lenses made these transmission media economically attractive only for very wideband (perhaps a million voice circuits or equivalent bandwidths of video or data) communication systems. In the meantime, it became clear that the dielectric waveguides, particularly the low-loss optical fibers, would be cheaper and simpler to make, would have smaller cross sections, and would permit the fabrication of multifiber cables capable of practically satisfying any foreseeable bandwidth need.

3.2 Glass Fibers for Guided Optical Transmission

John Tyndall, the famous British physicist, demonstrated the basic principle of the dielectric waveguide in 1870 by showing that light moving through a medium with a higher index of refraction and striking an interface with a lower index of refraction at a sufficiently small glancing angle is totally reflected as though the interface were a perfect mirror. By the 1950s, the light pipe principle was being applied in medical instrumentation using glass-fiber bundles. By that time, methods had been developed for making what became known as a clad fiber—a core of glass of one refractive index surrounded by a glass cladding of lower index to isolate the core from its environment. However, the losses in these fibers were so high that their use was restricted to transmission over a few meters at most.

Reasonable estimates in the 1960s suggested that for an economically viable long-haul lightwave communications system, losses as low as 20 dB/km (one percent of the input power arriving at the end of one kilometer) would be needed. In those days the best optical glasses had losses of about 1000 dB/km, which were caused by impurities present even in the best available raw materials and in the crucibles used to melt them.

Early evidence that silica could indeed be made with optical loss sufficiently low for a communications system was advanced in 1966 by K. C. Kao and colleagues at the Standard Telecommunications Laboratories in England. In fact, they measured commercially available bulk silica with losses as low as a few dB/km. During the period between 1965 and 1970, research aimed at obtaining lower-loss fibers began in Japan, in England, and in the United States at Bell Laboratories and at Corning Glass Works. Kao and G. A. Hockham had speculated that glass fibers with losses as low as 20 dB/km should be achievable, and materials experts agreed that the possibility justified an exploration. For a detailed discussion of the research activities and achievements of Bell Labs scientists in low-loss fiber glass see Chapter 13, section 2.1.1 in the Physical Sciences (1925-1980) volume.

3.2.1 Fiber Structures

A number of different fiber structures have been made and studied over the years. The simplest is a solid dielectric fiber of a single material, with