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MEANS OF INCREASING THE EMISSIVITY OF A SOURCE WITH
A REFLECTING EMITTER ELEMENT

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FIG. 1

FIG. 2

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MEANS OF INCREASING THE EMISSIVITY OF A SOURCE WITH A REFLECTING EMITTER ELEMENT

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This invention relates to a radiation reference source, and more particularly to a means for increasing the emissivity of a high temperature reference source.

Radiation reference sources provide a means of linking measurable temperatures with emitted radiation. The standard used in infrared work is called a "black body" which is an ideal emitter from which the total radiation energy is emitted and the spectral distribution of the energy is known. A black body thus simulates the desired characteristics in order to measure the relationship between temperature and radiation. Reference sources are generally electrically heated insulated cavities with small apertures. The energy radiated by a reference source covers a wide range of frequencies and wavelengths, with the peak radiation shifting to shorter wavelengths, and the total amount of radiated energy increasing as the temperature increases. At very high temperatures, for example on the order of 2,000°-3,000° C., the insulated cavity-type source is not practical, and sources in this range are made in the form of strip filament lamps in which the strip or emitter is made of tungsten or other suitable material. In such a high temperature range, however, the emissivity of tungsten is only approximately 0.2 in the infrared spectral region. The performance and effectiveness of such a reference source could be greatly improved if the emissivity could be increased. One method of improving the results, when the angle illuminated by the source is small, would be to shape the source in the form of a hollow cone or "Mendenhall wedge." For many applications, however, it is desirable to use an intense tungsten source with a fast projection optical system where a solid angle of 1 steradian or more must be illuminated, in which case the aforementioned cone or wedge approach provides little gain in emissivity.

Accordingly, it is an object of this invention to provide a radiation reference source in a high temperature range with increased emissivity even for applications where wide angle illumination is necessary.

In carrying out this invention, a lamp source is provided having an emitter which is enclosed by a hemispherical envelope with the emitter being located at the center of curvature of the envelope. A surface of the hemispherical envelope is made specularly reflecting over its entire surface except for a transmitting area from which the emission is to be collected. The area of the specularly reflecting surface is large with respect to the area occupied by the emitter.

The invention, both as to organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings in which:

FIG. 1 shows a reference source as embodied in this invention having an emitter which is considered to be a diffuse reflector, and

FIG. 2 shows a reference source of the type embodied in this invention in which the emitter is considered to be a specular reflector.

Referring now to FIG. 1, a reference source as embodied in this invention and referred to generally with the reference character 10 includes a base 12, and a hemispherical envelope 14. An emitter or filament 16 mounted on a support 18 is located at the center of curvature of the hemispherical envelope 14. The emitter 16 is in ribbon form, and considered a diffuse reflector, which may be made of any suitable material, such as tungsten. The hemispherical envelope 14 includes an aperture 22 in the form of a cone from which the emission of the source 10 is to be collected, surrounded by a specular reflecting surface 20. The reflecting surface 20, which is illustrated in FIG. 1 as being on the inner surface, may be either on the inner or outer surface of the envelope 14 if the envelope through aperture 22 transmits the desired spectral range. If not, the reflecting surface 20 must be on the inner surface with a special transmitting window being used in the aperture 22 which transmits the desired spectral range.

Since by reciprocity the absorption equals the emissivity, the operation of the lamp of FIG. 1 can best be described by determining the absorption at the emitter 16 of a ray entering through the aperture 22 on the first and all subsequent reflections. For the diffusely reflecting emitter 16 of FIG. 1, the absorption of the emitter 16 on the initial incidence of radiation through the aperture 22 is the bare emissivity ε. The remaining radiation (1—ε) is diffusely reflected from the emitter 16 into the forward hemisphere. A portion of this diffusely reflected radiation (sinθ) escapes through the aperture 22, and the remaining portion (1—sinθ) is reflected back from the specularly reflecting surface 20 to the emitter 16, since the emitter is at the center of curvature of the specular reflecting envelope 14. The total radiation returning to the emitter after the first reflection is (1—ε)(1—sinθε), where r is the reflectivity of the mirrored surface 20 of the envelope 14. This radiation again strikes the emitter 16 with the fraction ε being absorbed. This process continues, and the total fraction absorbed, which is equal to the effective emissivity εeff, is given by the following series:

\[ ε_{eff} = ε + (1—ε)(1—sinθε) + (1—ε)(1—sinθε)^2 + \cdots \]

whose sum is:

\[ ε_{eff} = \frac{ε}{1 — (1—ε)(1—sinθε)} \]

As an example of the effectiveness of increasing the emissivity in accordance with this invention using an emitter having a bare emissivity of .2, θ being equal to 26.6° thereby providing a wide-angle source, and assuming unity reflectivity, the effective emissivity of the source is raised to .56.

In FIG. 2, the emitter 16 is in the form of a wedge or a V to make its reflectivity specular. Also, merely for purposes of illustration, the envelope 14 is coated with a reflective surface 20 which is shown as being on the outer surface of the envelope 14. In such a case, as was previously pointed out, with such a configuration it would be necessary for the envelope to transmit the desired spectral range. For the case of FIG. 2 where the emitter 16 reflectivity is specular, the sides of the emitter 16 make an angle with the center line of 90°—θ where θ is the extreme exit angle. As is illustrated by the ray trace on FIG. 2, any entrance ray striking the emitter 16 is reflected to the envelope 14, then reflected from the mirrored surface 20 back to the emitter 16, and from the emitter 16 reflected out of the aperture. The effective emissivity in such a case is then

\[ ε_{eff} = ε + (1—ε)ε = ε(2—ε) \]

Either where the emitter is in the form of a diffuse reflector as shown in FIG. 1, or where it is in the form of a specular reflector as shown in FIG. 2, the emitter 16 is located at the center of curvature of the hemispherical lamp envelope 14. Furthermore, the reflective sur-
face 20 on the envelope 14 provides a considerably larger area than the area occupied by the emitter 16. By placing the emitter at the center of curvature of the envelope, deterioration or spattering of the emitter 16 will not heat up or deteriorate the reflective coating on the envelope as badly as would be the case of close positioning of the emitter to the reflective surface 20. By making this reflective surface large and positioned away from the emitter, a better source is provided which is less likely to deteriorate.

Since other modifications, varied to fit particular operating requirements and environments, will be apparent to those skilled in the art, the invention is not considered limited to the examples chosen for purposes of disclosure, and covers all changes and modifications which do not constitute departures from the true spirit and scope of this invention.

What I claim as new and desire to secure by Letters Patent is:

1. A means of increasing the emissivity of an infrared source comprising
   (a) a lamp source having a reflecting emitter enclosed by a hemispherical lamp envelope,
   (b) said reflecting emitter being located at the center of curvature of said envelope,
   (c) said envelope having a radiation transmitting area surrounded by a specularly reflecting surface on said envelope with the areas of said specularly reflecting surface being large with respect to the area of said emitter.

2. The structure set forth in claim 1 wherein said emitter is a diffuse reflector.

3. The structure set forth in claim 1 wherein said emitter is a specular reflector.

4. The structure set forth in claim 1 wherein said specular reflecting surface is on the inner surface of said envelope.

5. The structure set forth in claim 1 wherein said specular reflecting surface is on the outer surface of said envelope.

6. The structure set forth in claim 1 wherein the reflecting surface on said envelope is on the inner surface thereof and said radiation transmitting area comprises a transmitting window which transmits the desired radiation.

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