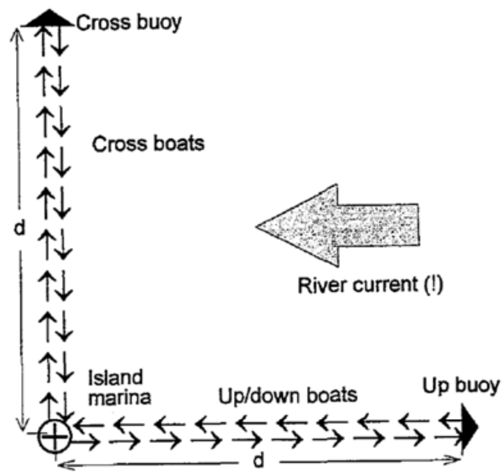

Figure 4.5b. Riverine analog to the M2 apparatus. The upstream and cross-stream buoys are a distance *d* from the marina. Compare Fig. 4.5a.

and orbited the Sun. There must be a current of ether moving through their laboratory. They expected that it would depend on the time of day and the season of the year, but the key factor was that the two rays, moving at right angles to each other, would be traveling in different directions with respect to the ether. It might be that one ray, during its round trip, would be traveling directly with and then against the ether current while the other ray would be traveling in a direction normal to the current. The two rays would be assisted or retarded by the current differently, and this would make their round trip times differ. From that difference, the direction and speed of the ether might be inferred.

We will not describe the details of their apparatus except to say that M2 did not *time* the rays on their paths. The time for a ray to complete its path was ~30 ns, not a trivial interval to measure even today, a century after M2.[y] Far worse was the fact that, under reasonable assumptions as to the magnitude of the ether current, the difference in time of the rays was about 10^{-17} s. They had no way to directly measure such a small quantity.[z] Rather, with a cleverness we can only admire, M2 created the two rays to be coherent and arranged for them, upon returning to the light source, to *interfere* with each other. A display of the interference "fringes" gave a hypersensitive indicator of any difference in transit time of the rays. The results of the M2 experiment are often described in texts in terms of "shifts" of the "fringes."

[y]M2 used paths that were ~11 m long.
[z]No more have we, today.

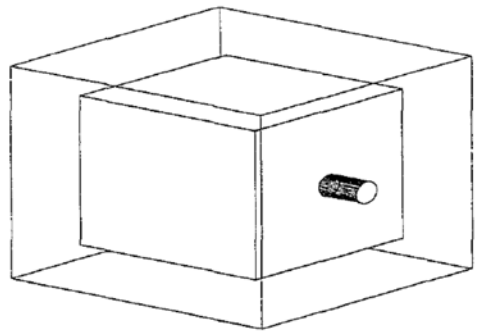

Figure 5.1. Blackbody cavity. Space between inner and outer walls packed with thermal insulation. Note peephole for observing interior radiation.

ible, easily controlled radiating body. A blackbody cavity is a heated, insulated enclosure, much like a pottery kiln (Fig. 5.1). Buried in the thick walls are heating elements, usually electrical resistance coils. The outer walls are made of insulating material to minimize the exchange of heat between the cavity and the outside. The important part of the cavity is its interior.

The cavity in the kiln is of any convenient shape and size and the walls of any refractory material. A narrow peephole penetrates the walls so that instruments can look in to observe the radiation filling the cavity.[i] The cavity is used in this manner: you turn on the heater coils to bring the interior to a desired uniform temperature. Then you read the cavity radiation through the peephole: so much energy at this wavelength, so much at that, etc. That is, you record the spectrum of the energy in the cavity.[16] If you heat the cavity to 5000 K, the spectrum is that of Fig. 5.2a.

The 5000-K Curve

Figure 5.2a shows how energy in the 5000-K cavity varies with wavelength. It is a plot of the *spectral radiant emittance* (SRE) of the blackbody against wavelength, λ. The SRE shows how much energy (in megawatts, MW) is emitted from a unit area (1 m^2) of the blackbody surface, within each narrow radiant band (in the figure, 1 μm wide).[j] At very short wavelengths in the ultraviolet (UV) region, the

[i]The peephole is narrow so that little radiation emerges from the interior; if much emerged, the spectrum of the light inside would be changed.

[j]We are discussing the *radiance* that a blackbody *emits*, and we are interested in how that radiance varies across the *spectrum* of wavelengths. The term *spectral radiant emittance* (SRE), although cumbersome, is apt. If we were to add up the spectral radiance at all the wavelengths to find the total energy emitted by the body, we would omit the qualifier "spectral" and talk about the *radiant emittance* (RE). The RE is the area under the SRE curve.

Since the emitter loses electrons, which carry negative charge, it becomes positively charged, thus explaining Hallwachs' earlier observations.

Up to this time, nothing startling had transpired. Light was recognized as a form of EM energy and it was known that an electron had a charge. If light landing on a metal body provided energy that influenced the emission of photoelectrons, what was odd about that?

Work on the PE continued in an effort to pin down the details: just how does light control the emission of photoelectrons? What role does the frequency of the light play? How does the intensity of the light affect emission? The laboratory conditions were primitive. Early investigators were plagued with erratic results: two pieces of the same metal didn't show the same photoelectric behavior. It was even difficult to get the same piece of metal to give the same results two days running. This is where the story becomes interesting.

1902 Philippe Lenard, a careful and talented investigator, studied the PE using many sources of light (most often a carbon arc whose intensity could be controlled) and a variety of metals as emitters. To avoid the erratic character of earlier measurements, Lenard carried out his measurements with the emitter in an evacuated tube.[5] His experimental setup is shown in Fig. 6.2: E is the emitter, a slab of the metal under test; C is the collector; the current to C consists of photoelectrons emitted by E. A retarding voltage can be applied to E to measure the energy of the photoelectrons.

We summarize Lenard's findings:

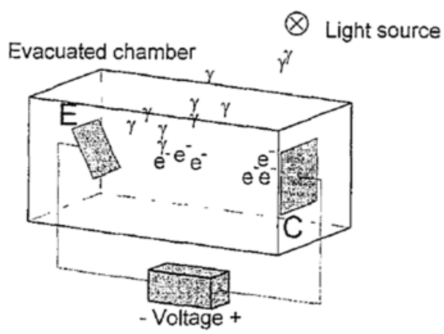

Figure 6.2. Lenard's apparatus. Photons (γ) from the light source enable the negatively charged emitter (E) to release photoelectrons (e^-), which move to the collector (C).