OPTICAL FIBER CABLES AND CONNECTORS FOR MINI-HUB

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INTRODUCTION

New large core fibers, special cable constructions, and associated optical connectors have been developed in support of a major system effort to distribute television signals within a high density area or high rise apartment buildings. This new system, known as MINI-HUB, has a star configuration with dedicated fiber pairs connecting each apartment to a Central Distribution Unit (CDU). One of the fibers is used to transmit a single modulated TV channel from the CDU to the subscriber while the other transmits a digital channel select signal from the subscriber back to the CDU. A more detailed description of this system is given in a paper entitled "MINI-HUB Addressable Distribution System for Hi-Rise Application," which is presented by M.F. Mesiya et al in the session on New Developments in Addressable Hardware. This paper deals with the optical fibers, cable constructions and optical connectors developed for the MINI-Hub system.

FIBERS

The development of fibers for this system was guided towards the most cost effective design that would satisfy the following technical requirements:

- Low loss: less than 10dB/km.
- A bandwidth length product sufficiently large to transmit TV signals at the Channel 3 or 4 carriers (60 or 66MHz) for distances up to 500 meters.
- A sufficiently large core that inexpensive connectors (approximately $1 per fiber end) could be used with insertion losses of no more than 2dB per connection.
- A large enough core and numerical aperture to accept more than 100μ Watts of light from state-of-the-art LED sources.

The preferred fiber design which economically satisfies all of these requirements has a 200μm core of pure silica and a 25μm thick cladding layer of borosilicate glass which builds up the outside diameter to 250μm. The core diameter at 200μm makes the cross-sectional area 16 times greater than that of the 50μm diameter international standard fiber used in telecommunications. This is a significant advantage since light collection from an LED is directly proportional to the core area. Another advantage of the large core is that it substantially reduces the tight tolerances and thus the cost associated with optical connectors.

Low fiber cost is realized through the use of the inexpensive binary borosilicate glass system: a low refractive index borosilicate cladding deposited over a pure fused silica core. This simple step index doping scheme enables tight process control. Processing time is minimized through the use of pre-sintered silica start rods of high optical quality, upon which a substantially constant composition of borosilicate glass is deposited. The cost of the materials used to make this fiber is only a fraction of the cost associated with the alternate germanium doped silica type fibers. The difference is due to the abundance of the boron dopant as compared to germanium, which is now considered a strategic material by the U.S. Government. The numerical aperture of this waveguide is targeted at 0.15. This produces an intrinsically large bandwidth-length product, atypical of higher numerical aperture step index waveguides, with the result that the highly practical value of 45MHz is achieved. Over short distances of 1/2 kilometer or less, single channel video bandwidths fit well within the capacity of these fibers.

CABLE

Two basic cable constructions have been designed for MINI-HUB. The first is a dual fiber construction for "home runs" directly from the CDU to a subscriber's Residential Interface Unit (RIU). The dedicated fiber pair cable construction used in these runs is packaged in a single oval element reinforced with two steel wires to give it a pull strength of over 80 pounds. A cross section of this cable is shown in Figure1. Its area is only a fraction of that of RG-59 coax, yet its durability and flexibility are comparable to coax.

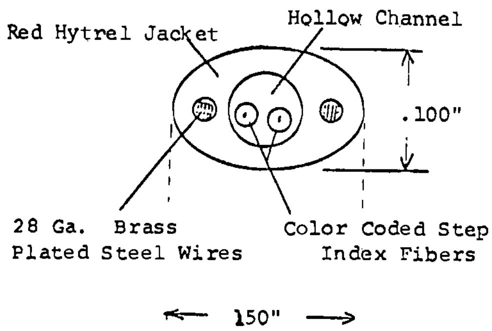

Figure 1

The other type of cable that has been developed for MINI-HUB is a multi-strand construction that will typically be run in vertical risers where space is at a premium. The riser cable may contain 8, 12, 16 and up to 24 fibers. The outside diameter of this cable is approximately 1/4 inch. Thus, a single riser cable, with dimensions comparable to RG-59 coax, can serve up to 12 subscribers. This multi-fiber cable is available with a polymer outer sheath or in a seamless aluminum jacket, where required by fire codes.

These cables are particularly well-suited for termination with optical connectors. The first step in terminating the oval element is to use a knife or razor blade to cut into the jacket about 6 to 8 inches from the end. The blade is then glided along steel reinforcing wires to strip away the polymer and expose the fibers. In completing the connector assembly, the steel wires are fastened to the backshell of the connector so that axial pull forces are not directly transmitted to the fibers. The fiber can be terminated with a rugged connector assembly in less than 5 minutes under field conditions using the connectors described in the following section.

CONNECTORS

Experience gained early in 1980 with our first MINI-HUB installation established that available connectors were not well suited either due to their high cost or long installation time. Installation was protracted by the curing time of the epoxy glue used to secure the glass fiber to the connector body and by the time to polish the fiber end. As a consequence we set the following objectives for our current MINI-HUB connector development:

- Installation time: less than 5 minutes per fiber end.
- Cost: approximately one dollar per end.
- Minimum reliability: comparable to a coax F-connector.

These objectives have been met by an internal development at TFC and are being in parallel by several other connector manufacturers. The TFC connector is shown in Figure 2a and Figure 2b.

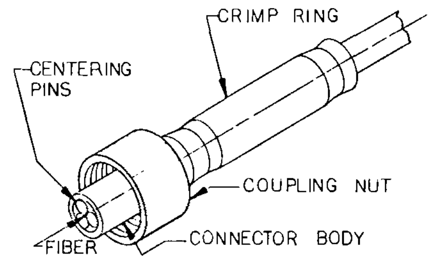

Figure 2a

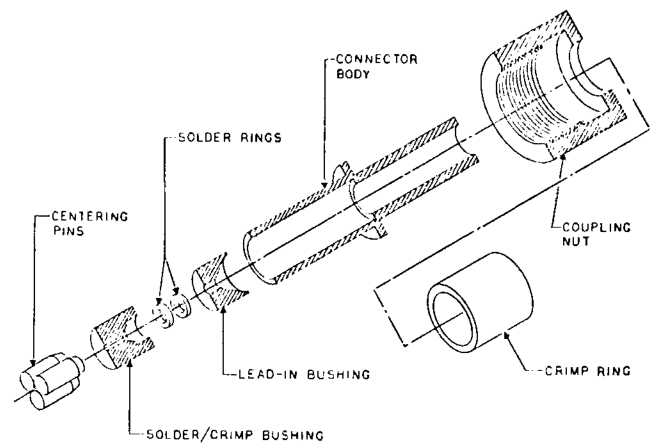

Figure 2b

There are three key features in this connector design. First, the fiber is aligned and precisely centered along the axis of the connector body by three precision ground pins. Secondly, the glass fiber is rapidly secured to the metal body of the connector by a unique soldering technique. Brief application of external heat with a soldering pliers causes the solder preform rings inside the connector barrel to melt. Upon cooldown the fiber is permanently fused in place with a direct pull strength of several pounds. It should be noted that the glass fiber is not subject to such a high tensile load in actual use because the load is transferred to one of the steel wires in the cable jacket which is secured to the connector backshell. The final feature of this connector relates to the elimination of the necessity to polish the fiber end. Rather than polish, we have developed a compatible cleaving tool which can be used to prepare the end of the fiber in a fraction of a minute.

CONCLUSION

In conclusion, a low cost, high quality glass optical fiber, associated cable constructions, and connectors have been optimized for use in high volume, short to medium distance applications. These items have passed through a complete development-cycle and are now in manufacturing. Fiber parameters have been chosen to match the objectives of a new video distribution system in a cost effective fashion. Although the fiber, cable and connectors were specifically tailored for MINI-HUB, similar system objectives tend to guide the fiber selection for most short to medium distance analog and digital links.

ACKNOWLEDGMENT

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