CONNECTIONS

Metal connectors protect fibers during termination and in the field

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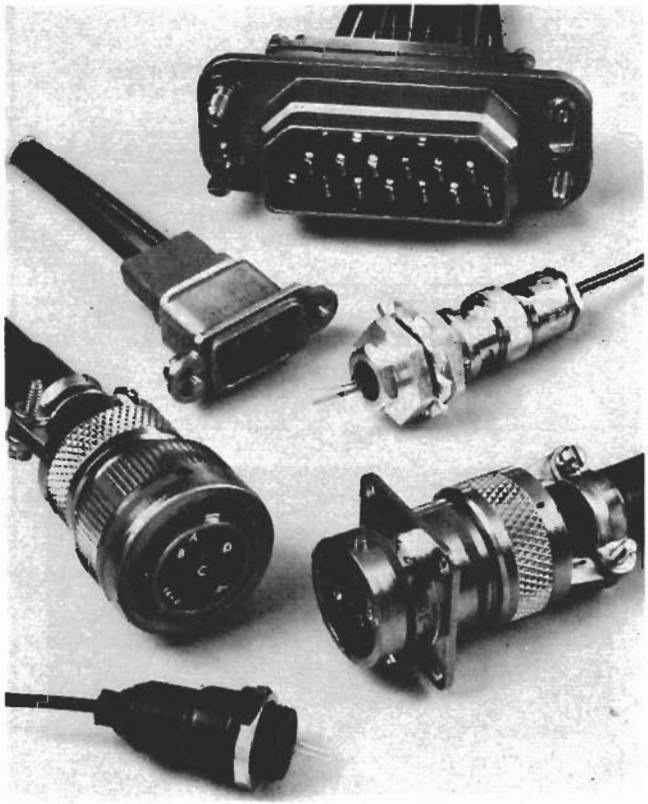
Metal connectors that terminate or couple fiber bundles differ from single-fiber metal connectors both in the way they deal with fiber alignment, handling and protection and in optical end preparation.

Some requirements, though, are identical. Both types of connector must provide for terminating the jackets, strength members, and buffering materials used in fiber cables, and both must insure that loads applied to the cable are not transmitted to the terminated fiber. Moreover, optical-fiber connector designs must provide for protection of the fibers during termination and end preparation as well as after they are installed in the connector.



1. Wide selection. Connectors for fiber-bundle cables are available in both circular and rectangular shapes and can accommodate from 1 to 18 optical channels. These products can also couple either photodetectors or light sources to fibers.

Alignment critical

The alignment of a fiber bundle with a LED or laser diode source, photodetector, or other bundles is far less critical than the alignment of a single fiber for these same three connection areas. The coupling losses between pairs of fiber bundles as well as single fibers depend heavily on their degree of lateral (or axial) misalignment.

Rather less critical than lateral alignment is the size of the gap between prepared fiber ends (though there must be a gap), and less critical still, though still important, the angular alignment of their center lines.

In separable connectors it is extremely important that the prepared ends of the fibers do not touch since otherwise repeated matings of vibration and shock will chip and scratch the optical-fiber surface and degrade the optical efficiency of the connector. But the gap cannot be too large—if the coupling losses contributed by it are to stay within 0.2 decibel, it should not exceed 10% of the active core diameter of the fiber bundle or single fiber. This works out as a 75-micrometer (0.003-inch) gap for a typical 1,125-μm (0.045-in.) bundle or a 5-μm (0.0002-in.) gap for a 50-μm (0.002-in.) core for single fiber.

The loss characteristics for these gaps also vary slightly as a function of the numerical aperture of the bundle or single fiber. Angular misalignment within $\pm 1^\circ$ for bundles of optical fibers and half that for single optical fibers results in acceptable losses of from 0.1 dB to 0.2 dB.

For both bundle and single-fiber connectors, a chip-free, scratch-free, flat surface, perpendicular to the fiber centerline, is essential for good optical coupling. If any of these conditions is lacking, light scattering occurs at the fiber ends.

Fiber-bundle termination

A rather simple polishing procedure can produce a sufficiently good optical interface on a fiber bundle. When being polished, all of the fibers must be held rigid and adequately supported to prevent them from

chipping or cracking.

Usually, the fiber bundle is first stripped of its jacket and fiber buffering materials, and the exposed fibers are cleansed of lubricants and contaminants. For most cables, epoxy is applied to the fibers to immobilize them, and the bundle is slipped into a termination device that packs it into a tight hexagon. The hex shape provides the optimum packing fraction (the ratio of the cross-sectional area of the fiber cores to the total area of the fiber bundle). At this point, the epoxy has cured, and any excess fiber length is cut off with wire cutters or scissors.

A two-step, wet-polishing procedure comes next. First a 400 grit abrasive is used to rough-polish the ends, and then a 0.03-micrometer paste applied with a felt wheel produces the final finish. The two steps take less than 1 minute. Additional polishing does not improve matters and often reduces optical efficiency because it may dome the fiber ends. The final step is to protect the prepared end with a thin, transparent cap supplied with the connector.

Single-fiber termination

The end preparation and termination for a single fiber is significantly different. The jacketing and fiber buffering materials are removed, as before, but the exposed fiber is then broken in a fixture to the precise length required. (Fixtures capable of producing the necessary controlled, consistent break have been developed by several manufacturers.) Also, the fiber end must be precisely located within the terminating device, and this critical step must be accomplished by other special fixtures.

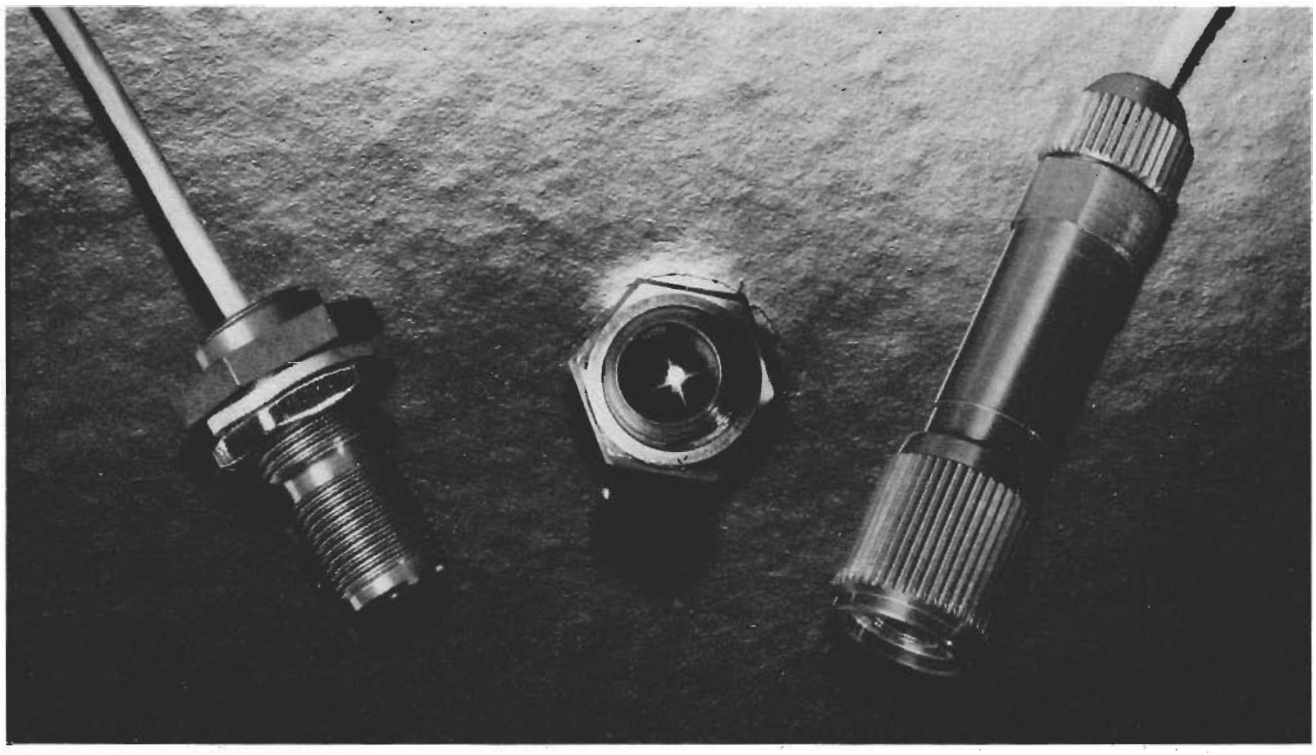
Several manufacturers offer a variety of optical connectors for the termination of fiber bundles. Circular or rectangular in shape, these accommodate from 1 to 18 optical channels or combinations of electrical and optical channels. Several connectors in various sizes and mounting styles available from ITT Cannon (Fig. 1) couple standard LED or laser-diode sources to fibers, fibers to fibers, and fibers to photodetectors.

Coupling losses depend on the size and number of fibers in the bundle, the core-to-cladding ratio of each fiber, and the numerical aperture of the fiber bundle. Losses from fiber bundle to fiber fall between 2.5 decibels and 3.5 dB.

Making a match

Source-to-fiber and fiber-to-detector coupling efficiency, however, varies not only with the connector but with the device characteristics and how well the fiber is matched to either detector or source. For example, an edge-emitting laser produces a doughnut of light in the near field; if the fiber is placed in the middle, then no light is coupled into it. As for the connector's effect, using different types to couple commercially available light-emitting diodes and photodetectors to fiber-bundle cables results in a wide range of coupling losses—source-to-fiber bundle coupling loss can vary from 3 dB to 14 dB with off-the-shelf devices while fiber-bundle-to-photodetector coupling loss can vary from 0.5 dB to 8.5 dB.

In addition to selling just optical connectors, some manufacturers offer an economical bundle-termination service as well as complete cable assemblies. Most also plan to offer tooling and fixtures to terminate bundles in the factory as well as in the field.



2. New entry. Few companies as yet are marketing single-fiber-per-channel connectors, but this recently released connector from ITT Cannon Electric can be used to join two single fibers or to couple a photo or a LED or laser diode to the fiber.

Connectors for some single-fiber cables are presently offered on a limited quantity, special-order basis. In fact, the only types available at present are for cables containing either one or six functionally different fibers. The single-fiber-per-channel connector shown in Fig. 2 is a very recent introduction.

The coupling efficiencies of these single-fiber connectors vary with fiber type, overall fiber size, core size, and the numerical aperture of the fiber. Fiber-to-fiber optical losses also vary, depending on the quality of the fiber-end preparation and accuracy of termination location within the termination device. Typically, coupling losses of from 1 dB to 2.5 dB are expected in these connectors.