

## History

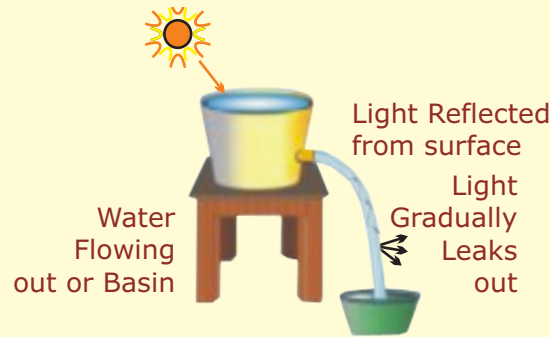
In 1870, **John Tyndall**, demonstrated that light used internal reflection to follow a specific path.

**Alexander Graham Bell**, in 1880, patented a method of light transfer called "piping light"

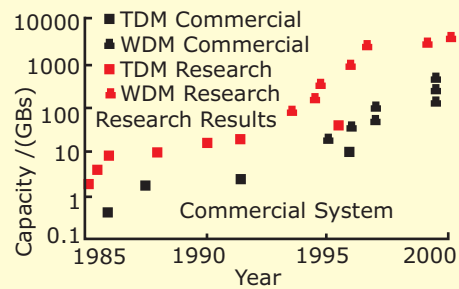
**William Wheeling** developed an optical voice transmission system he called the photophone.

## Light wave Evolution

- 1975 : Coax, 274 Mb/s at 1km repeater spacing
- 1980 : 0.8 um GaAs lasers, MMF, 45 Mb/s @ 10km
- 1987 : 1.3 um, In GaAsP lasers, SMF, 1.7 Gb/s @ 50km
- 1990s : 1.55 um In GaAsP DFB lasers, SMF, 2.5-10 Gb.s @ 40km
- 1990s : WDM, 1.55 um InGaAsP DFB lasers, EDFA, SMF, 2.5-10 Gb.s @ 300-10,000km repeater spacing
- 2002 : 64 WDM chx 10Gbps over 250,000 km span

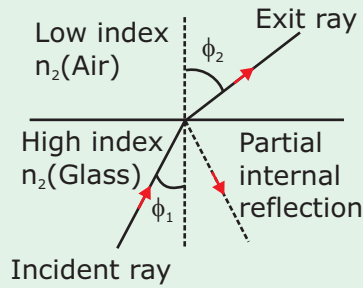


## The Arrival of Optical Revolution



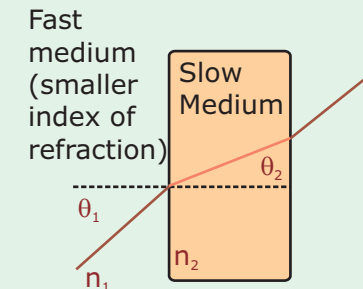
## Total Internal Reflection

The angle of incidence  $\phi_1$  and refraction  $\phi_2$  are related to each other and to refractive indices of dielectrics by Snell's Law of Refraction which states that:



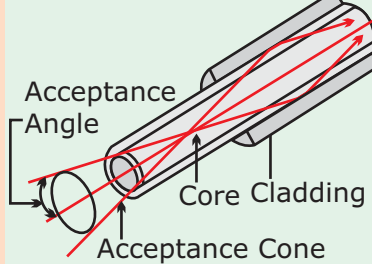
## Snell's Law

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$



## Numerical Aperture & Acceptance Angle

$$N.A. = \sqrt{(n_1)^2 - (n_2)^2}$$

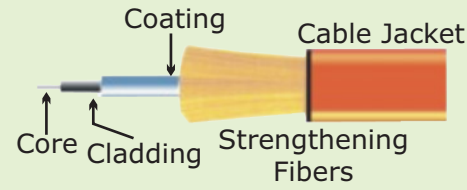


## Advantages of F.O.

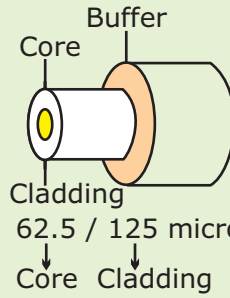
- Greatly increased bandwidth and capacity
- Low signal attenuation (loss)
- Immunity of Electrical Noise
- Immune to noise (Electromagnetic interference) [EMI] and radio frequency interference [RF]
- No crosstalk
- Lower bit error rates
- Signal Security
- Difficult to tap
- Non-conductive (does not radiate signals Electrical Isolation)
- No common ground required
- Fiber optic components are expensive
- The lack of standardization
- More difficult and expensive to splice than wires.

- Freedom from short circuit and sparks.
- Size and Weight
- Environmental Protection
- Resistant to radiation and corrosion
- Resistant to Temperature variations.
- Improved ruggedness and flexibility.
- Less restrictive in harsh environments
- Overall System Economy
- Low per-channel cost
- Lower installation cost.

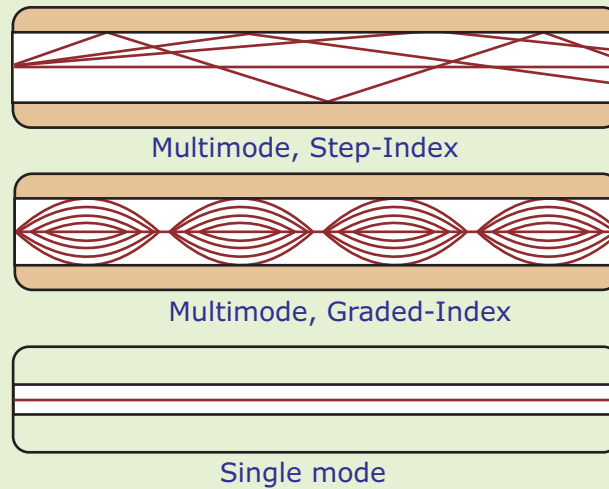
## F.O. Cable Construction



The simplest fiber optic cable concentric of two concentric layers of transparent materials. The inner portion (the core) transports the light; the outer covering (the cladding) must have a lower refractive index than the core so the two are made of different materials. To provide mechanical protection of the cladding an additional plastic layer; the Primary Buffer is added. Some constructions of optic fiber have additional layers of buffer, which are then referred to as Secondary Buffer. It is very important to note that the whole fiber Core, Cladding & Primary Buffer is solid and the light is confined to the core by the Total Internal Reflection due to the difference in the refractive index of the core compared to that of cladding.



## Cables



## Refractive Indexing Material

Vacuum	1.00000	Glass	1.5
Air at STP	1.00029	Sodium Chloride	1.54
Ice	1.31	Flint glasses	1.57-1.75
Water 20°C	1.33	Extra dense Flint	
Acetone	1.36	EDF-	1.7200
Ethyl alcohol	1.36	Diamond	2.417
Glycerine	1.473	Sapphire	2.417
Sugar (80%)	1.49		

## F.O. Communication System



Transmitter	Optical Fiber	Optical Regenerator
Produces and encodes the light signals	Conducts the light signals over a distance	May be necessary to boost the light signal (for long distance)
! Format	! Loss	! Bandwidth
! Bandwidth	! Dispersion	! Responsivity
! Protocol	! 4-Wave Mixing	! Sensitivity
! Modulation	! Boise	! Noise
! Characteristics	! Crosstalks	! Wavelength
! Power	! Distortion	

Fiber is deployed at a rate of 200 miles every hour.

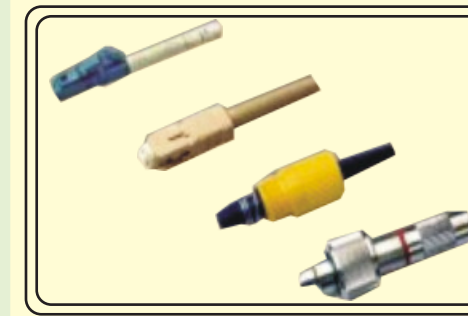
## Losses in F.O.

- Attenuation
- Material Absorption Losses
- Linear Scattering Losses
  - Ray Leigh Scatter
  - Mie Scattering
- Non Linear Scattering
- Micro Bending and Macro Bending
- Dispersion
  - Inter modal Dispersion
  - Intra modal Dispersion

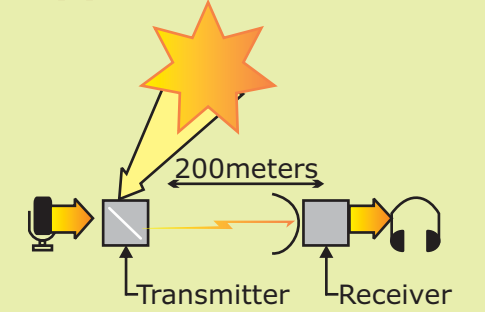
## F.O. Components

### Transmitter ! LEDs, Laser Diode Receiver

- ! Cables
- ! Connectors
- ! Splices
- ! Amplifiers
- ! Hardware (Installation hardware, patch panels, splice closures, conduit)



## Applications of F.O.



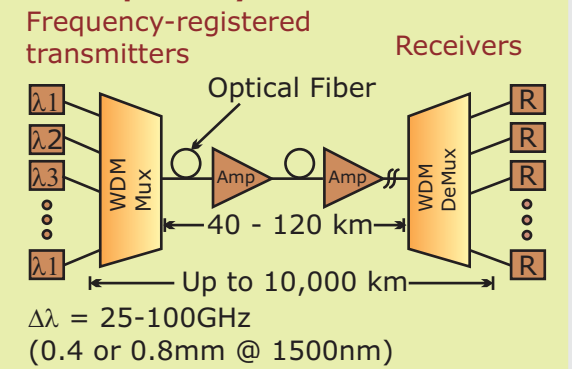
### Applications-Networks

- ! Telecom, SONET, ATM, DWDM,
- ! Fiber Amps, CATV
- ! AM vs FM vs Digital HFC, LANs, Ethernet
- ! Token Ring, FDDI, SANs, ESCON, Fiber

### Applications-Links

- ! Video, Security, Broadcast TV, Industrial links
- ! RS-232, RS-422, Wireless Antennas
- ! Utility gnd management, Sensors

### VDM Optical System



## Fiber Optics Connectors

Connector	Insertion Loss	Repeatability	Fiber Type	Applications
	0.50 -1.00dB	0.20 dB	SM, MM	Datacom Telecommunications
	0.20 -0.70dB	0.20dB	SM, MM	Fiber Optic Network
	0.15 dB(SM) 0.10dB (MM)	0.2dB	SM, MM	High Density Interconnector
	0.30 -1.00dB	0.25dB	SM, MM	High Density Interconnector
	0.20-0, 45dB	0.10dB	SM, MM	Datacom
	0.20-0, 45dB	0.10dB	SM, MM	Datacom
	Typ. 0.40dB (SM) Typ. 0.50 dB (MM)	Typ. 0.40dB (SM) Typ. 0.20 dB (MM)	SM, MM	Inter/Intra Building, Security, Navy



28505 Fibre-Optic trainer



28507 Laser Fibre Optic Trainer



28508 Physics of Fiber Optics Trainer



28512 Multiplexer / Demultiplexer



28520-21 Fiber Optic Connectorization Kit



28522 Fiber Optic Connectors Kit



28524 Optical Power Meter



28526 Fibre Optics Communication Trainer