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MILITARY TECHNICAL COLLEGE

CAIRO - EGYPT

NEW DISPLAY SYSTEM FOR NEW MILITARY AIRCRAFT TAKING BENEFIT FROM NEW AVAILABLE TECHNICS

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A B S T R A C T

* To catch up with the increasing rapidity of evolution in the conditions of tactical missions execution, the adaptation of display systems organization needs to be globally reanalyzed more frequently and deeply.

The accelerated technical evolution provides, happily, an increasing number of new possibilities which may provide solution to solve some of the new problems induced by the new operational needs.

* In the past years THOMSON-CSF has gained a well recognized leadership in aircraft electronic display systems development by following this process, and by, at the same time, refering constantly to the unchanging human physical characteristics of pilots or other operators, "users to be" for such systems.

One of the main factor of the succes of this approach, has been that the readaptations of these systems has been thought, not in a static, but in a dynamic manner, where, the "time" parameter has received the primary importance it actually desserves.

The introduction, by THOMSON-CSF, of COLOR in electronic dysplays is a good example of that. Indeed, color coding introduces a combination of chrominance and luminance contrasts on CRT screens which decreases both the delay and the risk of error in information seizure.

* In the same spirit, for the future generation of COMBAT AIRCRAFT DISPLAY Systems besides a huge CONTINUOUS effort for increasing SOFTWARE CAPABILITIES the main guide-lines retained by THOMSON-CSF for it's CONTINUOUS research of HARWARE ERGONOMY are :

- to keep on trying to get as much advantage as possible from the use of COLOR,
- to use as necessary new technics such as holography, to try to increase the part of data presented in COLLIMATION, in order to reduce the problems of pilot eye reaccomodation delays between external environment observation and cockpit displays scanning.

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1 - OVERVIEW OF THE COLOR DISPLAY DEVELOPMENT BEGINNINGS (1970 to 1975)

HOW AND WHY IT STARTED ?

1970 - In several countries, the idea emerges of using; on board aircraft, CRTs, not only for radar raw data presentation but also for the day display of more extensive pilot information.

However at this time monochrome raster displays developed here and there show mostly data presentation of poor quality.

For more ergonomic data presentation, THOMSON-CSF AVIONICS Division decides to experiment the possibilities offered by color "penetrons" CRTs as by this time they are under development by THOMSON-CSF Tubes Division.

1973 - The first experimental color electronic panel for airliner presented at "LE BOURGET 1973 AIRSHOW".

1975 - The NASA is a conjunction with the european space agency places the first order for penetron color displays for flight data presentation on board the Space Lab.

- The russian ministery of transportation orders a color electronic panel for the TUPOLEV 154 Aircraft. It will be presented at "LE BOURGET 1981 AIRSHOW", with in flight presentation of this aircraft.

2 - TWO MILITARY AIRCRAFT PROGRAMS WITH, FOR THE FIRST TIME, ELECTRONIC COLOR DISPLAY SYSTEMS.

They are launched around 1976, that is to say, just at a time when the THOMSON-CSF "penetrons" penetration color CRTs development is arriving to a level sufficient to envisage the use of these penetrons for military aircraft electronic display.

They are :

- a maritime patrol aircraft program, the ATLANTIC M2 program
- a combar aircraft program .... the MIRAGE 2000 program

Why such choice ?

ON BOARD A MARITIME PATROL AIRCRAFT

Color coding added to ape coding of symbols is very suitable for tactical situation synthesis presentation, penetration CRT technic allows to introduce not only different colors but different phosphorus luminance decay time also very suitable for a neat simultaneous presentation fo tracked moving mobile versus raw radar data.

The first ones being presented with green low remanence phosphorus, the second ones with yellowish more remanent phosphorus.

ON BOARD A FIGHTER

The addition of color coding to shape coding allows a decrease in the delay of operational data visual acquisition, and in the same time, a decrease in the risk of misinterpretation.

COLOR CODING

"Penetrons" CRTs retain two phosphorus layers one red, one green. Modulation of excitation of the phosphorus gives to the eye the perception of either red or green of yellow when both are excited simultaneously.

So, only three colors are usable for coding, but the interval between their wave lentghs, or more generally between their position on the C.I.E. colors diagram, is wide enough for a good chrominance visual contrast. It is in any way better than the chrominance contrast which may be obtained when using a greater number of colors.

In the code retained by french Air-Force for MIRAGE 2000 color code :

- RED is for safety related data presentation,
- GREEN for measured on board flight parameters,
- YELLOW for system computed tactical data.

Additional remark about color display integration in MIRAGE 2000 cockpit :

Without color coding, presentation of useful parameters would have required a spatial dispatching over several screens. For an aircraft as slim as MIRAGE 2000, this would not be as suitable as the concentration of tactical synthesis on a central colored screen.

3 - SHADOW MASK C R T MULTICOLOR DISPLAY AIRCRAFT PROGRAMS.

3-1. Around 1978, it appears that recent shadow mask CRTs are usable on transport aircraft projects, for electronic full color panels instrumentation.

At the end of the seventies two programs are launched, one by BOEING for the BOEING 767-737, one by AIRBUS INDUSTRY for the AIRBUS A 310.

THOMSON-CSF wins the contract for the AIRBUS A 310.

The introduction of the new color CRT marks the biginning of a new era characterized by a widening competition. It also prepares new developments for the military applications....

3-2. At about the same period, around 1980, the french Airforce issues indeed requirement for a new project : the MIRAGE 2000 N program.

This Aircraft will have to be able to carry out low level penetration strike missions, for this, it will be a two seater, it needs the best navigation display system for accurate low level target zone transit.

→ THOMSON-CSF makes a proposal for a dual cockpit electronic display system which will provide, in full electronic manner, the display in full color of a mape in the same time as synthetique data. This is the "ICARE" system based upon the use of the first electronic Remote Map Reader developped in the world : the THOMSON CSF "MERCATOR".

4 - NEW TRENDS CONCERNING THE EVOLUTION OF DISPLAY SYSTEMS FOR NEW MILITARY AIRCRAFT

4-1. The next effort orientation towards making progress worth citing is that which consists in attempting to make more and more flexible the information to pilots, in adaptation to evolving requirements.

This implies :

- Progress in the field of software flexibility, with research carried out, among other means, using architectural concepts more favorable to software modularity and by the development of higher level languages to facilitate further evolution.
- Progress regarding the capacity of systems to store larger and larger quantity of information and process this information so that it can be used in real time in combination with in flight measured parameters.

THOMSON-CSF is among the world leaders in striving towards this fundamentally important data processing progress.

N.B -

Concerning the second point, the case of the THOMSON-CSF "MERCATOR" film reader is worth special mention, because it offers a particularly elegant on board solution for real time reading of stored information.

Indeed, this information, stored in code on film, is read by an extremely versatile real time electronic process which takes benefit of the isotropic organization of a film memory. So, even at a time when others techniques are envisaged to store-useful data on board aircraft , memorization on film presents specific advantages worth of full consideration.

4-2. The second area in which an effort towards progress is being made, is that which consists in attempting to physically present information so that it can be assimilated by the pilot extremely quicly, complying with the conditions under which maneuvers are carried out at high speed near the ground or on contact with the enemy.

To this end and to maintain its leader's position concerning the ergonomic quality of its display systems, in its unceasingly renewed research, THOMSON-CSF :

For all types of Air-craft.

- Continues its attempt to improve information acquisition by selective use of color. The choices are adapted to the requirements specific to each program, by selective choosing of the number of colors, the writing modes, the screen sizes, etc ... while constantly benefiting from the latest sophistications of the technique.

NB - A recent reward of this approach was THOMSON-CSF selection as only supplier for the electronic instrument panel on the future AIRBUS : the A 320.

For Combat Aircraft

- Tries to provide for the pilot, an improved possibility of continuous observation of the outside environment without any interruption in the possibility of reading simultaneously the information which could be useful on the instant.

To this end, THOMSON-CSF has undertaken the evaluation of coherent juxtapositions of collimated displays between which the pilot's eyes can move without any intermediate reaccomodation delays.

The functional qualities of each of these associated displays is also pushed to the very attainable limuts by the use of the latest techniques. This is particularly true for the displays "open to the outside world" for which recourse to holographic techniques offers improved transparency and wider fields.

N.B.

Using hologramms as optical elements may indeed provide such improvements. THOMSON-CSF has realized two REFLECTIVE Head Up Displays (H.U.D.) bread-bords. Such a reflective HUD has, among others, the advantage that the collimator element can be larger because it is above the instrument panel. Indeed, the combiner concave plate performs both the conbining and collimation functions simultaneously. Such a combiner uses a "BRAGG DIFFRACTION STACK", sandwiched between two plates of glass, after, the completion of the stack in the form of a series of parallel sheets of alternating reflective index in a layer a gelatin. This diffractive element realized by holographic techniques exploits the frequency and angle selectivity which characterizes the diffractive optics.

One of these THOMSON-CSF HOLOGRAPHIC HUD is presently enduring extensive in flight testing by the French Official Services.

Other application of HOLOGRAPHIC OPTICAL ELEMENTS are also in study and/or development including wide field of view HELMET MOUNTED DISPLAYS.

4-3. To conclude, it should be noted that the various lines of approach mentioned are not being followed in individual or independant action, but within an effort to coordinate these actions in order to have them converge in such a way as to obtain overall synergic improvement of the task execution conditions.

Accordingly, the distribution of information between the various display surfaces must result from an in-depth study of balance between space distribution (numbers and sizes of screens) and time distribution (utilization cycles, sequentiations/superimpositions ...). It is becoming more and more obvious that most information should not, as in the "old days", remain displaid permanently but only appear when requested by the pilot or triggered automatically at certain time intervals yet to be specified.

The trend is towards greater integration in all areas, implying among others a gradual sophistication of the display system "internal management".

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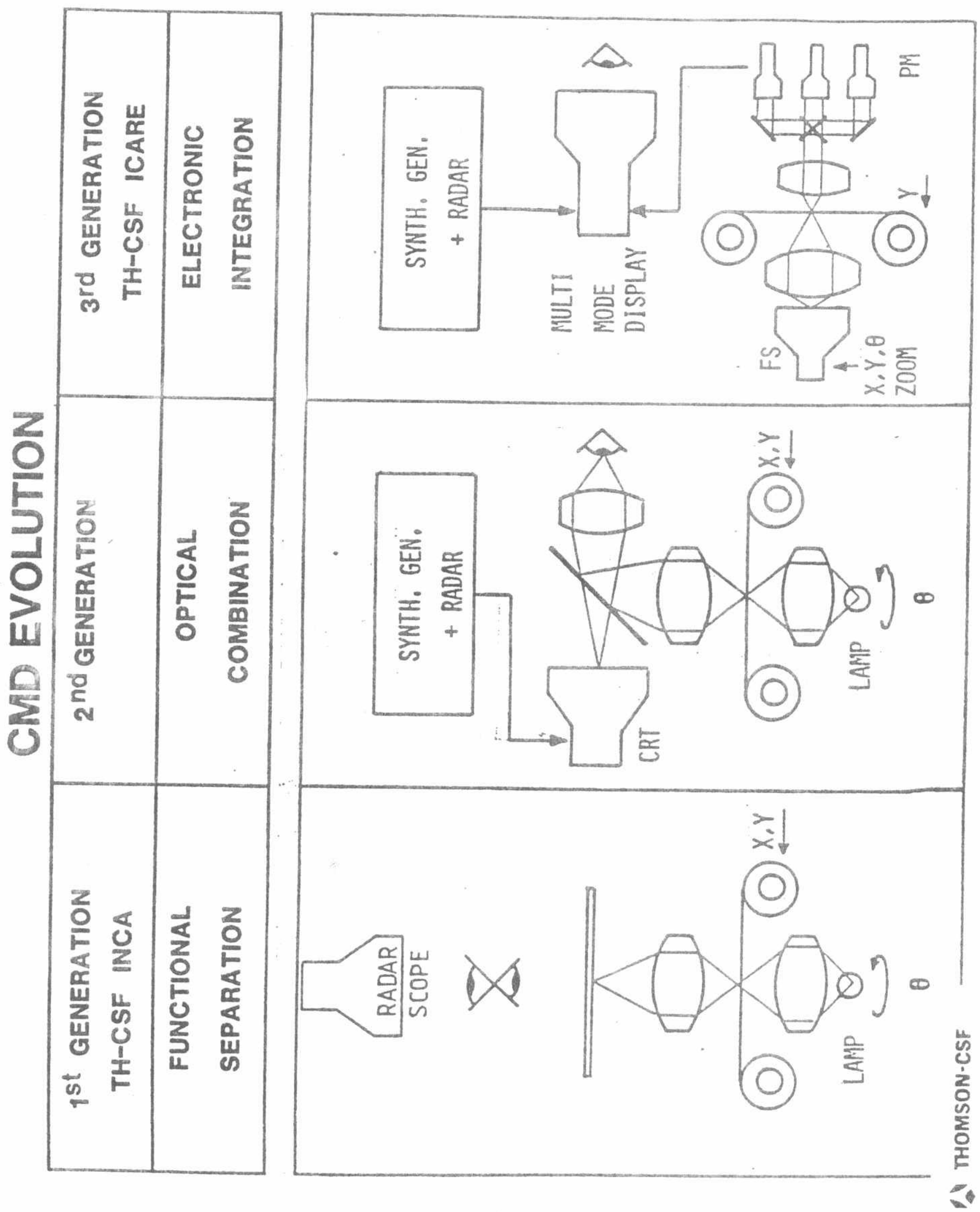
CMD EVOLUTION
1st GENERATION
TH-CSF INCA
FUNCTIONAL
SEPARATION
2nd GENERATION
OPTICAL
COMBINATION
3rd GENERATION
TH-CSF ICARE
ELECTRONIC
INTEGRATION
RADAR
SCOPE
X,Y
LAMP
θ
SYNTH. GEN.
+ RADAR
CRT
X,Y
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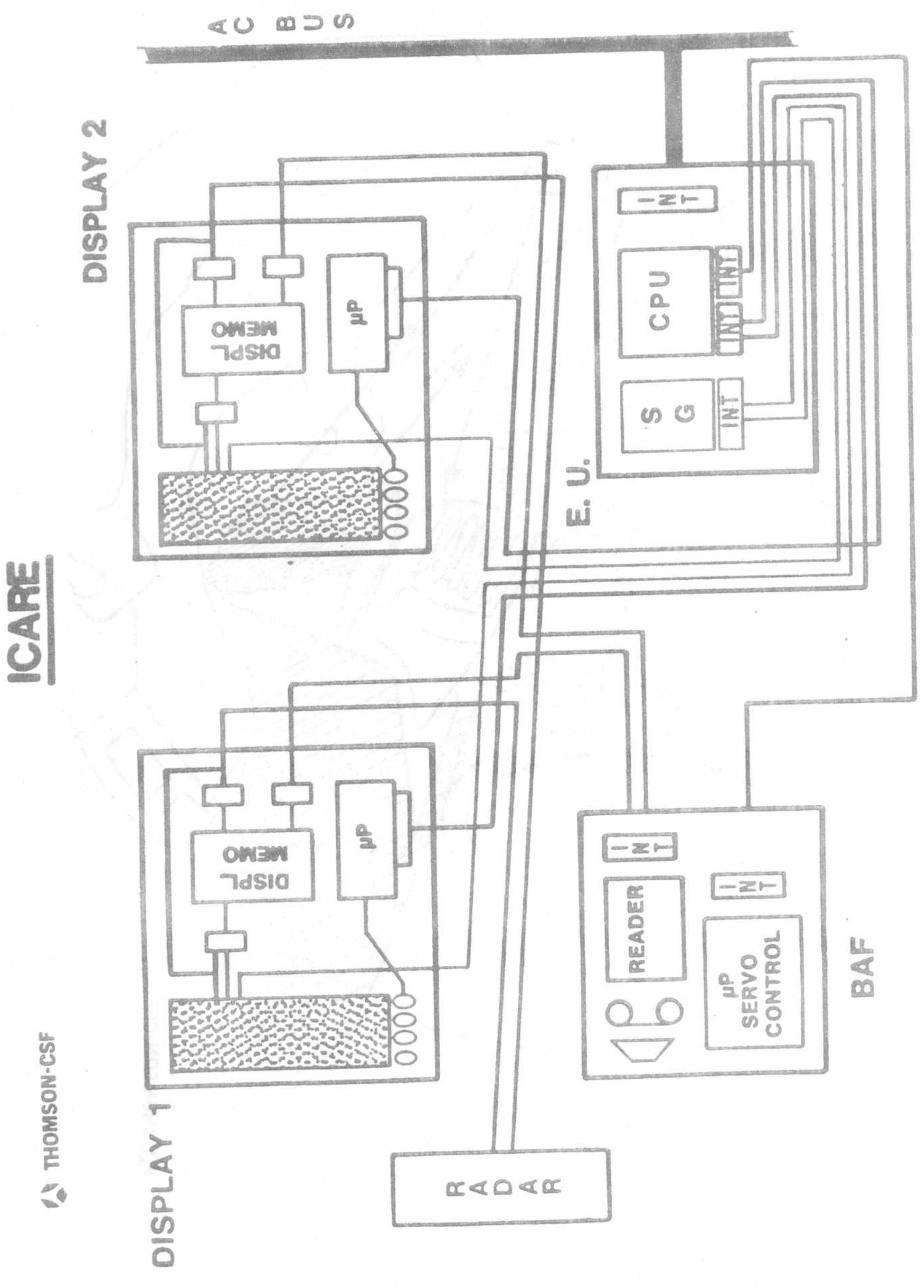
SYNTH. GEN.
+ RADAR
MULTI
MODE
DISPLAY
FS
X,Y,θ
ZOOM
Y
PM
THOMSON-CSF

II


ICARE
THOMSON-CSF
DISPLAY 2
DISPLAY 1
DISPL MEMO
µP
DISPL MEMO
µP
A C BUS
E. U.
INT
CPU
INT
INT
S G
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RADAR
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READER
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µP SERVO CONTROL

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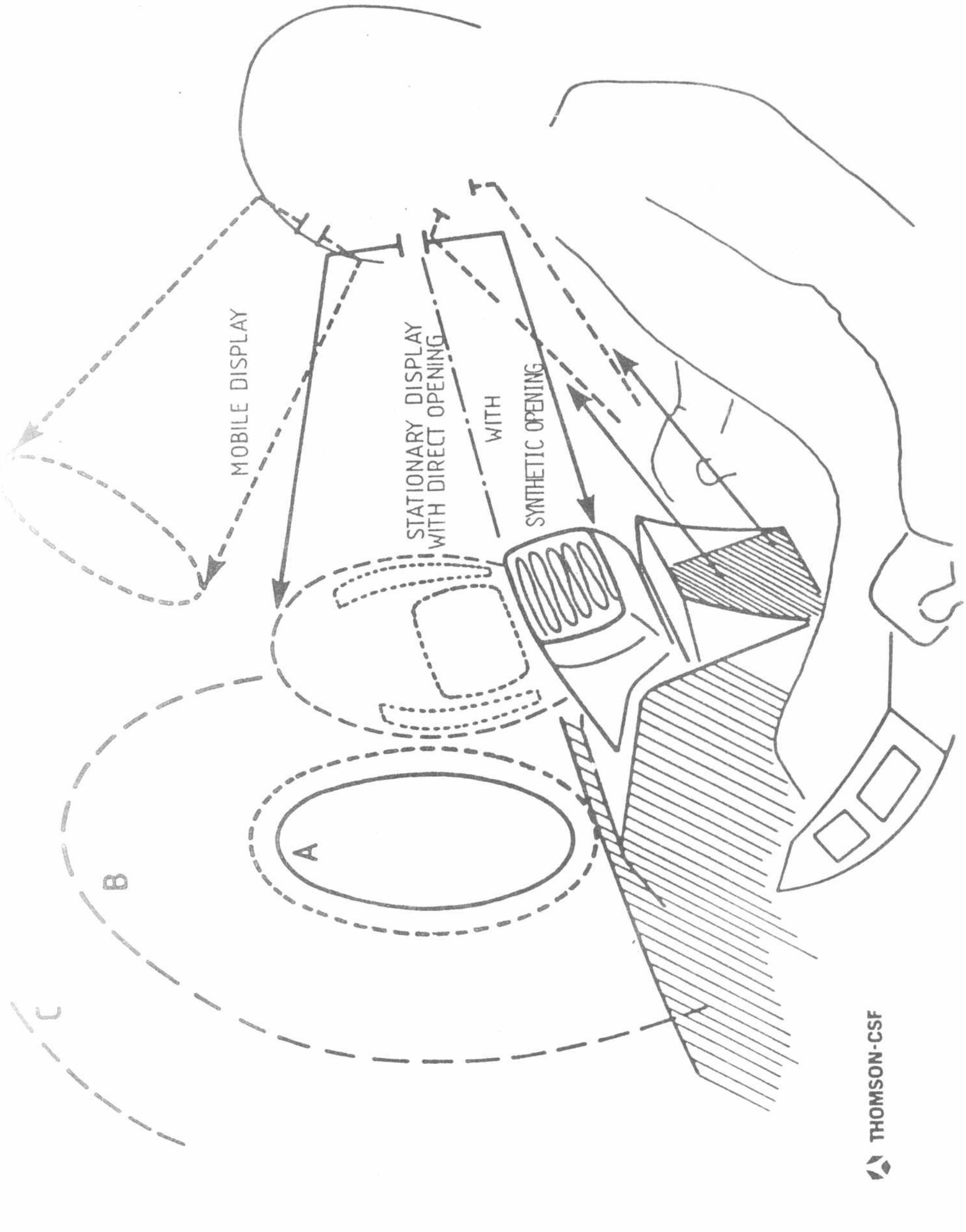
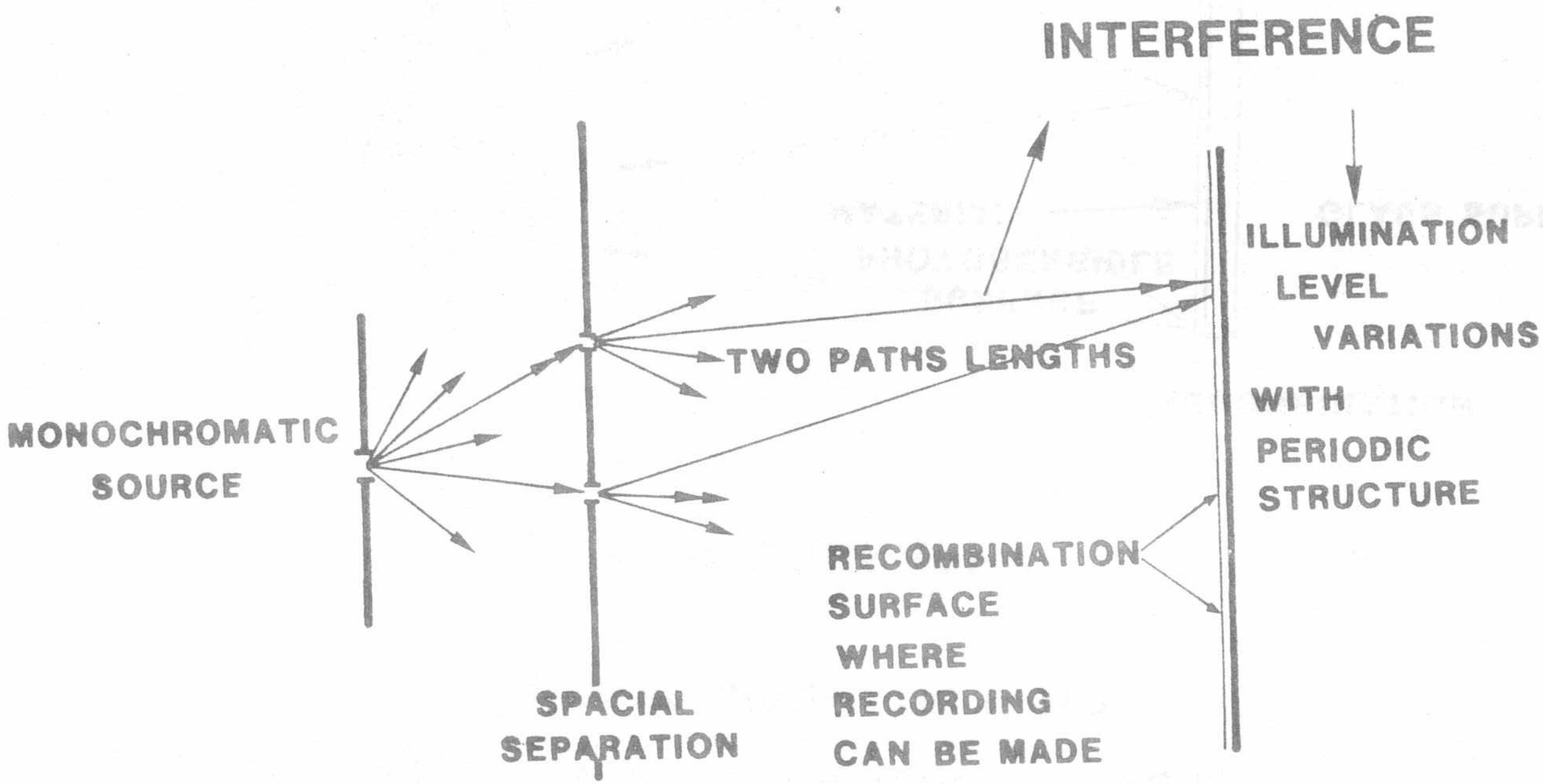
III



A PHENOMENON KNOWN SINCE A LONG TIME



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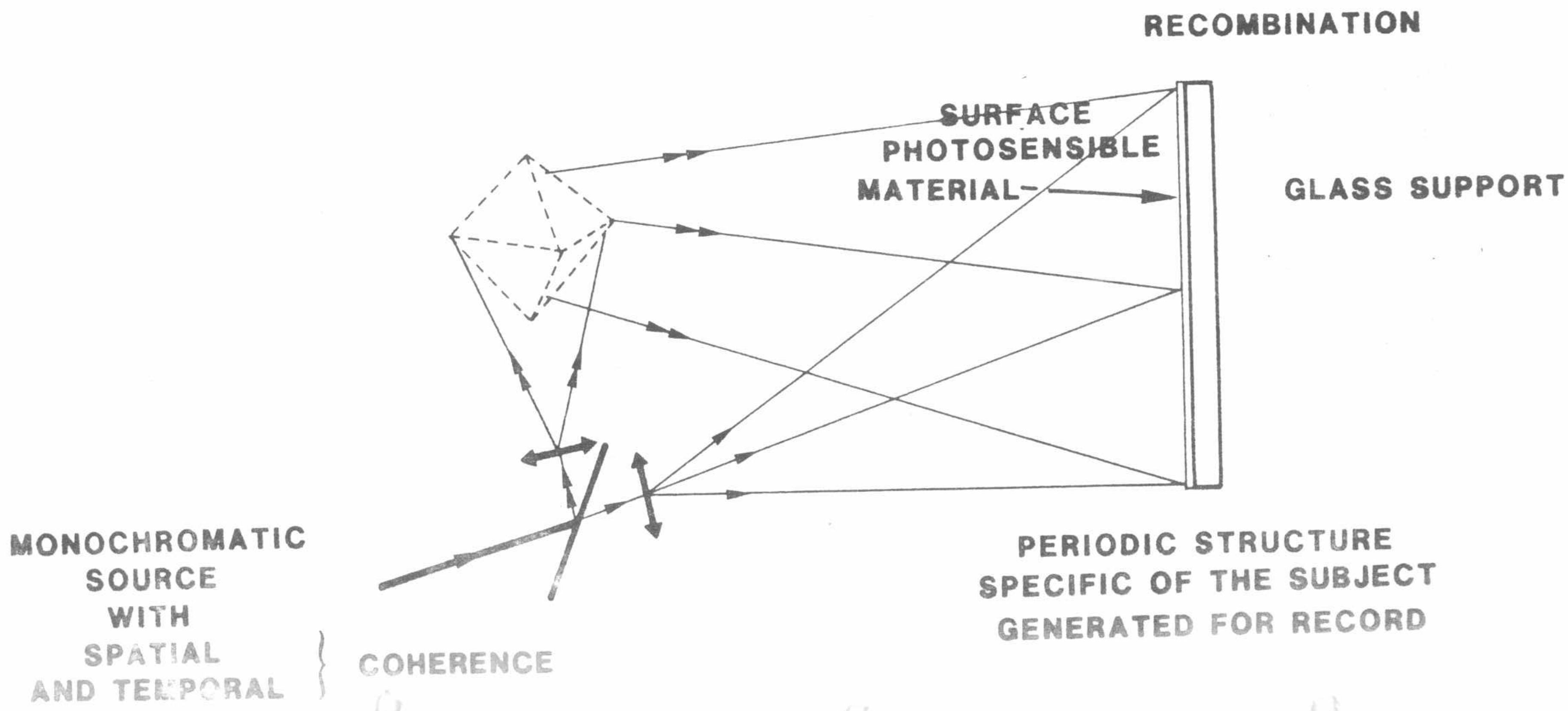
THE USE OF SUCH INTERFERENCE PHENOMENA UNDER MONOCHROMATIC LIGHT

→ HOLOGRAPHY



V

THE RESTITUTION OF THE RECORDED

TRIDIMENSIONAL APPEARANCE

OF A SUBJECT

"JUST BY LIGHTING...

,WITH THE ORIGINAL WAVELENGTH,

THE SPECIFIC INTERFERENTIAL PATTERN

WHICH HE HAD CREATED WHEN HE WAS THERE"

... MAY BE THE MOST

THRILLING EXPERIENCE

...BUT , PRESENTLY, THE MOST

REWARDING APPLICATION

OF HOLOGRAPHY

IS THE CREATION BY HOLOGRAPHIC TECHNICS

OF THE SYNTHETIC "OPTICAL ELEMENTS"

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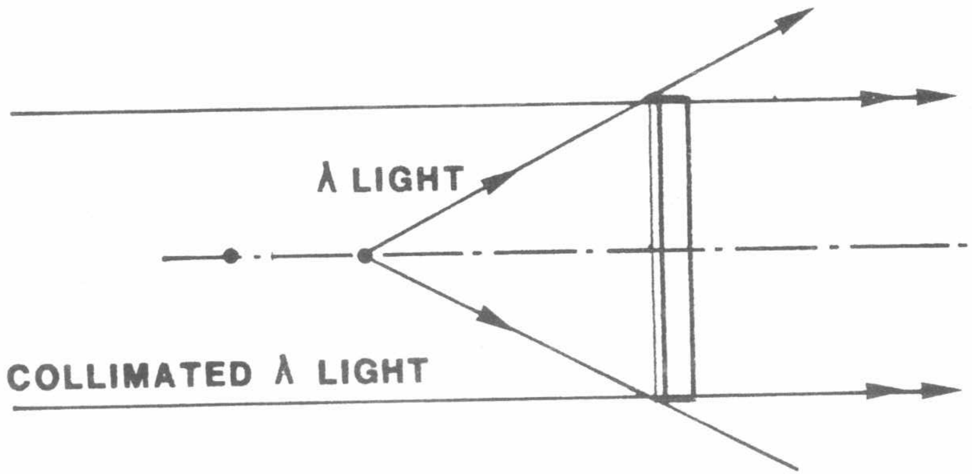
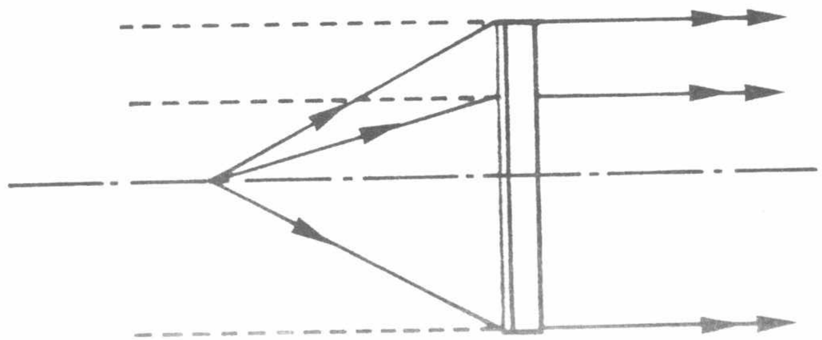
EXAMPLE

CREATION OF HOLOGRAPHIC CONVERGENT COLLIMATING ELEMENTS (FOR λ LENGTHWAVE LIGHT)



BY RECORDING OF THE RELATED INTERFERENCE PATTERN

USE OF THE RECORDED PATTERN



BY RESTITUTION WITH λ LIGHT

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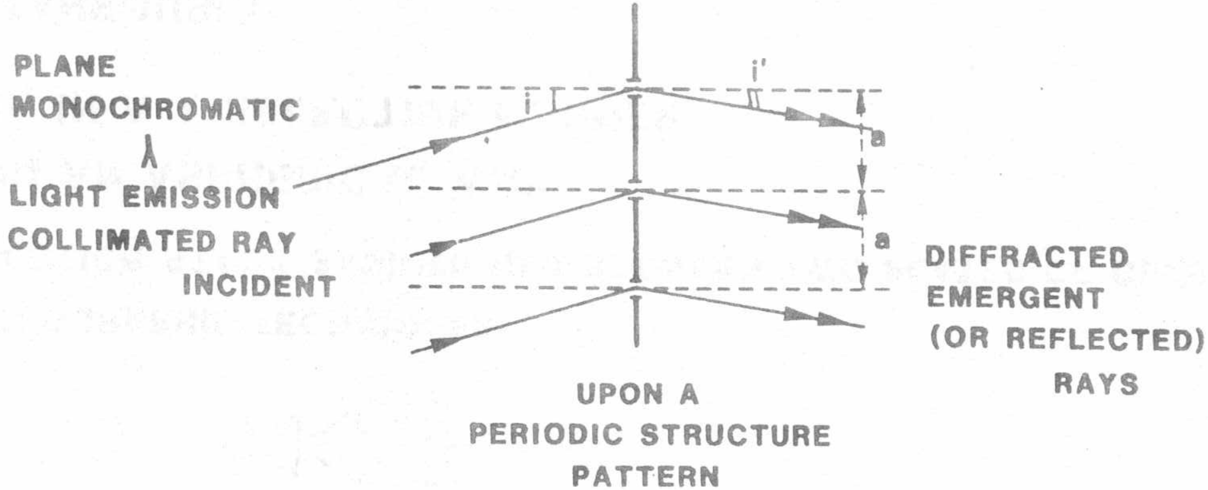
THE HOLOGRAPHIC OPTICAL ELEMENTS
TO BE USED
WILL WORK BY **DIFFRACTION**



WITH $a \simeq \lambda$

THE PATTERN INDUCES
DEVIATION
(OR REFLECTION) OF THE
LIGHT EMISSION

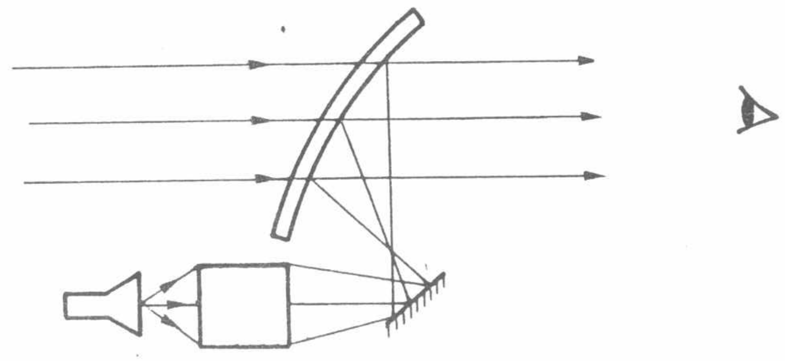
IN A SELECTIVE MANNER
FOR λ WAVELENGTH LIGHT
AS A FUNCTION OF INCIDENCE ANGLES

THIS HAS BEEN DONE BY

THOMSON-CSF

TO REALIZE

REFLECTIVE HUD /PDU WITH WIDER FOV



CREATING BY HOLOGRAPHIC TECHNIQUES

A BRAGG DIFFRACTION STACK SANDWICHED BETWEEN TWO PLATES OF GLASS

TO BE USED, IN AN ASPHERICAL WAY

AND, IN A λ SELECTIVE MANNER

SIMULTANEOUSLY

AS A DIFFRACTIVE MIRROR

AS A DIFFRACTIVE COLLIMATOR

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