INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

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WINTER COLLEGE ON
LASER PHYSICS: SEMICONDUCTOR LASERS
AND INTEGRATED OPTICS

(22 February - 11 March 1988)

APPLICATIONS OF INTEGRATED OPTICS
TO OPTICAL FIBRE COMMUNICATIONS

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APPLICATIONS OF INTEGRATED OPTICS TO OPTICAL FIBRE COMMUNICATIONS

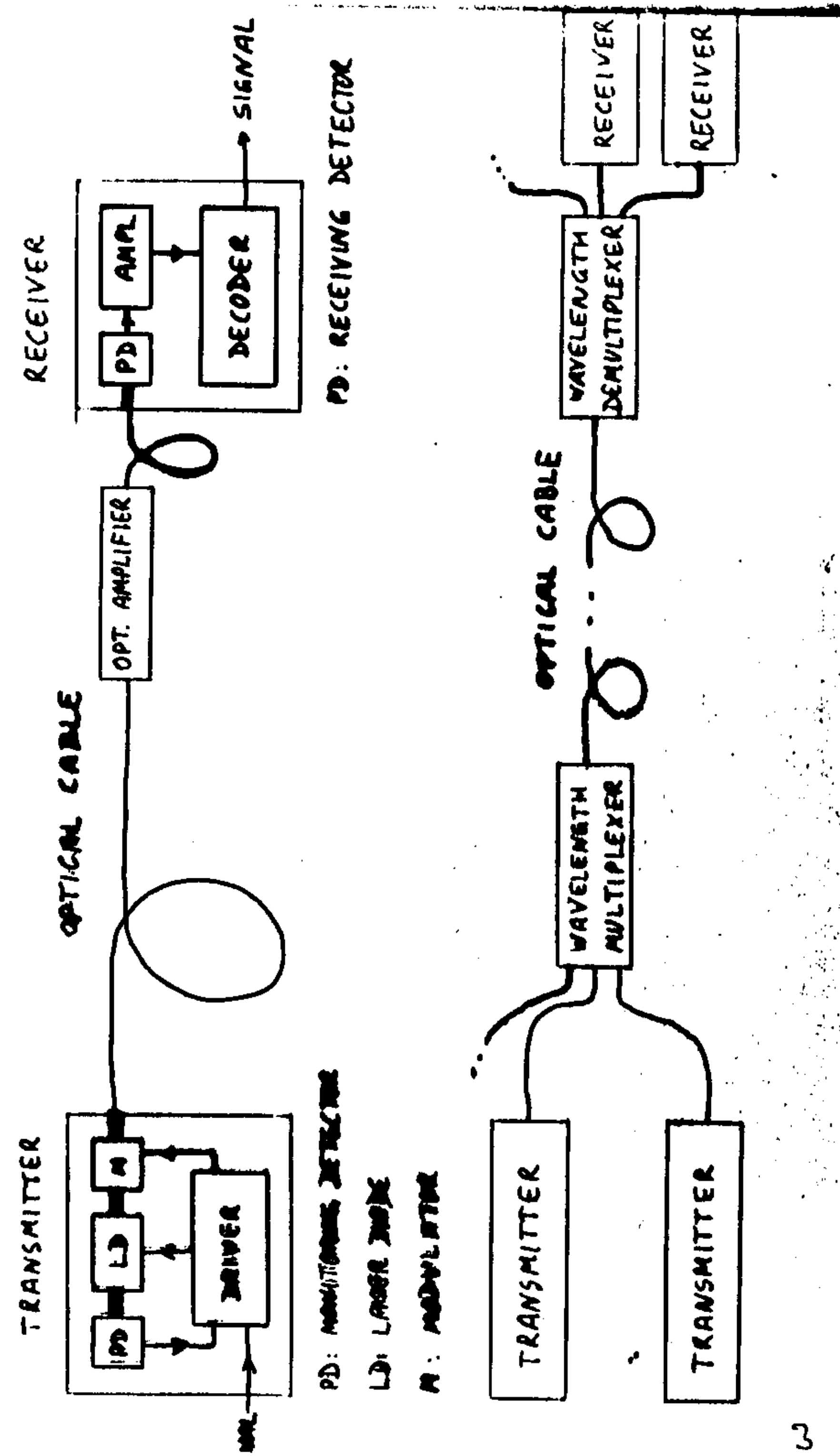
APPLICATIONS OF INTEGRATED OPTICS

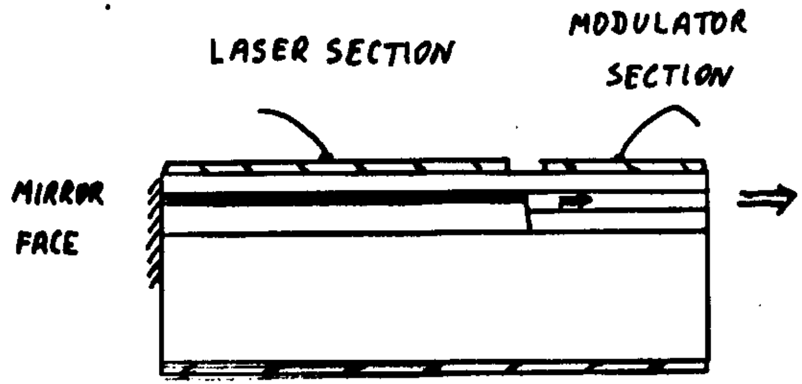
SIGNAL PROCESSING
- RF SPECTRUM ANALYSERS
- A/D & D/A CONVERTERS
- OPTICAL MEMORY READ/WRITE DEVICES
- OPTICAL COMPUTING

SENSING
- ROTATION (OPTICAL GYRO)
- TEMPERATURE
- HUMIDITY
- PRESSURE & SOUND
- ELECTRICAL & MAGNETIC FIELDS
- REFRACTIVE INDEX

COMMUNICATIONS
- VERY HIGH SPEED MODULATION
- COUPLERS & SPLITTERS
- OPTICAL WDM & TDM MUX/DEMUX
- SWITCHING MATRICES
- STABILIZED-SPECTRUM SOURCES
- MULTI-WAVELENGTH COHERENT AND CONVENTIONAL TRANSMITTERS
- OPTICAL RECEIVERS
- OPTICAL AMPLIFIERS & REPEATERS

SCHEMATIC STRUCTURE OF OPTICAL LINK





INTEGRATED LASER + MODULATOR :

a) Δn MODULATION IN MOD. SECTION :

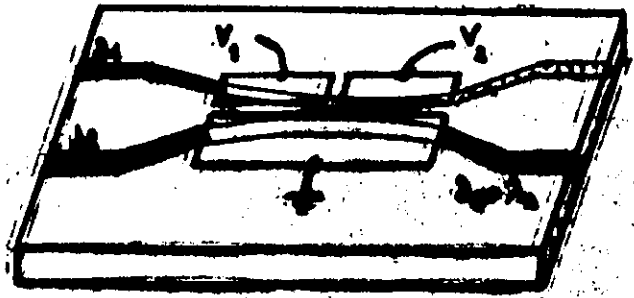
FREQUENCY MODULATED, CONSTANT AMPLITUDE

b) α MODULATION IN MOD. SECTION :

AMPLITUDE MODULATED SOURCE

ADVANTAGES :

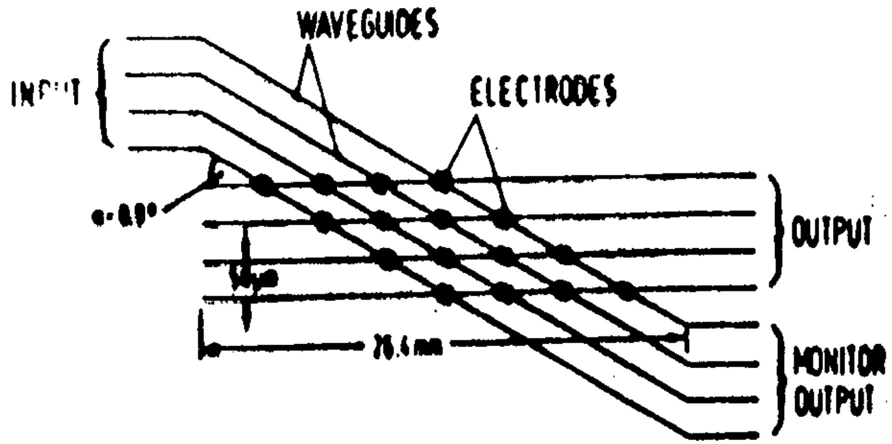
- HIGHER SPECTRAL STABILITY THAN FOR DIRECTLY MODULATED LASER AT HIGH FREQUENCY
- FINE TUNING OF LASER FREQUENCY



TUNABLE DIRECTIONAL COUPLER DEMULTIPLEXER

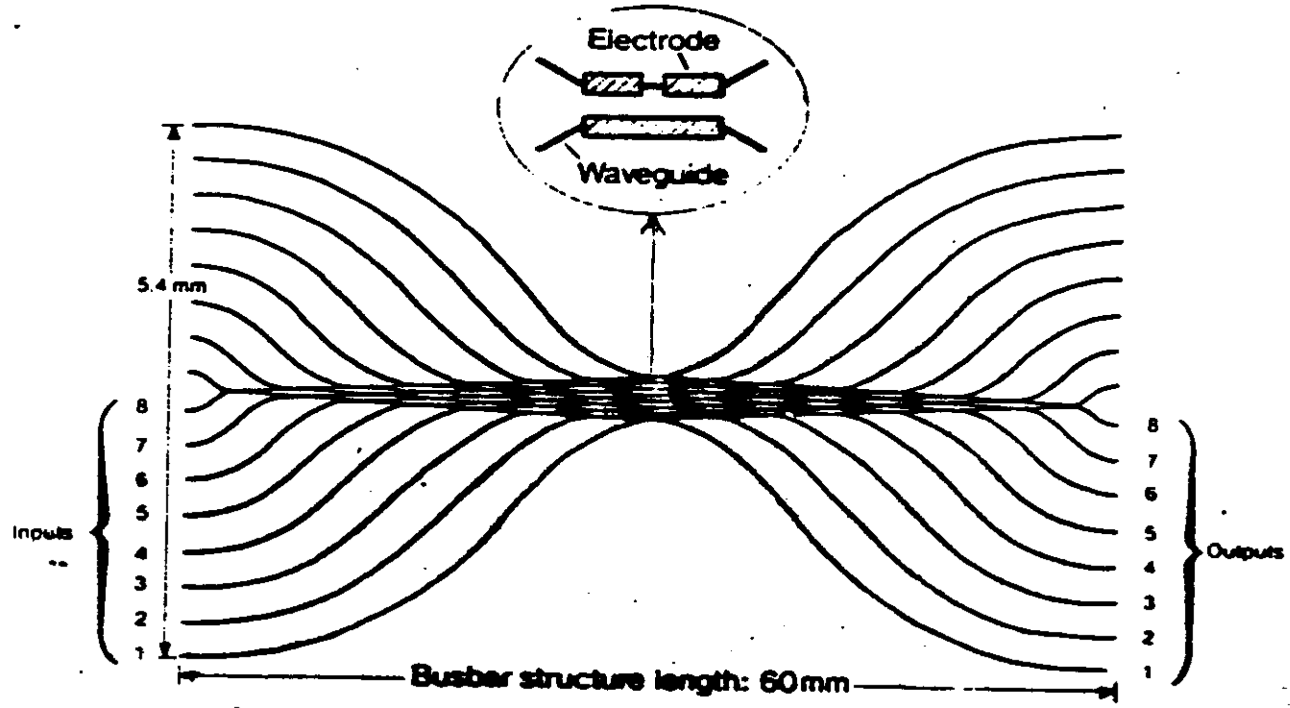
MULTICHANNEL DEMULTIPLEXER

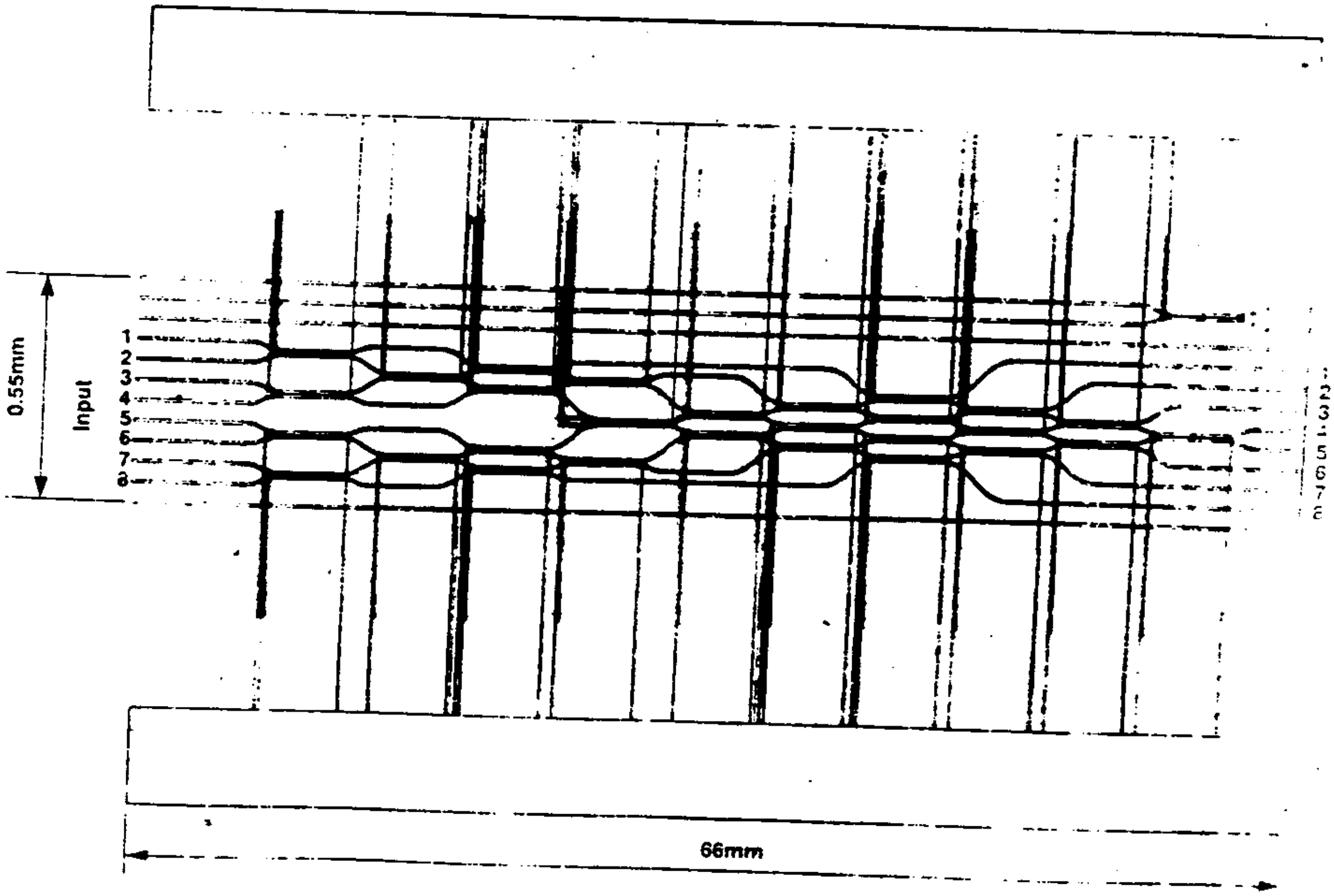
BRAGG FILTER DEMULTIPLEXED RECEIVER



4 x 4 SWITCHING MATRIX IN Ti:LiNbO$_3$
BASED ON X-SWITCHES

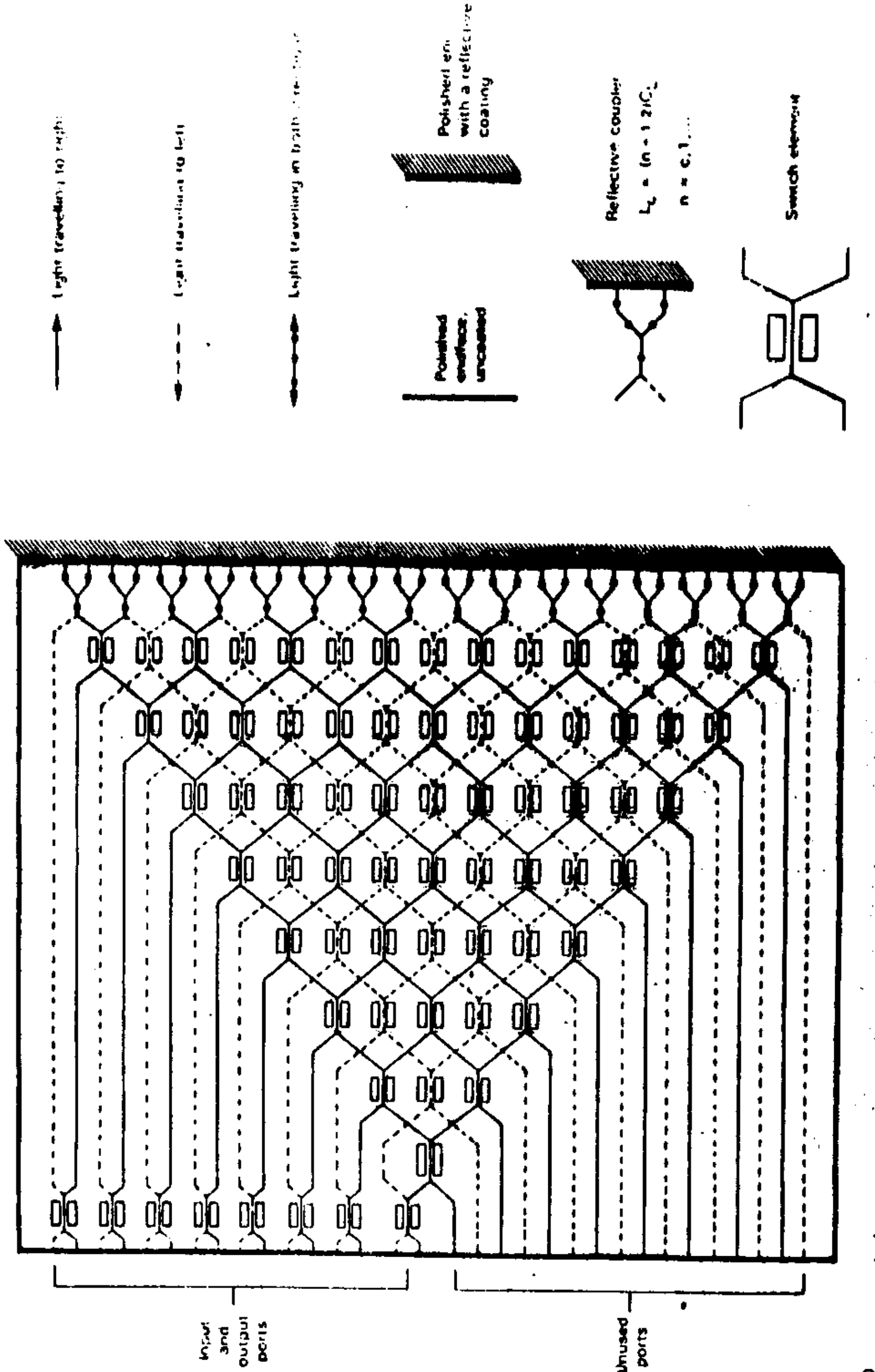
8×8 SWITCHING MATRIX IN Ti : $LiNbO_3$ - BASED ON DIRECTIONAL COUPLERS



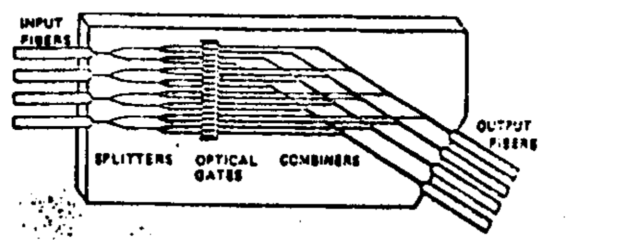


8×8 SWITCHING MATRIX (DIRECTIONAL COUPLER SWITCHES)

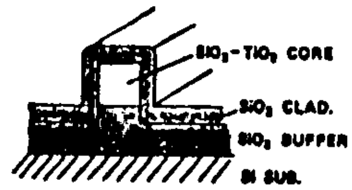
FOLDED-STRUCTURE 8x8 SWITCHING MATRICES



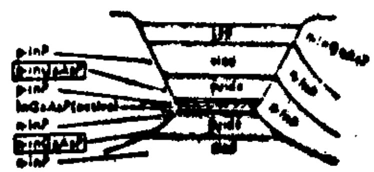
4x4 Optical Gate Matrix Switch
(NTT, 1988)



Schematic diagram of the 4x4 switch



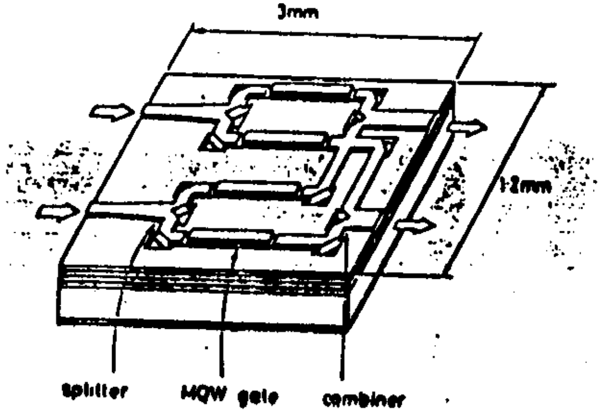
Waveguide structure



Gate (laser) structure

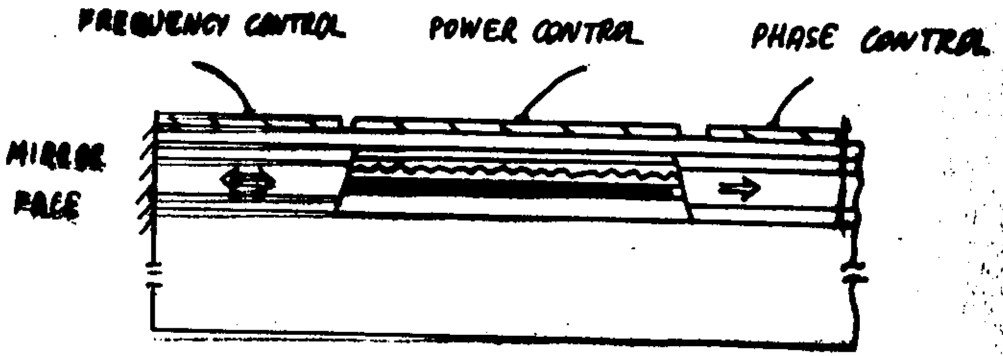
Wavelength	1.3μm
Crosstalk ratio	< -13dB
Gate extinction ratio	18dB
Injected current	60mA
Insertion losses	22.8dB
Fabrication Gate	hybrid LPE
Dimensions	10x25mm
Number of elementary switches	16

2x2 Gate Matrix Switch
(NEC, 1987)



Schematic diagram of the switch

Wavelength	0.86 μm
Extinction ratio	20dB
Driving voltage	-12V
Losses propagation mirrors splitting scattering	24dB 9dB 8dB 3dB 4dB
Fabrication	RIBE
Dimensions	3x1.2mm
Number of elementary switches	4



INTEGRATED MULTICAVITY SOURCE WITH FULL SPECTRAL CONTROL

a) POWER CONTROL BY INJECTION CURRENT IN DFB LASER SECTION

b) FREQUENCY CONTROL BY ELECTRO-OPTIC OR CARRIER-DENSITY CHANGE OF n IN THE COUPLED CAVITY SECTION

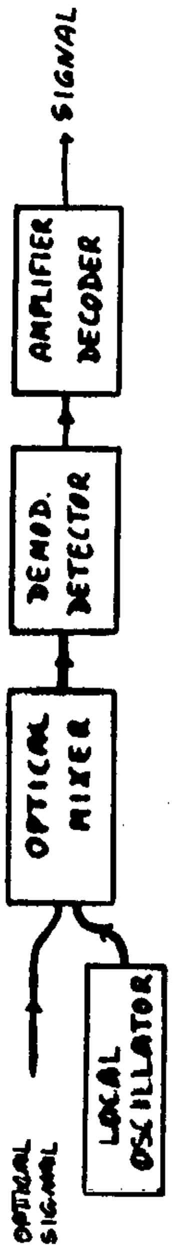
c) PHASE CONTROL BY SAME EFFECTS IN A SECTION OF THE OUTPUT GUIDE

ADVANTAGES :

- INDEPENDENT CONTROL OF ALL THE PARAMETERS OF THE OPTICAL WAVE
- HIGH OPERATION STABILITY IN THE REQUIRED MODE
- MUCH HIGHER SPECTRAL STABILITY THAN EQUIVALENT HYBRID STRUCTURES

SCHEMATIC OF COHERENT OPTICAL RECEIVER

SIGNAL IS CODED AS MODULATION OF OPTICAL CARRIER PHASE OR FREQUENCY

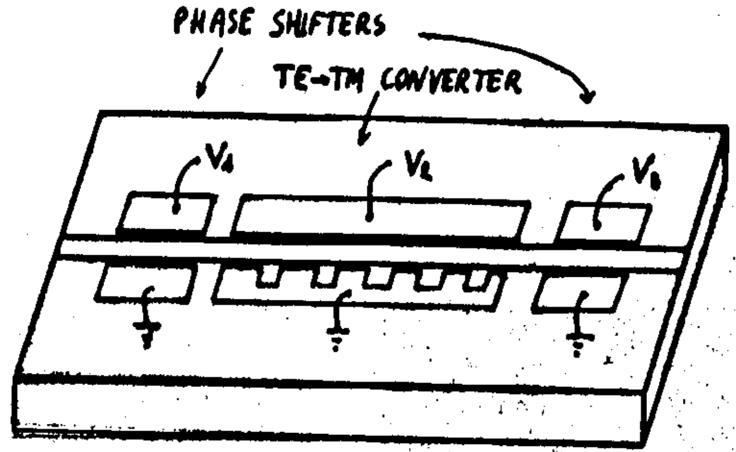


HETERODYNE : LOCAL OSCILLATOR LASER FREQUENCY ≠ SIGNAL CARRIER

HOMODYNE : – – – = SIGNAL CARRIER

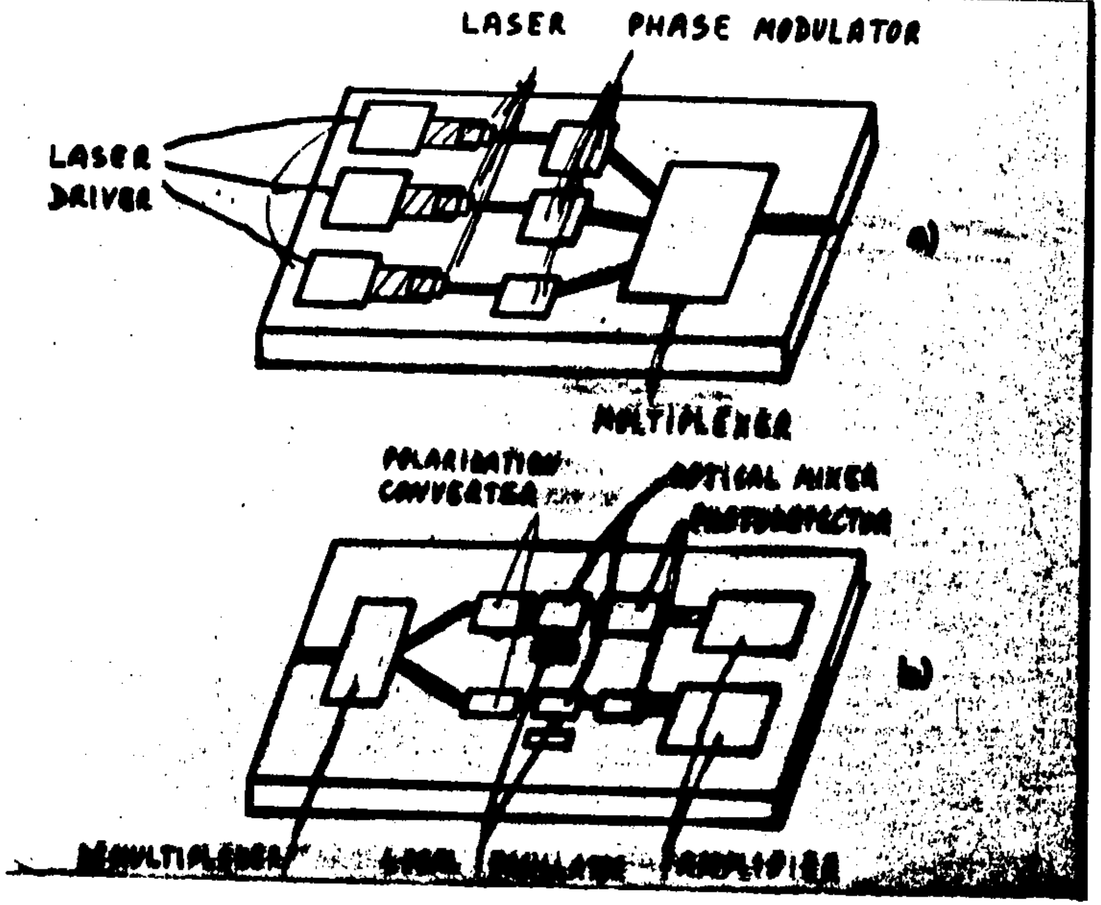
ADVANTAGES COMPARED TO CONVENTIONAL RECEIVER :

- HIGHER SENSITIVITY (≤ 20 dB)
- BETTER USE OF AVAILABLE OPTICAL BANDWIDTH



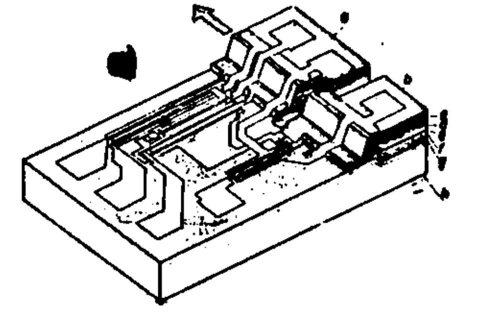
POLARIZATION CONVERTER

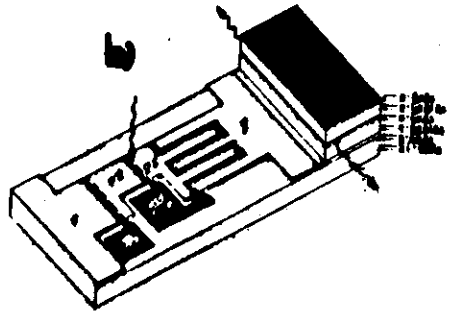
- PHASE SHIFTERS CHANGE RELATIVE PHASE BETWEEN TE AND TM WAVE BY V_1 AND V_3
- PERIODIC ELECTRODE TRANSFERS POWER BETWEEN TE AND TM WAVE WITH EFFICIENCY SET BY V_2



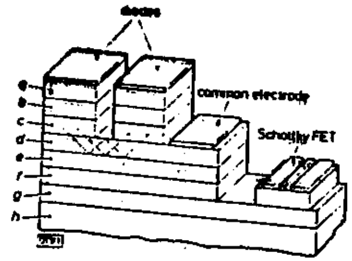
SCHEMATIC OF MONOLITHIC TRANSMITTER (a) AND RECEIVER (b) FOR MULTICHANNEL OPTICAL COHERENT TRANSMISSION SYSTEMS

EXAMPLES OF MONOLITHIC OPTOELECTRONIC INTEGRATION





a Laser, b Photomonitor, c GaAs, d GaAlAs, e GaAlAs active layers, f GaAlAs, g GaAs ... layers h Semi-insulating GaAs



a p-GaAs cap layer
b p-GaAlAs upper guide
c n-GaAs active layer
d n-GaAlAs lower guide
e n-GaAlAs buffer layer
f n-GaAs FET layer

a) TRANSMITTER

b) REPEATER

c) MULTI-PURPOSE CIRCUIT