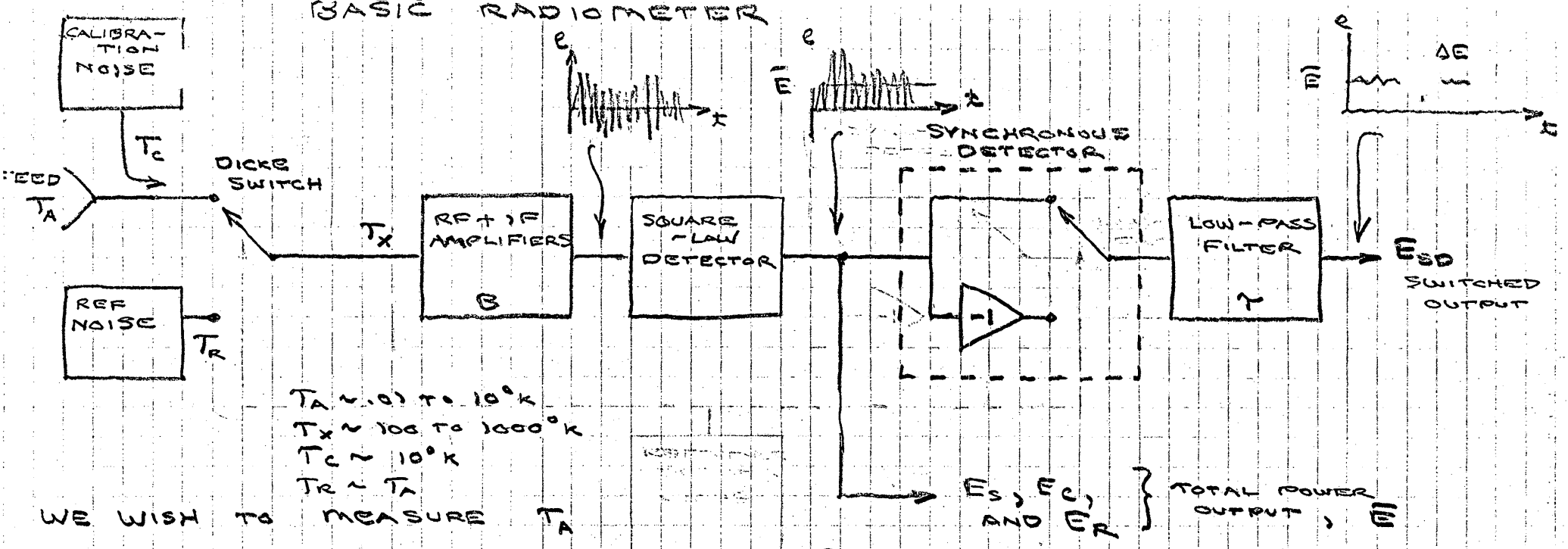
BASIC RADIOMETER



$T_A \sim .01$ TO $10^\circ K$

$T_x \sim 100$ TO $1000^\circ K$

$T_c \sim 10^\circ K$

$T_R \sim T_A$

WE WISH TO MEASURE T_A

BASIC INPUT - OUTPUT RELATION $\longrightarrow$

$$\left(\begin{array}{c}\text{AVERAGE DETECTOR OUTPUT VOLTAGE,} \\ E\end{array}\right) = \left(\overbrace{k\,B\,G'}^{=G}\right) \times \left(\begin{array}{c}\text{TOTAL INPUT NOISE TEMPERATURE}\end{array}\right)$$

$k = 1.38 \times 10^{-23}$; B = NOISE BANDWIDTH ; G' = TOTAL POWER GAIN

SWITCH UP, CAL OFF $\longrightarrow$ $E_S = G(T_x + T_A)$ SIGNAL VOLTAGE

SWITCH UP CAL ON $\longrightarrow$ $E_C = G(T_x + T_A + T_c)$ CALIBRATION VOLTAGE

SWITCH DOWN CAL OFF OR ON $\longrightarrow$ $E_R = G(T_x + T_R)$ REFERENCE VOLTAGE

3 EQUATIONS, 3 UNKNOWNS (T_A, G, T_x)

LECTURE NOTES
S. WEINREB
JUNE 20, 1974

SENSITIVITY LIMITATIONS

①

RMS/MEAN $\equiv \frac{\Delta E}{E} = \frac{\Delta T_A}{T_x + T_A} = \frac{1}{\sqrt{B\tau}}$ — LIMIT DUE TO STATISTICAL FLUCTUATIONS OF NOISE

B: NOISE BANDWIDTH; τ: INTEGRATION TIME

②

$\frac{\Delta G}{G} \sim 1\%$ — LIMIT DUE TO RECEIVER GAIN STABILITY

MODIFICATIONS TO BASIC RECEIVER

① DICKE SWITCHING – SYNCHRONOUS DETECTION

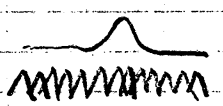
$$\bar{E}_{SD} = E_S - E_R = G(T_A - T_R)$$

② COMPUTER SYNCHRONOUS DETECTION

$$T_A = \frac{\bar{E}_S - \bar{E}_R}{\bar{E}_C - \bar{E}_S} \cdot T_C + T_R$$

③ MULTICHANNEL LINE RECEIVER

– COMB FILTERS AND MULTIPLE DETECTORS



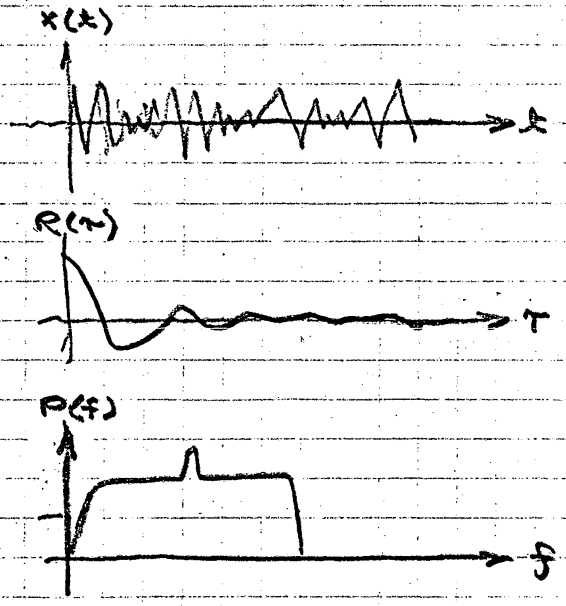
AUTOCORRELATION RECEIVERS

$$T(f) = \int_{-\infty}^{\infty} R(\tau) \cos 2\pi f \tau \, d\tau$$

{ TEMPERATURE SPECTRUM $T(f)$ AS FOURIER TRANSFORM OF AUTOCORRELATION FCN, $R(\tau)$

$$R(\tau) = \lim_{T \to \infty} \frac{1}{2T} \int_{-T}^{T} X(t) X(t+\tau) \, dt$$

{ DEFINITION OF $R(\tau)$ IN TERMS OF SIGNAL TIME FUNCTION, $X(t)$.



MODIFICATIONS TO THEORY

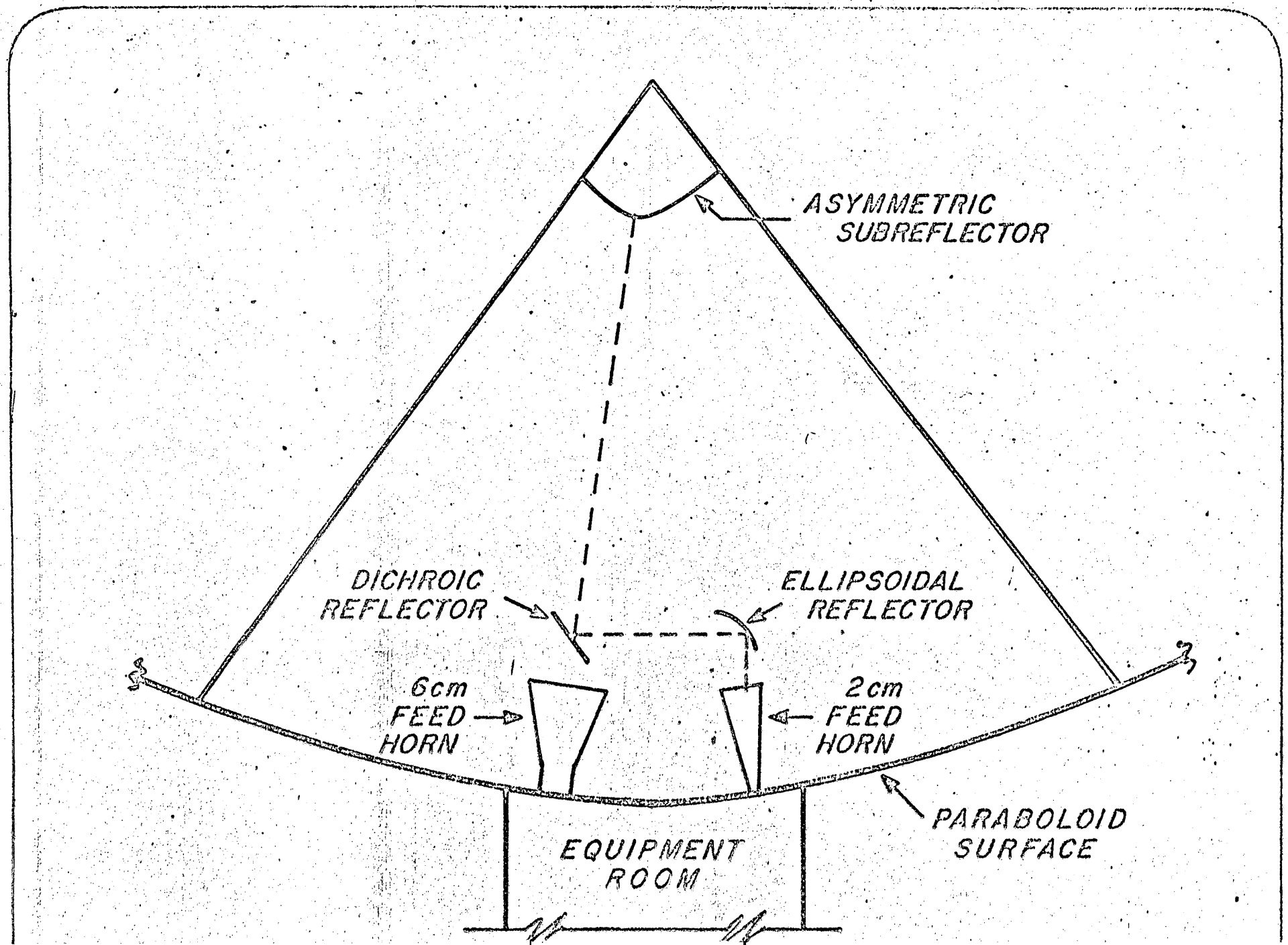
MODIFICATION	EFFECT
τ CANNOT $\to \infty$	FREQUENCY RESOLUTION $\Delta B \sim \frac{1}{\tau_{MAX}}$
T CANNOT $\to \infty$	STATISTICAL FLUCTUATION $\frac{\Delta T}{T} = \frac{1}{\sqrt{BT}} \sim \sqrt{\frac{\tau_{MAX}}{T}}$
$R(\tau)$ IS SAMPLED IN STEPS OF $\Delta\tau$	$f_{MAX} = \frac{1}{2\Delta\tau}$
$X(t)$ IS SAMPLED IN STEPS OF Δt	NO EFFECT IF $f_{MAX} = \frac{1}{2\Delta t}$
$X(t)$ IS QUANTIZED IN N BITS	$\frac{\Delta T}{T}$ SLIGHTLY INCREASED

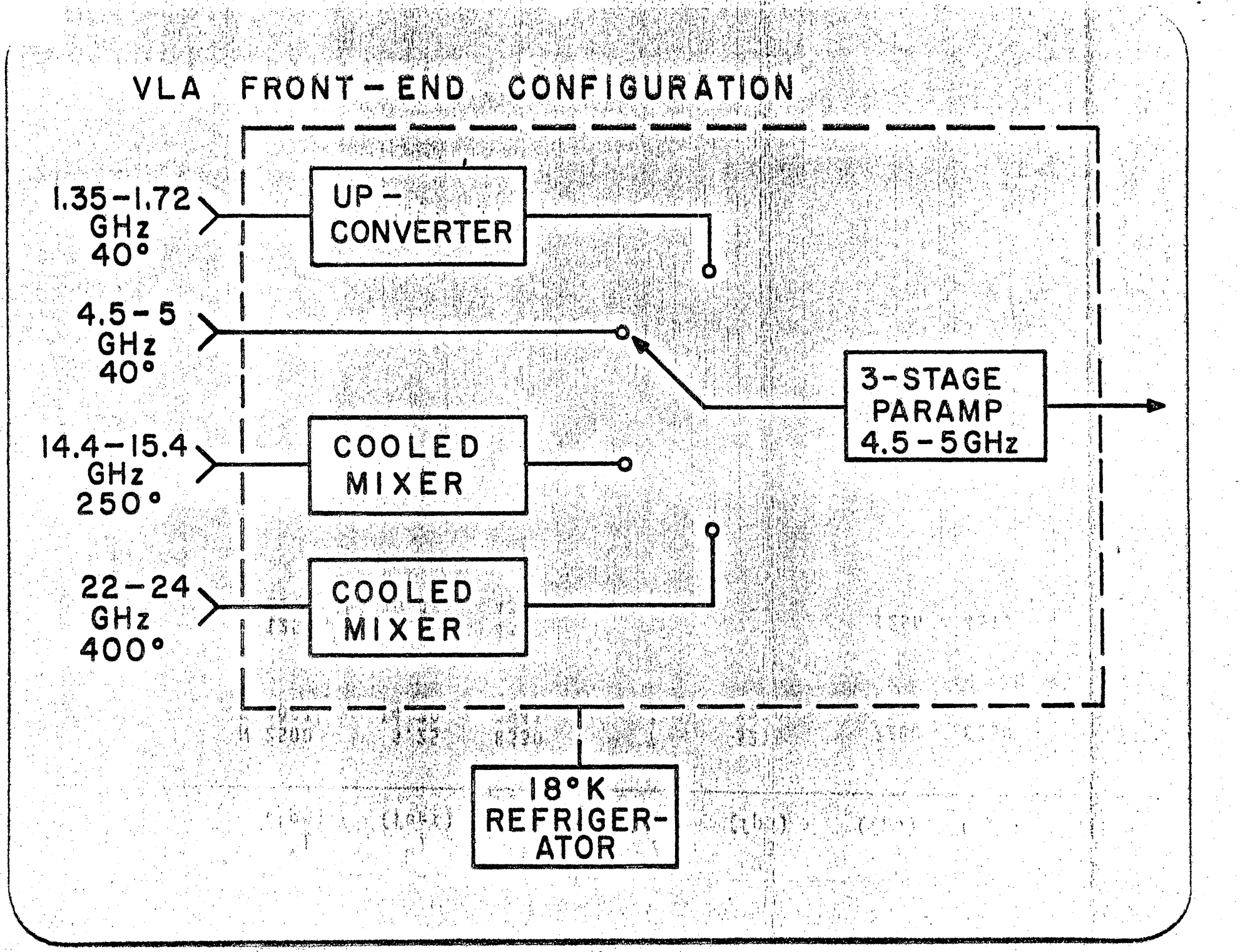
RADIOMETER SENSITIVITY

(For Rectangular IF Bandwidth, B, and Square Law Detector)

$\Delta T/T$	Case
$\frac{1}{\sqrt{B\tau}}$	Total Power Receiver, Ideal Integration For Time τ
$\frac{1}{\sqrt{2B\tau}}$	Total Power Receiver, $\tau \equiv$ RC Integrator
$\frac{2}{\sqrt{B\tau}}$	Square Wave Switched Receiver, Ideal Integrator
$\frac{2}{\sqrt{2B\tau}}$	Square Wave Switched Receiver, RC Integrator
$\frac{\pi}{2\sqrt{2}} \cdot \frac{2}{\sqrt{2B\tau}}$ $= \frac{\pi}{2} \cdot \frac{1}{\sqrt{B\tau}}$	Square Wave Switched, Tuned Amplifier After Detector, RC Integrator

VLA FEED CONFIGURATION




VLA FRONT-END CONFIGURATION
1.35-1.72 GHz 40°
UP-CONVERTER
4.5-5 GHz 40°
3-STAGE PARAMP 4.5-5GHz
14.4-15.4 GHz 250°
COOLED MIXER
22-24 GHz 400°
COOLED MIXER
18°K REFRIGER-ATOR

Left Center Right Sequence No.