

Section - B

Lecture – 8

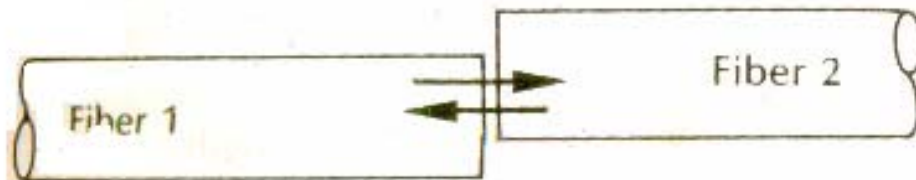
Fiber Couplers & Types

Fiber Couplers

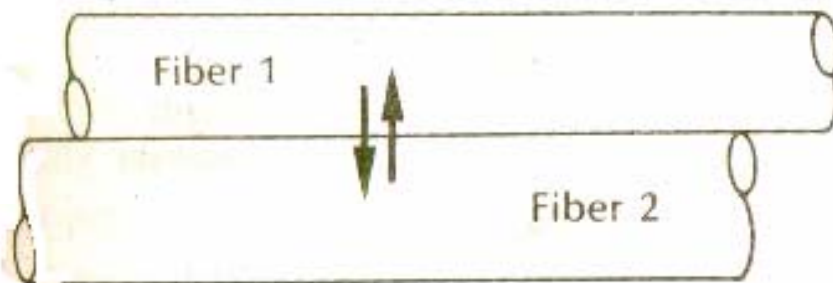
Fiber Coupler is a device which distributes light from a main fiber into one or more branch fibers.

Power Transfer can take place either

- Through fiber core cross –section by butt-jointing the fibers (core interaction).
- Through surface interaction (normal to axis).



(a)



(b)

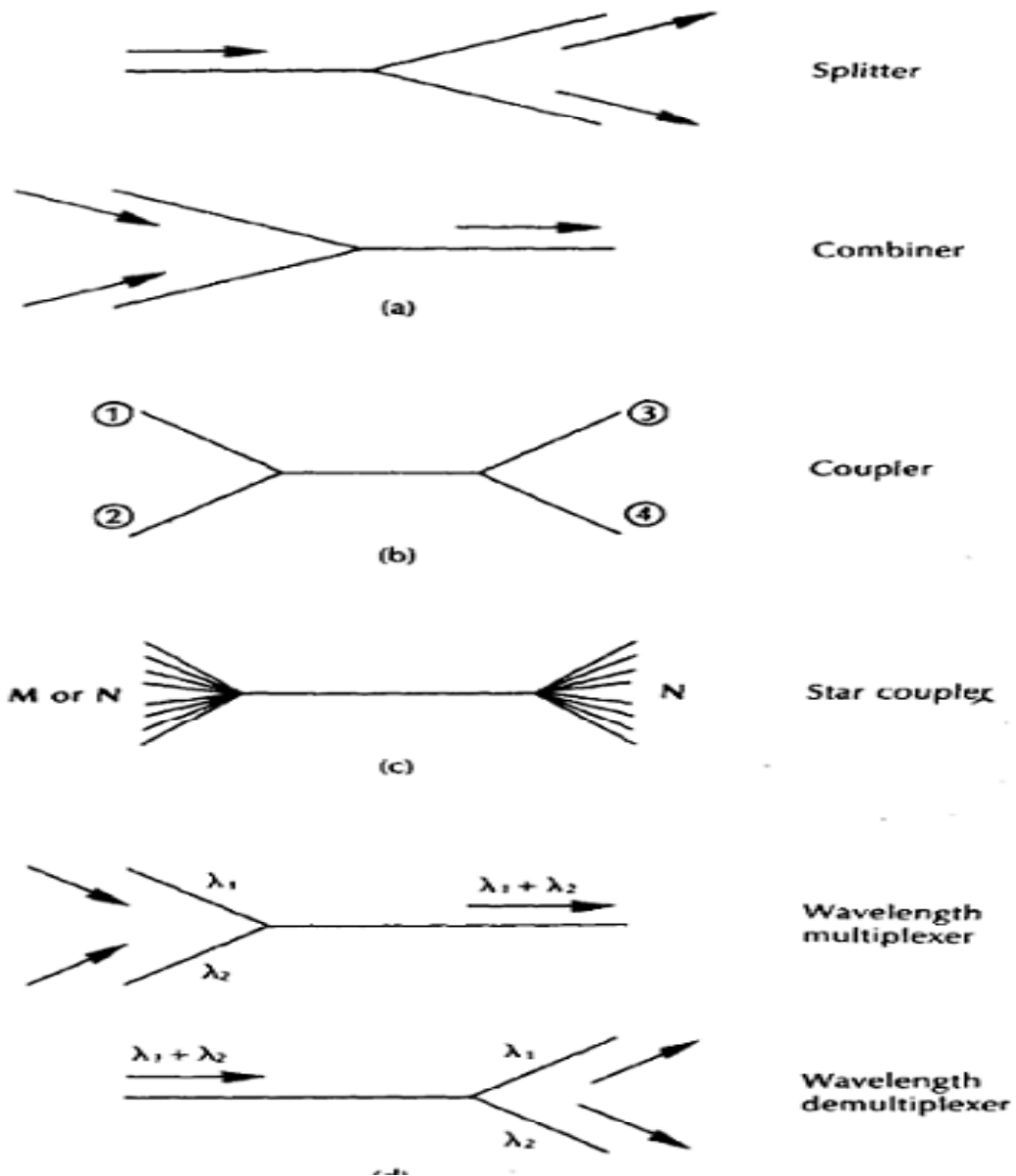
Classification of optical fiber couplers: (a) core interaction type; (b) surface interaction type.

Coupler Types & Functions

Coupler Type	Function
Three /Four port couplers	signal splitting, combining ,distribution
Star Couplers	Single I/P- multiple outputs.
Wave Length division multiplexing	Multiplexing
Wavelength division De-multiplexing	De-Multiplexing

Note : Ideal fiber couplers should distribute light among branch fibers with no scattering loss/noise etc. and should be insensitive to fiber modes & polarization of light.

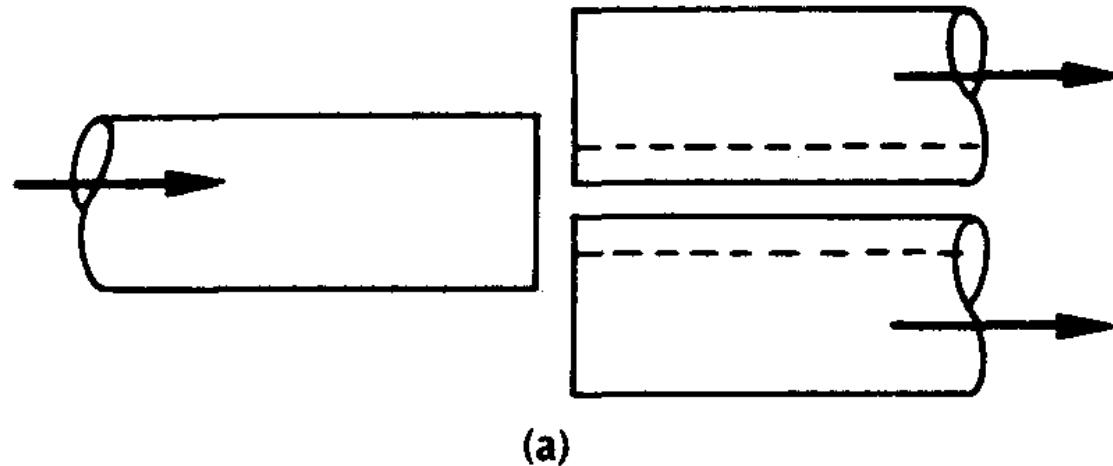
TYPES OF COUPLERS



Optical fiber coupler types and functions: (a) three port couplers; (b) four port coupler; (C) star coupler; (d) wavelength division multiplexing and demultiplexing couplers.

- Note:1) The finite scattering loss at the coupler limits the number of terminals that can be connected.
- 2) generation of noise can cause problems in the specification of network performance.

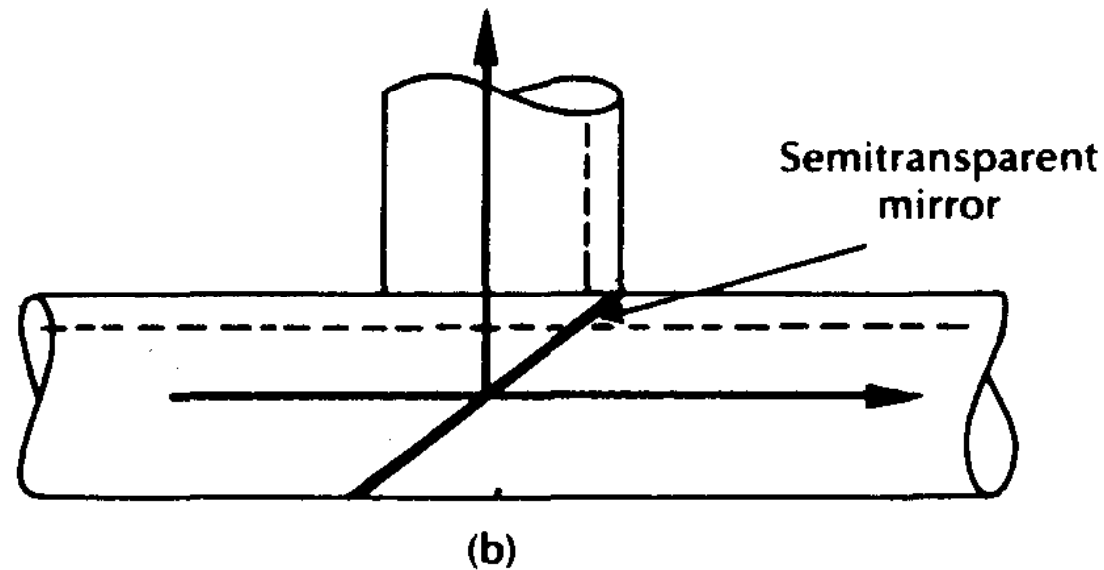
Fabrication Of 3 port fiber coupler



Fabrication techniques for three port fiber couplers: (a) the lateral offset method;

Lateral Offset Method

- Relies on overlapping of fiber end faces
- Coupling of light (between I/P & O/P fibers) depends on degree of overlap. Thus lateral offsets control the proportion of power transferred to o/p fibers
- Technique is bidirectional
- However losses are higher

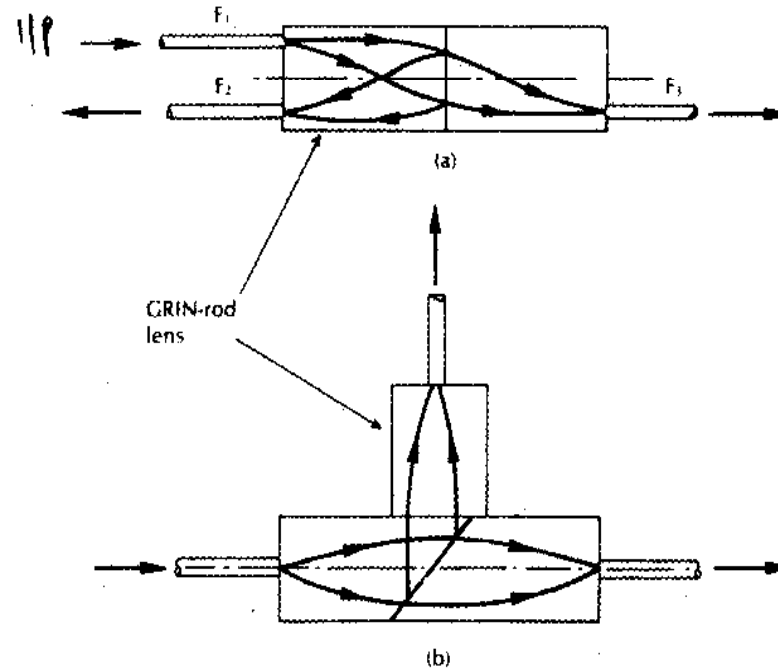


(b) the semitransparent mirror method.

- The partially reflecting mirror is a thin film beam splitter
- The i/p power can be split in any ratio between reflected & transmitted beams depending upon mirror properties.
- Typical excess Loss : 1 to 2 dB.

Grin –rod Lens based micro-optic fiber couplers.

- Consists of 2 quarter pitch lens with a semitransparent mirror in between.
- A portion of light incident on mirror is reflected back. (fiber F_2).
- The transmitted light goes to fiber F_3

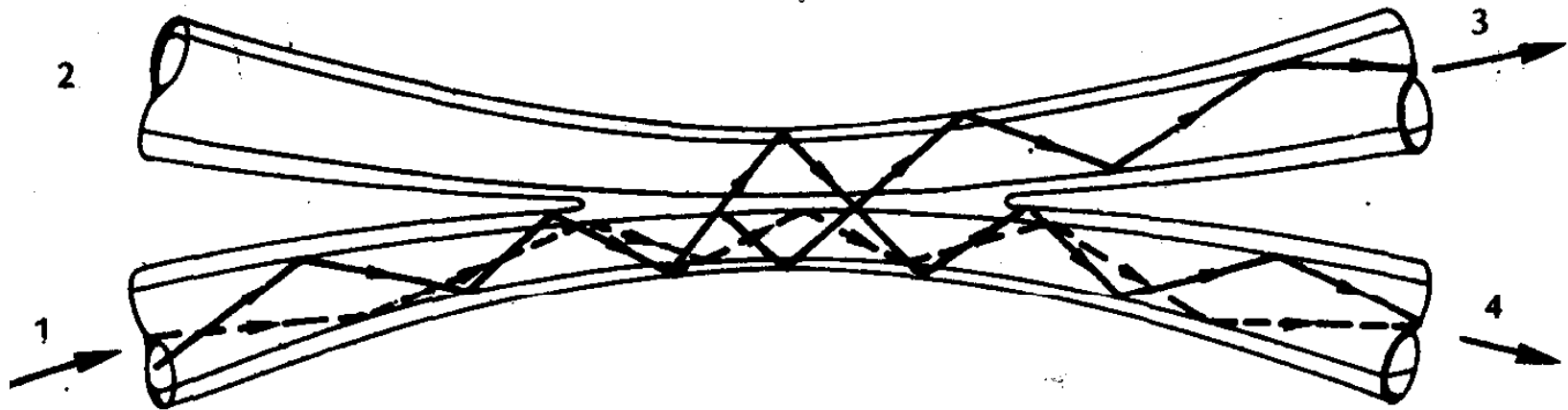


GRIN-rod lens based microoptic fiber couplers: (a) parallel surface type; (b) slant surface type.

- Note : Parallel surface type, is more attractive due to its ease of fabrication, compactness, simplicity and relatively low insertion loss.

FUSED BICONICAL TAPER TECHNIQUE

Fibers are generally twisted together and spot fused under tension, so as to form an elongated biconical taper structure.



Structure and principle of operation for the fiber fused biconical taper coupler.

FBT (contd)

- **3 port coupler is formed by removing one of the i/p fibers.**
- Optical power launched propagates in the form of guided core modes.
- Higher order modes take part and only a portion of the total power gets coupled (lower order modes generally remain within the main fiber)
- When waist of taper is narrow, entire mode volume participates and a large portion of i/p power can be shared between o/p fibers.

Note: coupling ratio obtained is mode dependent.

Various loss parameters(4 port coupler)

$$\text{Excess loss} = \frac{\text{Power I/P}}{\text{Power O/P}} = 10 \log_{10} \frac{P1}{P3 + P4} \text{ (dB)}$$

$$\text{Insertion loss (port 1 to port 4)} = 10 \log_{10} \frac{P1}{P4} \text{ (dB)}$$

$$\text{Cross talk} = 10 \log_{10} \frac{P2}{P1} \text{ (dB)}$$

This provides a measure of directional isolation where P2=backward scatter power (port 2)

$$\text{Splitting ratio} = \frac{P3}{P3 + P4} * 100\%$$

Losses in star coupler

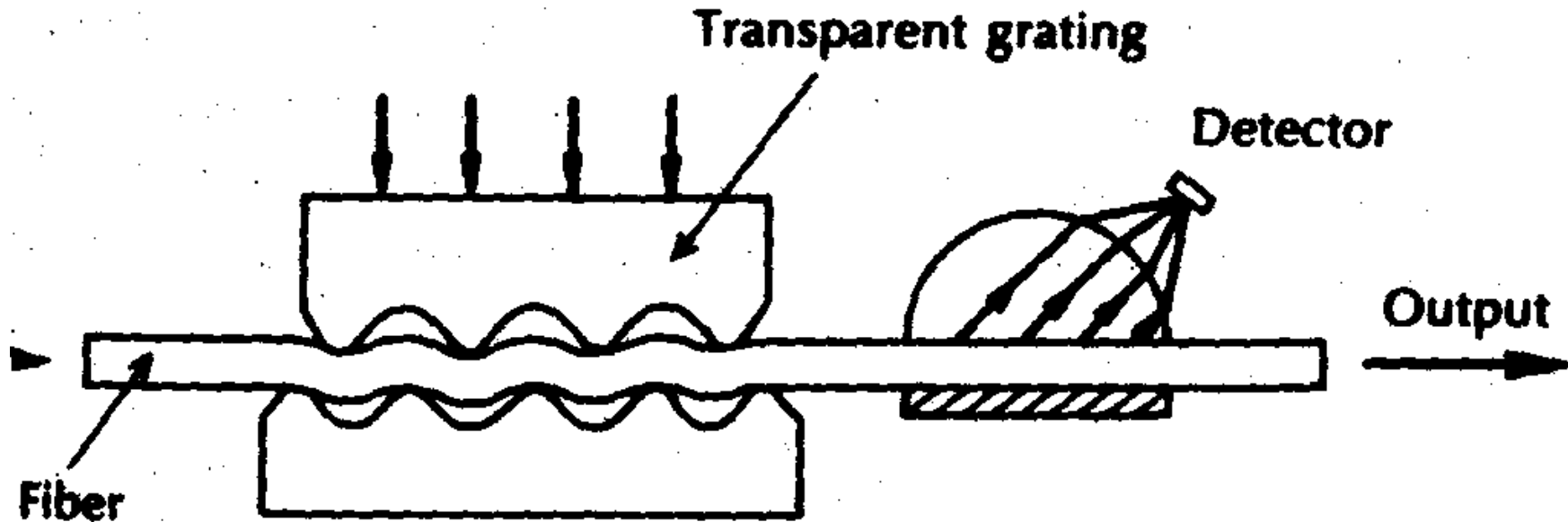
$$\text{Splitting loss} = 10 \log_{10} N \text{ (dB)}$$

Where N=total no. of ports (i/p+o/p)

$$\text{Cross talk} = 10 \log_{10} \frac{P2}{P1} \text{ (dB)}$$

Splitting ratio indicates the % age division of Optical Power between output ports.

TYPES OF COUPLERS- microbend type



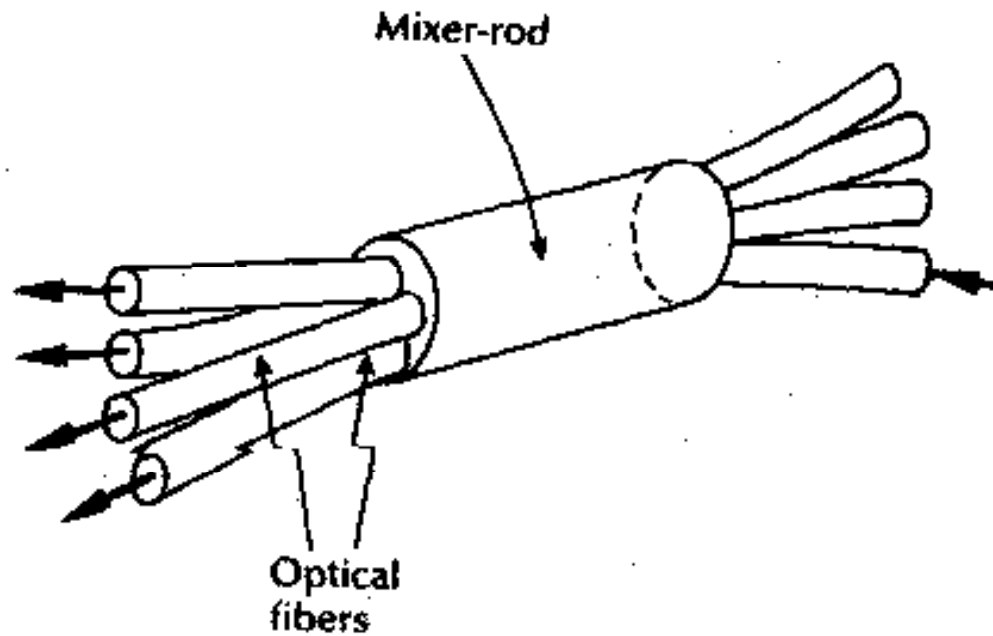
❏ Schematic diagram of a microbend type coupler.

Microbend type Coupler

- A transparent mech grating is used to obtain mode coupling between guided and radiation modes
- **Variable coupling ratios can be obtained by altering the pressure on the fiber**
- Accordingly, low light levels can be extracted from the fiber with very little excess loss (0.05 db)

Grating - Optical device consisting of a surface with many parallel grooves in it; disperses a beam of light (or other electromagnetic radiation) into its wavelengths to produce its spectrum

FIBER STAR COUPLERS-mixer rod technique

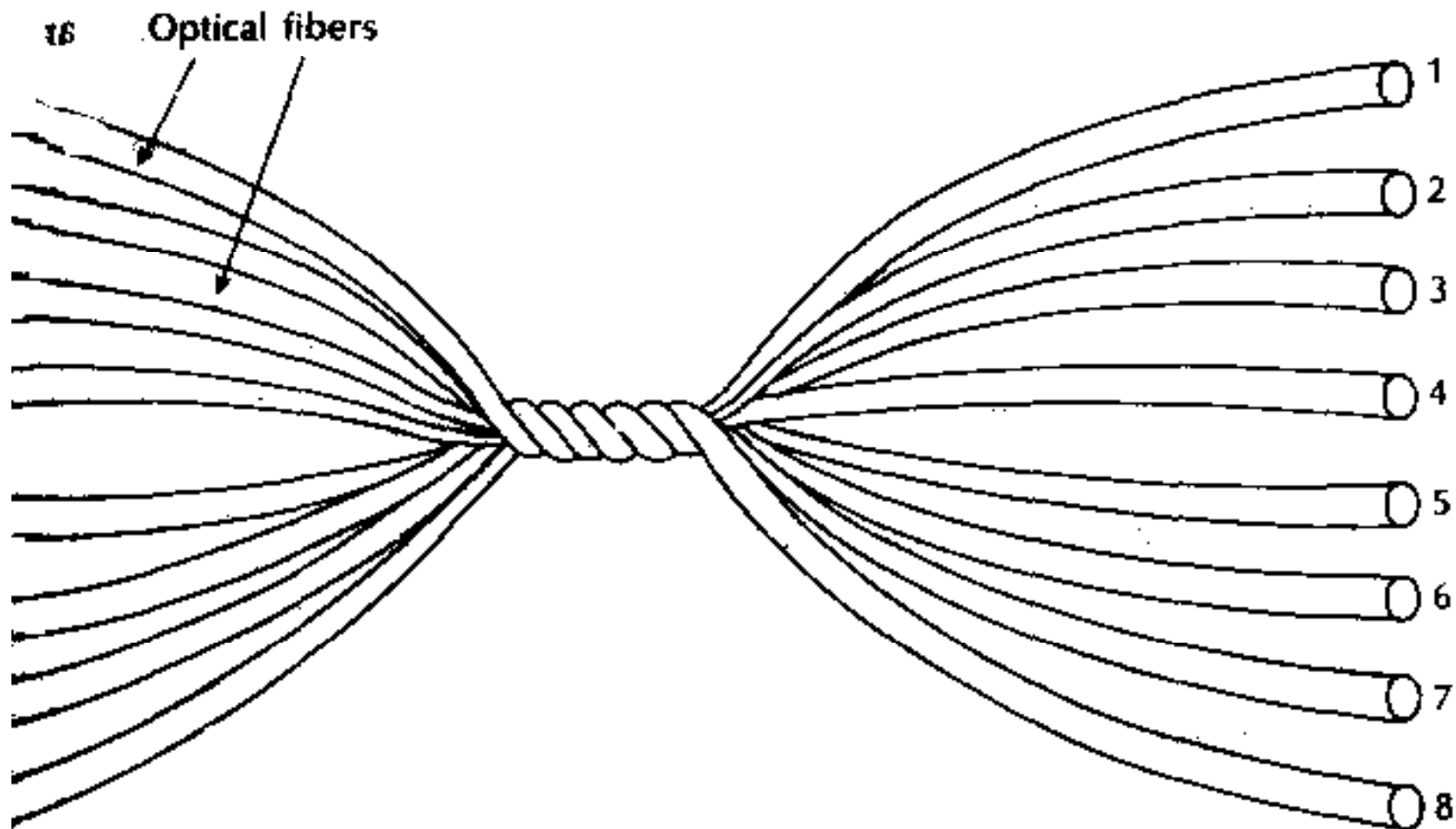


STAR COUPLER

- **Mixer rod method**: a thin platelet of glass is employed for mixing the light and dividing it among the outgoing fibers
- Typical loss for an 8*8 mixer-rod transmissive star coupler = 12.5 db
- **Fused biconical taper star coupler**

The fibers are bundled, twisted, heated and pulled to form the device

TYPES OF COUPLERS-biconical 8*8 port star



Fiber fused biconical taper 8 x 8 port star coupler.

STAR COUPLER

$$\text{Splitting loss} = 10 \log_{10} N \text{ db}$$

$$\text{Excess loss} = 10 \log_{10} P_i / \sum_{1}^n P_j \text{ db}$$

$$\text{Total loss} = \text{Splitting loss} + \text{Excess loss}$$

ASSIGNMENT NO 6

- Explain various types of misalignment.
- What are fiber couplers? Give their different types and functions?