

# EXTENDING THE BOUNDARIES OF LIGHTWAVE TECHNOLOGY

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This issue of the *AT&T Technical Journal* is largely devoted to the subject of lightwave communication. Fiber optics were first incorporated as a trial system in the telephone network of the United States in 1977. It would be conventional for an issue such as this to mark some particular event in the deployment of lightwave facilities in today's national network—events such as the use of fiber in the long-haul network or in the loop, or the use of a particularly advanced technology such as single-mode fiber, wavelength division multiplexing, single-frequency lasers, or systems operating at gigabits per second, or systems operating under water.

In fact, we have passed or are about to go beyond these and many other milestones. In less than 10 years, a totally new multi-billion-dollar industry has sprung up and most industrial nations across the world are striving to benefit from this industry both as manufacturers and as beneficiaries of the new technology, primarily in their telecommunication networks. The torrid pace of change seems likely to continue for years to come—change both in the technology, and in the extent to which this technology is used by society.

Thus, it cannot be claimed that this issue of the *AT&T Technical Journal* describes a particular plateau of achievement. Rather, it presents some of the major accomplishments of AT&T in lightwave technology up to the present and puts forward ideas of how the field may evolve in the future.

To those interested in the technology itself, the advances have been astonishing. Glass fiber can be made so pure that light signals carrying vast amounts of information can travel without amplification for well over 100 miles. Not only is this glass of unprecedented purity, but the fibers are constructed with remarkably subtle compositional variations across their diameters so that the light remains within the fiber over these long distances. In addition, the sharply defined pulses of light launched into the fiber do not become broadened and indistinct after their long journey.

## **In This Issue**

*This issue of the AT&T Technical Journal has as its theme the recent advances in lightwave technology. The articles are a representative sample of the field including research, development, and manufacturing.*

- In "Advances in Lightwave Systems Research," Tingye Li describes recent research milestones with special emphasis on high-speed transmission enhanced by wavelength multiplexing. He also discusses the possibility of coherent lightwave transmission in both long-haul trunking and local networks.
- Focusing on single-mode fiber, Kallish and Cohen deal with the design and performance of step-index core fiber with depressed-index cladding, and examine three other potentially useful fiber types: dispersion-shifted fiber, dispersion-flattened fiber, and polarization-maintaining fiber.
- Jablonowski, Paek, and Watkins describe recent advances in optical fiber manufacture, especially the fiber drawing process. Fiber draw rate has been increased significantly without any degradation in fiber performance or specifications.
- In "Lightwave Device Technology," Dixon and Dutta discuss lightwave transmission system lasers and LEDs as well as PIN and avalanche photodiodes.
- Anderson, Frey, and Miller present optical fiber splicing techniques for single and multiple fibers. They also review basic connectors, including the biconic connector for single-fiber lightguide cable and the ST® connector for short-haul multimode applications. Methods for minimizing optical loss in splices and connectors are also included.
- In "Lightwave Data Links and Interfaces," Welsh discusses the ODL® family of optical transmitter and receiver modules. These products allow communication over optical fibers as well as parallel-to-serial translation and standard communications interfaces.
- Gartside, Panuska, and Patel summarize the optical and mechanical performance of ribbon and Lightpack™ single-mode lightwave cables. Both cables perform well in underground ducts, buried plant, and aerial installations.
- Sanferrare discusses lightwave systems for metropolitan and long-haul trunking applications and the use of the AT&T FT Series G system in a nationwide integrated digital network.
- As reported by Nantz and Shenk, the AT&T DDM-1000 lightwave multiplexer and the SLC® Series 5 carrier system are designed to meet the requirements of the loop (small size, flexibility, environmental robustness, and maintenance capabilities). These devices make fiber an economic alternative for the feeder loop.

Equally remarkable are the semiconductor structures that generate and detect light pulses transmitted by the fibers. Semiconductor lasers are complex in their chemistry and can sustain enormous energy densities. In addition, their quality and reliability are such that they are being used in transoceanic submarine cable systems with only minimal system failures expected over more than 24 years.

Many other technological achievements have rapidly and successfully become industrial realities. As a

result, lightwave communication is having a profound effect upon all sectors of the telecommunication business. These include the loop area extending to customer premises, the exchange area between central offices in a metropolitan region, the long-haul intercity arena, and the submarine cable area. In all of these, fiber is already dominant or soon will be. Other applications abound, such as links within electronic assemblies or as essential parts of local area networks, or in military applications. Many such applications are described in this issue.

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But how will customers benefit from this remarkable technology? Because this is a cost-effective technology providing bandwidth less expensively than competing technologies, customers should see lower prices, or at least lower increases than would otherwise be the case.

But it is not only price benefits that will be apparent. Lightwave communication finally has made possible cost-effective digital voice transmission on an end-to-end basis. Until now, digital voice transmission could not compete with analog voice transmission in the long-haul market. There was no elegant and convenient way of combining all forms of communication (voice, data, and image) onto one universal stream.

Now however, as a result of digital connectivity, many new digital services are appearing in the market place that will offer greater capabilities. Customers will have almost unlimited bandwidth at low cost, which can be used in a variety of ways. Customers will be able to monitor and reconfigure dedicated parts of the network themselves. There can be little doubt that this convenient, flexible capability will lead to uses and services that not even the network providers themselves have fully understood or anticipated.

The effects on society will be profound. As some claim, we may indeed be on the verge of the era of Universal Information Services. One reason for such bold claims is that lightwave technology has by no means reached maturity. To cite just one example, at present all sources of light used for practical purposes in the industry are of a spectral purity that one can only describe as grossly coarse when compared to the spectral purity of radio carrier waves. Furthermore, those sources are not tunable in the way that radio oscillators may be tuned. There is no reason that such sources can not be brought into practical form. In research laboratories, they already exist. As a result, new fields exist that may provide still more spectacular capabilities and services.

This issue of the *AT&T Technical Journal* provides a useful and interesting review of where this remarkable lightwave technology is today, less than a decade after its initial use. It also provides some vision of where it may be ten years hence.

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