Title
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PHOTOMETRY DURING MANHIGH III BALLOON FLIGHT*

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INTRODUCTION AND SUMMARY

The Visibility Laboratory of the University of California, La Jolla Campus, participated in Manhigh III high altitude balloon ascension which took place 8 October 1958 at Holloman Air Force Base, New Mexico. The Visibility Laboratory participation consisted of (1) Modification of Spectra Brightness Spot Meter, Serial No. 382, by installation of a Bausch & Lomb interference type spectrum wedge to provide spectroradiometric capabilities, and the mounting of a Robot camera bore-sighted with the axis of the instrument to provide positive identification of the small target area whose luminance or radiance was being measured, and (2) communicating with the pilot of the balloon during the flight to advise him as to what sky measurements he should make.

Only limited data were obtained because the flight was terminated earlier than scheduled. The data which were obtained are tabulated herewith:

*This paper represents results of research which has been supported by the Bureau of Ships, U. S. Navy and the Geophysics Research Directorate, Air Force Cambridge Research Center, Bedford, Massachusetts.

TABLE I

Mountain Standard Time	Sun's Elevation	Photometer Sighting Elevation	Photometer Azimuth Rel. to Sun	Scattering Angle	Filter	Luminance or Radiance
1228	39.2°	+15°	179.3°	125.8°	Photopic	19.4 Foot-Lamberts
1231	39.4°	+15°	177.8°	125.6°	Photopic	23.4 Foot-Lamberts
1233	39.6°	+15°	136.5°	112.0°	Blue	.0089 Watt/Ω Ft^2
1235	39.8°	+15°	135.3°	111.2°	Blue	.0097 Watt/Ω Ft^2
1238	39.9°	+15°	113.8°	97.6°	Red	.0033 Watt/Ω Ft^2
1241	40.0°	0	92.5°	70.5°	Photopic	271 Foot-Lamberts
1245	40.1°	0	71.0°	75.6°	Red	.033 Watt/Ω Ft^2
1248	40.3°	0	89.2°	83.9°	Blue	.123 Watt/Ω Ft^2

PROCEDURE

Lt. McClure had the Spectra Brightness Spot Meter in the capsule during Manhigh III flight. Previous to the flight he was thoroughly instructed in the use of the instrument and its accessories. After the balloon and its capsule had reached maximum altitude, he placed the meter in operation. At approximately 1215 M.S.T. the Visibility Laboratory scientist at the launch site went on the radio circuit between the balloon capsule and ground station to advise Lt. McClure in his sky measuring program. At this time the instrument had been in operation more than an hour and was thoroughly warmed, thirty minutes being considered adequate warm up time.

The circumstances for making measurements were good. Prior to making measurements Lt. McClure was asked specifically if the window of the capsule through which measurements were to be made was clean, frost free, and shadowed. He replied in the affirmative. He was asked if the polaroid filter which had been at the window had been removed. Again his answer was affirmative. Then before each measurement he zeroed the instrument and so reported.

Luminance and radiance measurements were made from 1208 to 1248 M.S.T. and were reported by Lt. McClure via radio to the ground station where they were recorded. (He also kept a written record.) In addition to the instrument meter reading, his report included the instrument's line of sight elevation angle, relative azimuth angle, and capsule azimuthal orientation. Another period for making sky measurements did not become available during the flight, consequently no spectroradiometric measurements were made.

The Robot camera fitted on the Spectra Brightness Spot Meter jammed and no pictures were obtained.

Results of the flight are listed in Table I in "Introduction and Summary."

DISCUSSION

The Spectra Brightness Spot Meter, manufactured by Photo Research Corporation, Hollywood, California, is a direct reading photometer designed to measure the luminance of a circular target of 1 1/2° angular subtense and indicate this on a built-in microammeter calibrated in foot lamberts. In addition to the photopic filter, labeled "FT-L," carried in one of six positions in a filter selector there are three other filters, an open hole, and a blank or zero transmittance position used for "zeroing" the instrument, i.e., making it read zero in the absence of flux. The three other filters are (1) a photopic filter plus a 2.0 neutral density filter, labeled "X 100" for measuring luminance of high intensity, (2) a "BLUE" filter and (3) a "RED" filter. The filtered phototube spectral response for the photopic (FT-L) filter is shown in Fig. 1, and the responses for the "BLUE" and "RED" filters are shown in Fig. 2.

The photopic filtered phototube spectral response as shown by the broken line of Fig. 1 is an approximation of the human eye luminosity curve. There is some deviation between these two curves and from 640 mu upward this increases. Calculations have shown that the error when measuring the luminance of the sky in a range of color temperatures from 7000°K to ∞ °K is less than 1%.

The blue and red filtered phototube spectral responses match closely the two similar responses which have been used by the Visibility Laboratory for all blue and red radiance measuring devices. The differences between the responses of the Spectra Brightness Spot Meter and other laboratory radiometers due to the mismatch of the filtered phototube spectral responses when measuring the sky in a color temperature range from 7000°K to ∞ °K varies from 8% to 7% in the case of the blue, and from 3% to 2% in the case of the red.

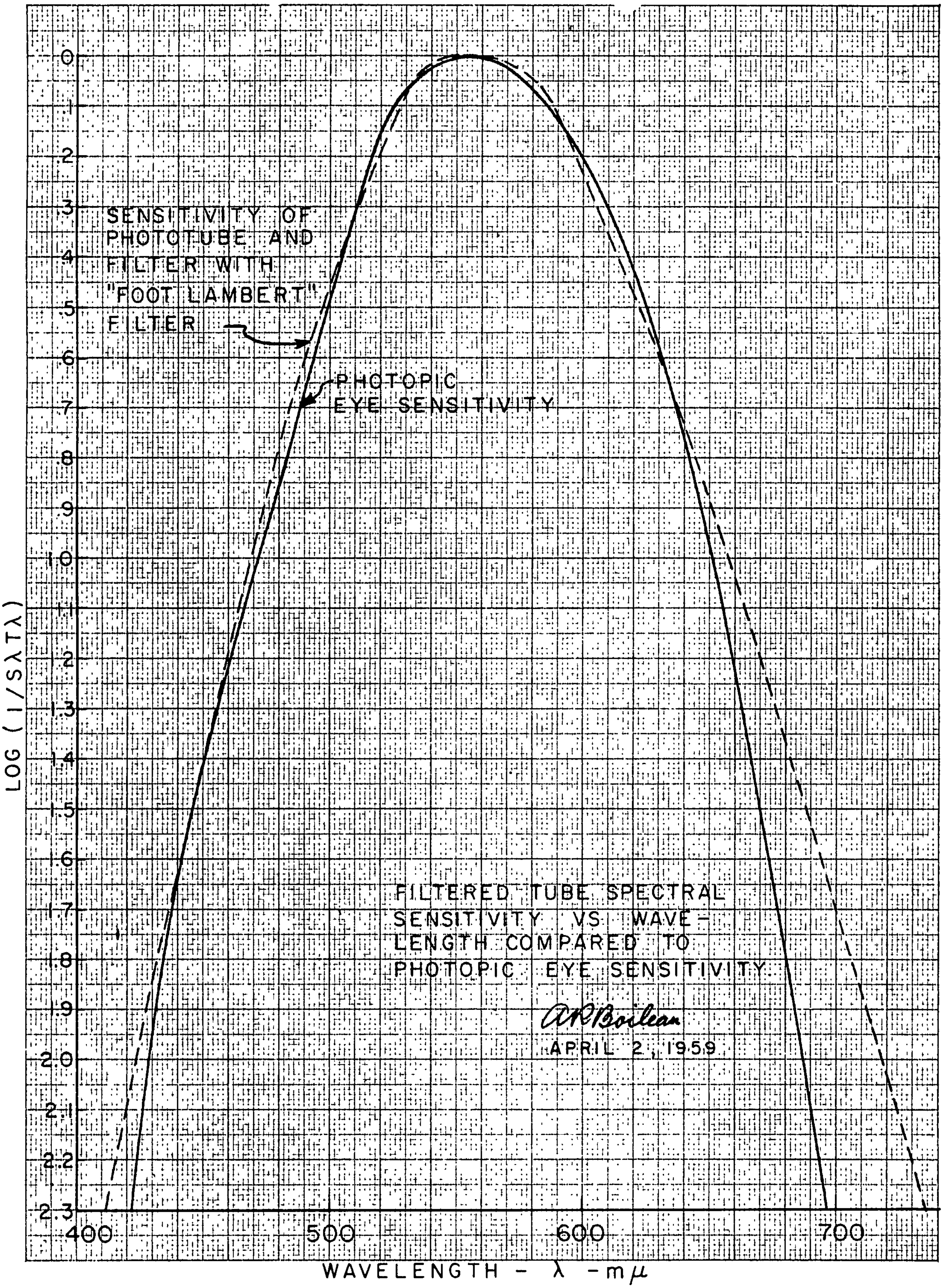
The relative areas under the blue and red filtered phototube spectral responses are 1.000 and .963, respectively. Thus by multiplying the red filtered responses by $\frac{1}{.963}$ or 1.038 a direct comparison of the radiance value measured through the "BLUE" and "RED" filters is obtained.

The spectroradiometer was not used during the Manhigh III balloon flight and will not be discussed here. A report concerning the total instrument is being prepared for publication at a later date.

Calibration of the Spectra Brightness Spot Meter was done in the Visibility Laboratory photometry room using a calibrated standard lamp as the light source. The calibration of the instrument consisted of having the known light source placed at known distances from a magnesium oxide screen placed perpendicular to the impinging ray, letting the instrument look at the center of the magnesium oxide screen, and correlating the various luminance and radiance values with the instrument's microammeter (calibrated in foot lamberts, full scale being equal to 100 foot lamberts). The standard lamp used in the calibration was operated at a color temperature of 2854°K.

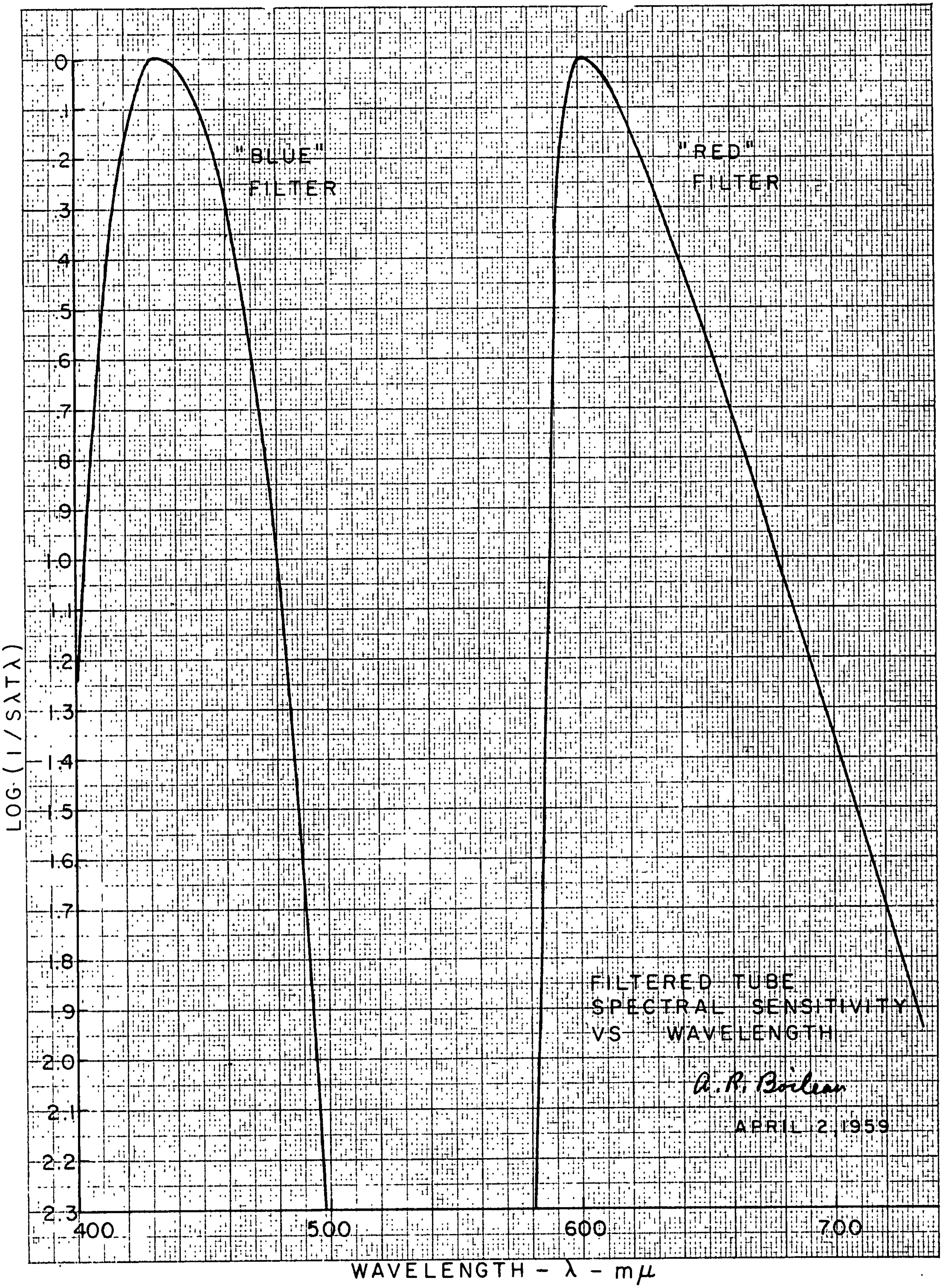
As shown in Fig. 3, the lamp's energy output is high in the red end of the spectrum. This, coupled with the increasing deviation between the photopic response of the instrument and the luminosity curve above 640 mu, will give a calibration which will be in error when the instrument is used to measure luminance values of a sky having a color temperature range of 7000°K to ∞ °K. Accordingly, an absorption filter of copper sulphate solution having spectral transmittance as shown in Fig. 4 was placed in the light path to lessen the red and infrared energy. This permitted the instrument to see a spectral distribution of energy during calibration which was more comparable to the higher color temperature distributions it will see in use. The copper sulphate filter was used for the "BLUE" and "RED" calibrations also.

The transmittance of the plexiglas from which the capsule windows were cut was determined 11 August 1958 by measuring a known luminance through a piece of the material. Spectral measurements of the plexiglas at the Visibility Laboratory had shown no discernible wavelength dependence. The transmittance of the plexiglas was determined to be 90%.



LOG (1/SλTλ)
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
400
500
600
700
WAVELENGTH - λ - mμ
SENSITIVITY OF PHOTOTUBE AND FILTER WITH "FOOT LAMBERT" FILTER
PHOTOPIC EYE SENSITIVITY
FILTERED TUBE SPECTRAL SENSITIVITY VS WAVE-LENGTH COMPARED TO PHOTOPIC EYE SENSITIVITY
A R Boilean
APRIL 2, 1959

Figure 1



"BLUE" FILTER
"RED" FILTER
FILTERED TUBE SPECTRAL SENSITIVITY VS WAVELENGTH
A. R. Boileau
APRIL 2, 1959
LOG (I / SλTλ)
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
400
500
600
700
WAVELENGTH – λ – mμ

Figure 2

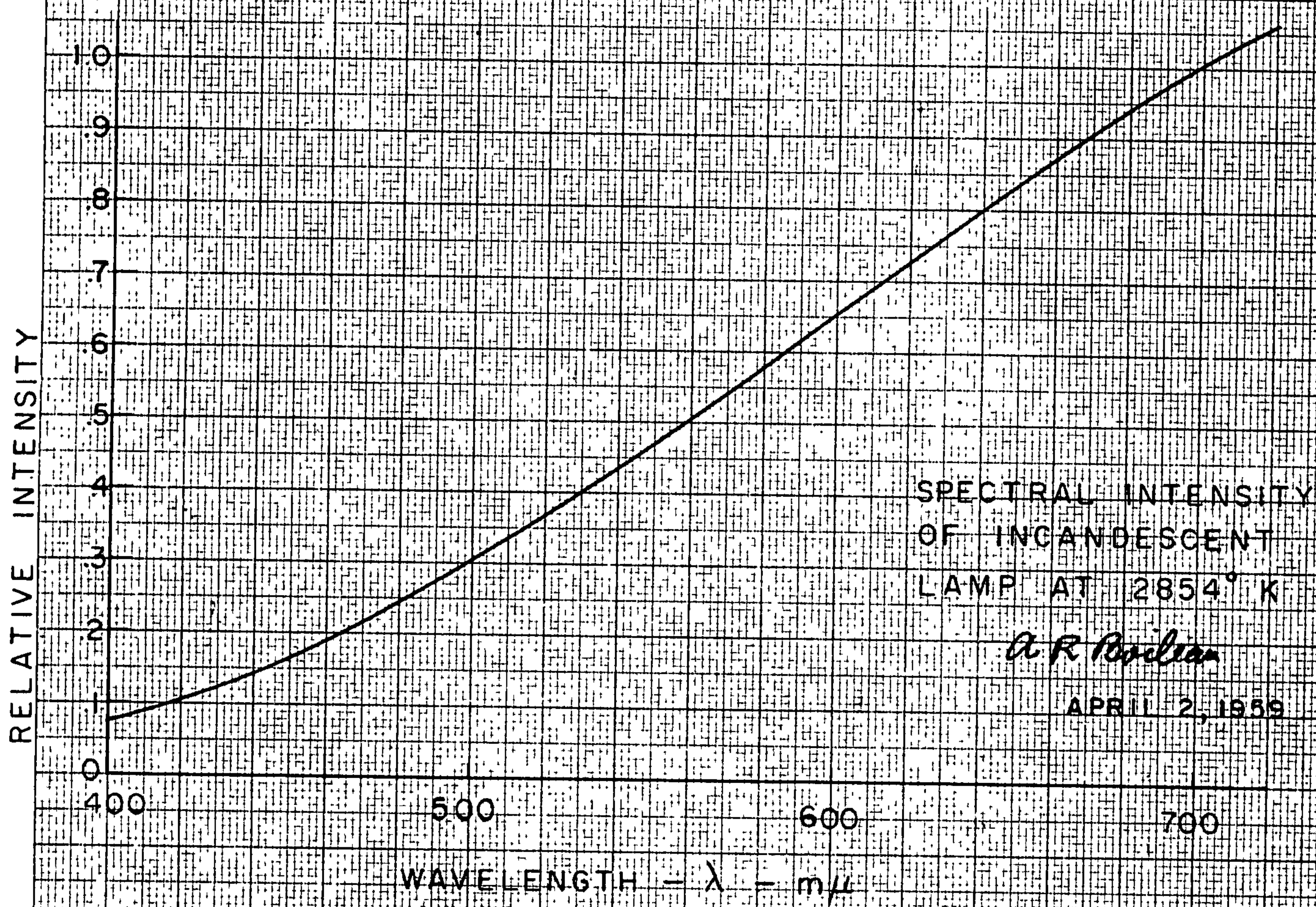
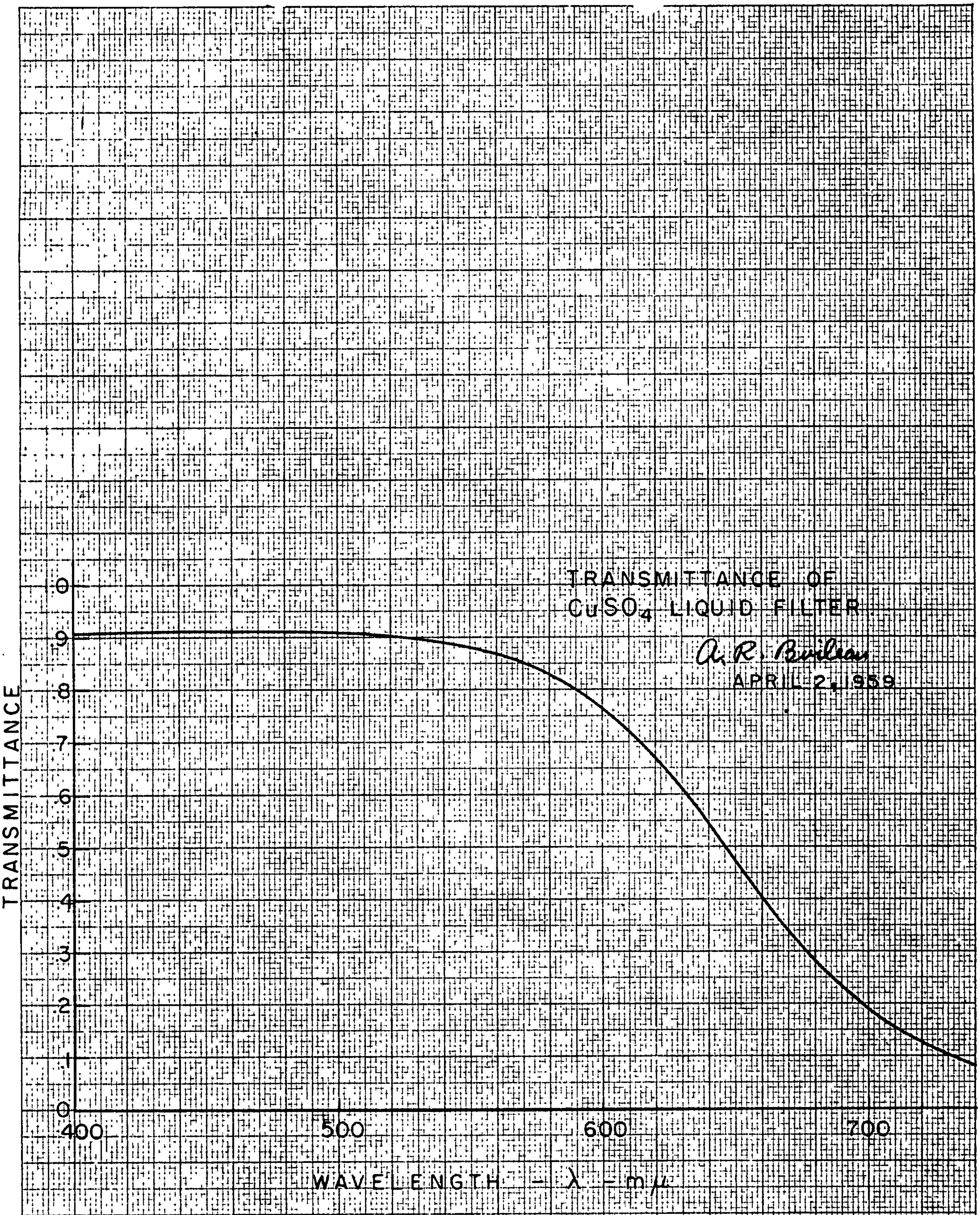

RELATIVE INTENSITY
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
400
500
600
700
WAVELENGTH – λ – mμ
SPECTRAL INTENSITY
OF INCANDESCENT
LAMP AT 2854° K
APRIL 2, 1959

Figure 3



TRANSMITTANCE OF
$CuSO_4$ LIQUID FILTER
A. R. Boileau
APRIL 2, 1959
TRANSMITTANCE
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
400
500
600
700
WAVELENGTH - λ - mμ

Figure 4