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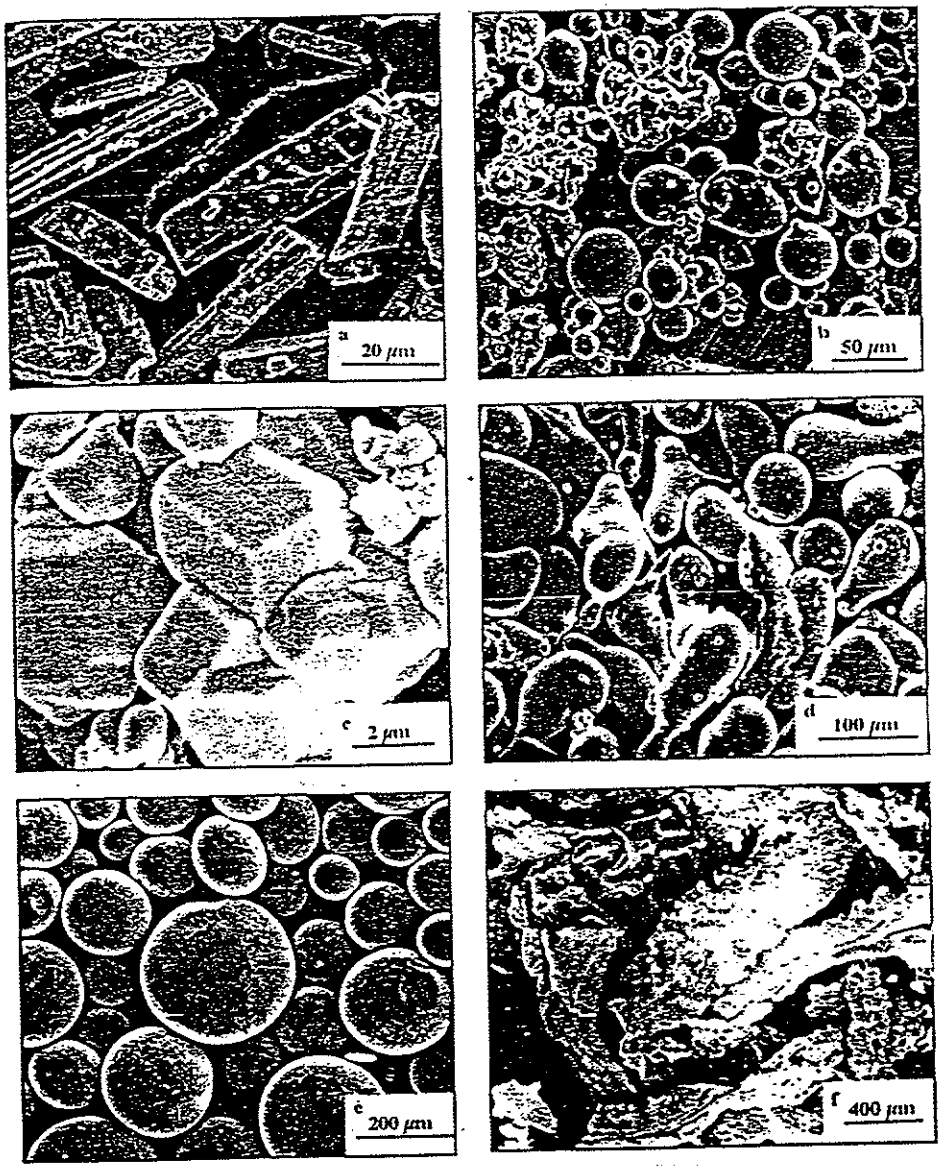
LAMPIRAN-LAMPIRAN

LAMPIRAN GAMBAR

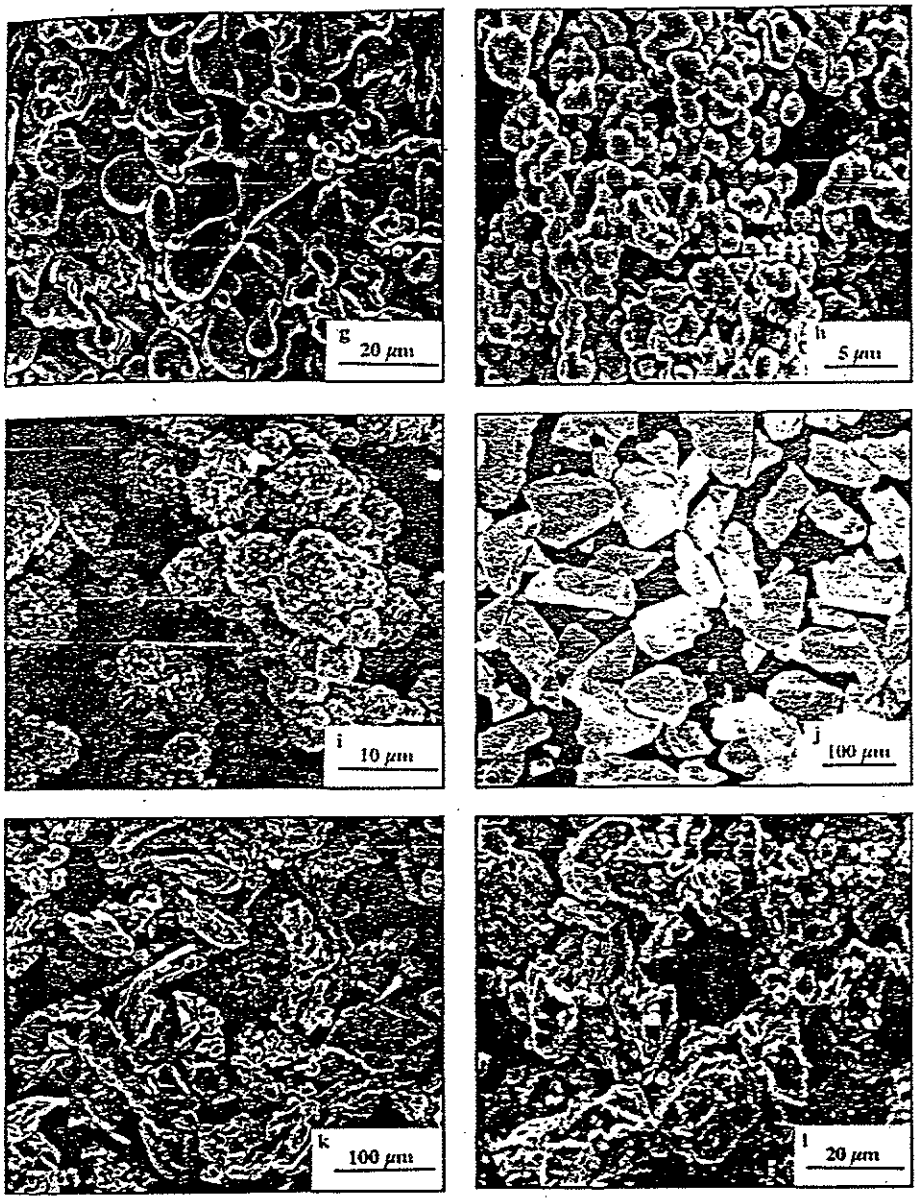
UNIVERSITAS
GADJAH MADA

Lampiran 1

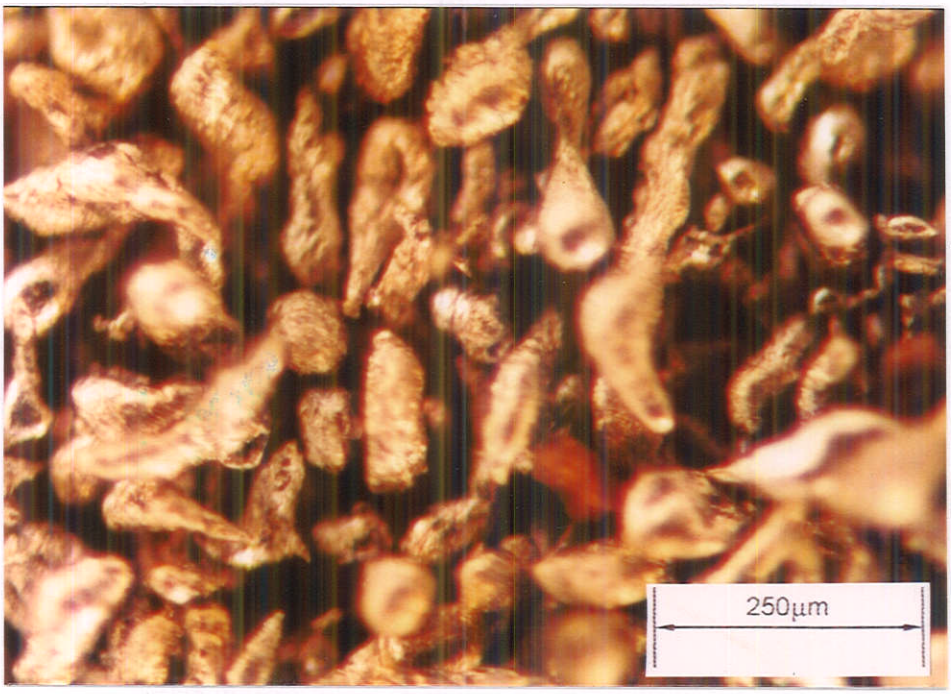


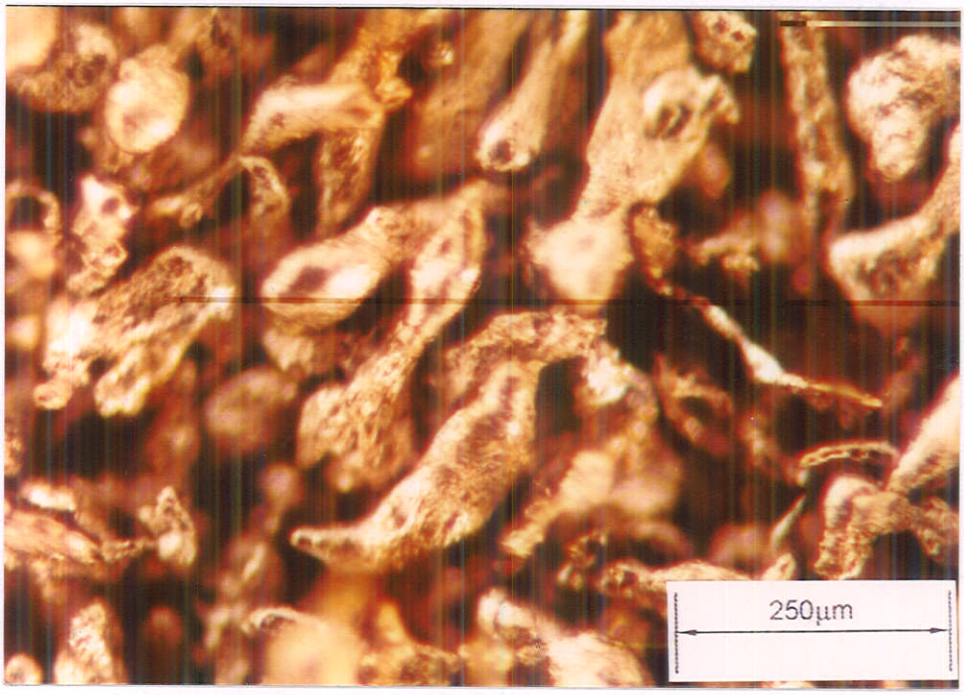
Keterangan: (a) acicular, (b)

Lampiran 2

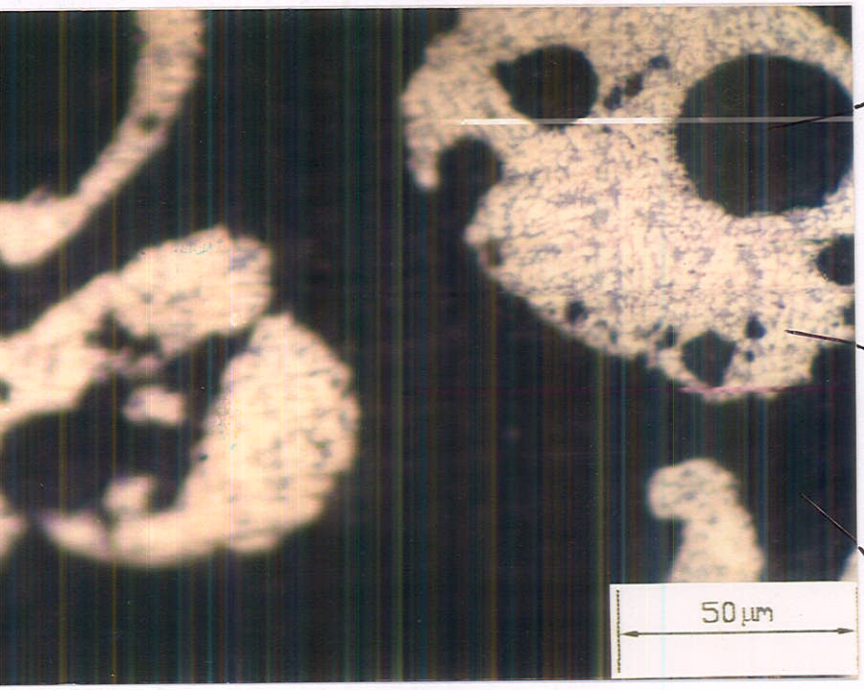


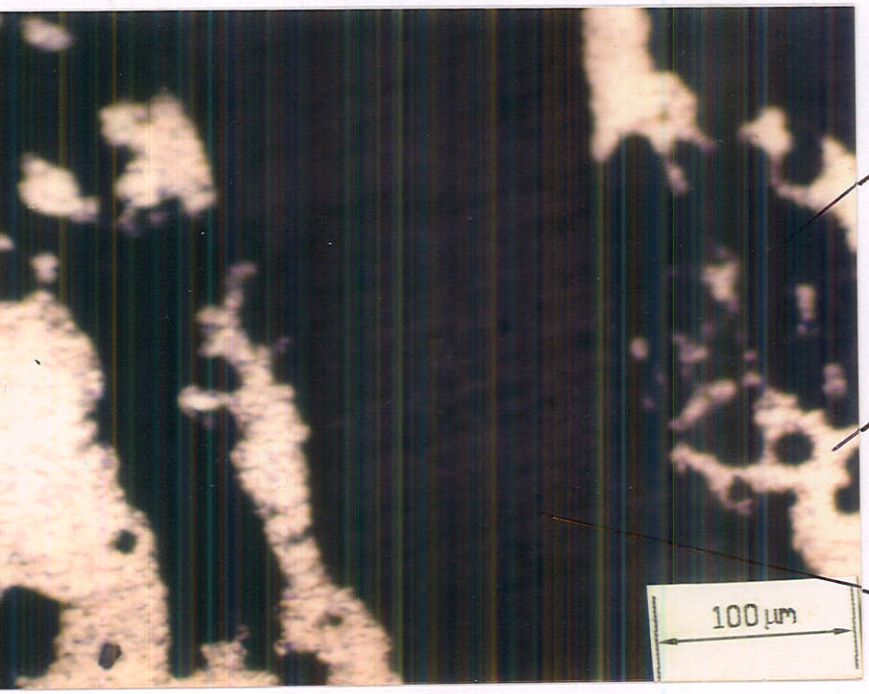
Gambar 2: Bentuk-bentuk partikel serbuk logam. Keterangan: (g) bulat ireguler,



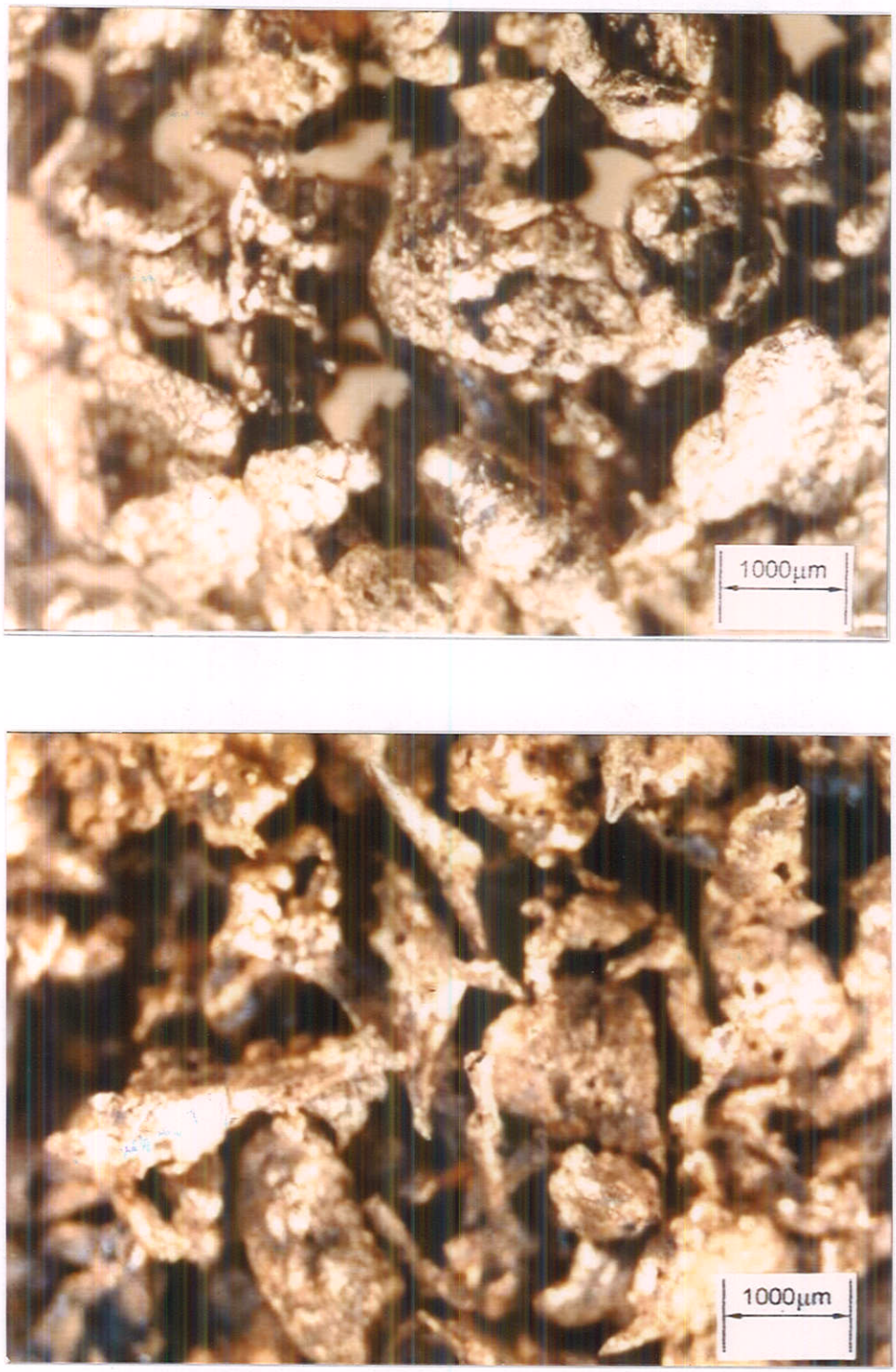


Gambar 3: Foto mikro partikel serbuk alumunium kelas interval 8 (150 – 210 µm)

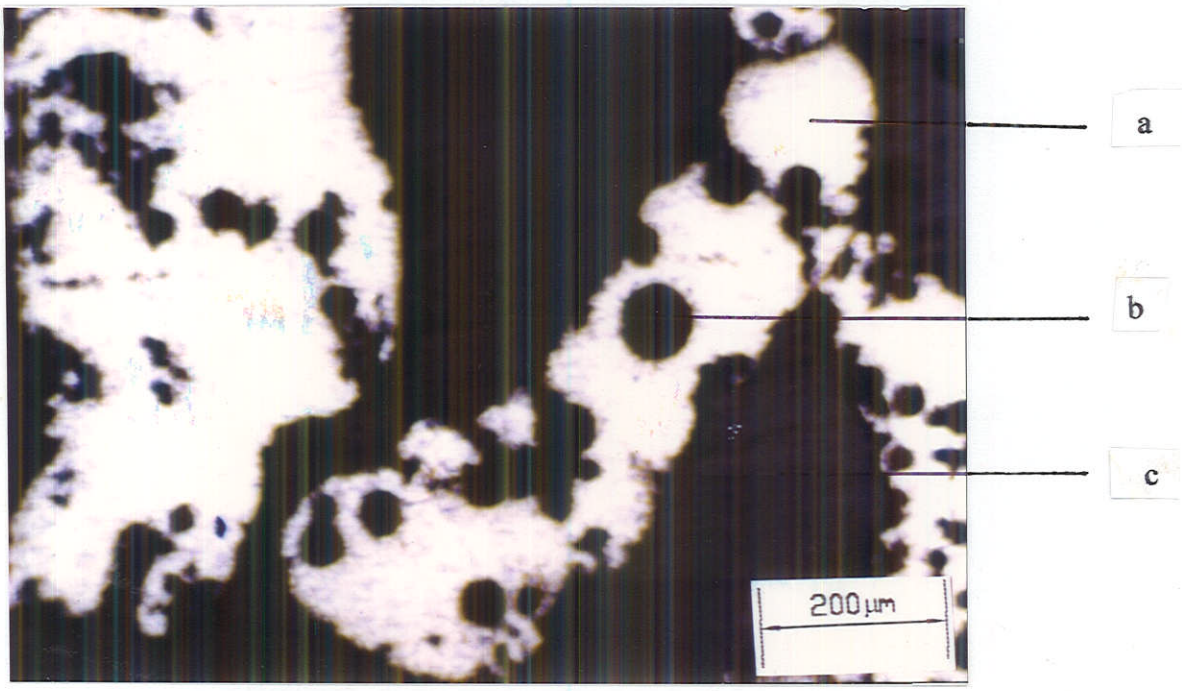




Gambar 4: Foto struktur partikel serbuk alumunium hasil atomisasi air dengan



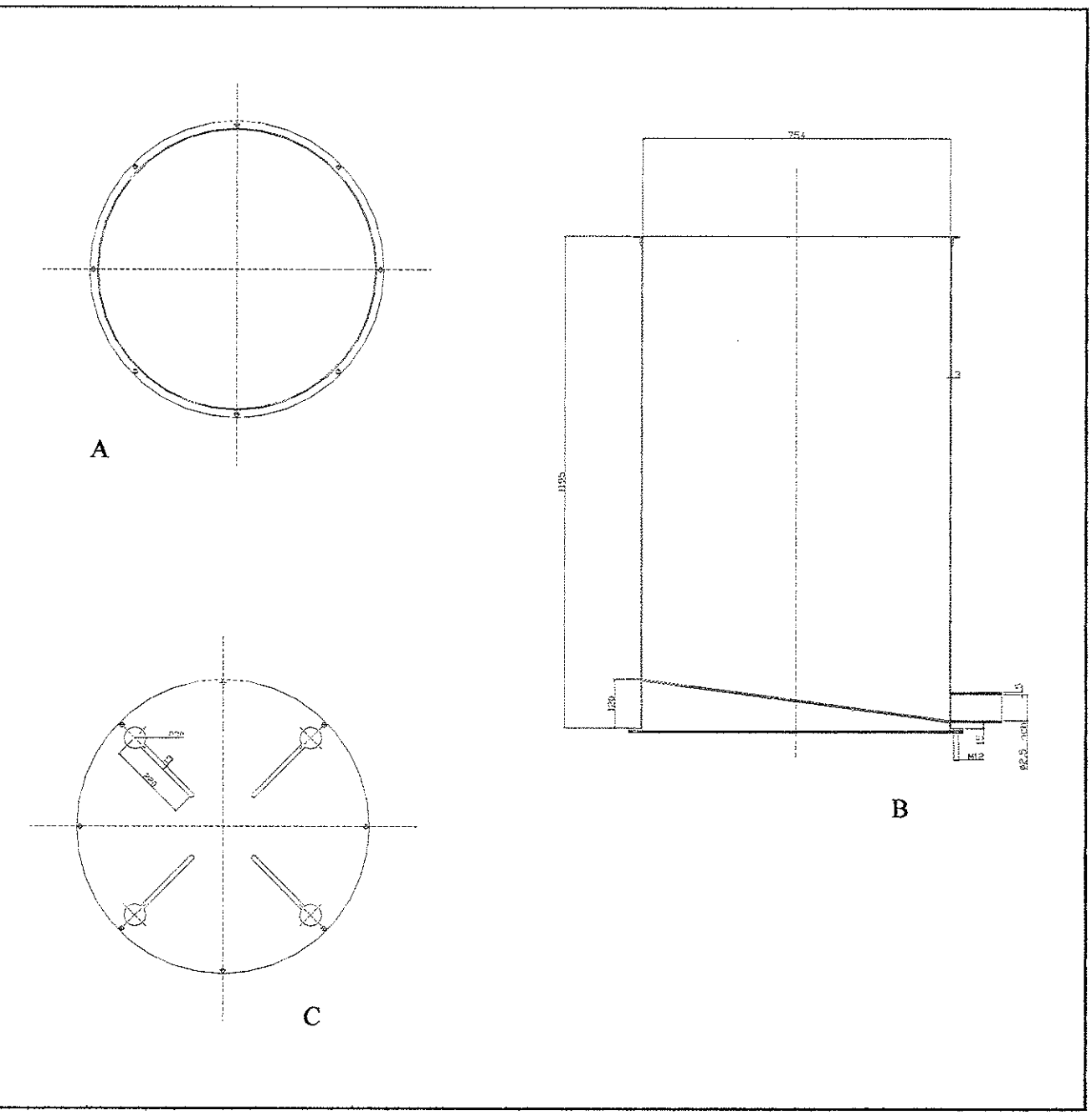
Gambar 5: Foto mikro partikel serbuk alumunium kelas interval 3 (841 - 1190 µm) hasil atomisasi air dengan menggunakan heater A pada P 6 MPa, α 75°, 2 sprayer



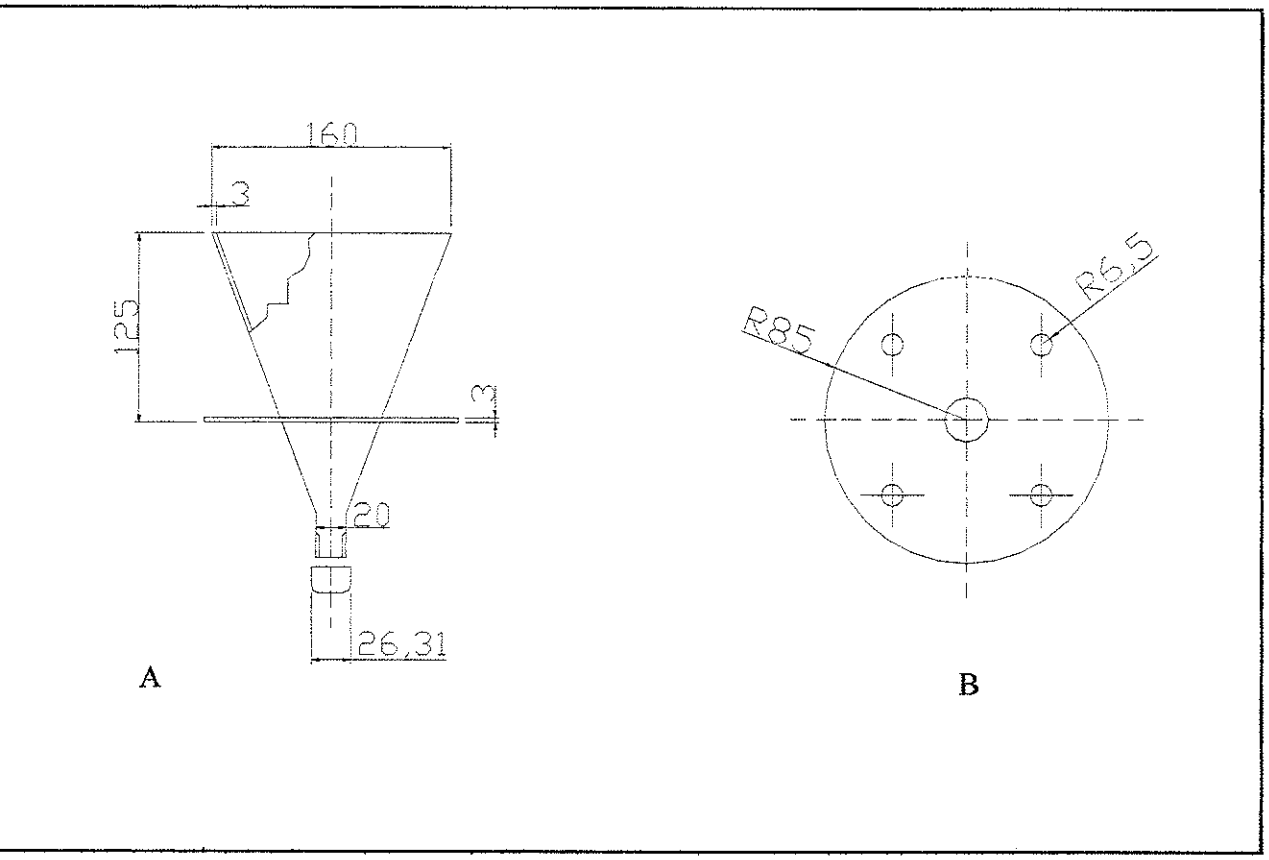
Gambar 6: Foto struktur partikel serbuk alumunium hasil atomisasi air dengan menggunakan heater A pada P 6 MPa, α 75°, 2 sprayer.

Keterangan Gambar 6:
a. partikel serbuk Al,
b. rongga-rongga di dalam partikel serbuk Al,
c. ruang antarpartikel.

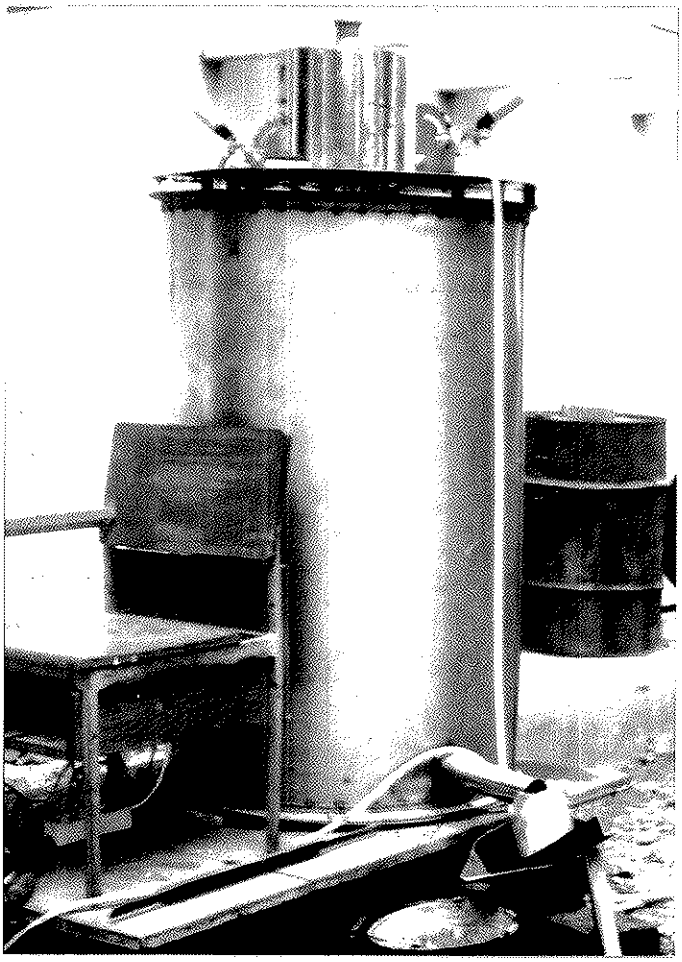
Lampiran 7



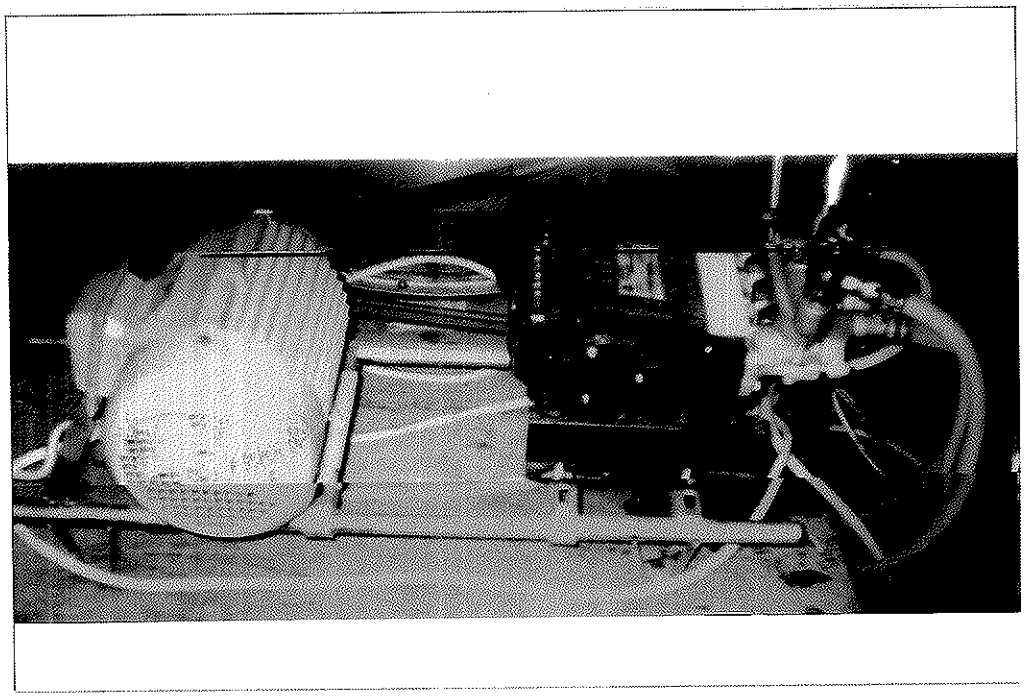
Gambar 7: Gambar tabung atomisasi. (A) Tampak atas, (B) tampak samping, dan (C) penutup tabung atomisasi tempat meletakkan heater, sprayer, dan tundish. Material stainless steel AISI 301 flat 3 mm dan 2 mm



Gambar 8: Gambar tundish. (A) Tampak samping, dan (B) tampak bawah. Material *tundish* baja flat 3 mm

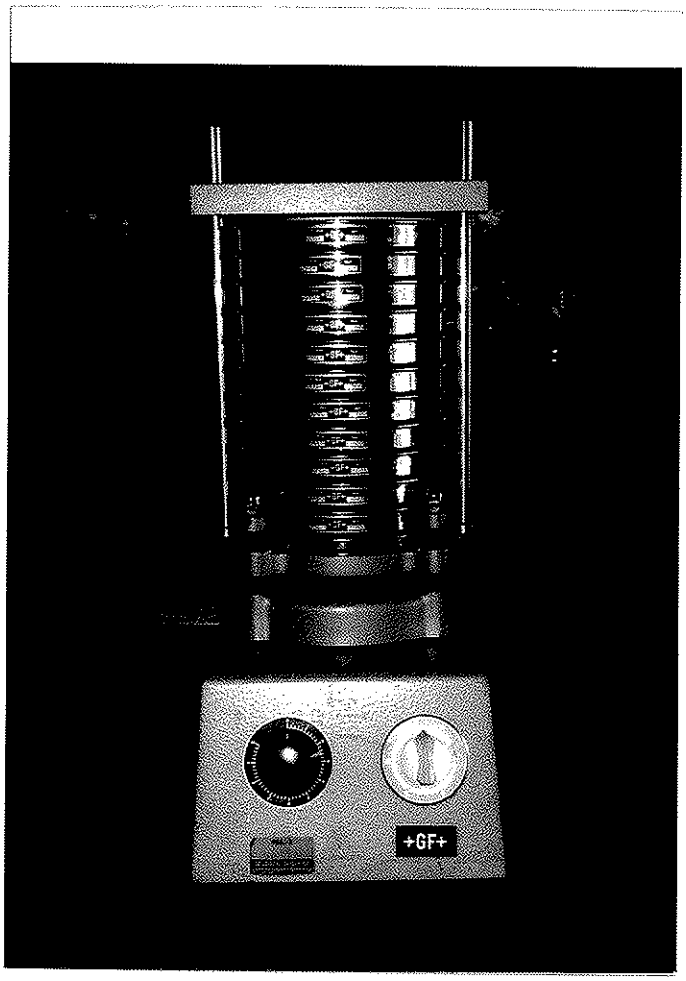


Gambar 9: Tabung atomisasi. Tampak di bagian atas tabung terletak dua nosel dan pelindung angin heater.

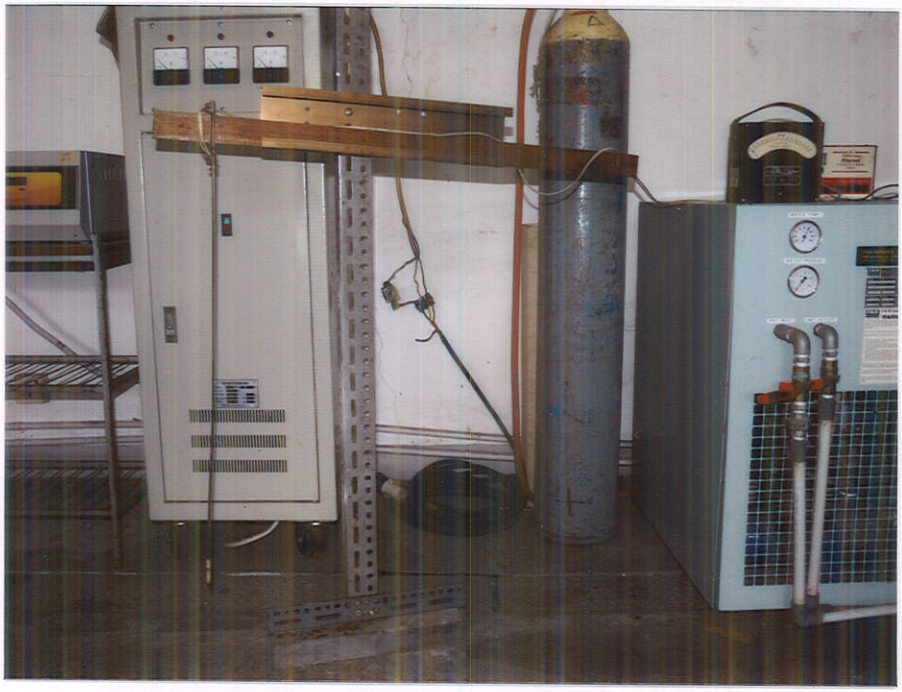


Gambar 10: Pompa air.

Gambar 11: Oven *programmable*. Digunakan untuk perlakuan panas tanah liat pemegang nikelin.

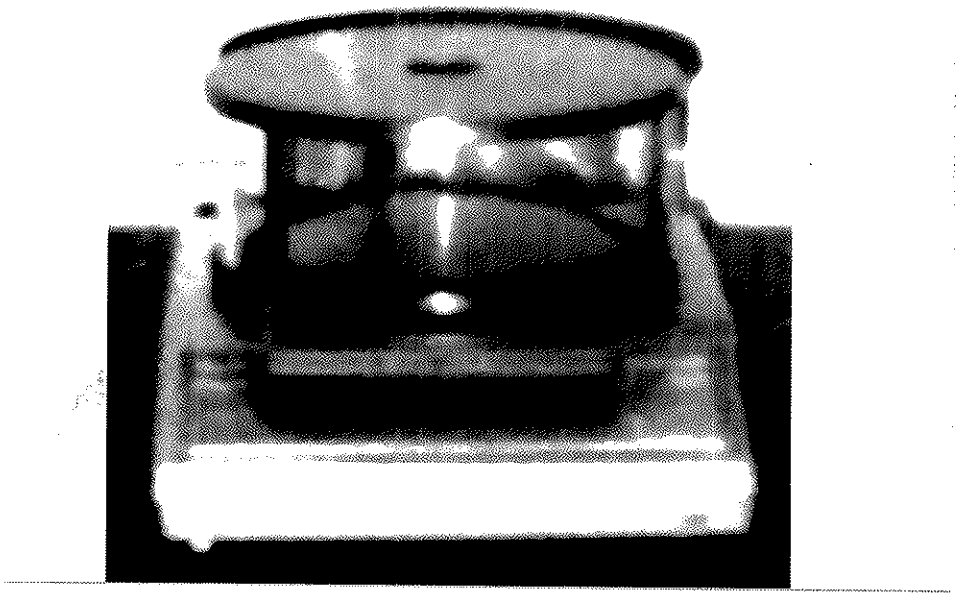


Gambar 12: *Screen mesh.*

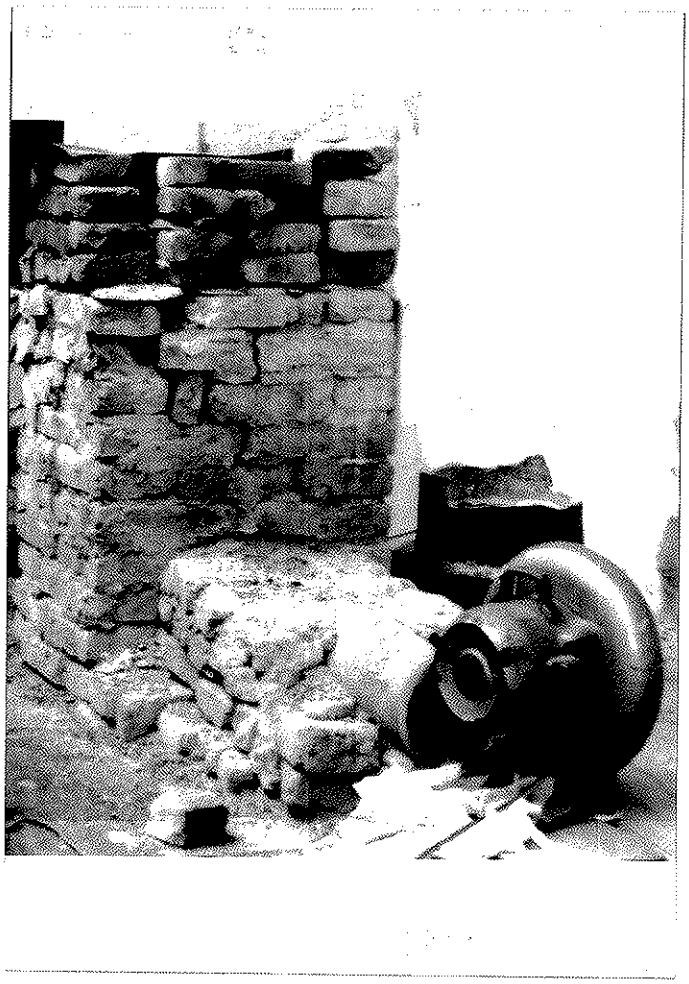


Gambar 13: Termokopel dan batang pemegang termokopel.

Gambar 14: Skala penunjuk temperatur pada termokopel



Gambar 15: Timbangan.



Gambar 16: Dapur peleburan dan *blower*.

LAMPIRAN TABEL

Lampiran 20

Tabel 2: Tabel sifat-sifat alumunium (Al) dan beberapa logam lainnya (German, 1994).

property		Ag	Al	Astroloy	Au	Be
1. atomic number	A_N	47	13	—	79	4
2. density, g/cm^3	ρ	10.5	2.7	8.9	19.3	1.9
3. crystal type	χ	FCC	FCC	—	FCC	HCP
4. atomic diameter, nm	a_o	0.288	0.286	—	0.292	0.224
5. melting temperature, °C	T_M	961	660	1400	1063	1283
6. boiling temperature, °C	T_B	2212	2467	—	2807	2970
7. heat capacity, J/(mol °C)	C_p	25	24	24	25	20
8. heat of fusion, kJ/mol	ΔH_f	11	11	—	13	10
9. heat of vaporization, kJ/mol	ΔH_v	258	291	—	343	309
10. atomic weight, g/mol	A_w	108	27	58	197	9
11. surface energy, J/m^2	γ	1.2	1.1	1.7	1.4	1.0
12. elastic modulus, GPa	E	76	71	213	79	318
13. yield strength, MPa	σ_y	40	75	905	20	240
14. Poisson's ratio	υ	0.37	0.35	0.31	0.42	0.02
15. thermal expansion, ppm/°C	α	19.2	23.8	12.0	14.3	12.3
16. thermal conductivity, W/(m	Q	431	237	11	316	194
17. electrical resistivity, μΩ cm	R	1.6	2.7	120	2.4	4.0
volume diffusion						
18. frequency factor, m^2/s	D_{VO}	$4 \cdot 10^{-5}$	$2 \cdot 10^{-4}$	$2 \cdot 10^{-4}$	$1 \cdot 10^{-5}$	$4 \cdot 10^{-5}$
19. activation energy, kJ/mol	Q_V	185	142	285	181	166
*grain boundary diffusion**						
20. frequency factor, m^3/s	D_{BO}	$6 \cdot 10^{-15}$	$3 \cdot 10^{-14}$	$2 \cdot 10^{6}$	$3 \cdot 10^{-16}$	—
21. activation energy, kJ/mol	Q_B	90	60	115	110	—
surface diffusion						
22. frequency factor, m^2/s	D_{SO}	$5 \cdot 10^{7}$	—	—	10^{6}	—
23. activation energy, kJ/mol	Q_S	266	142	285	234	—

* the grain boundary diffusion frequency factor includes the grain boundary width, hence the dimensions of m^3/s

Tabel 3: Kalor jenis (c), masa jenis (ρ), konduktivitas termal (k), difusivitas termal (α) pada 20°C dan konduktivitas termal pada beberapa tingkat temperatur alumunium dan beberapa logam lainnya (Holman, 1984).

Logam	Sifat-sifat pada 20° C: ρ, kg/m³	c_p, kJ/kg·°C	k, W/m·°C	α, m²/s × 10⁶	Konduktivitas termal k, W/m·°C: 100°C −148°F	0°C 32°F	100°C 212°F	200°C 392°F	300°C 572°F	400°C 752°F	600°C 1112°F	800°C 1472°F	1000°C 1832°F	1200°C 2192°F
Aluminum:														
Murni	2.707	0,896	204	8,418	215	202	206	215	228	249				
Al-Cu (Duralumin), 94–96% Al, 3–5% Cu, runut Mg	2.787	0,883	164	6,676	126	159	182	194						
Al-Si (Silumin, mengandung tembaga), 86,5% Al, 1% Cu	2.659	0,867	137	5,933	119	137	144	152	161					
Al-Si (Alusil), 78–80% Al, 20–22% Si	2.627	0,854	161	7,172	144	157	168	175	178					
Al-Mg-Si, 97% Al, 1% Mg, 1% Si, 1% Mn	2.707	0,892	177	7,311		175	189	204						
Timbal	11.373	0,130	35	2,343	36,9	35,1	33,4	31,5	29,8					
Besi														
Murni	7.897	0,452	73	2,034	87	73	67	62	55	48	40	36	35	36
Besi Tempa, 0.5% C	7.849	0,46	59	1,625		59	57	52	48	45	36	33	33	33
Baja (C maks ~ 1,5%)														
Baja karbon														
C = 0,5%	7.833	0,465	54	1,474		55	52	48	45	42	35	31	29	31
1,0%	7.801	0,473	43	1,172		43	43	42	40	36	33	29	28	29
1,5%	7.753	0,486	36	0,970		36	36	36	36	33	31	28	28	29
Baja nikel														
Ni = 0%	7.897	0,452	73	2,026										
20%	7.933	0,46	19	0,526										
40%	8.169	0,46	10	0,279										
80%	8.618	0,46	35	0,872										
Invar 36% Ni	8.137	0,46	10,7	0,286										
Baja krom														
Cr = 0%	7.897	0,452	73	2,026	87	73	67	62	56	48	40	36	35	36
1%	7.865	0,46	61	1,665		62	55	52	47	42	36	33	33	
5%	7.833	0,46	40	1,110		40	38	36	36	33	29	29	29	
20%	7.689	0,46	22	0,635		22	22	22	22	24	24	26	29	
Cr-Ni (krom-nikel): 15% Cr, 10% Ni	7.865	0,46	19	0,527										
18% Cr, 8% Ni (V2A)	7.817	0,46	16,3	0,444		16,3	17	17	19	19	22	27	31	
20% Cr, 15% Ni	7.833	0,46	15,1	0,415										
25% Cr, 20% Ni	7.865	0,46	12,8	0,361										
Baja wolfram														
W = 0%	7.897	0,452	73	2,026										
1%	7.913	0,448	66	1,858										
5%	8.073	0,435	54	1,525										
10%	8.314	0,419	48	1,391										
Copper:														
Murni	8.954	0,3831	386	11,234	407	386	379	374	369	363	353			
Perunggu aluminium 95% Cu 5% Al	8.666	0,410	83	2,330										
Perunggu 75% Cu, 25% Sn	8.666	0,343	26	0,859										
Kuningan merah 5% Cu, 9% Sn, 6% Zn	8.714	0,385	61	1,804		59	71							
Kuningan 70% Cu, 30% Zn	8.522	0,385	111	3,412	88		128	144	147	147				
Perak Jerman 62% Cu, 15% Ni, 22% Zn	8.618	0,394	24.9	0,733	19,2		31	40	45	48				
Konstantan 60% Cu, 40% Ni	8.922	0,410	22.7	0,612	21		22,2	26						
Magnesium:														
Murni	1.746	1,013	171	9,708	178	171	168	163	157					
Mg-Al (elektrolitrik) 6-8% Al, 1-2% Zn	1.810	1,00	66	3,605		52	62	74	83					
Molybden	10.220	0,251	123	4,790	138	125	118	114	111	109	106	102	99	92
Nikel														
Murni (99,9%)	8.906	0,4459	90	2,266	104	93	83	73	64	59				
Ni-Cr 90% Ni, 10% Cr	8.666	0,444	17	0,444		17,1	18,9	20,9	22,8	24,6				
80% Ni, 20% Cr	8.314	0,444	12.6	0,343		12,3	13,8	15,6	17,1	18,0	22,5			
Perak:														
Murni					418	417	415	412						

Tabel 4: Konduktivitas termal (k), massa jenis (ρ), kalor jenis (c), dan difusivitas termal (α) bahan-bahan bangunan dan penahan kalor pada temperatur tertentu (Holman, 1984).

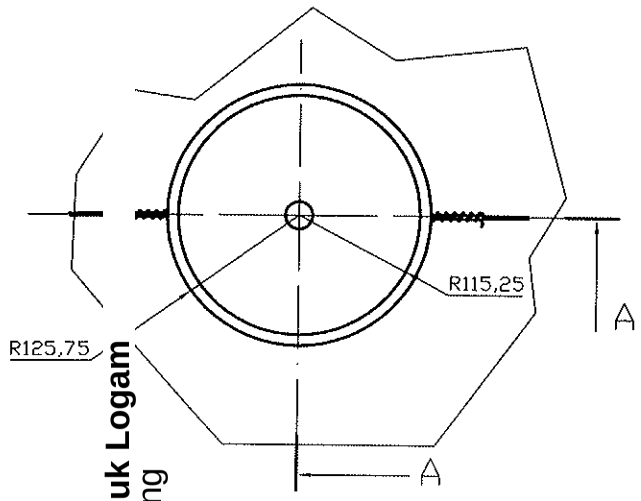
Bahan	*Suhu* °C	*k*, W/m·°C	*ρ*, kg/m³	*C*, kJ/kg·°C	*α*, m²/s × 10⁷
Bahan-bahan bangunan dan penahan-kalor					
Aspal	20–55	0,74–0,76			
Bata:					
Bata bangunan	20	0,69	1600	0,84	5,2
muka biasa		1,32	2000		
Bata karborundum	600	18,5			
	1400	11,1			
Bata krom	200	2,32	3000	0,84	9,2
	550	2,47			9,8
Tanah diatomea	900	1,99			7,9
dicetak dan					
dibakar	200	0,24			
	870	0,31			
Bata tahan-api	500	1,04	2600	0,96	5,4
dibakar 2426° F	800	1,07			
	1100	1,09			
Dibakar 2642° F	500	1,28	2300	0,96	5,8
	800	1,37			
	1100	1,40			
Missouri	200	1,00	2600	0,96	4,0
	600	1,47			
	1400	1,77			
Magnesit	200	3,81		1,13	
	650	2,77			
Semen portland	1200	1,90			
moster		0,29	1500		
Beton sinder	23	1,16			
Batu 1-2-4 campur	23	0,76			
Gelas jendela	20	1,37	1900–2300	0,88	8,2–6,8
Korosilikat	20	0,78 (avg)	2700	0,84	3,4
Plaster, gips	30–75	1,09	2200		
lat logam	20	0,48	1440	0,84	4,0
lat kayu	20	0,47			
Batu	20	0,28			
Granit		1,73–3,98	2640	0,82	8–18
Batu kapur	100–300	1,26–1,33	2500	0,90	5,6–5,9
Marmar		2,07–2,94	2500–2700	0,80	10–13,6
Batu pasir	40	1,83	2160–2300	0,71	11,2–11,9
Kayu (melintas serat)					
Balsa, 8,8 lb/ft³	30	0,055	140		
Sipres	30	0,097	460		
Fir	23	0,11	420	2,72	0,96
Mapel	30	0,166	540	2,4	1,28
Pinus kuning	23	0,147	640	2,8	0,82
Pinus putih	30	0,112	450		

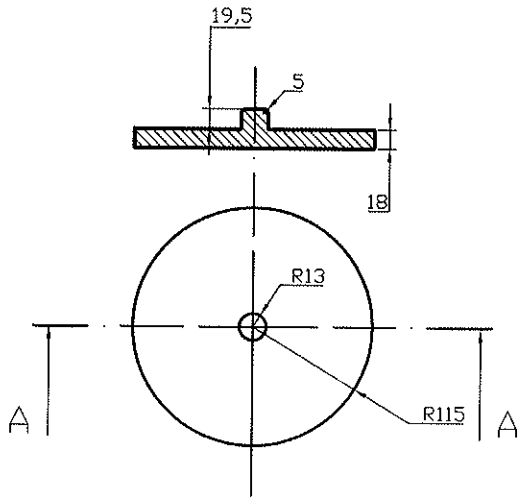
Lampiran 23

el 5: Konduktivitas termal (k), massa jenis (ρ), kalor jenis (c), dan difusivitas ermal (α) bahan-bahan isolasi pada temperatur tertentu (Holman, 1984).

Bahan	*Suhu* °C	*k*, W/m·°C	*ρ*, kg/m³	*C*, kJ/kg·°C	*α*, m²/s × 10⁷
		Bahan isolasi			
Asbes:					
Ditetal longgar	−45	0,149			
	0	0,154	470–570	0,816	3,3–4
	100	0,161			
Papan asbes semen	20	0,74			
Lembaran	51	0,166			
Lakan, 40 laminasi/m	38	0,057			
	150	0,069			
	260	0,083			
20 laminasifin	38	0,078			
	150	0,095			
	260	0,112			
Gelombang, 4 plai/in	38	0,087			
	93	0,100			
Asbes semen	150	0,119			
Wol balsam, 2, 2, lb/ft³	—	2,08			
Karton, gelombang	32	0,04	35		
Celotex	—	0,064			
Papan gabus, 10 lb/ft³	32	0,048			
Gabus butiran ulang	30	0,043	160		
Giling halus	32	0,045	45–120	1,88	2–5,3
Tanah diatomer	32	0,043	150		
(sil-o-cel)	0	0,061	320		
Lakan, rambut	30	0,036	130–200		
wol	30	0,052	330		
Serat, appan isolasi	20	0,048	240		
Wol gelas, 1,5 lb/ft³	23	0,038	24	0,7	22,6
Insulex, kering	32	0,064			
		0,144			
Kapuk	30	0,035			
Magnesia, 85%	38	0,067	270		
	93	0,071			
	150	0,074			
	204	0,080			
Wol batuan, 10 lb/ft³	32	0,040	160		
Ditetal longgar	150	0,067	64		
	260	0,087			
Serbuk gergaji	23	0,059			
Silika, aerogel	32	0,024	140		
Serutan kayu	23	0,059			

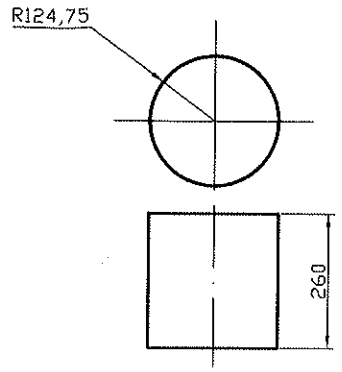
† Adaptasi dari satuan SI dari A-1. Brown dan s.m. Maus, "Introduction to Heat Transfer," 3d ed. McGraw-Hill Book Company, New York, 1956.





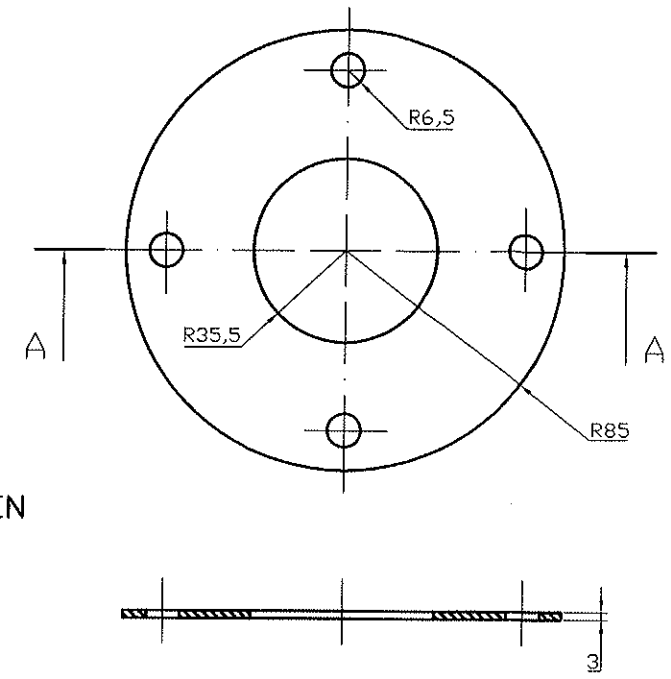
1 TUTUP TUNDISH

SKALA 1 : 5



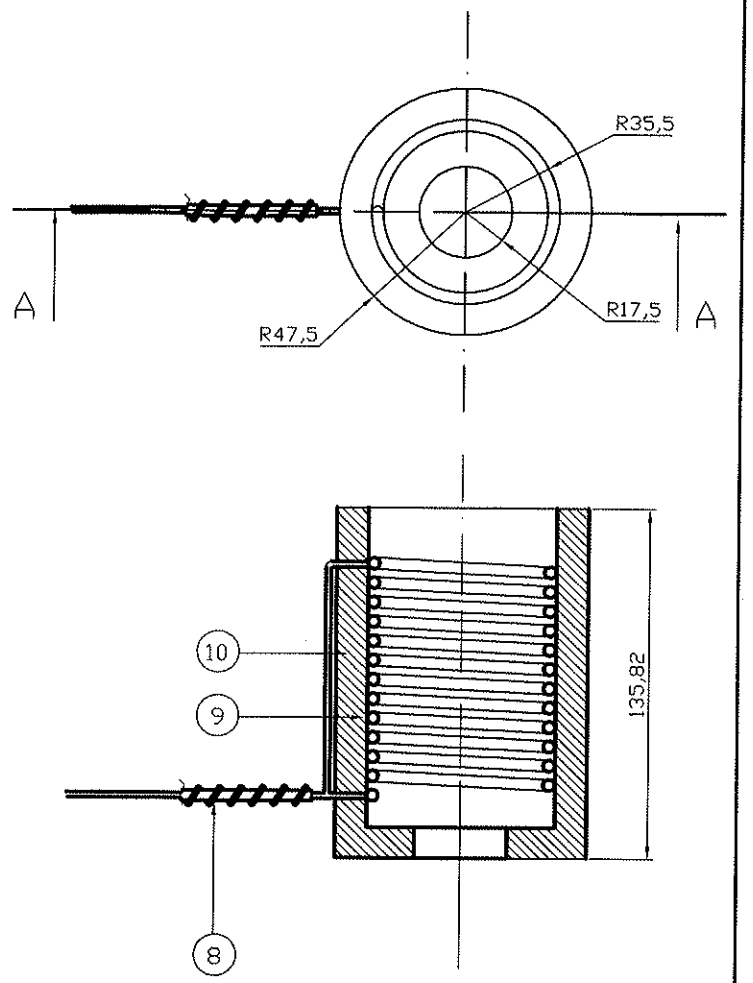
4 PELINDUNG ANGIN

SKALA 1 : 10



A – A

5 PENAHAN PEMANAS ATAS



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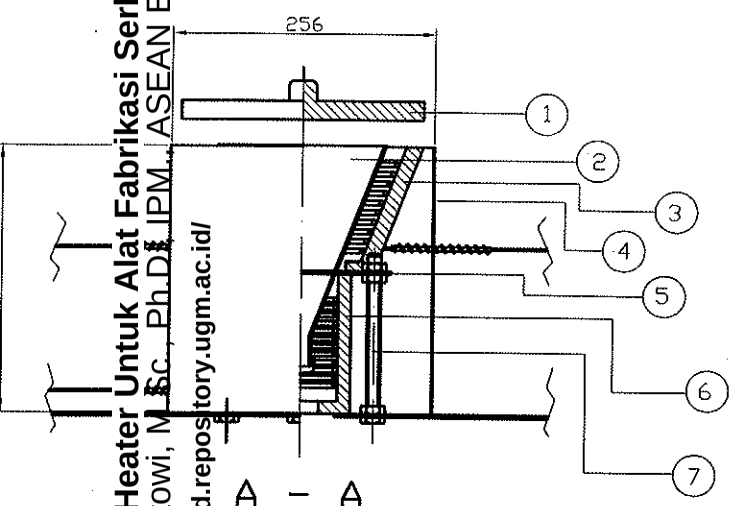
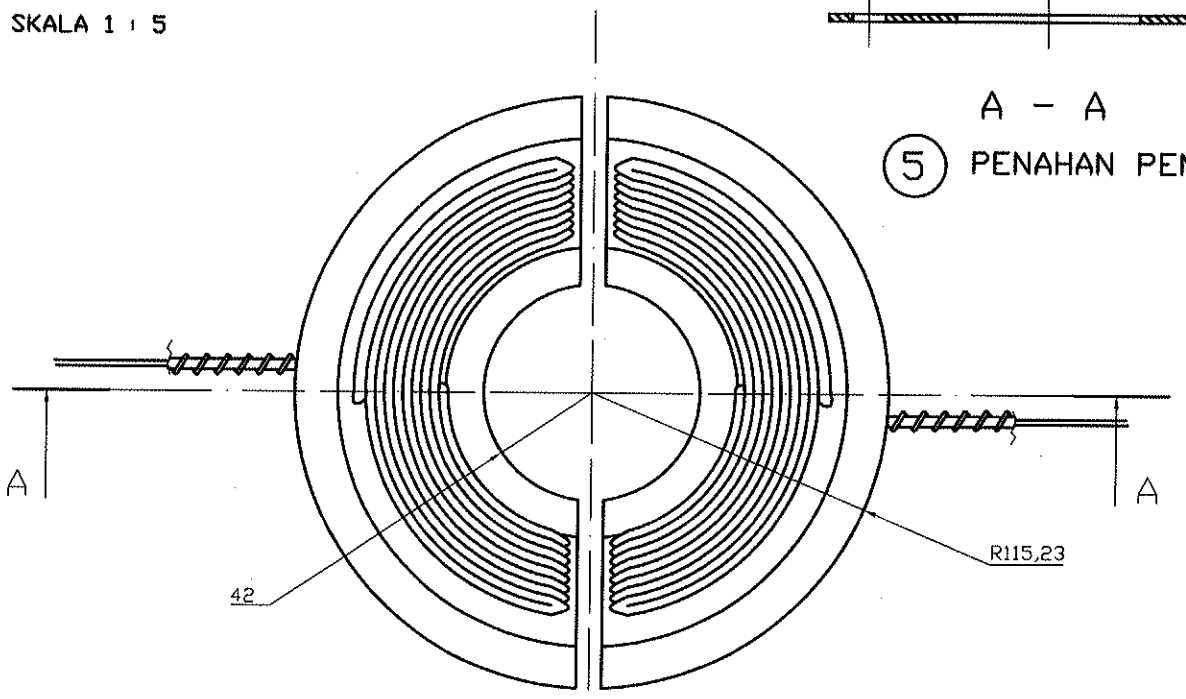
7 PEMANAS BAWAH

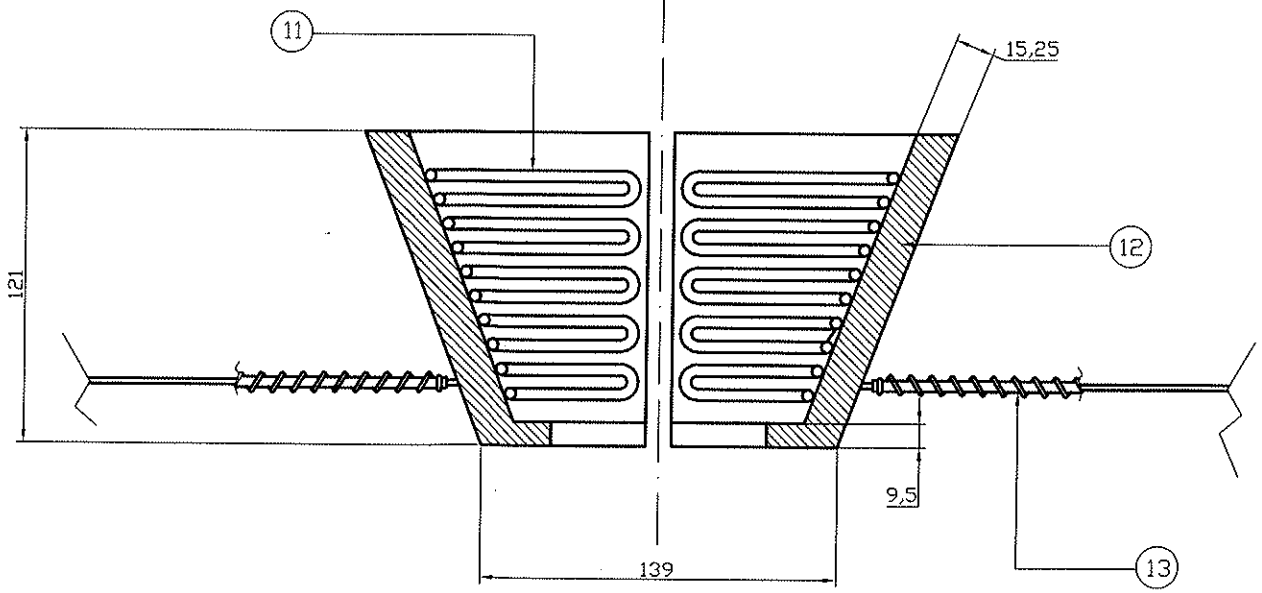


A – A

GAMBAR UTAMA

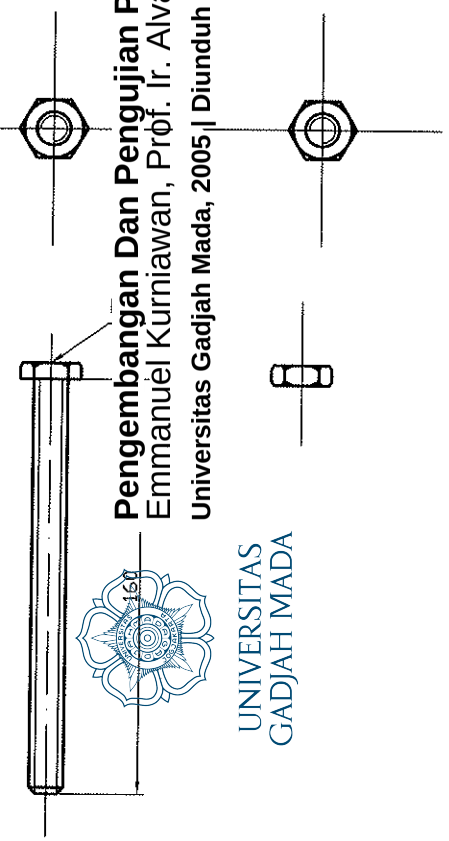
SKALA 1 : 5





A – A

3 PEMANAS ATAS

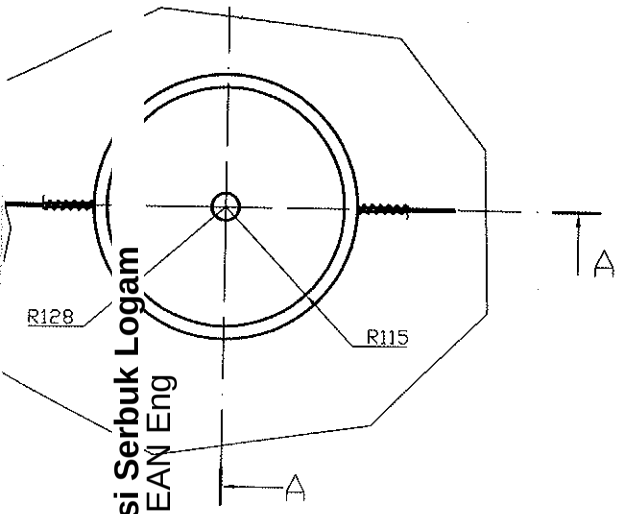


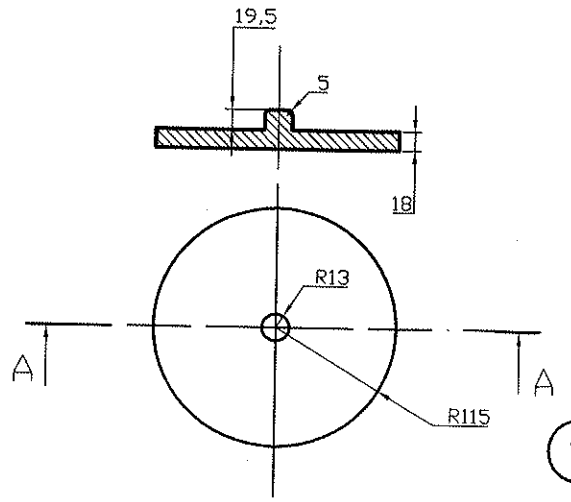
6 BAUT PENAHAN PEMANAS ATAS

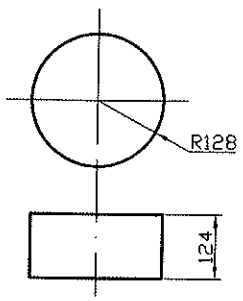
No BAG	JUMLAH	NAMA	BAHAN	NORMALISASI	KETERANGAN
13	2	KABEL PMNS ATAS	CU, ASBES		
12	2	HOLDER NIKELIN	TANAH LIAT		DENGAN PERLAKUAN PANAS
11	2	NIKELIN			
10	1	HOLDER NIKELIN BWH	TANAH LIAT		DENGAN PERLAKUAN PANAS
9	1	NIKELIN			
8	1	KABEL PMNS BWH	CU, ASBES		
7	1	PEMANAS BAWAH			
6	4	BAUT PNHAN PMNS ATAS	SS41		M13
5	1	PNHAN PMNS ATAS	FC30		
4	1	PELINDUNG ANGIN	SENG		TEBAL 0,5mm
3	1	PEMANAS ATAS			
2	1	TUNDISH	BESI KARBON		
1	1	TUTUP TUNDISH	TANAH LIAT		

SKALA 1 : 2	DIGAMBAR	EMMANUEL KURNIAWAN	KETERANGAN
SATUAN mm	NIM	97/114640/TK/21811	
TANGGAL 15-10-2004	DILIHAT	IR ALVA E. TONTOWI	

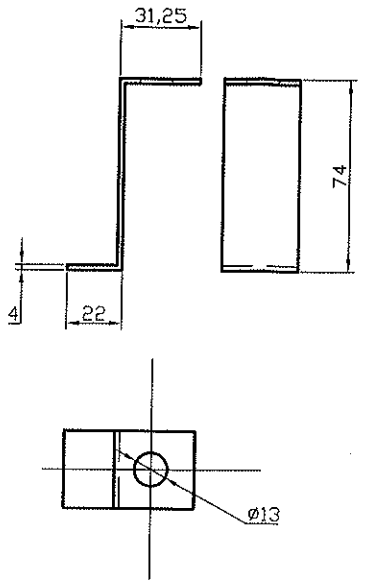
T MESIN FT UGM	HEATER MODEL C		A2

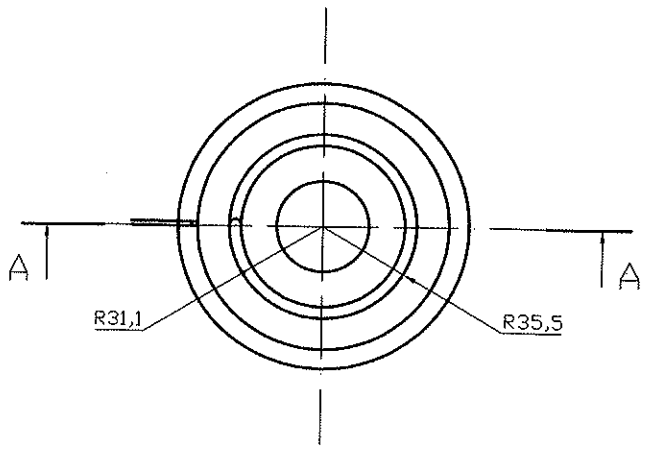


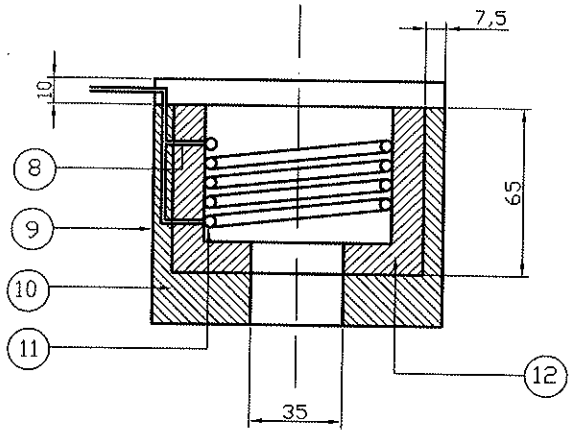


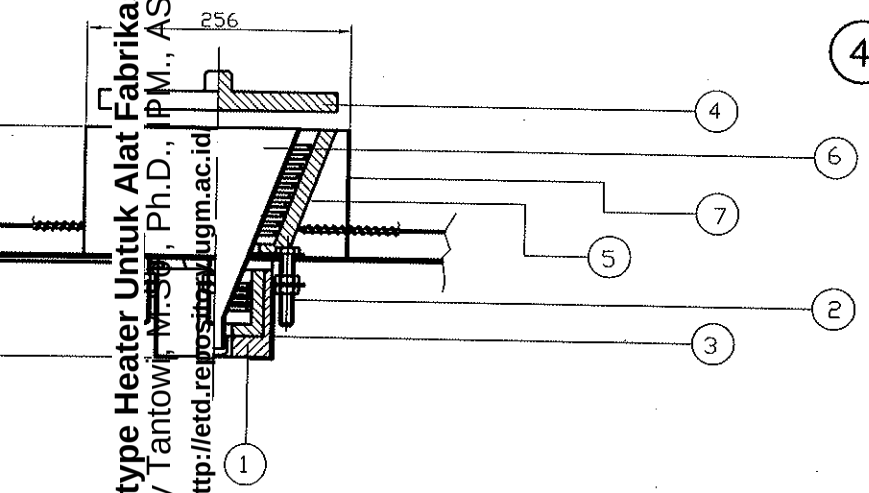


7 PELINDUNG ANGIN
SKALA 1 : 10



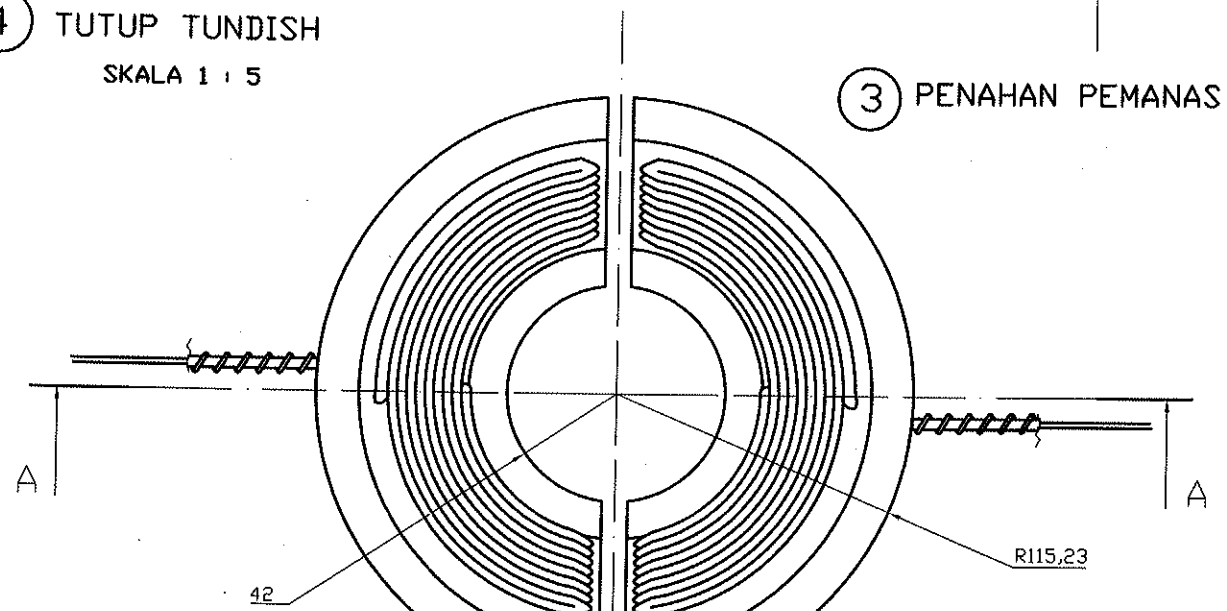




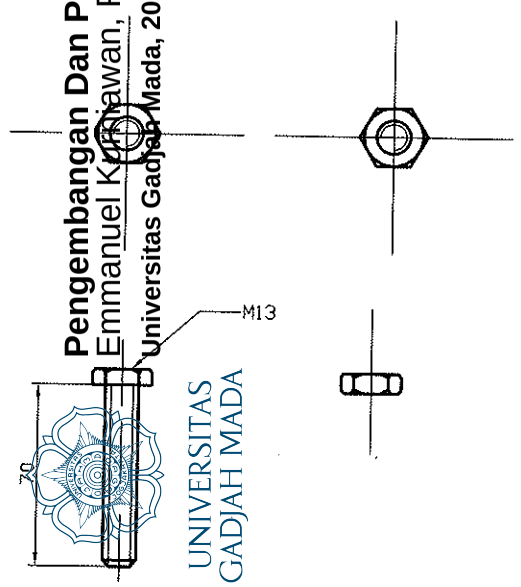


A - A
GAMBAR UTAMA
SKALA 1 : 5

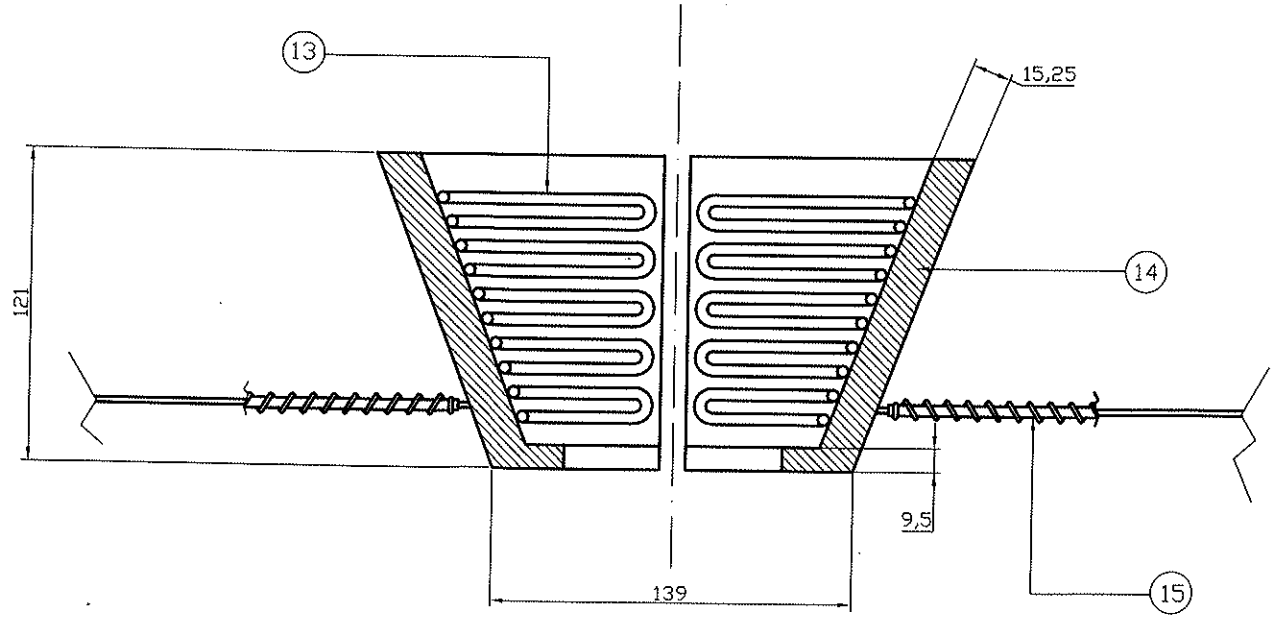
4 TUTUP TUNDISH
SKALA 1 : 5



3 PENAHAN PEMANAS BAWAH



2 BAUT PENAHAN PEMANAS BAWAH



A - A
5 PEMANAS ATAS

A - A
1 PEMANAS BAWAH

No BAG	JUM LAH	NAMA	BAHAN	NORMALISASI	KETERANGAN
15	2	KABEL PMNS ATAS	CU, ASBES		
14	2	HOLDER NIKELIN	TANAH LIAT		DENGAN PERLAKUAN PANAS
13	2	NIKELIN			
12	1	HOLDER NIKELIN	TANAH LIAT		DENGAN PERLAKUAN PANAS
11	1	NIKELIN			
10	1	ISOLATOR PMNS BWH	BT TAHAN API		
9	1	PELINDUNG PMNS BWH	SENG		TEBAL 0,5mm
8	2	KABEL PMNS BWH	CU, ASBES		
7	1	PELINDUNG ANGIN	SENG		TEBAL 0,5mm
6	1	TUNDISH	BESI KARBON		
5	1	PEMANAS ATAS			
4	1	TUTUP TUNDISH	TANAH LIAT		
3	4	PNHAN PMNS BWH	FC30		
2	4	BAUT PNHAN PMNS BWH	SS41		M13
1	1	PEMANAS BAWAH			

SKALA 1 : 2	DIGAMBAR EMMANUEL KURNIAVAN	KETERANGAN	
SATUAN mm	NIM 97/114640/TK/21811		
TANGGAL 15-10-2004	DILIHAT IR ALVA E. TONTOWI		
T MESIN FT UGM	HEATER MODEL B		A2