

# **The Invention and Early History of the CCD**

**Dr. George E. Smith**

# **To be Covered**

**Bell Labs Background**

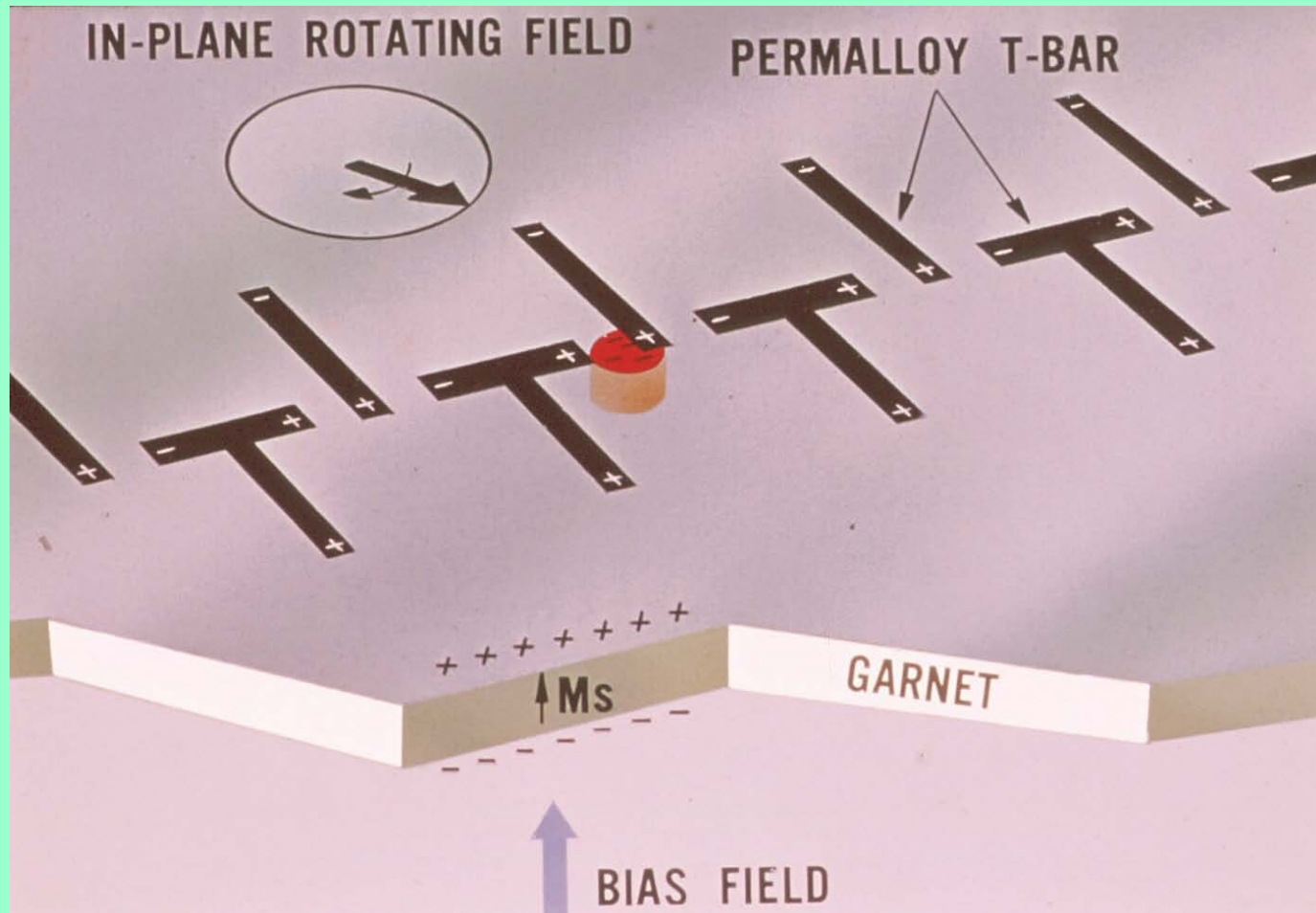
**CCD Invention**

**Device Basics**

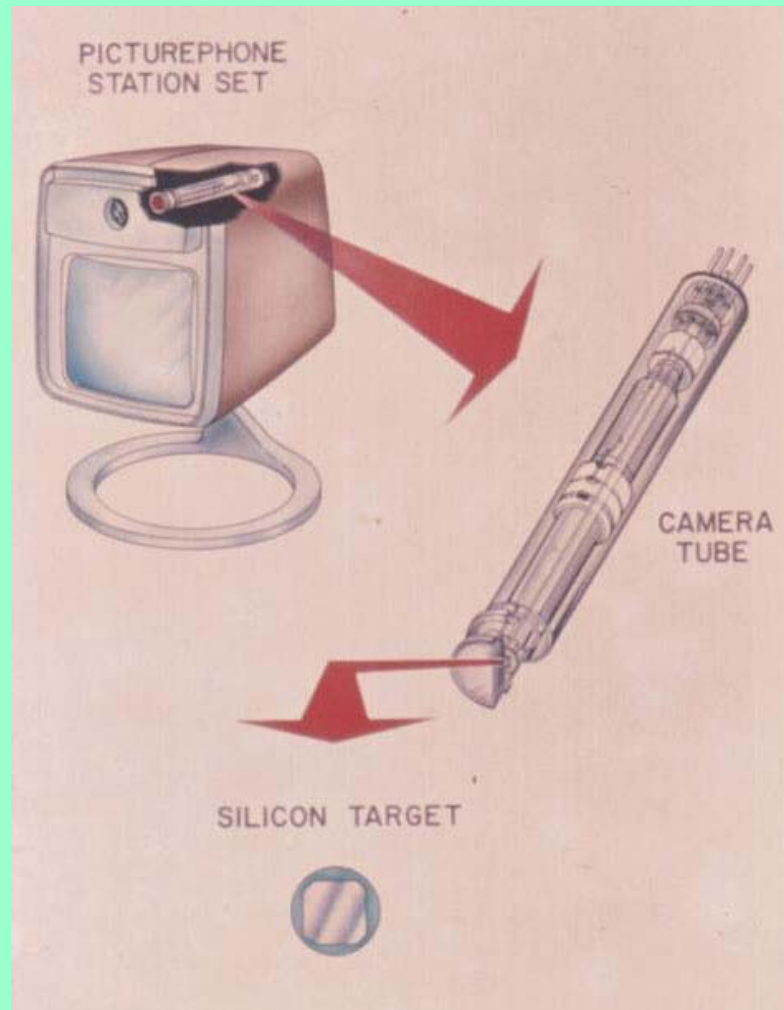
**Early Devices**

**Applications**

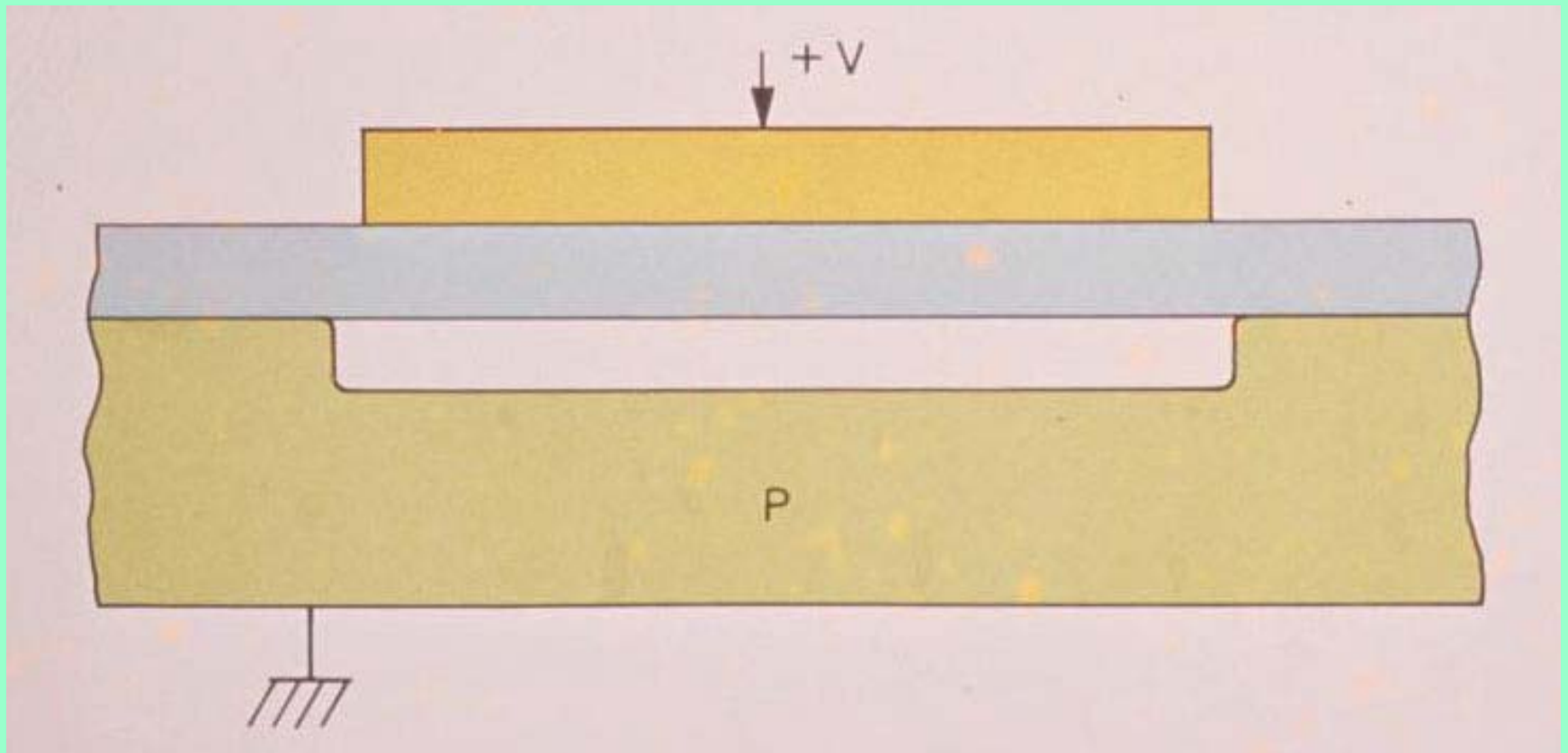
# Magnetic Bubbles



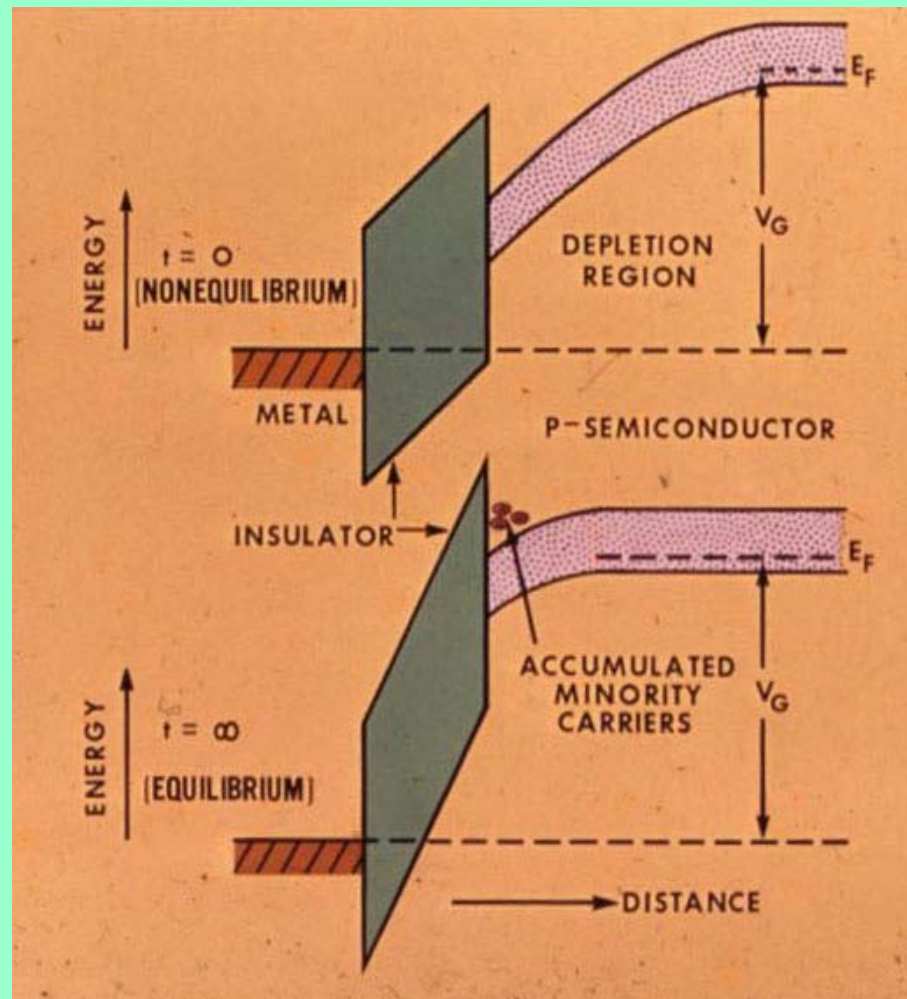
# Picturephone



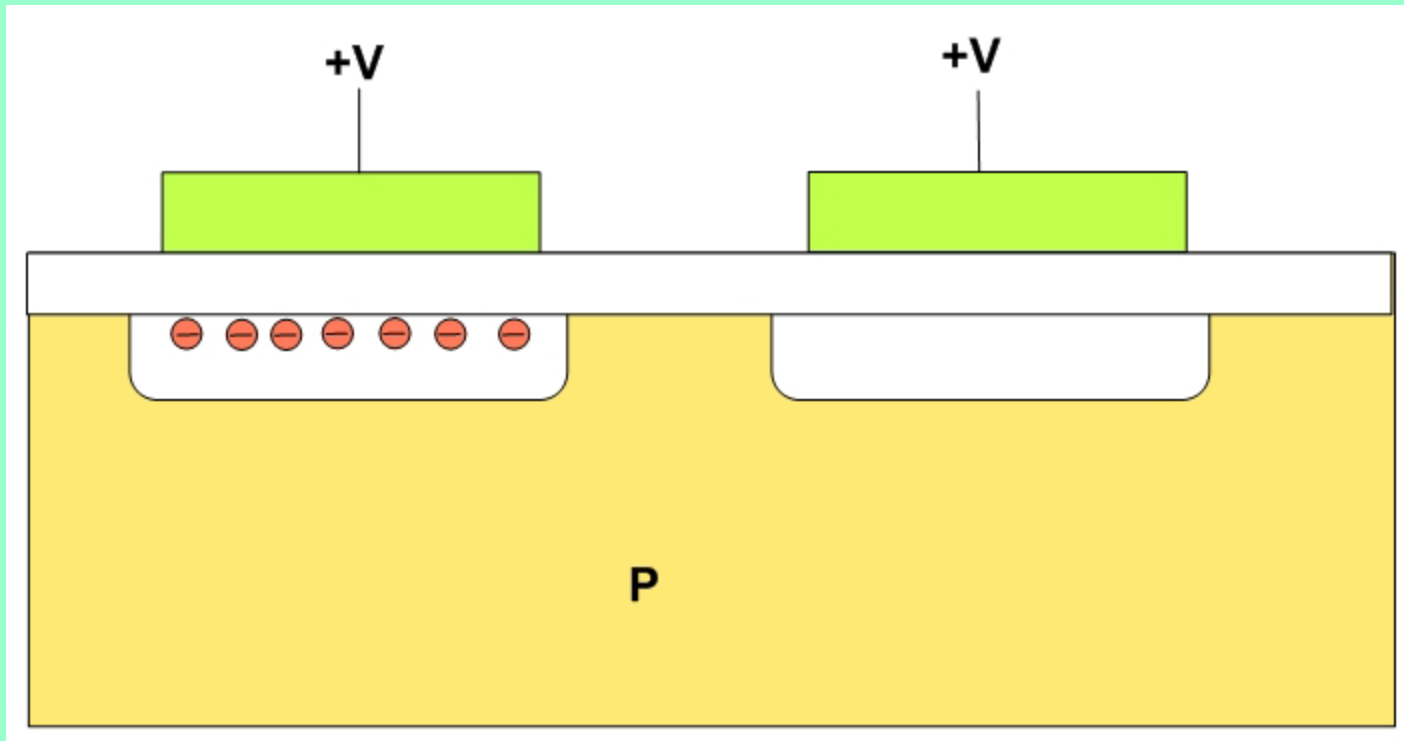
# MOS Capacitor



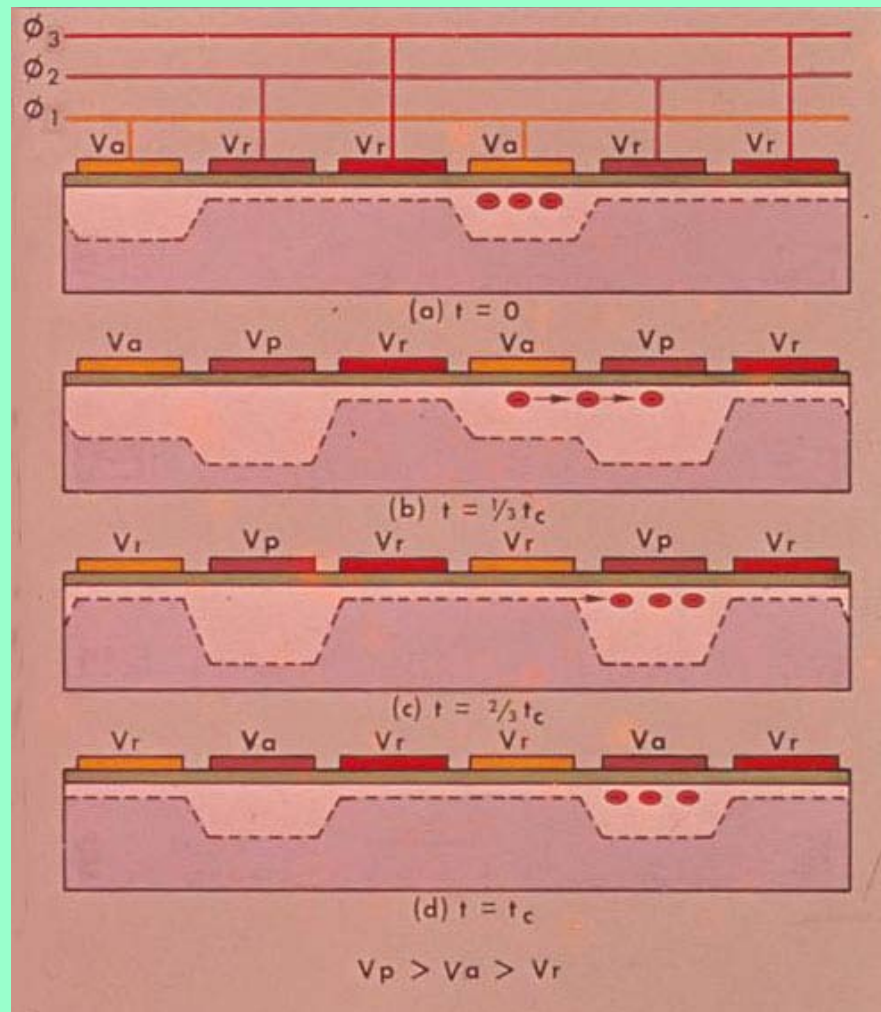
# MOS Energy Diagram



# Two MOS Capacitors

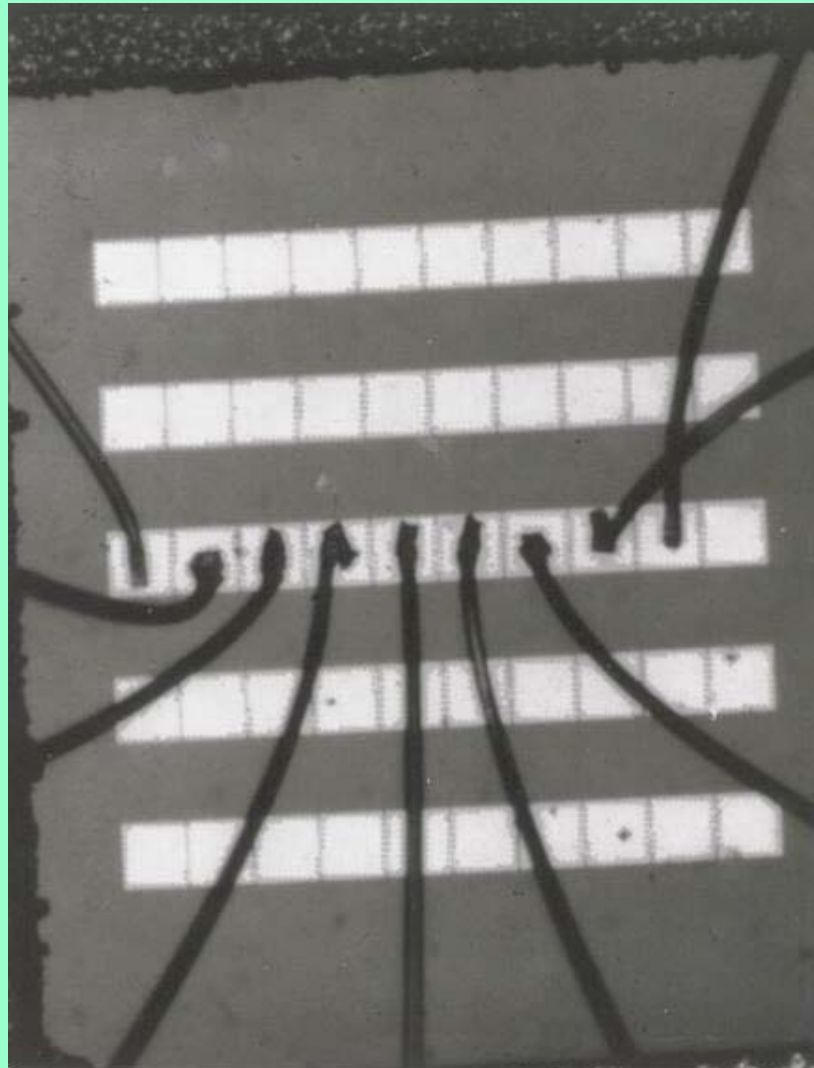


# Three Phase CCD

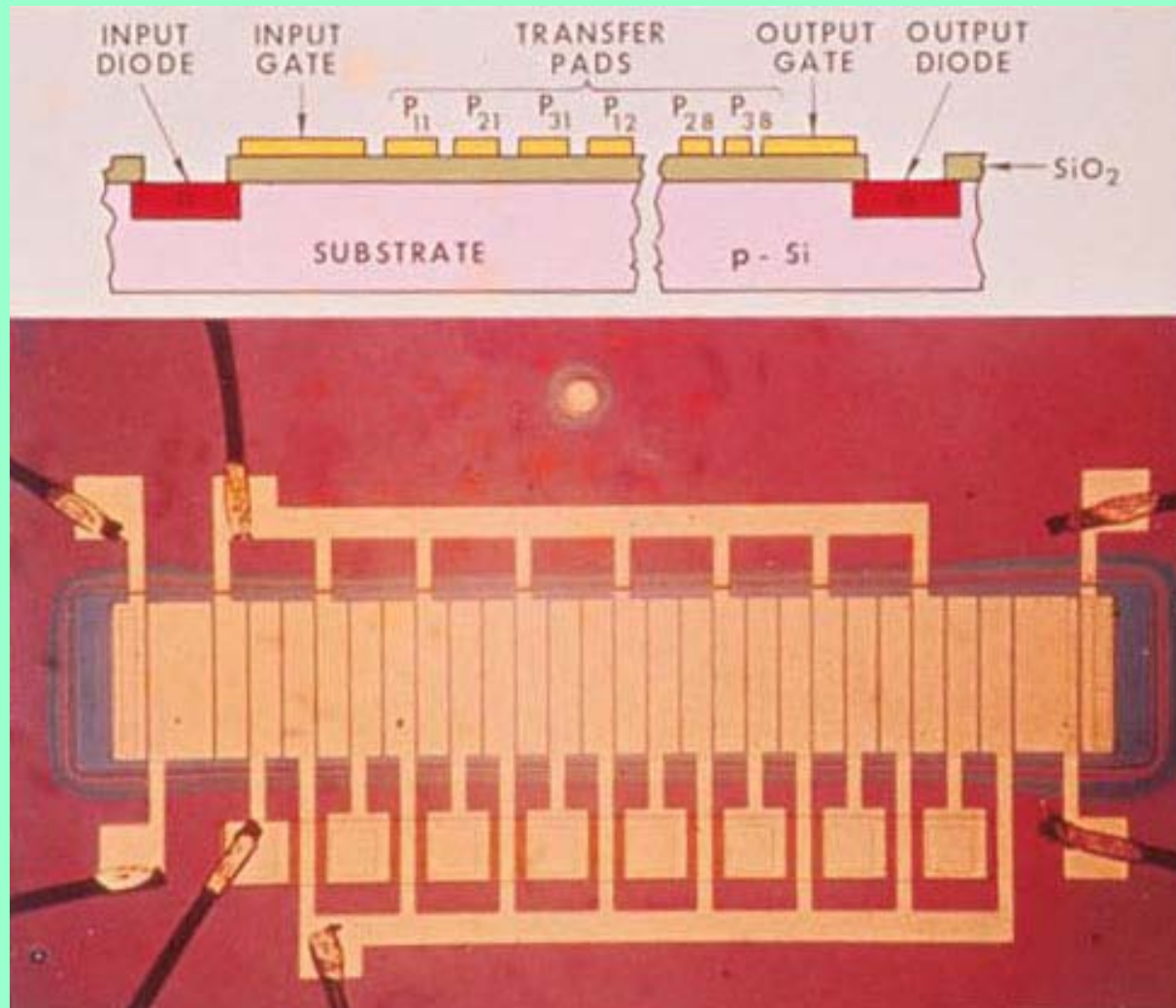




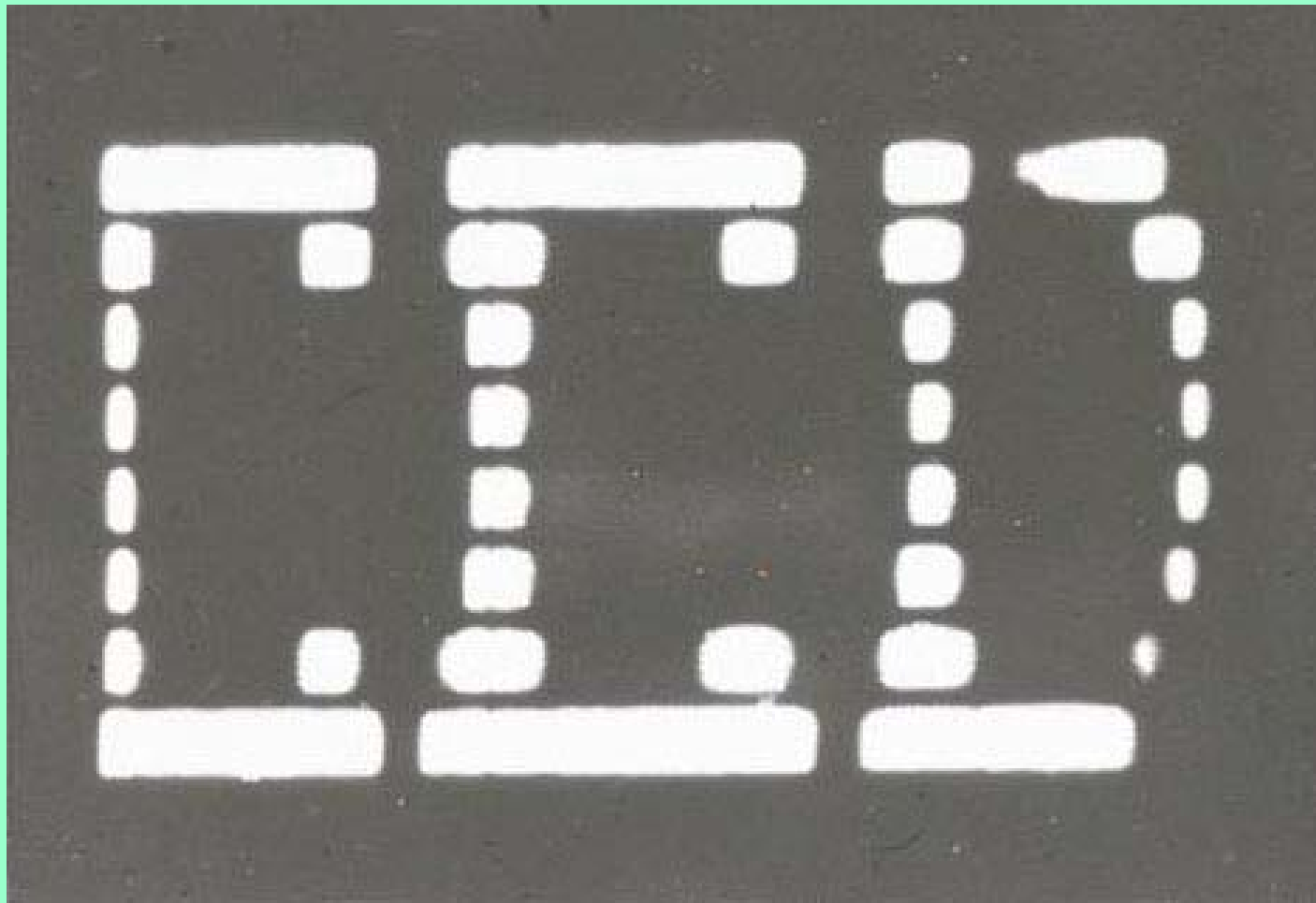
# First CCD



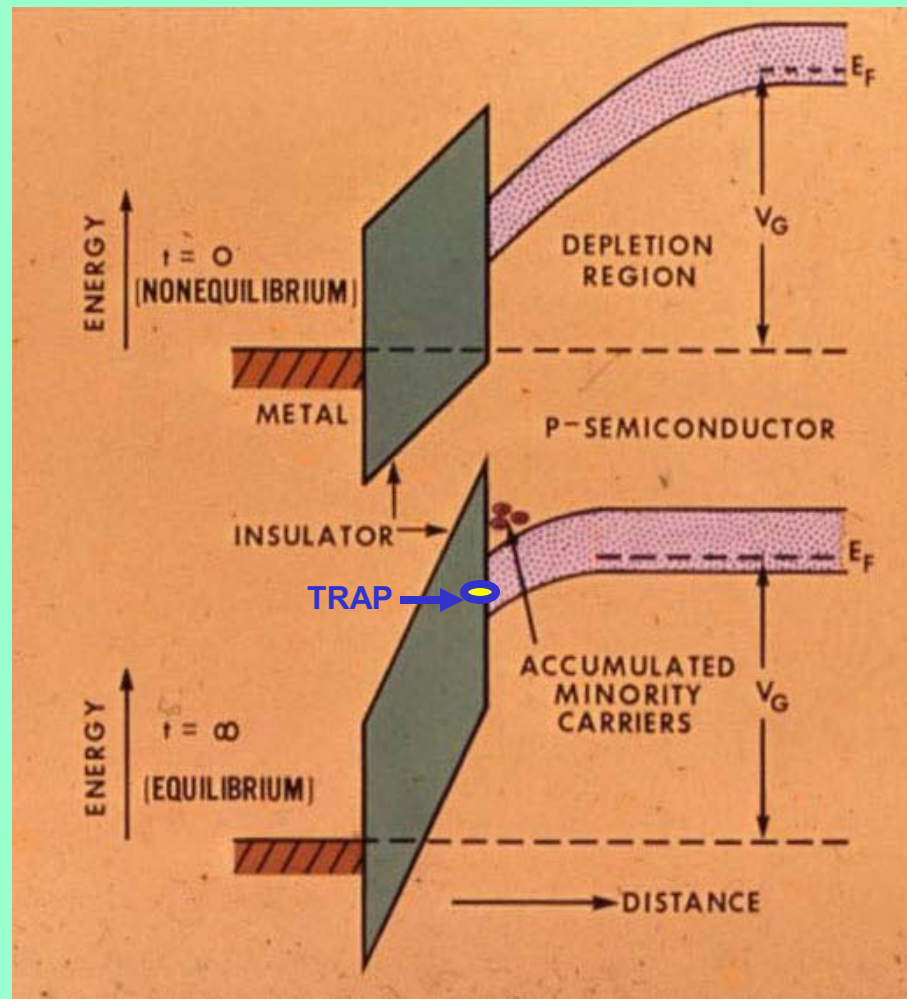
# First Functional Device



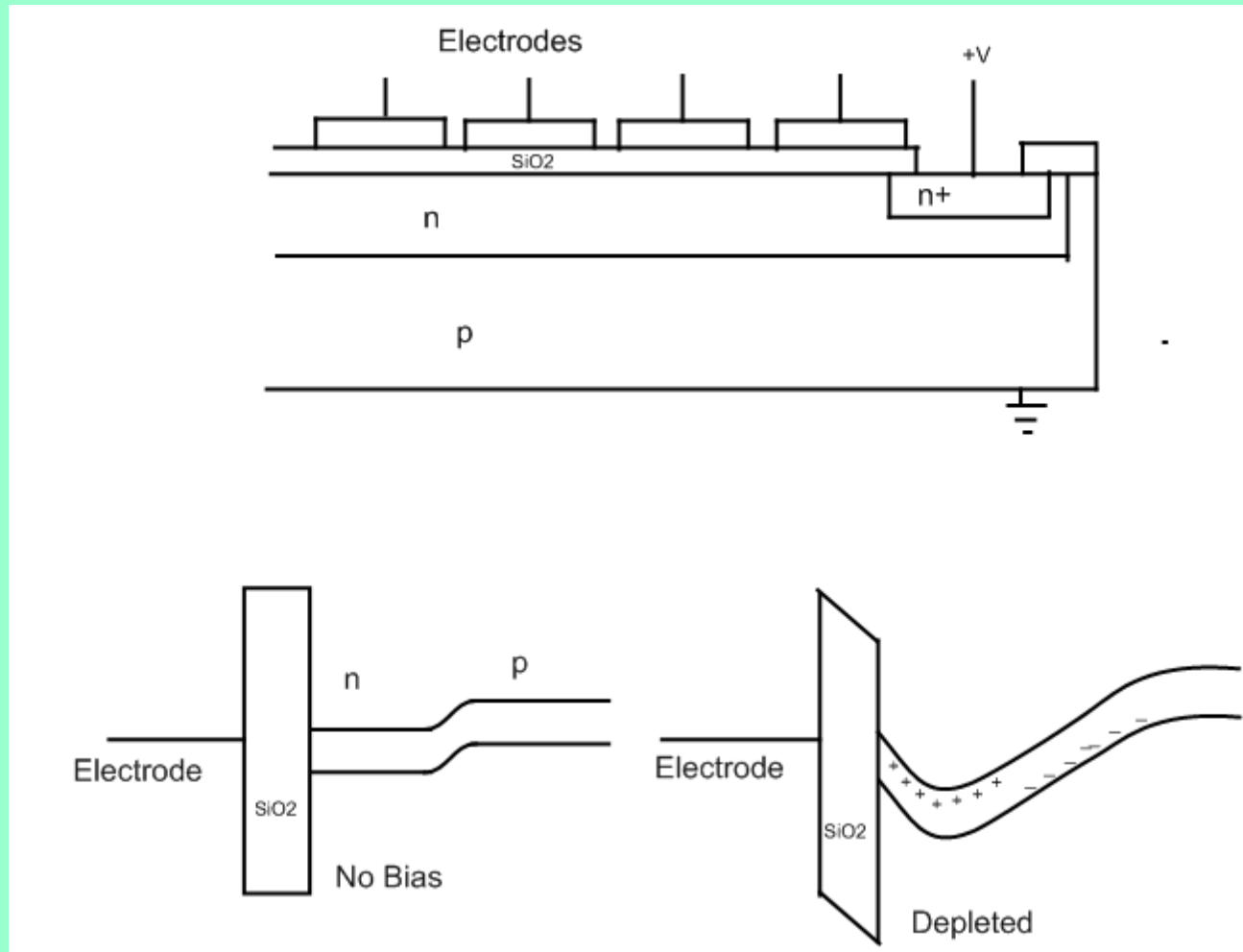
# First CCD Image



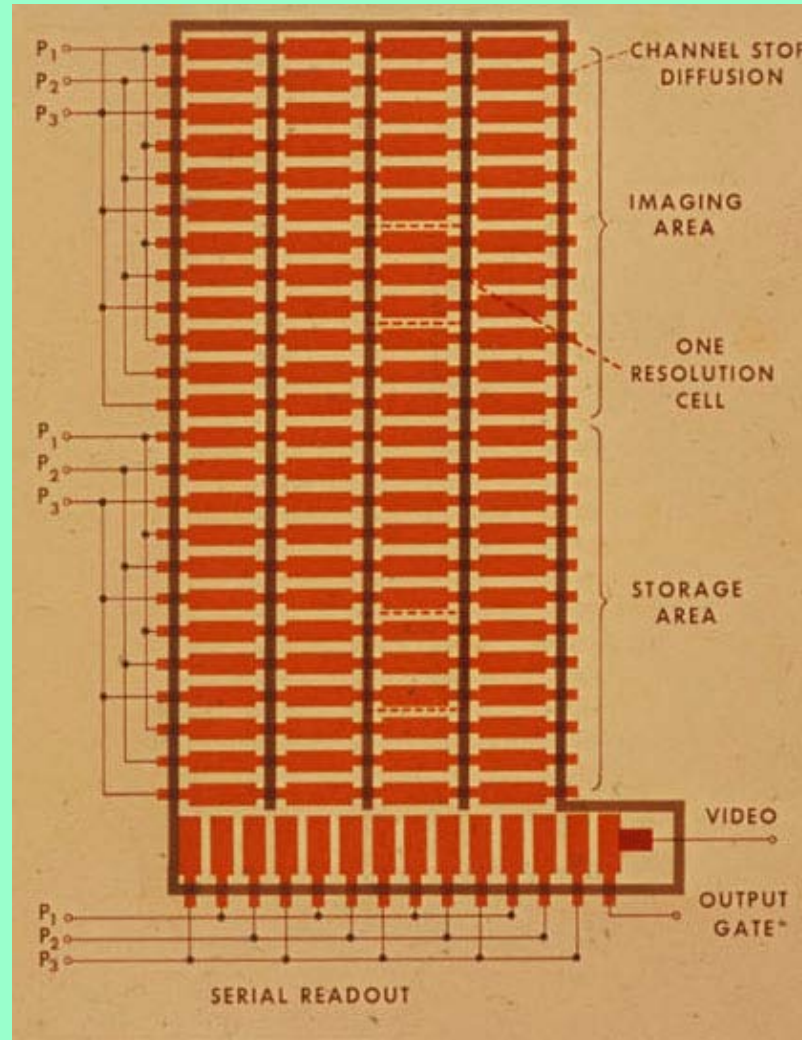
# MOS Energy Diagram



# Buried Channel CCD

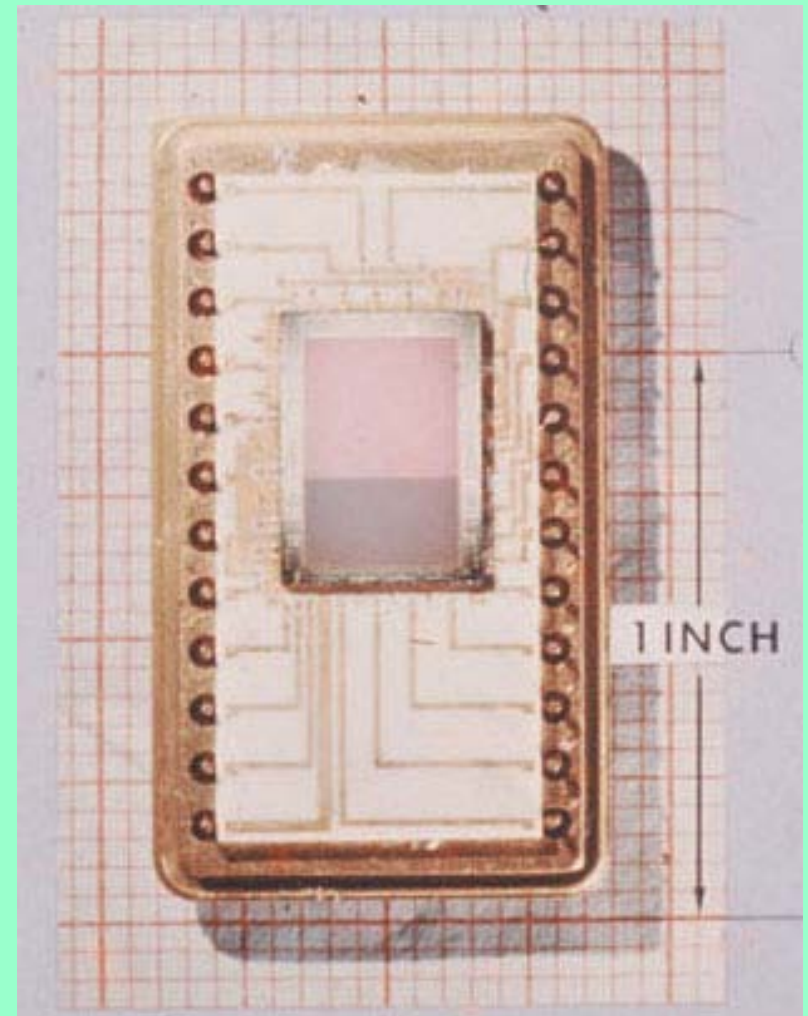


# Area CCD

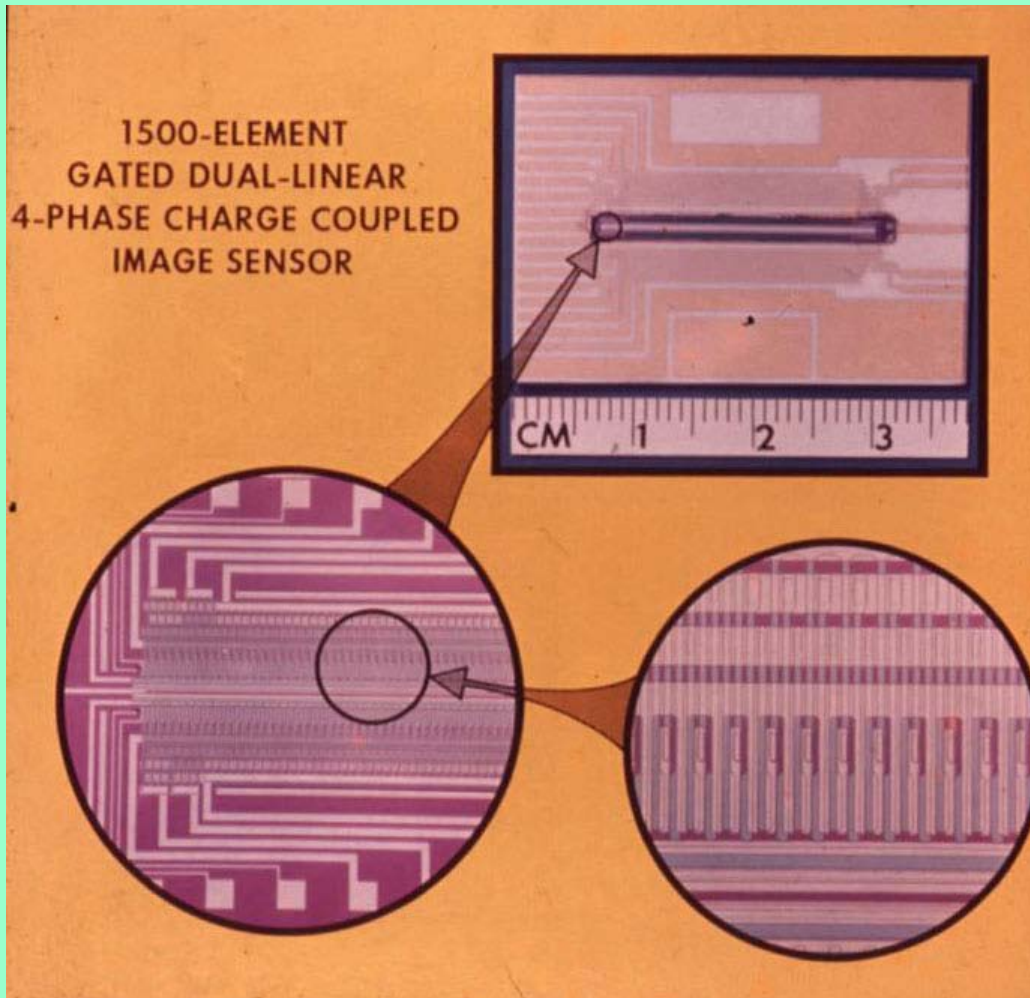




# First Self Contained Camera



# Linear CCD





# Linear Scan

## Meet the new Omega. If you think you can't afford an Olds, think again.

### **A smaller Olds at a lower price.**

Omega is a whole new kind of Olds—a compact, but one with Olds big-car thinking built into three interesting variations: 2-door coupe, 3-door hatchback and 4-door sedan. All of them a lot of Olds for the money.

### **Omega is not your basic little car.**

It's nearly 500 pounds more car than some smaller compacts. The wheelbase is longer—111 inches. And you can feel this extra size and heft working for you on the road. It's solid and steady. Roomy.

Comfortable. Agile and maneuverable.

### **You get what you bargained for.**

Omega gives you nice things you may have to pay extra for in other compacts. A deluxe interior with new "wet look" vinyl trim. Full carpeting. Chrome trim around the windows and wheel openings. And 230 cubic inches of engine. There are

also things some compacts don't offer at any price! A glove compartment with a door and a lock. Rear windows that roll down. And generous trunk space.

### **Add some neat ideas of your own.**

You can order a vinyl roof for looks. Our famous Rocket 350 V8 for gas. Sporty high-back bucket seats and a console for the coupe and hatchback. Even a special tent that converts the hatchback into a camper.

### **It feels like a bigger car.**

Get into an Omega and notice the comfort. The way you sit up, how right the steering wheel position seems, how easily the car responds. Sure, you can get a lesser compact for less money—but then, it wouldn't be an Olds Omega Oldsmobile. Always a step ahead.

**'73 Oldsmobile Omega.**



# Aerial Photo

LINEAR IMAGE SENSORS  
APPLICATION: AERIAL  
RECONNAISSANCE

FAIRCHILD

6114

CCD121  
1728 x 1 SENSOR IN

FAIRCHILD MINI-CAMERA

TAKEN AT:  
2000 ft. ALTITUDE  
150 KNOTS OVER  
SOUTHERN LONG ISLAND

PHOTO REPRODUCED FROM  
STORED DATA BY LASER  
RECORDING PROCESS



# **Current Applications**

**Digital Cameras**

**TV Cameras**

**Scanners**

**Medical devices**

**Fax machines**

**Bar Code Readers**

**Satellite Surveillance**

**Earthly Surveillance**

**Astronomy**

# CCD's in Astronomy

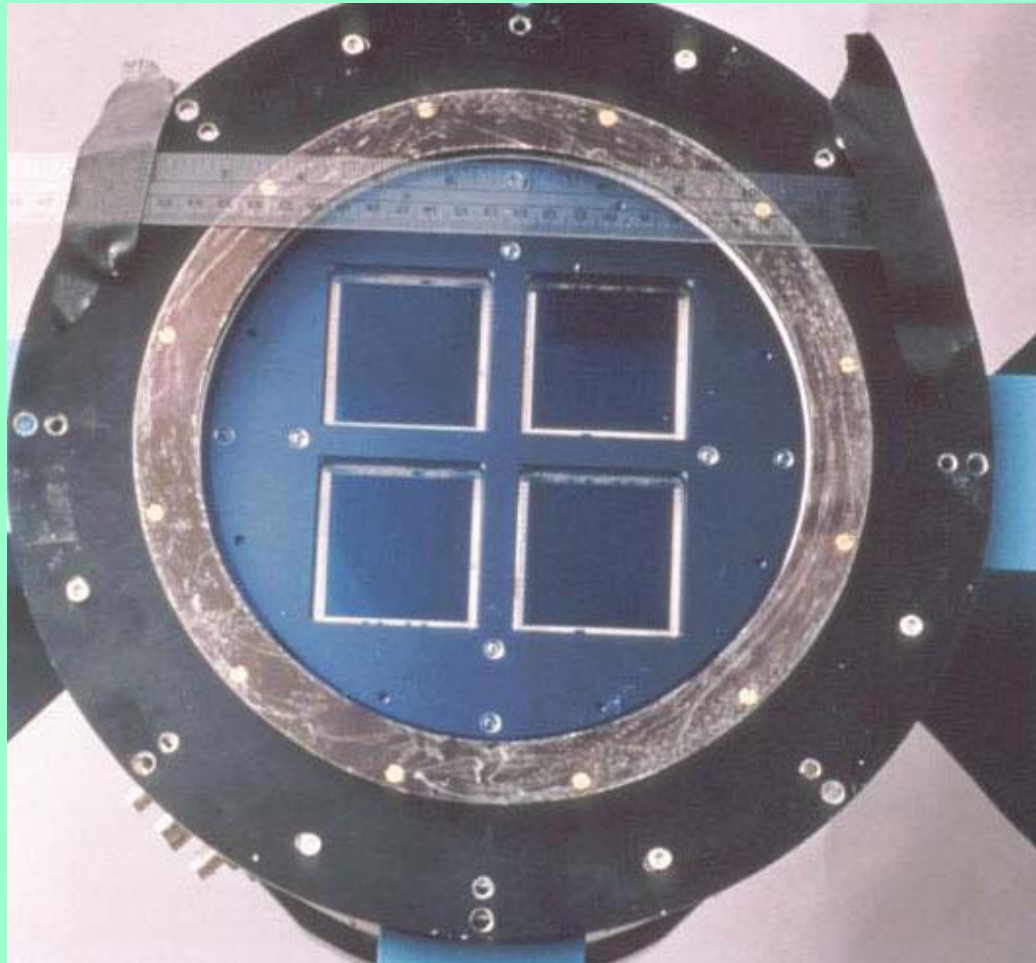
**90% Quantum Efficiency (Film is 5%)**

**Long integration times (at 160° K) 20 electrons/hr/pixel)**

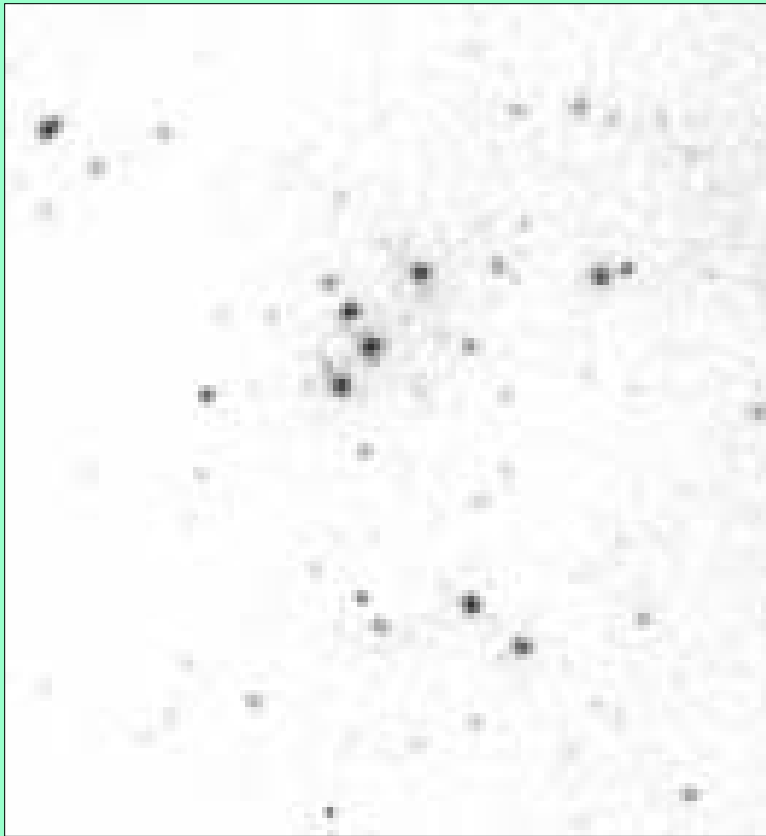
**Large dynamic range  $10^5$  electrons/pixel**

**Repeatability eliminates systematic errors**

# Astronomical Camera



# More Before & After



# Summary

**CCDs born in the Si-SiO<sub>2</sub> Revolution**

**1<sup>st</sup> Practical Solid State Imaging Device**

**Widespread Applications**