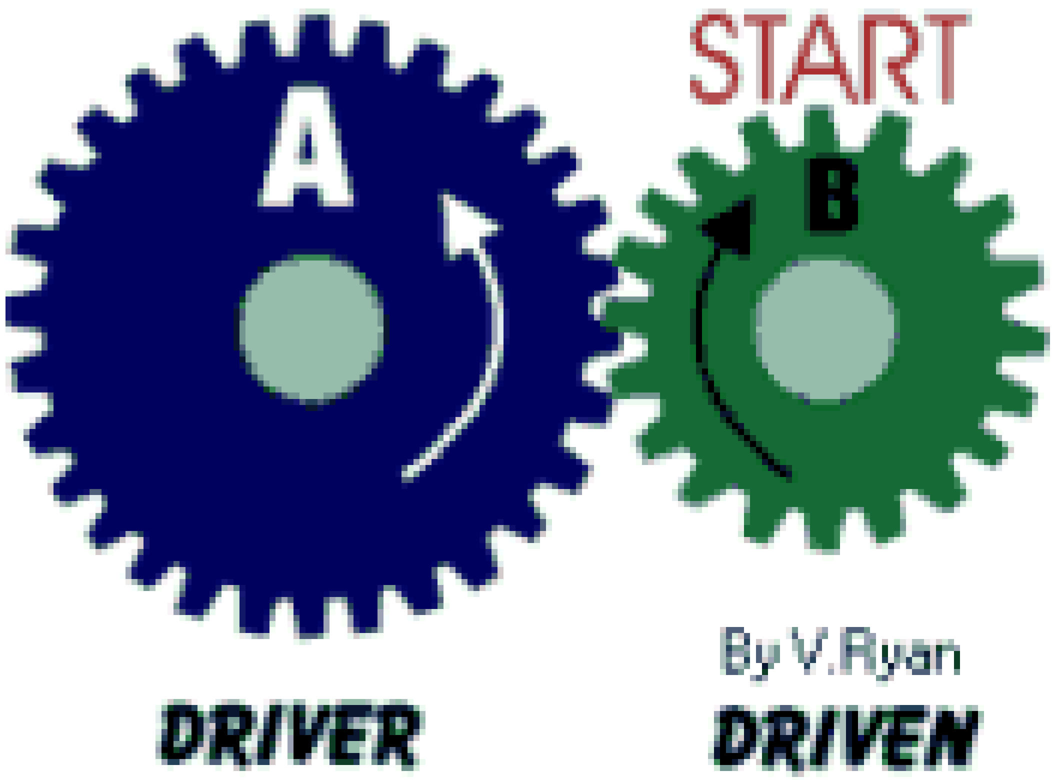
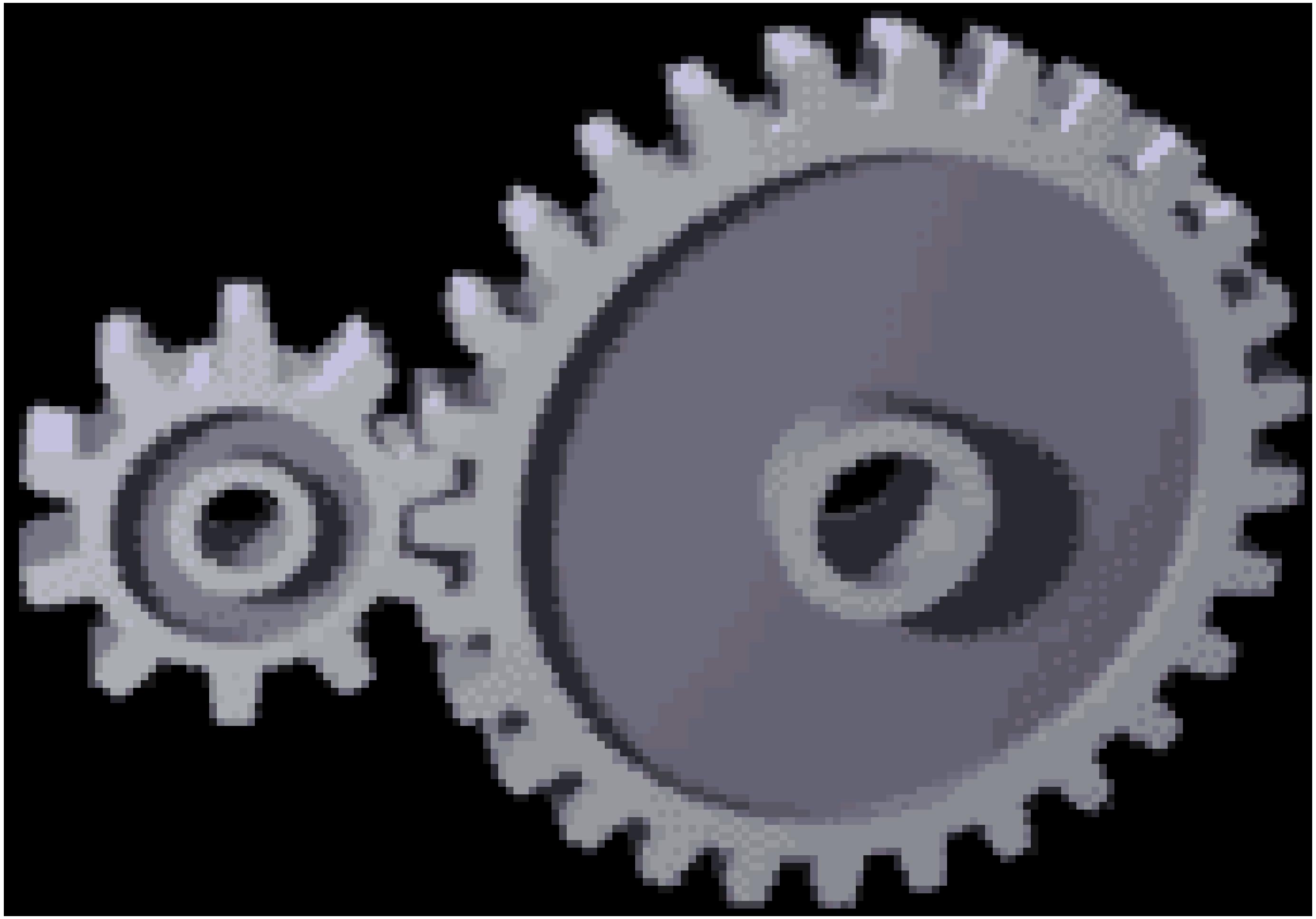
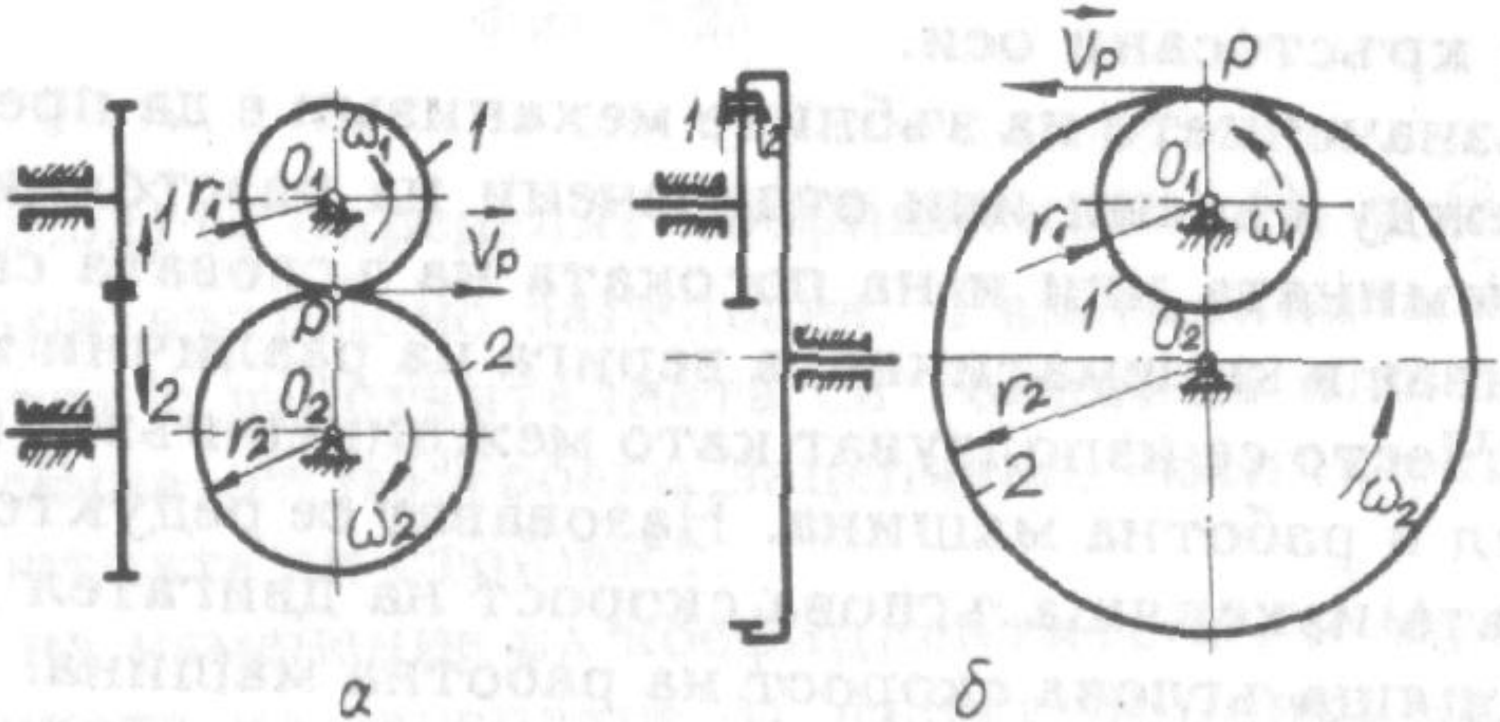
Кинематика и синтез на зъбни механизми

1. Кинематика на зъбни механизми с неподвижни оси на въртене (обикновени)

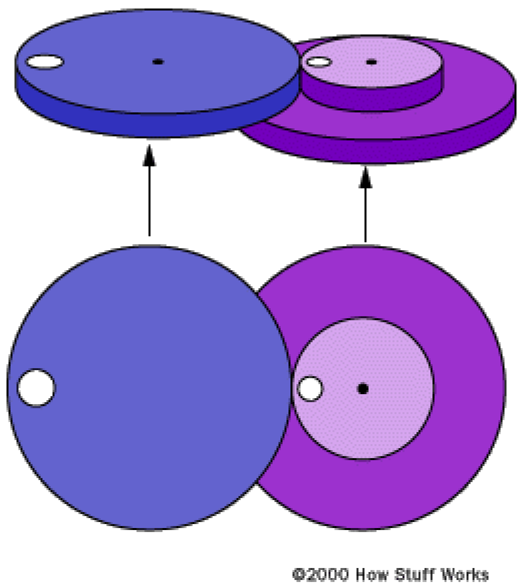
Цилиндрични кръгли колела с прави зъби







$$i_{12} = \frac{\omega_1}{\omega_2} = \frac{n_1}{n_2} = \frac{V_P / r_{w_1}}{V_P / r_{w_2}} = \mp \frac{r_{w_2}}{r_{w_1}} = \mp \frac{d_{b_1}}{d_{b_2}} = \mp \frac{z_2}{z_1}.$$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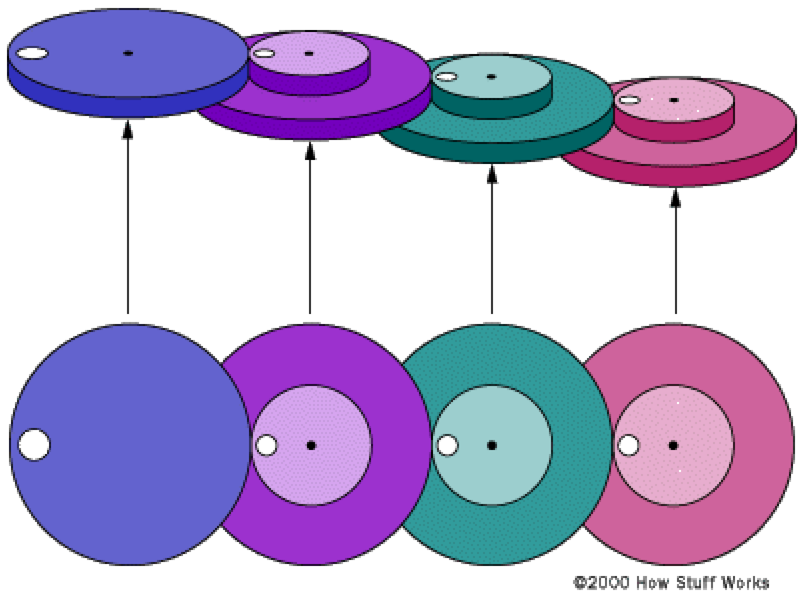
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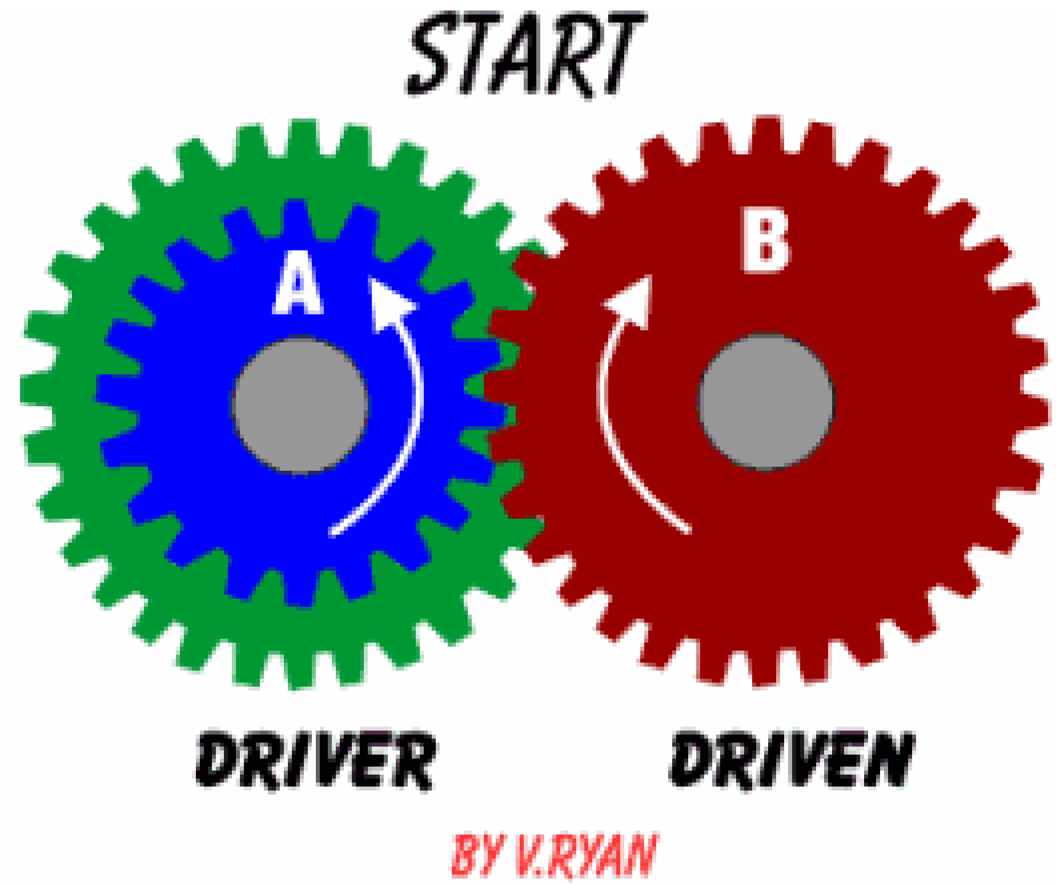
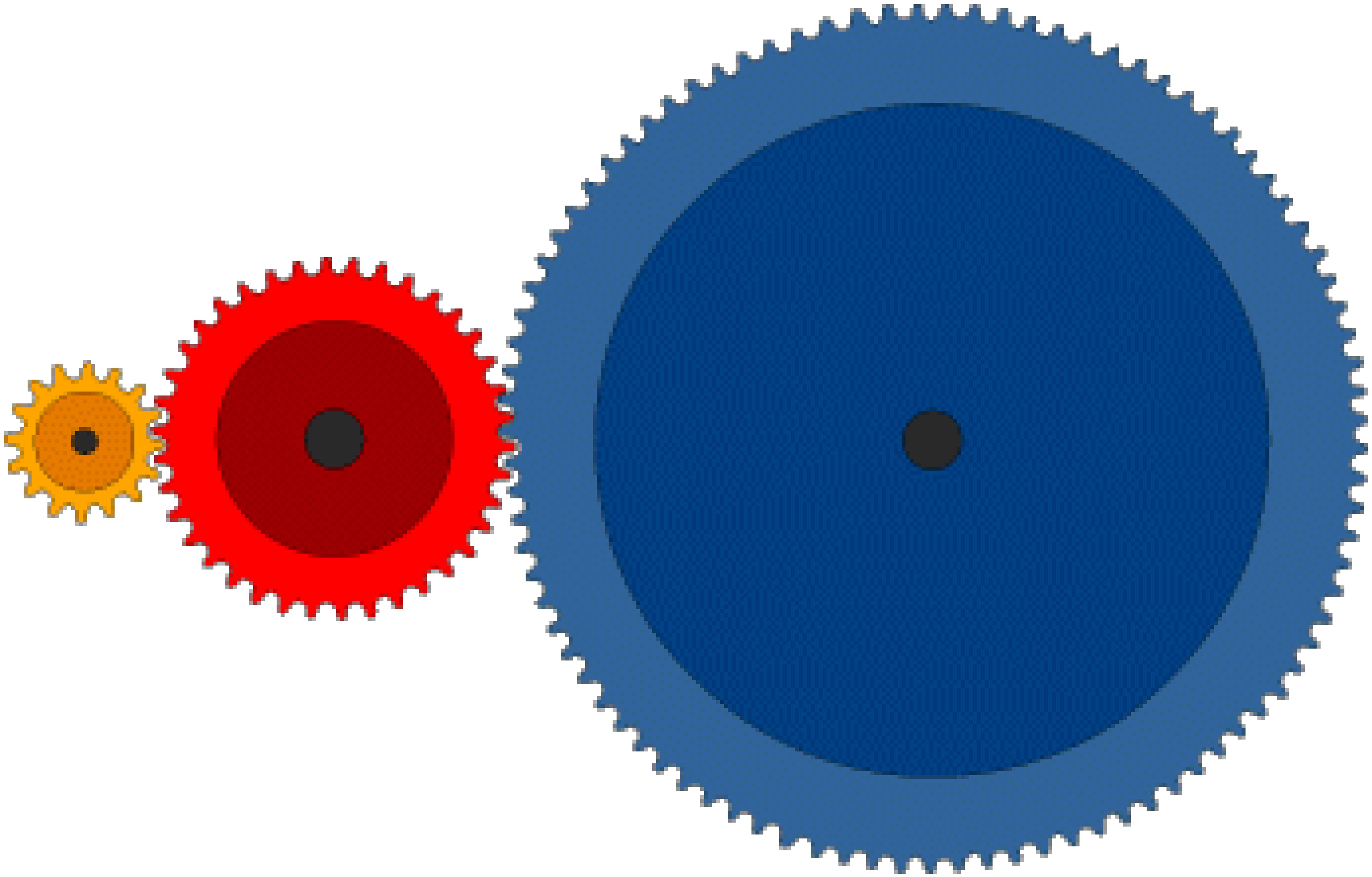
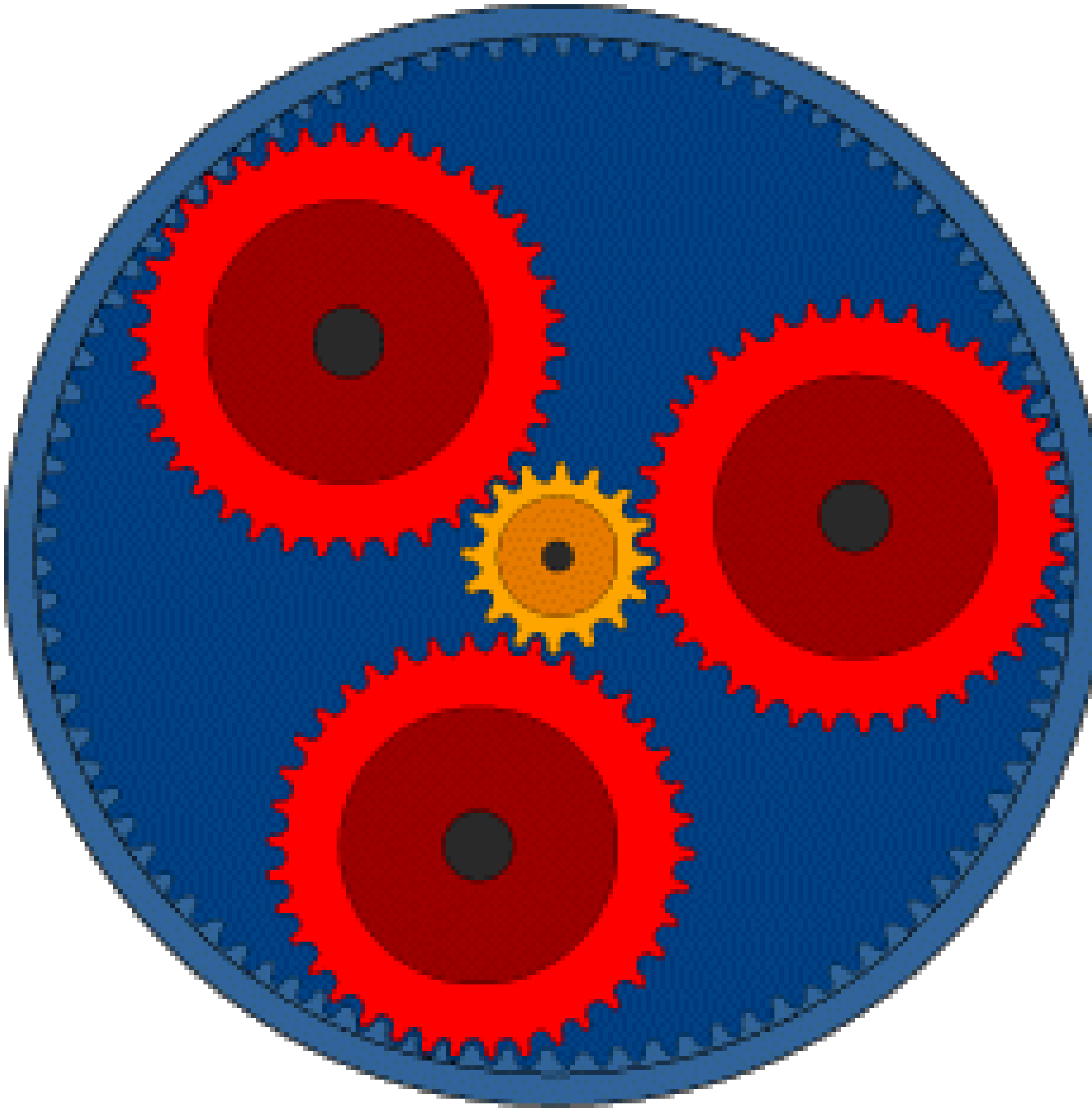
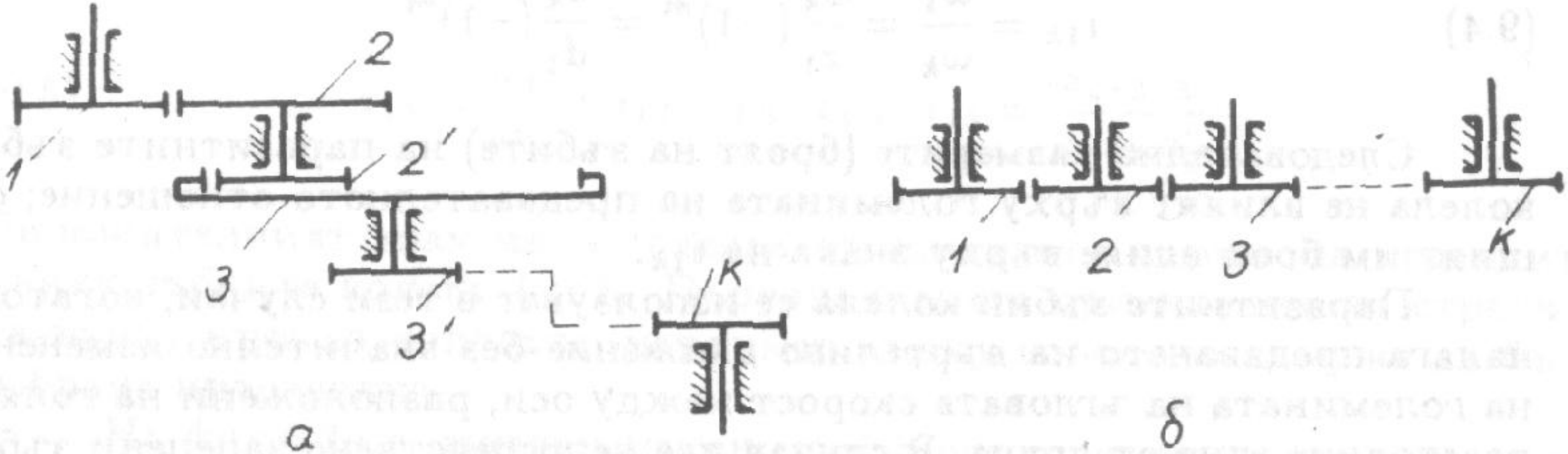
Блок от цилиндрични кръгли колела с прави зъби







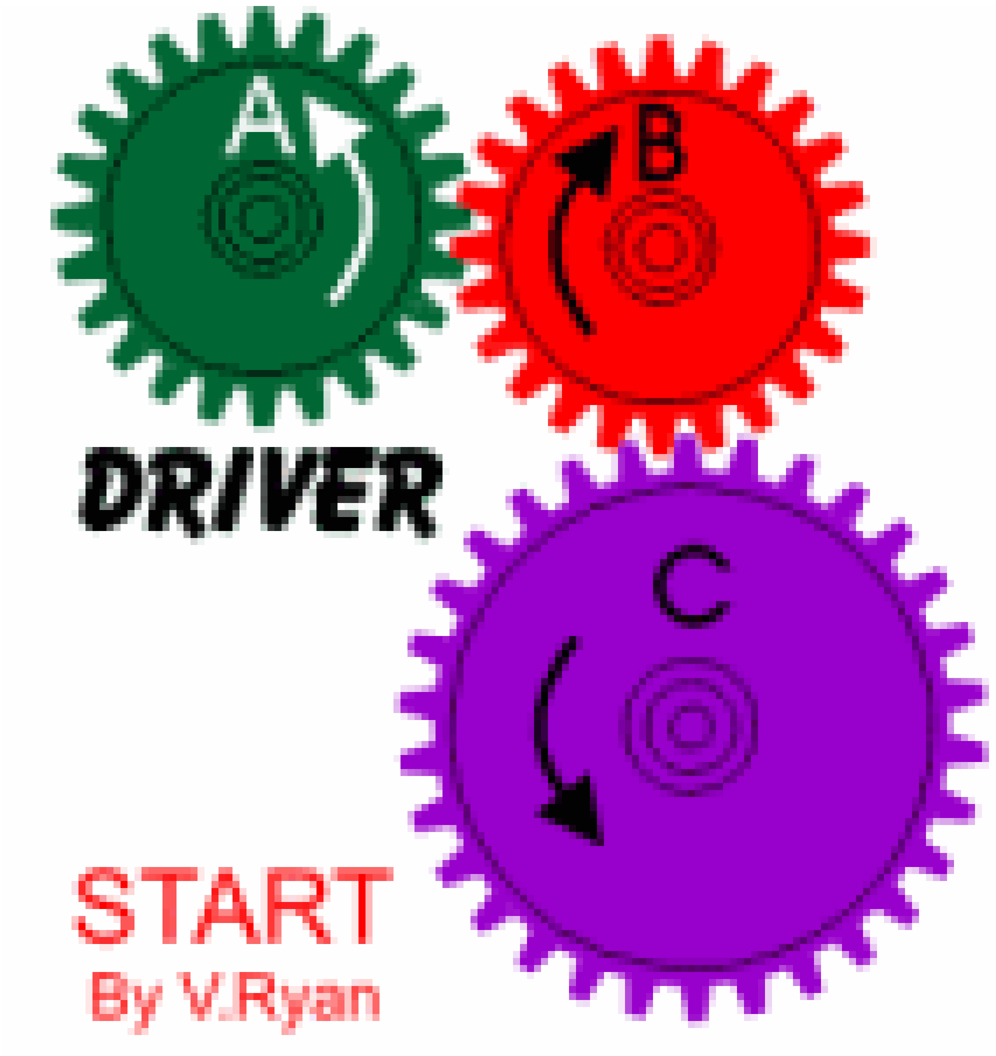


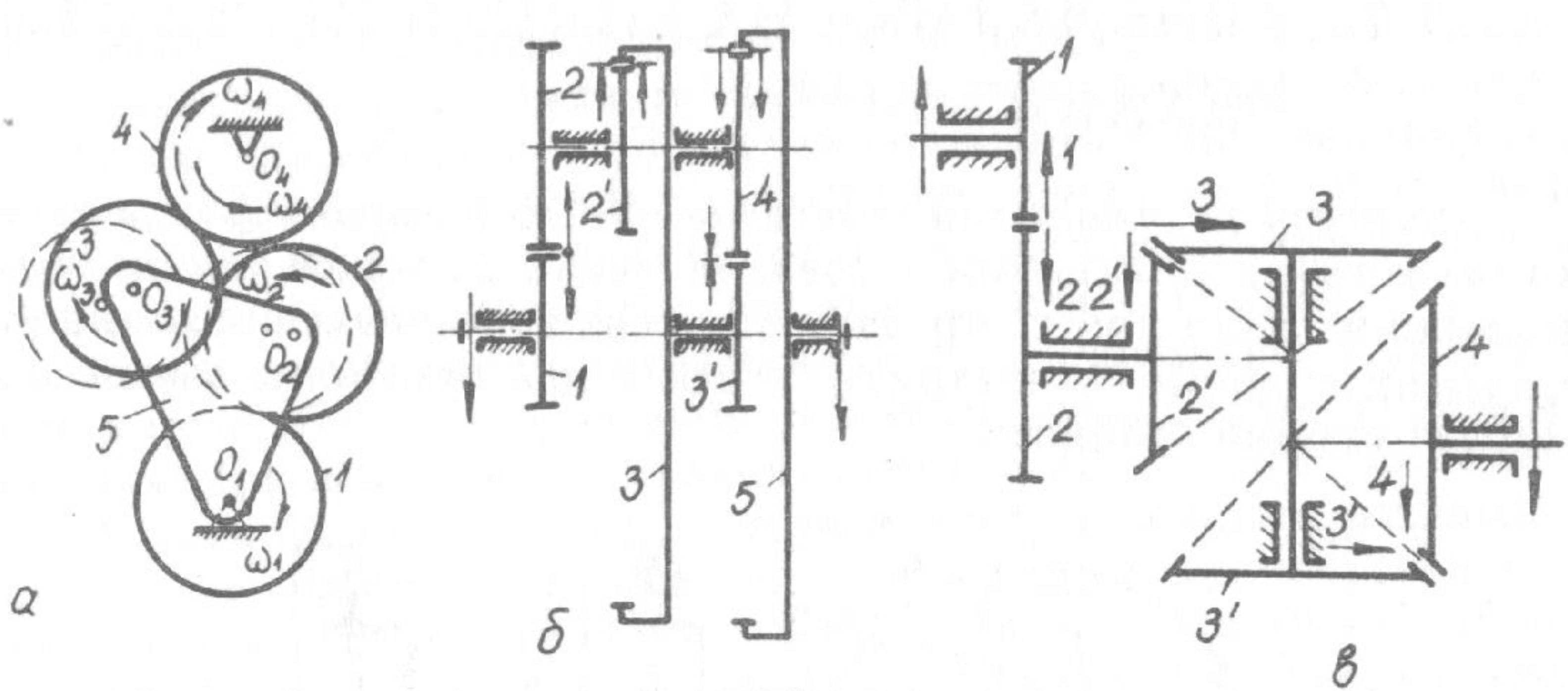
$$i_{12} = \frac{\omega_1}{\omega_2} = \frac{z_2}{z_1}; \quad i_{23} = \frac{\omega_2}{\omega_3} = \frac{z_3}{z_{2'}}; \quad \dots i_{k-1,k} = \frac{\omega_{k-1}}{\omega_k} = \frac{z_k}{z'_{k-1}}.$$

$$i_{1k} = \frac{\omega_1}{\omega_k} = \frac{\omega_1}{\omega_2} \cdot \frac{\omega_2}{\omega_3} \cdot \frac{\omega_3}{\omega_4} \cdot \frac{\omega_{k-1}}{\omega_k} = i_{12} \cdot i_{23} \cdot i_{34} \cdots i_{k-1,k}.$$

$$i_{1k} = \frac{\omega_1}{\omega_k} = \frac{z_2 z_3 \dots z_k}{z_1 z_{2'} \dots z'_{k-1}} (-1)^m = \frac{d_2 d_3 \dots d_k}{d_1 d_{2'} d_{k'-1}} (-1)^m.$$

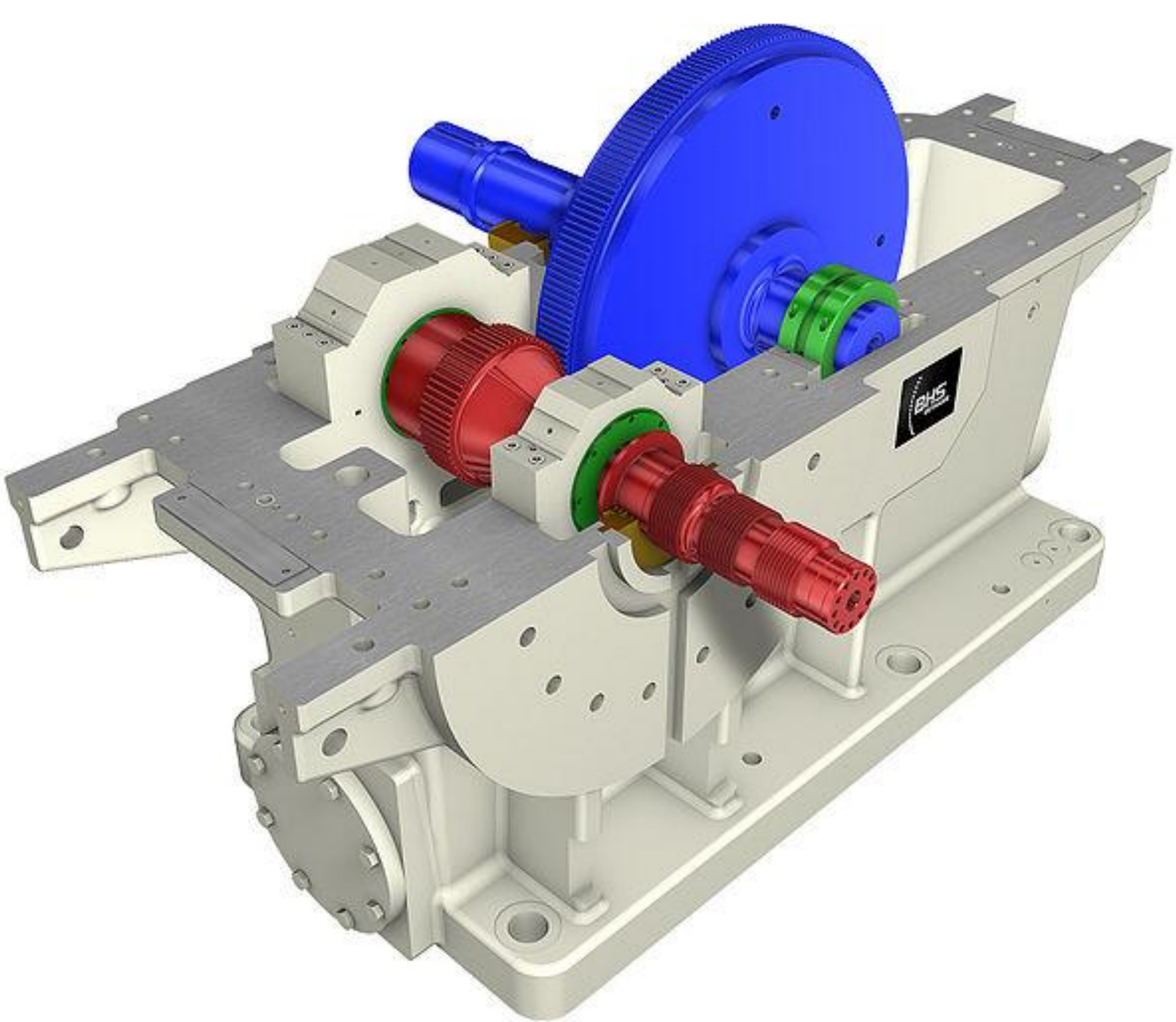
$$i_{1k} = \frac{\omega_1}{\omega_k} = \frac{z_2 z_3 \dots z_k}{z_1 z_{2'} \dots z'_{k-1}} (-1)^m = \frac{d_2 d_3 \dots d_k}{d_1 d_{2'} d_{k'-1}} (-1)^m.$$

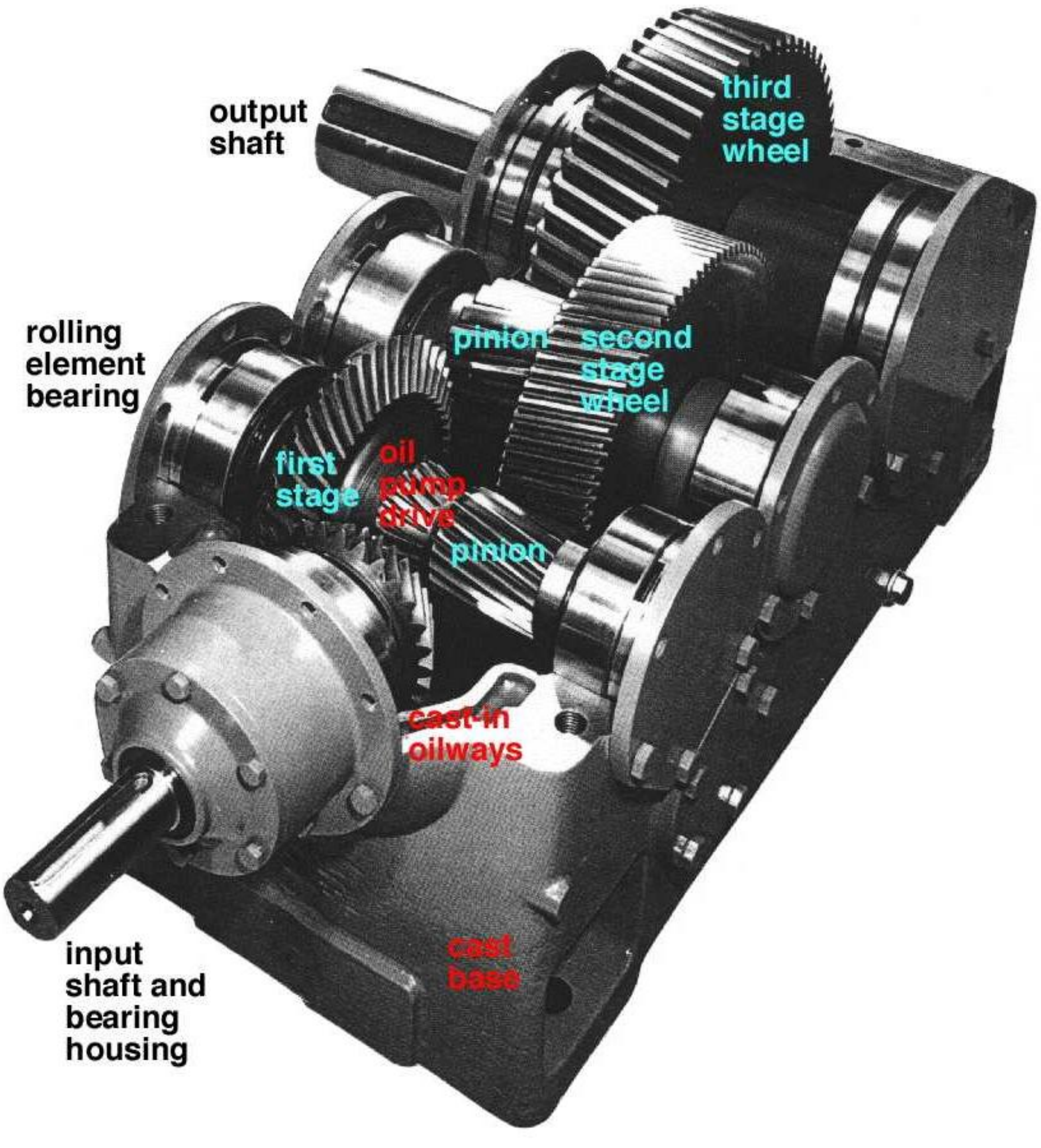

A
B
DRIVER
C
START
By V.Ryan

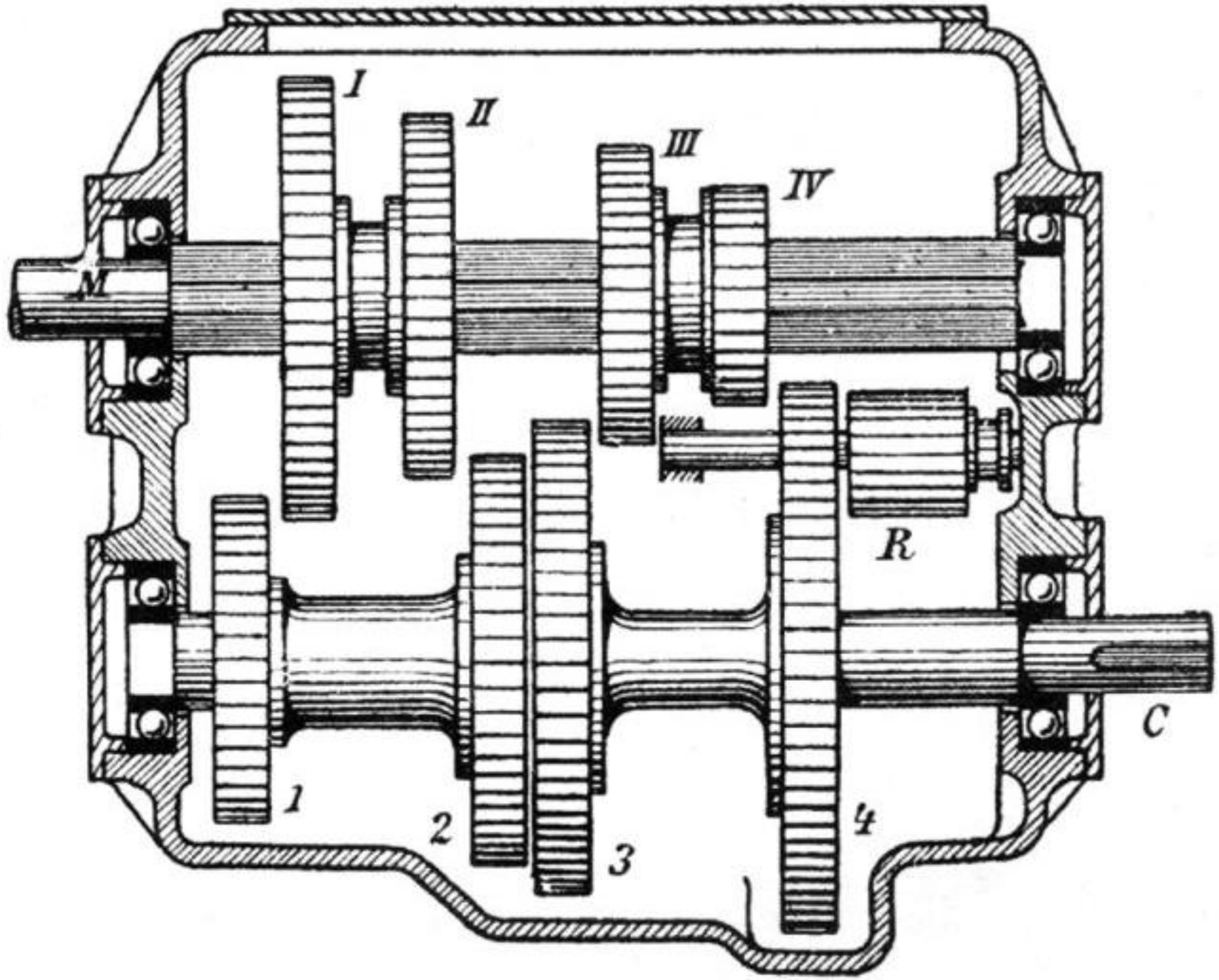


$$i_{15} = \frac{\omega_1}{\omega_5} = i_{12} \cdot i_{2'3} \cdot i_{3'4} \cdot i_{45} = \frac{z_2 z_3 z_5}{z_1 z_{2'} z_3'}.$$

$$i_{14} = \frac{\omega_1}{\omega_4} = i_{12} \cdot i_{2'3} \cdot i_{3'4} = -\frac{z_2}{z_1} \cdot \frac{z_3}{z_{2'}} \cdot \frac{z_4}{z_{3'}}.$$

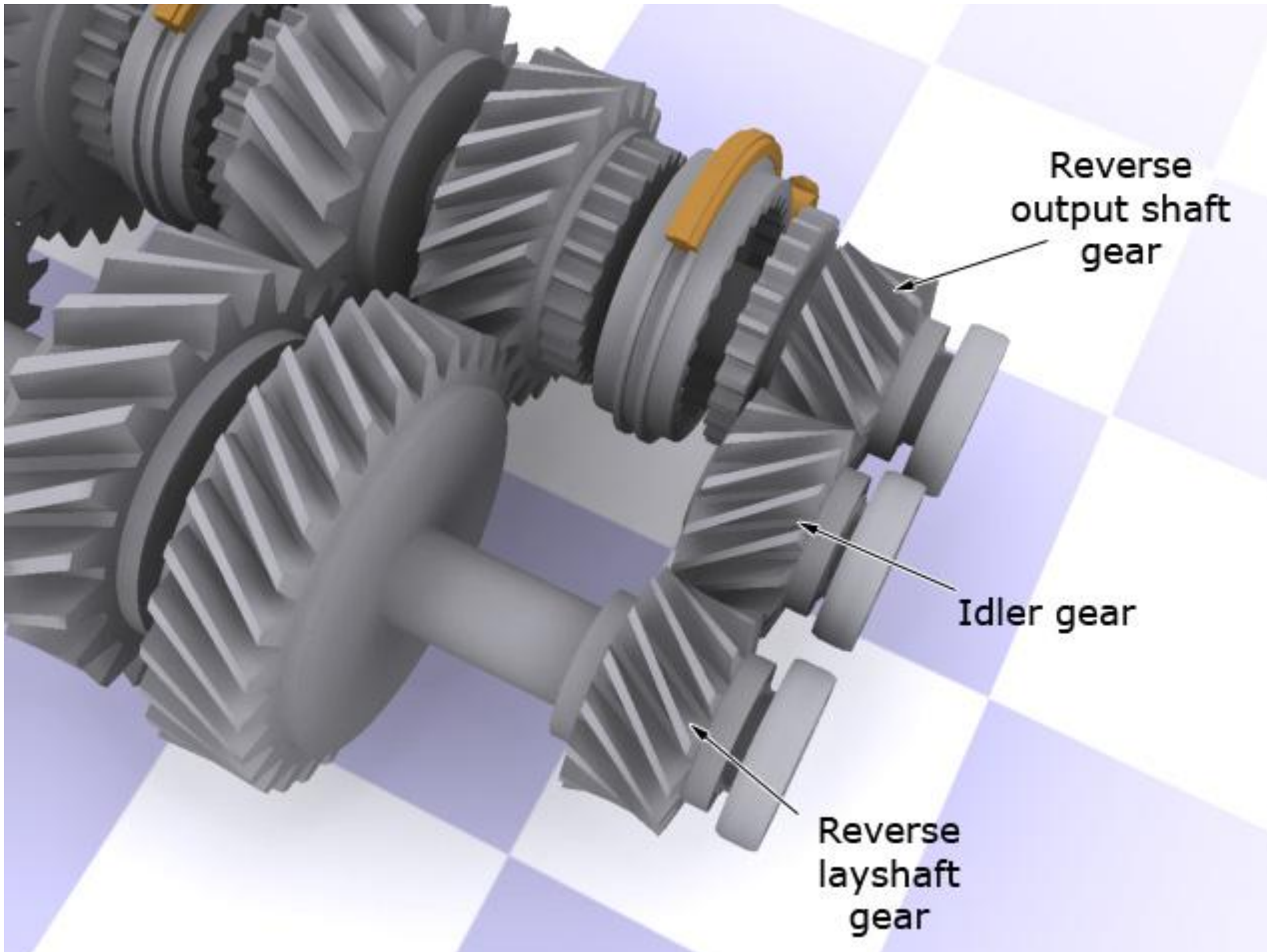

BHS


output shaft
third stage wheel
rolling element bearing
pinion
second stage wheel
first stage
oil pump drive
pinion
cast-in oilways
cast base
input shaft and bearing housing



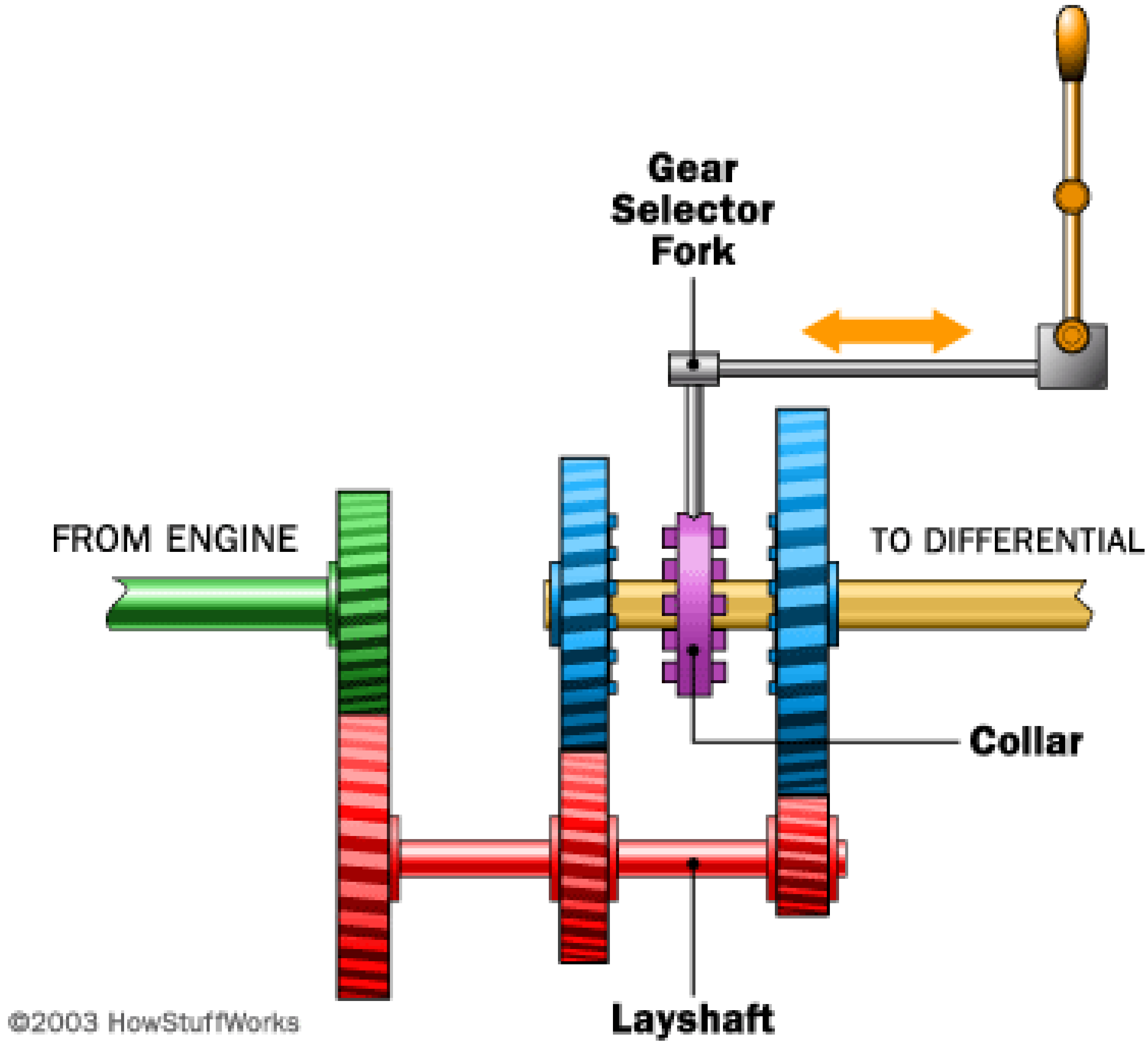
6. Wechselgetriebe für vier Geschwindigkeiten und Rücklauf:

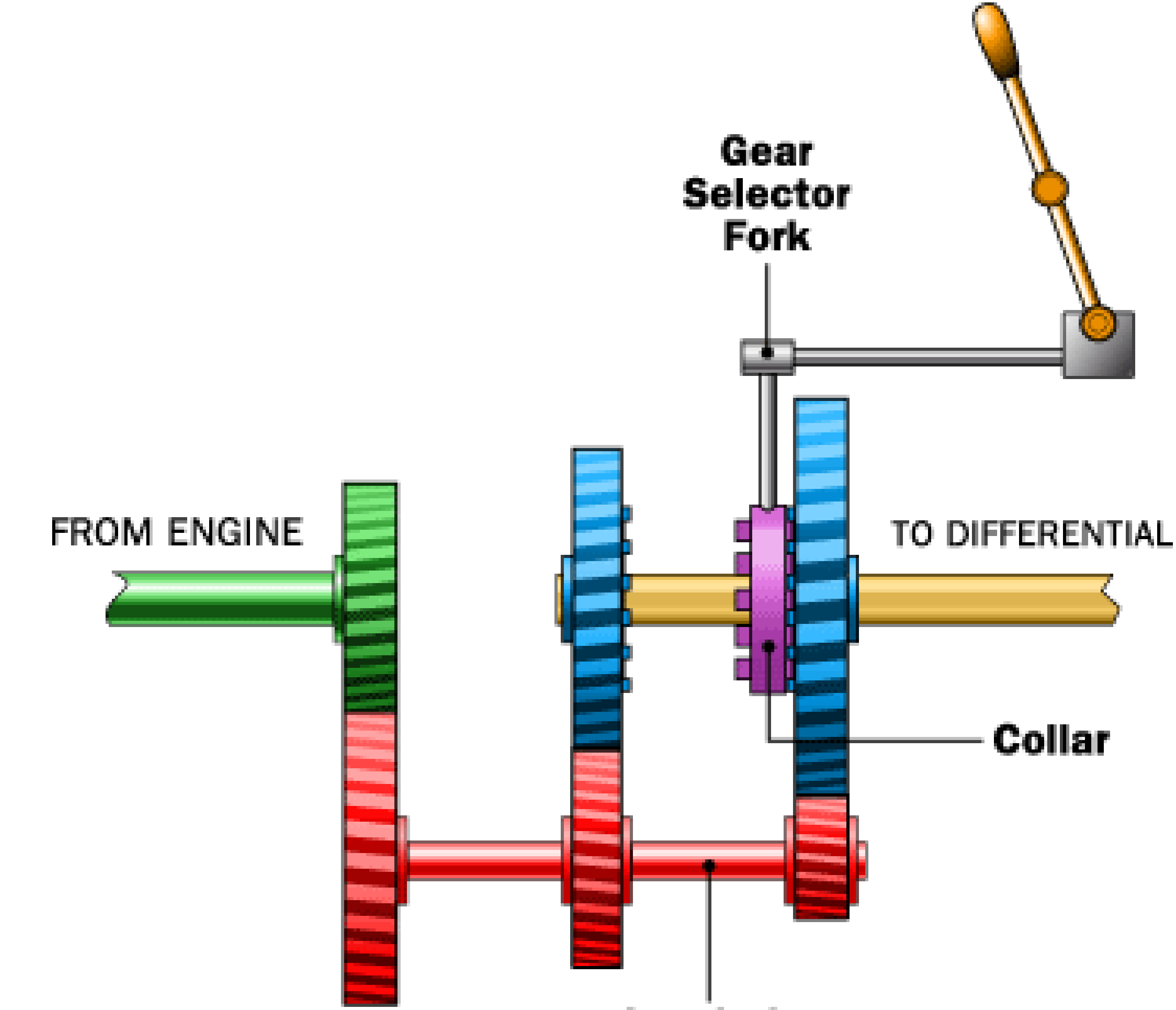
M Angriff der Motorwelle, *C* Angriff der Cardanwelle; Geschwindigkeitsräder *I*, *II*, *III*, *IV*, durch Verschiebung mit *1*, *2*, *3*, *4* in Eingriff gebracht; Rücklaufrad *R*, durch Linksschiebung mit *IV* und *4* in Eingriff gebracht.

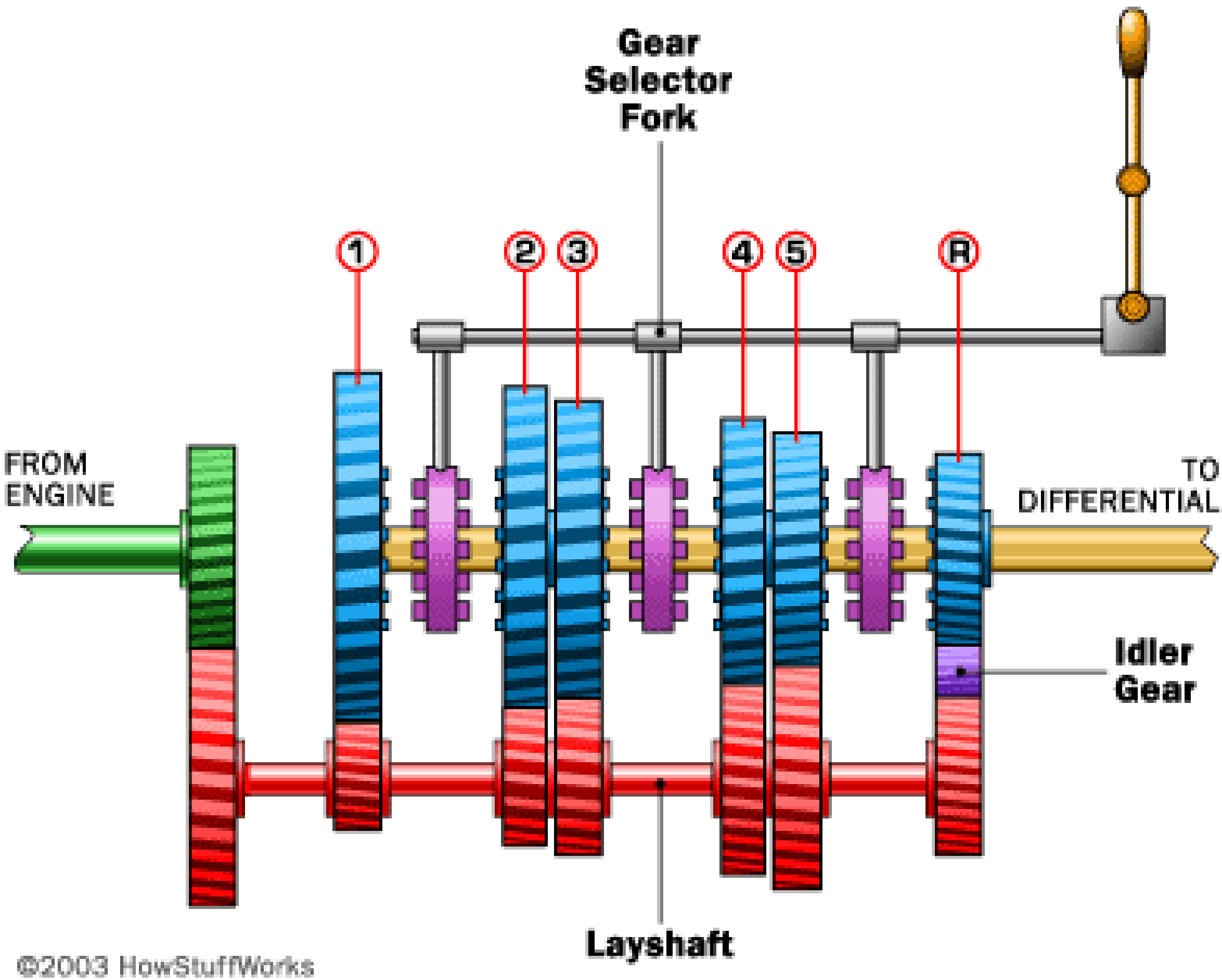

Reverse
output shaft
gear
Idler gear
Reverse
layshaft
gear

Gear.swf

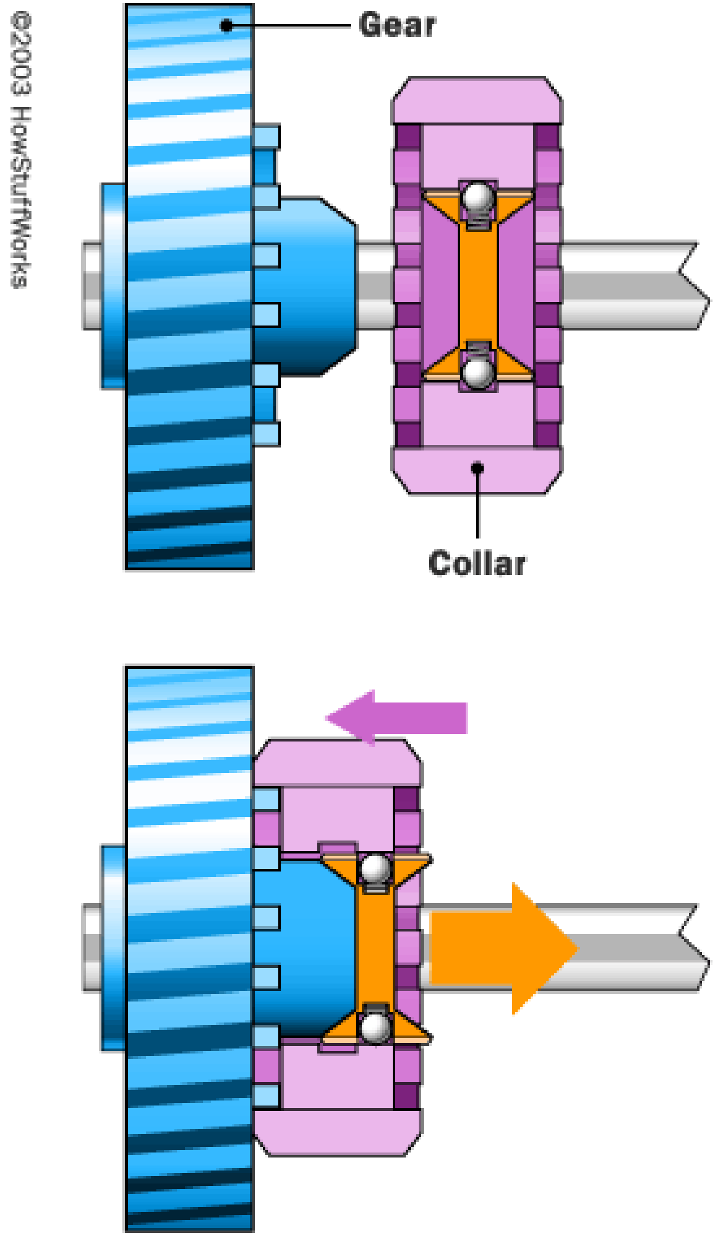
Sinchro.flv


Gear
Selector
Fork
FROM ENGINE
TO DIFFERENTIAL
Collar
Layshaft
©2003 HowStuffWorks


Gear
Selector
Fork
FROM ENGINE
TO DIFFERENTIAL
Collar
Layshaft
©2003 HowStuffWorks



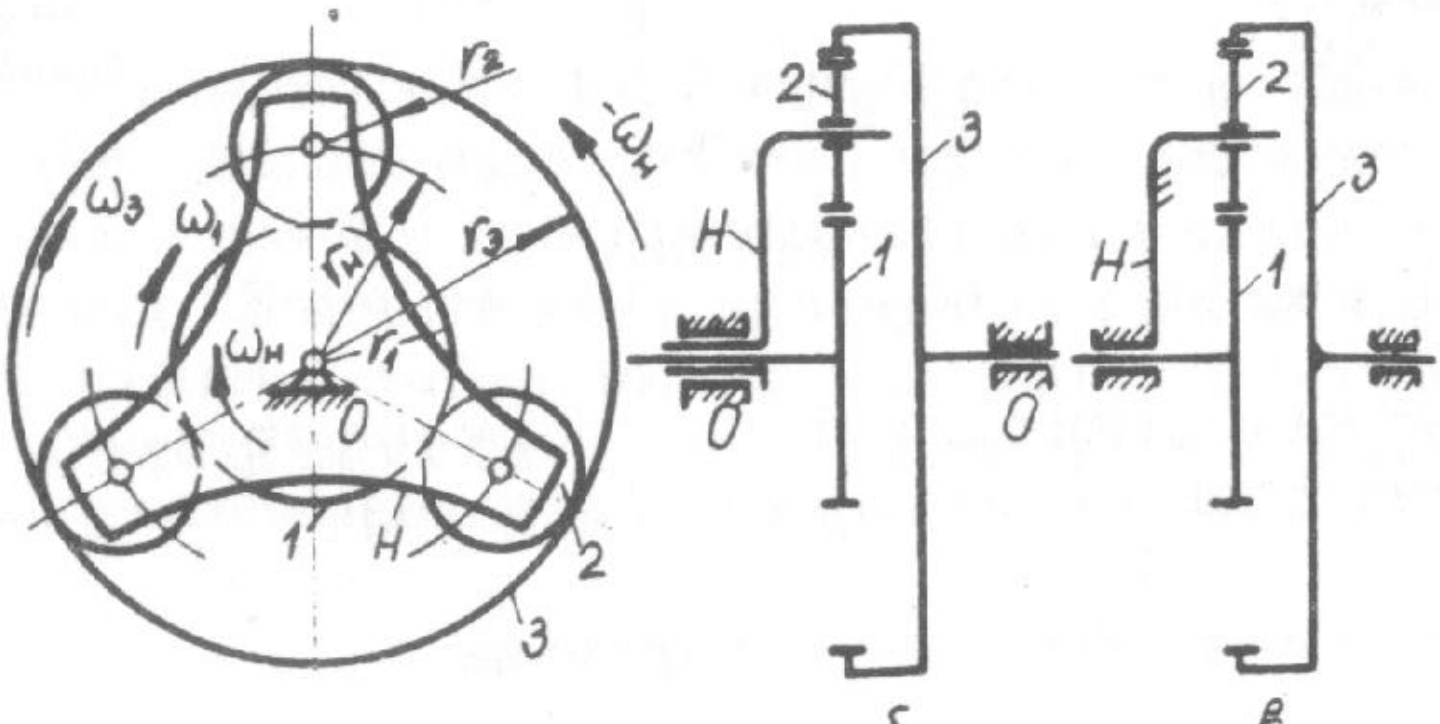
Gear
Selector
Fork
1
2
3
4
5
R
FROM
ENGINE
TO
DIFFERENTIAL
Idler
Gear
Layshaft
©2003 HowStuffWorks



©2003 HowStuffWorks
Gear
Collar

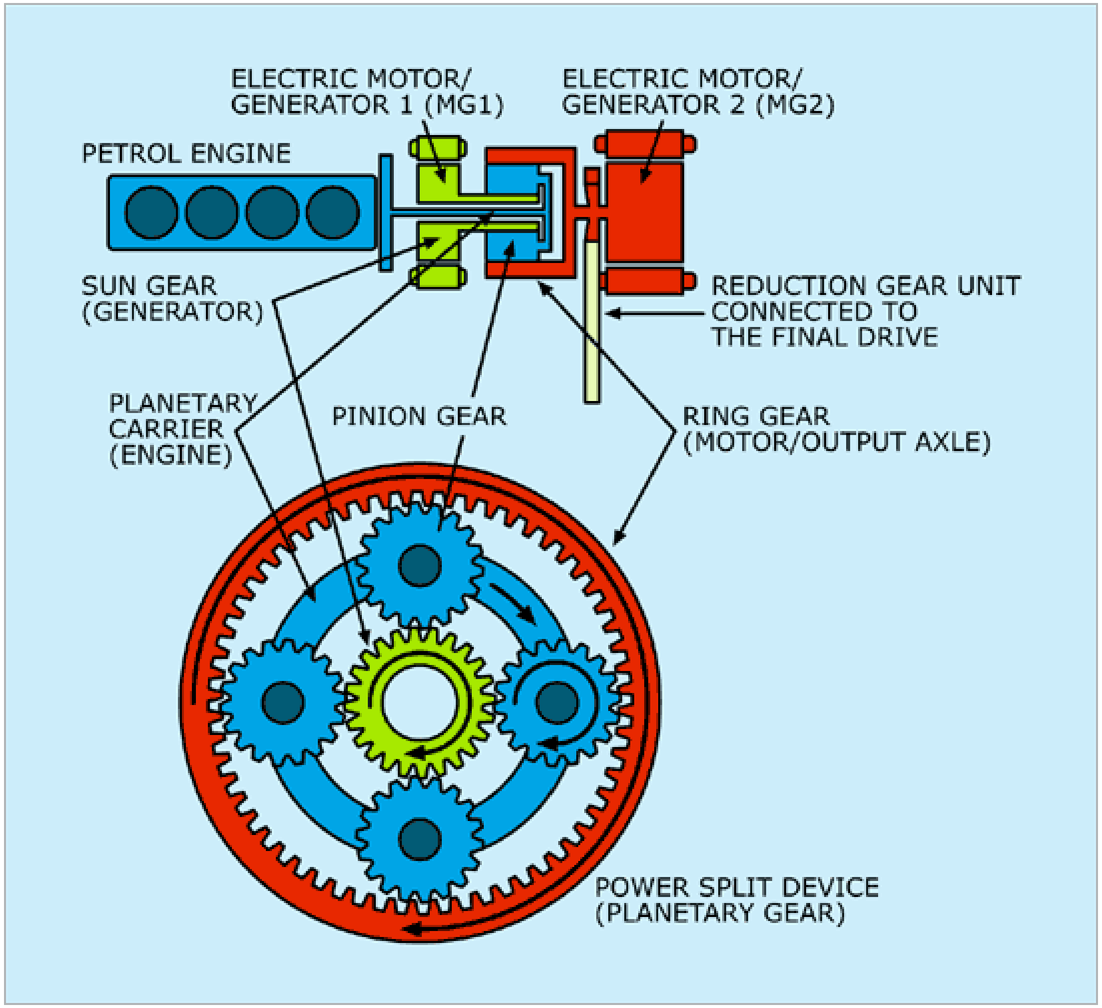
2. Кинематика на зъбни механизми с подвижни оси на въртене (епициклични)

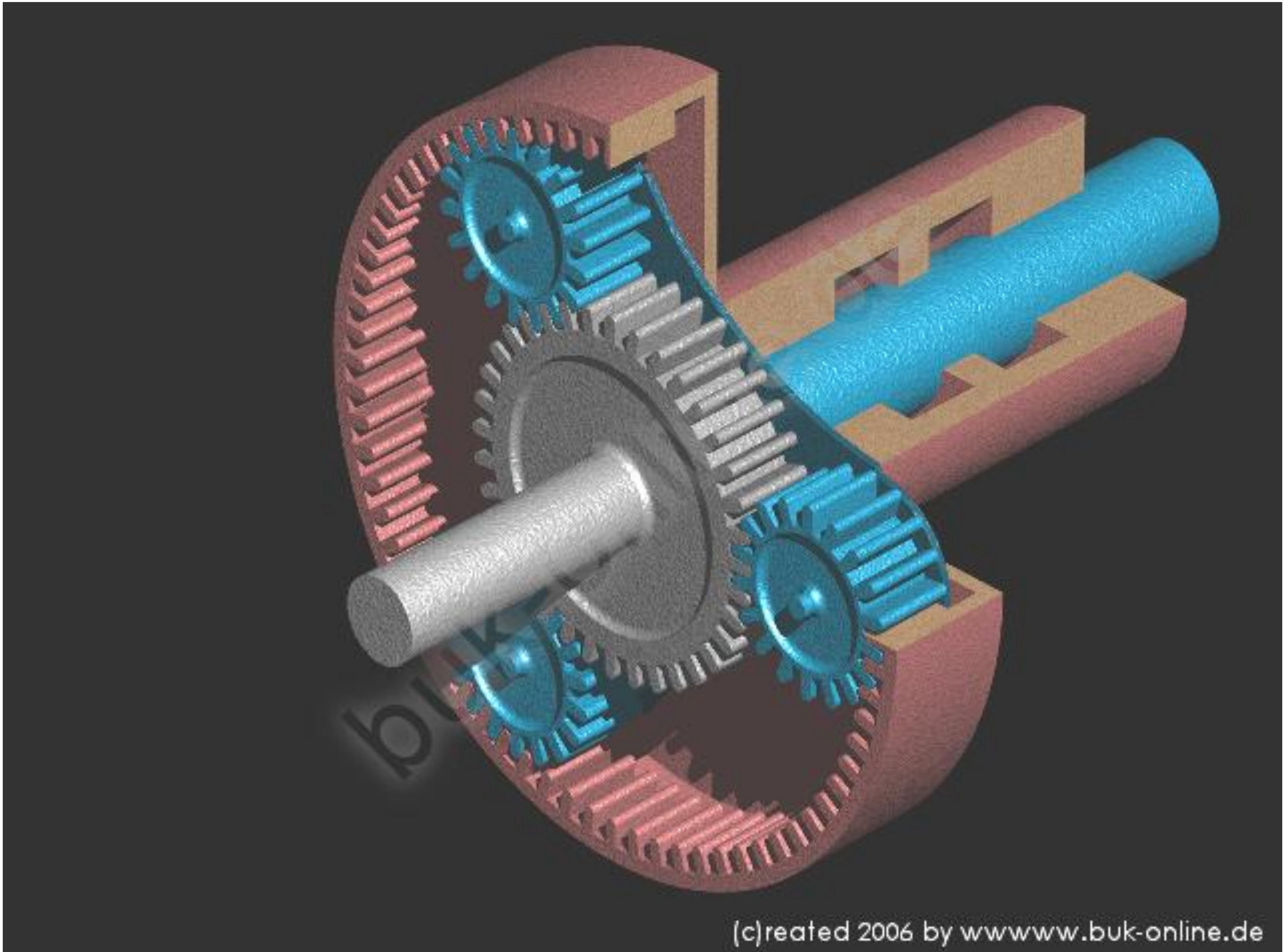
2. 1. Планетни механизми.

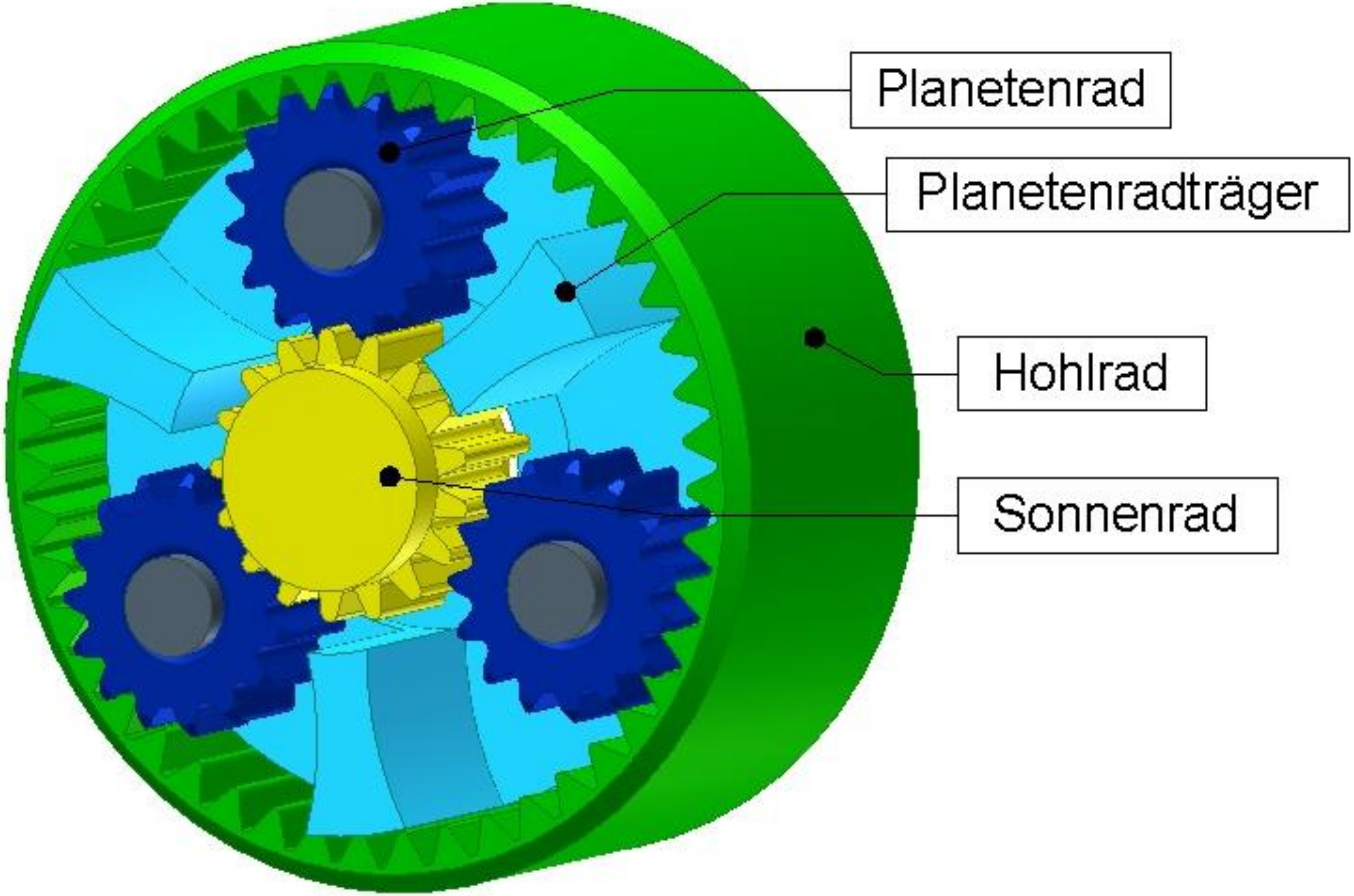


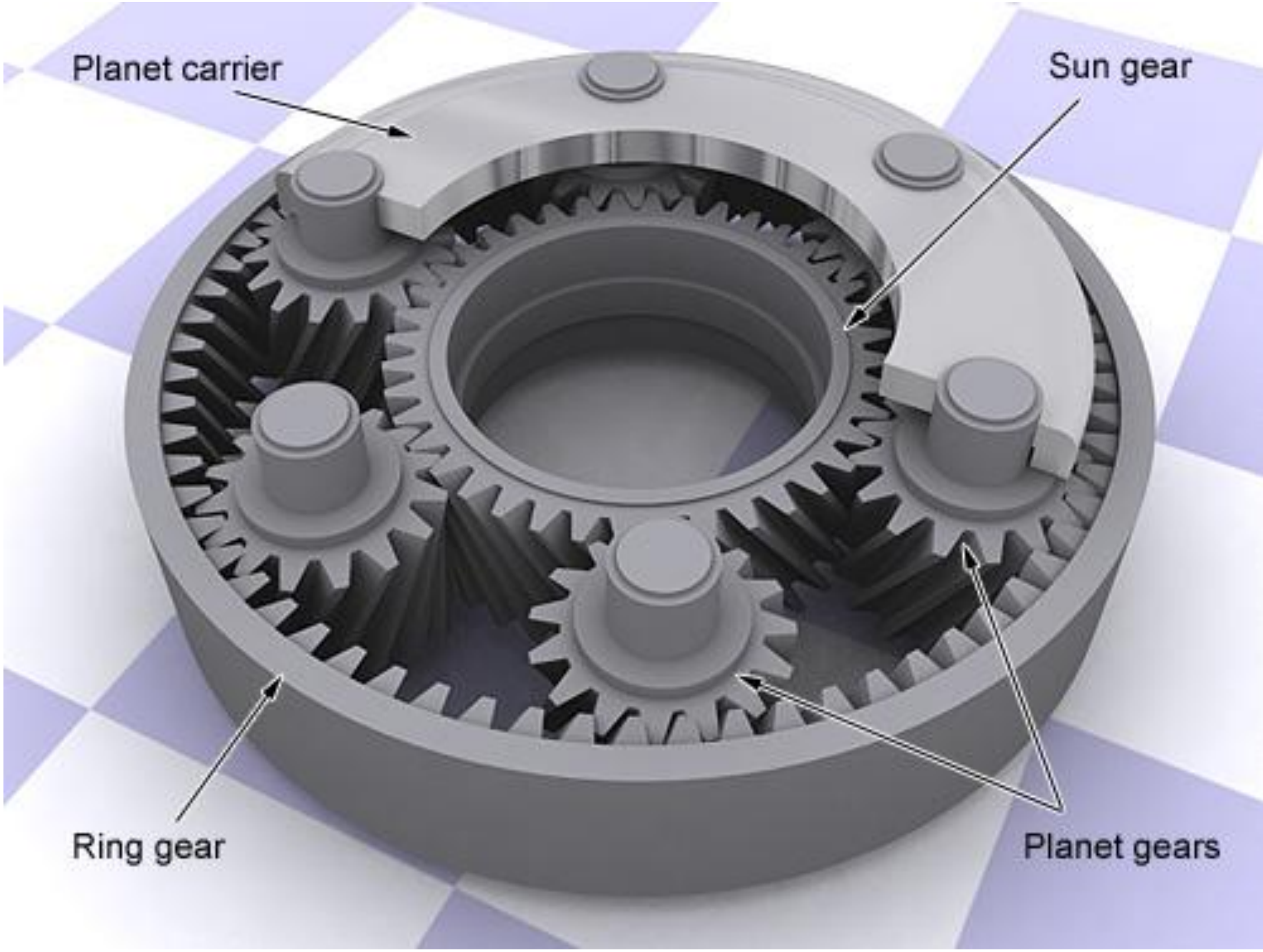
а б в

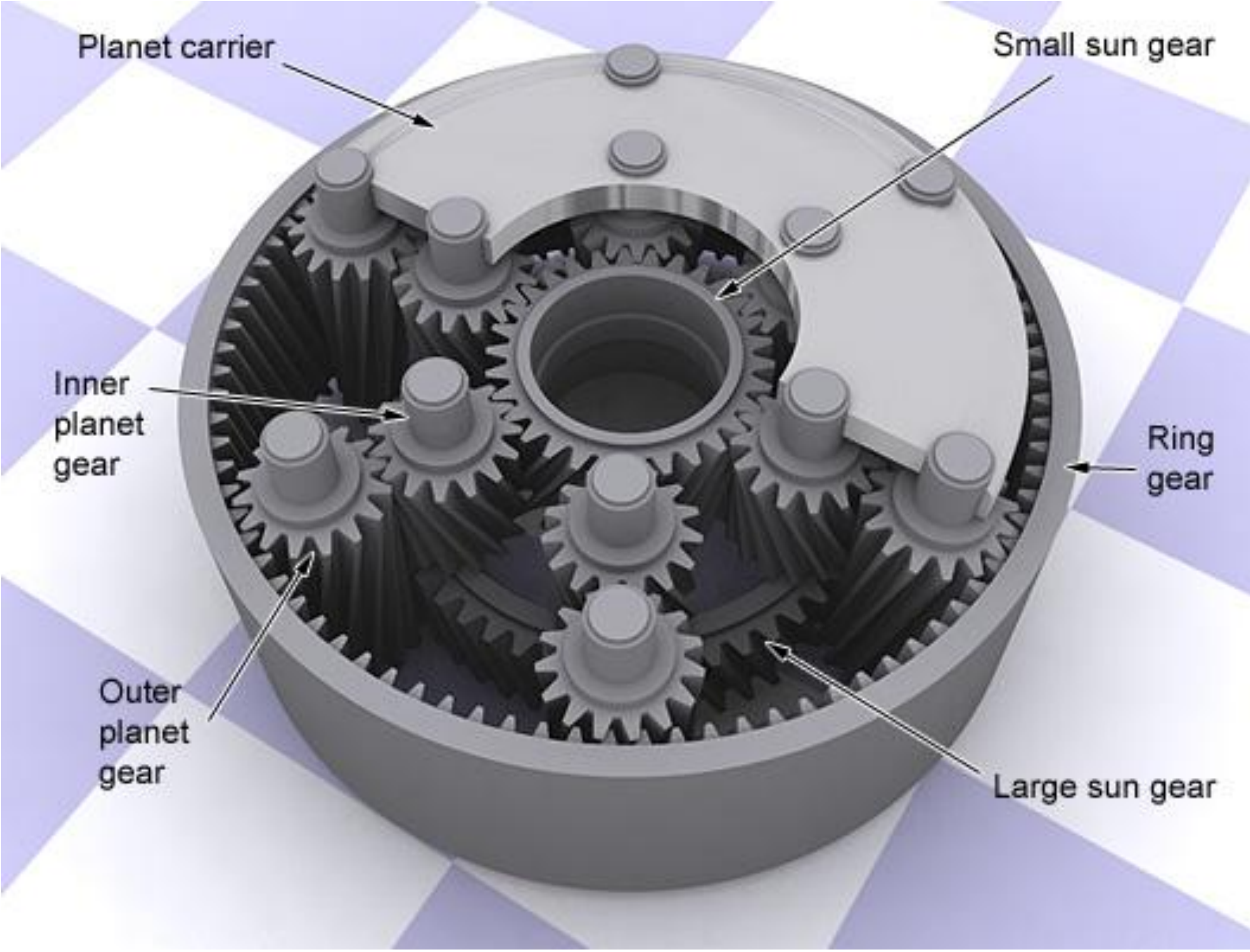
$$h = 3n - 2p_5 - p_4 = 3.4 - 2.4 - 2 = 2.$$

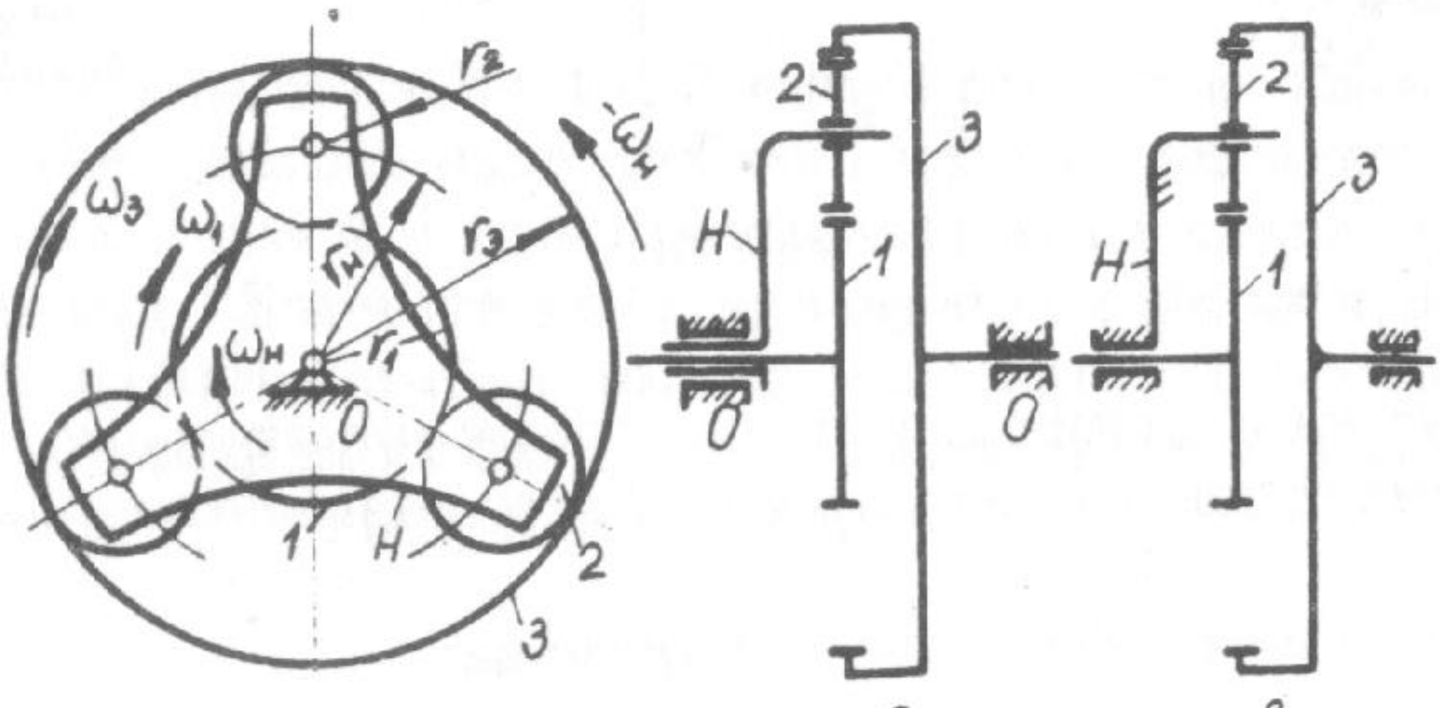

ELECTRIC MOTOR/
GENERATOR 1 (MG1)
ELECTRIC MOTOR/
GENERATOR 2 (MG2)
PETROL ENGINE
SUN GEAR
(GENERATOR)
REDUCTION GEAR UNIT
CONNECTED TO
THE FINAL DRIVE
PLANETARY
CARRIER
(ENGINE)
PINION GEAR
RING GEAR
(MOTOR/OUTPUT AXLE)
POWER SPLIT DEVICE
(PLANETARY GEAR)


(c)reated 2006 by wwwww.buk-online.de


Planetenrad
Planetenradträger
Hohlrad
Sonnenrad


Planet carrier
Sun gear
Ring gear
Planet gears


Planet carrier
Small sun gear
Inner planet gear
Ring gear
Outer planet gear
Large sun gear



а б в

$$h = 3n - 2p_5 - p_4 = 3.4 - 2.4 - 2 = 2.$$

Звена	Ъглови скорости на звената	
	Спрямо стойката от диференциалния механизъм (абсолютни)	Спрямо спряното водило H от преобразувания механизъм (след задаване на $-\omega_H$)
0 – стойка	$\omega_0 = 0$	$\omega_0^H = 0 - \omega_H$
1	ω_1	$\omega_1^H = \omega_1 - \omega_H$
2	ω_2	$\omega_2^H = \omega_2 - \omega_H$
3	ω_3	$\omega_3^H = \omega_3 - \omega_H$
H	ω_H	$\omega_H^H = \omega_H - \omega_H = 0$

$$i_{13}^{H} = \frac{\omega_1^H}{\omega_3^H} = \frac{\omega_1 - \omega_H}{\omega_3 - \omega_H} = \frac{n_1 - n_H}{n_3 - n_H},$$

$$i_{12}^{H} = \frac{\omega_1^H}{\omega_2^H} = \frac{\omega_1 - \omega_H}{\omega_2 - \omega_H} = \frac{n_1 - n_H}{n_2 - n_H},$$

$$i_{23}^{H} = \frac{\omega_2^H}{\omega_3^H} = \frac{\omega_2 - \omega_H}{\omega_3 - \omega_H} = \frac{n_2 - n_H}{n_3 - n_H}.$$

$$i_{12}^{H} = -\frac{z_2}{z_1} = -\frac{d_2}{d_1};\ i_{23}^{H} = \frac{z_3}{z_2} = \frac{d_3}{d_2};\ i_{13}^{H} = i_{12}^{H} \cdot i_{23}^{H} = -\frac{z_3}{z_1} = -\frac{d_3}{d_1}.$$

$$i_{13}^{H} = \frac{\omega_1 - \omega_H}{-\omega_H} = 1 - \frac{\omega_1}{\omega_H} = 1 - i_{1H}^{(3)}.$$

$$\frac{\omega_1}{\omega_H} = i^{(3)}_{1H} = 1 - i^{H}_{13}, \quad \text{където} \quad i^{H}_{13} = -\frac{z_3}{z_1} = -\frac{d_3}{d_1}.$$

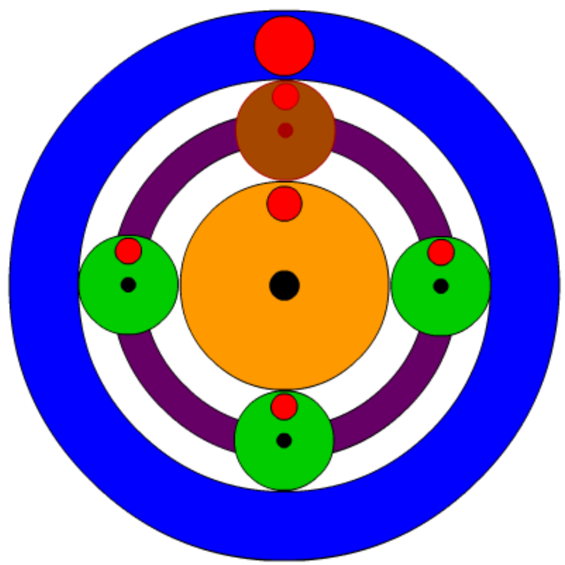
$$i^{H}_{13} = \frac{-\omega_H}{\omega_3 - \omega_H} = \frac{1}{1 - \frac{\omega_3}{\omega_H}} \quad \text{или} \quad \frac{1}{i^{H}_{31}} = \frac{1}{1 - i^{(1)}_{3H}}.$$

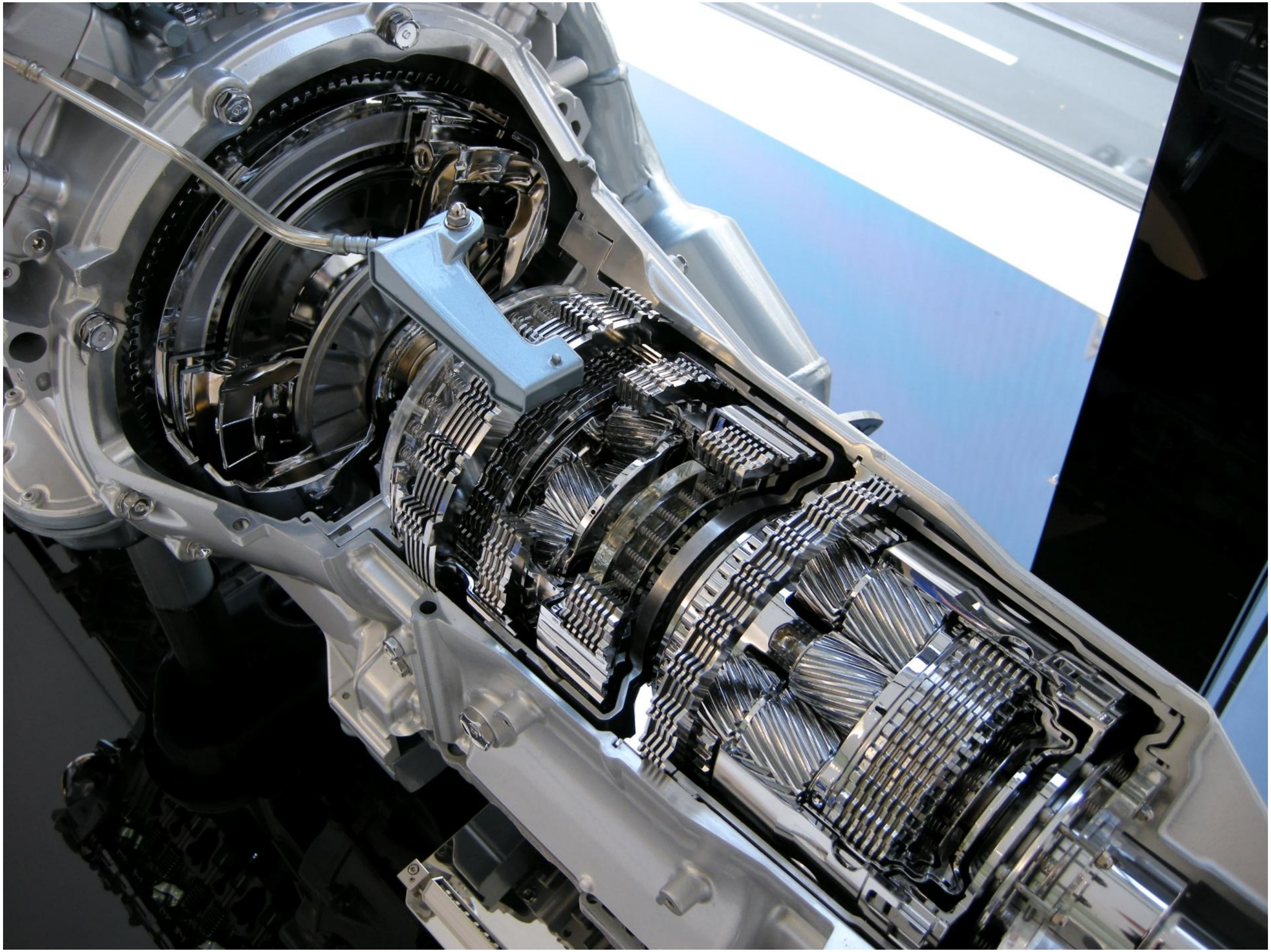
$$\frac{\omega_3}{\omega_H} = i^{(1)}_{3H} = 1 - i^{H}_{31}, \quad \text{където} \quad i^{H}_{31} = -\frac{z_1}{z_3} = -\frac{d_1}{d_3}.$$

$$i^{(m)}_{kH} = 1 - i^{H}_{km}.$$

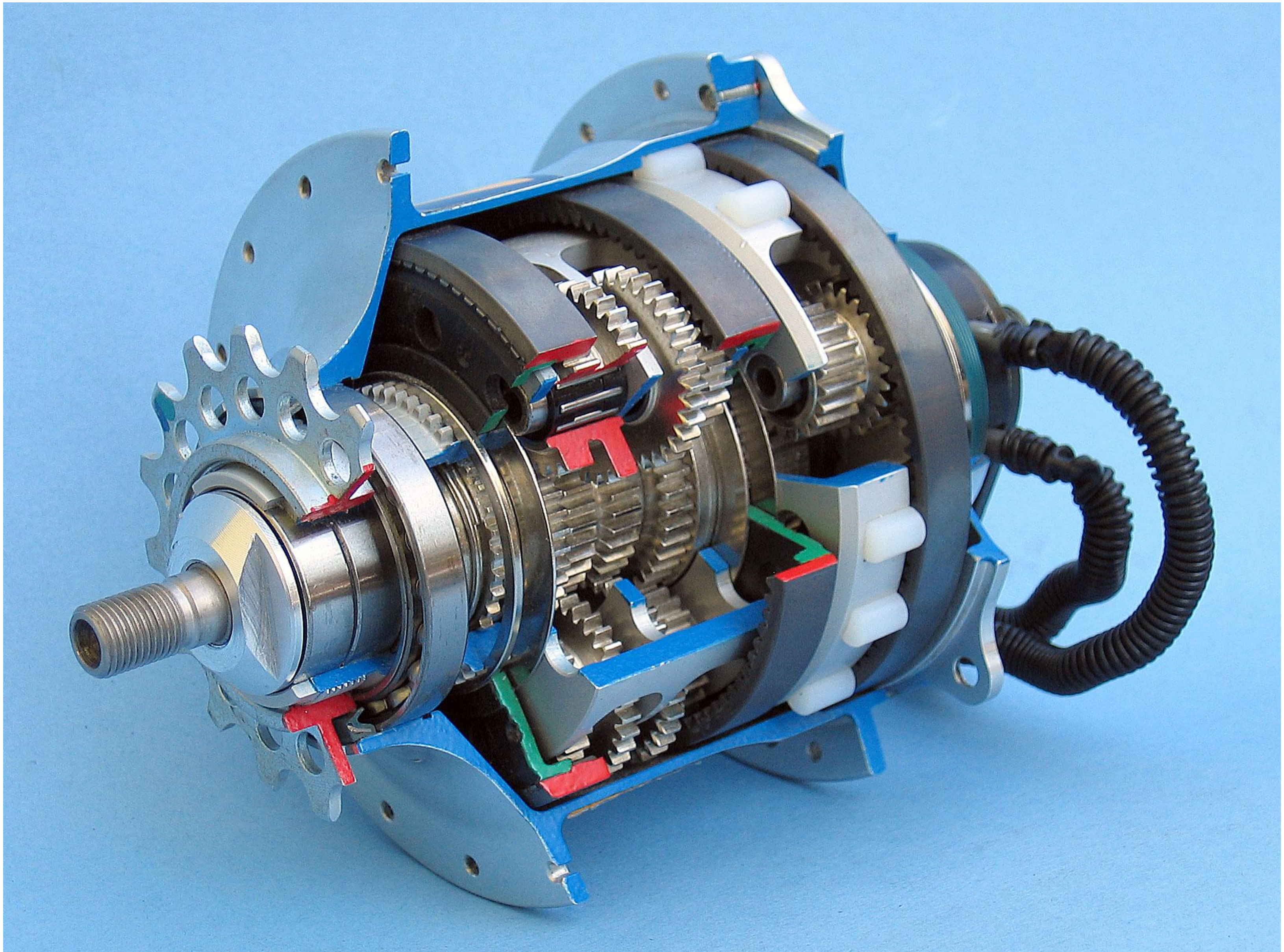
	Input	Output	Stationary	Calculation	Gear Ratio
A	Sun (S)	Planet Carrier (C)	Ring (R)	1 + R/S	3.4:1
B	Planet Carrier (C)	Ring (R)	Sun (S)	1 / (1 + S/R)	0.71:1
C	Sun (S)	Ring (R)	Planet Carrier (C)	-R/S	-2.4:1

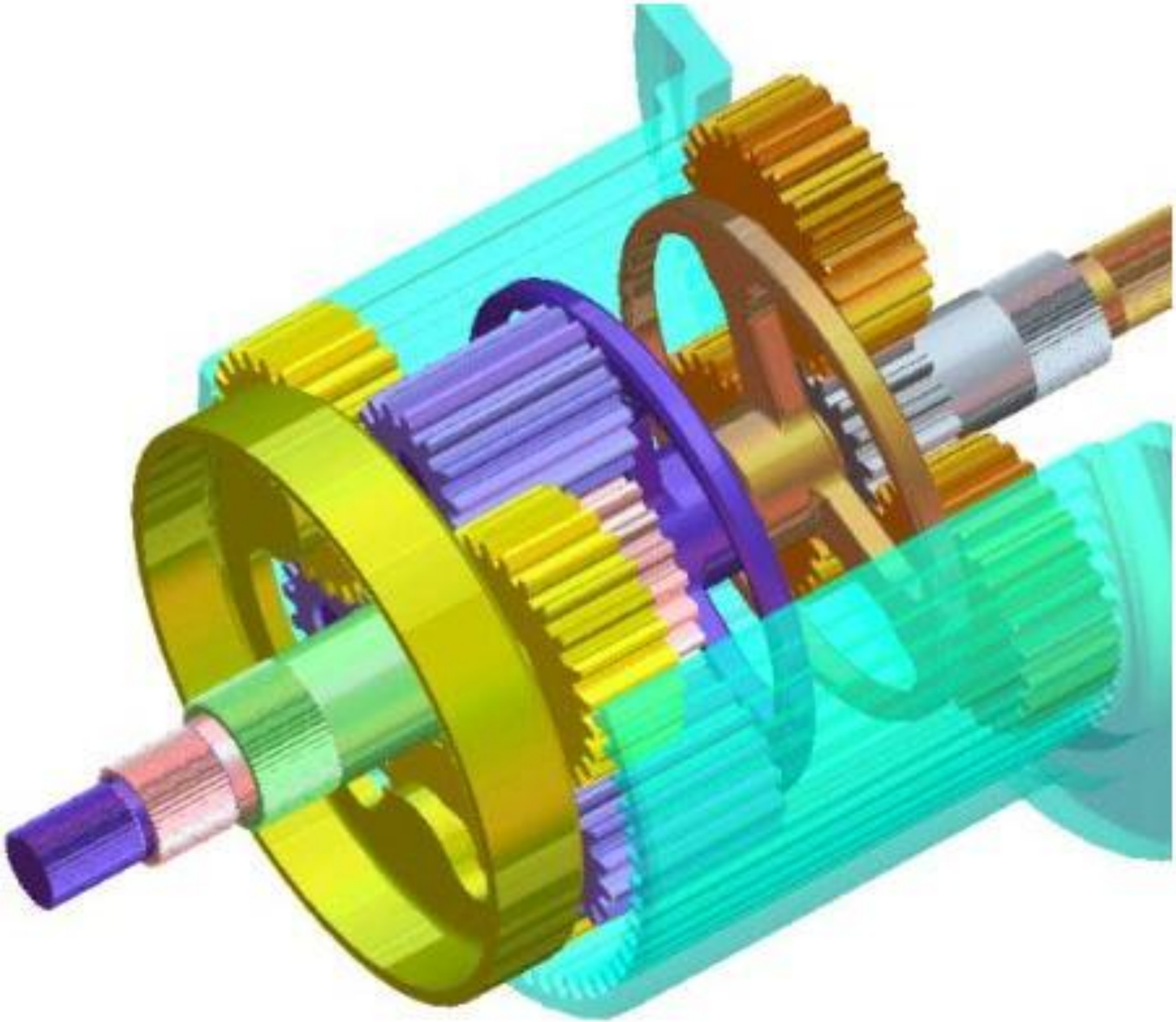
Input	Output	Stationary	Gear Ratio
Sun (S)	Planet Carrier (C)	Ring (R)	3.4:1
Planet Carrier (C)	Ring (R)	Sun (S)	0.71:1
Sun (S)	Ring (R)	Planet Carrier (C)	-2.4:1

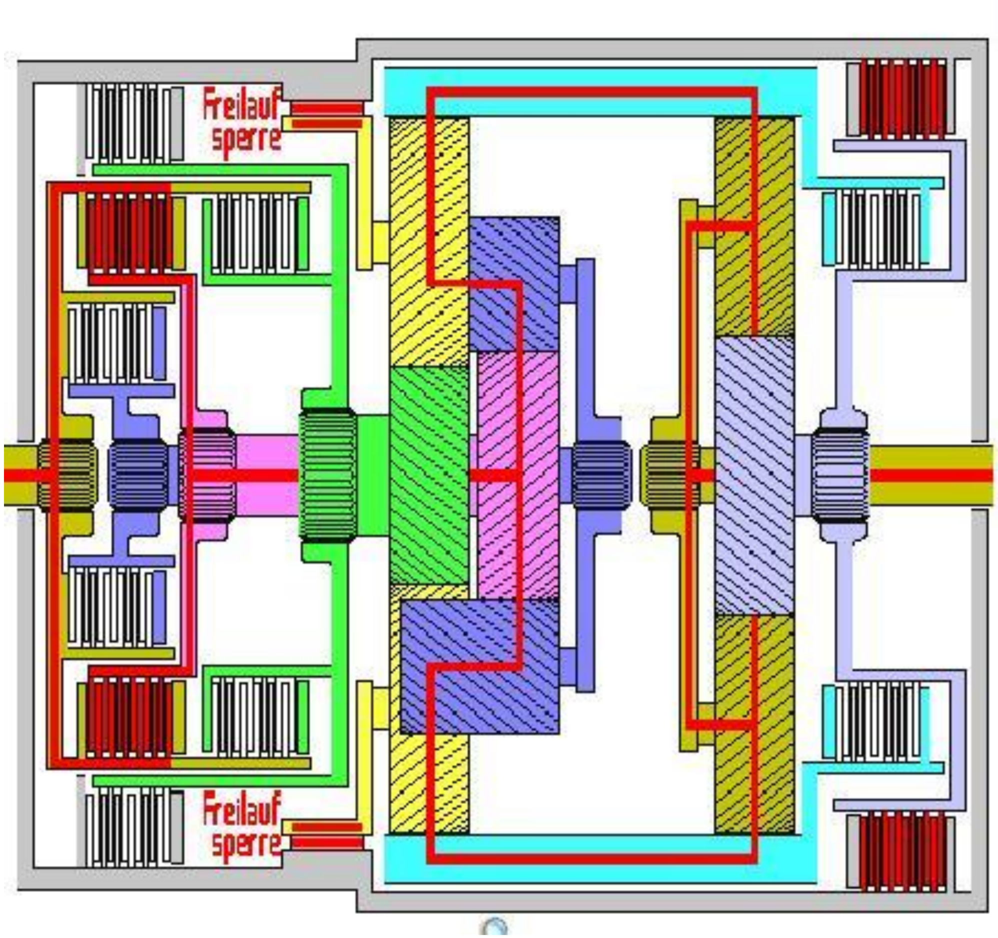





SHIMANO
DEORE XT

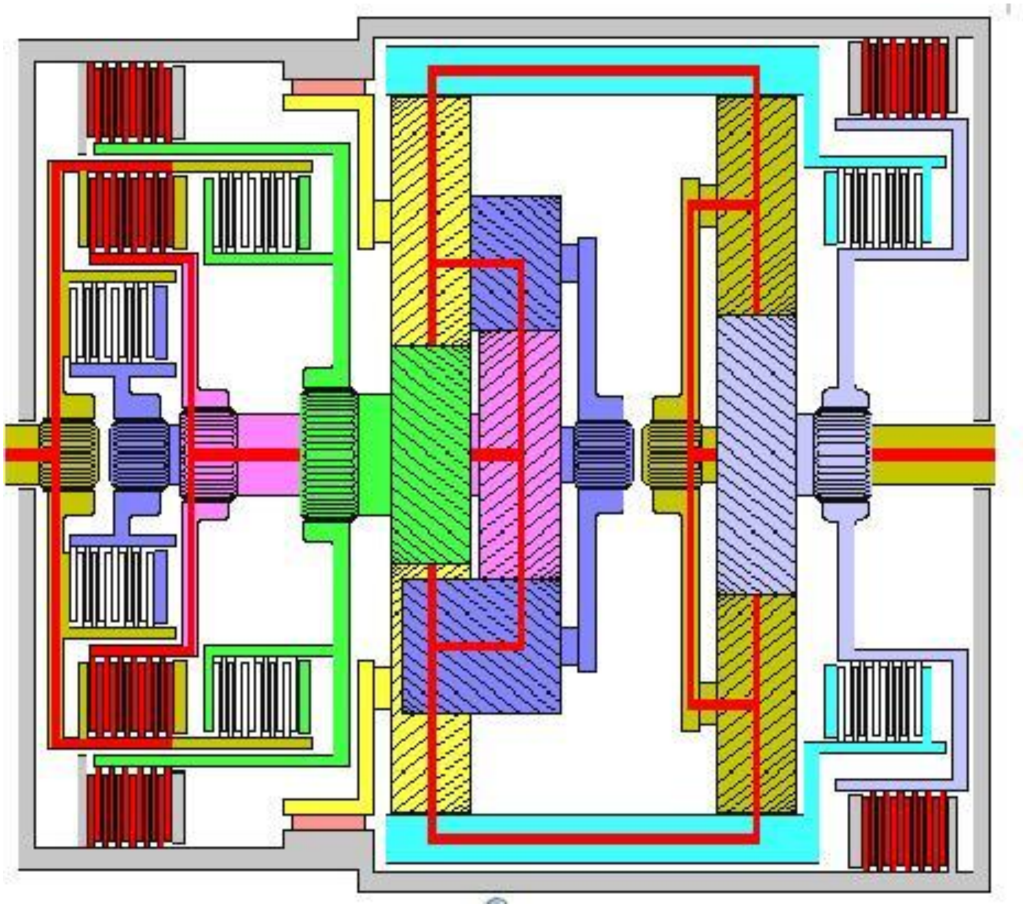






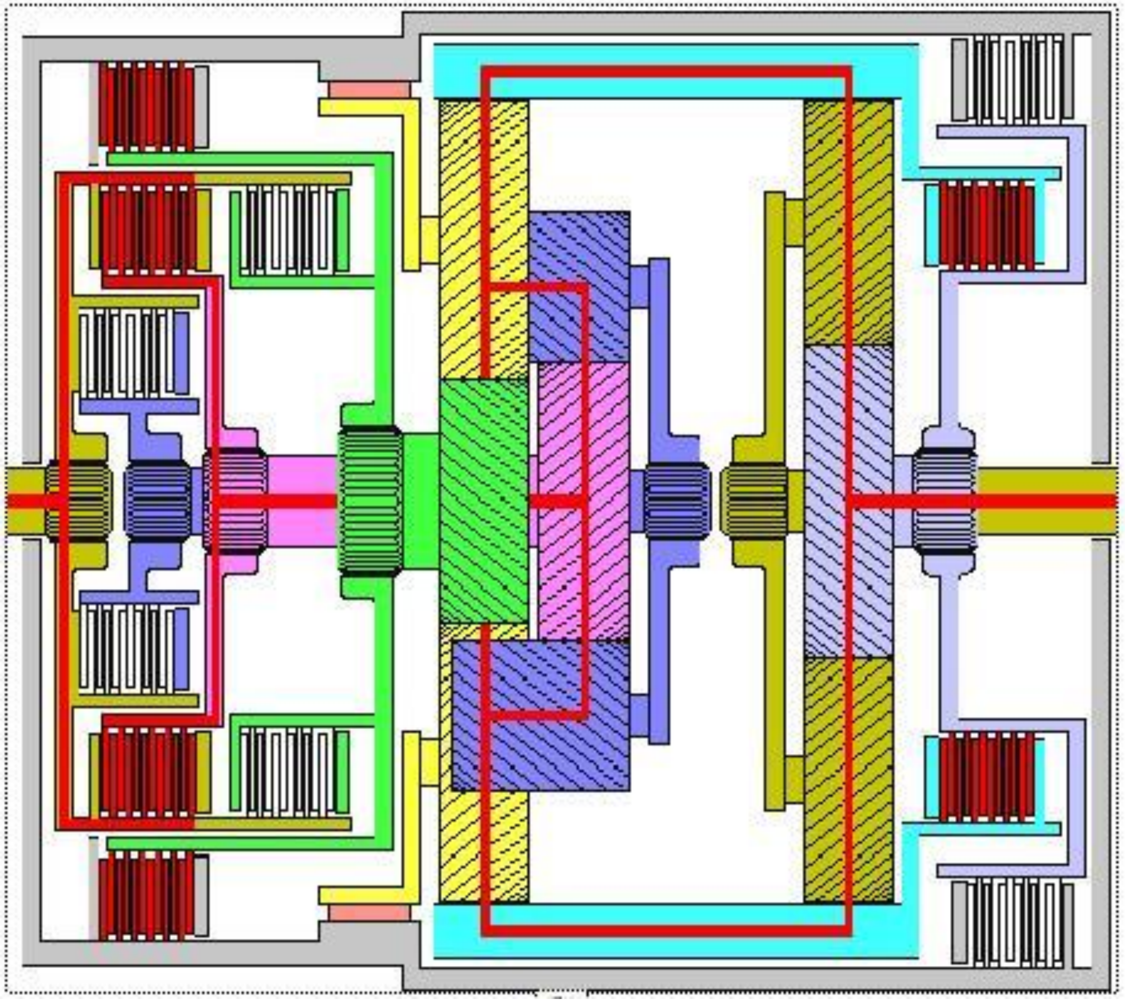
1.

the torque is transferred from the **input shaft** through a corresponding multiple-disc clutch to the smaller **hollow shaft** and the bigger **sun wheel**. Because the accompanying **planet wheel carrier** is locked by the freewheel against run-back, the torque is then transferred through the other **planet wheels** to the **hollow-wheel-ring**. Because the **sun wheel** of the rear planet set is also locked by a suitable rib brake, the **planet wheels** roll on the sun wheel. Thus the way through the **planet wheel carrier** to the output shaft is free.



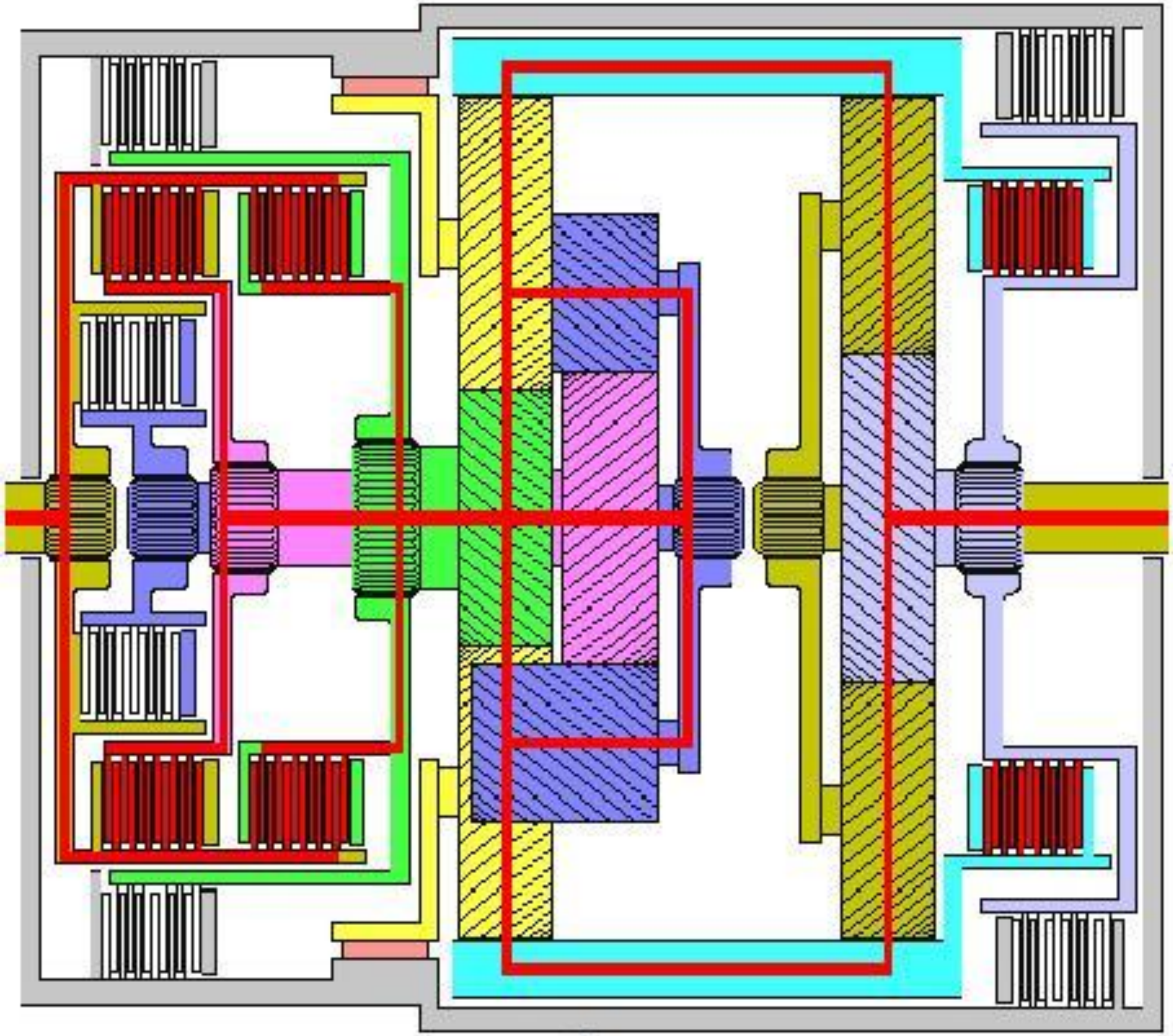
2

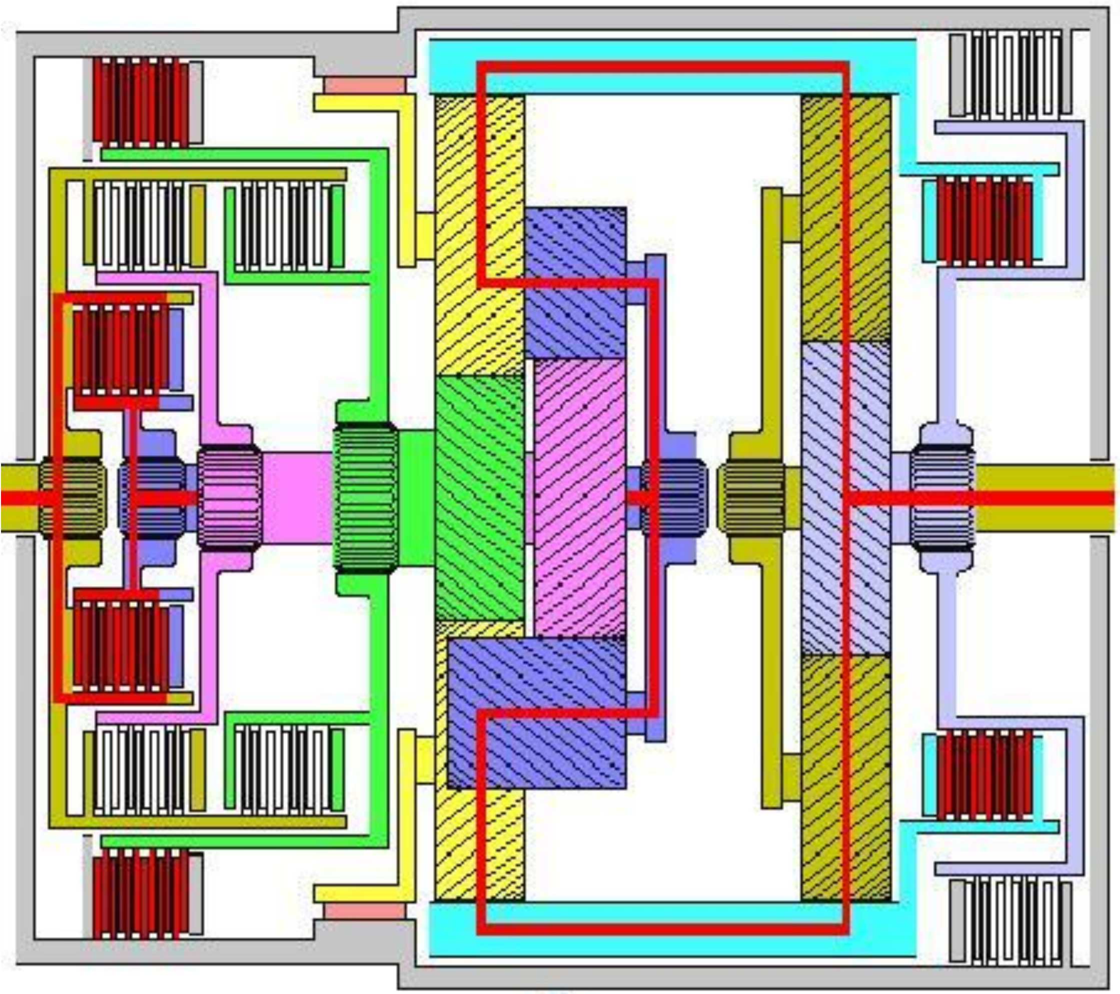
The larger **hollow shaft**, together with the smaller front **sun wheel** is now fixed by the left rib brake. The **planet wheel carrier** is thereby moved in the direction not locked by the freewheel. The smaller **planet wheels** mesh with the larger **planet wheels** and these with the **sun wheel**. They provide for a higher gear ratio. The rest remains as in the first gear.



3

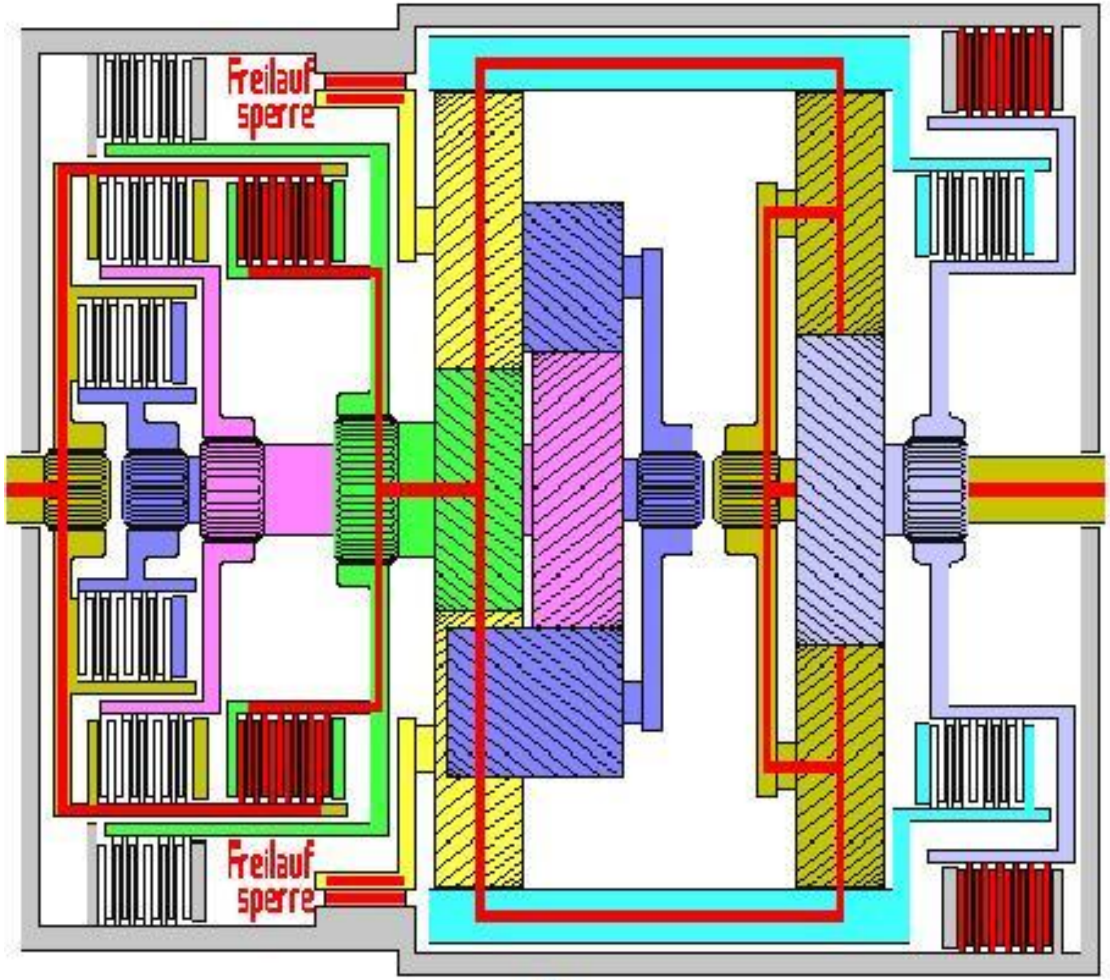
The rear planet set now is locked by the opening of the right rib brake and the simultaneous closing of the right multiple-disc clutch and runs as a unit without gear reduction. The front part stays the same as in the second gear.





5

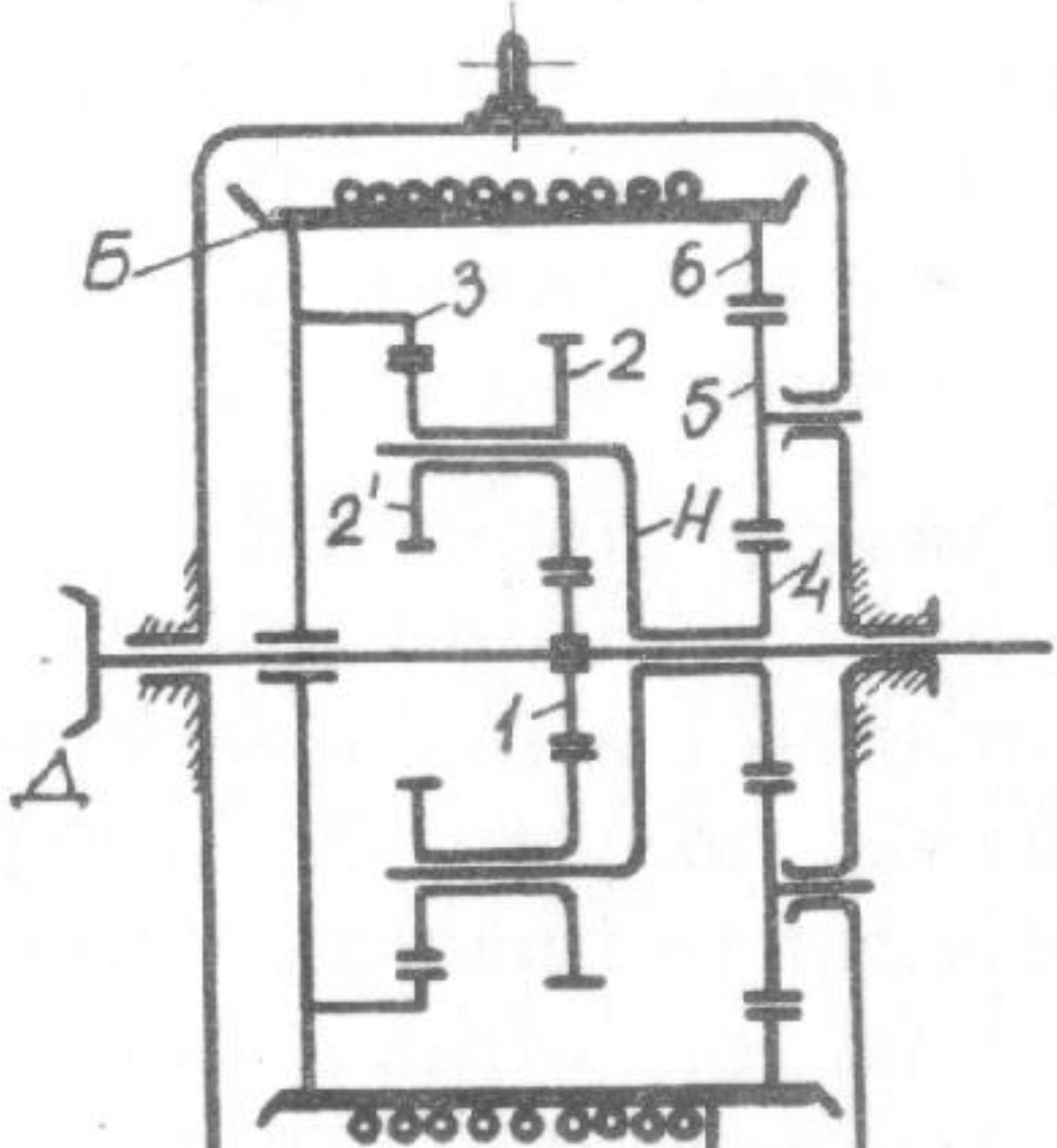
To reach a reduction of the gear ratio lower than 1, the left **sun wheel** is held by the left rib brake. At the same time the torque of the **input shaft** is transferred by the corresponding multiple-disc clutch to the innermost shaft. This re-appears in the rear, in the **planet wheel carrier**. The rear **planet wheels** mesh with the front **planet wheels**. These mesh themselves with the now static **sun wheel** and drive the **hollow-wheel-ring** at the, up to now, highest RPMs in comparison to the engine speed. In the rear everything remains as in the 4th gear.



Reverse gear

The freewheel lock is used for the second time after its deployment in the 1st gear. The **input shaft** connects with the larger **hollow shaft** and with it to the small front **sun wheel**. The **planet wheels** provide for a reversal of the rotary direction. The rest remains as in the first gear.

2. 2. Диференциални механизми.



Б
3
2
6
5
2'
Н
4
1
Д

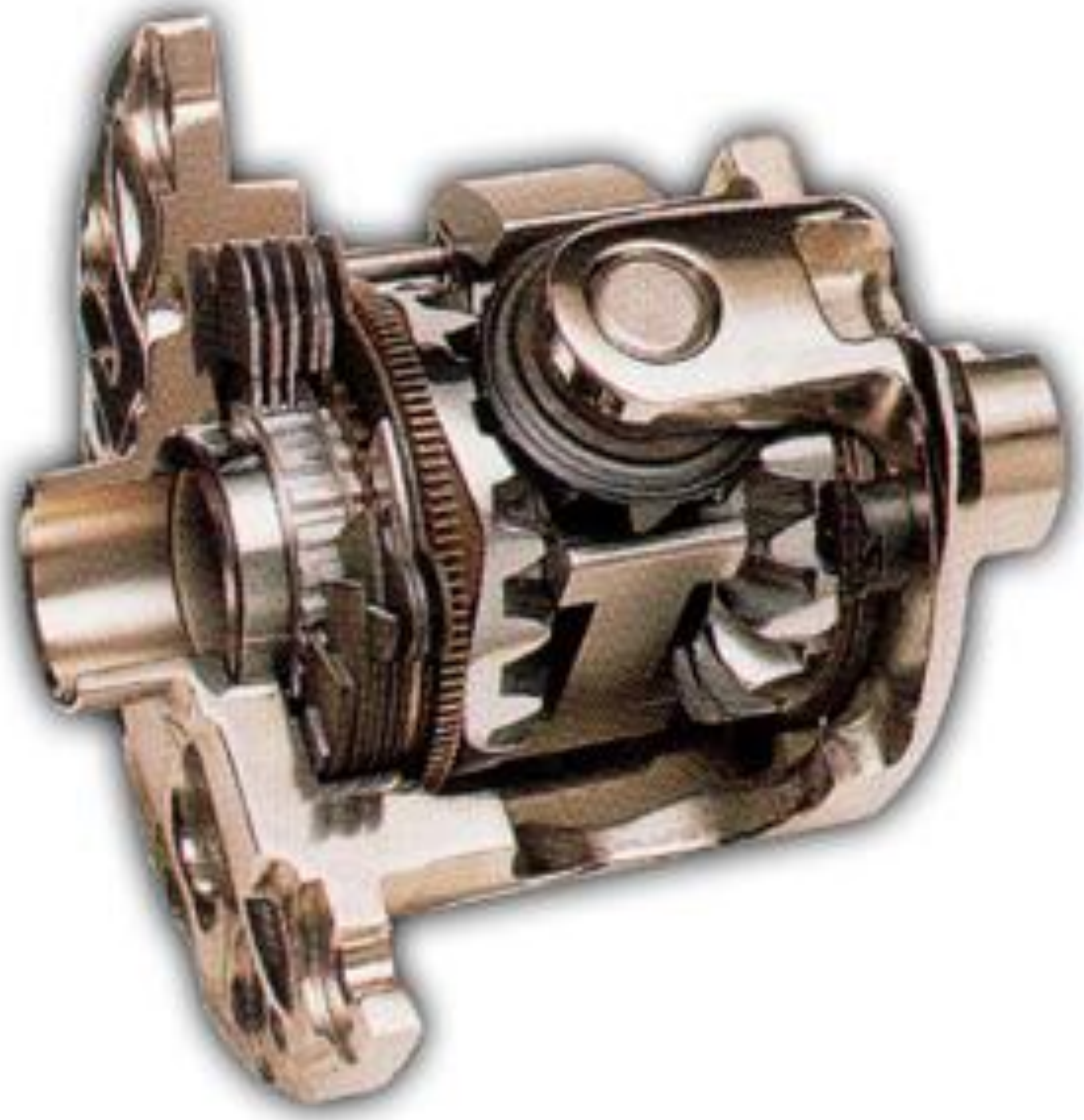
$$i_{13}^{H} = \frac{\omega_1 - \omega_H}{\omega_3 - \omega_H}, \quad \text{където } i_{13}^{H} = i_{12}^{H} i_{2'3}^{H} = -\frac{z_2}{z_1}\frac{z_3}{z_{2'}}.$$

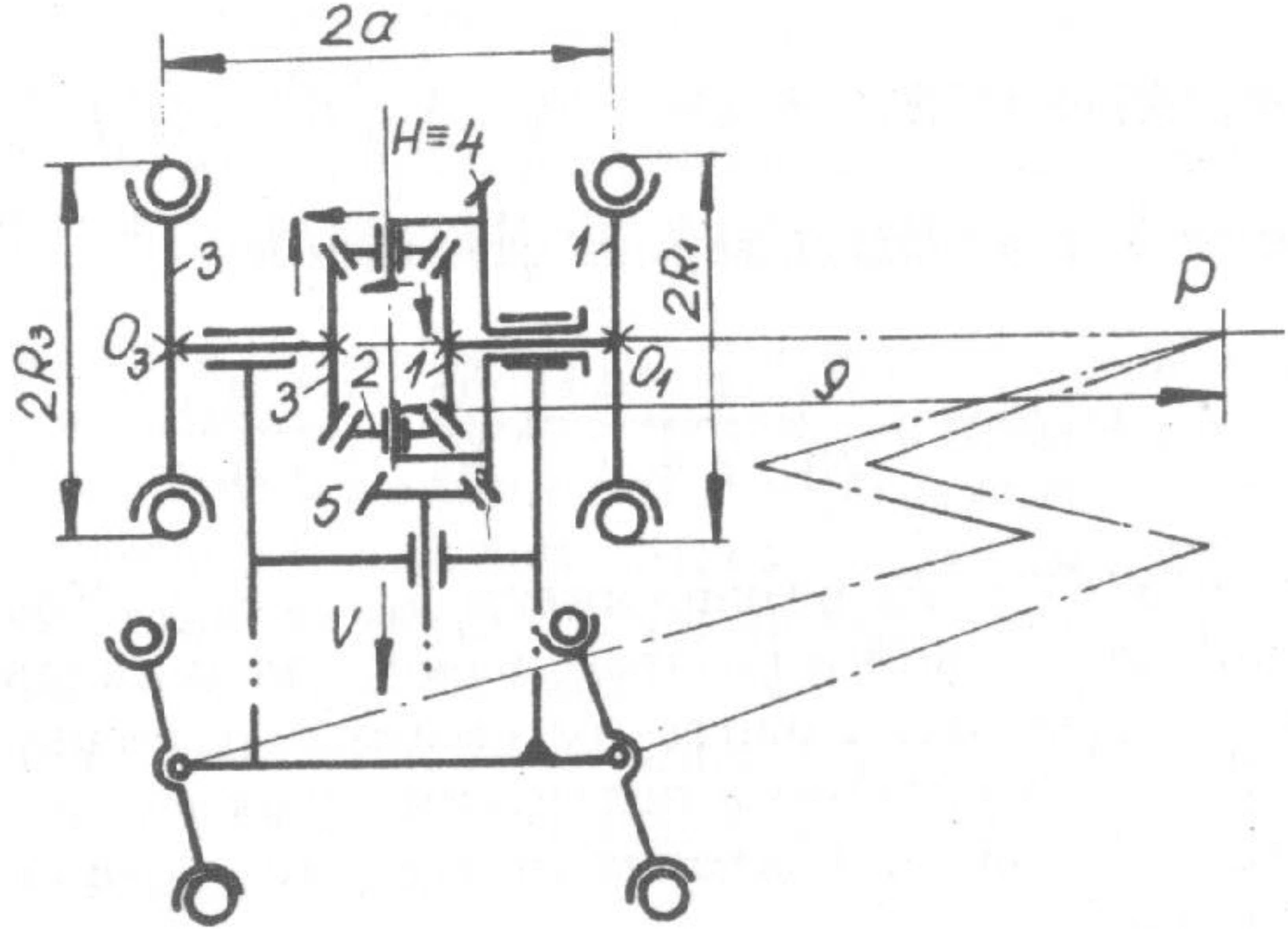
$$i_{H3} = \frac{\omega_H}{\omega_3} = \frac{\omega_4}{\omega_6}, \quad \text{където } i_{H3} = i_{45} \cdot i_{56} = -\frac{z_6}{z_4}$$

$$i_{13}^{H} = \frac{\omega_1/\omega_3 - \omega_H/\omega_3}{1 - \omega_H/\omega_3} = \frac{i_{13} - i_{H3}}{1 - i_{H3}}.$$

$$i_{13} = \frac{\omega_1}{\omega_3} = \frac{\omega_Д}{\omega_Б} = -\frac{z_6}{z_4} - \frac{z_3 z_3}{z_1 z_{2'}}\left(1 + \frac{z_6}{z_4}\right).$$

$$\frac{\omega_1}{\omega_3} = i_{13} = i_{H3} + i_{13}^{H}(1 - i_{H3}).$$





2a
H≡4
3
1
2R₁
P
2R₃
O₃
2
1
O₁
3
ρ
5
V

Diferential.swf

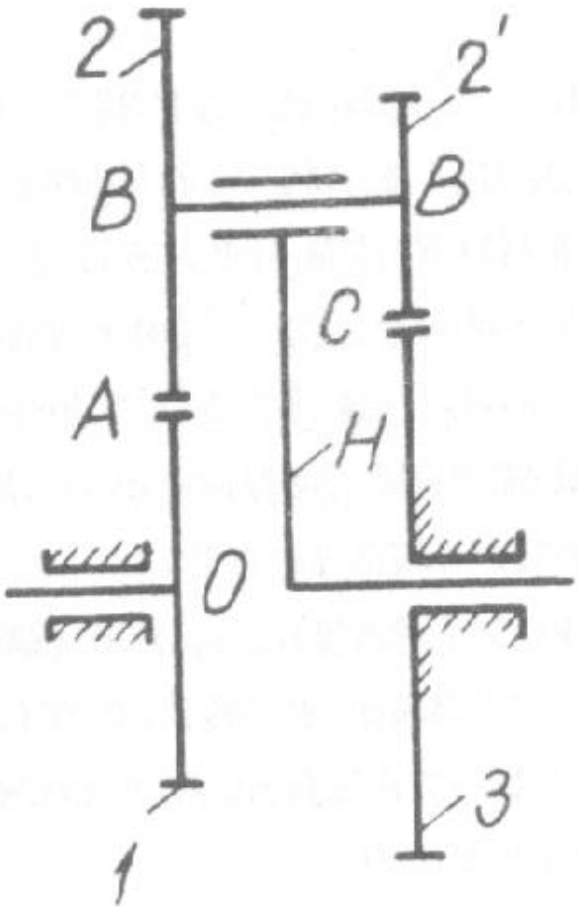
$$i_{13}^{\cdot H} = \frac{\omega_1 - \omega_4}{\omega_3 - \omega_4}, \quad \text{където } i_{13}^{\cdot H} = i_{12}^{\cdot H}.i_{23}^{\cdot H} = -\frac{z_3}{z_1}.$$

$$\omega_4 = \frac{\omega_1 + \omega_3}{2}.$$

$$\omega_1 = V_1/R_1 = \Omega/R_1(\varrho - a); \quad \omega_3 = V_3/R_3 = \Omega/R_3(\varrho + a).$$

$$\omega_1/\omega_3 = \frac{R_3}{R_1} \; \frac{\varrho - a}{\varrho + a} = \frac{R_3}{R_1} \; \frac{1 - a/\varrho}{1 + a/\varrho}.$$

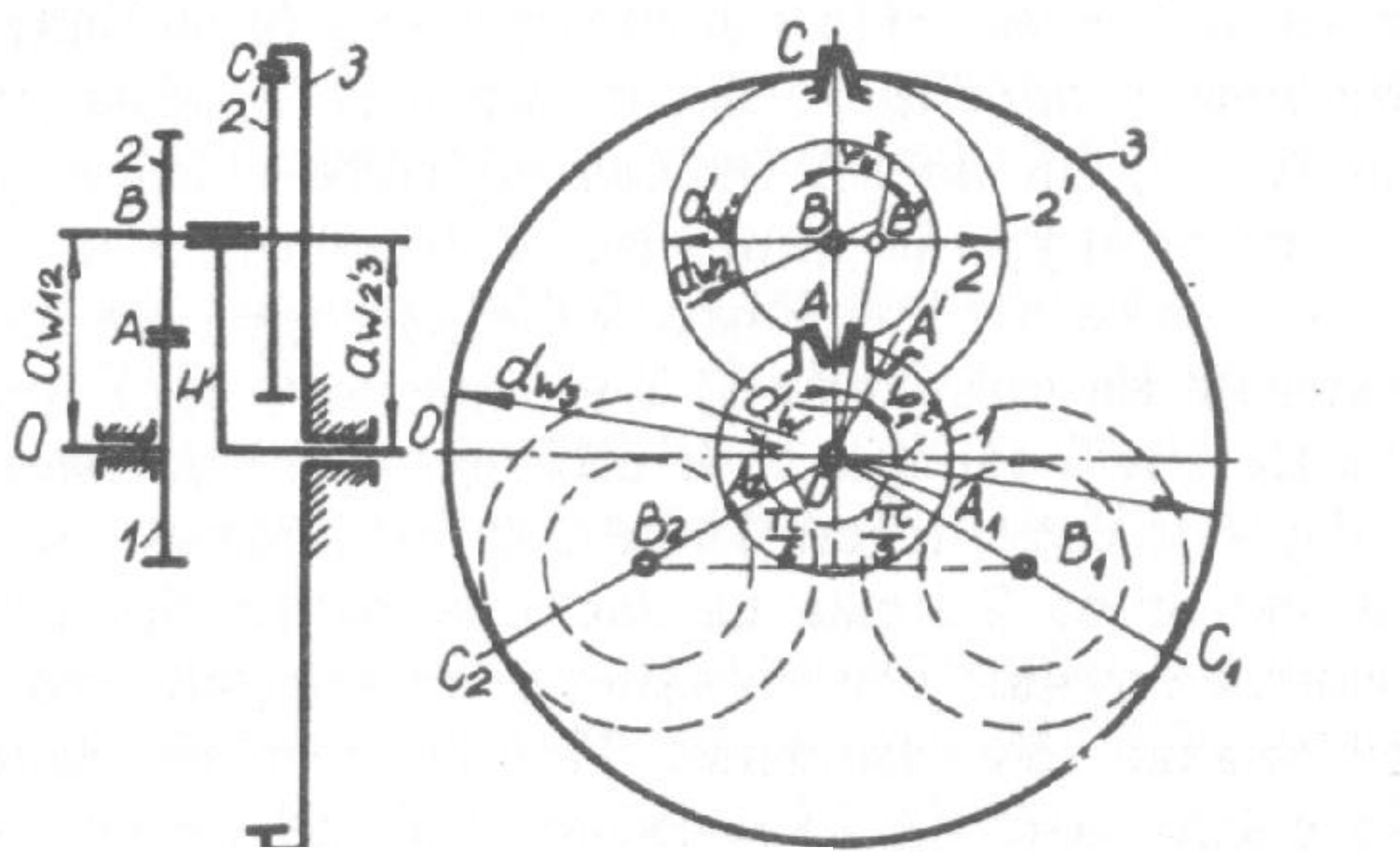
2. 3. Синтез на епициклични механизми.(Условия)



$$i_{1H} = 1 - i_{13}^{H};$$

$$i_{13}^{H} = i_{12}^{H} \cdot i_{2'3}^{H} = \left(-\frac{z_2}{z_1}\right)\left(-\frac{z_3}{z_{2'}}\right).$$

$$i_{1H} = 1 - \frac{z_2 z_3}{z_1 z_2'} = 1 - \frac{99.101}{100.100} = \frac{1}{10\ 000}.$$



$$\frac{1}{2}(d_{w_1} + d_{w_2}) = \frac{1}{2}(d_{w_3} - d_{w_{2'}}).\qquad z_1 + z_2 = z_3 + z_{2'}.$$

$$z_1 + z_2 = z_3 - z_{2'}.\qquad z_1 + 2z_2 = z_3$$

$$\varphi_1^{\tau} = \frac{2\pi}{z_1}. \qquad \varphi_H^{\tau} = \varphi_1^{\tau} / i_{1H}^{(3)}$$

$$\varphi_H = k_1 \varphi_H^{\tau} = k_1 \frac{2\pi}{z_1} \cdot \frac{1}{i_{1H}^{(3)}} = \frac{2\pi}{s} + \nu_1 2\pi,$$

$$\frac{z_1 (1 - i_{13}^{H})}{s} (1 + s\nu_1) = k_1.$$

$$\frac{z_1 z_{2'} + z_2 z_3}{s z_{2'}}(1 + s\nu_1) = k_1;$$

$$\frac{z_1 + z_3}{s}(1 + s\nu_1) = k_1;$$

$$\frac{z_1 z_{2'} - z_2 z_3}{s z_{2'}}(1 + s\nu_1) = k_1,$$

$$\frac{z_1 z_{2'} + z_2 z_3}{sD} = k,$$

$$\frac{z_1 + z_3}{s}(1 + s\nu) = k,$$

$$\frac{z_1 z_{2'} - z_2 z_3}{sD} = k,$$

$$B_1B_2 \geq d_{a_2}, \quad (d_1 + d_2)\sin\frac{\pi}{s} \geq d_{a_2},$$

$$B_1B_2 \geq d_{a_{2'}}, \quad (d_3 - d_{2'})\sin\frac{\pi}{s} \geq d_{a_{2'}}.$$

$$(z_1 + z_2)\sin\frac{\pi}{s} \geq z_2 + 2,$$

$$(z_3 - z_{2'})\sin\frac{\pi}{s} \geq z_{2'} + 2.$$

$$i = |i_{13}^H| = \frac{z_2 z_3}{z_1 z_{2'}} \quad \text{и} \quad i = |i_{13}^H| = \frac{z_3}{z_1}.$$