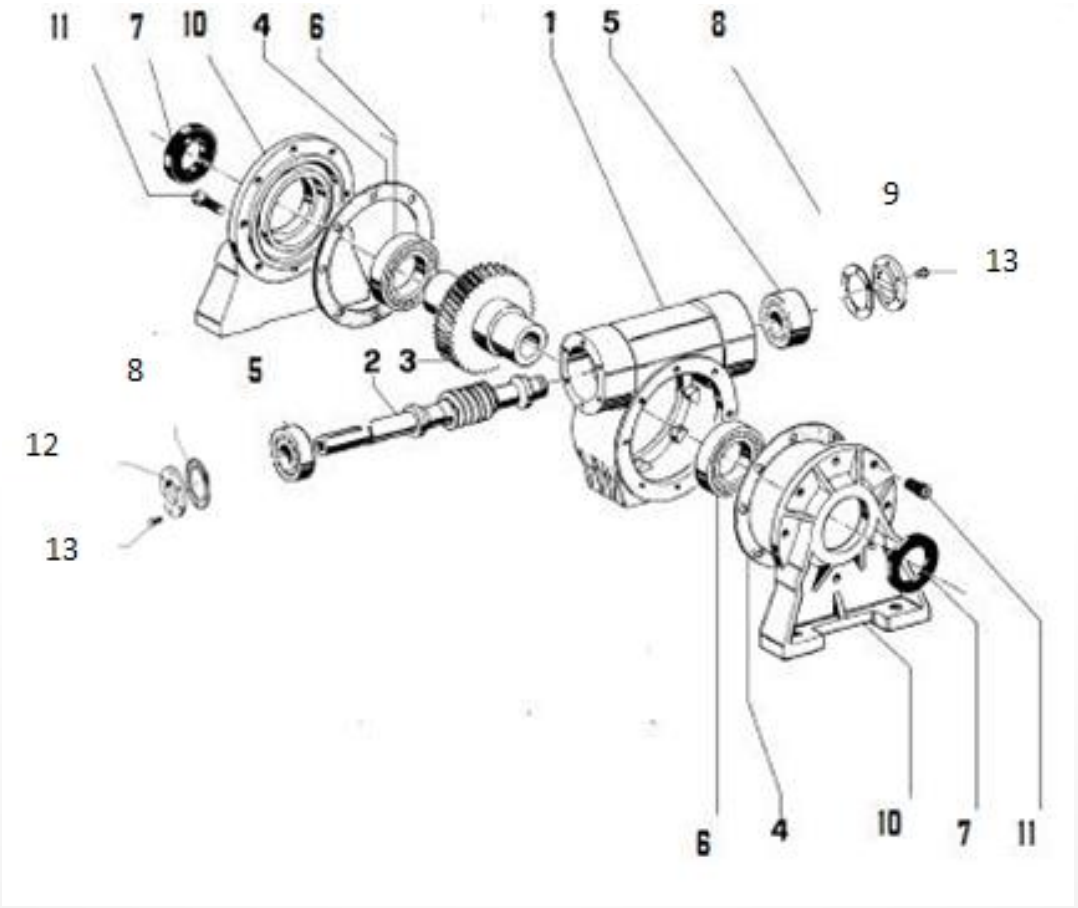
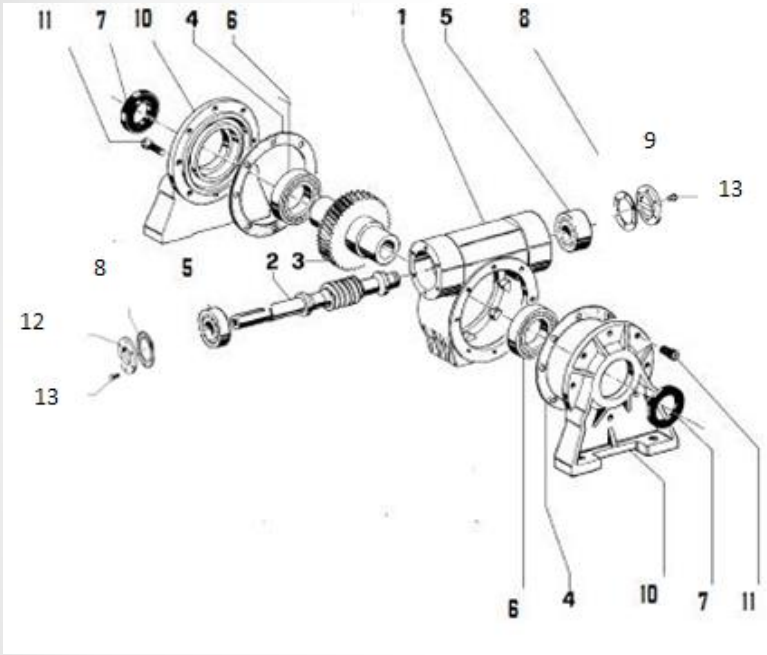
WORM GEARBOX

Tutorial

Model A

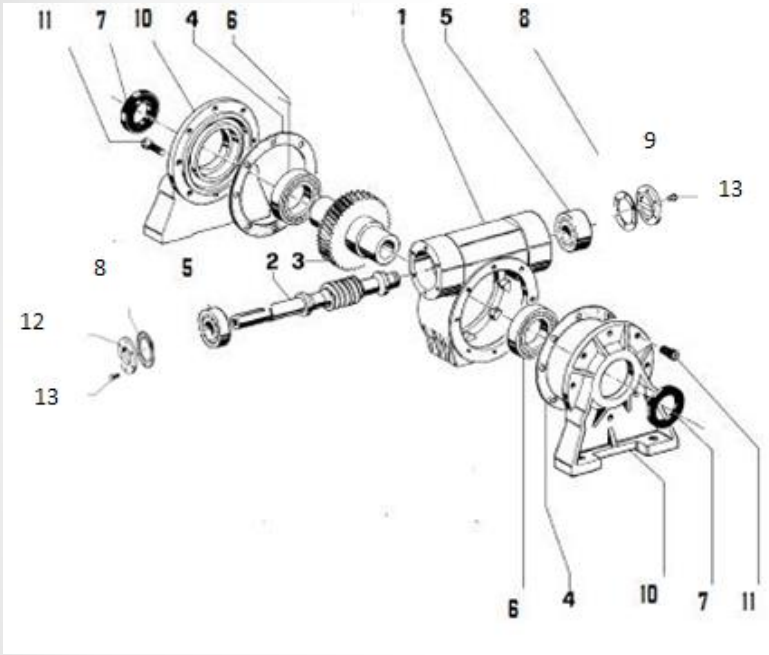


List of parts (1/3)



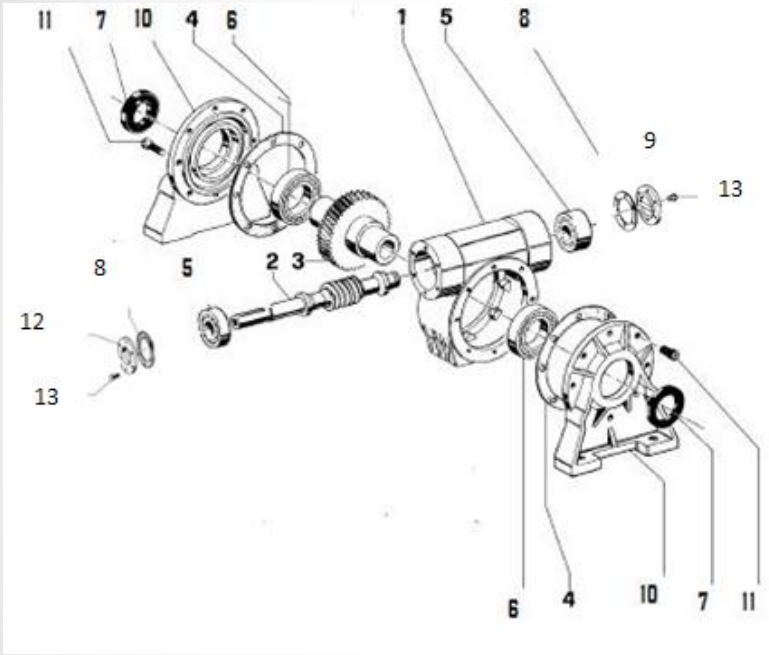
PART NUMBER	NAME	QUANTITY	PICTURE
1	Case	1	
2	Wormshaft	1	
3	Wormwheel	1	
4	Gasket	2	
5	Bearing Ø 3,2mm	2	

List of parts (2/3)



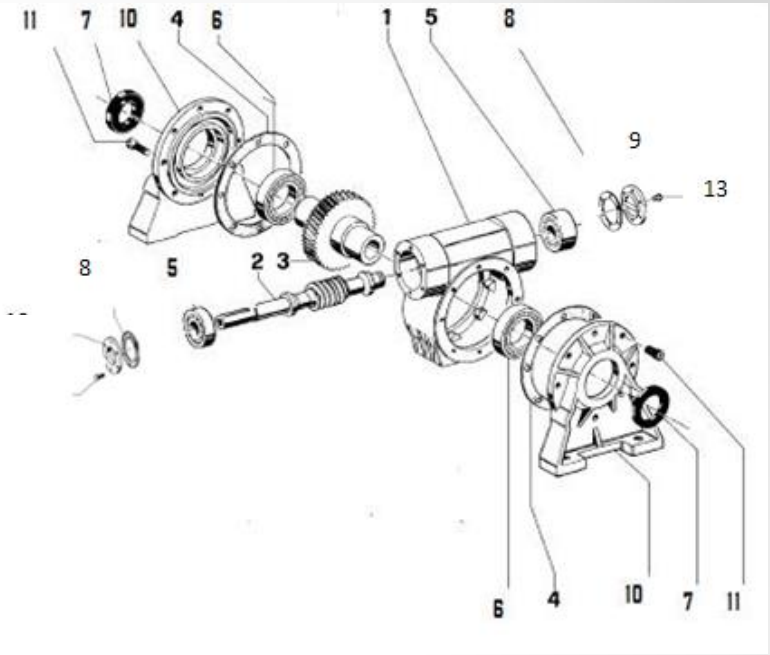
6	Bearing Ø 5,4mm	2	
7	Oilseal	2	
8	Circlip Ø e	2	
9	Cap	1	

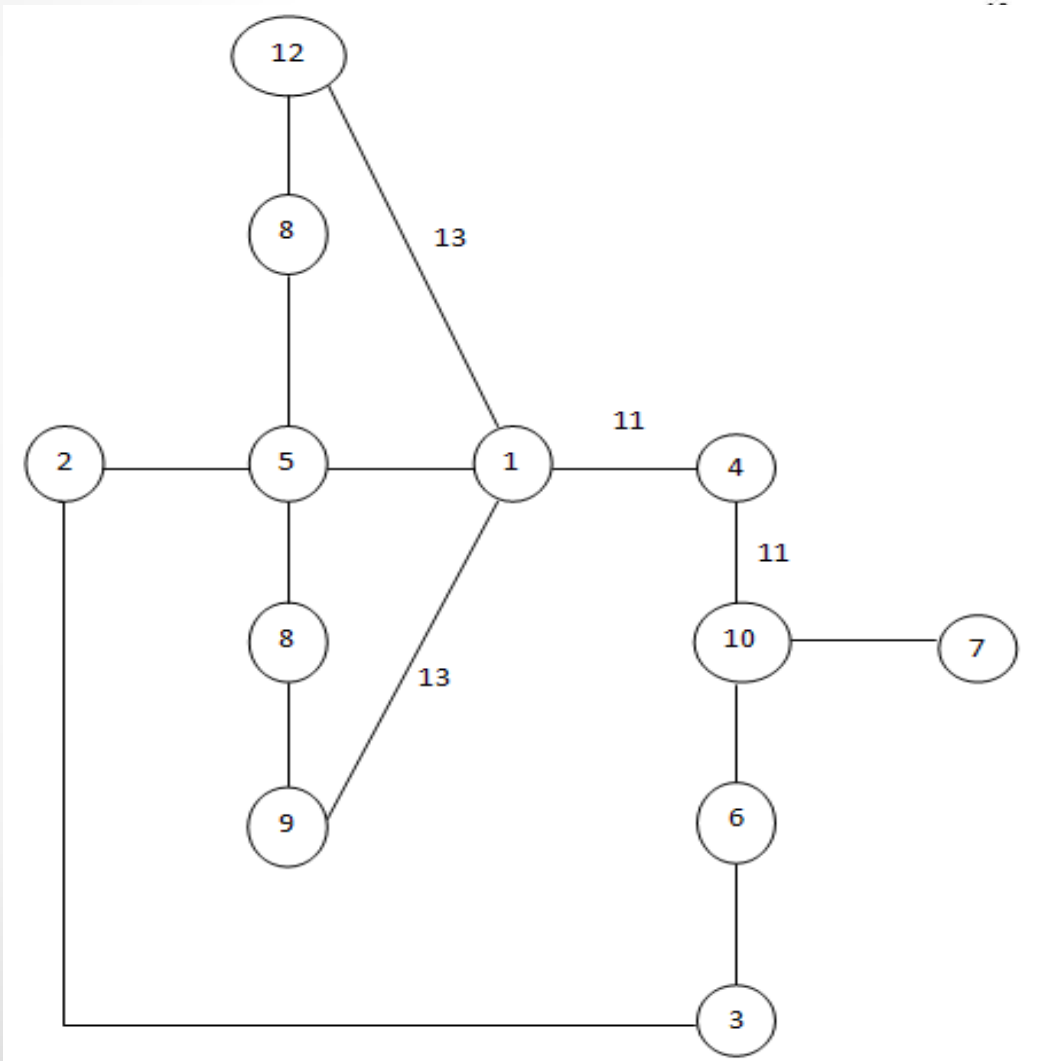
List of parts (3/3)



10	Foot cover	2	
11	Hexagonal head screw	8	
12	Cap	1	
13	Hexagonal head screw	6	

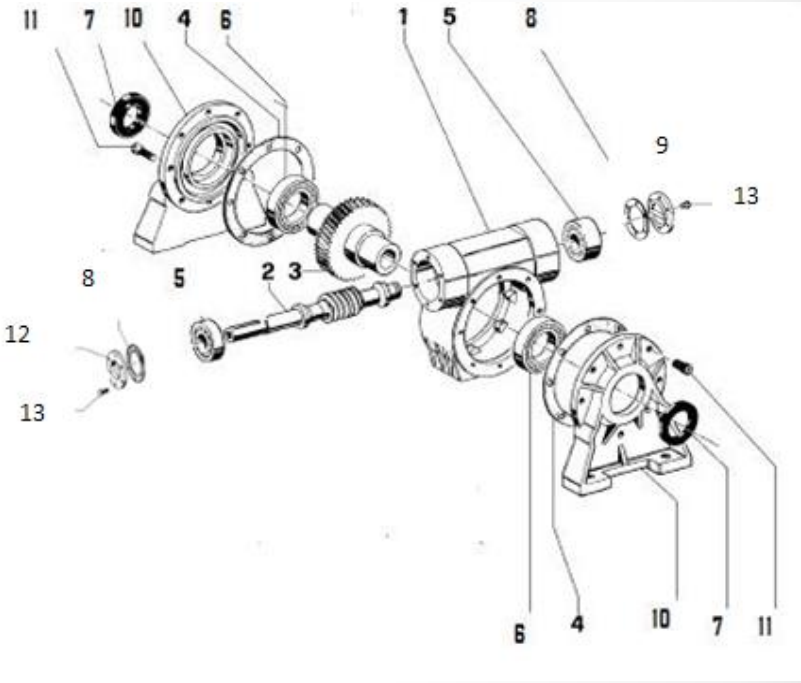
Connections



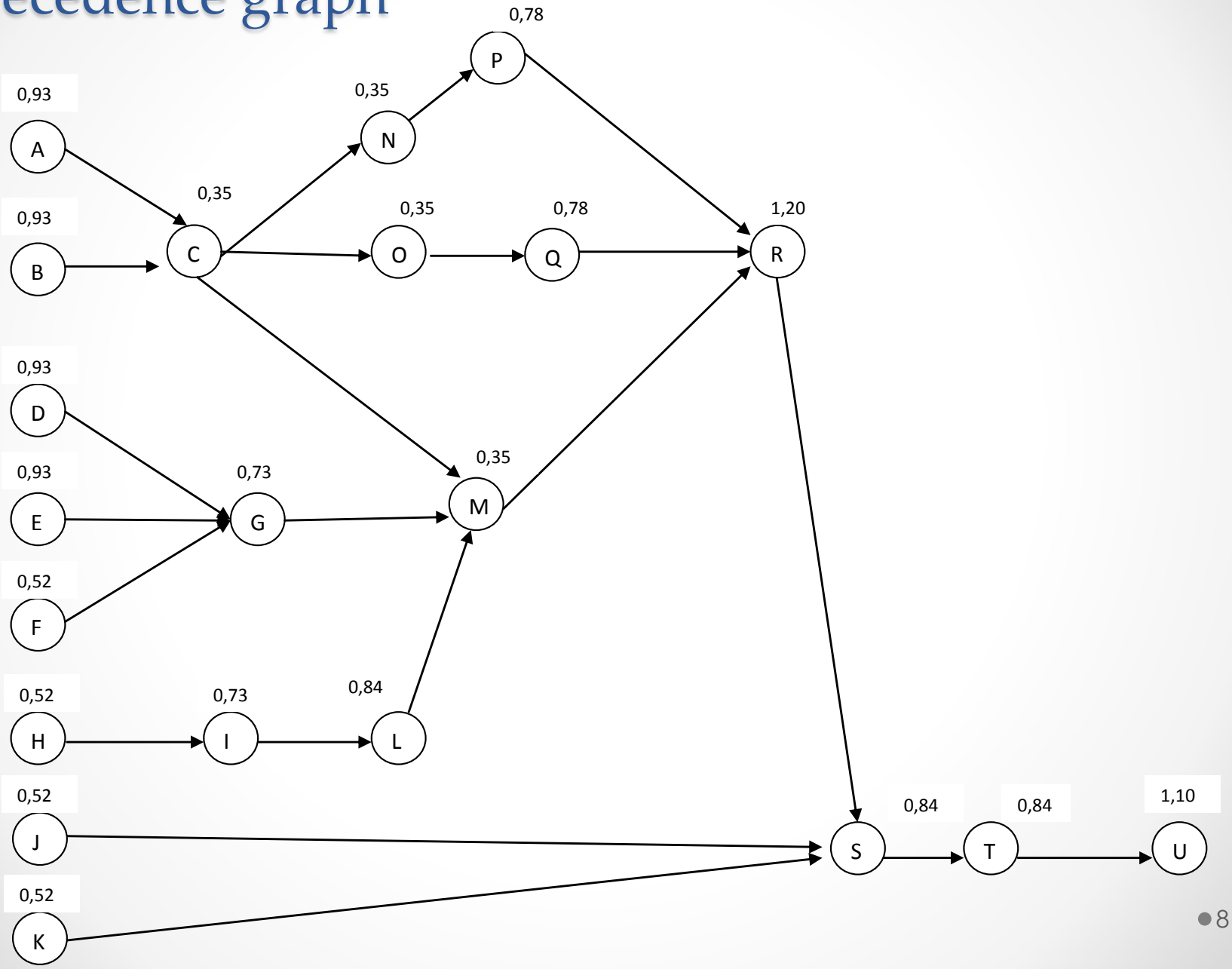


Assembly operations

A	One bearing n.5 on wormshaft n.2
B	Other bearing n.5 on housing in case n.1
C	Block n.2-5 in case n.1
D	One bearing n.6 on wormwheel n.3
E	Other bearing n.6 on wormwheel n.3
F	One oilseal n.7 on one foot cover n.10
G	Block n.3-6-6 with foot cover n.10
H	One gasket n.4 on one foot cover n.10
I	Block 4-10 with case n.1
J	Other oilseal n.7 on the other foot cover n.10
K	Other gasket n.4 on the other foot cover n.10
L	4 screws n.11 on foot cover n.10
M	Block n.1-2-5-5 with block n.3-6-6-4-10-7-11
N	One circlip Ø e n.8 and cap n.9 with block n.1-2-5-5
O	Other circlip Ø e n.8 and cap n.12 with block n.1-2-5-5
P	3 screws n.13
Q	Other 3 screws n.13
R	Oil addition
S	Assembling of the previous block with the other foot cover n.10
T	4 screws n.11 on foot cover n.10
U	Final test



Precedence graph



Assembly line balancing: single model

Hp

- D_a = 50.000 [products/year]
- W_y = 50 [weeks/year]
- S_w = 5 [shifts/week]
- H_s = 8 [hours/shift]
- T_r = 0,05 [min]
- η_L = 95%

- $R_p = \frac{D_a}{W_y\, S_w\, H_s} = \frac{50.000}{50\ x\ 5\ x\ 8}$ = 25 pieces/h
- $T_c = \frac{60\ \eta_L}{R_p}$ = 60 x 0,95 / 25 = 2,28 min
- $T_p = \sum T_{ek}$ = 15,04 min
- W = = T_p / T_c = 6,59 so N = 7
- $T_{max} = T_c - T_r$ = 2,26 – 0,05 = 2,23 min
- $\eta_r = \frac{T_{max}}{T_c}$ = 2,23 / 2,28 = 97,8% (repositioning efficiency)
- $\eta_b = \frac{T_p}{W\, T_{max}}$ = 96,3%
- $\eta = \eta_L\ \eta_R\ \eta_B$ = 0,95 x 0,978 x 0,963 = 89,4%
- W = $R_p\ T_p$ / 60 η = 7 OK

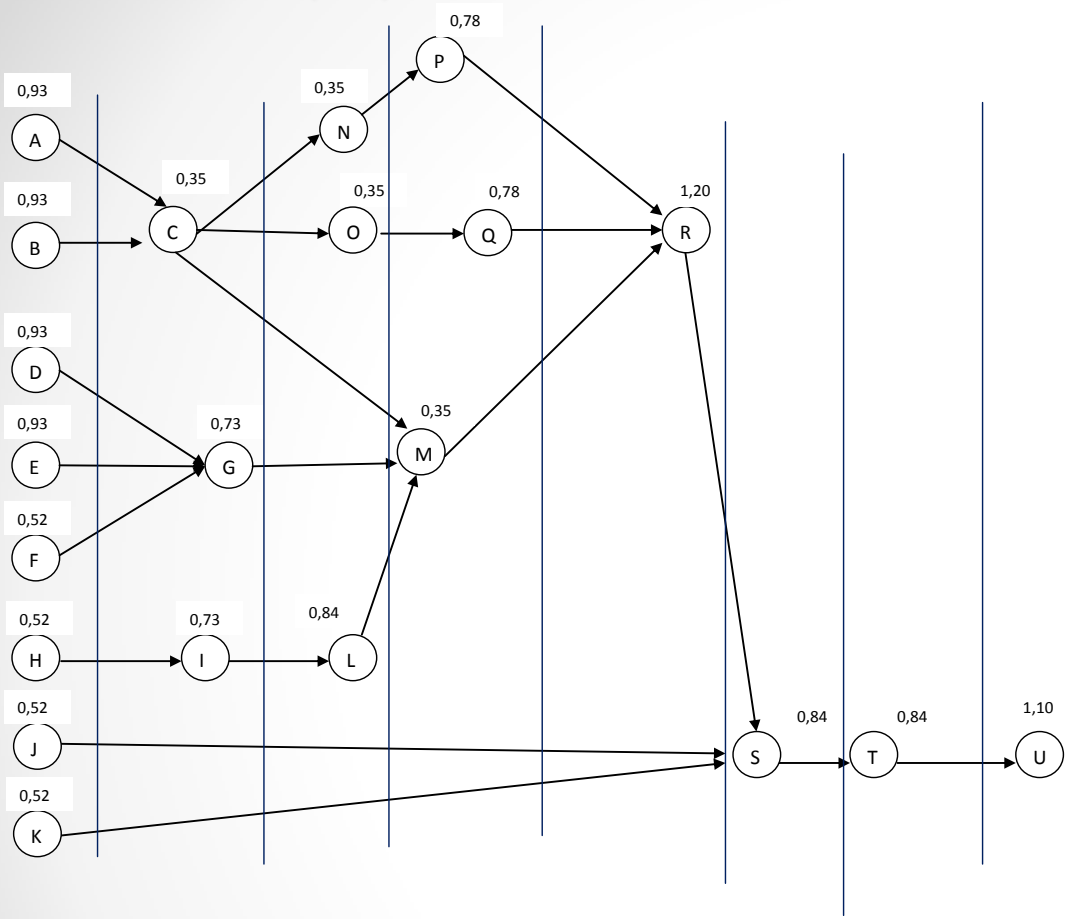
Some of the equations have different names. For example Twc is Tp. This is a problem of translation between the two version of the exercises. For the following exercise use this convention

LCR (2/5)

NAME	EXECUTION TIME [min]	PRECEDENCE
R	1,20	M,P,Q
U	1,10	T
A	0,93	-
B	0,93	-
D	0,93	-
E	0,93	-
L	0,84	I
S	0,84	J,K,R
T	0,84	S
P	0,78	N
Q	0,78	O
G	0,73	D,E,F
I	0,73	H
F	0,52	-
H	0,52	-
J	0,52	-
K	0,52	-
C	0,35	A,B
M	0,35	C,G,L
N	0,35	C
O	0,35	C

STATION	OPERATIONS	T_{max}	T_{si}	T_{ai}
1	A-B-C	2,23	2,21	0,02
2	D-E-N	2,23	2,21	0,02
3	P-F-G	2,23	2,03	0,20
4	H-I-L	2,23	2,09	0,14
5	J-K-M-O	2,23	1,74	0,49
6	Q-R	2,23	1,98	0,25
7	S-T	2,23	1,68	0,55
8	U	2,23	1,10	1,13

K&W (3/5)



OPERATIONS	COLUMN	T_{ek} [min]	PRECEDENCES
A	1	0,93	-
B	1	0,93	-
D	1	0,93	-
E	1	0,93	-
F	1	0,52	-
H	1	0,52	-
J	1	0,52	-
K	1	0,52	-
G	2	0,73	D,E,F
I	2	0,73	H
C	2	0,35	A,B
L	3	0,84	I
N	3	0,35	C
O	3	0,35	C
P	4	0,78	N
Q	4	0,78	O
M	4	0,35	C,G,L
R	5	1,20	P,Q,M
S	6	0,84	R,J,K
T	7	0,84	S
U	8	1,10	T

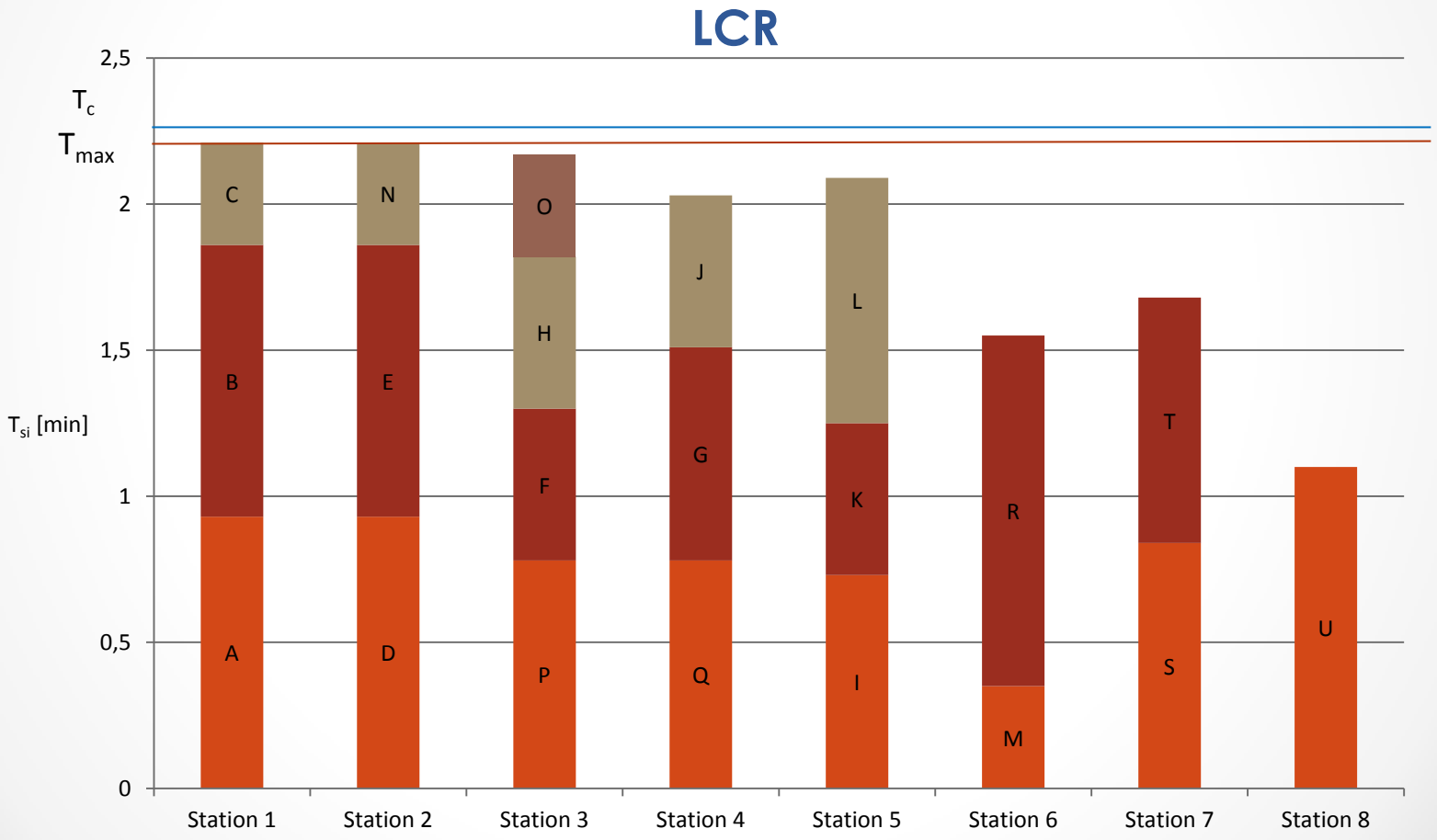
STATION	OPERATIONS	T_{max}	T_{si}	T_{ai}
1	A-B-C	2,23	2,21	0,02
2	D-E-N	2,23	2,21	0,02
3	F-H-J-K	2,23	2,08	0,15
4	G-I-O	2,23	1,81	0,42
5	L-P-M	2,23	1,97	0,26
6	Q-R	2,23	1,98	0,25
7	S-T	2,23	1,68	0,55
8	U	2,23	1,10	1,13

RPW (4/5)

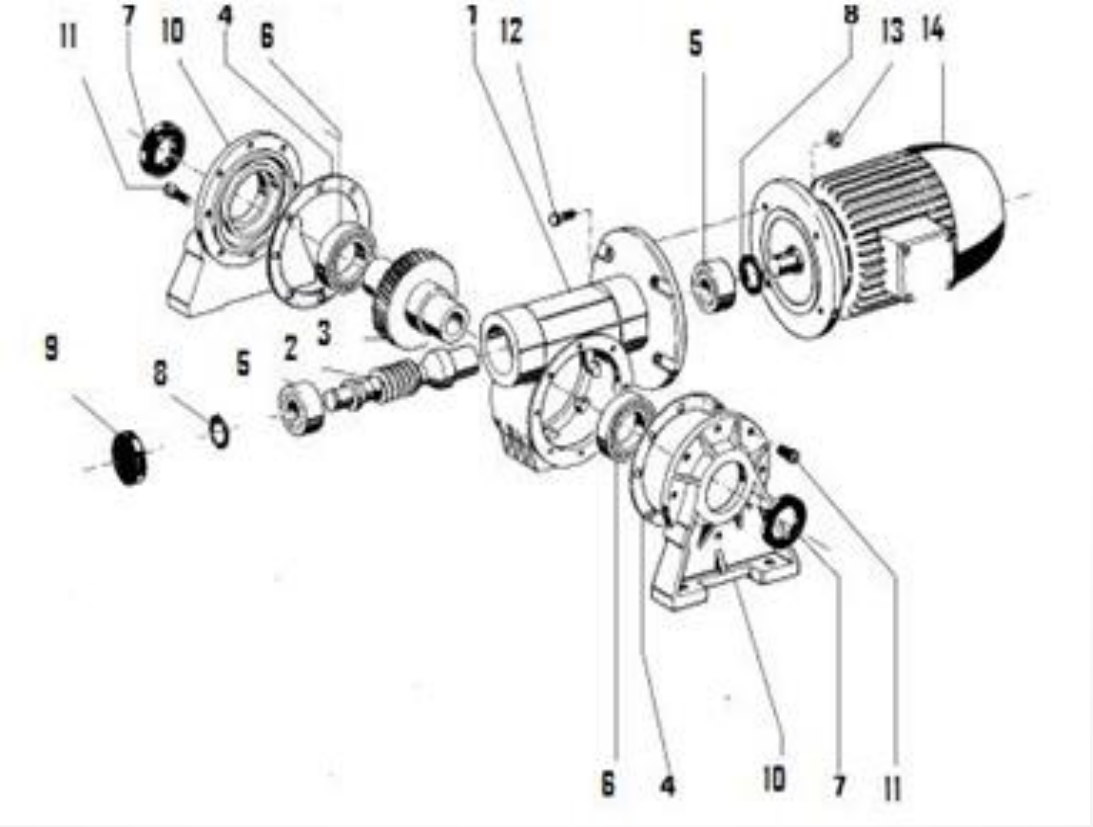
OPERATIONS	RPW	T_{ek} [min]	PRECEDENCES
A	7,76	0,93	-
B	7,76	0,93	-
C	6,83	0,35	A,B
H	6,31	0,52	-
D	5,88	0,93	-
E	5,88	0,93	-
I	5,79	0,73	H
F	5,47	0,52	-
L	5,06	0,84	I
N	5	0,35	C
O	5	0,35	C
G	4,95	0,73	D,E,F
P	4,65	0,78	N
Q	4,65	0,78	O
M	4,22	0,35	C,G,L
R	3,87	1,20	M,P,Q
J	3,19	0,52	-
K	3,19	0,52	-
S	2,67	0,84	J,K,R
T	1,83	0,84	S
U	1,1	1,10	T

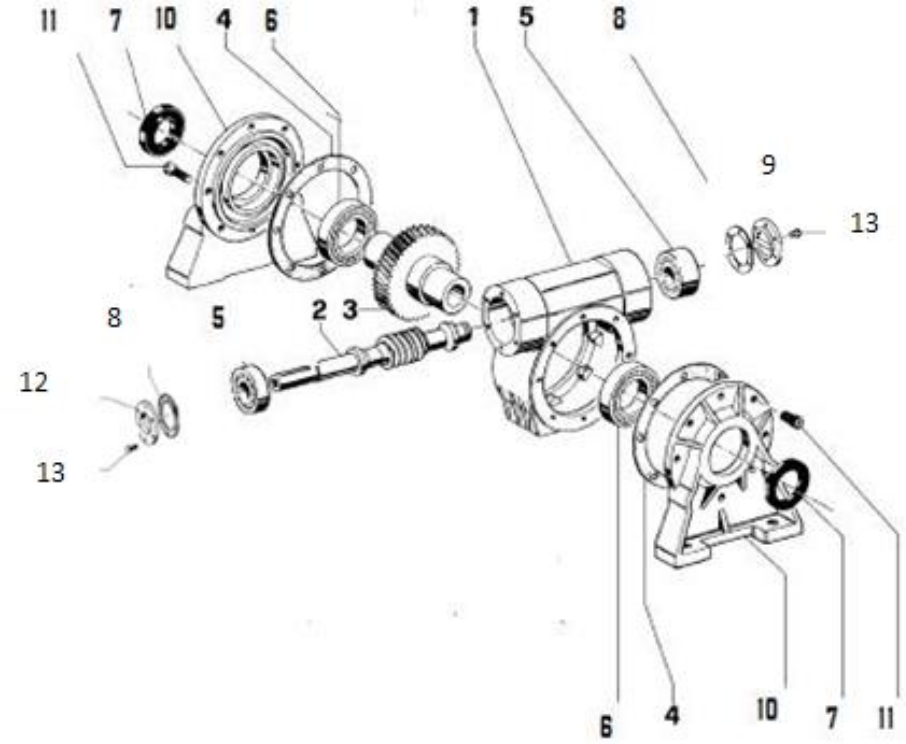
STATION	OPERATIONS	T_{max}	T_{si}	T_{ai}
1	A-B-C	2,23	2,21	0,02
2	H-D-I	2,23	2,18	0,05
3	E-F-N-O	2,23	2,15	0,08
4	L-G-M	2,23	1,92	0,31
5	P-Q-J	2,23	2,08	0,15
6	R-K	2,23	1,72	0,51
7	S-T	2,23	1,68	0,55
8	U	2,23	1,10	1,13

Final Configuration (5/5)



Model B





DIFFERENCES:

8: Circlip
9: Cap
12: Cap
13: Hexagonal head screw

8: Oilseal
9: Rubber cap
12: Hexagonal head screw
13: Nut
+
14: Electric motor