and in foreign seas. War is now our principal business; all national efforts are ancillary to its successful termination in a permanent peace by decisive victory. In this struggle the entire nation is mobilized and, as an integral part of its citizenry, the medical profession cheerfully and enthusiastically offers its all. Our profession is the trustee of the nation's health, and as such its obligations are to furnish adequate medical care to the armed forces while at the same time maintaining faithful service to the civilian population and productive war industry installations. It further demands that public health programs be cheerfully guarded, maintained or even increased as the need grows larger and larger. We are committed to the decision that provision for graduate education and for special education to develop specialists be continued at their present high level of efficiency. These and other essential duties which unfold continually in our daily duties must, and will be, accepted and accomplished to the extent of our capacity. In the inescapably somber times ahead, often our fortitude will be challenged, often our ideals will appear frustrated by circumstance; but the true mettle of a profession emerges only when tried in the fires of adversity.

Changes, unavoidable and unpleasant, face us in our daily and professional lives; we do not speak of the inevitable essential sacrifices; we speak rather of the glories of service. To serve is our destiny, to serve freely, faithfully and effectively is our wish and ambition.

Our duty is plain to see: we shall go forward to our task, and we shall not fail.

INFRARED RADIATION

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ALL bodies, whether they feel hot or cold, emit infrared radiation, or what is usually classed as heat. Hot and cold are relative terms. A so-called hot body radiates energy faster than the human body, while a cold body radiates energy at a slower rate than human bodies do.

Infrared radiations are electromagnetic vibrations, similar to visible light but of longer wave-lengths. They extend from the visible red radiations of about 7,000 angstrom units to some arbitrarily selected limit such as 5,000,000 or 10,000,000 angstrom units. At this point the radiations approach the region of the shortest radiations produced by ultra-high-frequency radio tubes.

Several physical laws that can be defined with mathematical formulas describe the principal phenomena of radiant energy from a black body, which is defined as a perfect non-selective absorber and emitter of radiations. The amount of energy radiated per unit area at any temperature is given by the Stefan-Boltzmann Law $E = \sigma T^4$. In this formula E = energy; $\sigma = 5.73 \times 10^{-5}$ ergs per cm² per sec; T = absolute temperature in Kelvin degrees (centigrade degrees plus 273). The relationship $\lambda_{max} \times T =$ 0.2886 centimeter degrees is derived from Wien's displacement law; λ_{max} is the wave-length at which the radiated energy is a maximum. For every given temperature there is a wave-length at which the radiated energy is a maximum.

Another useful relationship is known as Planck's radiation law. It gives the intensity I of radiated energy for every wave-length and every temperature T. Expressed mathematically,

$$I_\lambda = \frac{A c_1}{\lambda^5 \left(e^{\frac{c_2}{\lambda T}} - 1 \right)}$$

in which A is the surface area and c_1 and c_2 are constants. This is a complex but highly accurate formula.

By applying these formulas one can learn several interesting things about radiation in general and about infrared radiation in particular. Table I shows a comparison of relative energy and wave-length of maximum radiated energy of a black body at several selected temperatures.

TABLE I

TEMPERATURE-ENERGY-WAVE-LENGTH CHARACTERISTICS OF A BLACK BODY

Selected Temperatures	max (microns)	Relative Energy
90°K (Boiling point of liquid oxygen)	32.1	0.000064
273°K (Melting point of ice)	10.55	0.0055
373°K (Boiling point of water)	7.75	0.019
1000°K (Approx. temp. of radiant electric heater)	2.89	1.00
2500°K (Approx. temp. of filament in drying lamp)	1.15	39.0
5300°K (Approx. temp. of surface of sun)	0.55	800.

The second column shows that the wave-length of maximum energy shifts toward shorter wave-lengths, as the surface temperature of a body is increased. This shows numerically that as a body is heated it goes through the color changes of dull red, bright red, yellow, white and at extreme temperatures it appears bluish white. In addition to color change the total radiated energy increases rapidly, the third column of the table shows.

By plotting Planck's equation for several temperatures one can see the shift in wave-length. Fig. 1 shows the energy distribution for several different temperatures, with energy at the wave-length of maximum radiating power maintained at unity. The points of maximum intensity are related by Wien's displacement law. The curves for melting ice and boiling water are relatively close together in the electromagnetic spectrum, yet these two substances typify sources of uncomfortably cold and hot sensations. By applying the Stefan-Boltzmann formula one learns that the energy radiated per unit area of a black body at zero degrees Centigrade is 29 per cent. of that radiated by a body at 100 degrees Centigrade—a surprisingly large value.

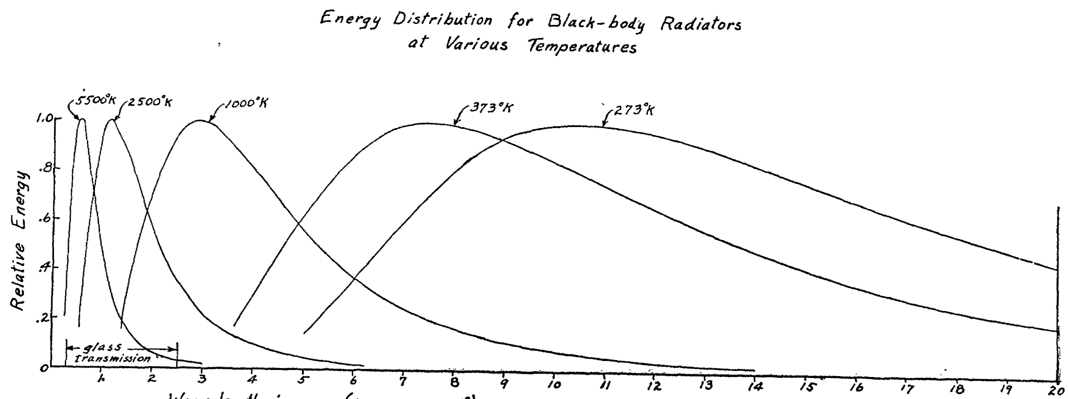

FIG. 1

MICRO WAVES FROM LIQUID HELIUM

By applying Wien's displacement law to a substance like liquid helium at its melting point (0.78 degrees Kelvin) one calculates the wave-length of maximum energy to be 3.7 millimeters. In the region of from 2 to 10 millimeters the energy is more than 20 per cent. of the maximum. This means that a flask of liquid helium is a thermal submicro-wave generator emitting extremely short radiations bordering on the region of shortest ultra-high-frequency radiations produced by electronic tubes.

There are several factors, neglecting availability, that prevent helium from being used practically as a generator of submicro waves. First, the total energy is insignificantly small as calculated with the aid of the Stefan-Boltzmann formula. Also, no single specific wave-length can be selected, for the entire band is generated and all possible phase relations exist. Relatively few atoms have exactly the same frequency of vibration and phase relationship at any one instant and hence preclude the generation of tuned radio-frequency oscillations.

TRANSMISSION OF RADIANT HEAT THROUGH GLASS

Fig. 1 shows a wave-length region in which glass is transparent to visible and near-infrared radiation. Glass is opaque to ultraviolet radiation shorter than 0.3 micron and also to infrared radiation longer than about 2.5 micron. The energy-distribution curves show that much of the radiant energy of the high-temperature radiators passes through window glass, but relatively little gets through from low-temperature radiators. This is the scientific explanation of the fact that the interior of an automobile with windows closed becomes unbearably hot in the summer sun. Upholstery absorbs some of the visible and near-infrared radiation shorter than 2.5 microns and converts it into radiation of longer wave-length. This long-wave heat energy can not get out of the car by radiation because glass and metal are opaque to it, so the energy density of heat radiation builds up to an uncomfortable degree.

Practical and desirable use can be made of this knowledge in the scientific construction of greenhouses and poultry houses where heat and sunlight are desired in winter. By judiciously using glass only where it will do the most good, such as on the south side of the building and part of the roof, much heat and light can be obtained free from the sun's rays. A glass-enclosed "sun porch" on the south side of a house may be comfortably warm without artificially heating on a sunny winter's day, even though the outside air be quite cold. The same natural laws that cause a closed automobile to be uncomfortable in summer can be used to good advantage in supplying heat to buildings in winter.

ROOM HEATING BY RADIANT ENERGY

Several years ago experiments were performed in the Westinghouse Research Laboratory to determine whether walls of a room could be heated by passing current through heater wires embedded in them or cooled by passing cool water through water pipes also embedded in the walls. It was found that the temperature of the walls rather than air temperature was the controlling factor in determining body comfort. With the walls at a temperature of about 80 degrees Fahrenheit an occupant was comfortable even with an air temperature of about 60 degrees as determined with a thermometer hung in the middle of the room. By cooling the walls to 60 degrees and passing heated air at 80 degrees into the room, one still felt uncomfortably cold. This is a good demonstration of the importance of radiant energy in making people feel comfortable or uncomfortable. This phenomenon might be used in heating special rooms of a sanitarium or hospital.

Medical Application of Radiant Energy

Local application of heat to a part of the body, as with a hot-water bottle or heating pad, is mostly a surface treatment. Heat is transmitted to the tissues chiefly by conduction, and penetration is limited because of the cooling effect of the circulating blood. Radiant energy plays a minor part because of the high absorption of long-wave infrared radiation by body tissues and by the relatively low intensities of radiant energy at that temperature. An incandescent filament gives rather intense radiations in the spectral region where surface tissue is somewhat transparent. Since the outer tissues are semi-transparent the radiant energy can fall upon and actually be absorbed by the tissues requiring local heating. In this application the emissivity of the highly heated filament matches the wave band of greatest transmission and thus allows maximum transmission to sub-surface tissues.

Infrared Transmission through Fog

Visible light is readily scattered by fog so that its penetration is limited. Scattering for blue light is greater than for yellow or red light, so even a white light appears yellowish through fog. This is the same phenomenon that causes the sky to be blue. Long red and yellow rays are readily transmitted through the air with but little back scattering, while the shorter blue rays are so intensely scattered by dust particles and air molecules in the atmosphere that they give the sky a blue color.

By adding microscopic water droplets to air molecules and dust particles even yellow and red light are readily scattered. It is possible, however, that near infrared radiations are capable of penetrating rather long distances through fog. The scattering of light is a function of particle size and wave-length of radiant energy. Water vapor has maximum absorption at about 7 microns, hence radiations somewhat shorter than this can be used efficiently. Infrared rays of wave-length between 3 and 5 microns can be transmitted and measured through dense fog at considerable distances. A suitable and efficient generator of such radiations used with a sensitive detector has many uses in navigation and signal work.

Power from Ice Water

Heat from a steam radiator is used to make homes comfortable in winter. Since the same radiator if filled with ice water would still contain a large amount of latent heat energy (if the heat could be extracted from it) it is interesting to speculate on the possibilities of extracting power from Arctic ice fields. While this is not a problem of radiant energy but rather one of heat transfer to an intermediate substance, the subject is still closely allied with infrared or heat energy.

This problem was carefully considered and worked out in detail by Dr. H. Barjot in an article "Extracting Heat and Power from Ice Water" published in *Power,* March, 1930. His heat engine uses ice water at 32 degrees Fahrenheit for "fuel" to volatilize a hydrocarbon which is a petroleum by-product. The vapor passes through a turbine and is condensed in a tank containing blocks of frozen brine. The brine is frozen in open troughs exposed to the air and attains a temperature of perhaps 6 degrees below zero Fahrenheit. By comparison, ice water is relatively warm and furnishes the temperature differential of 38 degrees Fahrenheit to make the engine work.

Ice water is passed through a mixing valve, where it mixes with the cooled liquid hydrocarbon that has been pumped from the condenser. The mixing of water and hydrocarbon causes the hydrocarbon to "boil" the water giving up the latent heat of ice to form ice crystals while the hydrocarbon absorbs this heat to produce rapid vaporization. The boiler is near atmospheric pressure while the condenser is only from one third to one fifth atmosphere. This pressure differential causes the turbine to operate.

This novel scheme may some day become practical in supplementing the power from rivers in the far north in winter when the flow of water, and hence available power, is lowest. This heat engine works best when air temperature is lowest, which causes the greatest temperature differential between boiler and condenser.

Direct Solar Energy

We burn fuel oil and coal that was formed by chemical processes ages ago, utilizing the radiant solar energy that went into the process of forming the hydrocarbons. Wood and other vegetation formed more recently can be made to release their latent heat energy in the same way. These are stored and transformed forms of energy that originally were supplied by the sun to make the vegetation grow. Dr. Abbot, of the Smithsonian Institution, made a solar engine in which he used direct radiation from the sun to furnish heat to the boiler. He made a practical operating model that gives promise of working satisfactorily in certain locations. One must select a place where sunshine is abundant, as in the southwestern states, so its field of application is limited. Since it requires the direct radiation from the sun for its operation it can be used only about half the time.

INFRARED SPECTROSCOPY

Spectroscopy in the visible and ultraviolet regions has been used for several decades in detection and analysis of some inorganic elements. During the last 10 years infrared radiations have become useful commercially in a similar manner, but with these radiations one can carry out investigations with organic substances that have hitherto been impossible by any other means. Some atoms or special groups of atoms forming component parts of a complex organic molecule are favorably situated to vibrate as small individual units uninfluenced by the molecule as a whole. Hence these groups may be identified by their absorption spectra in the infrared part of the spectrum.

The water molecule has a strong absorption band at 3.0 microns because of the hydroxyl or OH radical. Other absorption bands are found for water at 1.5, 4.75 and 6.0 microns. Minerals having water of crystallization in the crystal structure should reveal the presence of water by absorption bands at some or all of the places where the water molecule shows strong absorption. Two substances such as selenite ($CaSO_4 + 2\ H_2O$) and anhydrite ($CaSO_4$) illustrate the phenomenon nicely. Anhydrite shows strong absorption at 4.55 microns which is caused by the sulfate (SO_4) radical but does not show the strong water bands. Selenite, however, shows a strong SO_4 band and in addition shows the strong water bands.

Opal ($SiO_2 + H_2O$) shows the characteristic bands of quartz (SiO_2) and also the strong water bands. The CO_2 band at 4.28 microns, the 4.6-micron band of CO and the CH_3 band at 3.43 microns are characteristic of these chemical groups.

In the study of organic substances, infrared spectroscopy is a powerful and useful tool. In the study of plastics and hydrocarbons infrared spectra have added much useful information. In a series of hydrocarbons each single substance gives its own characteristic absorption band. A mixture of two or more such substances registers the composite structure. Having built up a library of absorption-band patterns of many simple substances it is relatively easy to match an unknown pattern to the known patterns to discover the composition.

Because of difficulties of manipulations, infrared radiations have not been studied as intensively as visible and ultraviolet radiations, but with increasing interest centered upon them they will yield much knowledge that can not be obtained by any other method of attack.

OBITUARY

JOSEPH CHARLES ARTHUR

THE death of Joseph Charles Arthur at Brook, Indiana, on April 30 removes one of the pioneer plant scientists in the United States and one of the foremost students of plant rusts in the world. He was connected with Purdue University for fifty-five years as professor of botany, botanist to the Indiana Experiment Station and emeritus professor.

Joseph Charles Arthur was born in Lowville, N.Y., on January 11, 1850, the only son of Charles and Ann (Allen) Arthur. His parents went westward when he was about six years old. They located first near Sterling, Ill., then at Charles City, Iowa, and later at Spirit Lake, Iowa. He received his bachelor's and master's degrees from the Iowa State College and his doctor's degree from Cornell University. He was a member of the first class to be graduated at Iowa State (1872), and his doctor's degree (1886) was the first conferred by Cornell University in the field of science. He studied also at Johns Hopkins, Harvard and Bonn. Later he received honorary degrees from the University of Iowa, Iowa State College and Purdue University.

The ambition to become a botanist developed early in the life of Joseph Charles Arthur. He had that goal in mind before he went to college and was greatly disappointed to find that botany was not being taught when he enrolled at Iowa State College. During his sophomore year Dr. Charles E. Bessey became a member of the faculty at Ames and an immediate friendship developed between the two men. A gifted and inspiring teacher gave an enthusiastic student his introduction to botanical science. Professor Bessey's courses in vegetable physiology and economic plants and lectures on weeds and parasitic fungi were an excellent foundation for a long and distinguished career in applied botany, plant pathology and mycology.

In 1872 the subject of botany had not been recognized by many colleges and universities in the United States, the state agricultural experiment stations had not been founded, and there were no state or national departments of agriculture. Little wonder that a graduate of that time found difficulty in obtaining a botanical position. The modern era of botanical teaching and research was in its infancy.