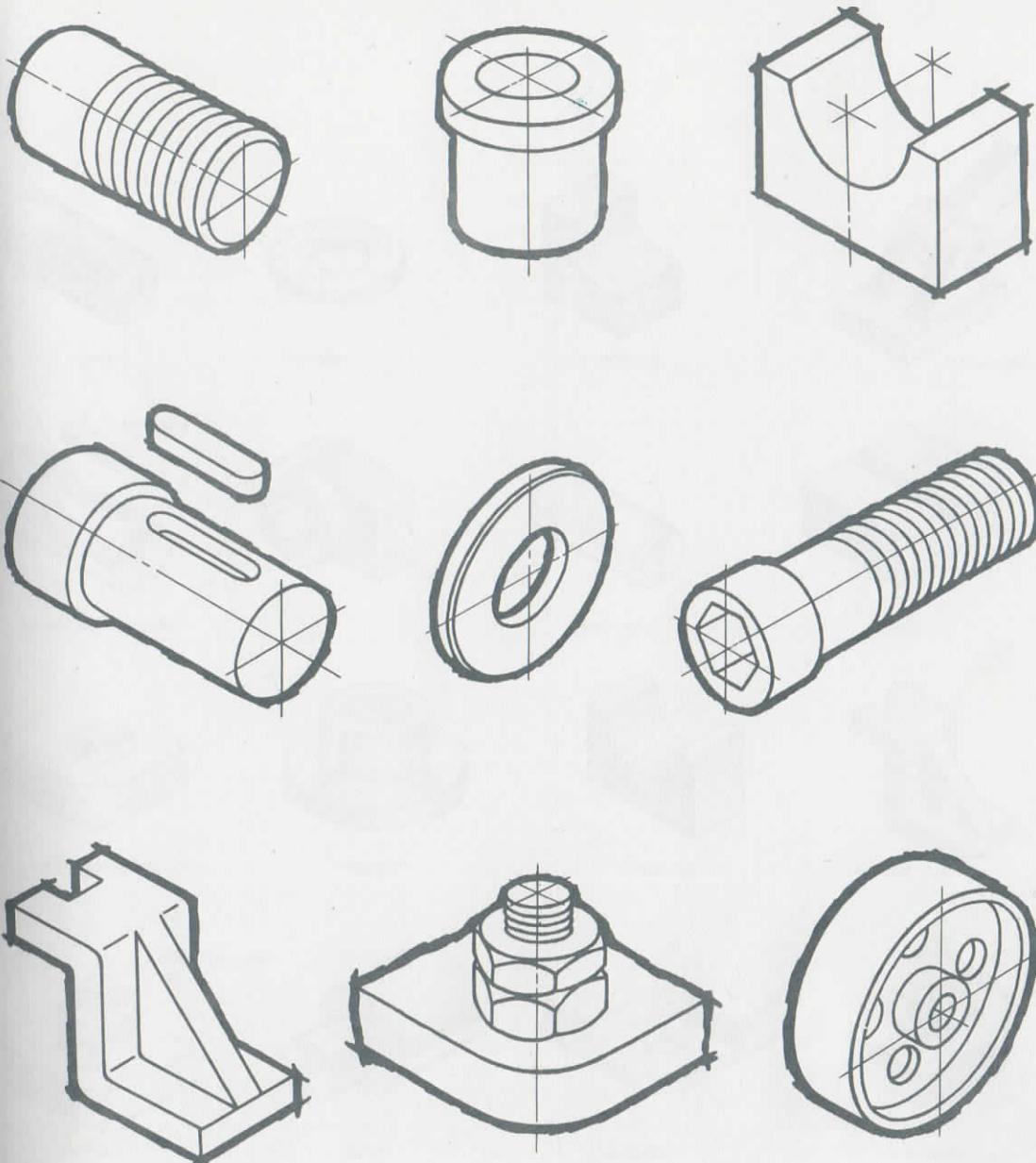


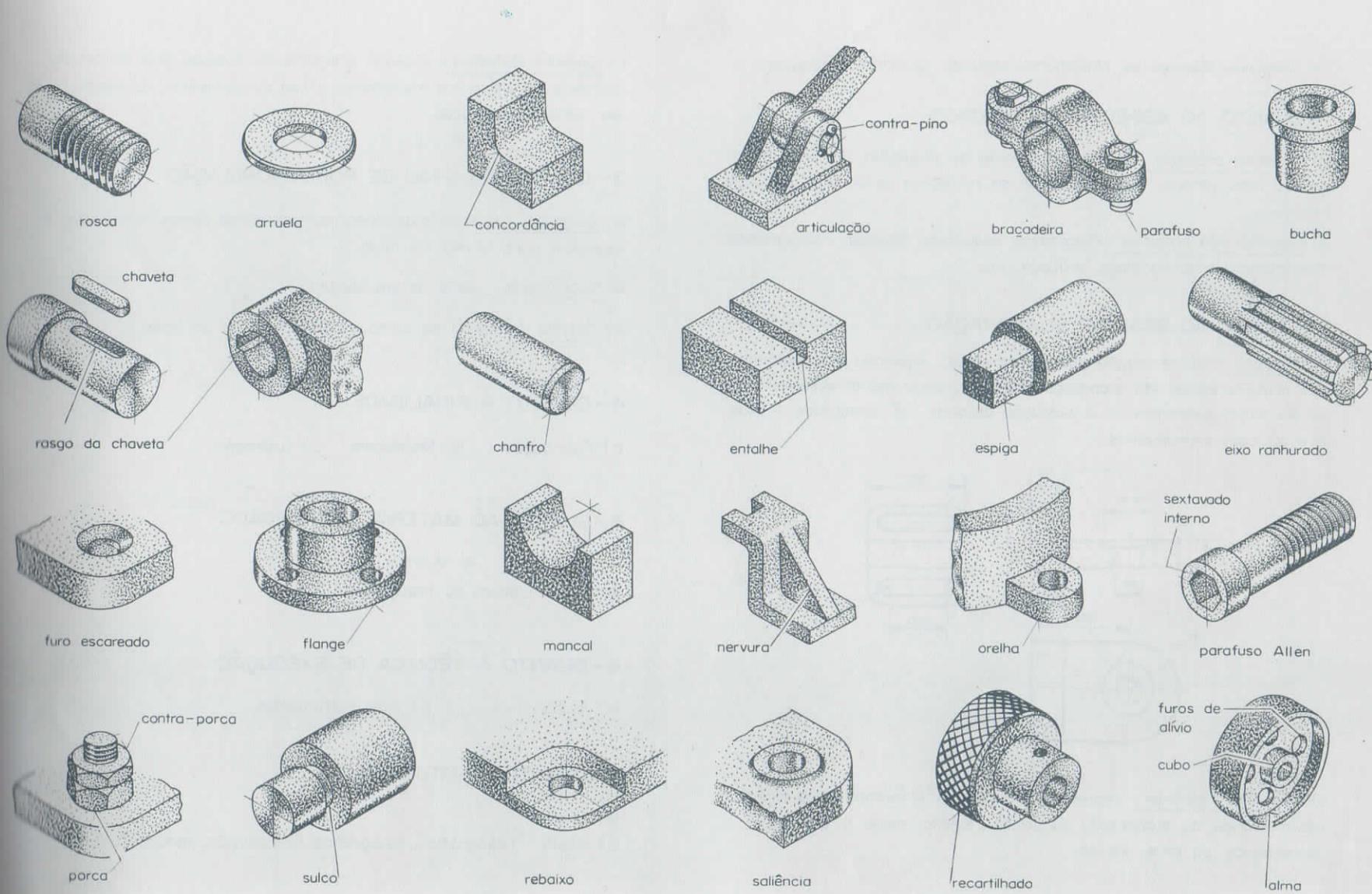
6

elementos de máquinas



glossário
rôscas
parafusos
porcas
pinos
chavetas
rebites
solda
polias
correntes
volantes
eixos
molas
rolamentos
engrenagens

GLOSSÁRIO



CLASSIFICAÇÃO DOS DESENHOS TÉCNICOS

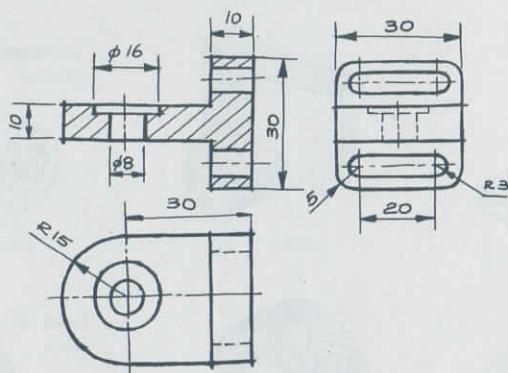
Os desenhos técnicos se classificam segundo os critérios seguintes:

1 - QUANTO AO ASPECTO GEOMÉTRICO

- a) Desenho projetivo: desenho resultante de projeções da peça sobre um ou mais planos, compreendendo as projeções ortogonais e as perspectivas.
- b) Desenho não projetivo: diagramas, esquemas, ábacos, nomogramas, fluxogramas, organogramas, gráficos, etc.

2 - QUANTO AO GRAU DE ELABORAÇÃO

- a) Croquis: Representação gráfica expedita. Aplicada habitualmente aos estágios iniciais da elaboração de um projeto ou à representação de elementos existentes ou à execução de obra. É executado à mão livre ou com instrumentos.



- b) Desenho preliminar: representação gráfica empregada nos estágios intermediários da elaboração do projeto, sujeito ainda a alterações. Corresponde ao ante-projeto.

c) Desenho definitivo: desenho integrante da solução final do projeto, contendo os elementos necessários à sua compreensão, de modo a poder servir à execução.

3 - QUANTO AO GRAU DE PORMENORIZAÇÃO

- a) Conjunto: desenho mostrando reunidos vários componentes, que se associam para formar um todo.
- b) Subconjunto: parte de um conjunto.
- c) Detalhe: desenho de componente isolado de um todo.

4 - QUANTO A FINALIDADE

- a) Fabricação b) Montagem c) Ilustração

5 - QUANTO AO MATERIAL EMPREGADO

- a) a lapis b) à tinta
em papel comum ou transparente

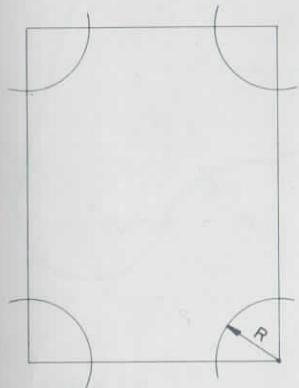
6 - QUANTO À TÉCNICA DE EXECUÇÃO

- a) à mão livre b) com instrumentos

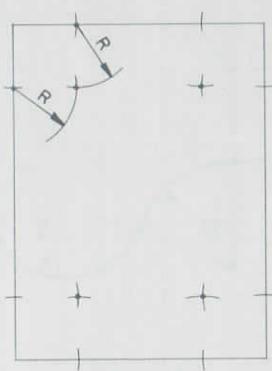
7 - QUANTO À NATUREZA

- a) Original
- b) Cópia: heliográfica, fotográfica (ampliação, redução), etc.

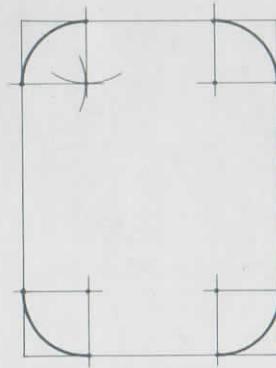
SEQUÊNCIA DO TRAÇADO DE CONCORDÂNCIAS



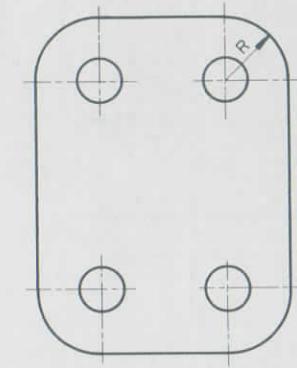
1^a etapa



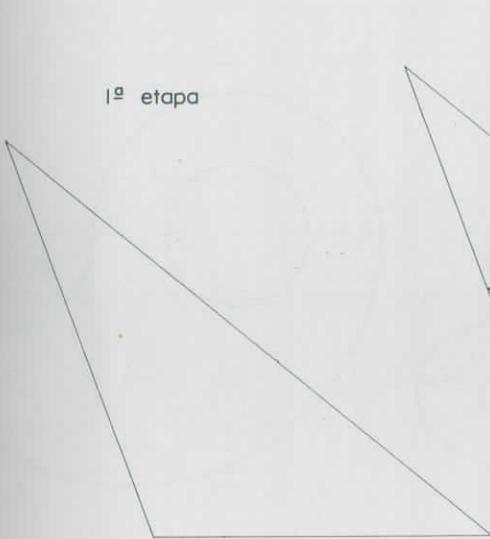
2^a etapa



3^a etapa



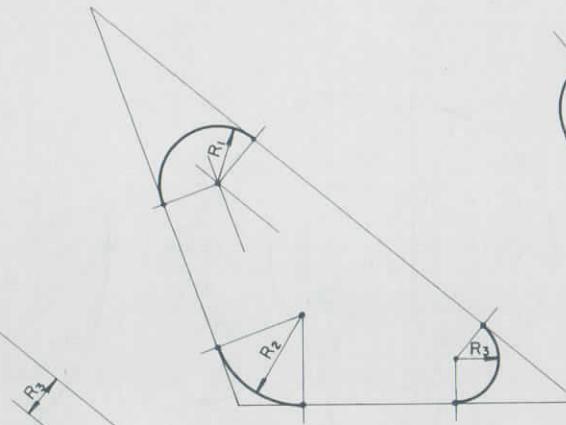
4^a etapa



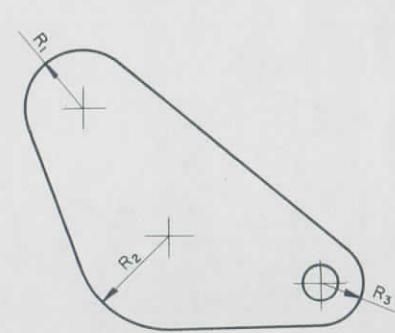
1^a etapa



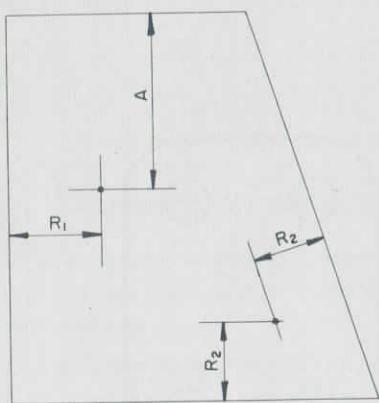
2^a etapa



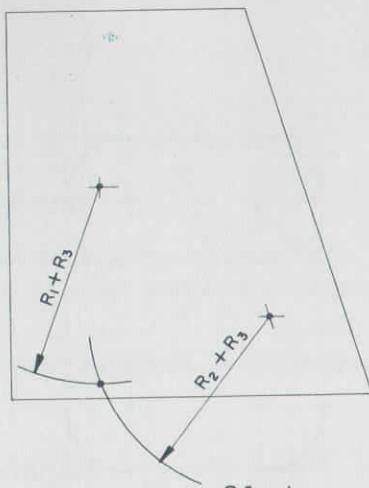
3^a etapa



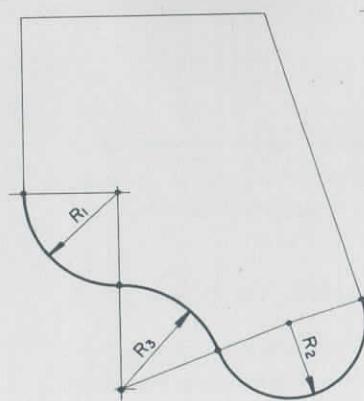
4^a etapa



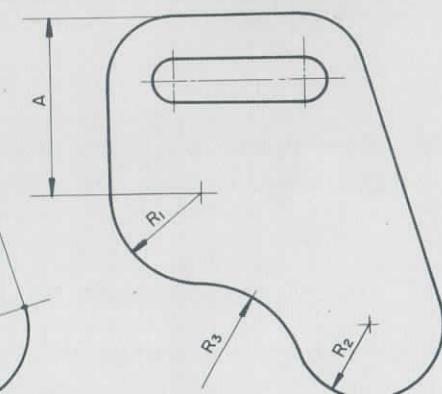
1^a etapa



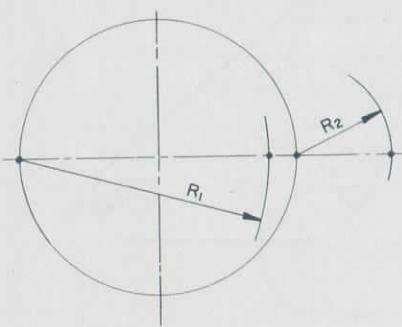
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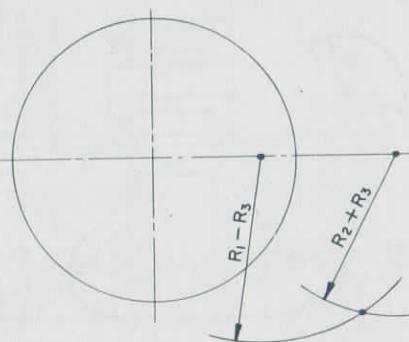
3^a etapa



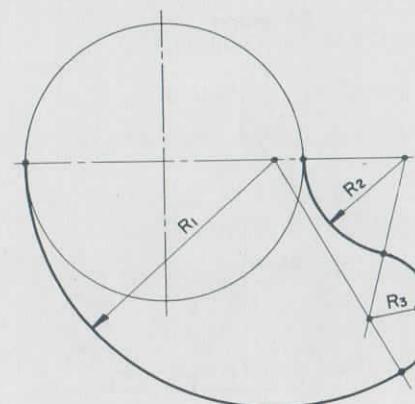
4^a etapa



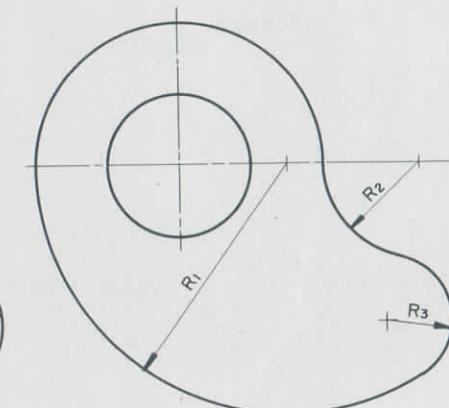
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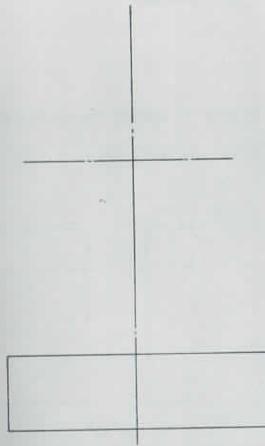
2^a etapa



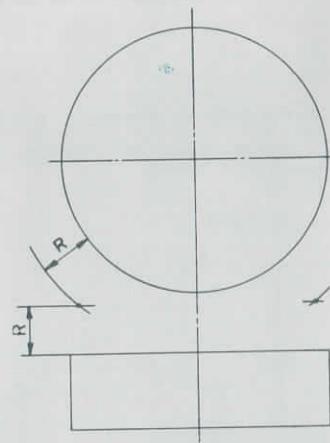
3^a etapa



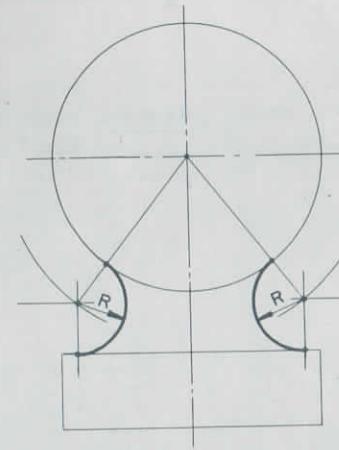
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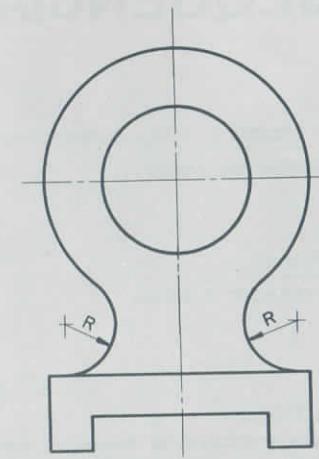
1^a etapa



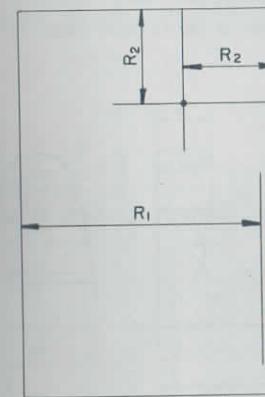
2^a etapa



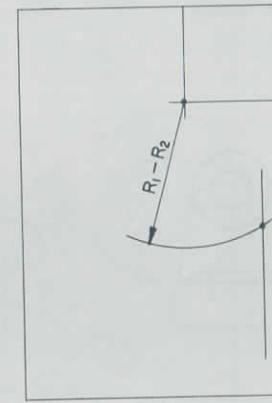
3^a etapa



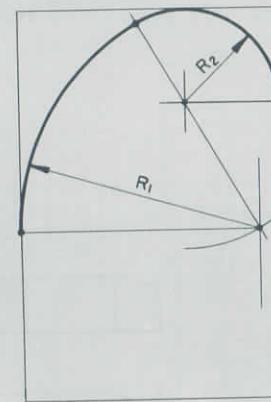
4^a etapa



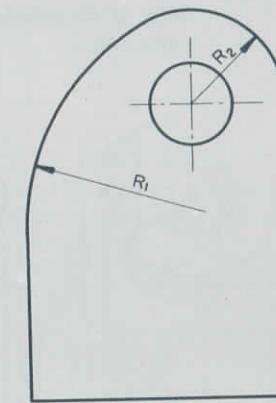
1^a etapa



2^a etapa



3^a etapa



4^a etapa

SEQUÊNCIA DO TRAÇADO DE DESENHO A LÁPIS

1^a etapa:

escolher as vistas

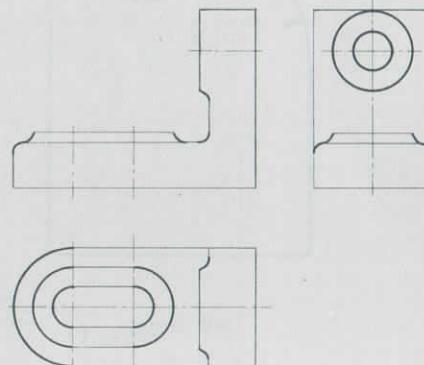
2^a etapa:

estabelecer a escala

3^a etapa:

dispor mentalmente as vistas, visando obter uma aparência bem equilibrada sobre o papel.

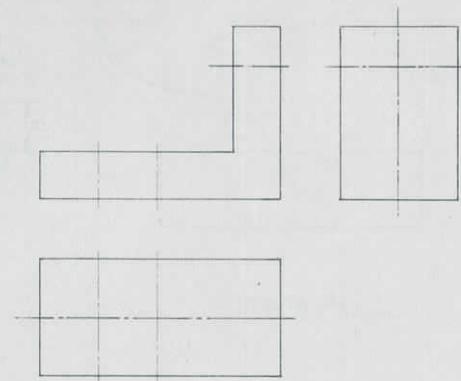
6^a etapa: traçar as concordâncias, os arcos e as circunferências com grafite HB.



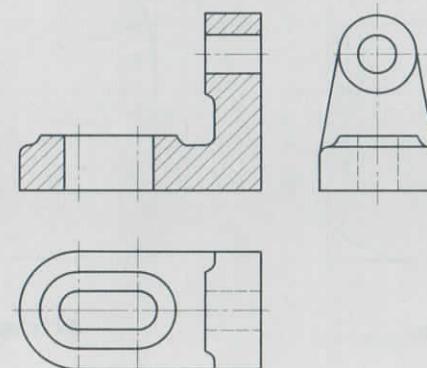
4^a etapa: traçar as linhas de centro com lápis F.



5^a etapa: traçar o contorno com lápis F.

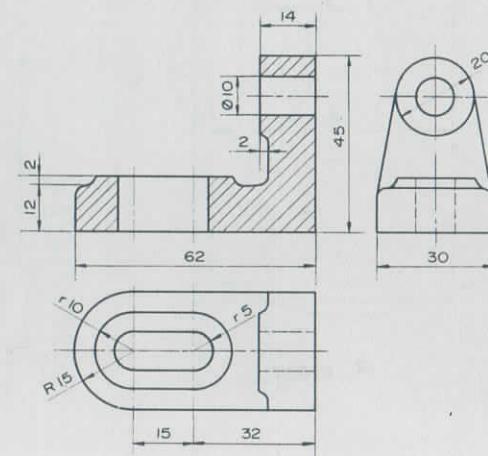


7^a etapa: reforçar o desenho com lápis HB e hachurar com lápis F.



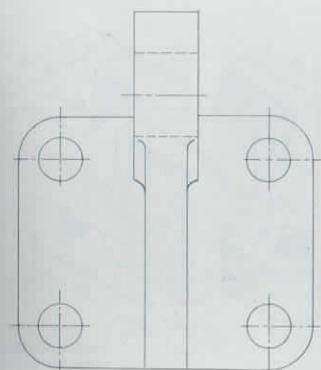
8^a etapa: colocar as cotas e as observações com lápis HB.

9^a etapa: fazer a verificação final.

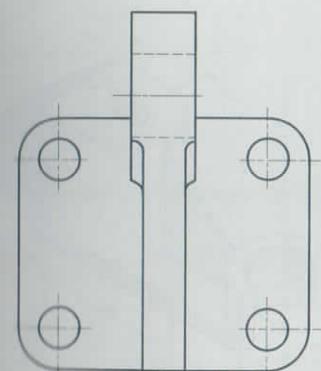


SEQUÊNCIA DO TRAÇADO DE DESENHO A TINTA

1^a etapa : fixar o papel vegetal sobre o desenho a lápis.
Passar a borracha para remover a gordura do papel vegetal

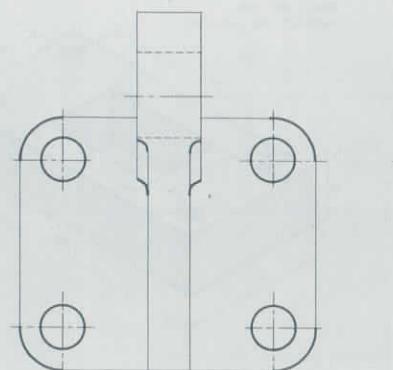


3^a etapa : passar a tinta o restante do contorno com
traco grosso.

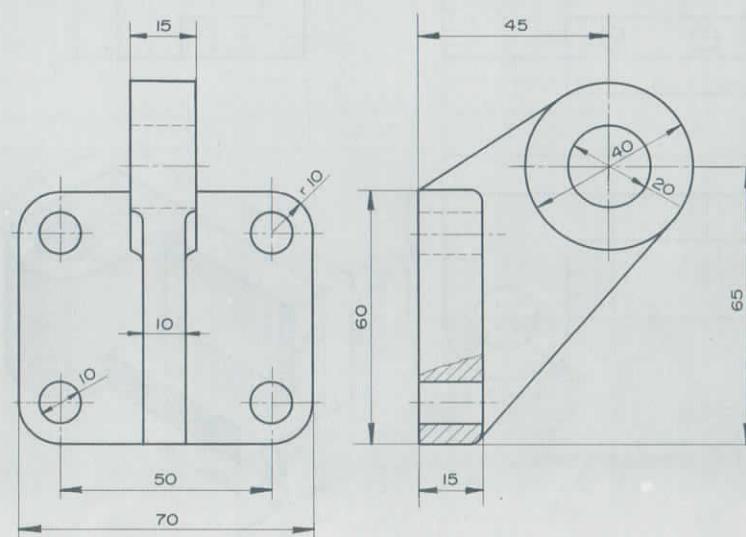


Normalmente são usadas para traço grosso pena 0,4 e para
traco fino pena 0,1.

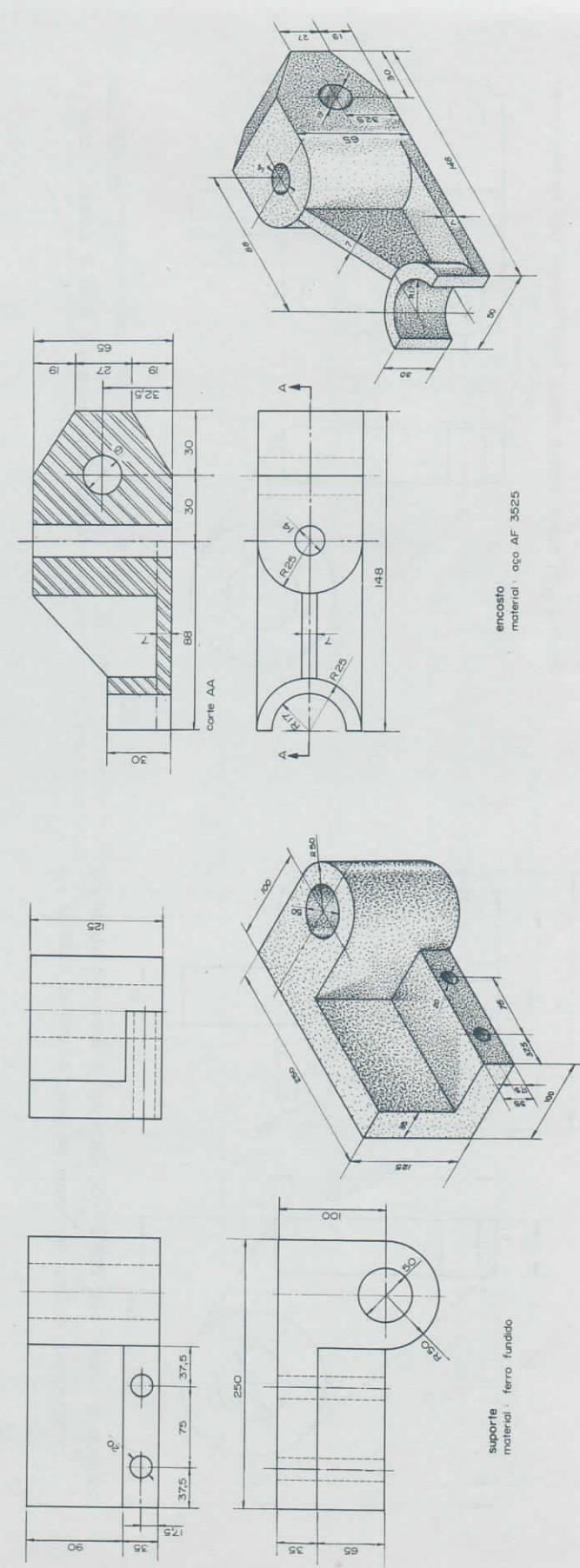
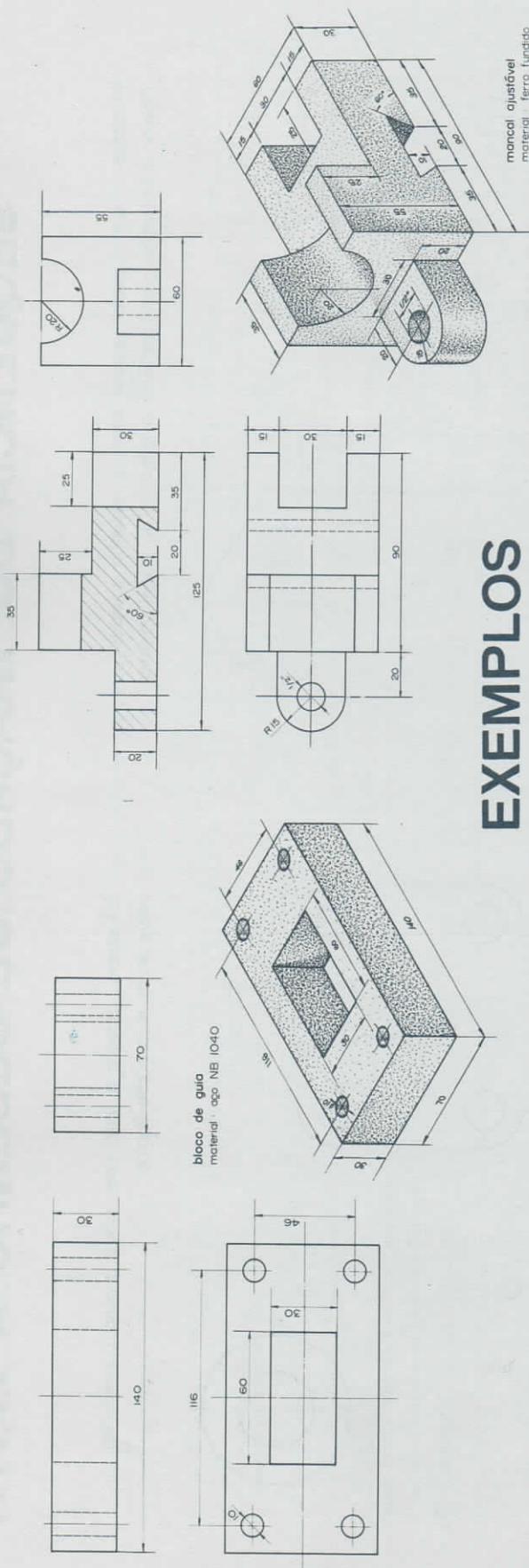
2^a etapa : passar a tinta com traço grosso começando
pelos arcos e circunferências.

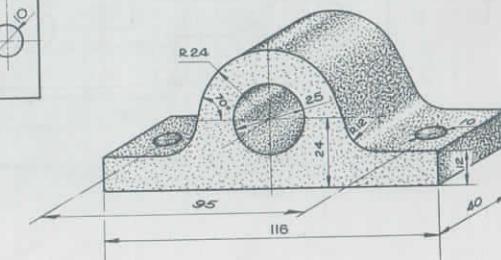
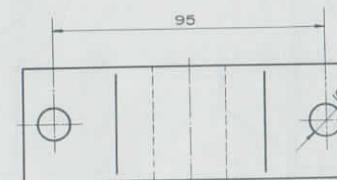
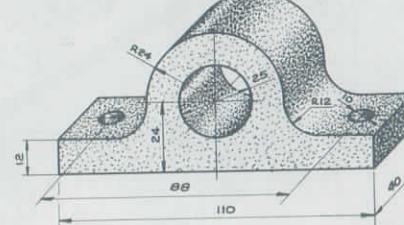
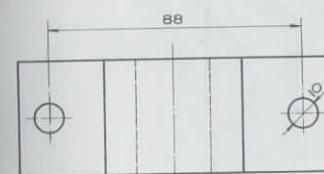
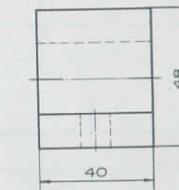
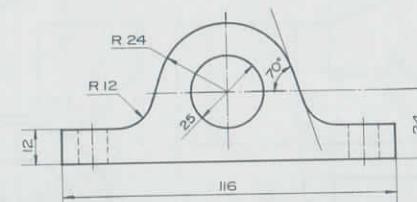
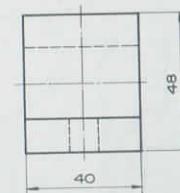
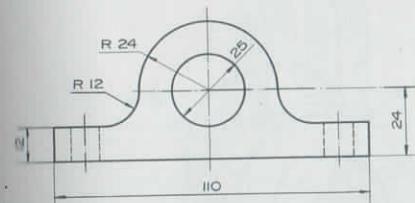
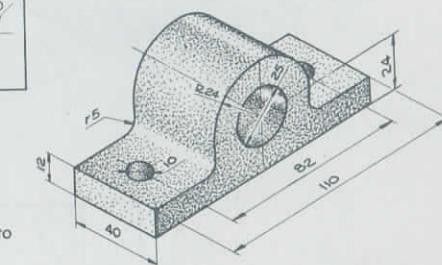
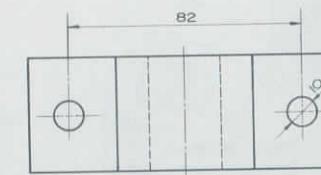
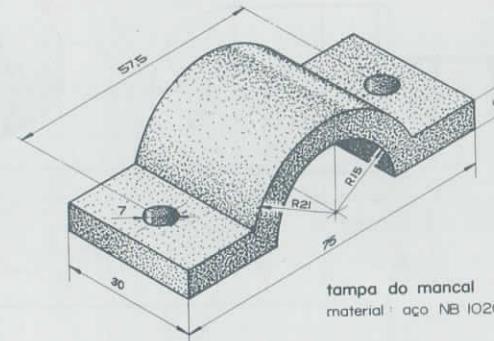
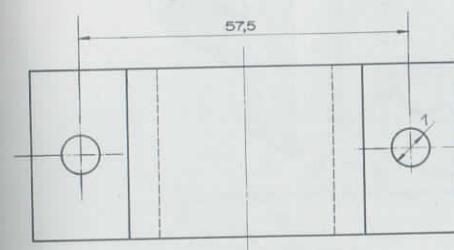
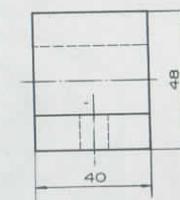
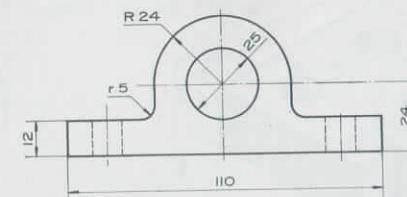
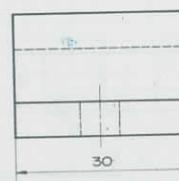
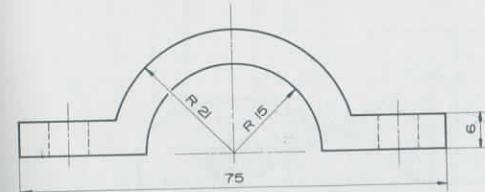


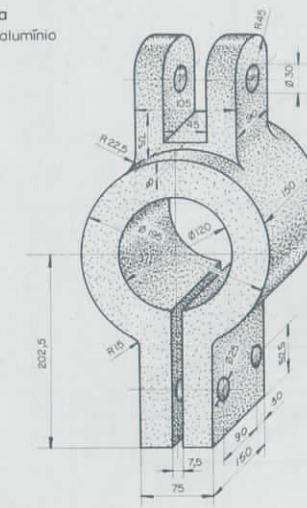
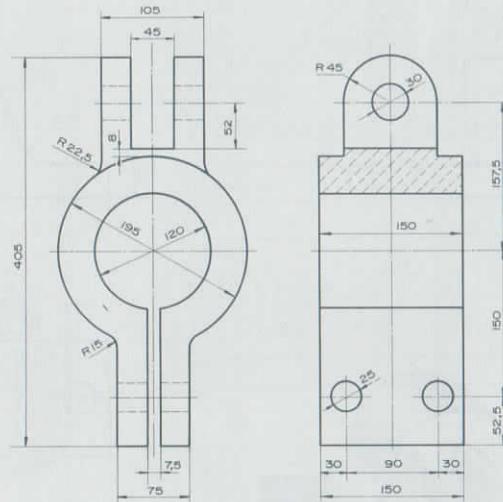
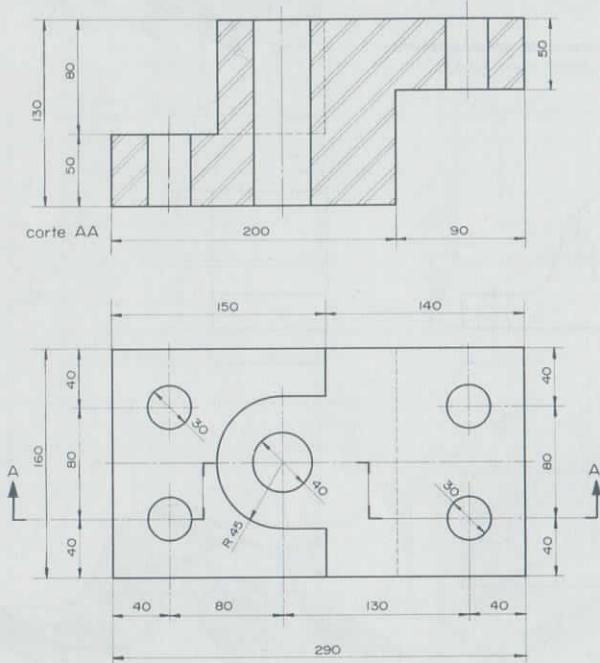
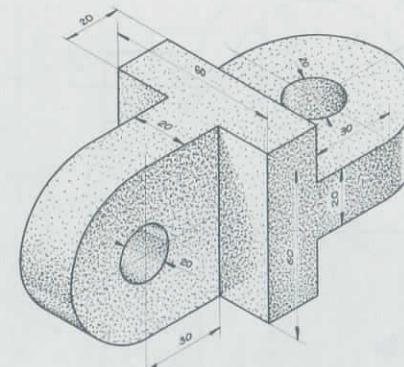
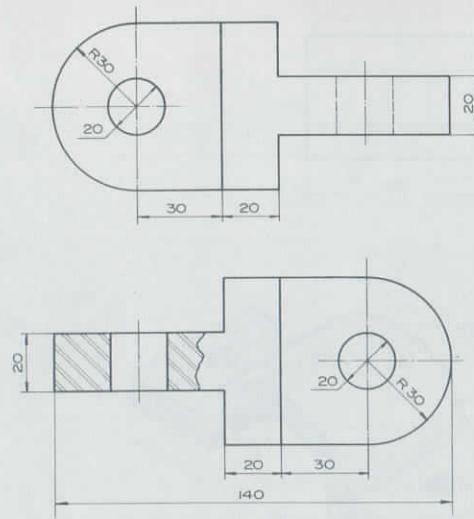
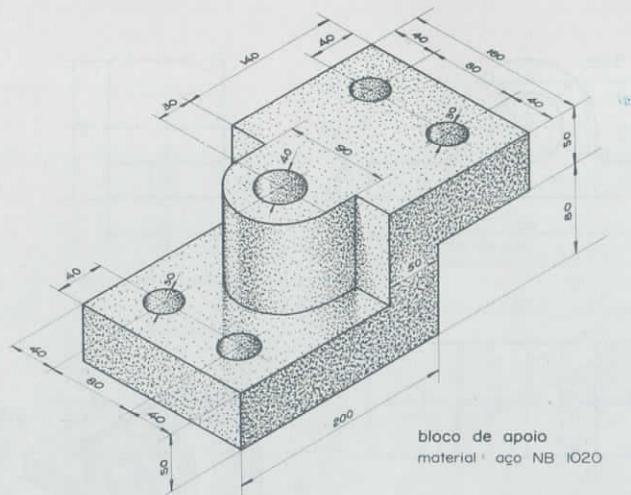
4^a etapa : passar a tinta as linhas de centro, hachuras,
linhas de chamada e de cota com traço fino. Cotar o desenho.

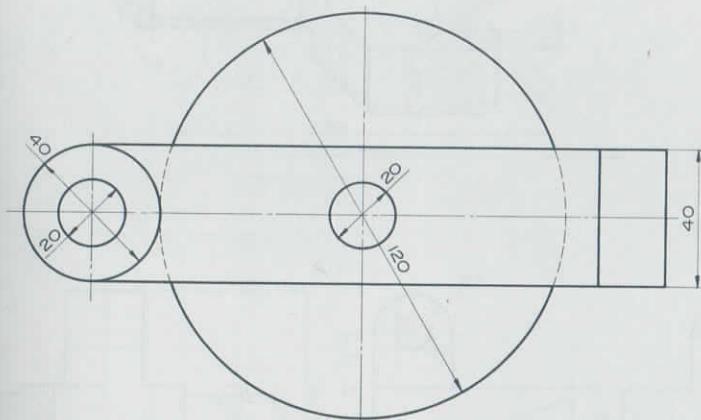
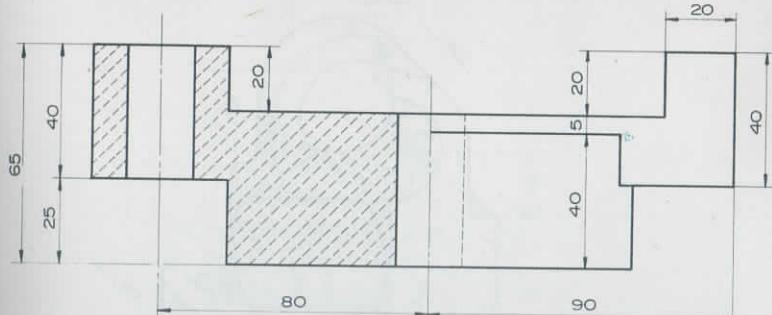


EXEMPLOS

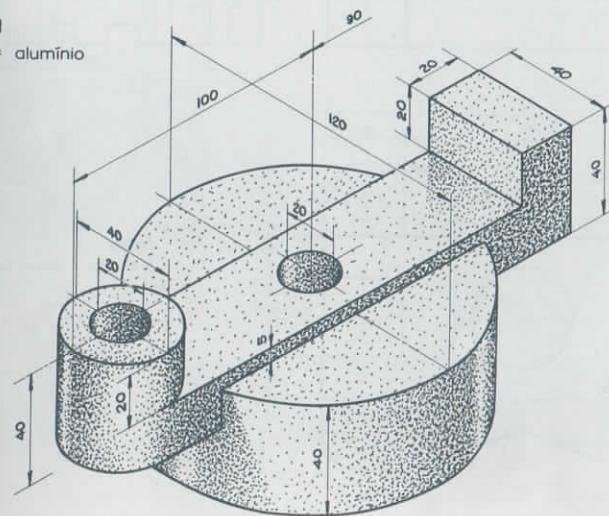




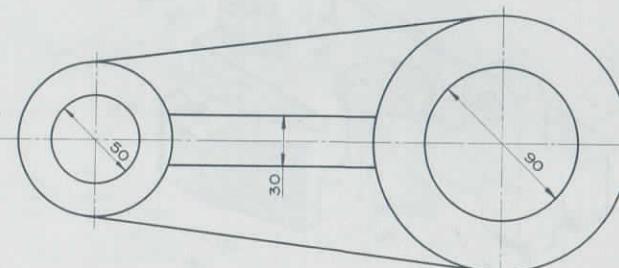
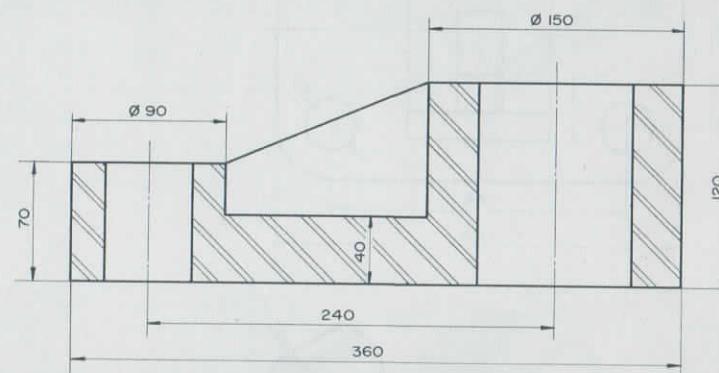
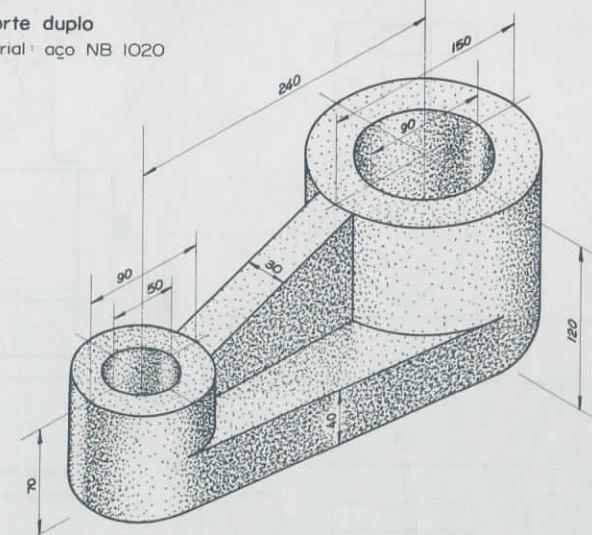


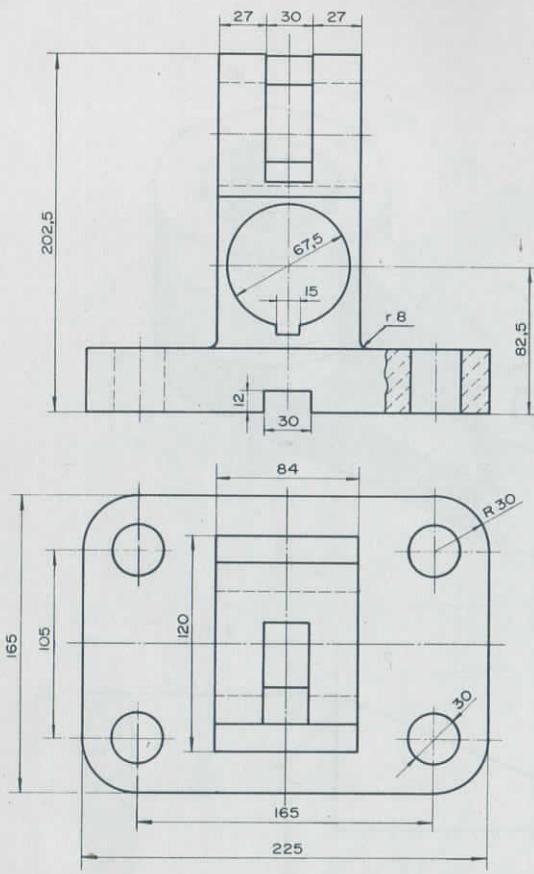


terminal
material: alumínio

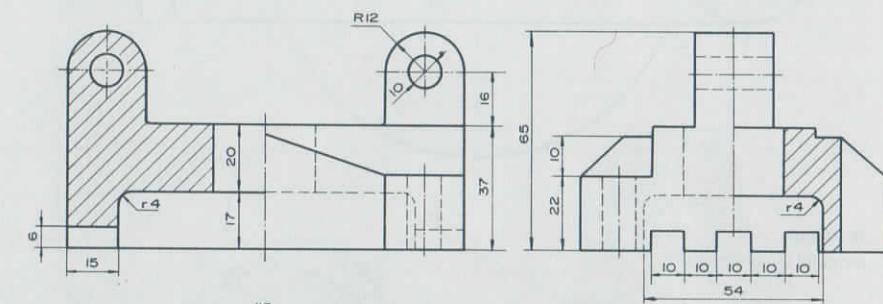
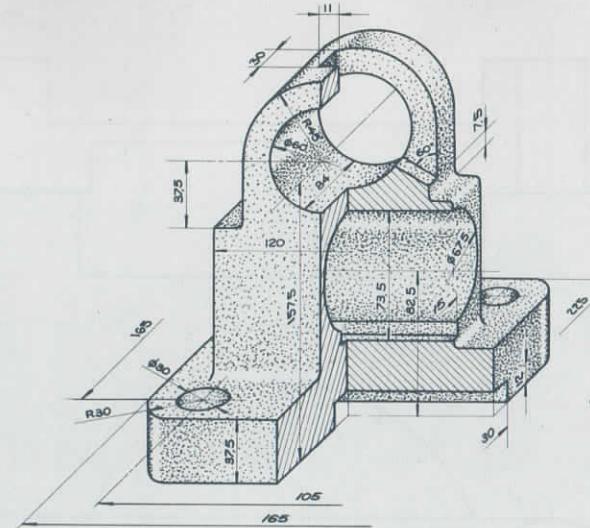
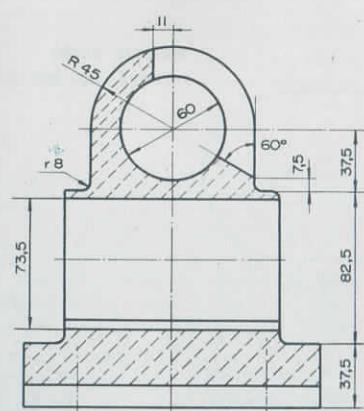


suporte duplo
material: aço NB 1020

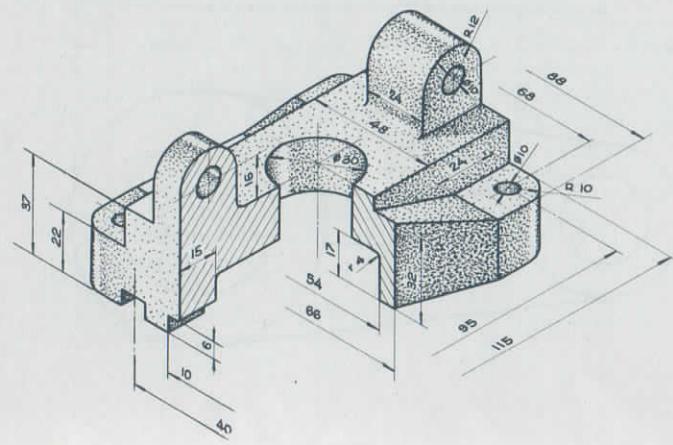
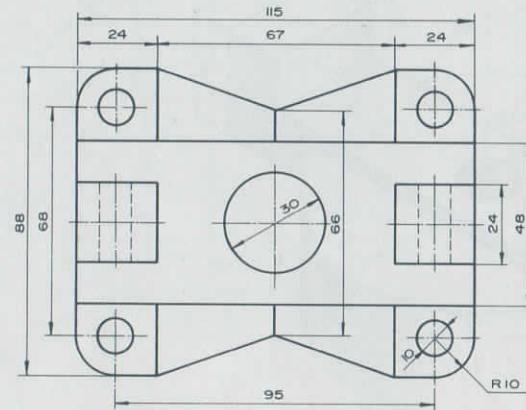


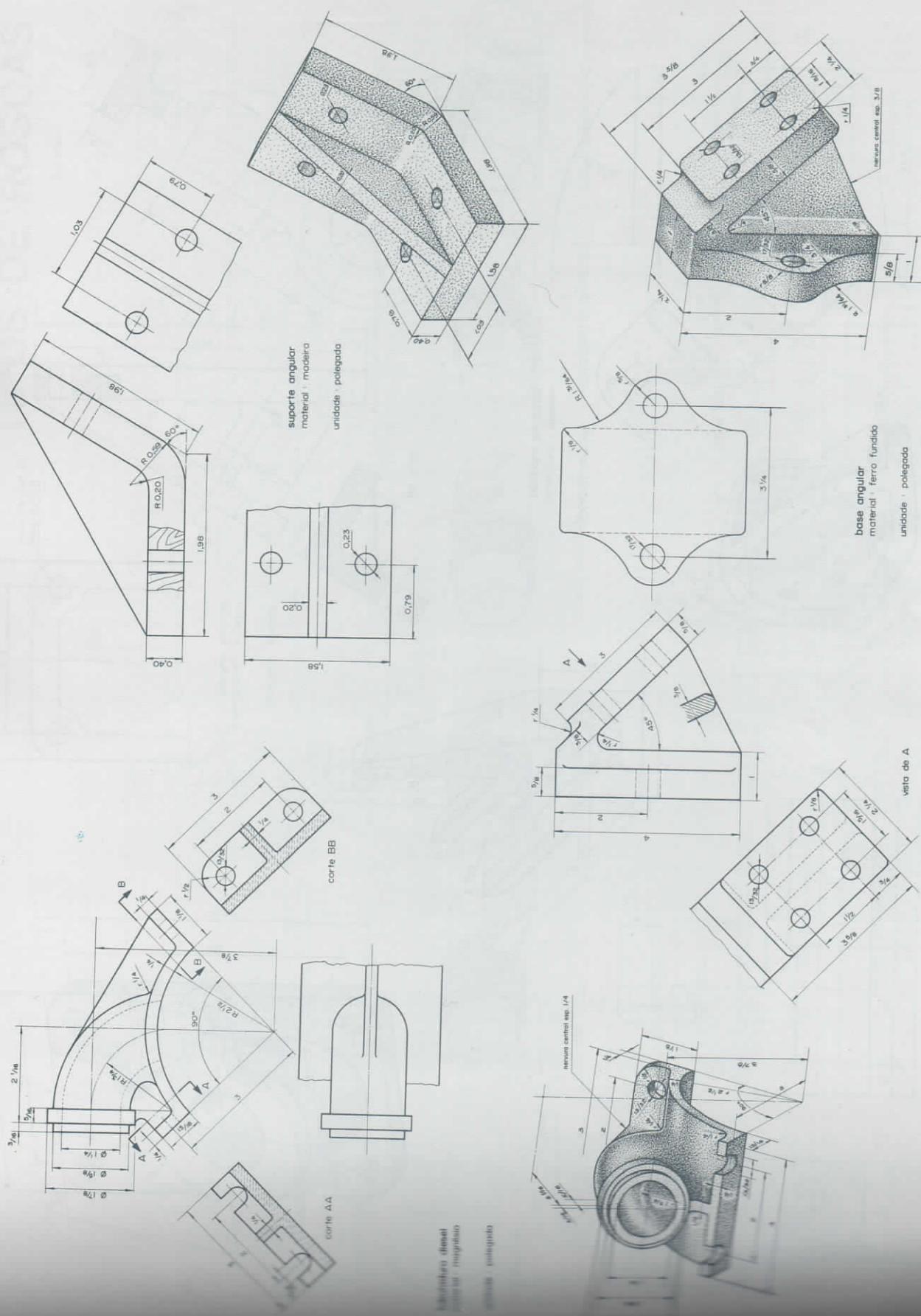


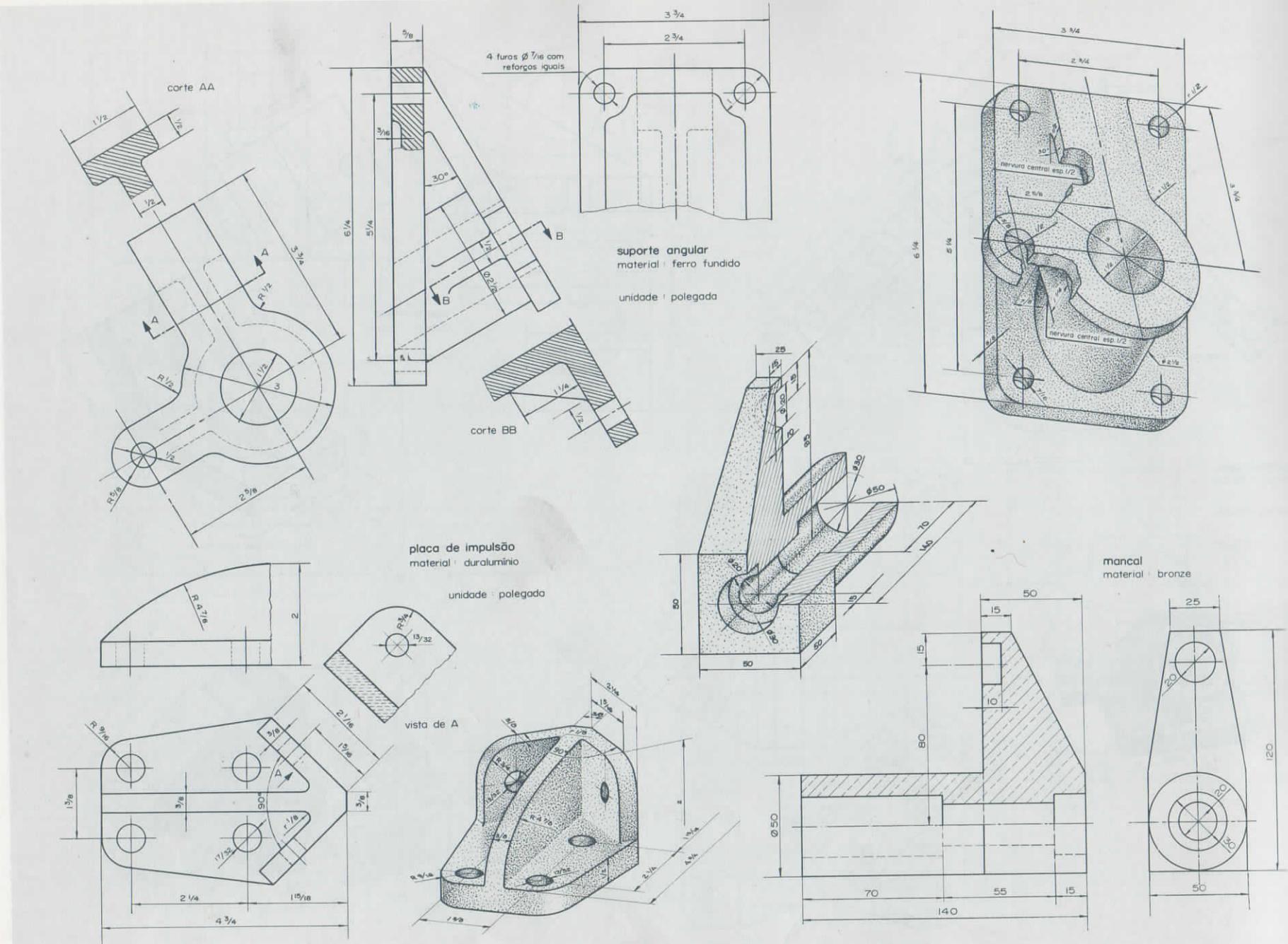
suporte de eixo
material: alumínio



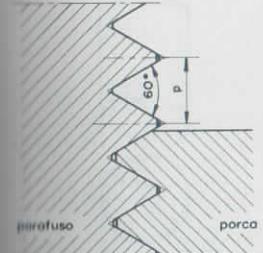
base
material : ferro fundido



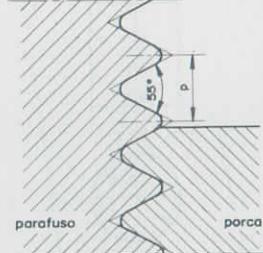




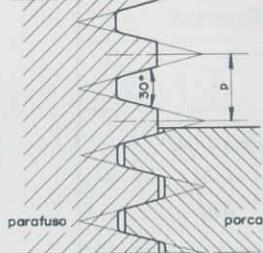
TIPOS DE ROSCAS



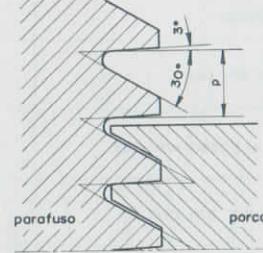
rosca métrica



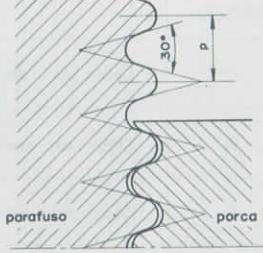
rosca whitworth



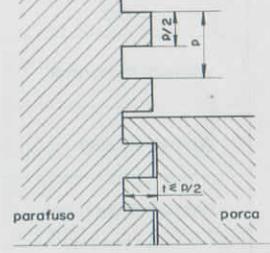
rosca trapezoidal



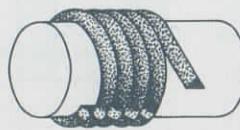
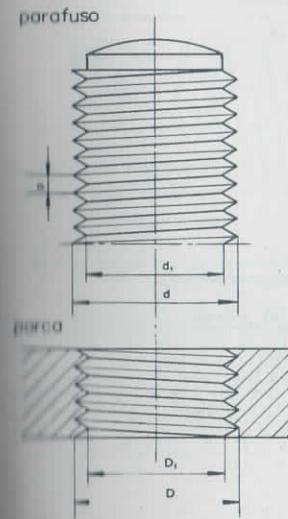
rosca dente de serra



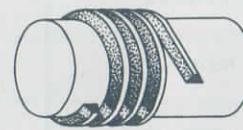
rosca de filete arredondado



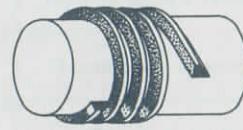
rosca quadrada



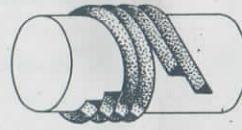
rosca triangular



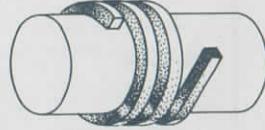
rosca trapezoidal



rosca dente de serra



rosca com 2 entradas



rosca quadrada à esquerda

LEGENDA

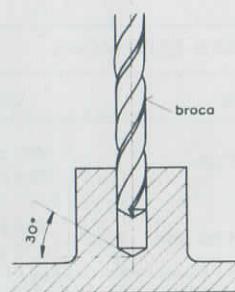
p = passo

d = diâmetro indicativo da rosca
(diâmetro externo do parafuso)

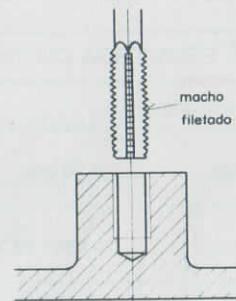
d_i = diâmetro interno do parafuso

D = diâmetro externo da rosca da porca

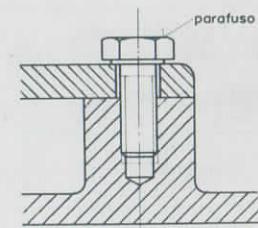
D_i = diâmetro do furo da porca



Furação



Abertura da rosca



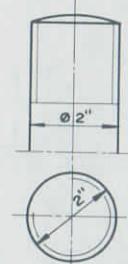
Montagem

INDICAÇÃO DAS ROSCAS

ROSCAS À DIREITA COM UMA ENTRADA			
Tipo	Símbolo	Medidas	Exemplo
Whitworth normal	—	Diâm. ext. da rosca em pol.	2"
Whitworth fina	W	Diâm. ext. em mm e passo em pol.	W 84 x 1/8"
Whitworth de tubos	R	Diâm. nominal do tubo em pol.	R 4"
Métrica normal	M	Diâm. ext. da rosca em mm.	M 80
Métrica fina	M	Diâm. ext. da rosca em mm e passo em mm.	M 104 x 4
Trapezoidal	Tr	Diâm. ext. da rosca em mm e passo em mm.	Tr 48 x 8
Redonda	Rd	Diâm. ext. da rosca em mm e passo em pol.	Rd 40 x 1/8"
Dentes de serra	S	Diâm. ext. da rosca em mm e passo em mm.	S 70 x 10
Edison	E	Diâm. nominal em mm.	E 27

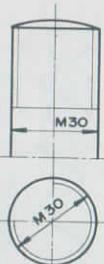
ROSCAS À ESQUERDA OU COM VÁRIAS ENTRADAS				
Tipo da rosca	Abreviatura	Exemplos		Válido para
Gás e vapor	gás	M 20 gás	2" gás	Métrica, Whitworth e Whitworth de tubos
Esquerda	esq.	W 104 x 1/8" esq.	M 80 esq.	Whitworth Métrica
Várias entradas à direita	(1 ent.)	2" (2 ent.)	Tr 48 x 16 (2 ent.)	Trapezoidal Redonda
Várias entradas à esquerda	esq. (1 ent.)	M 10 esq. (2 ent.)	Tr 48 x 16 esq. (2 ent.)	Dentes de serra

Parafuso



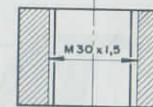
Parafuso com rosca Whitworth normal de diâm. 2"

Parafuso

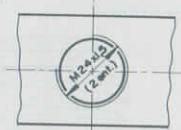
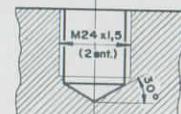


Parafuso com rosca Métrica normal de diâm. 30mm

Furo roscado passante

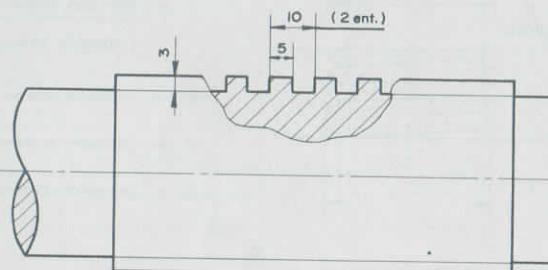


Furo roscado cego



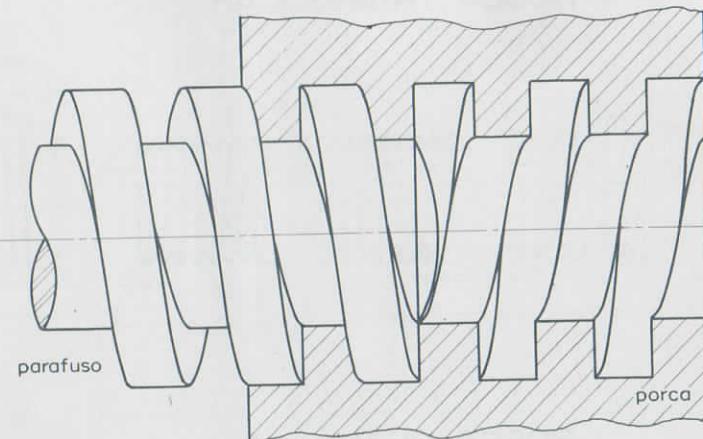
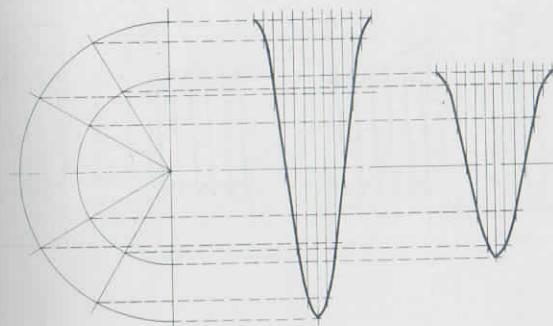
Rosca métrica fina de diâm. 30mm e passo 1,5mm.

As roscas quadradas têm a seguinte indicação:



TRAÇADO DE ROSCAS

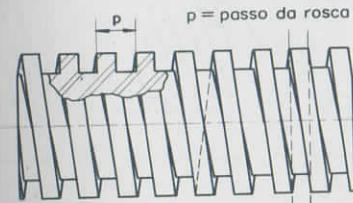
TRAÇADO EXATO DE UMA ROSCA



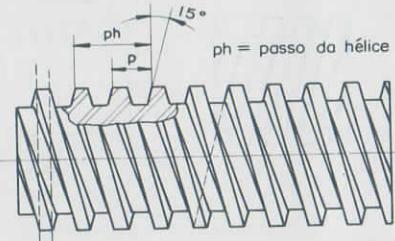
Observar a diferença entre o traçado do parafuso e da porca.

O traçado exato de uma rosca é raramente empregado nos desenhos a não ser em roscas de grandes diâmetros. Para casos comuns deve-se usar o traçado simplificado como nas figuras abaixo.

ROSCA QUADRADA COM UMA ENTRADA À DIREITA



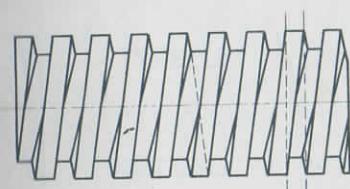
ROSCA TRAPEZOIDAL COM DUAS ENTRADAS À DIREITA



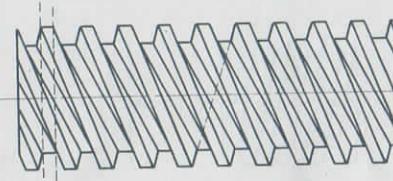
REPRESENTAÇÃO SIMPLIFICADA DE UMA ROSCA QUADRADA



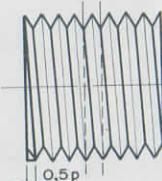
ROSCA QUADRADA COM UMA ENTRADA À ESQUERDA



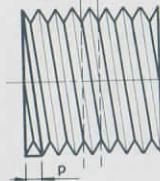
ROSCA TRAPEZOIDAL COM TRÊS ENTRADAS À DIREITA



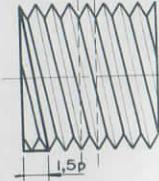
UMA ENTRADA



DUAS ENTRADAS



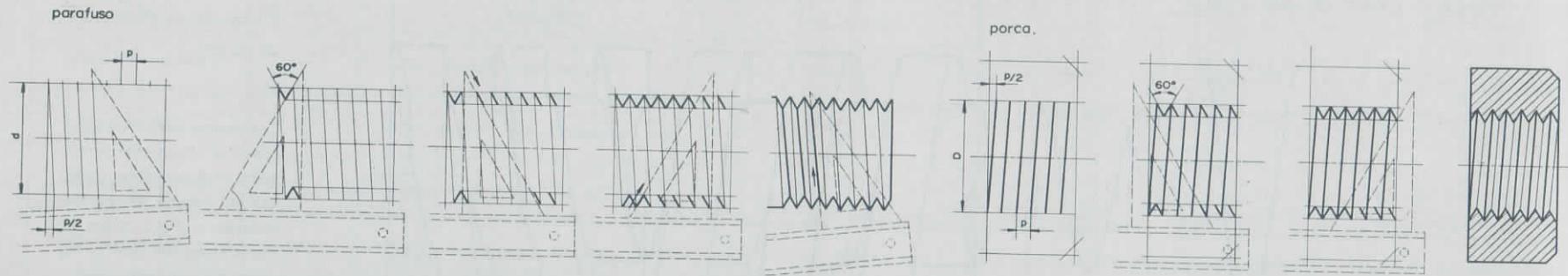
TRÊS ENTRADAS



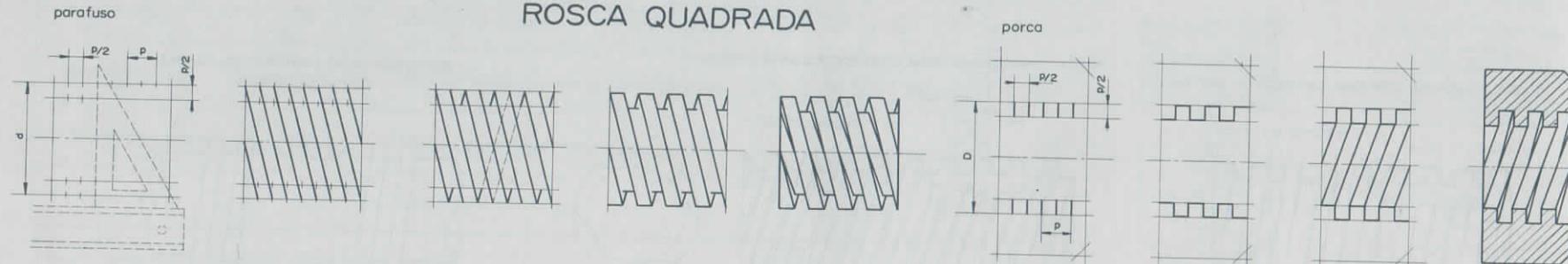
Observar pelas linhas tracejadas, perpendiculares à linha de centro do parafuso que nas roscas com número par de entradas o dente de um lado coincide com o dente do lado oposto e nas roscas com número ímpar de entradas, o dente de um lado coincide com o vão do lado oposto.

SEQUÊNCIA DO TRAÇADO DE ROSCAS

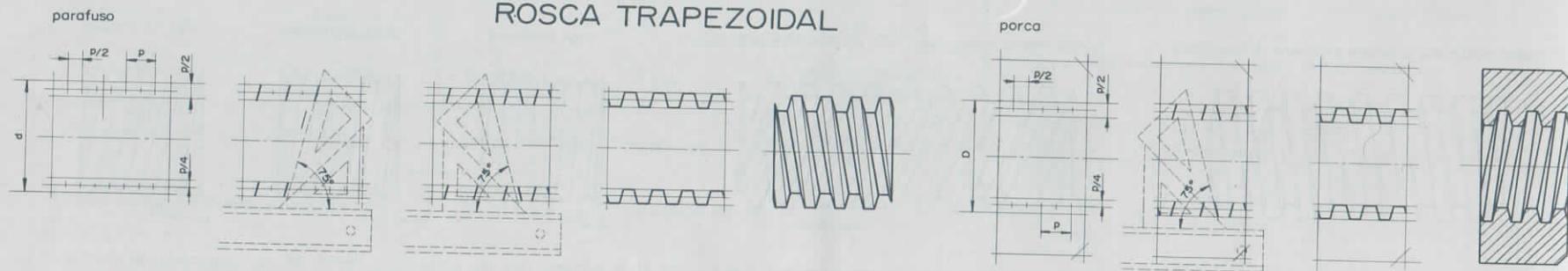
ROSCA TRIANGULAR



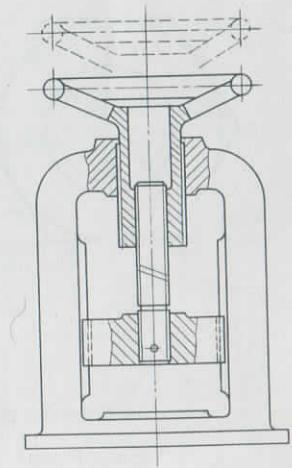
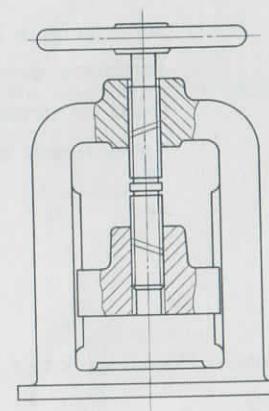
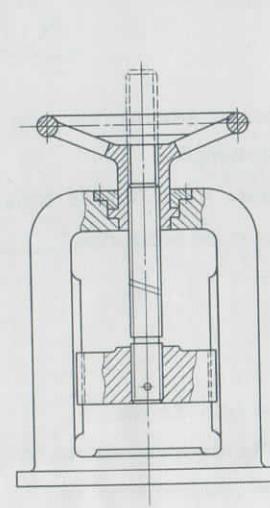
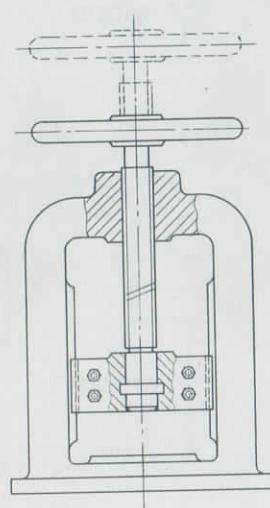
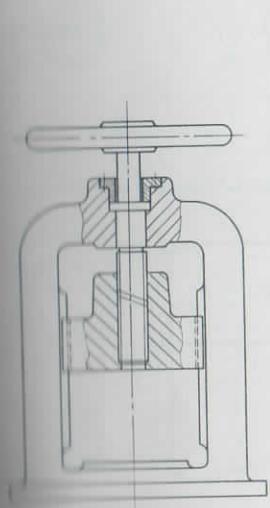
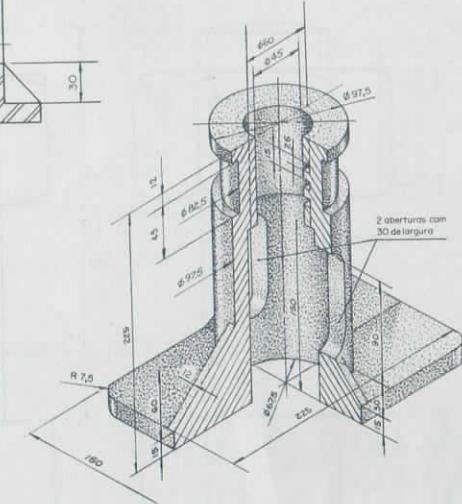
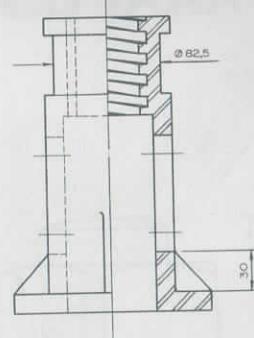
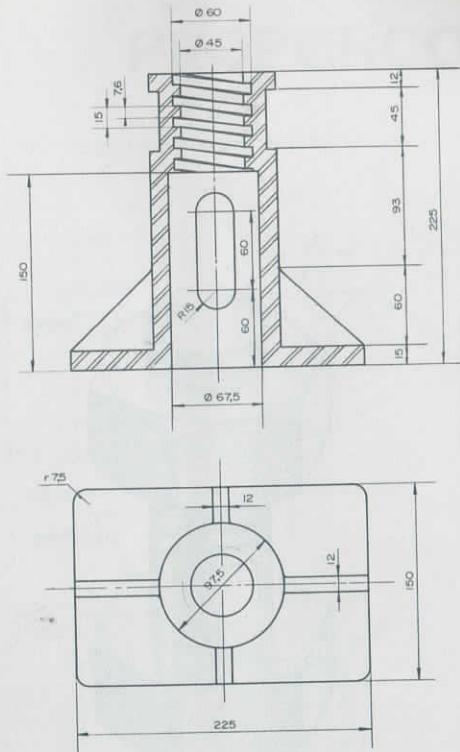
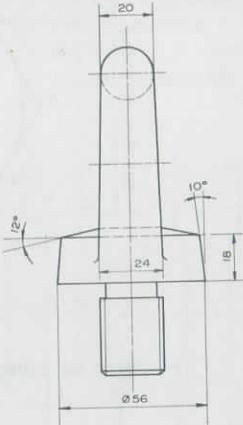
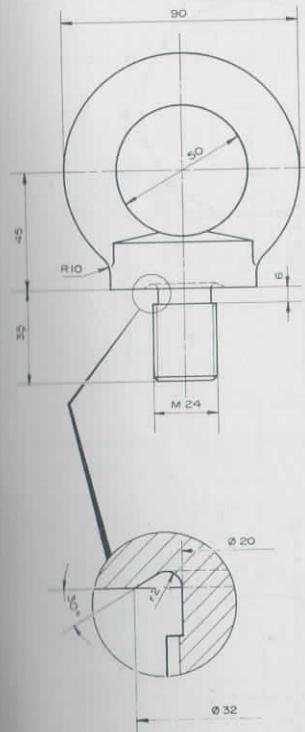
ROSCA QUADRADA



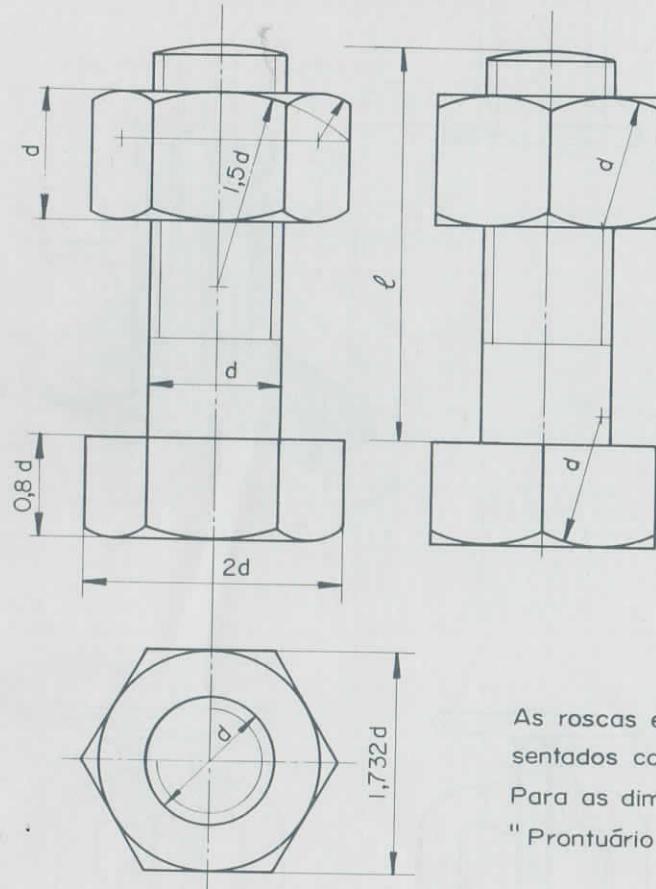
ROSCA TRAPEZOIDAL



APLICAÇÃO DE ROSCAS



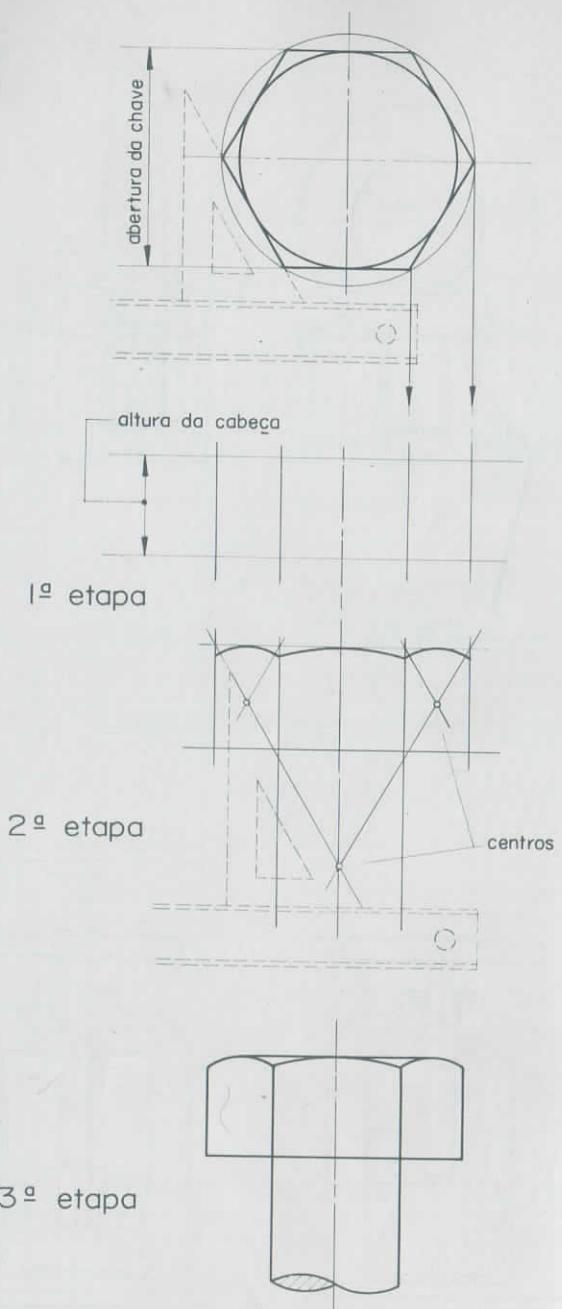
PORCA E PARAFUSO



Indicação do parafuso: Parafuso $k \times \ell$
Ex.: Paraf. M15 x 50

As rosas e os parafusos sextavados são representados com estas proporções.
Para as dimensões reais, consultar as tabelas de "Prontuário do Projetista de Máquinas".

k = tipo da rosca
 d = diâmetro da rosca
 ℓ = comprimento útil

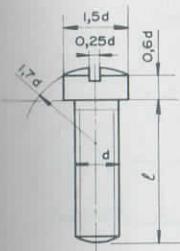


PROPORÇÕES DOS PARAFUSOS

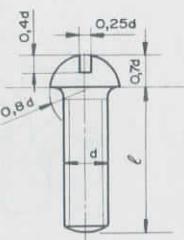
Indicação: Paraf. zkd x l

z = tipo do parafuso
 k = tipo da rosca
 d = diâmetro da rosca
 l = comprimento útil

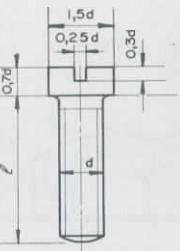
Ex.: Paraf. cabeça chata M10x30.



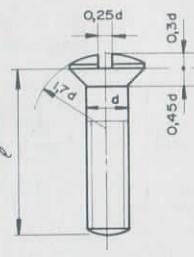
cabeça cilíndrica oval



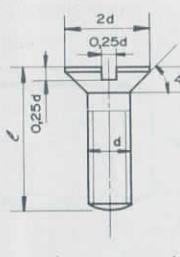
cabeça redonda



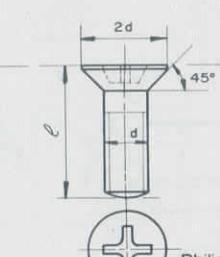
cabeça cilíndrica



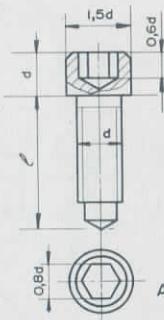
cabeça escareada oval



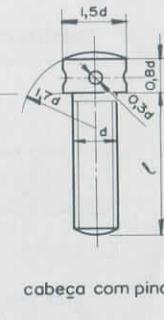
cabeça escareada



Philip

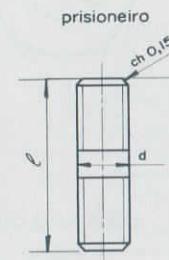
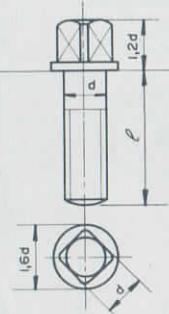
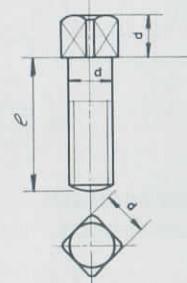
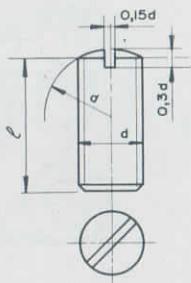
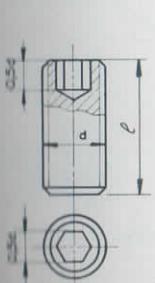


Allen

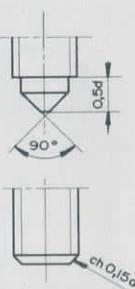
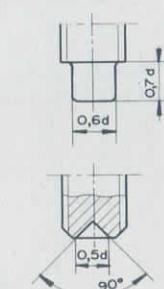
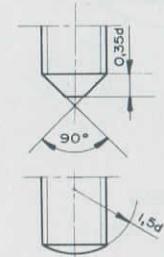


cabeça com pino

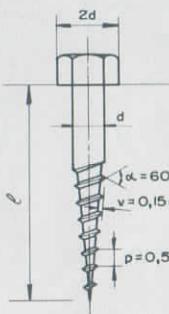
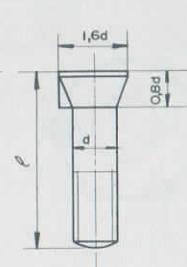
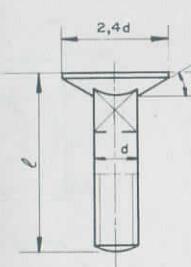
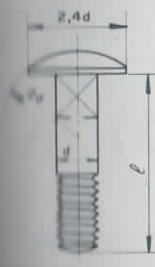
PARAFUSOS DE FIXAÇÃO



EXTREMIDADES INTERIORES DOS PARAFUSOS



PARAFUSOS PASSANTES PARA MADEIRA

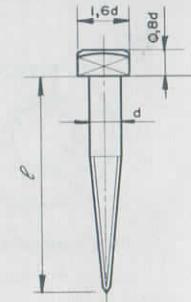
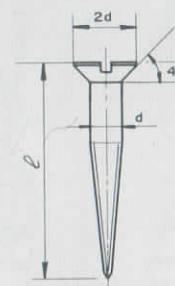
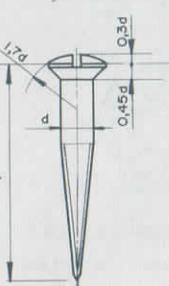
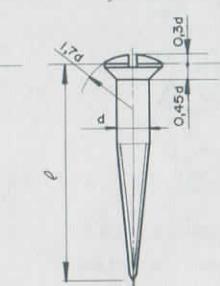


$\alpha = 60^\circ$

$v = 0.15d$

$p = 0.5d$

PARAFUSOS PARA MADEIRA COM ROSCA SOBERBA



cabeça lenticular

cabeça chata

cabeça cônica

cabeça sextavada

cabeça redonda

cabeça oval

cabeça chata

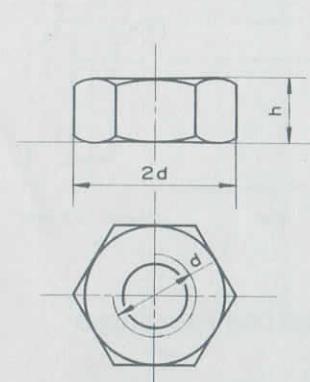
cabeça quadrada

TIPOS DE PORCAS

Indicação : Porca ykd
Ex. : Porca cega M20

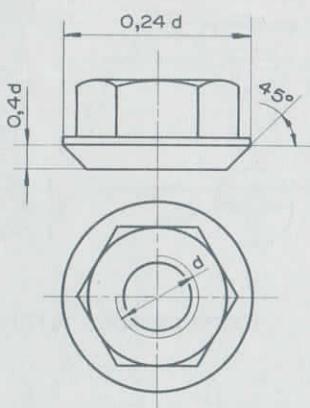
y = tipo da porca
k = tipo da rosca
d = diâmetro da rosca

sextavada

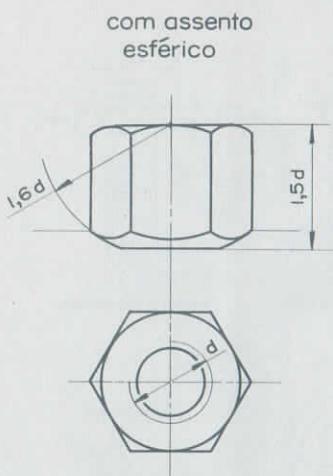


porca pesada : $h = d$
porca normal : $h = 0,8d$
porca leve : $h = (0,4 \div 0,6)d$

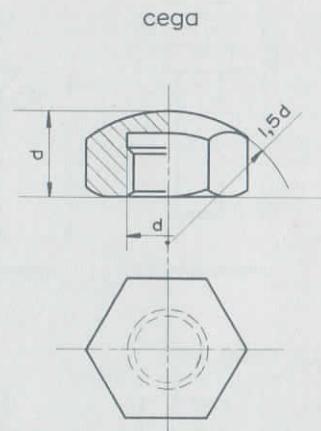
com assento cônico



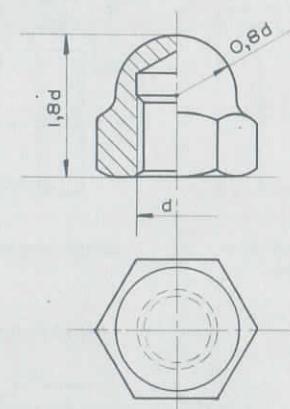
com assento esférico



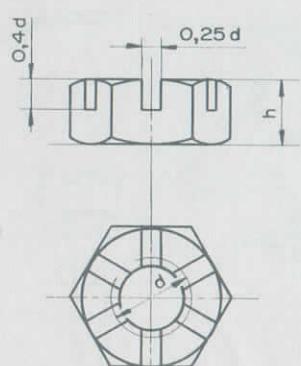
cega



chapéu

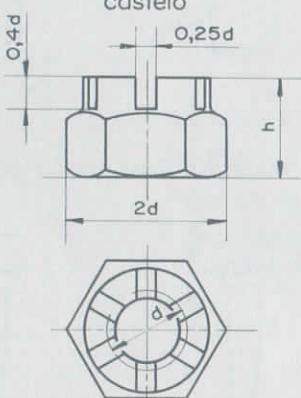


com entalhes radiais



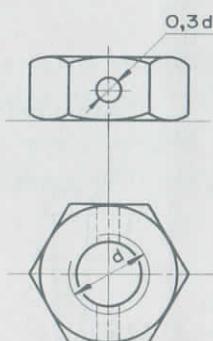
porca pesada : $h = 1,4d$
porca normal : $h = 0,8d$

castelo

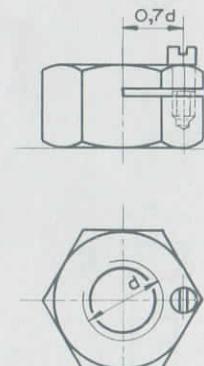


porca pesada : $h = 1,4d$
porca normal : $h = 0,8d$

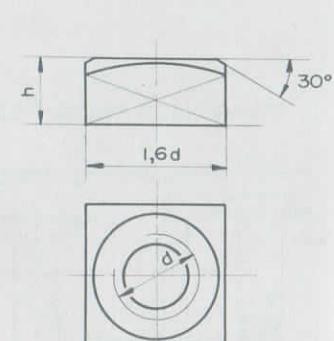
com furo de fixação



com parafuso de fixação



quadrada



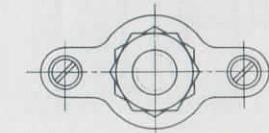
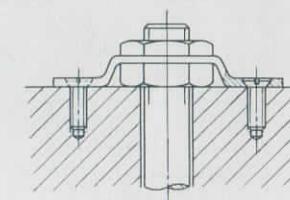
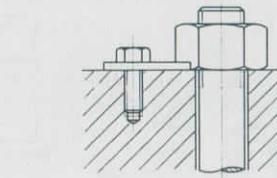
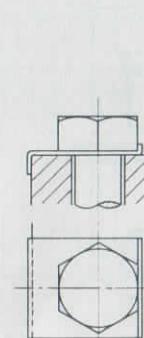
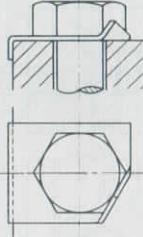
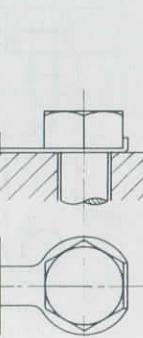
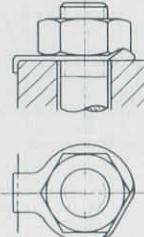
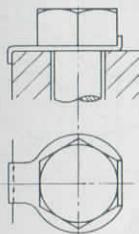
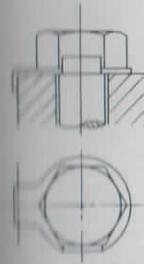
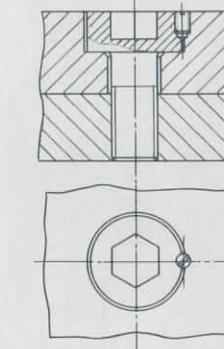
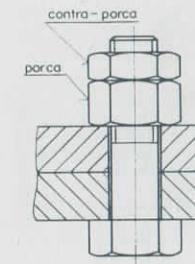
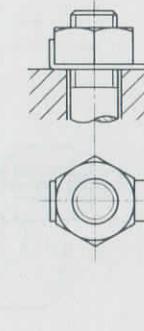
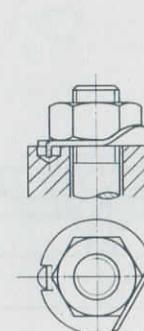
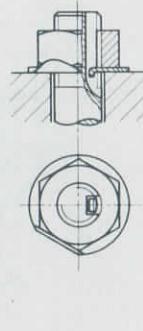
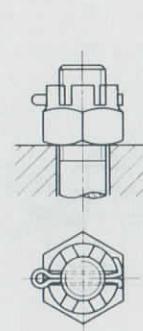
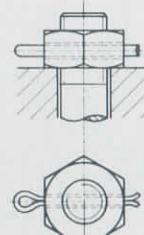
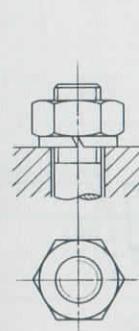
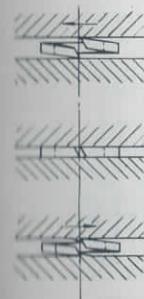
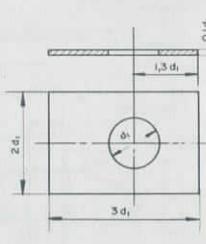
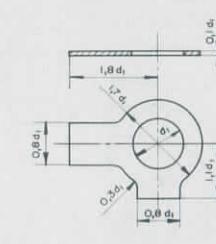
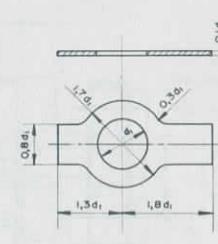
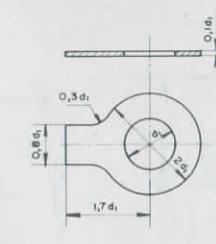
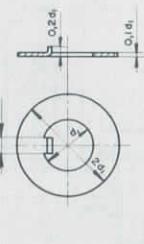
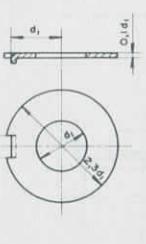
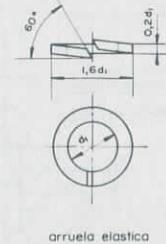
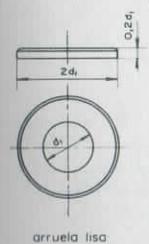
porca alta : $h = 0,8d$
porca baixa : $h = 0,5d$

ARRUELAS E DISPOSITIVOS DE SEGURANÇA

Indicação arruela d_1

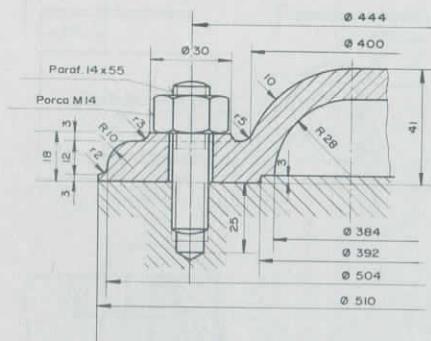
$d_1 \approx l_1 d$

$d = \text{diâmetro do parafuso}$

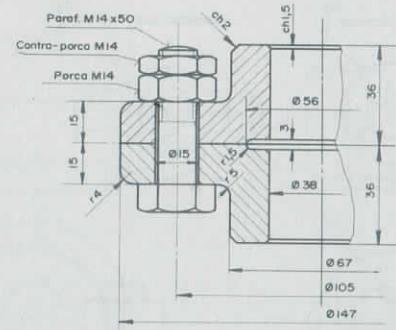


EXEMPLOS DE APLICAÇÃO

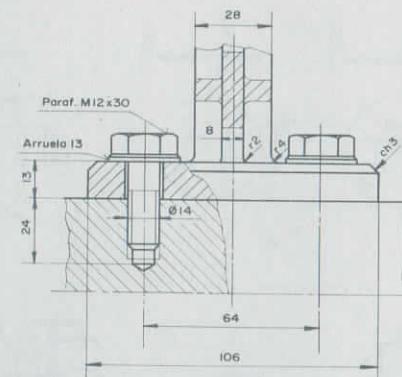
PARAFUSO PRISIONEIRO



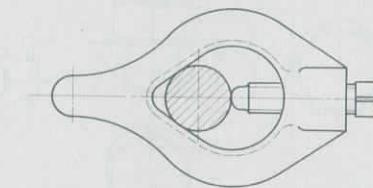
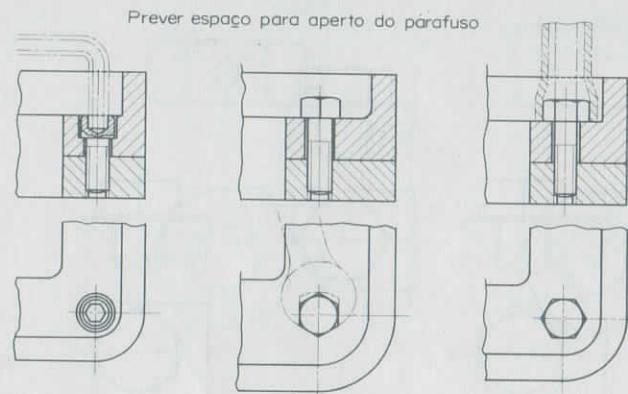
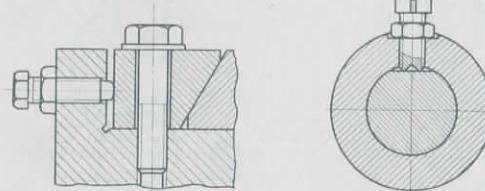
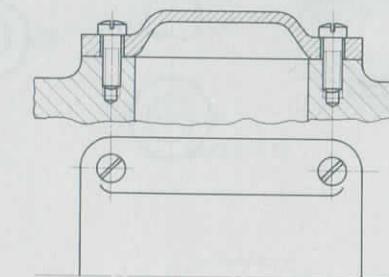
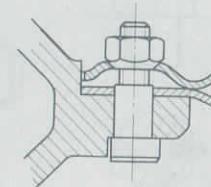
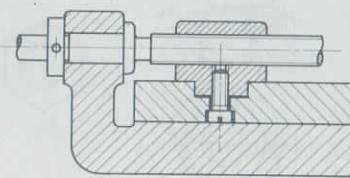
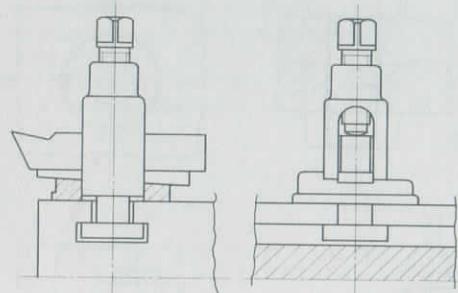
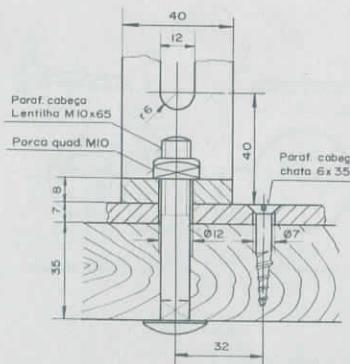
PARAFUSO PASSANTE

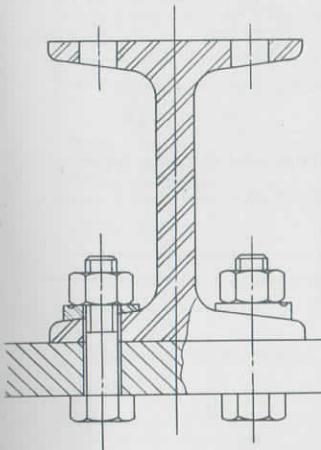
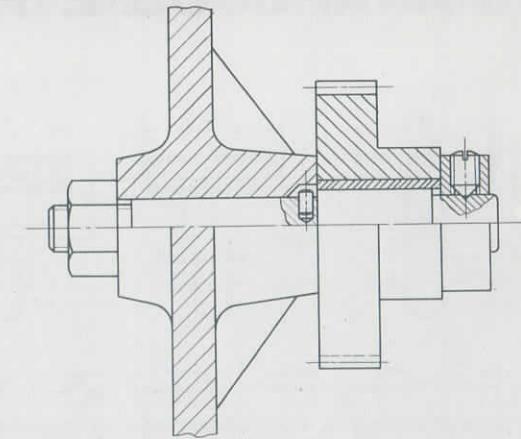
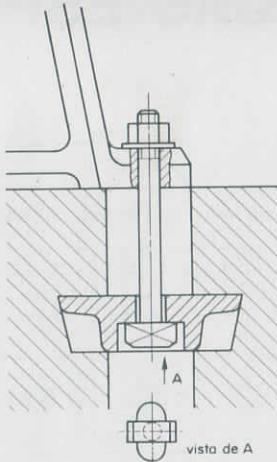
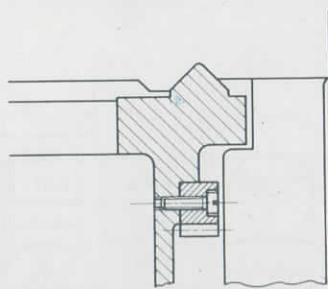
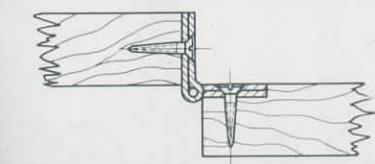


PARAFUSO DE FIXAÇÃO

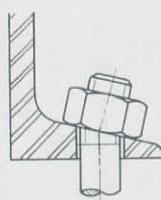


UNIÃO MISTA METAL-MADEIRA

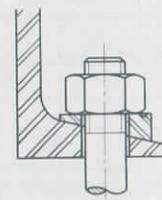




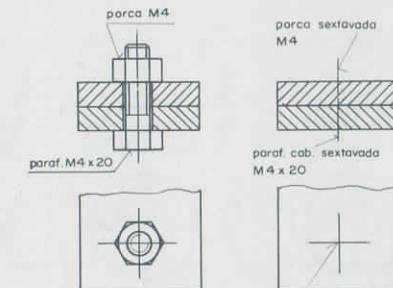
chapinha



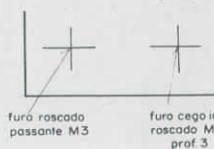
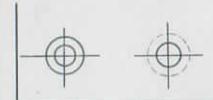
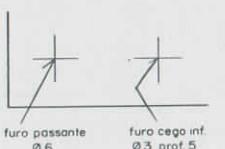
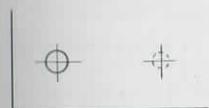
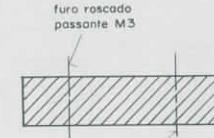
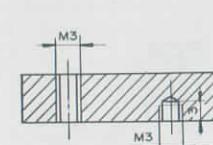
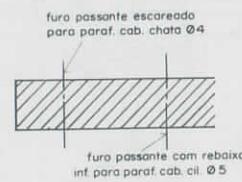
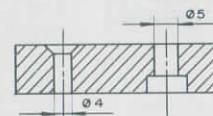
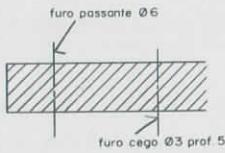
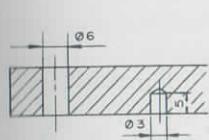
errado



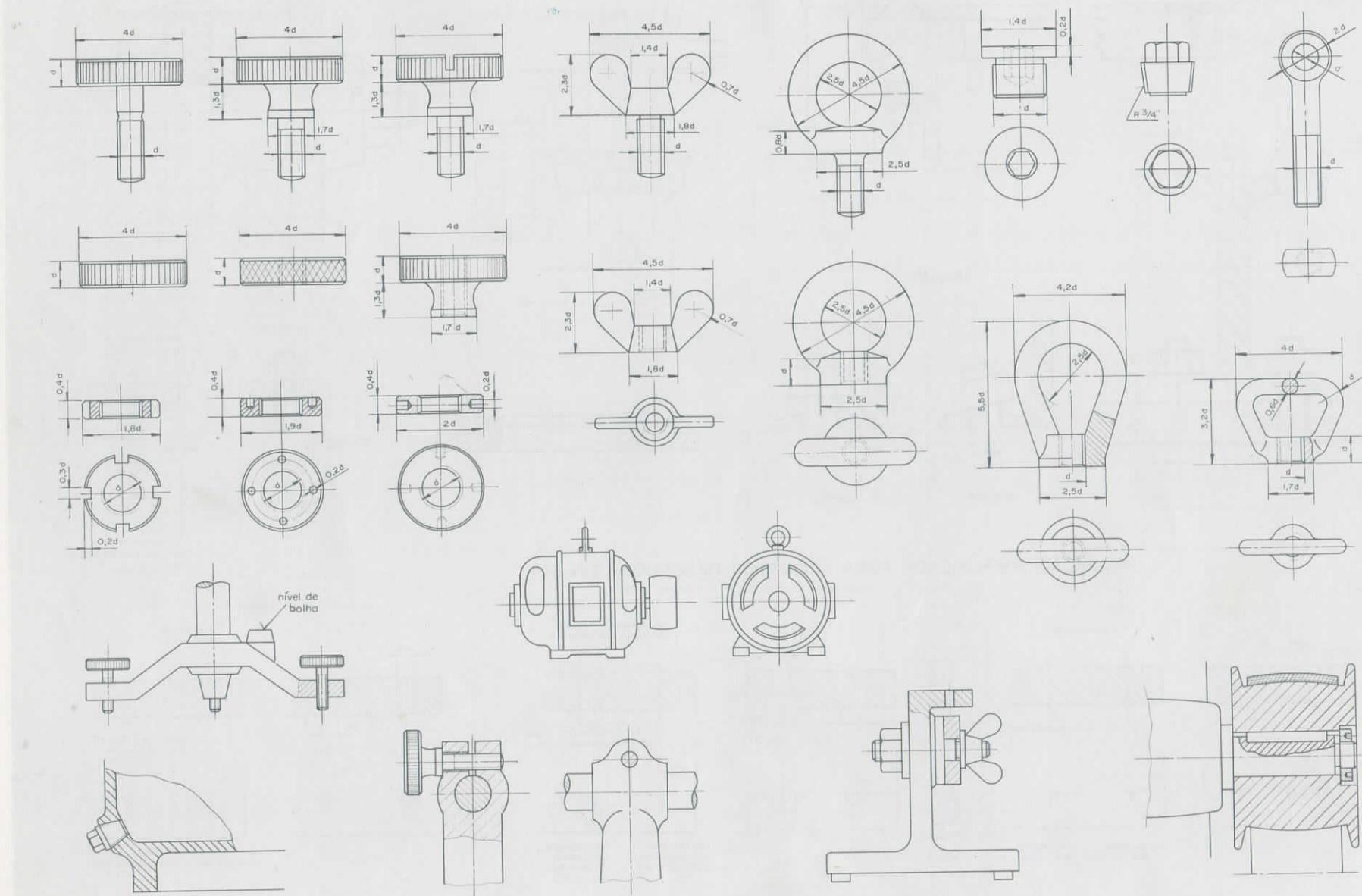
certo



INDICAÇÃO SIMPLIFICADA PARA PEQUENOS DESENHOS. (DIN 30)



PARAFUSOS E PORCAS ESPECIAIS

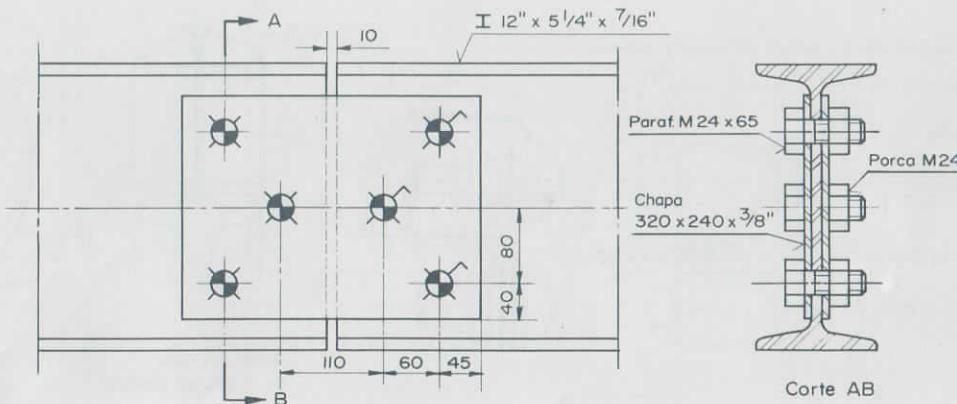


SÍMBOLOS DE PARAFUSOS

Indicação da rôsca	M 8	M 10	M 12	(M 14)	M 16	(M 18)	M 20	M 22	M 24	M 27	M 30	(M 33)	M 36
Diâmetro do parafuso (mm)	8	10	12	14	16	18	20	22	24	27	30	33	36
Secção do núcleo (mm ²)	31,9	50,9	74,3	102	140	171	220	276	317	419	509	636	745
Diâmetro do furo (mm)	8,4	11	13	15	17	19	21	23	25	28	31	34	37
SÍMBOLOS CONVENCIONAIS	Parafuso com furo passante de série normal	8,4											
	Parafuso com furo passante fora de série												
	Furo rosado												
	Parafuso com cabeça embutida												
	Parafusar na montagem	8,4											
	Furar na montagem	8,4											

Até à escala 1:5 os símbolos convencionais serão representados com diâmetros iguais aos furos, para escalas menores usar-se-ão diâmetros iguais às cabeças dos parafusos.

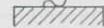
Evitar os valores entre parênteses.



INDICAÇÃO DO ACABAMENTO E TRABALHO SUPERFICIAL



Superfícies em bruto.



Superfícies em bruto, porém, limpas de rebarbas e saliências.



Superfícies apenas desbastadas



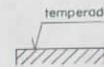
Superfícies alisadas



Superfícies polidas



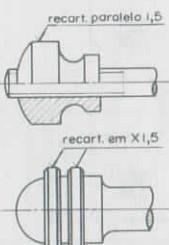
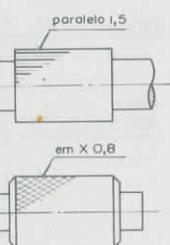
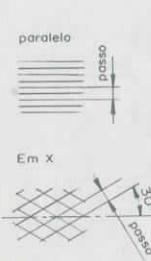
Para qualquer outro acabamento, indicar ao lado o modo de obtê-lo.



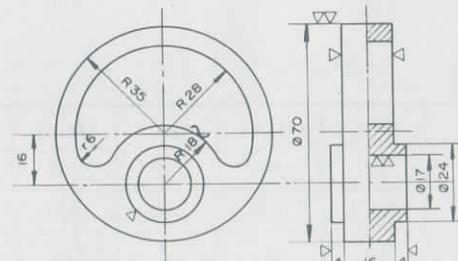
Superfícies sujeitas a tratamento especial, são indicadas sobre uma linha horizontal.
Ex.: temperado, niquelado, pintado, etc.

Estes sinais são indicados sobre as linhas de contorno da superfície em consideração, ou na impossibilidade, sobre as linhas de chama-
da que saem desta.

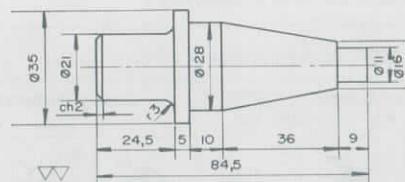
O recartilhado é indicado da seguinte maneira:



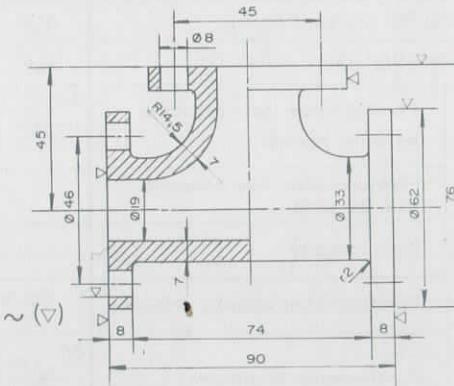
Passos aconselhados – Paralelo: 0,5 – 0,8 – 1 – 1,5 mm
Em X : 0,5 – 0,8 – 1 – 1,5 – 2 mm



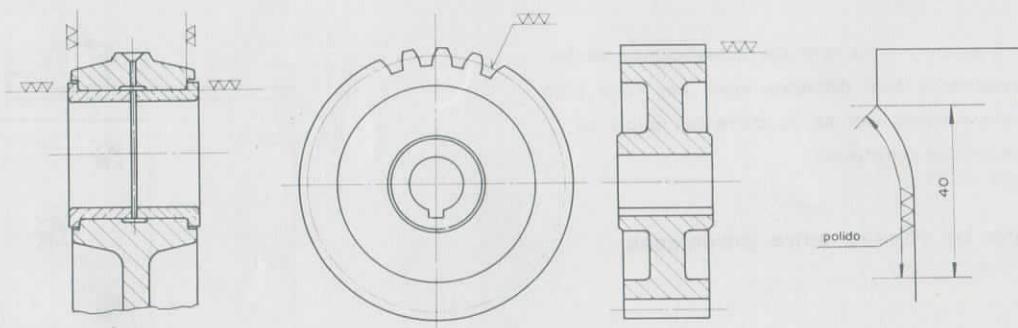
Cada superfície é indicada com o sinal de trabalho relativo.



Quando todas as superfícies deverão receber o mesmo acabamento, o sinal de trabalho é indicado em baixo à esquerda do desenho ou em lugar visível.



Esta peça deverá ter todas as superfícies em bruto, sem rebabas, exceto as indicadas com ▽ as quais serão desbastadas.



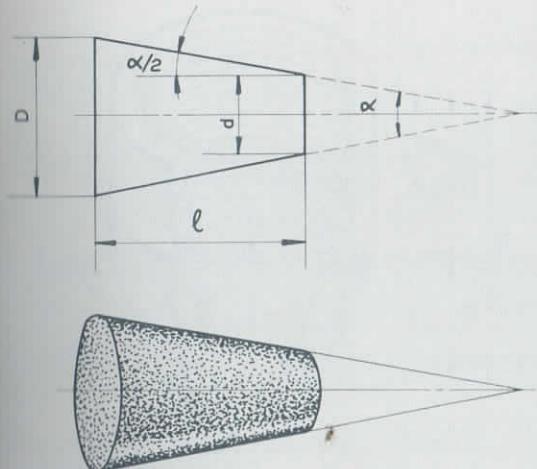
Neste exemplo:
As faces em contato
receberão, ambas, os
mesmos acabamentos.

O acabamento dos dentes das engrenagens
é indicado no diâmetro primitivo.

Se um determinado acabamento
só se referir a uma parte da su-
perfície, esta será indicada por
uma linha de cota (com ou
sem medida).

CONICIDADE E INCLINAÇÃO

CONICIDADE é a relação $(D-d) : l$



A conicidade é indicada paralelamente ao eixo, e seu valor pode ser calculado das seguintes maneiras:

$$k = \frac{l}{D-d} = \frac{100}{p\%} = \frac{1}{2} \cotg \frac{\alpha}{2}$$

$$p\% = 100 \frac{D-d}{l} = \frac{100}{K} = 200 \operatorname{tg} \frac{\alpha}{2}$$

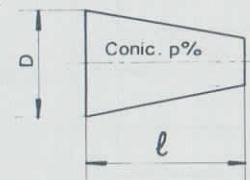
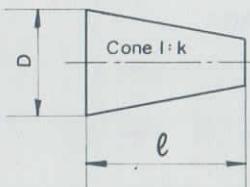
$$\alpha/2 = \operatorname{arc} \operatorname{tg} \left(\frac{D-d}{2} : l \right) = \operatorname{arc} \operatorname{tg} \frac{p\%}{200} = \operatorname{arc} \operatorname{cotg} 2K$$

CONICIDADES PADRONIZADAS

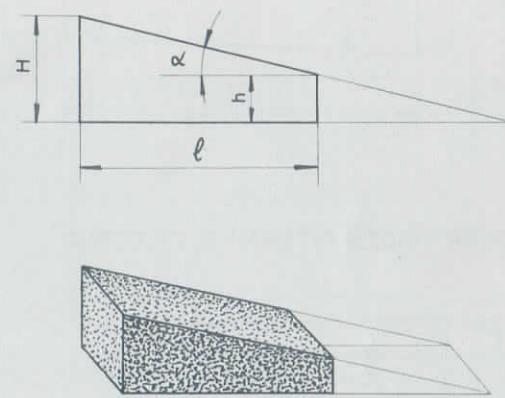
a) Cone Morse

Nº	Conicidade $l:k$
0	$l : 19,212$
1	$l : 20,047$
2	$l : 20,020$
3	$l : 19,922$
4	$l : 19,254$
5	$l : 19,002$
6	$l : 19,180$

b) Cone métrico: Conicidade $l:20 = 5\%$



INCLINAÇÃO é a relação $(H-h) : l$



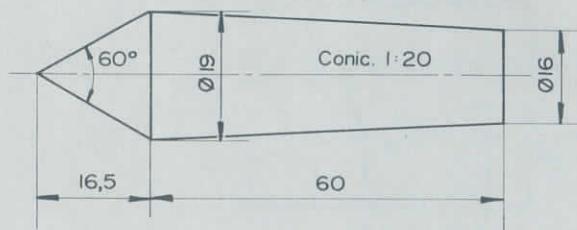
A inclinação é indicada paralelamente a face inclinada e seu valor pode ser calculado das seguintes maneiras.

$$k = \frac{l}{H-h} = \frac{100}{p\%} = \operatorname{cotg} \alpha$$

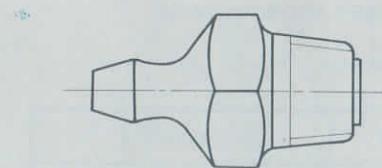
$$p\% = 100 \frac{H-h}{l} = \frac{100}{K} = 100 \operatorname{tg} \alpha$$

$$\alpha = \operatorname{arc} \operatorname{tg} \left(\frac{H-h}{l} \right) = \operatorname{arc} \operatorname{tg} \frac{p\%}{100} = \operatorname{arc} \operatorname{cotg} K$$

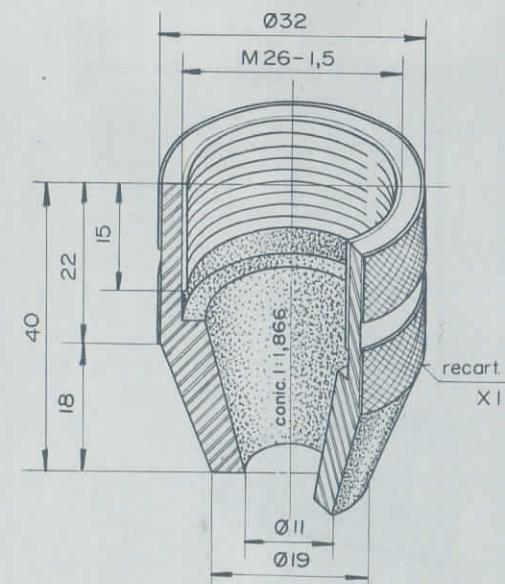
CONTRA-PINO FIXO



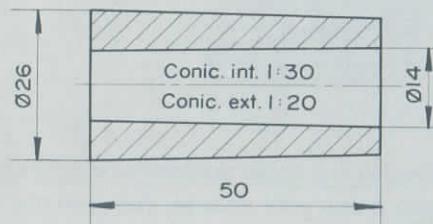
ENGRAXADEIRA LUB



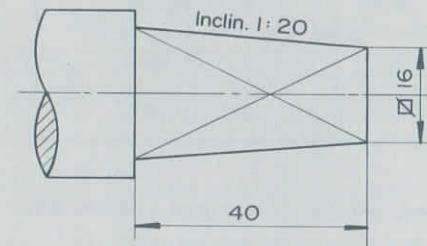
CAPA DO MANDRIL



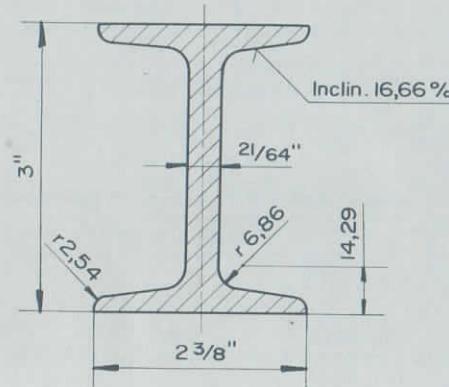
CONICIDADES INTERNA E EXTERNA



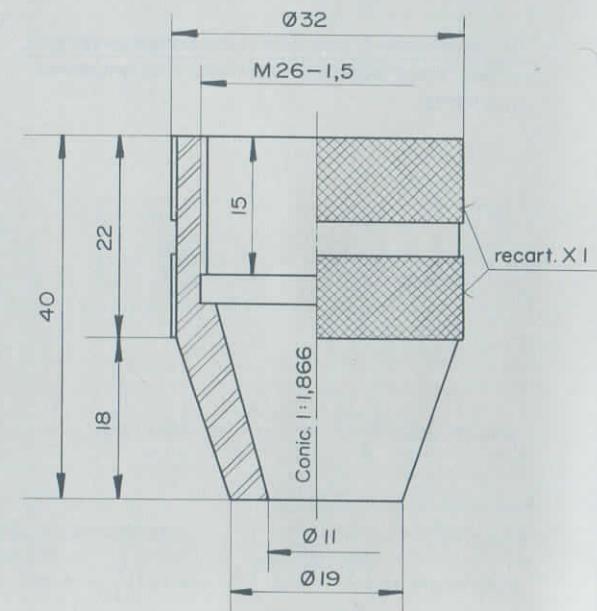
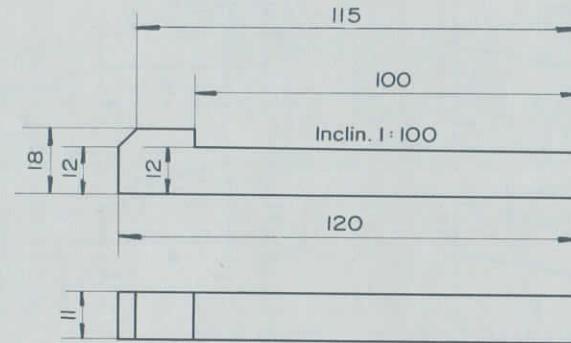
ESPIGA



PERFIL DE VIGAS

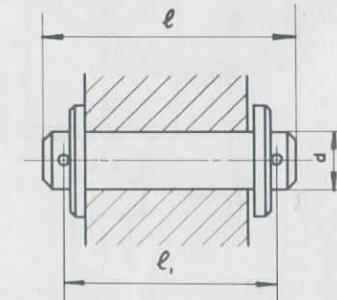
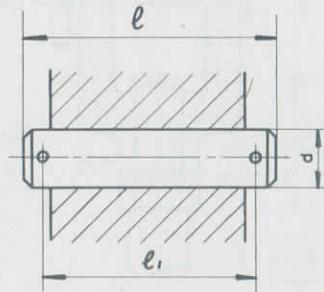
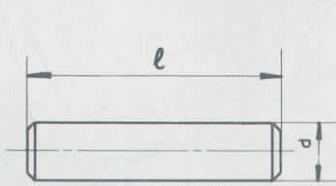
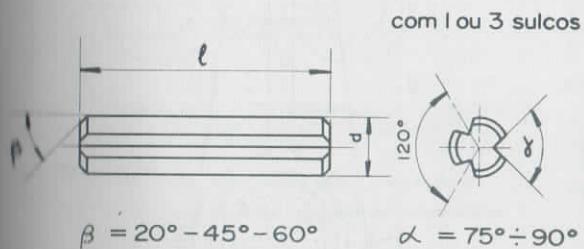


CHAVETA ENCAIXADA



PINOS E CONTRA-PINOS

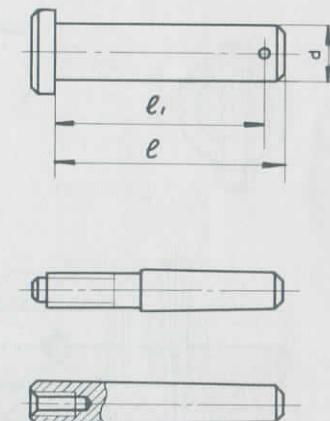
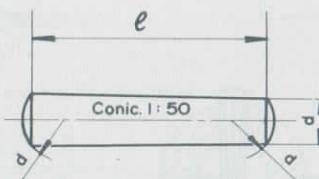
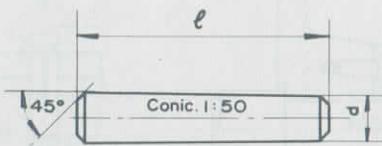
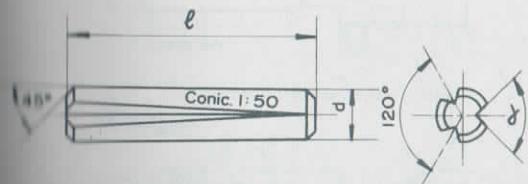
PINOS CILÍNDRICOS



Comprimentos l normais: 8-9-10-12 ... 22-25-28-30-35 ... 150-160 ... 320

Indicação de um pino $d \times l \times l_1$, Exemplos: Pino cil. sem cabeça 65x95x70
 Pino cil. com cabeça 10x35x31,5

PINOS CÔNICOS

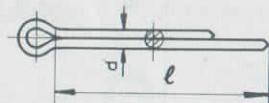


O diâmetro indicativo do pino cônicos é o menor.

Comprimentos l normais: 4 - 6 ... 32 - 36 - 40 - 45 ... 150 - 165 - 180 - 200 - 230 - 260

Indicação de um pino cônicos: Pino cônicos $d \times l$ Ex.: Pino cônicos 4x35

CONTRA-PINO



Material: aço

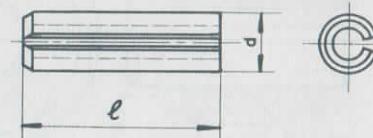
Material: outro metal

Indicação de um contra-pino

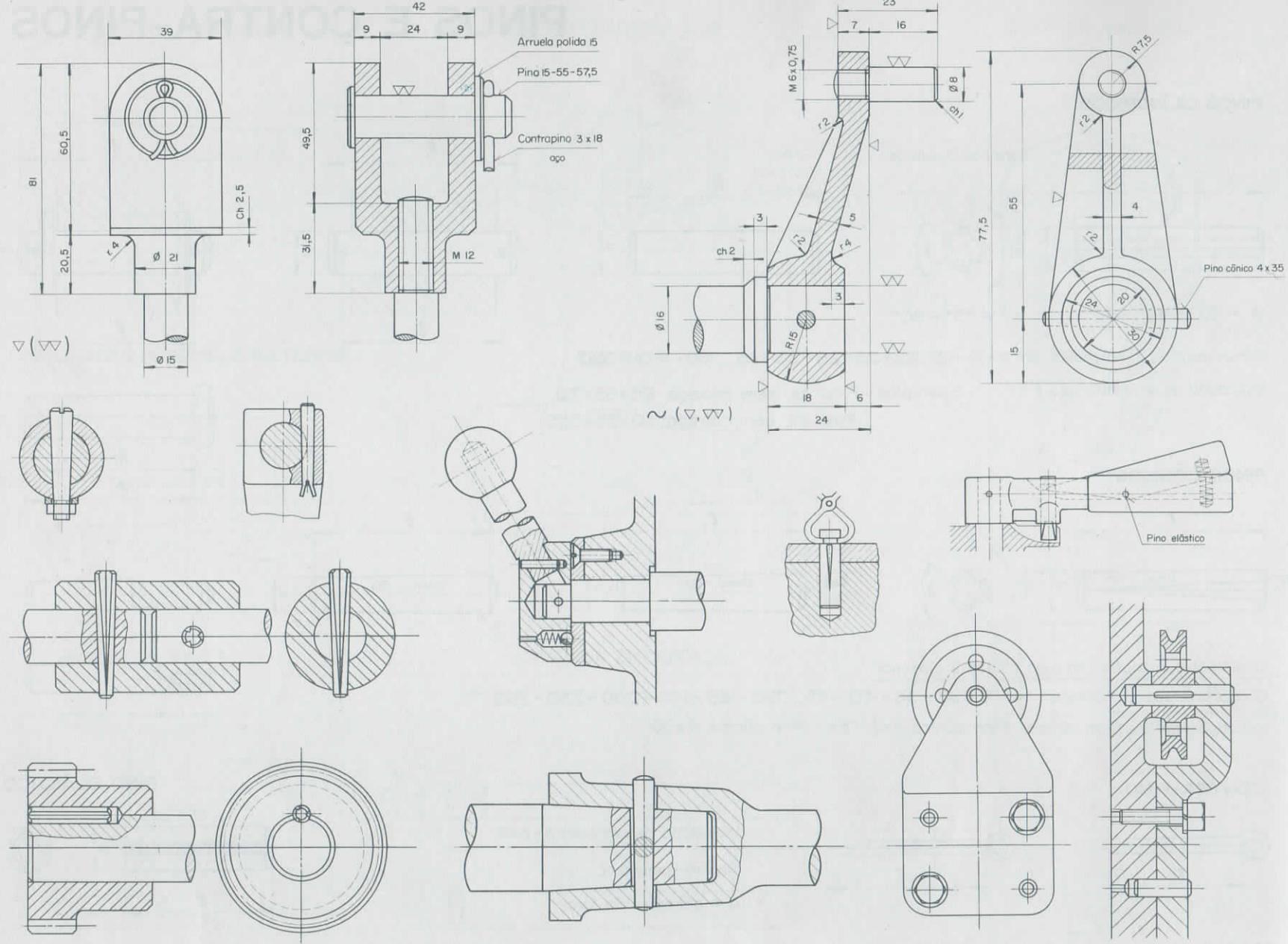
Contra-pino $d \times l$

d = diâmetro do furo

PINO ELÂSTICO

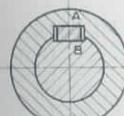


Indicação: Pino elástico $d \times l$



CHAVETAS E LINGUETAS

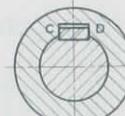
Chaveta
(união forjada)



trabalham as
faces A e B (inclin.)

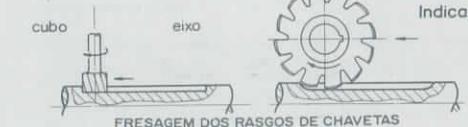
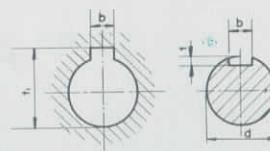
direção do golpe para montar
--- direção do golpe para desmontar

Linguela ou
chaveta deslizante



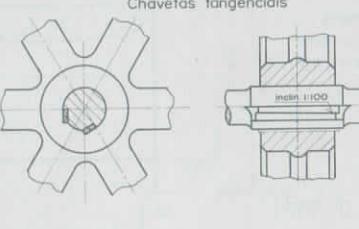
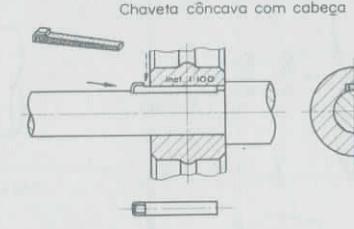
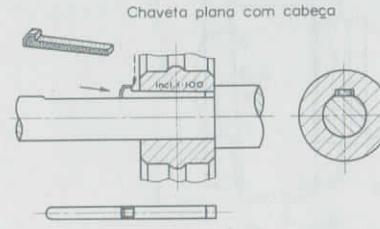
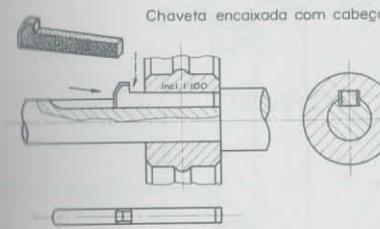
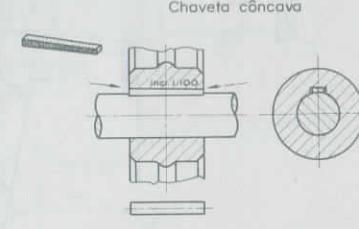
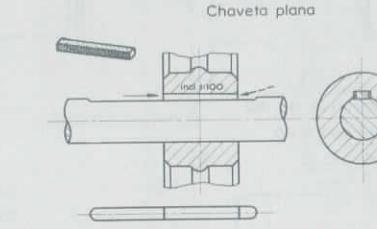
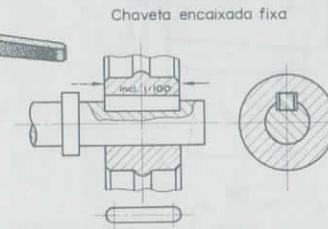
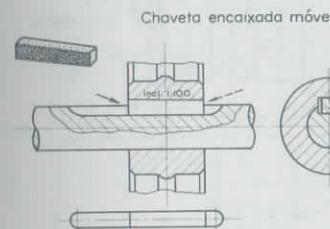
trabalham as
faces C e D (paralelas)

Dimensões dos rasgos

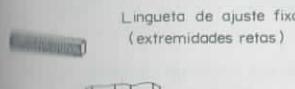


UNIÕES COM CHAVETAS

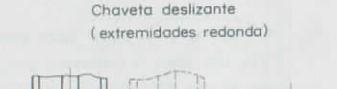
$$t \geq 1,5 d$$



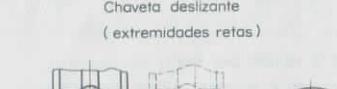
UNIÃO COM LINGUETAS



Linguela de ajuste fixo
(extremidades redondas)



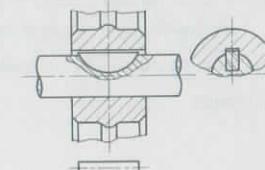
Chaveta deslizante
(extremidades redondas)



Chaveta deslizante
(extremidades retas)

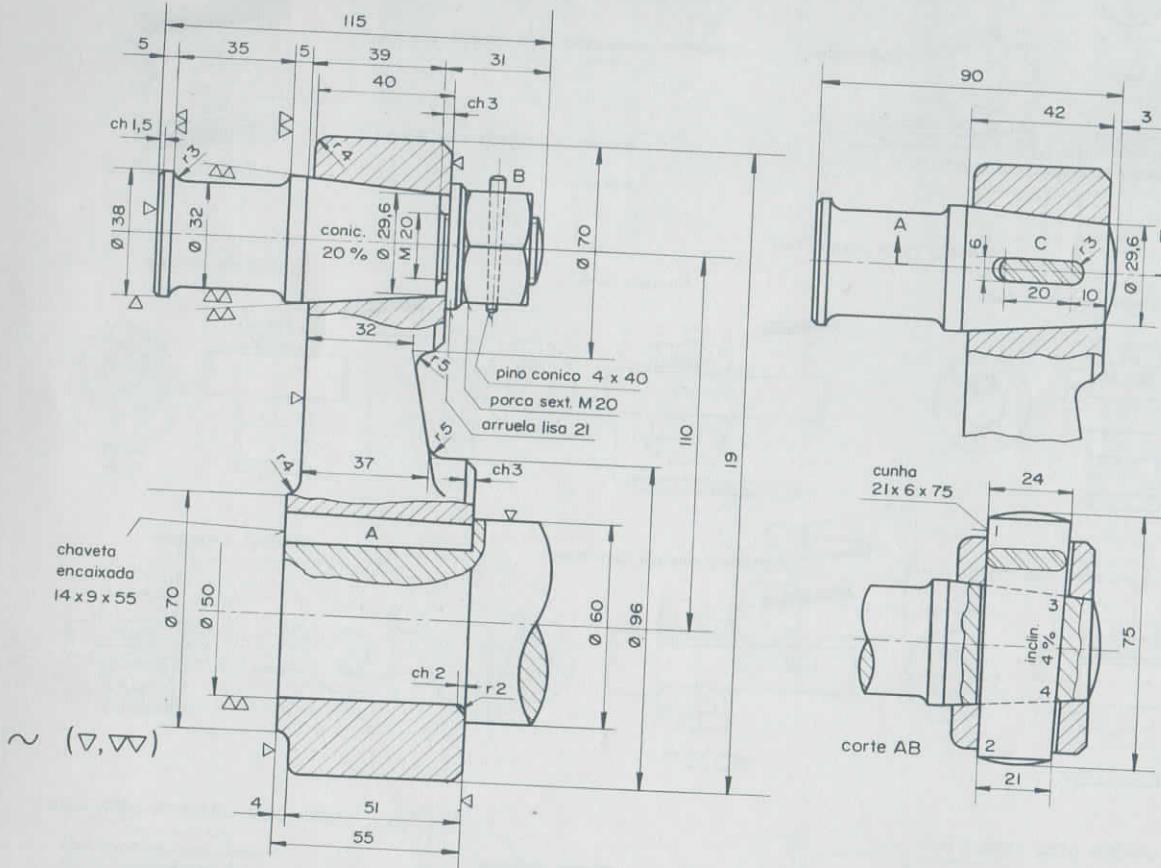
UNIÃO COM CHAVETA MEIA LUA

Chaveta meia-lua, americana
ou WOODRUFF



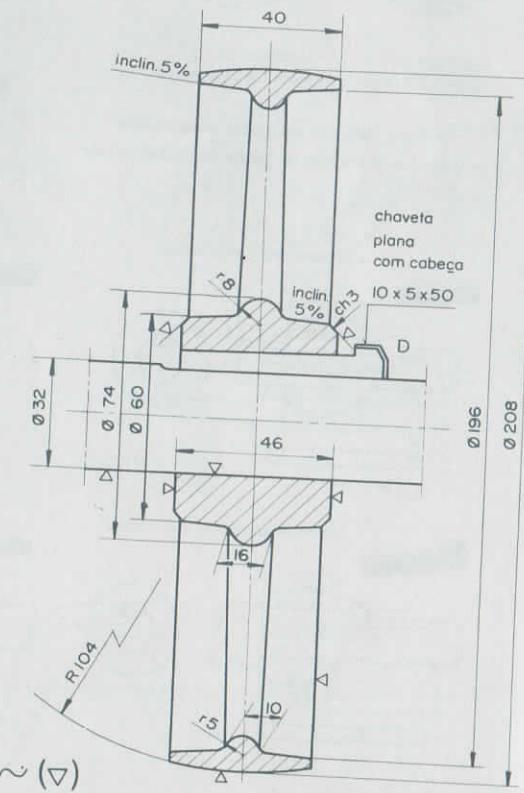
UNIÕES FORÇADAS - EFEITO DE CUNHA

MANIVELA DE EXTREMIDADE



A união do eixo com a manivela é obtida por meio da chaveta encaixada (A). O pino da manivela é forçado no seu lugar por meio da porca (B) na qual é colocado um pino cônic de segurança.

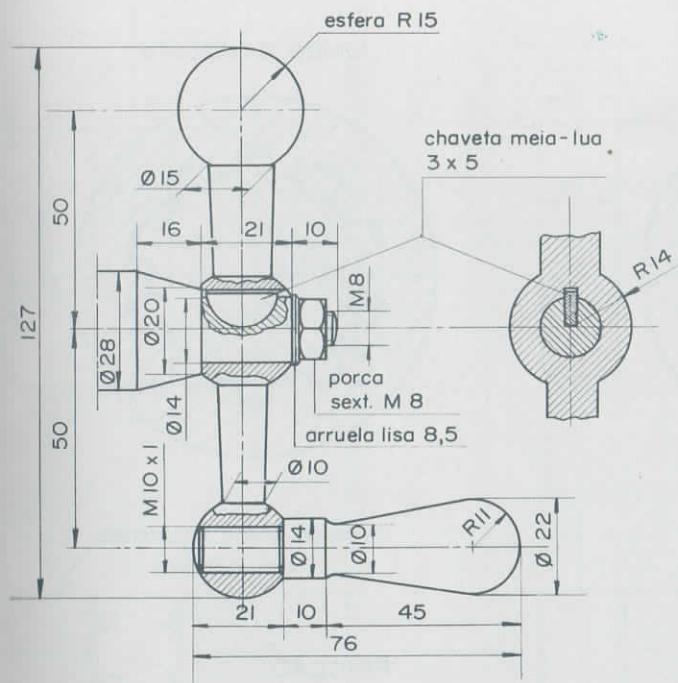
POLIA PARA CORREIA PLANA



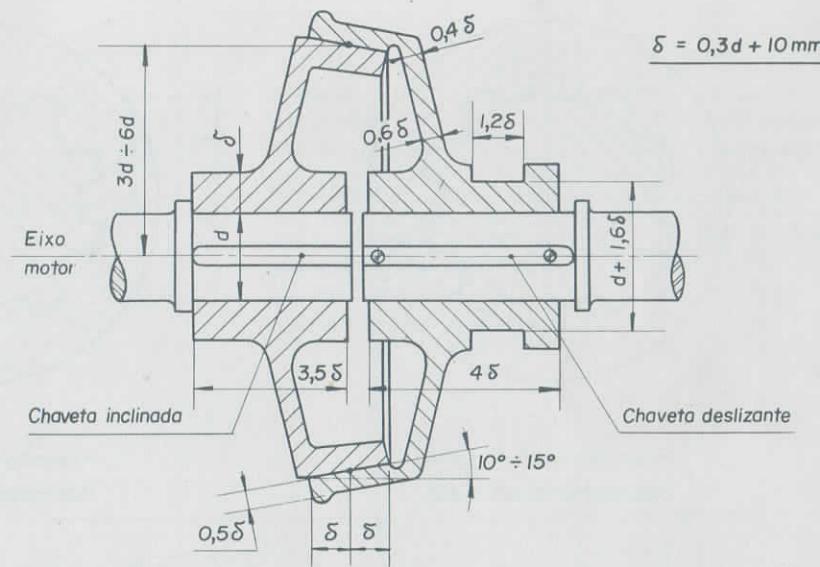
O mesmo pino pode ficar em união forçada com a manivela por meio da cunha C. Observar que a cunha força contra a parede 1-2 do furo da manivela e contra a parede opos ta 3-4 do furo do pino.

A união é obtida por meio da chaveta plana com cabeça (D). Observar que não há encaixe no eixo e sim um simples aplaçamento.

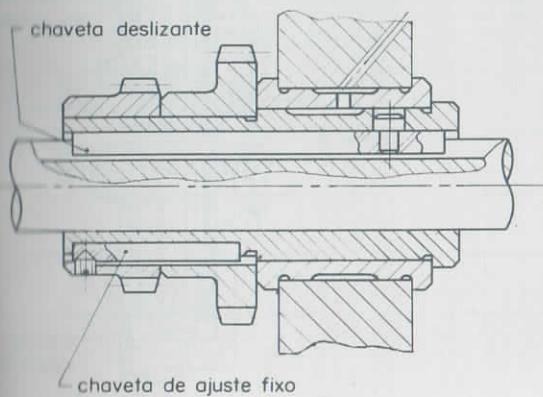
MANIVELA DE COMANDO



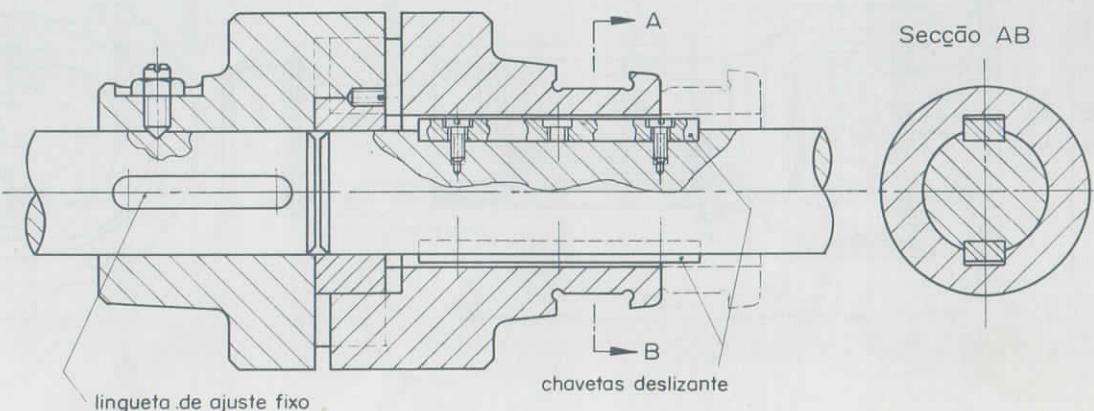
FRICÇÃO CÔNICA



CÂMBIO

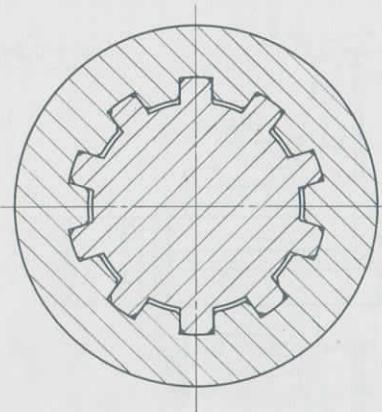


ENGATE



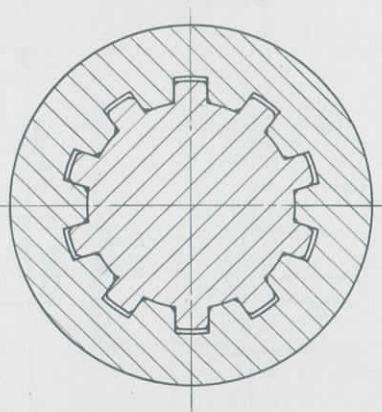
EIXOS RANHURADOS

União forcada



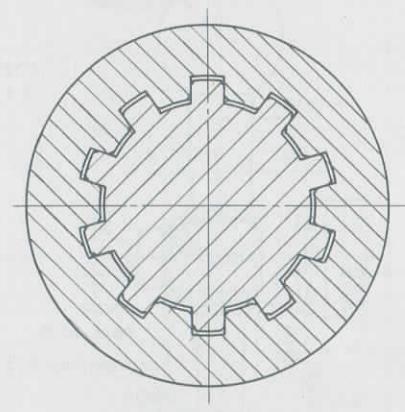
Pressão sobre o fundo
das ranhuras do cubo

União forcada



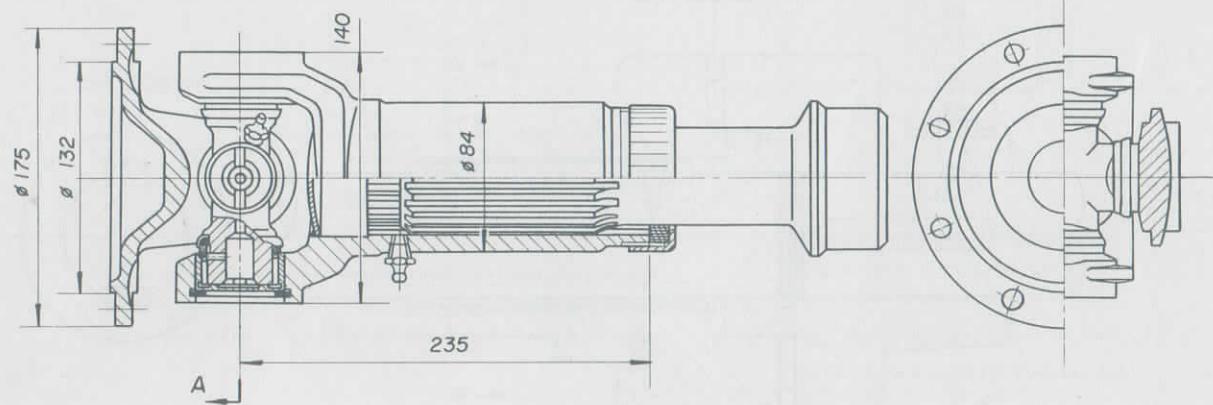
Pressão sobre o fundo
das ranhuras do eixo

União deslizante

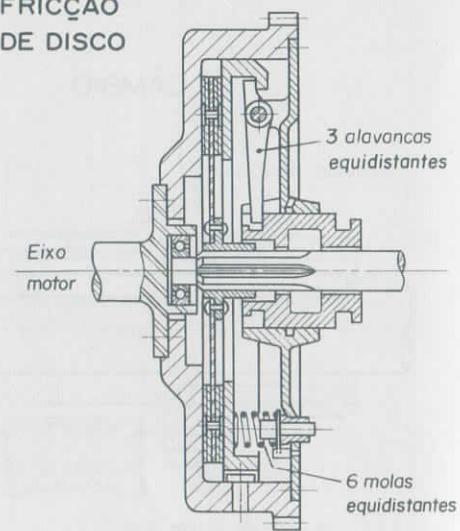


Pressão sobre as laterais
das ranhuras

EIXO CARDAN

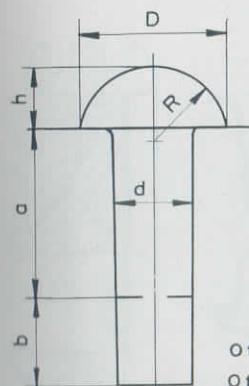


FRIÇÃO
DE DISCO



Obs.: não se cortam rebites em sentido longitudinal.

REBITOS



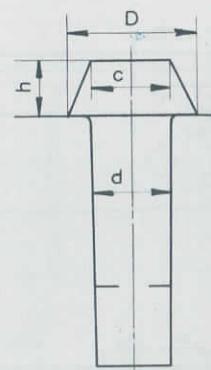
cabeça redonda

$$D = 1,8d$$

$$h = 0,7d$$

$$R = 0,9d$$

O trecho a é cilíndrico
O trecho b é levemente cônicos

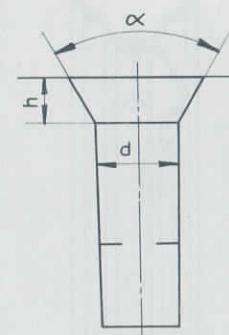


cabeça tronco-cônica

$$D = 1,6d$$

$$c = d$$

$$h = 0,65d$$



cabeça escareada plana

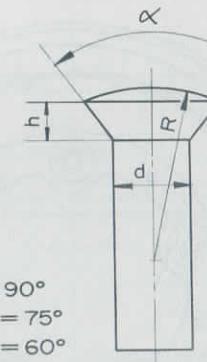
$$h = 0,5d$$

$$d = 1 \div 8 \rightarrow \alpha = 90^\circ$$

$$d = 10 \div 13 \rightarrow \alpha = 75^\circ$$

$$d = 16 \div 19 \rightarrow \alpha = 60^\circ$$

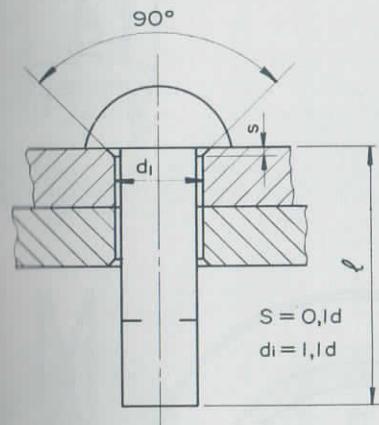
$$d = 24 \div 40 \rightarrow \alpha = 45^\circ$$



cabeça escareada ovalizada

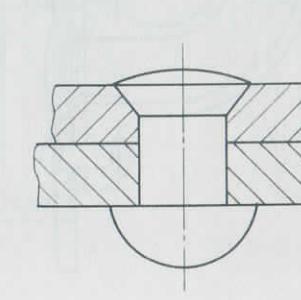
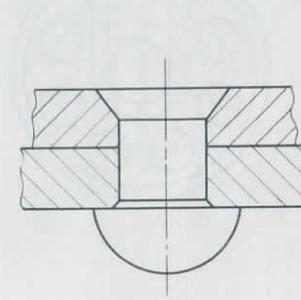
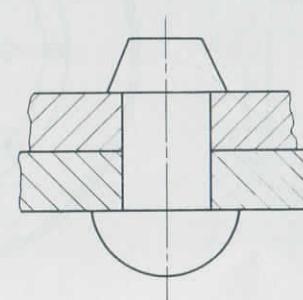
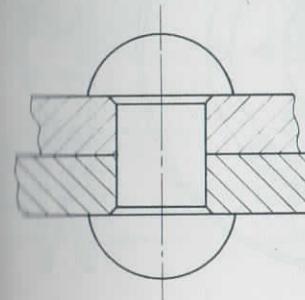
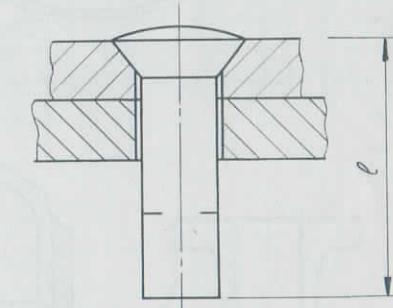
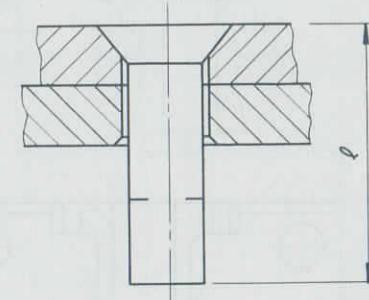
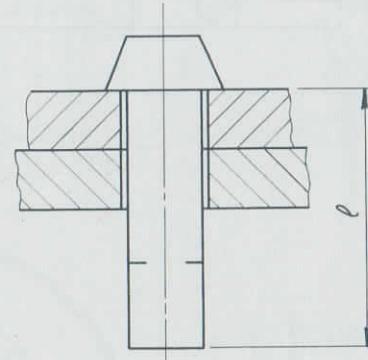
$$h = 0,6d$$

$$R = 2 \div 2,5d$$

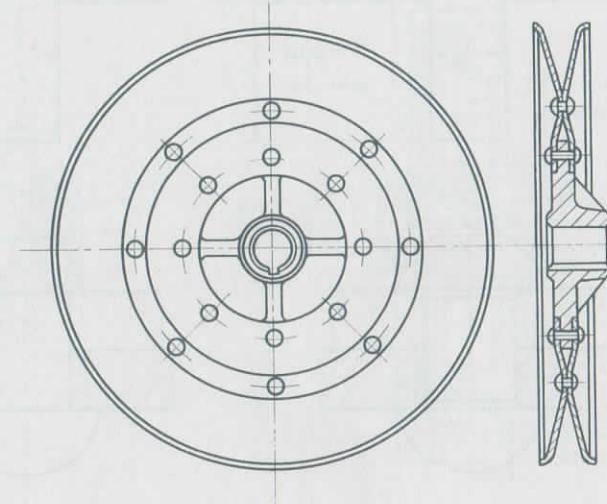
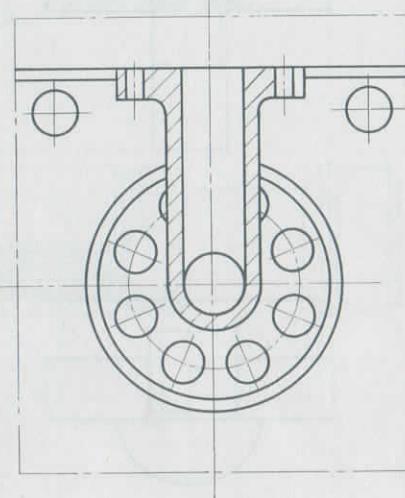
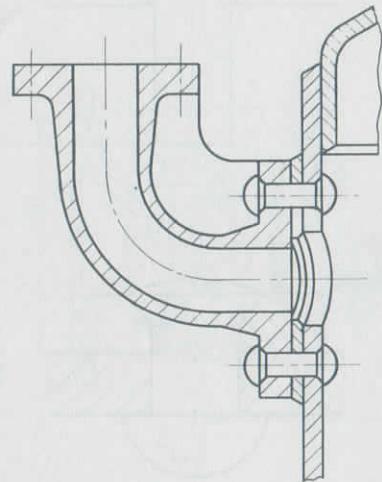
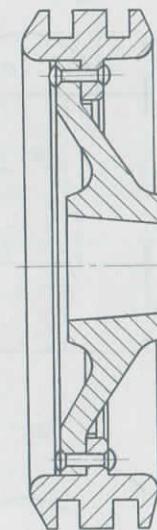
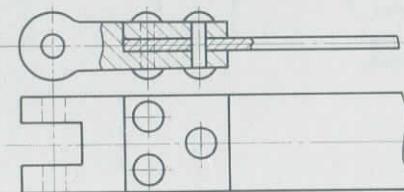
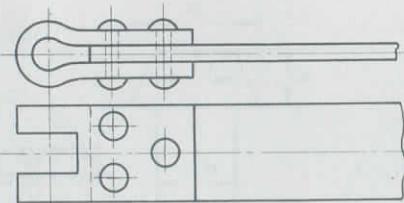
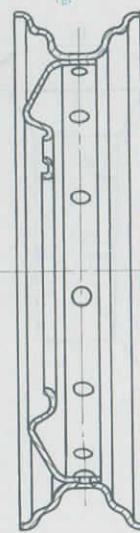
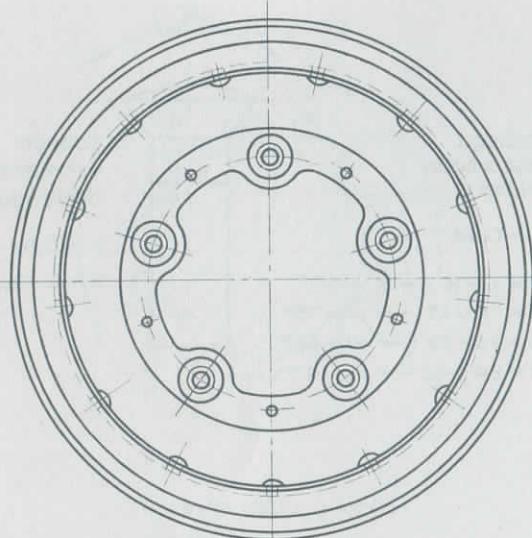


$$S = 0,1d$$

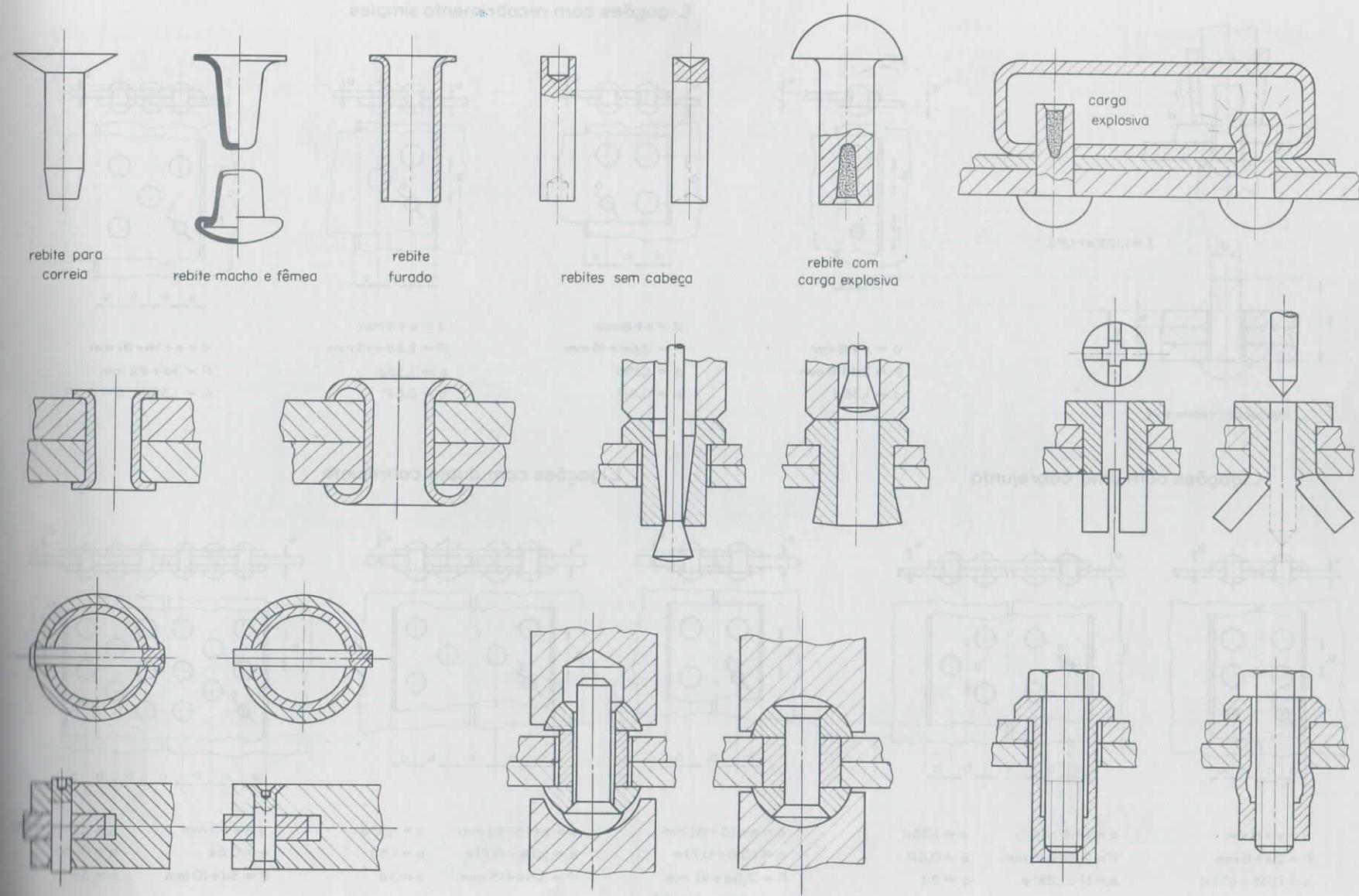
$$d_1 = 1,1d$$



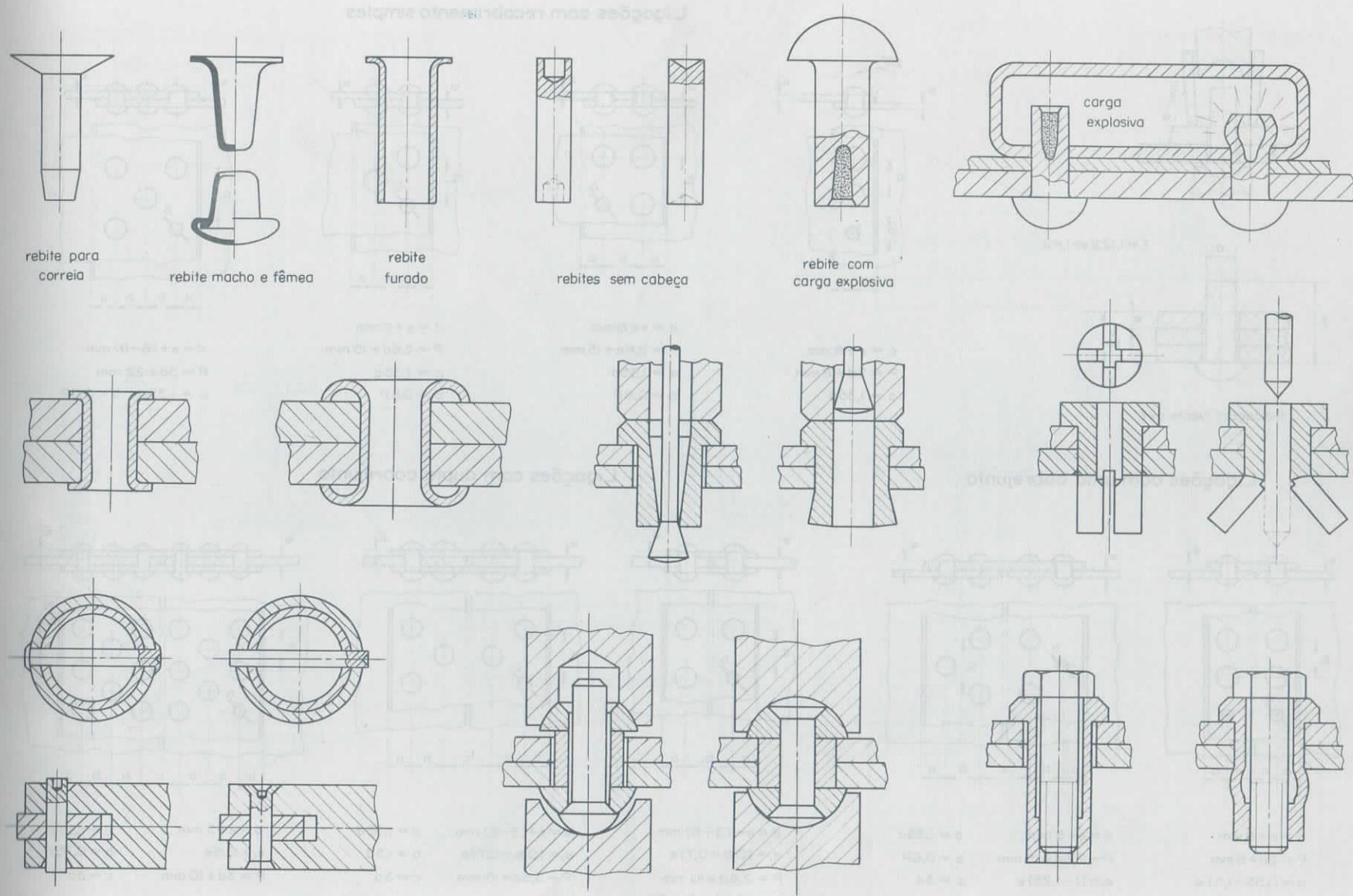
APLICAÇÃO DE REBITES



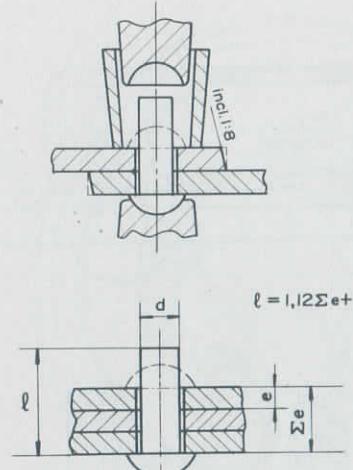
AIRARIA REBITES ESPECIAIS



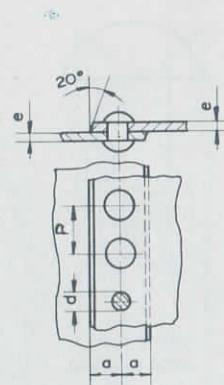
REBITES ESPECIAIS



REBITAGEM DE CALDEIRARIA

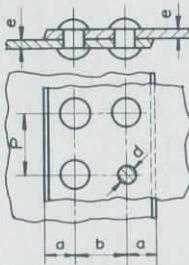


Indicação: rebite $dx\ell$

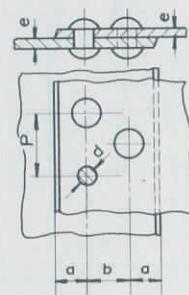


$$\begin{aligned} d &= e + 8 \text{ mm} \\ P &= 2d + 8 \text{ mm} \\ a &= 1,35d \end{aligned}$$

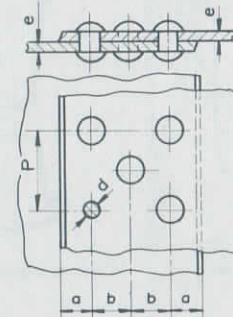
Ligações com recobrimento simples



$$\begin{aligned} d &= e + 8 \text{ mm} \\ P &= 2,6d + 15 \text{ mm} \\ a &= 1,35d \\ b &= 0,8P \end{aligned}$$

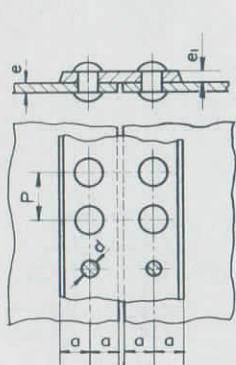


$$\begin{aligned} d &= e + 8 \text{ mm} \\ P &= 2,6d + 15 \text{ mm} \\ a &= 1,35d \\ b &= 0,6P \end{aligned}$$

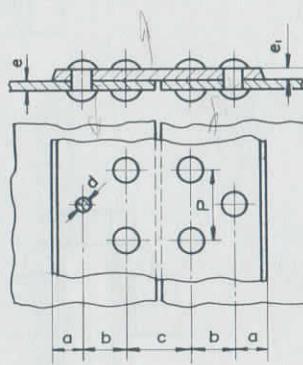


$$\begin{aligned} d &= e + (6-8) \text{ mm} \\ P &= 3d + 22 \text{ mm} \\ a &= 1,35d \\ b &= 0,5P \end{aligned}$$

Ligações com uma cobrejunta

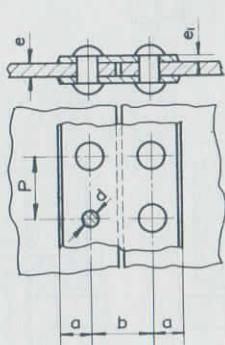


$$\begin{aligned} d &= e + 8 \text{ mm} \\ P &= 2d + 8 \text{ mm} \\ a &= (1,35 \div 1,5)d \\ e_i &= (1 \div 1,25)e \end{aligned}$$

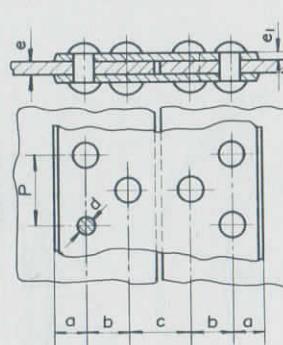


$$\begin{aligned} d &= e + 8 \text{ mm} \\ P &= 2,6d + 15 \text{ mm} \\ a &= 1,35d \\ e_i &= (1 \div 1,25)e \\ c &= 3d \end{aligned}$$

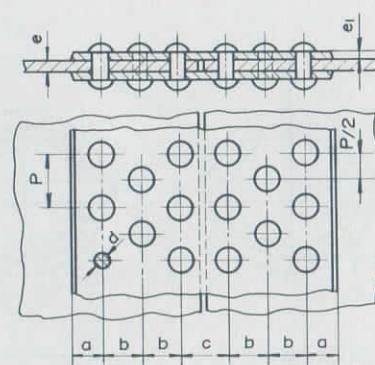
Ligações com dupla cobrejunta



$$\begin{aligned} d &= e + (5 \div 6) \text{ mm} \\ e_i &= (0,6 \div 0,7)e \\ P &= 2,6d + 10 \text{ mm} \\ a &= 1,35d \\ b &= 3d \end{aligned}$$

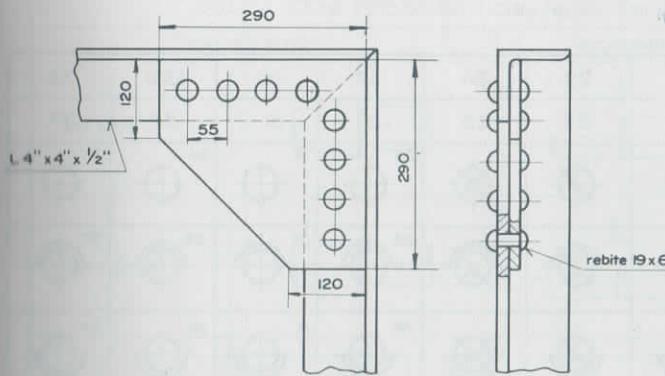


$$\begin{aligned} d &= e + (5 \div 6) \text{ mm} \\ e_i &= (0,6 \div 0,7)e \\ P &= 3,5d + 15 \text{ mm} \\ a &= 1,35d \\ b &= 1,5d \\ c &= 3d \end{aligned}$$

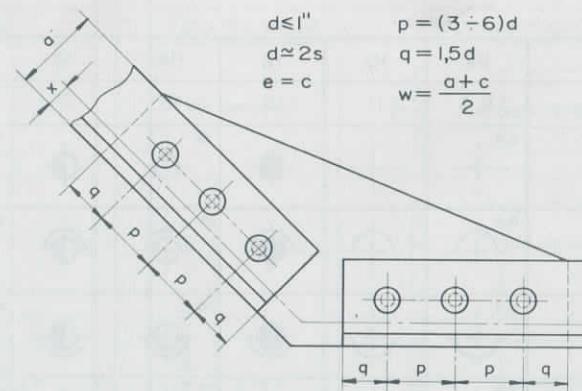


$$\begin{aligned} d &= e + 5 \text{ mm} \\ e_i &= 0,8e \\ P &= 3d + 10 \text{ mm} \\ a &= 1,35d \\ b &= 0,75t \\ c &= 3d \end{aligned}$$

ESTRUTURAS REBITADAS

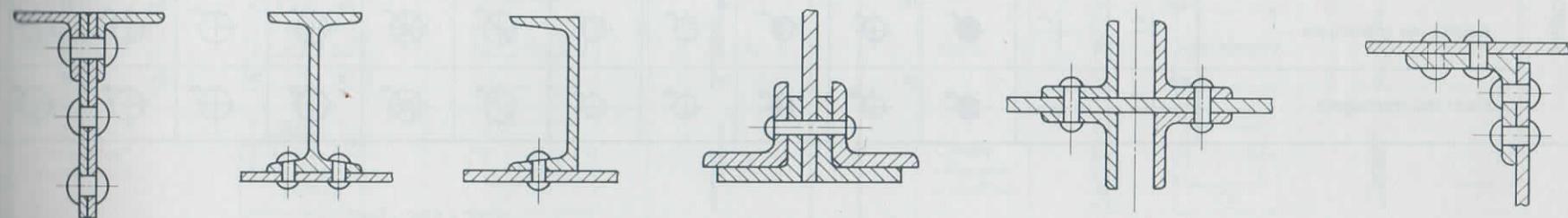


a, c, x ver tabelas

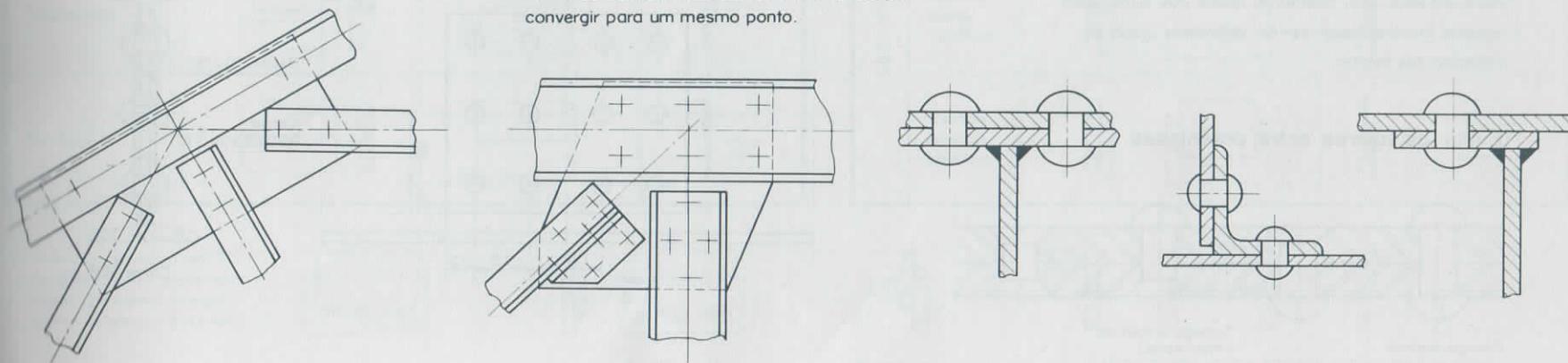


$$\ell = \text{comprimento do rebite}$$

$$\ell = 1,2 \sum e + 1,4d$$



As linhas baricêntricas das cantoneiras devem convergir para um mesmo ponto.

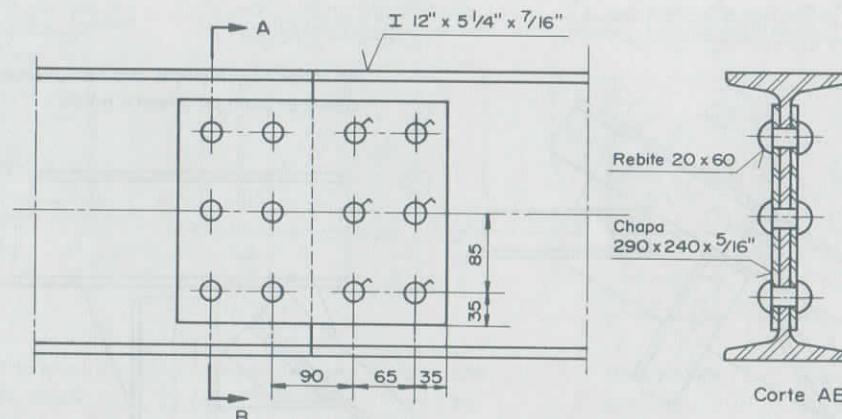
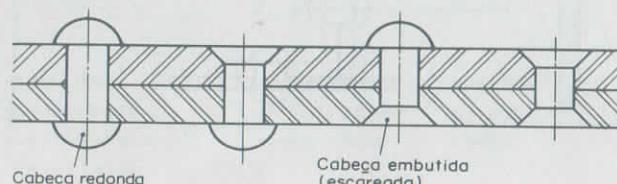


SÍMBOLOS DE REBITES

Diametro do rebite (mm)		(8)	10	12	(14)	16	(18)	20	22	24	27	30	(33)	36
Diametro do furo (mm)		8,4	11	13	15	17	19	21	23	25	28	31	34	37
SÍMBOLOS CONVENCIONAIS	Cabeças redondas de ambos os lados	8,4	-+	-+	●	15	19				28	31	34	37
	Cabeça superior embutida	8,4	—	—	●	15	19				28	31	34	37
	Cabeça inferior embutida	8,4	—	—	●	15	19				28	31	34	37
	Ambas as cabeças embutidas	8,4	—	—	●	15	19				28	31	34	37
	Rebitar na montagem	8,4	—	—	●	15	19	—	—	—	28	31	34	37
	Furar na montagem	8,4	—	—	●	15	19	—	—	—	28	31	34	37

Até à escala 1:5 os símbolos convencionais serão representados com diâmetros iguais aos furos; para escalas menores usar-se-ão diâmetros iguais às cabeças dos rebites.

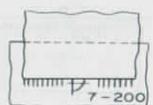
Evitar os valores entre parênteses.



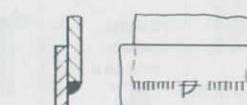
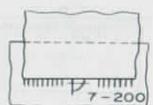
SÍMBOLOS DE SOLDAS - DIN 1911 - 1912

SOLDADURA COM PRESSÃO (COM RESISTÊNCIA ELÉTRICA)		
Tipo da solda	Representação simbólica	
De topo		
Com fusão		
Por pontos em série		
Por pontos em cadeia		
Por pontos escalonados		
Sobreposta		
De topo		

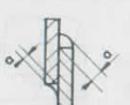
Além da grossura do cordão (7 mm) pode-se indicar também o comprimento da solda (200 mm)



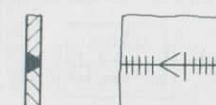
SOLDADURA COM FUSÃO (A ARCO OU A GÁS)		
Tipo da solda	Representação	Represent. simbólica
De borda (I)		
Em I		
Em V		
Em X		
Solda de topo (I)		
Cordão reforçado e contínuo		
Cordão plano contínuo		
Cordão aliviado contínuo		



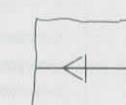
Solda oculta



Significado de a



(1) As soldas planas são indicadas com traço reto em vez de arco.

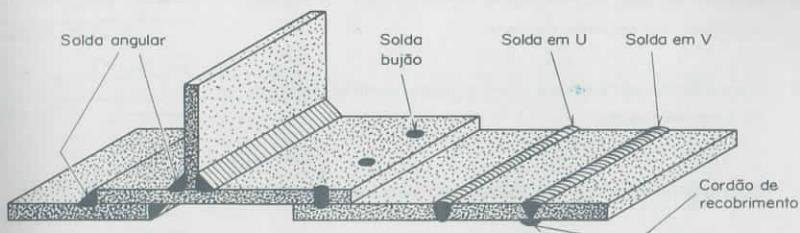


Tipo	Representação (I)		Representação (II)	Representação simbólica
	Frontal	Transversal		
Juntas com ranhuras			Furo alongado	
			Furo redondo	
			Cordão angular em um lado	
			Cordão angular nos dois lados	
			Cordão angular em um lado	
			Cordão angular nos dois lados	
			Cordão angular alternado	
			Cordão angular externo	
			Cordão angular externo e interno	

Tipo	Representação (I)		Representação simbólica	
	Frontal	Transversal	Frontal	Transversal
Juntas superpostas				

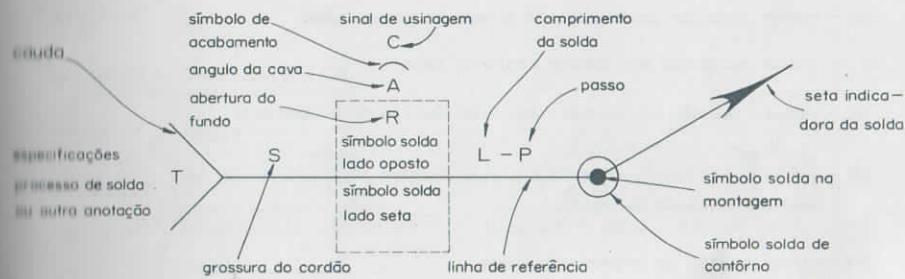
(1) Os cordões reforçados, planos e aliviados são representados com os símbolos correspondentes.

SOLDA A ARCO ELÉTRICO OU A GÁS NORMA AMERICANA



INDICAÇÃO E SÍMBOLOS

TIPOS DE SOLDA							
Recortes de chapas					bujão e ranhura	Cordões	
reto	V	bisel	U	J	recobrimento	filéte ou angular	
	√	√	U	J	□	—	△
Acabamento do cordão	Solda em todo o contorno	Solda de campo ou de montagem	Soldar varando a junta	Revestimento ou enchimento			
fuso	convexo						
—	—	○	●				



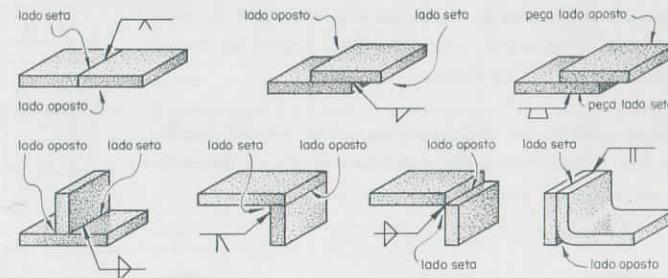
JUNTAS



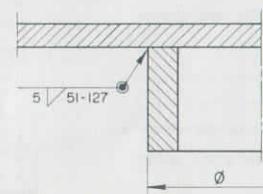
ENTALHES DUPLOS



LADO OPOSTO E LADO SETA



EXEMPLO



Significado

- Cordão de solda do lado seta.
- Grossura do cordão : 5 mm
- Cordão de solda angular
- Solda descontínua em todo contorno
- Comprimento dos trechos de solda : 51 mm
- Passo : 127 mm
- Solda na montagem

OBSERVAÇÕES

1 - Aplicar as setas tantas vezes quantas forem as mudanças bruscas na direção do cordão, exceto quando o cordão for o mesmo para todo o contorno, caso em que será empregado o símbolo correspondente.



2 - Todos os cordões são considerados contínuos, exceto quando indicado em contrário.

3 - As dimensões colocadas nos símbolos são indicadas sempre em mm.

4 - Usar a cauda da seta para especificar particularidades da soldagem se houver, caso contrário omiti-la.

5 - Nas soldas do lado seta, representar o símbolo no lado inferior da seta acontecendo o contrário para as soldas do lado oposto.



6 - Nos entalhes duplos, representar os símbolos, em ambos os lados da seta.



7 - Indicar as dimensões de uma solda somente uma vez quando em ambos os lados da emenda ela é do mesmo tipo e tamanho, caso contrário indicar as dimensões em ambos os lados.



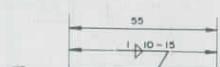
8 - Onde somente um dos elementos sofrer entalhe, representar a seta, indicando precisamente aquele elemento com mudança brusca de direção da seta.



9 - Na colocação da seta na posição vertical seguir o mesmo procedimento usado para colocação de cotas.



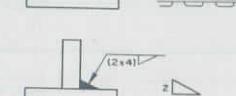
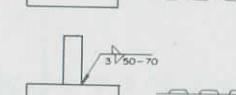
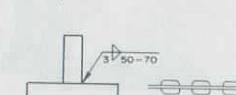
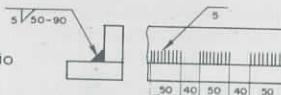
10 - Indicar o comprimento próprio de cada solda em combinação com a linha de cota.



11 - Representar as soldas nas mudanças bruscas de direção conforme indica o desenho ao lado, exceto, quando se usar o símbolo de solda de contorno.



12 - Quando se quer representar o contorno real do cordão proceder da seguinte maneira:



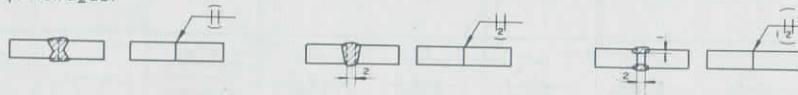
13 - Representar os símbolos com o traço vertical sempre no lado esquerdo.

14 - Representar a solda em cadeia da seguinte maneira:

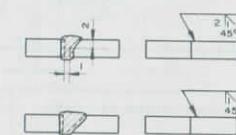
15 - Representar a solda escalonada da seguinte maneira:

16 - Quando o cordão de solda angular, fizer um ângulo diferente de 45°, indicar da seguinte maneira:

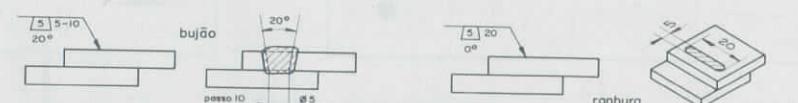
17 - Indicar o lado em que é feita a solda de recorte reto, por meio do símbolo da solda convexa ou raso. Quando a penetração da solda não é completa, indicar a penetração.



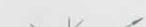
18 - Indicar a profundidade do entalhe das soldas de recorte em V ou em bisel quando o entalhe não for completo. Caso contrário dispensar a indicação.



19 - Indicar as soldas de ranhura e de bujão da seguinte maneira:



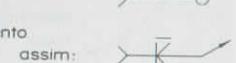
20 - Indicar qualquer solda que não é feito na oficina assim:



21 - Indicar as soldas em todo o contorno assim:



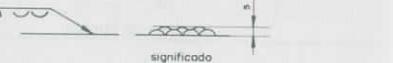
22 - Indicar solda com cordão raso, sem recurso de acabamento assim:



23 - Indicar solda com cordão raso e com acabamento utilizando os respectivos símbolos de usinagem.

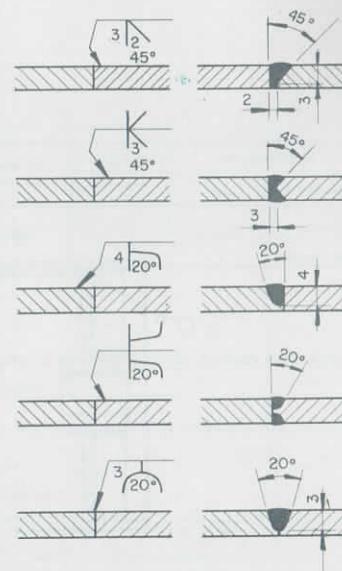
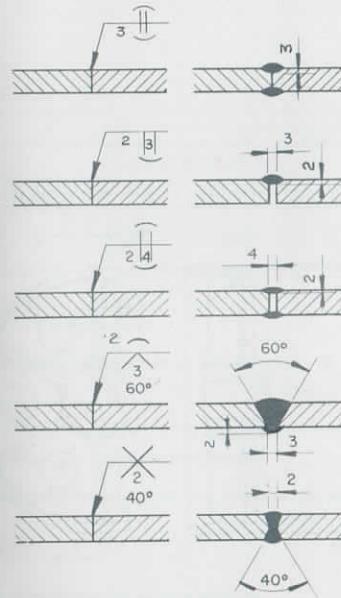


24 - Indicar cordão de enchimento assim:

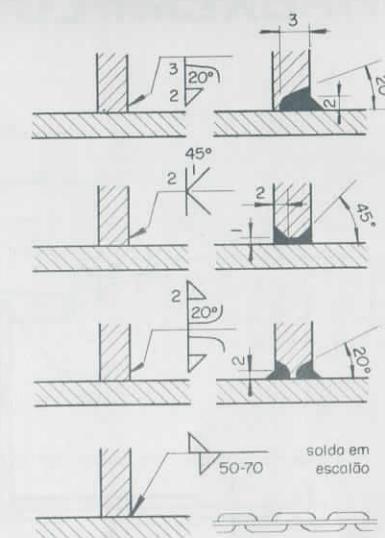
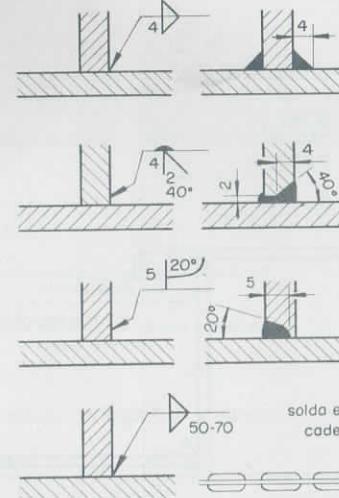


JUNTA DE TOPO

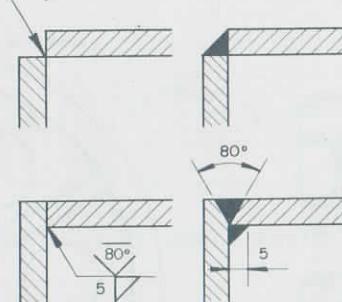
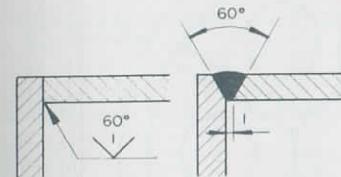
OBS.: a flecha deve indicar a peça a ser chanfrada



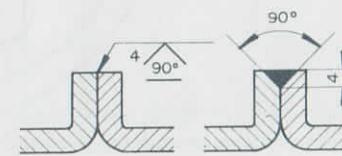
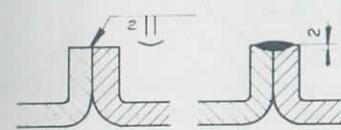
JUNTA EM T



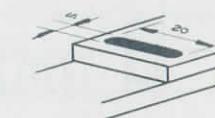
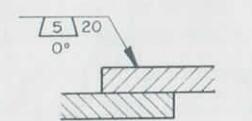
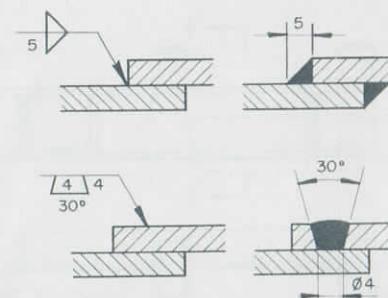
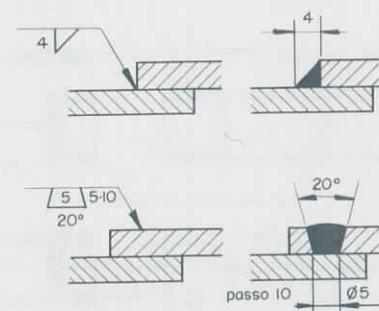
JUNTA EM ÂNGULO



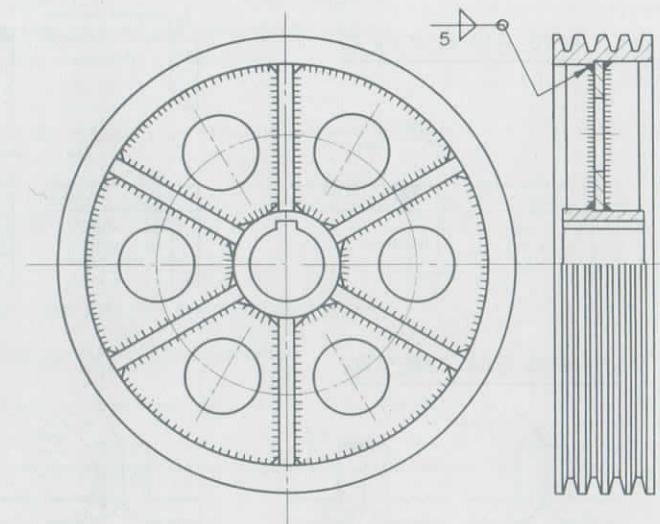
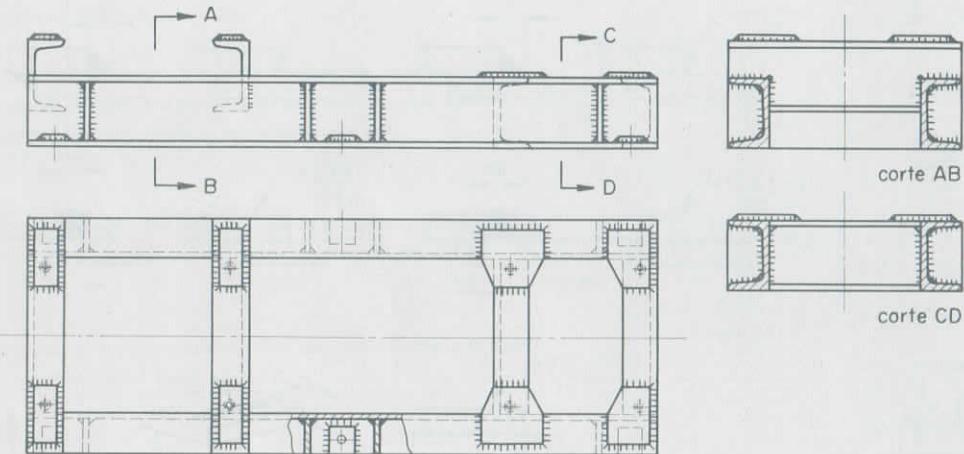
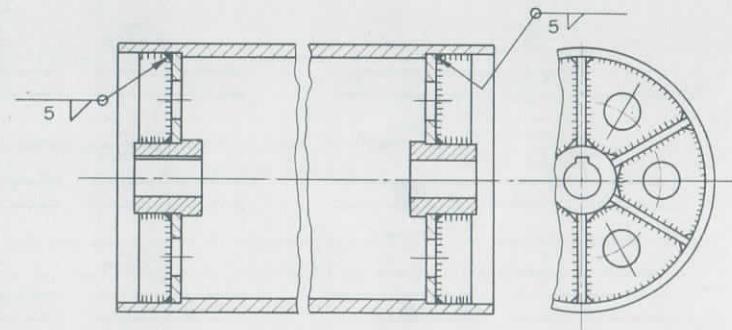
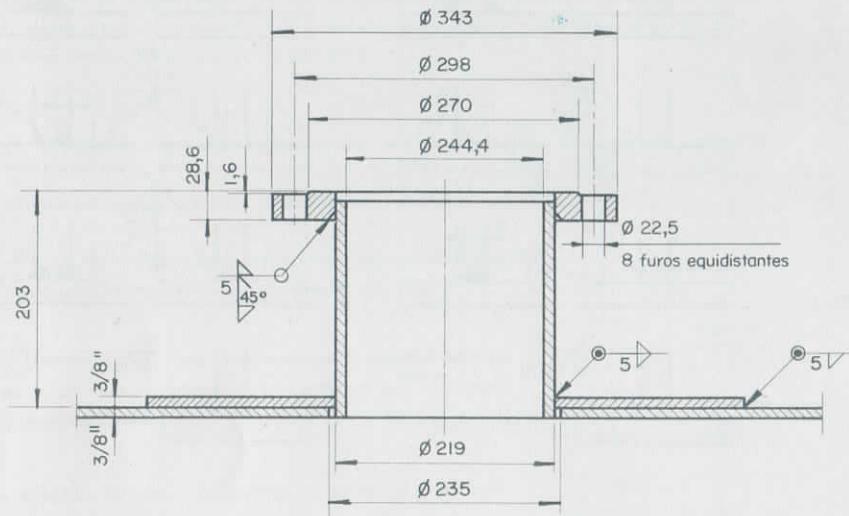
JUNTA EM ARESTA



JUNTA SUPERPOSTA



EXEMPLOS DE SOLDA A ARCO



SOLDAS COM RESISTÊNCIA ELÉTRICA - NORMA AMERICANA

SÍMBOLOS

Tipo de solda				solda na montagem	solda em todo o contorno	Acabamento	
por pontos	por saliências	por costura	de topo			liso	c/rebordo
* X	X	XXX		●	○	—	(solda de topo)

OBSERVAÇÕES

- 1 - Na solda com resistência elétrica, a designação lado seta e lado oposto não tem significado, a não ser no caso de solda por saliências.
- 2 - Indicar as soldas com resistência elétrica pelo esforço que são capazes de resistir e não por suas dimensões.
- 3 - Representar a solda por pontos da seguinte maneira:

R = resistência ao cisalhamento de cada ponto em kg.
p = passo em mm

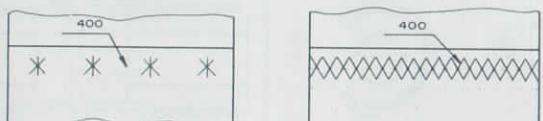


- 4 - Representar a solda por costura da seguinte maneira:

R = resistência ao cisalhamento em kg/cm de solda



- 5 - Os símbolos de solda por pontos ou por costura podem ser usados diretamente nos desenhos.



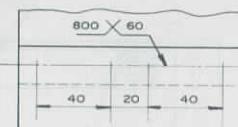
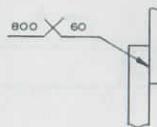
- 6 - A solda é considerada com costura, quando os pontos são tangentes ou se sobrepõem em parte. Existindo qualquer espaço entre os pontos, será considerada por pontos em série e, neste caso, empregar-se-á o símbolo da solda por pontos.

- 7 - Representar a solda por saliências da seguinte maneira:



R = resistência ao cisalhamento de cada saliência em kg.

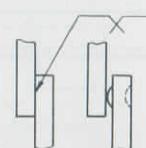
p = distância de centro a centro de lances em mm.



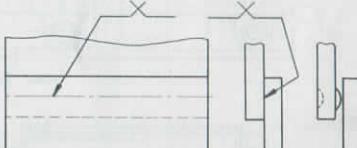
- 8 - Indicar na solda por saliências o lado que fica em relevo da seguinte maneira:



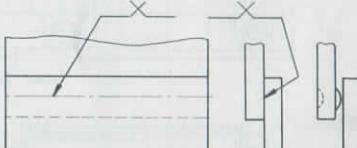
elevação



perfil significado



elevação

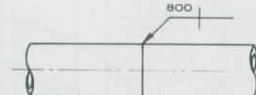


perfil significado

- 9 - Representar a solda de topo da seguinte maneira:



R = resistência à tração em kg/cm²

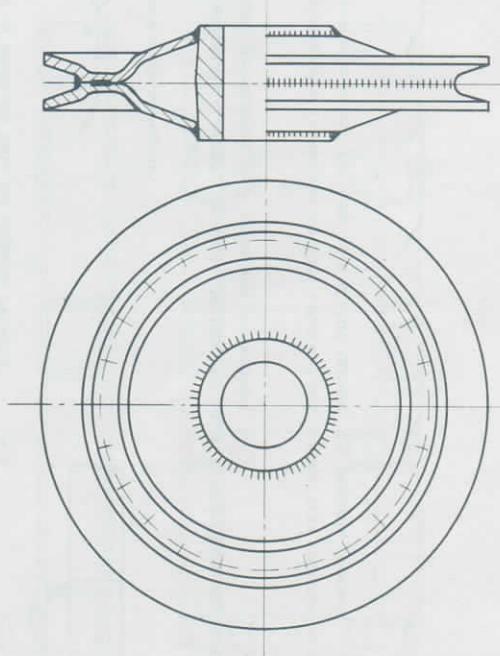
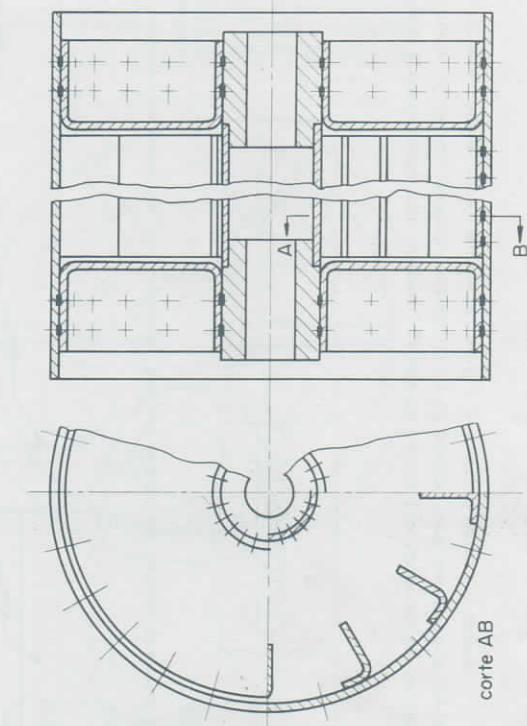
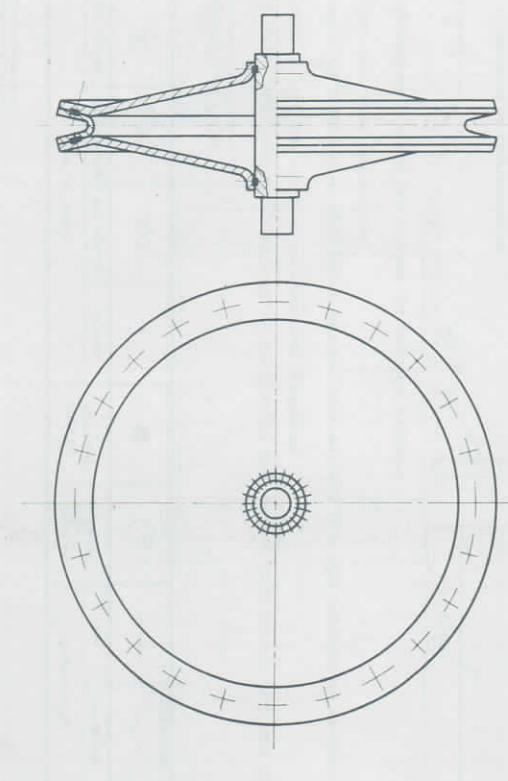
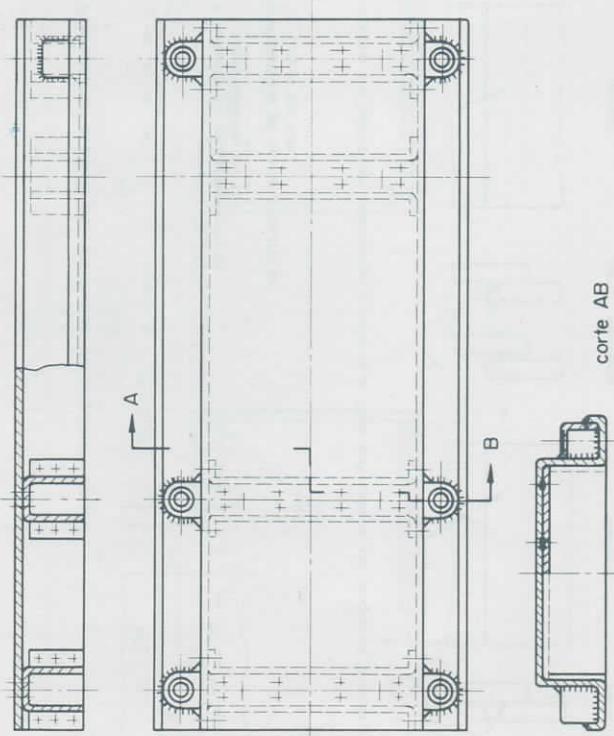


- 10 - Quando a resistência à tração da solda de topo for igual à resistência da secção do metal soldado, a indicação de R pode ser dispensada.

- II - Indicar o acabamento (solda lisa ou com rebordo) das soldas com resistência elétrica, obedecendo o significado do lado seta e lado oposto, da seguinte maneira:

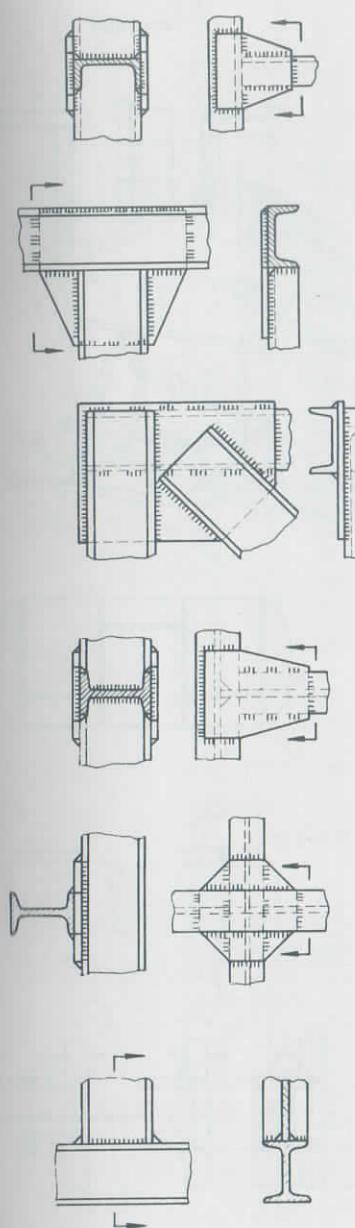


EXEMPLOS DE SOLDA COM RESISTÊNCIA ELÉTRICA

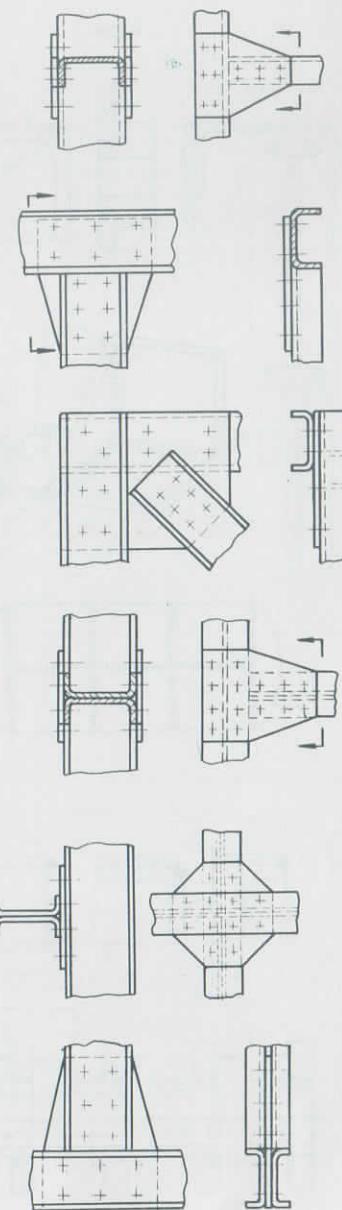


COMPARAÇÃO

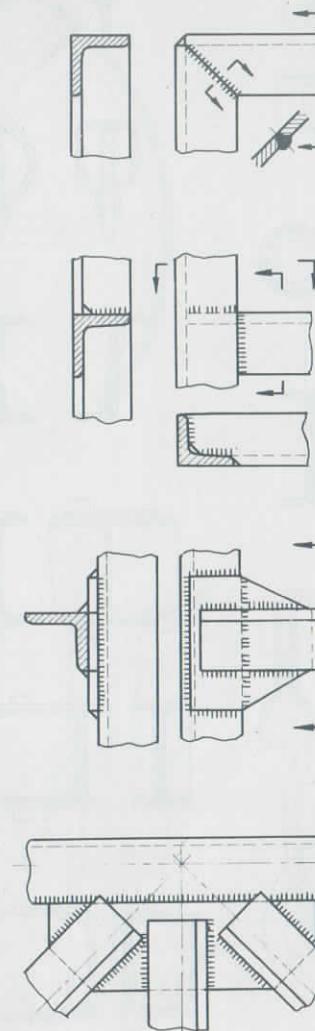
SOLDA A ARCO



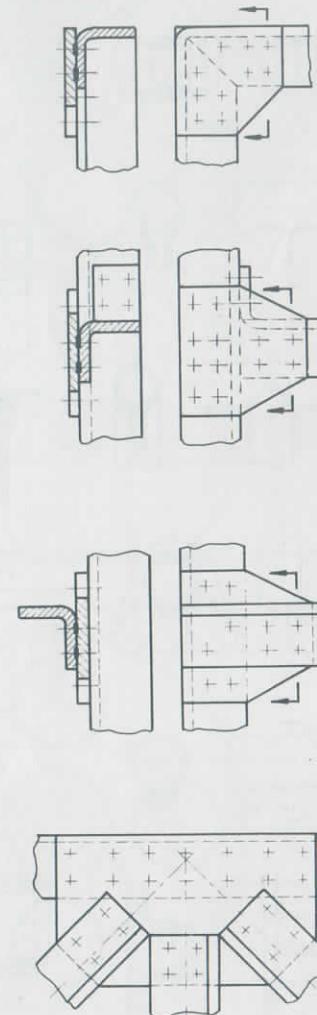
SOLDA COM RESISTÊNCIA



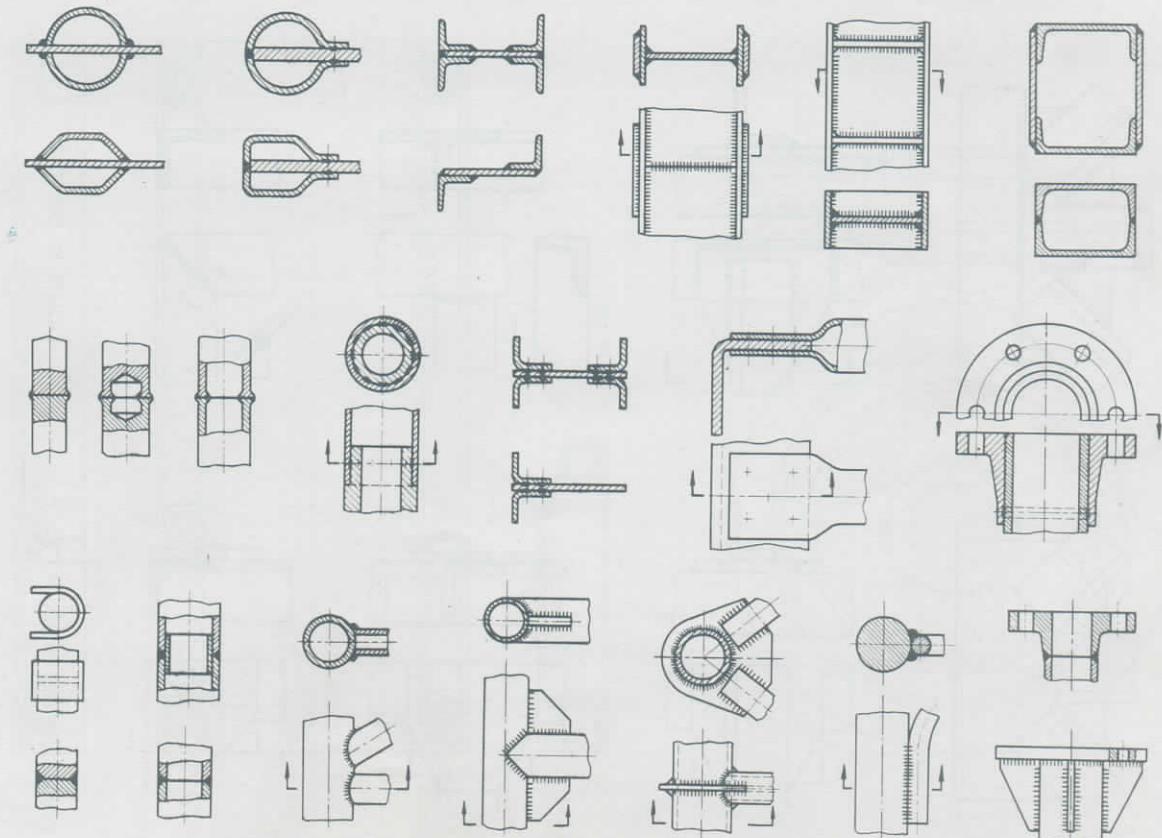
SOLDA A ARCO



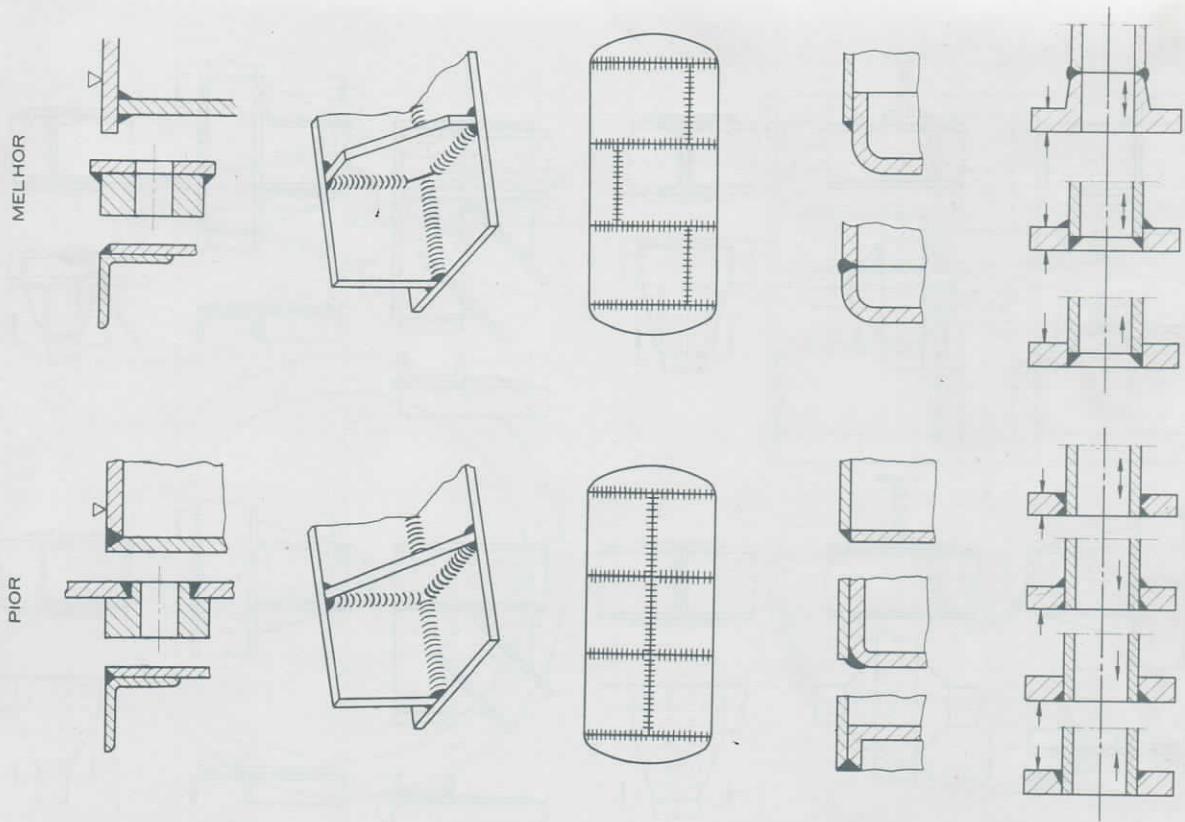
SOLDA COM RESISTÊNCIA



EXEMPLOS DE APLICAÇÃO

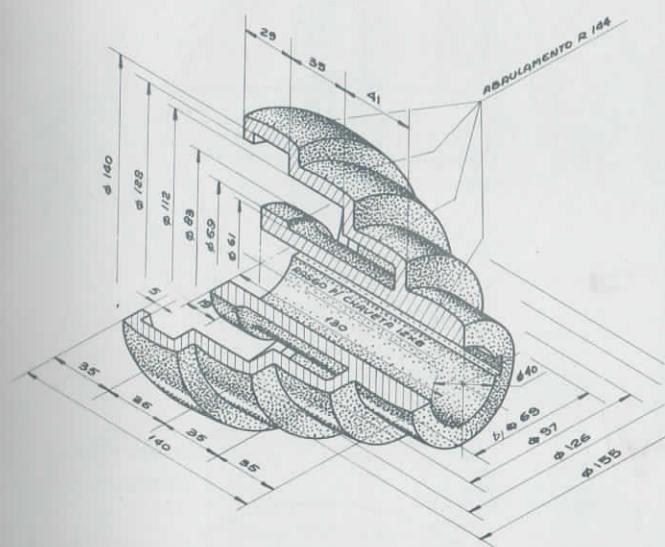


SOLUÇÕES

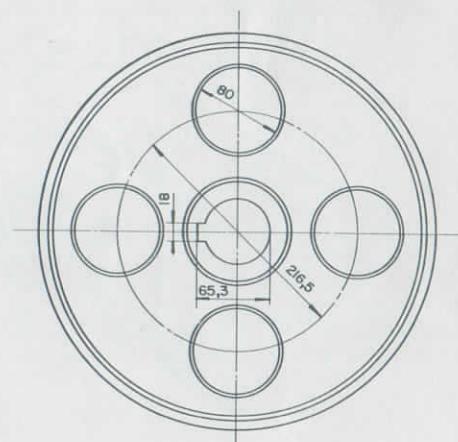
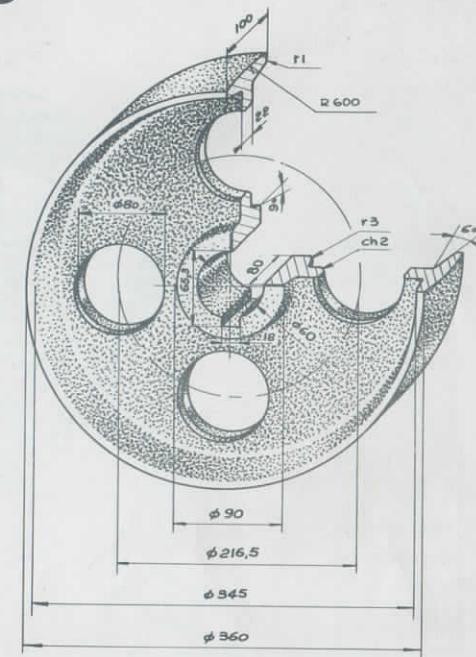
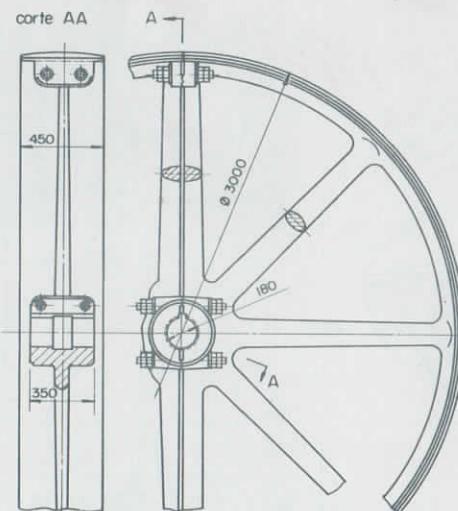


POLIAS

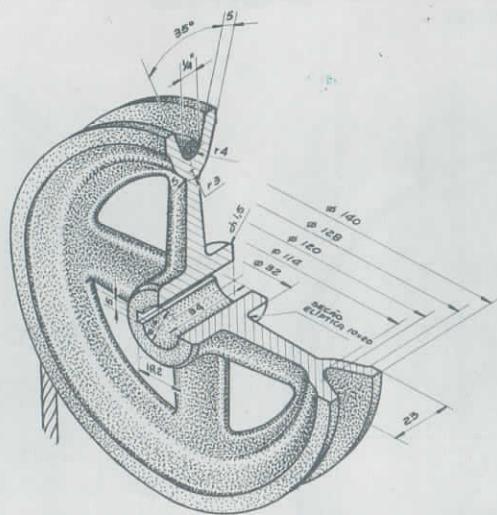
POLIA ESCALONADA



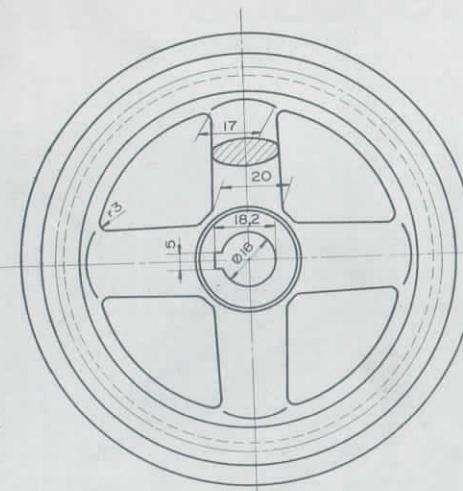
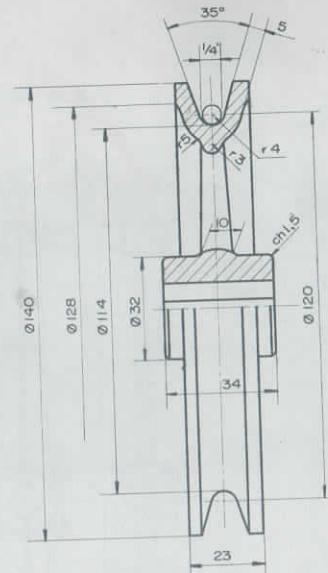
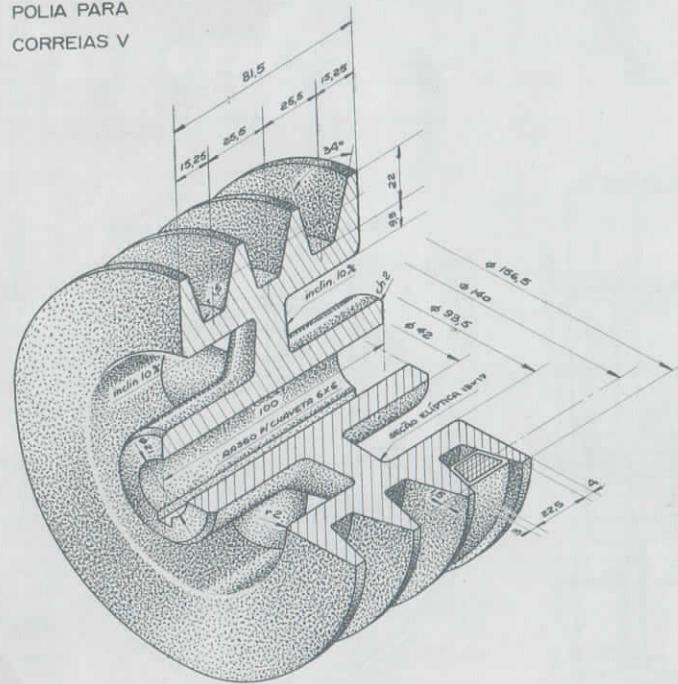
POLIA SECCIONADA



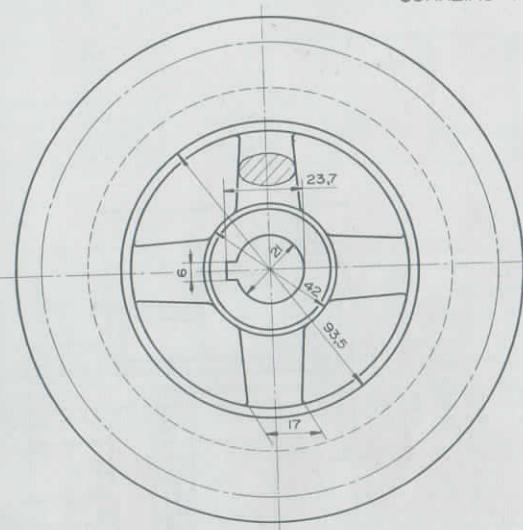
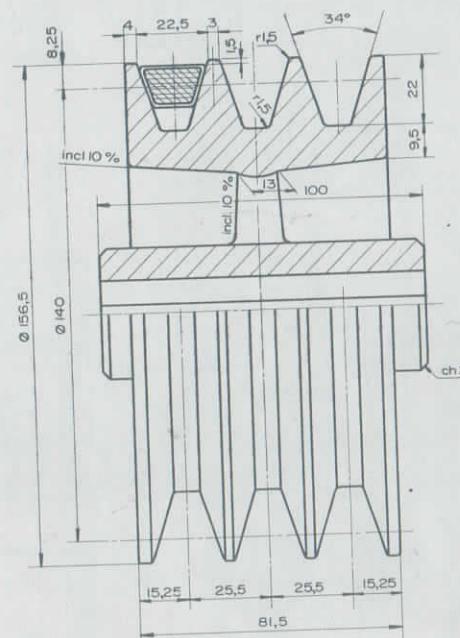
POLIA PARA
CABO DE AÇO



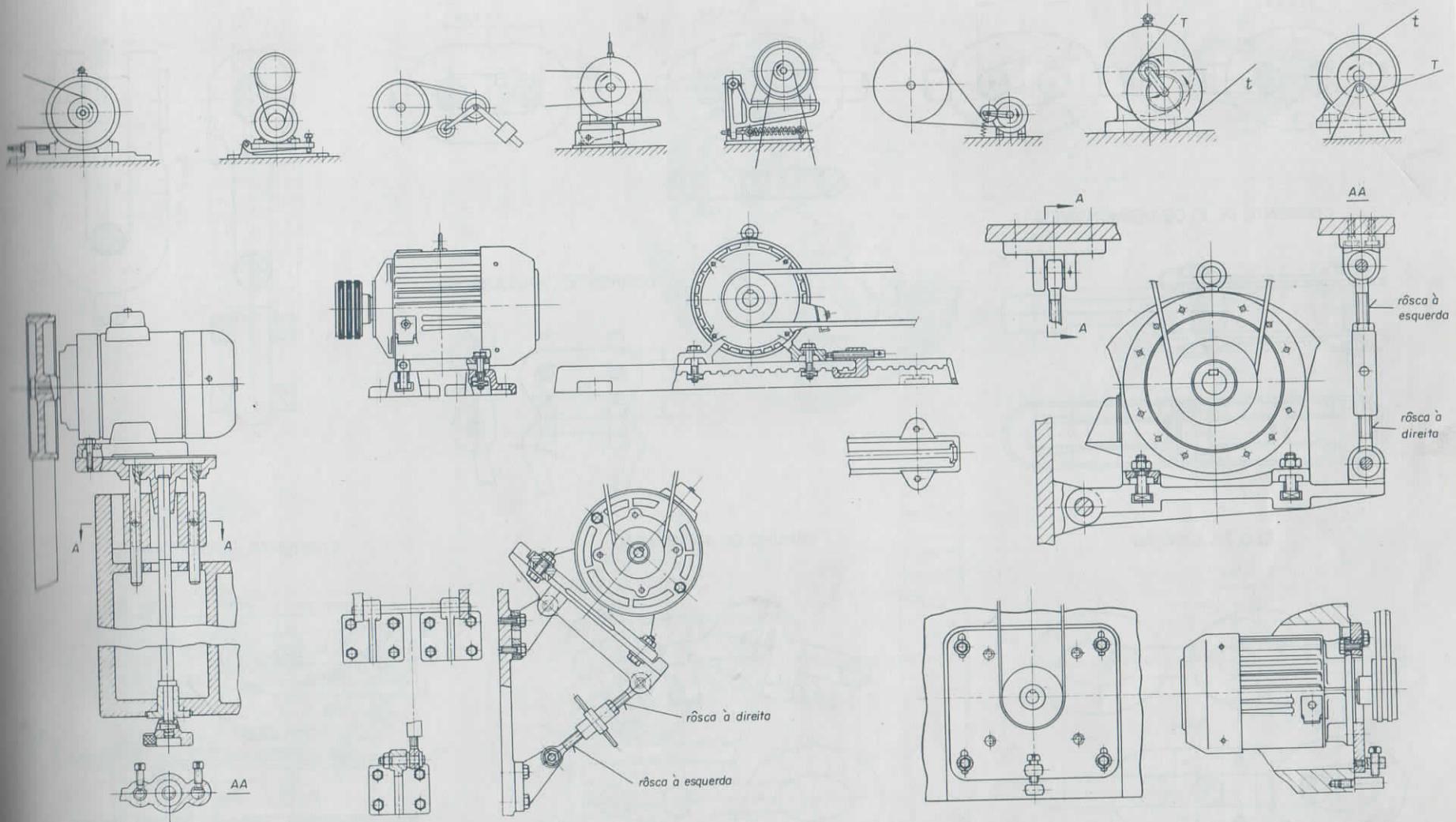
POLIA PARA
CORREIAS V



POLIA PARA
CORREIAS V

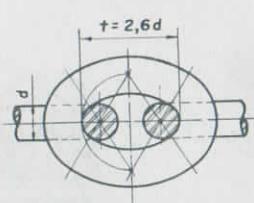


ESTICADORES DE CORREIA

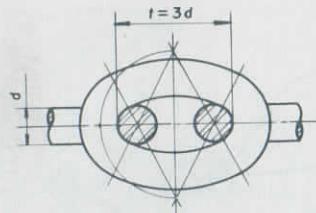


CORRENTES

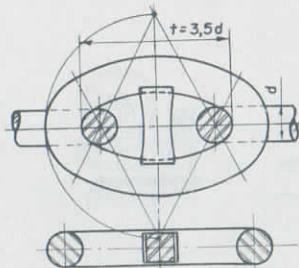
ELO CURTO



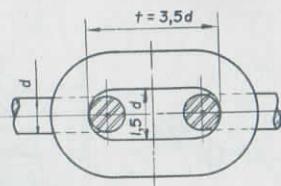
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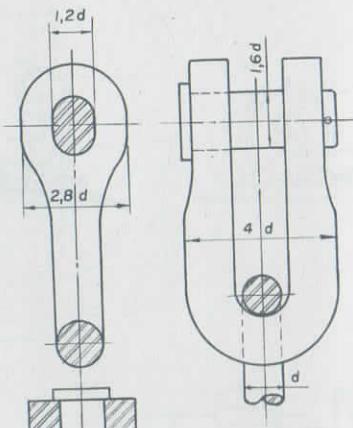
ELO COM TRAVESSA



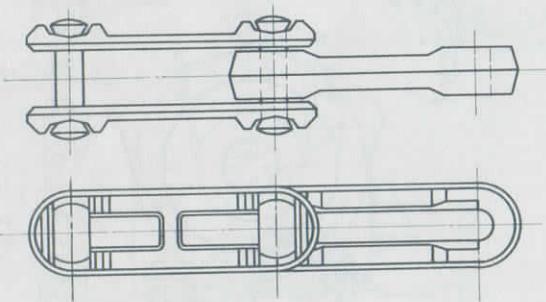
ELO COMPRIDO



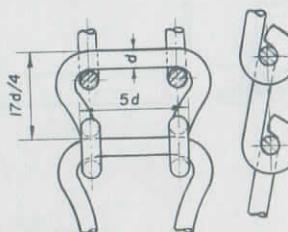
GANCHO DE AMARRAÇÃO



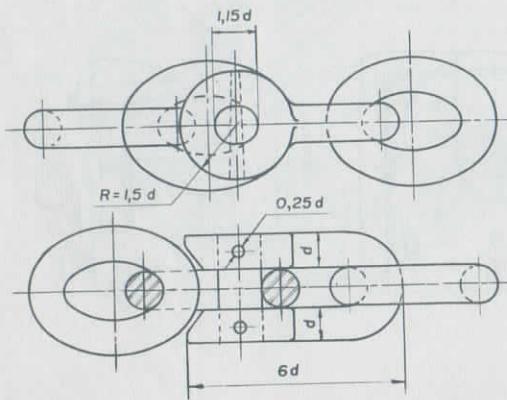
CORRENTE DE ELOS DESMONTÁVEIS



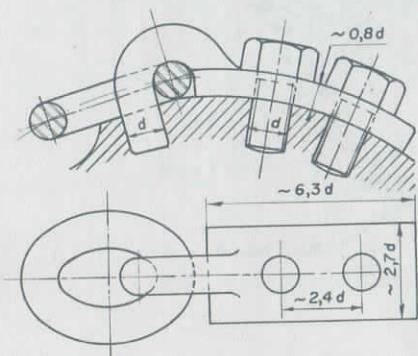
CORRENTE "WAUCANSON"



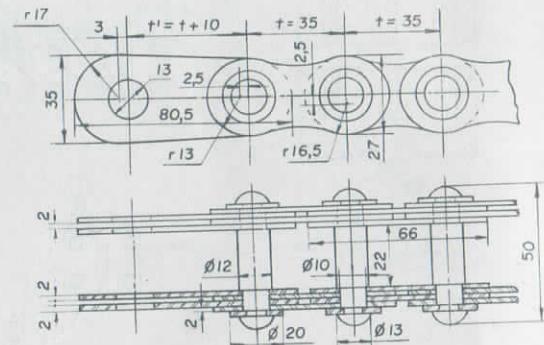
ELO DE LIGAÇÃO



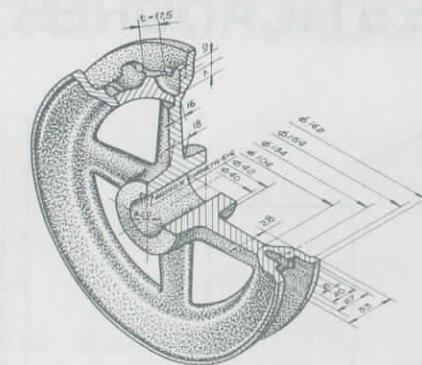
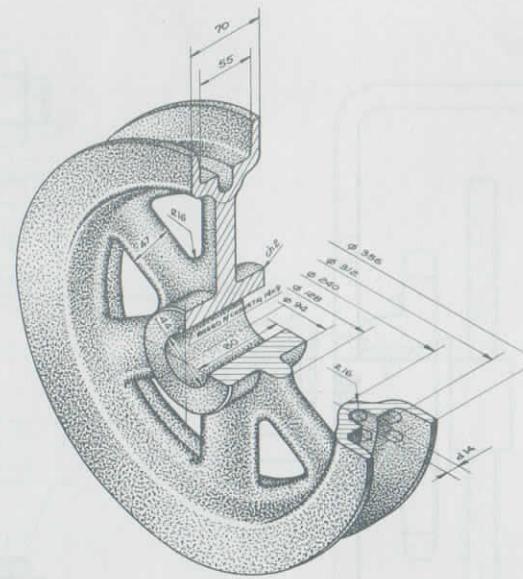
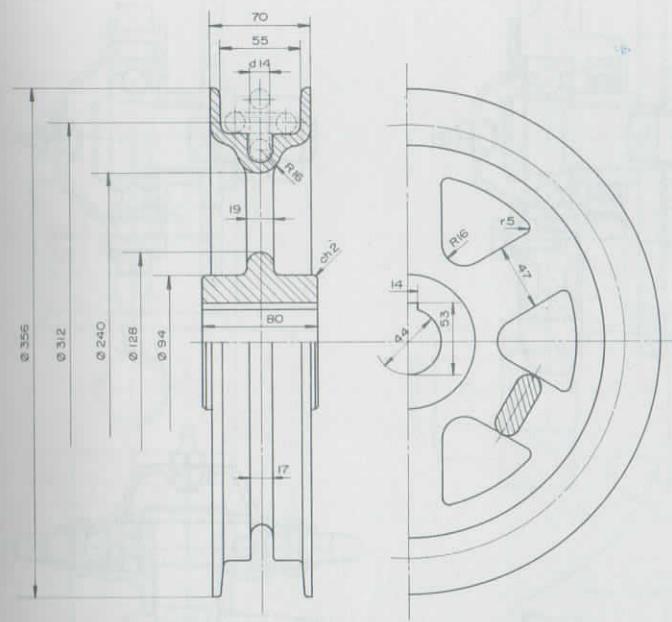
GANCHO DE AMARRAÇÃO



CORRENTE "GALLE"



RODAS PARA CORRENTE

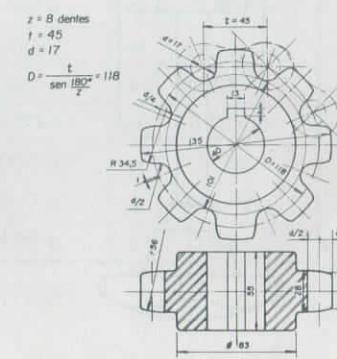
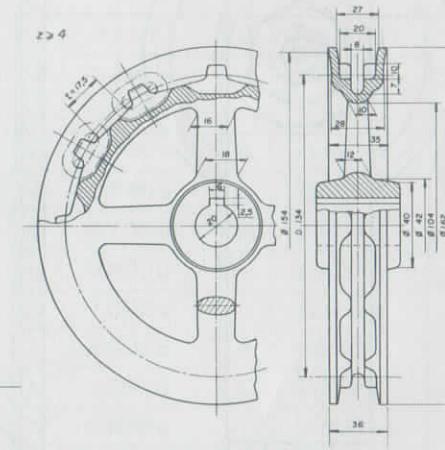
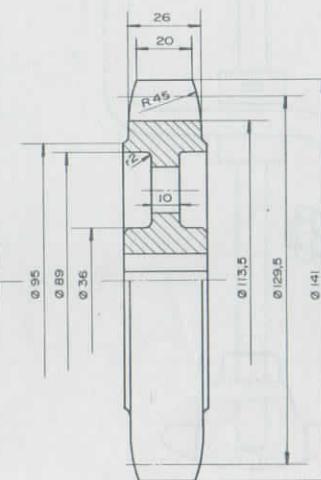
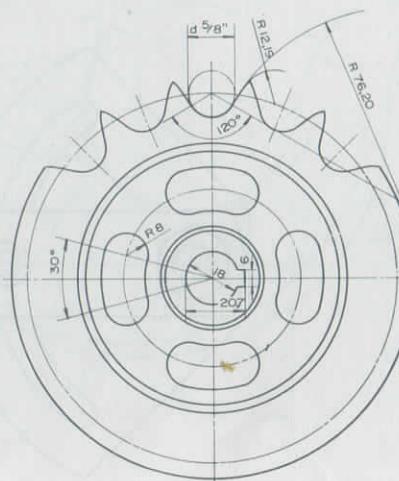
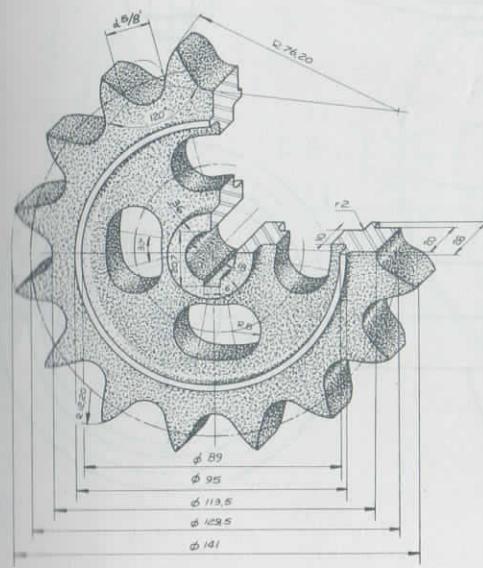


$$z = 12 \text{ dentes}$$

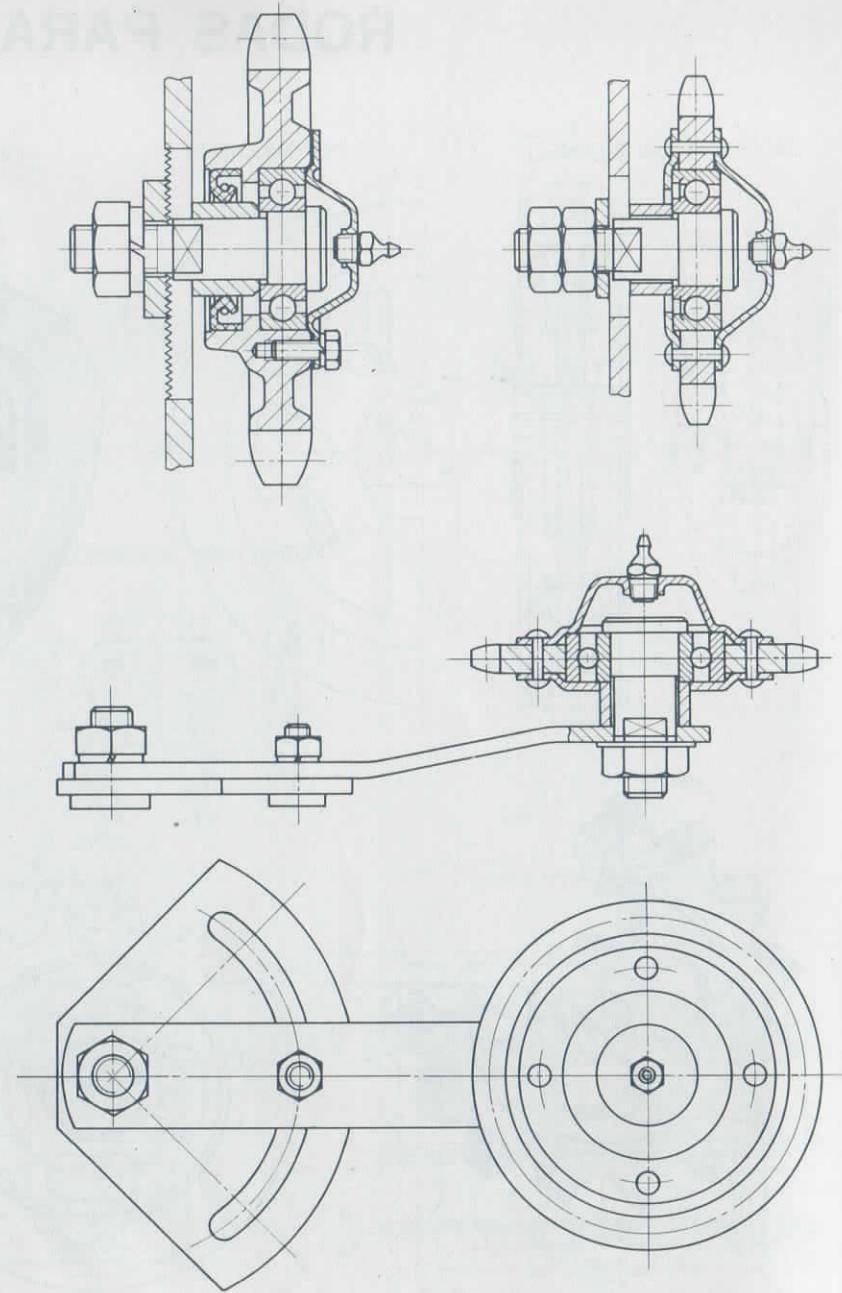
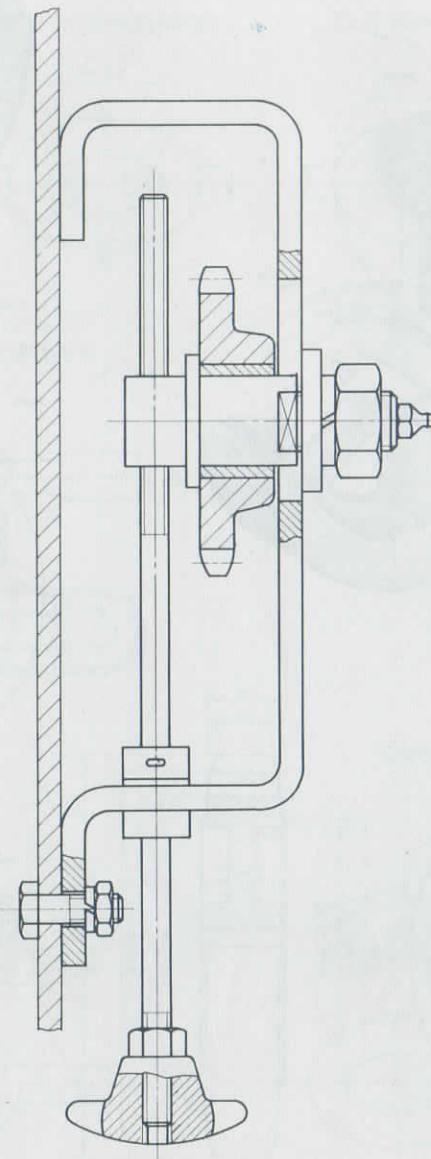
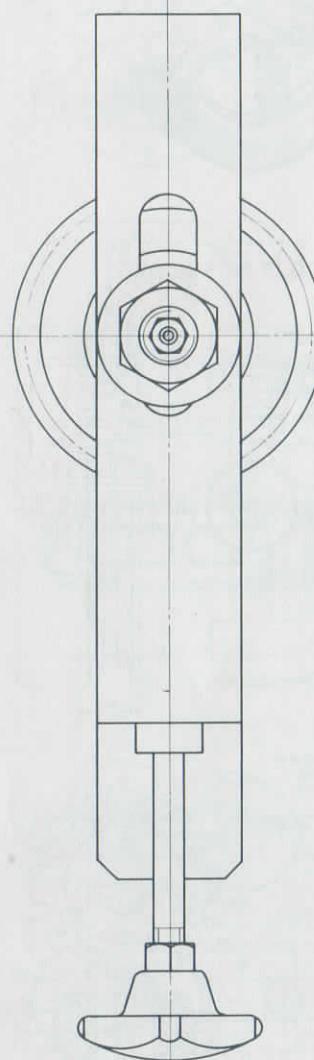
$$t = 17,5$$

$$d = 5$$

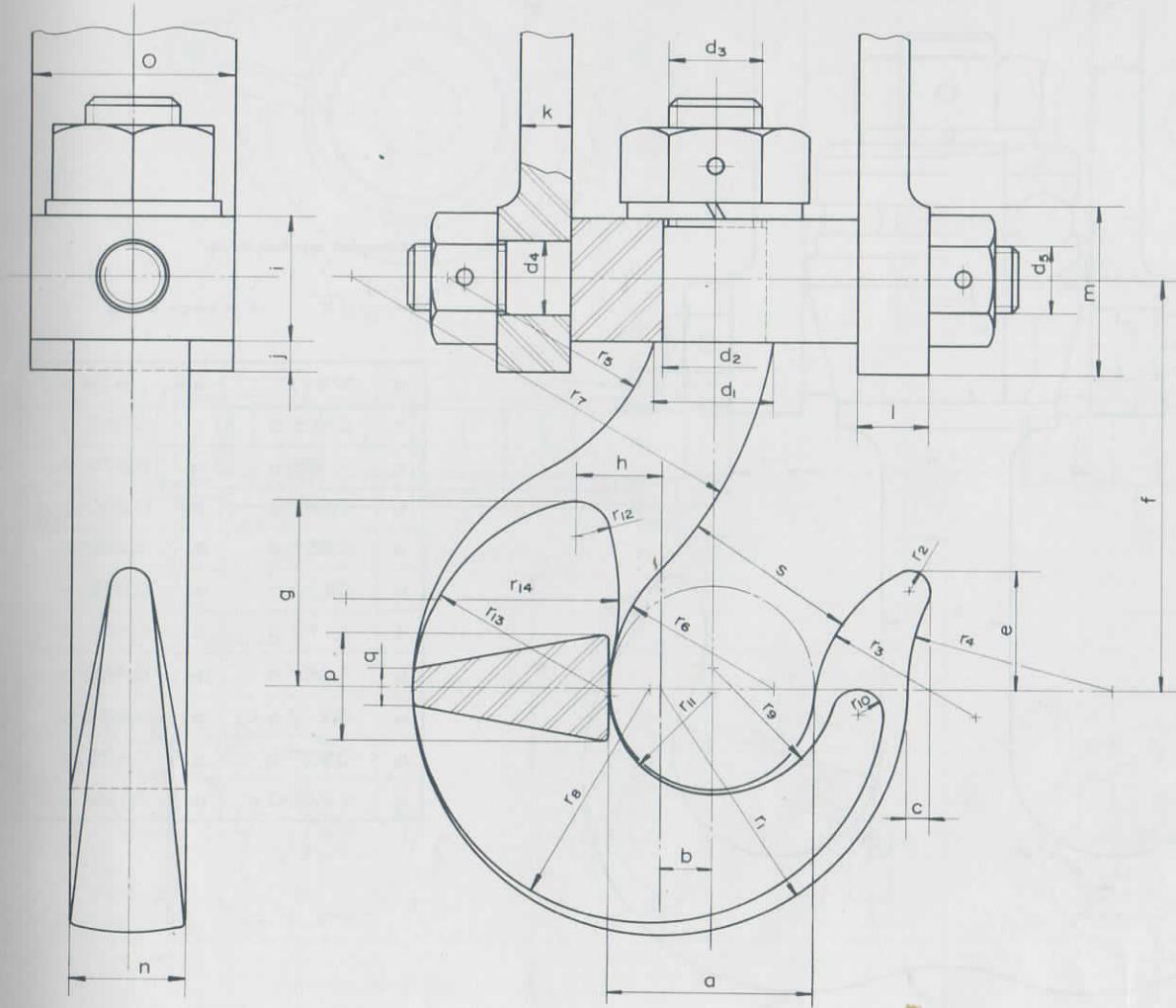
$$D = \sqrt{\left(\frac{t}{\sin \frac{20^\circ}{2}}\right)^2 + \left(\frac{d}{\cos \frac{20^\circ}{2}}\right)^2} = 134$$



ESTICADORES DE CORRENTE



GANCHO FORJADO

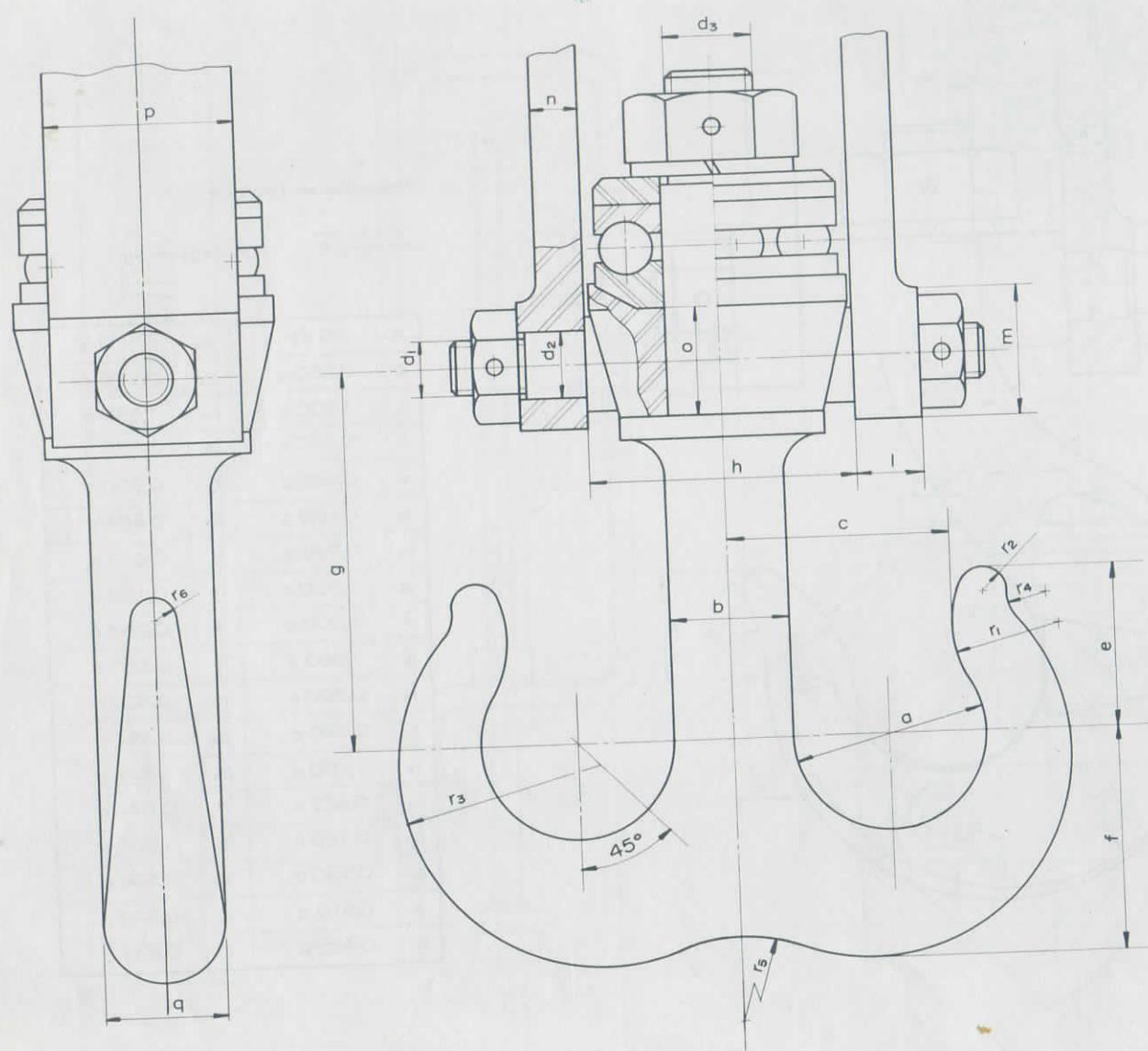


Proporções em função de

$$a = \frac{7}{5} \sqrt[5]{P} \quad P = \text{carga em kg}$$

a	$\frac{7}{5} \sqrt[5]{P}$	r ₁₂	0,170 a
b	0,250 a	r ₁₃	0,970 a
r ₁	1,200 a	r ₁₄	1,330 a
c	0,100 a	d ₁	0,580 a
e	0,580 a	d ₂	0,500 a
r ₂	0,100 a	d ₃	0,464 a
r ₃	0,800 a	i	0,607 a
r ₄	1,000 a	j	0,150 a
f	2,000 a	k	0,250 a
r ₅	1,060 a	l	0,357 a
r ₆	0,800 a	m	0,800 a
r ₇	2,090 a	d ₄	0,357 a
r ₈	1,150 a	d ₅	0,321 a
r ₉	0,625 a	n	0,571 a
r ₁₀	0,120 a	o	1,000 a
r ₁₁	0,500 a	p	0,536 a
g	0,910 a	q	0,179 a
h	0,420 a	s	0,833 a

GANCHO FORJADO DUPLO

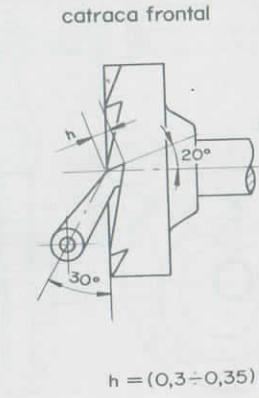
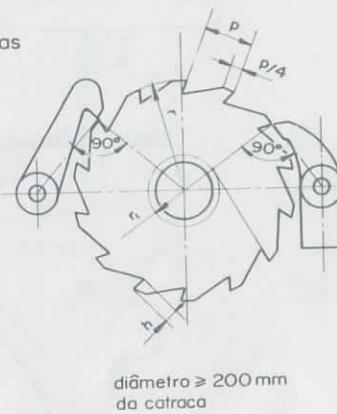
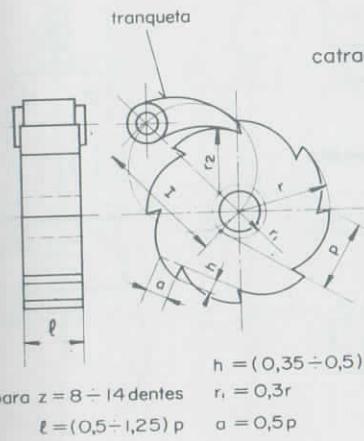
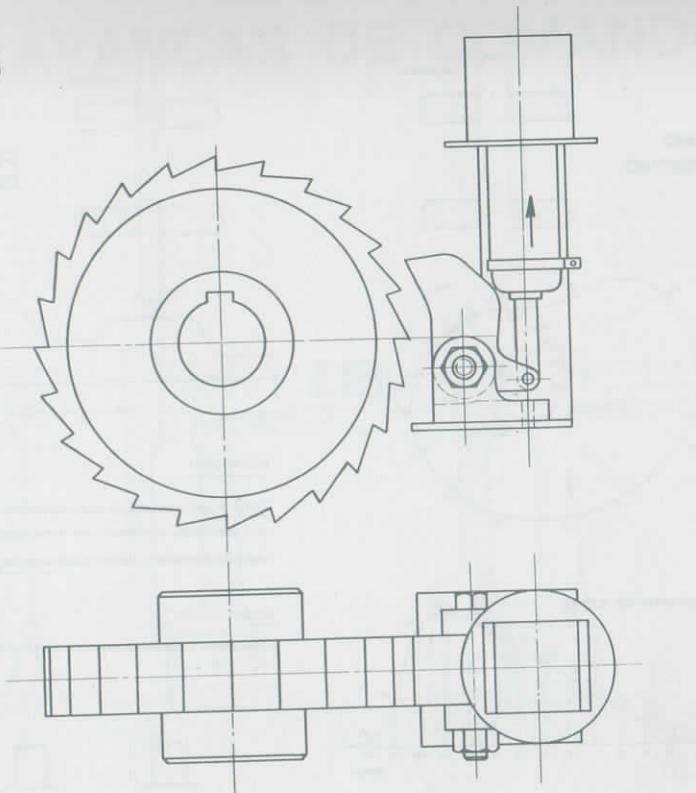
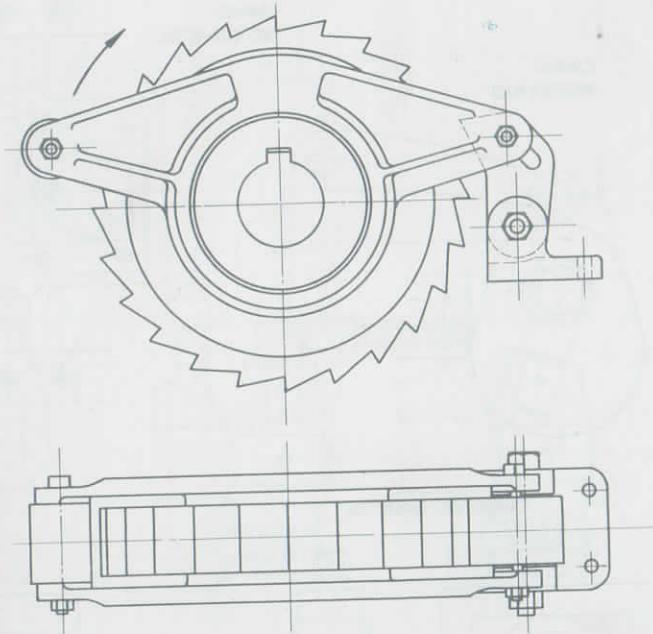


Proporções em função de

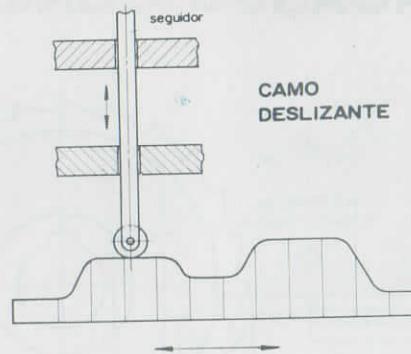
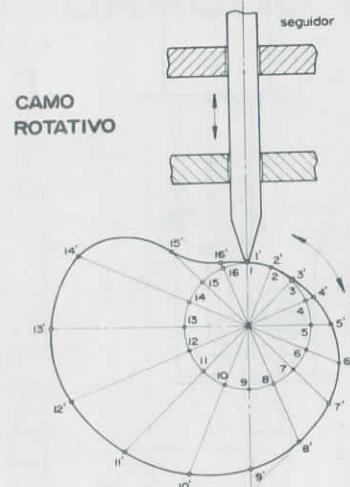
$$a = \frac{7}{5} \sqrt{P} \quad P = \text{carga em kg}$$

a	$7/5\sqrt{P}$	h	1,428 a
b	0,625 a	l	0,357 a
c	1,165 a	m	0,679 a
r ₁	0,562 a	n	0,250 a
e	0,857 a	d ₁	0,300 a
r ₂	0,120 a	d ₂	0,355 a
f	1,172 a	o	0,571 a
r ₃	1,062 a	d ₃	0,469 a
r ₄	0,212 a	p	1,000 a
r ₅	0,937 a	q	0,625 a
g	$\leq 2,000 a$	r ₆	0,120 a

CATRACAS

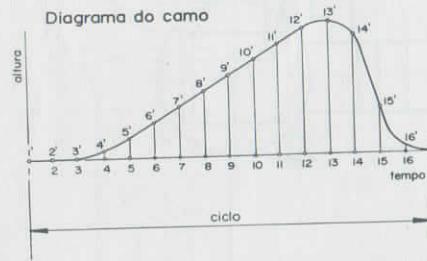


CAMOS



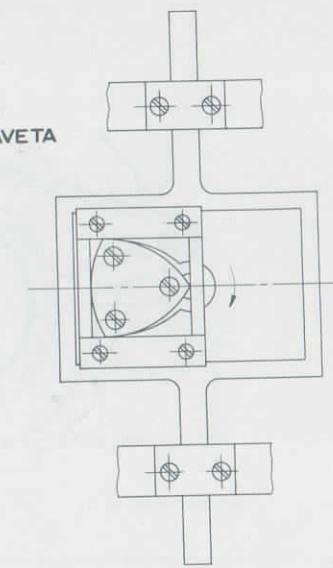
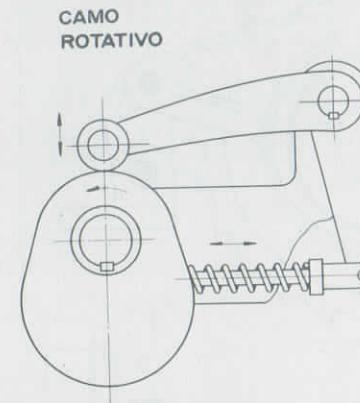
DEFINIÇÃO

Camo é um mecanismo com superfície de forma especial, destinado a produzir um movimento particular num segundo elemento, denominado seguidor.

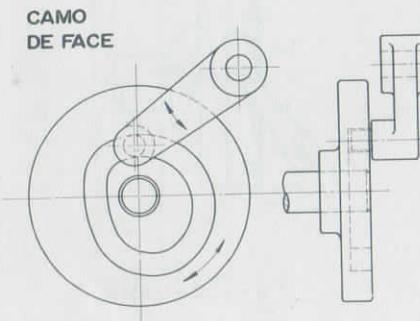
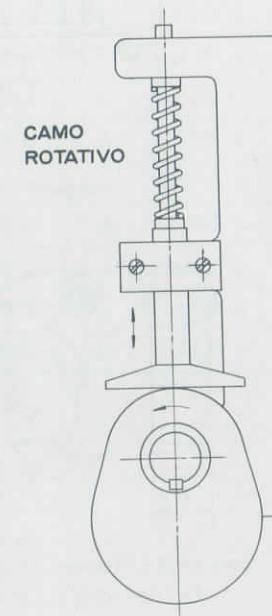
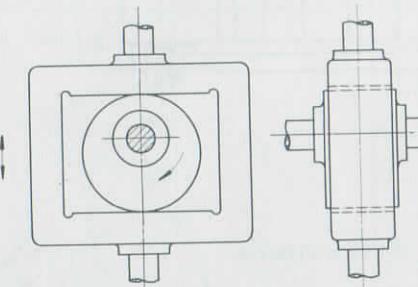


NOTA

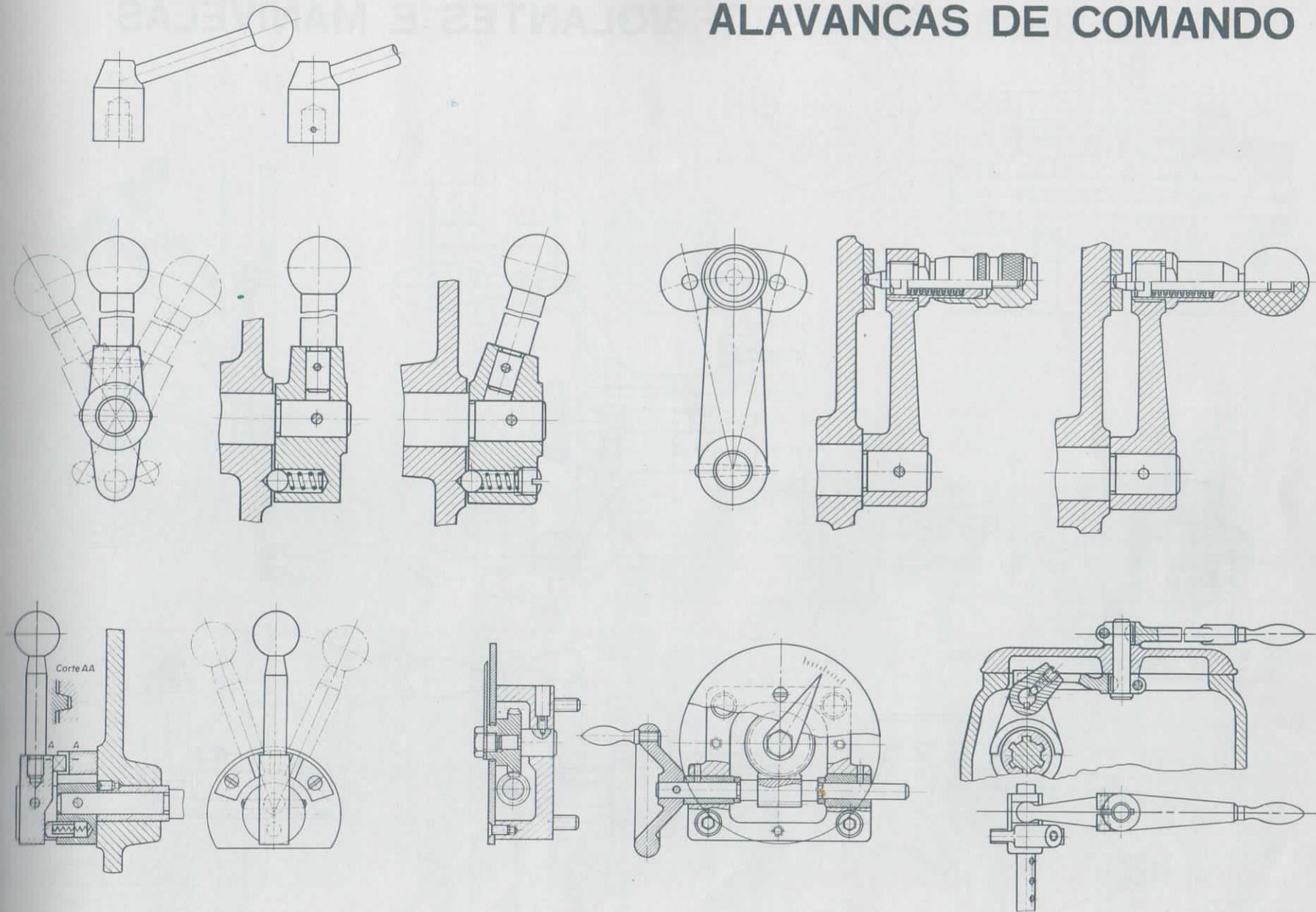
O diagrama do camo representa o perfil do camo deslizante.



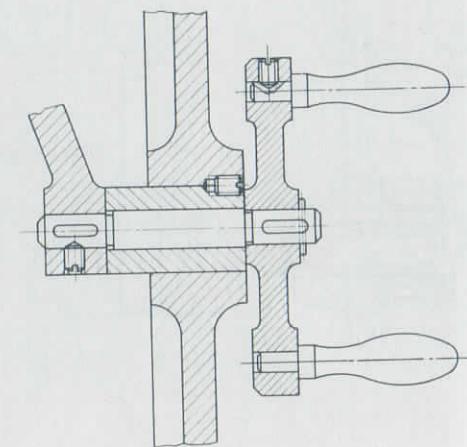
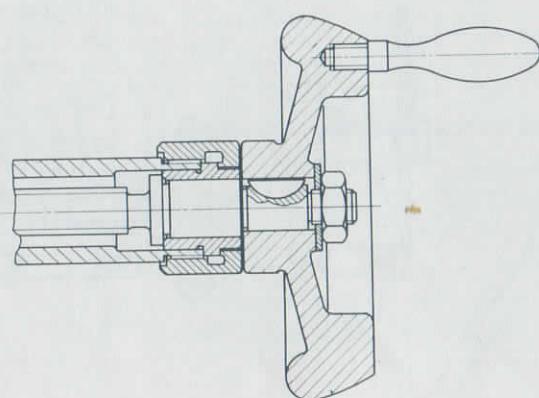
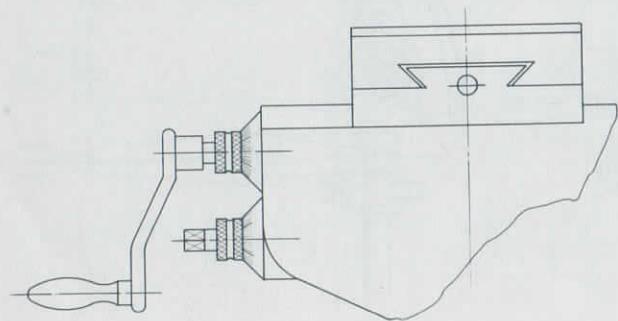
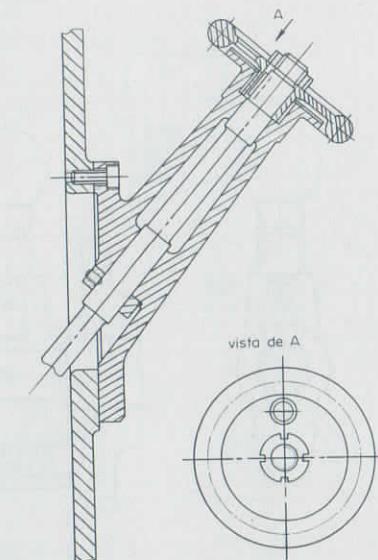
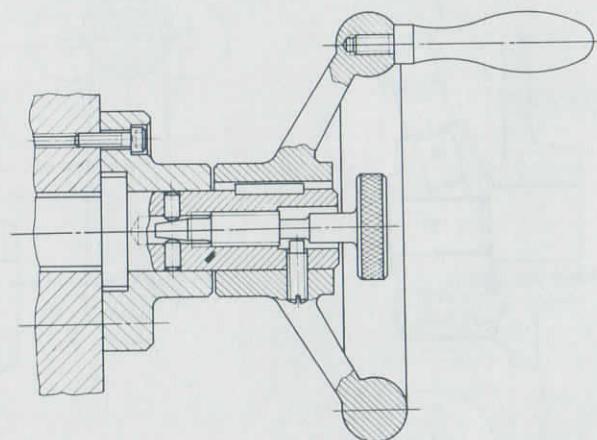
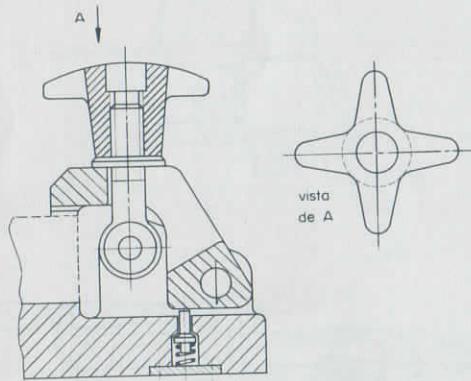
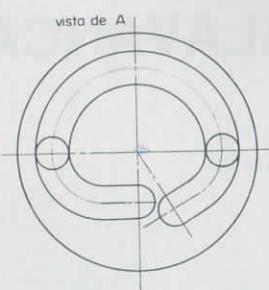
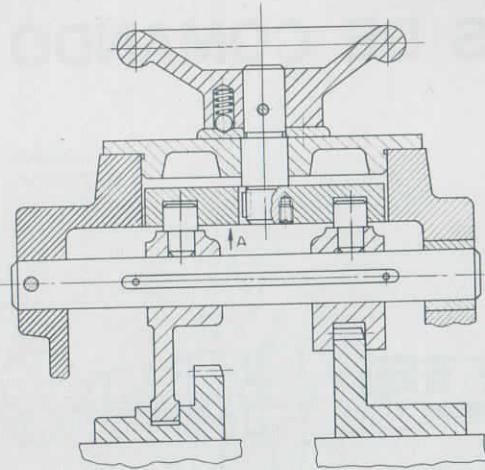
CAMO DE GAVETA



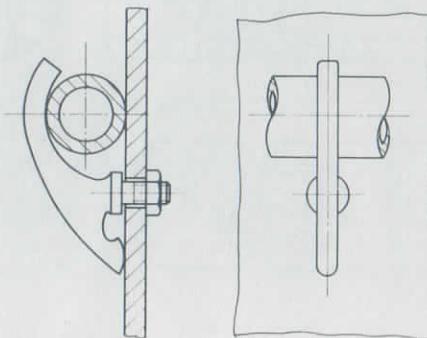
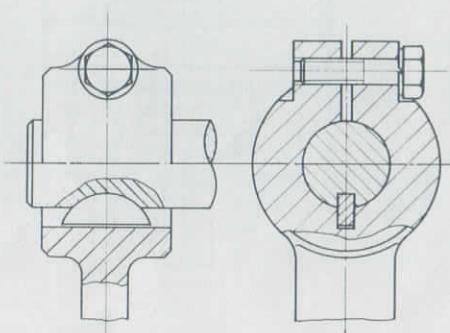
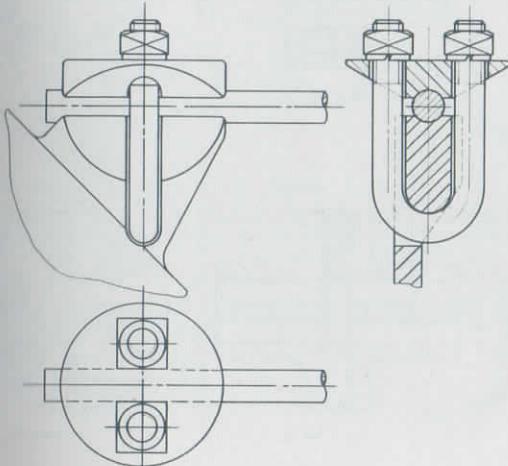
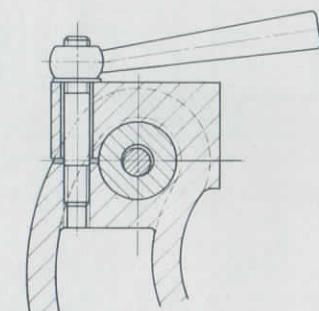
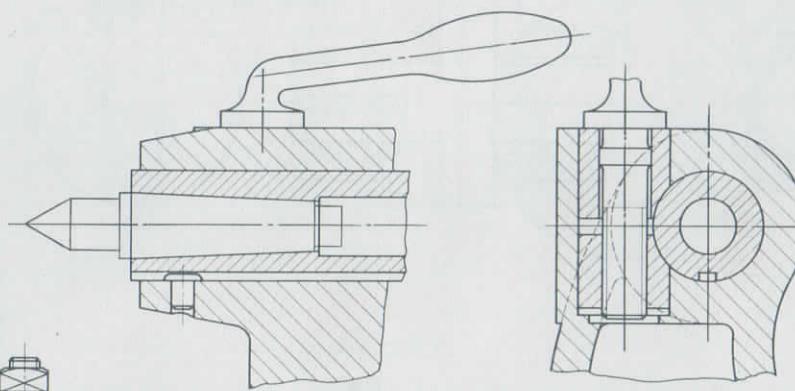
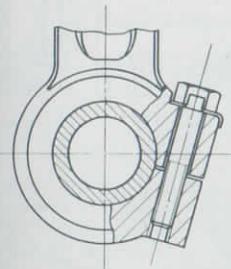
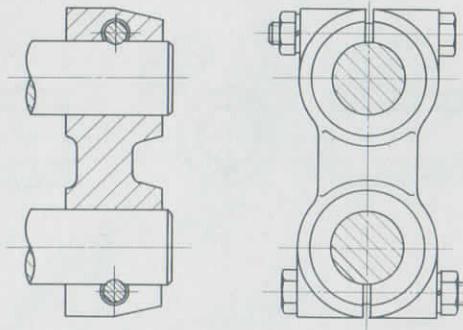
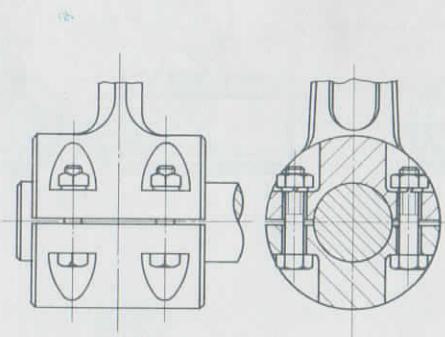
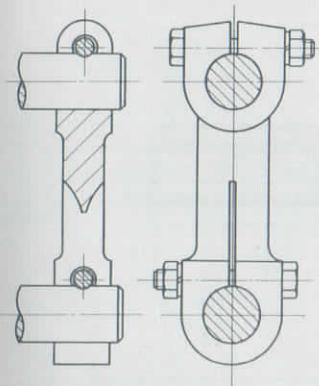
ALAVANCAS DE COMANDO



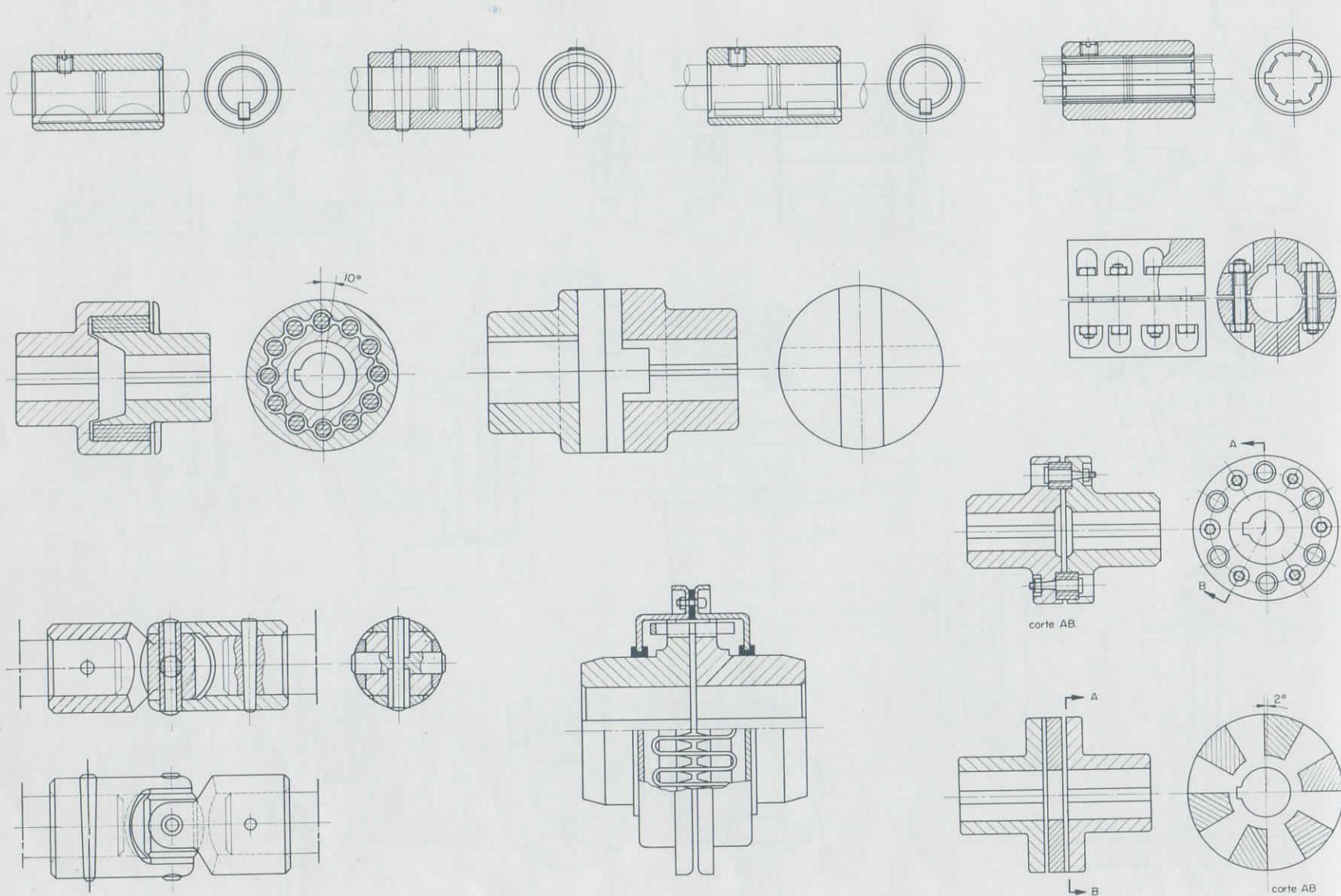
VOLANTES E MANIVELAS

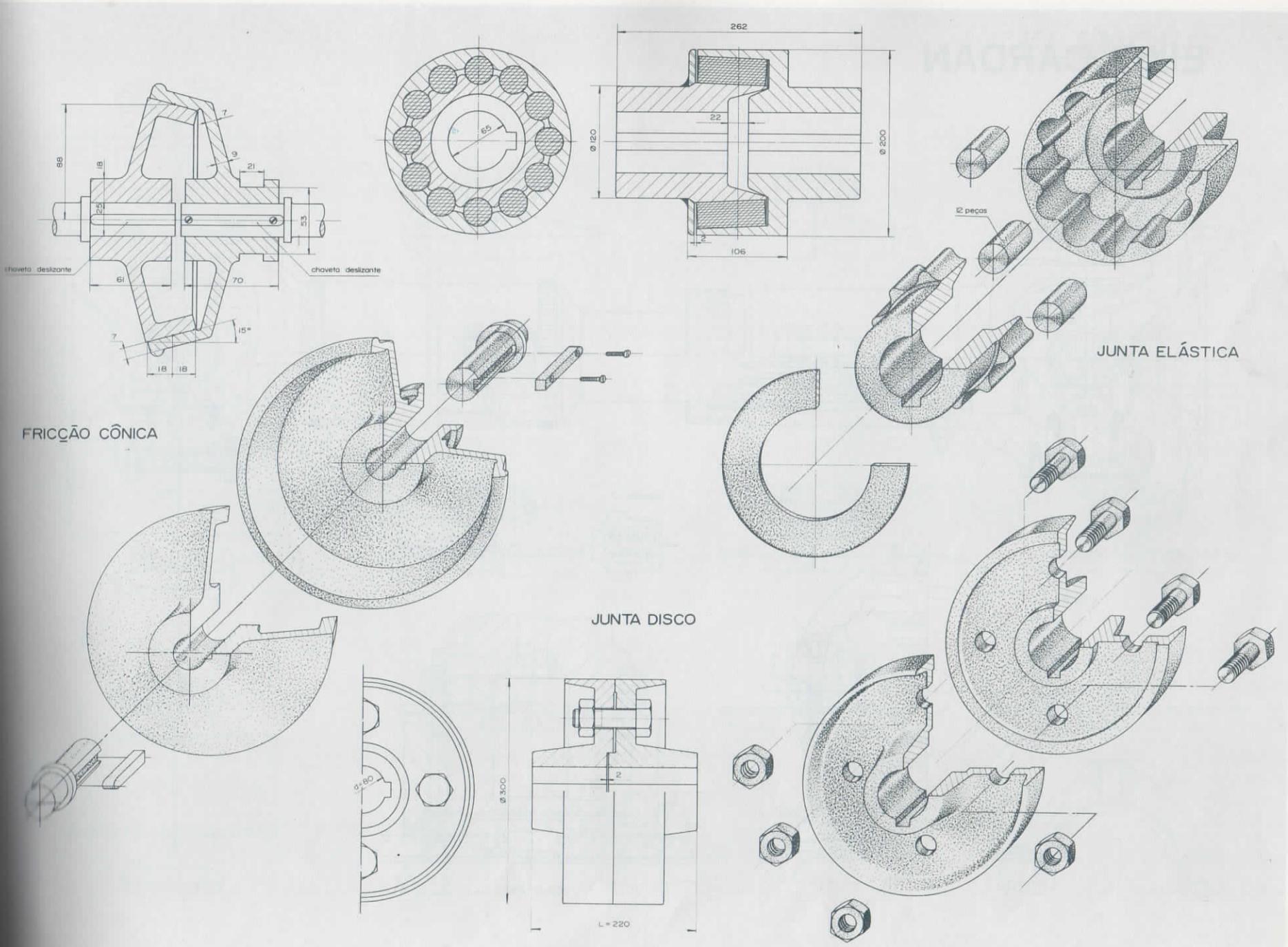


DISPOSITIVOS DE FIXAÇÃO

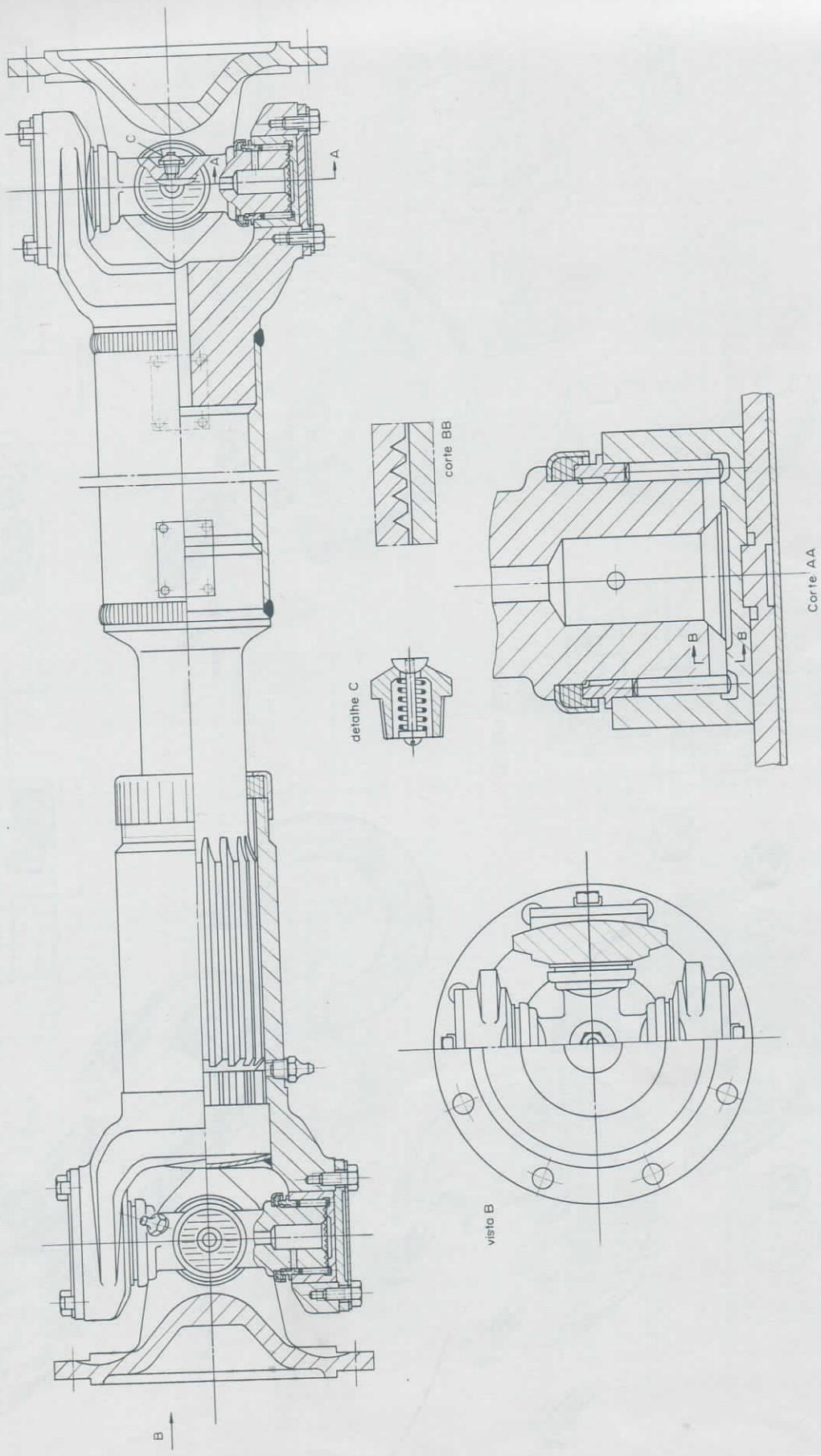


JUNTAS - UNIÕES

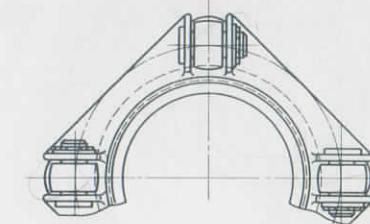
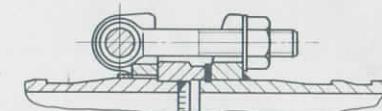
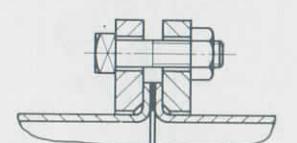
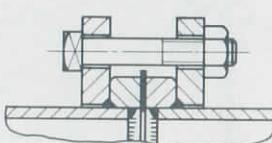
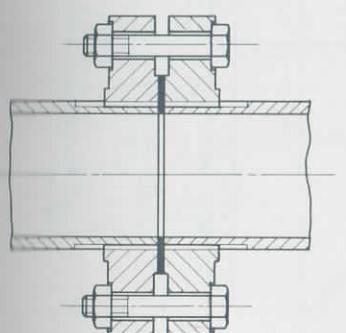
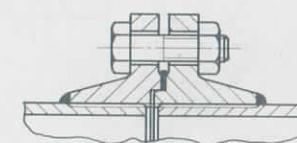
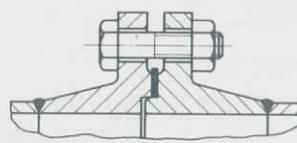
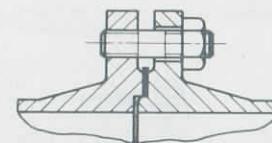
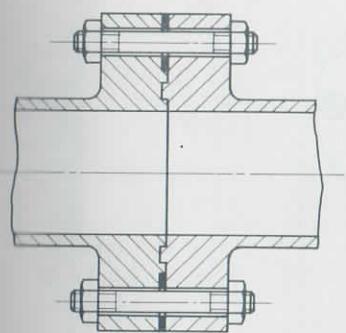
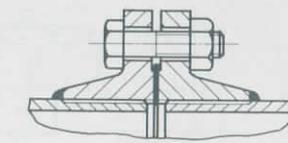
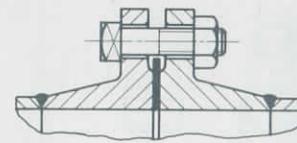
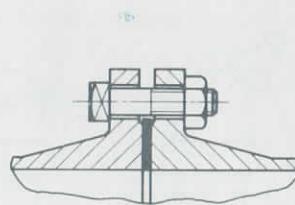
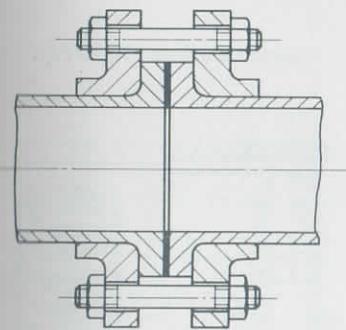




EIXO CARDAN

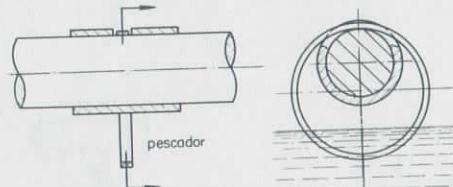
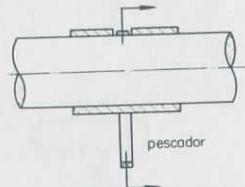
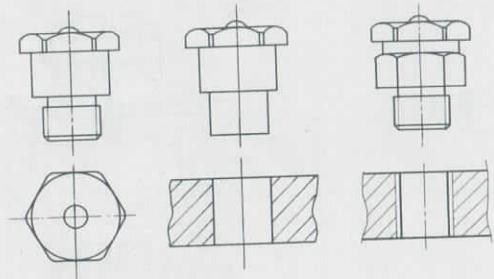


FLANGES

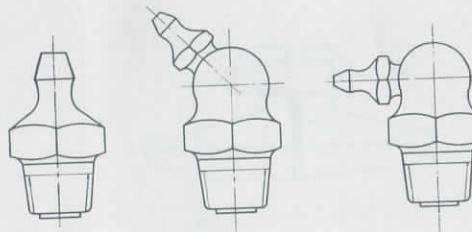


ENGRAXADEIRAS E MARCADORES DE ÓLEO

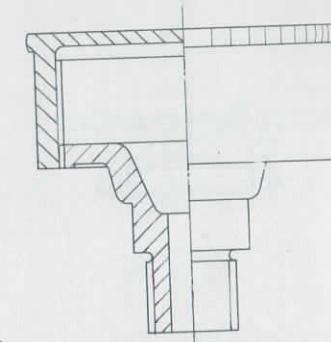
ENGRAXADEIRAS TECALEMIT



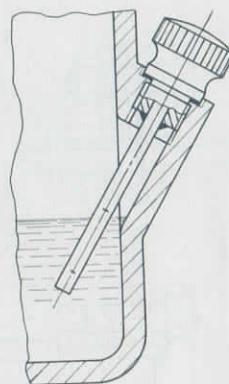
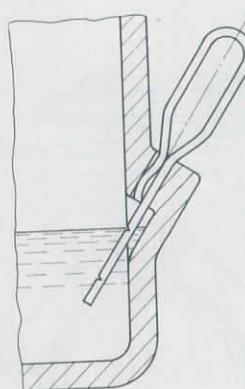
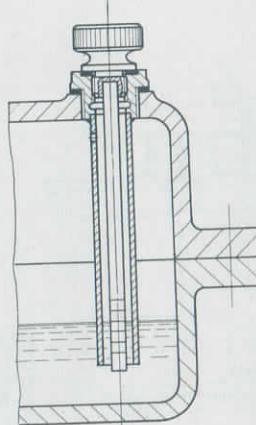
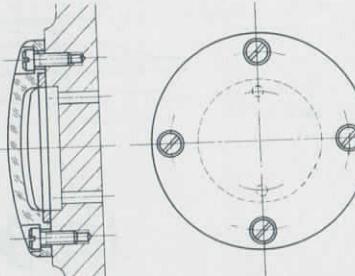
ENGRAXADEIRAS LUB



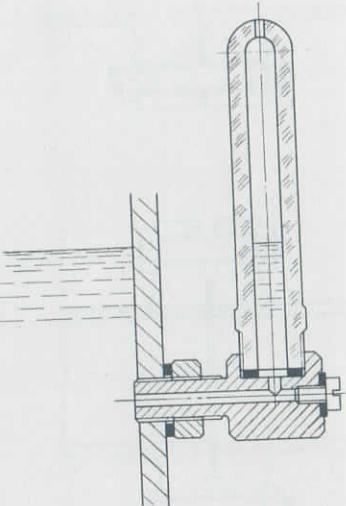
ENGRAXADEIRA STAUFFER



VISORES



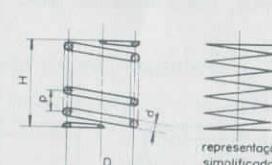
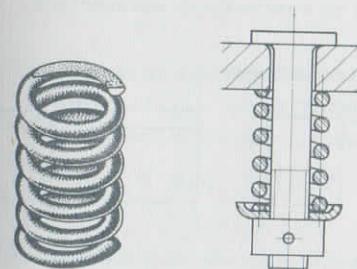
VARETAS



NÍVEL TUBULAR

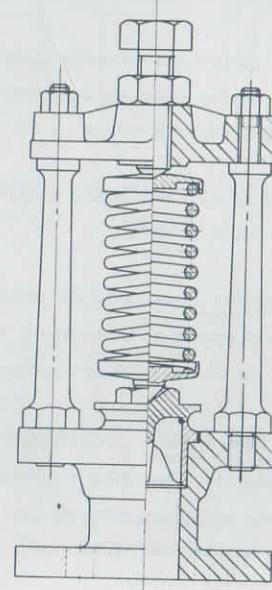
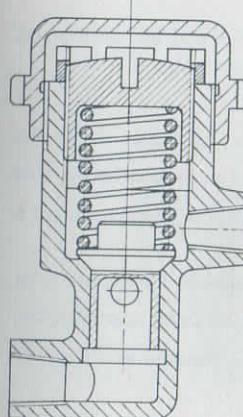
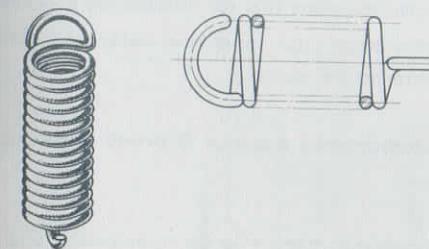
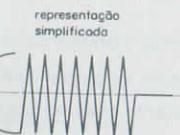
MOLAS

MOLAS HELICOIDAIS

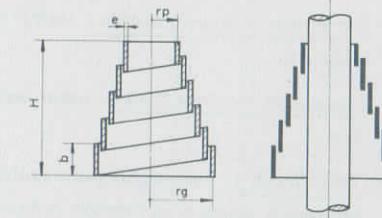


Indicar no desenho:
 n = número de espiras
 D = diâmetro da espira
 d = diâmetro de fio

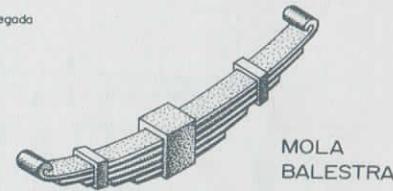
p = passo
 H = comprimento da mola descarregada



MOLA CÔNICA

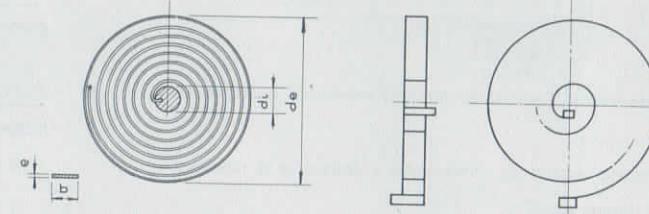


Indicar no desenho:
 b x e = secção de fita
 H = comprimento da mola descarregada
 rp = raio pequeno
 rg = raio grande
 n = número de espiras

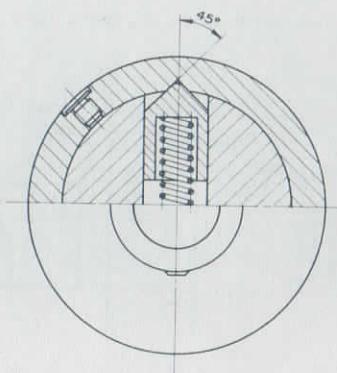
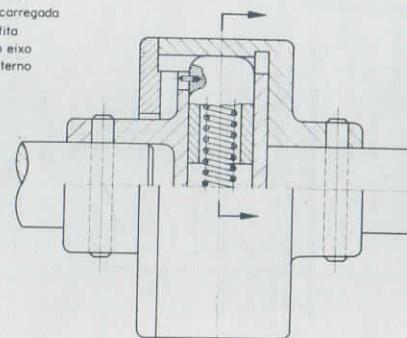


MOLA
BALESTRA

MOLA EM ESPIRAL



Indicar no desenho:
 n = número de voltas quando descarregada
 b x e = secção de fita
 di = diâmetro do eixo
 de = diâmetro externo



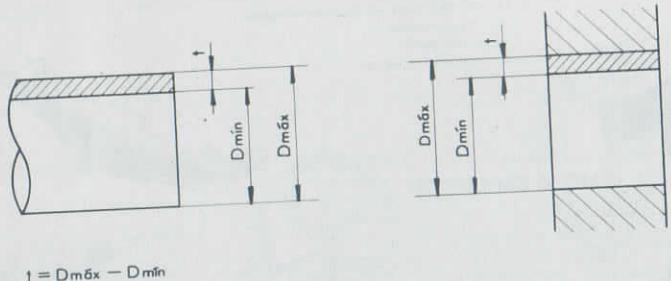
TOLERÂNCIAS E AJUSTES

1 - Dimensão efetiva: valor obtido medindo a peça.

2 - Dimensão máxima $D_{máx}$: valor máximo admissível para a dimensão efetiva.

3 - Dimensão mínima $D_{mín}$: valor mínimo admissível para a dimensão efetiva.

4 - Tolerância t : variação permitível da dimensão da peça, dada pela diferença entre a dimensão máxima e a mínima.

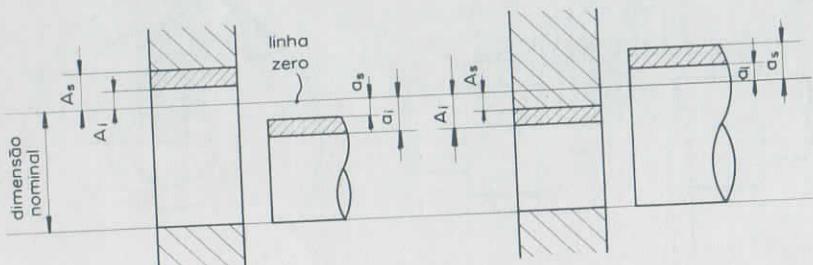


$$t = D_{máx} - D_{mín}$$

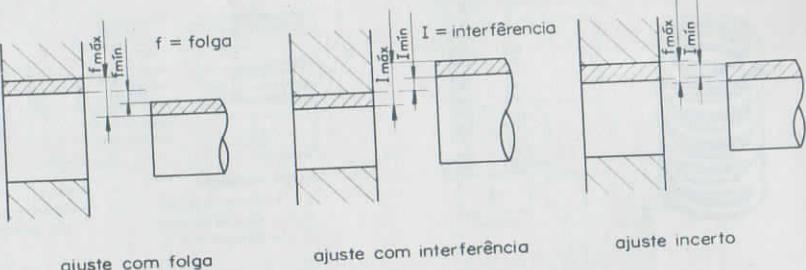
5 - Linha zero: linha que nos desenhos fixa a dimensão nominal e serve de origem aos afastamentos.

6 - Afastamento inferior: diferença entre a dimensão mínima e a nominal. Símbolos: A_i para furo, a_i para eixo.

7 - Afastamento superior: diferença entre a dimensão máxima e a nominal. Símbolos: A_s para furo, a_s para eixo.



8 - Ajuste: comportamento de um eixo num furo, ambos da mesma dimensão nominal, caracterizado pela folga ou interferência apresentada.



9 - Eixo: termo convencionalmente aplicado para fins de tolerâncias e ajustes, como sendo qualquer parte de uma peça cuja superfície externa é destinada a alojar-se na superfície interna de outra.

10 - Eixo base: é o eixo em que o afastamento superior é preestabelecido como sendo igual a zero.

11 - Furo: termo convencionalmente aplicado para fins de tolerâncias e ajustes, como sendo todo espaço delimitado por superfície interna de uma peça e destinado a alojar o eixo.

12 - Furo base: é o furo em que o afastamento inferior é preestabelecido como sendo igual a zero.

13 - Sistema de ajuste: conjunto de princípios, regras, fórmulas e tabelas que permite a escolha racional de tolerâncias no acoplamento eixo-furo, para se obter economicamente uma condição preestabelecida.

14 - Sistema de tolerância: conjunto de princípios, regras, fórmulas e tabelas que permite a escolha racional de tolerâncias para a produção econômica das peças mecânicas intercambiáveis. (v. tabelas do "Prontuário do Projetista de Máquinas".)

15 - A escolha das tolerâncias é feita por meio de fórmulas ou por meio de tabelas.

16 - A qualidade de trabalho (campo de tolerância) é designada por números: O1, O, I, 2, ..., 15, 16 na ordem decrescente de qualidade.

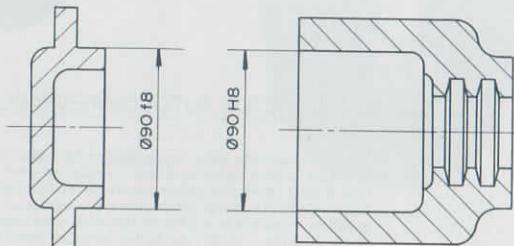
17 - A posição dos campos de tolerância em relação à dimensão nominal é designada por letras. As letras maiúsculas são reservadas para os furos e as minúsculas para os eixos.

furos : A, B, C, ..., Y, Z

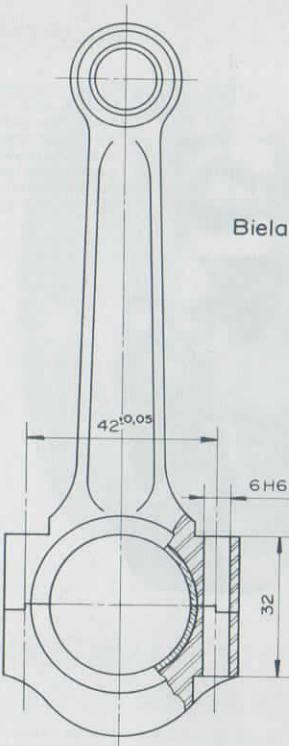
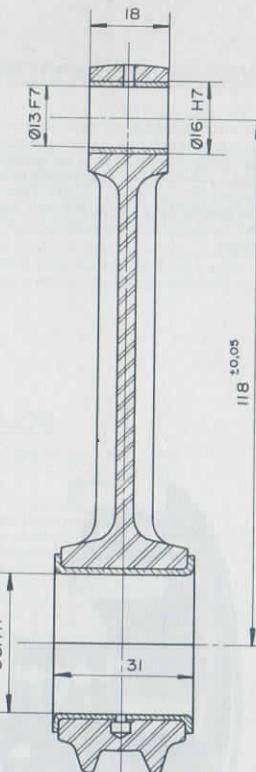
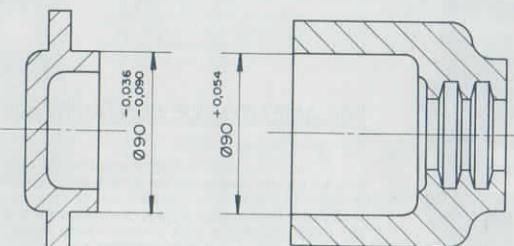
eixos : a, b, c, ..., y, z

18 - A indicação da tolerância é feita por meio de símbolos. Cada símbolo é formado acrescentando à letra do campo o número indicativo da qualidade.

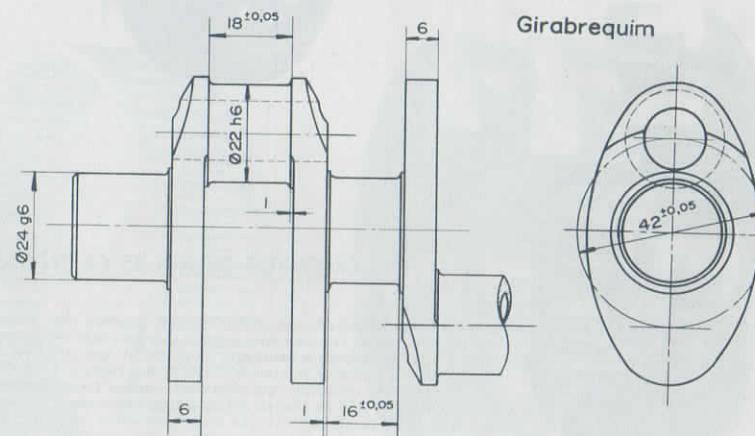
Exemplo : Eixo f8 e furo H8.



19 - A indicação da tolerância também pode ser feita colocando-se diretamente sobre o desenho os valores obtidos em tabelas.

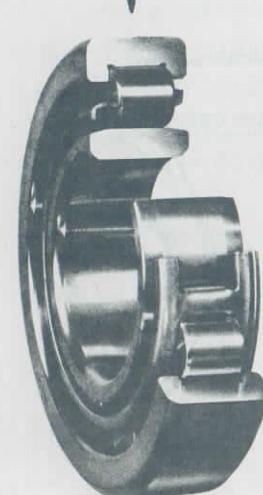
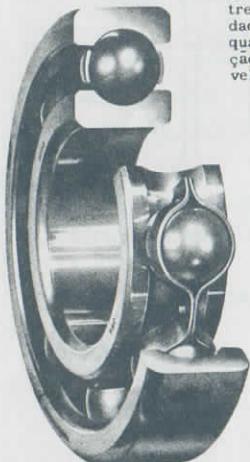


Girabrequim



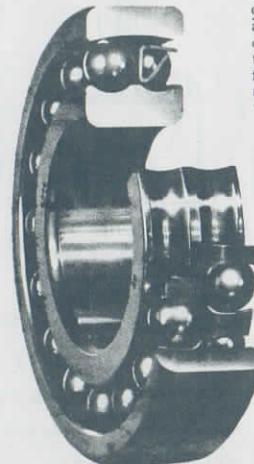
ROLAMENTOS FIXOS DE UMA CARREIRA DE ESFERAS

O rolamento fixo de uma carreira de esferas tem pistas profundas, sem orifício para a entrada das esferas. Graças a profundidade das pistas, ao tamanho das esferas e ao íntimo contacto entre as esferas e as pistas, possui esse rolamento grande capacidade de carga, inclusive no sentido axial. É por isso muito adequado para resistir a cargas de todas as direções. Sua construção lhe permite suportar consideráveis cargas axiais, mesmo a velocidades muito elevadas.



ROLAMENTOS DE ROLOS CILÍNDRICOS

Os rolos do rolamento cilíndrico são guiados por rebordos em um dos anéis. O outro anel geralmente não tem rebordos. Esta execução apresenta a vantagem de permitir que o eixo se desloque axialmente dentro de certos limites, em relação à caixa. Os rolamentos com rebordos nos dois anéis podem fixar axialmente o eixo, sempre que as forças sejam muito reduzidas. A desmontagem é muito fácil, mesmo que ambos os anéis estejam montados com ajuste forte. Este rolamento é adequado para cargas relativamente grandes e pode também suportar altas velocidades.



TIPOS DE ROLAMENTOS

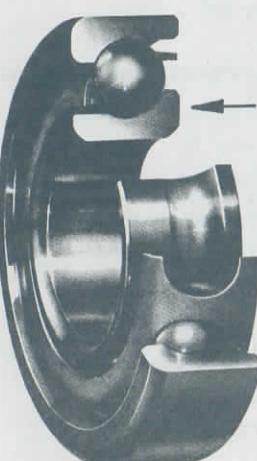
ROLAMENTOS AUTOCOMPENSADORES DE ESFERAS

O rolamento autocompensador de esferas tem duas carreiras de esferas e uma pista esférica comum no anel externo. Graças à esfericidade da pista, o rolamento é autocompensador, o que o torna insensível a ligeiros desalinhamentos do eixo, provenientes de montagem defeituosa, esforços sobre o eixo, desnível das fundações, etc. Pelo mesmo motivo, o rolamento não podeoccasionar flexões no eixo, o que é de grande importância quando se trata de aplicações em que se requer alta velocidade e exatidão.



ROLAMENTOS AUTOCOMPENSADORES DE ROLOS

O rolamento autocompensador de rolos tem duas carreiras de rolos e uma pista esférica comum no anel externo, característica à qual deve sua propriedade de alinhamento automático. O número e o tamanho de seus rolos e a exatidão com que estes são guiados, conferem a esse rolamento uma capacidade de carga muito grande. O de tipo largo também pode suportar cargas axiais consideráveis, provenientes de qualquer direção.



ROLAMENTOS DE CONTACTO ANGULAR

O rolamento de contacto angular de uma carreira de esferas tem as pistas dispostas de forma que a pressão exercida pelas esferas está dirigida em ângulo agudo com respeito ao eixo. Em consequência desta disposição, o rolamento é especialmente apropriado para resistir a uma grande carga axial, devendo-se montá-lo contraposto a outro rolamento que possa receber a carga axial existente em sentido contrário. Este rolamento não é desarmável.



ROLAMENTOS DE CONTACTO ANGULAR DE 2 CARREIRAS DE ESFERAS

O rolamento de contacto angular de duas carreiras tem as pistas de maneira que as linhas de pressão formadas pelas duas carreiras de esferas se dirigem a dois pontos do eixo relativamente distante entre si. Ao contrário de outros tipos de rolamento, este tem carga prévia, que lhe permite reduzir, entre pequenos limites, os movimentos axiais do eixo, mesmo sob cargas de direção variável. Por sua construção, este rolamento é apropriado para órgãos giratórios de máquinas que requerem dois apoios, porém nos quais se dispõe de espaço para um só rolamento.



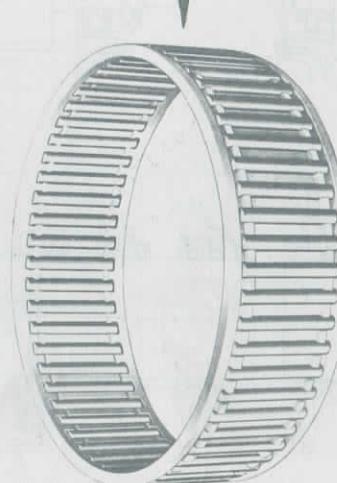
ROLAMENTOS AXIAIS DE ESFERAS ESCORA SIMPLES

O rolamento axial de esferas de escora simples consta de uma carreira de esferas entre duas placas, uma das quais, a placa móvel, é de assento plano, enquanto que a outra, a placa fixa, pode ter assento plano ou esférico. Neste último caso, o rolamento se apoia em uma contraplaca. Os rolamentos com assento plano deveriam, sem dúvida, ser preferidos para a maioria das aplicações, porém, os de assento esférico são muito úteis em certos casos, para compensar pequenas inexatidões de fabricação das caixas. O rolamento destina-se a suportar carga axial em uma só direção.



ROLAMENTOS DE ROLOS CÔNICOS DE UMA CARREIRA DE ESFERAS

O rolamento de rolos cônicos, graças à posição oblíqua dos rolos e da pista, é especialmente adequado para resistir a cargas radiais e axiais. Para os casos em que a carga axial é muito importante, há uma série de rolamentos cujo ângulo é muito aberto. Este rolamento deve ser montado contraposto a outro capaz de suportar os esforços axiais em sentido contrário. O rolamento é desarmável; o anel interno com seus rolos e o anel externo armam-se cada um separadamente.



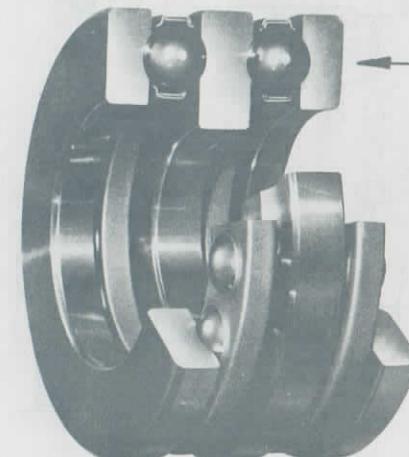
ROLAMENTOS DE AGULHAS

Os rolamentos de agulhas, indicados para suportar esforços radiais intensos, são de pequena espessura, possibilitando, assim, o emprego de assentos mais leves e de dimensões reduzidas; apresentam alta rigidez, o que permite que suportem maiores cargas com muito menor desgaste; funcionam silenciosamente, mesmo quando são submetidos a regimes de altas rotações.

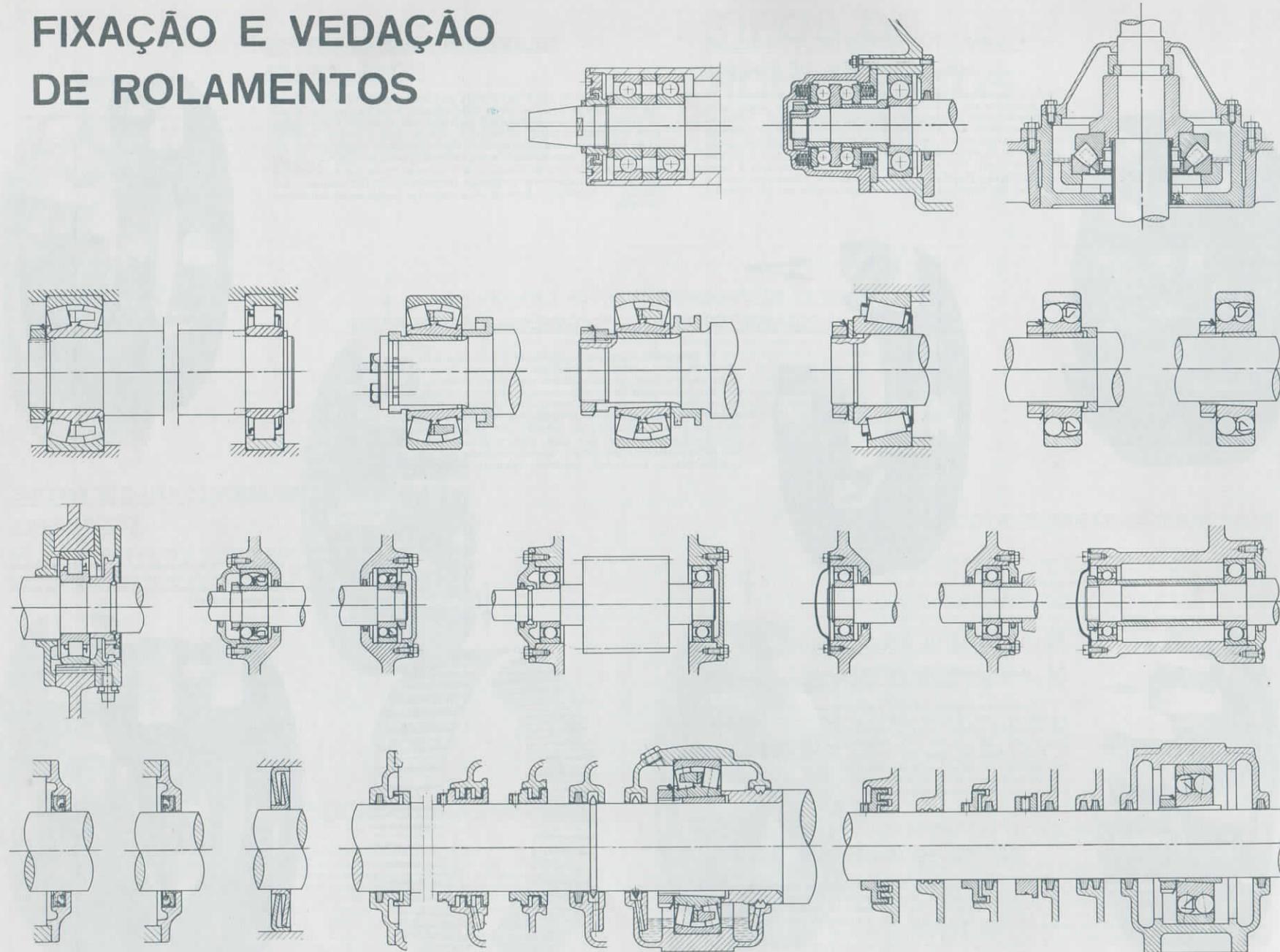


ROLAMENTOS AXIAIS DE ESFERAS ESCORA DUPLA

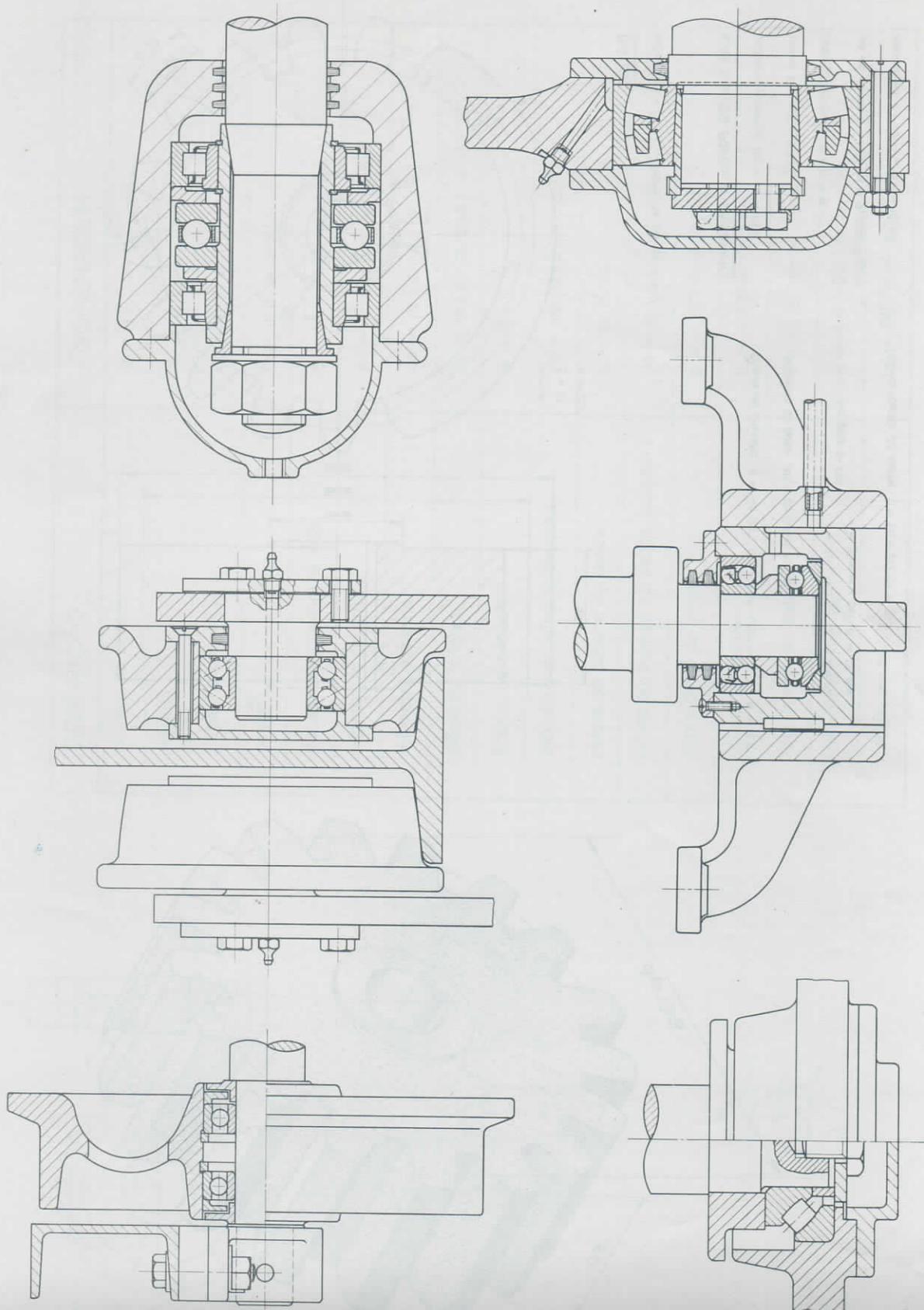
O rolamento axial de esferas de escora dupla tem duas carreiras de esferas, uma para cada direção de carga, e três placas fixas são iguais às do rolamento de escora simples, podendo ser de assento plano ou esférico. O rolamento destina-se a resistir a cargas axiais de direção variável.



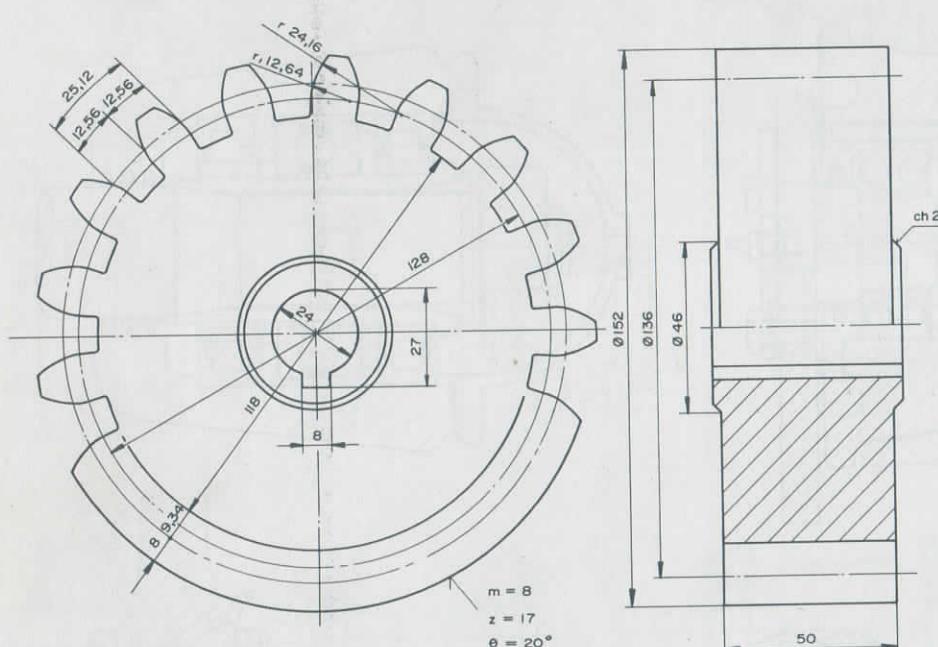
FIXAÇÃO E VEDAÇÃO DE ROLAMENTOS



APLICAÇÃO DE ROLAMENTOS



ENGRANAGENS CILÍNDRICAS DE DENTES RETOS



DADOS

módulo $m = 8$ número de dentes $z = 17$

CÁLCULOS PARA O DESENHO

$$\text{diâmetro primitivo } dp = mz = 136$$

$$\text{passo } P = m\pi = 25,12$$

$$\text{cabeça do dente } a = m = 8$$

$$\text{pé do dente } b = 1,167m = 9,336 \cong 9,34$$

$$\text{espessura } s = \text{vão } v = P/2 = 12,56$$

$$\text{ângulo de pressão } \theta = 14^\circ 30' - 15^\circ - 20^\circ - 22^\circ 30' \therefore \theta = 20^\circ$$

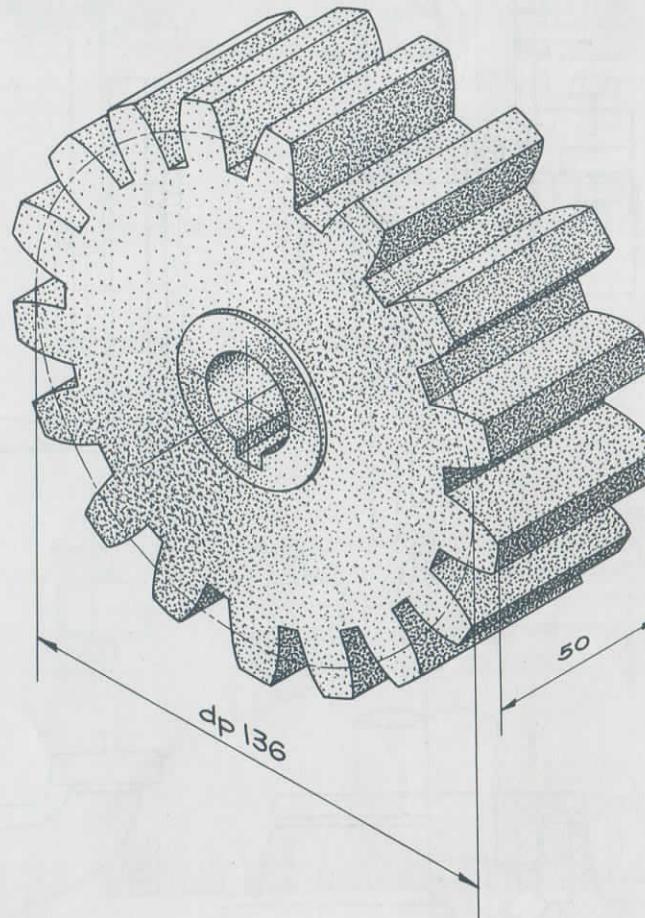
$$\text{diâmetro de base } db = dp \cos \theta = 128$$

r e r_i : ver pág. 6-105

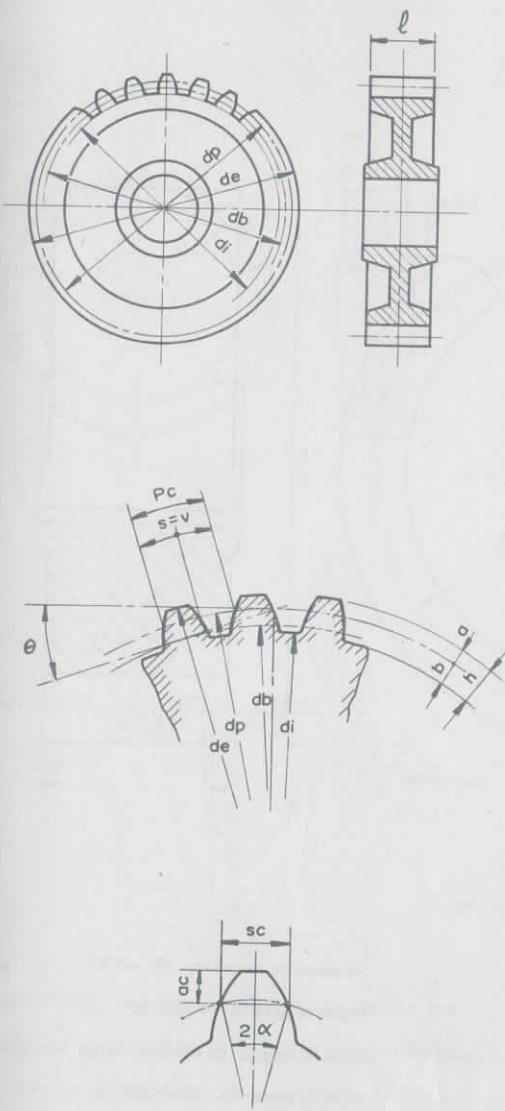
$$r = fm = 3,02 \cdot 8 = 24,16$$

$$r_i = f'm = 1,58 \cdot 8 = 12,64$$

$$\text{comprimento do dente } l = (6 \div 20)m = 50$$

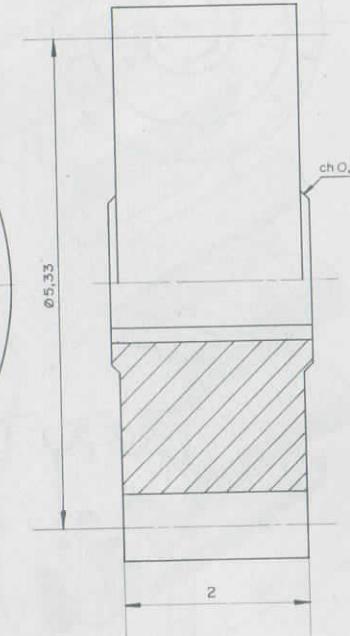
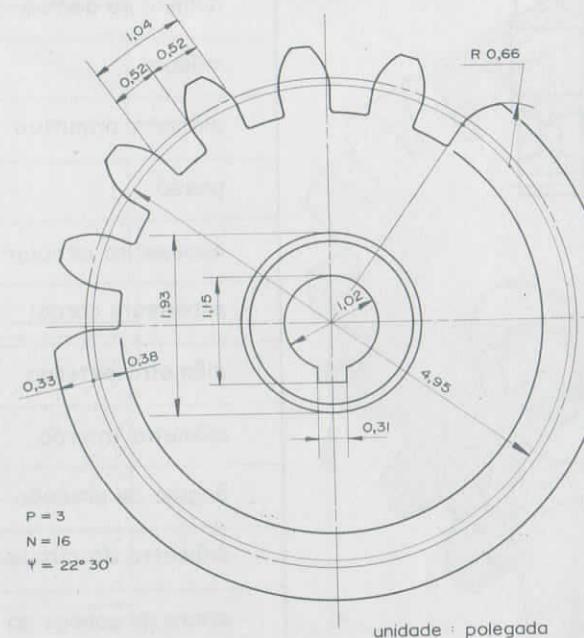
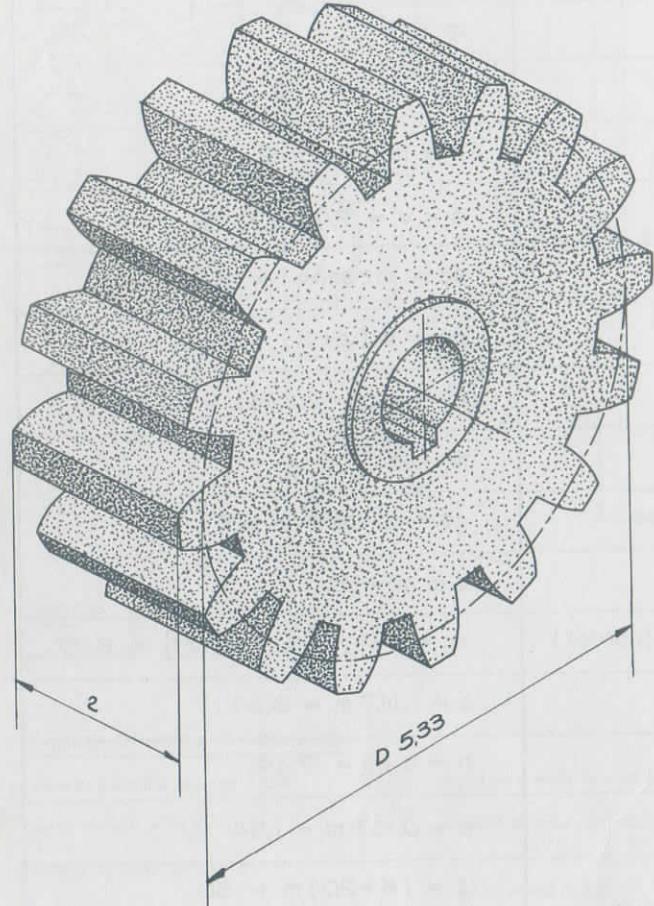


CÁLCULOS



DESCRICAÇÃO	ENGRENAGEM
número de dentes	$z = 17$
módulo	$m = 8$
diâmetro primitivo	$dp = mz = 136$
passo	$P = m\pi = 25,12$
espessura circular e vāo	$s = v = P/2 = 12,56$
espessura cordal	$sc = mz \operatorname{sen}\alpha = 12,56$
diâmetro externo	$de = m(z+2) = 152$
diâmetro interno	$di = m(z-2,334) = 117,32$
ângulo de pressão	$\theta = 20^\circ$
diâmetro do círculo de base	$db = dp \cos\theta = 128$
altura da cabeça do dente	$a = m = 8$
altura da cabeça do dente (cordal)	$ac = m \left[1 + \frac{z}{2} (1 - \cos\alpha) \right] = 8,27$
altura do pé do dente	$b = 1,167 m = 9,34$
altura do dente	$h = a + b = 17,34$
folga no pé do dente	$e = 0,167 m = 1,34$
comprimento do dente	$l = (6 \div 20) m = 50$
ângulo do dente	$\alpha = 90/z = 5^\circ 18'$

ENGRAGENS CILÍNDRICAS DE DENTES RETOS SISTEMA PITCH



DADOS

Diametral Pitch $P = 3$ número de dentes $N = 16$

CÁLCULOS PARA O DESENHO

diâmetro primitivo $D = N/P = 5,33$

passo circunferencial (Circular Pitch) $P' = \pi/P = 1,04$

cabeça do dente $A = 1/P = 0,33$

pé do dente $B = 1,1571/P = 0,38$

espessura do dente $T_c = P/2 = 0,52$

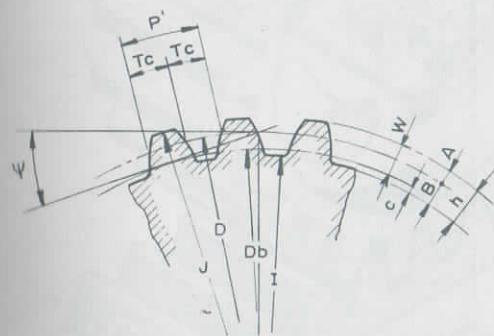
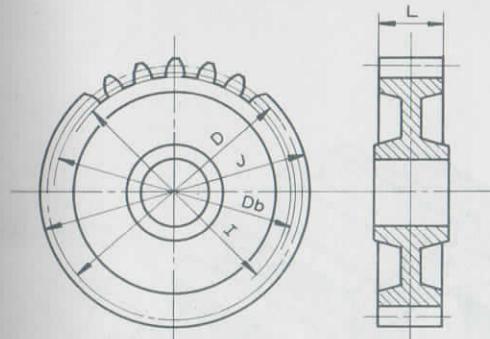
ângulo de pressão $\psi = 22^\circ 30'$

diâmetro de base $D_b = D \cos \psi = 4,95$

perfil do dente $R = D/B = 0,66$

comprimento do dente $L = (6-20)/P = 2$

CÁLCULOS



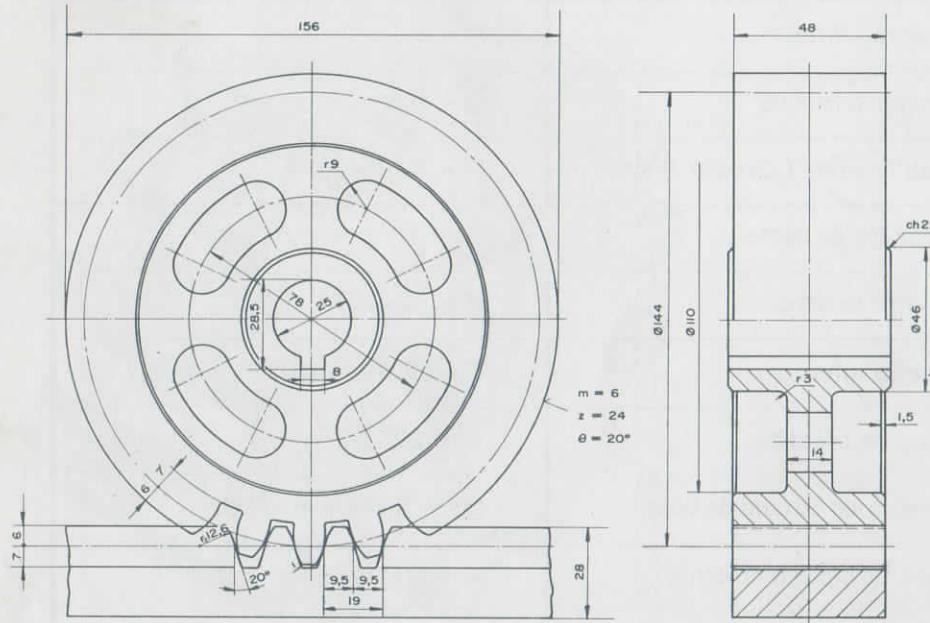
DIAMETRAL PITCH é o número de dentes por polegada de diâmetro primitivo e corresponde ao inverso do módulo : $P = 25,4/m$ [1/pol.]

CIRCULAR PITCH é o passo em polegada

DESCRÍÇÃO	ENGRENAGEM
número de dentes	$N = 16$
Diametral Pitch	$P = 3$
diâmetro primitivo	$D = N/P = 5,33$
passo circunf. (Circular Pitch)	$P' = \pi/P = 1,04$
espessura do dente	$T_c = P'/2 = 0,52$
diâmetro externo	$J = (N+2)/P = 6,0$
diâmetro interno	$I = (N - 2,3142)/P = 4,56$
ângulo de pressão	$\psi = 22^\circ 30'$
diâmetro do círculo de base	$D_b = D \cos \psi = 4,95$
altura da cabeça do dente	$A = I/P = 0,33$
altura do pé do dente	$B = 1,157I/P = 0,38$
altura do dente	$h = A + B = 0,71$
altura teórica do dente	$W = 2/P = 0,66$
folga no pé do dente	$c = 0,157I/P = 0,05$
comprimento do dente	$L = (6 - 20)/P = 2$

(polegada)

ENGRENAGEM E CREMALHEIRA



DADOS

$m = 6$ $z = 24$ Ângulo de pressão $\theta = 20^\circ$

CÁLCULOS PARA O DESENHO

diâmetro primitivo $dp = mz = 144$

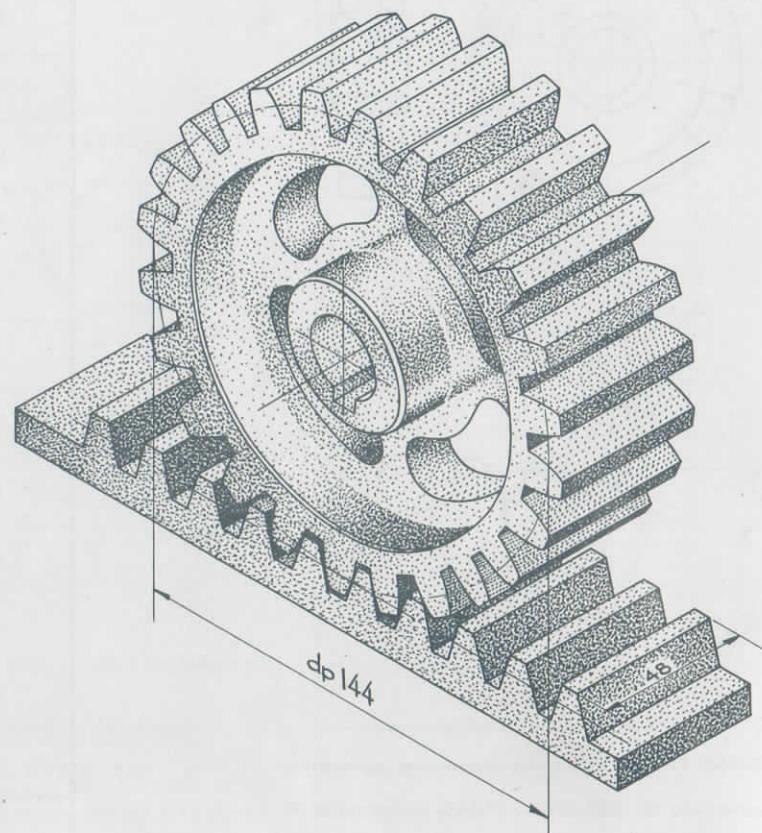
cabeça do dente $a = m = 6$

pé do dente $b = 1,167m = 7$

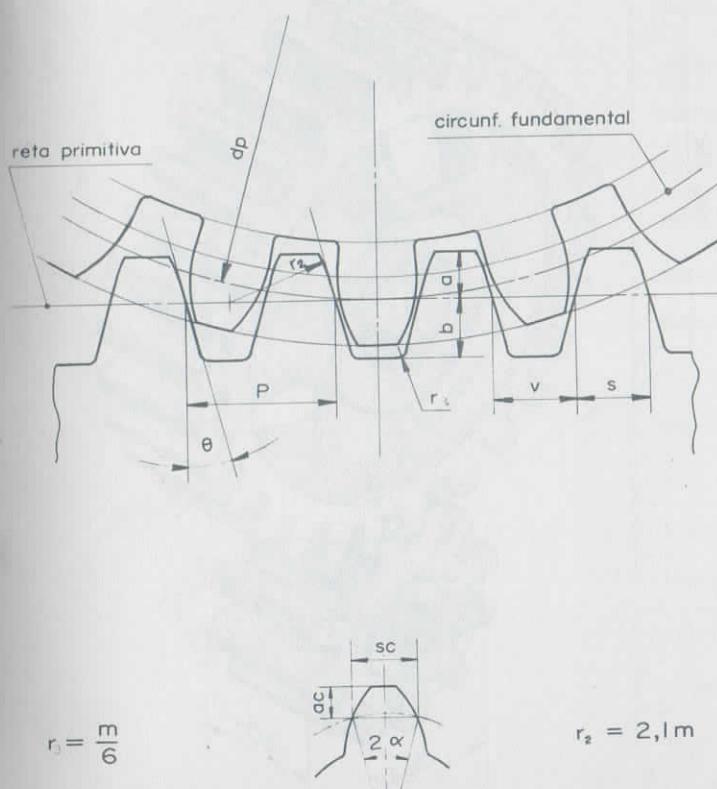
comprimento do dente $\ell = (6 - 20)m = 48$

$r_2 = 2,1m = 12,6$

$$r_1 = \frac{m}{6} = 1$$

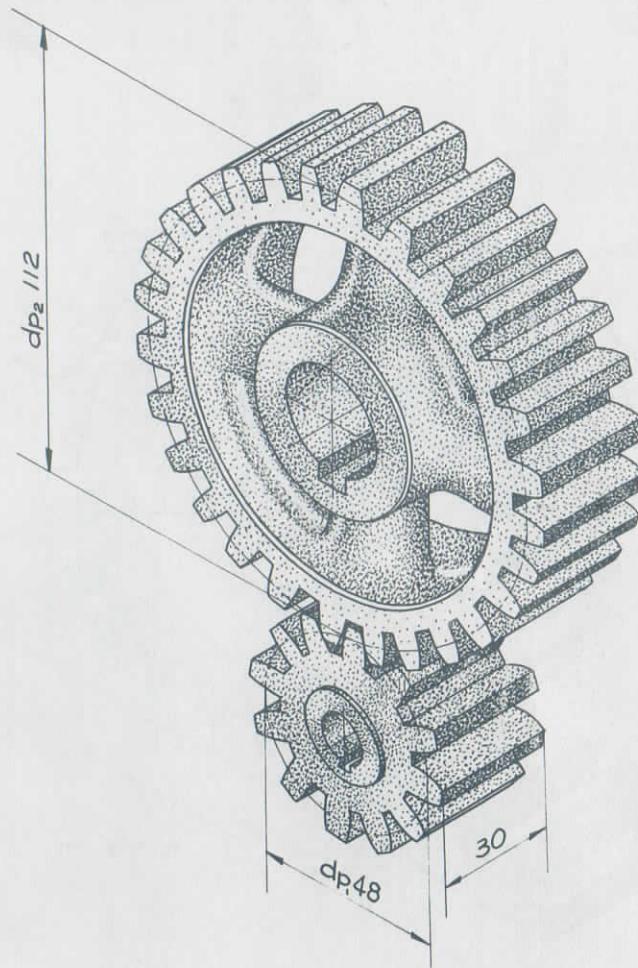
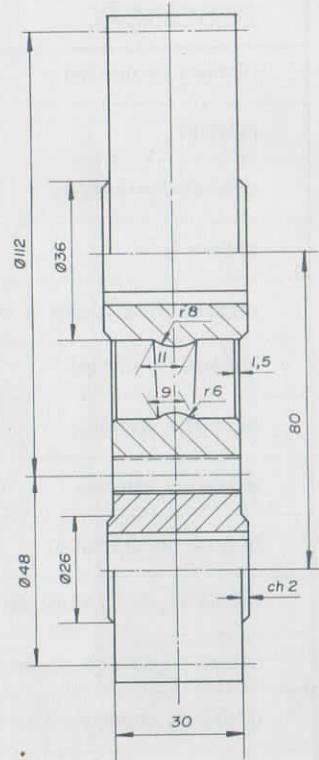
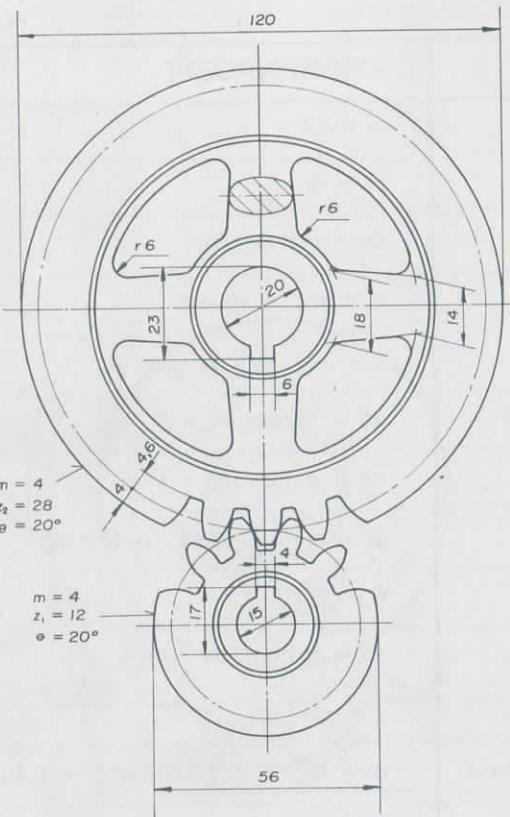


CÁLCULOS



DESCRICAÇÃO	ENGRENAGEM
número de dentes	$z = 24$
módulo	$m = 6$
diâmetro primitivo	$d_p = m z = 144$
passo	$P = m\pi = 18,84$
espessura circular e vāo	$s = v = P/2 = 9,42$
espessura cordal	$sc = m z \operatorname{sen}\alpha = 9,417$
diâmetro externo	$d_e = m(z+2) = 156$
diâmetro interno	$d_i = m(z-2,334) = 129,99$
ângulo de pressão	$\theta = 20^\circ$
diâmetro do círculo de base	$d_b = d_p \cos\theta = 135,4$
altura da cabeça do dente	$a = m = 6$
altura da cabeça do dente (cordal)	$ac = m \left[1 + \frac{z}{2} (1 - \cos \alpha) \right] = 6,154$
altura do pê do dente	$b = 1,167 \text{m} = 7$
altura do dente	$h = a + b = 13$
folga no pê do dente	$e = 0,167 \text{m} = 1$
comprimento do dente	$\ell = (6 \div 20) \text{m} = 48$
ângulo do dente	$\alpha = 90/z = 3^\circ 45'$

ENGRENAGENS CILÍNDRICAS DE DENTES RETOS



DADOS

módulo $m = 4$ número de dentes do pinhão $z_1 = 12$ da coroa $z_2 = 28$ $\theta = 20^\circ$

CÁLCULOS PARA O DESENHO

diâm. primitivo do pinhão $dp_1 = mz_1 = 48$

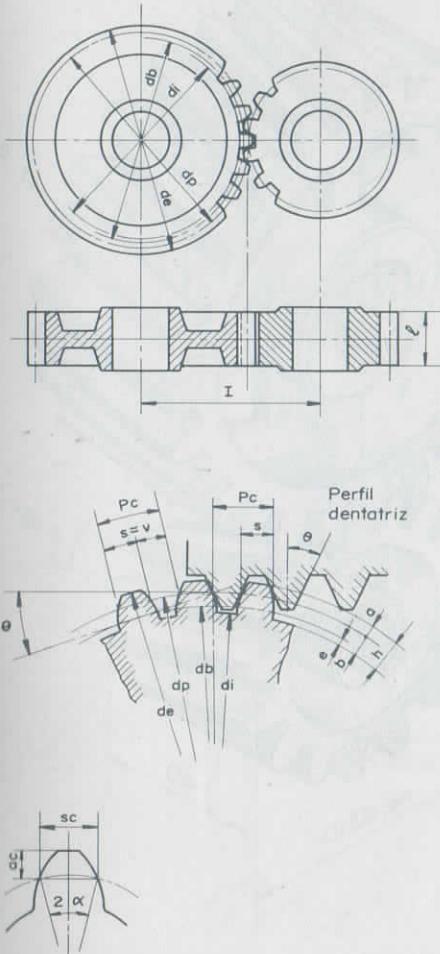
diâm. primitivo da coroa $dp_2 = mz_2 = 112$

cabeça do dente $a = m = 4$

pé do dente $b = 1,167m = 4,668$

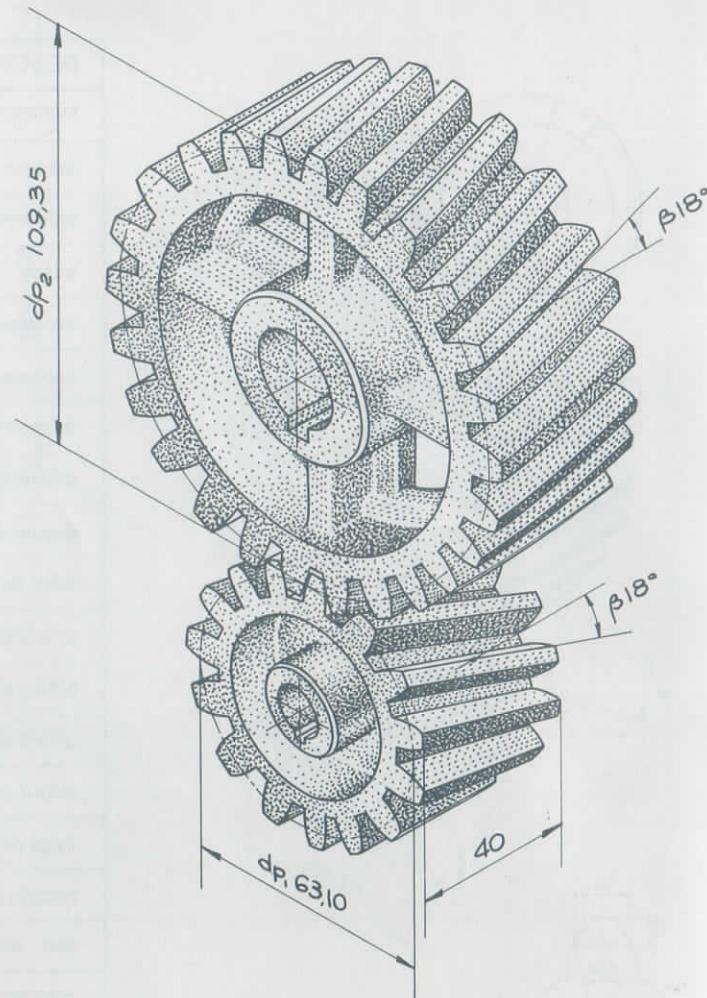
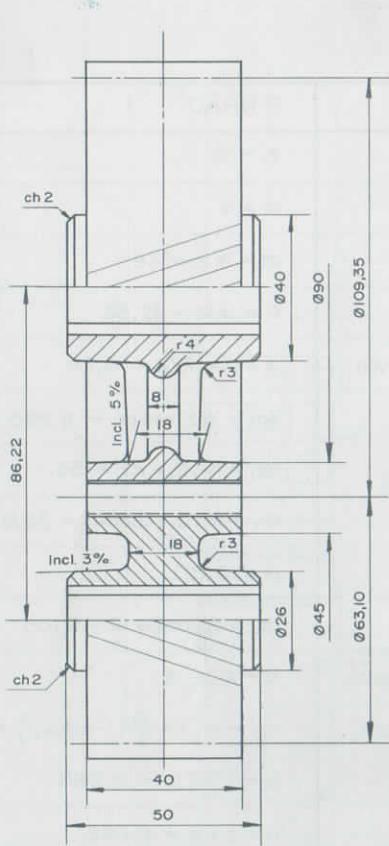
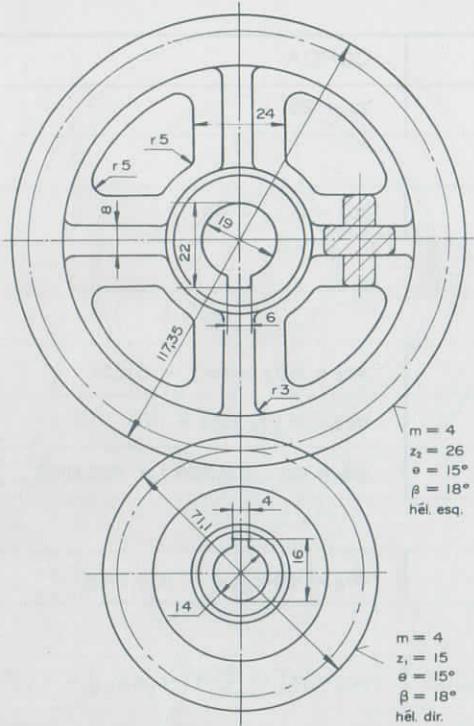
comprimento do dente $\ell = (6 - 20) = 30$

CÁLCULOS



DESCRICAÇÃO	PINHÃO	COROA
número de dentes	$z_1 = 12$	$z_2 = 28$
módulo	$m = 4$	
diâmetro primitivo	$dp_1 = m z_1 = 48$	$dp_2 = m z_2 = 112$
passo	$P = m \pi = 12,56$	
espessura circular e vão	$s = v = P/2 = 6,28$	
espessura cordal	$sc_1 = m z_1 \operatorname{sen} \alpha_1 = 6,265$	$sc_2 = m z_2 \operatorname{sen} \alpha_2 = 6,251$
diâmetro externo	$de_1 = m(z_1 + 2) = 56$	$de_2 = m(z_2 + 2) = 120$
diâmetro interno	$di_1 = m(z_1 - 2,334) = 38,664$	$di_2 = m(z_2 - 2,334) = 102,664$
ângulo de pressão	$\theta = 20^\circ$	
diâm. do círc. de base	$db_1 = dp_1 \cos \theta = 45,105$	$db_2 = dp_2 \cos \theta = 105,245$
altura da cabeça do dente	$a = m = 4$	
altura da cabeça (cordal)	$ac_1 = m \left[1 + \frac{z_1}{2} (1 - \cos \alpha_1) \right] = 4,205$	$ac_2 = m \left[1 + \frac{z_2}{2} (1 - \cos \alpha_2) \right] = 4,087$
altura do pé do dente	$b = 1,167 m = 4,668$	
altura do dente	$h = a + b = 8,668$	
folga no pé do dente	$e = 0,167 m = 0,668$	
relação de transmissão	$\varphi = z_1/z_2 = 0,43 = 1:2,34 = 3:7$	
dist. entre centros	$I = (dp_1 + dp_2)/2 = 80$	
comprimento do dente	$\ell = (6 \div 20) m = 30$	
ângulo do dente	$\alpha_1 = \frac{90}{z_1} = 7^\circ 30'$	$\alpha_2 = \frac{90}{z_2} = 3^\circ 12'$

ENGRENAGENS CILÍNDRICAS DE DENTES HELICOIDAIS



DADOS

$m = 4$ $z_1 = 15$ $z_2 = 26$ ângulo de inclinação do dente $\beta = 18^\circ$ ângulo de pressão $\theta = 15^\circ$

CÁLCULOS PARA O DESENHO

$$\text{diâm. primitivo do pinhão } d_{p1} = mz_1 / \cos\beta = 63,08 \approx 63,10$$

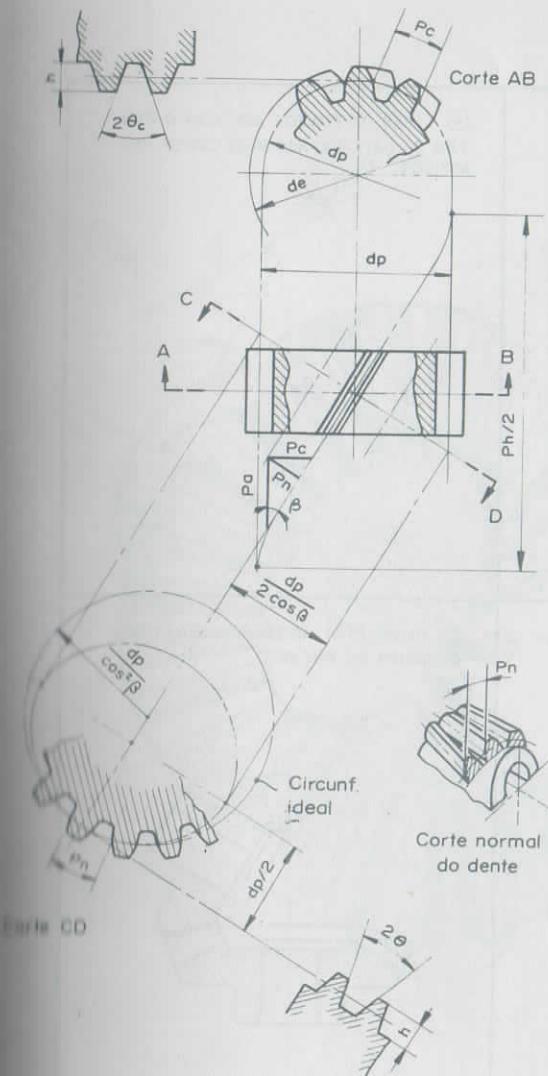
$$\text{diâm. primitivo da coroa } d_{p2} = mz_2 / \cos\beta = 109,35$$

$$\text{cabeça do dente } a = m = 4$$

$$\text{pê do dente } b = 1,167m = 4,668$$

$$\text{largura da engrenagem } l \cong 3m\pi / \cos\beta \cong 40$$

CÁLCULOS



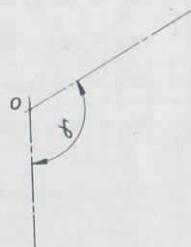
DESCRICAÇÃO	PINHÃO	COROA
número de dentes	$z_1 = 15$	$z_2 = 26$
número de dentes ideal	$z_{1d} = z_1 / \cos^3 \beta = 17,424$ (Escolha de fresa)	$z_{2d} = z_2 / \cos^3 \beta = 30,218$
módulo circunferencial	$m_c = m / \cos \beta = 4,206$	
módulo normal	$m = 4$	
módulo axial	$m_a = m / \sin \beta = 12,944$	
diâmetro primitivo	$d_{p1} = m_c \cdot z_1 = 63,10$	$d_{p2} = m_c \cdot z_2 = 109,35$
diâmetro externo	$d_{e1} = d_{p1} + 2m = 71,10$	$d_{e2} = d_{p2} + 2m = 117,35$
diâmetro primitivo ideal	$d_{pi1} = d_{p1} / \cos^2 \beta = 69,732$	$d_{pi2} = d_{p2} / \cos^2 \beta = 120,907$
diâmetro interno	$d_{i1} = d_{p1} - 2,334m = 53,764$	$d_{i2} = d_{p2} - 2,334m = 100,014$
altura da cabeça do dente	$a = m = 4$	
altura do pé do dente	$b = 1,167m = 4,668$	
folga no pé do dente	$e = 0,167m = 0,668$	
esp. circ. aparente do dente	$s = m\pi/2 = 6,594$	
esp. cord. aparente do dente	$s_{c1} = m_c z_1 \sin \alpha_c = 6,585$	$s_{c2} = m_c z_2 \sin \alpha_c = 6,588$
passo normal	$P_n = m\pi = 12,56$	
passo circunferencial	$P_c = m_c\pi = 13,188$	
passo da hélice	$P_h1 = z_1 P_n / \sin \beta = 609,669$	$P_h2 = z_2 P_n / \sin \beta = 1056,828$
passo axial	$P_a = P_n / \sin \beta = 40,64$	
ângulo de pressão	$\theta = 15^\circ$	
ângulo de pressão circumf.	$\tan \theta_c = \tan \theta / \cos \beta = 0,356 \therefore \theta_c = 19^\circ 35'$	
âng. de inclinação da hélice	$\beta = 8^\circ + 30^\circ \therefore \beta = 18^\circ$	
distância entre centros	$I = (d_{p1} + d_{p2})/2 = 86,22$	
relação de transmissão	$\varphi = z_1/z_2 = 0,57 = 1:1,73$	
largura da engrenagem	$\ell = (6/16)m = 40$	
ângulo do dente	$\alpha_1 = 90^\circ/z_1 = 6^\circ$	$\alpha_2 = 90^\circ/z_2 = 3^\circ 27'$

ENGRANAGENS CÔNICAS

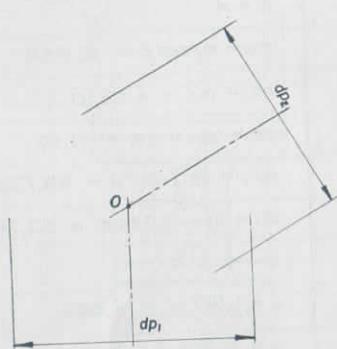
SEQUÊNCIA DO TRAÇADO

DADOS: ℓ , m , Z_1 , Z_2

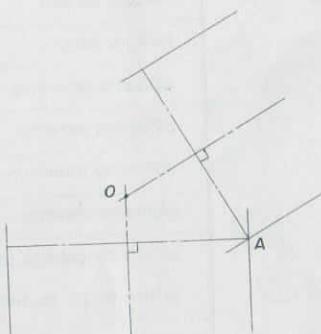
① TRAÇAR OS EIXOS.



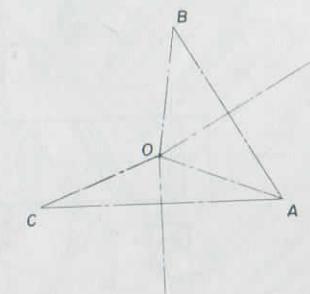
② TRAÇAR OS LUGARES GEOMÉTRICOS DOS DIÂMETROS PRIMITIVOS.
($dp_1 = m Z_1$; $dp_2 = m Z_2$).



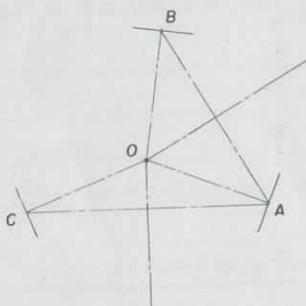
③ TRAÇAR AS PERPENDICULARES AOS EIXOS PELO PONTO A.



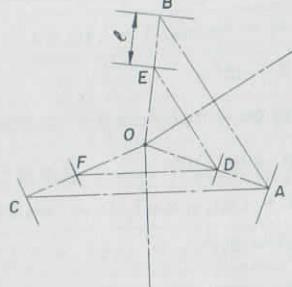
④ LIGAR OS PONTOS ABC COM O CENTRO O, OBTENDO ASSIM OS CONES PRIMITIVOS.



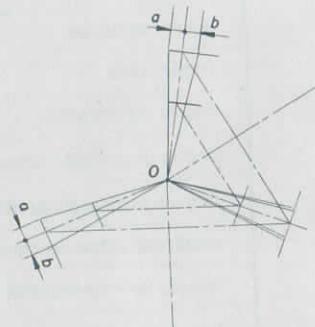
⑤ TRAÇAR AS PERPENDICULARES ÀS GERATRIZES PELOS PONTOS ABC.



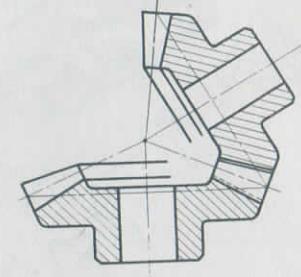
⑥ MARCAR O COMPRIMENTO ℓ DO DENTE NAS GERATRIZES E TRAÇAR AS PERPENDICULARES PELOS PONTOS DEF.



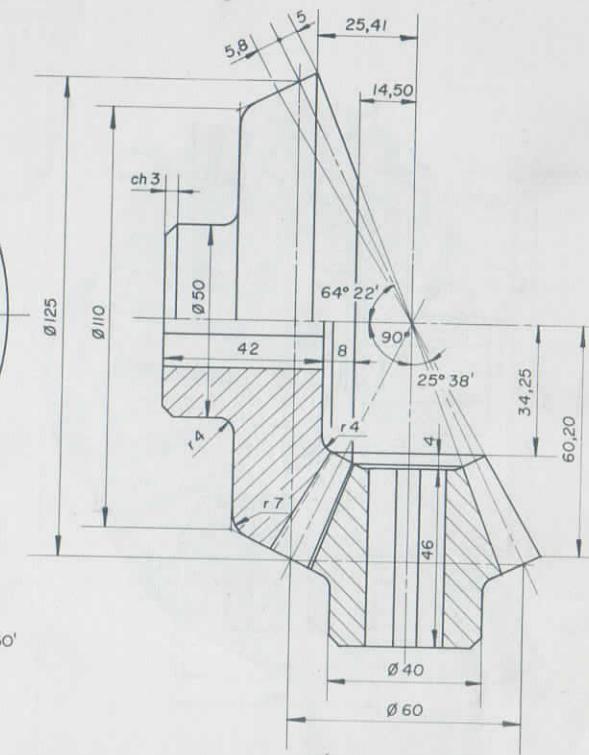
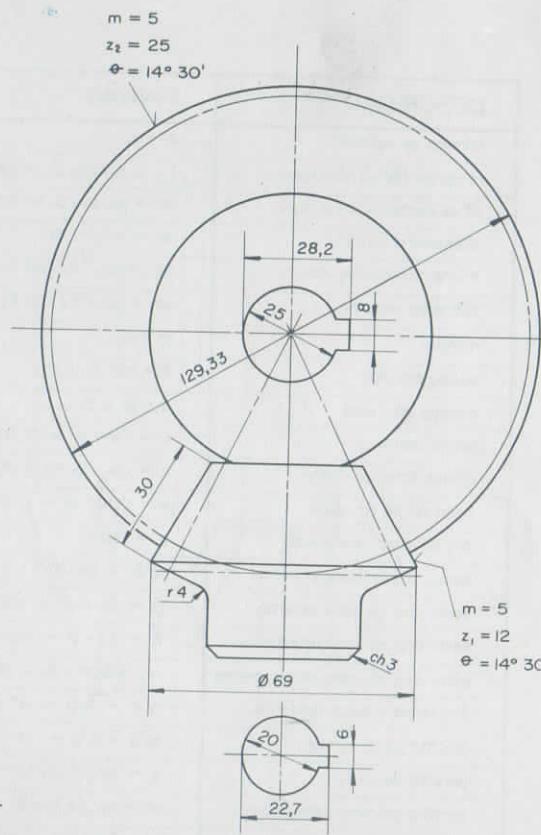
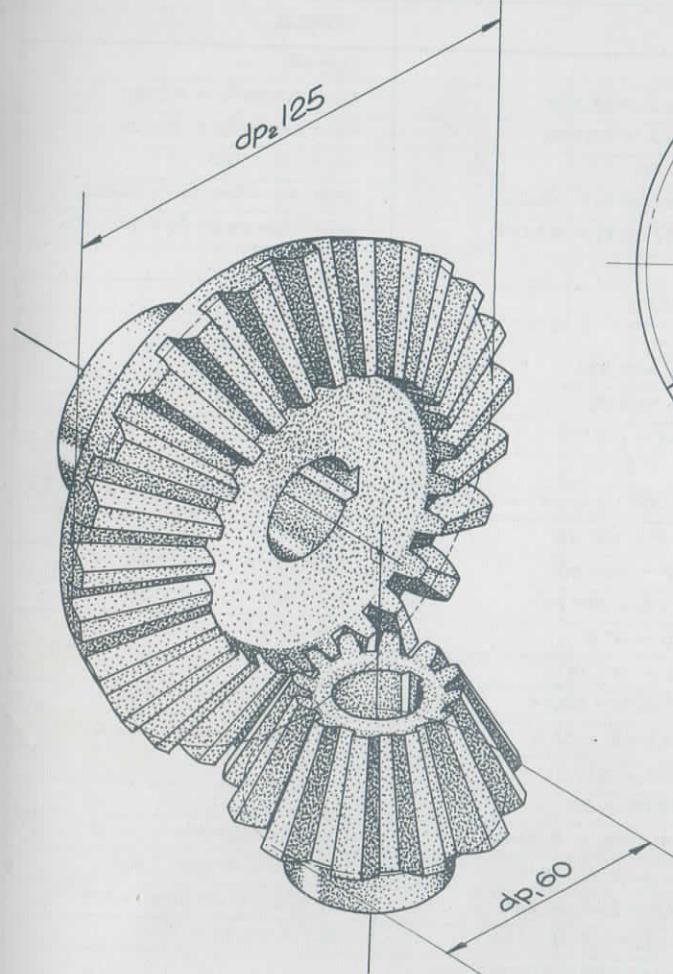
⑦ MARCAR A CABECA ($a=m$) E O PÉ ($b=1,167m$) DO DENTE.



⑧ COMPLETAR AS ENGRANAGENS COM OS DADOS DO PROJETO.



ENGRANAGENS CÔNICAS A 90°



DADOS

$m = 5 \quad z_1 = 12 \quad z_2 = 25$

ângulo entre os eixos $\gamma = 90^\circ$

ângulo de pressão $\Theta = 14^\circ 30'$

CÁLCULOS PARA O DESENHO

diâmetro primitivo do pinhão $dp_1 = mz_1 = 60$

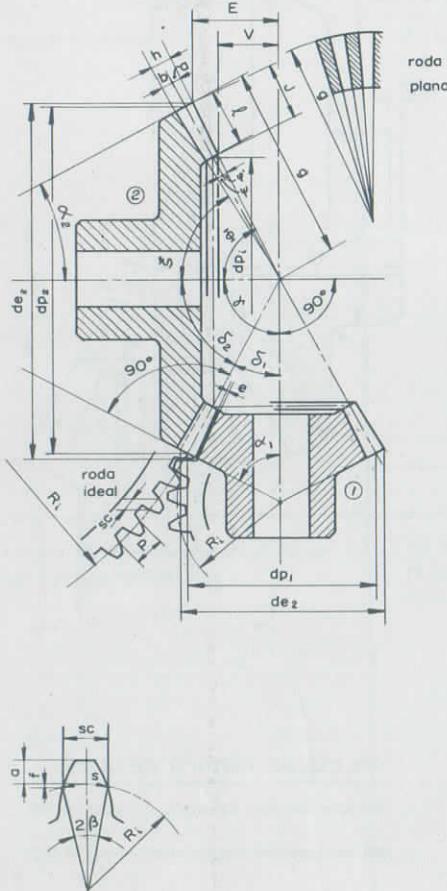
diâmetro primitivo da coroa $dp_2 = mz_2 = 125$

cabeça do dente $a = m = 5$

pé do dente $b = 1,167m = 5,835$

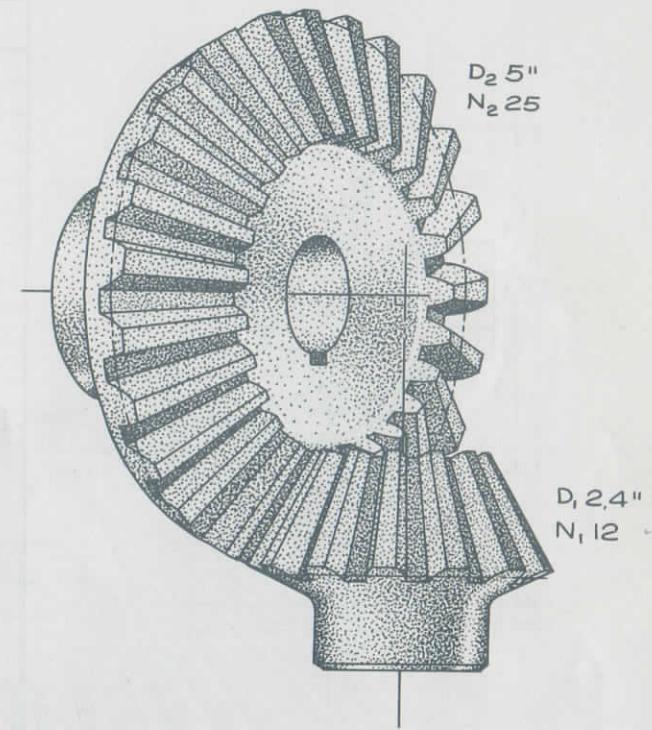
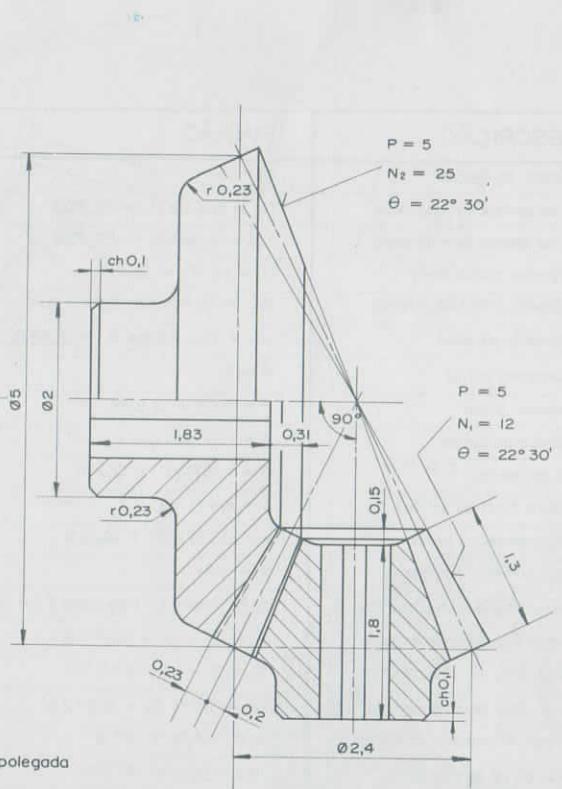
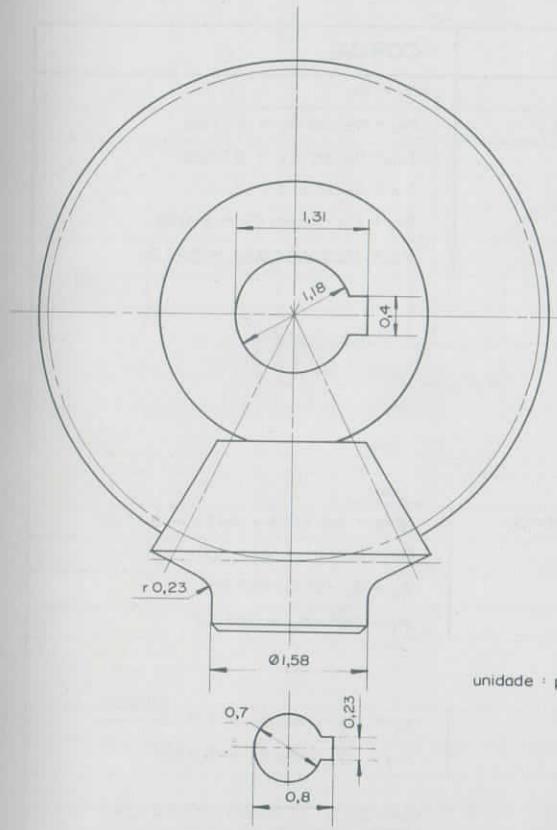
comprimento do dente $l = (5 - 12)m = 30$

CÁLCULOS



DESCRIÇÃO	PINHÃO	COROA
número de dentes	$z_1 = 12$	$z_2 = 25$
nº de dentes da roda ideal	$z_{i1} = z_1/\cos \delta_1 = 13,309$	$z_{i2} = z_2/\cos \delta_2 = 57,788$
nº de dentes da roda plana	$zp_1 = z_i/\sin \delta_1 = 27,738$	$zp_2 = z_2/\sin \delta_2 = 27,729$
diâmetro primitivo	$dp_1 = mz_1 = 60$	$dp_2 = mz_2 = 125$
diâmetro primitivo interno	$dpi_1 = dp_1 - 2\ell \sin \delta_1 = 34,04$	$dpi_2 = dp_2 - 2\ell \sin \delta_2 = 70,905$
diâmetro externo	$de_1 = dp_1 + 2a \cos \delta_1 = 69,015$	$de_2 = dp_2 + 2a \cos \delta_2 = 129,326$
módulo	$m = 5$	
passo circular	$P = m\pi = 15,70$	
cabeça do dente	$a = m = 5$	
pé do dente	$b = 1,167 m = 5,835$	
altura total do dente	$h = a + b = 10,835$	
folga no pé do dente	$e = 0,167 m = 0,835$	
âng. de inclin. dos eixos	$\gamma = 90^\circ$	
semi-âng. do cone primitivo	$\operatorname{tg} \delta_1 = \sin \delta / (\ell/\varphi + \cos \delta) = 25^\circ 38'$	$\operatorname{tg} \delta_2 = \sin \delta / (\ell/\varphi + \cos \delta) = 64^\circ 22'$
semi-âng. do cone externo	$\Phi_1 = \delta_1 + \varphi = 29^\circ 46'$	$\Phi_2 = \delta_2 + \varphi = 68^\circ 30'$
semi-âng. do cone interno	$\xi_1 = \delta_1 - \psi = 20^\circ 50'$	$\xi_2 = \delta_2 - \psi = 49^\circ 34'$
semi-âng. do cone complementar	$\alpha_1 = 90^\circ - \delta_1 = 64^\circ 22'$	$\alpha_2 = 90^\circ - \delta_2 = 25^\circ 38'$
ângulo da cabeça do dente	$\operatorname{tg} \varphi = m/g = 4^\circ 8'$	
âng. do pé do dente	$\operatorname{tg} \psi = b/g = 4^\circ 48'$	
geratriz primitiva	$g = dp_1/2 \sin \delta_1 = 69,34$	$g = dp_2/2 \sin \delta_2 = 69,34$
geratriz do cone complementar	$Ri_1 = dp_1/2 \cos \delta_1 = 33,3$	$Ri_2 = dp_2/2 \cos \delta_2 = 144,4$
geratriz do dente	$J = \ell/\cos \varphi = 30$	
comprimento do dente	$\ell = (5+12)m = 30$	
flecha do dente	$f_1 = Ri_1 - Ri_1 \cos \beta_1 = 0,234$	$f_2 = Ri_2 - Ri_2 \cos \beta_2 = 0,145$
espes. cordal do dente	$sc_1 = 2Ri_1 \sin \beta_1 = 7,828$	$sc_2 = 2Ri_2 \sin \beta_2 = 7,812$
dist. do vért. ao dente (superior)	$V_1 = (g - \ell) \cos \Phi_1 = 34,249$	$V_2 = (g - \ell) \cos \Phi_2 = 14,418$
dist. do vért. ao dente (inferior)	$E_1 = g \cos \Phi_1 = 60,19$	$E_2 = g \cos \Phi_2 = 25,41$
relação de transmissão	$\varphi = z_1/z_2 = 0,48 = 1:2,083$	
ângulo do dente	$\beta_1 = 90^\circ/z_1 = 6,76 \quad 6^\circ 45'$	$\beta_2 = 90^\circ/z_2 = 1,55 \quad 1^\circ 33'$

ENGRENAGENS CÔNICAS A 90° - SISTEMA PITCH



DADOS

Diametral Pitch $P = 5$ $N_1 = 12$ $N_2 = 25$

$\theta = 22^\circ 30'$

CÁLCULOS PARA O DESENHO

diâmetro primitivo do pinhão $D_1 = N_1/P = 2,4$

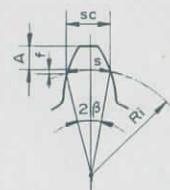
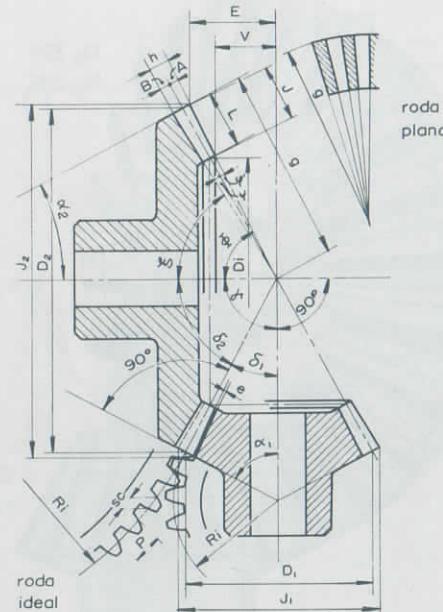
diâmetro primitivo da coroa $D_2 = N_2/P = 5$

cabeça do dente $A = I/P = 0,2$

pé do dente $B = 1,157I/P = 0,23$

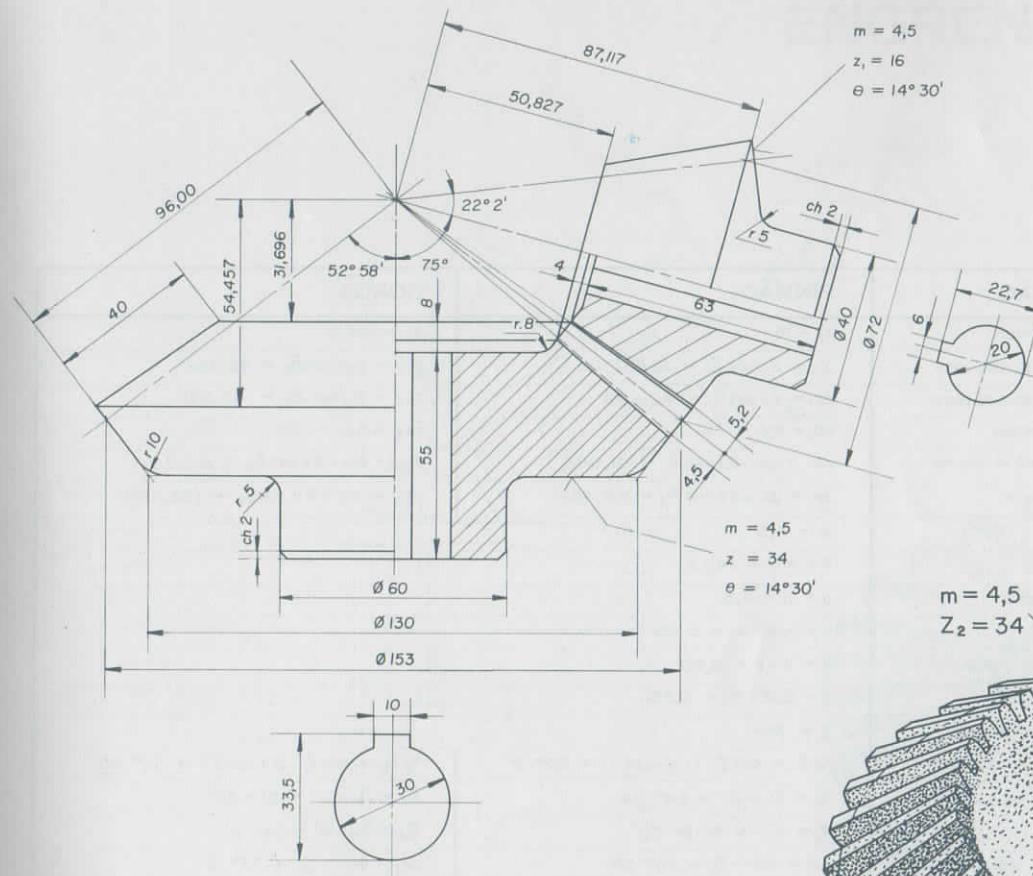
comprimento do dente $L = (5 - 12)/P = 33 = 1,3$

CÁLCULOS



DESCRICAÇÃO	PINHÃO	COROA
número de dentes	$N_1 = 12$	$N_2 = 25$
nº de dentes da roda ideal	$N_{i1} = N_1/\cos \delta_1 = 13,309$	$N_{i2} = N_2/\cos \delta_2 = 57,788$
nº de dentes da roda plana	$N_{p1} = N_1/\sin \delta_1 = 27,738$	$N_{p2} = N_2/\sin \delta_2 = 27,729$
diâmetro primitivo	$D_1 = N_1/P = 2,4$	$D_2 = N_2/P = 5$
diâmetro primitivo interno	$D_{i1} = D_1 - 2L \sin \delta_1 = 1,276$	$D_{i2} = D_2 - 2L \sin \delta_2 = 2,658$
diâmetro externo	$J_1 = D_1 + 2A \cos \delta_1 = 2,760$	$J_2 = D_2 + 2A \cos \delta_2 = 5,173$
diametral pitch	$P = 5$	
circular pitch	$P' = \pi/P = 0,628$	
cabeça do dente	$A = 1/P = 0,2$	
pé do dente	$B = 1,1571/P = 0,231$	
altura total do dente	$h = A + B = 0,43$	
folga no pé do dente	$e = 0,1571/P = 0,031$	
âng. de inclin. dos eixos	$\gamma = 90^\circ$	
semi-âng. do cone primitivo	$\tg \delta_1 = \sin \gamma / (1/\varphi + \cos \gamma) = 25^\circ 38'$	$\tg \delta_2 = \sin \gamma / (\varphi + \cos \gamma) = 64^\circ 22'$
semi-âng. do cone externo	$\Phi_1 = \delta_1 + \varphi = 29^\circ 46'$	$\Phi_2 = \delta_2 + \varphi = 68^\circ 30'$
semi-âng. do cone interno	$\xi_1 = \delta_1 - \psi = 20^\circ 52'$	$\xi_2 = \delta_2 - \psi = 49^\circ 36'$
semi-âng. do cone complementar	$\alpha_1 = 90^\circ - \delta_1 = 64^\circ 22'$	$\alpha_2 = 90^\circ - \delta_2 = 25^\circ 38'$
ângulo da cabeça do dente	$\tg \psi = A/g = 4^\circ 8'$	
âng. do pé do dente	$\tg \psi' = B/g = 4^\circ 46'$	
geratriz primitiva	$g_1 = D_1/2 \sin \delta_1 = 2,774$	$g_2 = D_2/2 \sin \delta_2 = 2,777$
geratriz do cone complementar	$R_{l1} = D_1/2 \cos \delta_1 = 1,333$	$R_{l2} = D_2/2 \cos \delta_2 = 5,780$
geratriz do dente	$J = L/\cos \varphi = 1,3$	
comprimento do dente	$L = (5+12)/P = 33 = 1,3$	
flecha do dente	$f_1 = R_{l1} - R_{l1} \cos \beta_1 = 0,01$	$f_2 = R_{l2} - R_{l2} \cos \beta_2 = 0,006$
espess. cordal do dente	$sc_1 = 2R_{l1} \sin \beta_1 = 0,312$	$sc_2 = 2R_{l2} \sin \beta_2 = 0,312$
dist. do vért. ao dente (superior)	$V_1 = (g_1 - L) \cos \Phi_1 = 1,279$	$V_2 = (g_2 - L) \cos \Phi_2 = 0,560$
dist. vêrt. ao dente (inferior)	$E_1 = g_1 \cos \Phi_1 = 2,407$	$E_2 = g_2 \cos \Phi_2 = 1,016$
relação de transmissão	$\varphi = N_1/N_2 = 0,48 = 1:2,083$	
ângulo do dente	$\beta_1 = 90^\circ/N_{i1} = 6,76 \dots 6^\circ 45'$	$\beta_2 = 90^\circ/N_{i2} = 1,55 \dots 1^\circ 33'$

ENGRENAGENS CÔNICAS A 75°



DADOS

$$m = 4,5 \quad z_1 = 16 \quad z_2 = 34 \quad \ell = 75^\circ \quad \theta = 14^\circ 30'$$

CÁLCULOS PARA O DESENHO

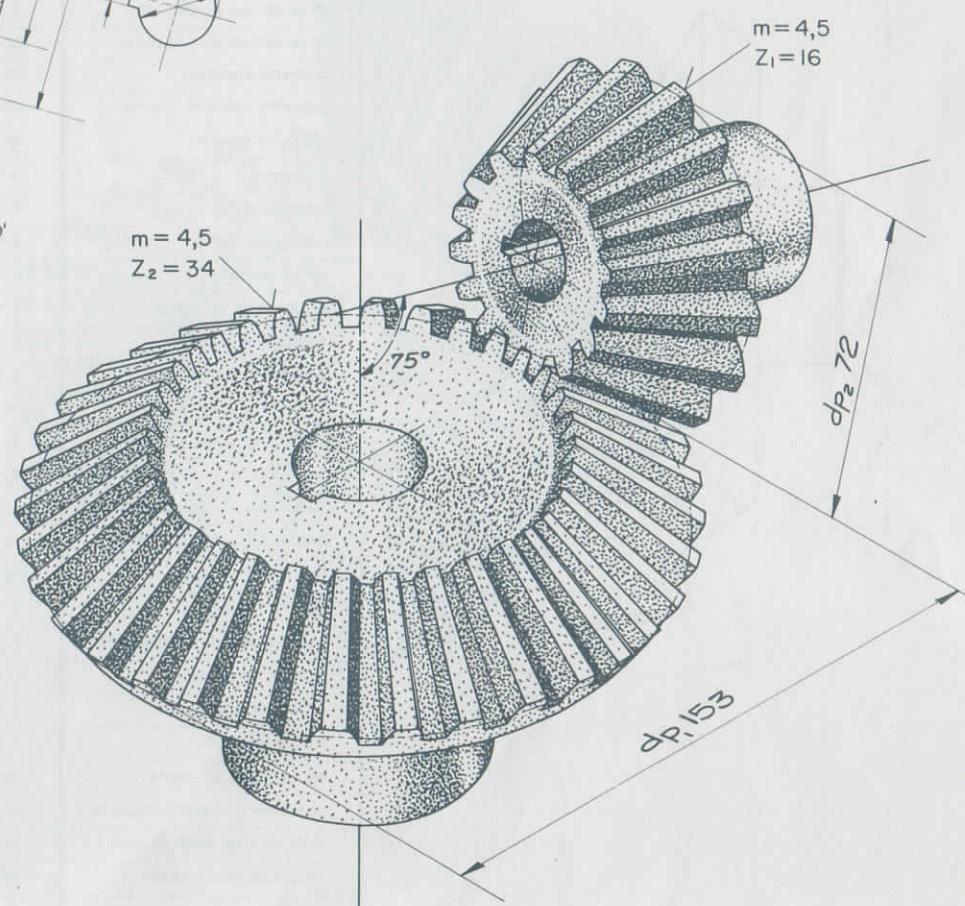
$$\text{diâmetro primitivo do pinhão} \quad dp_1 = mz_1 = 72$$

$$\text{diâmetro primitivo da coroa} \quad dp_2 = mz_2 = 153$$

$$\text{cabeça do dente} \quad a = m = 4,5$$

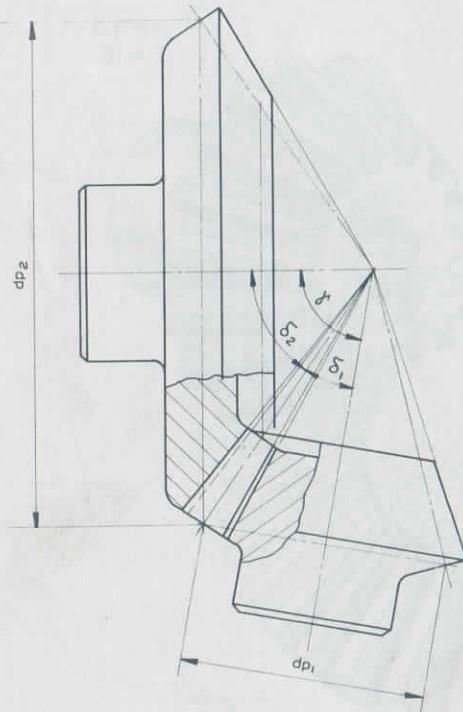
$$\text{pé do dente} \quad b = 1,167m = 5,25$$

$$\text{comprimento do dente} \quad l = (5 + 12)m = 40$$



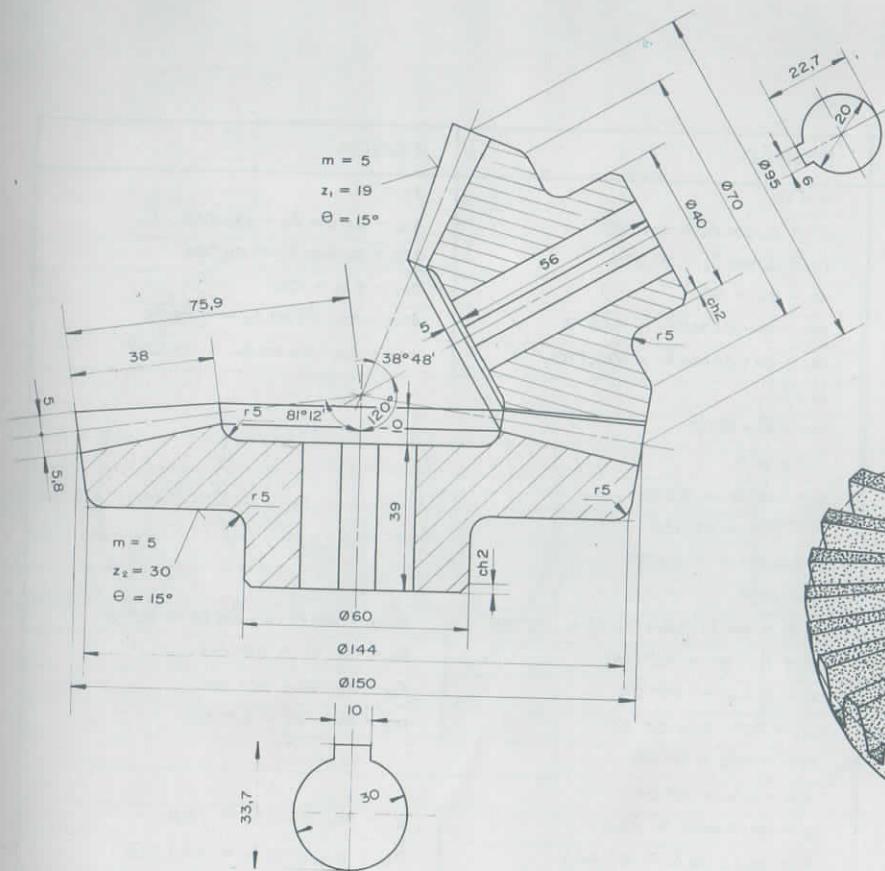
CÁLCULOS

DE CÔNCAS A LIGADURAS



DESCRICAÇÃO	PINHÃO	COROA
número de dentes	$z_1 = 16$	$z_2 = 34$
nº de dentes da roda ideal	$z_{1i} = z_1/\cos \delta_1 = 16,610$	$z_{2i} = z_2/\cos \delta_2 = 56,452$
nº de dentes da roda plana	$z_{p1} = z_1/\sin \delta_1 = 42,649$	$z_{p2} = z_2/\sin \delta_2 = 42,591$
diâmetro primitivo	$dp_1 = m z_1 = 72$	$dp_2 = m z_2 = 153$
diâmetro primitivo interno	$dp_{1i} = dp_1 - 2\ell \sin \delta_1 = 41,988$	$dp_{2i} = dp_2 - 2\ell \sin \delta_2 = 89,136$
diâmetro externo	$de_1 = dp_1 + 2a \cos \delta_1 = 80,667$	$de_2 = dp_2 + 2a \cos \delta_2 = 158,420$
módulo	$m = 4,5$	
passo circular	$P = m\pi = 14,13$	
cabeça do dente	$a = m = 4,5$	
pé do dente	$b = 1,167 m = 5,251$	
altura total do dente	$h = a + b = 9,751$	
folga no pé do dente	$e = 0,167 m = 0,751$	
âng. de inclin. dos eixos	$\delta = 75^\circ$	
semi-âng. do cone primitivo	$\operatorname{tg} \delta_1 = \operatorname{sen} \delta / (1/\varphi + \cos \delta) = 22^\circ 2'$	$\operatorname{tg} \delta_2 = \operatorname{sen} \delta / (\varphi + \cos \delta) = 52^\circ 58'$
semi-âng. do cone externo	$\Phi_1 = \delta_1 + \varphi^i = 24^\circ 44'$	$\Phi_2 = \delta_2 + \varphi^i = 55^\circ 30'$
semi-âng. do cone interno	$\xi_1 = \delta_1 - \psi = 18^\circ 52'$	$\xi_2 = \delta_2 - \psi = 56^\circ 6'$
semi-âng. do cone complementar	$\alpha_1 = 90^\circ - \delta_1 = 67^\circ 58'$	$\alpha_2 = 90^\circ - \delta_2 = 37^\circ 2'$
ângulo da cabeça do dente	$\operatorname{tg} \varphi^i = m/g = 2^\circ 42'$	
âng. do pé do dente	$\operatorname{tg} \psi = b/g = 3^\circ 8'$	
geratriz primitiva	$g = dp_1/2 \operatorname{sen} \delta_1 = 95,961 \approx 96$	$g = dp_2/2 \operatorname{sen} \delta_2 = 95,829 \approx 96$
geratriz do cone complementar	$R_{l1} = dp_1/2 \cos \delta_1 = 37,384$	$R_{l2} = dp_2/2 \cos \delta_2 = 127,017$
geratriz do dente	$J = \ell/\cos \varphi^i = 39,93 \approx 40$	
comprimento do dente	$\ell = (5+12)m = 40$	
flecha do dente	$f_1 = R_{l1} - R_{l1} \cos \beta_1 = 0,166$	$f_2 = R_{l2} - R_{l2} \cos \beta_2 = 0,128$
espess. cordal do dente	$sc_1 = 2 R_{l1} \operatorname{sen} \beta_1 = 7,274$	$sc_2 = 2 R_{l2} \operatorname{sen} \beta_2 = 7,069$
dist. do vêrt. ao dente (superior)	$V_1 = (g - \ell) \cos \Phi_1 = 50,827$	$V_2 = (g - \ell) \cos \Phi_2 = 31,696$
dist. vêrt. ao dente (inferior)	$E_1 = g \cos \Phi_1 = 87,117$	$E_2 = g \cos \Phi_2 = 54,457$
relação de transmissão	$\varphi = z_1/z_2 = 0,470 = 1:2,125$	
ângulo do dente	$\beta_1 = 90^\circ/z_{1i} = 5,41 = 5^\circ 24'$	$\beta_2 = 90^\circ/z_{2i} = 1,59 = 1^\circ 35'$

ENGRANAGENS CÔNICAS A 120°



DADOS

$$m = 5 \quad z_1 = 19 \quad z_2 = 30 \quad \beta = 120^\circ \quad \theta = 15^\circ$$

CÁLCULOS PARA O DESENHO

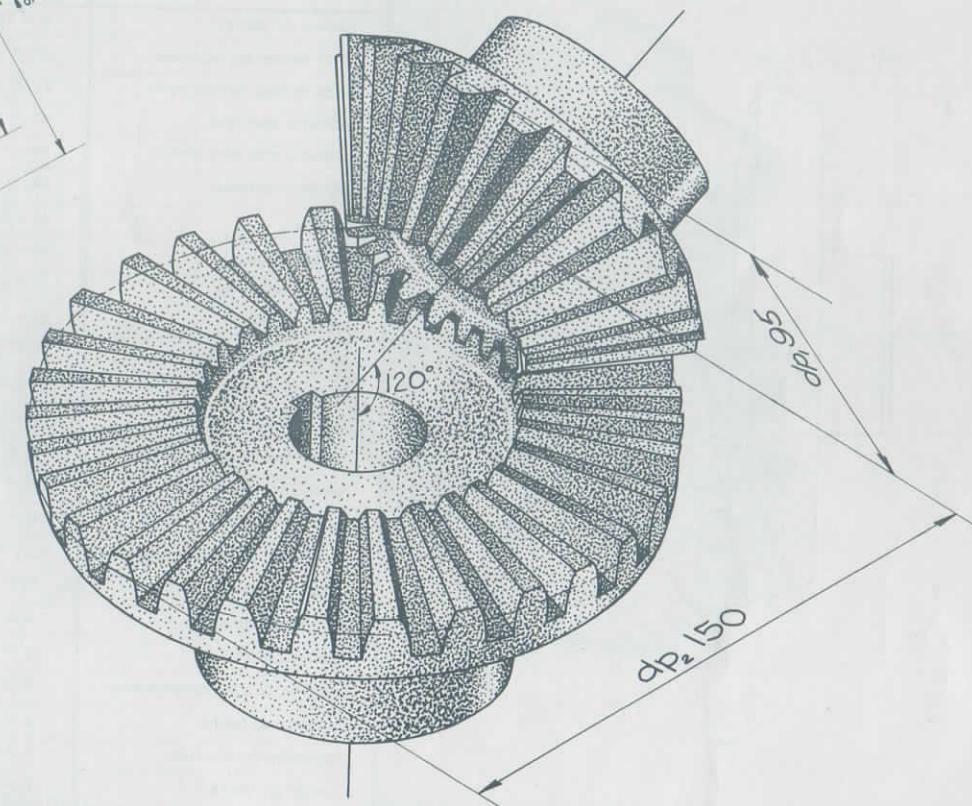
$$\text{diâmetro primitivo do pinhão} \quad dp_1 = mz_1 = 95$$

$$\text{cabeça do dente} \quad a = m = 5$$

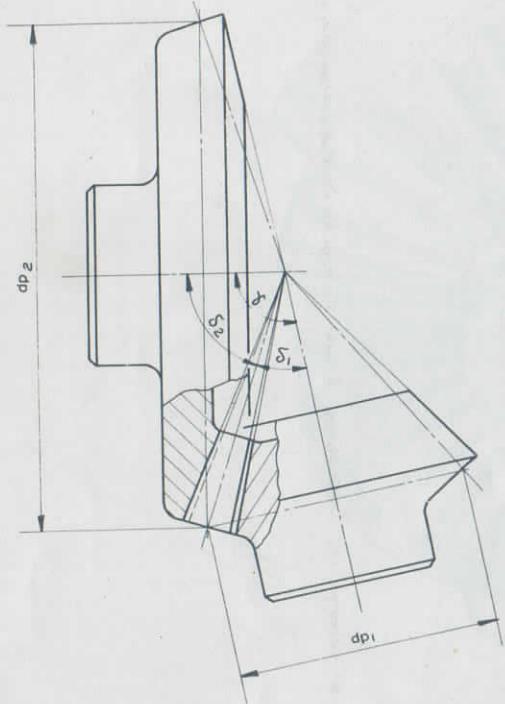
$$\text{diâmetro primitivo da coroa} \quad dp_2 = mz_2 = 150$$

$$\text{pé do dente} \quad b = 1,167m = 5,835$$

$$\text{comprimento do dente} \quad l = (5 - 12)m = 38$$

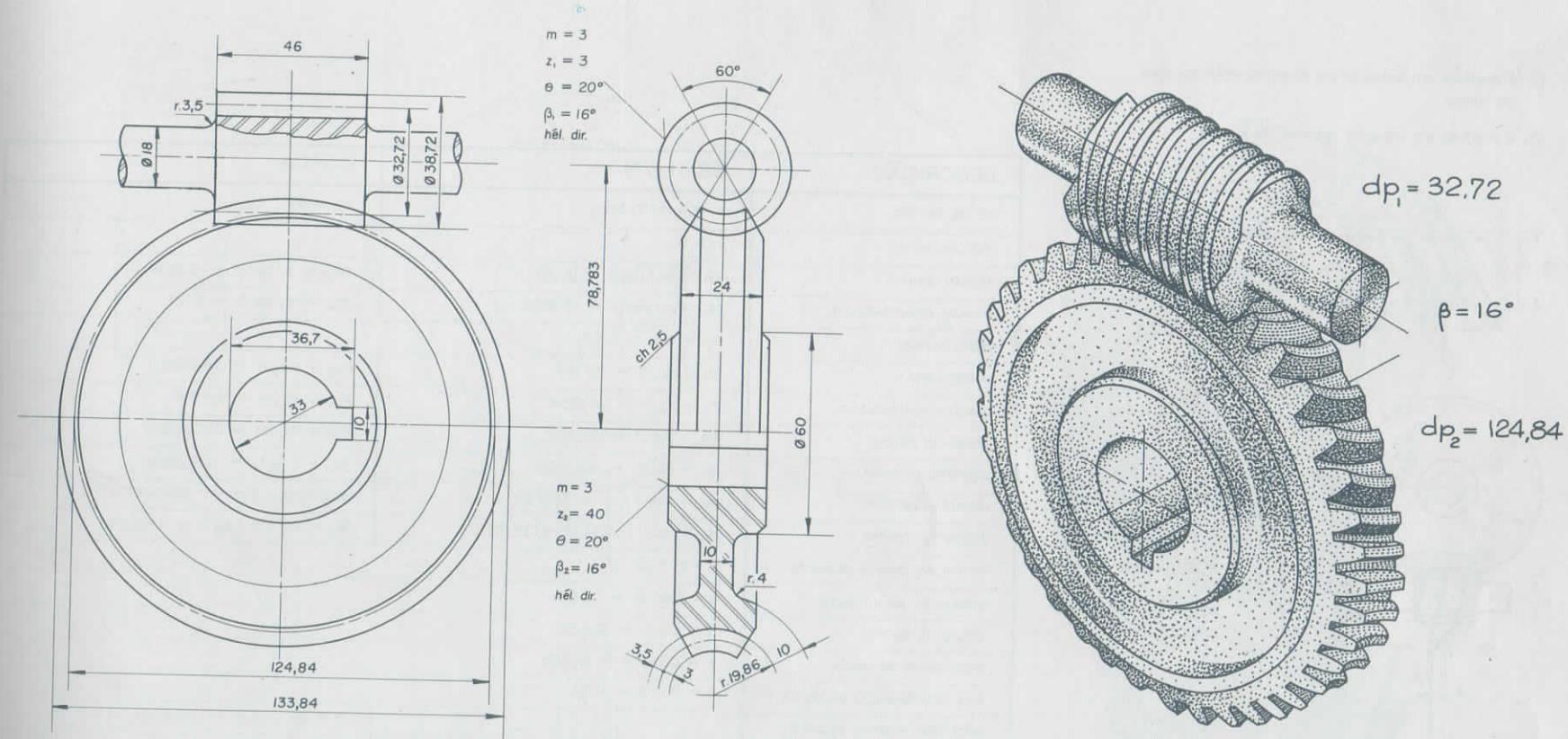


CÁLCULOS



DESCRICAÇÃO	PINHÃO	COROA
número de dentes	$z_1 = 19$	$z_2 = 30$
nº de dentes da roda ideal	$z_{1i} = z_1/\cos \delta_1 = 24,373$	$z_{2i} = z_2/\cos \delta_2 = 196,091$
nº de dentes da roda plana	$zp_1 = z_1/\sin \delta_1 = 31,279$	$zp_2 = z_2/\sin \delta_2 = 151,786$
diâmetro primitivo	$dp_1 = mz_1 = 95$	$dp_2 = mz_2 = 150$
diâmetro primitivo interno	$dpi_1 = dp_1 - 2\ell \sin \delta_1 = 47,379$	$dpi_2 = dp_2 - 2\ell \sin \delta_2 = 74,895$
diâmetro externo	$de_1 = dp_1 + 2a \cos \delta_1 = 102,793$	$de_2 = dp_2 + 2a \cos \delta_2 = 151,529$
módulo	$m = 5$	
passo circular	$P = m\pi = 15,70$	
cabeça do dente	$a = m = 5$	
pé do dente	$b = 1,167 m = 5,835$	
altura total do dente	$h = a + b = 10,835$	
fogão no pé do dente	$e = 0,167 m = 0,835$	
âng. de inclin. dos eixos	$\gamma = 120^\circ$	
semi-âng. do cone primitivo	$\tg \delta_1 = \sin \gamma / (1/\varphi + \cos \gamma) = 38^\circ 48'$	$\tg \delta_2 = \sin \gamma / (\varphi + \cos \gamma) = 81^\circ 12'$
semi-âng. do cone externo	$\Phi_1 = \delta_1 + \varphi = 42^\circ 34'$	$\Phi_2 = \delta_2 + \varphi = 84^\circ 58'$
semi-âng. do cone interno	$\xi_1 = \delta_1 - \psi = 34^\circ 24'$	$\xi_2 = \delta_2 - \psi = 76^\circ 48'$
semi-âng. do cone complementar	$\alpha_1 = 90^\circ - \delta_1 = 51^\circ 12'$	$\alpha_2 = 90^\circ - \delta_2 = 8^\circ 48'$
ângulo da cabeça do dente	$\tg \psi = m/g = 3^\circ 46'$	
âng. do pé do dente	$\tg \psi = b/g = 4^\circ 24'$	
geratriz primitiva	$g = dpi_1/2 \sin \delta_1 \approx 75,9$	$g = dp_2/2 \sin \delta_2 \approx 75,9$
geratriz do cone complementar	$Ri_1 = dpi_1/2 \cos \delta_1 = 60,949$	$Ri_2 = dp_2/2 \cos \delta_2 = 490,228$
geratriz do dente	$J = \ell / \cos \varphi = 38,082$	
comprimento do dente	$\ell = (5 + 12) m = 38$	
flecha do dente	$f_1 = Ri_1 - Rl_1 \cos \beta_1 = 0,127$	$f_2 = Ri_2 - Rl_2 \cos \beta_2 = 0,150$
espess. cordal do dente	$sc_1 = 2Ri_1 \sin \beta_1 = 7,830$	$sc_2 = 2Ri_2 \sin \beta_2 = 7,696$
dist. do vért. ao dente (superior)	$V_1 = (g - \ell) \cos \Phi_1 = 27,913$	$V_2 = (g - \ell) \cos \Phi_2 = 3,355$
dist. vêrt. ao dente (inferior)	$E_1 = g \cos \Phi_1 = 55,899$	$E_2 = g \cos \Phi_2 = 6,659$
relação de transmissão	$\varphi = z_1/z_2 = 0,634 = 1:1,579$	
ângulo do dente	$\beta_1 = 90^\circ/z_1 = 3,69 = 3^\circ 41'$	$\beta_2 = 90^\circ/z_2 = 0,45 = 0^\circ 27'$

COROA E ROSCA SEM-FIM



DADOS

$$m = 3 \quad z_1 = 3 \quad z_2 = 40$$

$$\beta_1 = 16^\circ \text{ hél. dir.} \quad \beta_2 = 16^\circ \text{ hél. dir.}$$

$$\theta = 20^\circ$$

CÁLCULOS PARA O DESENHO

$$\text{diâmetro primitivo da rosca } dp_1 = m z_1 / \sin \beta = 32,72$$

$$\text{diâmetro primitivo da coroa } dp_2 = m z_2 / \cos \beta = 124,84$$

$$\text{cabeça do dente } a = m = 3$$

$$\text{pé do dente } b = 1,167 m = 3,501$$

$$\text{ângulo do chanfro da coroa } \alpha' = 60^\circ \div 90^\circ \quad \alpha' = 60^\circ$$

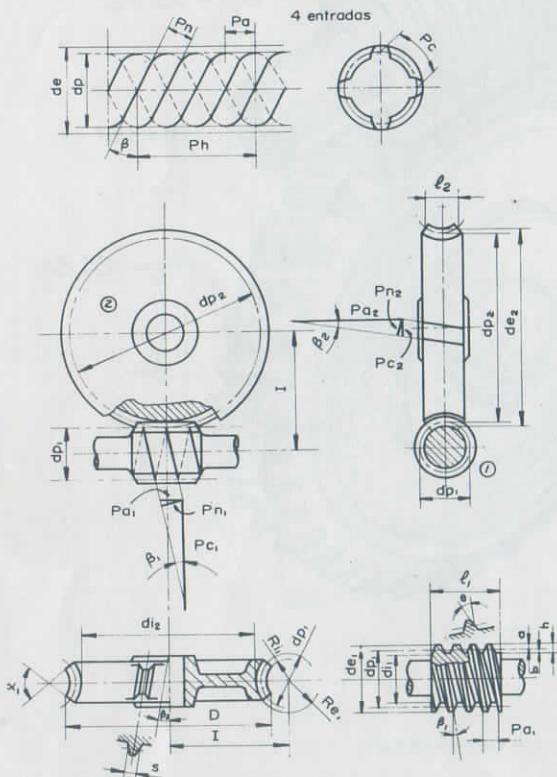
$$\text{comprimento da rosca } l_1 = 2 \frac{m}{\cos \beta} (1 + \sqrt{z_1}) = 46$$

$$\text{largura da coroa } l_2 = (6-8)m = 24$$

CÁLCULOS

β_1 é medido em relação ao plano normal ao eixo da rosca.

β_2 é medido em relação ao eixo da coroa.



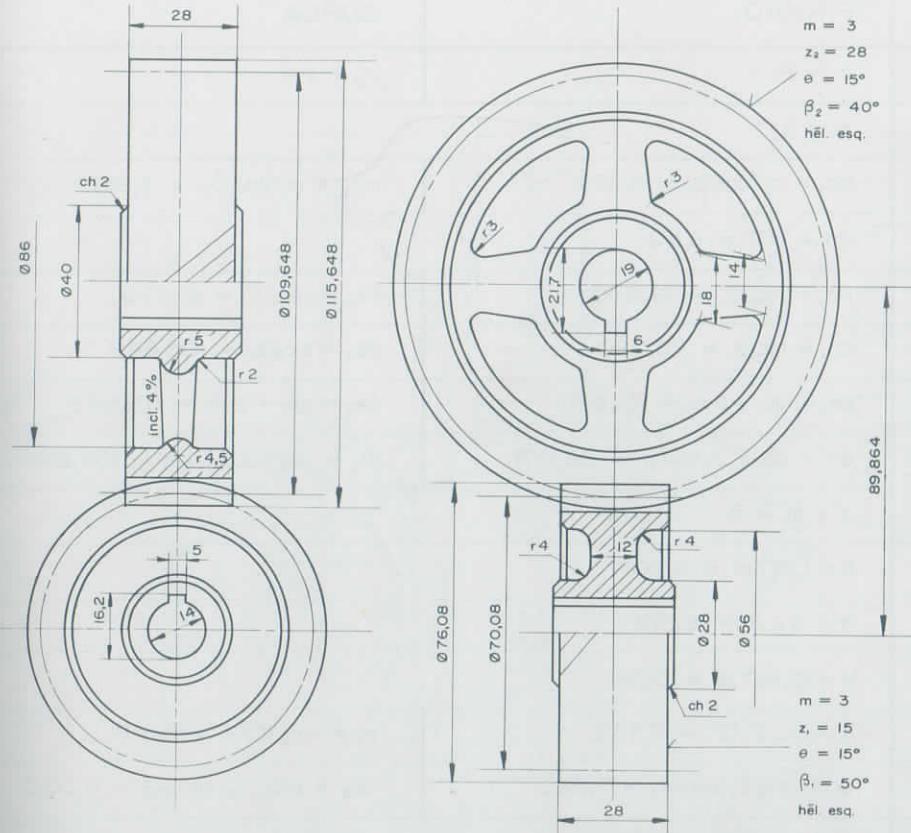
$$\beta_1 = \beta_2 = \beta$$

O valor de θ é escolhido de acordo com o valor de β

β	$\leq 12^\circ$	$12^\circ \div 20^\circ$	$20^\circ \div 25^\circ$	$> 25^\circ$
θ	$14^\circ 30'$	20°	$22^\circ 30'$	25°

DESCRÍÇÃO	SEM-FIM	COROA
nº de dentes	$z_1 = 3$ entradas	$z_2 = 40$
módulo normal	$m = 3$	
módulo axial	$ma_1 = m / \cos \beta = 3,121$	$ma_2 = m / \sin \beta = 10,909$
módulo circumferencial	$mc_1 = m / \tan \beta = 10,909$	$mc_2 = m / \cos \beta = 3,121$
passo normal	$Pn = m\pi = 9,42$	
passo axial	$Pa_1 = ma_1\pi = 9,799$	$Pa_2 = ma_2\pi = 34,254$
passo circumferencial	$Pc_1 = mc_1\pi = 34,254$	$Pc_2 = mc_2\pi = 9,799$
passo da hélice	$Ph_1 = Pa_1 z_1 = 29,397$	$Ph_2 = Pa_2 z_2 = 1370,160$
diâmetro primitivo	$dp_1 = mc, z_1 = 32,727$	$dp_2 = mc_2 z_2 = 124,840$
diâmetro externo	$de_1 = dp_1 + 2m = 38,727$	$de_2 = dp_2 + 2m = 130,840$
diâmetro interno	$di_1 = dp_1 - 2,334m = 25,725$	$di_2 = dp_2 - 2,334m = 117,838$
altura da cabeça do dente	$a = m = 3$	
altura do pé do dente	$b = 1,167m = 3,501$	
altura do dente	$h = a + b = 6,501$	
folga no pé do dente	$e = 0,167m = 0,501$	
esp. círcular do dente	$s = Pn/2 = 4,71$	
diâm. máx. externo da coroa		$D \cong dp_2 + 3m = 133,840$
largura da coroa		$l_2 = (6 \div 8)m = 24 < 0,75 de_1$
comprimento da sem-fim	$l_1 = 2 ma_1 (1 + \sqrt{z_2}) = 46$	
semi-ângulo do dente	$\theta = 20^\circ$	
ângulo da hélice	$\beta_1 = 16^\circ$	$\beta_2 = 16^\circ$
âng. do chanfrado da coroa	$\alpha_1 = 60^\circ \div 90^\circ \therefore \alpha_1 = 60^\circ$	
raio externo da garganta		$Re = I - de_2/2 = 19,864$
raio interno da garganta		$Ri = I - de_1/2 = 13,363$
distância entre centros	$I = (dp_1 + dp_2)/2 = 78,783$	
relação de transmissão	$\varphi = z_1/z_2 = 0,075 = 13,333$	

ENGRENAGENS HELICOIDAIS DE EIXOS ORTOGONIAIS



DADOS

$$m = 3 \quad z_1 = 15 \quad z_2 = 28 \quad \beta_1 = 50^\circ \text{ hél. esq.} \quad \beta_2 = 40^\circ \text{ hél. esq.} \quad \theta = 15^\circ$$

CÁLCULOS PARA O DESENHO

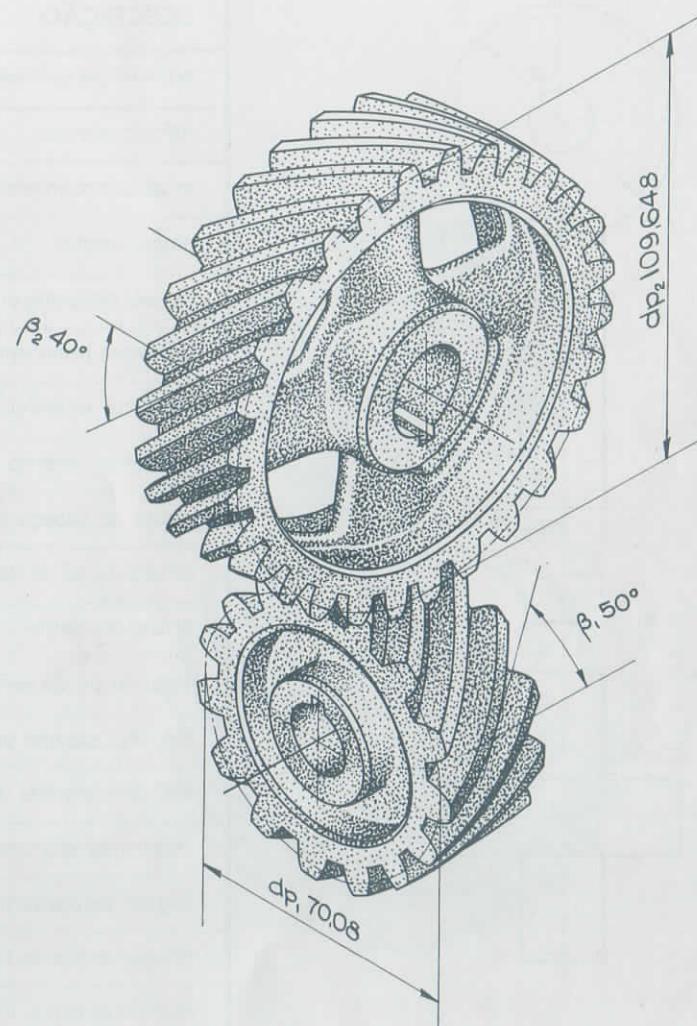
$$\text{diâmetro primitivo do pinhão } d_{p1} = m z_1 / \cos \beta_1 = 70,08$$

$$\text{diâmetro primitivo da coroa } d_{p2} = m z_2 / \cos \beta_2 = 109,648$$

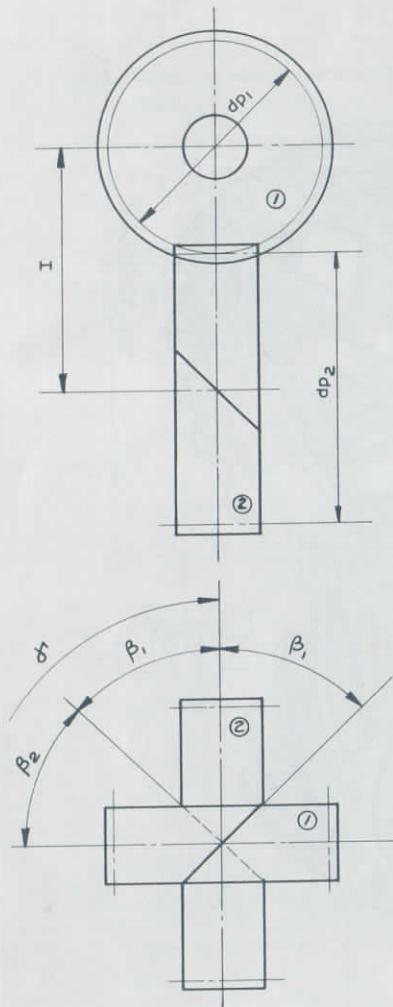
$$\text{cabeça do dente } a = m = 3$$

$$\text{pé do dente } b = 1,167m = 3,501$$

$$\text{largura das engrenagens } l = (6 - 16)m = 28$$

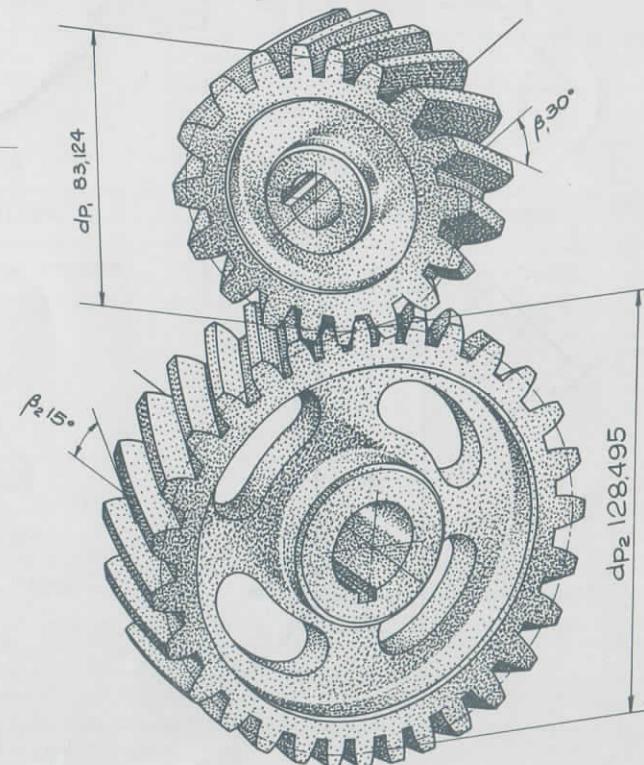
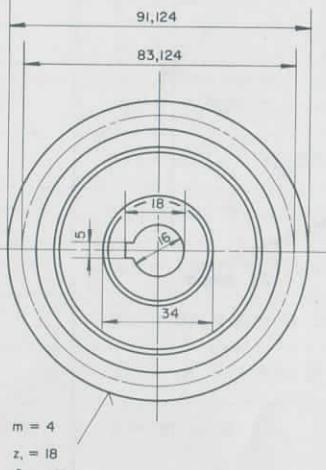
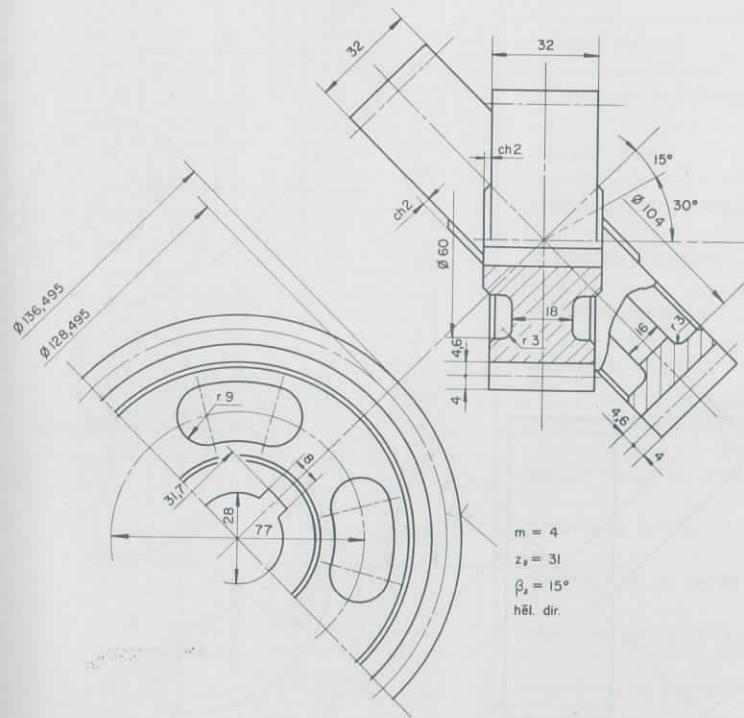


CÁLCULOS



DESCRICAÇÃO	PINHÃO	COROA
número de dentes	$z_1 = 15$	$z_2 = 28$
módulo normal	$m = 3$	
módulo circunferencial	$mc_1 = m/\cos\beta_1 = 4,672$	$mc_2 = m/\cos\beta_2 = 3,916$
passo normal	$P_n = m\pi = 9,42$	
passo circunferencial	$P_{c1} = mc_1\pi = 14,670$	$P_{c2} = mc_2\pi = 12,296$
diâmetro primitivo	$dp_1 = mc_1 z_1 = 70,080$	$dp_2 = mc_2 z_2 = 109,648$
diâmetro externo	$de_1 = dp_1 + 2m = 76,080$	$de_2 = dp_2 + 2m = 115,648$
diâmetro interno	$di_1 = dp_1 - 2,334m = 63,078$	$di_2 = dp_2 - 2,334m = 102,646$
altura da cabeça do dente	$a = m = 3$	
altura do pé do dente	$b = 1,167m = 3,501$	
altura do dente	$h = a + b = 6,501$	
folga no pé do dente	$e = 0,167m = 0,501$	
esp. circ. aparente do dente	$s_1 = mc_1\pi/2 = 7,335$	$s_2 = mc_2\pi/2 = 6,148$
esp. cord. aparente do dente	$sc_1 = mc_1 z_1 \sin\alpha_1 = 7,288$	$sc_2 = mc_2 z_2 \sin\alpha_2 = 6,030$
largura da engrenagem	$\ell = (6 \div 16)m = 28$	
ângulo de pressão	$\theta = 15^\circ$	
ângulo entre os eixos	$\delta = \beta_1 + \beta_2 = 50^\circ + 40^\circ = 90^\circ$	
distância entre centros	$I = (dp_1 + dp_2)/2 = 89,864$	
relação de transmissão	$\varphi = z_1/z_2 = 0,535 = 1:1,866$	
ângulo do dente	$\alpha_1 = 90^\circ/z_1 = 6^\circ$	$\alpha_2 = 90^\circ/z_2 = 3^\circ 12'$

ENGRANAGENS HELICOIDAIS DE EIXOS REVERSOS



DADOS

$m = 4$ $z_1 = 18$ $z_2 = 31$
 $\beta_1 = 30^\circ$ hél. dir. $\beta_2 = 15^\circ$ hél. dir. $\theta = 20^\circ$

CÁLCULOS PARA O DESENHO

diâm. primitivo do pinhão $dp_1 = m z_1 / \cos \beta_1 = 83,124$

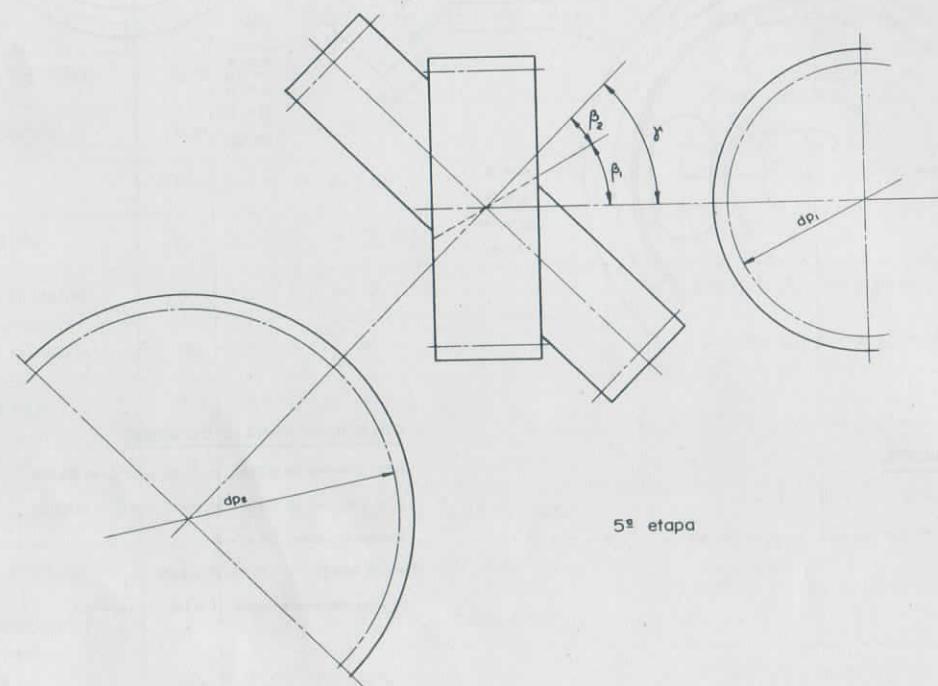
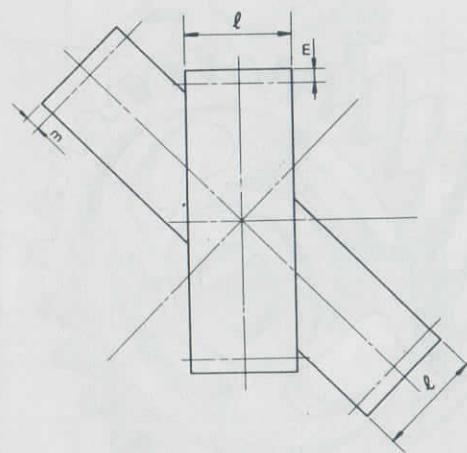
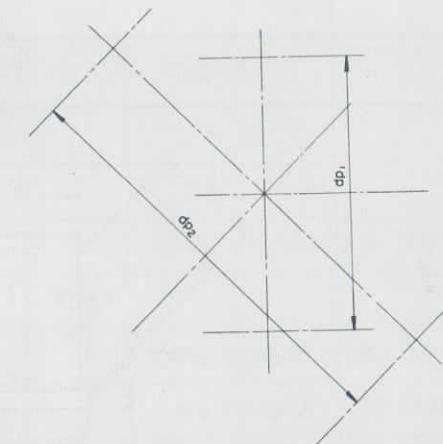
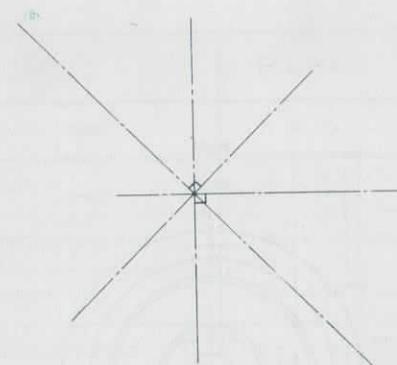
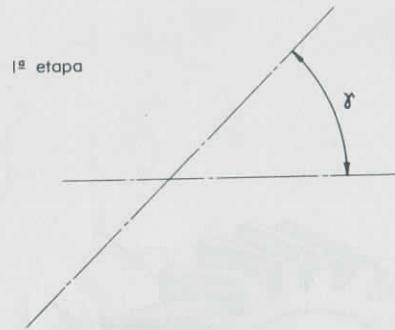
diâm. primitivo da coroa $dp_2 = m z_2 / \cos \beta_2 = 128,495$

cabeça do dente $a = m = 4$

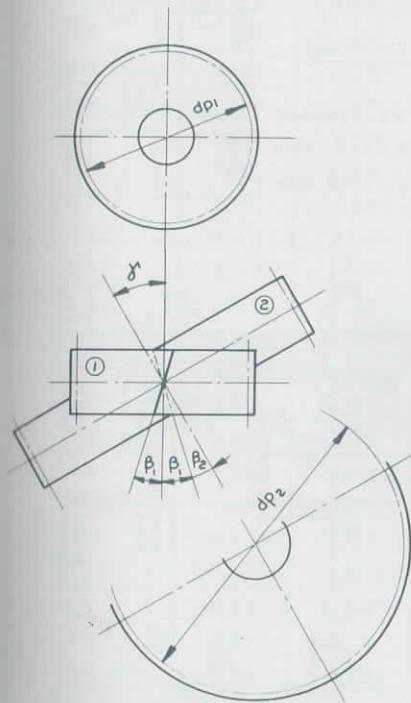
pé do dente $b = 1,167m = 4,668$

largura das engrenagens $l = (6 + 16)m = 32$

SEQUÊNCIA DO TRAÇADO

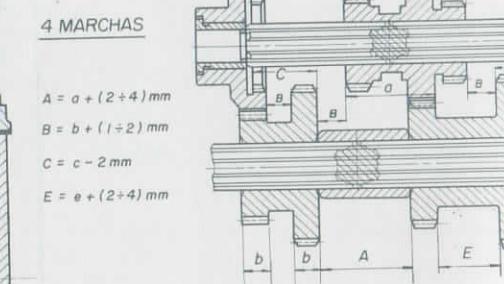
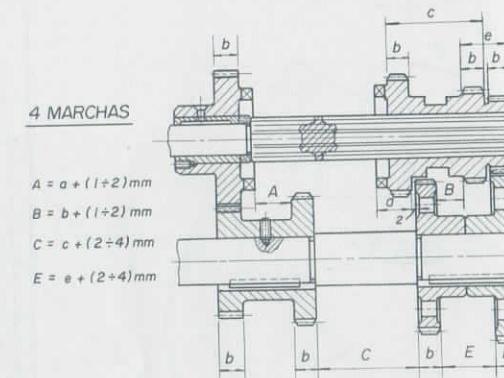
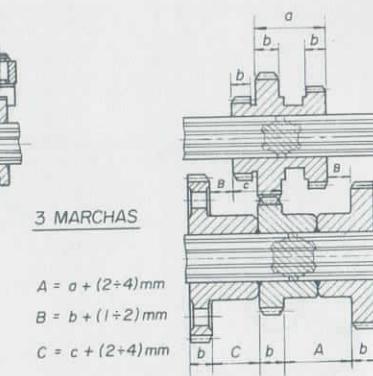
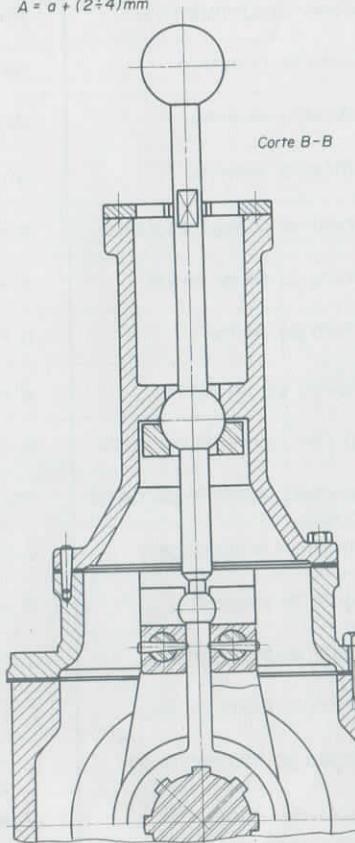
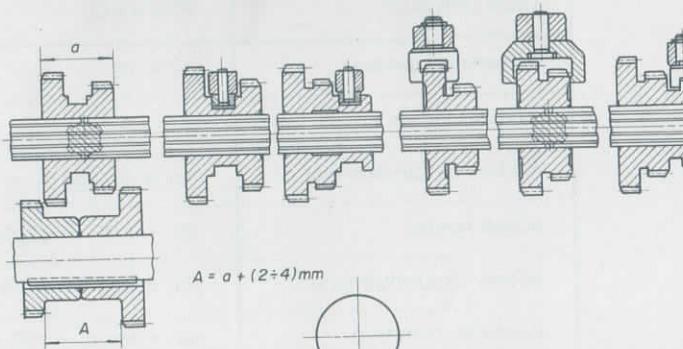
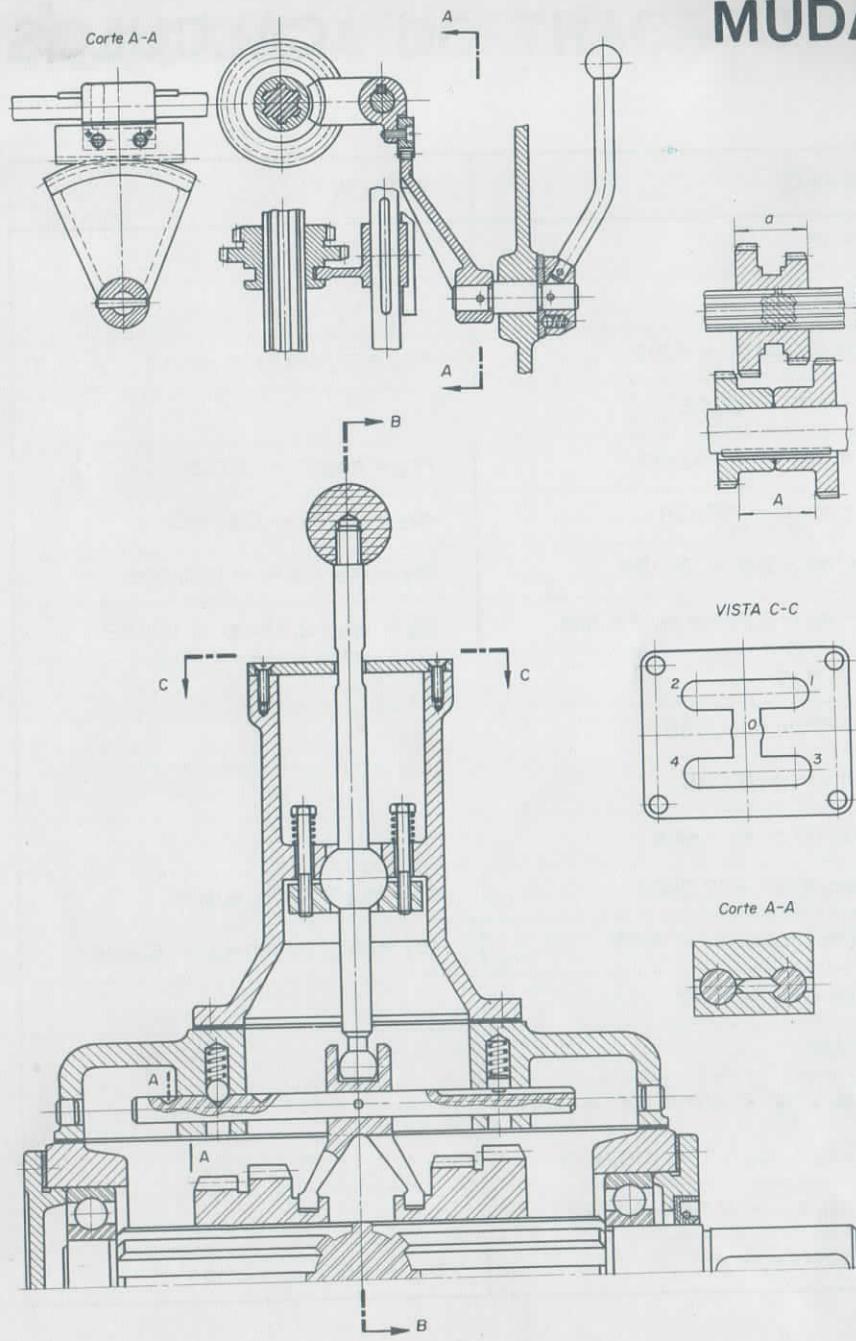


CÁLCULOS



DESCRICAÇÃO	PINHÃO	COROA
número de dentes	$z_1 = 18$	$z_2 = 31$
módulo normal	$m = 4$	
módulo circunferencial	$mc_1 = m/\cos\beta_1 = 4,618$	$mc_2 = m/\cos\beta_2 = 4,145$
passo normal	$P_n = m\pi = 12,56$	
passo circunferencial	$P_{c1} = mc_1\pi = 14,500$	$P_{c2} = mc_2\pi = 13,015$
diâmetro primitivo	$dp_1 = mc_1 z_1 = 83,124$	$dp_2 = mc_2 z_2 = 128,495$
diâmetro externo	$de_1 = dp_1 + 2m = 91,124$	$de_2 = dp_2 + 2m = 136,495$
diâmetro interno	$di_1 = dp_1 - 2,334m = 73,788$	$di_2 = dp_2 - 2,334m = 119,159$
altura da cabeça do dente	$a = m = 4$	
altura do pé do dente	$b = 1,167m = 4,668$	
altura do dente	$h = a + b = 8,668$	
folga no pé do dente	$e = 0,167m = 0,668$	
esp. circ. aparente do dente	$s_1 = mc_1\pi/2 = 7,250$	$s_2 = mc_2\pi/2 = 6,507$
esp. cord. aparente do dente	$sc_1 = mc_1 z_1 \sin\alpha_1 = 7,231$	$sc_2 = mc_2 z_2 \sin\alpha_2 = 6,424$
largura da engrenagem	$\ell = (6 \div 16)m = 32$	
ângulo de pressão	$\Theta = 20^\circ$	
ângulo entre os eixos	$\delta = \beta_1 + \beta_2 = 30^\circ + 15^\circ = 45^\circ$	
distância entre centros	$I = (dp_1 + dp_2)/2 = 105,809$	
relação de transmissão	$\varphi = z_1/z_2 = 0,58 = 1:1,722$	
ângulo do dente	$\alpha_1 = 90^\circ/z_1 = 5^\circ$	$\alpha_2 = 90^\circ/z_2 = 2^\circ 54'$

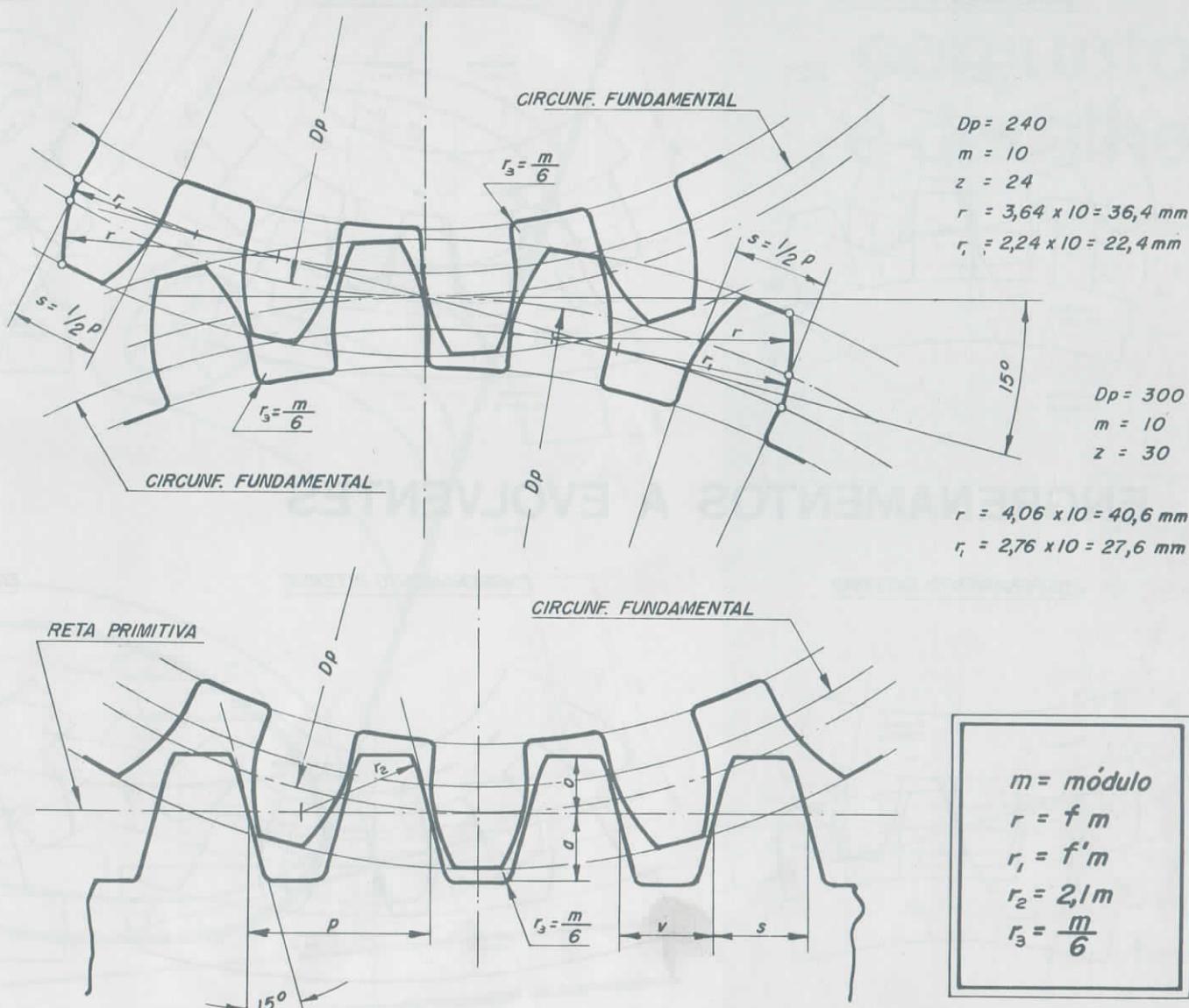
MUDANÇA DE MARCHA



Nº DE DENTES	COEFICIENTES	
Z	f	f'
8	2,10	0,45
10	2,28	0,69
11	2,40	0,83
12	2,51	0,96
13	2,62	1,09
14	2,72	1,22
15	2,82	1,34
16	2,92	1,46
17	3,02	1,58
18	3,12	1,69
19	3,22	1,79
20	3,32	1,89
21	3,41	1,98
22	3,49	2,06
23	3,57	2,15
24	3,64	2,24
25	3,71	2,33
26	3,78	2,42
27	3,85	2,50
28	3,92	2,59
29	3,99	2,67
30	4,06	2,76
32	4,20	2,93
33	4,27	3,01
34	4,33	3,09
35	4,39	3,16
36	4,45	3,23
37-40	4,20	
41-45	4,63	
46-51	5,06	
52-60	5,74	
61-70	6,52	
71-90	7,72	
91-120	7,78	
121-180	13,38	
181-360	21,62	

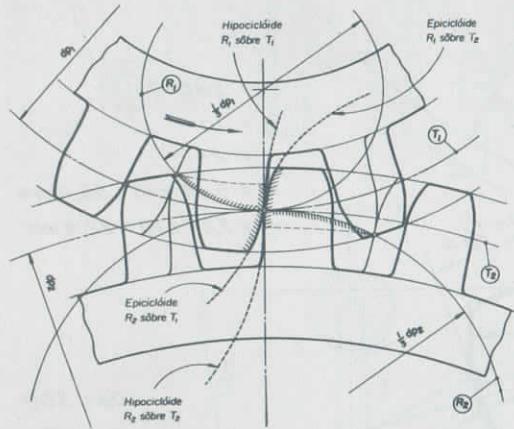
ODONTÓGRAFO DE GRANT

PARA TRAÇADO APROXIMADO DE PERFIS A ENVOLVENTE

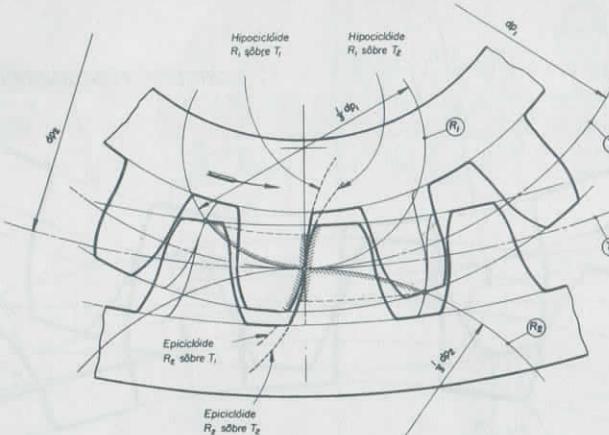


ENGRENAIMENTOS A CICLÓIDES

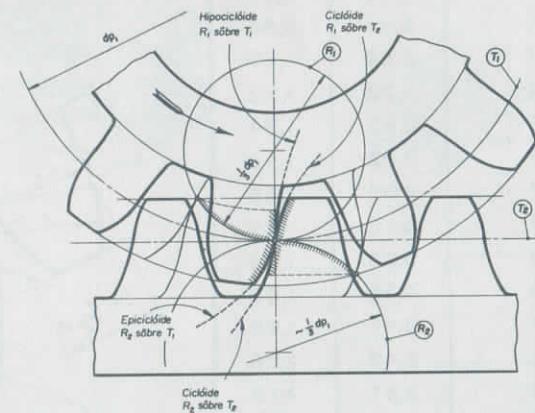
ENGRENAIMENTO EXTERNO



ENGRENAIMENTO INTERNO

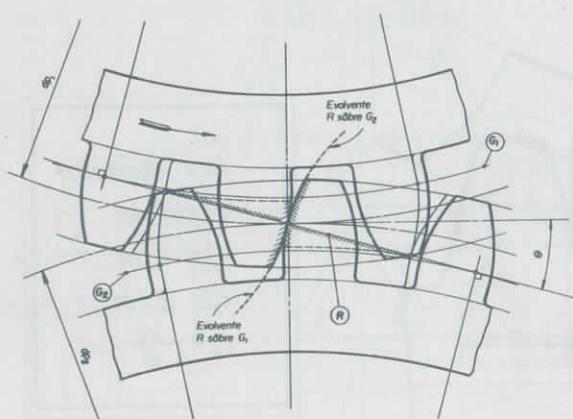


ENGRENAJEM E CREMALHEIRA

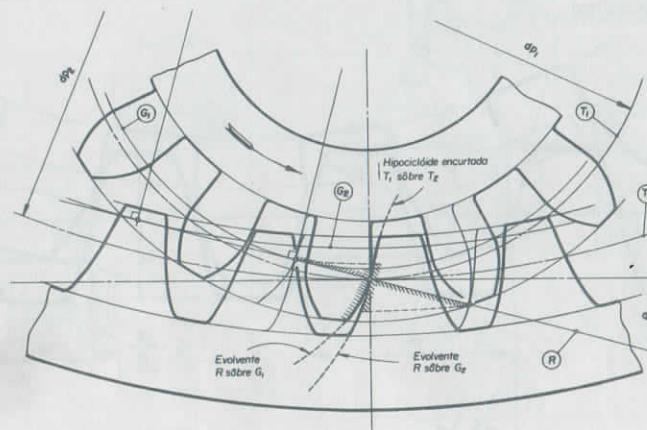


ENGRENAIMENTOS A EVOLVENTES

ENGRENAIMENTO EXTERNO



ENGRENAIMENTO INTERNO



ENGRENAJEM E CREMALHEIRA

