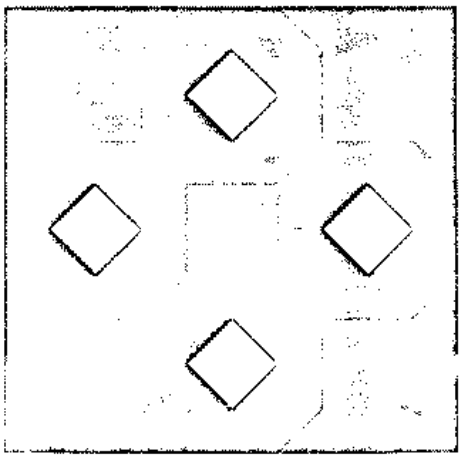
R&D MANAGEMENT CONFERENCE

CAN EUROPEANS MANAGE
THE NEW TECHNOLOGIES?

Brussels,
12-14
November
1984



Management Centre Europe

THEME: Strategic Planning and R & D

Morning plenary sessions:

- **Changing the role and importance of strategic planning in today's industrial environment** – Ch. Lorenz
- **Corporate strategy/R & D interfaces** – E.G. Krubasik
- **R & D strategy** – R. Boschi
- **Effects of culture and limits to planning** – S. Bergen

Afternoon Case Histories of R & D Strategy:

- **Natural evolution and technological innovation** – Prof. Businaro
- **How the R & D strategy problem can be tackled in highly innovative industries** – H. Heckl
- **Case history of R & D strategies** – A. Bisio
- **Small group discussions**
  'What should the R & D strategy be?'

Overhead charts for the oral presentation

#1

TWO CULTURAL PARADIGMS

PREVAILING PARADIGM IN NATURAL SCIENCES

- LINEARITY OF CAUSE/EFFECT
- DETERMINISM (IF THE INITIAL STATE IS KNOWN)
- MICROSCOPIC REVERSIBILITY
- MACROSCOPIC IRREVERSIBILITY, FROM STATISTICAL VIEW

REDUCTIONIST APPROACH

"THE PAST OF COMPLEX SYSTEM CAN BE UNDERSTOOD TOP-DOWN
BY REDUCING TO ITS ELEMENTARY COMPONENTS,
AND ITS FUTURE FORECASTED BY BOTTOM-UP SYNTHESIS"

PREVAILING PARADIGM IN HUMANITIES AND ARTS

- A MELODY CANNOT BE EXPLAINED BY ANALYZING ITS COMPONENTS
- SMALL VARIATIONS IN THE MICROSCOPIC "CAUSE"MIGHT PRODUCE LARGE EFFECTS

HOLISTIC APPROACH

"SYSTEM BEHAVIOUR IS AN IRREDUCIBLE CHARACTERISTIC OF ITS GLOBALITY. TOP-DOWN ANALYSIS SERVES ONLY TO HAVE SOME UNDERSTANDING OF PAST BEHAVIOUR"

#2

WHAT PARADIGM TO STUDY COMIPLEX SYSTEM ?

A THRESHOLD OF COMPLEXITY SEEMS TO EXIST.
ABOVE IT, THE REDUCTIONIST APPROACH IS OF LITTLE USE,

HOWEVER, THE POWER OF REDUCTIONIST ANALYSIS COULD APPLY,
DEPENDING ON THE DYNAMIC CONDITION OF THE SYSTEM :

- WHEN THE SYSTEM IS STABLE (WITH A STABLE STRUCTURE),
  FAR FROM CATASTROFY (CHANGE CF ITS STRUCTURE)

BUT

CAN WE DETECT, OBSERVING THE SYSTEM, WHETHER OR NOT IT IS FAR FROM CATASTROPHV ?

IF THE SYSTEM IS TOO COMPLEX TO BE REDUCED TO ITS COMPONENTS,
DOES IT SHOW GLOBAL TYPICAL PATTERNS THAT COULD HELP
IN PREDICTING ITS FUTURE ?

#3

A CYCLICAL PATTERN MODEL FOR THE DYNAMICS OF OPEN SYSTEMS

- A PERIOD OF STABILITY WITH PREDICTABLE EVOLUTION EXPLOITING SYSTEM'S POTENTIALITIES.
- A PERIOD OF TRANSITION WHEN LARGE FLUCTUATIONS APPEAR AND ARE SUSTAINED,
- PASSING THROUGH A CATASTROPHY WHERE THE SYSTEM STRUCTURE CHANGES.
- A NEW PERIOD OF STABILITY WITH PREDICTABLE EVOLUTION WITH A NEW SYSTEM STRUCTURE,

THE APPROPRIATE,CULTURAL PARADIGM SHOULD ALSO BE CYCLED

REDUCTIONIST APPROACH → HOLISTIC APPROACH → REDUCTIONIST APPROACH

#4

THE SIGNALS FROM THE TRANSITION STATE

A) INCREASED DIFFICULTIES TO MATCH ENVIRONMENTAL CHANGES.

B) SATURATION OF SYSTEM GROWTH POTENTIALITIES / "COMPLEXIFICATIONS" / REDUCED EFFICIENCY,

C) POSITIVE FEEDBACKS OF FLUCTUATION PRODUCING IRREVERSIBLE CHANGES.

#5

THE TECHNICAL SYSTEM (TS) - AN OPEN COMPLEX SYSTEM

TS = THE SET OF TECHNIQUES, ENSEMBLE OF TECHNIQUES FILIERES, PRODUCTS, THEIR USE.

THE HYSTORY OF TECHNIQUES HAS SHOWN THAT **TS** FOLLOWS THE DYNAMICAL PATTERN TYPICAL OF COMPLEX OPEN SYSTEM

- THERE ARE PERIODS IN HYSTORY CHARACTERIZED BY A GIVEN **TS**;
- FOLLOWED BY A PERIOD OF TRANSITION;
- TO A NEW **TS**.

HOW MANY DIFFERENT TS IN HYSTORY ?
~10 OF WHICH 5 IN THE LAST 200 YEARS,

THE **TS** FAR FROM TRANSITION IS NOT STATIC

BUT

- INNOVATION CHANGES SHOULD BE COMPATIBLE WITH THE TS STRUCTURE;
- RADICAL INNOVATION CAN BE BLOCKED.

#6

R & D - SUBSYSTEM OF TECHNICAL SYSTEM

- TECHNOL. INNOVATIONS - A BASIC DETERMINANT OF CHANGE FOR **TS**.
- R & D - A BASIC DETERMINANT FOR RADICAL TECHNOLOGICAL INNOVATIONS AND FOR DIFFUSION OF INNOVATIONS IN PRODUCTS/PROCESSES.
- R & D IS AN OPEN COMPLEX SYSTEM
  - ITS DYNAMICS IS INTERRELATED TO THAT OF **TS**

THE CASE FOR INDUSTRIAI- R & D

- THE ROLE OF R & D CHANGES WITH THE STATE OF **TS**
  THE R & D MANAGERS' ATTITUDE SHOULD CHANGE ACCORDINGLY
  1. WHEN **TS** IS FAR PROM TRANSITION :
     - THE MAIN ROLE OF R & D IS TO PUSH THE DIFFUSION OF INNOVATION IN THE COMPANY WELL ESTABLISHED PRODUCTS & PROCESSES.
  2. WHEN TS IS UNDER TRANSITION :
     - R & D SHOULD INTERVENE DIRECTLY IN THE CONCEPTION OF NEW PRDUCTS & PROCESSES, COMPATIBLE WITH THE EXPECTED NEW TECHNOLOGICAL **TS** STRUCTURE.
- CORRFSPONDINGLY :
  1. THE TRENDS OF TECHNOLOGY ARE :
     A) WELL KNOWN (FORECASTING TECHNQ=TF)
     B) UNCERTAIN (FORECASTNG TECHNQ=SCENARIO)

THE NEEDED ATTITUDE OF R & D MANAGERS IS
A) ANALYSIS / REDUCTIONIST APPR. (ESPRIT GEOMETRIQUE)
B) SYNTHESIS / HOLISTIC APPR.. (ESPRIT DE FINESSE)

7

IS TODAY THE TECHNICAL SYSTEM UNDER TRANSITION ?

- DRASTIC TECHNOLOGICAL CHANGES IN HORIZONTAL TECHNOLOGIES:
  - MATERIALS (COMPOSITES)
  - PROCESSING UNITS (LASER, ROBOT)
  - PRODUCTION SYSTEM (FMS)
  - INFORMATION PROCESSING (VLSI, AI)
- IN IMPORTANT INDUSTRY NEW TECHNOLOGIES HAVE DEEPLY DIFFUSED
  - E.G. **:** NEW MATERIALS IN AEROSPACE
  - E.G.. : CIM (COMP. INTEGRATED MNFTNG) FOR FABRICATION OF COMPUTERS
- ENVIRONMENTAL CHALLENGES TO PRODUCTS & PROCESSES HAVE STARTED A DEMATURITY PROCESS IN MASS-PRODUCING INDUSTRIES (E.G., AUTOMOTIVE)
- RADICAL NEW TECHNOLOGIES (E.G. GENETIC ENGNRNG) STRONGLY PUSH FOR RADICAL INNOVATIONS IN IMPORTANTINDUSTRIES (E.G. BIOTECHNOLOGY)

#8

THE INADEQUACY OF A REDUCTIONIST APPROACH IN R D MANAGEMENT

- INTRINSIC HIGH UNCERTAINTIES IN R & D MAKE ALWAYS QUESTIONABLE A RATIONAL REDUCTIONIST APPROACH (OPTIMAL CHOISE OF PROJECTS FOR MAX. UTILITY)
  - THE MORE SO, WHEN **TS** IS UNDER'TRANSITION
- IS A RATIONAL APPROACH IN R & D MANAGEMENT IMPOSSIBLE ?
- HOW AN HOLISTIC APPROACH MIGHT HELP RATIONAL MANAGEMENT ?
  - BY DEVELOPING ABILITIES IN MANAGEMENT TO GRASP PATTERNS THAT EMERGE AT THE DIFFERENT LEVELS OF CORPORATE HIERARCHY
  - E.G. HOW MUCH OF COMPANY RESOURCES FOR R & D INVESTMENT?

THE CASE OF A SECTOR MOVING FROM AN EMPIRICAL KNOWLEDGE BASE TO A SCIENTIFIC BASE

- ARE INDICA TORS. (E.G. R & D/SALES) FROM HYSTORICAL SERIES OF THE INDUSTRY MEANINGFUL ?
- WHAT PATTERNS CAN BIL GRASPED FROM R D MANAGEMENT IN SCIENCE BASED INDUSTRIES ?

- IF R & D MANAGERS HAVE PERCIEIVED THE NEED TO CHANGE CULTURAL PARADIGM, THEN THERE IS THE NEED

- TO HELP RATIONAL STRATEGIC DECISION MAKING -

FOR A DETAILED HEURISTIC MODEL TO HELP UNDERSTANDING THE DYNAMICS OF THE INNOVATION PROCESS

#9

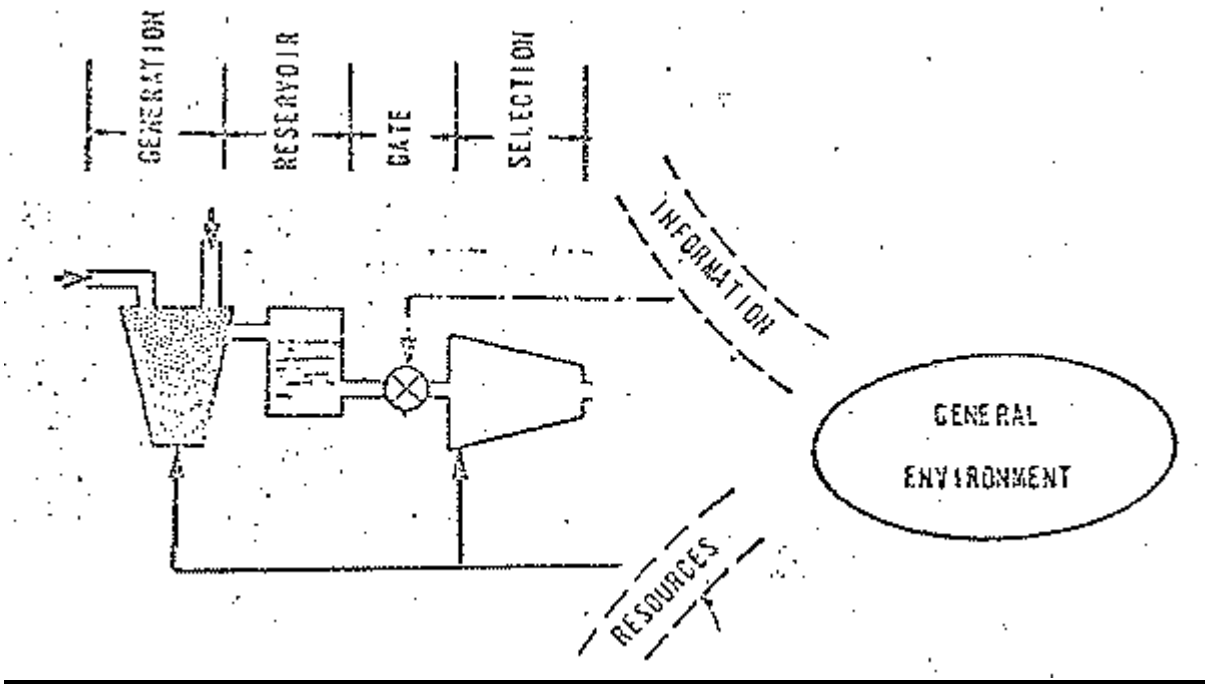
THE NATURAL EVOLUTION METAPHOR FOR THE INNOVATION PROCESS

- THE LIVING SYSTEM IS A COMPLEX OPEN SYSTEM WHOSE DYNAMICS HAVE BEEN STUDIED IN DETAIL AND FRAMED IN A COMPREHENISIVE THEORY
- THE BASIC INGREDIENTS OF THE METAPHOR FOR INNOVATION
  - AN UP-DATED CHANGE/NECESSITY BASIC MECHANISM OF EVOLUTION
  - SPECIATION MODES :
    - ISOLATION OF POPULATIONS/TRANSPLANTING PREGNANT FEMALE/ HYBRIDIZATION
    - THE PARADIGM OF CYCLICAL PATTERN OF CHANGE
    - A DEFINITION OF THE DIRECTION OF CHANGE TOWARDS
      = PROGRESS AN: INCREASING COMPLEXITY MANAGED BY A HIGHER INTELLIGENCE (ABILITY TO MANAGE 1NFORMATION)
      = BUT, WITH CONSTRAINT FROM THE PAST (BASIC ARCHITECTURE)

- SYSTEM OF SYSTEMS = IRREDUCIBLE COMPLEXITY OF A SYSTEM NO MATTERS HOW IT IS AGGREGATED OR DISAGGREGATED (THE HOLON CONCEPT = A SYSTEM IS A PART AND IS A ALL)

#10

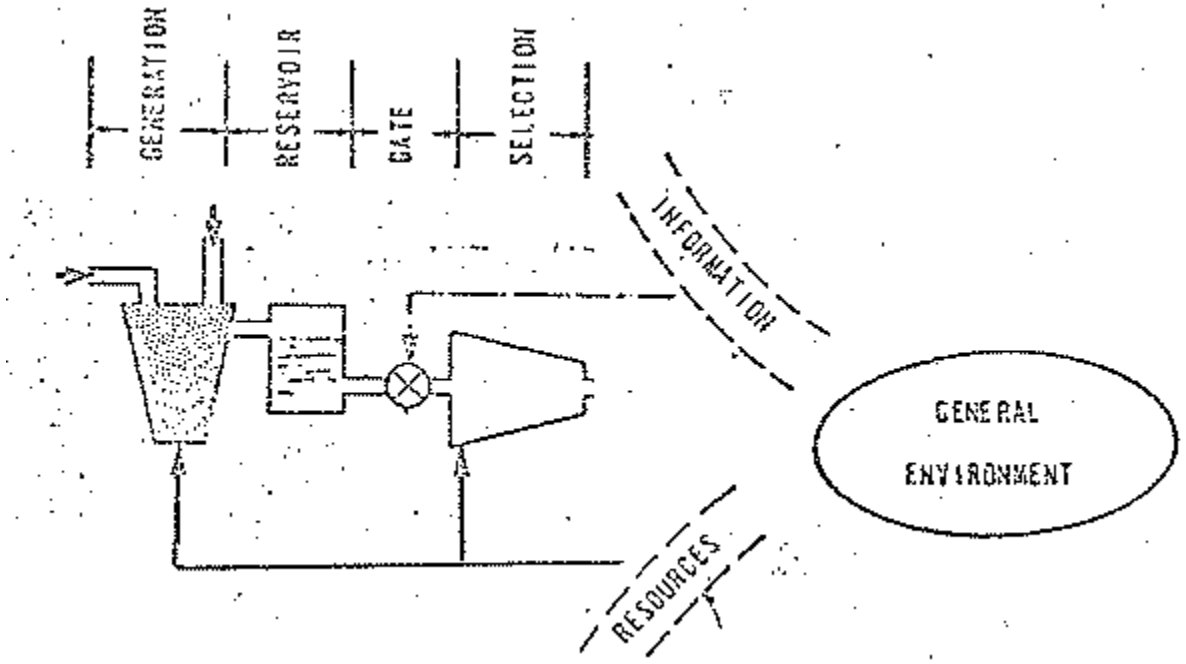
AN UP-DATED CHANGE/NECESSITY MECRANISM OF EVOLUTION



- A PROCESS OF GENERATING IDEAS/INVENTION
- A "STORAGE CONTAINER" WHERE INVENTIONS COULD BE ACCUMULATED
- A DUCT WITH AN ON-OFF VALVE WHICH CONNECTS THE CONTAINER TO :

A SELECTION MACHINE, WHICH TESTS INVENTIONS, ACCEPTING ONLY THOSE WHICH ARE FITTED FOR THE "ENVIRONMENT"

A MULTISTAGE GENERATION – SELECTION MODEL FOR THE INNOVATION PROCESS



#11

APPLYING THE NATURAL EVOLUTION METAPHOR TO IONG TERM INNOVATION CHANGE

- LONG TERM ECONOMIC WAVES (KONDRATIEV) :
  OPEN SYSTEM DYNAMIC PATTERN ?
- WHY MICRO/MACRO CYCLES AND HYPERCYCLES ?
  - INTERACTIONS AMONG THE DYN. PATTERNS OF THE SUBSYSTEMS (OPEN SYSTEMS) OF THE SOCIO-ECONOMIC SYSTEM
- HOW MANY TECHNOLOGICAL WAVES IN THE LAST 200 YEARS ?
  - 5 WAVES (KONDRATIEV CYCLES/SCHUMPETER ANALYSIS)
  - 2 WAVES (GIARINI-LOUBERGE)
    - XVIII CENTURY : EMPIRICAL TECHNOLOGY WAVE
    - XIX " " : SCIENCE/TECHNOLOGY WAVE
- APPLYING THE METAPHOR TO GIARINI-LOUBERGE
  - XVIII CNT.: INDUSTRIAL REVOLUTION BASED ON EMPIRICAL KNLDG.
    * INTERESTED SUBSYSTEM IN R & D : **D** + **I**
    * INVENTION -> STORAGE -> SELECTION OF INNOVATIONS IN **D**+**I**
  - XIX CNT.: THE R &D SUBSYSTEM STARTS A SCIENCE BASED CYCLE (INVENTION -> STORAGE->SELECTION) THAT INTERACTS WITH **D** SUBSYS, TO CREATE NEW SCIENTIFIC BASED INDUSTRIES (CHEMISTRY, ELECTRICITY) (SPECIATION PROM HYBRIDIZATION)
    * BECAUSE OF THE SCIENCE BASE :
      TECHNOL. PROGRESS CAN BE PREDICTED
    * BUT, TODAY, SIGNS OF SATURATION (IN CHEM., ELECTR.,)
      TO EXPLOIT THE POTENTIALITY OF THE SCIENCE KNWOLEDGE

#12

NEW MODES OF LONG TERM INNOVATION CHANGE

A THIRD TECHNOLOGICAL WAVE TODAY, BECAUSE OF INTERACTION OF THE SCIENCE SUBSYSTEM, WITH THE R & D OF EMPIRICAL BASE INDUSTRIES ?

- MEETING OF THE FRONTIERS OF SCIENTIFIC KNOWLDG AND EMPIRICAL KNOWLDG.
- UTILIZATION OF THE KNOWI,EDGE WHICH FILLS THE **R** RESERVOIR, BY OPENING THE VALVES TO THE **D** + **I** SUBSYST. SELECTION.

A PECULIARITY OF XX CENT. : LAUNCHING BIG APPLIED RESEARCH PROJECTS (NUCLEAR, SPACE)

- A NEW STARTING POINT IN-THE INNOVATION PROCESS ? INTERACTION OF SCIENTIFIC KNOWLDG (**R** SUBSYST) WITH APPLIED RESEARCH (**AR**) SUBSYST.
  - THE LARGE **AR** PROJECTS OPEN THE VALVES FROM THE **R** SUBSYST (E.G. FISSION) (THE RESOURCE AVAILABLE FOR THE BIG **RA** PROJECTS = SPECIATION FROM A PREGNANT FEMALE IN A NEW ENVIRONMENT)
  - WILI NEW INDUSTRIES DEVTLOP ?
    - TELECOMMUNICATION
    - NUCLEAR ENERGY ? / SPACE TELECOMMUNICATION ?
    - OIL FROM DEEP SEA ? / METALS PROM SEA NODULES ?

#13

APPLICATION OF THE NATURAI EVOLUTION METAPHOR TIME PHASING OF INDUSTRIAL INNOVATIONS

IMPORTANCE OF SEPARATION INTO SUBSYSTEMS OF R-RA-D-I
EACH SUBSYST. HAS A DIFFERENT TIME SCALE
E.G. : A PRODUCT INNOV. (MASS PRODCD GDS) WILL NOT PASS UNLESS IT IS TIME TO RENOVATE PRODCTN CAPITAL INVESTMNTS,
= CYCLES FOR AUTOMOTIVE IND. : - 5 YEARS - MAJOR RESTYLING
- 10 YEARS - NEW CAR - 20 YEARS - NEW.ENGINE

THE "INNOVATION CLOCKS" DIFFER FROM ONE ENTRP. TO THE OTHERS

- HOW, THEN, THE ENTIRE INDUSTRY SHOWS A TYPICAL OPEN SYSTEM GLOBAL DYN. PATTERN ? (See UTTERBACH, ABERNATHY).
- THE REDUCTIONIST APPROACH DOES NOT EXPLAIN THAT,
- SYSTEM FEEDBACK EFFECT SEEMS TO APPLY (HOLISTIC APPRCH).

THE EXISTFNCE OF EXTERNAL "SYSTEM CLOCK" HAS TO BE CONSIDERED WHEN DEVELOPING A COMPANY STRATEGY.

- E.G. : IS THE AUTOMOTIVE INDUSTRY IN A MATURE PHASE OR IN A "REJUVINATING" PHASE ?

THE GENERAL ECONOMIC CRISIS : A SYSTEM CLOCK (PUT THE ENTERPRISES DIFFERENT CLOCKS TO THE SAME TIME)

- DURING THE CRISIS, EACH COMPANY -TO RESIST ON THE MARKET- IS LOOKING FOR "COMPATIBLE" INNOVATIVE CHANGES (OPEN THE VALVE FROVI **R & D** TO **I**).

WHEN THE WAVE UPSURGES AGAIN, THE NEW TECHNOLOGIES HAVE BEEN LEARNED AND CAN BE USED FOR THE NEW CAPTL INVESTMENT.

#14

STRATEGY F OR-THE WORLD OF PRODUCTS

- THE CHANGE/NECESSITY NATURAL EVOLUTION THEORY DOES NOT FORESEE "FINALITY". NEVERTHELESS NATURAL EVOL. SEEMS TO FOLLOW AN APPARENT FINALITY TOWARDS PROGRESS (COMPLEXITY + INTELLIGENCE)
- THE CASE FOR MAN MAD'E PRODUCTS :
  - E.G. : CLAY VASE GLASS VASE PLASTIC VASE
    - INCREASING COMPLEXITY IN VIANUFACTURING
      BUT
  - KNOWLEDGE USE IS CONCURRENTLY SIMPLIFIED (KNOWLDG PACKGNG)
- A RECIPE FOR DIRECTION OF CHANGES OF PRODUCTS
  - LOOK FOR INCREASING COMPLEXITY PROVIDED THERE IS AN INCREASED ABILITY TO MATCH IT (INFORMATION TREATMENT)
    - E.G. : THE CAR INTERACTING WITH TRAFFIC CONTROL
    - AN INCREASED MIX OF MATERIALS (FROM STEEL TO COMPOSITES) MANAGED BY **CAE**
    - NEW INFRASTRUCTURE FOR SERVICES (E.G.- TELECOMM.) WITH SIMPLE TO USE INTERCONNECTED PRODUCTS.

#15

A RECIPE TO ANALYSE TECHNOLOGICAL CHANGE DURING TRANSITION

- IST STEP
  - IDENTIFY THE TECHNOLOGICAL CHANGES AND THEIR POTENTIAL FOR DIFFUSION TO RENEW TODAY PRODUCTS & PROCESSES.
- 2ND STEP
  - ANALYSE THE SECTORS WHERE THE CHANGES HAVE TAKEN PLACE, AS CASE HISTORIES FOR OTHER SECTORS,
  - ASK THE QUESTIONS :
    - WAS THE CHANGE PRECEDED BY "TECHNOLOGICAL CONFUSION"
    - HAS THE R & D ROLE CHANGED ?
- 3RD STEP
  - ANALYSE THE NEEDS OF CHANGE (ENVIRONMENT, TECHNOL. CONFUSION, R & D INEFFICIENCY) FOR MATURE SECTORS,
  - ANY SIGNALS OF DE-MATURITY ?
- 4TH STEP
  - ANALYSE WHETHER NEW TCCHNOLOGIES COULD BE
    - BLOCKED BY
      - SOCIAL/ECONOMIC CONSTRAINTS
      - NON SATURATION OF EXISTING TECHNOL. ETC.
    - OR ACCELERATED BY
      - SOCIETY NEEDS
      - CULTURAL ATTITUDES
      - ETC.