REFERENCES

Baxter, M. Product design. London: Chapman & Hall, 1995.

Beer, F. P., and Johnston R., E. Vector mechanics for engineers. Singapore: McGraw-Hill, 1990.

Beitz, Wolfgang, and Karl-Heinz. Handbook of mechanical engineering. London: Spring-Verlag, 1994.

Carter, D. E., and Baker, B. S. Concurrent engineering the product development environment for the 1990s. Massachusetts, 1992.

Chonwilai, S. Volumetric Valve. Bachelor's Thesis. Department of mechanical engineering, King Mongkut's Instutite of Technology North Bangkok, 1995.

Garbutt, D. Planning and Control of New Product Marketing. London, Chartered Institute of Management Accountants, 1989.

Harold, A. R. Mechanical design system handbook, 2nd ed. US, MCGraw-Hill, 1986

Jeerapol Chayudtit. Mechnical valve selection guide. Bangkok, M&E,1992.

Juvinall, C. R., and Marshek, M. K. Fundamentals of machine component design. Canada: John Wiley & Sons, 1991.

Oakley, M. Design management : A Hand book of issues and methods. UK, Basil Blackwell, 1990

Pugh, S., and Hollins, B. Successful product design. England: Butterworth, 1990.

Rassam, C. Design and corporate success. England: Gower, 1995.

Roozenburg, N. F., Eckels J. Product design : fundamentals and methods. US, John Wiley & Sons, 1995.

Ullman, D. G. The mechanical design process. Singapore: McGraw-Hill, 1997.

Ulrich, K. T., and Eppinger, S. D. Product design and development. Singapore: McGraw-Hill, 1995.

Waitl, A. M. Mechanical Springs 2nd ed. US: McGraw-Hill, 1987.

Warwick Manufacturing Group. Competitive design management Module note, University of Warwick, 1999.

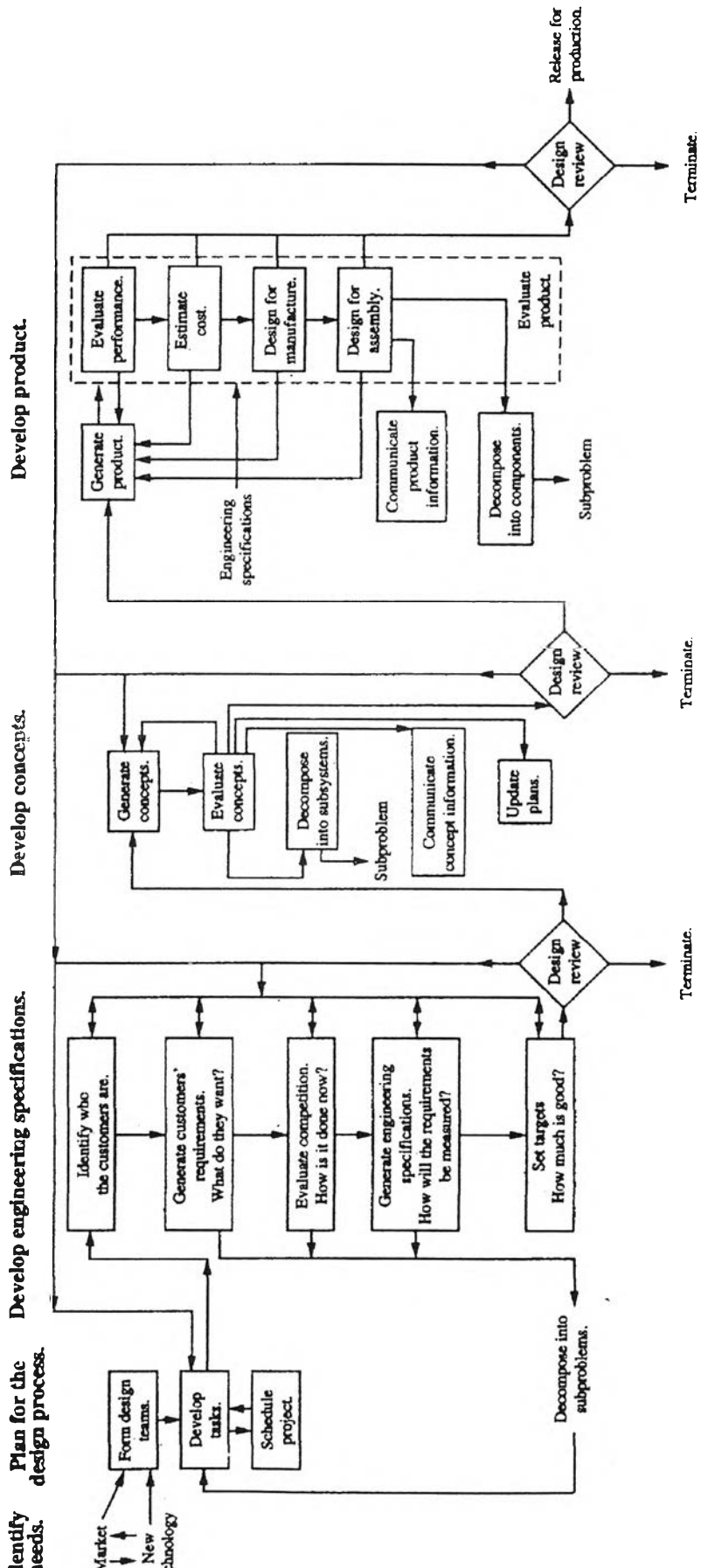
Wenhan, E. J., Dorlina, G.W., and Snell T. Physics: concepts and models, 2nd ed. US, Addison-Wesley, 1984

APPENDICES

APPENDIX A

APPENDIX A

Product development process



APPENDIX B

APPENDIX B

Modulus of Elasticity

For steel and stainless				For nonferrous materials		
Material		Modulus of elasticity			Modulus of elasticity	
(in.)	(mm)	G (psi) (MPa)	E (psi) (MPa)	Material	G (psi) (MPa)	E (psi) (MPa)
Hard-drawn MB				Spring brass		
	Up to			Type 70-30	5 000 000	15 000 000
up to 0.032	0.80	11 700 000	28 800 000		34 500	103 400
		80 700	198 600	Phosphor-bronze		
0.033-0.063	1.60	11 600 000	28 700 000	5% tin	6 000 000	15 000 000
		80 000	197 900		41 400	103 400
0.064-0.125	3.00	11 500 000	28 600 000	Beryllium-copper		
		79 300	197 200	cold-drawn 4 nos.	7 000 000	17 000 000
0.126-0.625	16.00	11 400 000	28 500 000		48 300	117 200
		78 600	196 500	Pretempered full hd.	7 250 000	19 000 000
Music wire					50 000	131 000
	Up to					
up to 0.032	0.80	12 000 000	29 500 000	Inconel 600	10 500 000	31 000 000 [a]
		82 700	203 400		72 400	213 700
0.033-0.063	1.60	11 850 000	29 000 000	Inconel X-750	10 500 000	31 000 000
		81 700	200 000		72 400	213 700
0.064-0.125	3.00	11 750 000	28 500 000			
		81 000	196 500	Monel 400	9 500 000	26 000 000
0.126-0.250	6.35	11 600 000	28 000 000		65 500	179 300
		80 000	193 000	Monel K-500	9 500 000	26 000 000
Oil-tempered MB		11 200 000	28 500 000		65 500	179 300
		77 200	196 500			
Chrome-vanadium		11 200 000	28 500 000	Duranickel 300	11 000 000	30 000 000
		77 200	196 500		75 800	206 800
Chrome-silicon		11 200 000	29 500 000	Permanickel	11 000 000	30 000 000
		77 200	203 400		75 800	206 800
Silicon-manganese		10 750 000	29 000 000			
		74 100	200 000	Ni-Span C 902	10 000 000	27 500 000
Stainless steel					69 000	189 600
Types 302, 304, 316		10 000 000	28 000 000	Elgiloy	12 000 000	29 500 000
		69 000	193 000		82 700	203 400
Type 17-7 PH		10 500 000	29 500 000	Iso-Elastic	9 200 000	26 000 000
		72 400	203 400		63 500	179 300
Type 420		11 000 000	29 000 000			
		75 800	200 000			
Type 431		11 400 000	29 500 000			
		78 600	203 400			

[a] May drop 2 000 000 if not full hard.

G is used for compression and extension springs; E is used for torsion, flat, and spiral springs.

Note: The reduced values of G and E for hard-drawn MB and music wire produce more accurate results. A single value may cause errors in forces up to 5 percent.

APPENDIX C

APPENDIX C

Friction coefficient

Material	Friction coefficient
Steel-Steel	0.4-0.7
Copper-Copper	0.6-1
Aluminum-Aluminum	0.94-1.35
Chromium-Chromium	0.41
Wood-Metal	0.32-0.45
Wood-Wood	0.2-0.4
Nickel-Nickel	0.39-0.70

APPENDIX D

APPENDIX D

Selection Criteria	DATUM	Concept					
		Fill valve			Ball valve		
		a	b	c	d	e	f
Ease of use	0						
Ease of install	0						
Ease of maintenance	0						
Portability	0						
Flexible in use	0						
Working accuracy	0						
Sum +'s Sum 0's Sum -'s	0 6 0						
Net Score	0						
Rank	3						
Continue?							

Table D-1 Concept evaluation matrix

APPENDIX E

APPENDIX E

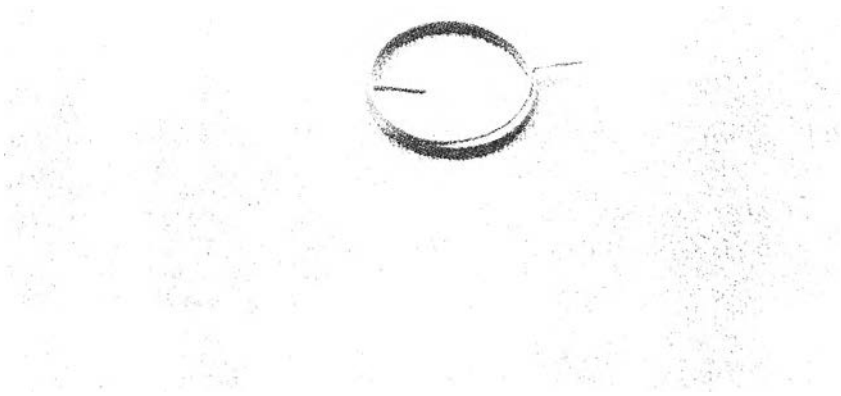


Figure E.1 Torsion spring in volumetric faucet

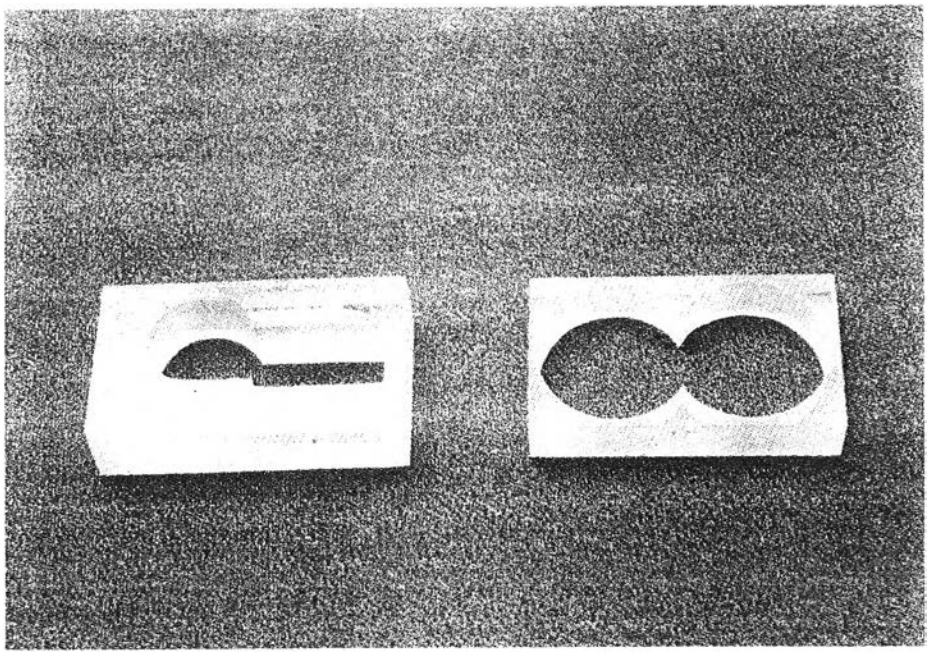


Figure E.2 Volumetric faucet's hosting

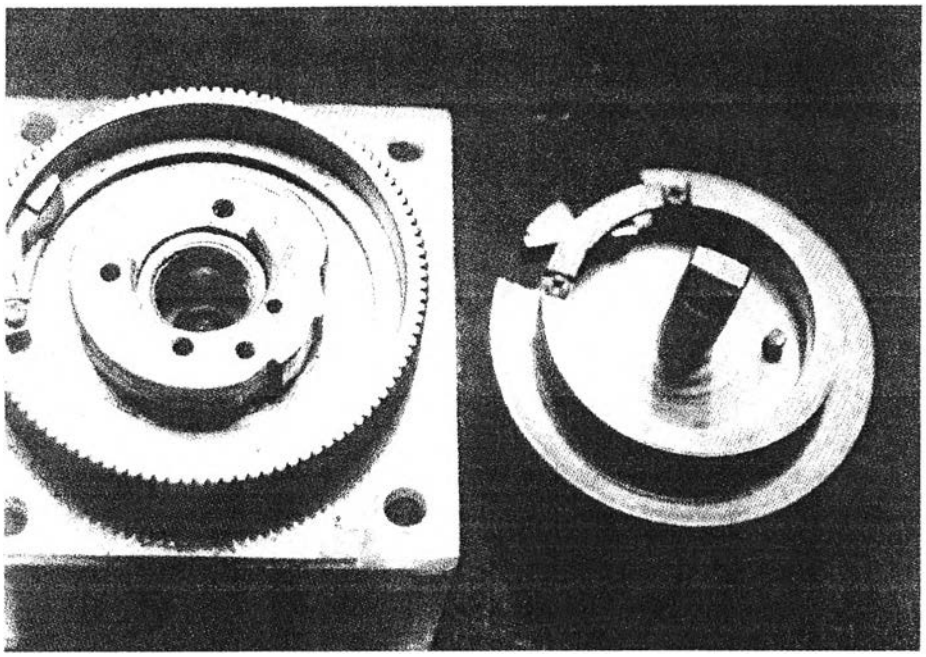


Figure E.3 Ratchet gear and ratchet's lock

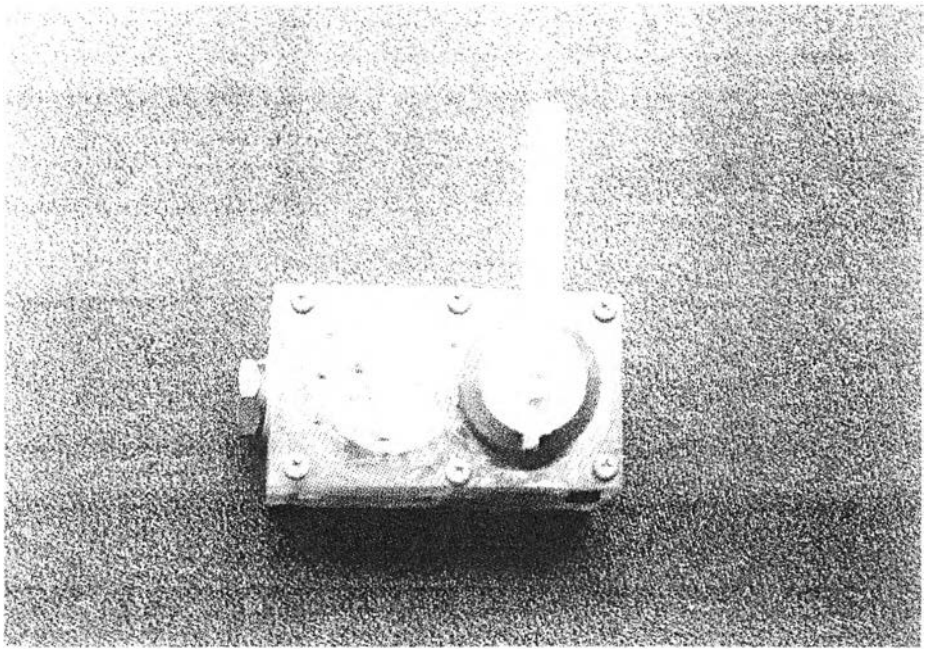


Figure E.4 Volumetric faucet prototype

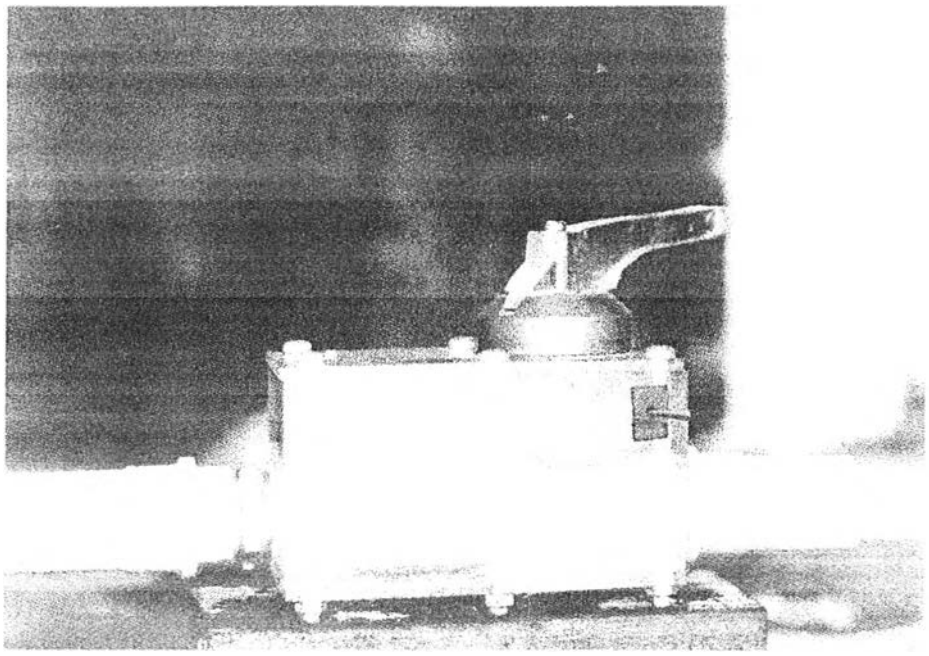


Figure E.5 Volumetric faucet install with testing equipment (close-up)

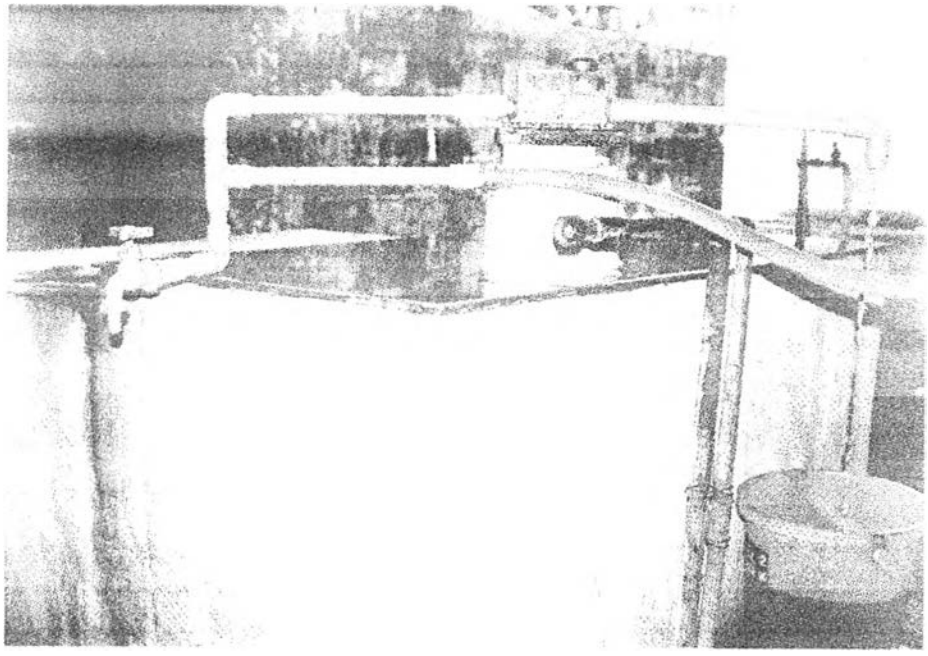
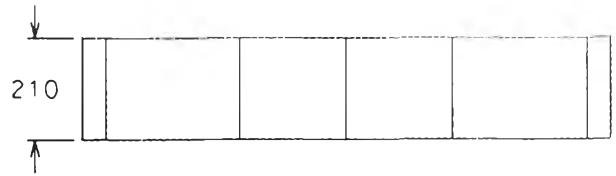
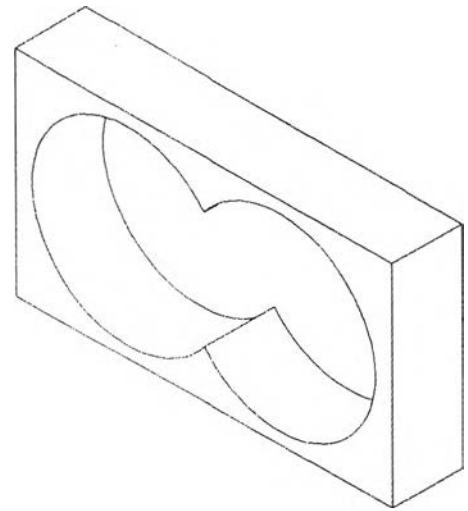
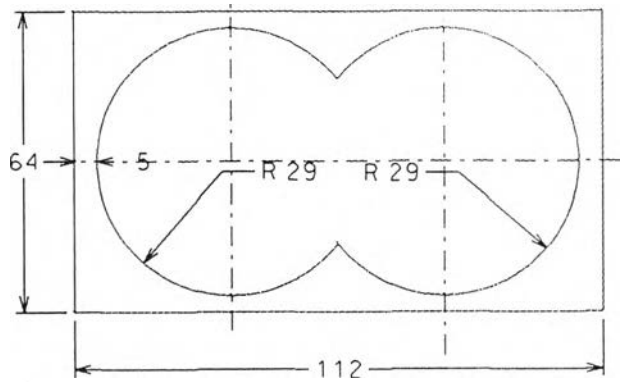


Figure E.6 Volumetric faucet install with testing equipment

APPENDIX F







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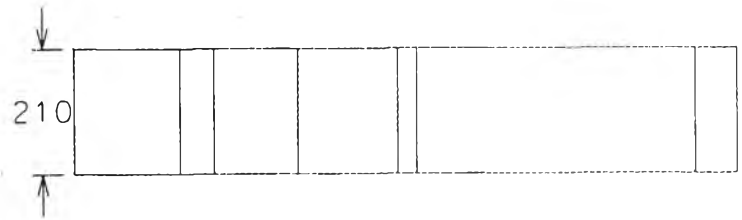

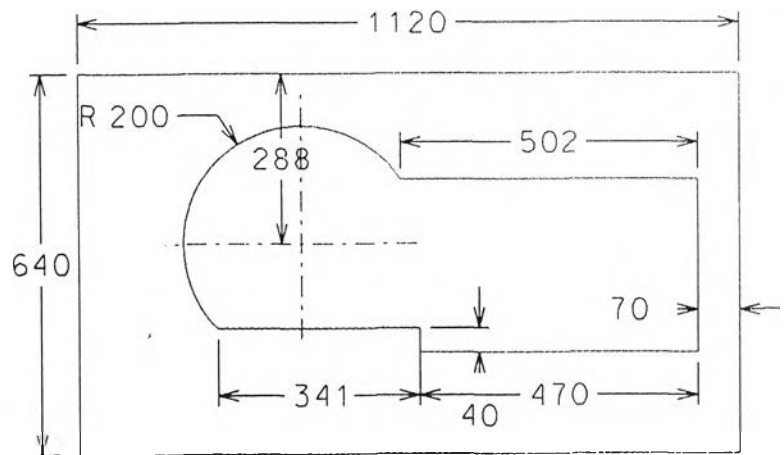

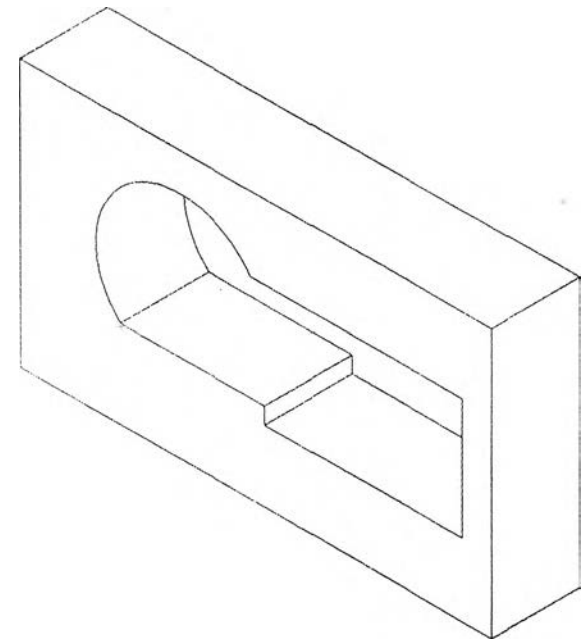

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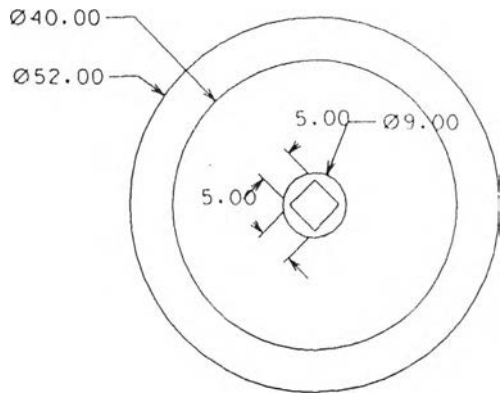

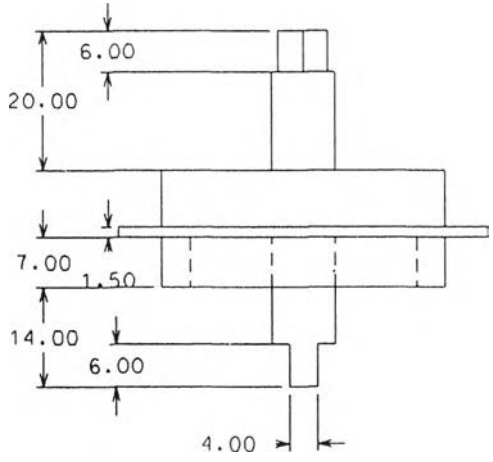

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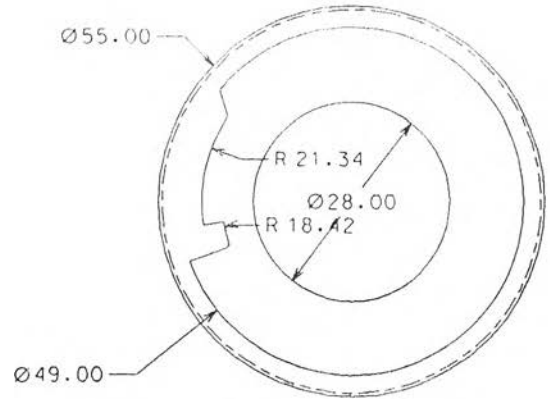
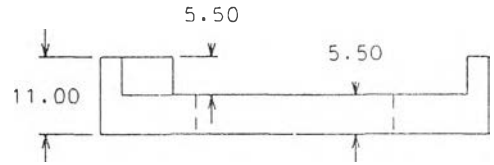
DESIGN:	SUTHIPONG CHONWILAI	FACULTY OF ENGINEERING
APPROVED:		
SCALE	Rotate Axis	NUMBER:

Module = 0.5
Teeth = 110
Pitch diameter = 54 mm.





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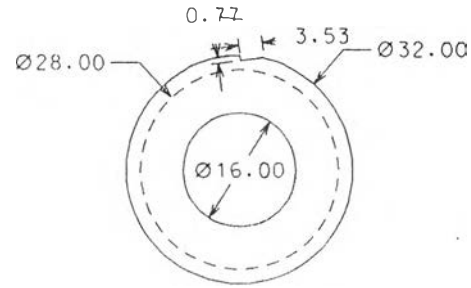
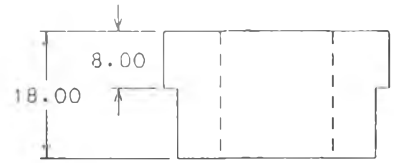
APPROVED:		
SCALE	Fix ratchet	NUMBER:





DATE:	MATERIAL:	
DESIGN:	SUTHIPONG CHONWILAI	FACULTY OF ENGINEERING
APPROVED:		
SCALE	Fix rotchet	NUMBER:

BIOGRAPHY

Mr.Suthipong Chonwilai was born on January 9, 1975 in Bangkok, Thailand. He obtained his Bachelor Degree in Mechanical Engineering from King Mongkut Instutite's North Bangkok in 1995. In academic year 1998 he has been registed as a full-time student and continued to pursue his graduate study in Engineering Management Program of Chulalongkorn University and in Engineering Business Management of The University of Warwick at the Regional Centre for Manufacturing System Engineering, Chulalongkorn University, Thailand.