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A COMPARISON OF INFRARED SOURCES

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Abstract—The spectral energy distributions of three commonly used infrared sources, the Nernst glower, the globar, and the gas mantle have been compared with a 900°C blackbody in the spectral region 2–40 μ. The results presented in this paper are compared with previously reported data in spectral intervals that were common among the various workers.

IN the design and performance of infrared experiments the spectral energy distribution of the source is an important parameter. Most previous studies(1–5) of the spectral radiant emittance of sources have been limited to wavelengths shorter than 20 μ. Our comparisons are for the spectral interval 2–40 μ.

Measurements were made using a Perkin–Elmer model 98* single-pass monochromator with appropriate source optics. The monochromator and source optics housing were purged with dry air. A schematic of these optics is shown in Fig. 1. Three prisms were used

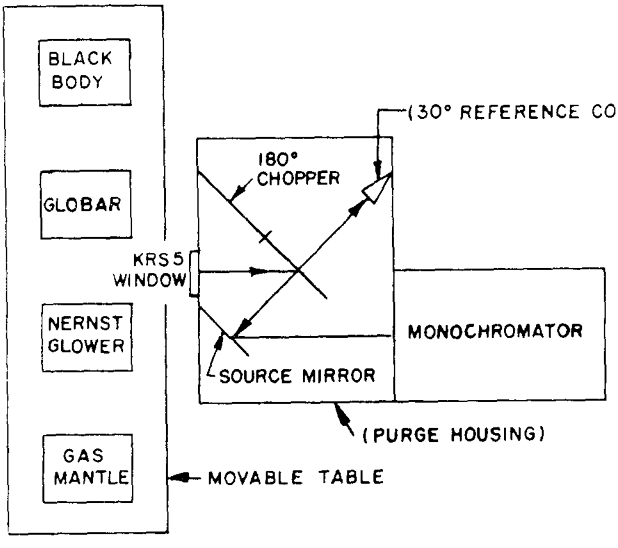

FIG. 1. Schematic of entrance optics.

for wavelengths from 2·0–40·0 μ; NaCl (2·0–12·0 μ), KBr (10·0–20·0 μ) and CsI (15·0–40·0 μ). The source mirror was masked with an iris diaphragm so that only the central portion of the mirror was used.

* The spectrometer is described in instruction manual 990-9004 published by Perkin–Elmer Corporation, Norwalk, Connecticut.

To compensate for the different vertical dimensions of the sources and to eliminate the effects of temperature gradients along them, the top and bottom thirds of the entrance and exit slits were masked.

The slit widths, 0·5 mm for the NaCl prism, and 1·0 mm for the KBr and CsI prisms, were chosen to give ample energy through-put consistent with the horizontal dimensions of the smallest source, the Nernst glowers.

Scattered light was controlled by use of a scatter plate, Perkin–Elmer Part No. 1283*, and filters located at the exit slit of the monochromator. A description of the filters and the spectral intervals in which they were used are given in Table 1.

TABLE 1

Filter†	Spectral interval used (μ)	Description
A	2·0–4·5	Germanium, anti-reflection coated for 10 μ.
B	4·5–7·0	Multi-layer, dielectric coated interference filter bandpass from 3 to 8 μ.
C	7·0–10·5	Indium antimonide.
D	10·5–15·0	Multi-layer dielectric coated filter Irtran-4 substrate long wave pass from 10·5 to 28 μ.
E	15·0–40·0	Multi-layer dielectric coated KRS-5 substrate long wave pass filter from 14 to beyond 40 μ.

† Filters A, B, and D were supplied by Optical Coating Laboratories, Inc. Santa Rosa, California. Filter C was supplied by Grubb Parsons Ltd., Newcastle upon Tyne, England, and Filter E was supplied by the Perkin–Elmer Corporation, Norwalk, Connecticut.

The transmission characteristics of the filters are shown in Fig. 2.

The sources were mounted on a rolling table as shown in Fig. 1 so that each source could be relocated and adjusted for peak energy.

The blackbody is an Electronics Communications Incorporated model 55A and was operated at 900°C ± 10°C as measured by a platinum, platinum–rhodium thermocouple. The blackbody's color temperature and the color temperatures of the other sources were measured with a Pyrometer Instrument Co. model 95 pyrometer.

To compensate for the small diameter of the Nernst glower (about 1 mm) a mosaic of 3 Nernst glowers wired in series was used. Operating conditions and dimensions for the sources are given in Table 2. A description of these sources is given by Strong.[(6)]

Figure 3 shows the instrument response (arbitrarily normalized to unity) to the blackbody as compared with an ideal blackbody (absolute scale). The filters are the main contributors to the deviations in the shape of the instrument response curve, as can be seen from Fig. 2. Each source was compared to the blackbody by taking ratios of the energy of the source to that of the blackbody. These ratios vs. wavelength are shown in Figs. 4a, 4b, and 4c.

RESULTS AND COMPARISONS

At short wavelengths, approximately 2·0–14·0 μ, the Nernst glower has greater spectral radiance than either the mantle or the globar, except from 3·5 to 4·5 μ, where the globar is superior.

The emittance of the Nernst glower declines rapidly at 13 μ and from 20 to 40 μ is little more than the blackbody.

TABLE 2. OPERATING CONDITIONS OF SOURCES

Source*	Conditions	Color temp. (°K)	Dimensions (mm)
Globar	200 W, 6 A	1470	5·1 × 20·3
Nernst glowers	45 W each, 0·6 A	1980	3·1 × 12·7
Mantle	Propane heated	1670	25·4 × 38·1
Blackbody		1173	27·9 × 19·6

* The globars were supplied by the Perkin–Elmer Corp., Norwalk, Conn. The Nernst glowers were supplied by Beckman Instruments, Inc., Fullerton, Calif. The gas mantles were manufactured by Coleman Co., Inc., Wichita, Kansas.

The globar and the Nernst glower curves cross each other at 3·5, 5·0, and 15·5 μ, with the globar clearly superior to the Nernst glower beyond 15·5 μ. At shorter wavelengths the mantle has the least spectral radiance of the 3 sources. However, its spectral radiance surpasses that of the Nernst glower at 14·0 μ and remains higher than the glower to 40·0 μ. The spectral radiance of the mantle surpasses that of the globar between 10·5 μ and 25·0 μ, beyond which both sources are approximately the same.

Figure 4a also shows (dashed curve) the ratios for a Nernst glower to a 900°C blackbody computed from results given by Sutherland.(5) At shorter wavelengths the present results are lower than those obtained by Sutherland; from 7 to 20 μ the two are nearly coincident. Sutherland implies that his glower was operated at about 1 A d.c., whereas ours was operated at 0·6 A a.c. The higher power dissipated in Sutherland's glower probably accounts for his greater ratios at shorter wavelengths.

Figure 4b shows, in addition to the new data, the same ratios computed from emissivity data given by Silverman(4) and the color temperature of our globar. The results agree between 15 and 20 μ, but at shorter wavelengths our measured values fall below the computed ones.

The dashed curve in Fig. 4c shows the ratios for a mantle calculated from results published by Sutherland.(5) An interesting feature here is the absence of the emission peak in the mantle as found by the present authors and by Pfund.(3) This peak probably results from emission by excited CO_2 molecules formed by the burning of the gas (in our case, propane) used to heat the mantle; Sutherland does not specify how his mantle was heated. At shorter wavelengths our ratios are larger than Sutherland's and from 8 to 12 μ they agree; and from 12 to 20 μ Sutherland's values become progressively larger than ours.

Figure 5 shows a comparison of our ratios of a gas mantle to a Nernst glower with those of Pfund.(3) The present work shows a sharper but lower emission peak at 4·5 μ and good agreement from 8·5 to 12·0 μ. From 2·0 to 8·5 μ our values are lower than those of Pfund, which could be attributable to the difference in operating current (Pfund operated his Nernst glower at 0·5 A).

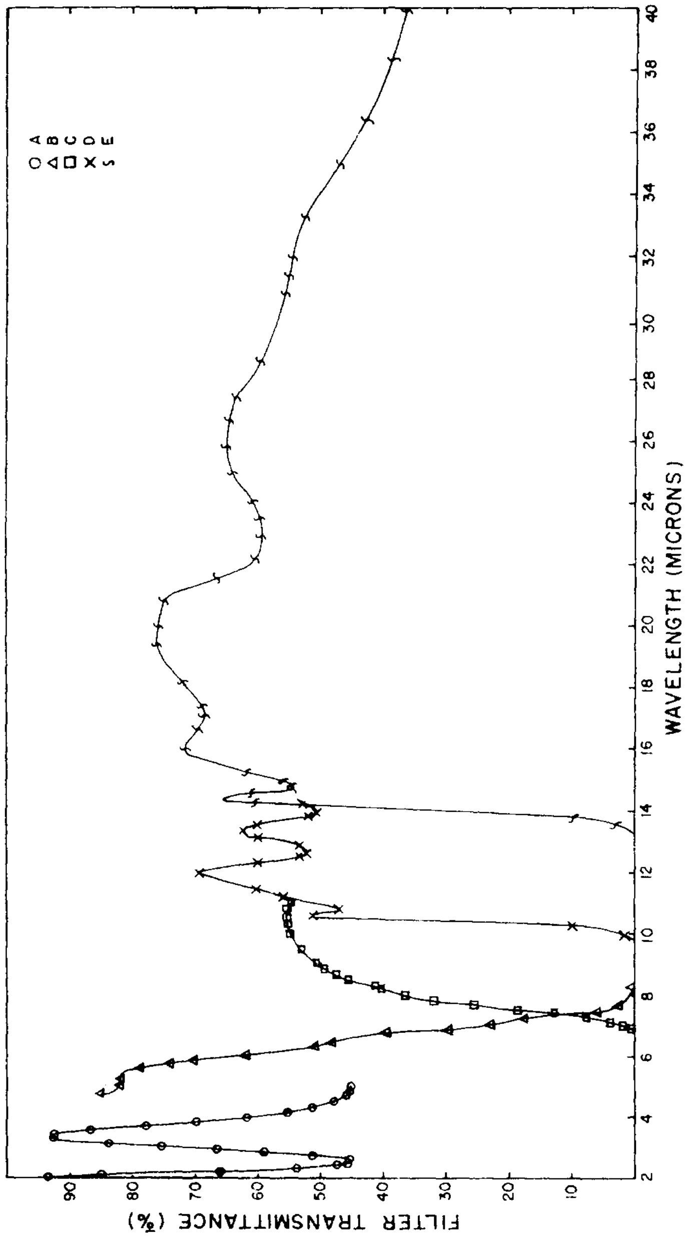

FIG. 2. Transmittance of the filters (as identified in Table 1) in the spectral intervals on which they were used.

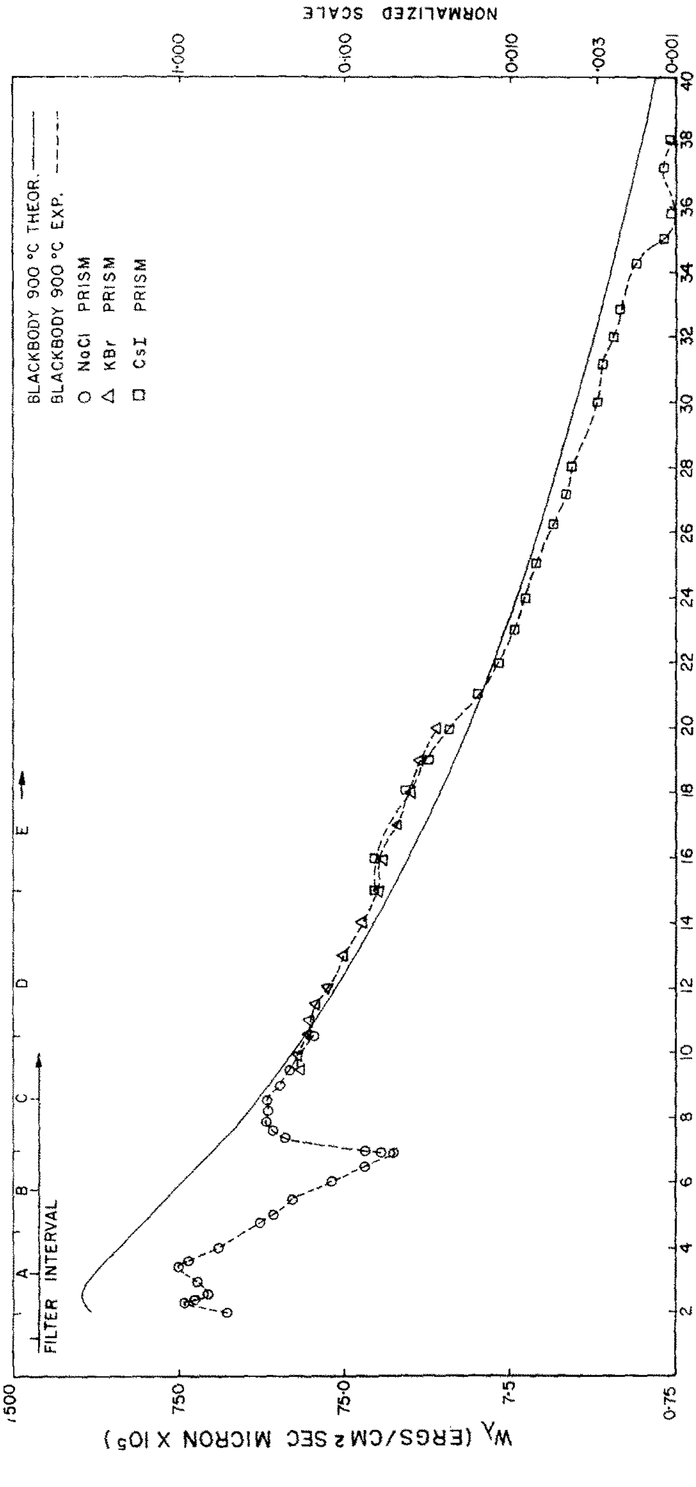

FIG. 3. Spectral radiant emittance (solid curve and left ordinate) and normalized relative instrument response (dashed curve and right ordinate).

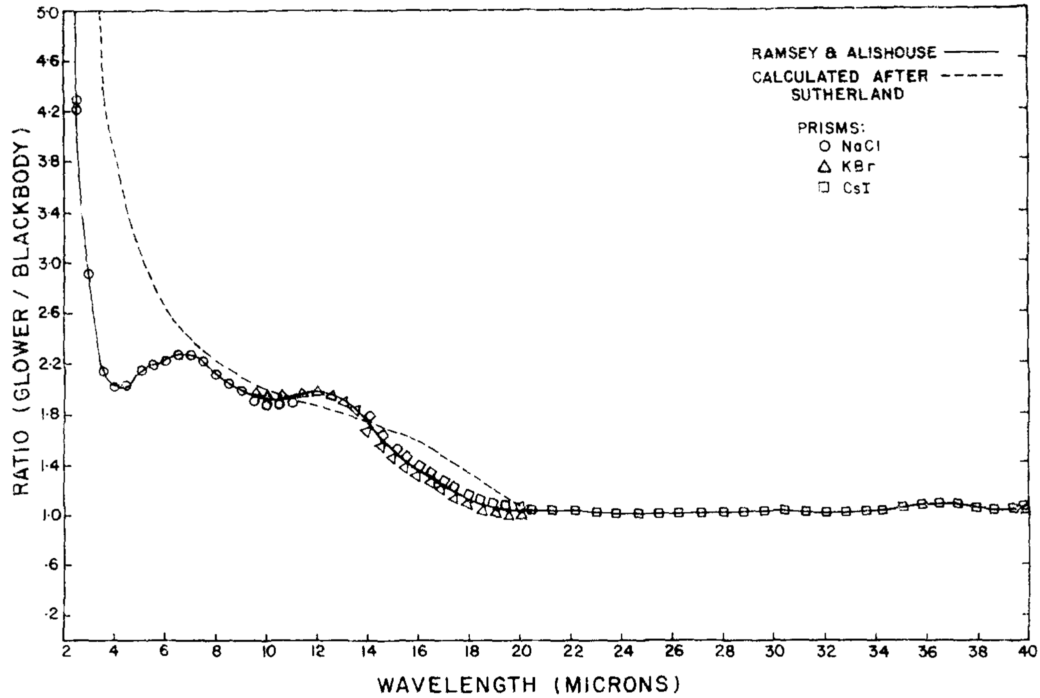

FIG. 4a. The ratios of a Nernst glower to a 900°C blackbody vs. wavelength. The dashed curve was computed after Sutherland.

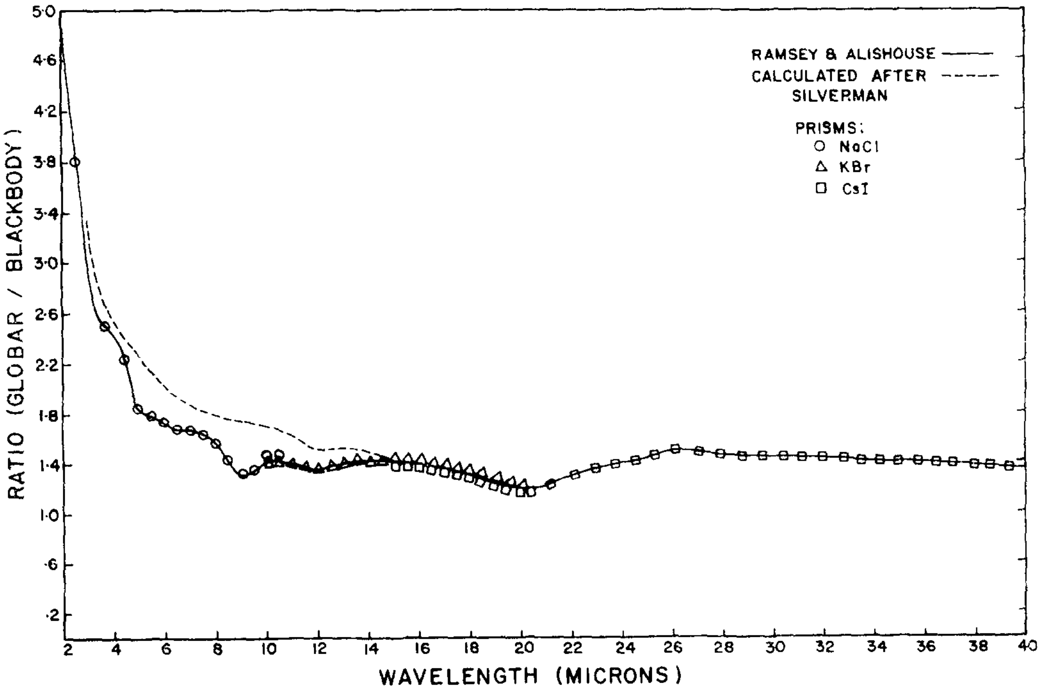

FIG. 4b. The ratios of a globar to a 900°C blackbody vs. wavelength. The dashed curve was computed after Silverman.

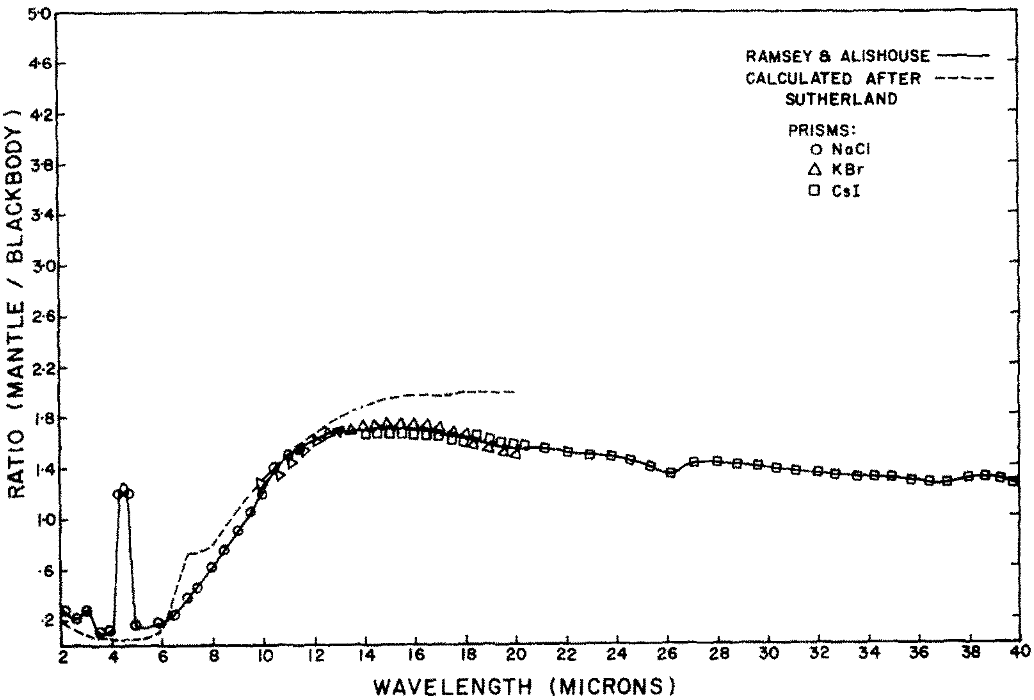

FIG. 4c. The ratios of a gas mantle to a 900°C blackbody vs. wavelength. The dashed curve was computed after Sutherland.

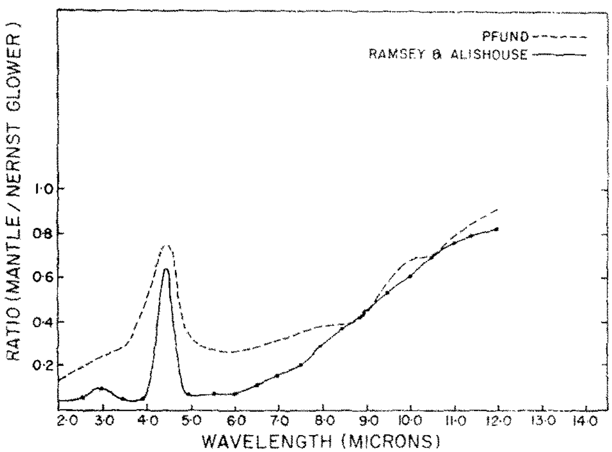

FIG. 5. The ratios of a gas mantle to a Nernst glower vs. wavelength. The dashed curve is after Pfund.

Figure 6 shows a comparison of ratios of the Nernst glower to the globar computed from our data and data reported by Friedel and Sharkey.[2] The shapes of the curves are in very good agreement, although our values are slightly higher. This is probably attributable to our using a higher Nernst glower current (0·6 A as compared with 0·5 A).

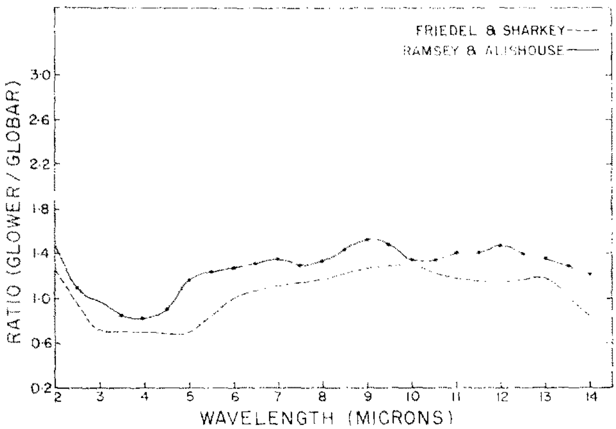

FIG. 6. The ratios of a Nernst glower to a globar vs. wavelength. The dashed curve is after Friedel and Sharkey.

Figure 7, which shows the spectral radiant emittances of the sources and the blackbody, summarizes the results of the present study. These values were computed using the ratios in Figs. 4a, 4b, and 4c. The spectral radiance (W/cm^2 sterad μ) may be obtained by multiplying the spectral radiant emittance (ergs/cm^2 sec μ) by $10^{-7}/\pi$.

DISCUSSION

The comparison of measurements by different authors was complicated by the fact that none of the authors cited in this paper gave any estimate of the spectral resolutions of their instruments. From manufacturer's specifications our spectral bandwidths were estimated to range from 0·04 μ at 12 μ to 0·13 μ at 3·4 μ for the NaCl prism; from 0·07 μ at 20 μ to 0·15 μ at 9·5 μ for the KBr prism; and from 0·50 μ at 40 μ to 1·1 μ at 15 μ for the CsI prism. The experimental points shown in Figs. 4a, 4b, and 4c are averages of three measurements. Typically the deviations in these measurements were less than 5%. The deviations between prisms were typically less than 2%.

The Nernst glower emits the most energy per unit area from 2 to 14 μ. The mantle surpasses the Nernst glower at 14 μ and the globar surpasses the Nernst glower at 15·5 μ; Sutherland[5] found that the mantle surpassed the Nernst glower at 13·3 μ. The mantle is superior to both the globar and Nernst glower from 14 to 25 μ. Beyond 25 μ the Nernst glower is approximately equivalent to a 900°C blackbody and the globar and mantle are approximately equivalent to each other. The globar and mantle are about 1·4 times better than the Nernst glower at these longer wavelengths.

In general, the choice of the source will depend upon the overall experimental configuration, the source optics, and the personal preferences of the individual experimenter.

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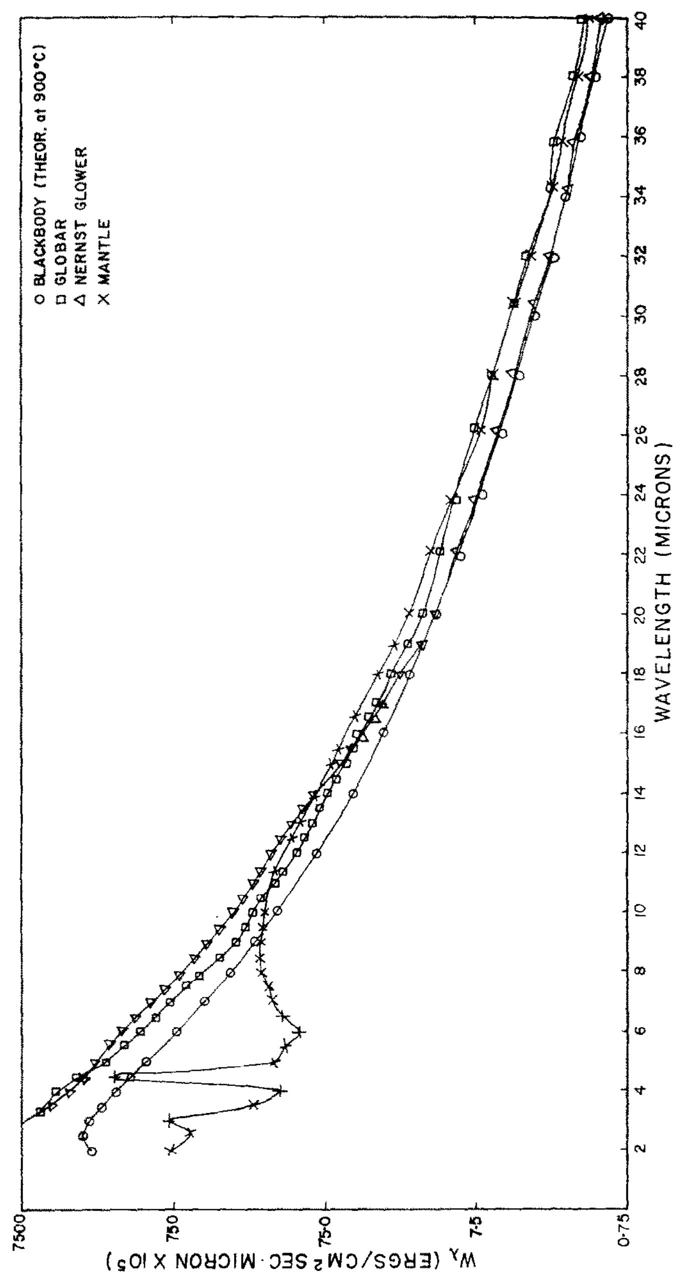

FIG. 7. The spectral radiant emittances of a globar, Nernst glower, 900°C blackbody, and gas mantle are shown vs. wavelength.

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