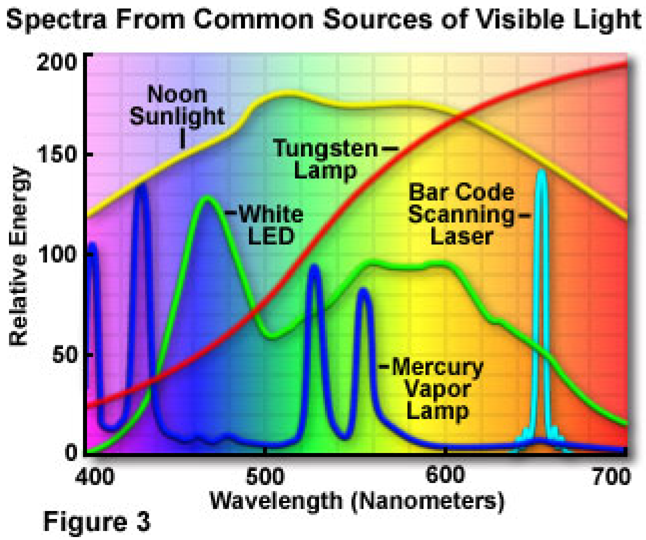
Optikk



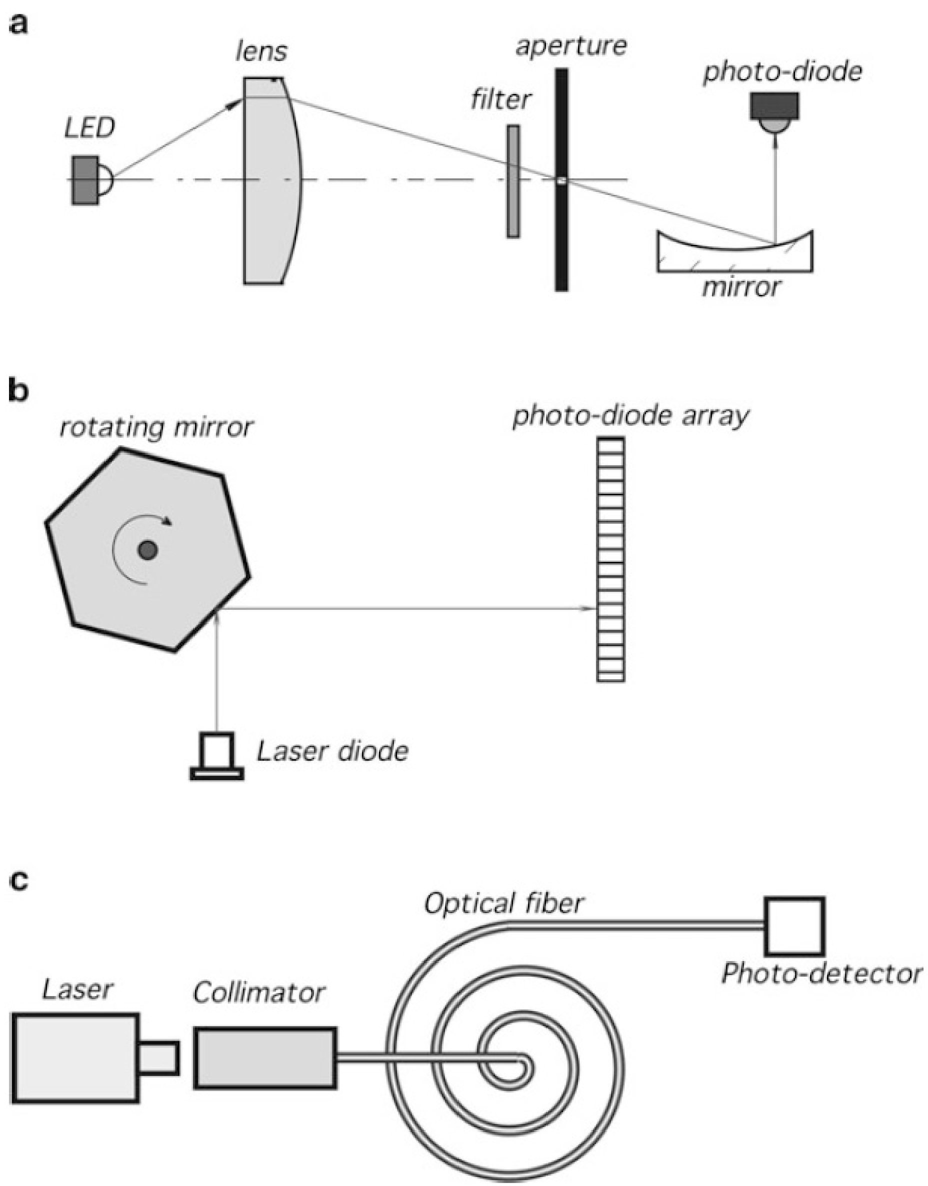


Fig. 4.1 Examples of optical systems that use refraction (**a**) and reflection (**a**, **b**, **c**)

Refraksjon

- Heron of Alexandria (1. C):

  $$\Theta_1 = \Theta'_1$$

- Snells lov (1621):

  $$n_1 \sin\Theta_1 = n_2 \sin\Theta_2$$

- *n* er refraksjonsindeks (brytningsindeks) og oppgis ofte ved λ = 0.58756 µm (gul/orange)
- Dessuten: $$n = \frac{c_0}{c} = \sqrt{\varepsilon_r}$$
- Refleksjonskoeffisient:

$$\rho = \frac{\Phi_\rho}{\Phi_0} = \left(\frac{n_1 - n_2}{n_1 + n_2}\right)^2$$

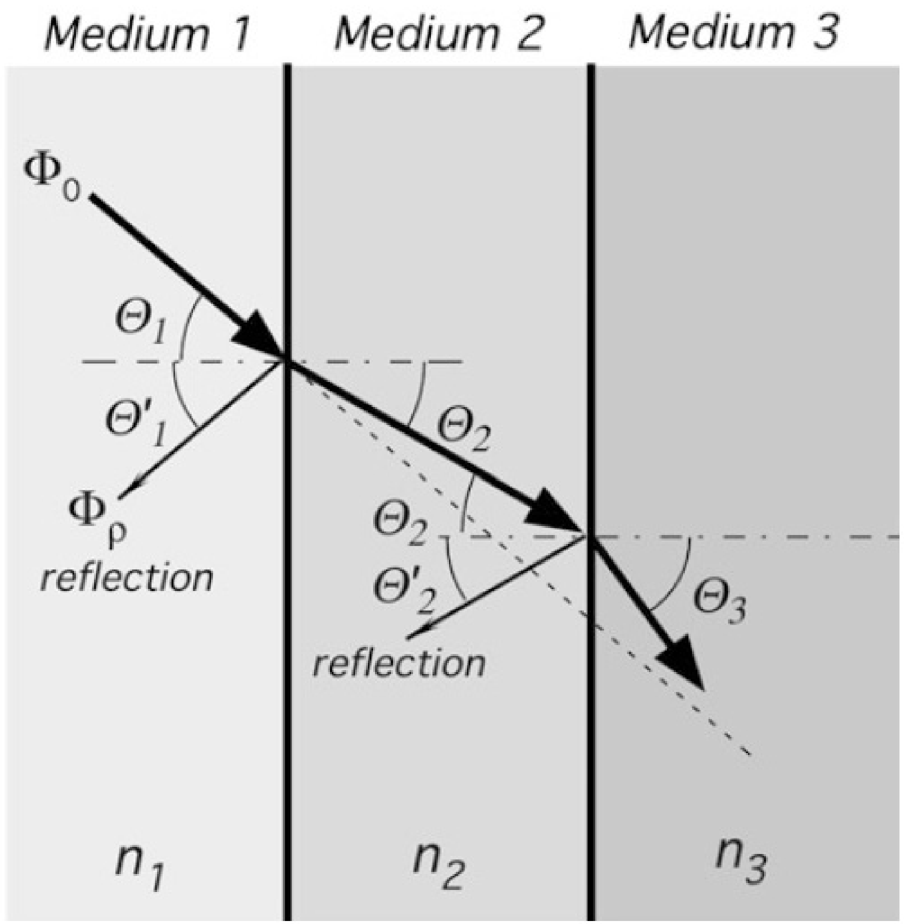


Fig. 4.2 Light passing through materials with different refractive indices

Transparens / transmittans

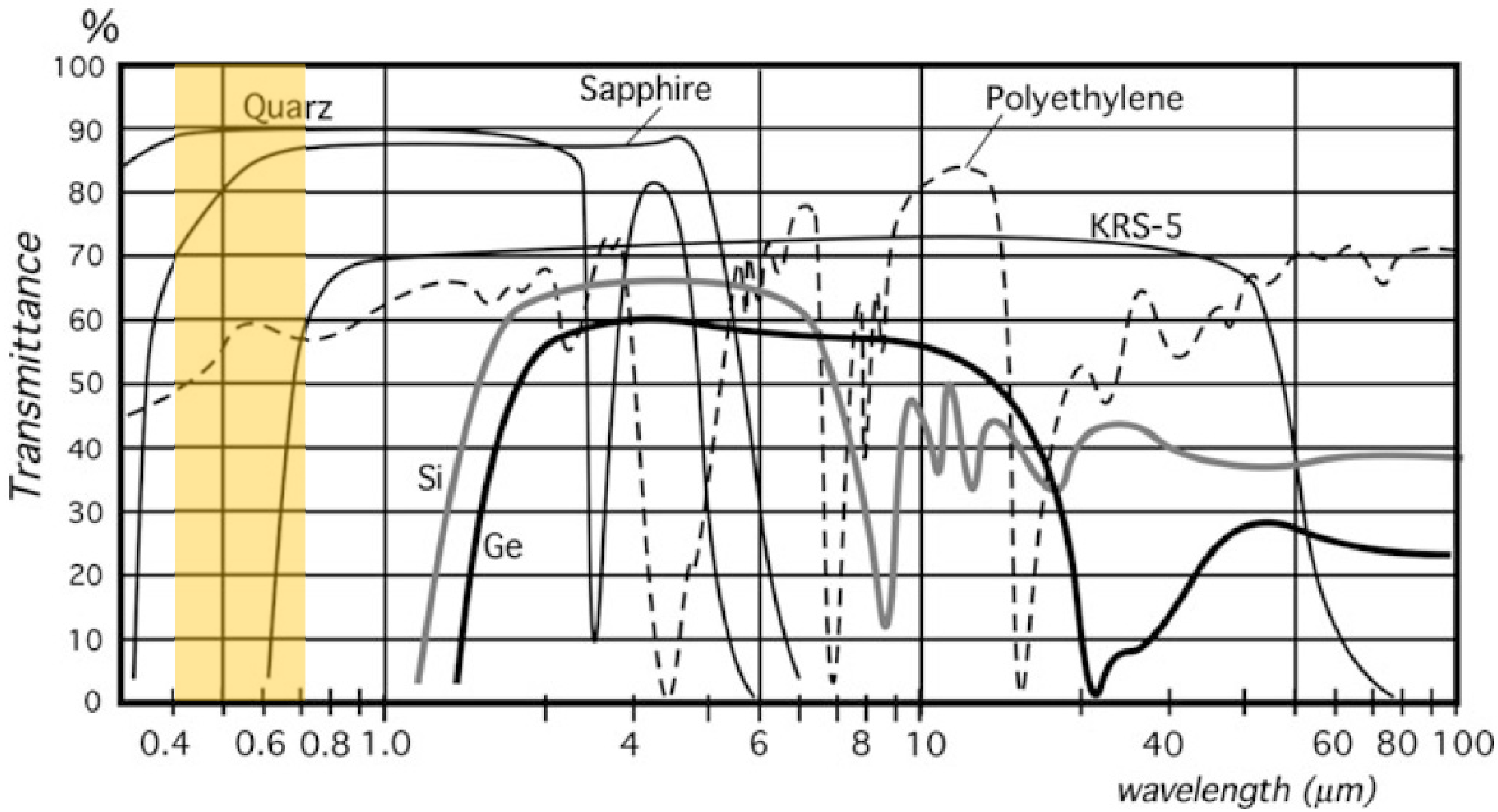


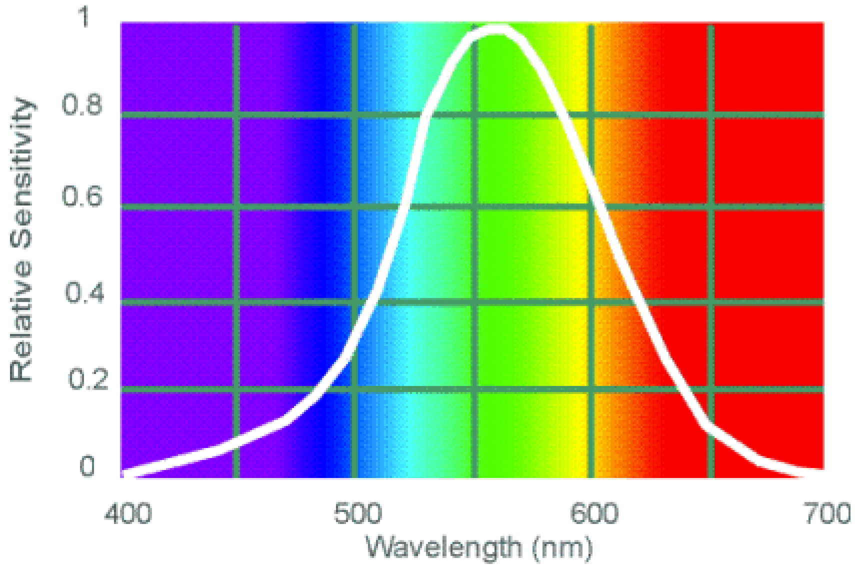
Fig. 4.3 Transparency characteristics for various optical materials

Fotometri

- Øyet har forskjellig følsomhet for forskjellige bølgelengder → Belysningsfluks F i lumen i stedet for watt. Angir total «mengde» av synlig lys som emitteres fra en kilde.

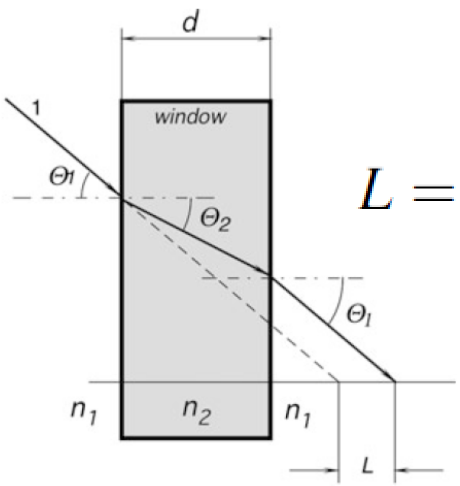
- Illuminans: $E = \frac{\mathrm{d}F}{\mathrm{d}A}$ (belysningsfluks per areal) [lumen/m^2 = lux]

- Belysningsintensitet: $I_L = \frac{dF}{d\omega}$ (belysningsfluks per romvinkel $\omega = \frac{A}{r^2}$) [candela]

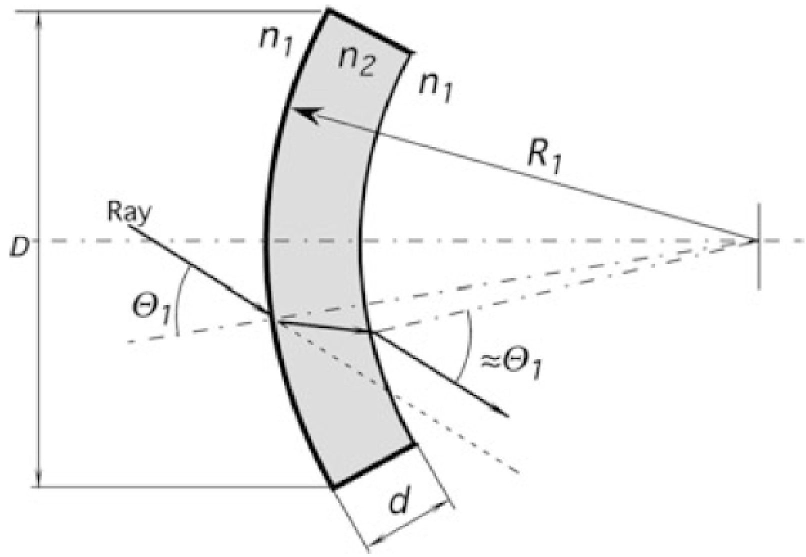


Vinduer

- For å beskytte lyskilde eller sensor
- Minimere optiske forvrengninger:
  - Aperture $D < R_1$
  - Tykkelse d uniform og << R_1
- Hvis ikke blir det en linse



$$L = d\frac{n-1}{n}$$



Speil

- Verdens eldste optiske instrument
- Belegget kan være på første eller andre flate
- Sølv, aluminium, chrom, rhodium for synlig lys

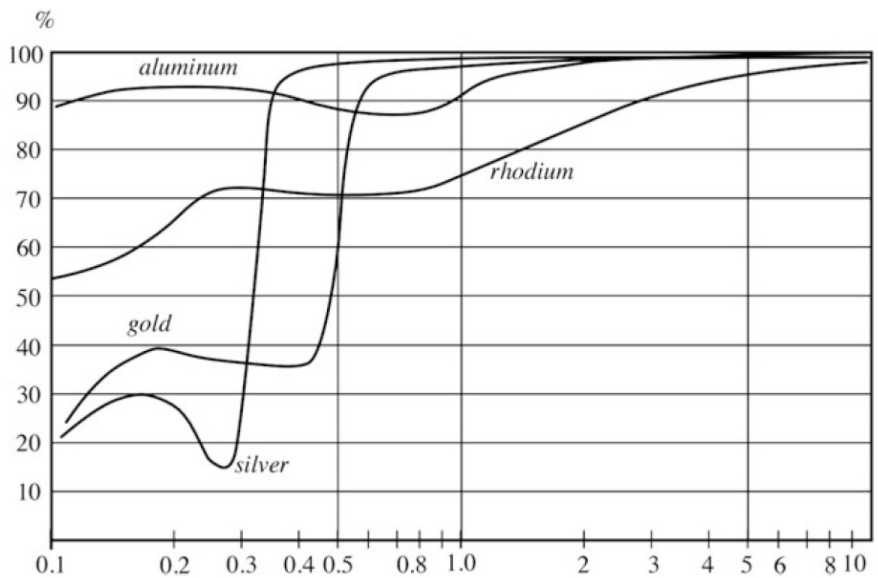
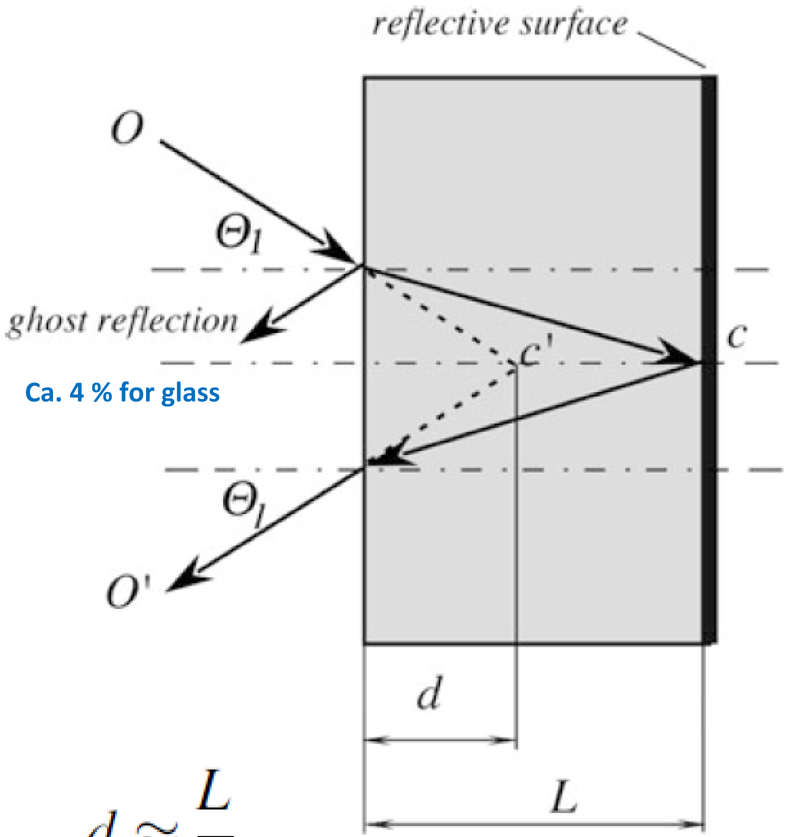


Fig. 4.10 Spectral reflectances of some mirror coatings



$$d \approx \frac{L}{n}$$

Krumme flater som speil

Fungerer som linser.
Brukes når parallelle lysstråler skal fokuseres

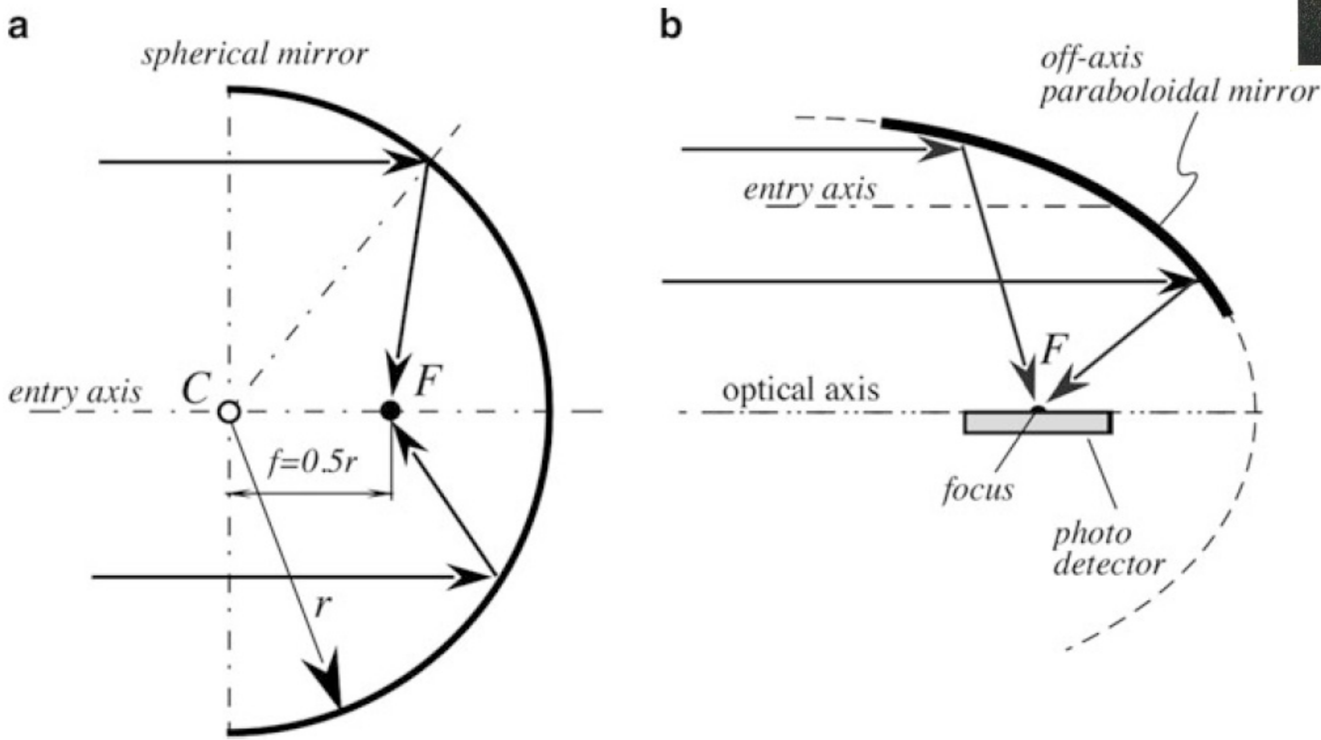


Fig. 4.11 Spherical (**a**) and parabolic (**b**) first surface mirrors

Linser

- For en tynn linse: $\frac{1}{f} = (n-1)\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$

- Brytningsindeks n og radier r_1 og r_2

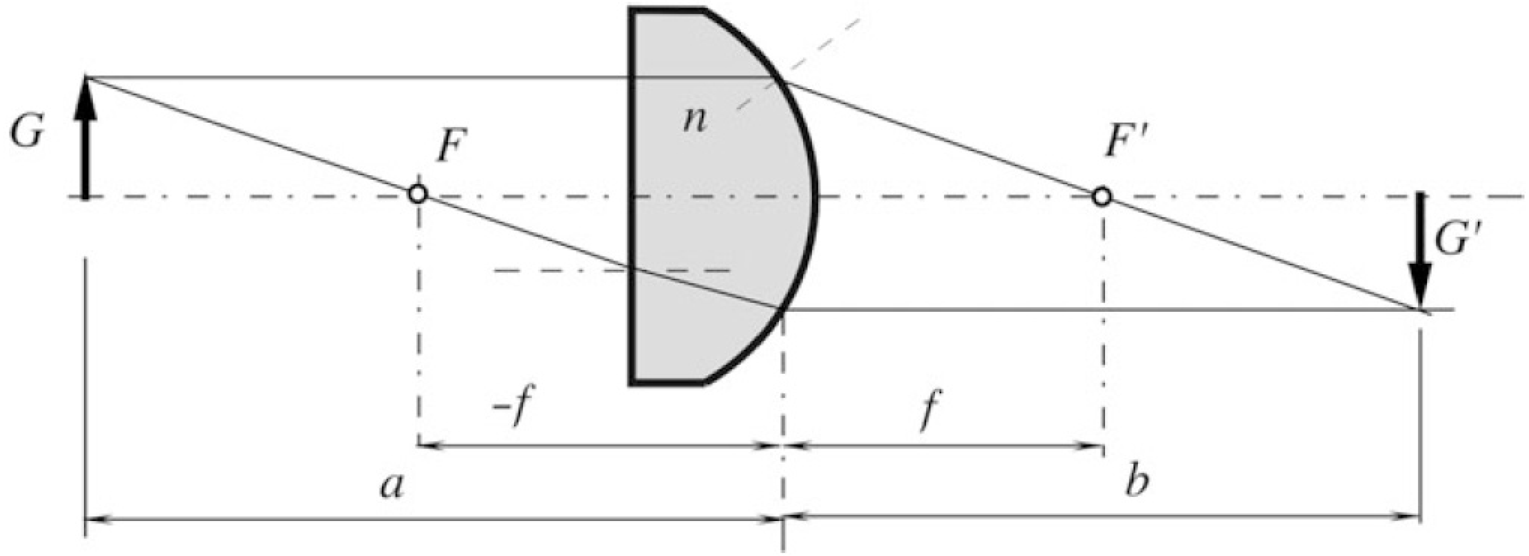
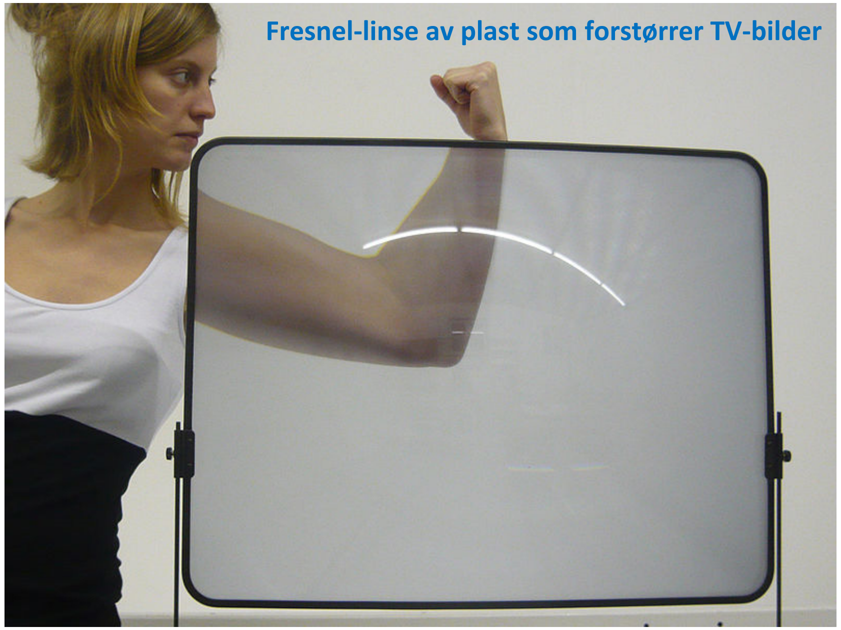


Fig. 4.12 Geometry of a plano-convex lens

Fresnel-linse

- Augustin Fresnel (1822)
- Fjerner deler som ikke bidrar til fokusering (*x* i figuren under)
- Buet overflate gjøres rett på hvert element



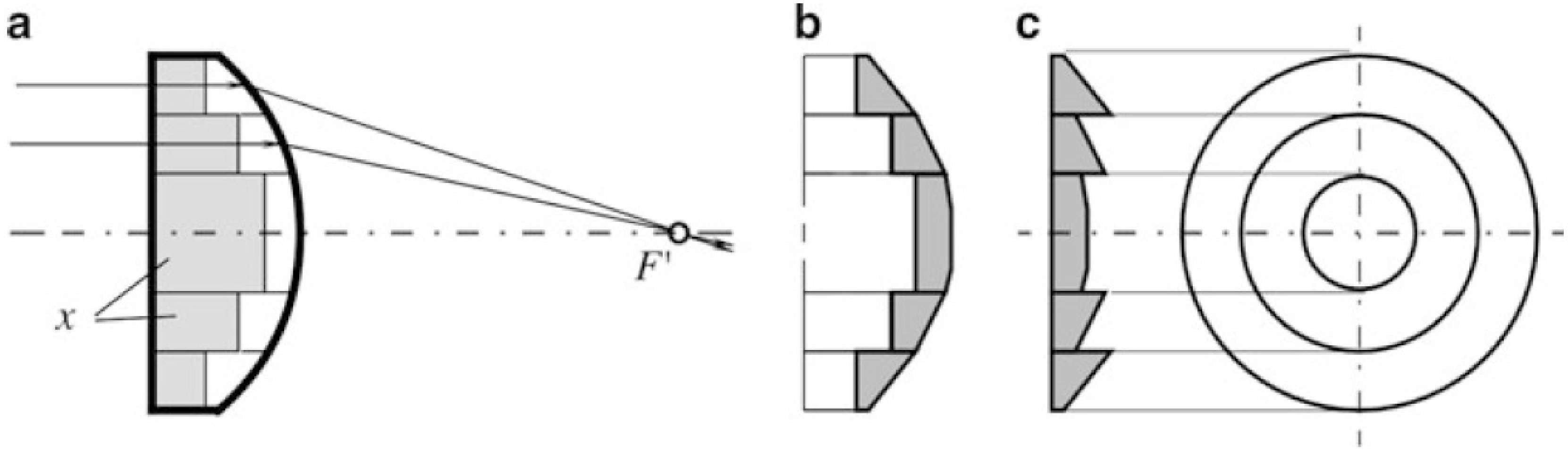


Fig. 4.13 Concept of a Fresnel lens.

Fiberoptikk

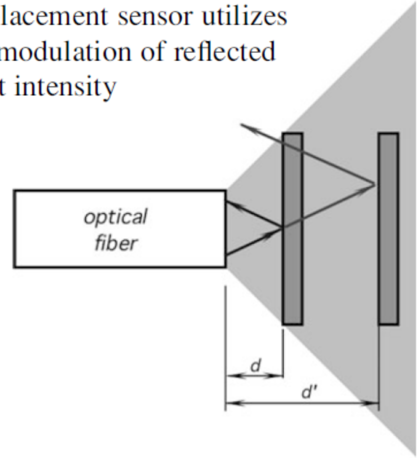


Fig. 4.18 Fiber-optic displacement sensor utilizes the modulation of reflected light intensity

- Bølgeledere leder lyset i ønsket retning
- Glass eller polymer (synlig og NIR)
- Høy refleksjonskoeffisient på indre overflate

$$\Theta_{in(\max)} = \arcsin\left(\sqrt{n^2 - n_1^2}\right)$$

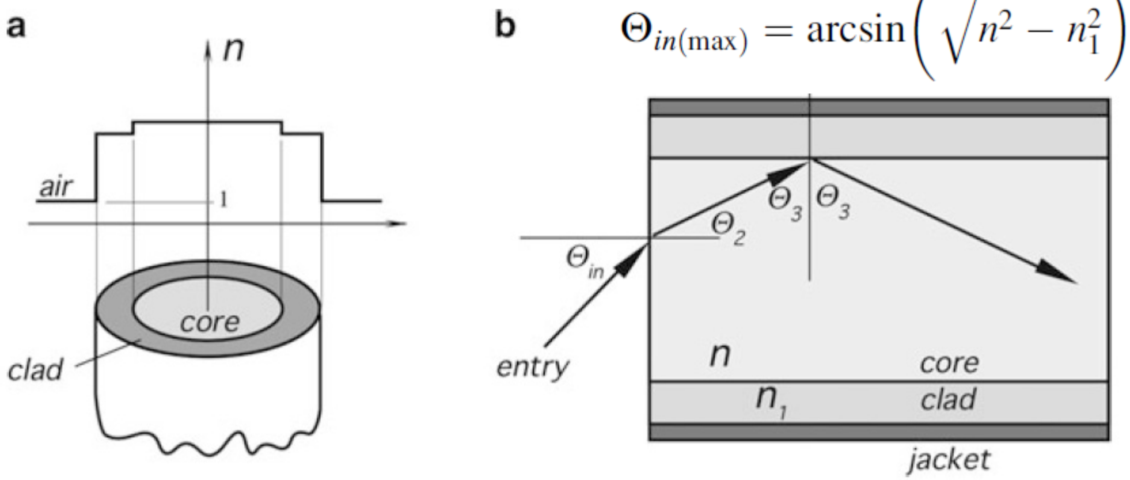


Fig. 4.16 Optical fibers: A step-index multiple fiber (**a**) and determination of the maximum angle of entry (**b**)

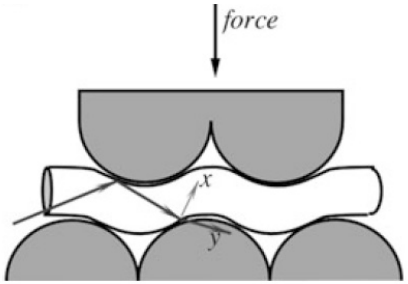
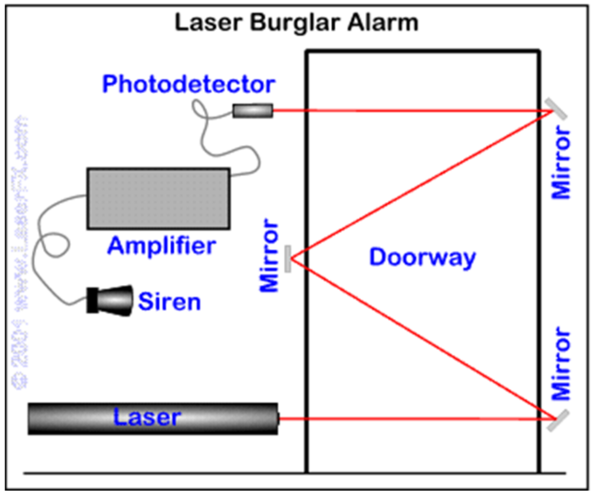


Fig. 4.19 Fiber-optic microbend strain gauge

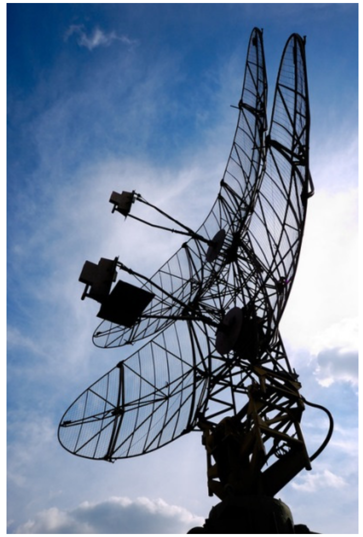
Bevegelse og tilstedeværelse

1. *Air pressure sensors:* detect changes in air pressure resulted from opening doors and windows
2. *Capacitive:* detectors of human body capacitance
3. *Acoustic:* detectors of sound produced by people
4. *Photoelectric:* interruption of light beams by moving objects
5. *Optoelectric:* detection of variations in illumination or optical contrast in the protected area
6. *Pressure mat switches:* pressure sensitive long strips used on floors beneath the carpets to detect weight of an intruder
7. *Stress detectors:* strain gauges imbedded into floor beams, staircases, and other structural components
8. *Switch sensors:* electrical contacts connected to doors and windows



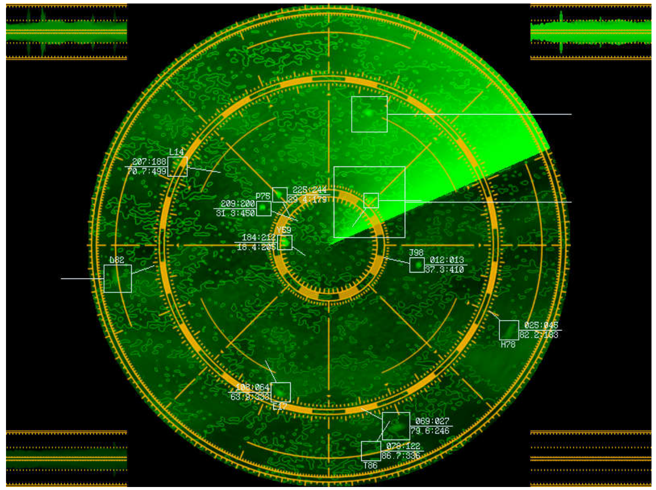
9. *Magnetic switches:* a noncontact version of switch sensors
10. *Vibration detectors:* react to the vibration of walls or other building structures. Also, may be attached to doors or windows to detect movements
11. *Glass breakage detectors:* sensors reacting to specific vibrations produced by shattered glass
12. *Infrared motion detectors:* devices sensitive to heat waves emanated from warm or cold moving objects
13. *Microwave detectors:* active sensors responsive to microwave electromagnetic signals reflected from objects
14. *Ultrasonic detectors:* devices similar to microwave detectors except that instead of electromagnetic radiation, ultrasonic waves are used
15. *Video motion detectors:* a video equipment that compares a stationary image stored in memory with the current image from a protected area
16. *Video face recognition system:* image analyzers that compare facial features with database
17. *Laser system detectors:* similar to photoelectric detectors, except that they use narrow light beams and combinations of reflectors
18. *Triboelectric detectors:* sensors capable of detecting static electric charges carried by moving objects

Mikrobølgedetektor for bevegelse

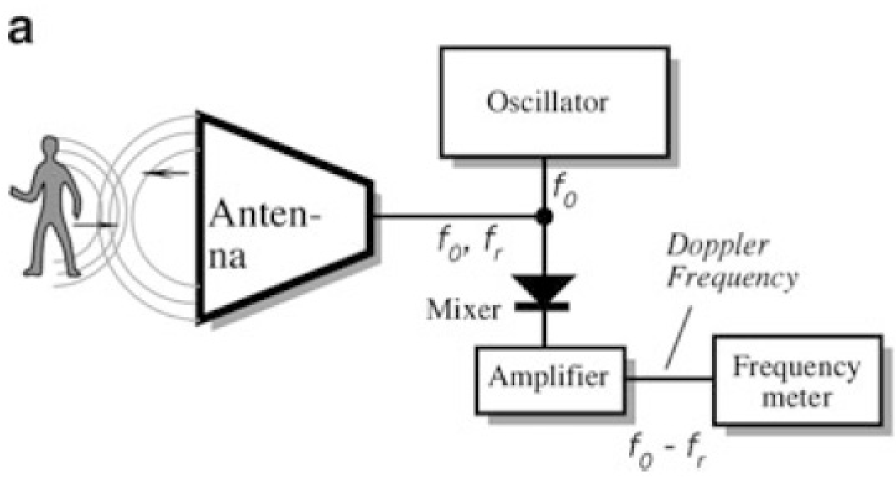


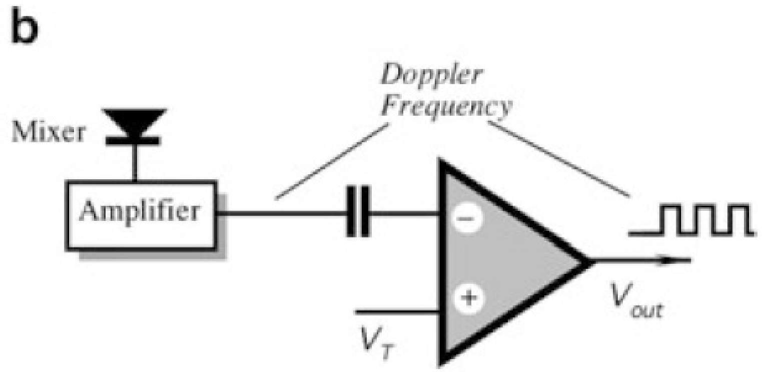
- Frekvensbåndet under IR-båndet
- Radio Detection And Ranging – RADAR
- Aktiv sensor som egner seg for vanskelige forhold (dårlig vær) og store områder
- Refleksjonstid → avstand
- Frekvensskift → bevegelse (Doppler-effekt)

Band	Frequency range (GHz), f	Wavelength range (cm), λ
K_a	26.0–40.0	0.8–1.1
K	18.0–26.5	1.1–1.67
X	8.0–12.5	2.4–3.75
C	4.0–8.0	3.75–7.50
S	2.0–4.0	7.5–15
L	1.0–2.0	15–30
P	0.3–1.0	30–100



Mikrobølge er < 4 cm:
- Langbølget nok til å passere støv og forurensning
- Kortbølget nok til å reflekteres fra store objekter





Mikseren gir ut diff-frekvensen – vet ikke om den er større eller mindre enn f_0.

Fig. 6.1 Microwave occupancy detector: a circuit for measuring Doppler frequency (**a**); circuit with a threshold detector (**b**)

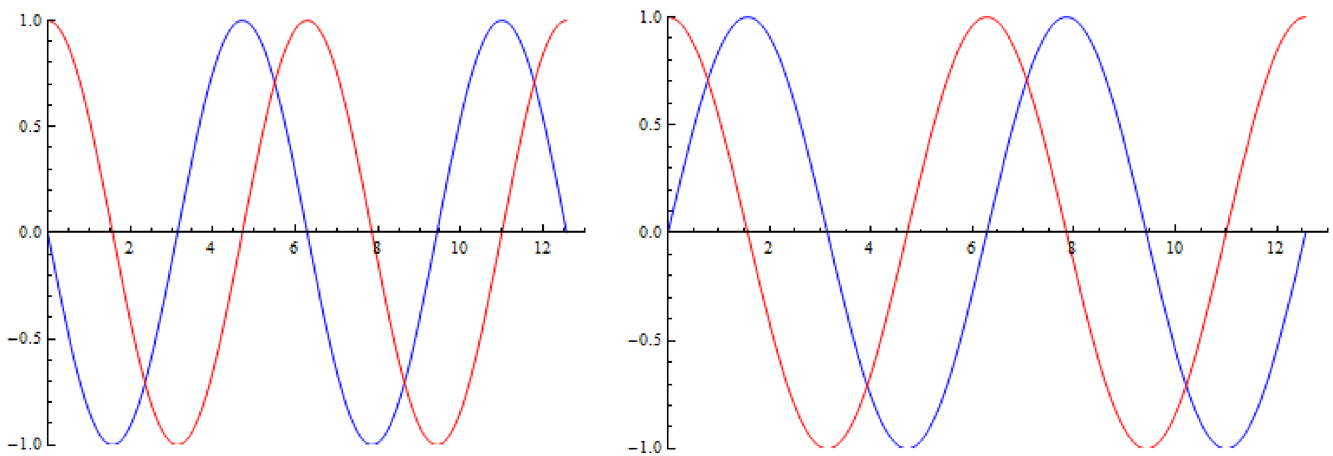
Teller ≈ 1

Einstein: $$f_r = f_0 \frac{\sqrt{1-\left(\frac{v}{c_0}\right)^2}}{1+\frac{v}{c_0}}$$

Hvis bevegelsen ikke er normalt på detektoren → cos φ

Retning ?

```
In[16]:= Plot[{Sin[x], Cos[x]}, {x, 0, 4 Pi}, PlotStyle → {Blue, Red}, PlotRange → {{0, 13}, {-1, 1}}]
         Plot[{Sin[-x], Cos[-x]}, {x, 0, 4 Pi}, PlotStyle → {Blue, Red}, PlotRange → {{0, 13}, {-1, 1}}]
```



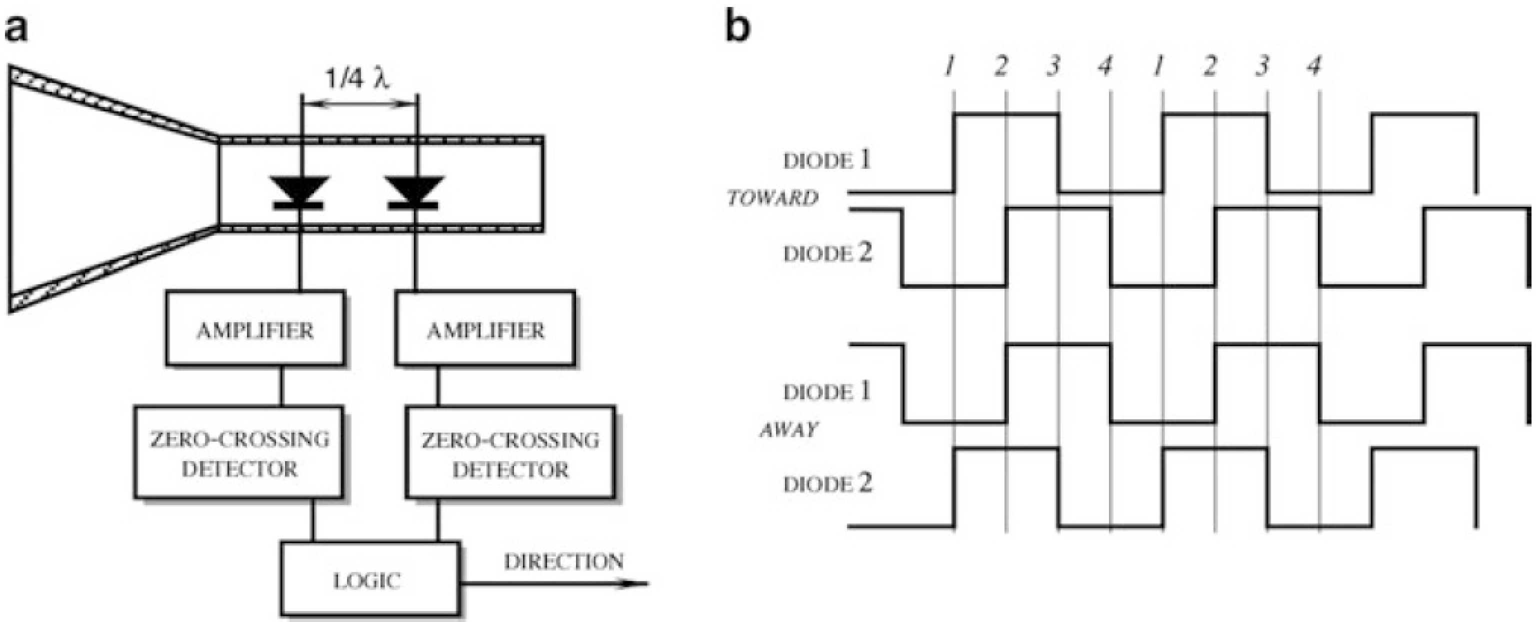
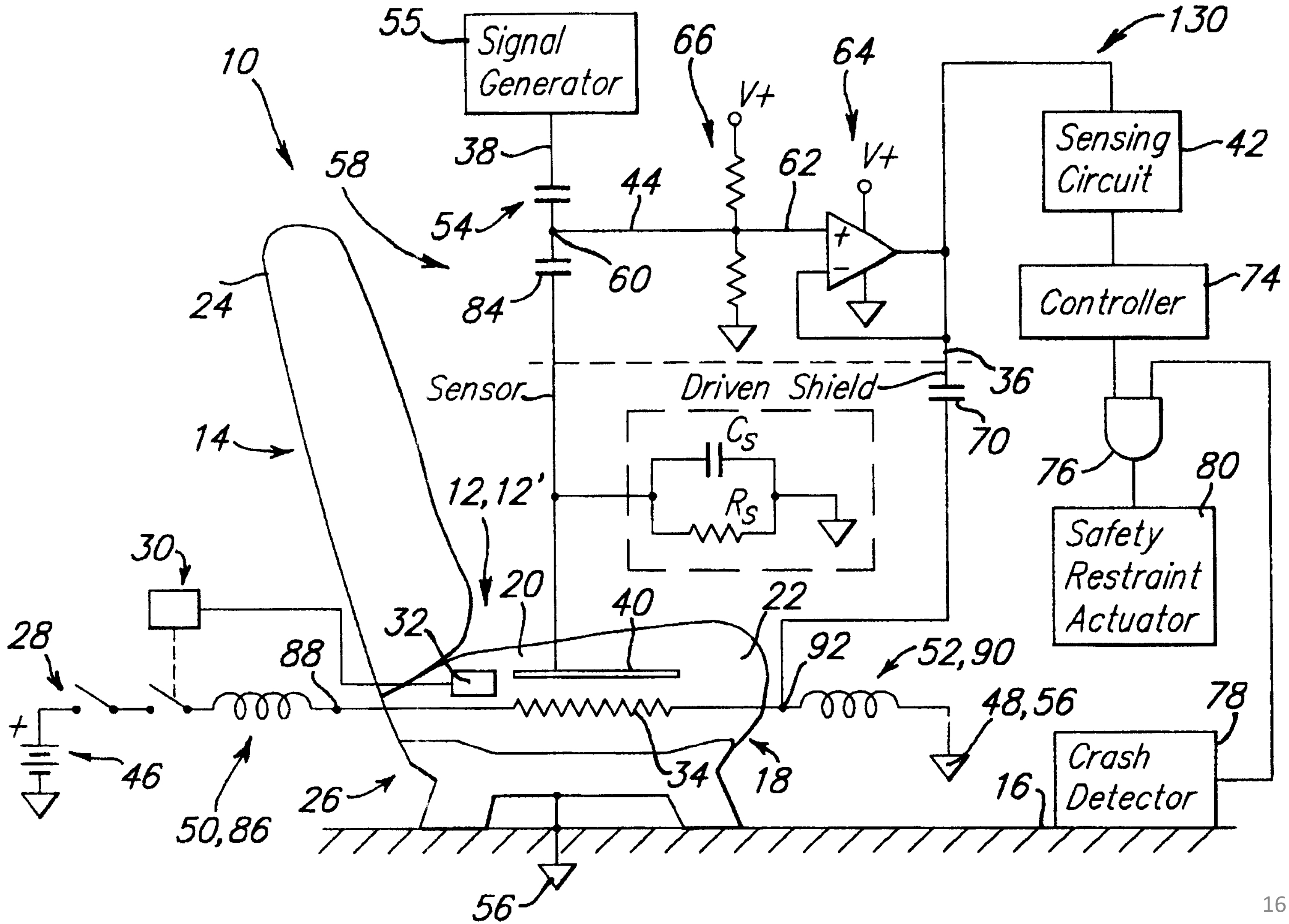


Fig. 6.2 Block diagram (**a**) and timing diagrams (**b**) of a microwave Doppler motion detector with directional sensitivity

Tilstedeværelsessensor (United States Patent 7098674)



Kapasitiv tilstedeværelsessensor

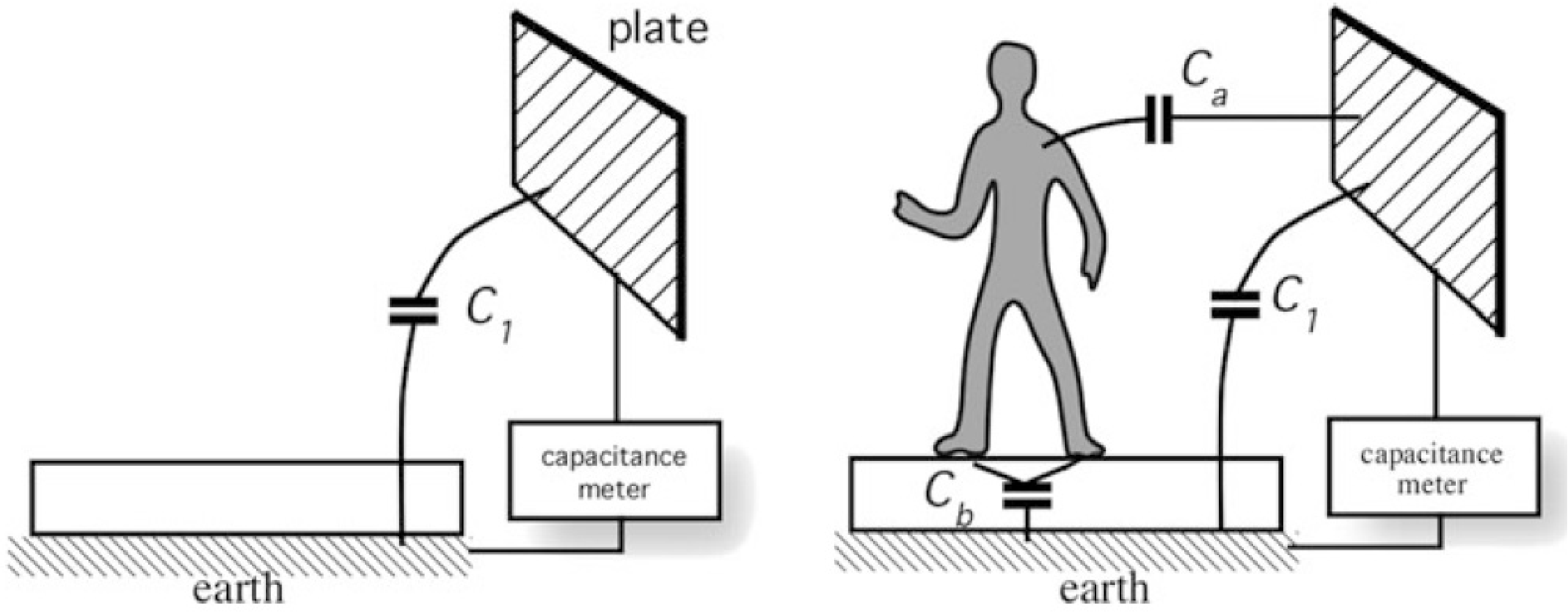


Fig. 6.3 An intruder brings in an additional capacitance to a detection circuit

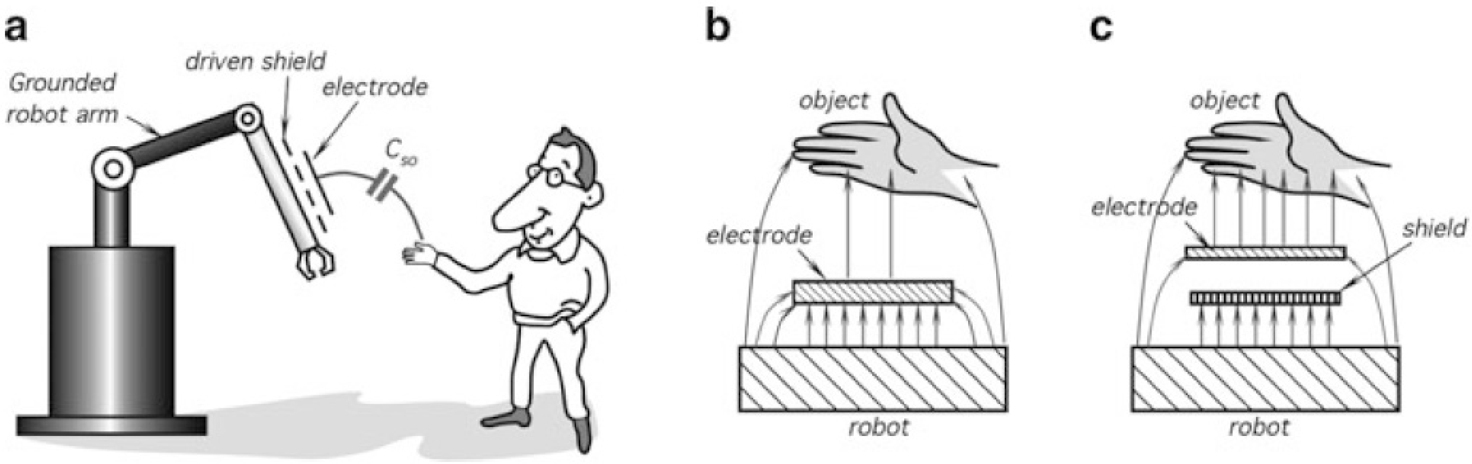
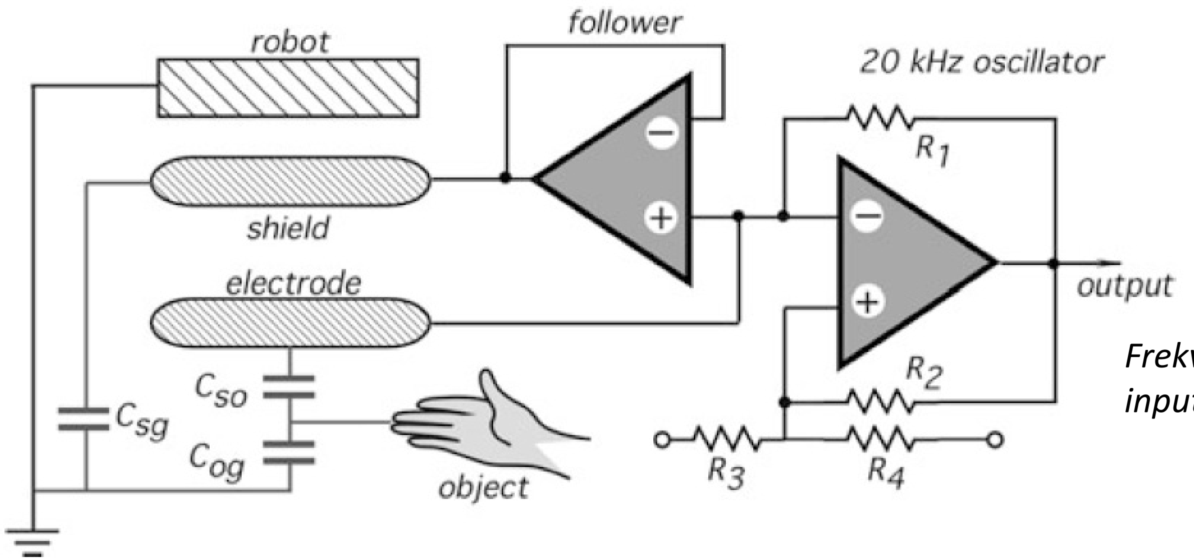


Fig. 6.6 Capacitive proximity sensor A driven shield is positioned on the metal arm of a grounded robot (**a**). Without the shield, the electric field is distributed between the electrode and the robot (**b**), while a driven shield directs electric field from the electrode toward the object (**c**)



Frekvens avhengig av input-kapasitansen

Fig. 6.7 Simplified circuit diagram of a frequency modulator controlled by the input capacitances

Triboelektrisk detektor

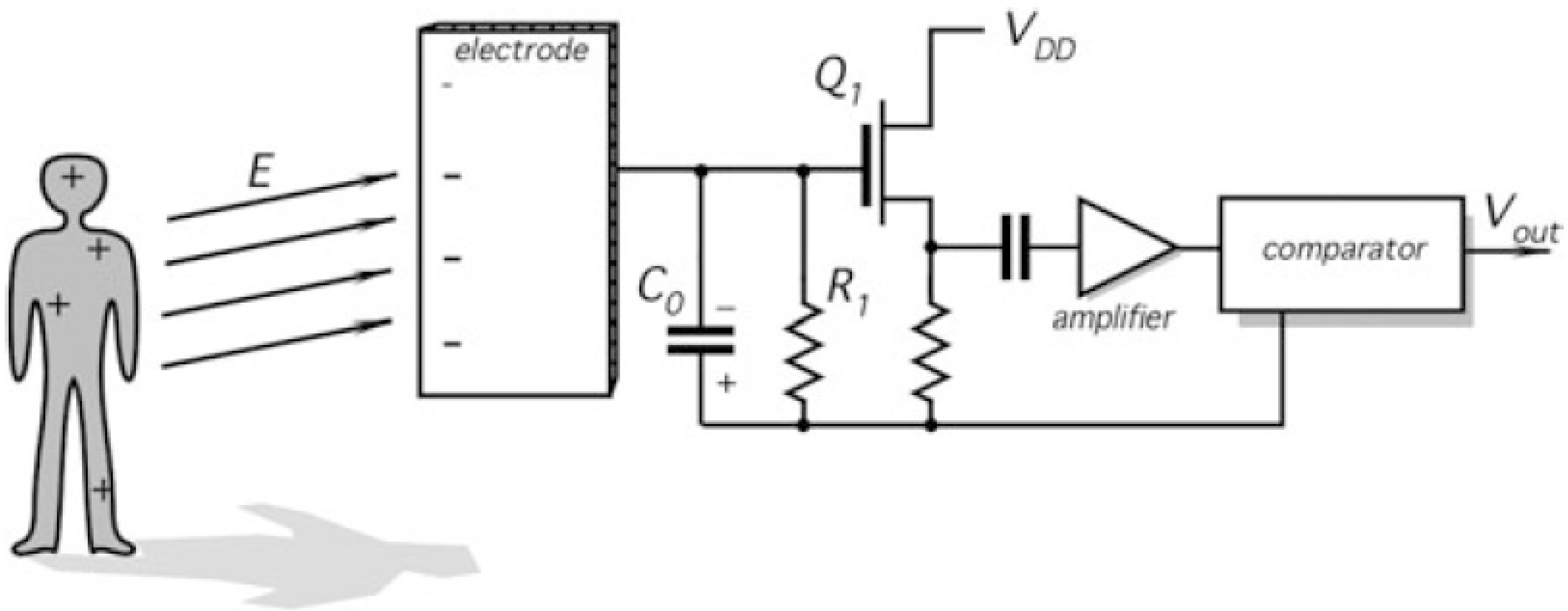


Fig. 6.8 Monopolar triboelectric motion detector

Optiske bevegelsessensorer

- 0,4 – 20 µm (synlig lys og IR)
- Lys fra lyskilde reflektert fra objekt i bevegelse
- Eller IR fra objekt med annen temperatur enn omgivelsene
- Bare bevegelse eller ikke-bevegelse (ikke fart)
- Bildet av personen må krysse den optiske brikken
- Personen må ha en viss optisk kontrast til omgivelsene
- Større deteksjonsflate kan oppnås ved:
  - Flere optiske brikker
  - Mangefasettert linse
  - Oppdeling av sensoren

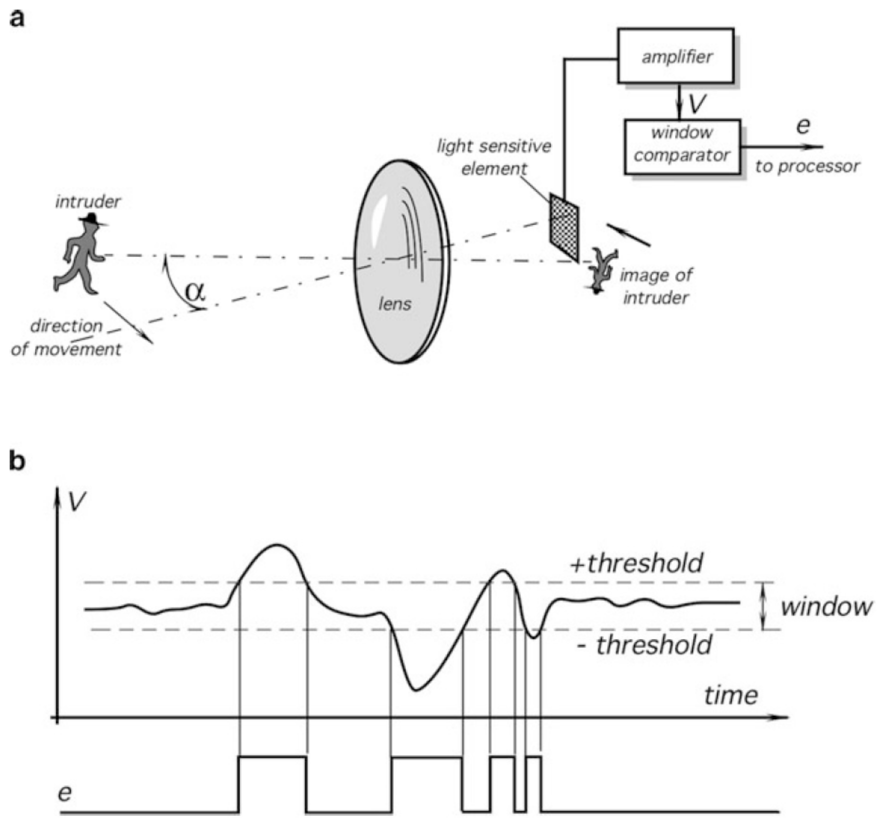


Fig. 6.9 General arrangement of an optoelectronic motion detector. A lens forms an image of a moving object (intruder). When the image crosses the sensor's optical axis it covers the sensitive element (a). The element responds with a signal that is amplified and compared with a window threshold in a comparator (b)

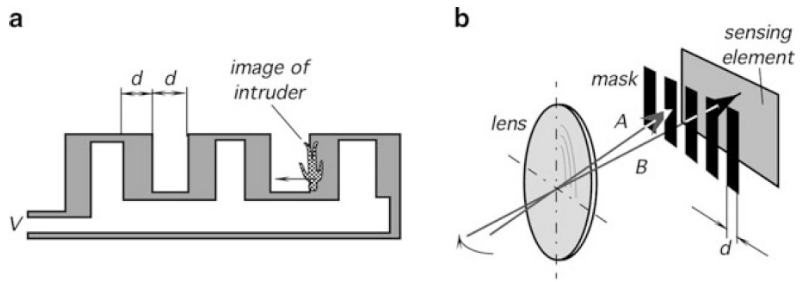


Fig. 6.10 Complex shape of a sensing element (a); and image distortion mask (b)

Synlig lys og NIR

- Passiv stråling fra objekter er kun MIR og FIR
- For synlig og NIR trenger man lyskilde (sol, lampe eller NIR-LED)

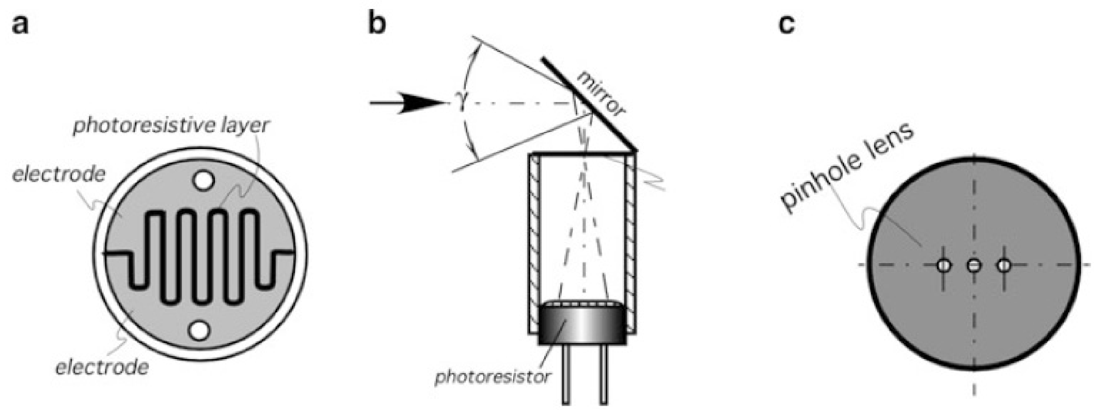


Fig. 6.13 A simple optical motion detector for a light switch and toys: (a) a sensitive surface of a photoresistor forms a complex sensing element; (b) a flat mirror and a pinhole lens form an image on a surface of the photoresistor; (c) pinhole lenses

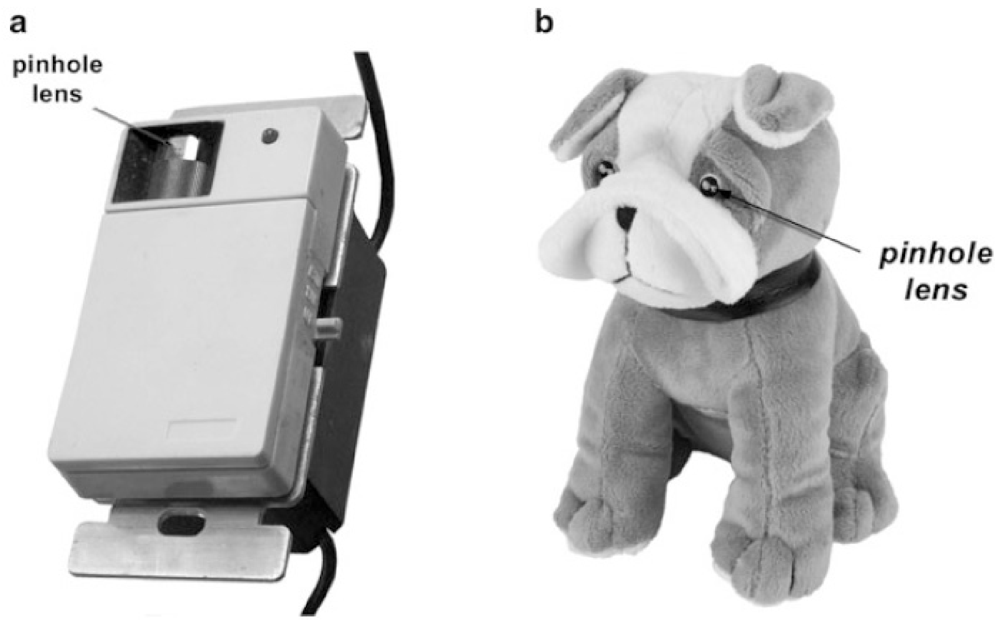


Fig. 6.14 Motion sensing light switch with a photoresistor and pinhole lens (a), interactive toy (b) that reacts to a child movement; the dog barks when motion is detected

MIR og FIR-detektorer

PIR Motion Sensor-D203S

http://www.sbcds.com.cn

- Stråling fra personer
- 4 – 20 µm
- 28 – 37 °C
- Som oftest pyroelektrisk element

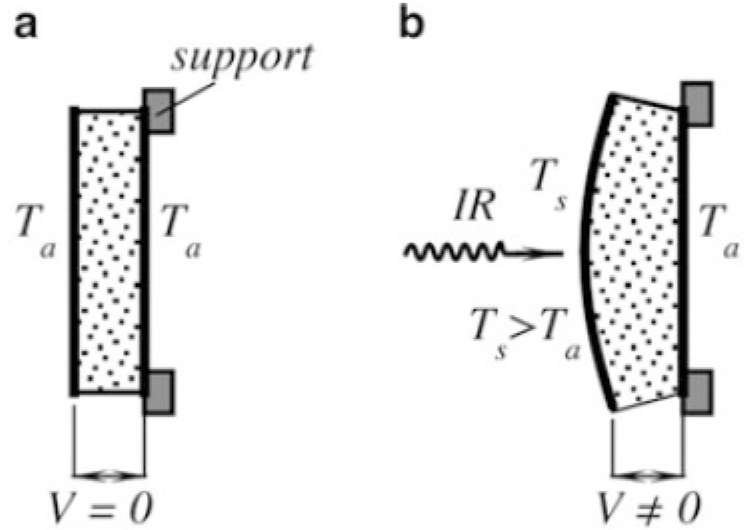


Fig. 6.15 Simplified model of a pyroelectric effect as a secondary effect of piezoelectricity. Initially, the element has a uniform temperature (**a**); upon exposure to thermal radiation, its front side warms up and expands, causing a stress-induced charge (**b**)

Doble pyroelektriske sensorer

- Siden pyroelektriske materialer også er piezoelektriske vil skarpe lyder eller vibrasjoner også kunne gi utslag
- Bruker derfor differensialmåling

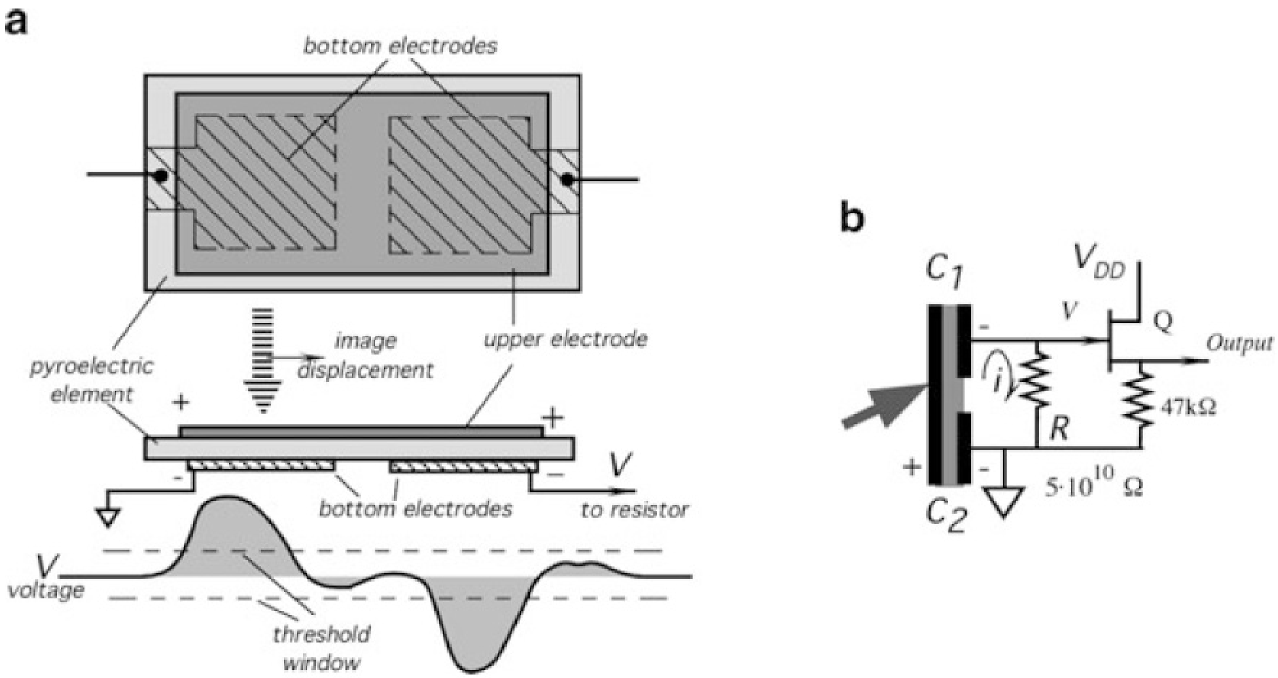


Fig. 6.16 Dual pyroelectric sensor
Sensing element with a front (*upper*) electrode and two bottom electrodes deposited on a common crystalline substrate (**a**). A moving thermal image travels from left part of the sensor to the right generating an alternate voltage across the bias resistor, *R* (**b**)

FIR bevegelsesdetektor

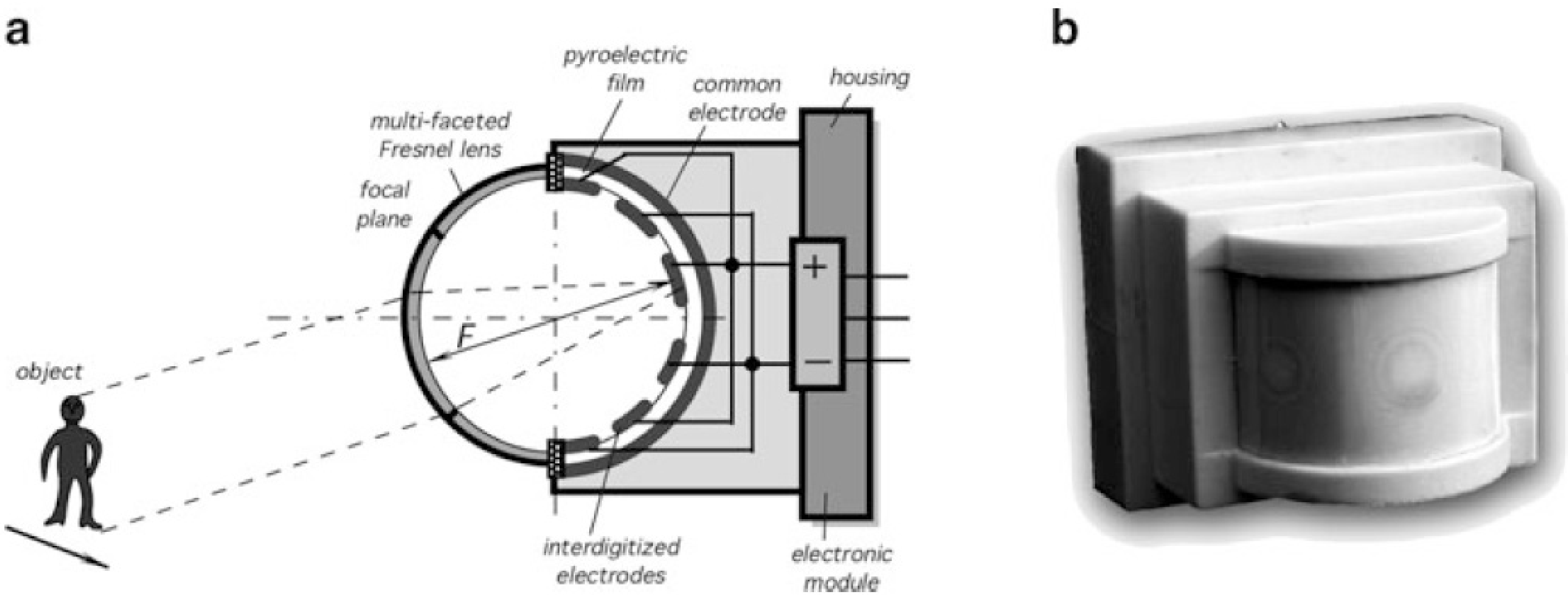


Fig. 6.17 Far infrared motion detector uses a curved Fresnel lens and a pyroelectric PVDF film. Internal structure of the sensor (**a**) and external appearance of the sensor (**b**)

Effektivitet i en pyroelektrisk sensor

NB: I Kelvin

$$i \approx \frac{2Pa\sigma\gamma}{\pi hc} bT_a^3 \frac{\Delta T}{L^2}$$

i = strømmen i sensoren

P = pyroelektrisk koeffisient

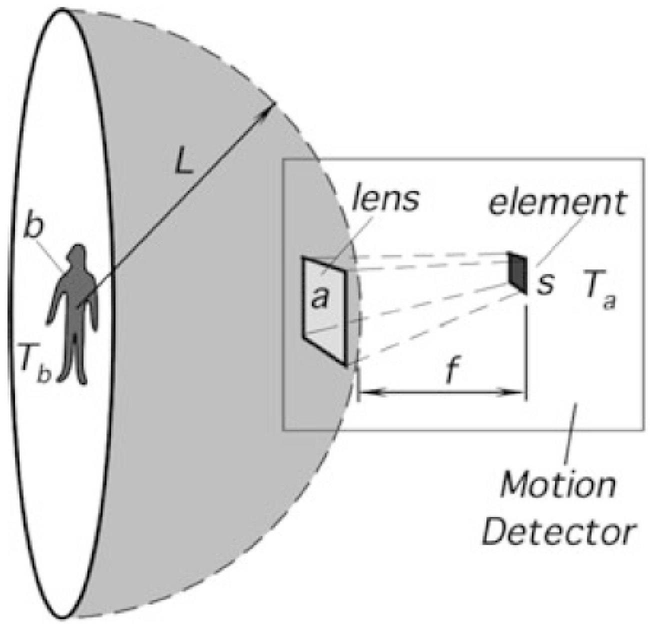
σ = Stefan-Boltzmanns konstant

γ = linsens transmisjonskoeffisient

h = elementets tykkelse

c = materialets spesifikke varmekapasitet

b = personens effektive areal



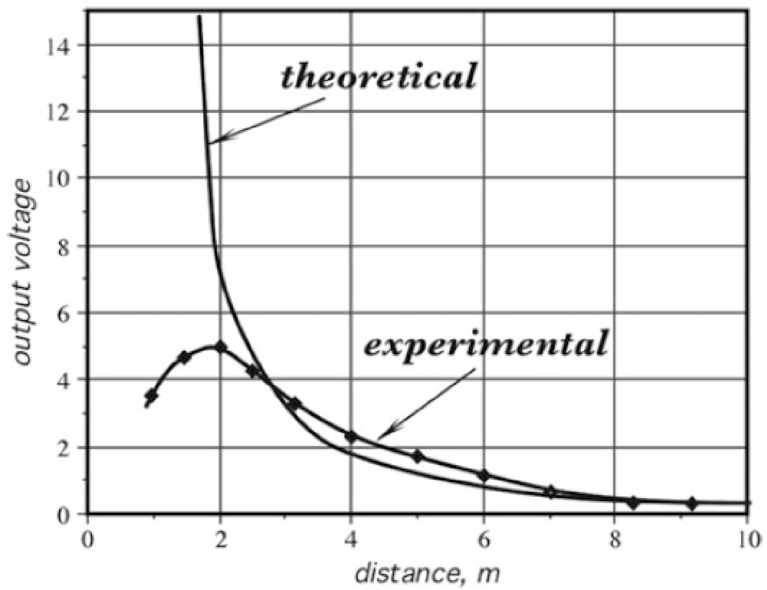


Fig. 6.19 Calculated and experimental amplitudes of output signals in a PIR detector

Optiske tilstedeværelsessensorer

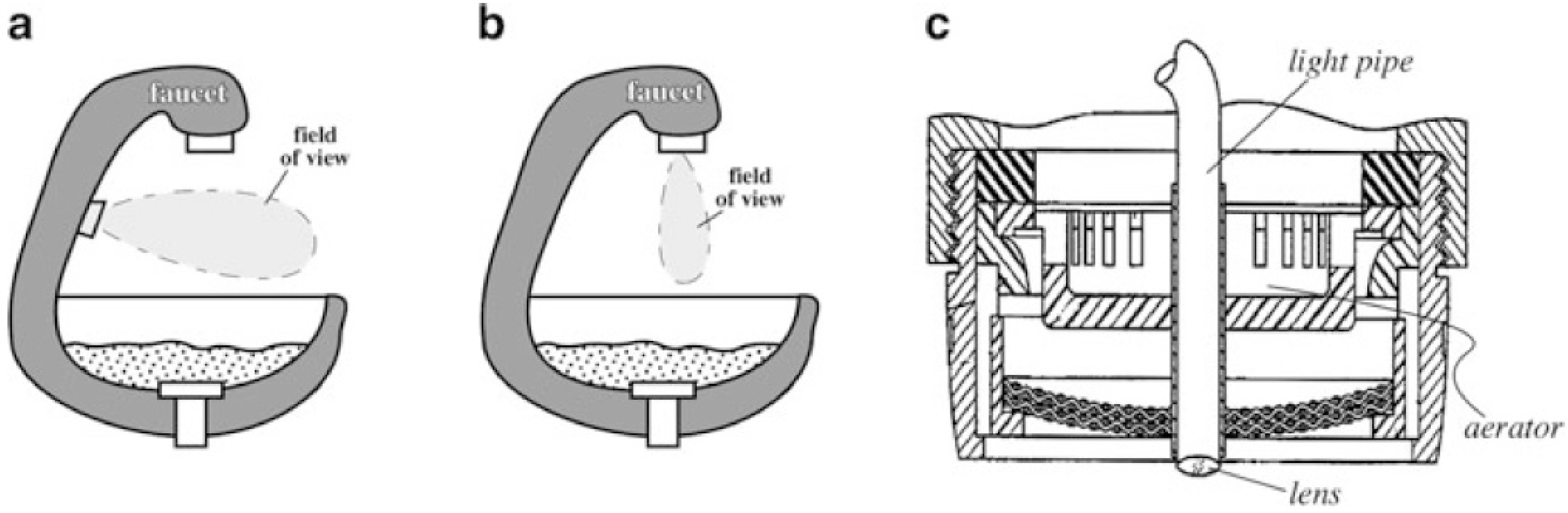


Fig. 6.20 Installation of the optical presence detector into a spout (**a**) and faucet (**b**). Cross-sectional view (**c**) of the faucet with a light pipe (adapted from Ref. [11])

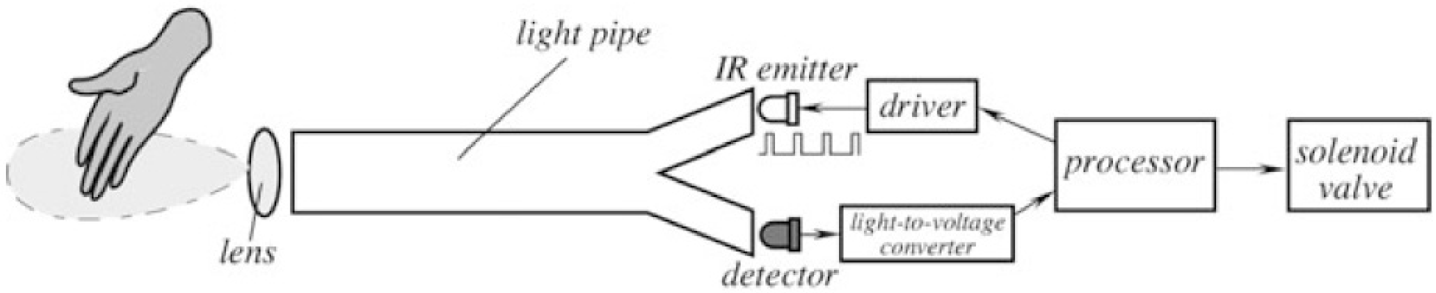


Fig. 6.21 Block diagram of the water flow controller with optical presence detector

Trykkgradient-detektor

Otto A. Smiseth *et al.*
American Journal of Physiology
- Heart and Circulatory Physiology
Published 1 September 1998
Vol. 275, no. H1062-H1069

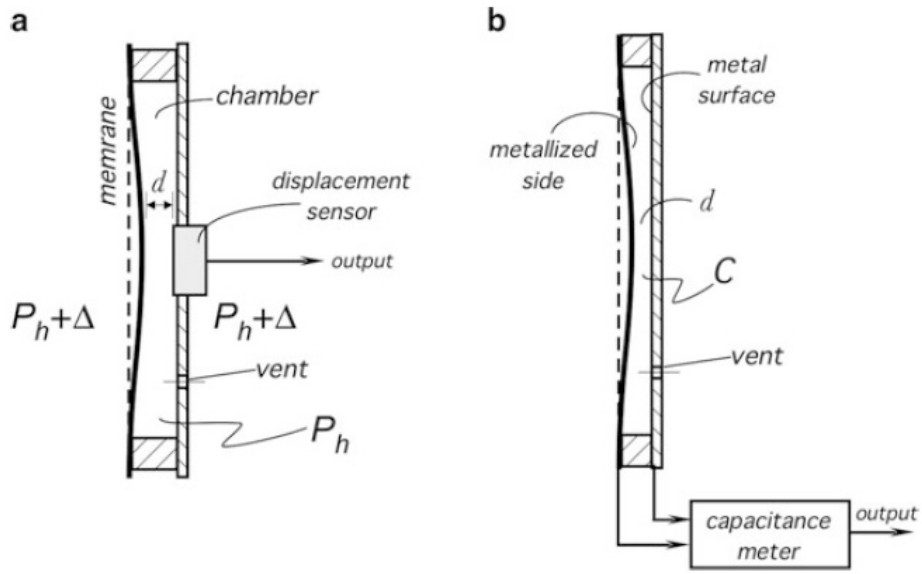


Fig. 6.22 Air pressure-gradient sensor (**a**) and the sensor with a capacitive displacement detector (**b**)

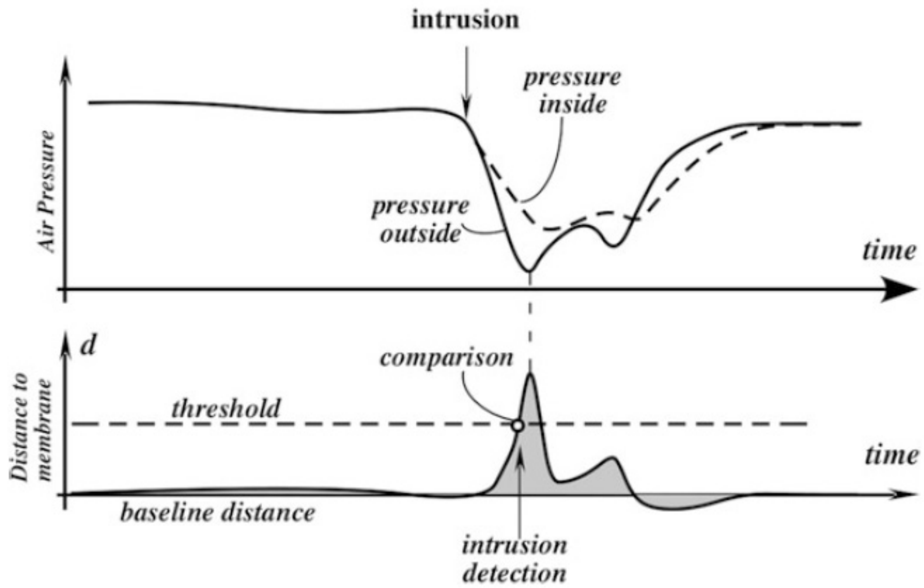


Fig. 6.23 Timing diagrams for the pressure-gradient detector