

Zuigermachines

➤ **Verbrandingsmotoren**

12u HOC

F. Daerden

12u HOC

M. Van Overmeire

➤ **Pompen**

12u HOC

P. Kool

➤ **Labo's**

5 Proeven

NN

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ZW102
(02 629)2863

Inwendige Verbrandingsmotoren

Motor

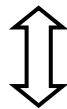
apparaat ter omzetting van *energie* naar *mechanische arbeid*, beweging en kracht

Verbranding

type omzetting: energie die vrijkomt uit *chemische reactie* tussen O₂ en brandstof

Inwendig

in *gesloten* ruimte
zonder
warmteoverdracht



hete lucht motor
stoommotor
gasturbine

Inwendige Verbrandingsmotoren

Basisprincipe: *repetitief* een hoeveelheid zuurstof (afkomstig uit lucht) en brandstof op *gecontroleerde* wijze in een gesloten ruimte laten reageren en de daarbij opgebouwde *druk* gebruiken om in een variabel volume mechanische onderdelen aan te drijven, m.a.w. *bewegende delen*

Energie-omzetting:

Chemisch



Thermisch



Mechanisch

Inwendige Verbrandingsmotoren

Brandstof: koolwaterstoffen—petroleumderivaten

zeer hoge *energie-inhoud*

benzine: LVW 44 MJ/kg \equiv 33MJ/ ℓ
(ter vgl. 33MJ = E_p van 10000kg
op 330m hoogte, E om 100 ℓ
water van 20°C naar 100°C te
brengen)

overvloedig aanwezig

relatief eenvoudige productie

gemakkelijke en veilige opslag en
transport

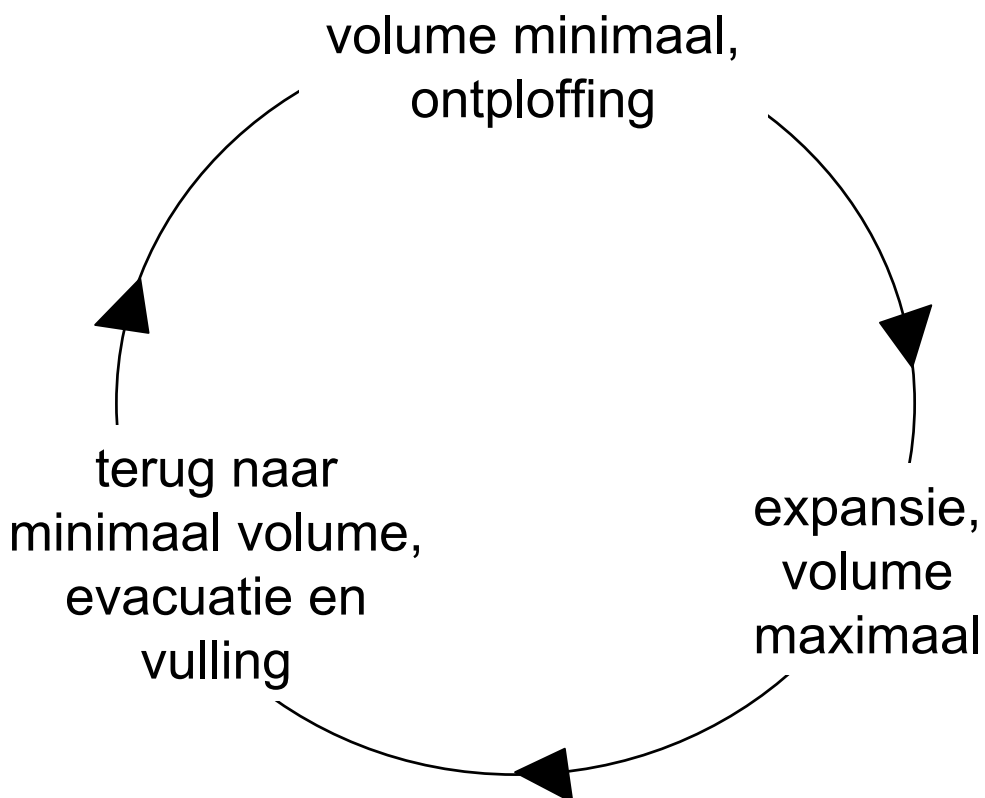
Bewegende delen: kruk-drijfstangmechanisme
(99%)

Wankel

swash plate / schommel-
plaat

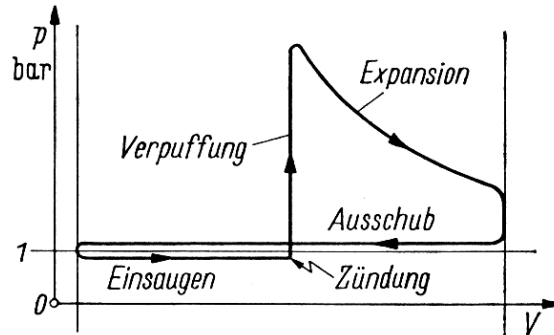
Inwendige Verbrandingsmotoren

Werking: *quasi kringproces*



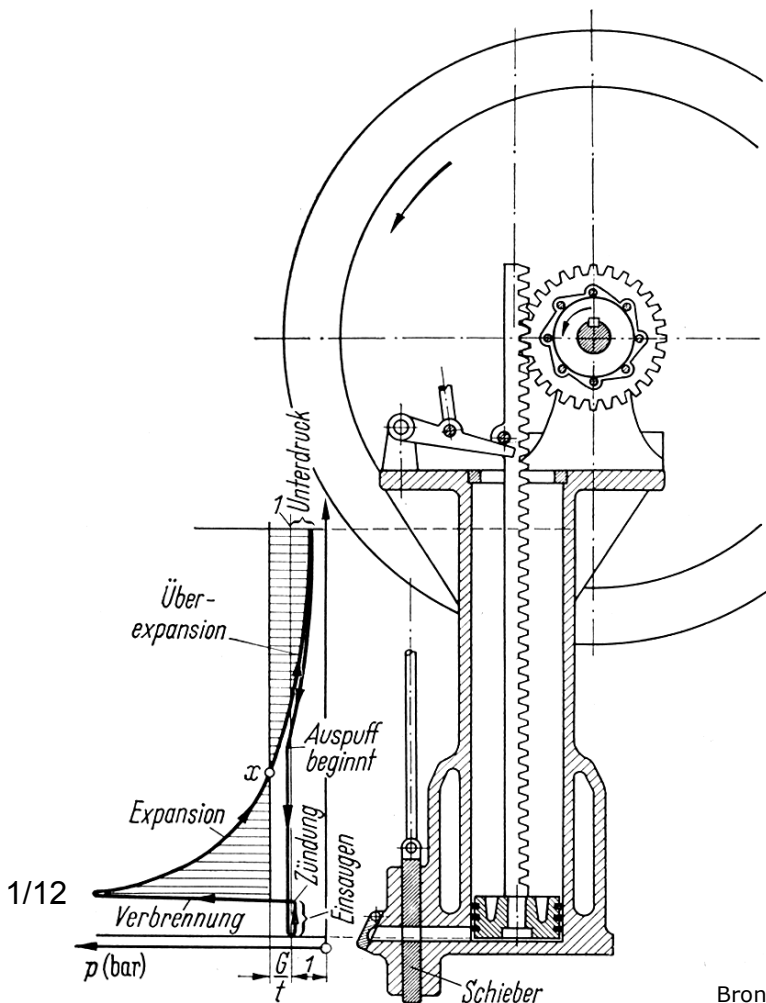
Eerste motoren: atmosferisch

Lenoir gasmotor (1860)



Otto/Langen gasmotor (1867)

Atmosferische motor
"Vliegende" cilinder

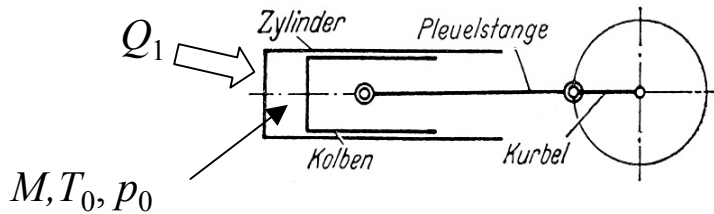


P (hp)	n (rpm)	cykli (cpm)	M (lbs)	H (ft)	Prijs (1876 DM)
1/4	110	40	900	7	960
1/2	95	36	1600	8.8	1380
1	90	32	2750	9.8	1890
2	90	30	4000	10.7	2460
3	90	28	4450	12.7	3000

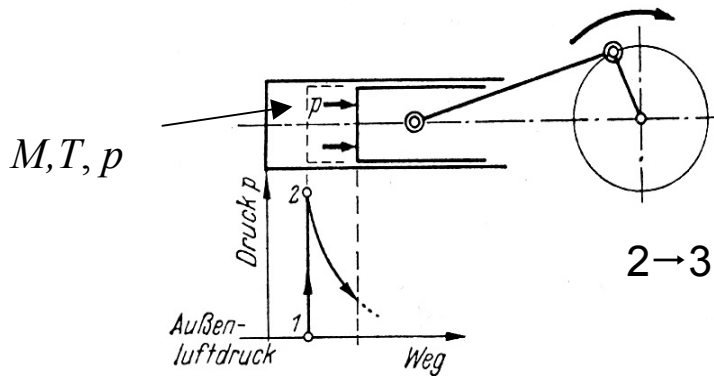
Bron: Internal Fire — The internal Combustion Engine, 1673-1900 ; Cummins, C. Lyle Jr. ; CB621.4 G CUMM 2000

Atmosferische motor

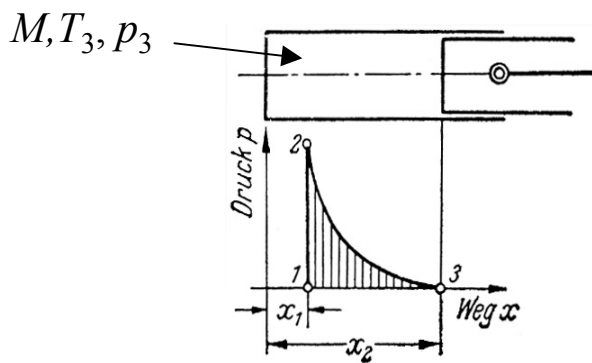
Vergelijkmingsmachine: hete-luchtmaschine



1→2: Q_1 toevoegen

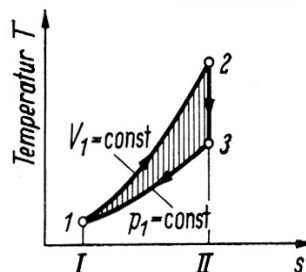


2→3: adiabatische expansie



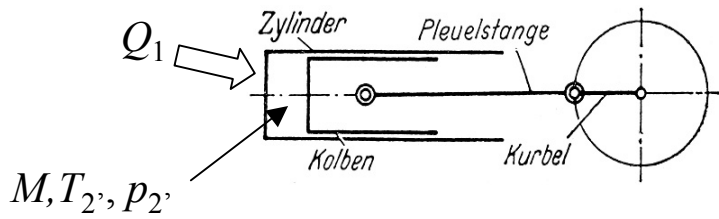
3→1: isobare afkoeling
 Q_2 afvoeren

$(T_3 > T_1 ?)$

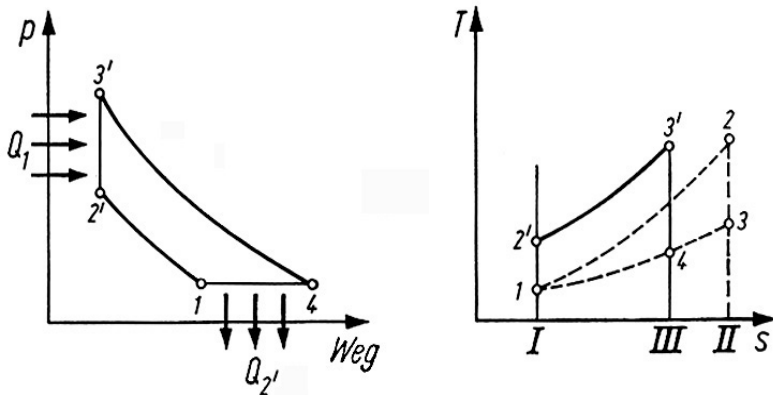


$$\eta = \frac{Q_1 - Q_2}{Q_1}$$

Compressieslag



$$T_{2'} > T_0, p_{2'} > p_0$$



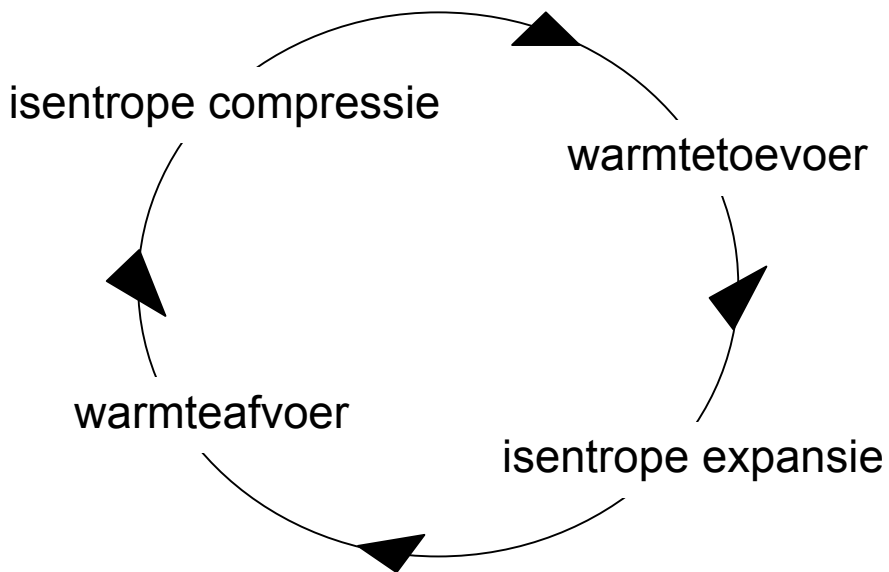
Q_1 gelijk voor beide processen
 \Rightarrow oppervlakte I12II = oppervlakte I2'3'III
 $\Rightarrow s_3 > s_4$ en $Q_2 > Q_{2'}$

$$\eta' > \eta \\
 \parallel \qquad \qquad \parallel \\
 1 - \frac{Q_{2'}}{Q_1} \qquad \qquad 1 - \frac{Q_2}{Q_1}$$

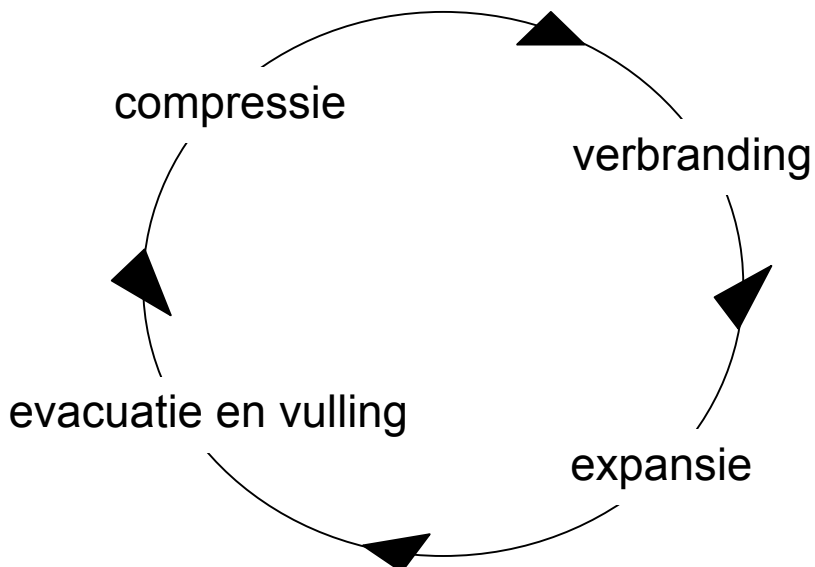
voorcompressie verhoogt rentabiliteit

Quasi kringproces

Theoretische machine:



Werkelijke machine:



Geschiedenis van de VM

- ± 1600 Verbiest, tekeningen van voertuig met stoommachine
- 1680 Huyghens, kruit in een cilinder
stoomwagen van Cugnot
- 1860 Lenoir, eerste VM, gasmotor (η 2 à 4%)
- 1861 Beau de Rochas, 4takt principe
- 1862 poging Otto 4takt poging (onafhankelijk)
- 1863 4takt Lenoir
- 1867 Otto en Langen gasmotor
- 1873 Reithmann 4takt poging (BdR)
- 1876 Otto/Langen (Deutz) 4takt gasmotor met voorcompressie, '78 wereldtentoonstelling Parijs**
- 1878-86 Daimler, Benz en Maybach, vloeibare fuel
- 1893 Rudolf Diesel, Carnot cyclus poging
- 1895/7 Dieselmotor (MAN, Krupp)
- 1903 Wright gebroers, VM in vliegtuig
- 1905 Buchi, uitlaatgasdrukvulling (turbo)
- 1910 Vulcanus met scheepsdiesel
- 1912 Ford T, massaproductie
- 1961 Wankelmotor

Types Verbrandingsmotoren

Ladingswissel
(evacuatie en vulling)



Viertakt
Tweetakt

Verbranding



Vlamdiffusie
Massadiffusie

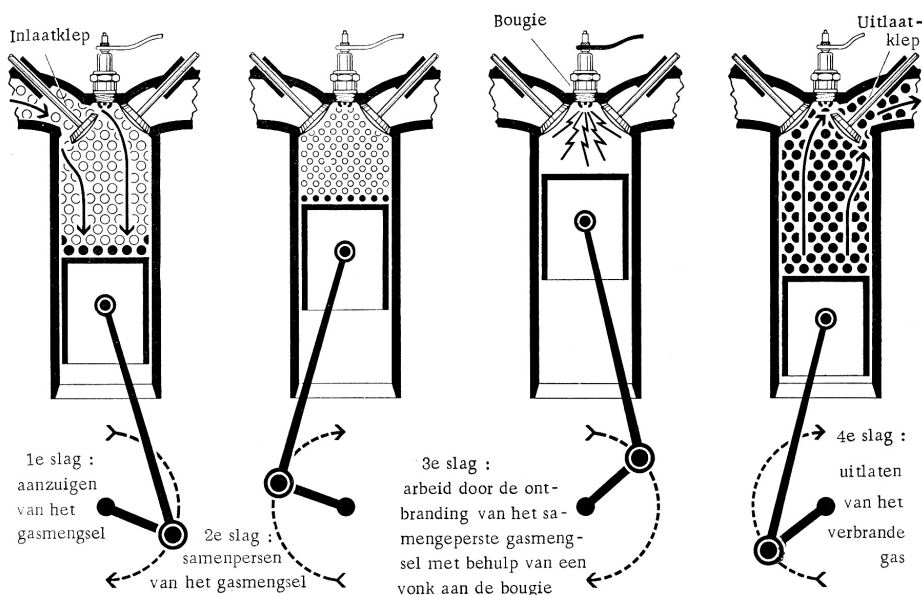
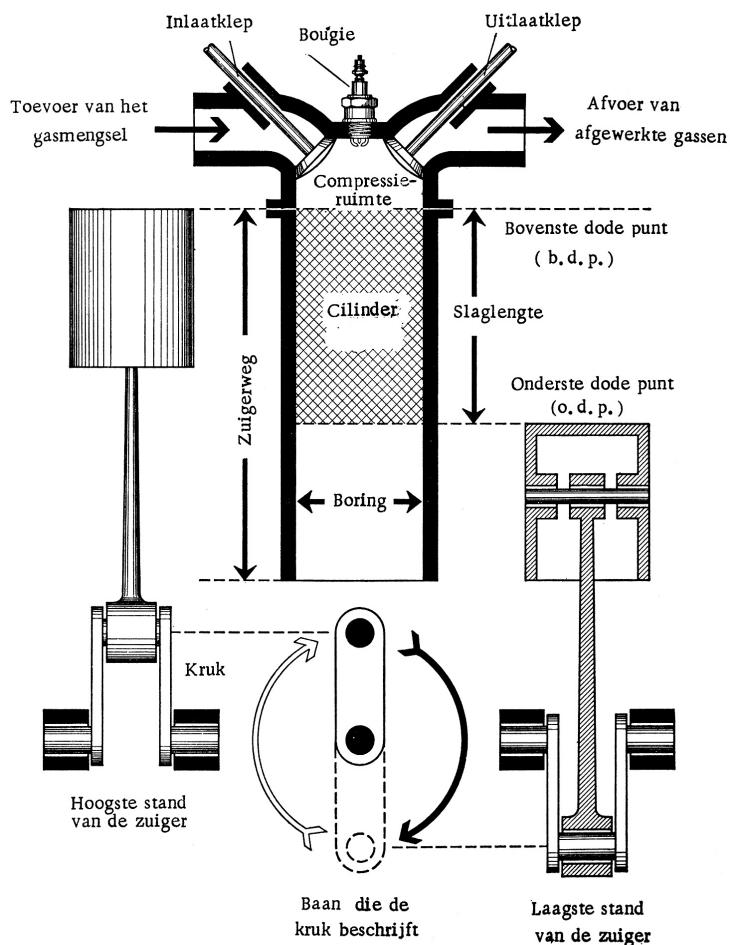
Viertakt: *vier slagen* per cyclus
evacuatie en vulling elk volledige slag

Tweetakt: *twee slagen* per cyclus
evacuatie en vulling gelijktijdig in ODP
(opm. Wankelmotor tweetakt of viertakt, zie later)

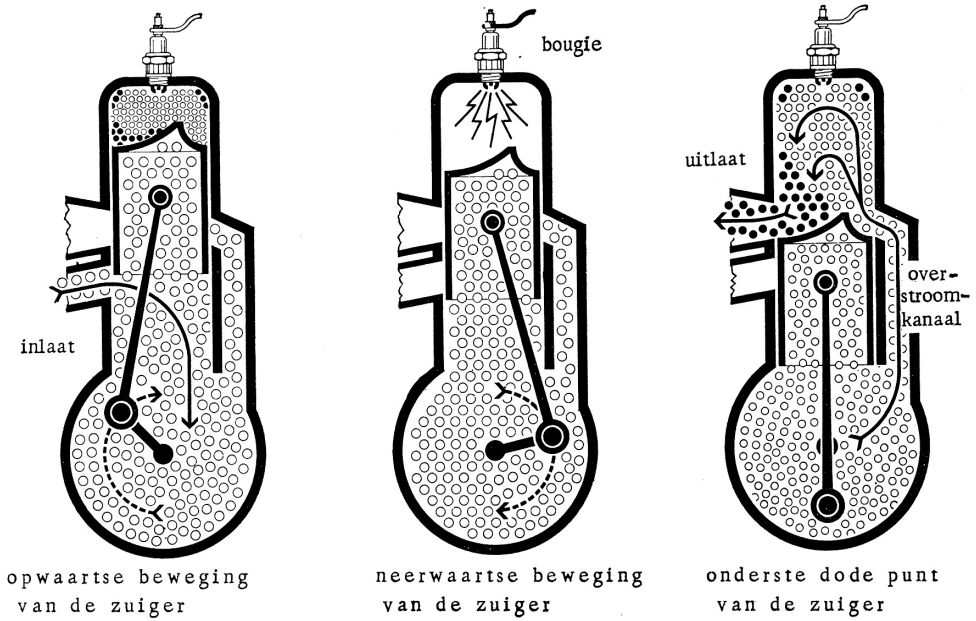
Vlamdiffusie: vlam wordt ingeleid door een vonk
deflagratie, vlamfrontvoortplanting
mengsel gevormd vóór ontsteking
benzinemotor
vonkontstoken motor, Ottomotor

Massadiffusie: ontsteking gebeurt lokaal door menging
compressiedruk en temperatuur hoog
zelfontsteking
mengsel gevormd vlak voor verbranding
dieselmotor
drukontstoken motor

4Takt Ottomotor

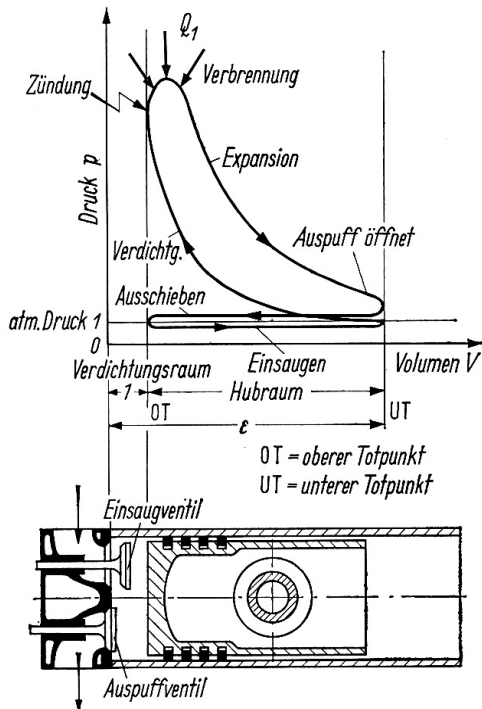


2Takt Ottomotor

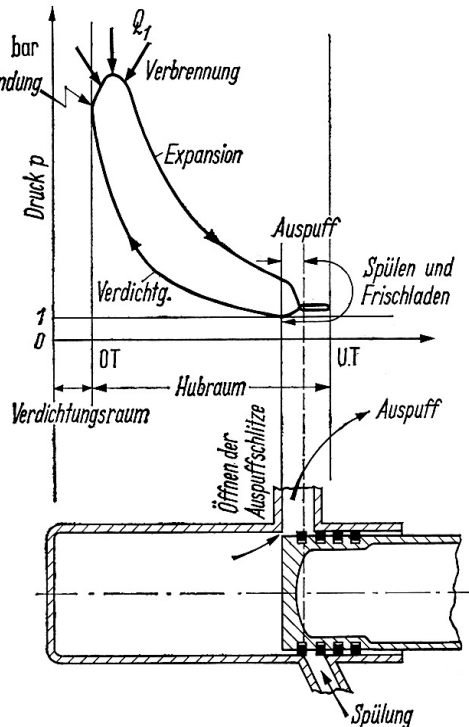


Druk-Volume Verloop

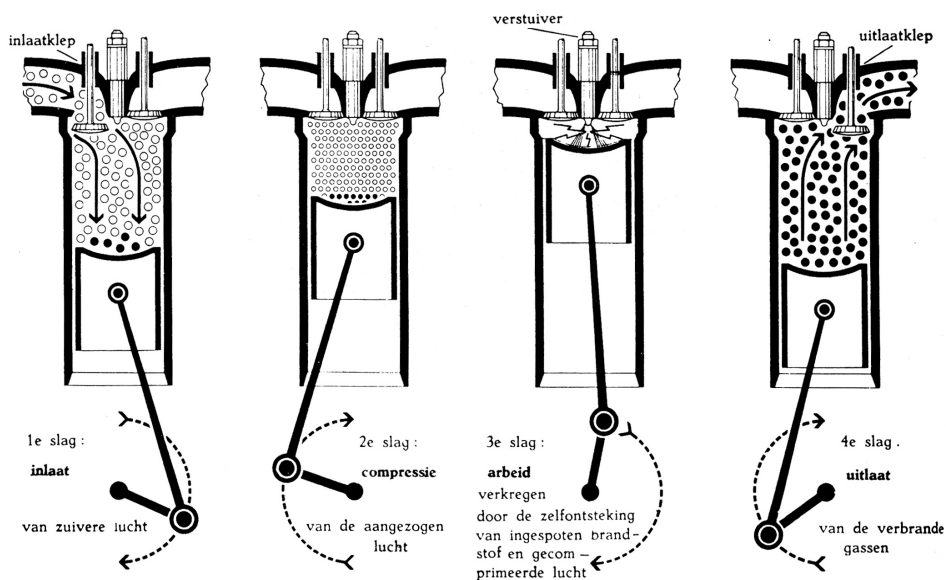
4 Takt



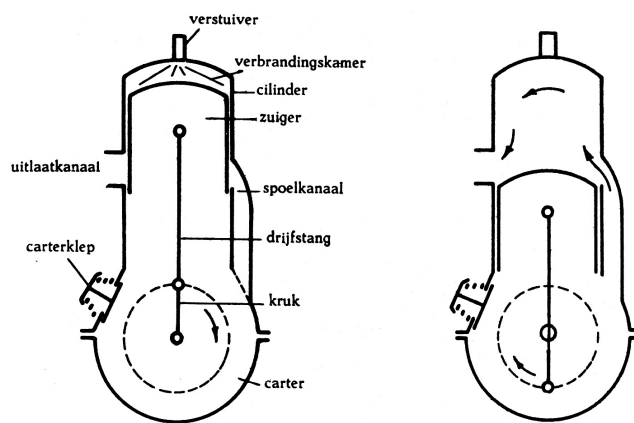
2 Takt



4Takt Dieselmotor



2Takt Dieselmotor



2Takt Motor

PRO

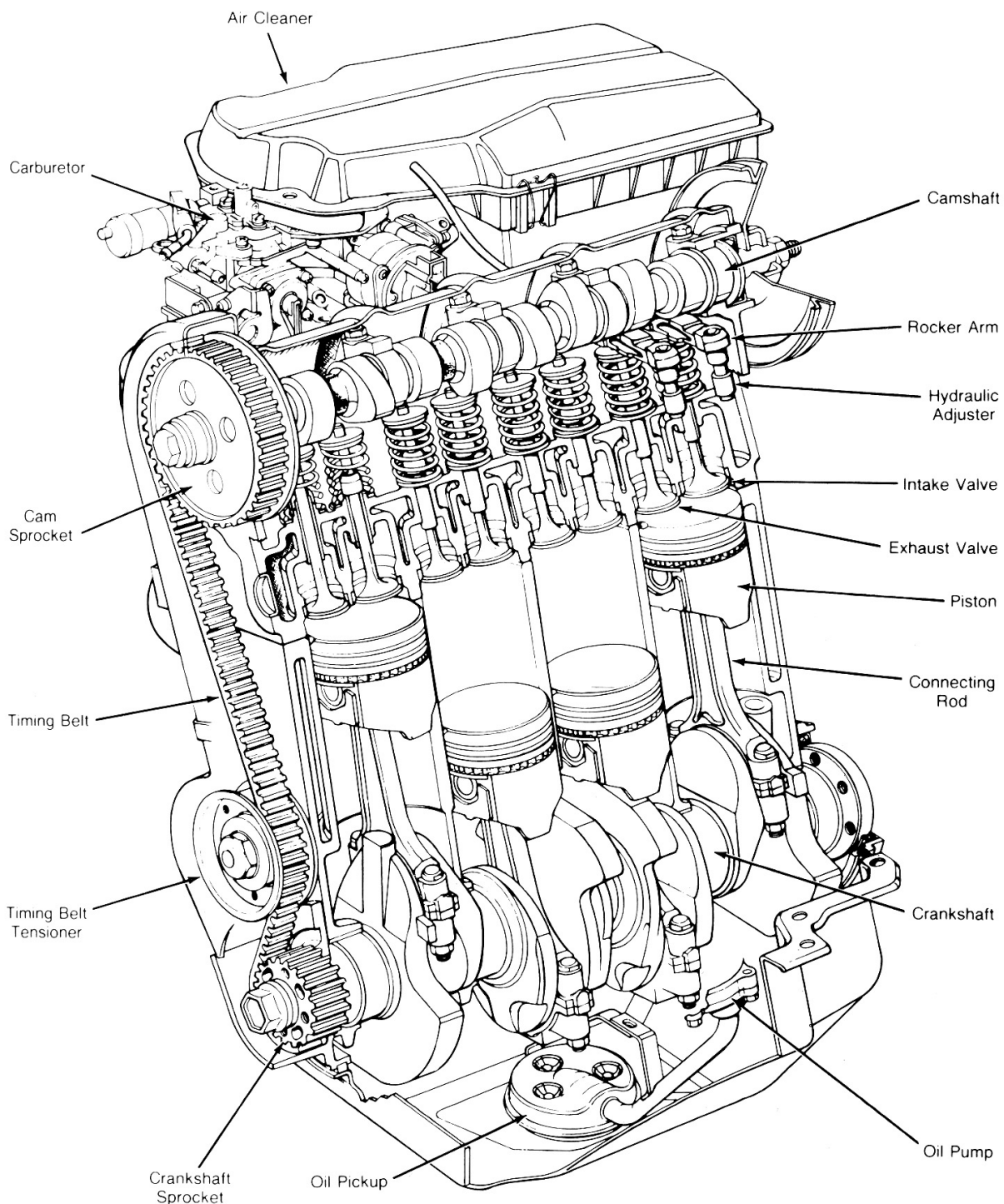
eenvoudige constructie
groot specifiek vermogen
regelmatig draaimoment

CONTRA

hoger brandstofverbruik
moeilijkere warmteafvoer
mengsmering (1/20 à 1/40)

Opbouw verbrandingsmotor

Heen- en weergaande



Krukas—Zuigers —Vliegwiel

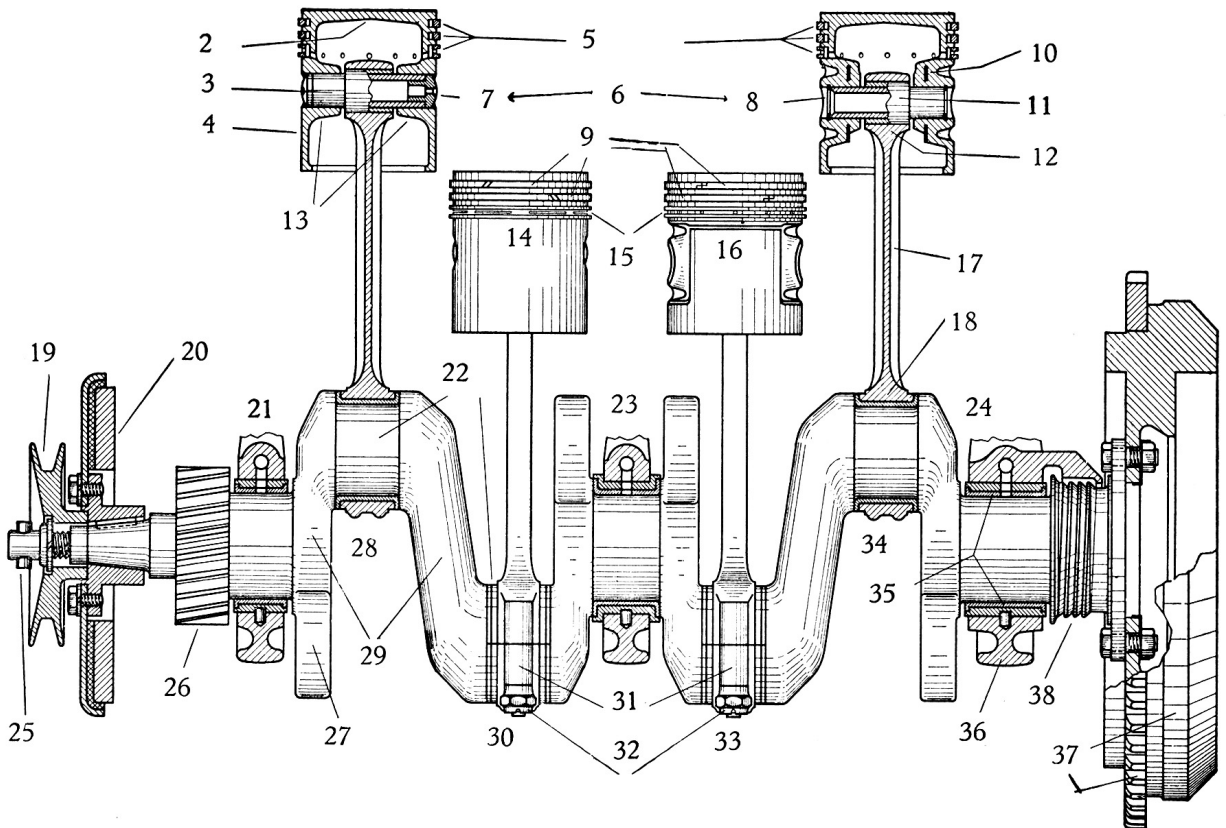
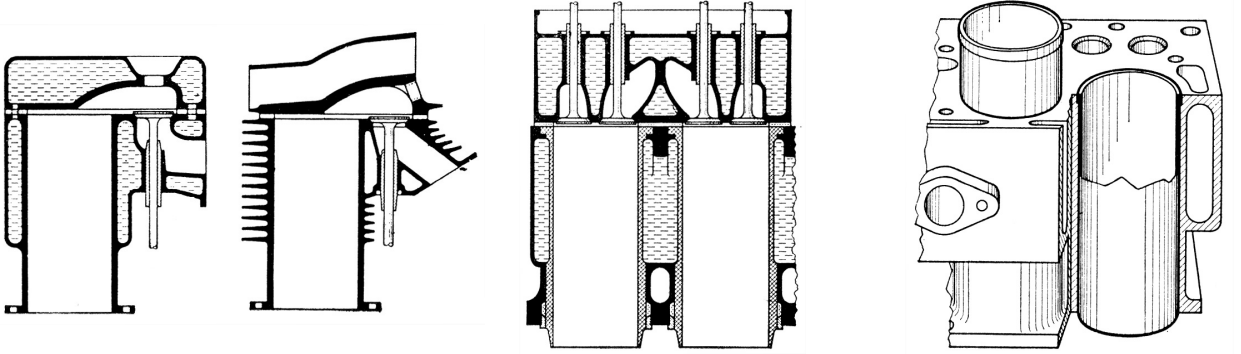


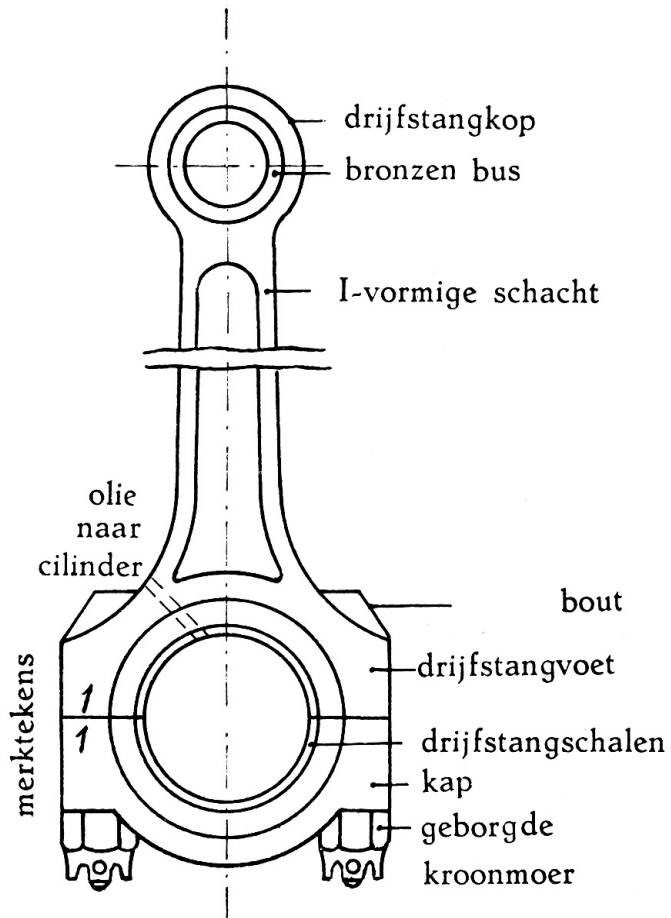
Fig. 12. Samenstel van zuigers, drijfstangen en krukas

- | | | | |
|--------------------------------------|-------------------------------------|------------------------------|--------------------------------|
| 2. Zuigerbodern | 12. Drijfstangkop | 21. Krukaslager (1) | 31. Drijfstanglagerkap |
| 3. Zuigerpen | 13. Zuigerpennaaf | 22. Krukpen | 32. Kapbouten |
| 4. Zuigermantel | 14. Zuiger met ononderbroken mantel | 23. Krukaslager (2) | 33. Drijfstanglager (3) |
| 5. Zuigerveren | 15. Olieschraapveer | 24. Krukaslager (3) | 34. Drijfstanglager (4) |
| 6. Borging van zuigerpen | 16. Zuiger met invarstalen brug | 25. Klauw voor aanzetslinger | 35. Krukaslagerschalen |
| 7. Borgstift | 17. Drijfstangschacht | 26. Krukastandwiel | 36. Krukaslagerkap |
| 8. Borging | 18. Drijfstangvoet | 27. Contragewicht | 37. Vliegwiel met starterkrans |
| 9. Compressieveren | 19. V-riemschijf | 28. Drijfstanglager (1) | 38. Oliekeerring |
| 10. Versterkingsbrug van in varstaal | 20. Trillingsdemper | 29. Krukwangen | |
| 11. Bus in drijfstangoog | | 30. Drijfstanglager (2) | |

Cilinder



Drijfstang



Kleppenmechanisme—Nokkenas

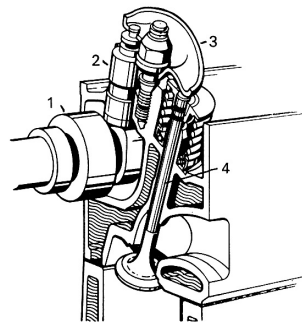
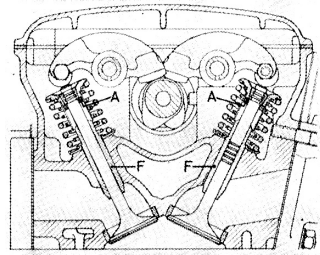
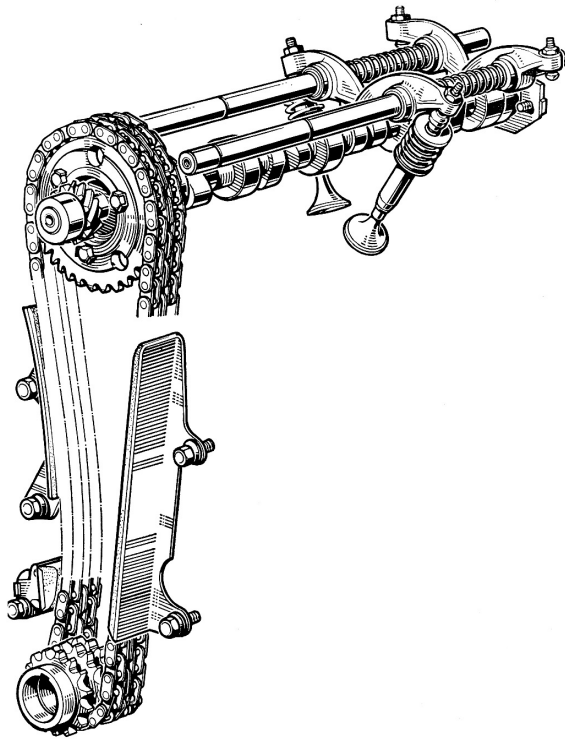
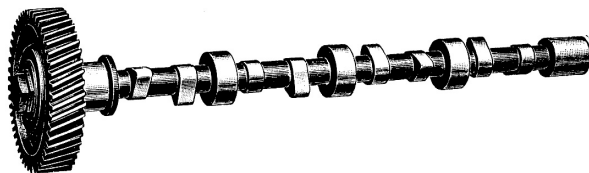
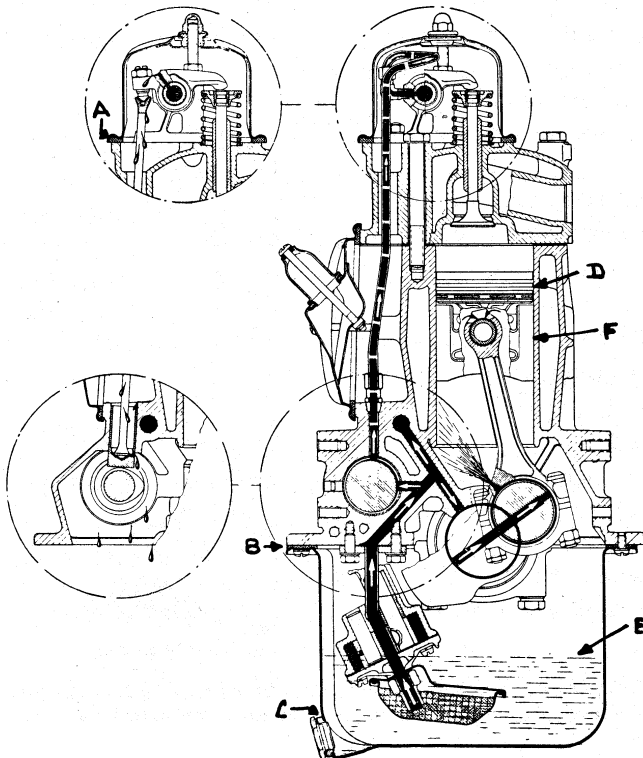
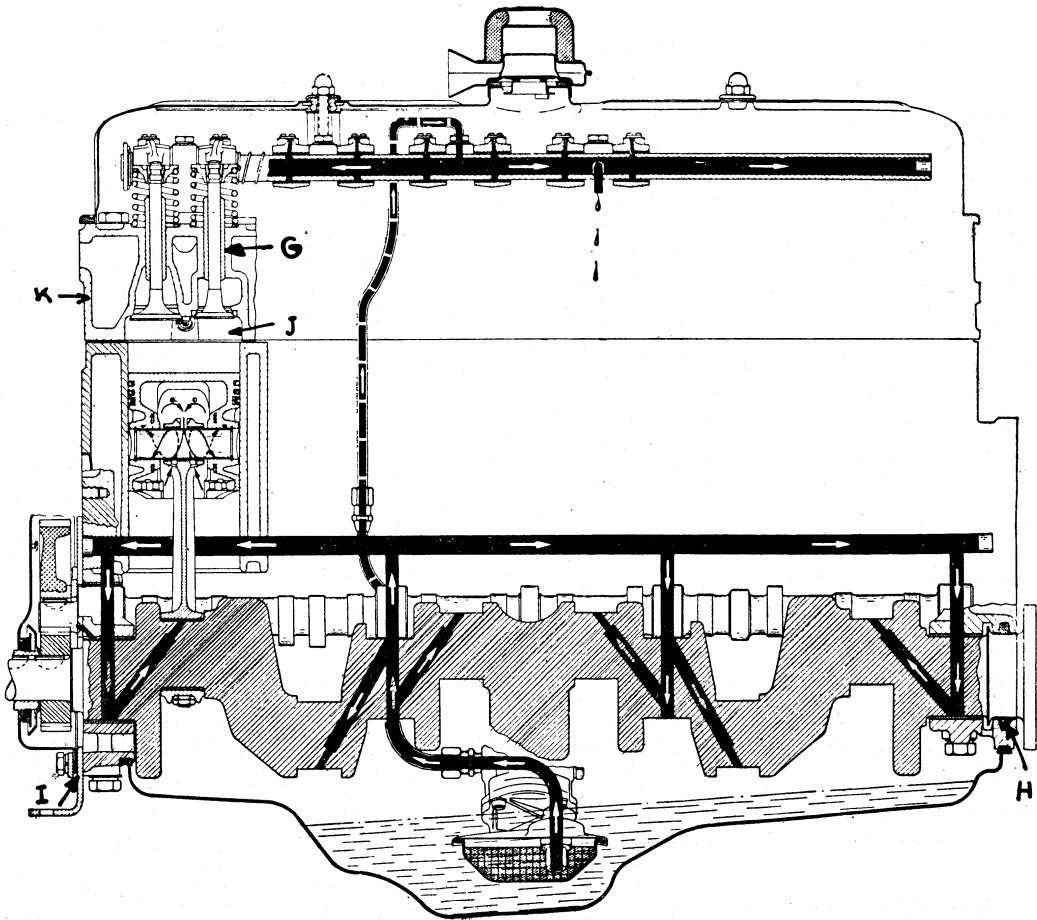


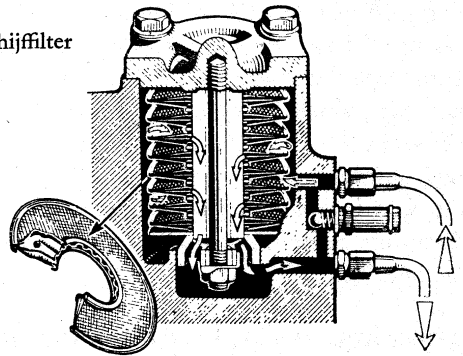
Fig. 22c. Kleppenbediening
Opel Rekord-C
1. nokkenas 3. tuimelaar
2. stoter 4. klep



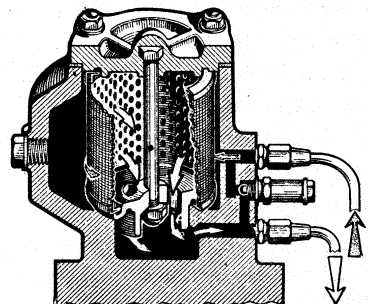
Druksmering



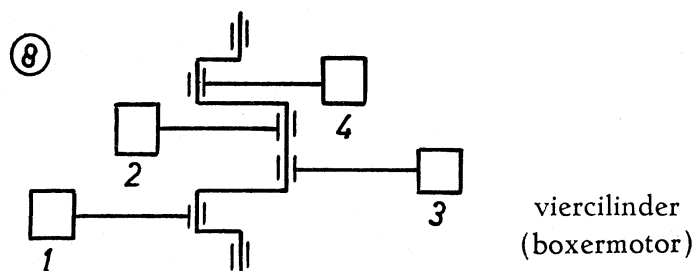
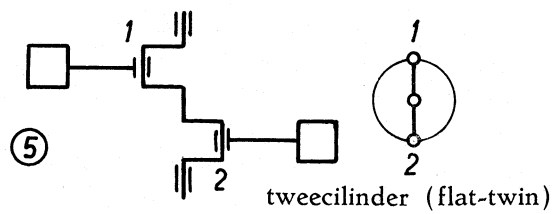
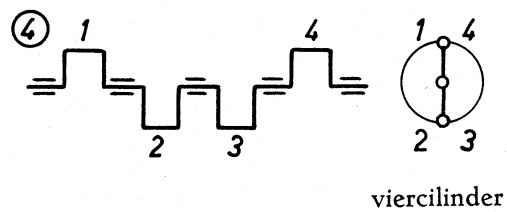
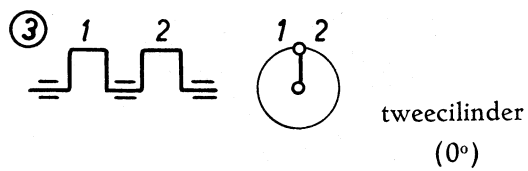
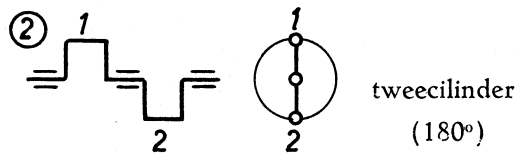
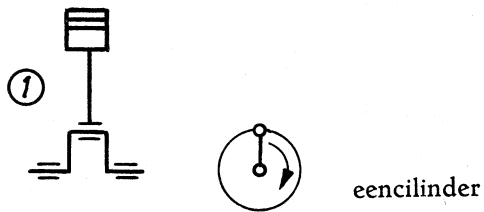
a. Schijffilter



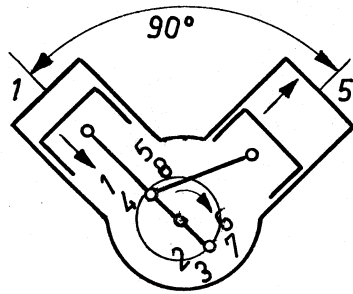
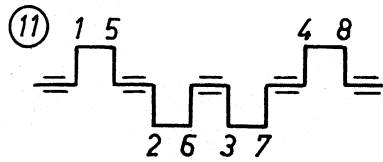
b. Gaasfilter



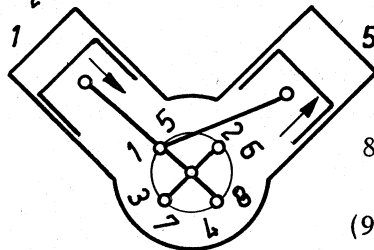
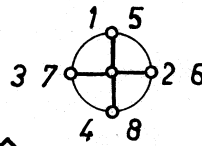
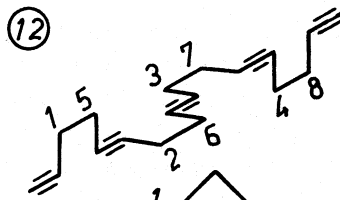
Cilinderopstellingen



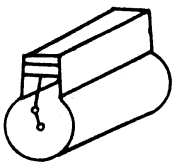
Cilinderopstellingen



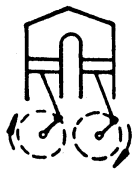
achtcilinder
in V (180°)



8-cilinder
in V
(90°-Ford)



In-line



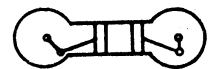
U type



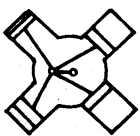
V type



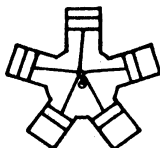
Opposed cylinder



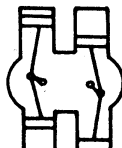
Opposed piston



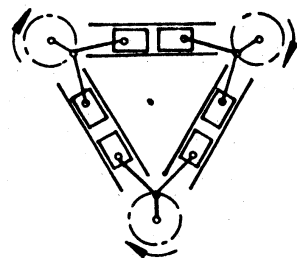
X-type



Radial

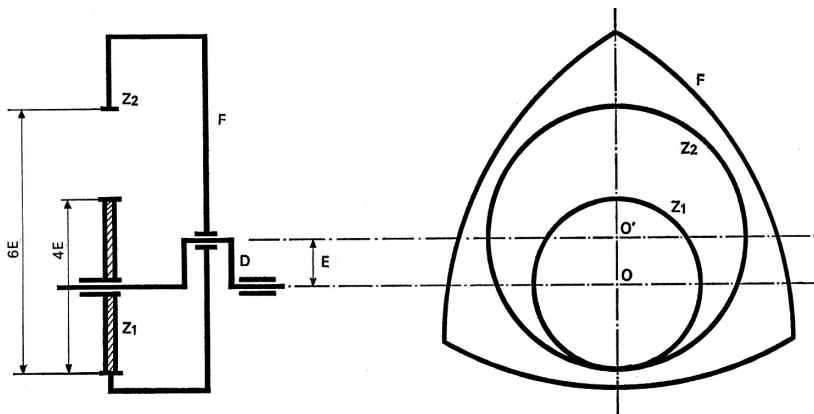
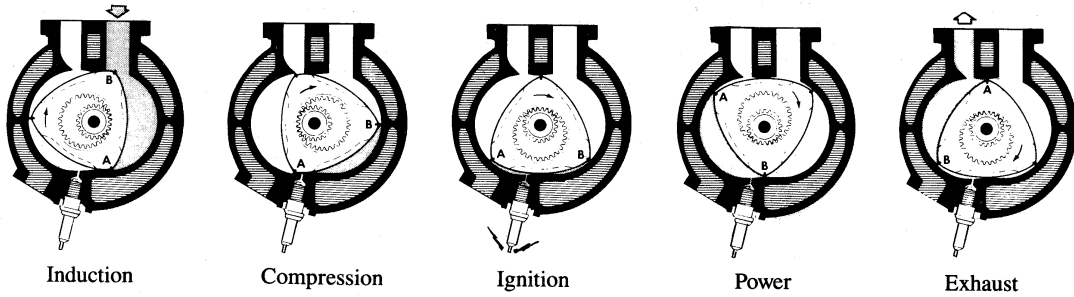
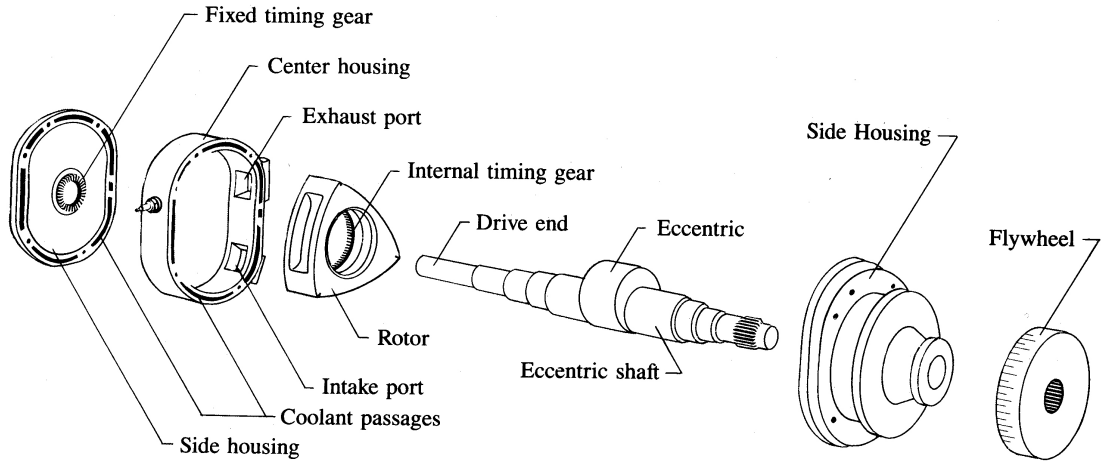


H type



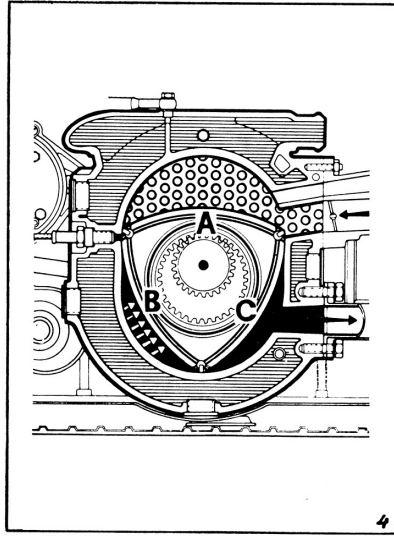
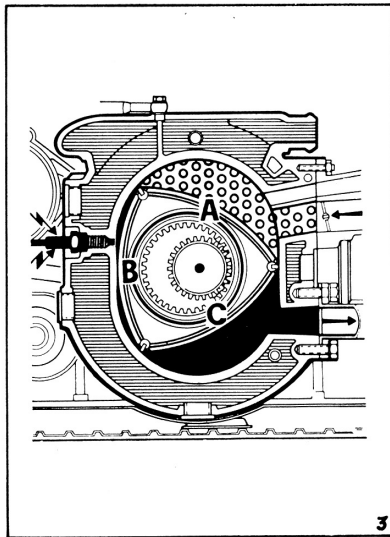
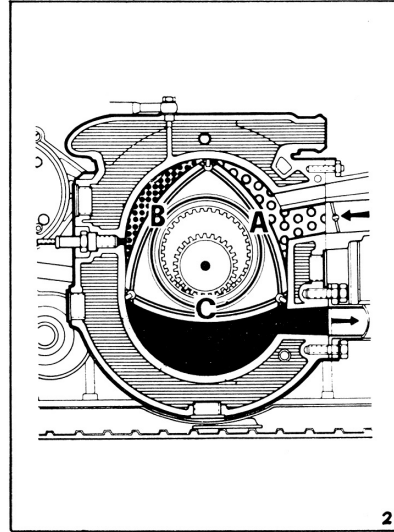
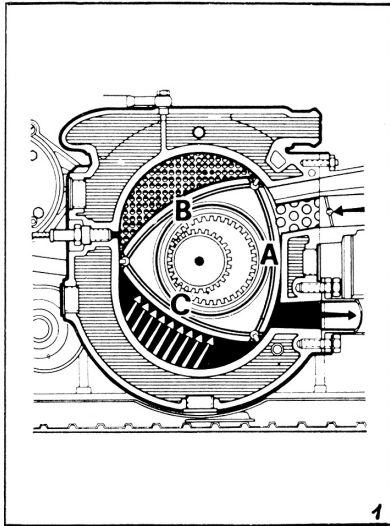
Delta type

Wankelmotor



	Z_1	Z_2	D
1ste beweging :	+ 1	+ 1	+ 1
2de beweging :	- 1	- $\frac{2}{3}$	0
resultaat :	0	+ $\frac{1}{3}$	+ 1

Wankelmotor



2Takt of 4Takt?