VNIR AND SWIR TRANSFER RADIOMETERS DEVELOPED AT NRLM FOR PREFLIGHT LABORATORY CROSS-CALIBRATION

5TH CAL/VAL PANEL MEETING

APRIL 7 TO 10, 1992

BOULDER, COLORADO

A. ONO

NATIONAL RESEARCH LABORATORY OF METROLOGY

MITI

[PURPOSE OF PREFLIGHT LABORATORY CROSS-CALIBRATION]

Avoiding Mistake

1. To avoid incorrect setting of instrument dynamic range due to calibration mistake at individual instrument manufacturers.

Relative Consistency

2. To make corrections of instrument responsivities to have consistent radiance scales among instruments.

Absolute Accuracy

3. To clarify the state of the art in the absolute responsivity determination of VIS/NIR and SWIR instruments in the EOS era.

4. To improve the preflight calibration accuracy if necessary to meet the EOS requirement.

[INTERCOMPARISON AT TWO LEVELS]

1. Intercomparison of spectral radiances established for standard radiant sources at individual instrument manufacturers and platform integrator.

2. Intercomparison of spectral radiance standards at national standards laboratories.

[ROUND-ROBIN MEASUREMENT]

(1) Circulating transfer radiometers through instrument manufacturers where the responsivity is calibrated against stand ard sources of individual instrument manufacturers.

(2) Circulating transfer radiometers through the national standards laboratories.

(3) Redundancy to be considered to enhance the intercomparison reliability (contingency in transfer radiometers); more than one radiometers with a radiant source if necessary.

[COMPARISON ACCURACY]

Desirable comparison accuracy is more than twice higher than the calibration accuracy stated by individual instrument teams; e.g. a level of 1% comparison accuracy.

[REQUIREMENT TO TRANSFER RADIOMETERS]

1. High stability in responsivity during circulation (environment and time)
2. Sufficient linearity
3. Small or known temperature coefficient of responsivity
4. Known spectral profile
5. Small size-of-source effect
6. Light weight and small volume

[VIS/NIR AND SWIR TRANSFER RADIOMETER]

1. Ambient temperature silicon photodiode filter radiometers with operating wavelengths of 0.56μm, 0.65μm, and 0.81μm.

2. Electronically cooled germanium photodiode filter radiometer with an operating wavelength of 1.6μm.

3. Liquid nitrogen cooled indium arsenide photodiode filter radiometer with an operating wavelength of 2.2μm.

Specifications of Si photodiode radiometer

Operating wavelength	
Center wavelength	560 nm 660 nm 810 nm
Full width at half maximum	80 nm 60 nm 100 nm
Target distance	variable (40 cm ~ ∞)
Nominal target size	3 mm in diameter at a target distance of 40 cm
Field of view	0.54° (flexible)
Detector	silicon photodiode (Hamamatsu Photonics)
Size-of-source effect	less than 0.5% between 6 mm and 50 mm at a target distance of 40 mm
Detector temperature monitor	Transistor thermometer
Mass	4 kg
Power voltage	100 V AC, 50 Hz
Mounting	tripod

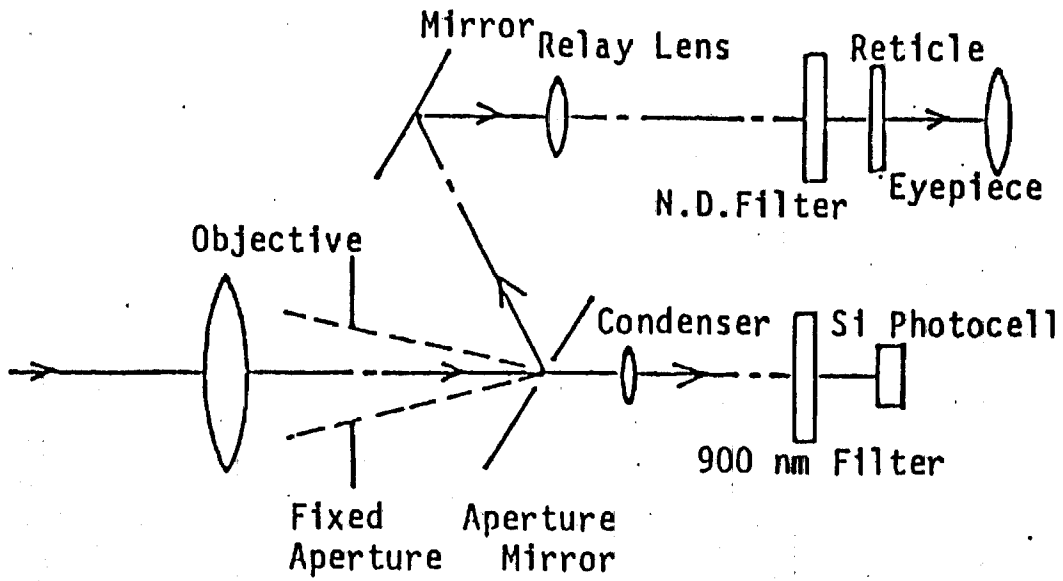
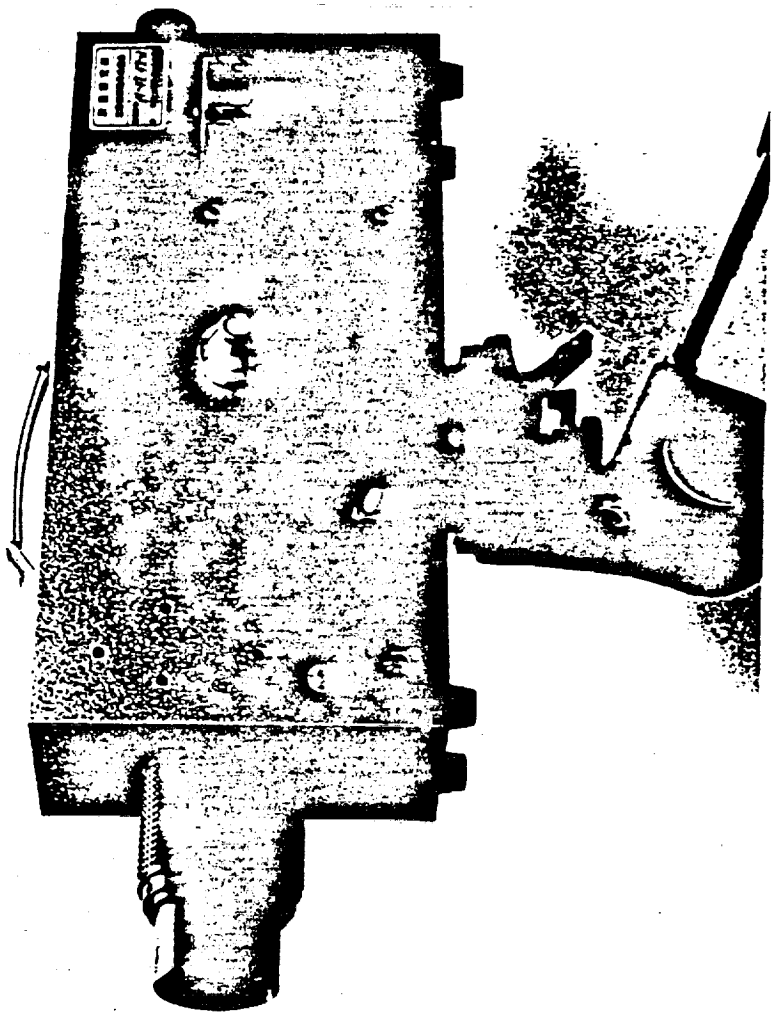
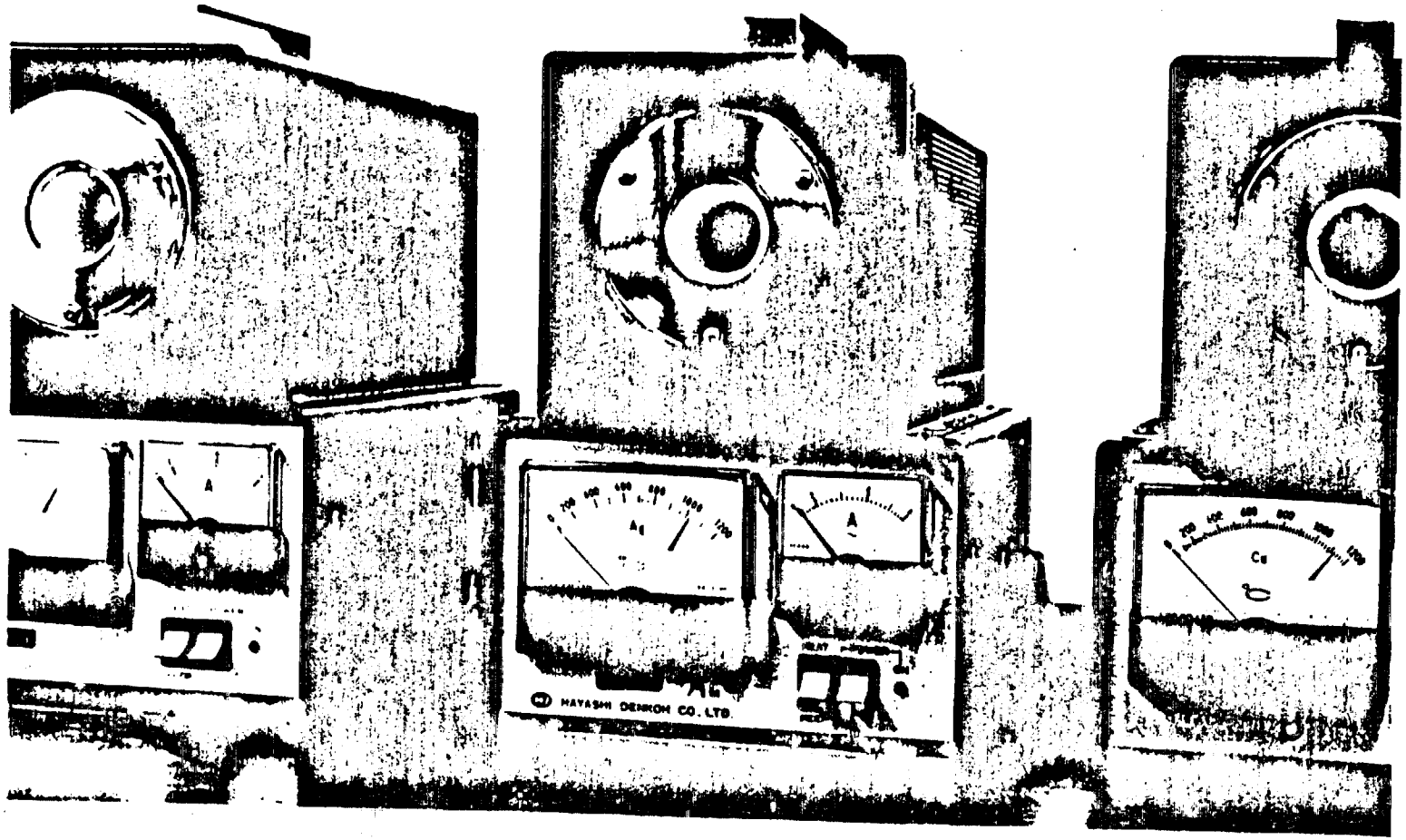


Figure 14.6 Schematic optics of silicon-based standard radiation thermometer.[7)]




HAYASHI DENKOH CO. LTD.

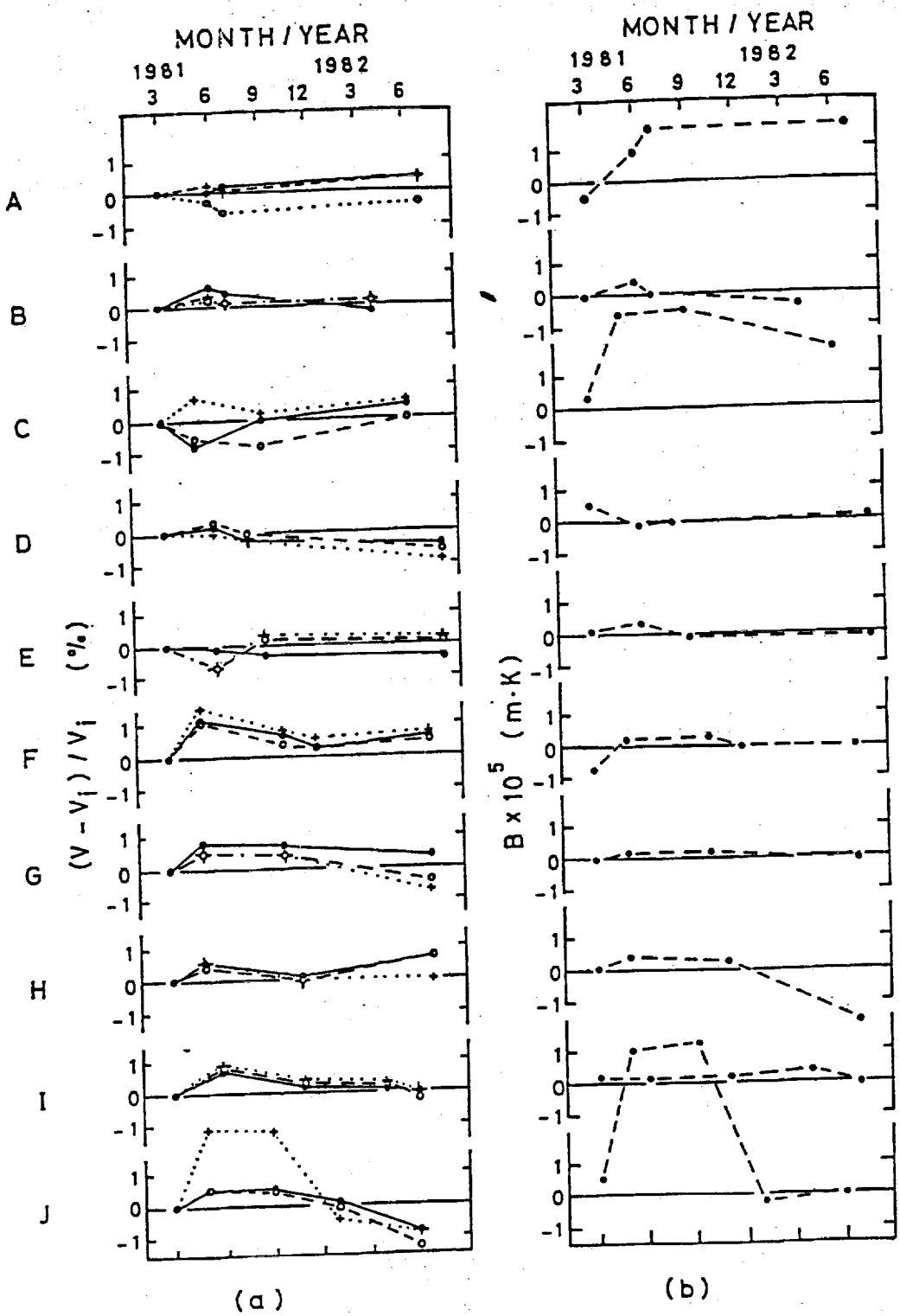
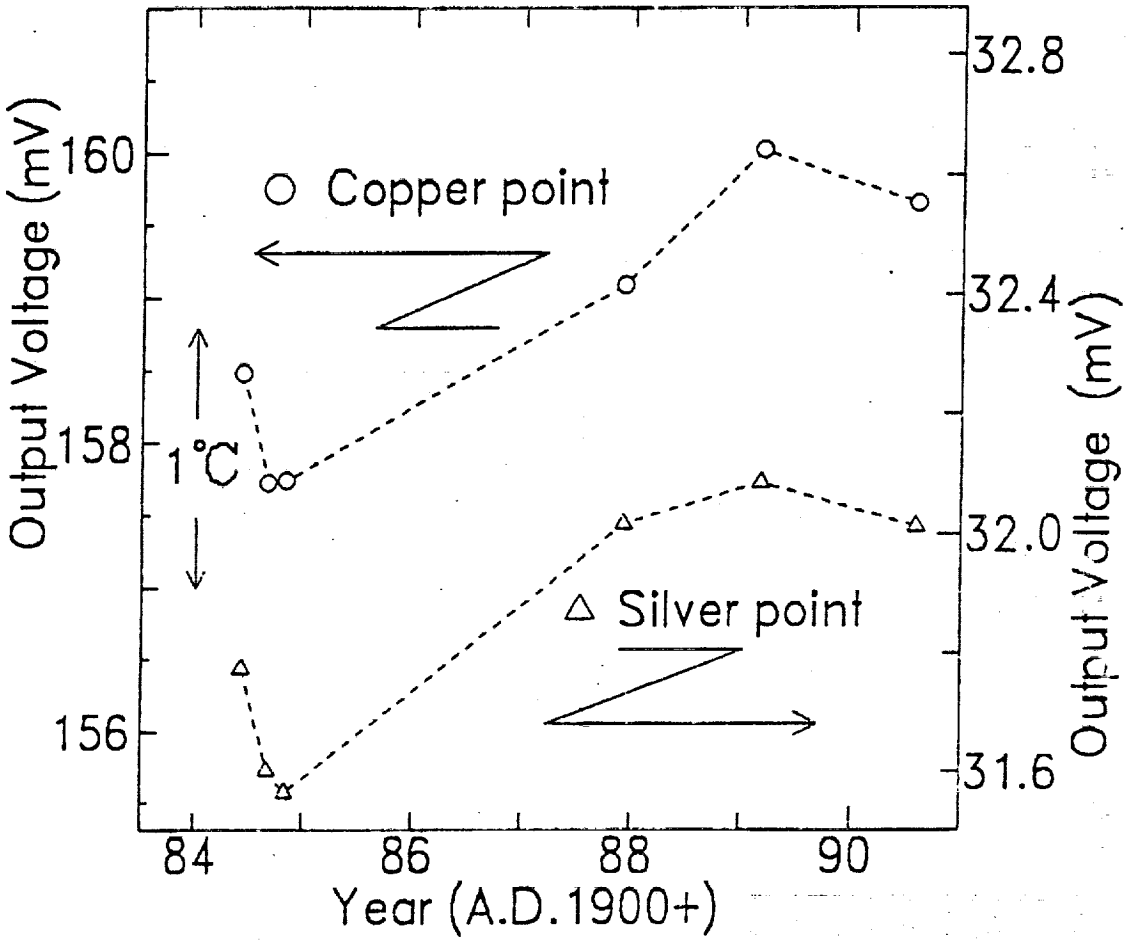
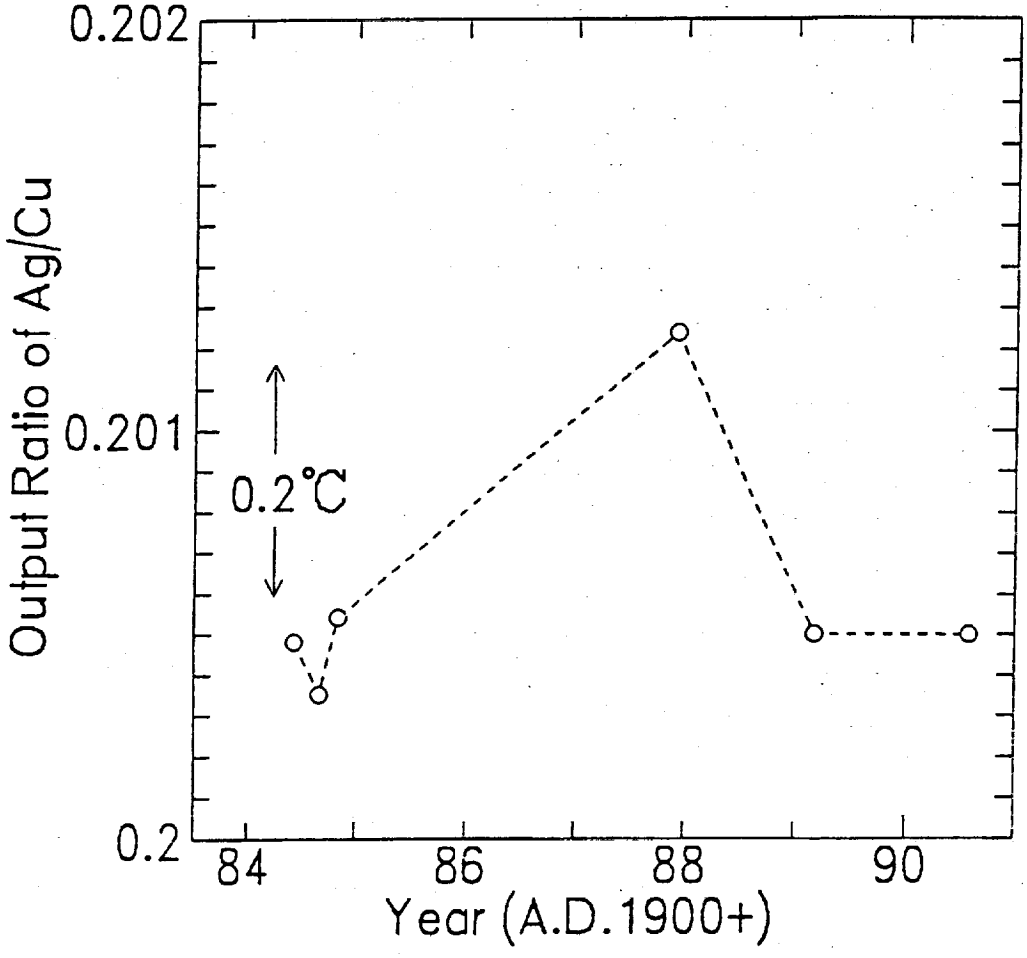
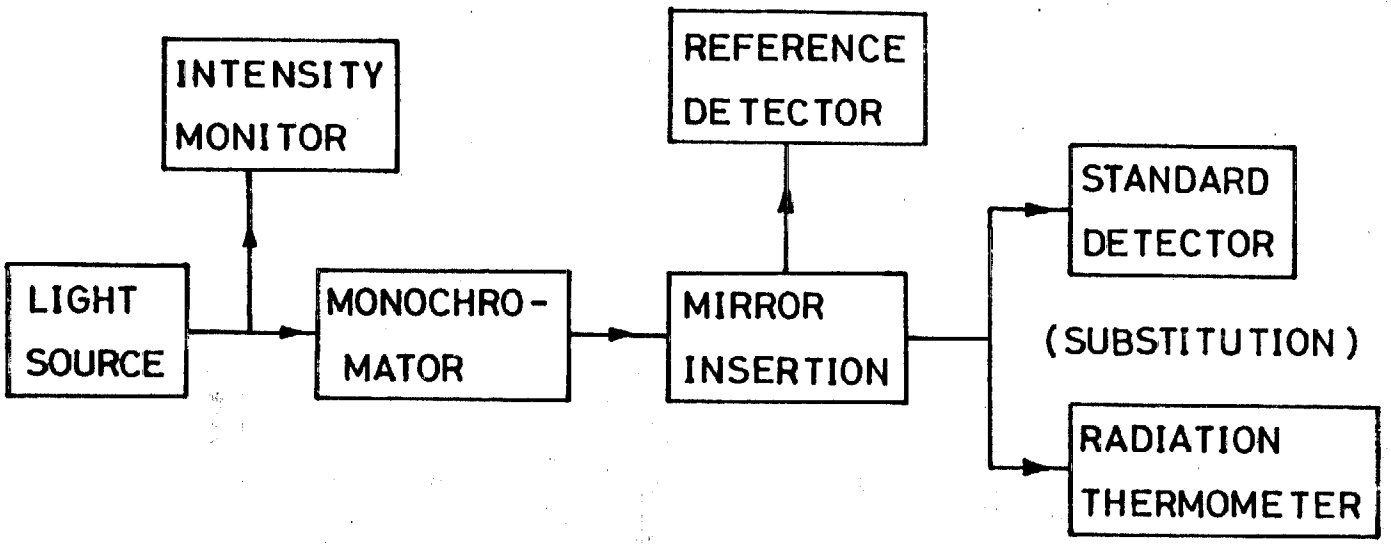
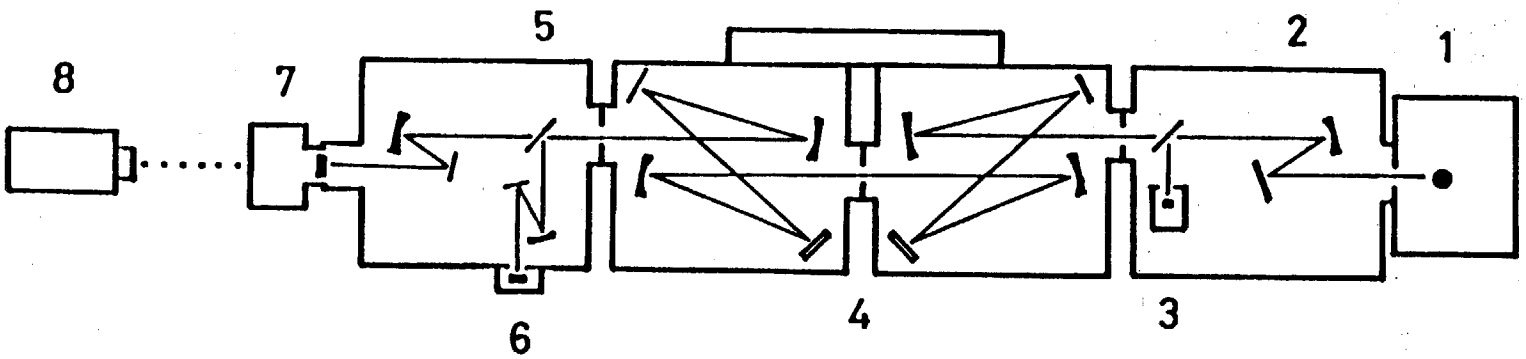


Figure 14.9


Output Voltage (mV)
160
158
156
32.8
32.4
32.0
31.6
Output Voltage (mV)
○ Copper point
△ Silver point
1℃
84
86
88
90
Year (A.D.1900+)

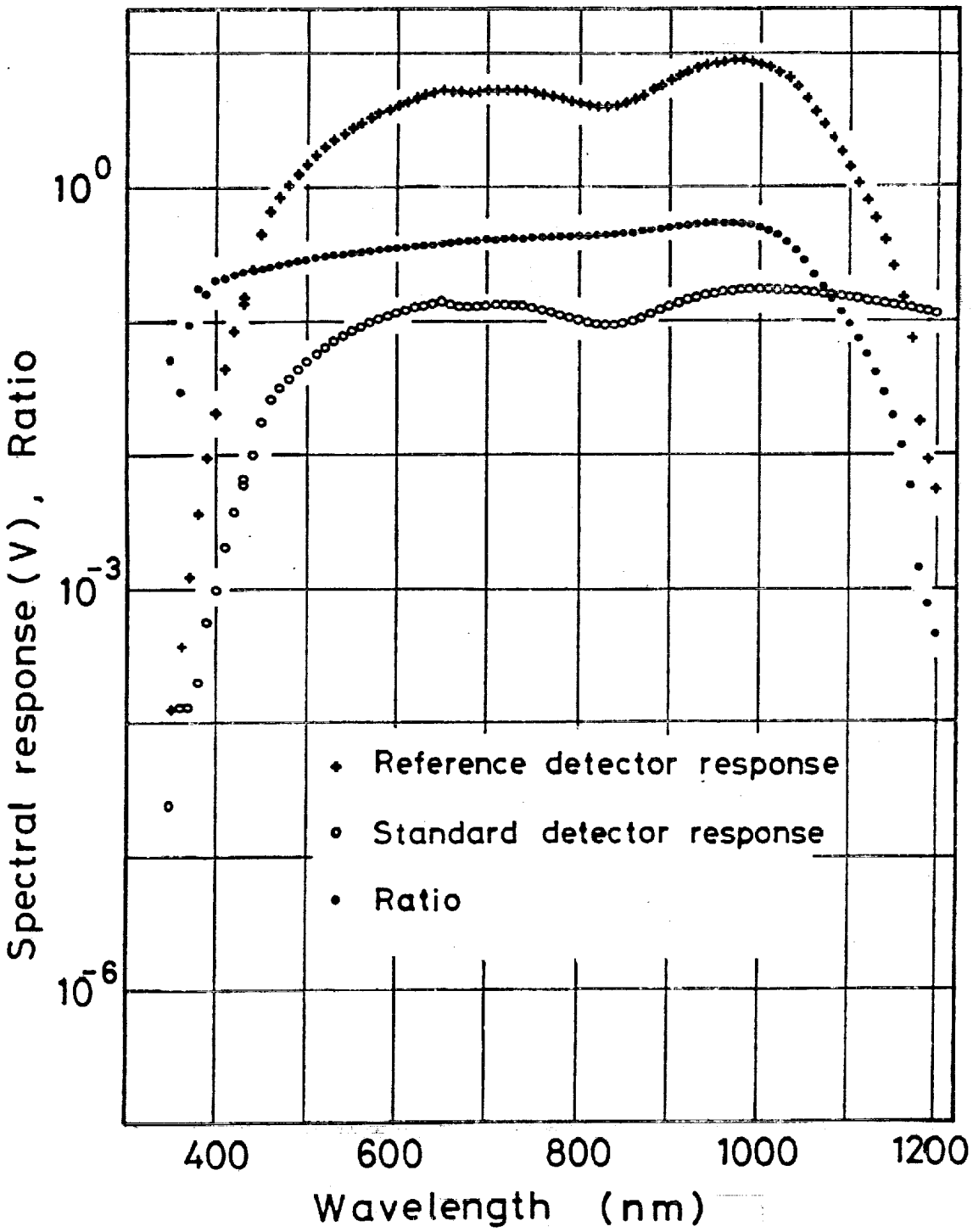

0.202
0.201
0.2
Output Ratio of Ag/Cu
0.2℃
84
86
88
90
Year (A.D.1900+)

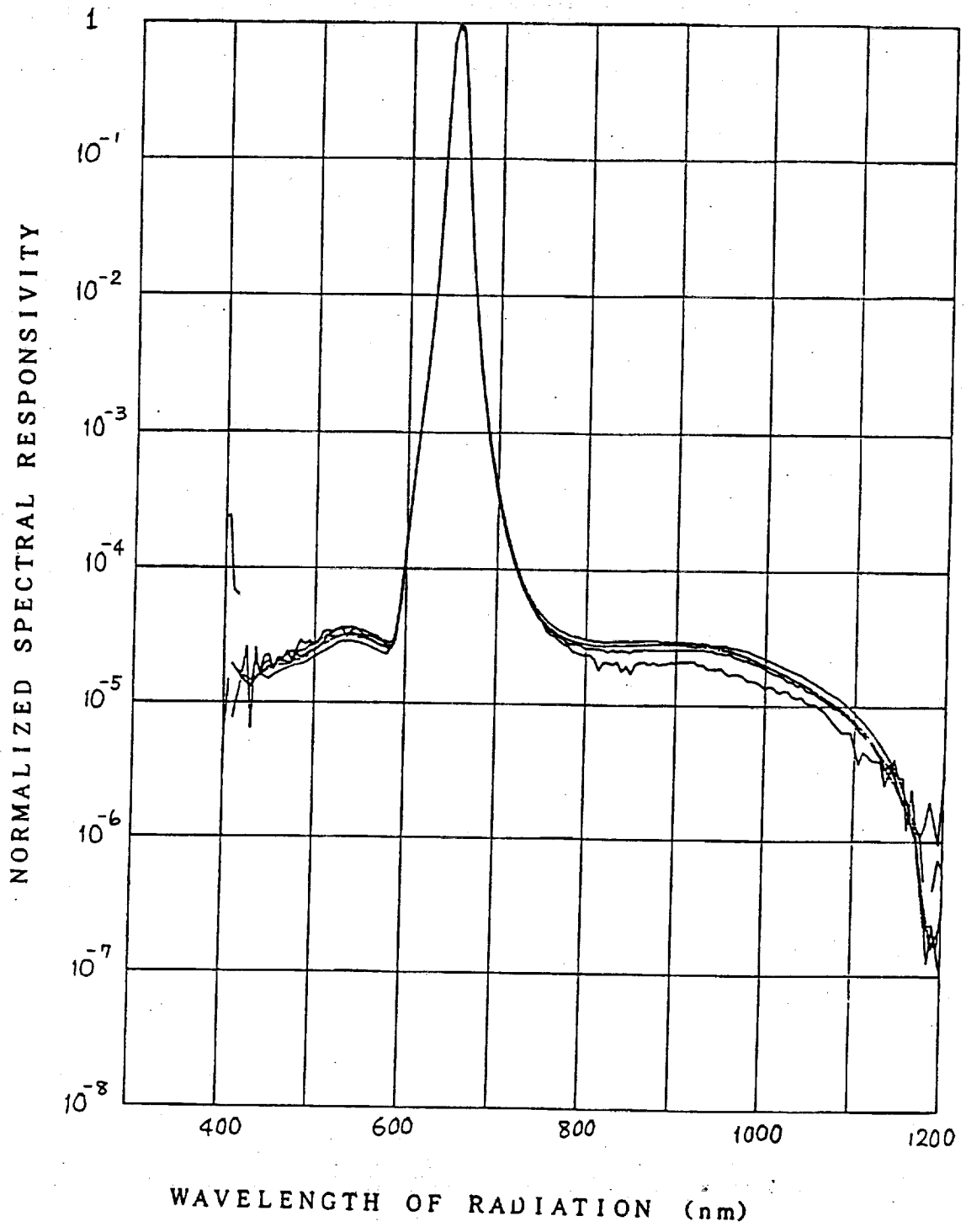

INTENSITY MONITOR
REFERENCE DETECTOR
STANDARD DETECTOR
LIGHT SOURCE
MONOCHRO-MATOR
MIRROR INSERTION
(SUBSTITUTION)
RADIATION THERMOMETER

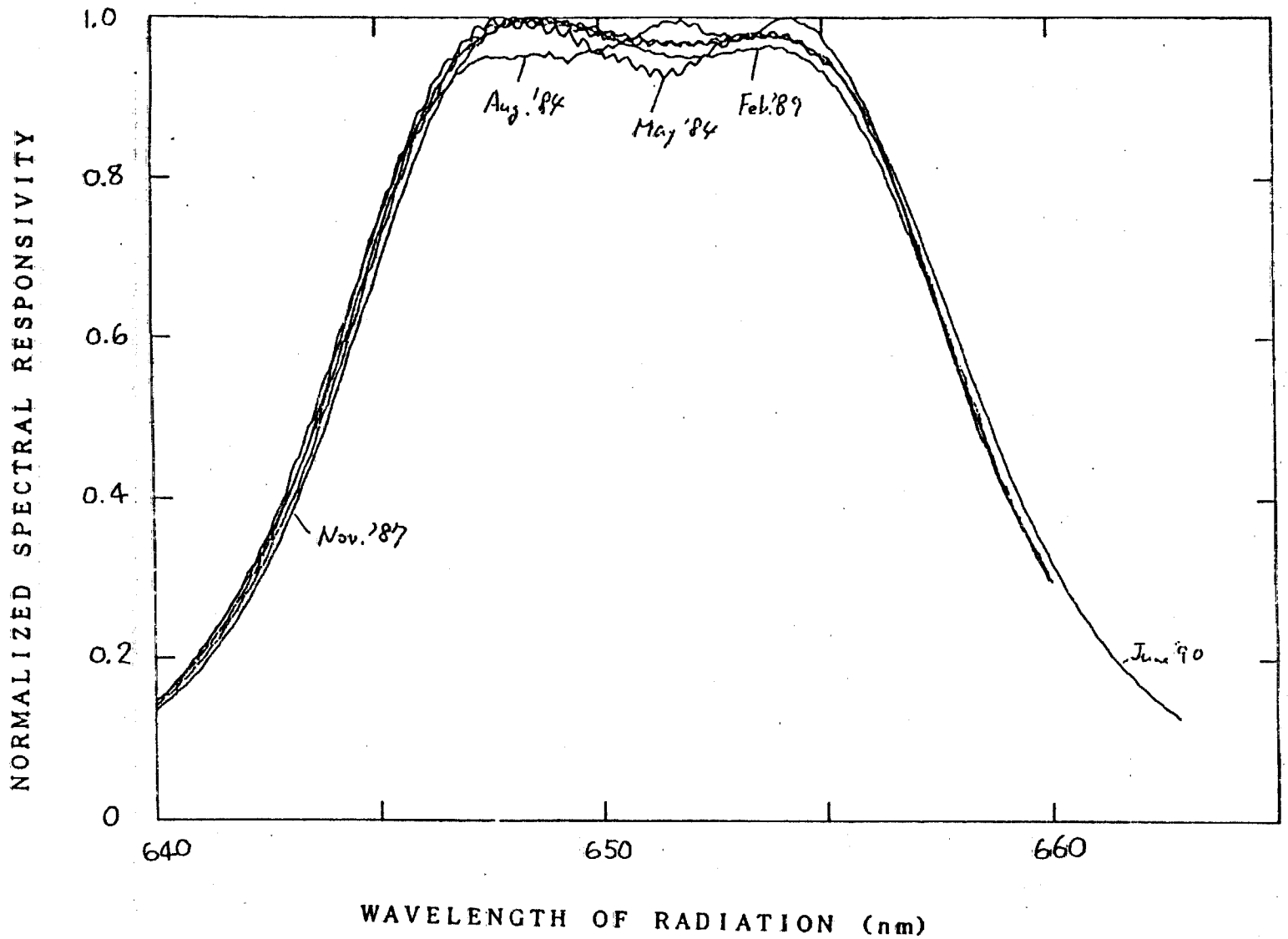


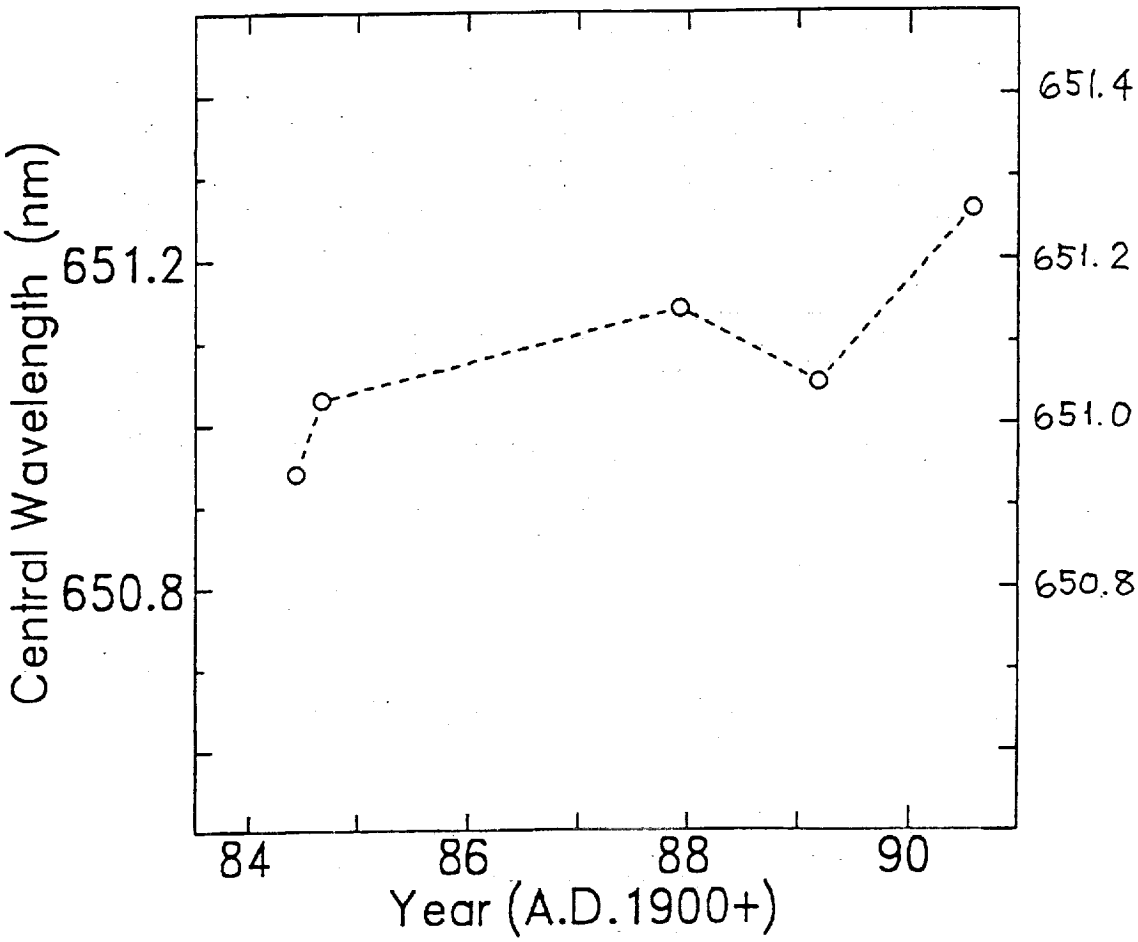
OPTICAL SCHEME FOR MEASURING THE SPECTRAL RESPONSIVITY DISTRIBUTION OF RADIOMETER

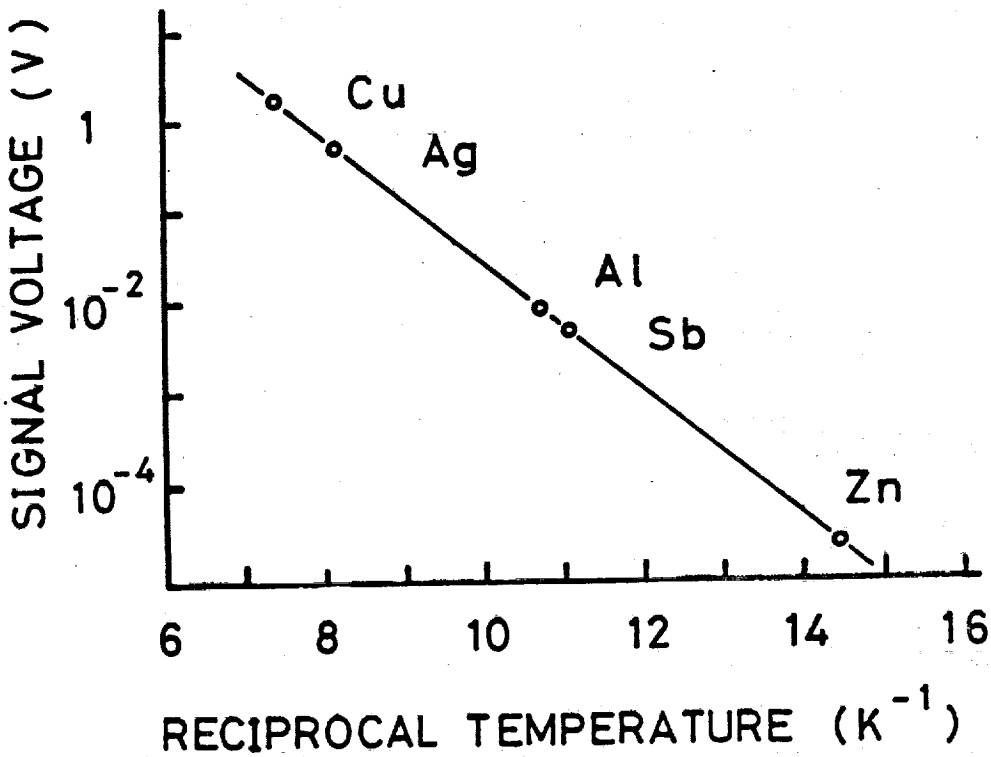
1, radiation source; 2, collimator; 3, source monitor; 4, double grating monochromator; 5, switching mirror; 6, reference detector; 7, standard detector; 8, radiometer


Spectral response (V), Ratio
10^0
10^-3
10^-6
400
600
800
1000
1200
Wavelength (nm)
Reference detector response
Standard detector response
Ratio


NORMALIZED SPECTRAL RESPONSIVITY
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
400
600
800
1000
1200
WAVELENGTH OF RADIATION (nm)


NORMALIZED SPECTRAL RESPONSIVITY
1.0
0.8
0.6
0.4
0.2
0
640
650
660
WAVELENGTH OF RADIATION (nm)
Aug. '84
May '84
Feb. '89
Nov. '87
Jun. '90


Central Wavelength (nm)
651.2
650.8
651.4
651.2
651.0
650.8
84
86
88
90
Year (A.D.1900+)


SIGNAL VOLTAGE (V)
1
10^{-2}
10^{-4}
Cu
Ag
Al
Sb
Zn
6
8
10
12
14
16
RECIPROCAL TEMPERATURE (K^{-1})

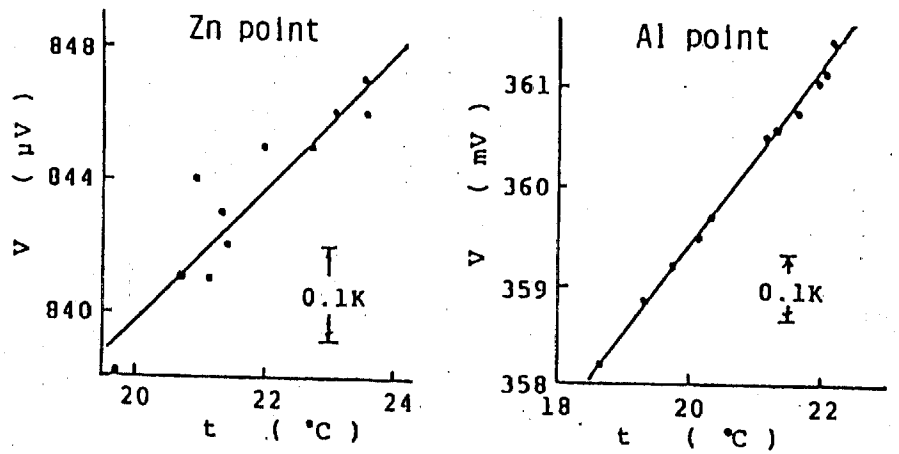
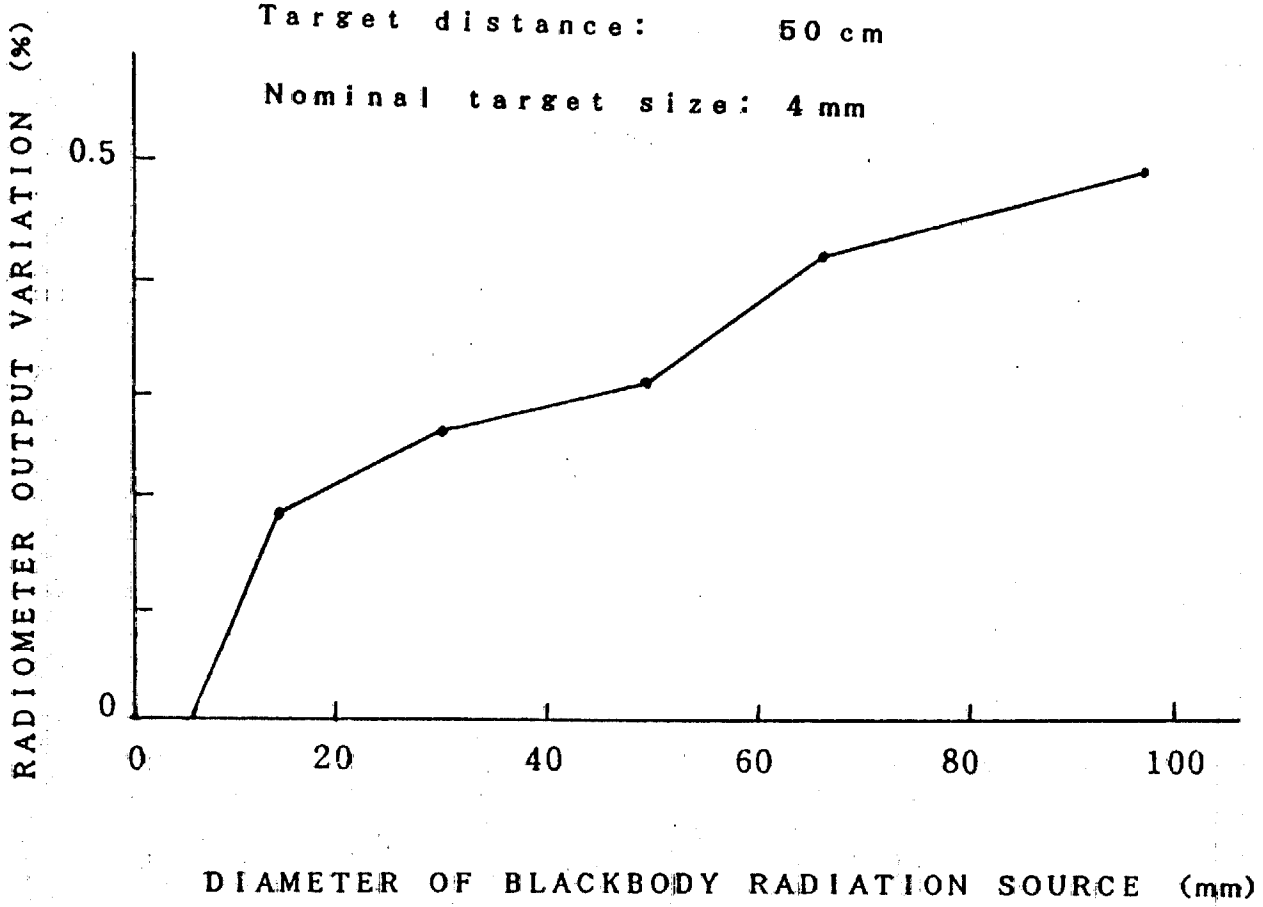


Figure 14.7 Relation between the signal level and the instrument temperature of a silicon-based standard radiation thermometer (the broader band interference filter).[8)]


Target distance: 50 cm
Nominal target size: 4 mm
RADIOMETER OUTPUT VARIATION (%)
0.5
0
0
20
40
60
80
100
DIAMETER OF BLACKBODY RADIATION SOURCE (mm)

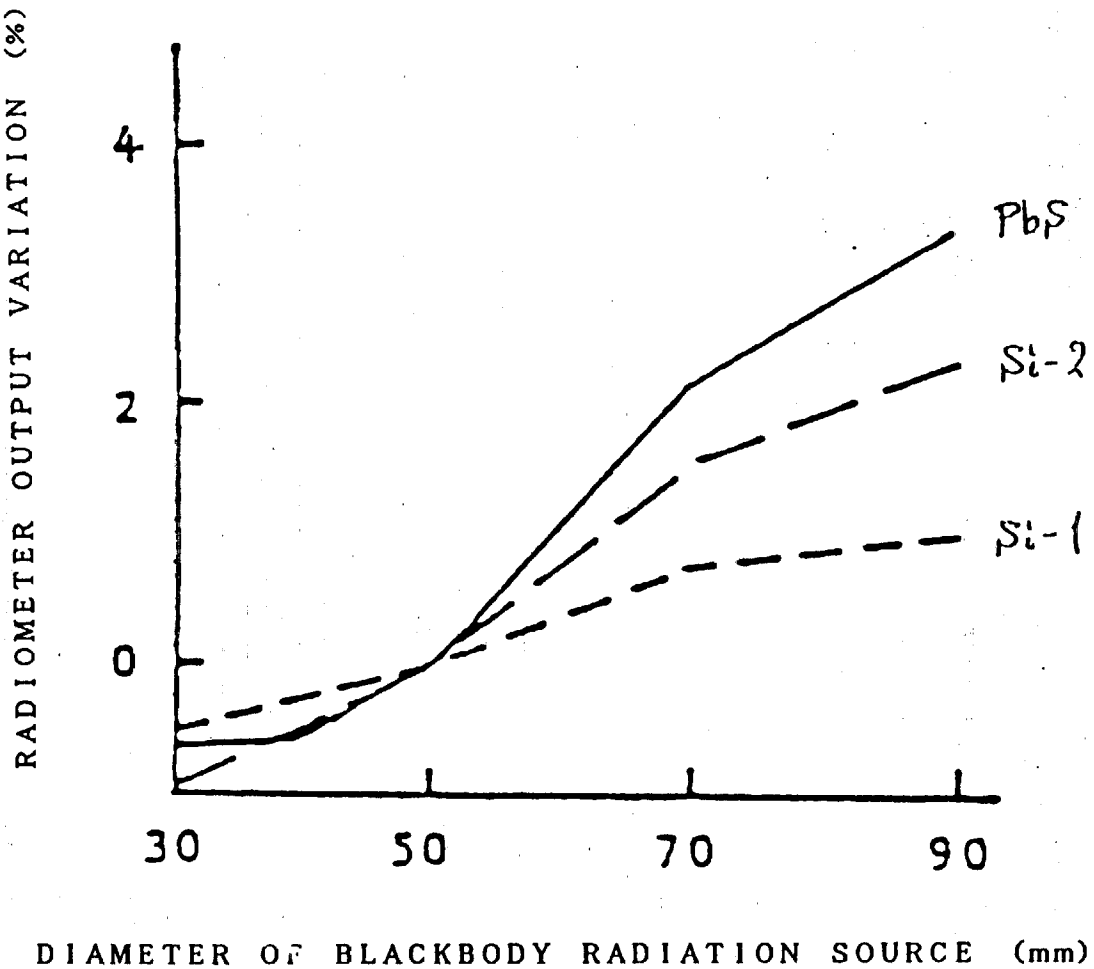
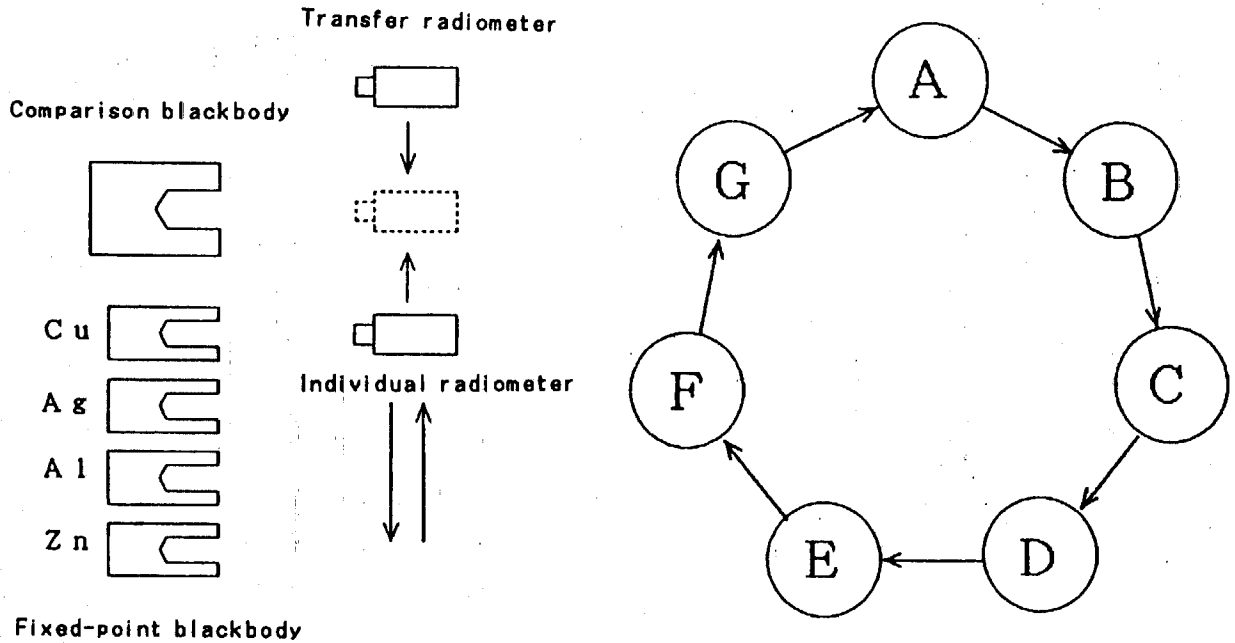

RADIOMETER OUTPUT VARIATION (%)
4
2
0
PbS
Si-2
Si-1
30
50
70
90
DIAMETER OF BLACKBODY RADIATION SOURCE (mm)

Table 1. Specifications of the Ge and InAs photodiode radiation thermometers.

Model	IR-RST-160	IR-RST-220
Detector type	Ge photodiode	InAs photodiode
Cooling of detector	Thermo-Electric cooling(-25℃)	LN_2 cooling (-195℃)
Wavelength (half width)	1.610μm (0.15μm)	2.183μm (0.17μm)
Temperature range	300 - 2000℃	200 - 2000℃
Gain of amplifier	×10, ×1, ×0.1, ×0.01	×10, ×1, ×0.1, ×0.01
Resolution	0.1℃(330℃), 0.01℃(1085℃)	0.03℃(230℃), 0.2℃(1085℃)
Object distance	400mm - ∞	400mm - ∞
Target size	3mmφ (at 400mm)	3mmφ (at 400mm)
Response	100μs(DC) / 0.1s(DC)	100μs(DC) / 0.1s(AC)
Output Voltage	0 - 10V	0 - 10V
Size	140×150×400mm	140×200×400mm



SCHEME FOR ROUND ROBIN TEST OF RADIATION TEMPERATURE SCALES

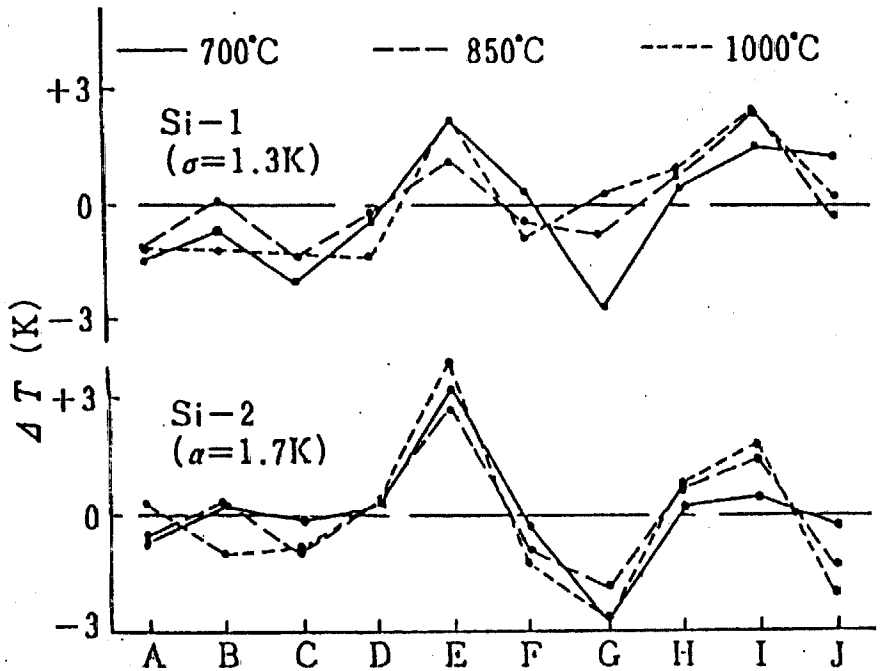
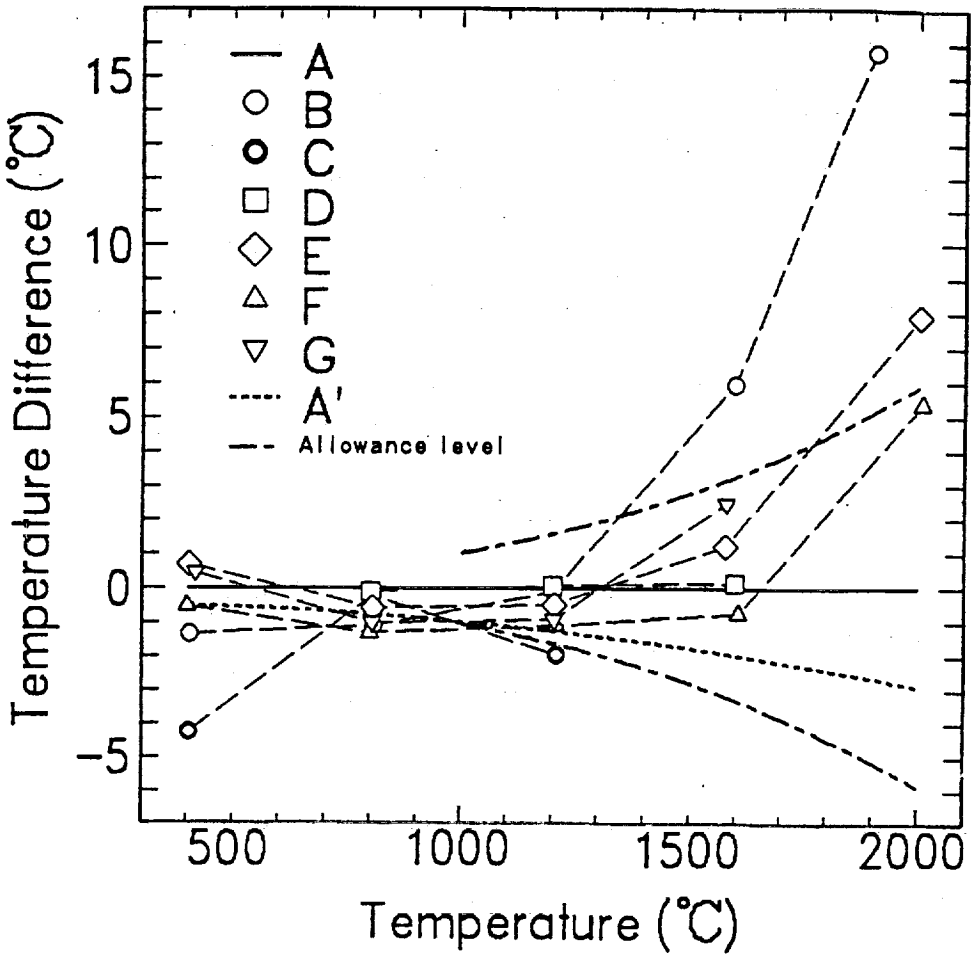
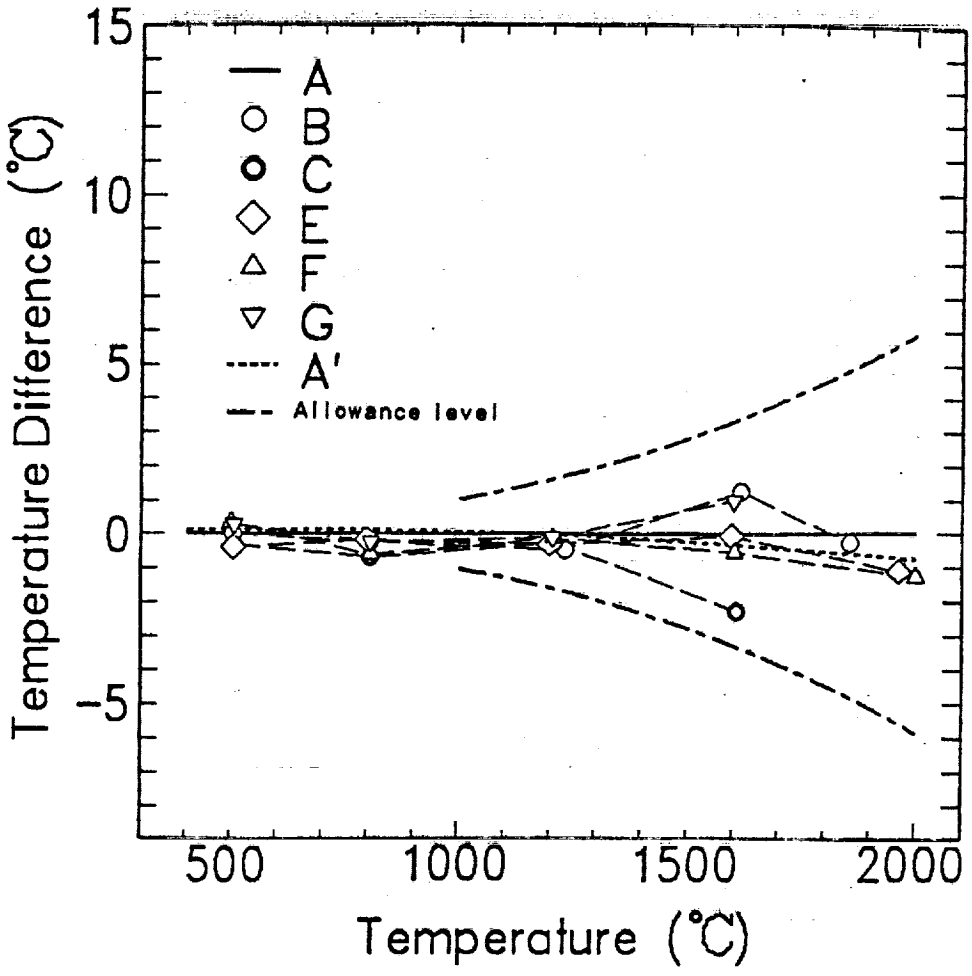


Figure 14.12 Intercomparison of the temperature standards.[8)]



ROUND ROBIN TEST IN 1989



ROUND ROBIN TEST IN 19~~00~~ 90