso
Z_{in}	$= \underbrace{R_{\Omega} + R_{rad}}_{R_{in}} + j X_{in}$	impedenza d'ingresso
Y_{in}	$= \underbrace{G_{\Omega} + G_{rad}}_{G_{in}} + j B_{in}$	ammettenza d'ingresso
P_{irr}	$= P_{in} \xi$	potenza irraggiata
ξ	$= \frac{R_{rad}}{R_{in}} = \frac{G_{rad}}{G_{in}}$	efficienza di radiazione
$g(\vartheta, \varphi)$	$= \frac{4\pi K(\vartheta, \varphi)}{P_{in}}$	guadagno
$D(\vartheta, \varphi)$	$= \frac{4\pi K(\vartheta, \varphi)}{P_{irr}}$	direttività
$\vec{p}(\vartheta, \varphi)$	$= \frac{\vec{N} - \vec{u}_r(\vec{u}_r \cdot \vec{N})}{\sqrt{ \vec{N} ^2 - \vec{u}_r \cdot \vec{N} ^2}} e^{j\psi}$	polarizzazione del campo elettrico irraggiato
$\psi(\vartheta, \varphi)$		termine di fase
		centro di fase

Dipolo Hertziano

$$\vec{N} = \vec{u}_z I_o L$$

$$\vec{E} = j \eta I_o L \frac{e^{-jkr}}{2 \lambda r} \sin \vartheta \vec{u}_\vartheta$$

$$\vec{H} = j I_o L \frac{e^{-jkr}}{2 \lambda r} \sin \vartheta \vec{u}_\varphi$$

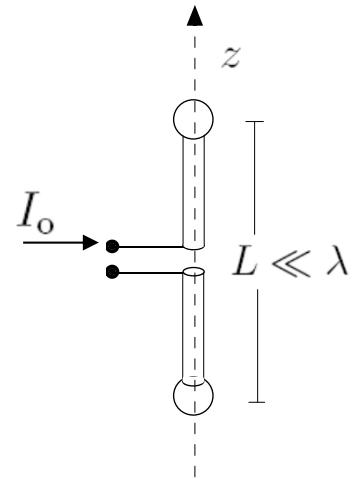
$$K = \frac{\eta}{8} |I_o|^2 \left(\frac{L}{\lambda}\right)^2 \sin^2 \vartheta$$

$$K_{\max} = K\left(\frac{\pi}{2}, \varphi\right) = \frac{\eta}{8} |I_o|^2 \left(\frac{L}{\lambda}\right)^2$$

$$P_{\text{irr}} = \frac{\eta \pi}{3} |I_o|^2 \left(\frac{L}{\lambda}\right)^2$$

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

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



Dipoli corti

$$\vec{N} = \vec{u}_z I_o L_{eq}$$

$$L_{eq} = \int_{-L/2}^{L/2} \frac{I(z)}{I_o} dz$$

$$\vec{E} = j \eta I_o L_{eq} \frac{e^{-jkr}}{2 \lambda r} \sin \vartheta \vec{u}_\vartheta$$

$$\vec{H} = j I_o L_{eq} \frac{e^{-jkr}}{2 \lambda r} \sin \vartheta \vec{u}_\varphi$$

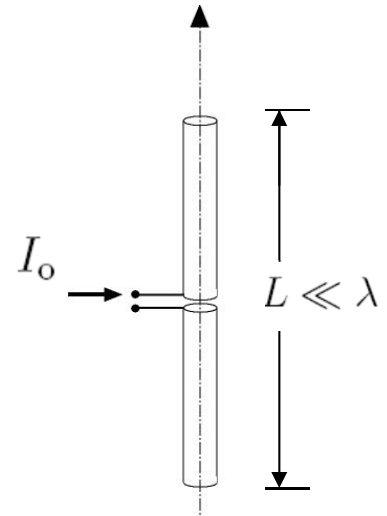
$$K = \frac{\eta}{8} |I_o|^2 \left(\frac{L_{eq}}{\lambda} \right)^2 \sin^2 \vartheta$$

$$K_{\max} = K\left(\frac{\pi}{2}, \varphi\right) = \frac{\eta}{8} |I_o|^2 \left(\frac{L_{eq}}{\lambda} \right)^2$$

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

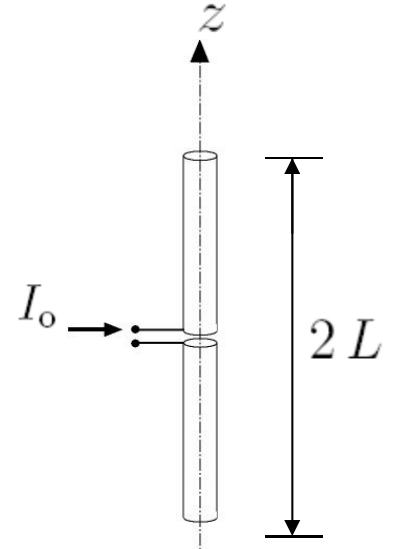
$$D = \frac{3}{2} \sin^2 \vartheta$$

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



Dipoli di dimensione paragonabile alla lunghezza d'onda

$$I(z) = I_o \frac{\sin k(L - |z|)}{\sin(kL)}$$



$$\vec{N} = 2 \vec{u}_z I_o \frac{\cos(kL \cos \vartheta) - \cos(kL)}{k \sin(kL) \sin^2 \vartheta}$$

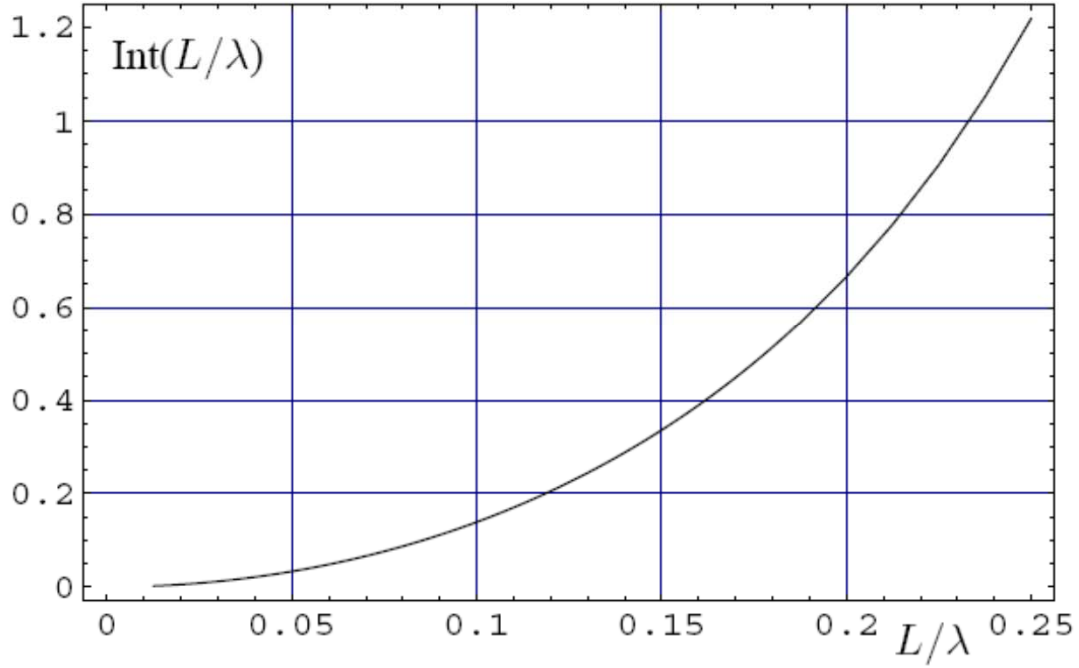
$$\vec{E} = j \eta I_o \frac{e^{-jkr}}{2 \pi r} \frac{\cos(kL \cos \vartheta) - \cos(kL)}{\sin(kL) \sin \vartheta} \vec{u}_\vartheta$$

$$\vec{H} = j I_o \frac{e^{-jkr}}{2 \pi r} \frac{\cos(kL \cos \vartheta) - \cos(kL)}{\sin(kL) \sin \vartheta} \vec{u}_\varphi$$

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

$$\begin{aligned} K_{\max} &= K\left(\frac{\pi}{2}, \varphi\right) \quad (\text{almeno per } L < \lambda/2) \\ &= \frac{\eta}{8 \pi^2} |I_o|^2 \left(\frac{1 - \cos(kL)}{\sin(kL)} \right)^2 \end{aligned}$$

$$\int_0^{2\pi} \int_0^\pi \left(\frac{\cos(kL \cos \vartheta) - \cos(kL)}{\sin(kL) \sin \vartheta} \right)^2 \sin \vartheta d\vartheta d\varphi = 2\pi \text{Int}(L/\lambda)$$

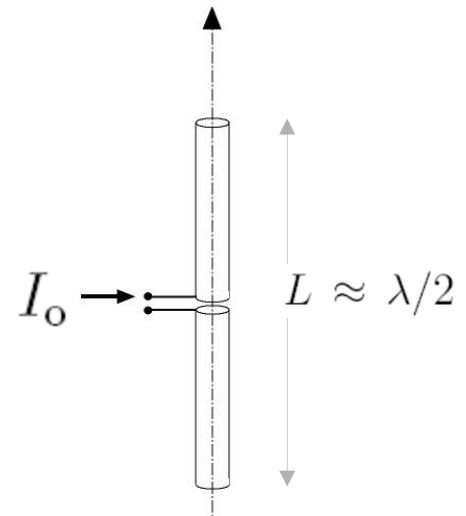


$$P_{\text{irr}} = \frac{\eta}{4\pi} |I_o|^2 \text{Int}(L/\lambda)$$

$$D = \frac{2}{\text{Int}(L/\lambda)} \left(\frac{\cos(kL \cos \vartheta) - \cos(kL)}{\sin(kL) \sin \vartheta} \right)^2$$

$$R_{\text{rad}} = \frac{\eta}{2\pi} \text{Int}(L/\lambda)$$

Dipolo risonante



$$\vec{N} = 2 \vec{u}_z I_o \frac{\cos\left(\frac{\pi}{2} \cos \vartheta\right)}{k \sin^2 \vartheta}$$

$$\vec{E} = j \eta I_o \frac{e^{-jkr}}{2 \pi r} \frac{\cos\left(\frac{\pi}{2} \cos \vartheta\right)}{\sin \vartheta} \vec{u}_\vartheta$$

$$\vec{H} = j I_o \frac{e^{-jkr}}{2 \pi r} \frac{\cos\left(\frac{\pi}{2} \cos \vartheta\right)}{\sin \vartheta} \vec{u}_\varphi$$

$$K = \frac{\eta}{8 \pi^2} |I_o|^2 \frac{\cos^2\left(\frac{\pi}{2} \cos \vartheta\right)}{\sin^2 \vartheta}$$

$$K_{\max} = K\left(\frac{\pi}{2}, \varphi\right) = \frac{\eta}{8 \pi^2} |I_o|^2$$

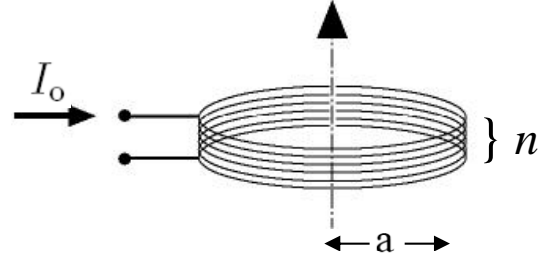
$$P_{irr} = \frac{\eta}{4 \pi} |I_o|^2 1.22$$

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

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

n spire di area S di piccole dimensioni

$$\sqrt{S} \ll \lambda$$



$$S = \pi a^2 \text{ per la spira circolare}$$

$$\vec{N} = j k S n I_o \sin \vartheta \vec{u}_\varphi$$

$$\vec{E} = \frac{\eta}{4 \pi} I_o n k^2 S \frac{e^{-jkr}}{r} \sin \vartheta \vec{u}_\varphi$$

$$\vec{H} = -\frac{1}{4 \pi} I_o n k^2 S \frac{e^{-jkr}}{r} \sin \vartheta \vec{u}_\vartheta$$

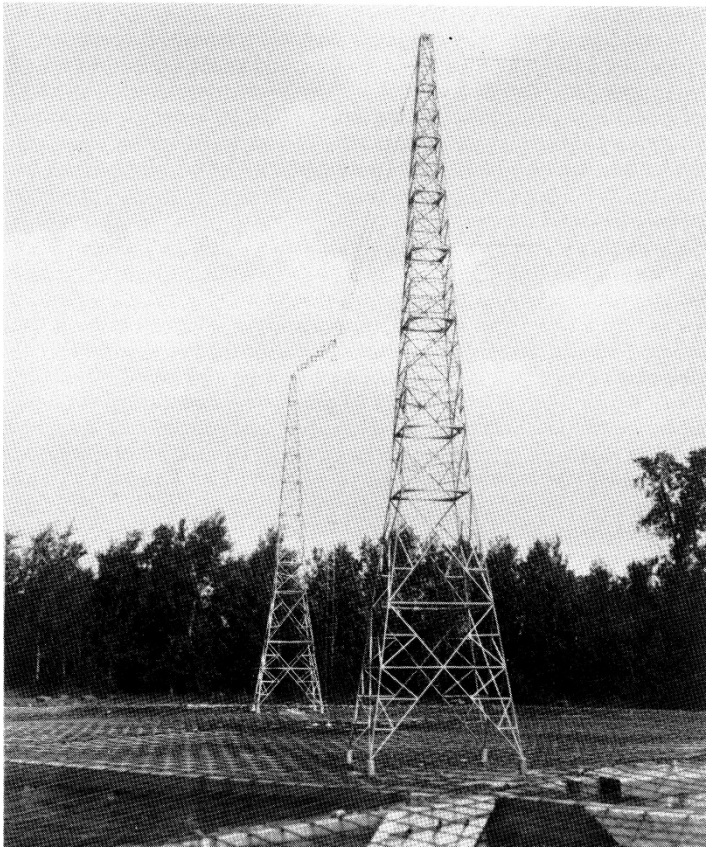
$$K = \frac{\eta}{32 \pi^2} |I_o|^2 (n k^2 S)^2 \sin^2 \vartheta$$

$$K_{\max} = K\left(\frac{\pi}{2}, \varphi\right) = \frac{\eta}{32 \pi^2} |I_o|^2 (n k^2 S)^2$$

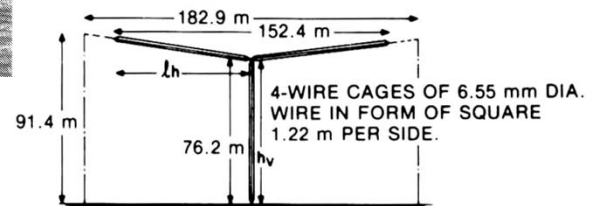
$$P_{\text{irr}} = \frac{\eta}{12 \pi} |I_o|^2 (n k^2 S)^2$$

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

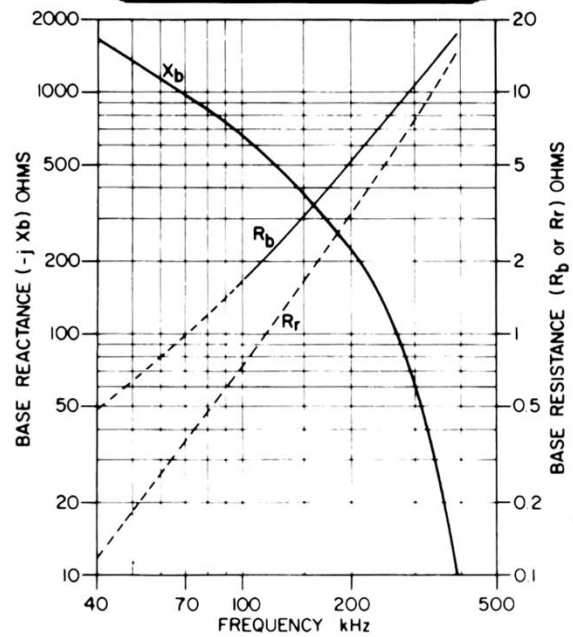
$$R_{\text{rad}} = \frac{\eta}{6 \pi} (n k^2 S)^2$$

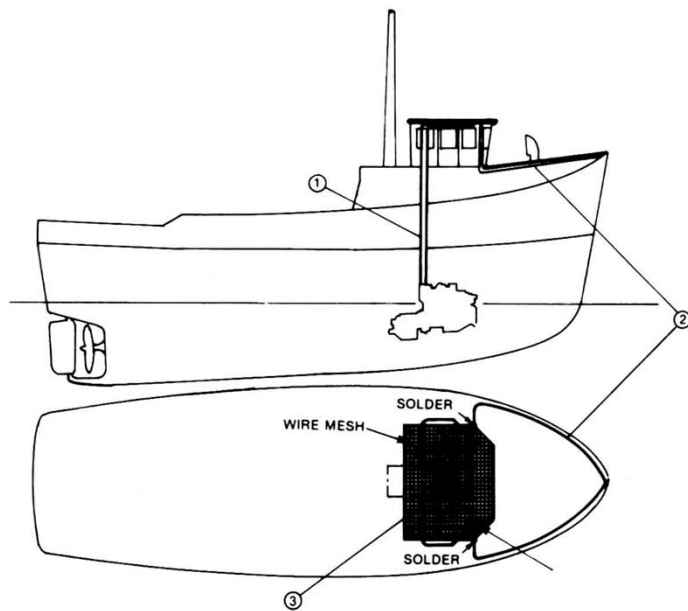
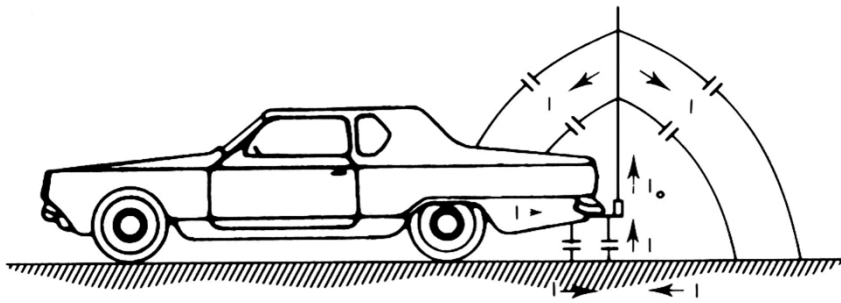
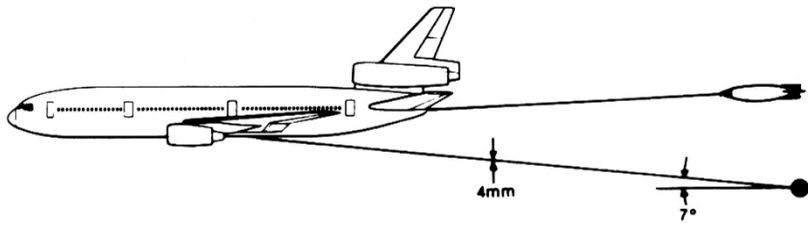


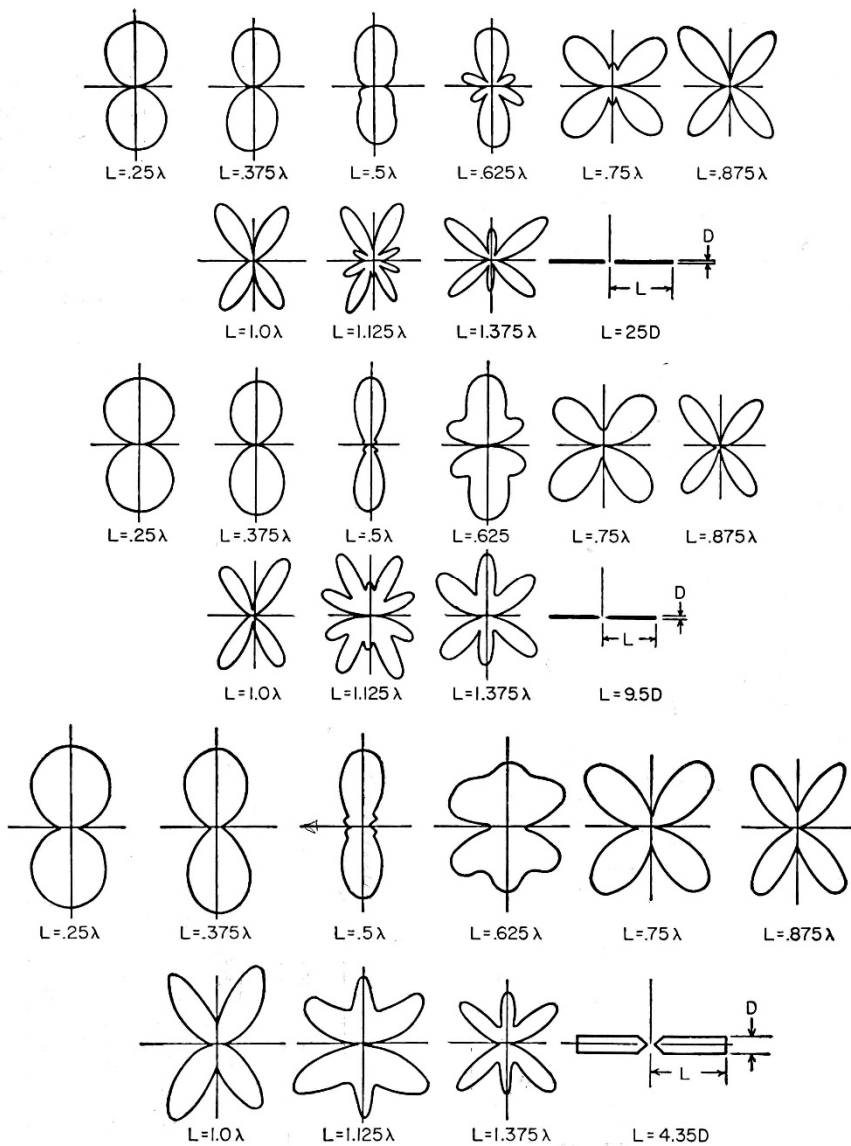
Antenna a T



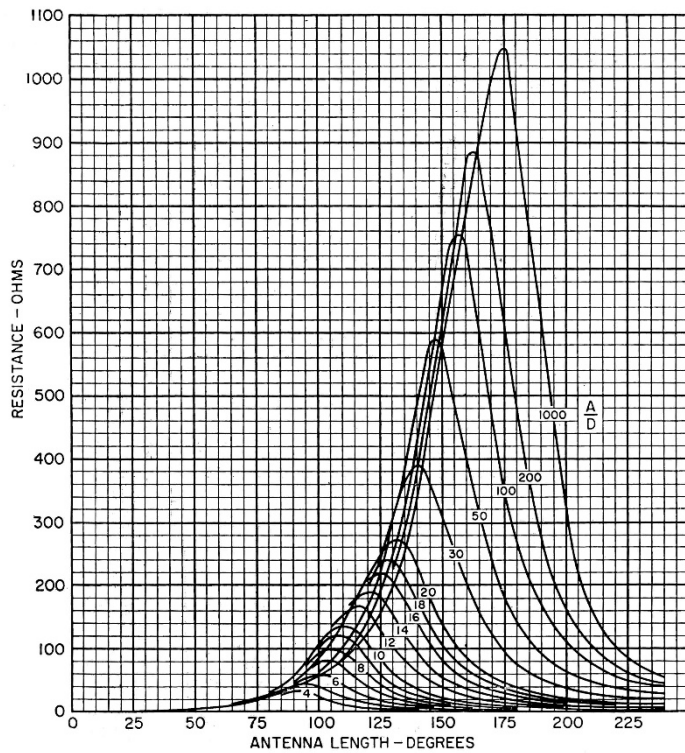
$f = 100 \text{ KHz}$
 $\xi = 30 \%$
 $B = 0.8 \text{ KHz}$
 $P_{in} = 25 \text{ kW}$
 $I_0 = 106 \text{ A}$
 $V_0 = 56 \text{ kV}$





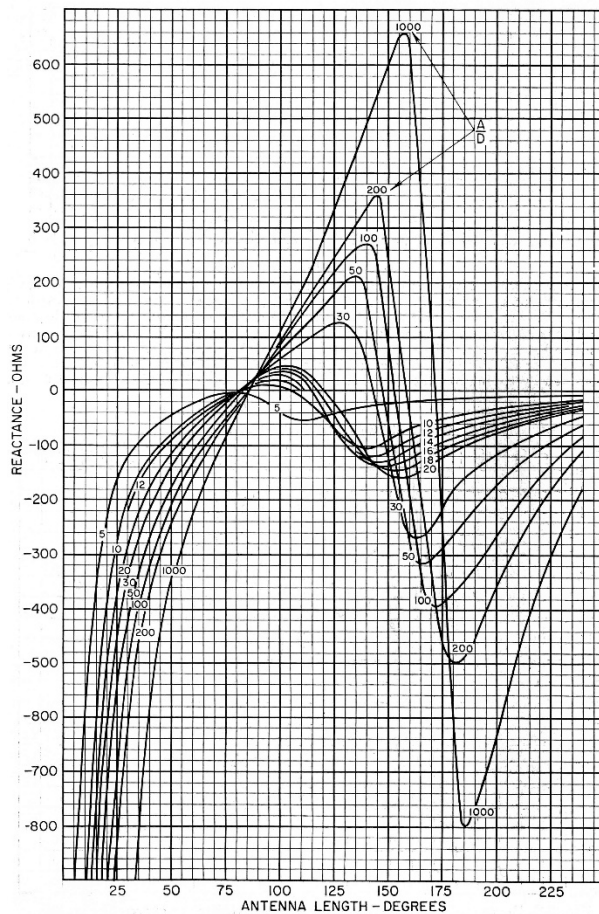


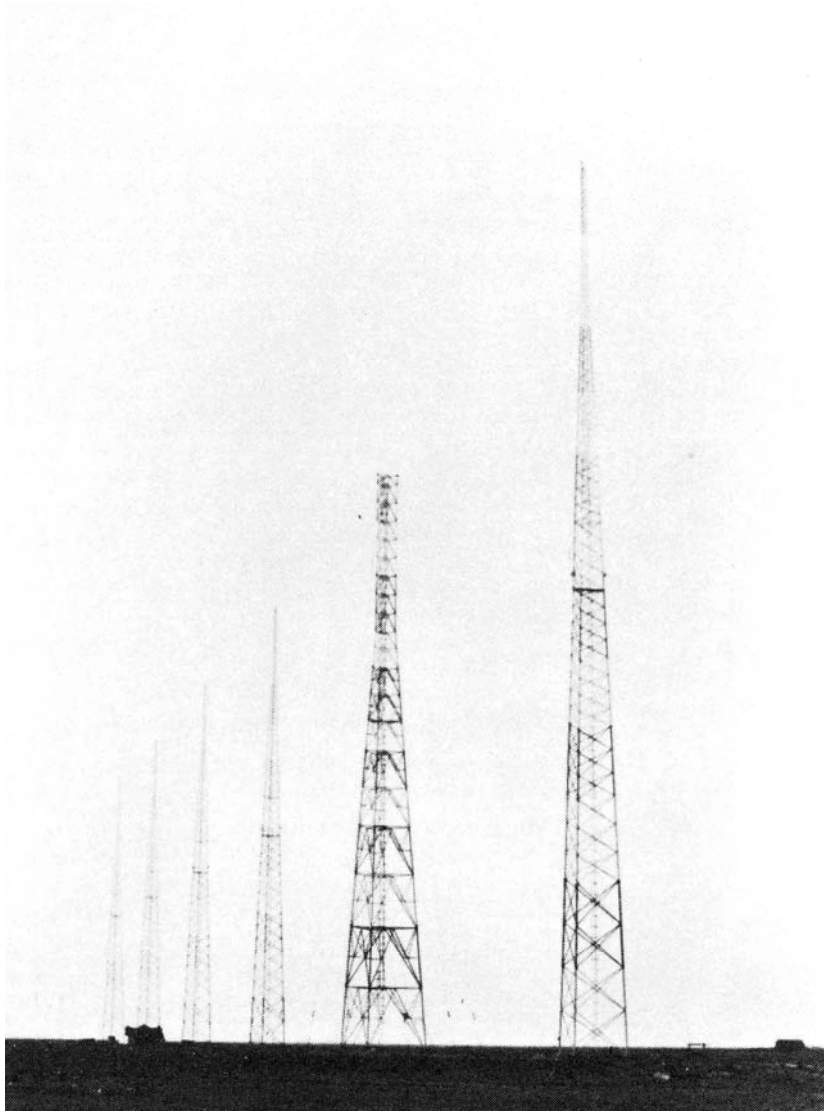
Diagrammi di radiazione di dipoli cilindrici di lunghezza $2L$ e diametro D , per diversi rapporti L / λ e L / D

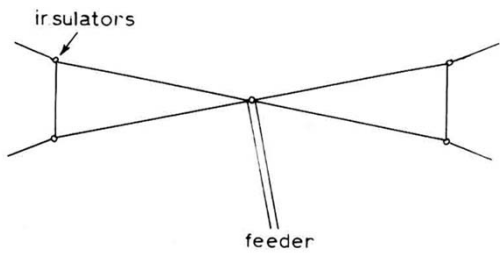


Resistenza d'ingresso di dipoli cilindrici di lunghezza $A = 2L$, al variare della lunghezza elettrica (espressa come $360^\circ L / \lambda$) e per diversi rapporti (A/D)

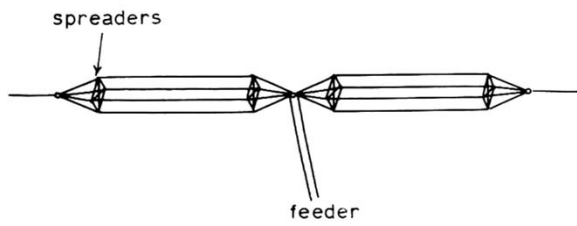
Reattanza d'ingresso di dipoli cilindrici variare della lunghezza elettrica e per diversi rapporti lunghezza/diametro



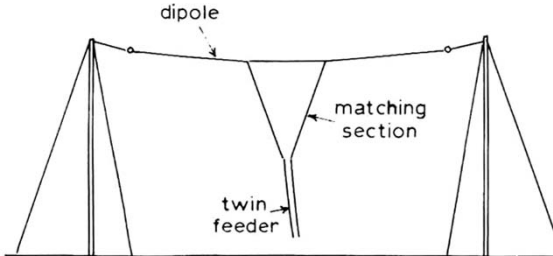




Bow-tie dipole

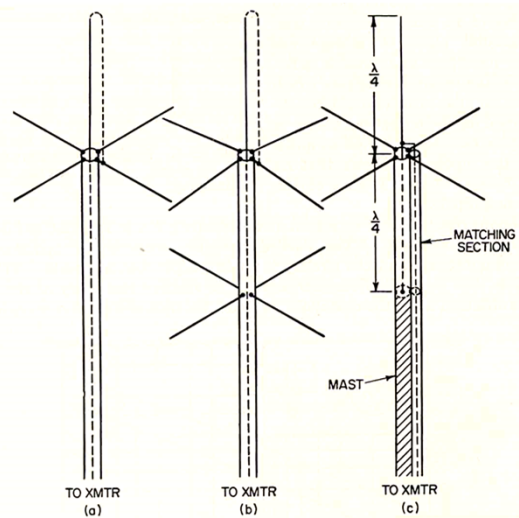


Cage dipole

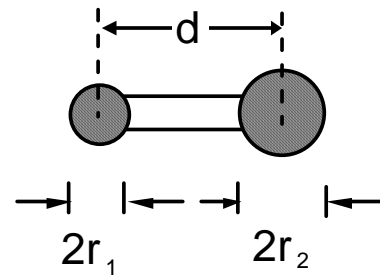
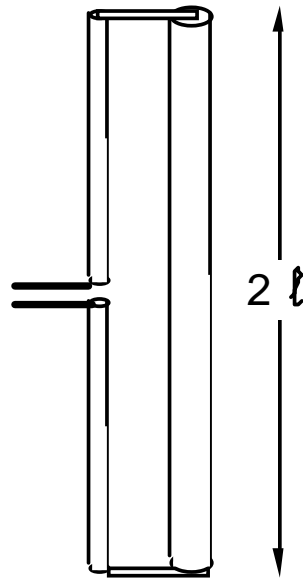


Y-matching to a dipole

asymmetric dipoles

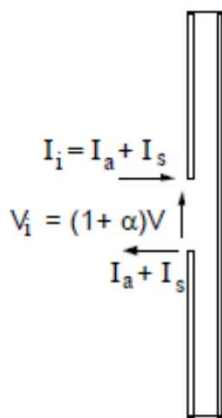


dipolo ripiegato

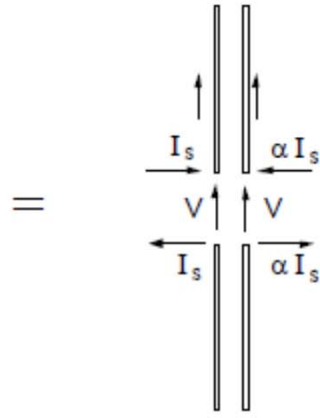


$$\mu = r_2 / r_1$$

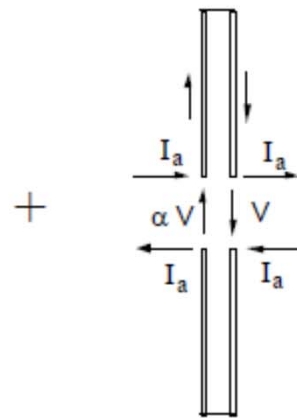
$$v = d / r_1$$



dipolo ripiegato

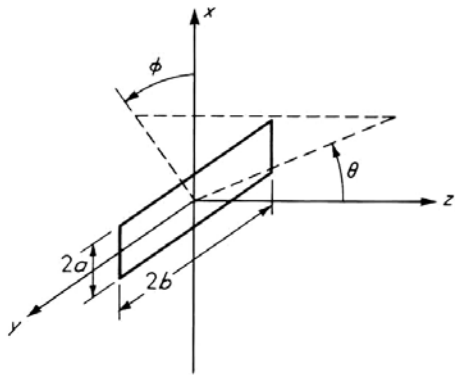


componente simmetrica
(dipolo composto)

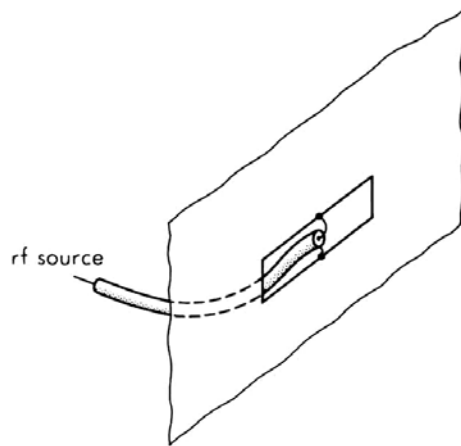


componente antisimmetrica
(due linee cortocircuitate)

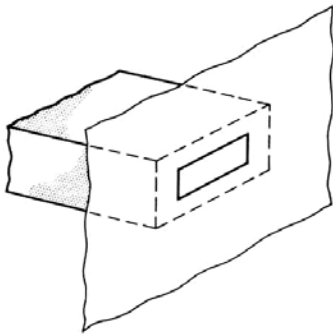
antenne a fessura



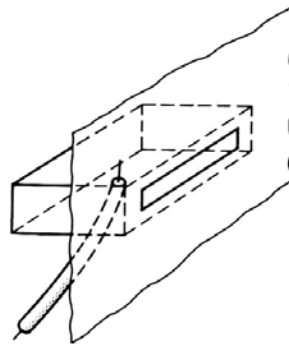
Slot in a ground plane.



Coax-fed slot.

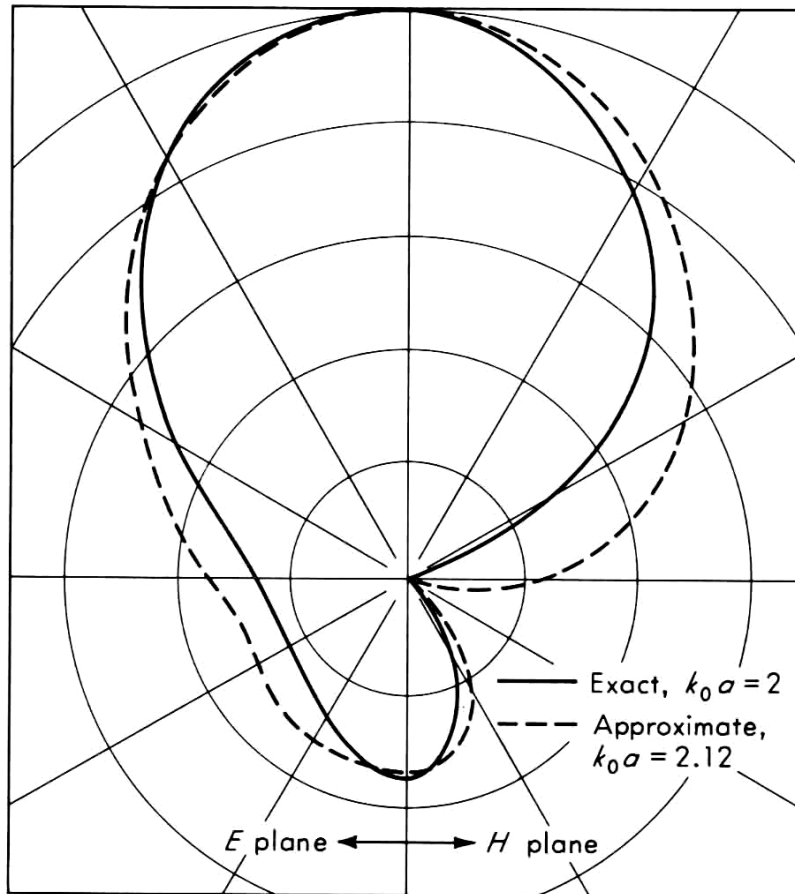


Endwall slot.



Cavity-fed slot.

Radiazione da guida circolare troncata (modo TE_{11})



apertura del fascio a -3 dB

$14.7 \lambda/a$ [gradi]

sul piano E

$18.6 \lambda/a$ [gradi]

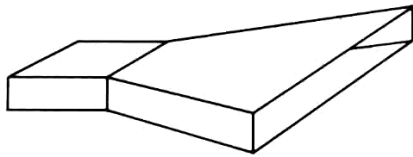
sul piano H

direttività

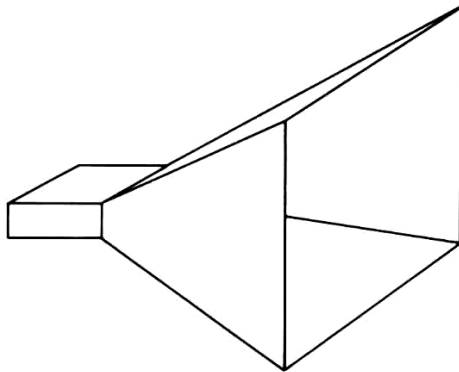
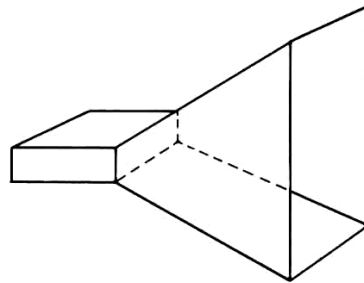
$10.5 \pi a^2 / \lambda^2$

antenne a tromba

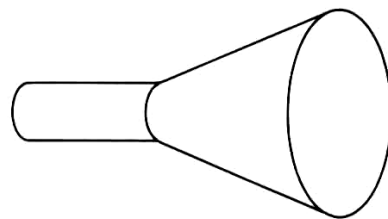
tromba settoriale sul piano H



tromba settoriale sul piano E

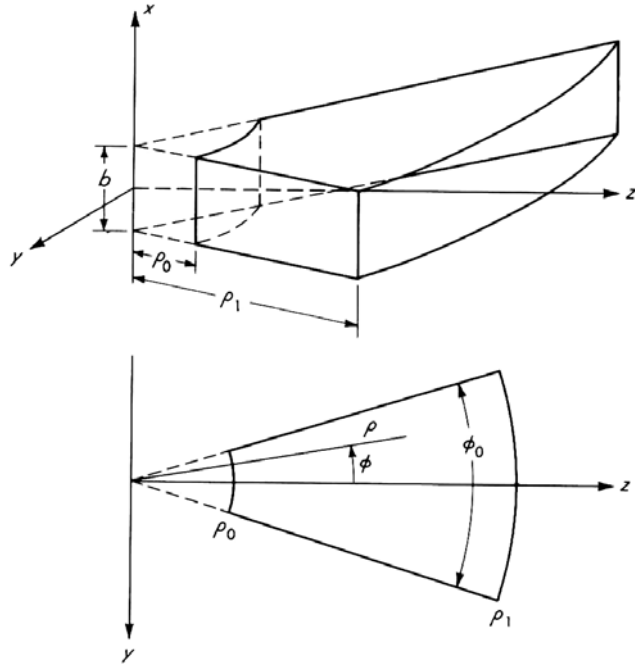


tromba piramidale



tromba conica

tromba sul piano H
 modo dominante in guida radiale

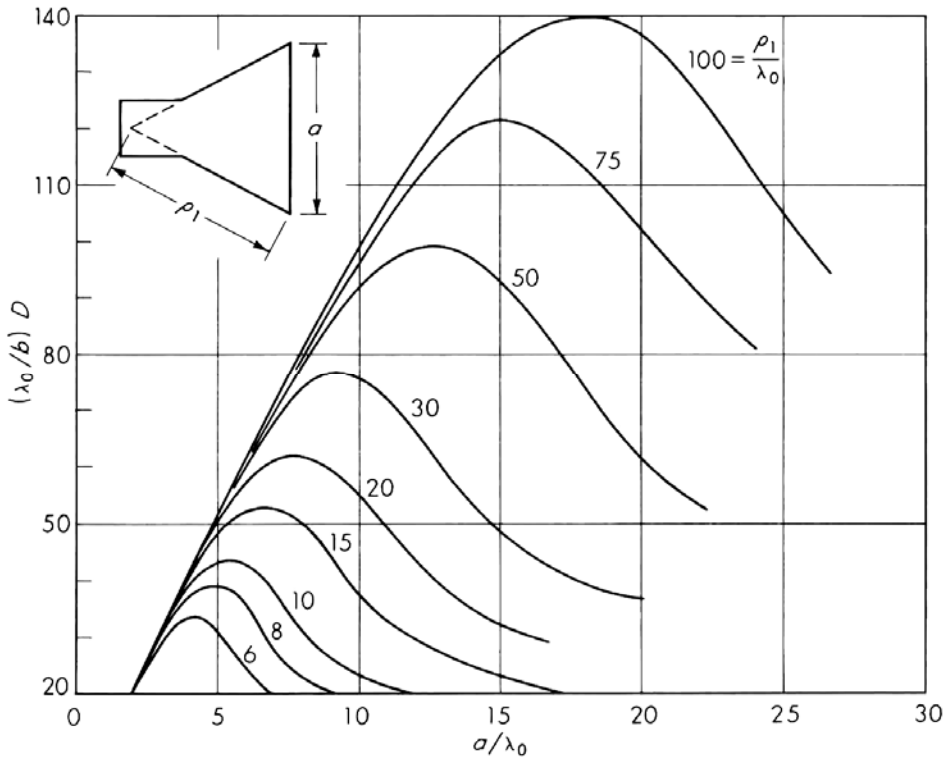


$$\left\{ \begin{array}{l} E_x = A \cos \nu \varphi H_\nu(k_o \rho) \\ H_\varphi = -j \frac{A}{\eta} \cos \nu \varphi \frac{\partial H_\nu(k_o \rho)}{\partial (k_o \rho)} \\ H_\rho = -j \frac{A}{\eta} \nu \sin \nu \varphi \frac{H_\nu(k_o \rho)}{k_o \rho} \end{array} \right. \quad \nu = \frac{m\pi}{\varphi_o} \quad (\text{m dispari})$$

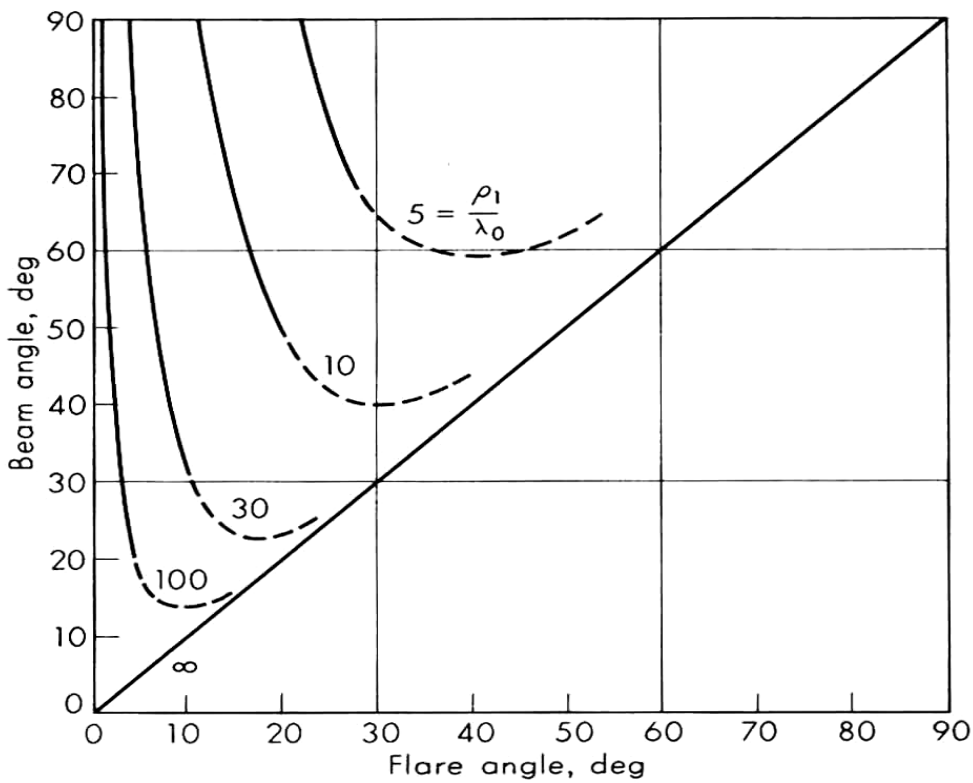
$$H_\nu(k_o \rho) \rightarrow \sqrt{\frac{2}{\pi k_o \rho}} e^{-j\left(k_o \rho - \pi \frac{2\nu+1}{4}\right)}$$

$$\frac{\partial H_\nu(k_o \rho)}{\partial (k_o \rho)} \rightarrow -j \sqrt{\frac{2}{\pi k_o \rho}} e^{-j\left(k_o \rho - \pi \frac{2\nu+1}{4}\right)}$$

antenna a tromba settoriale piano H

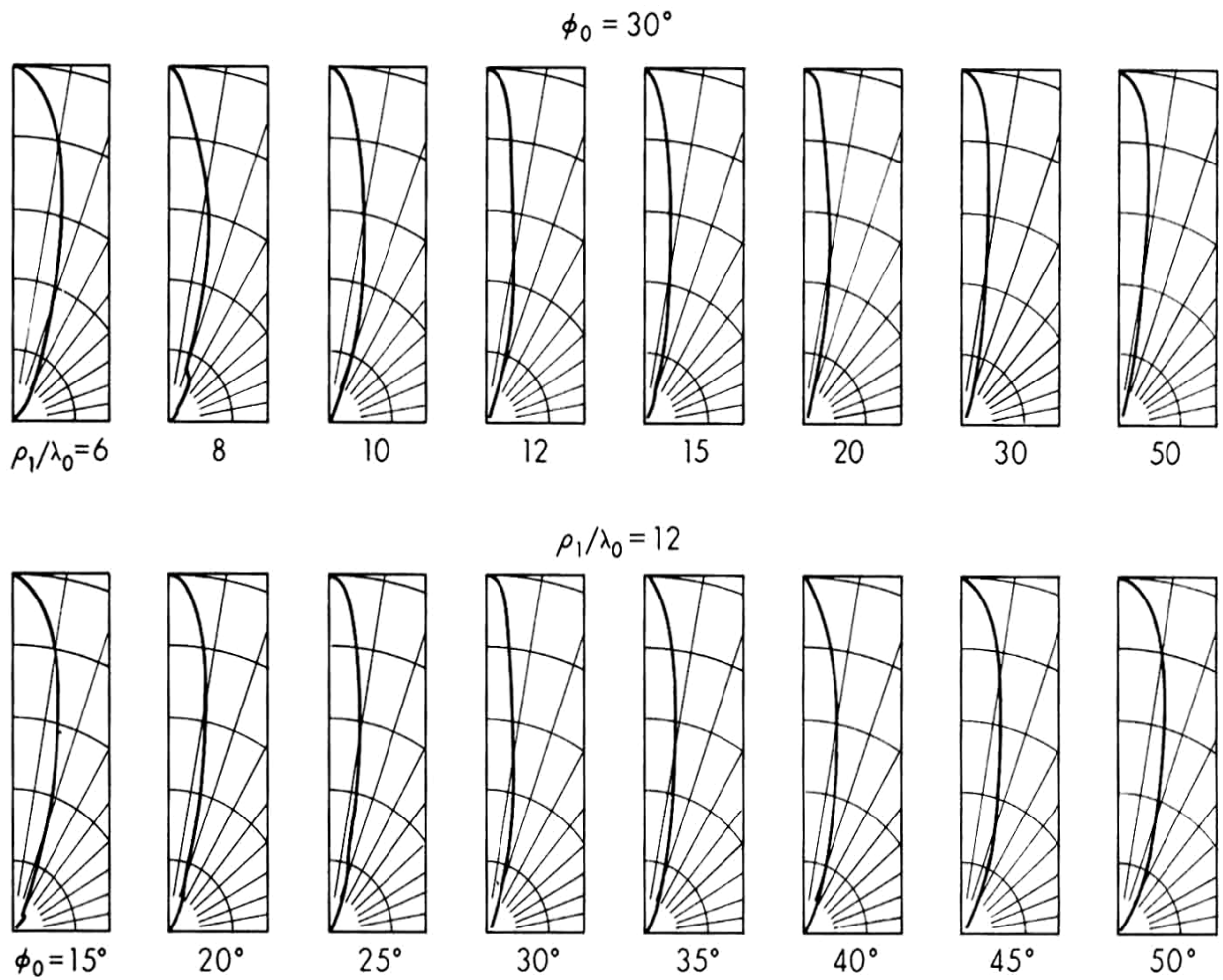


direttività



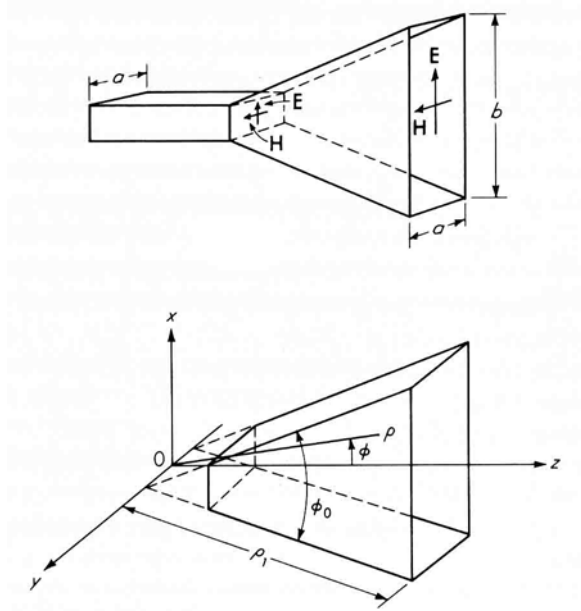
apertura
del fascio

antenna a tromba settoriale piano H



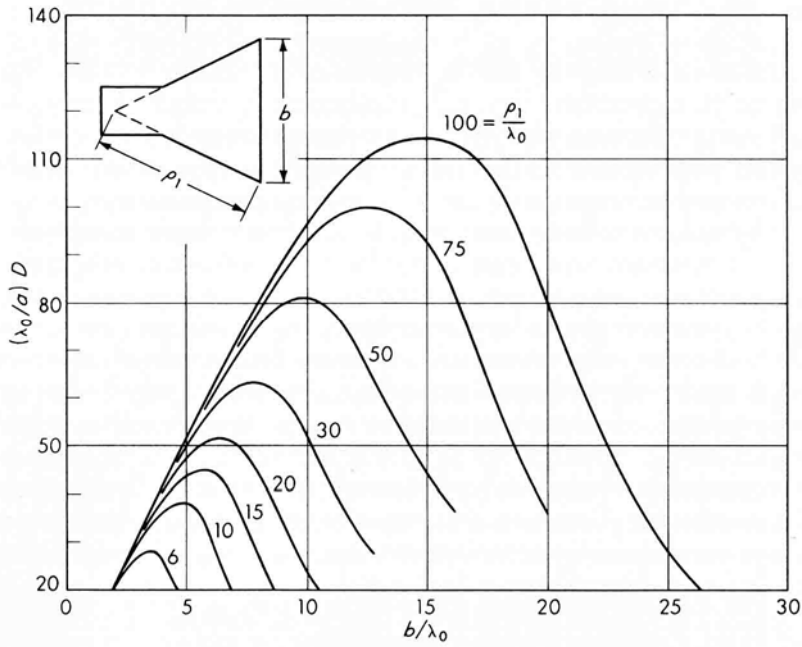
diagrammi di radiazione sul piano H

tromba sul piano E
 modo dominante in guida radiale

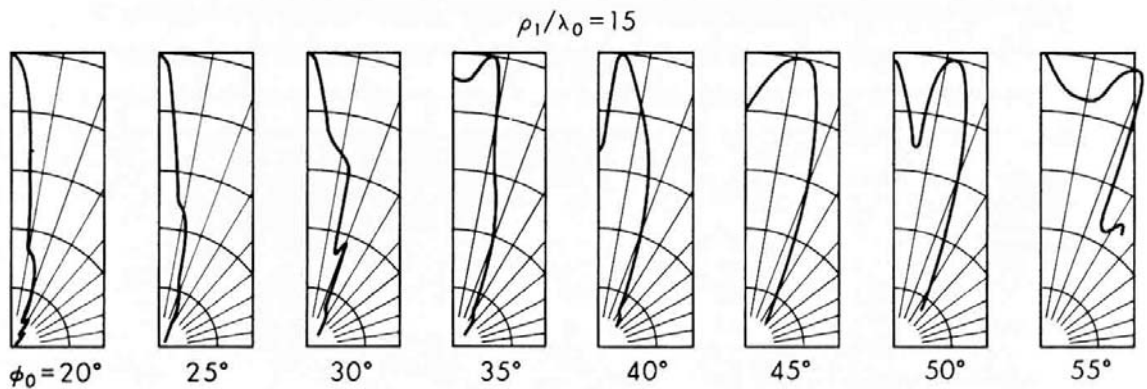
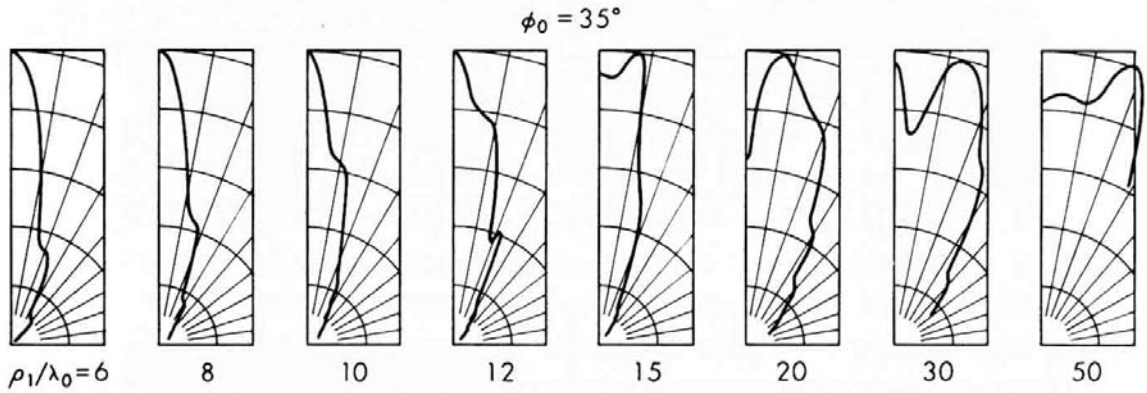


$$\left\{ \begin{array}{l} E_{\phi} = B \cos \frac{n\pi y}{a} H_1(\gamma\rho) \\ H_y = j \frac{B}{\eta} \cos \frac{n\pi y}{a} \frac{\partial H_1(\gamma\rho)}{\partial(\gamma\rho)} \\ H_{\rho} = -j B \frac{n\pi}{\eta k_o a} \sin \frac{n\pi y}{a} H_1(\gamma\rho) \end{array} \right. \quad \gamma = \sqrt{k_o^2 - \left(\frac{n\pi}{a}\right)^2}$$

antenna a tromba settoriale piano E

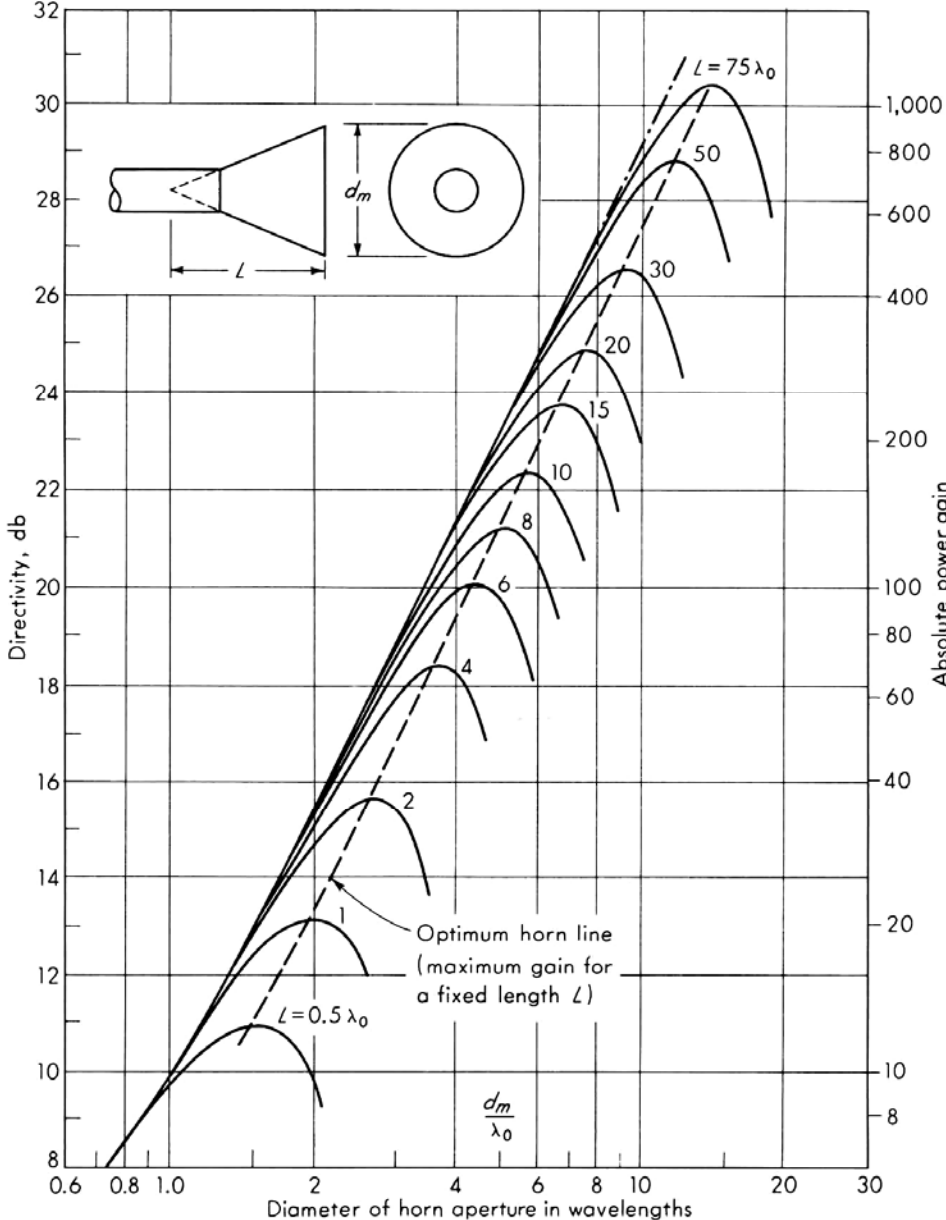
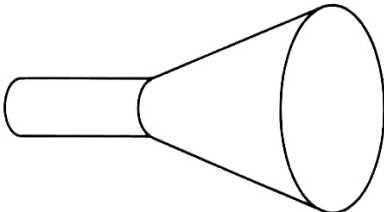


direttività

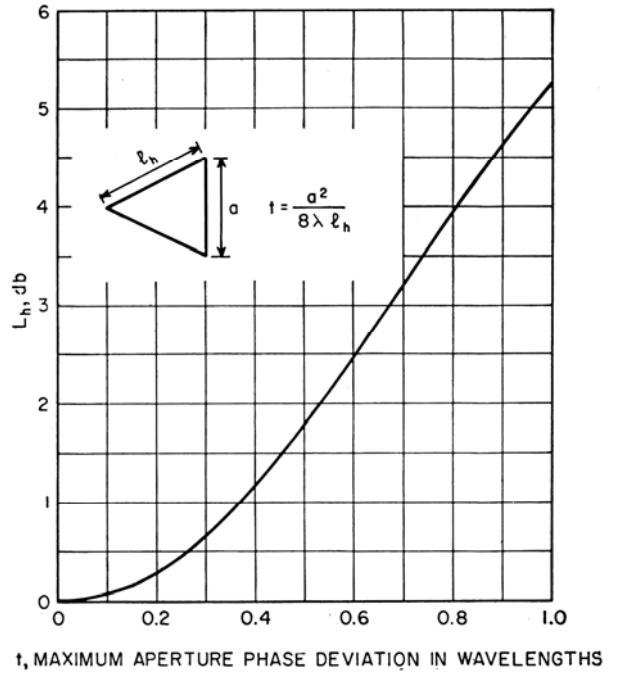
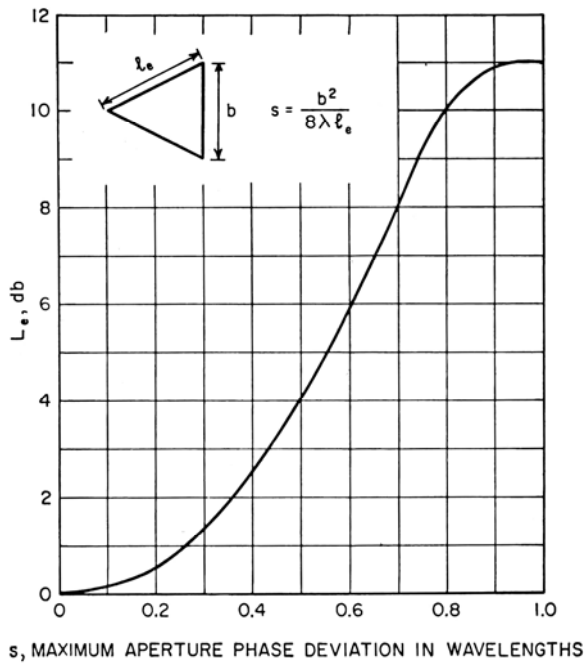
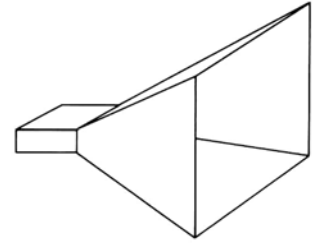


diagrammi di radiazione sul piano E

antenna a tromba conica



antenna a tromba piramidale



s, t = massima differenza di fase in lunghezze d'onda sul piano E e sul piano H

L_e, L_h = corrispondenti fattori correttivi del guadagno [dB]

$$g = 10 \left(1.008 + \text{Log} \frac{ab}{\lambda^2} \right) - (L_e + L_h) \quad [\text{dB}]$$

antenna a tromba piramidale ottimizzata

la tromba ottimizzata è quella che ha il massimo guadagno a parità di lunghezza. Questa situazione si trova se tra le dimensioni dell'apertura e le lunghezze l_e e l_h sono rispettate le seguenti relazioni:

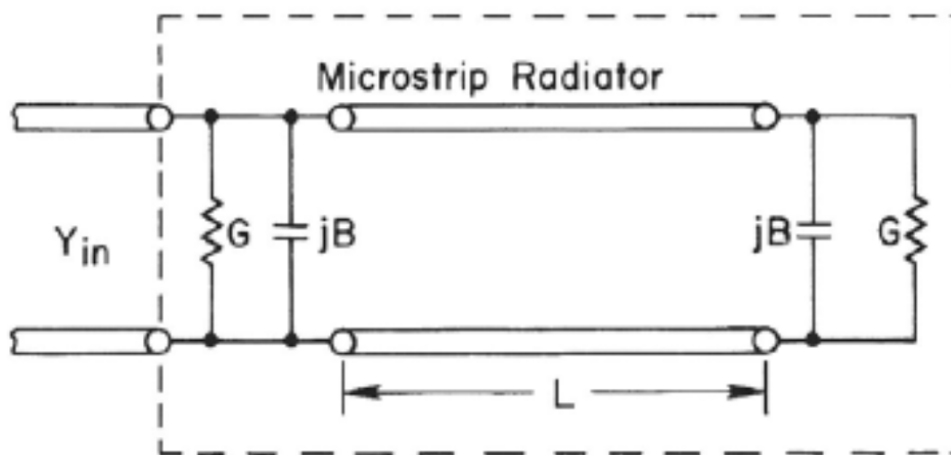
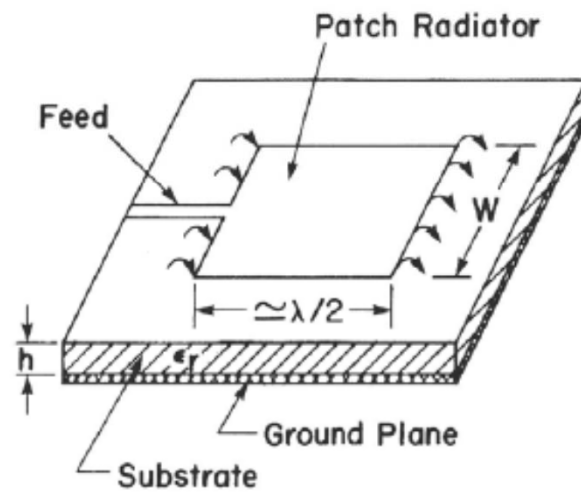
$$a = \sqrt{3\lambda l_h} \qquad b = \sqrt{3\lambda l_e}$$

in queste condizioni risulta:

$$A_{eff} \approx \frac{A}{2}$$

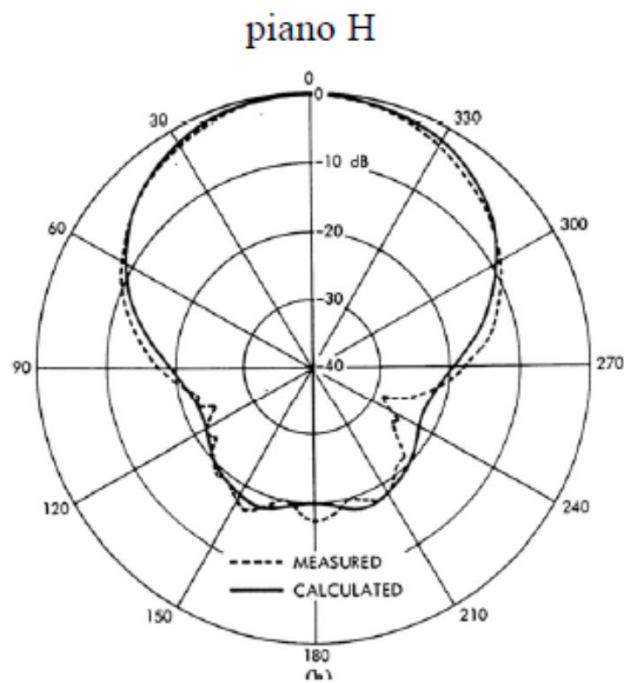
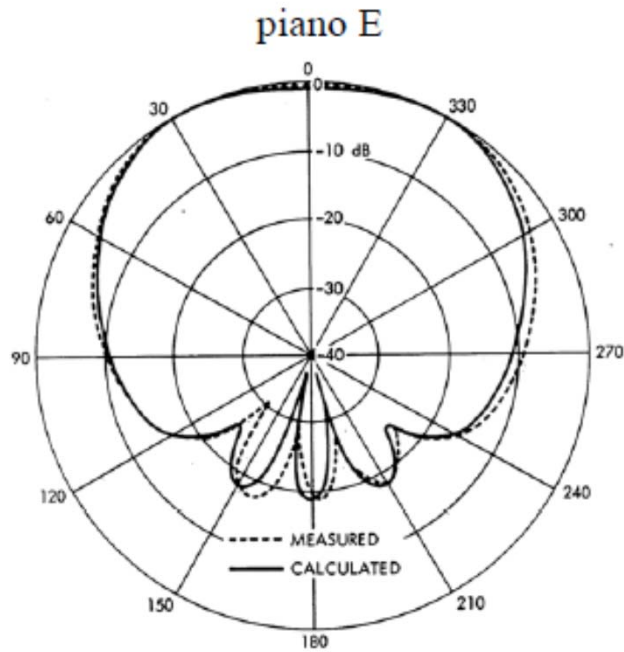
$$g = 10 \left(0.808 + \text{Log} \frac{ab}{\lambda^2} \right) \quad [\text{dB}]$$

Antenna patch rettangolare

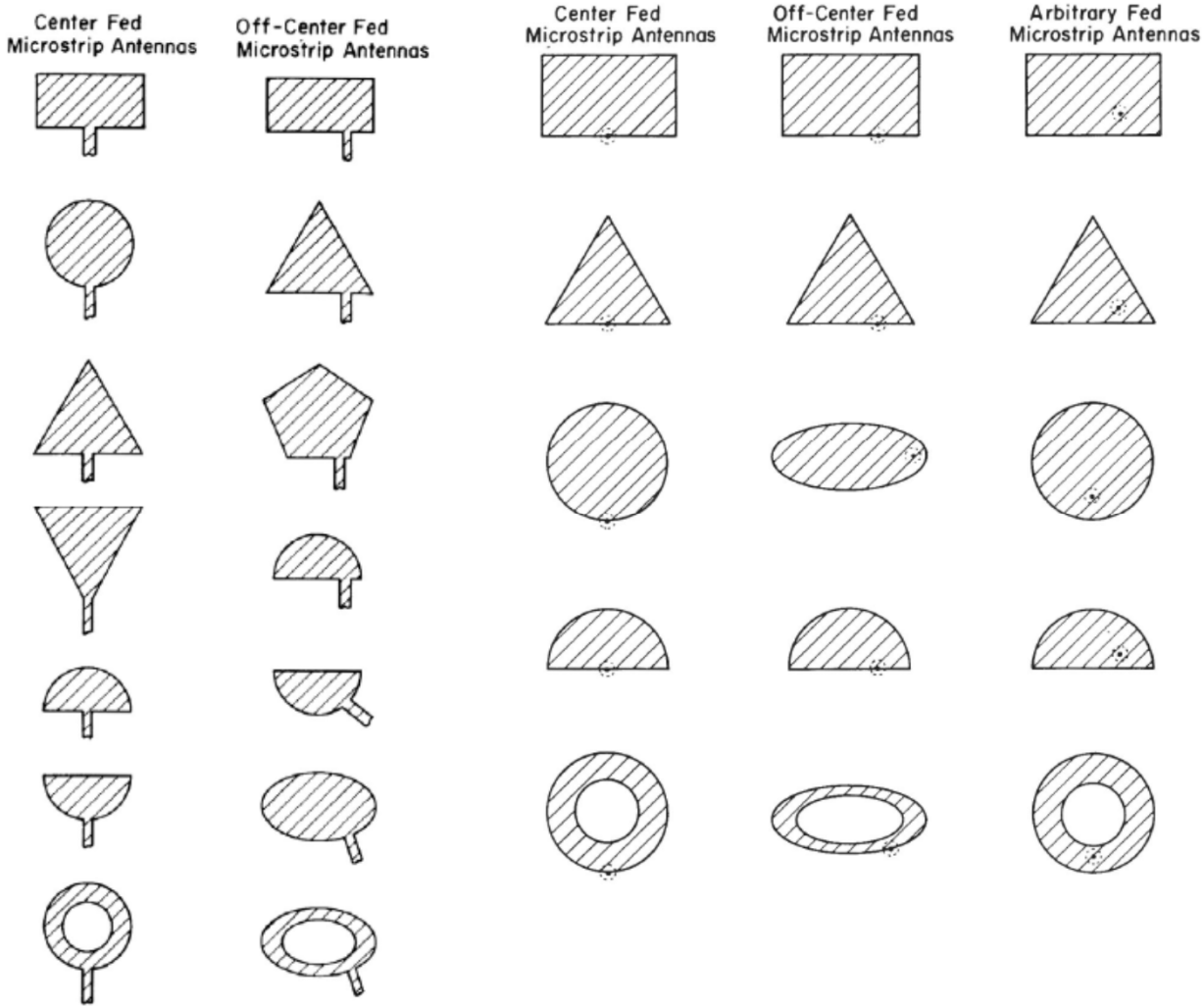


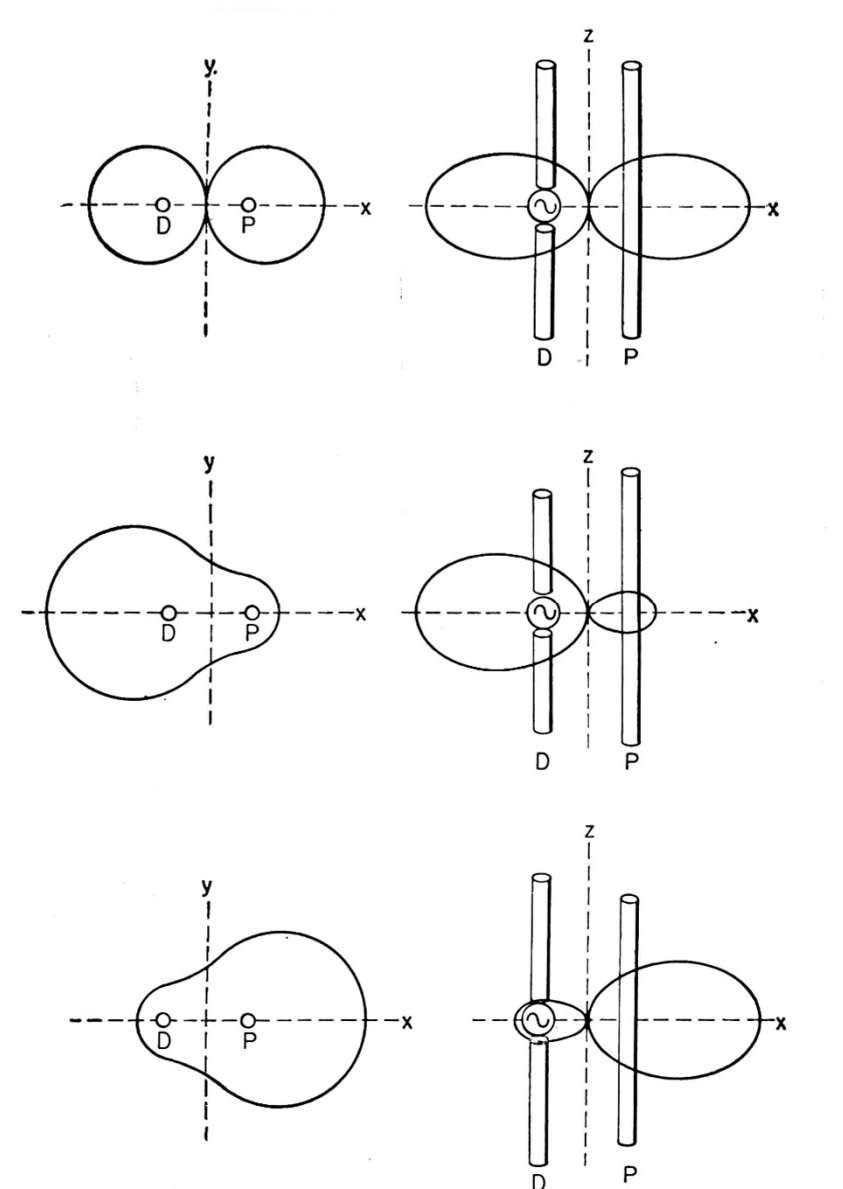
Circuito equivalente di un radiatore patch rettangolare, alimentato in microstriscia

diagramma di radiazione di un patch rettangolare



Varie forme di antenne stampate con alimentazione in microstriscia o in coassiale

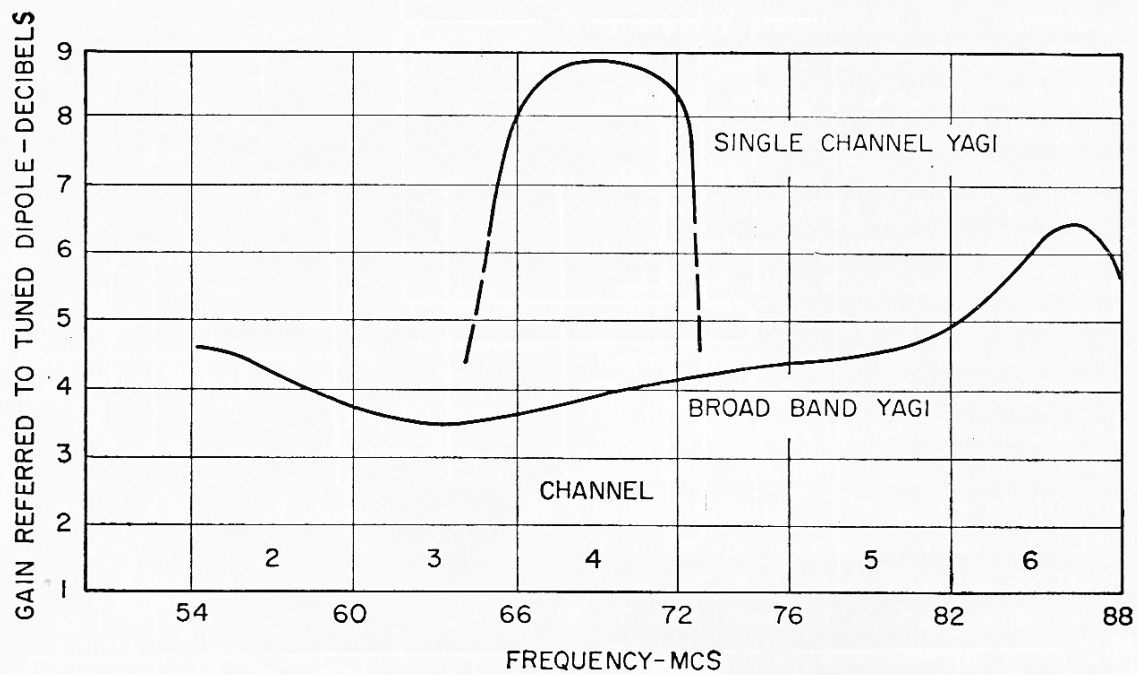




diagrammi di radiazione sul piano H di due dipoli paralleli
distanti 0.04λ di cui uno alimentato (d) e uno passivo (p):

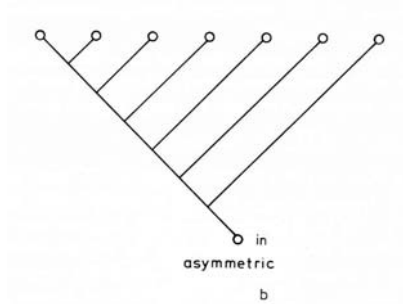
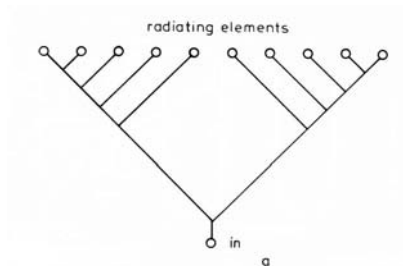
- i due dipoli sono risonanti
- la lunghezza del dipolo passivo è incrementata del 5%
(dipolo riflettore)
- la lunghezza del dipolo passivo è diminuita del 5%
(dipolo direttore)

antenne Yagi-Uda

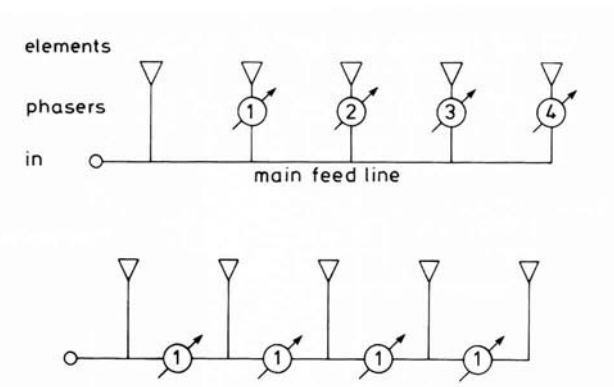


guadagni di antenne Yagi-Uda di 5 elementi a singolo canale e a larga banda

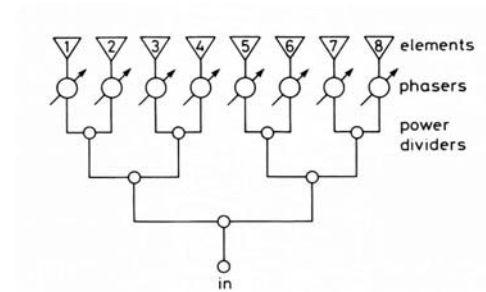
schemi di alimentazione di schiere



alimentazione a pari cammino simmetrica e asimmetrica

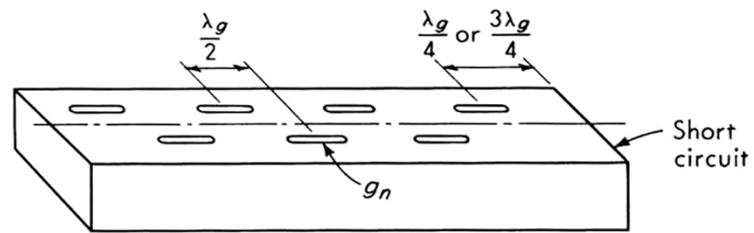


alimentazione tipo serie con sfasatori nella linea principale o derivata

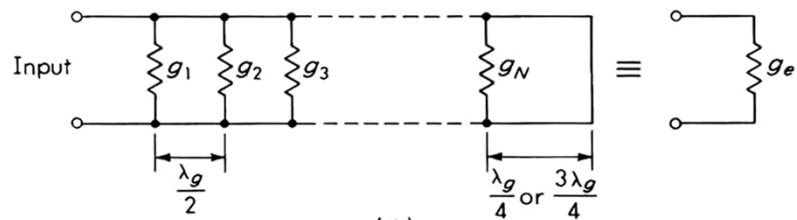


alimentazione gerarchica reattiva (reactive corporated feed)

schiera risonante di fenditure



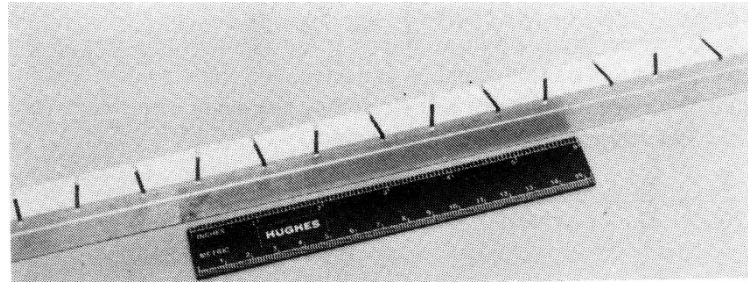
(a)



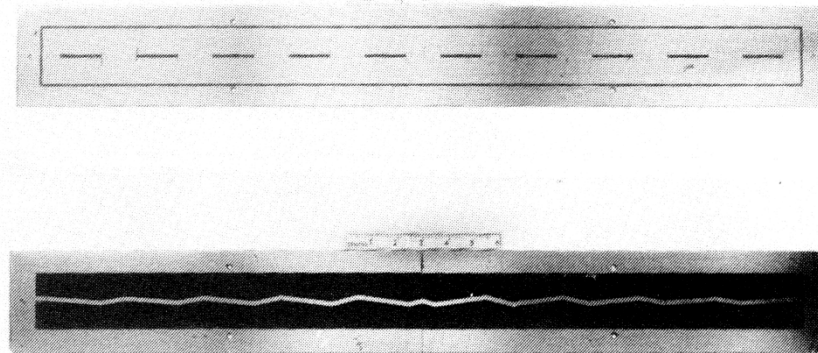
(b)

$$g_e = \sum_{n=1}^N g_n$$

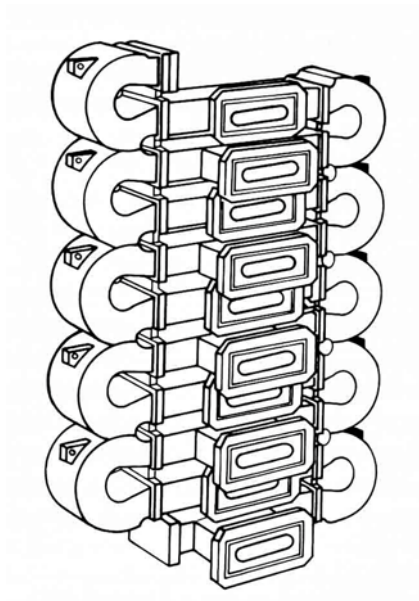
schiere di fenditure



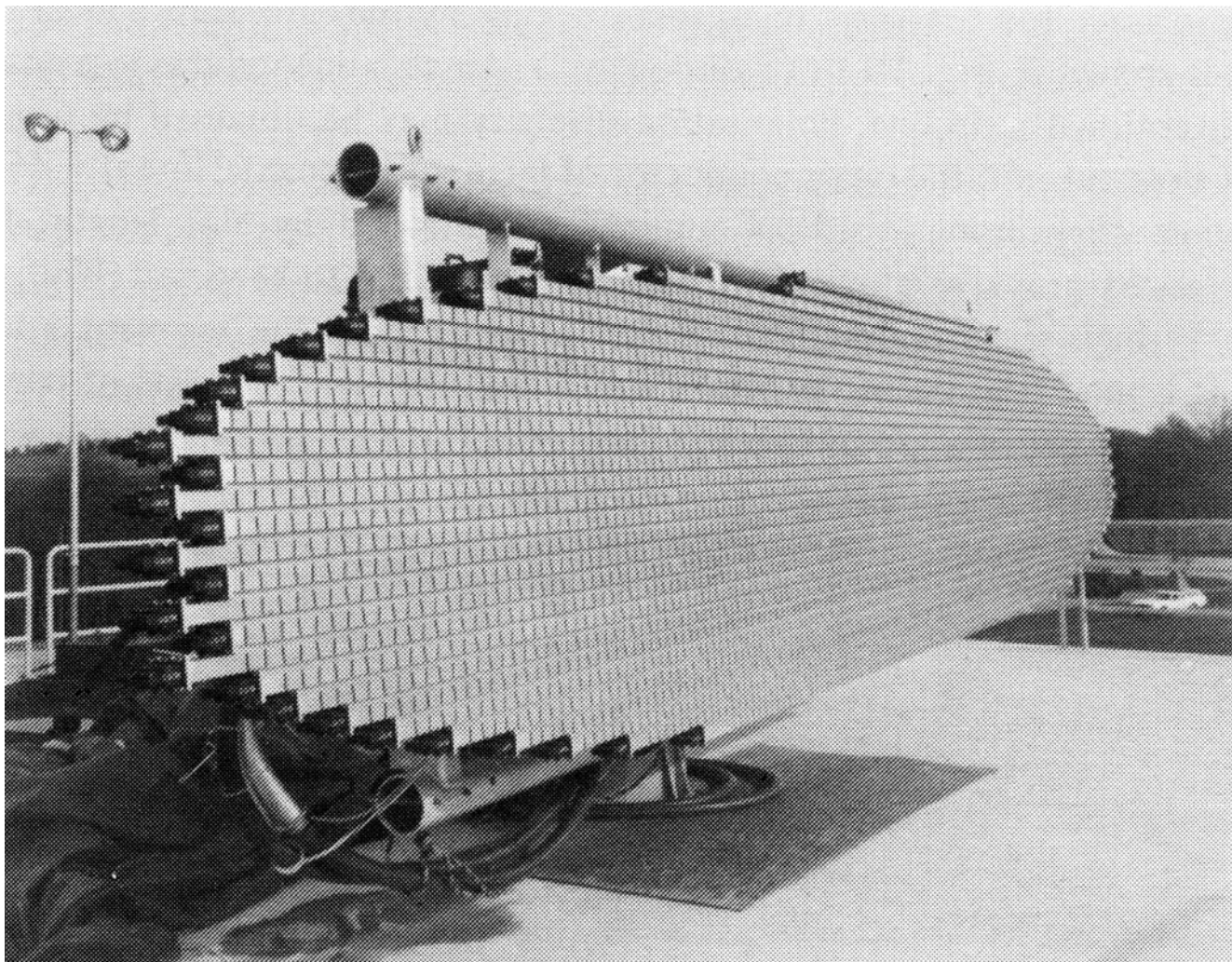
schiera non risonante fenditure (ad onda viaggiante)



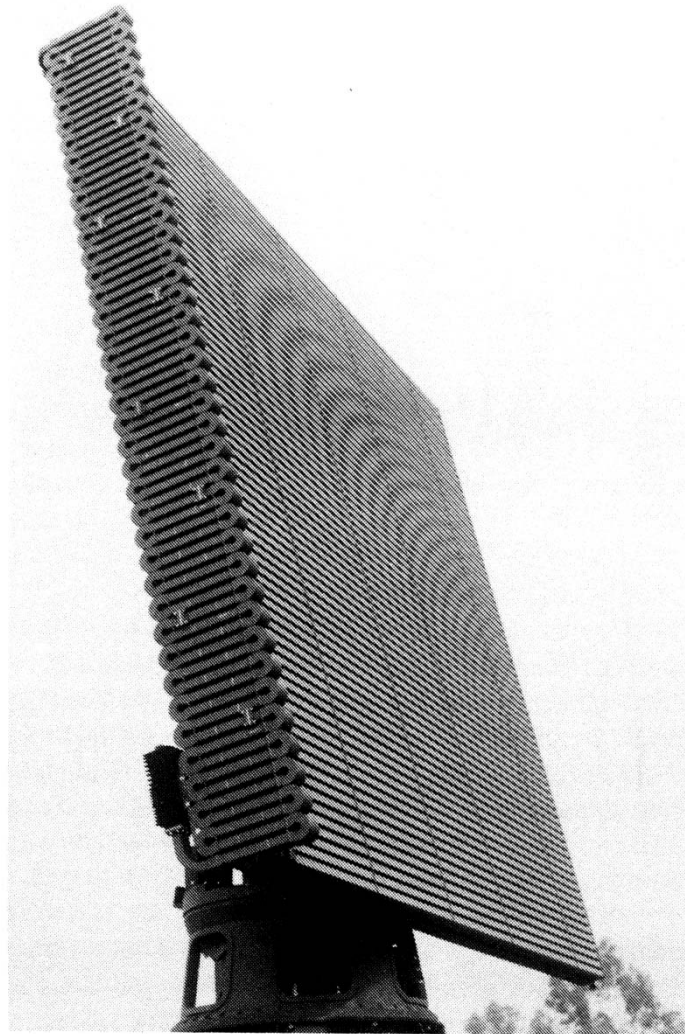
schiera risonante di fenditure con alimentazione in stripline schermata per il controllo accurato dei lobi laterali
il coefficiente di eccitazione delle fenditure dipende dall'inclinazione locale della stripline rispetto alla direzione dell'allineamento



schiera non risonante di fenditure con alimentazione in guida a serpentina per avere una significativa variazione del puntamento del fascio per piccole variazioni di frequenza

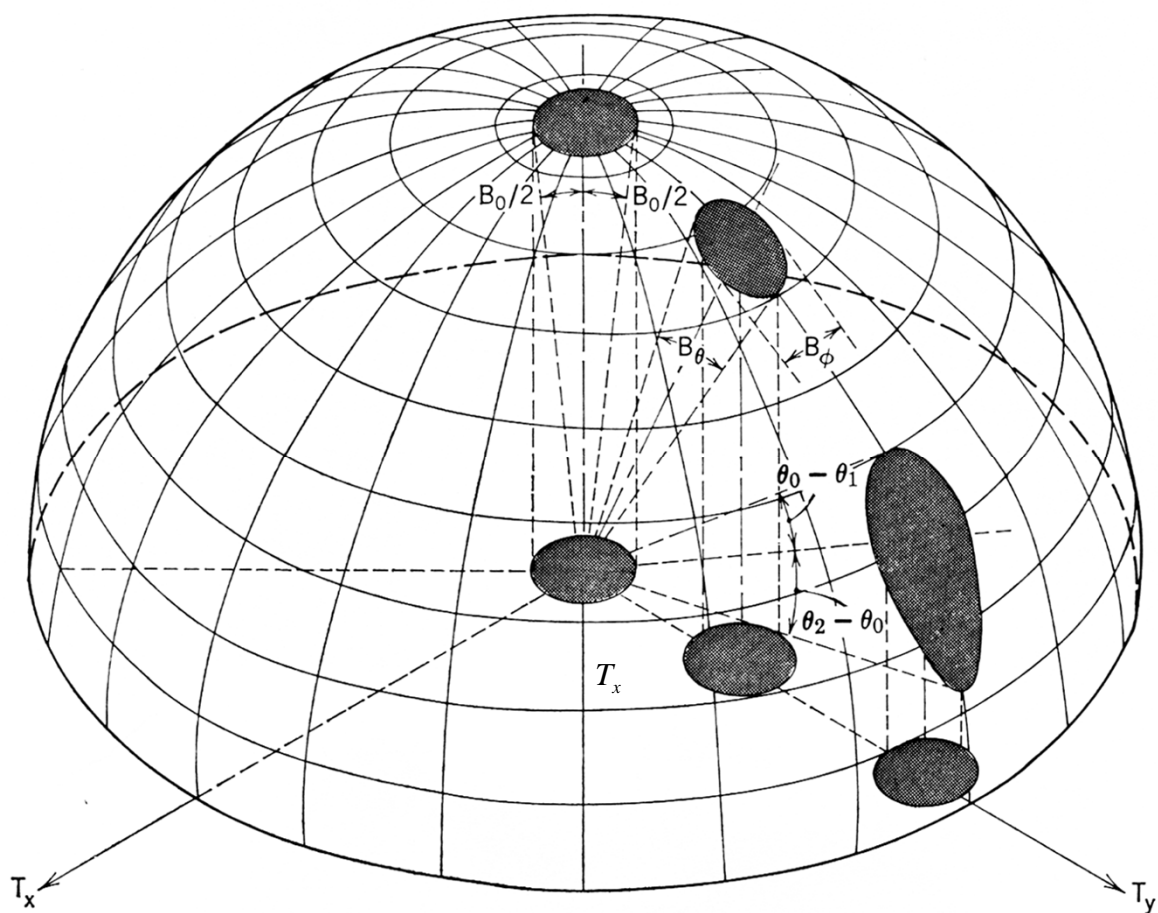


AWACS (Westinghouse Defence & Electronic Systems) antenna radar realizzata con un insieme di schiere lineari risonanti di fenditure.

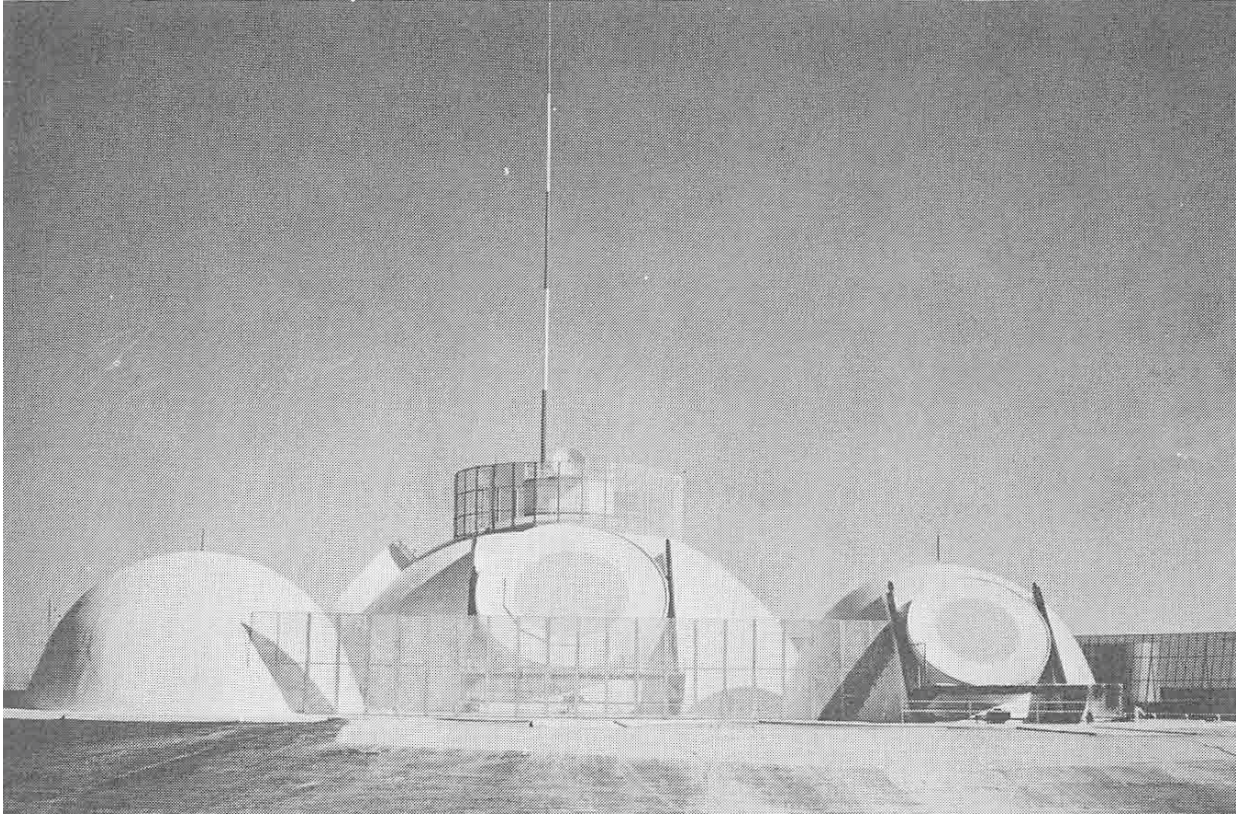


schiera lineare di schiere lineari risonanti di fenditure.
L'alimentazione ad onda progressiva delle schiere di fenditure è realizzata mediante la guida a serpentina laterale per realizzare la scansione del fascio con la variazione della frequenza

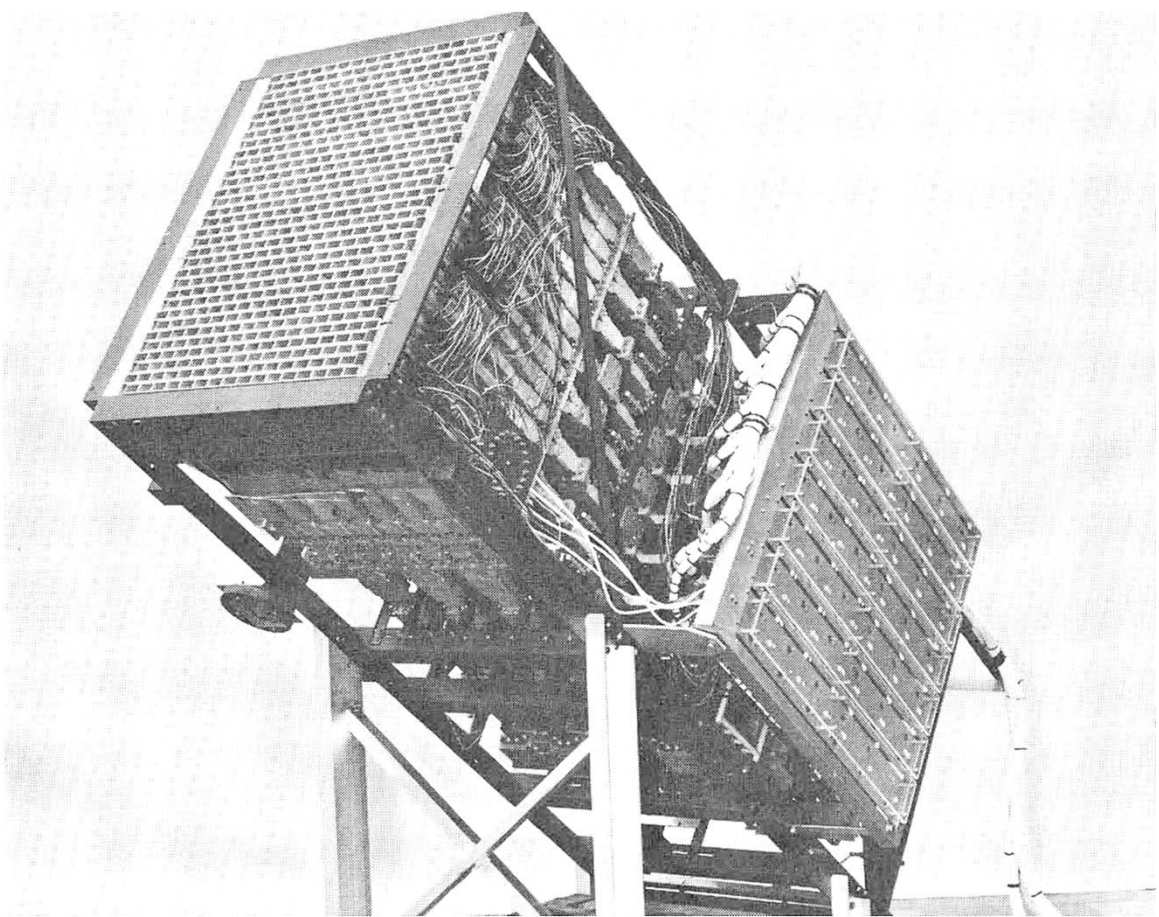
Deformazione del fascio con la scansione



(T_x, T_y) : piano dei coseni direttori

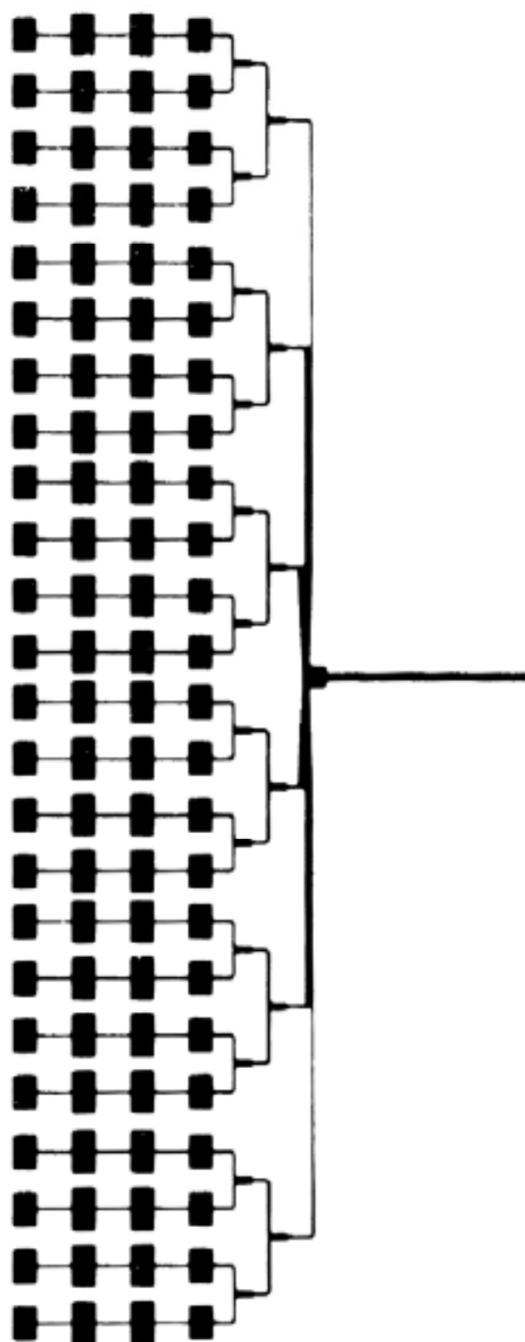


MAR / WSMR (Multifunction Array Radar) installato a White Sand Missile Range – Bell Telephone Laboratories

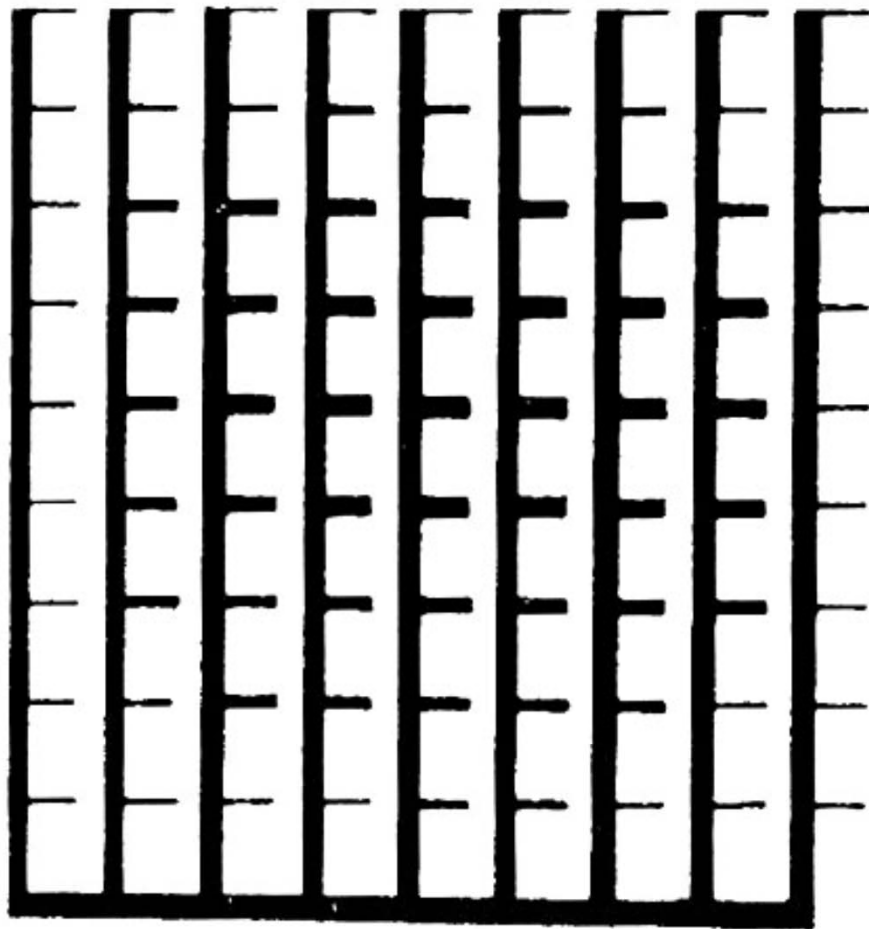


Radars mobile di superficie – Hughes Aircraft Company

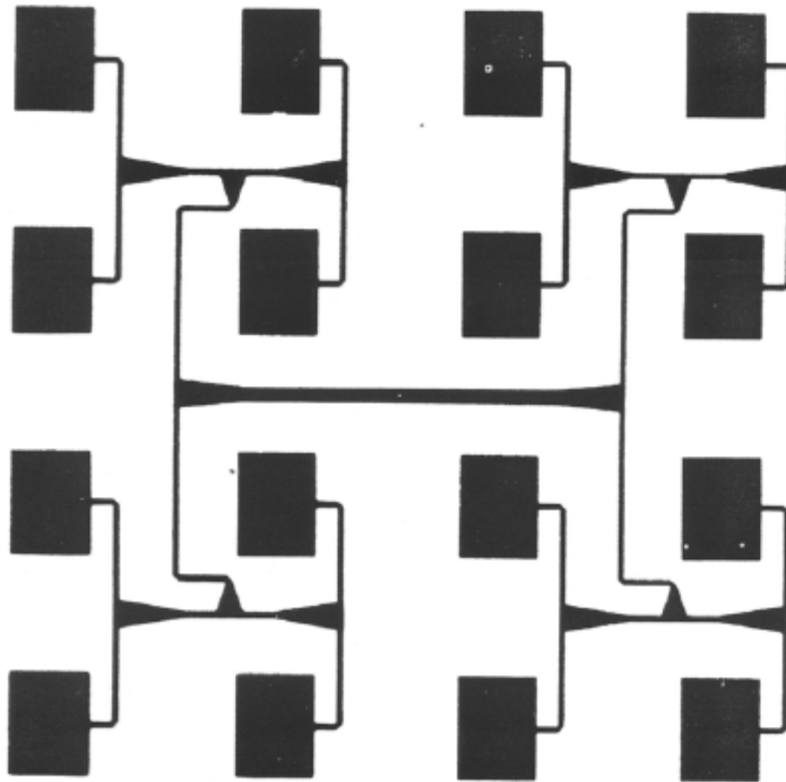
antenna a schiera di patch rettangolari in
microstriscia (AEG-Telefunken)



schiera piana di 9 schiere lineari di 9 stub radianti

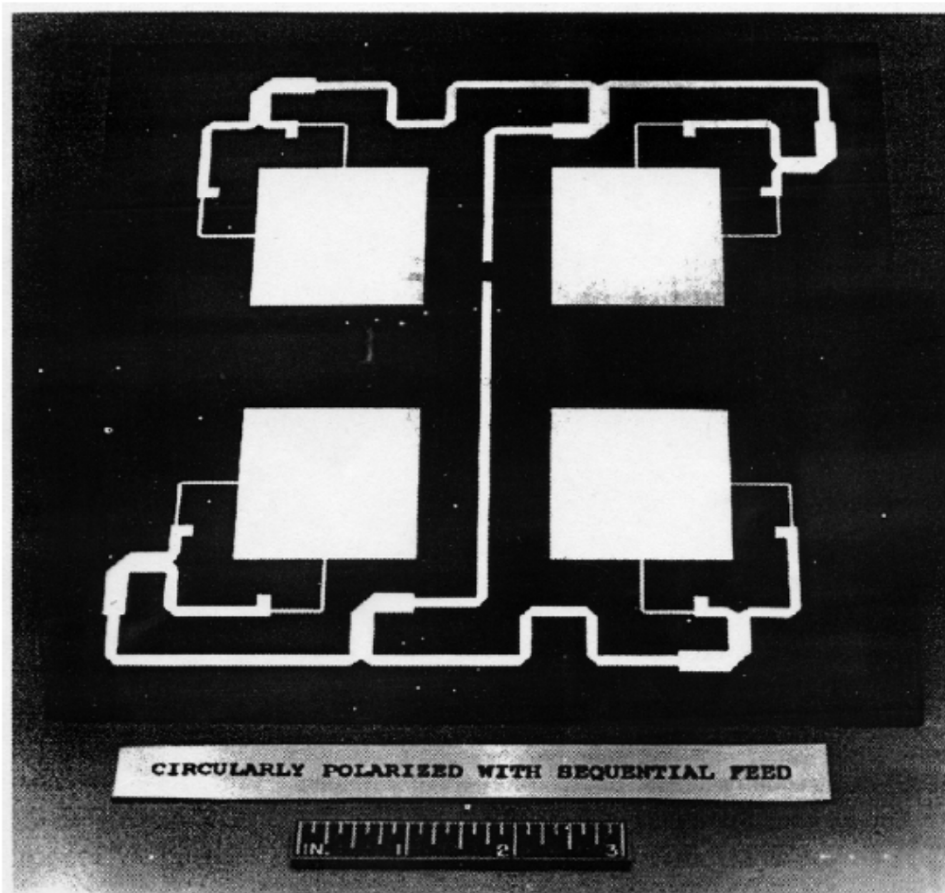


frequenza di lavoro 17.196 GHz,
guadagno 20 dB.

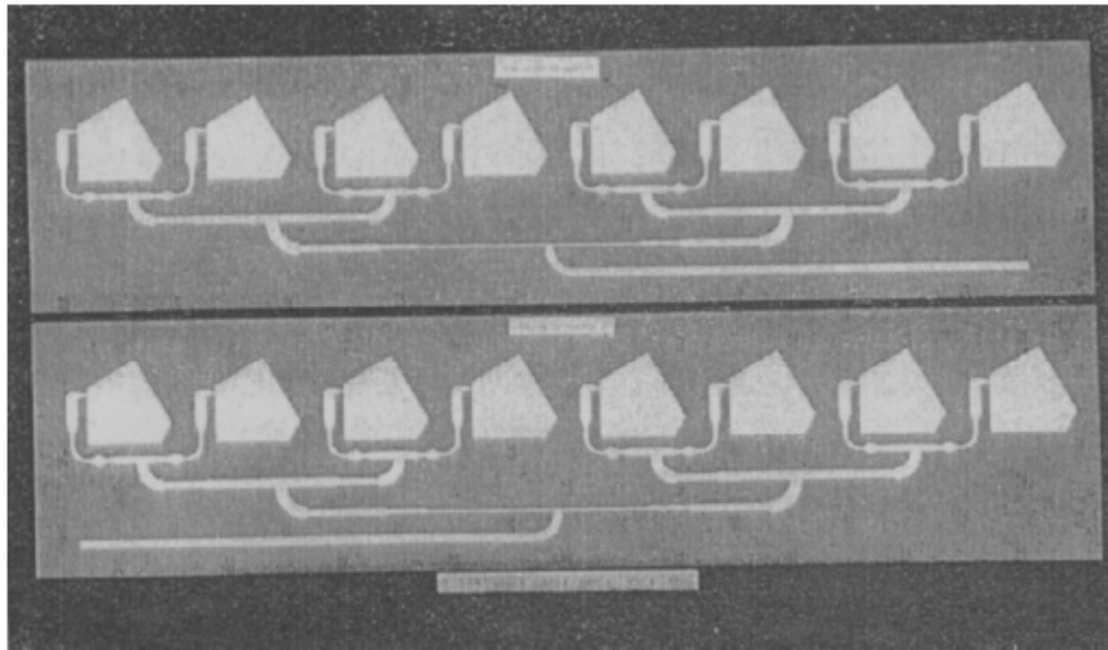


*Silhouette of corporately fed patch array for linear polarisation
with uniform aperture distribution*

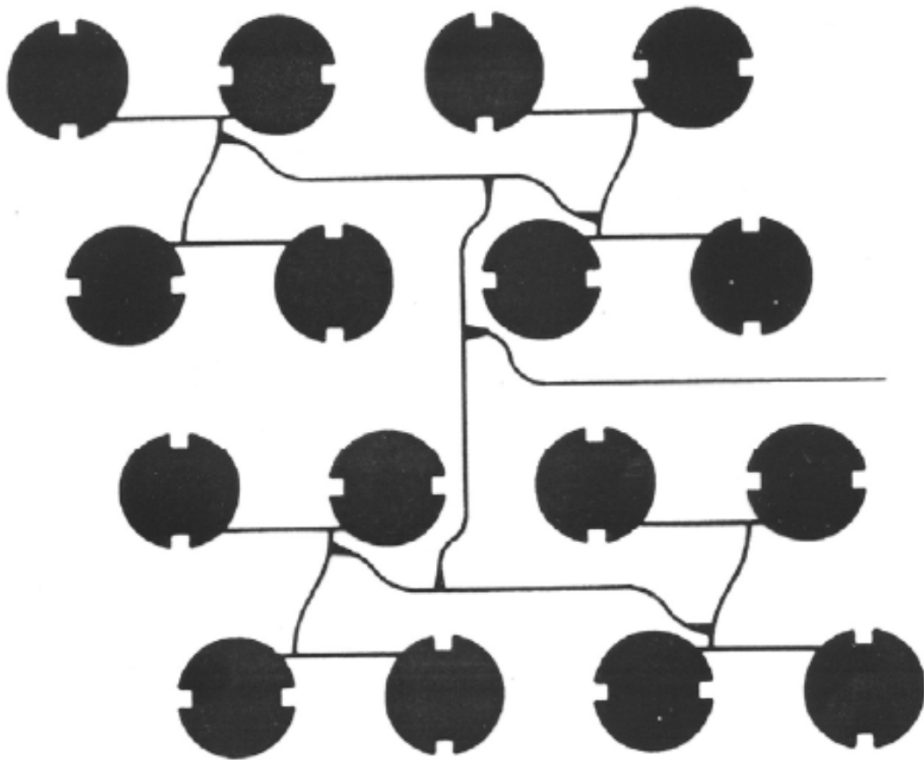
$\epsilon_r = 2.32$; $h = 1.59$ mm; $h/\lambda_0 = 0.06$; frequency = 12.0 GHz; $d/\lambda_0 = 0.7$



S-band microstrip array with briefcase size for Direct Broadcast Satellite Radio (DBSR) service.



antenna a schiera di radiatori in microstriscia funzionante in banda S con polarizzazione circolare e circuito di formazione del fascio di tipo gerarchico reattivo.



Silhouette of disc array for circular polarisation using sequentially rotated feeding