

Fig. 3 shows a schematic illustration of water ex-
 position in a row town. Fig. 4 illustrates the con-
 cept of a uniform load of thermal energy use through-
 out the year.

The inventory of potential uses should be developed
 with assurance that new town planning has access
 to this store. Some other use of potential energy
 important to provide off-peak thermal load.
 Melting snow from streets and sidewalks, for example,
 cannot stand alone, but may contribute a bonus in the
 well-planned and optimized new town.

Some of the other potential uses require steam, some
 require hot fluid at somewhat enhanced temperature,
 and some use low-grade thermal energy as normally
 discharged from a steam electric power plant.

Use of steam for industrial processing combined
 with power generation have been demonstrated to be
 advantageous. Steam distillation with steam from
 the energy center may be made advantageous with
 proper planning.

If greenhouse and/or phytotron can be justified
 in the new town, a small economic bonus can be
 obtained by heating with low-grade thermal energy
 from the energy center. Preliminary studies show
 that biological processing of sewage can be accelerated
 by raising the temperature using low-grade heat.
 Gain of a factor of 10 appears reasonable. This means
 that for a given plant size, the footprint might be
 increased by a factor of 10.

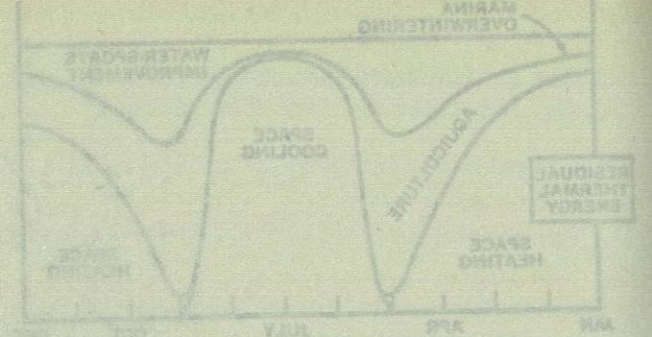


Fig. 4 Concept of using thermal energy throughout the year

Great farming in Japan and Australia is now largely
 based on primitive techniques and very labor-inten-
 sive. Considerable knowledge of soil experimental
 techniques for water control have been developed in
 this country [4-6], but they have yet to be applied on
 a large scale.

The very small-scale experiments in this country
 are characterized by improvisation. Oyster farms
 have grown on "straps" of oyster shells or wire sus-
 pended from a spar. They are also frequently used
 for propagating oysters and other shellfish. Inter-
 polating densities and yields achieved in these
 small-scale experiments to a general case would
 indicate that an oyster farm should yield an annual crop worth
 \$40,000 per acre per year with application of energy
 water heat. The knowledge available needs to be
 put to use with appropriate engineering skill and man-
 agement.

Although many questions concerning oyster farming
 techniques remain unanswered, the essential knowl-
 edge and experience in hand should support
 a well-managed oyster farming project relying on re-
 cycled thermal energy from an energy center for op-
 erating various steps of oyster culture and oyster food
 chains. The same is true for many types of animal
 husbandry.

The optimized temperature profile shown in Fig. 3
 is also very attractive as a means of extending the ex-
 position of water sports and recreation to six or eight
 months instead of two or three.

It is that we can add little or no heat to the water
 in winter, depending on the ambient temperature
 of the available water and our selection of the pro-
 cedure. This optimum temperature is
 held for as long as practical. The additional

heat in fish and shell fish under natural conditions
 is in water which is for most of the year substan-
 tially too cold for optimum growth rates. The optimized
 temperature profile shown in Fig. 3 if applied for ex-
 ample to Chesapeake Bay water could result in making
 oysters to marketable size in one season instead of
 three or four seasons.

There is a large and growing body of knowledge in
 marine and fresh-water bionomics pertinent to oyster
 culture which has been largely unexploited to date.
 There are many promising application opportunities
 for shell fish and fish agriculture in marine and
 fresh water. These opportunities include use of elec-
 tric heating to optimize use of culture and market-
 ability of the product. They include selection of an
 optimum species, perhaps from other parts of the world,
 which have particularly attractive market features.

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RADIATION

Part 1—Recent Advances and Trends

Here's a survey of changes in the field of ra-
 diation thermometry over the past decade. Considerable advantage has been derived from operating modern photodetectors in selected spectral regions, and extension of the low-temperature limit by use of infrared radiation. Highly accurate automatic versions of disappearing-filament optical pyrometers have been developed for high-temperature applications. Criteria for selecting wavelength and spectral bandwidth appropriate under various circumstances are given with special emphasis on effects of atmospheric spectral absorption and spectral emissivity.

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RADIATION THERMOMETRY has long played a vital role in industrial and laboratory measurement of temperatures. It is unique among temperature-measurement methods in that direct physical contact with the object whose temperature is being measured is not required. At very high temperatures there is no alternative method, since contact thermometers degrade too rapidly to be useful, or they simply melt or vaporize. This noncontact characteristic is, however, a mixed blessing. The physical laws that govern the behavior of thermally emitted radiation are not always in concert with the desires of those who must use thermal radiation as a means of measuring temperature, and in general such methods require more knowledge on the part of the user than do the methods of contact thermometry.

Radiation Temperature Scale

Radiation thermometry is based on the concept of blackbody radiation, illustrated in Fig. 1, for which spectral radiance is an exactly known function of the

absolute temperature of the blackbody as given by the Planck radiation function.

$$N_{b\lambda} = C_1 \pi^{-1} \lambda^{-5} (e^{C_2/\lambda T} - 1)^{-1} \quad (1)$$

where

- $N_{b\lambda}$ = spectral radiance (radiant power per unit projected target area per unit solid angle per unit wavelength interval)
- $N_{b\lambda}$ = spectral radiance of a blackbody
- C_1 = the first radiation constant
- $C_2 = 0.01438 \text{ m} \cdot \text{K}$, the second radiation constant
- λ = wavelength of electromagnetic radiation
- T = absolute temperature of the blackbody.

Equation (1) is used to define the International Practical Temperature Scale (IPTS) at temperatures above the freezing temperature of gold. Late in 1968, the IPTS was again updated [1]² and is now designated IPTS-68. A significant change in terms of radiation thermometry was the new value assigned to the freezing temperature of gold (1064.43 C ± 0.2 C), about 1.4 C higher than the previous value. The value assigned to C_2 was changed from 0.01438 to 0.014388 m·K. If $C_2/\lambda T \gg 1$, Planck's radiation law may be replaced by the mathematically simpler approximate form known as Wien's law:

$$N_{b\lambda} = C_1 \pi^{-1} \lambda^{-5} e^{-C_2/\lambda T} \quad (2)$$

Although equation (1) is used to define the IPTS, the accuracy of equation (2) is adequate for most calculations in the analysis of radiation thermometry.

Since about the turn of the century, radiometry has been employed as a means of temperature measurement, and until the development and widespread application of modern photodetectors only two general classes of radiation thermometers have been available. These have been the "disappearing-filament optical pyrometer," or minor variations thereof, and the so-called "total-radiation pyrometer."

Disappearing-Filament Optical Pyrometer

The disappearing-filament optical pyrometer had reached a state of essentially complete development by about 1920 [2], with practically no significant change since then. It measures the nearly monochromatic radiance of a high-temperature source and indicates the temperature of a blackbody radiator having the same spectral radiance.

² Numbers in brackets designate References at end of article.