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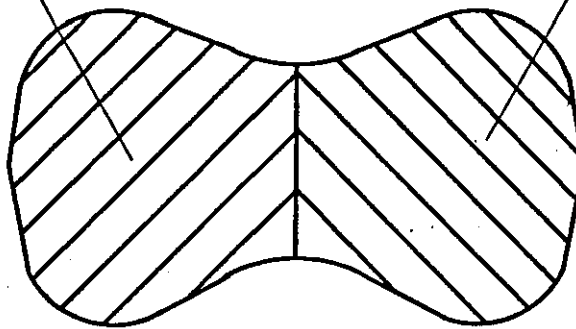
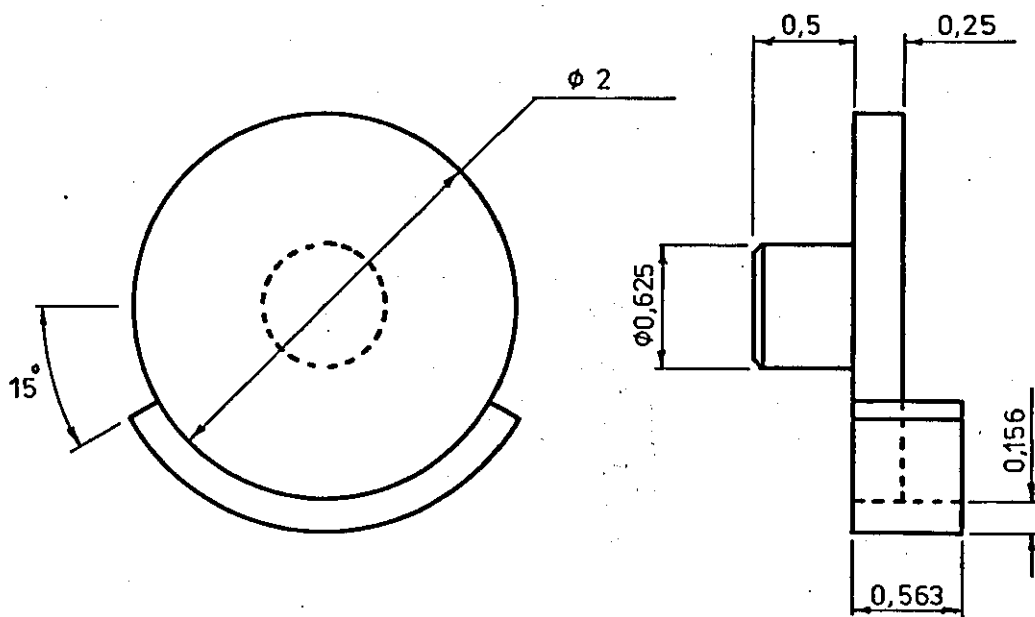


FIGURE 4.1 : COMPOSITE TENSILE TEST SPECIMEN



( ins)

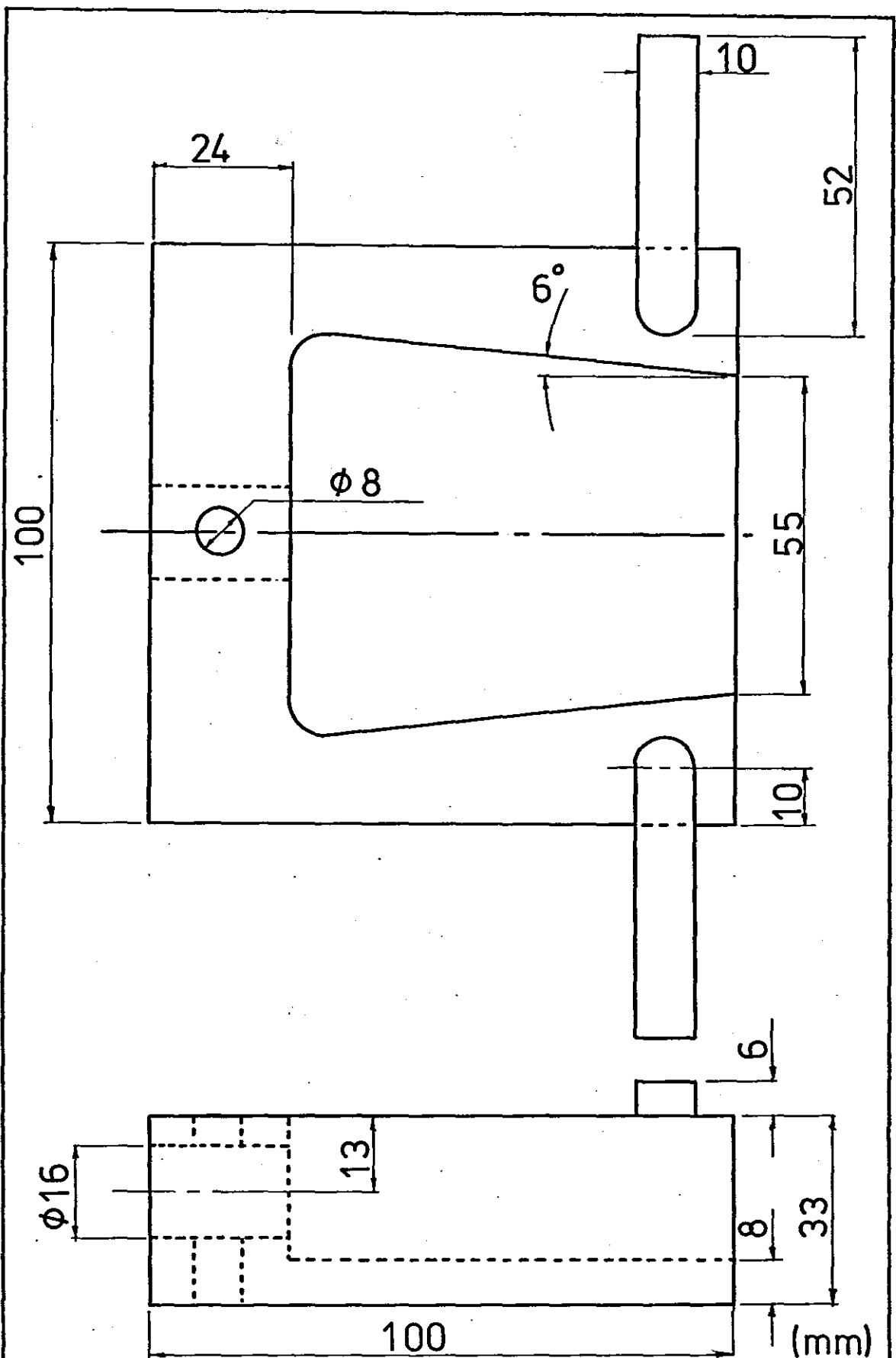
DRAWING NO.

FIGURE 4.2

DESCRIPTION:

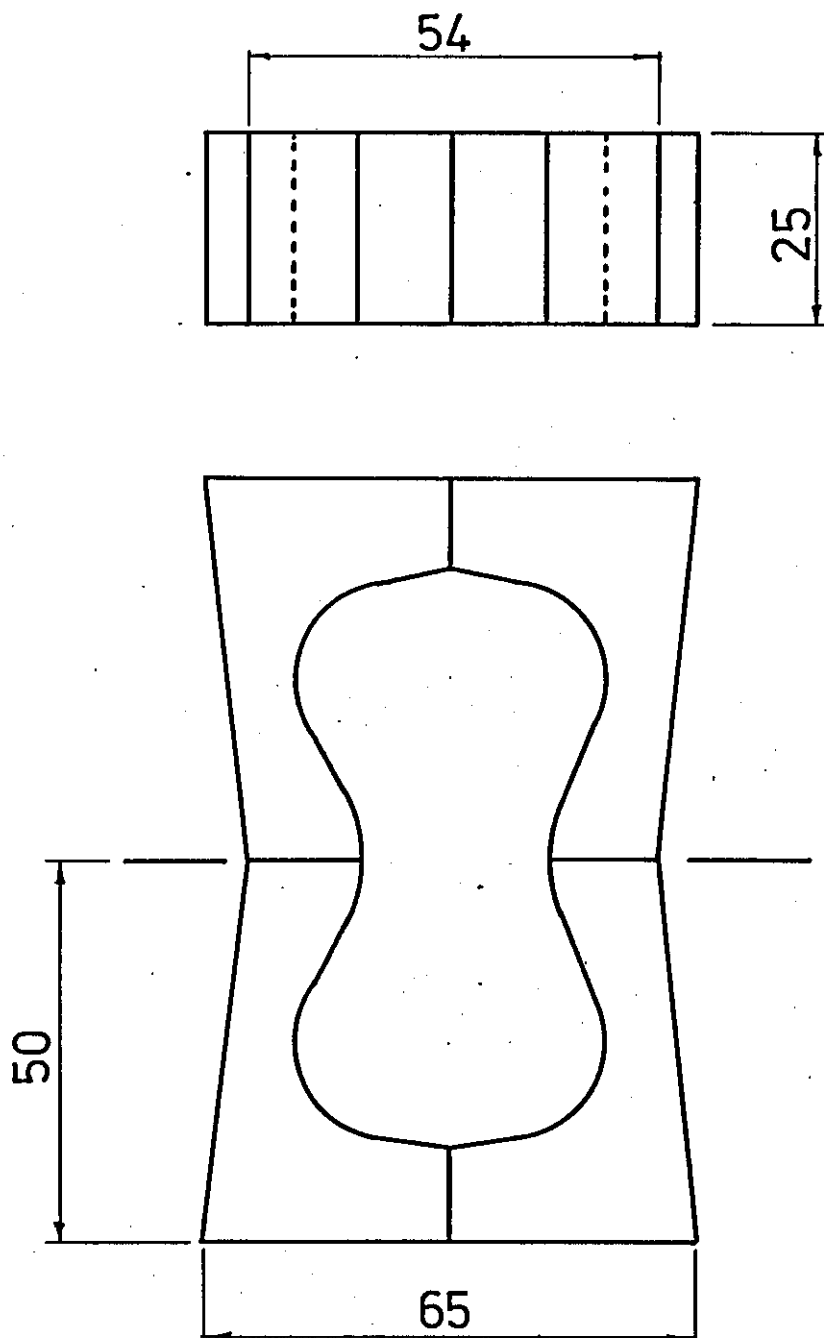
COMPRESSION STRENGTH TEST SPECIMEN  
HOLDERS





DRAWING NO. FIGURE 4.3(i)

DESCRIPTION: TENSILE TEST SPECIMEN FIXTURE

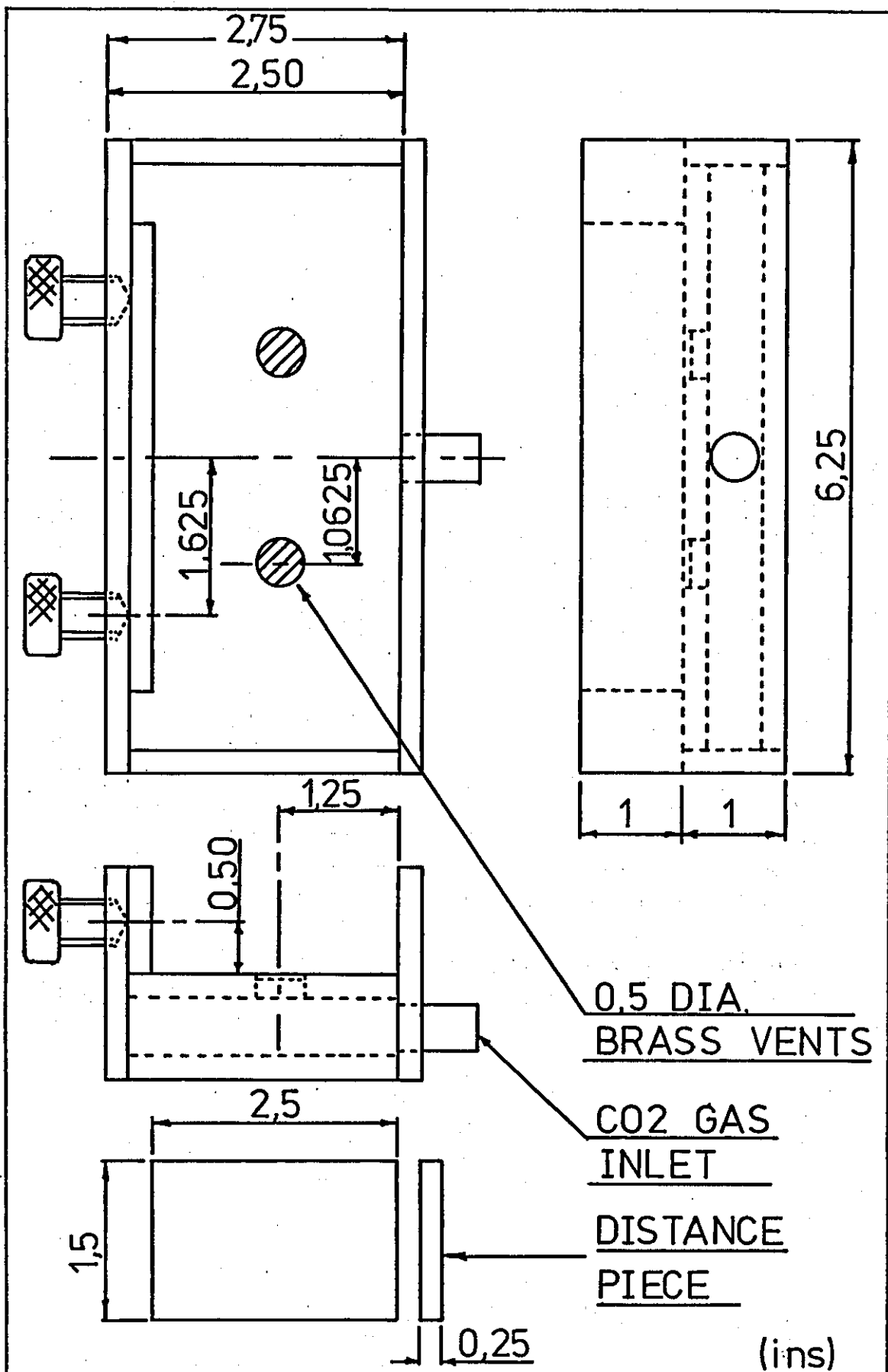


FOR TENSILE TEST SPECIMEN  
DIMENSIONS SEE FIGURE 4.6

(mm)

DRAWING NO. FIGURE 4.3(i1)

DESCRIPTION: TENSILE TEST SPECIMEN FIXTURE

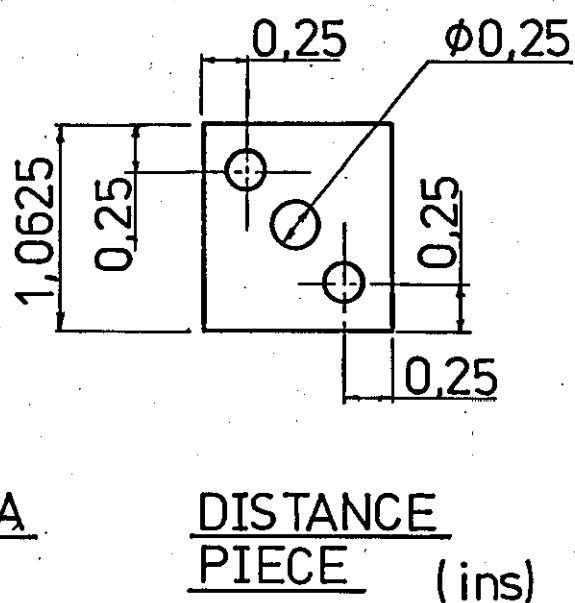
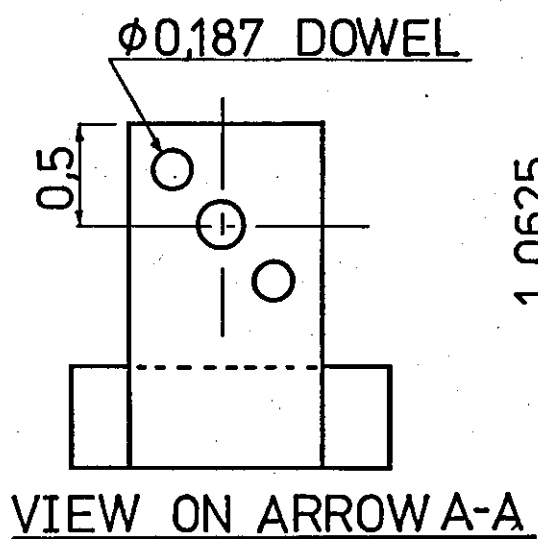
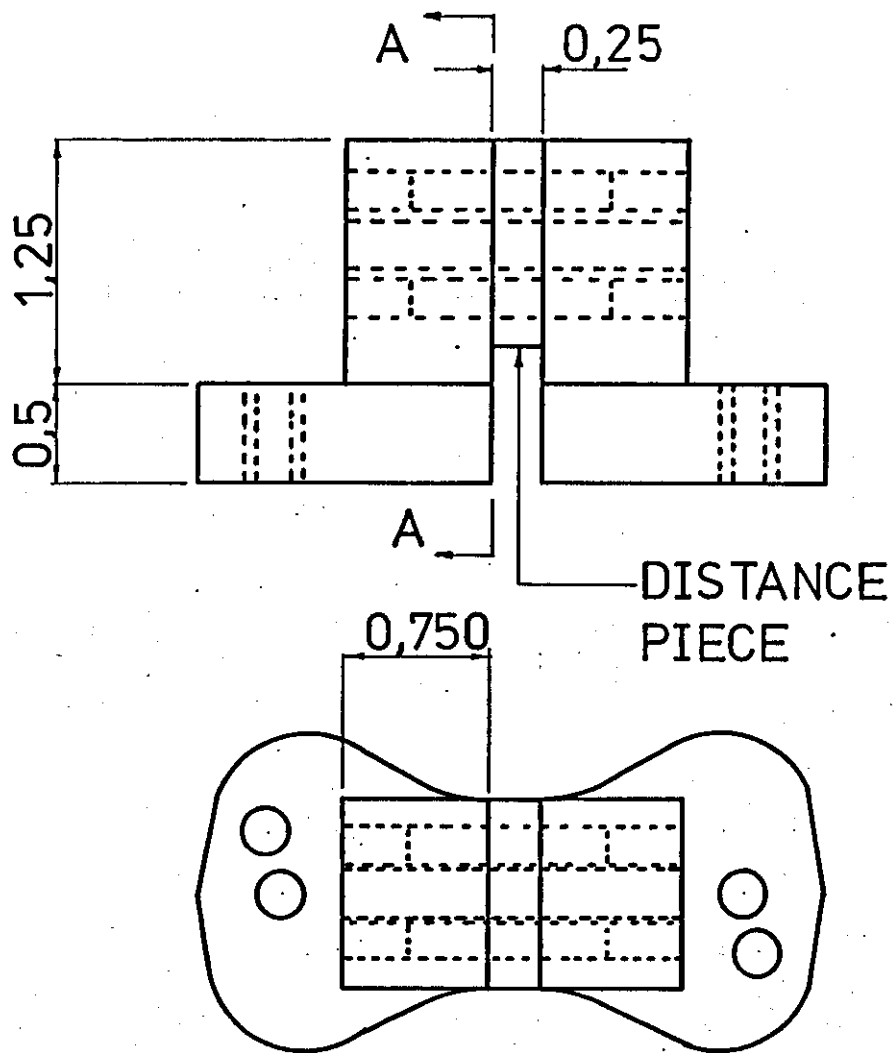


DRAWING NO.

FIGURE 4.4

DESCRIPTION:

TENSILE STRENGTH SPECIMEN  
GASSING FIXTURE

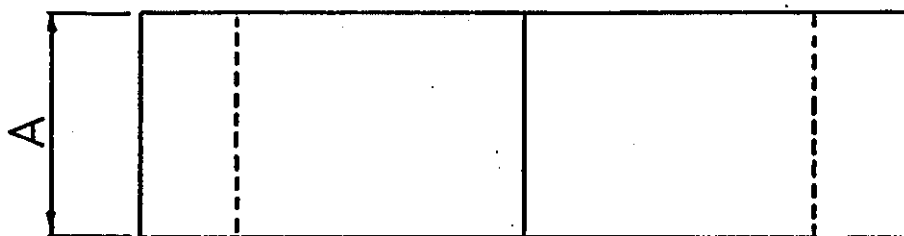
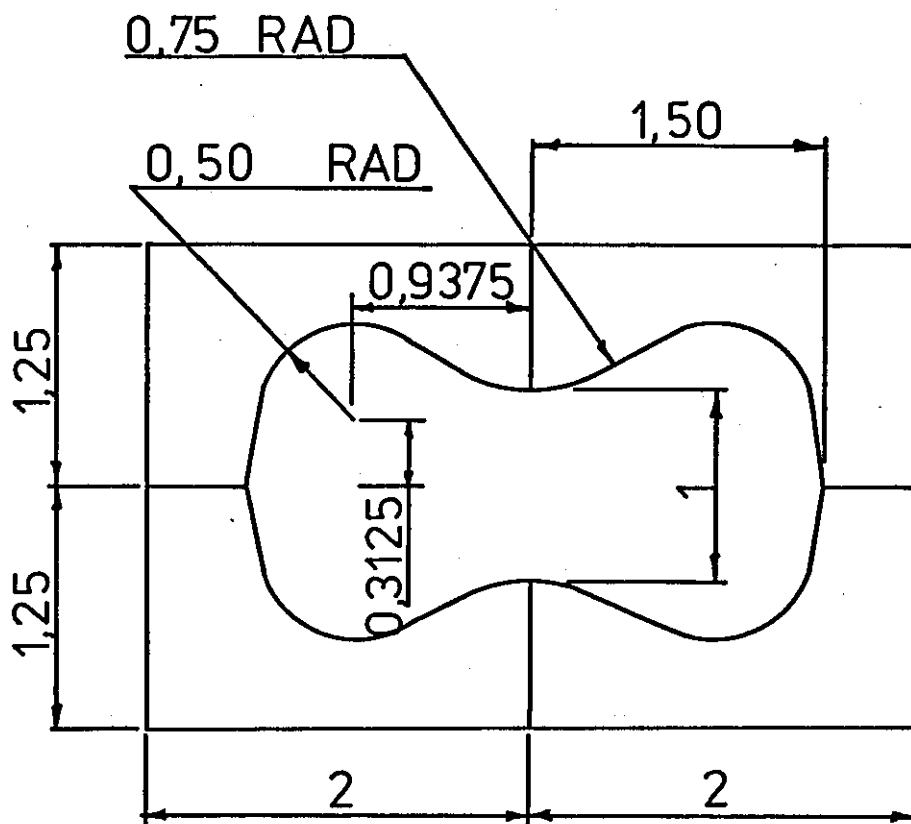


DRAWING NO.

FIGURE 4.5

DESCRIPTION:

TENSILE STRENGTH SPECIMEN  
RAMMING FIXTURE



DIMENSION A : ONE SET AT 1,5  
TWO SETS AT 1,0

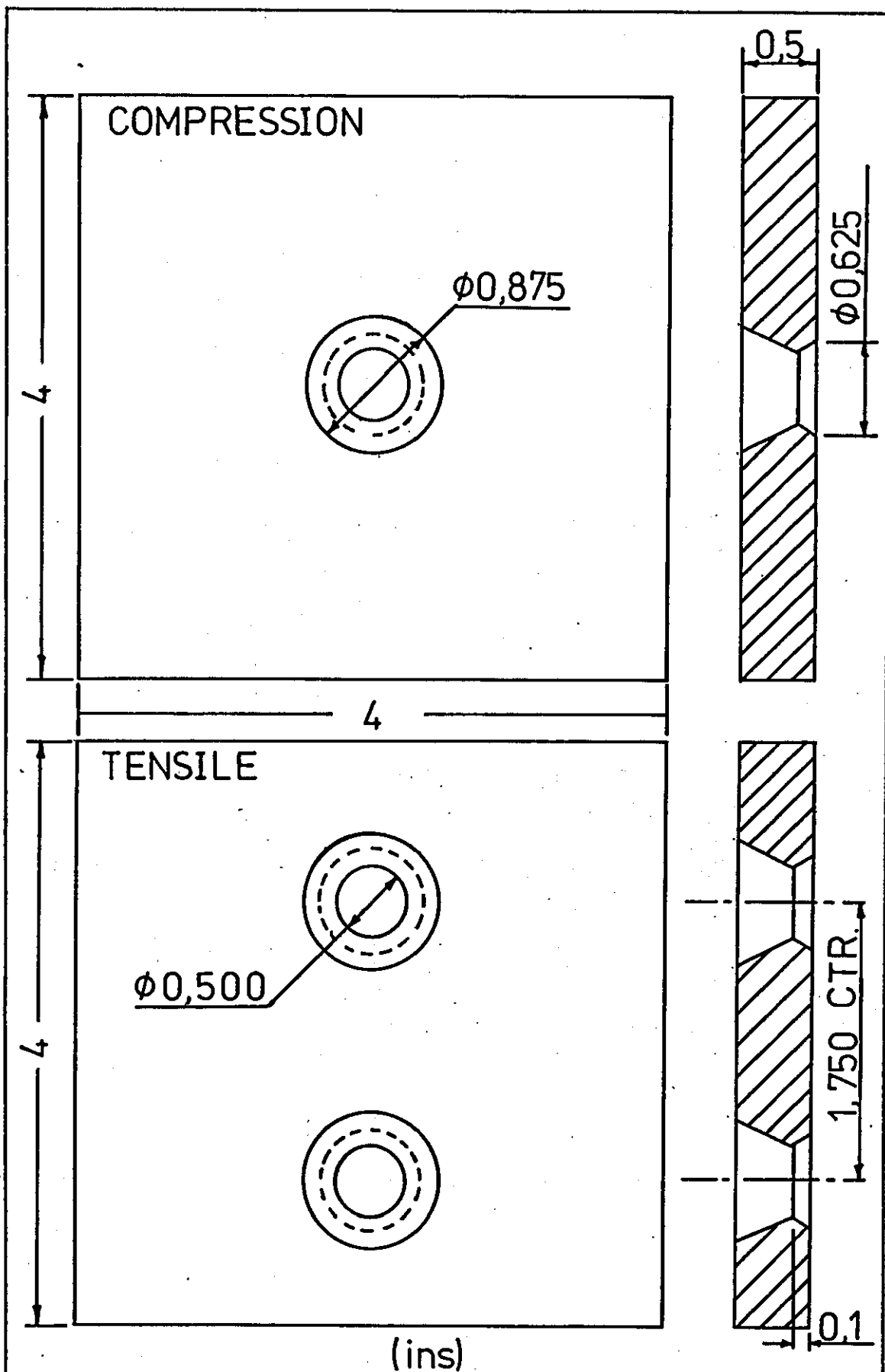
(ins)

DRAWING NO.

FIGURE 4.6

DESCRIPTION:

TENSILE STRENGTH SPECIMEN  
MOULD DIMENSIONS

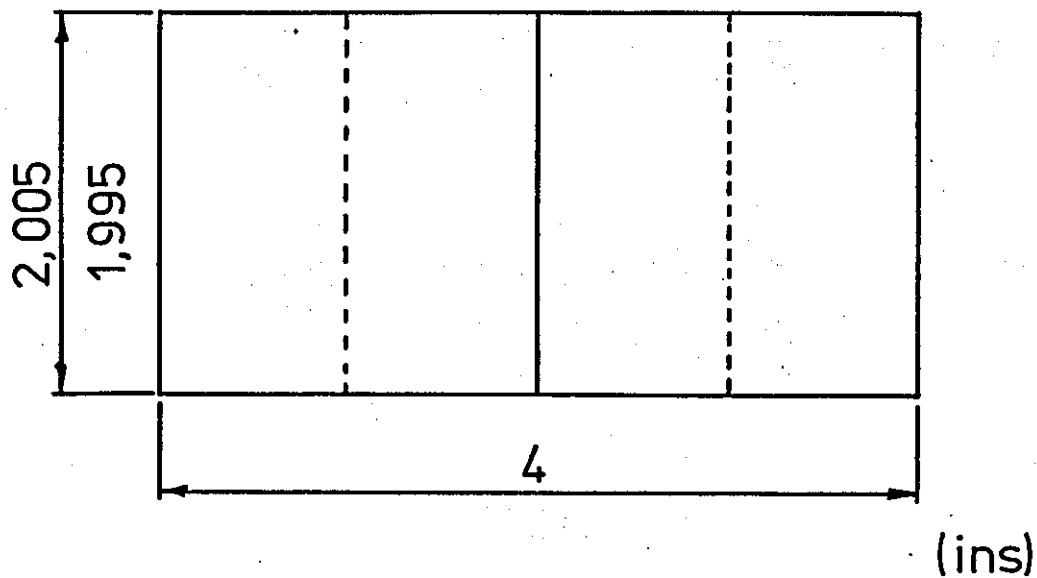
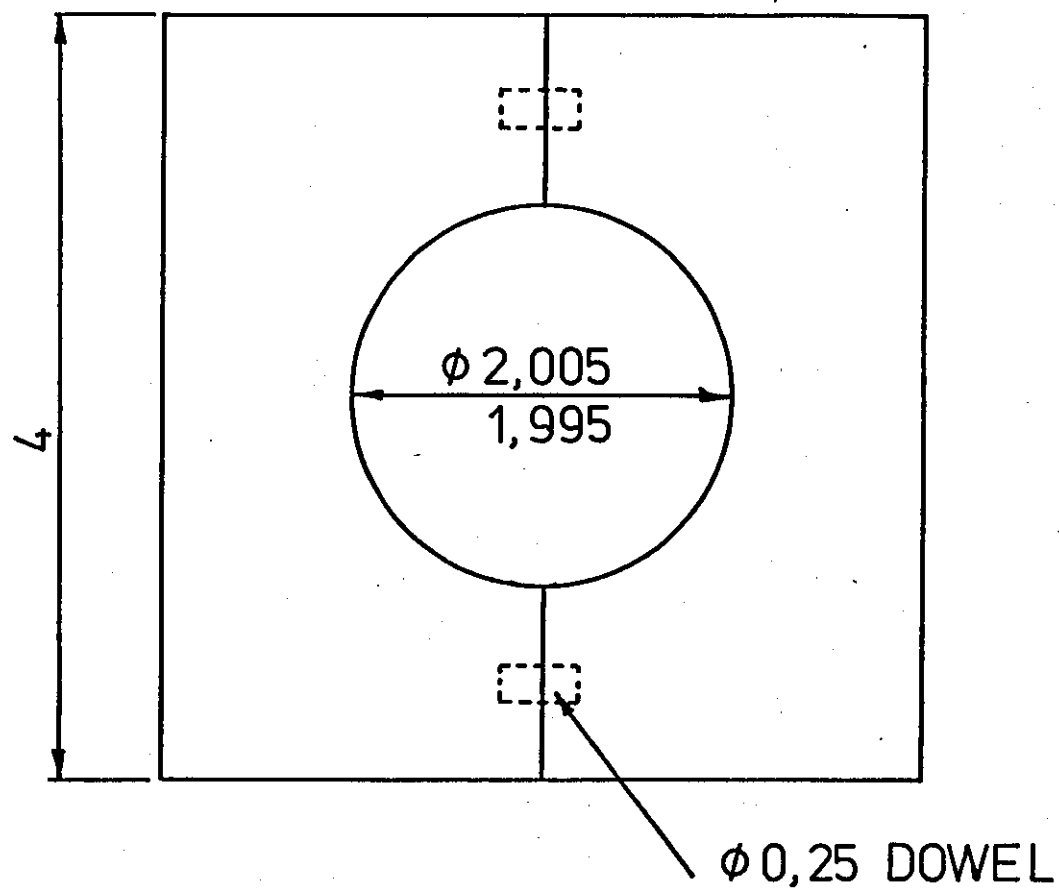


DRAWING NO.

FIGURE 4.7

DESCRIPTION:

SLURRY POURING PLATES



DRAWING NO.

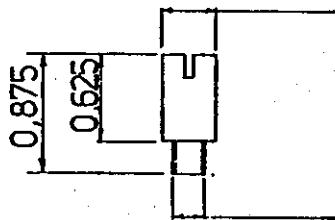
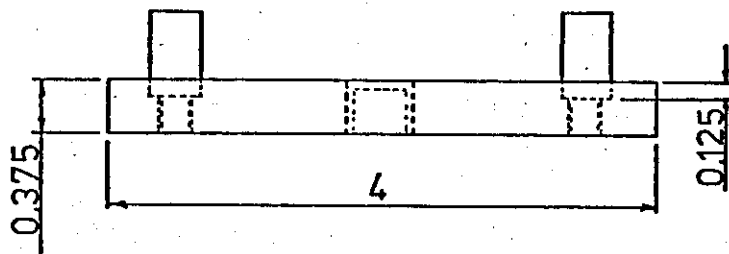
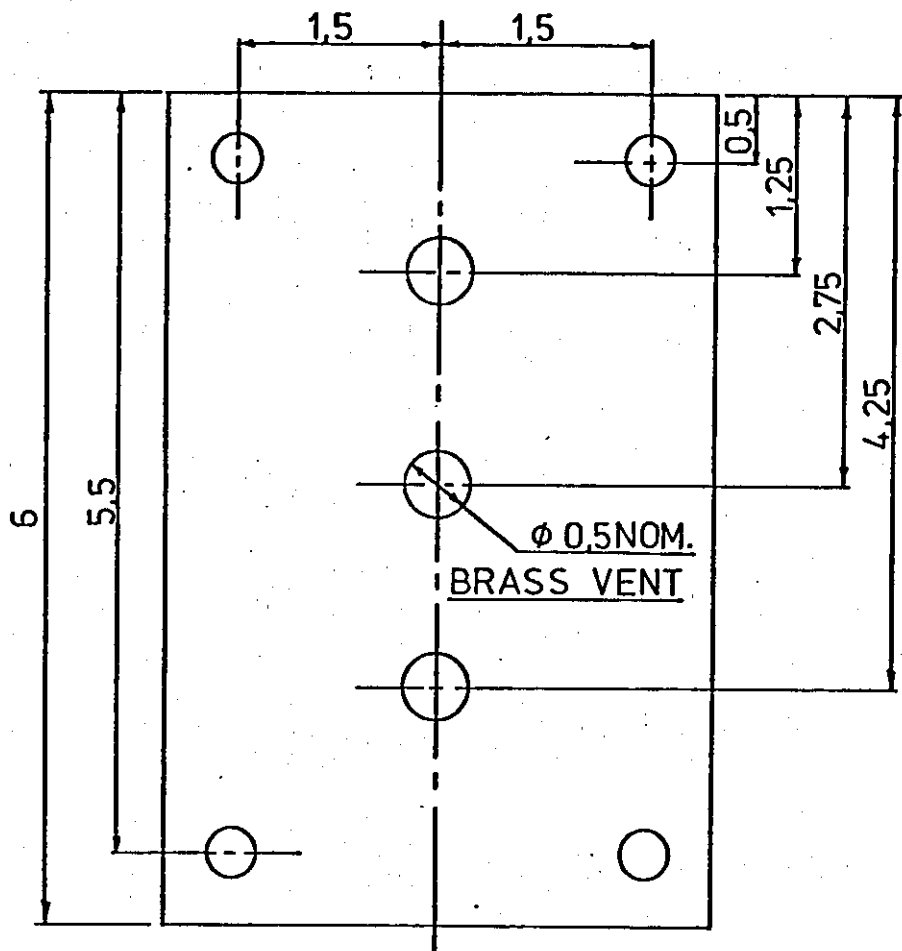
FIGURE 4.8

DESCRIPTION:

COMPRESSION STRENGTH SPECIMEN  
SLURRY MOULD







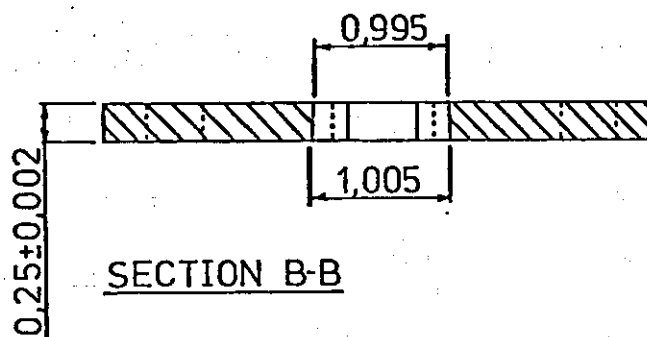
(ins)

DRAWING NO.

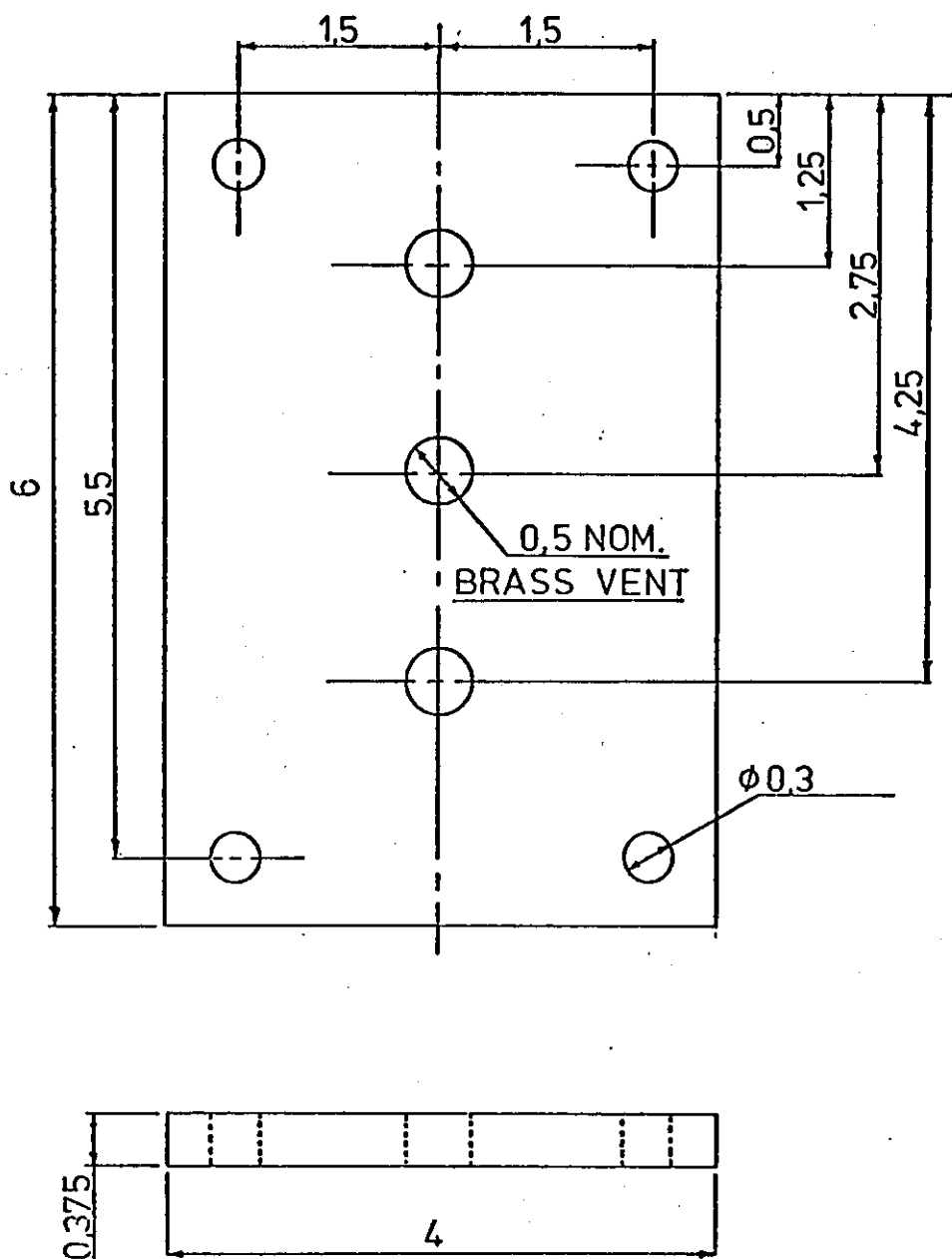
FIGURE 4.10(1)

DESCRIPTION:

HOT DISTORTION SPECIMEN MOULD AND  
GASSING FIXTURE



DESCRIPTION: HOT DISTORTION SPECIMEN MOULD AND GASSING FIXTURE



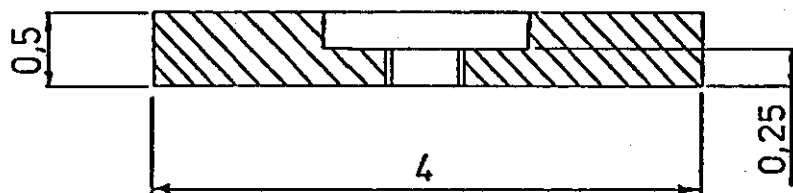
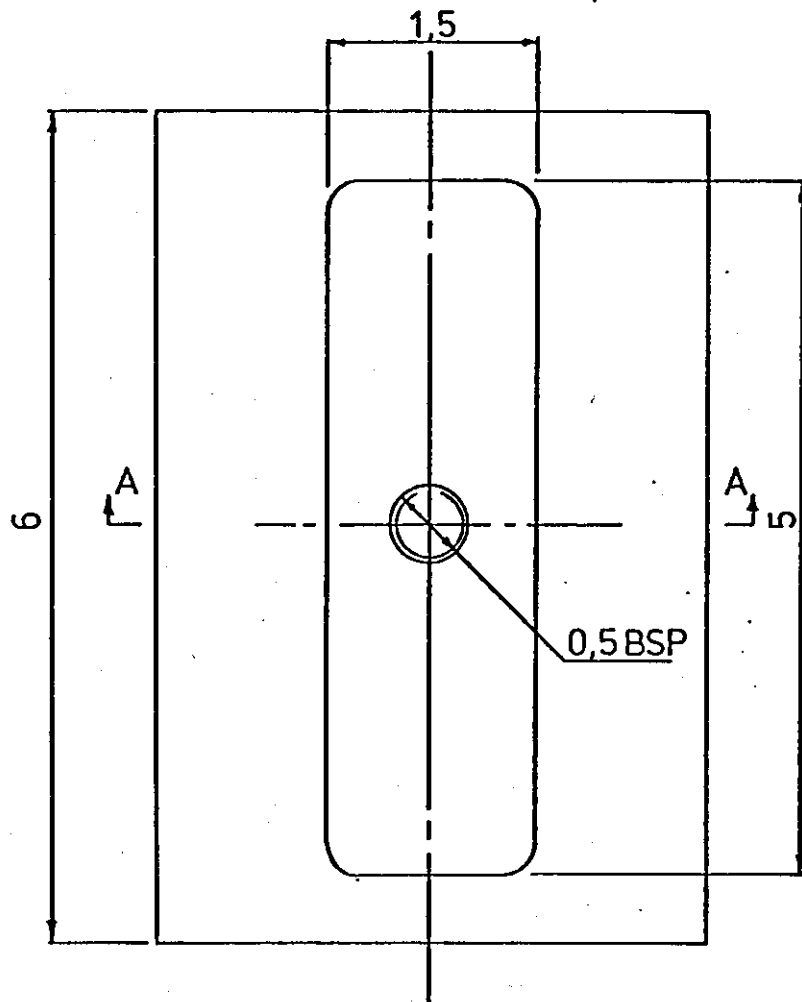
(ins)

DRAWING NO.

FIGURE 4.10(iii)

DESCRIPTION:

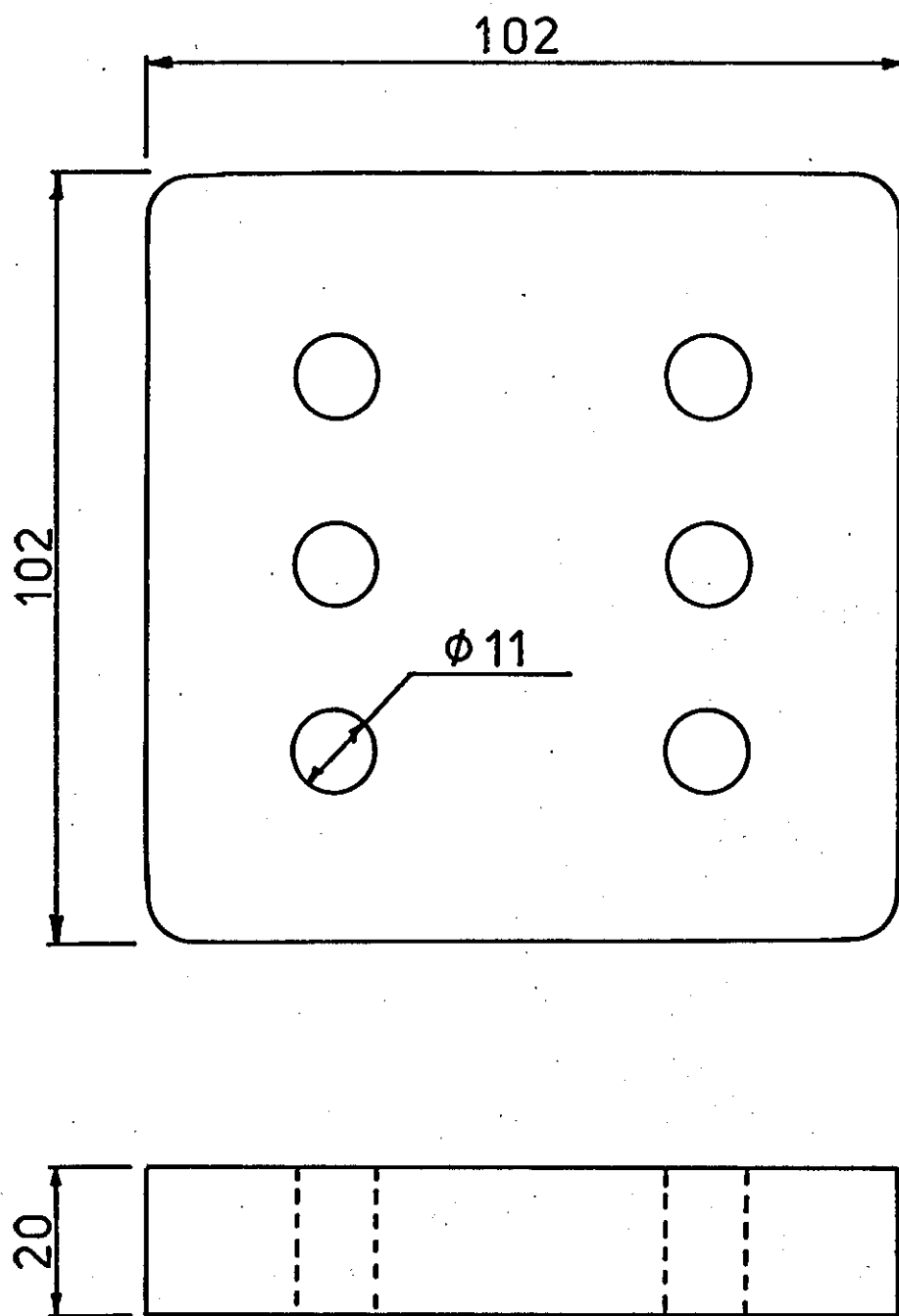
HOT DISTORTION SPECIMEN MOULD AND  
GASSING FIXTURE



(ins)

DRAWING NO. FIGURE 4.10 (iv)

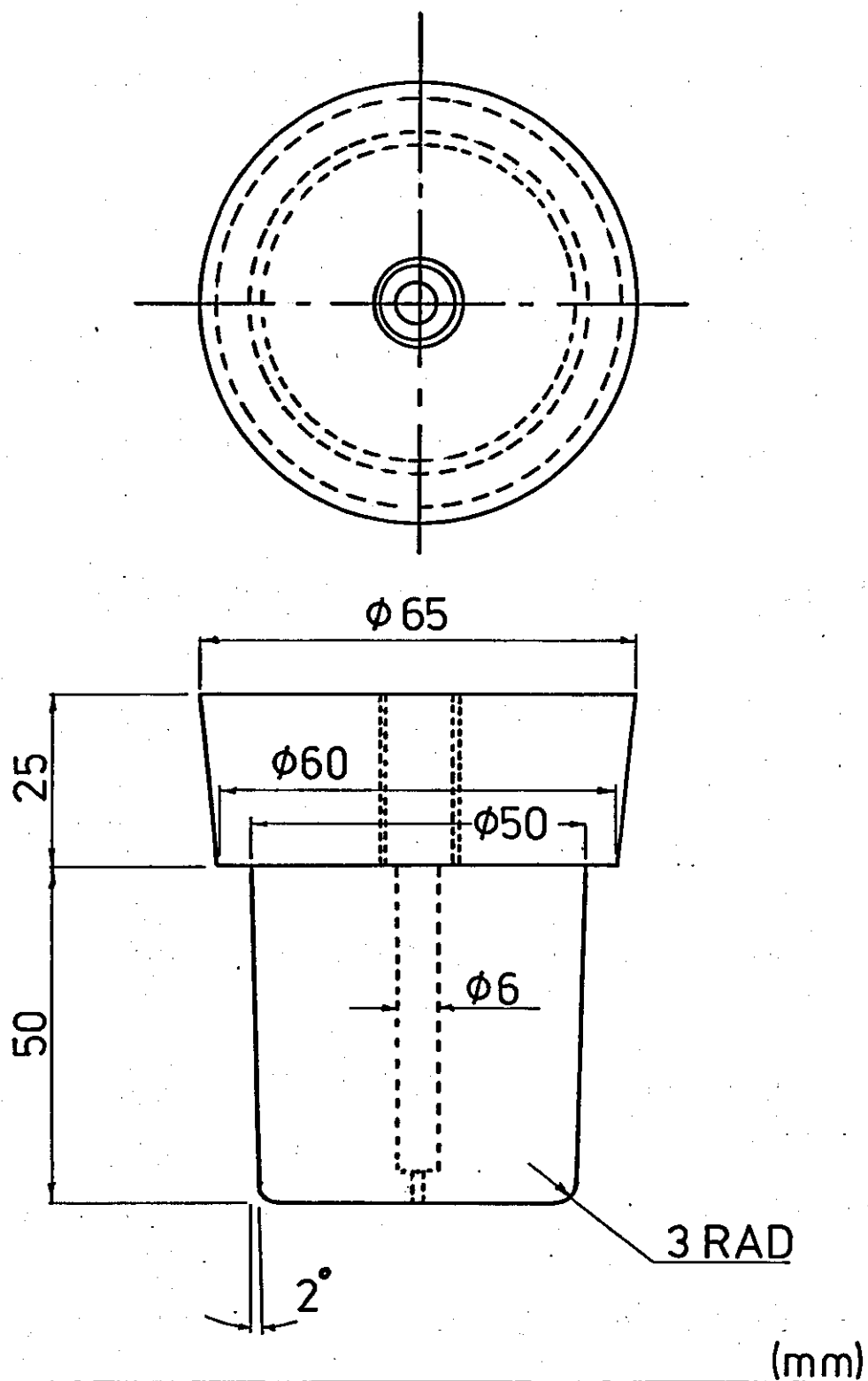
DESCRIPTION: HOT DISTORTION SPECIMEN MOULD AND GASSING FIXTURE



(mm)

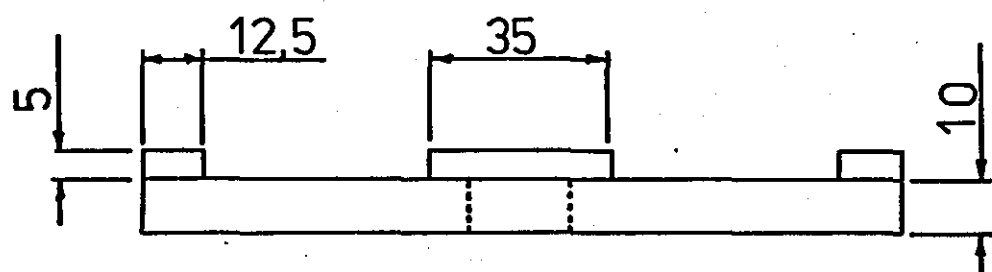
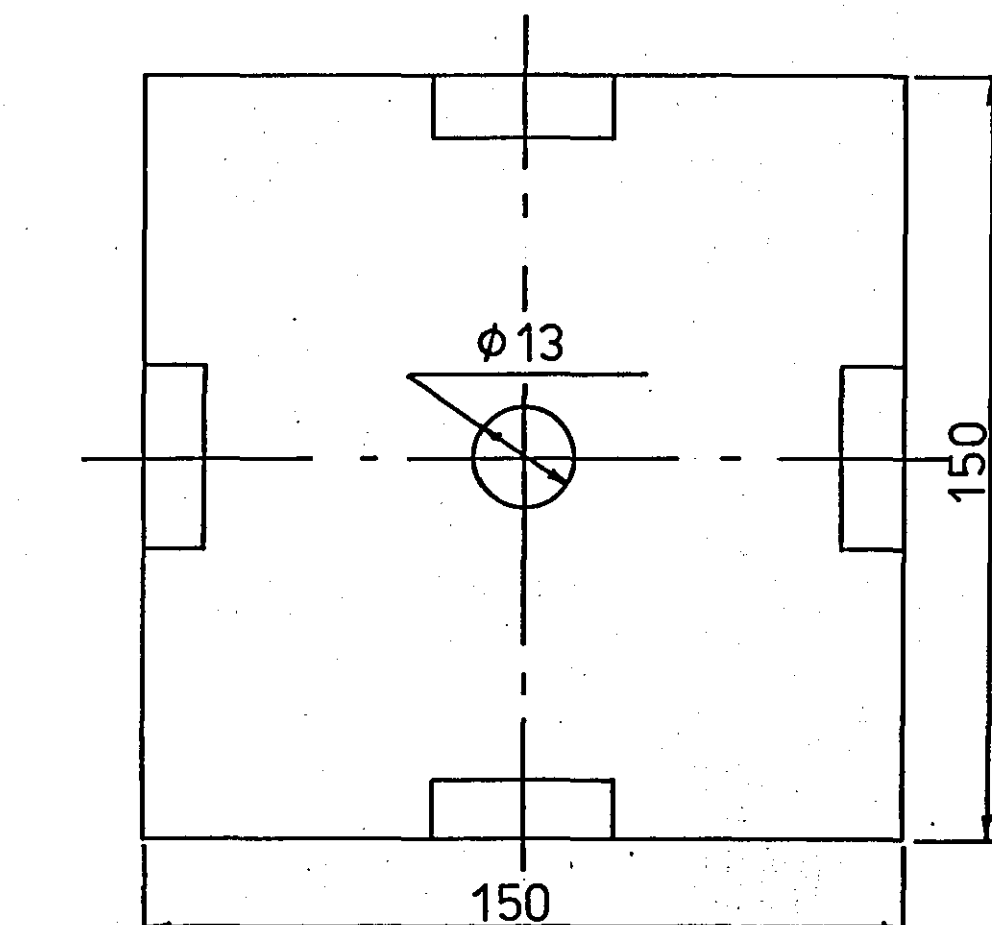
DRAWING NO. FIGURE 4.10 (v)

DESCRIPTION: HIGH TEMPERATURE TESTING SPECIMEN  
MOULD



DRAWING NO. FIGURE 4.11

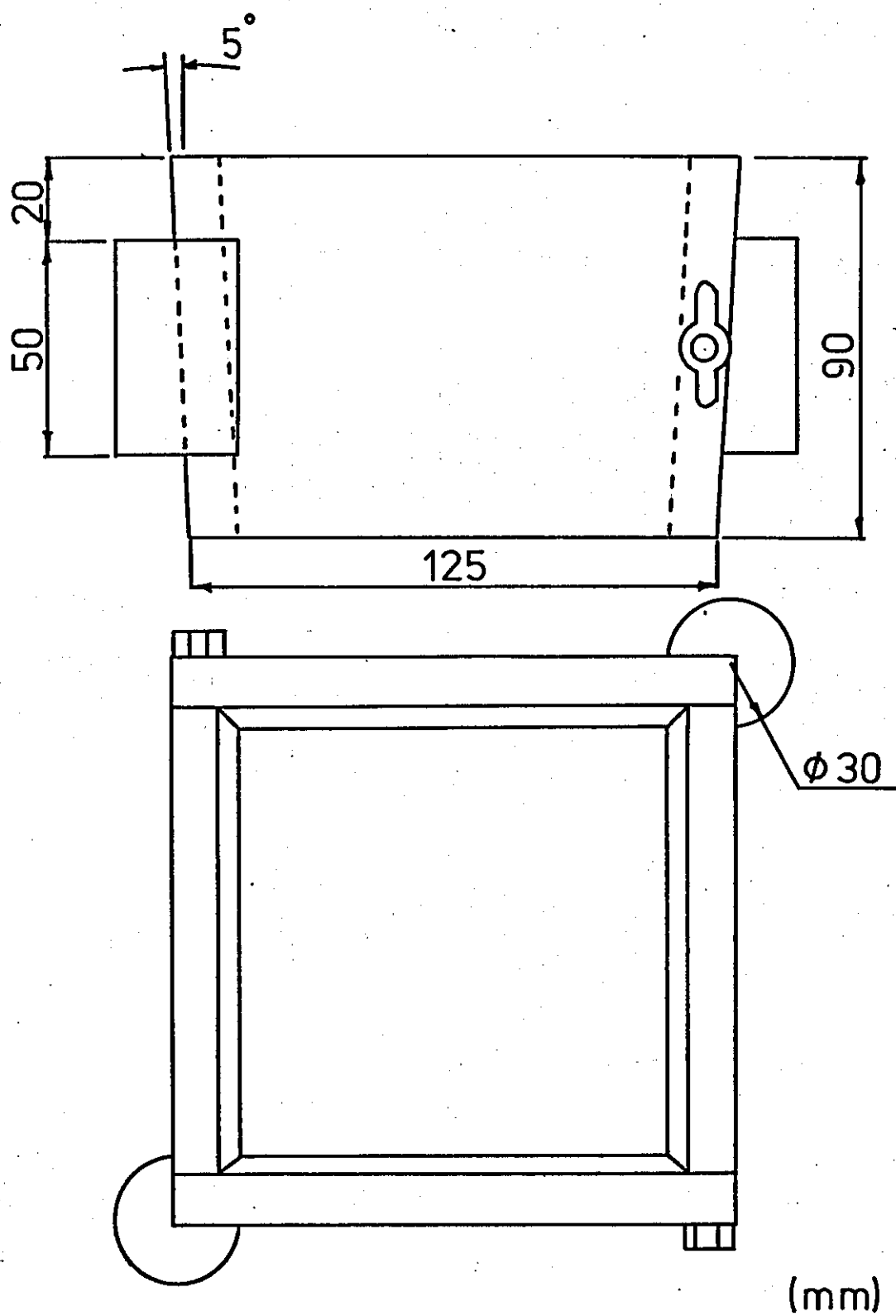
DESCRIPTION: INGOT PATTERN DIMENSIONS



(mm)

DRAWING NO. FIGURE 4.12

DESCRIPTION: INGOT PATTERN PLATE DIMENSIONS

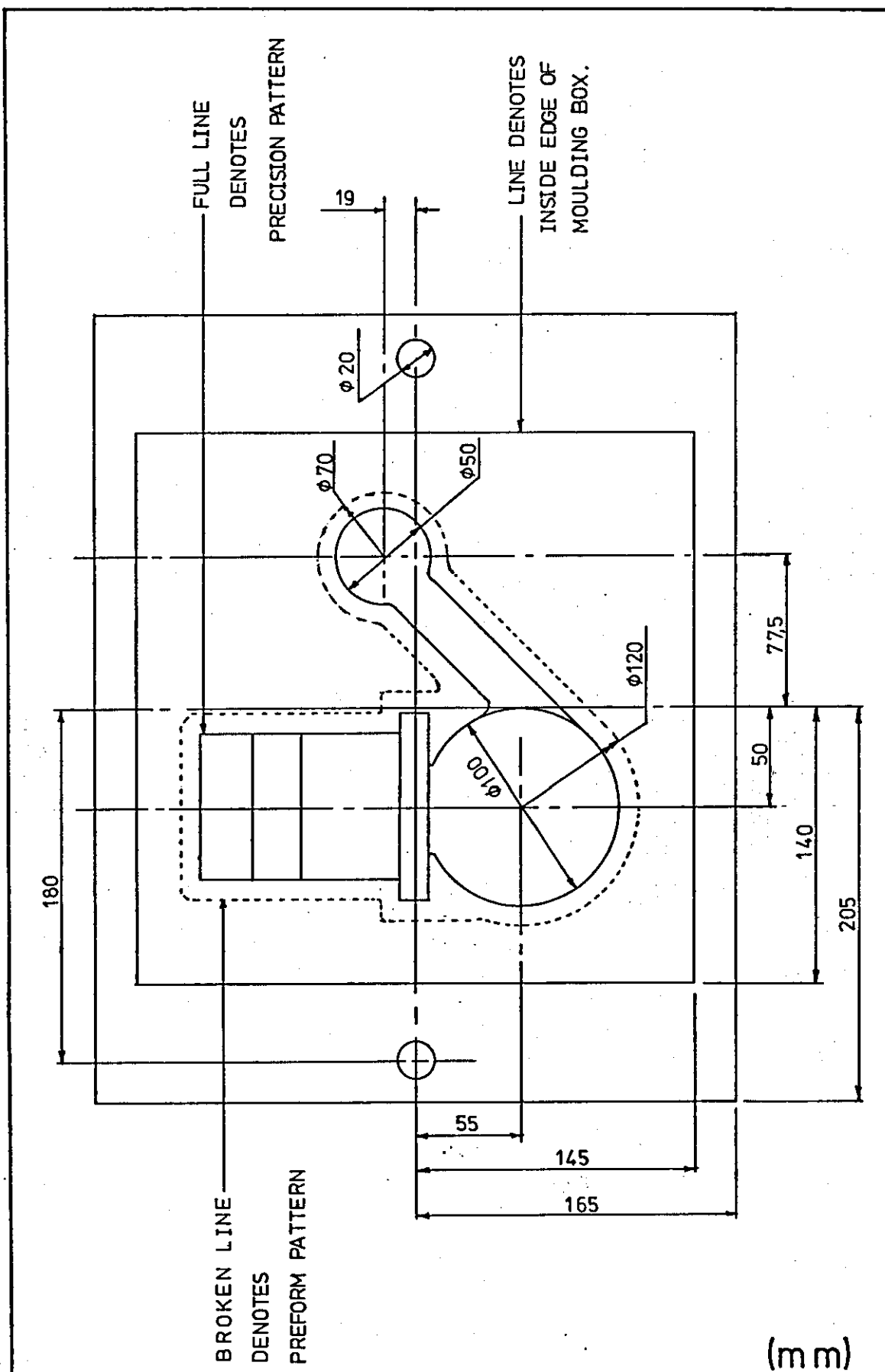


DRAWING NO. FIGURE 4.13

DESCRIPTION: INGOT MOULDING BOX FRAME

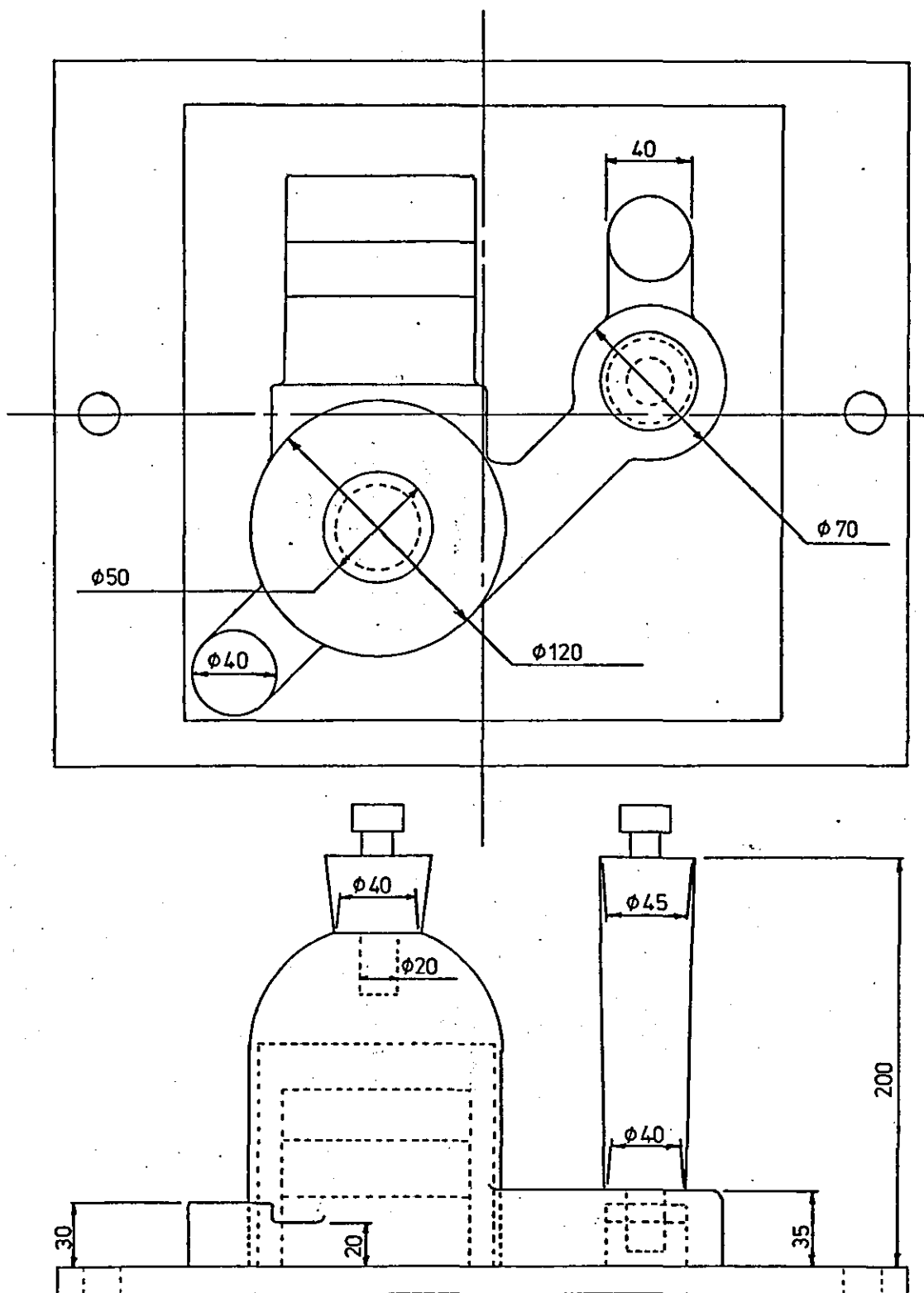






DRAWING NO. FIGURE 4.15 (i)

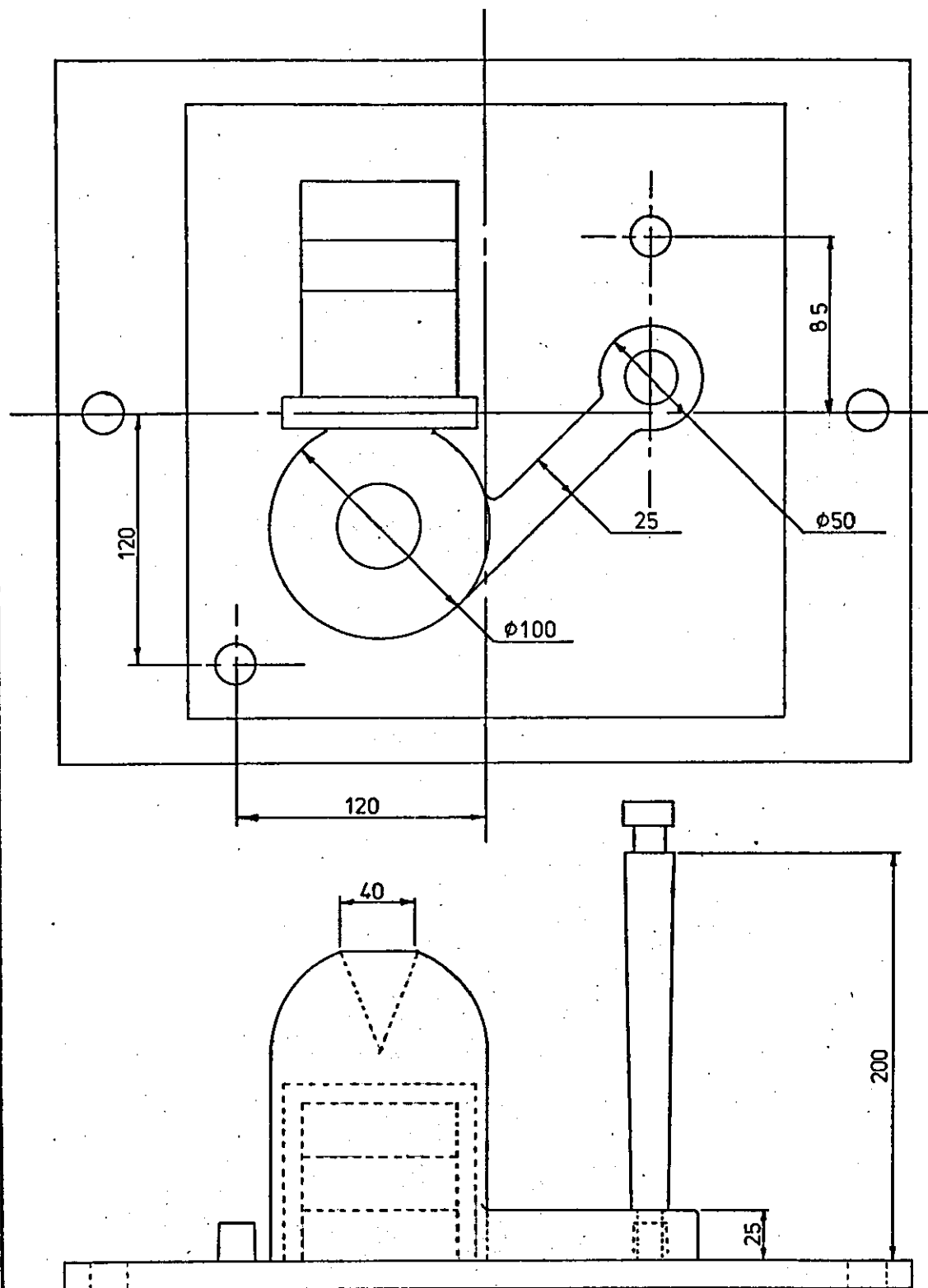
DESCRIPTION: PATTERN PLATE LAYOUT



(mm)

DRAWING NO. FIGURE 4.15 (11)

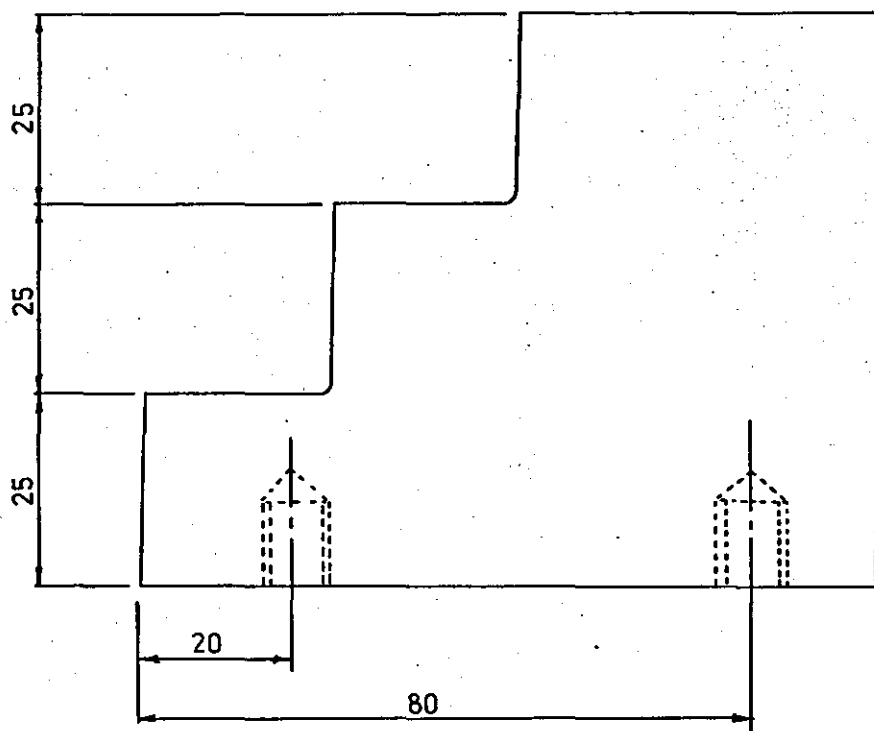
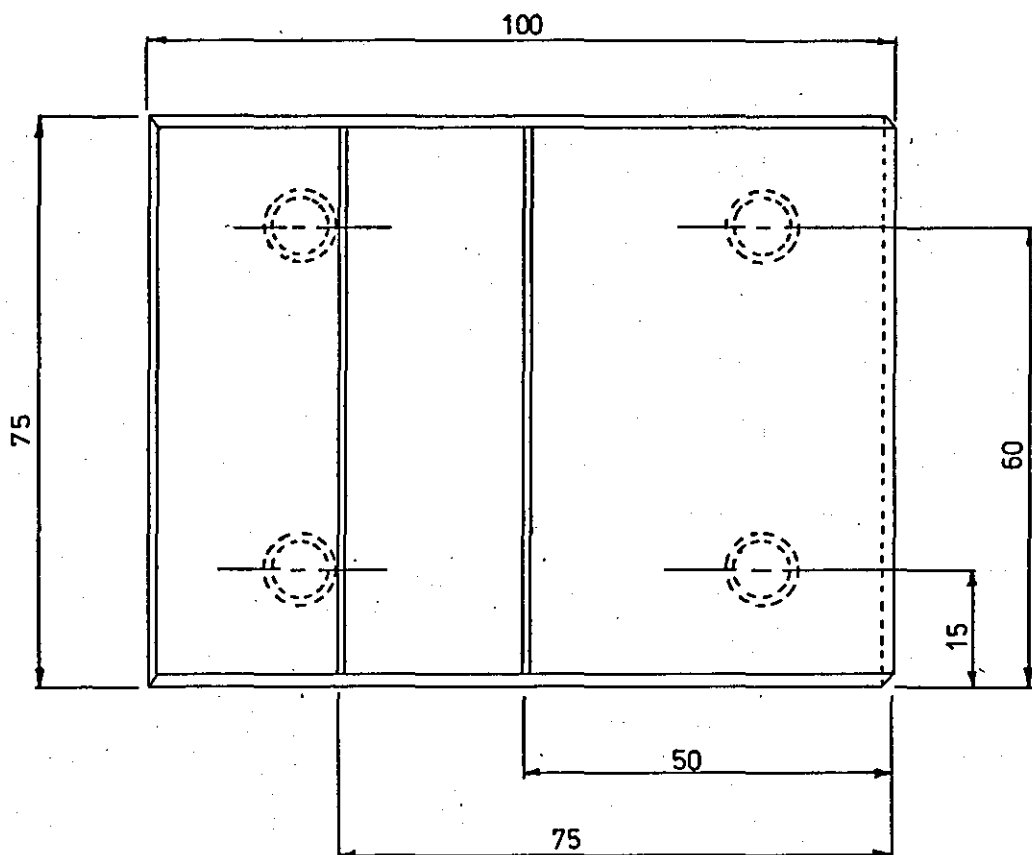
DESCRIPTION: PREFORM COPE PATTERN PLATE  
LAYOUT (STEPPED BLOCK)



(mm)

DRAWING NO. FIGURE 4.15 (iii)

DESCRIPTION: PRECISION COPE PATTERN PLATE  
LAYOUT (STEPPED BLOCK)



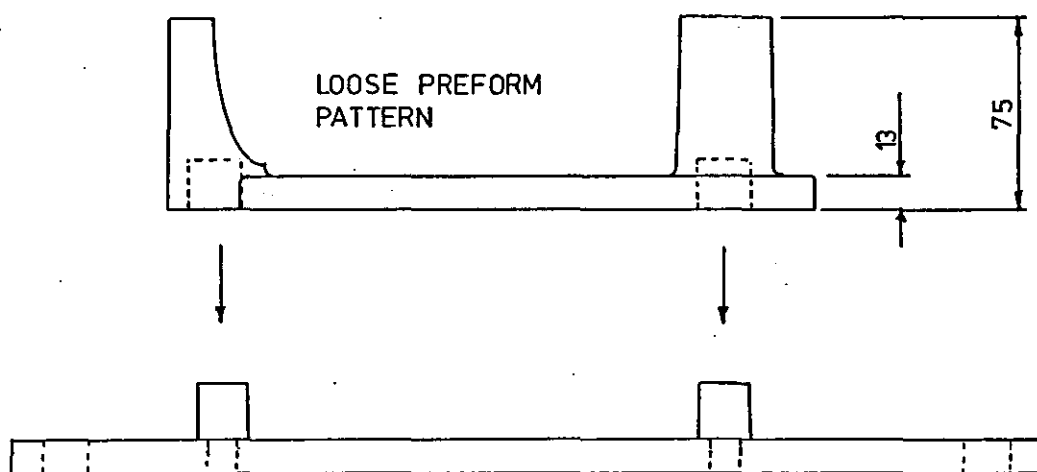
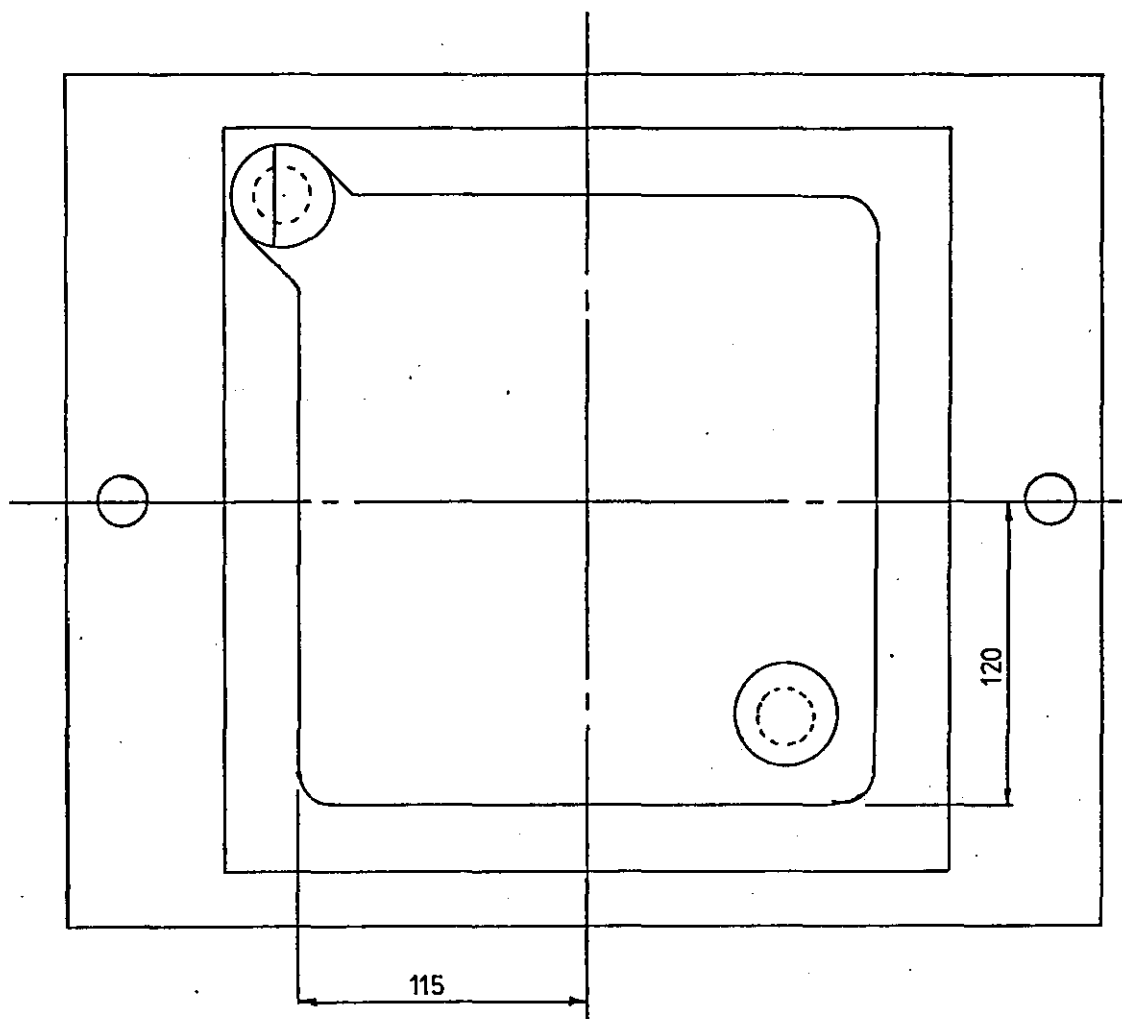
(mm)

DRAWING NO.

FIGURE 4.15 (1v)

DESCRIPTION:

STEPPED BLOCK PRECISION PATTERN  
DIMENSIONS



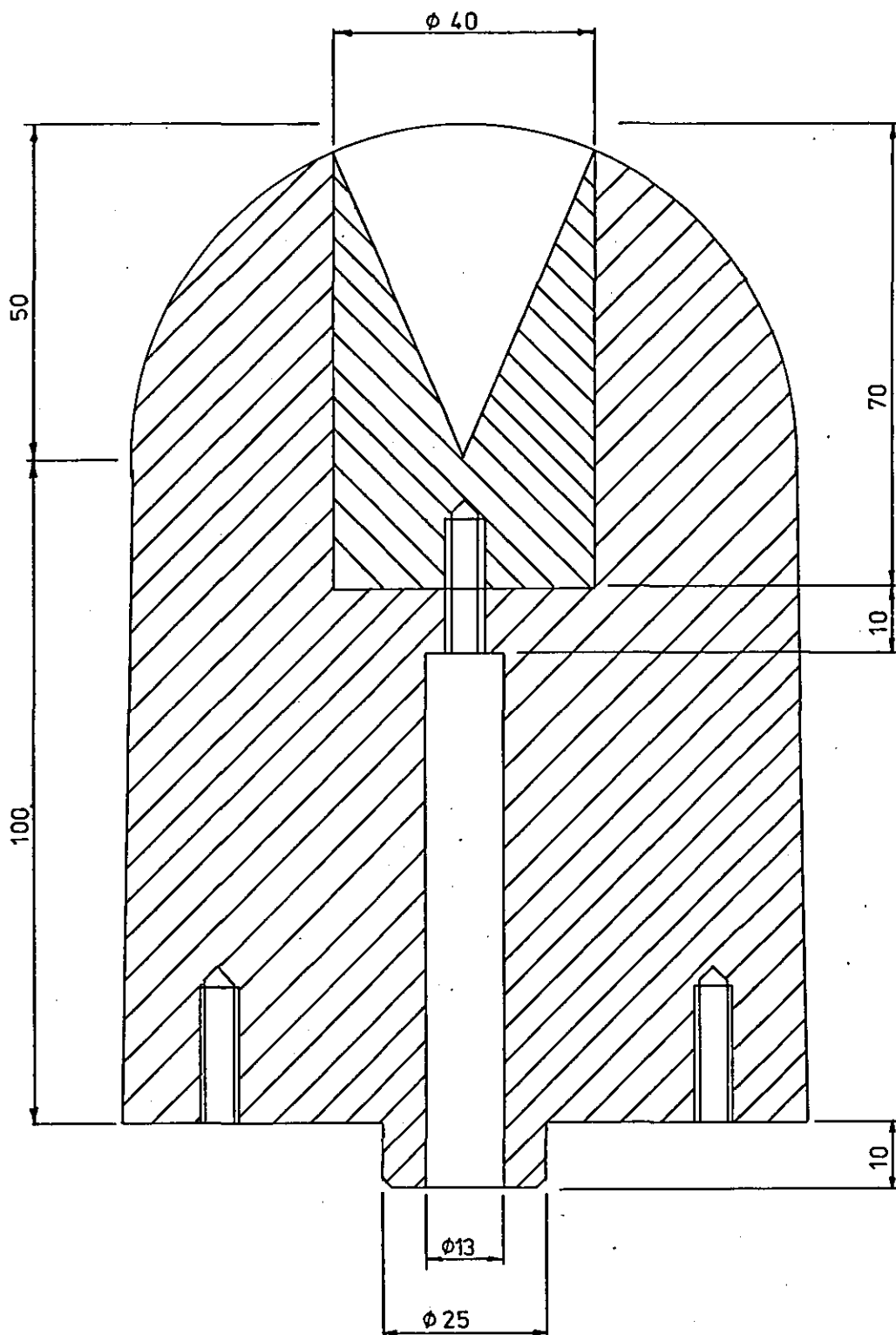
(mm)

DRAWING NO.

FIGURE 4.15 (v)

DESCRIPTION:

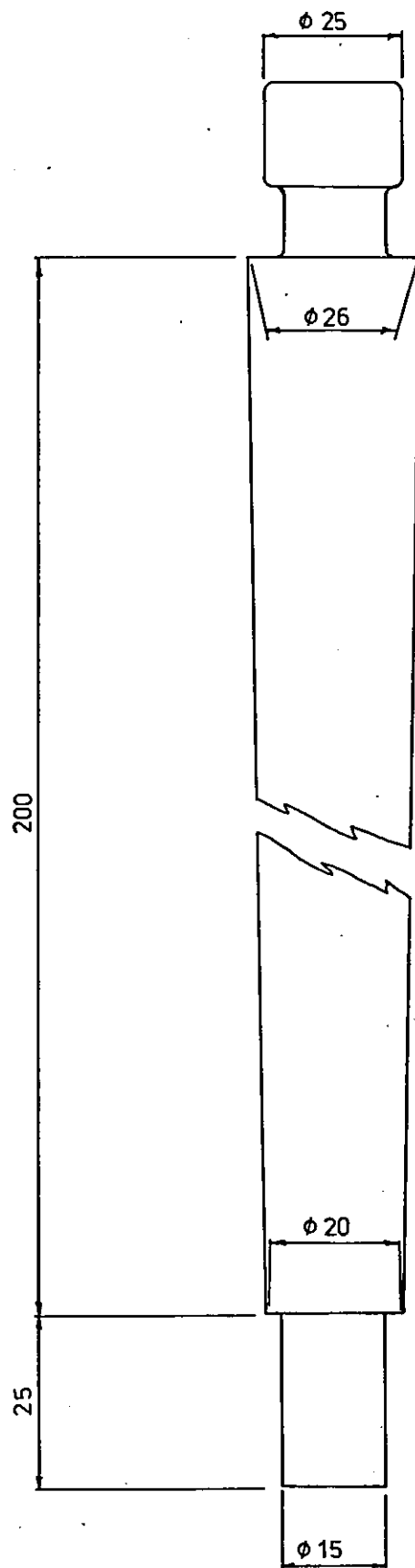
PREFORM/ PRECISION DRAG PATTERN  
PLATE LAYOUT (STEPPED BLOCK)



(mm)

DRAWING NO. FIGURE 4.16

DESCRIPTION: FEEDER HEAD DIMENSIONS



(mm)

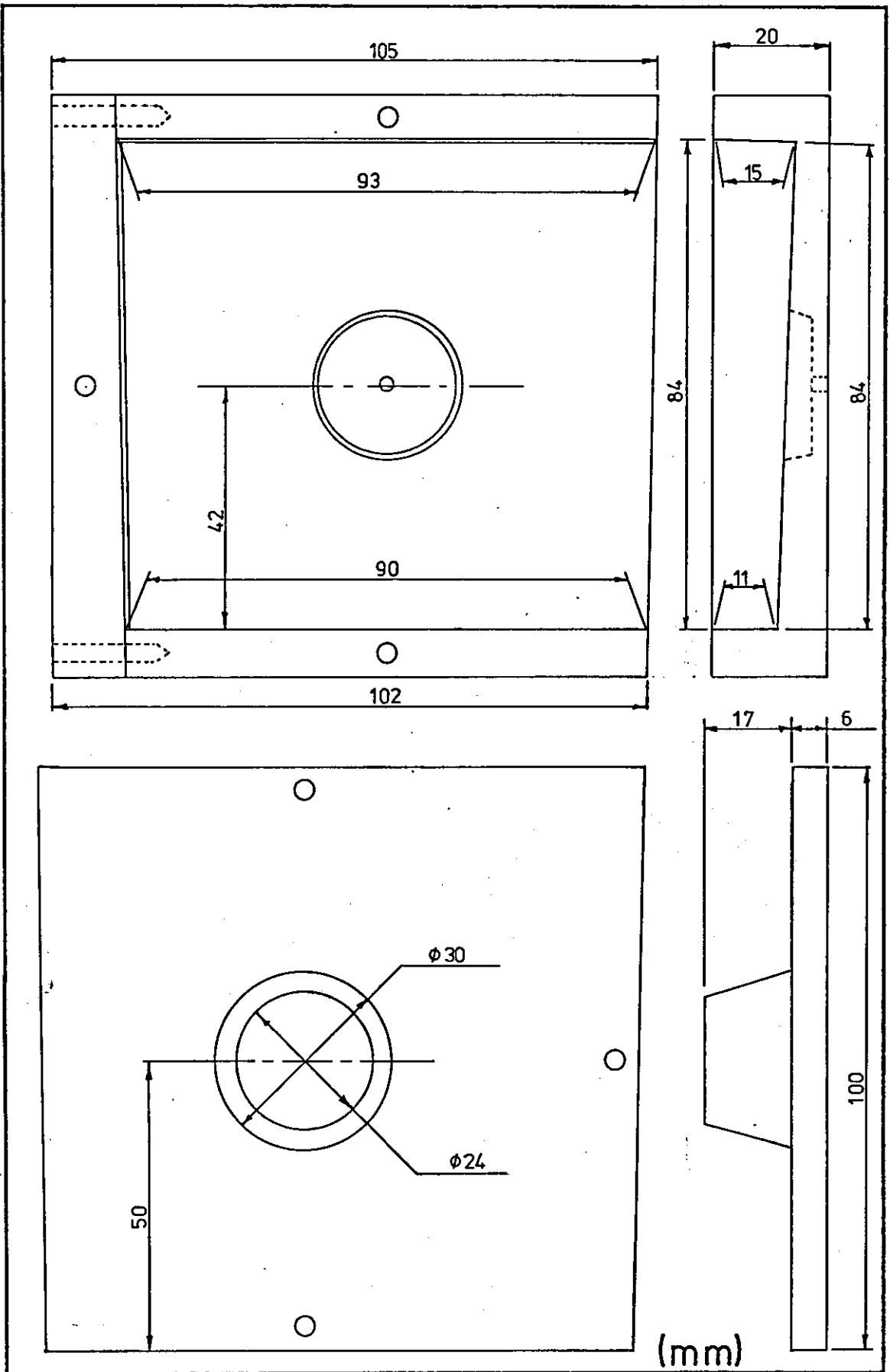
DRAWING NO.

FIGURE 4.17

DESCRIPTION:

SPRUE DIMENSIONS





DRAWING NO. FIGURE 4.18

DESCRIPTION: WASHBURN COREBOX DIMENSIONS

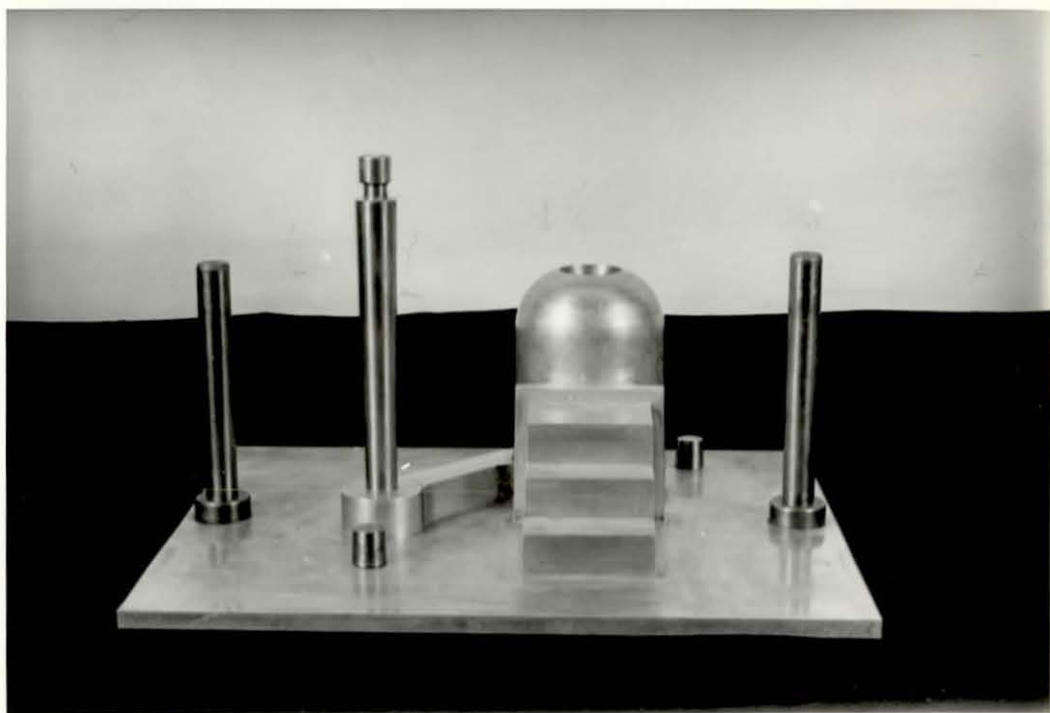
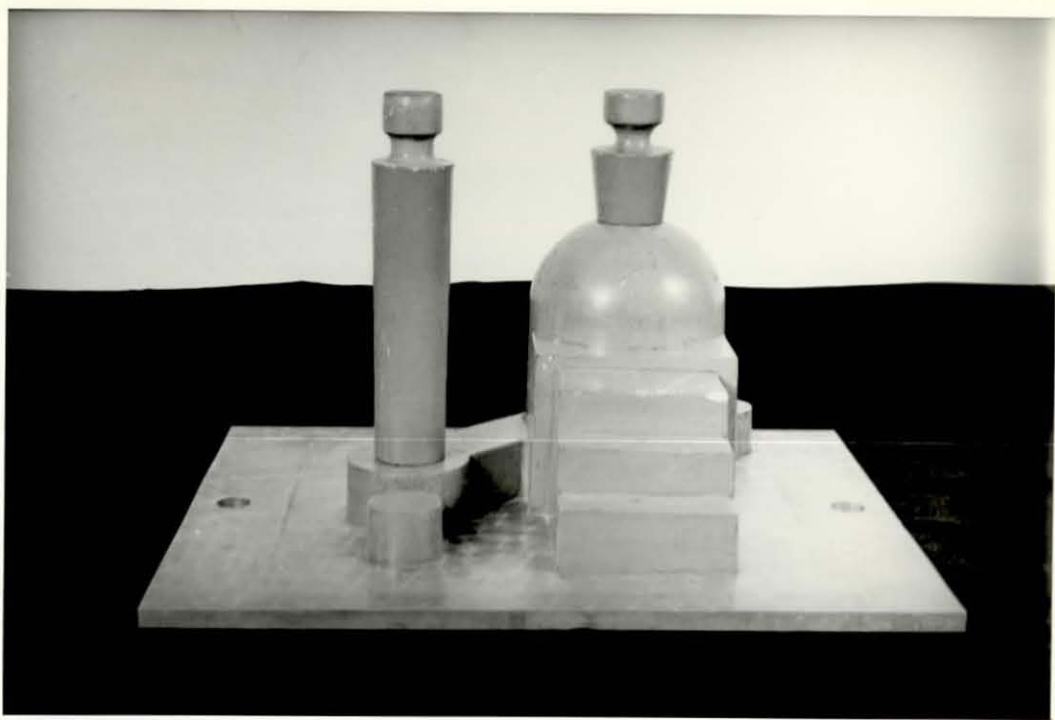


FIGURE 4.19      PHOTOGRAPHS OF THE STEPPED BLOCK PREFORM  
AND PRECISION COPE PATTERN ASSEMBLIES

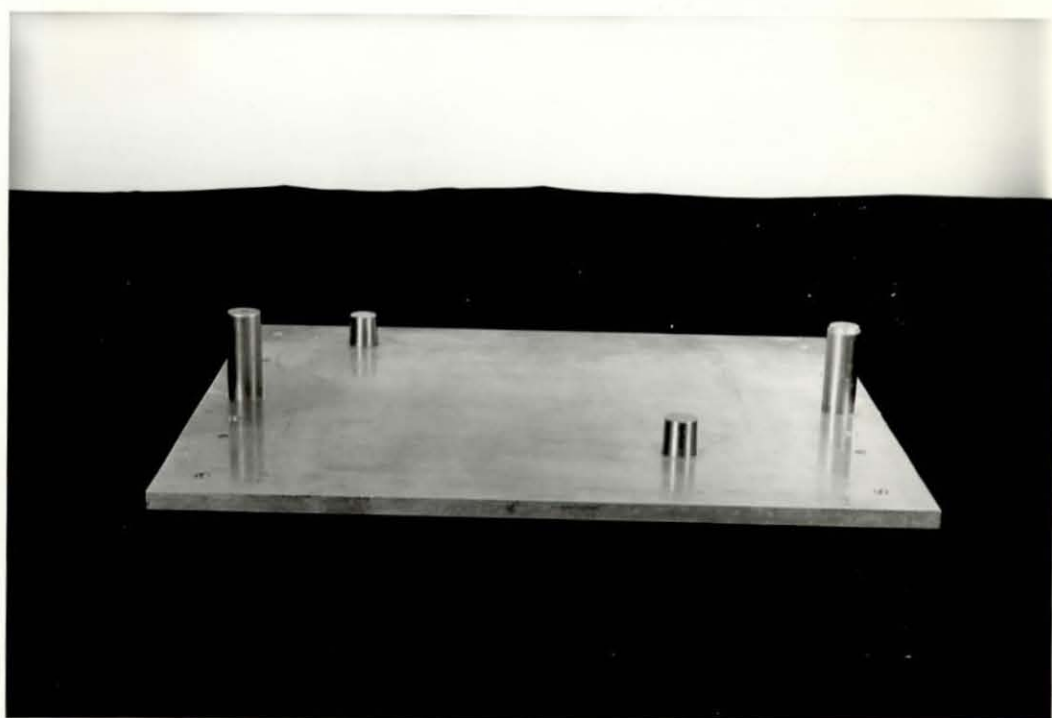
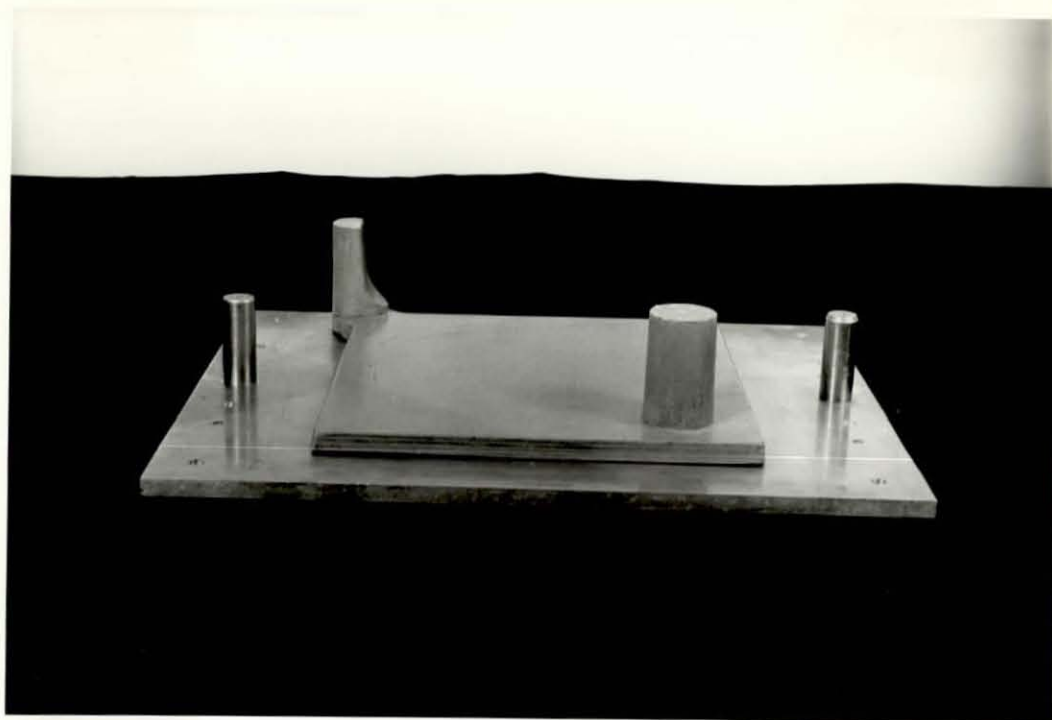
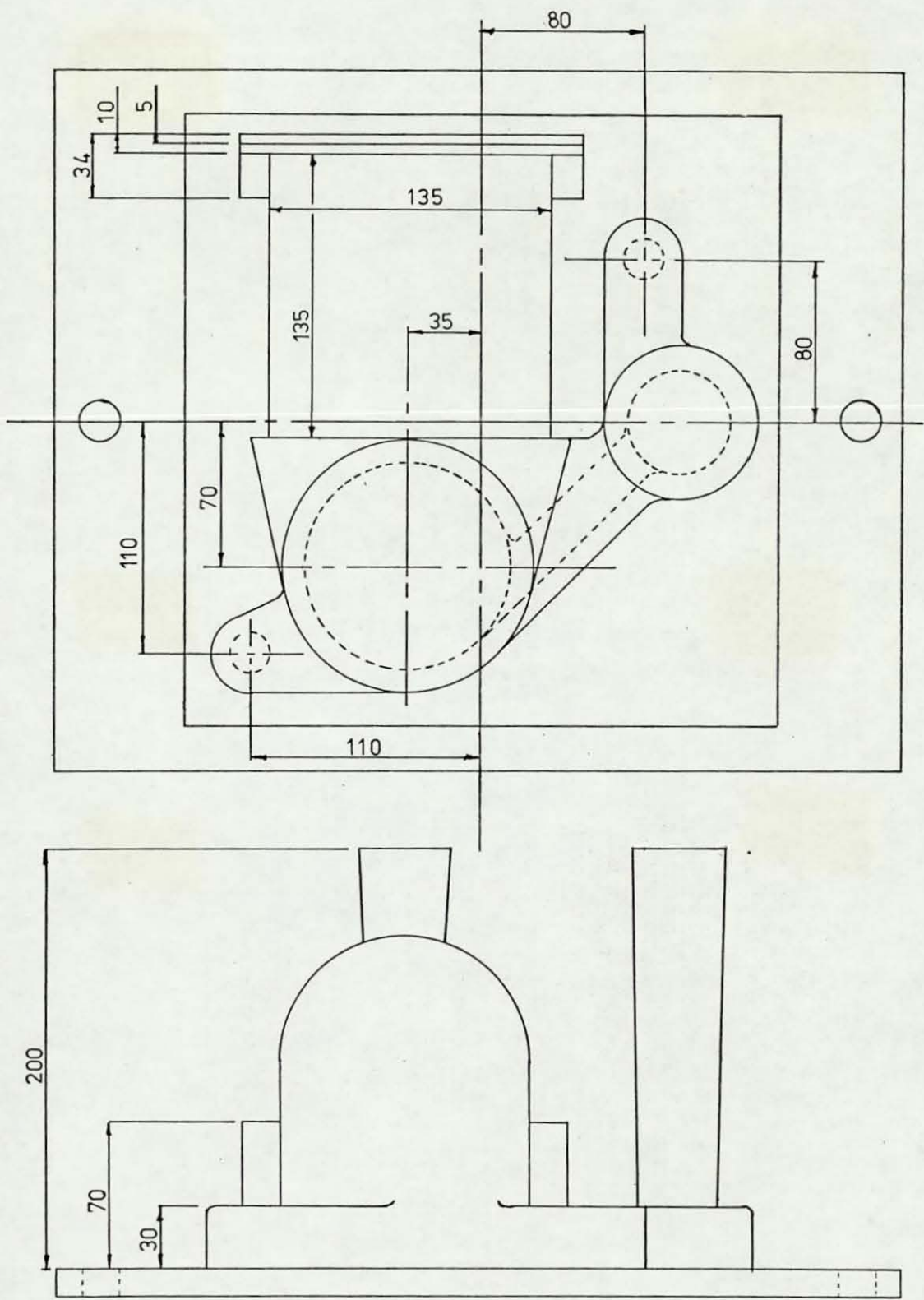


FIGURE 4.20    PHOTOGRAPHS OF THE STEPPED BLOCK PREFORM  
AND PRECISION DRAG PATTERN ASSEMBLIES



(mm)

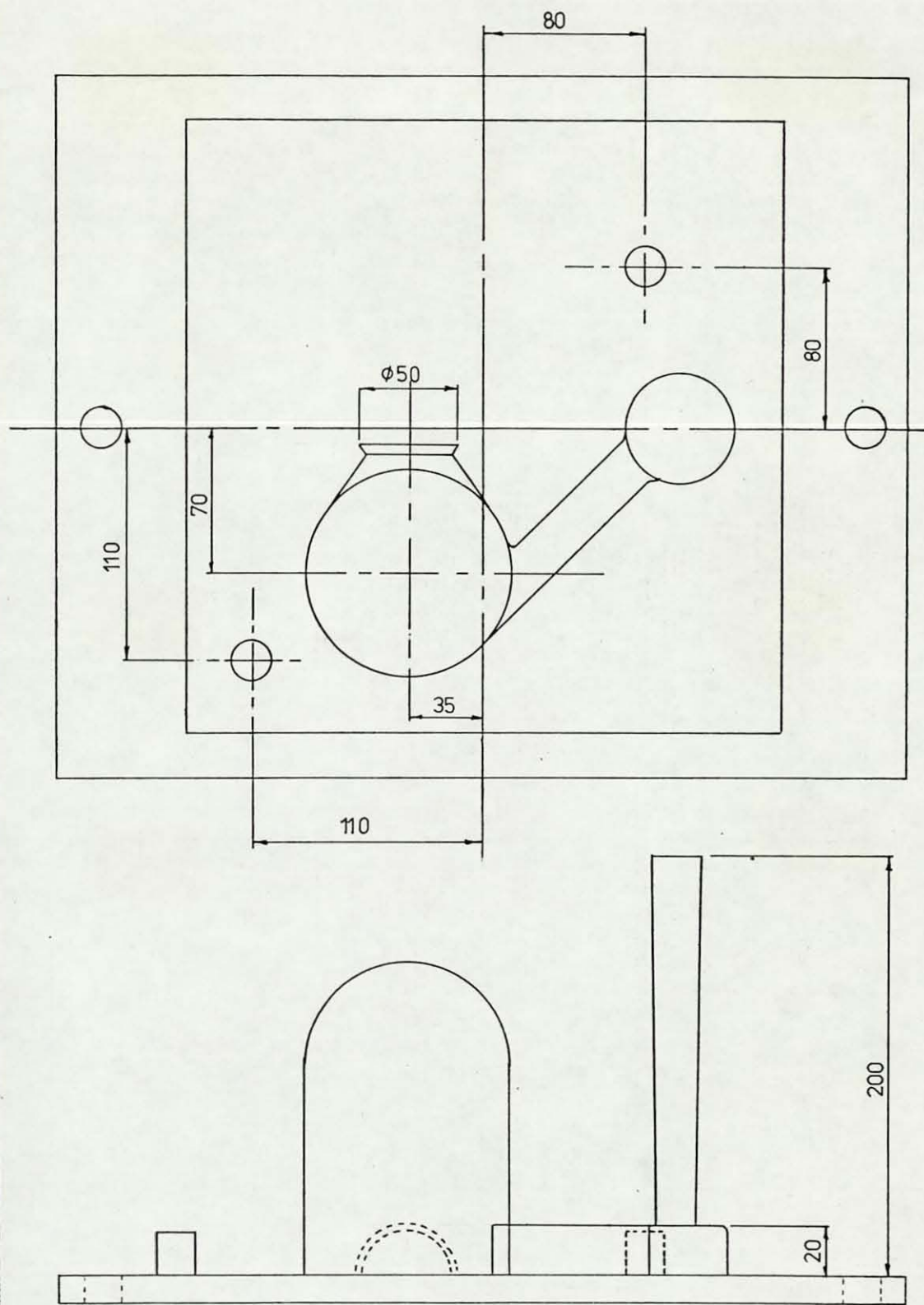
DRAWING NO.

FIGURE 4.21 (1)

DESCRIPTION:

PREFORM COPE PATTERN PLATE LAYOUT  
(SPIDER FORGING DIE)





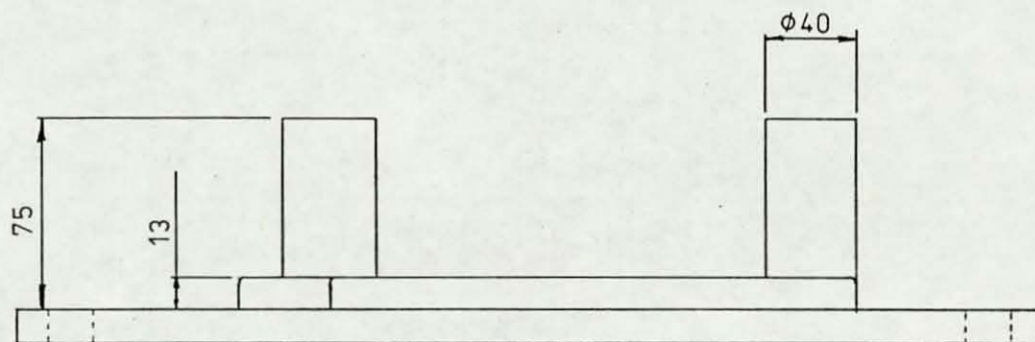
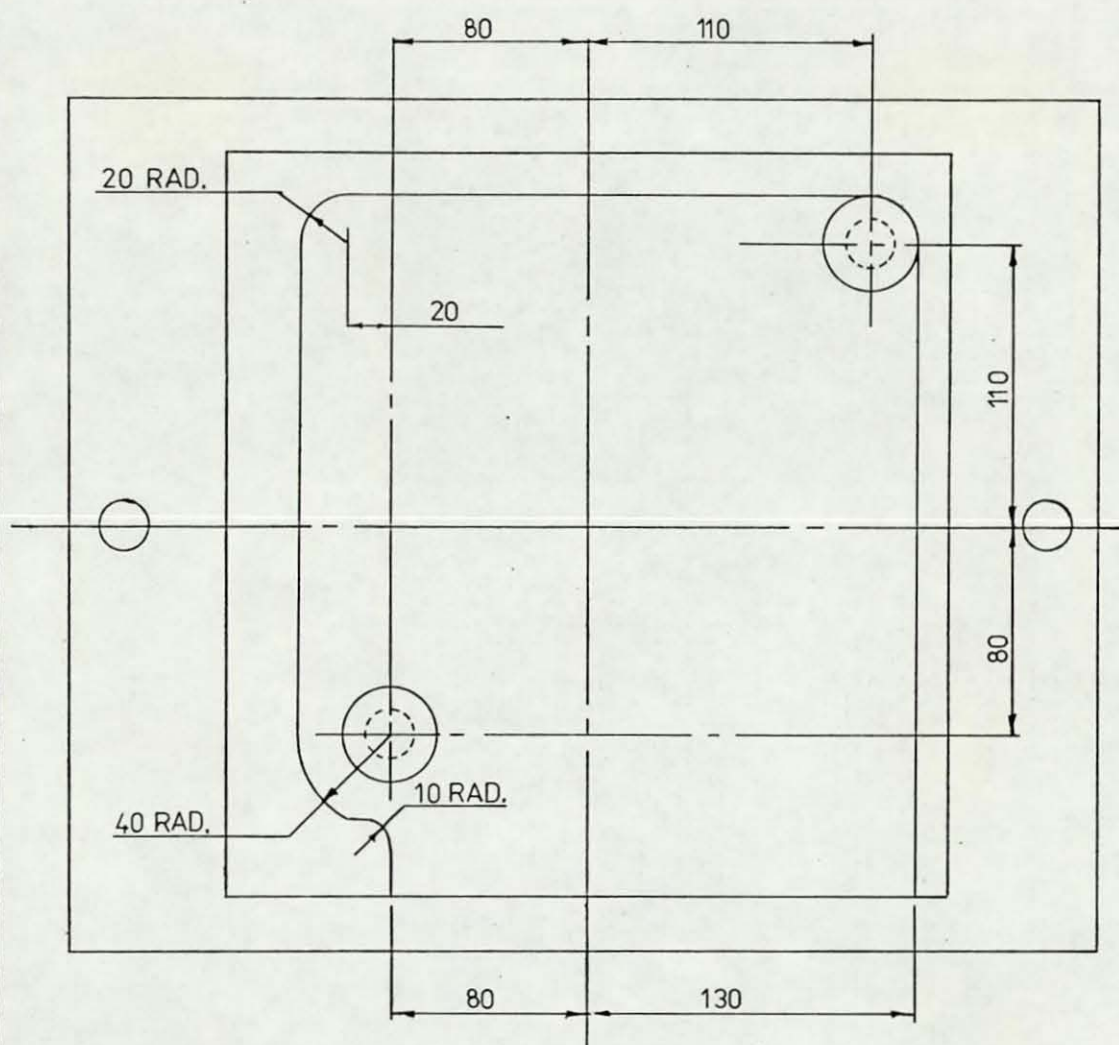
(mm)

DRAWING NO.

FIGURE 4.21 (ii)

DESCRIPTION:

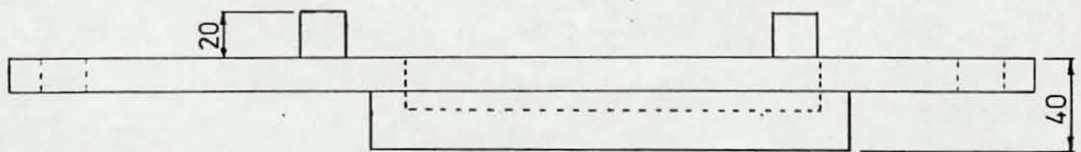
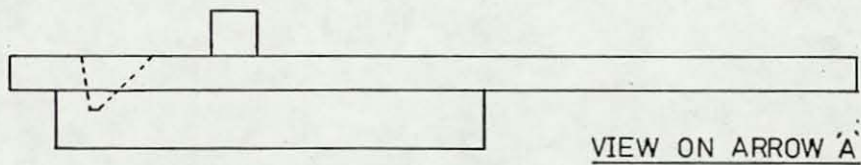
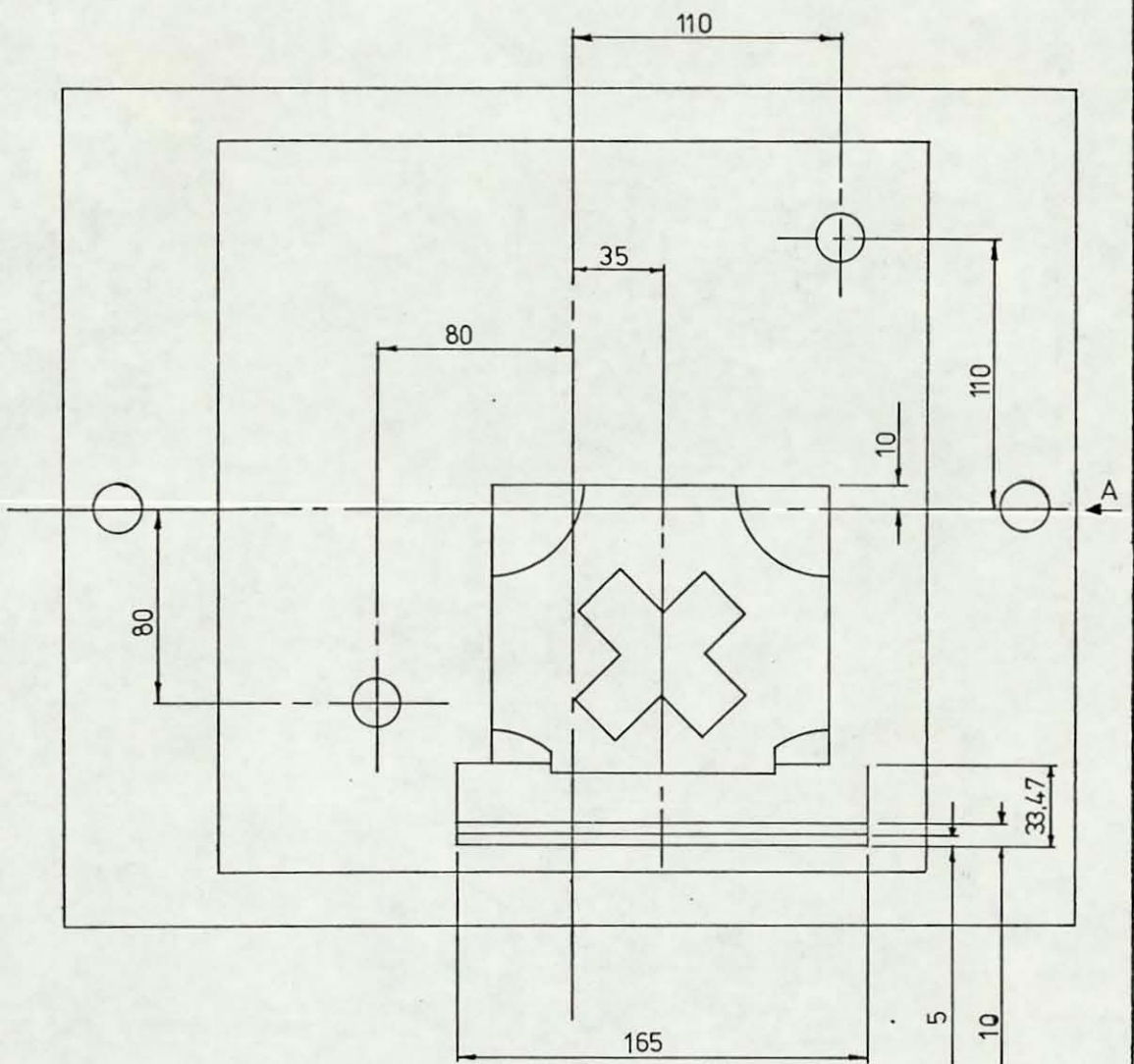
PRECISION COPE PATTERN PLATE LAYOUT  
(SPIDER FORGING DIE )



(mm)

DRAWING NO. FIGURE 4.21 (iii)

DESCRIPTION: PREFORM DRAG PATTERN PLATE LAYOUT  
(SPIDER FORGING DIE)



(mm)

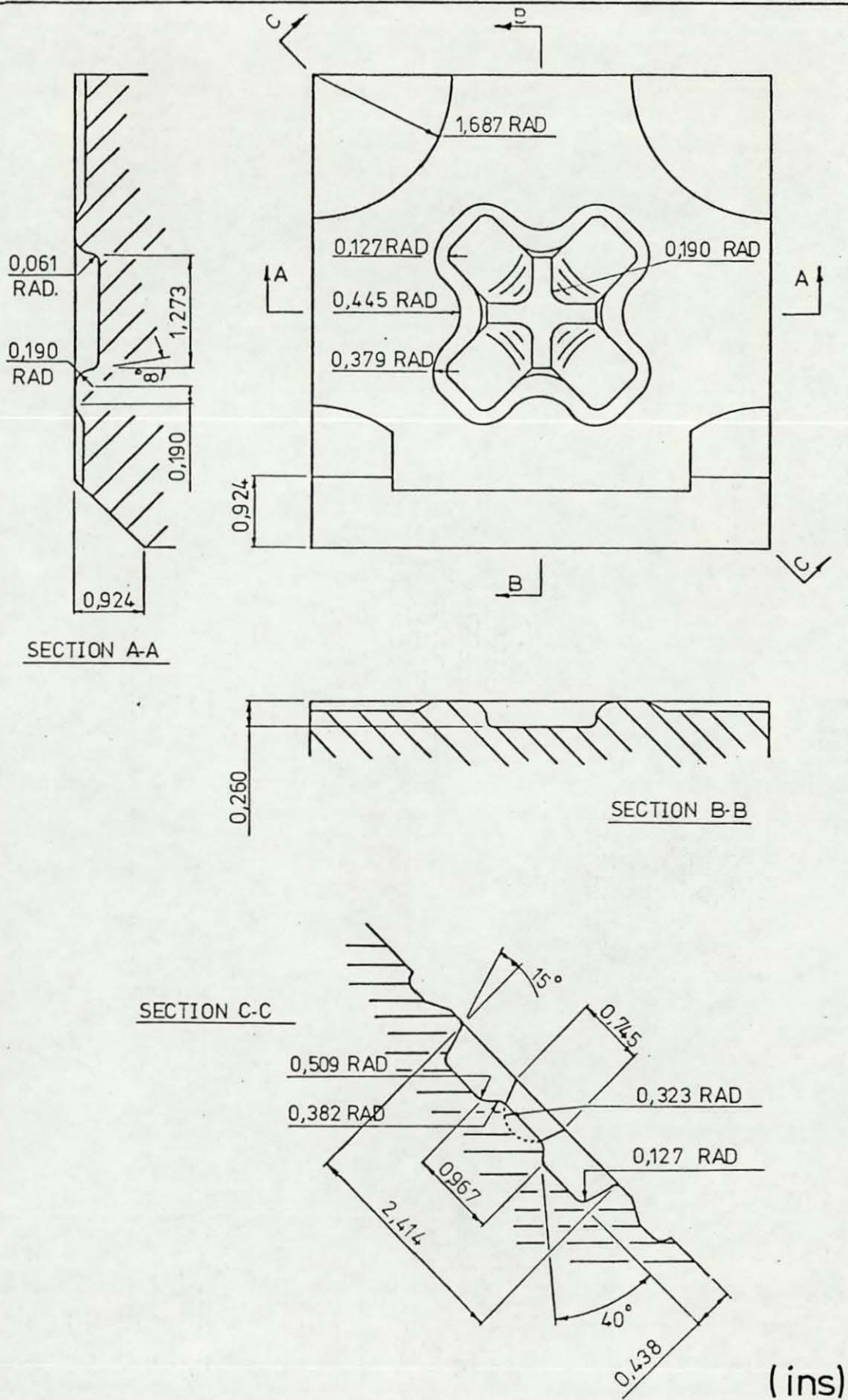
DRAWING NO.

FIGURE 4.21 (iv)

DESCRIPTION:

PRECISION DRAG PATTERN PLATE LAYOUT  
(SPIDER FORGING DIE)





DRAWING NO.

FIGURE 4.21 (v)

DESCRIPTION:

SPIDER FORGING DIE IMPRESSION  
DIMENSIONS



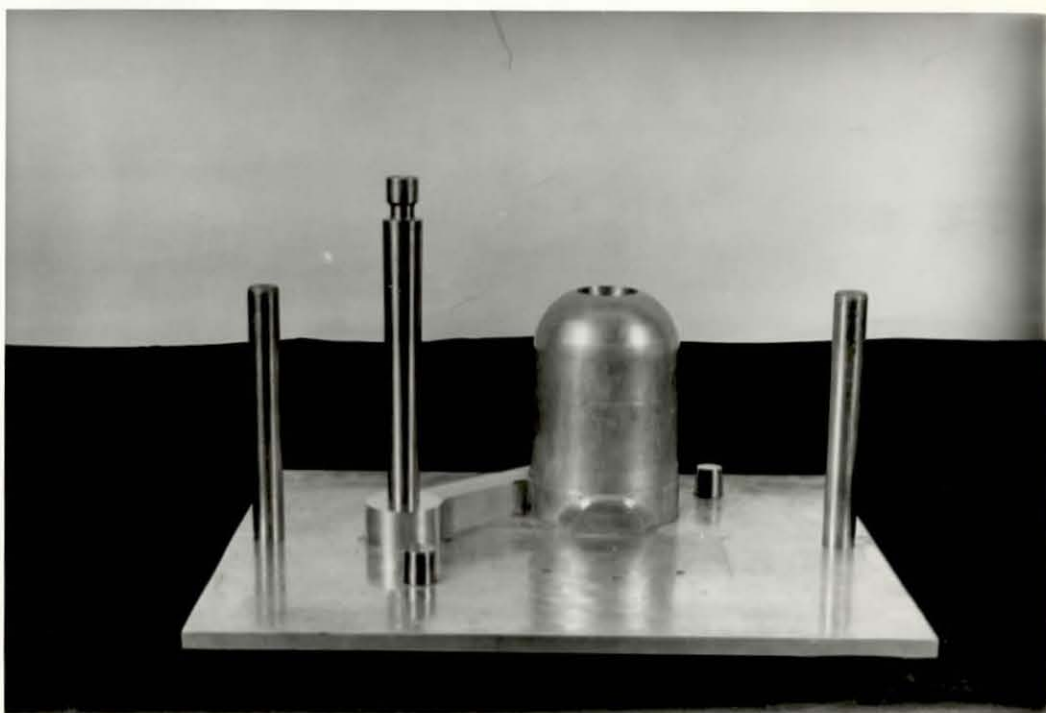
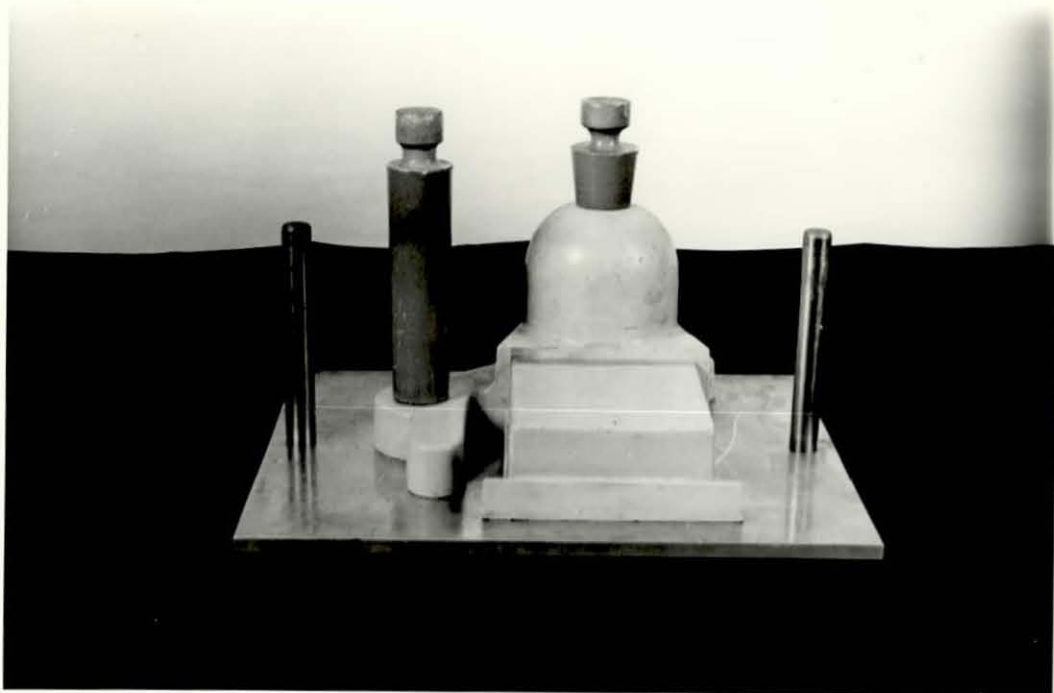


FIGURE 4.21 (vi) PHOTOGRAPHS OF THE SPIDER FORGING  
DIE PREFORM AND PRECISION COPE  
PATTERN ASSEMBLIES

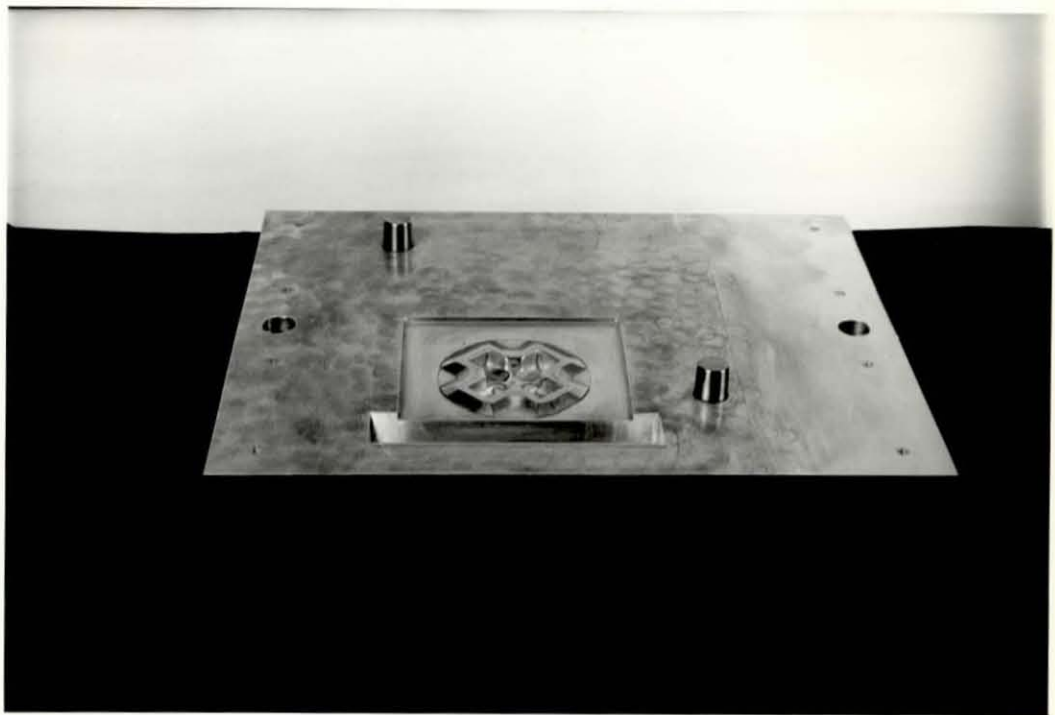
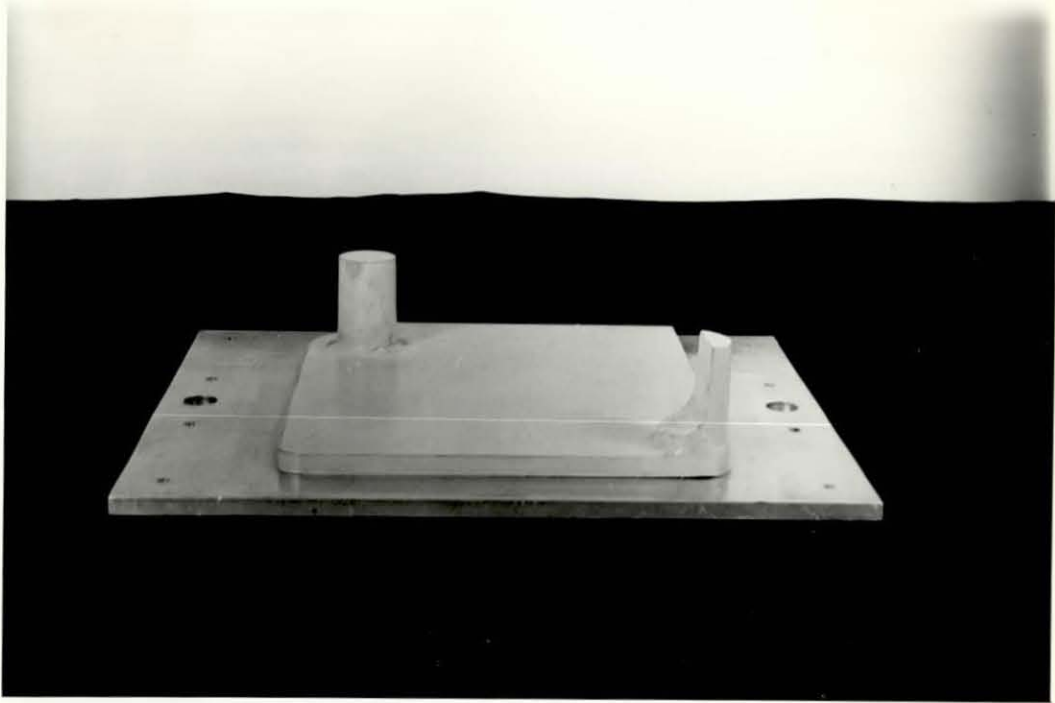
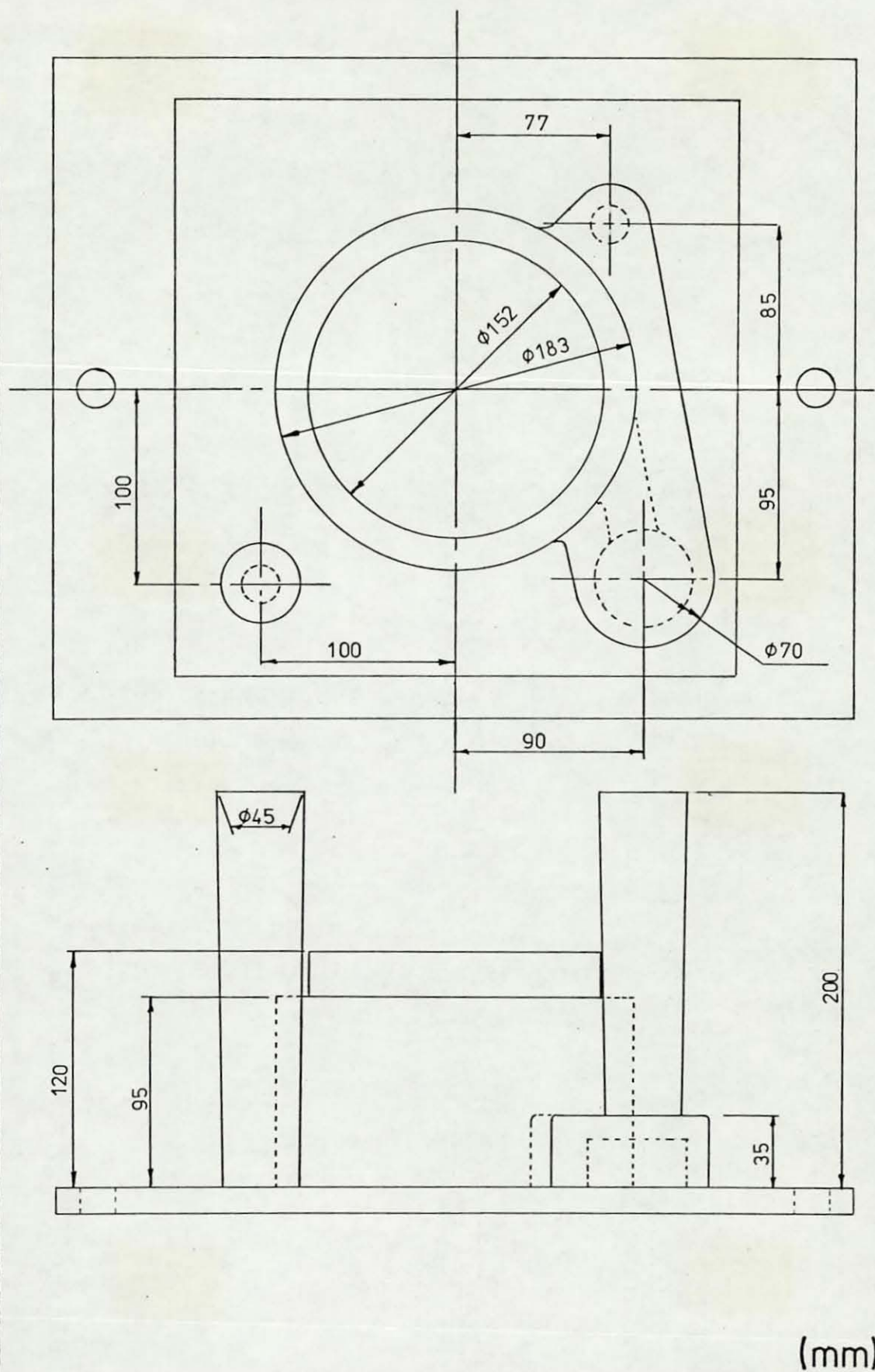


FIGURE 4.21 (vii)      PHOTOGRAPHS OF THE SPIDER FORGING  
DIE PREFORM AND PRECISION DRAG  
PATTERN ASSEMBLIES



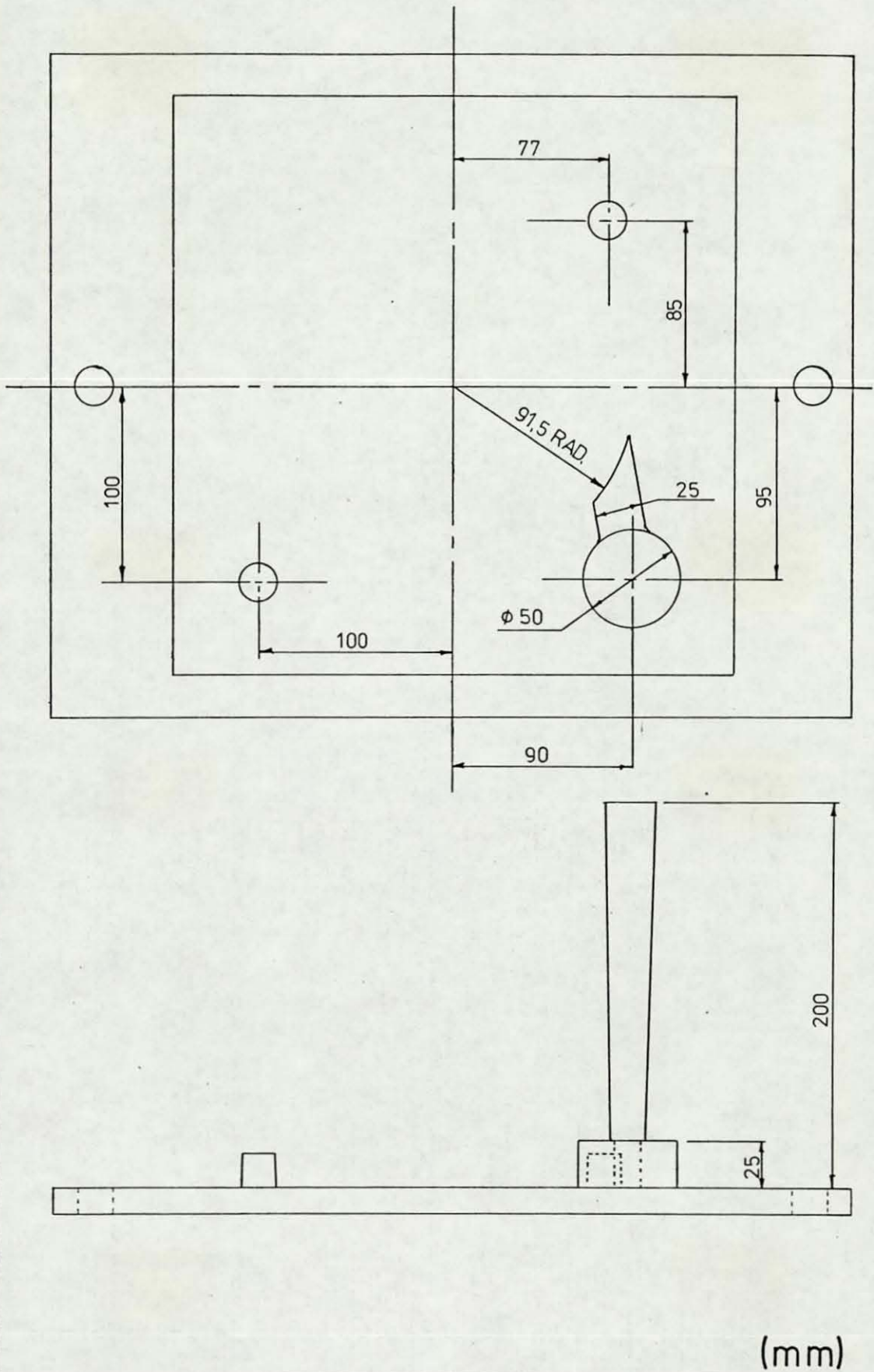
DRAWING NO.

FIGURE 4.22 (i)

DESCRIPTION:

PREFORM COPE PATTERN PLATE LAYOUT  
(FLANGE YOKE DIE)



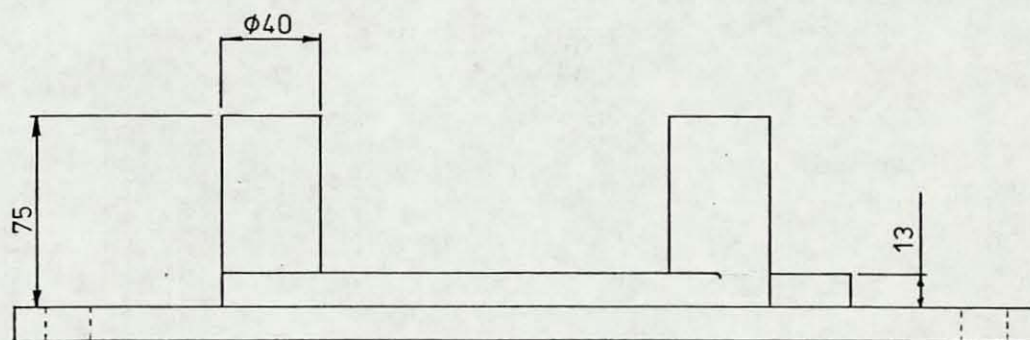
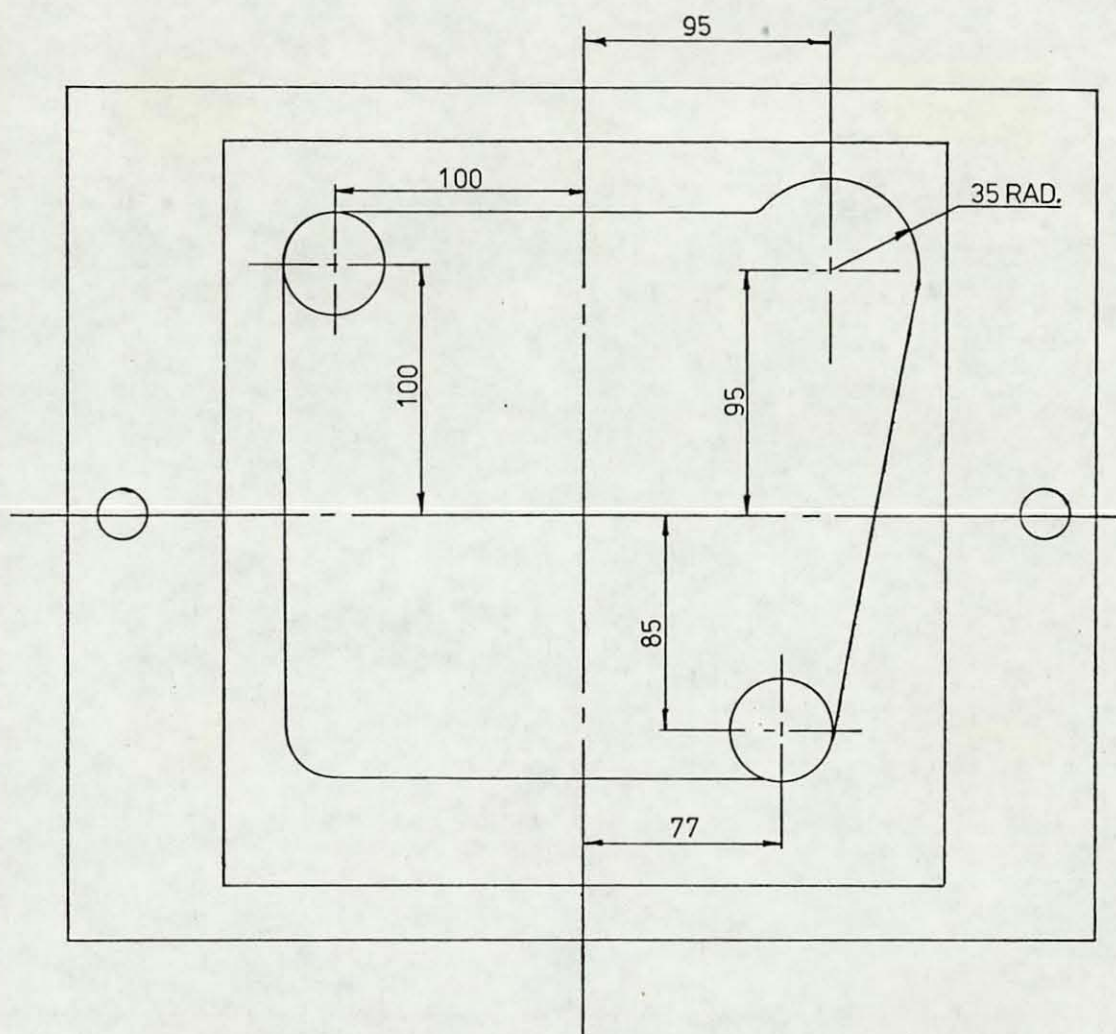


DRAWING NO.

FIGURE 4.22 (ii)

DESCRIPTION:

PRECISION COPE PATTERN PLATE LAYOUT  
(FLANGE YOKE DIE)



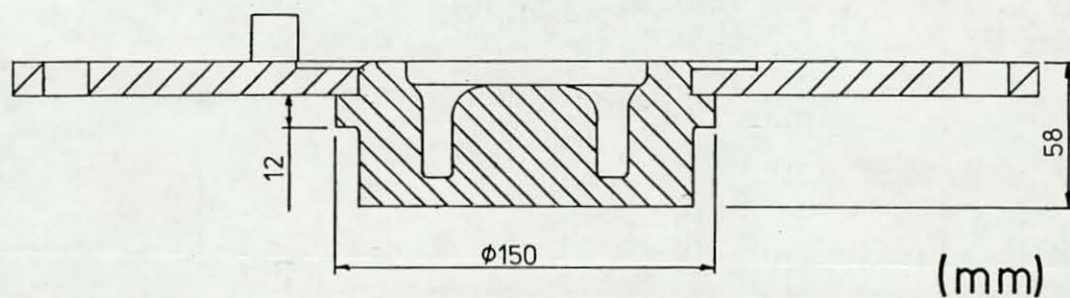
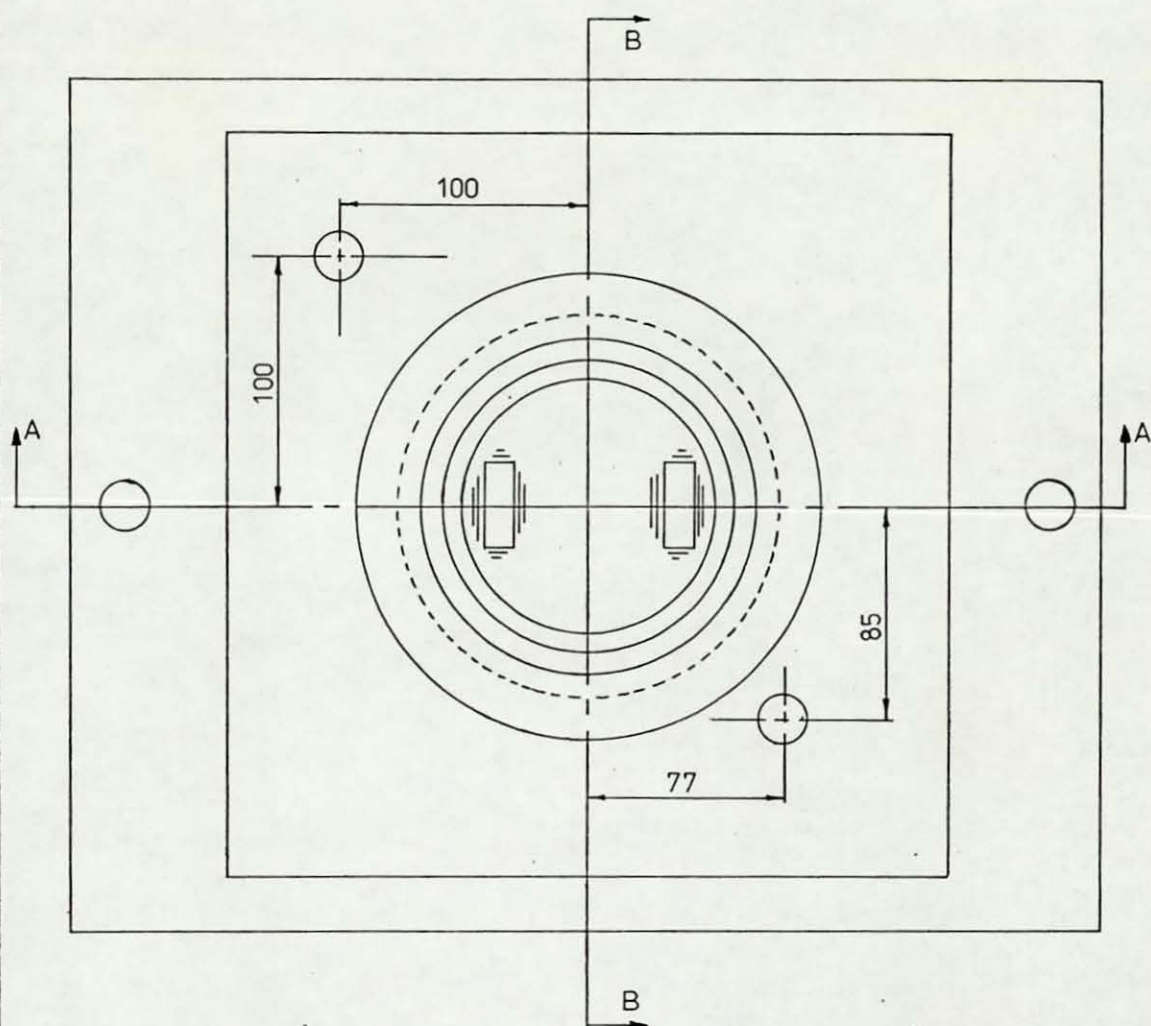
(mm)

DRAWING NO.

FIGURE 4.22(iii)

DESCRIPTION:

PREFORM DRAG PATTERN PLATE LAYOUT  
(FLANGE YOKE DIE)



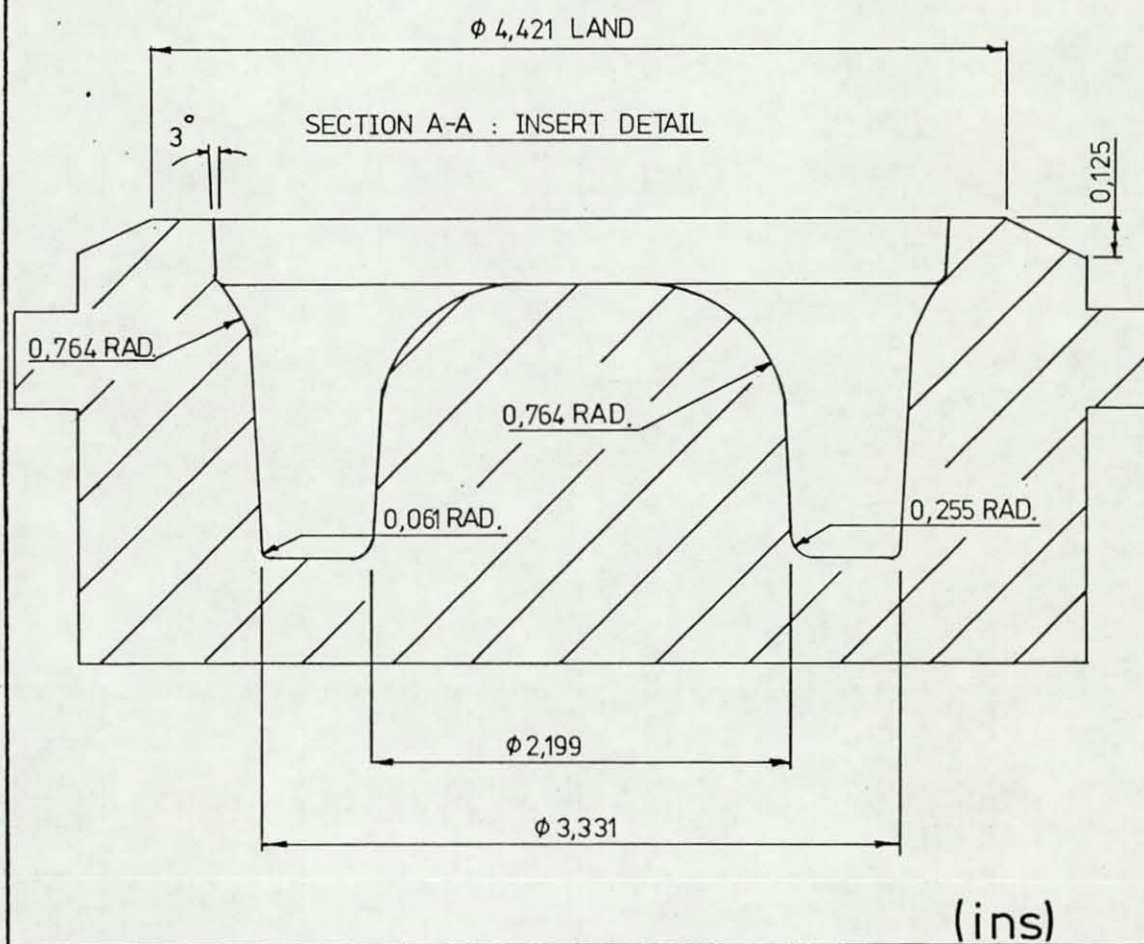
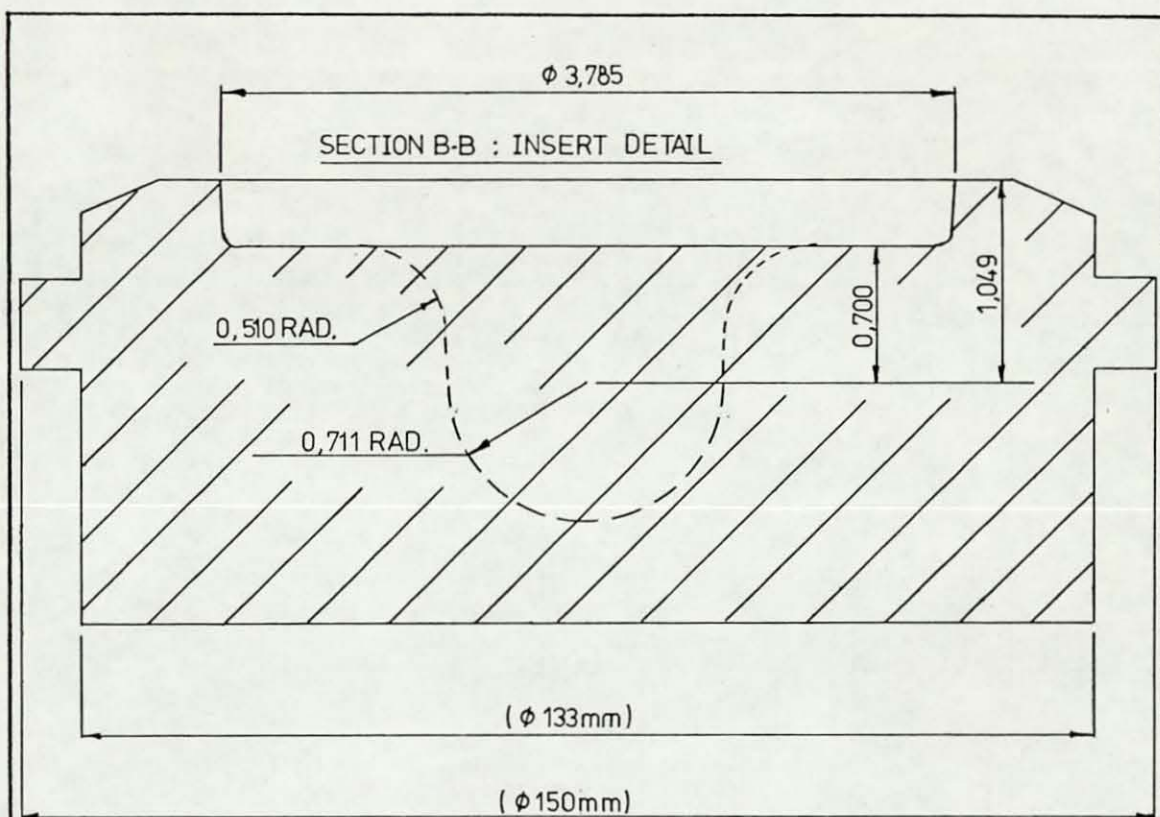
DRAWING NO.

FIGURE 4.22 (iv)

DESCRIPTION:

PRECISION DRAG PATTERN PLATE LAYOUT  
(FLANGE YOKE DIE)





DRAWING NO.

FIGURE 4.22 (v)

DESCRIPTION:

FLANGE YOKE DIE IMPRESSION DIMENSIONS

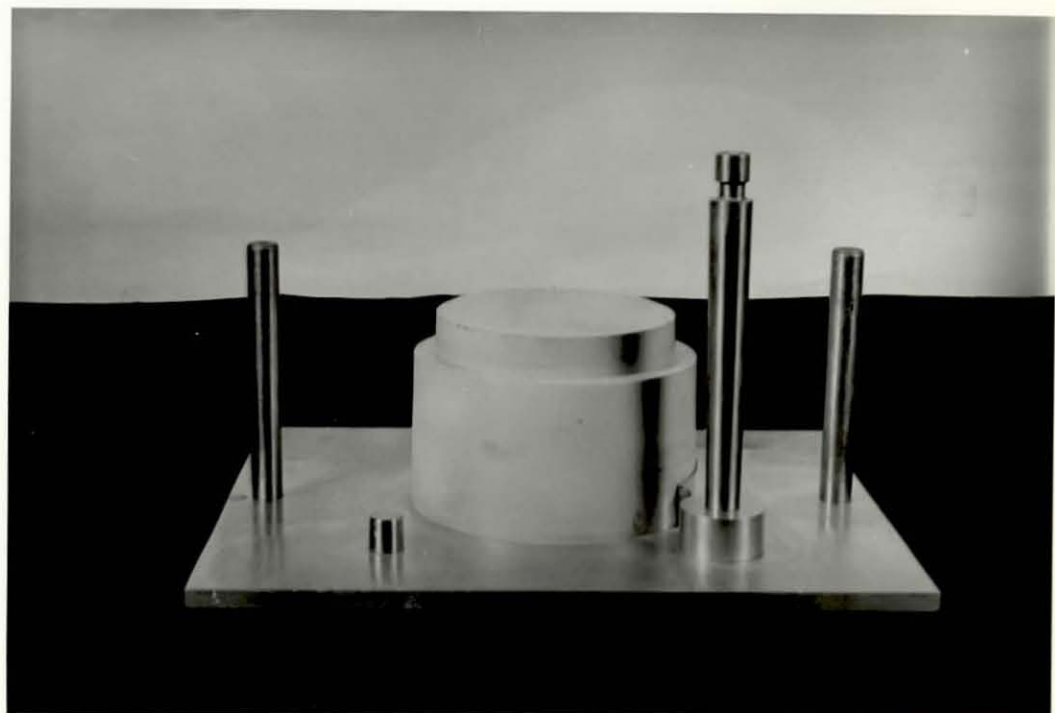
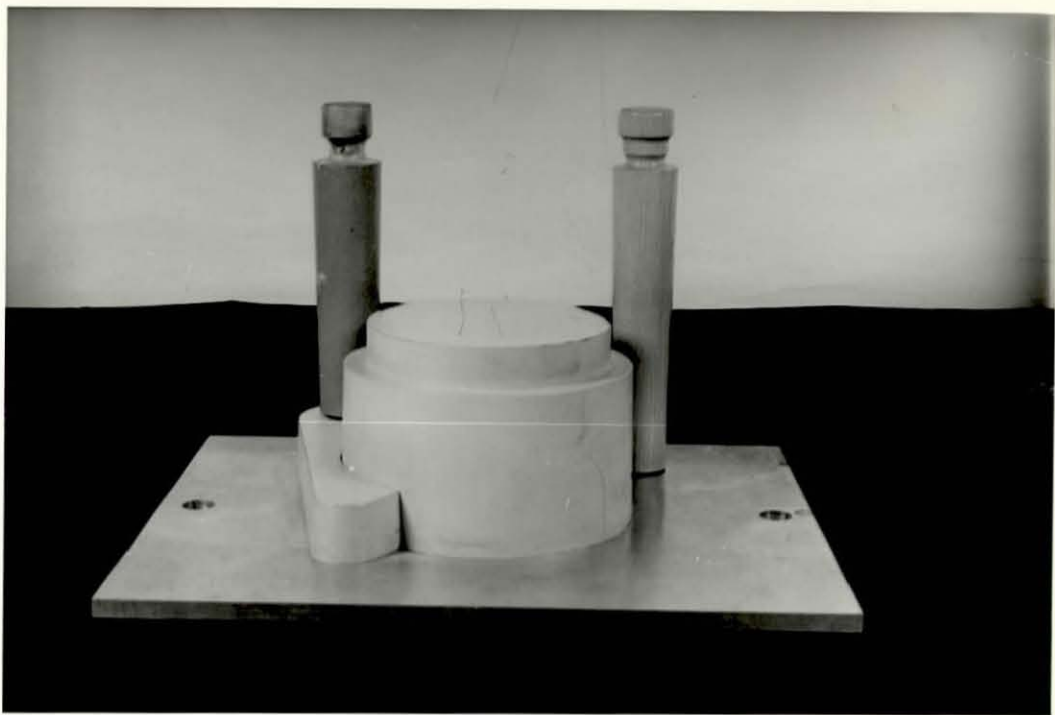


FIGURE 4.22 (vi)      PHOTOGRAPHS OF THE FLANGE YOKE DIE  
PREFORM AND PRECISION COPE  
PATTERN ASSEMBLIES



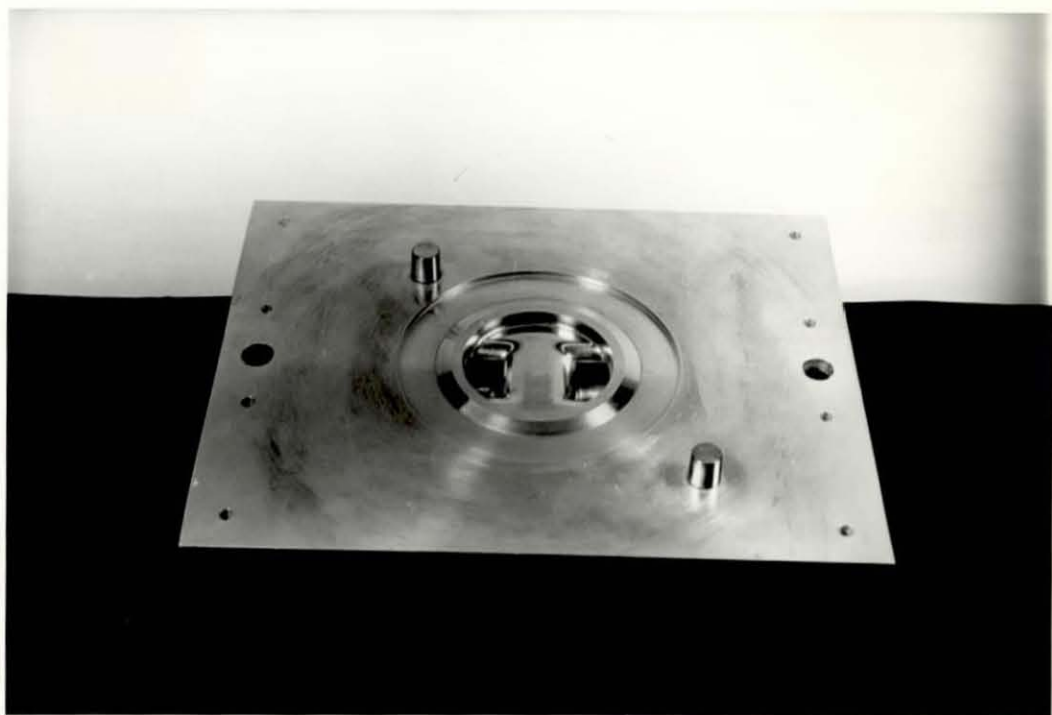
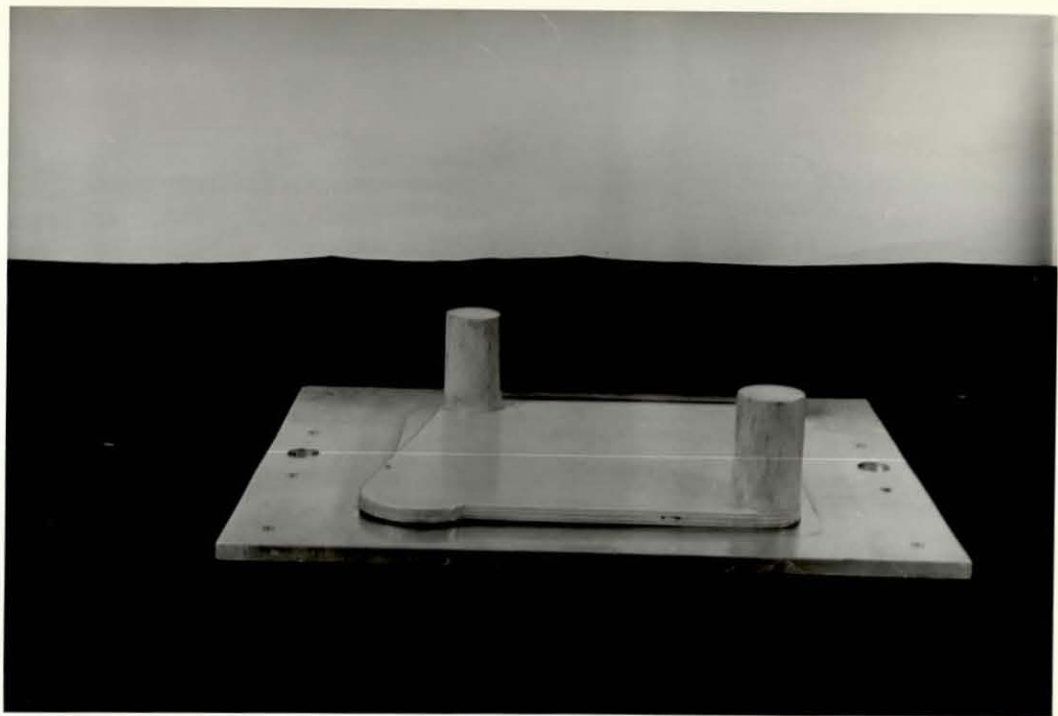
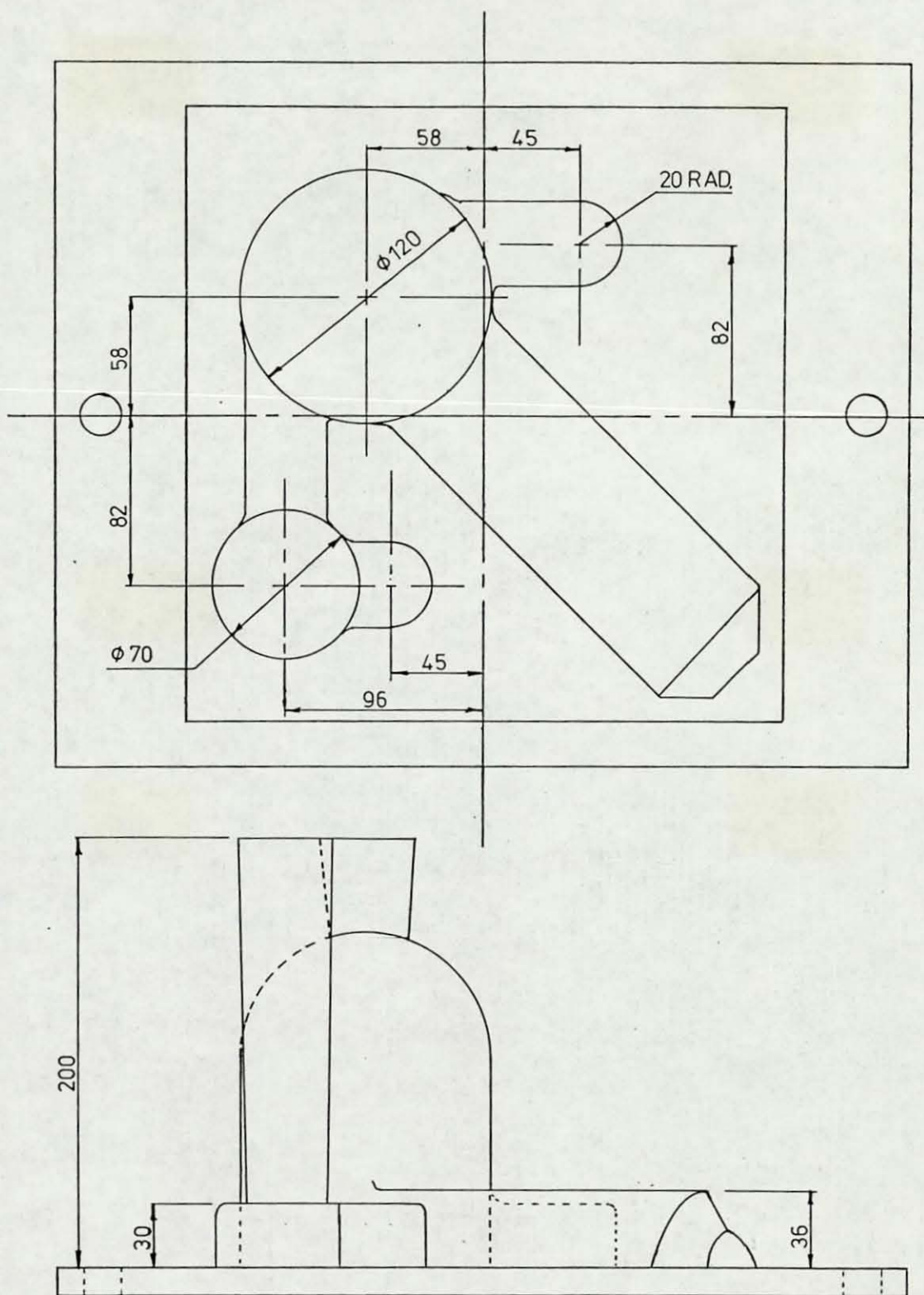


FIGURE 4.22 (vii)      PHOTOGRAPHS OF THE FLANGE YOKE DIE  
PREFORM AND PRECISION DRAG  
PATTERN ASSEMBLIES



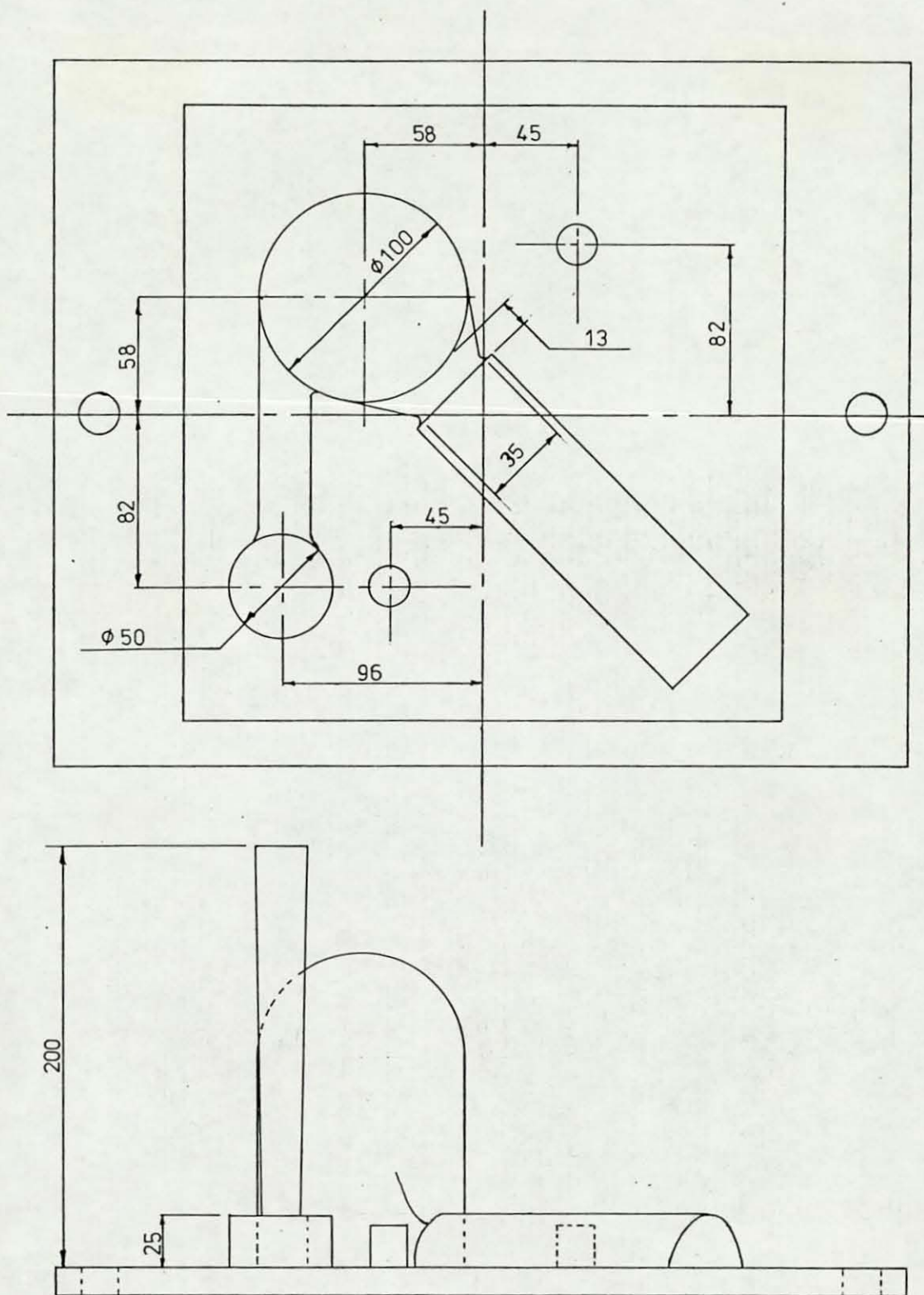
(mm)

DRAWING NO.

FIGURE 4.23 (1)

DESCRIPTION:

PREFORM COPE PATTERN PLATE LAYOUT  
(RETRACTABLE DIE CORE)



(mm)

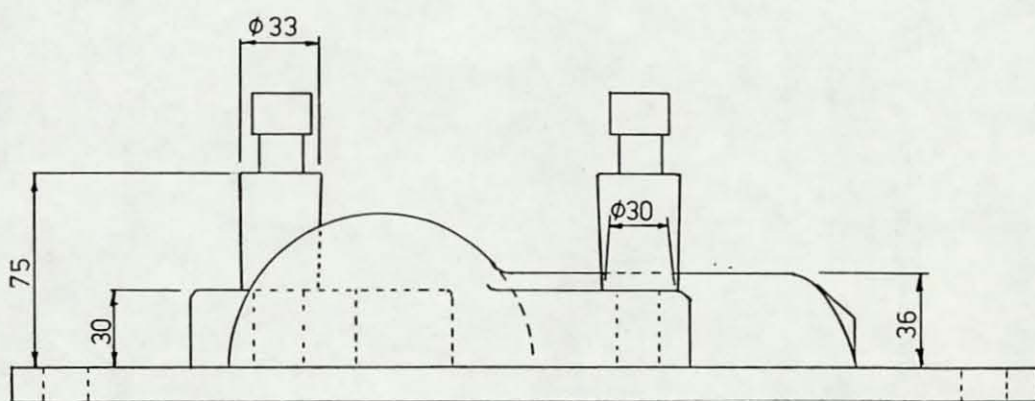
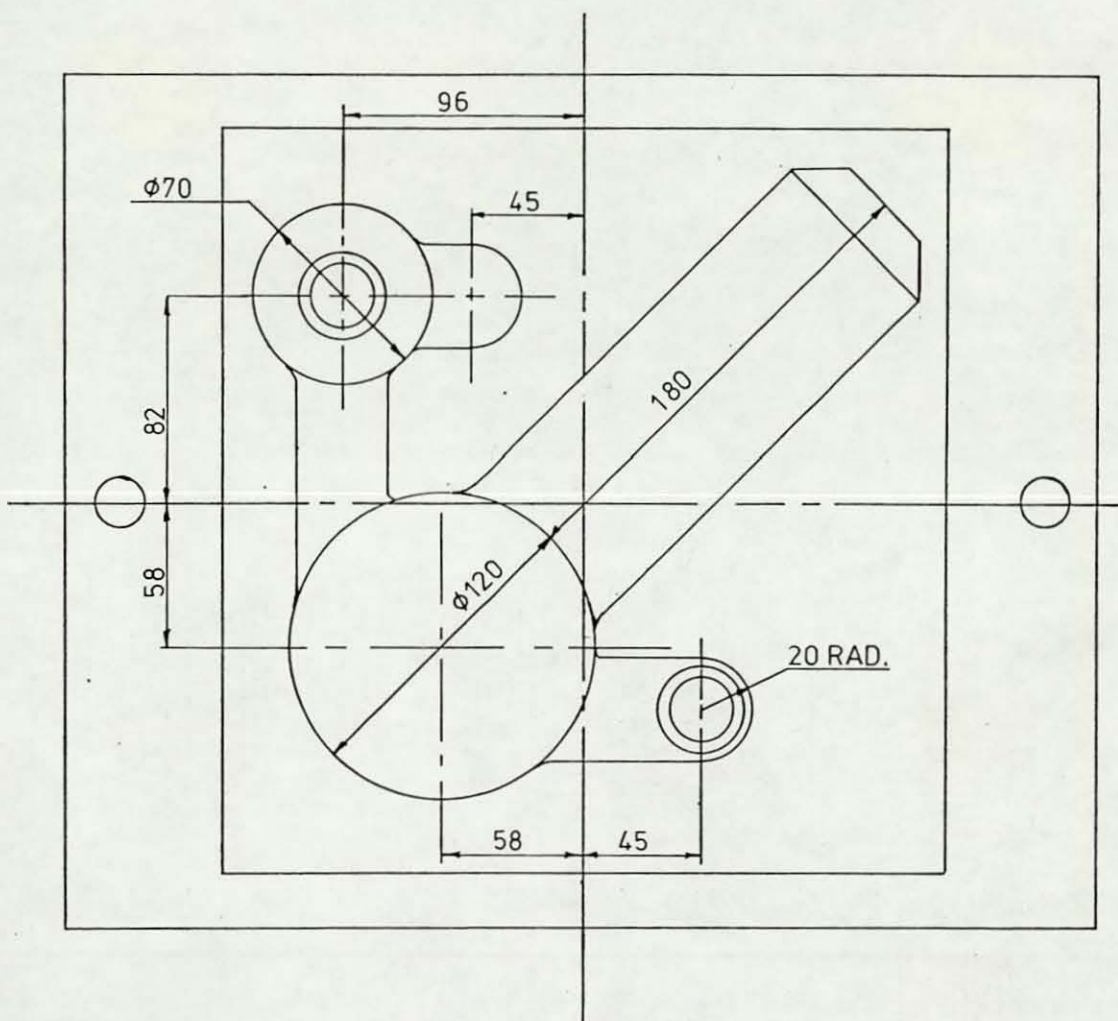
DRAWING NO.

FIGURE 4.23 (ii)

DESCRIPTION:

PRECISION COPE PATTERN PLATE LAYOUT  
(RETRACTABLE DIE CORE)





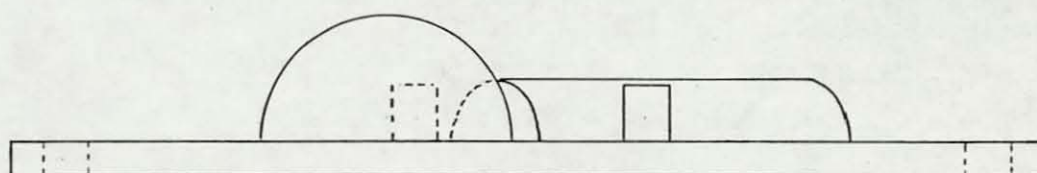
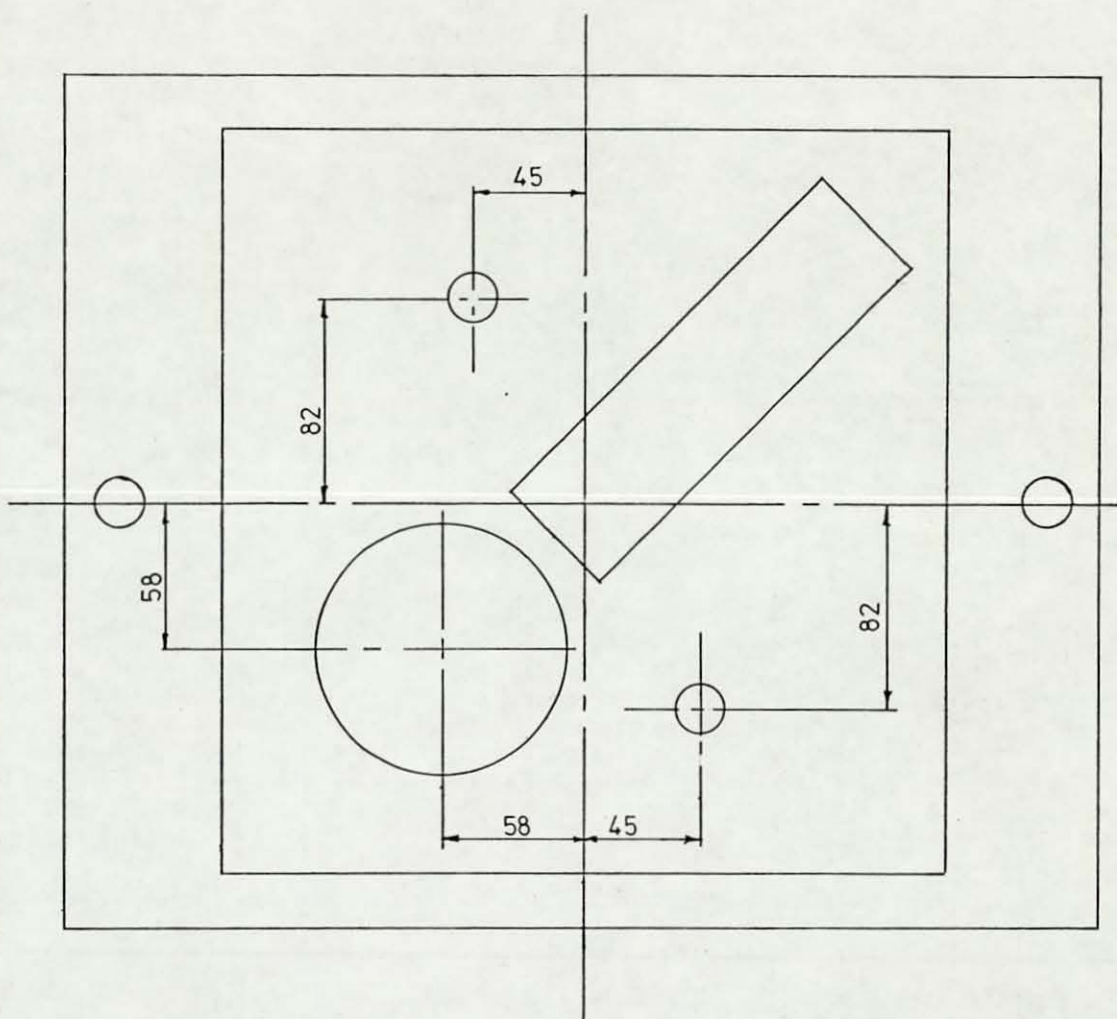
(mm)

DRAWING NO.

FIGURE 4.23 (iii)

DESCRIPTION:

PREFORM DRAG PATTERN PLATE LAYOUT  
(RETRACTABLE DIE CORE)



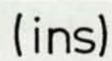
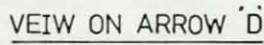
(mm)

DRAWING NO.

FIGURE 4.23 (iv)

DESCRIPTION:

PRECISION DRAG PATTERN PLATE LAYOUT  
(RETRACTABLE DIE CORE)

RETRACTABLE DIE CORE PRECISION  
PATTERN DIMENSIONS



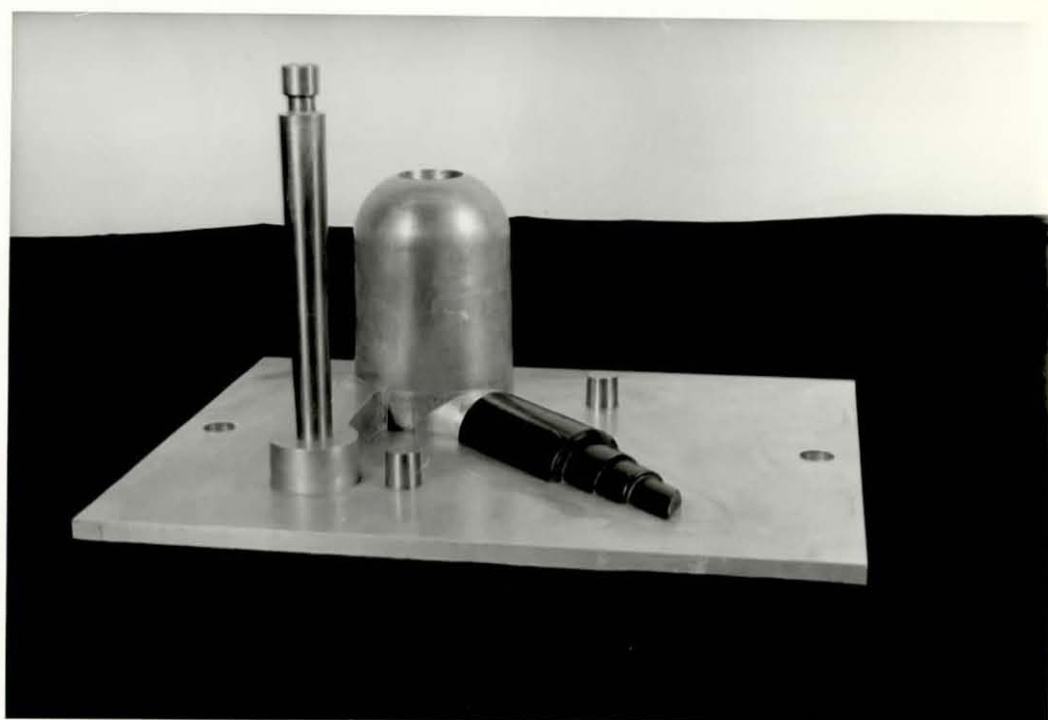
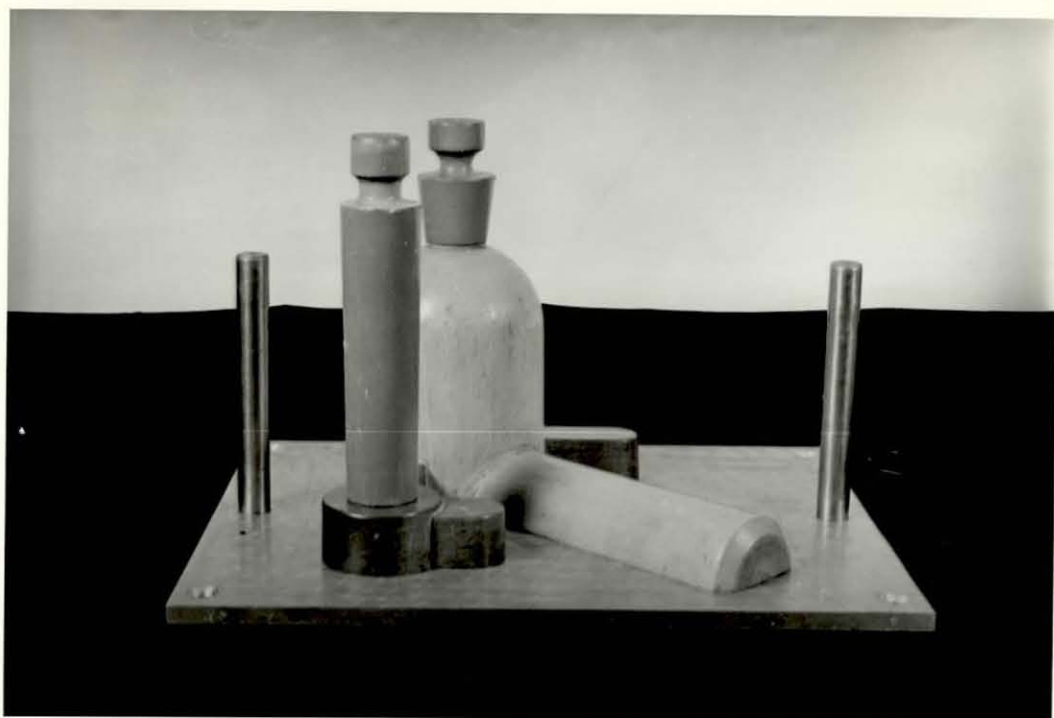


FIGURE 4.23 (vi)      PHOTOGRAPHS OF THE RETRACTABLE DIE  
CORE PREFORM AND PRECISION COPE  
PATTERN ASSEMBLIES

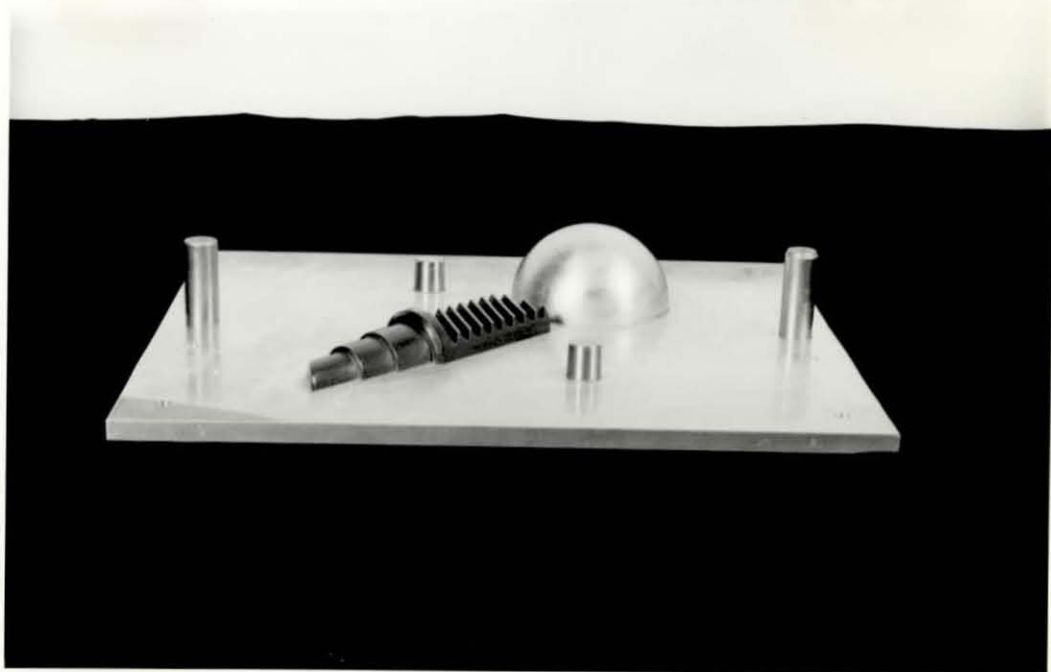
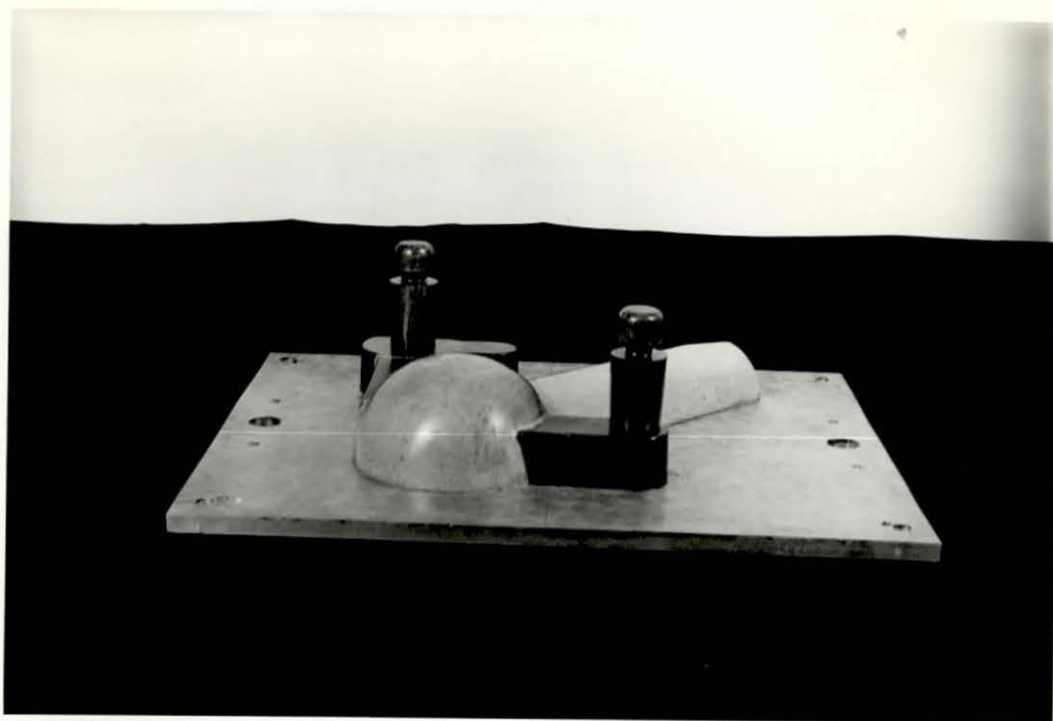
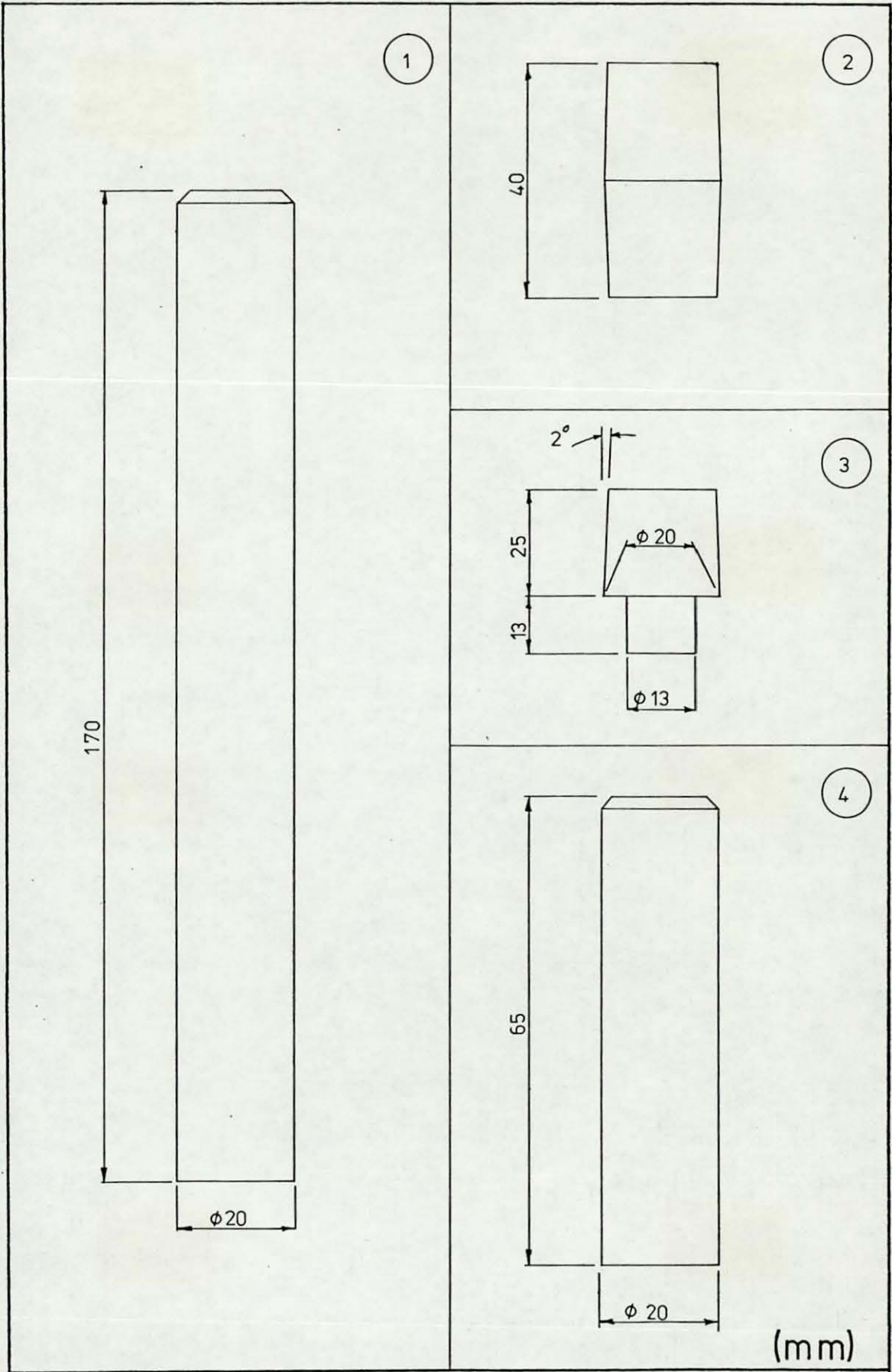


FIGURE 4.23 (vii)      PHOTOGRAPHS OF THE RETRACTABLE DIE  
CORE PREFORM AND PRECISION DRAG  
PATTERN ASSEMBLIES





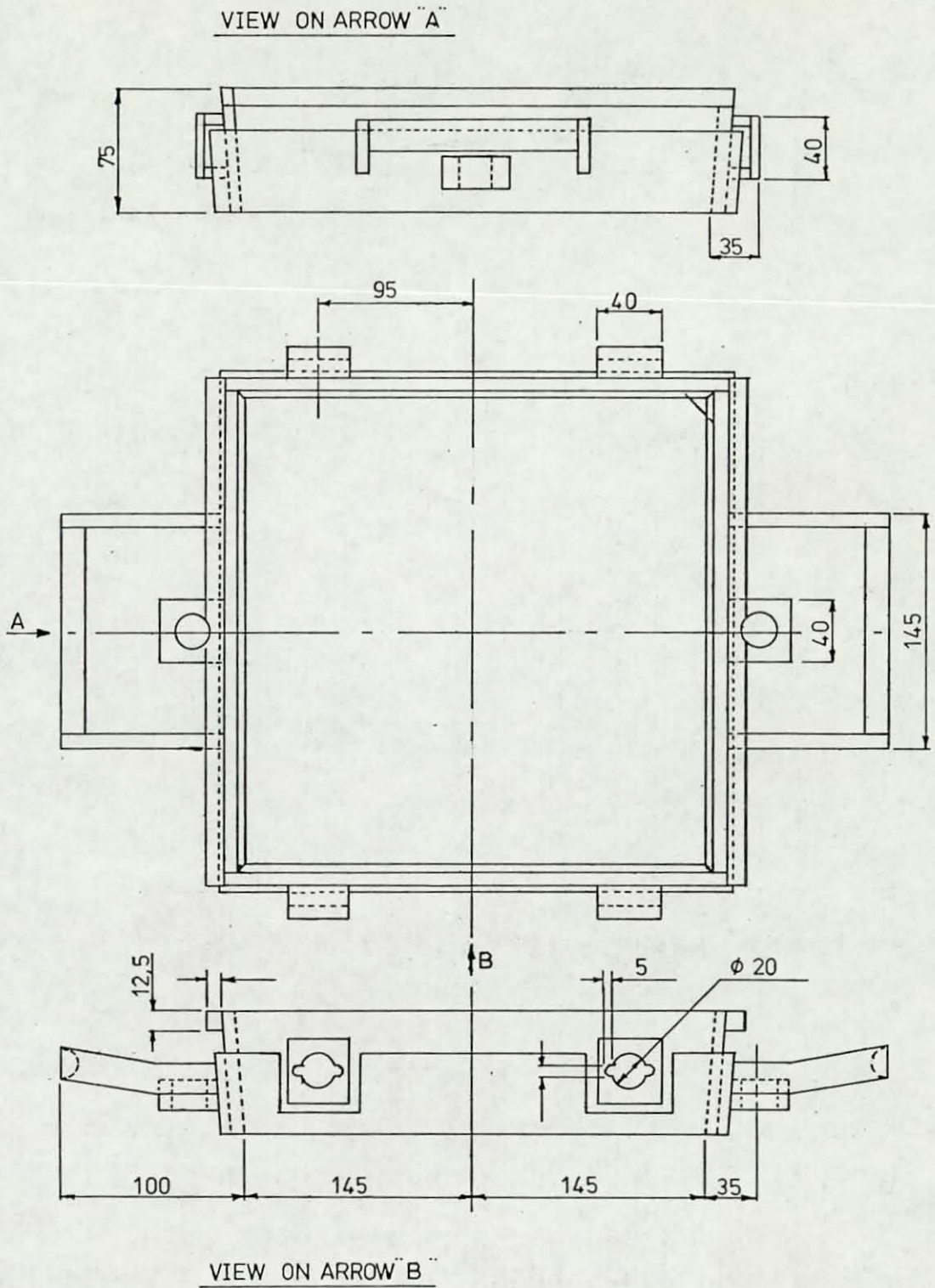
DRAWING NO.

FIGURE 4.24

DESCRIPTION:

BOX AND MOULD LOCATION PIN  
DIMENSIONS





(mm)

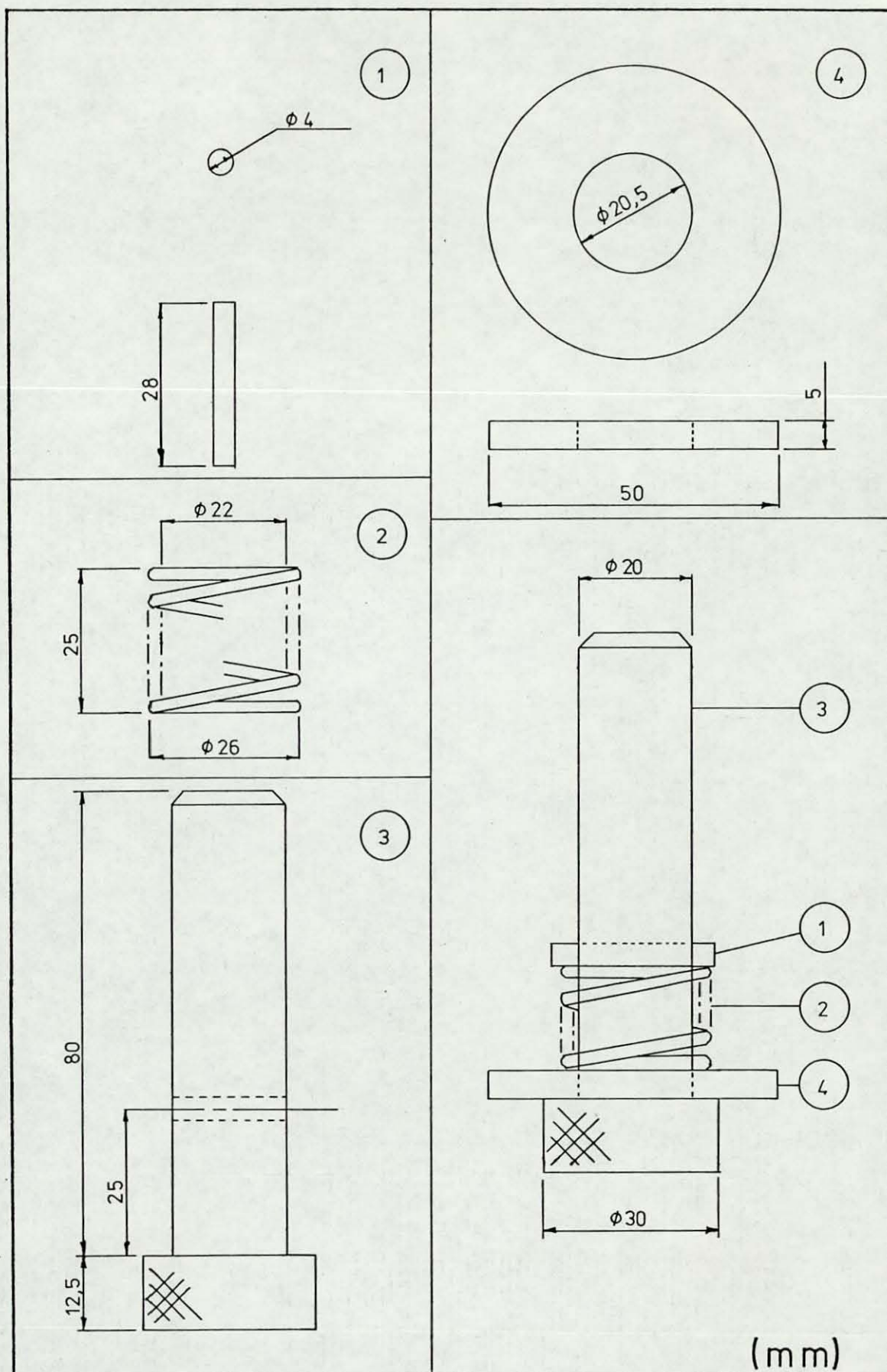
DRAWING NO.

FIGURE 4.25 (ii)

DESCRIPTION:

DRAW MOULDING BOX DIMENSIONS



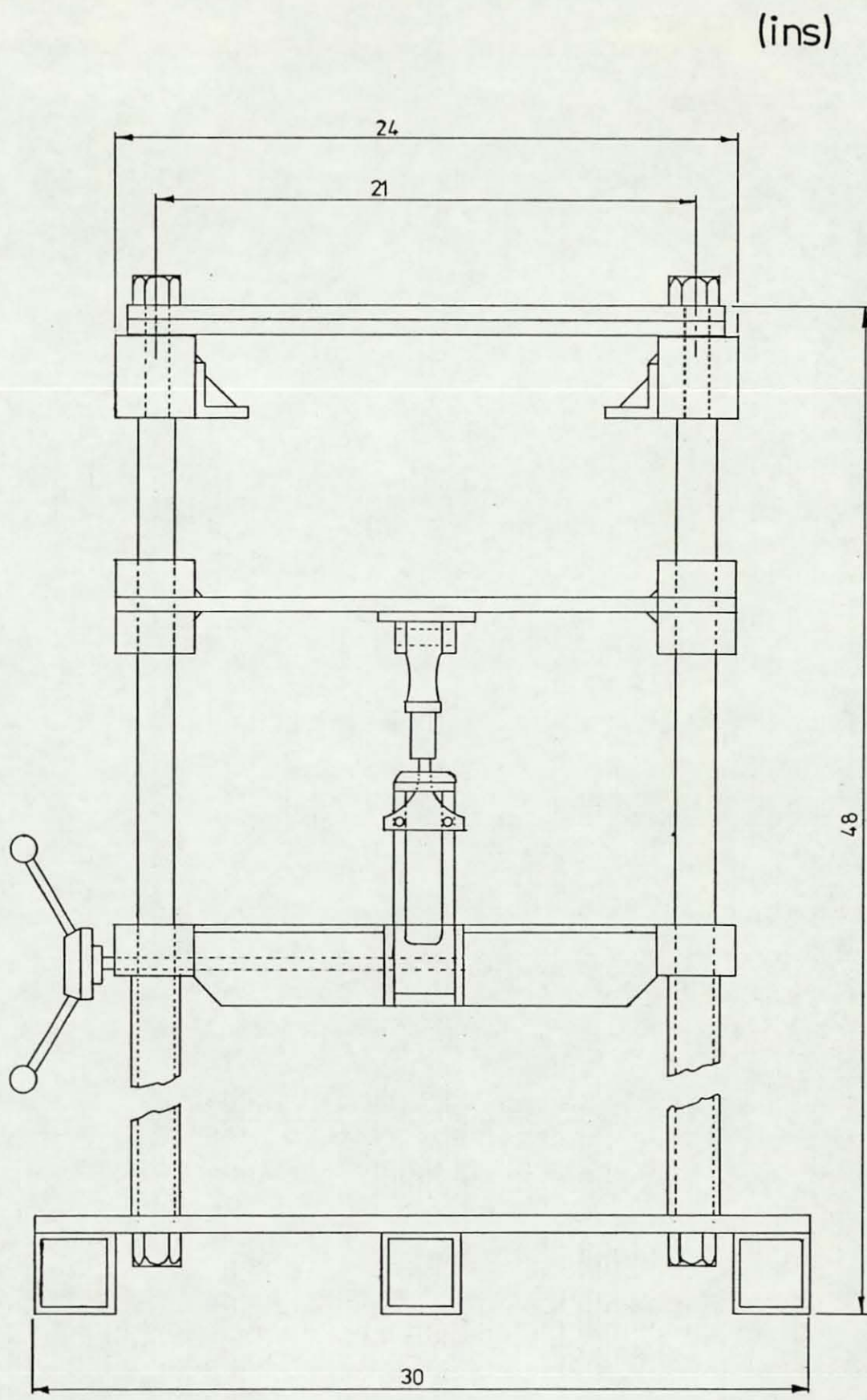


DRAWING NO.

FIGURE 4.25 (iii)

DESCRIPTION:

MOULD RETAINING PIN DIMENSIONS

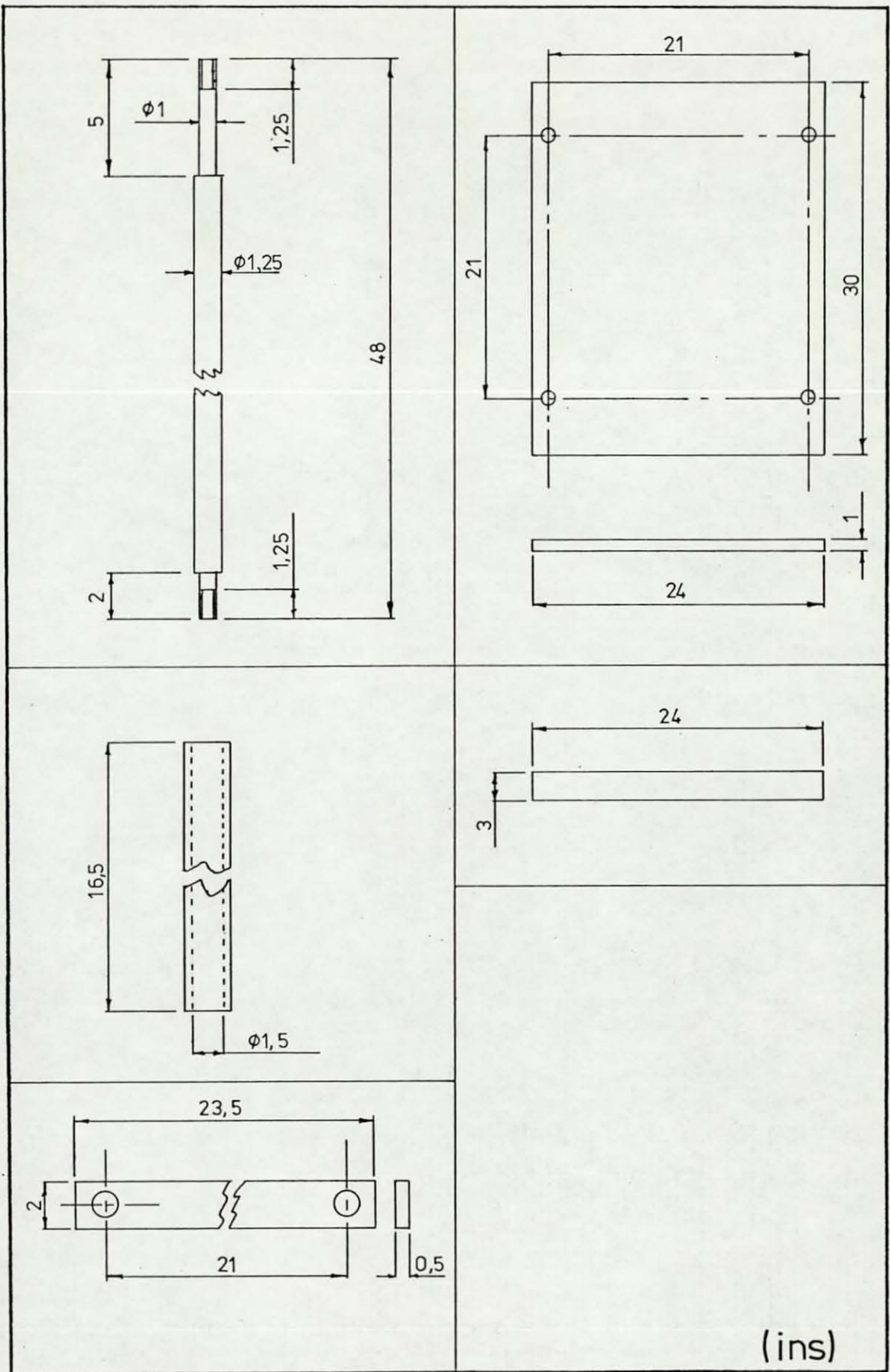


DRAWING NO.

FIGURE 4.26 (1)

DESCRIPTION:

END ELEVATION OF PATTERN  
STRIPPING MACHINE



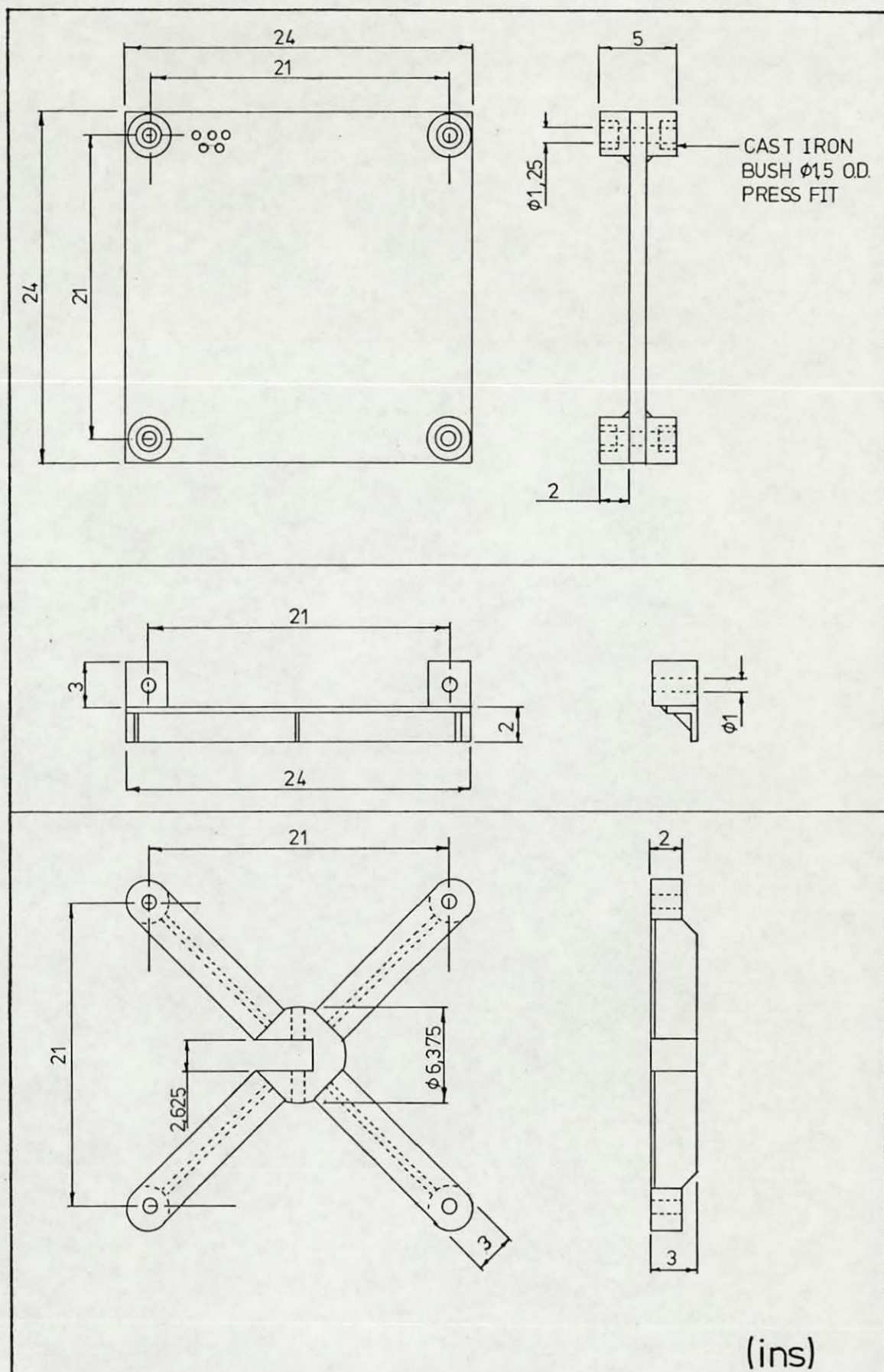
DRAWING NO.

FIGURE 4.26 (ii)

DESCRIPTION:

DETAILS OF PATTERN STRIPPING  
MACHINE PARTS





DRAWING NO.

FIGURE 4.26(iii).

DESCRIPTION:

DETAILS OF PATTERN STRIPPING  
MACHINE PARTS

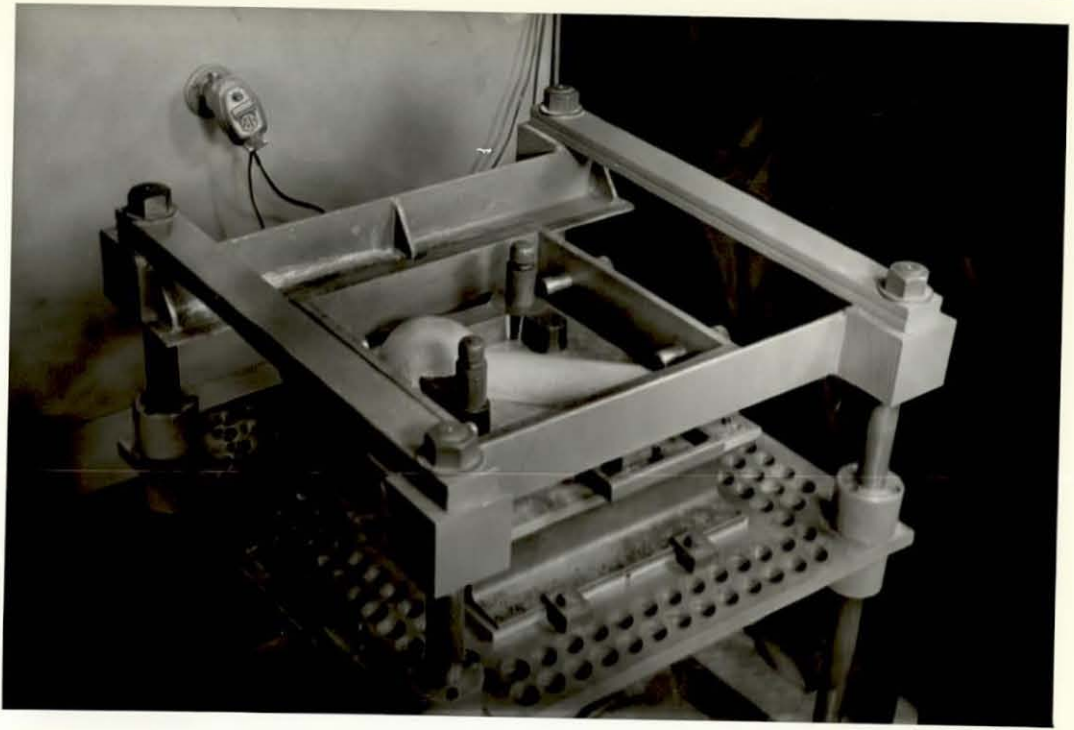


FIGURE 4.27

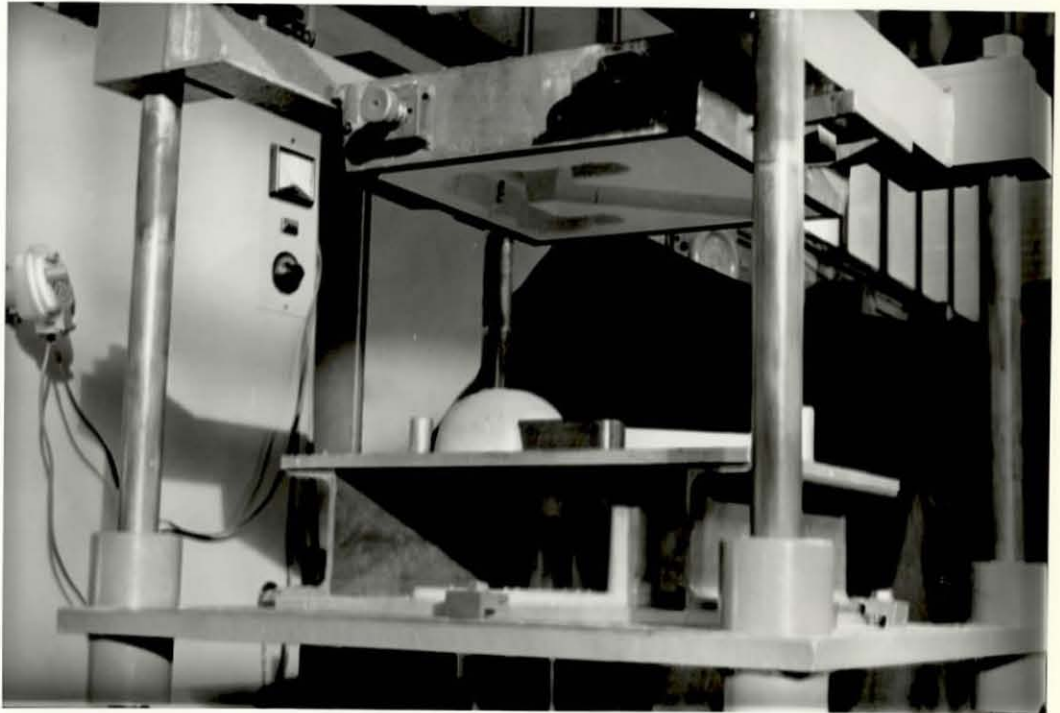


FIGURE 4.28

FIGURES 4.27 & 4.28 PHOTOGRAPHS SHOWING : 4.27-THE  
MOULDING BOX AND PATTERN PLATE ASSEMBLY ON THE PATTERN  
STRIPPING MACHINE ; 4.28 - A COMPLETED MOULD SEPARATED  
FROM THE PATTERN



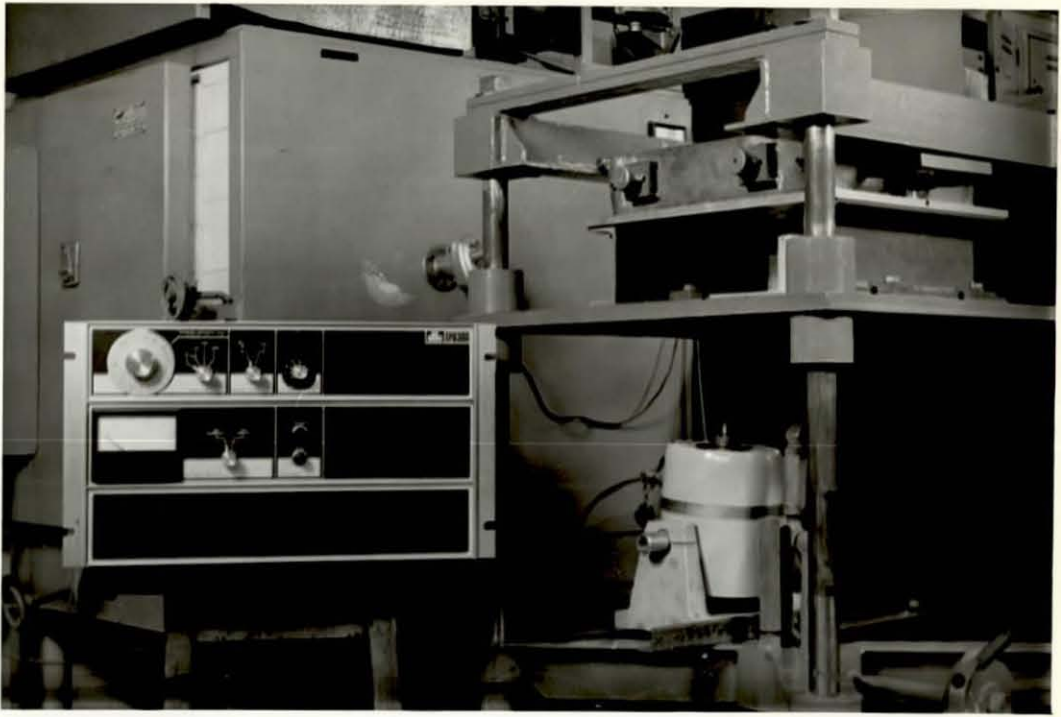


FIGURE 4.29



FIGURE 4.30

FIGURE 4.29 PHOTOGRAPH SHOWING THE VIBRATOR AND CONTROL

FIGURE 4.30 PHOTOGRAPH SHOWING MOULD IGNITION

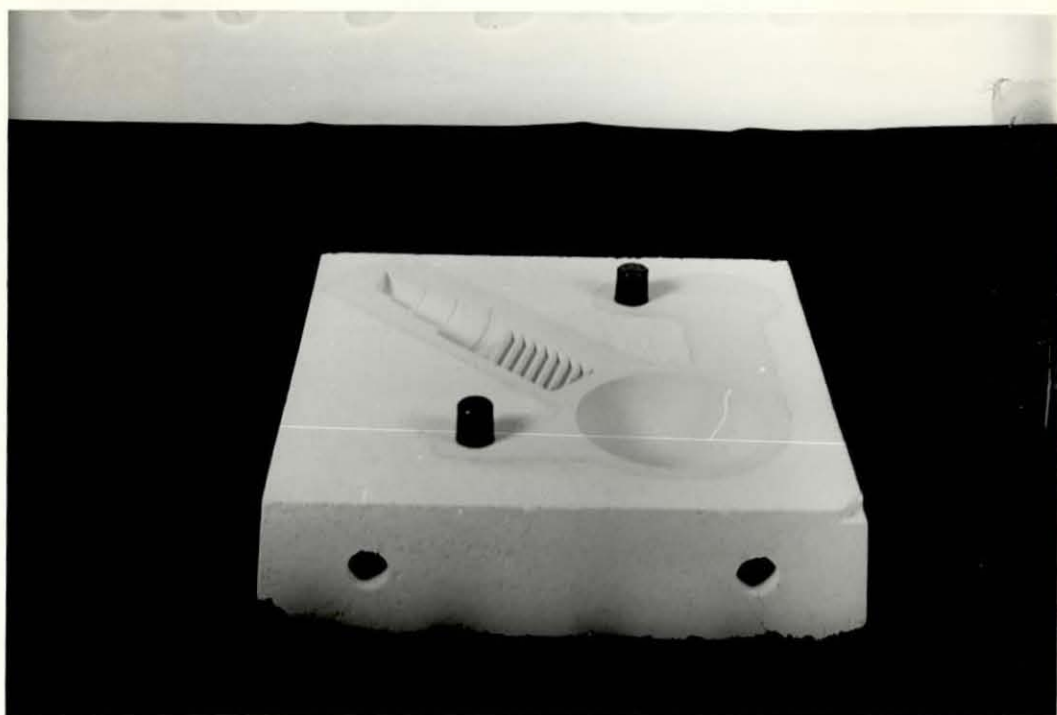


FIGURE 4.31

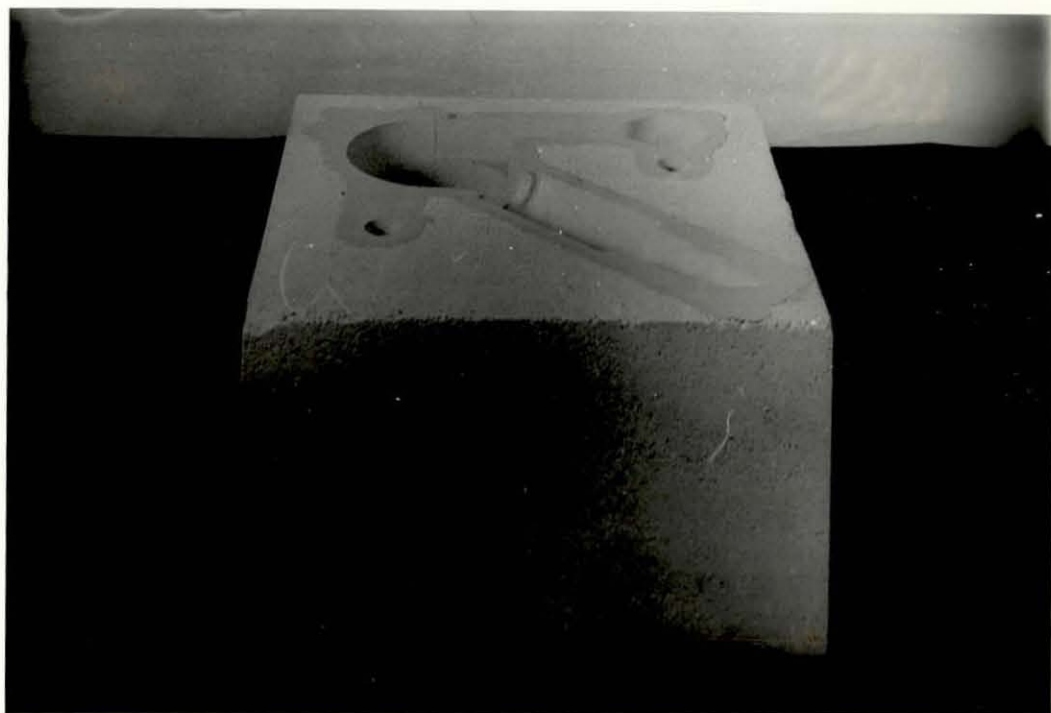
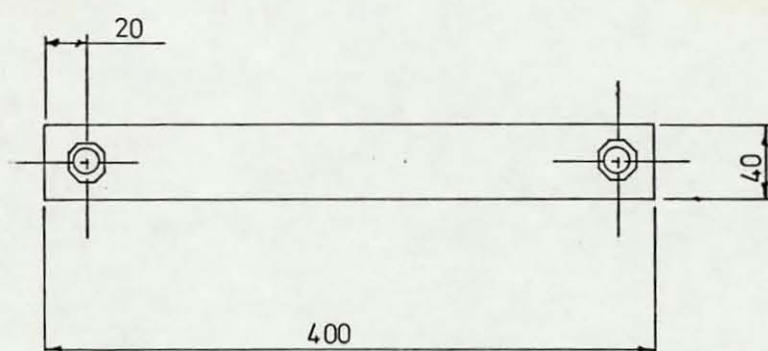
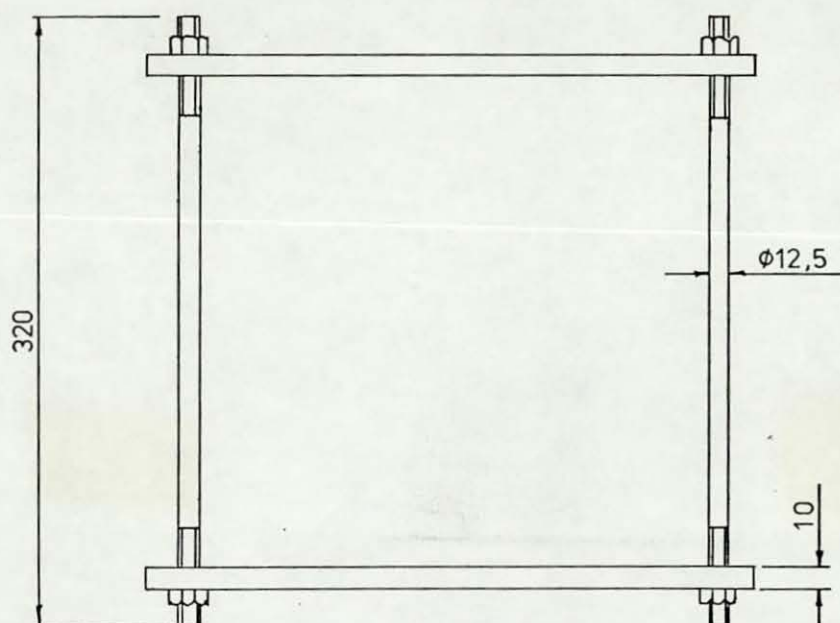


FIGURE 4.32

FIGURE 4.31 PHOTOGRAPH OF A FIRED COPE MOULD

FIGURE 4.32 PHOTOGRAPH OF A FIRED DRAG MOULD

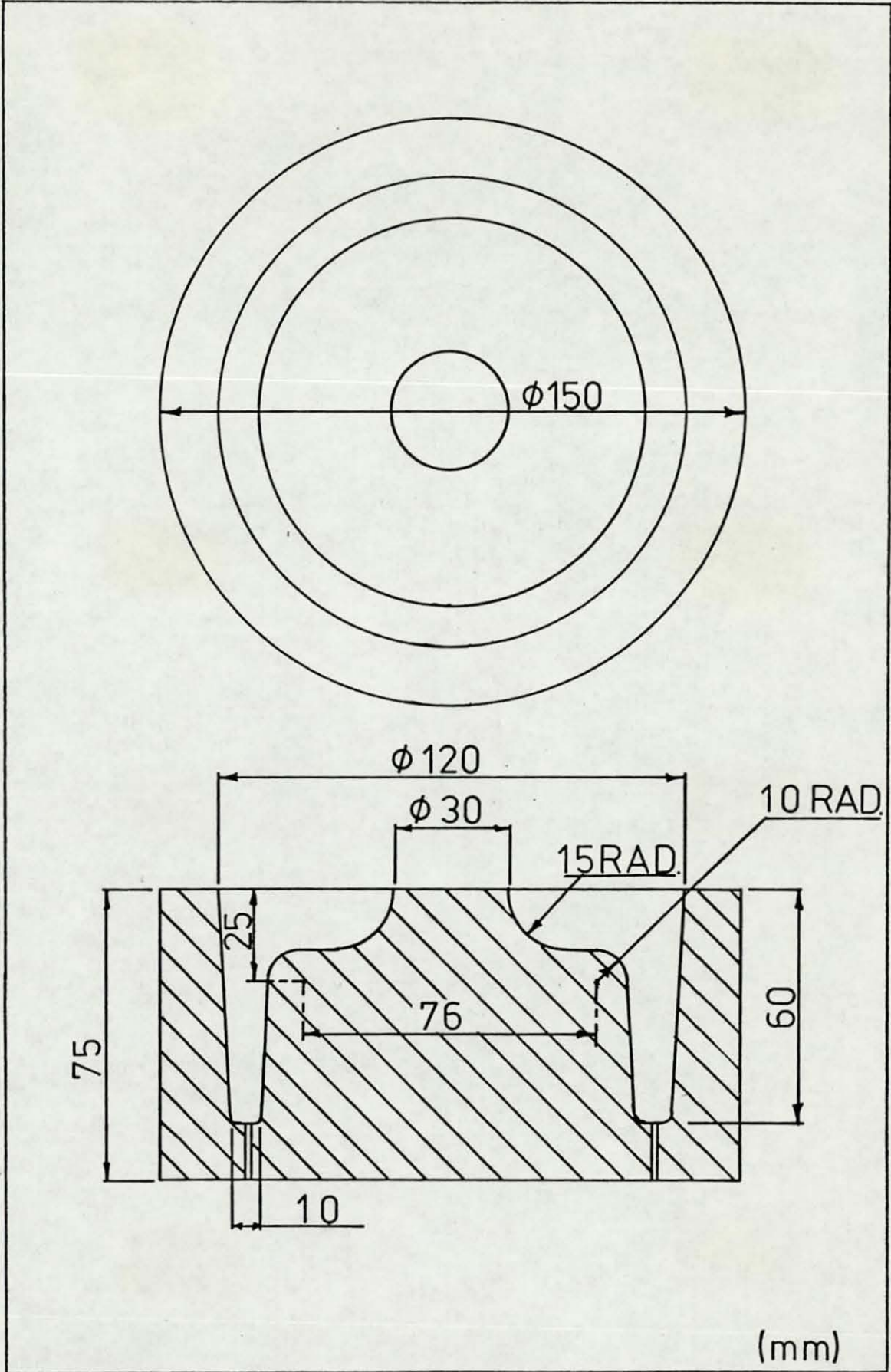


(mm)

DRAWING NO.      FIGURE 4.33

DESCRIPTION:      MOULD CLAMPS





DRAWING NO.

FIGURE 4.34

DESCRIPTION:

POURING CUP DIMENSIONS

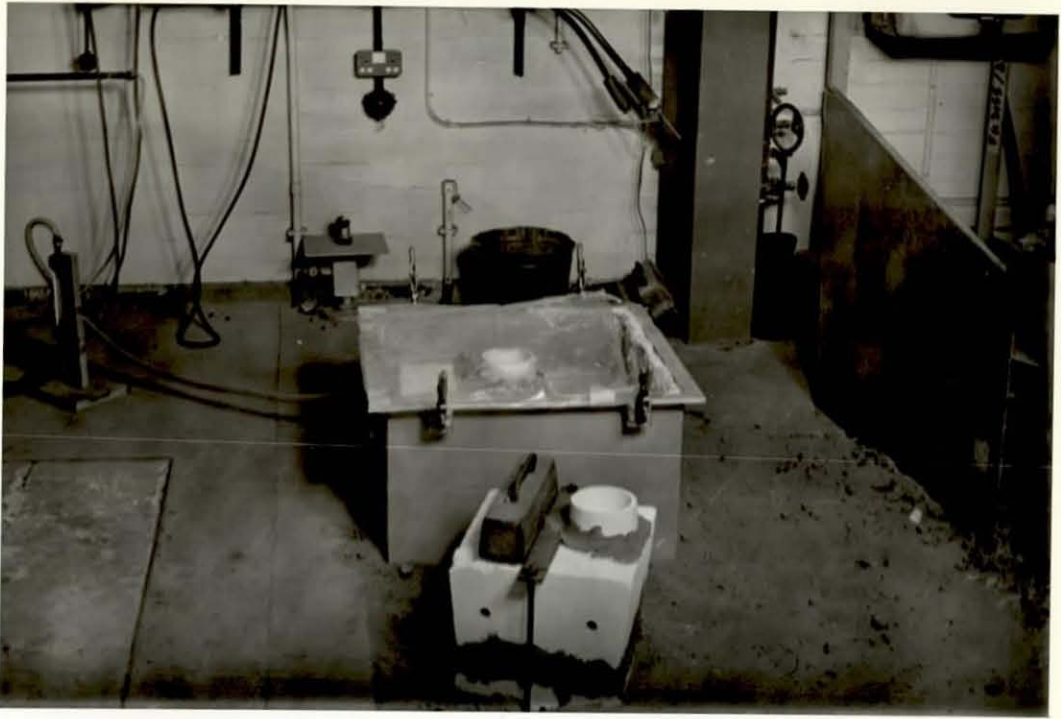
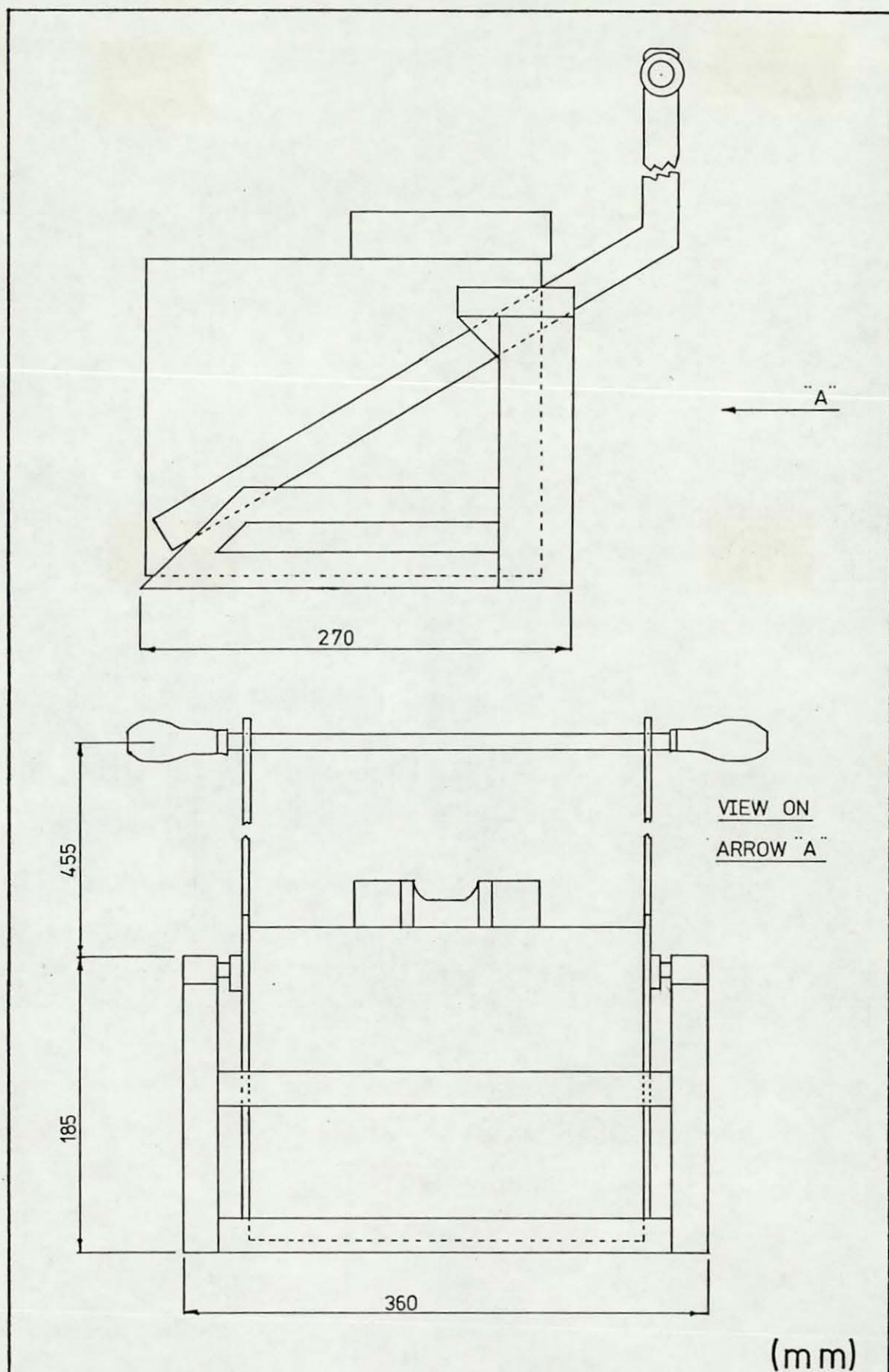


FIGURE 4.35

THE PHOTOGRAPH SHOWS ONE MOULD POSITIONED IN THE  
GAS CONTAINER ( SEE FIGURE 4.40 ) TO PROVIDE A  
NITROGEN MOULD ATMOSPHERE. THE SECOND MOULD WAS TO  
BE CAST IN AIR .

FIGURE 4.35 PHOTOGRAPH OF MOULDS PREPARED FOR CASTING



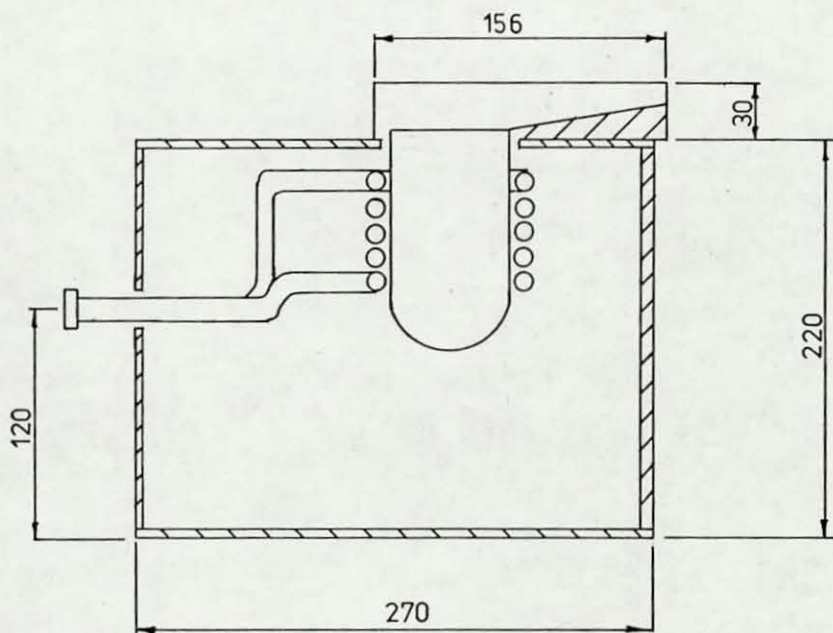
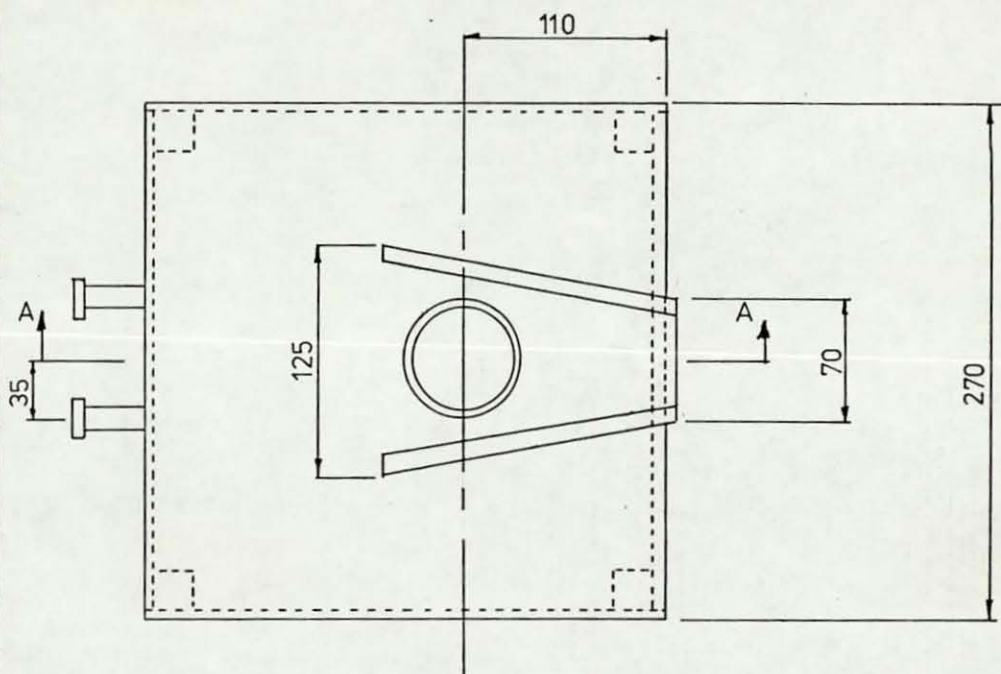


DRAWING NO.

FIGURE 4.36 (i)

DESCRIPTION:

EXPERIMENTAL MELTING FURNACE DESIGN



SECTION A-A

COIL DIMENSIONS :  $\phi 70$  CENTRE LINE  
70 DEPTH  
5 TURNS

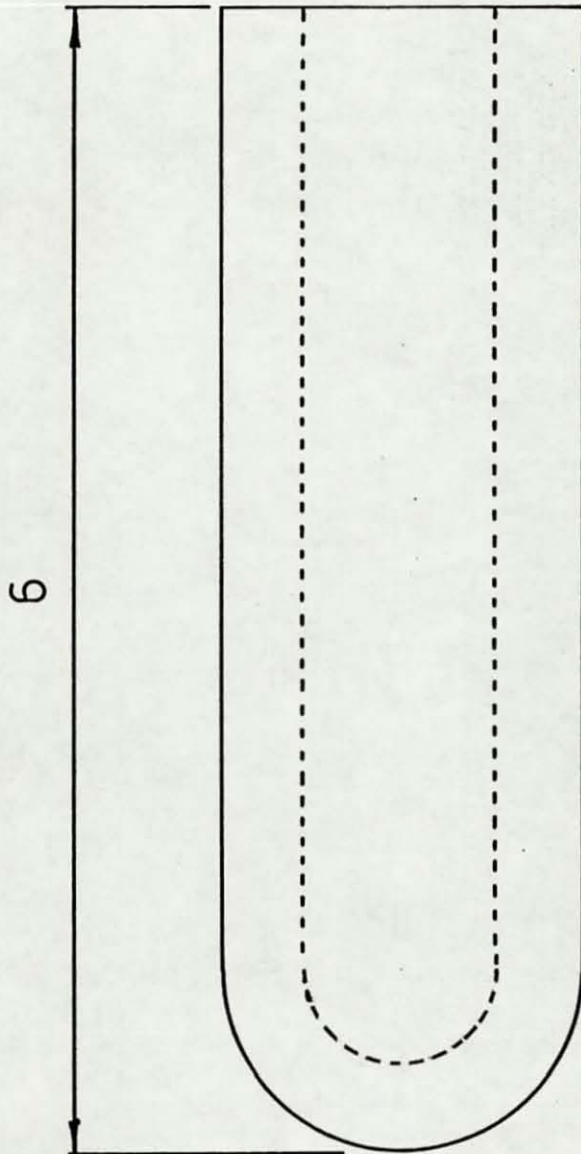
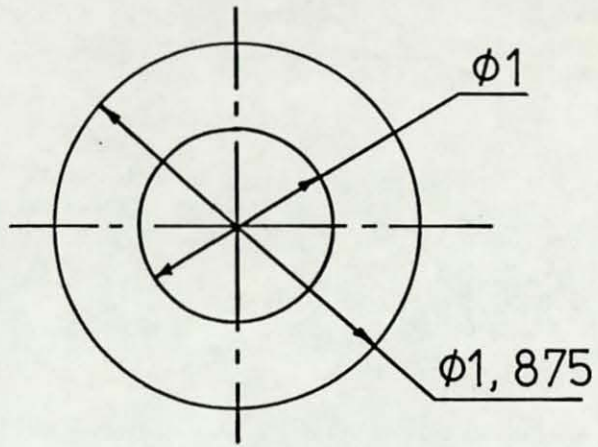
(mm)

DRAWING NO.

FIGURE 4.36 (ii)

DESCRIPTION:

EXPERIMENTAL MELTING FURNACE DESIGN



(ins)

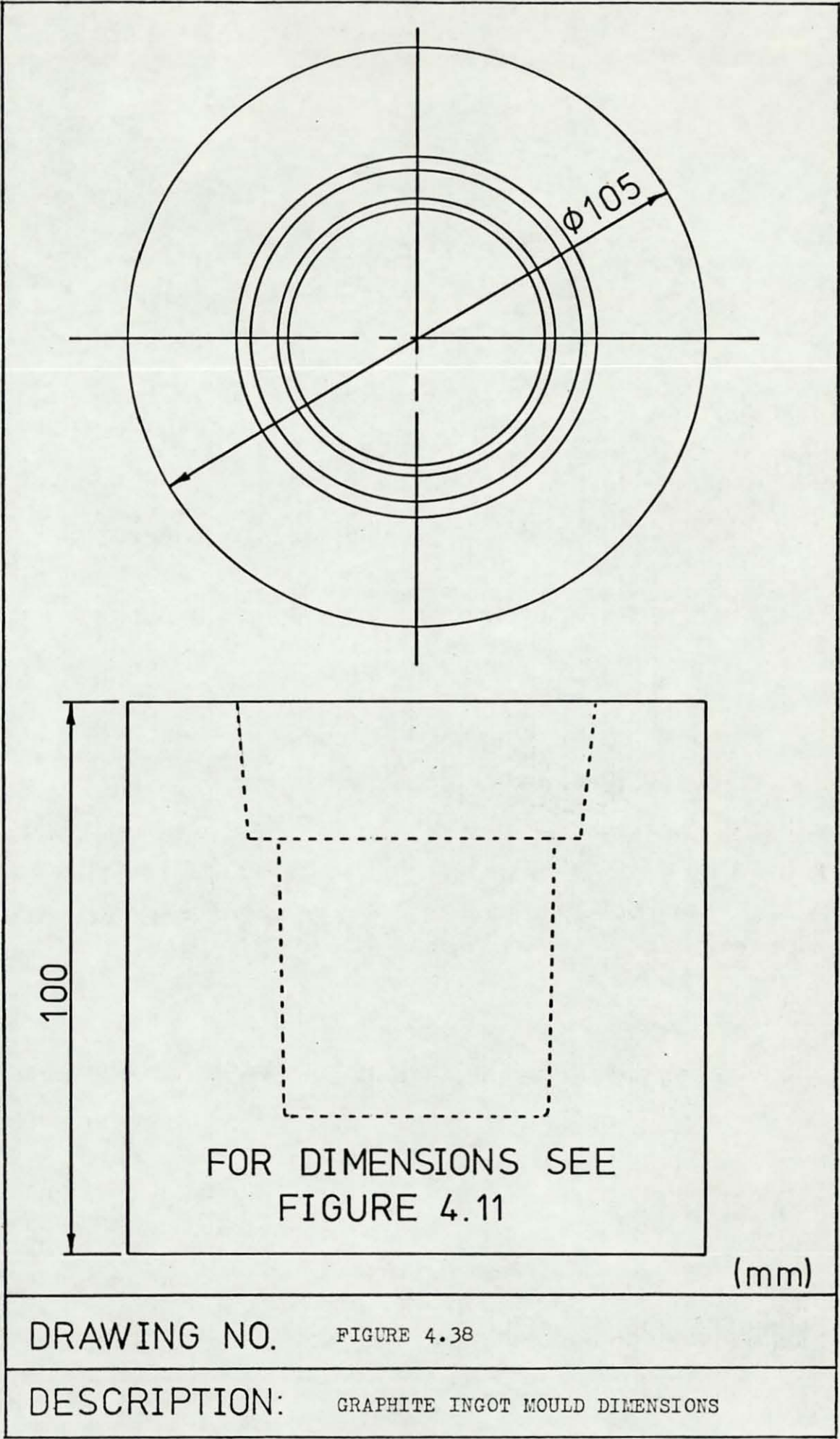
DRAWING NO.

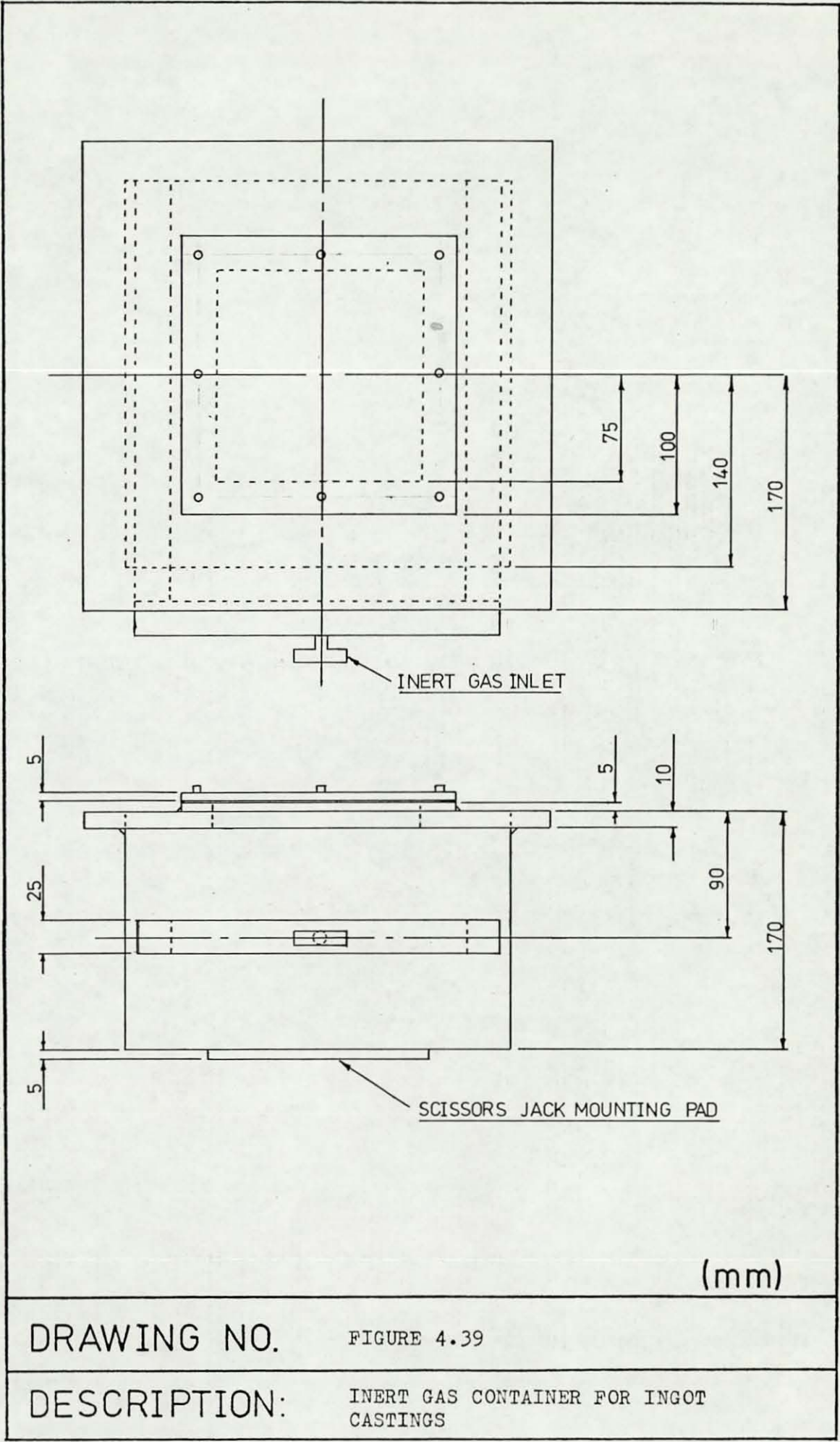
FIGURE 4.37

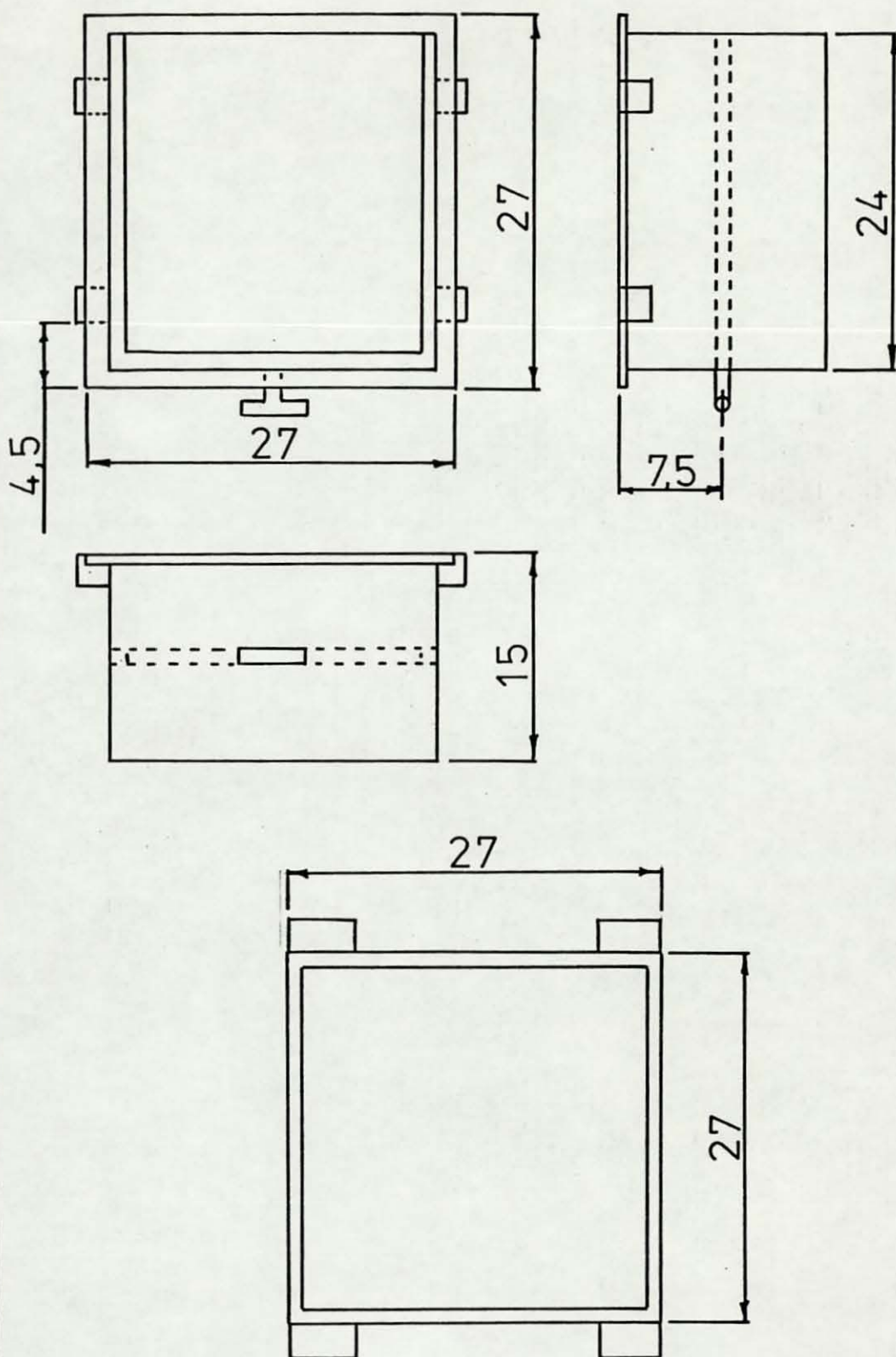
DESCRIPTION:

GRAPHITE SUSCEPTOR DESIGN









(ins)

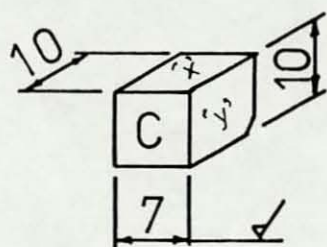
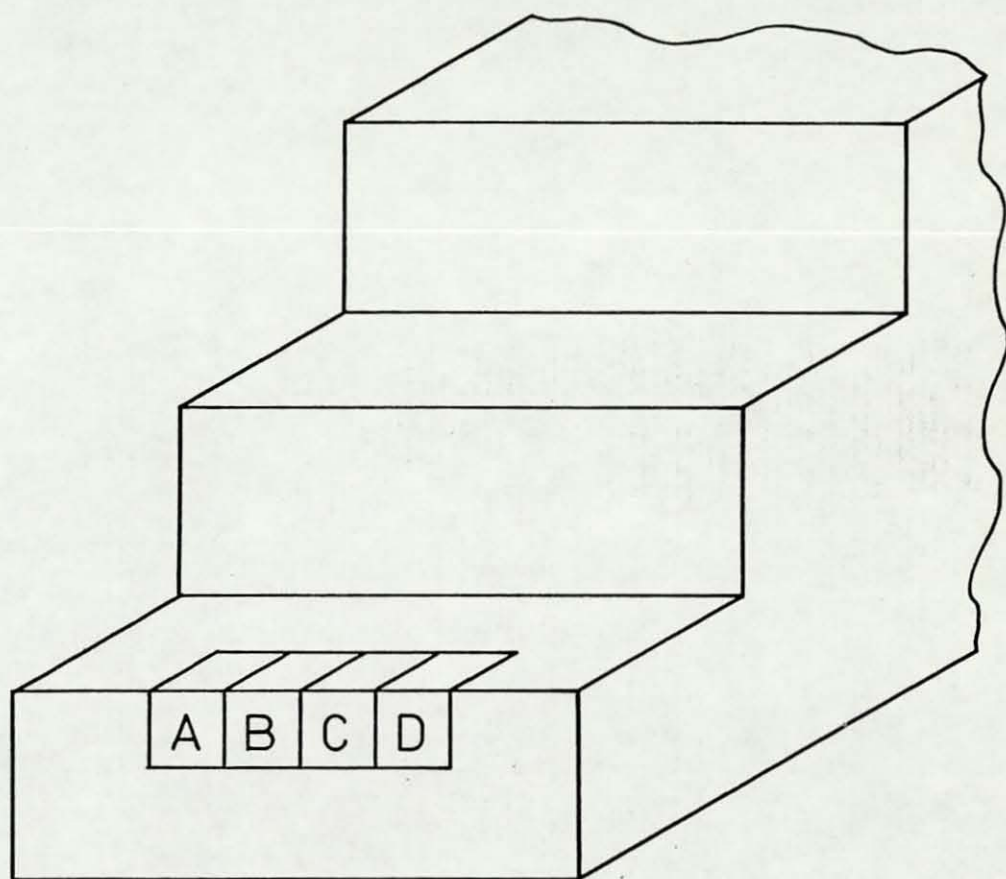
DRAWING NO.

FIGURE 4.40

DESCRIPTION:

INERT GAS CONTAINER FOR LARGE  
TEST CASTINGS





FACE x THE FACE FROM WHICH  
MATERIAL WAS REMOVED BY EDM

FACE y THE FACE SUBJECTED  
TO EXAMINATION BY EPMA AND  
OTHER TECHNIQUES

(mm)

DRAWING NO.

FIGURE 4.41

DESCRIPTION:

LOCATION AND DIMENSIONS OF SPECIMENS  
FOR EDM FINISHING AND EXAMINATION

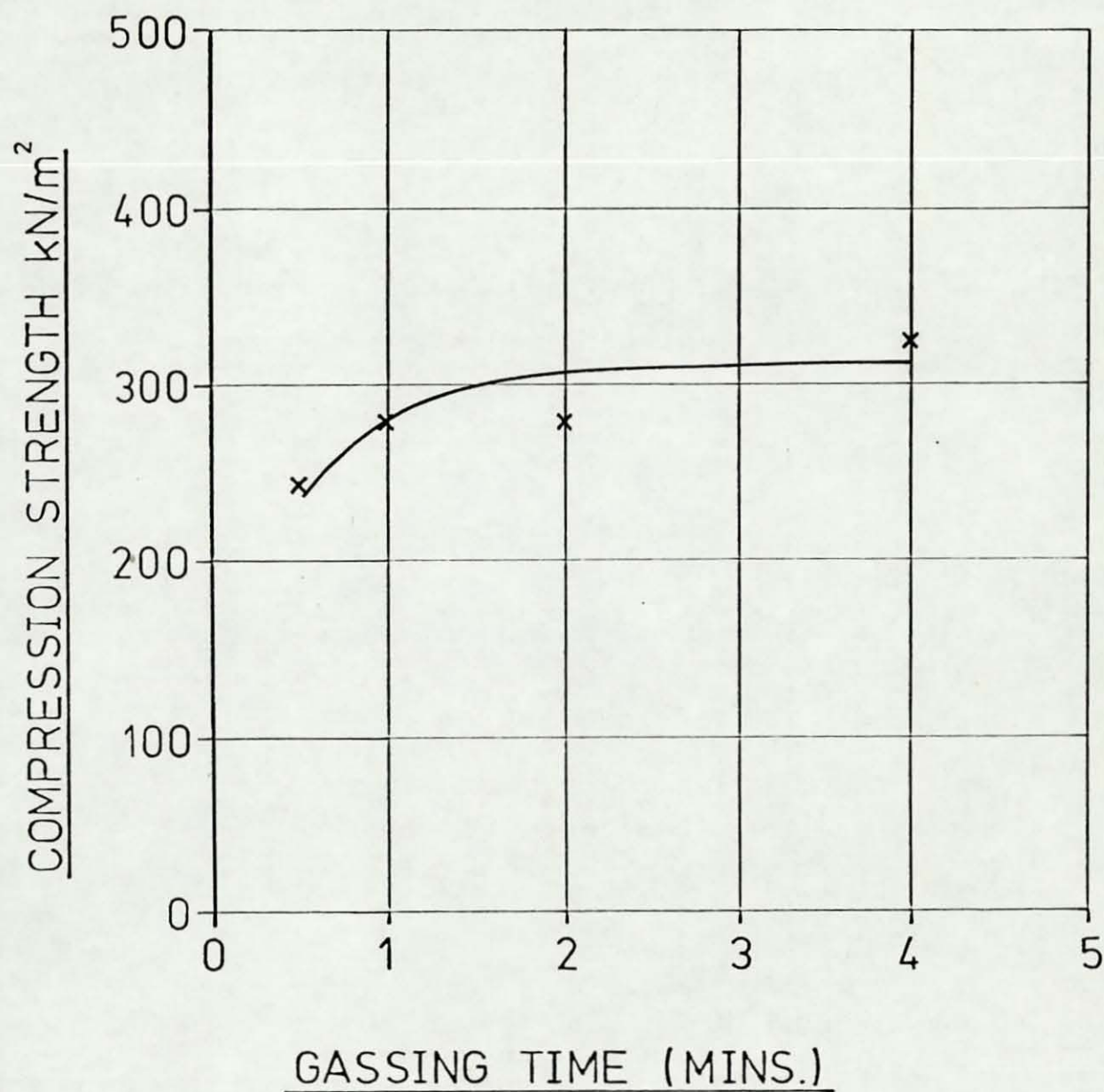


FIGURE 5.1 THE EFFECT OF GASSING TIME ON THE COMPRESSION STRENGTH OF FIRECLAY GROG BONDED WITH 4% C125 SODIUM SILICATE (FLOW RATE 5 l/m)



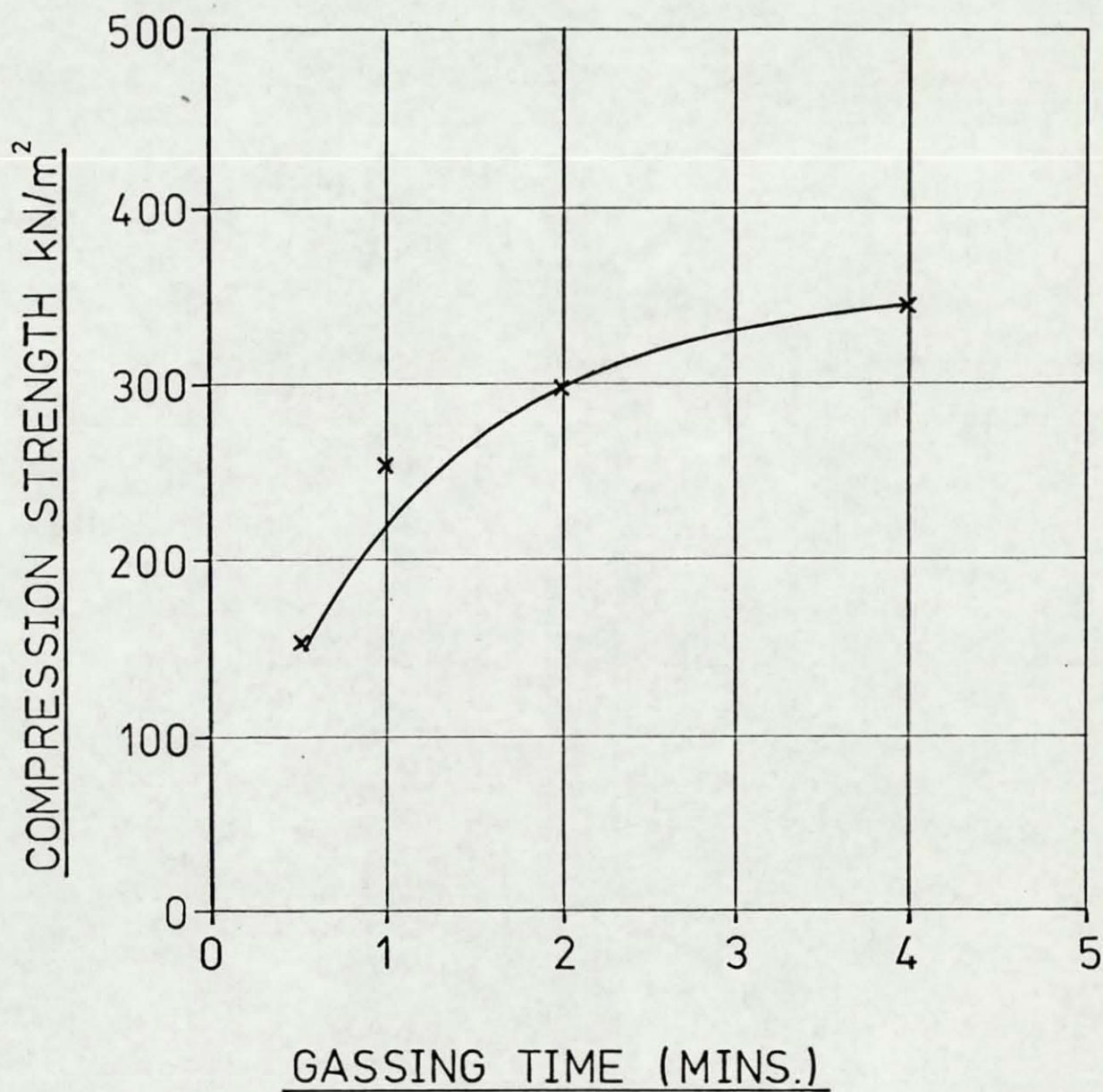


FIGURE 5.2 THE EFFECT OF GASSING TIME ON THE COMPRESSION STRENGTH OF FIRECLAY GROG BONDED WITH 6% C125 SODIUM SILICATE (FLOW RATE 5 l/m)

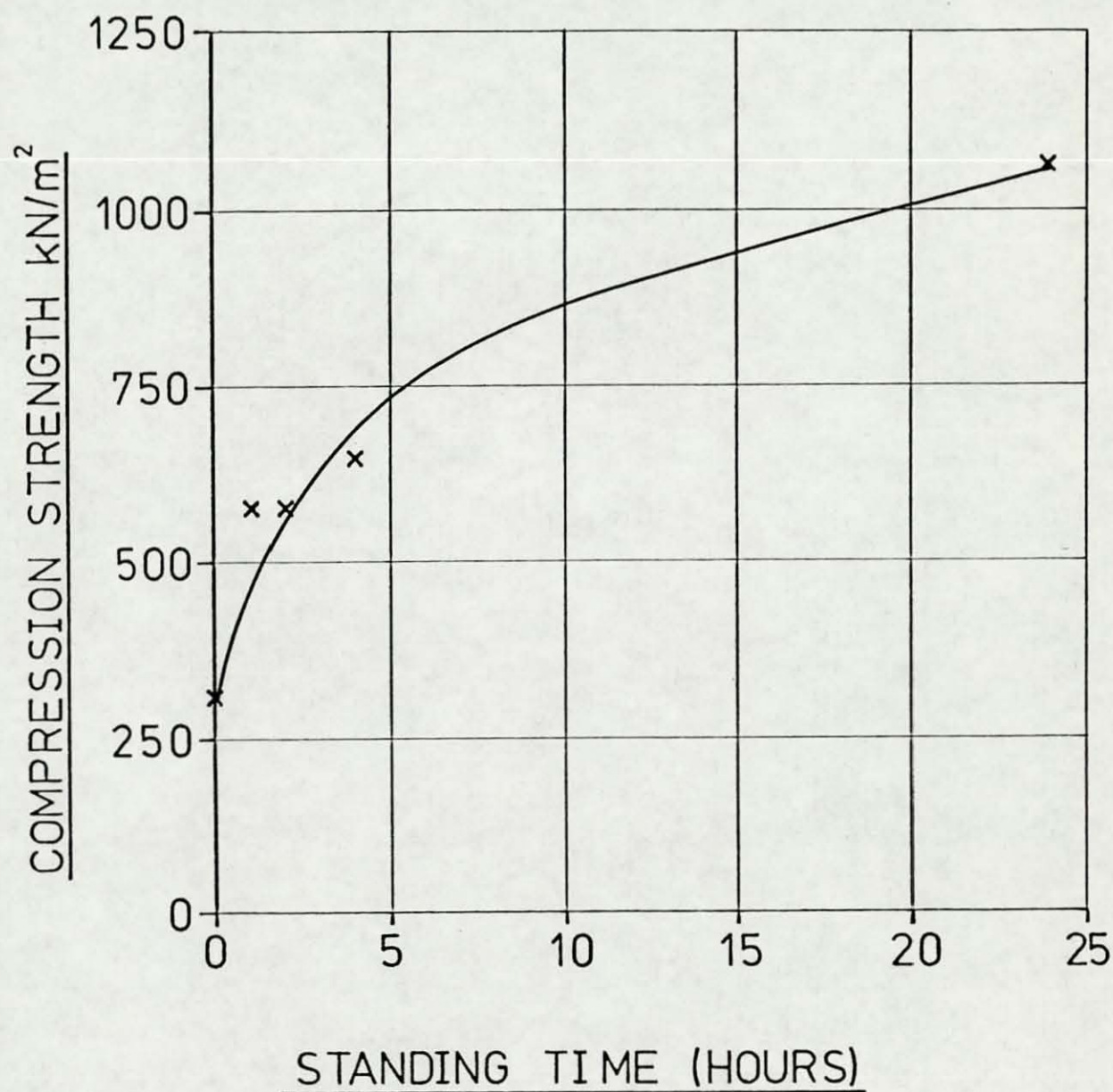


FIGURE 5.3 THE EFFECT OF STANDING TIME ON THE GASSED COMPRESSION STRENGTH OF FIRECLAY GROG BONDED WITH 6% C125 SODIUM SILICATE (FLOW RATE 5 l/m)

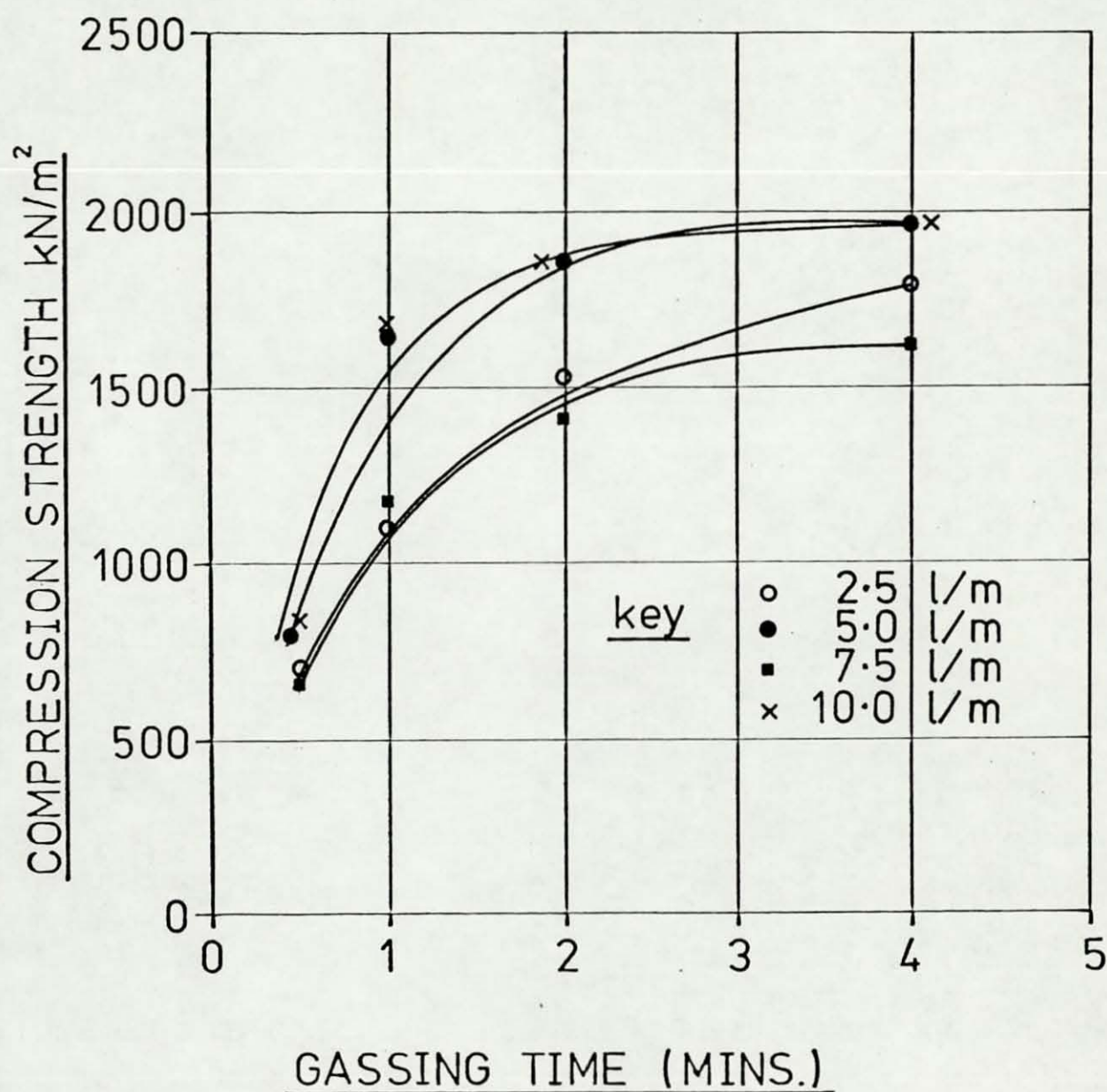


FIGURE 5.4 THE EFFECT OF GASSING TIME AND FLOW RATE ON THE COMPRESSION STRENGTH OF BLENDED MOLOCHITE BONDED WITH 6% C125 SODIUM SILICATE



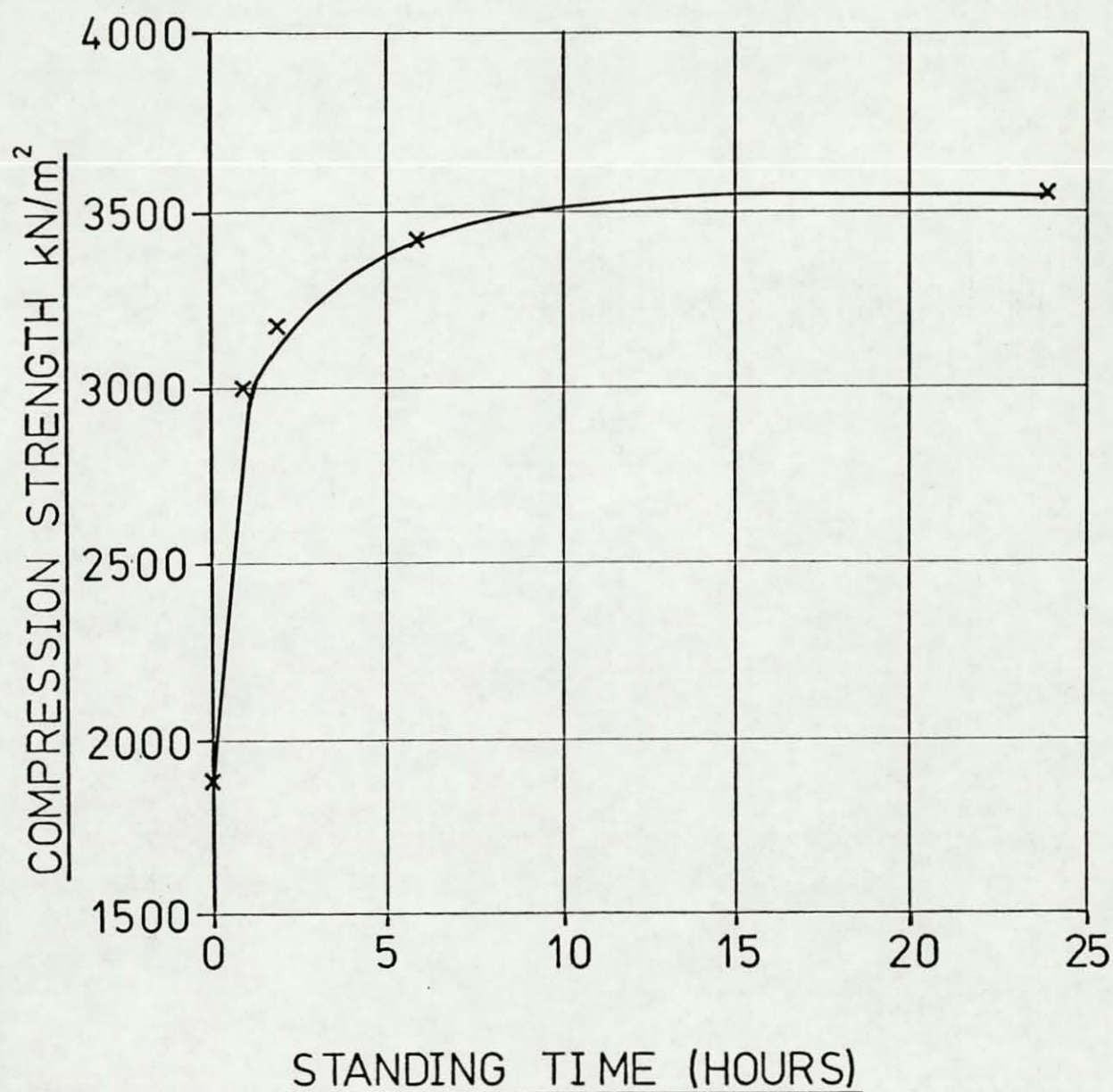


FIGURE 5.5 THE EFFECT OF STANDING TIME ON THE GASSED COMPRESSION STRENGTH OF BLENDED MOLOCHITE BONDED WITH 6% C125 SODIUM SILICATE (FLOW RATE 5 l/m)

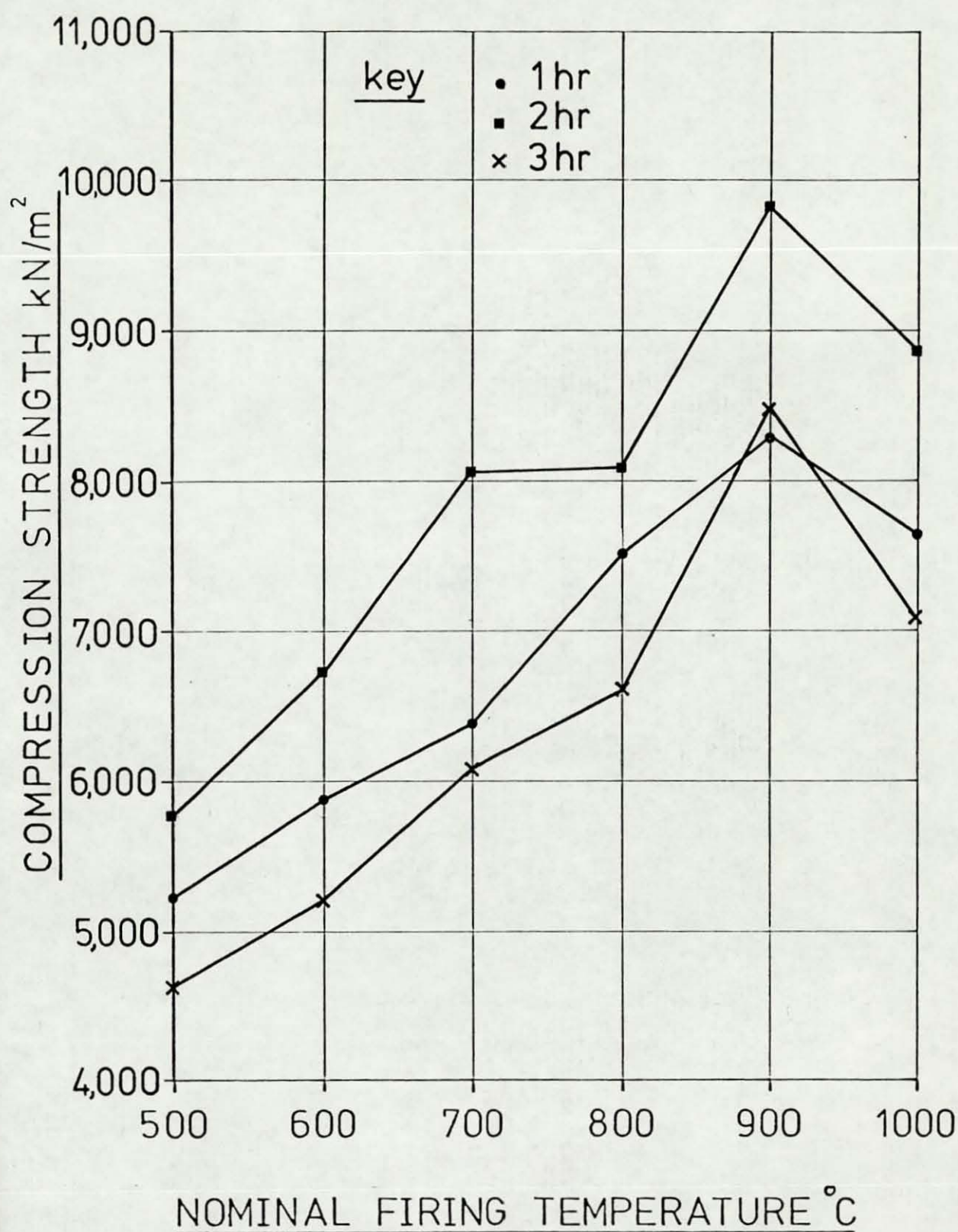


FIGURE 5.6 THE EFFECT OF FIRING TEMPERATURE AND TIME AT FIRING TEMPERATURE ON THE RETAINED COMPRESSION STRENGTH OF SODIUM SILICATE BONDED MOLOCHITE



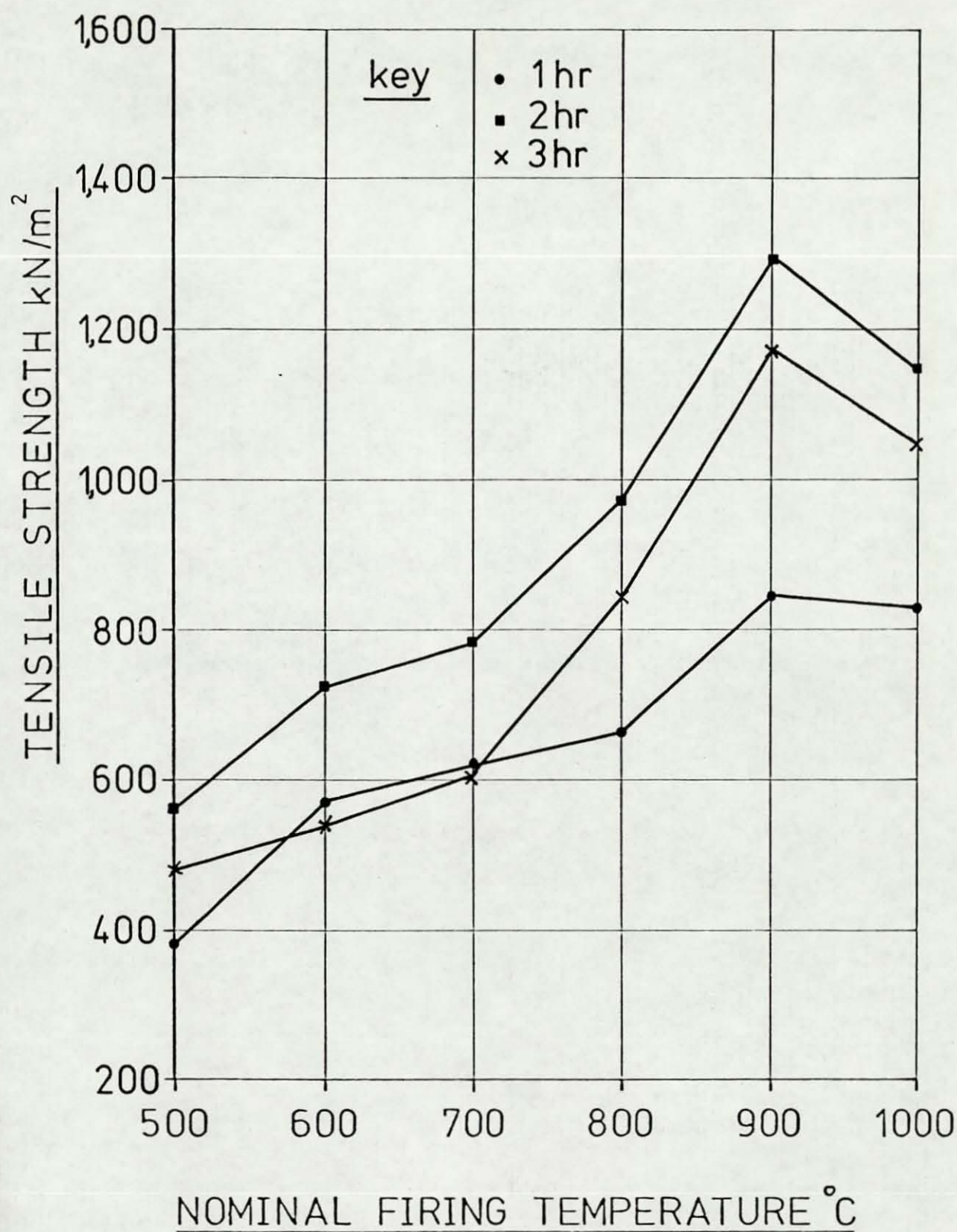


FIGURE 5.7 THE EFFECT OF FIRING TEMPERATURE AND TIME AT FIRING TEMPERATURE ON THE RETAINED TENSILE STRENGTH OF SODIUM SILICATE BONDED MOLOCHITE

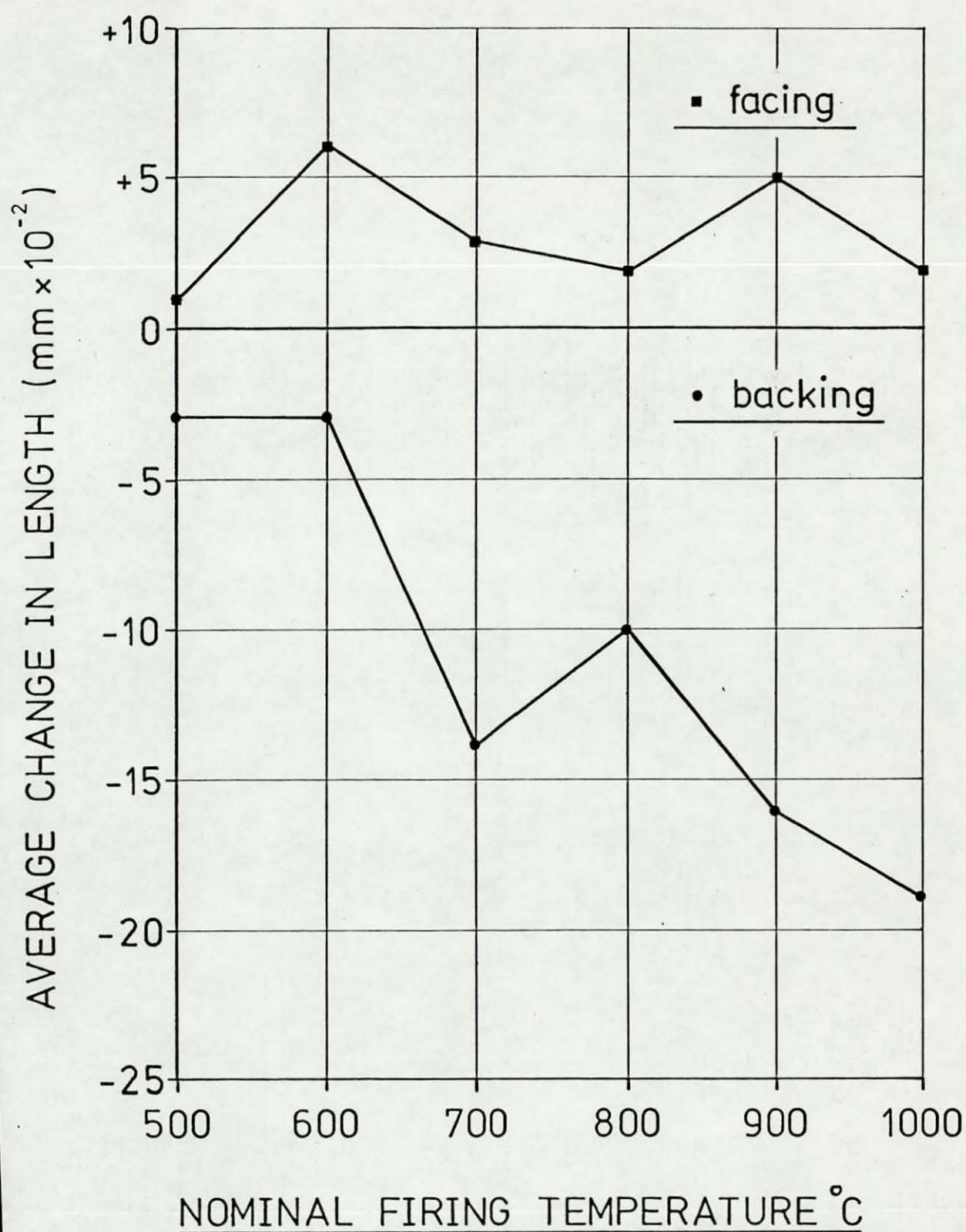


FIGURE 5.8 THE EFFECT OF FIRING TEMPERATURE ON THE DIMENSIONAL STABILITY OF THE CERAMIC FACING SLURRY AND THE SODIUM SILICATE BONDED MOLOCHITE



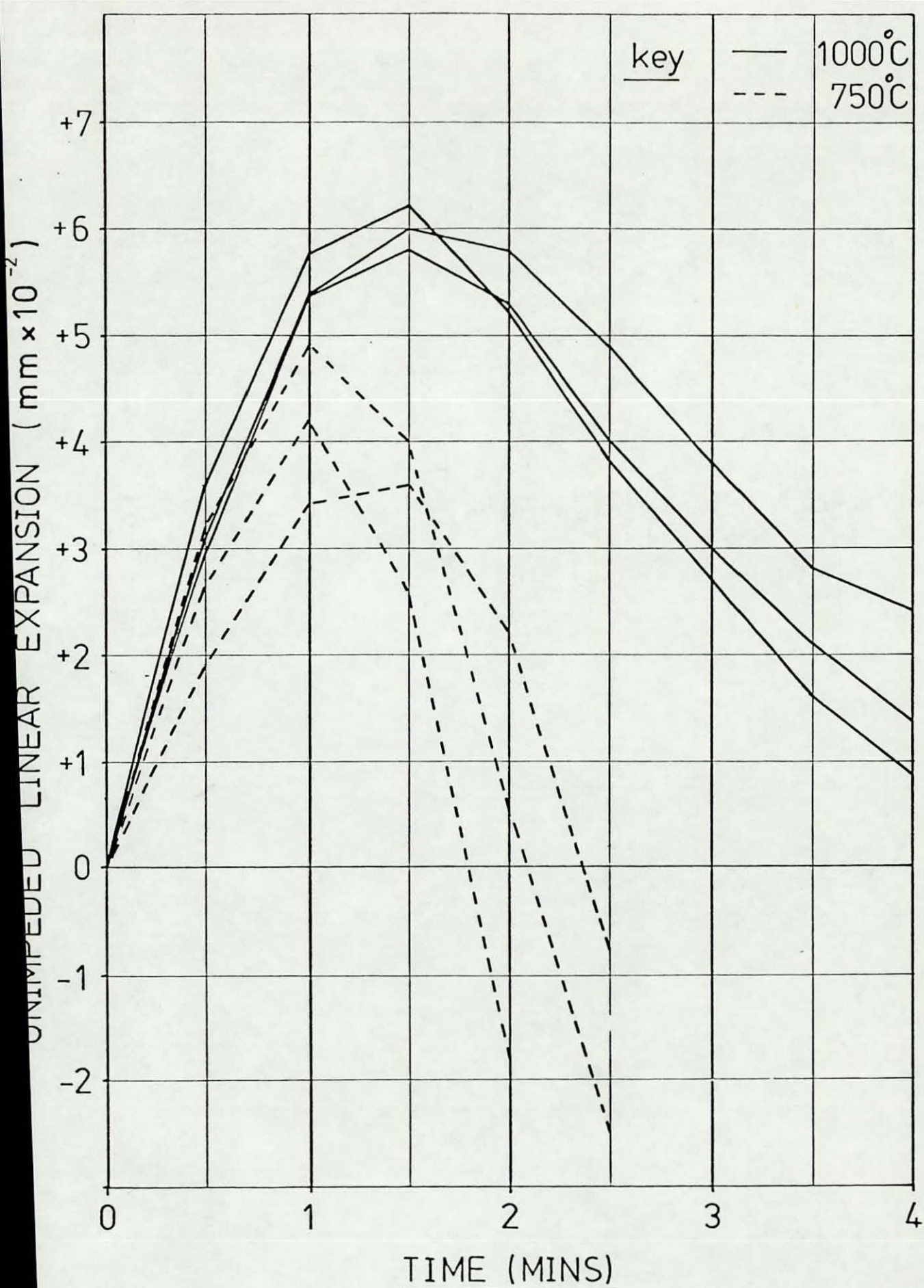


FIGURE 5.9 UNIMPEDED LINEAR EXPANSION OF THE SODIUM SILICATE BONDED MOLOCHITE

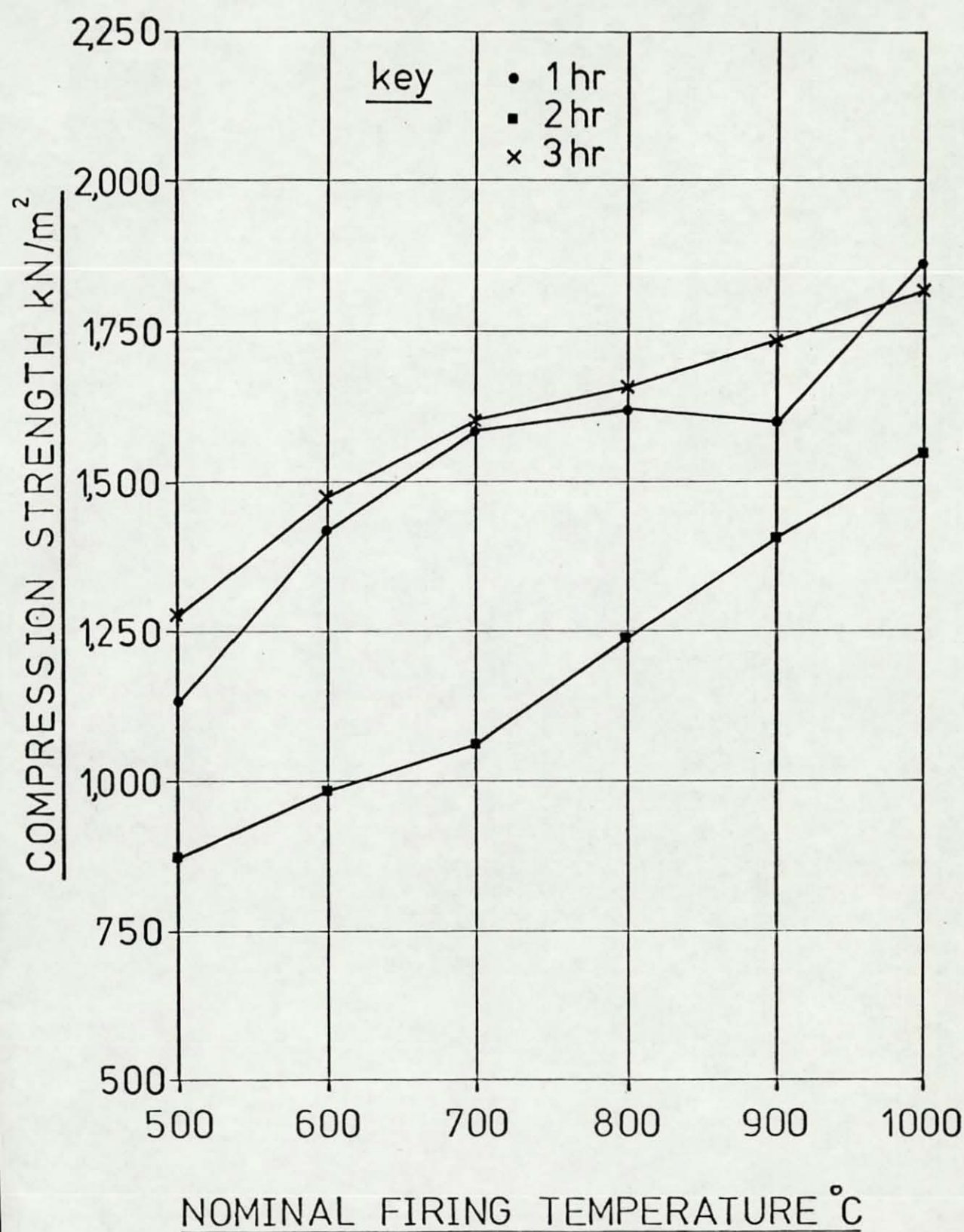


FIGURE 5.10 THE EFFECT OF FIRING TEMPERATURE AND TIME  
AT FIRING TEMPERATURE ON THE RETAINED COMPRESSION  
STRENGTH OF THE CERAMIC FACING SLURRY

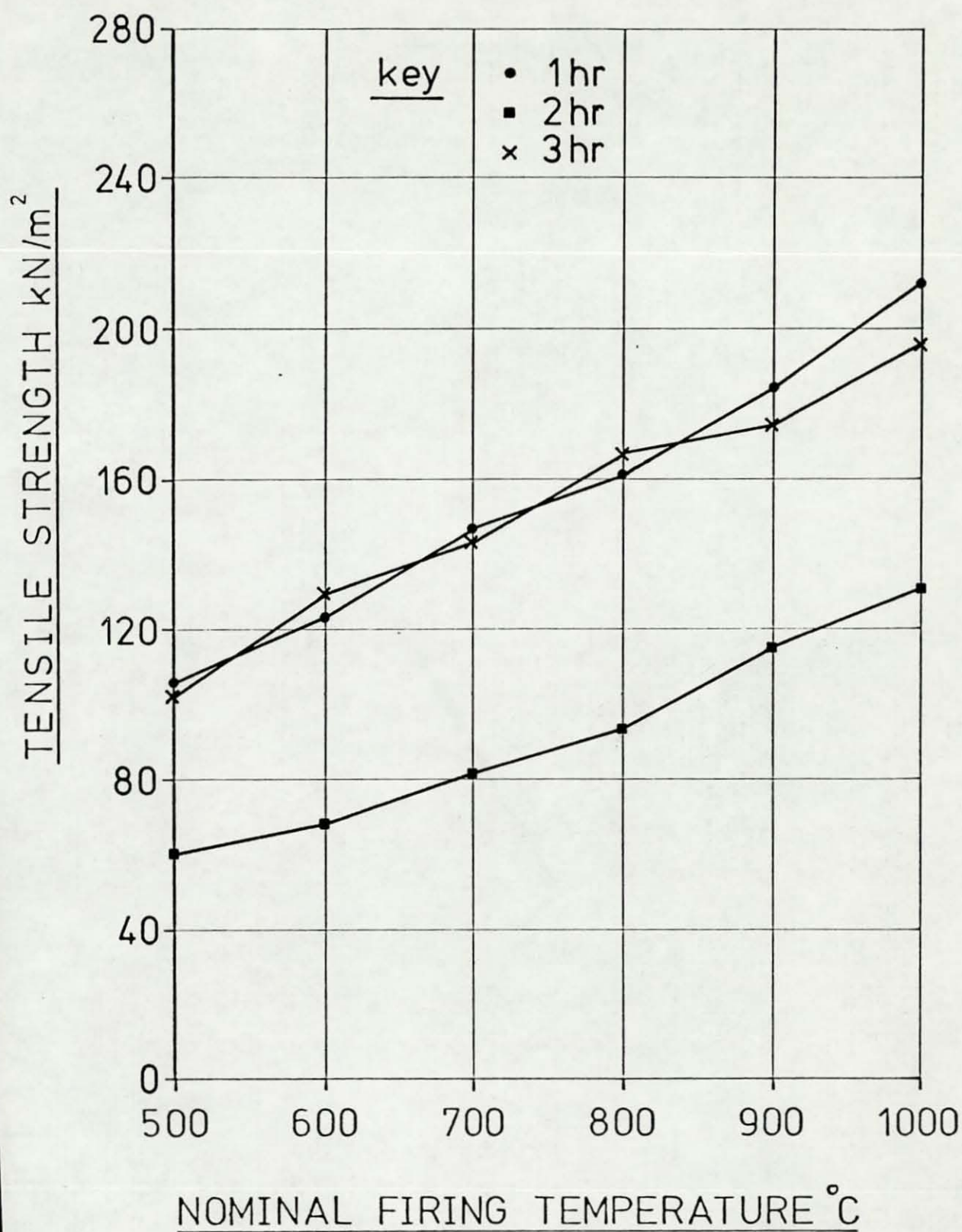


FIGURE 5.11 THE EFFECT OF FIRING TEMPERATURE AND TIME AT FIRING TEMPERATURE ON THE RETAINED TENSILE STRENGTH OF THE CERAMIC FACING SLURRY



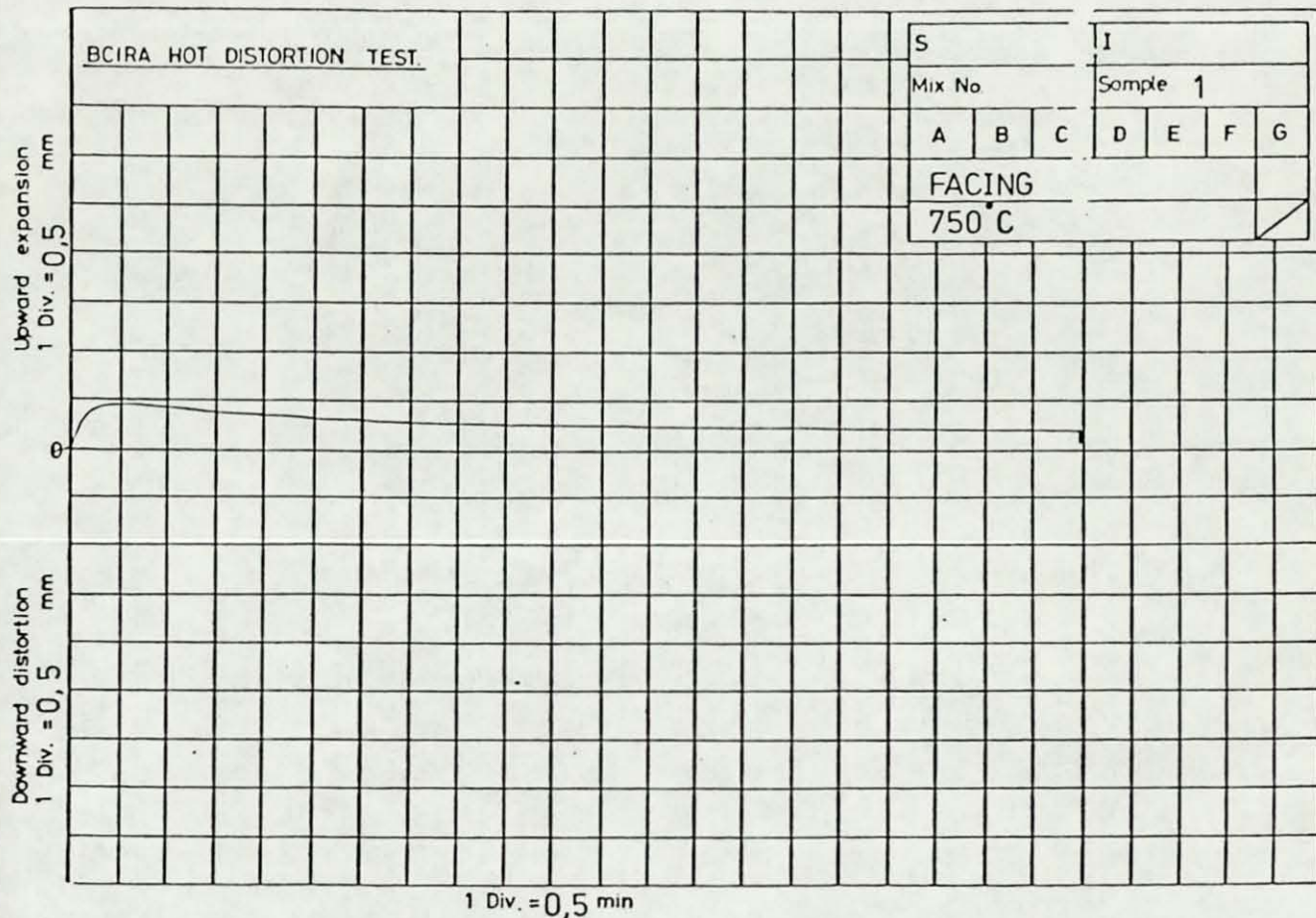


FIGURE 5.12a HOT DISTORTION OF THE CERAMIC FACING SLURRY FIRED AT 750°C

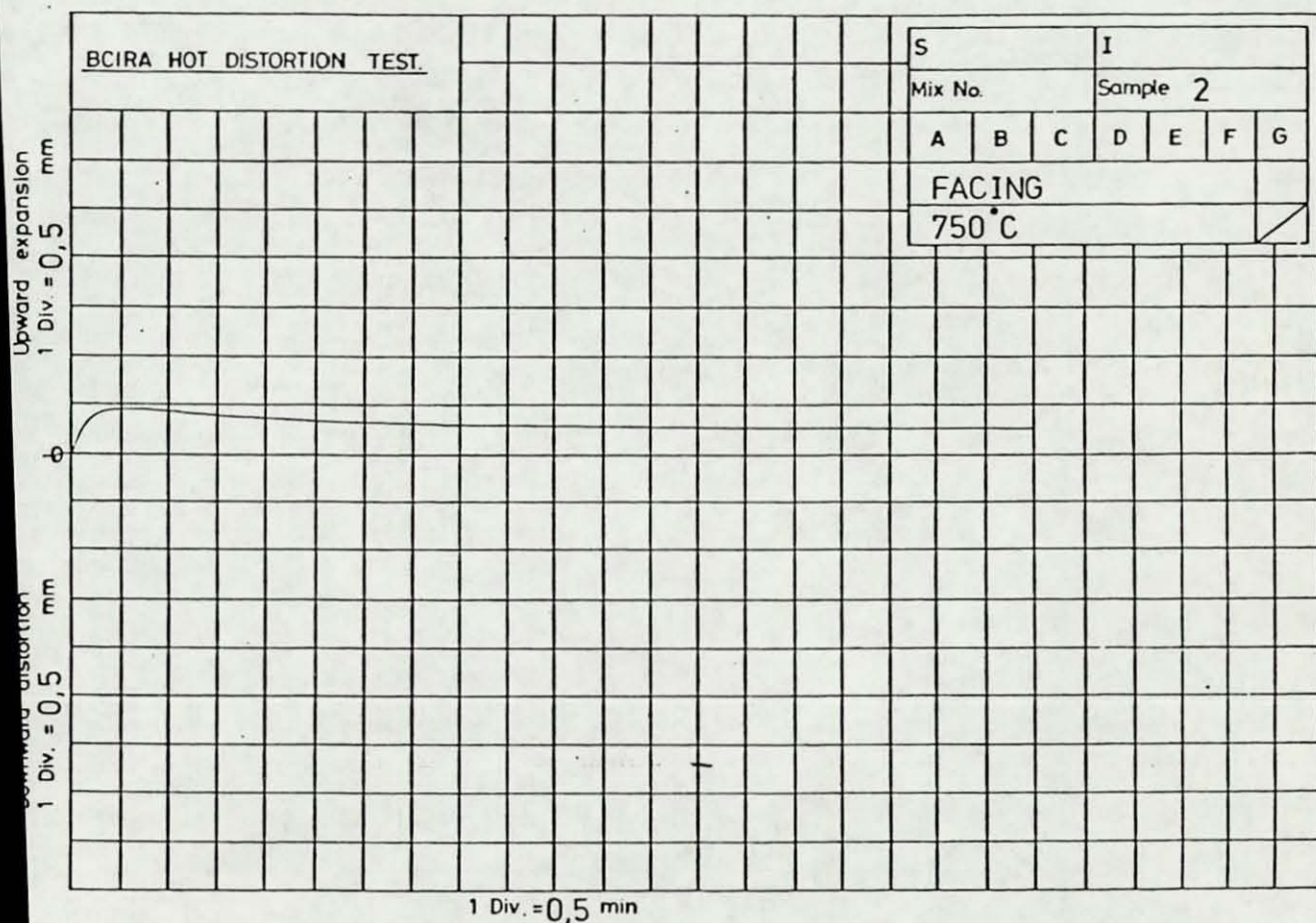


FIGURE 5.12b HOT DISTORTION OF THE CERAMIC FACING SLURRY FIRED AT 750°C

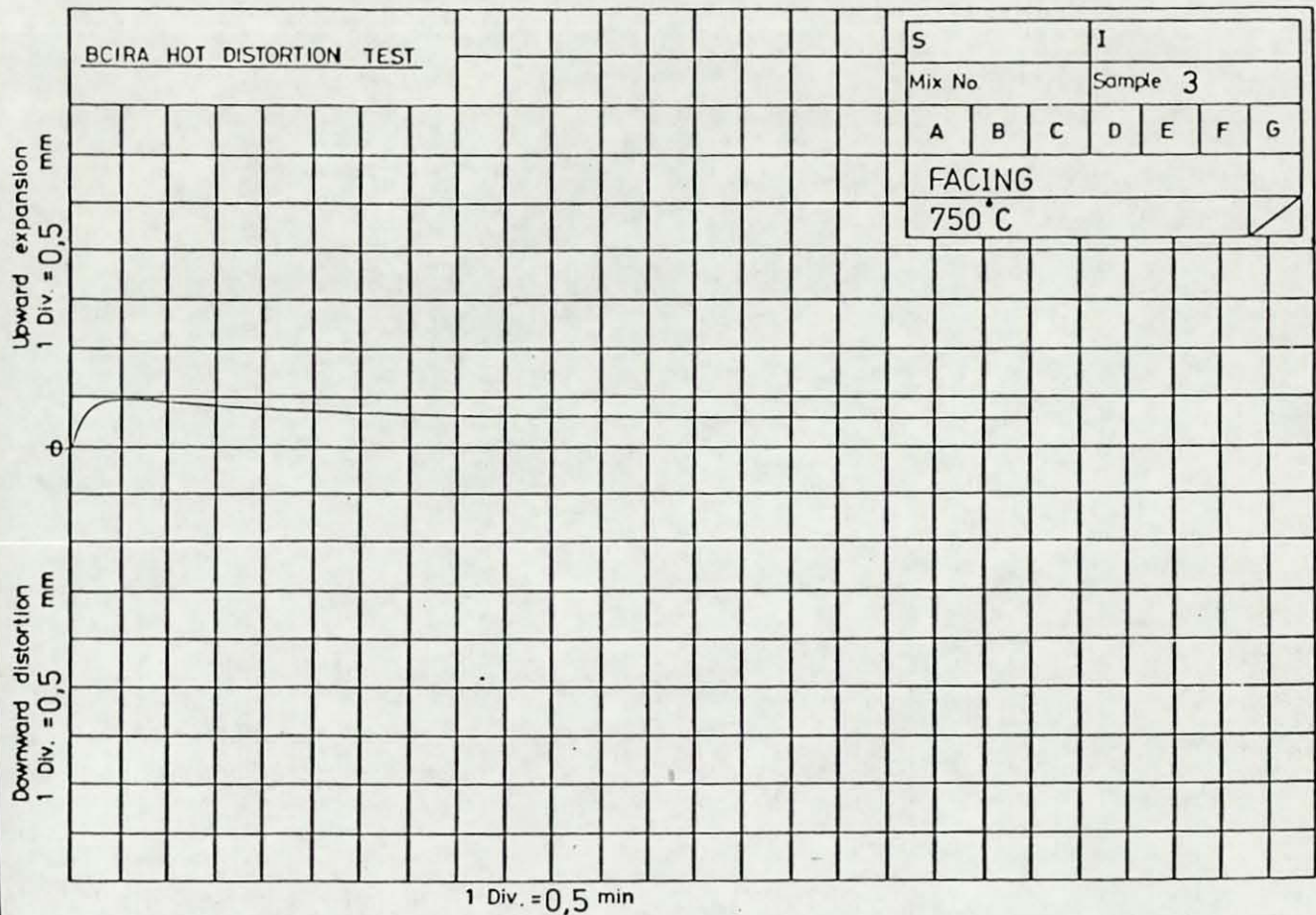


FIGURE 5.12c HOT DISTORTION OF THE CERAMIC FACING SLURRY FIRED AT 750°C

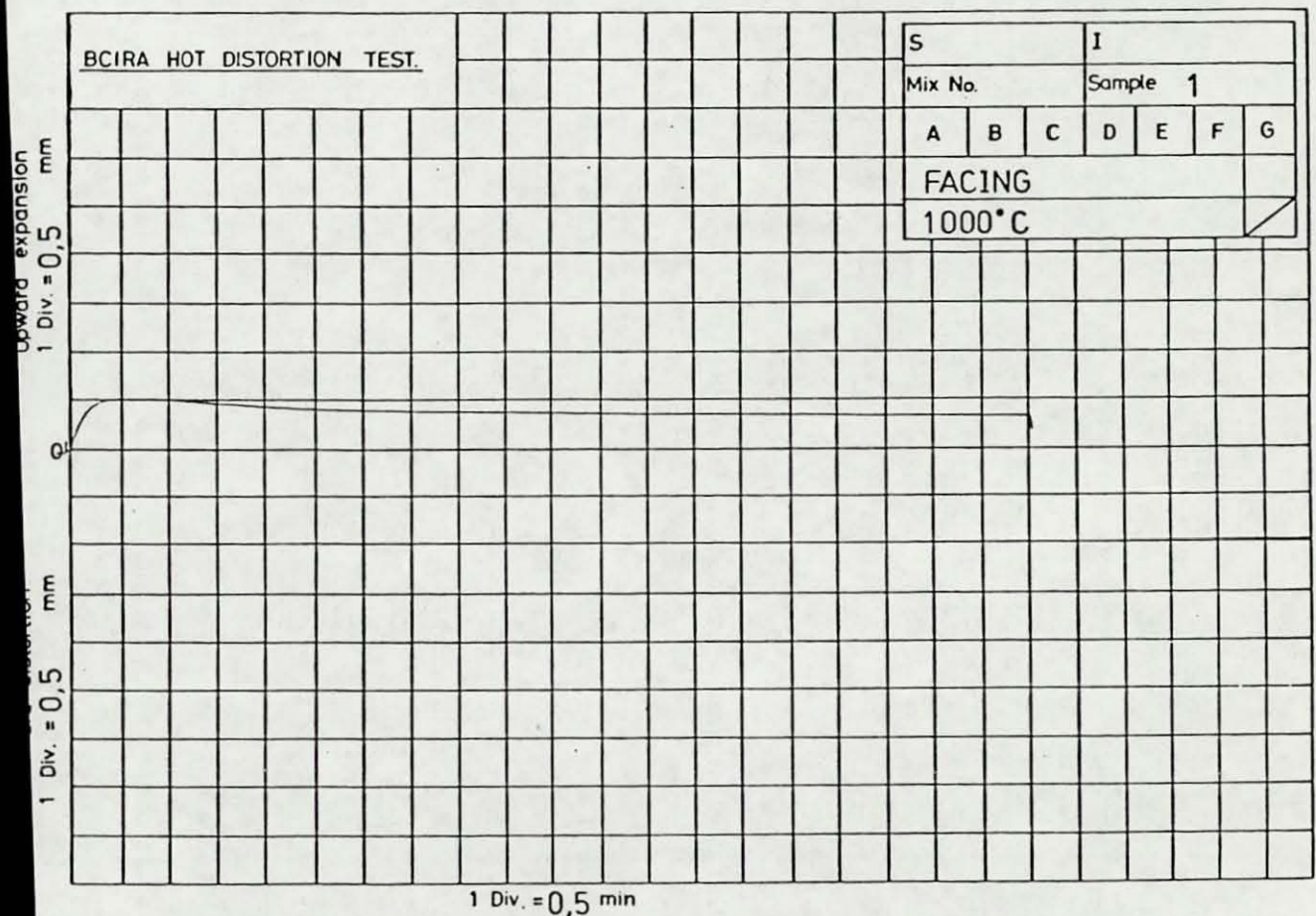


FIGURE 5.13a HOT DISTORTION OF THE CERAMIC FACING SLURRY FIRED AT 1000°C



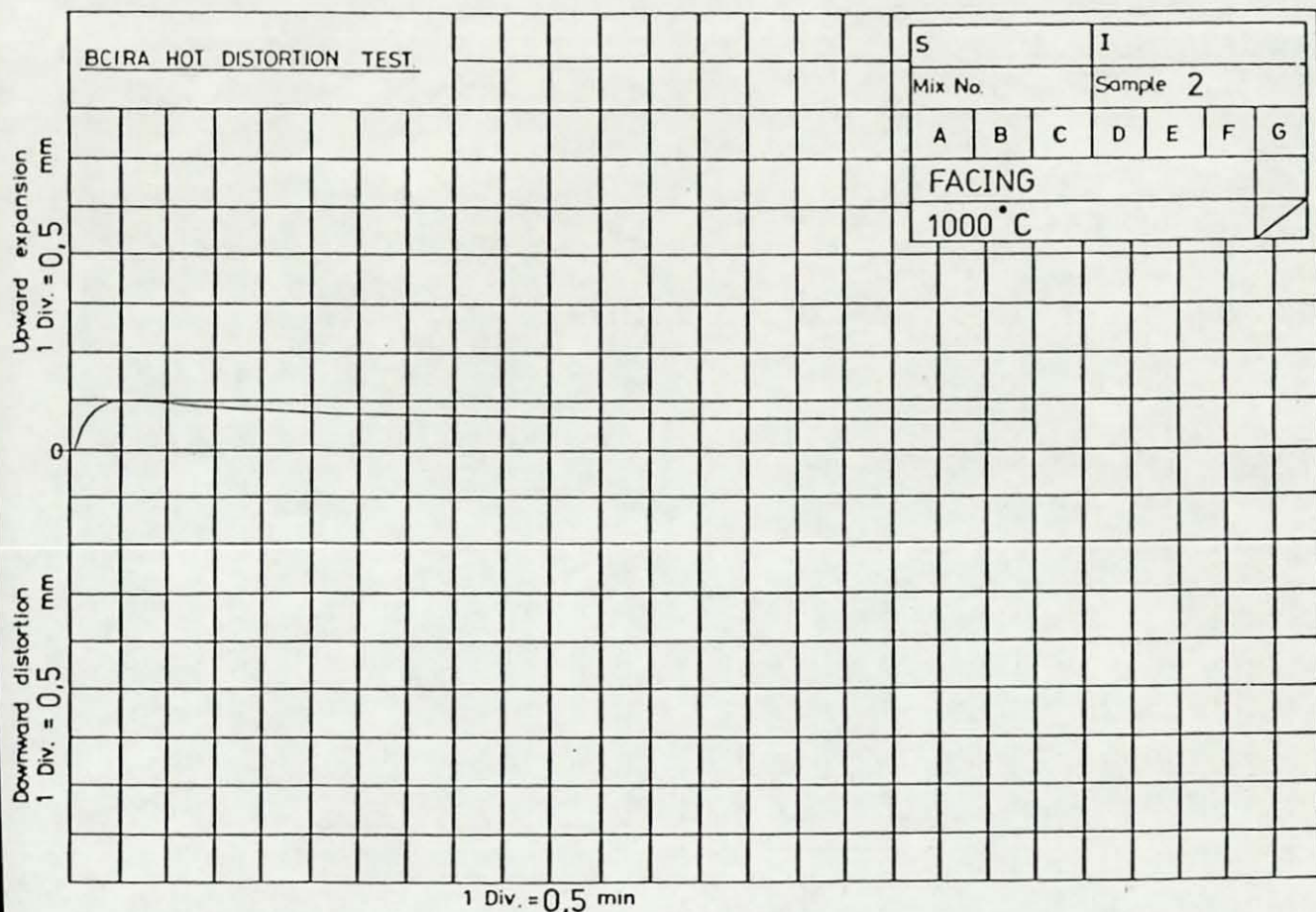


FIGURE 5.13b HOT DISTORTION OF THE CERAMIC FACING SLURRY FIRED AT 1000°C

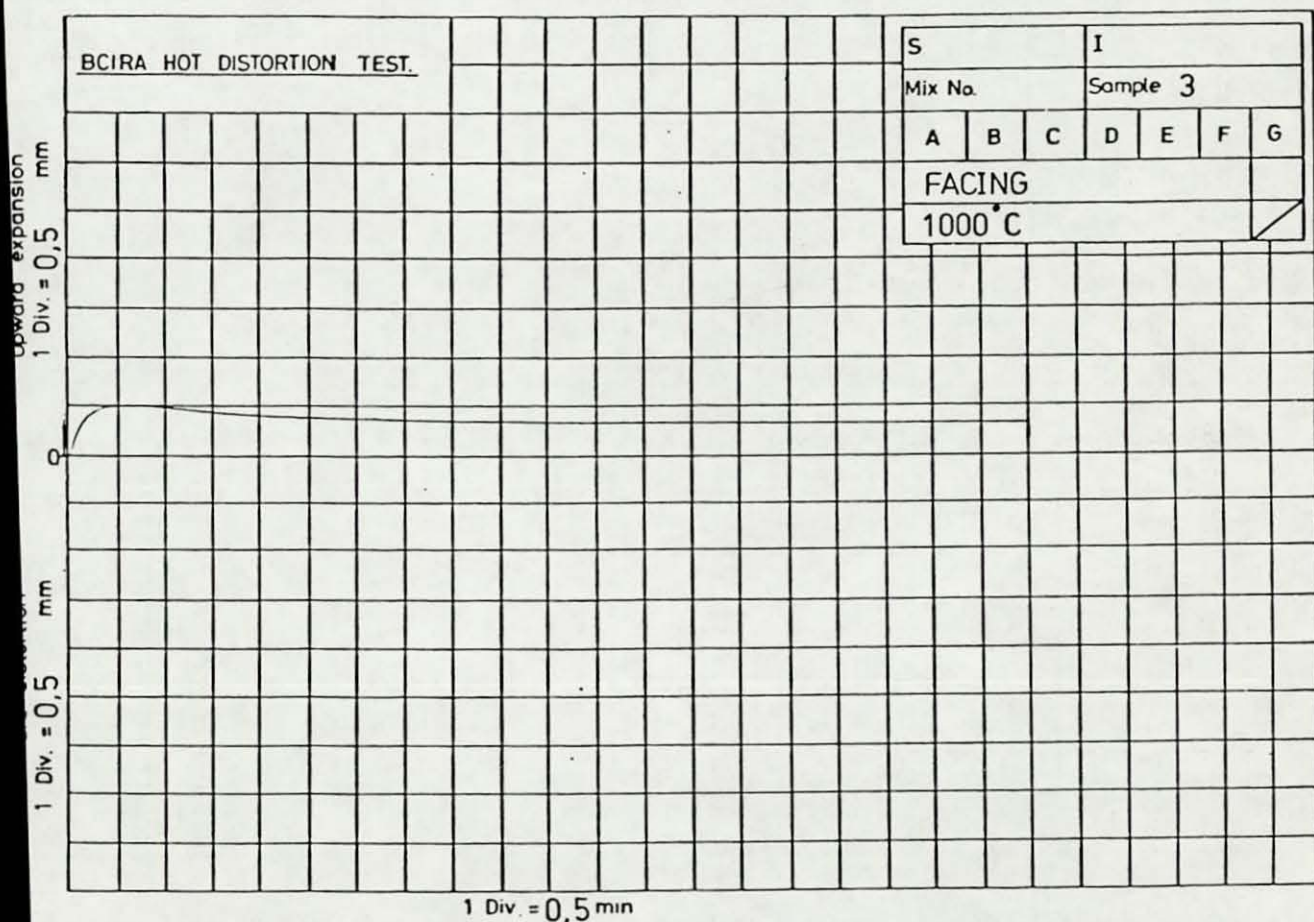


FIGURE 5.13c HOT DISTORTION OF THE CERAMIC FACING SLURRY FIRED AT 1000°C

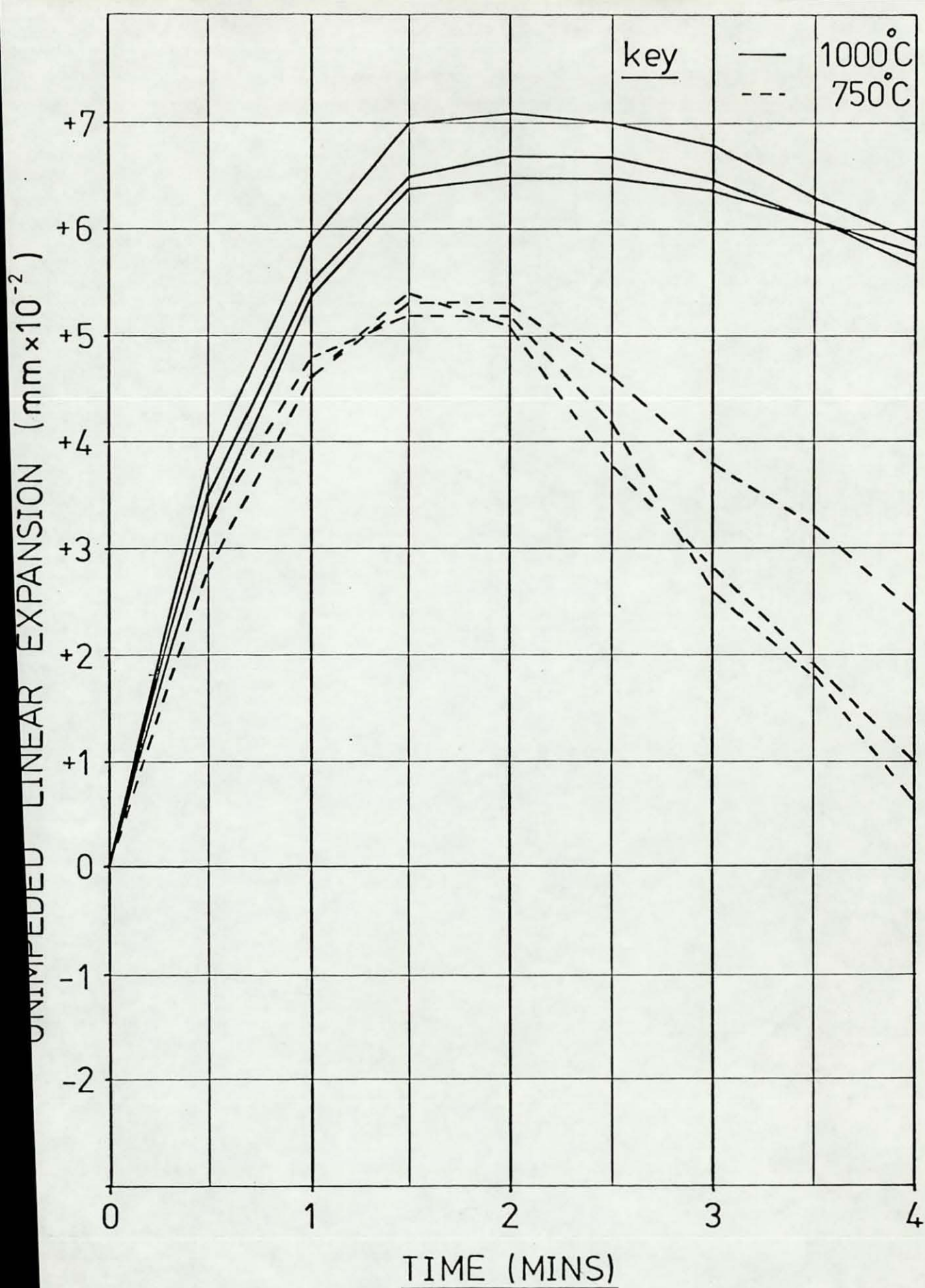


FIGURE 5.14 UNIMPEDED LINEAR EXPANSION OF THE CERAMIC FACING MATERIAL



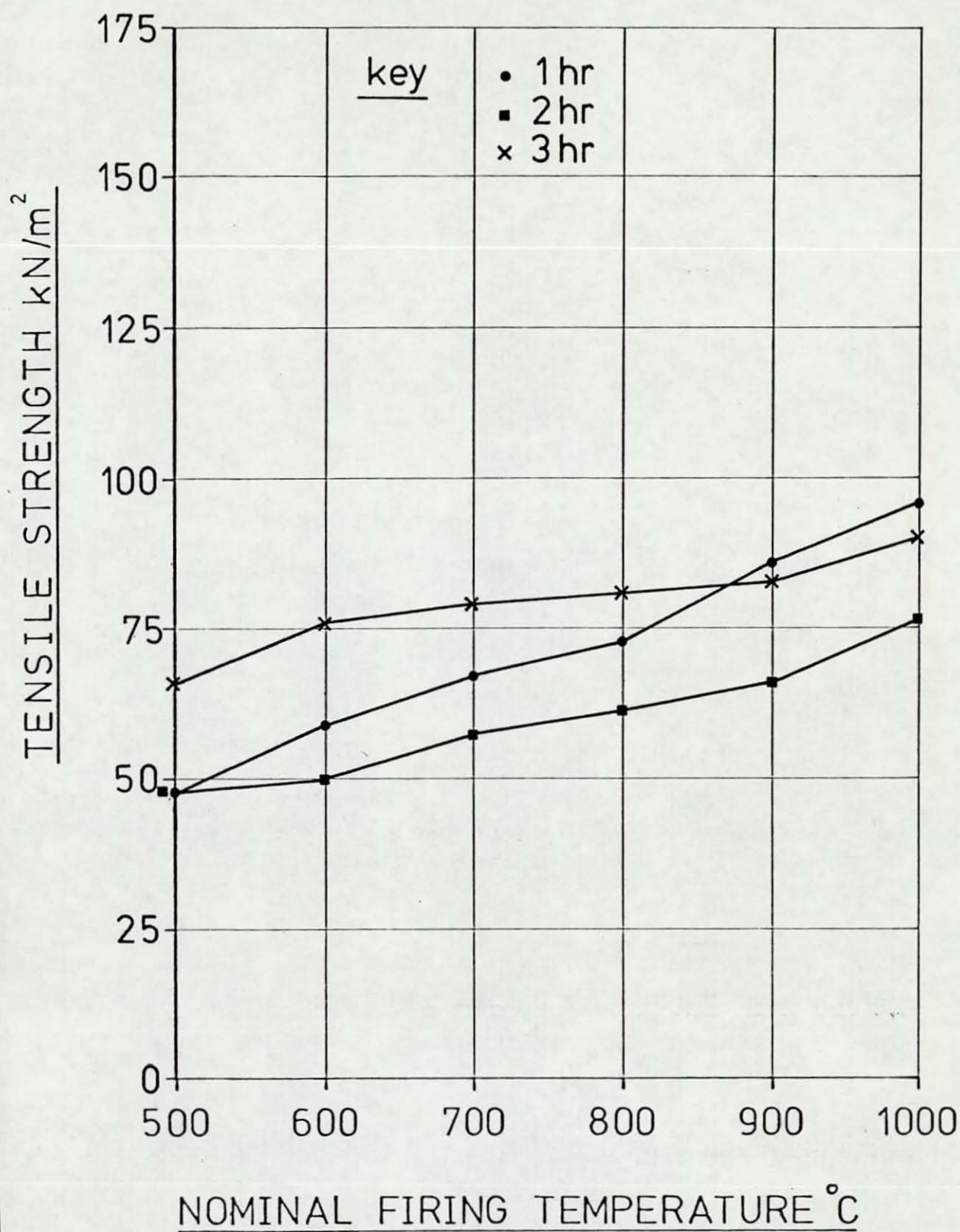


FIGURE 5.15 THE EFFECT OF FIRING TEMPERATURE AND TIME AT FIRING TEMPERATURE ON THE RETAINED TENSILE STRENGTH OF THE SODIUM SILICATE BONDED MOLOCHITE/CERAMIC FACING SLURRY COMPOSITE





MOULD MATERIAL	:	MULLITE
MOULD TEMPERATURE	:	AMBIENT
MOULD ATMOSPHERE	:	AIR
MELT ADDITIONS	:	NONE
FURNACE TEMPERATURES	:	4    1600°C
		3    1650°C
		2    1700°C

FIGURE 5.16    SERIES I INGOT CASTINGS



MOULD MATERIAL	:	MULLITE
MOULD TEMPERATURE	:	500°C
MOULD ATMOSPHERE	:	AIR
MELT ADDITIONS	:	NONE
FURNACE TEMPERATURES	:	10 1600°C
		9 1650°C
		8 1700°C

FIGURE 5.17 SERIES II INGOT CASTINGS



MOULD MATERIAL	:	MULITE
MOULD TEMPERATURE	:	800°C
MOULD ATMOSPHERE	:	AIR
MELT ADDITIONS	:	NONE
FURNACE TEMPERATURES	:	23    1600°C
		36    1650°C
		39    1700°C

FIGURE 5.18 SERIES III INGOT CASTINGS





MOULD MATERIAL	:	MULLITE
MOULD TEMPERATURE	:	AMBIENT
MOULD ATMOSPHERE	:	NITROGEN
MELT ADDITIONS	:	NONE
FURNACE TEMPERATURES	:	41    1600°C
		50    1650°C
		46    1700°C

FIGURE 5.19 (i) SERIES IV INGOT CASTINGS



MOULD MATERIAL	:	MULLITE
MOULD TEMPERATURE	:	AMBIENT
MOULD ATMOSPHERE	:	NITROGEN
MELT ADDITIONS	:	NONE
FURNACE TEMPERATURES	:	41    1600° C
		50    1650° C
		46    1700° C

FIGURE 5.19 (ii) SERIES IV INGOT CASTINGS (AS CAST)





MOULD MATERIAL	:	MULLITE
MOULD TEMPERATURE	:	AMBIENT
MOULD ATMOSPHERE	:	AIR
MELT ADDITIONS	:	
42	0.25 wt % STELLAGEN	
34	0.50 wt % STELLAGEN	
37	0.75 wt % STELLAGEN	
FURNACE TEMPERATURES	:	1650° C (ALL THREE)

FIGURE 5.20 SERIES V INGOT CASTINGS



MOULD MATERIAL	:	MULLITE
MOULD TEMPERATURE	:	AMBIENT
MOULD ATMOSPHERE	:	AIR
MELT ADDITIONS	:	
44		0.025 wt % FeTi + 0.0025 wt % FeNb
35		0.050 wt % FeTi + 0.0050 wt % FeNb
38		0.075 wt % FeTi + 0.0075 wt % FeNb
FURNACE TEMPERATURES	:	1650° C (ALL THREE)

FIGURE 5.21 SERIES VI INGOT CASTINGS



MOULD MATERIAL	:	MULLITE
MOULD TEMPERATURE	:	AMBIENT
MOULD ATMOSPHERE	:	AIR
MELT ADDITIONS	:	
0.5 wt % STELLAGEN+ 0.05 wt % FeTi+ 0.005 wt % FeNb		
(ALL THREE)		
FURNACE TEMPERATURES	:	66    1600 °C
		63    1650 °C
		62    1700 °C

FIGURE 5.22 SERIES VII INGOT CASTINGS





MOULD MATERIAL	:	MULLITE
MOULD TEMPERATURE	:	AMBIENT
MOULD ATMOSPHERE	:	NITROGEN
MELT ADDITIONS	:	
0.5 wt % STELLAGEN + 0.05 wt % FeTi + 0.005 wt % FeNb		
(ALL THREE)		
FURNACE TEMPERATURES	:	64    1600° C
		58    1650° C
		60    1700° C

FIGURE 5.23 SERIES VIII INGOT CASTINGS





MOULD MATERIAL	:	MULLITE + 10 wt % GRAPHITE
MOULD TEMPERATURE	:	AMBIENT
MOULD ATMOSPHERE	:	AIR
MELT ADDITIONS	:	NONE
FURNACE TEMPERATURES	:	7    1600 °C
		6    1650 °C
		5    1700 °C

FIGURE 5.24 SERIES IX INGOT CASTINGS



MOULD MATERIAL	:	MULLITE + 10 wt % GRAPHITE
MOULD TEMPERATURE	:	500 °C
MOULD ATMOSPHERE	:	AIR
MELT ADDITIONS	:	NONE
FURNACE TEMPERATURES	:	13    1600 °C
		12    1650 °C
		11    1700 °C

FIGURE 5.25 SERIES X INGOT CASTINGS



MOULD MATERIAL	:	MULLITE + 10 % GRAPHITE
MOULD TEMPERATURE	:	800 °C
MOULD ATMOSPHERE	:	AIR
MELT ADDITIONS	:	NONE
FURNACE TEMPERATURES	:	54    1600 °C
	:	53    1650 °C
	:	24    1700 °C

FIGURE 5.26 SERIES XI INGOT CASTINGS





MOULD MATERIAL	:	MULLITE + 10 wt % GRAPHITE
MOULD TEMPERATURE	:	AMBIENT
MOULD ATMOSPHERE	:	AIR
MELT ADDITIONS	:	
0.5 wt % STELLAGEN + 0.05 wt % FeTi + 0.005 wt % FeNb		
(ALL THREE)		
FURNACE TEMPERATURES	:	65    1600 °C
		59    1650 °C
		61    1700 °C

FIGURE 5.27 SERIES XII INGOT CASTINGS





MOULD MATERIAL	:	MULLITE+ 10 wt % GRAPHITE
MOULD TEMPERATURE	:	AMBIENT
MOULD ATMOSPHERE	:	NITROGEN
MELT ADDITIONS	:	NONE
FURNACE TEMPERATURES	:	20    1600 °C
		57    1700 °C

FIGURE 5.28 SERIES XIII INGOT CASTINGS



MOULD MATERIAL	:	MULLITE + 10 wt % GRAPHITE
MOULD TEMPERATURE	:	AMBIENT
MOULD ATMOSPHERE	:	ARGON
MELT ADDITIONS	:	NONE
FURNACE TEMPERATURES	:	55    1550 °C
		25    1650 °C
		56    1700 °C

FIGURE 5.29 SERIES XIV INGOT CASTINGS



MOULD MATERIAL	:	ZIRCON
MOULD TEMPERATURE	:	AMBIENT
MOULD ATMOSPHERE	:	AIR
MELT ADDITIONS	:	NONE
FURNACE TEMPERATURES	:	21    1600° C
		15    1650° C

FIGURE 5.30 SERIES XV INGOT CASTINGS

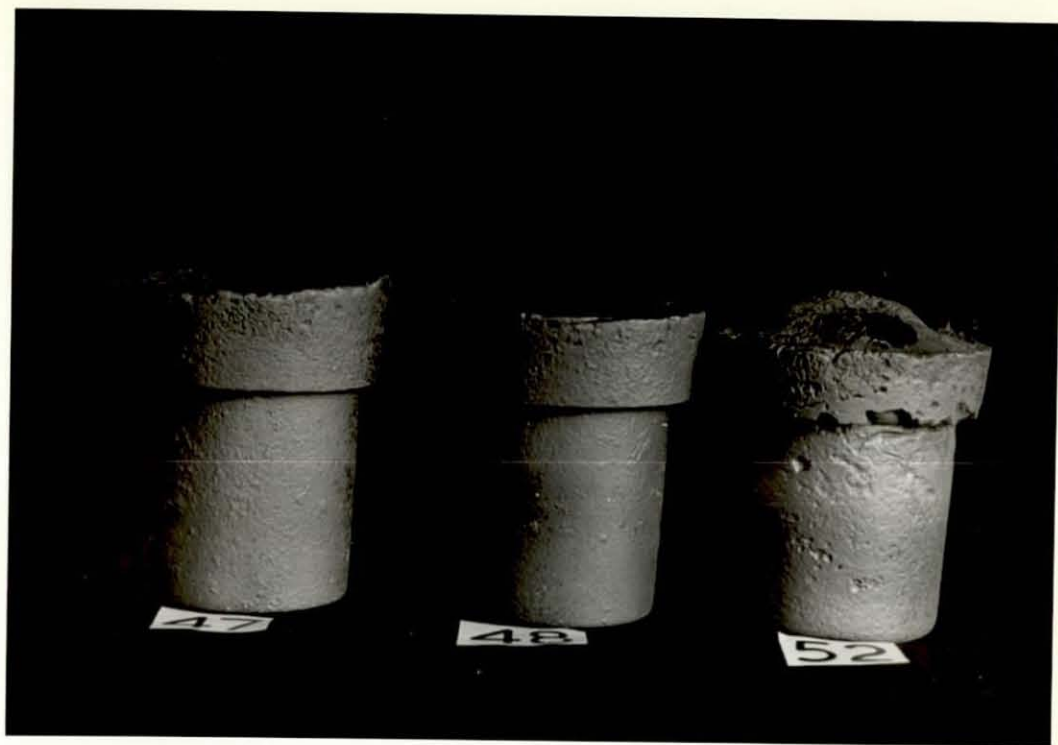




MOULD MATERIAL	:	MACHINED GRAPHITE
MOULD TEMPERATURE	:	26 AMBIENT
		27 150° C
MOULD ATMOSPHERE	:	AIR
MELT ADDITIONS	:	NONE
FURNACE TEMPERATURES	:	1675° C (BOTH)

FIGURE 5.31 SERIES XVI INGOT CASTINGS





MOULD MATERIAL	:	MULLITE
MOULD TEMPERATURE	:	AMBIENT
MOULD ATMOSPHERE	:	AIR
MELT ADDITIONS	:	47 1 wt % NICKEL
		48 2 wt % NICKEL
		52 3 wt % NICKEL
FURNACE TEMPERATURES	:	1650° C (ALL THREE)

FIGURE 5.32 SERIES XVII INGOT CASTINGS

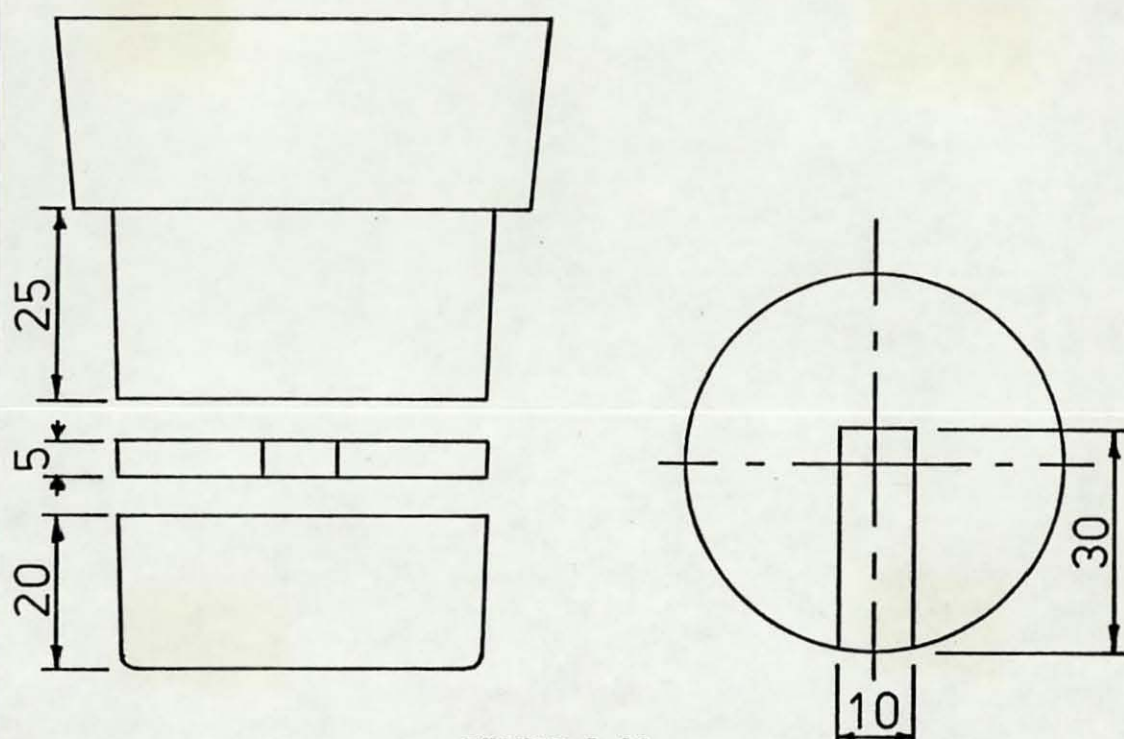


FIGURE 5.33

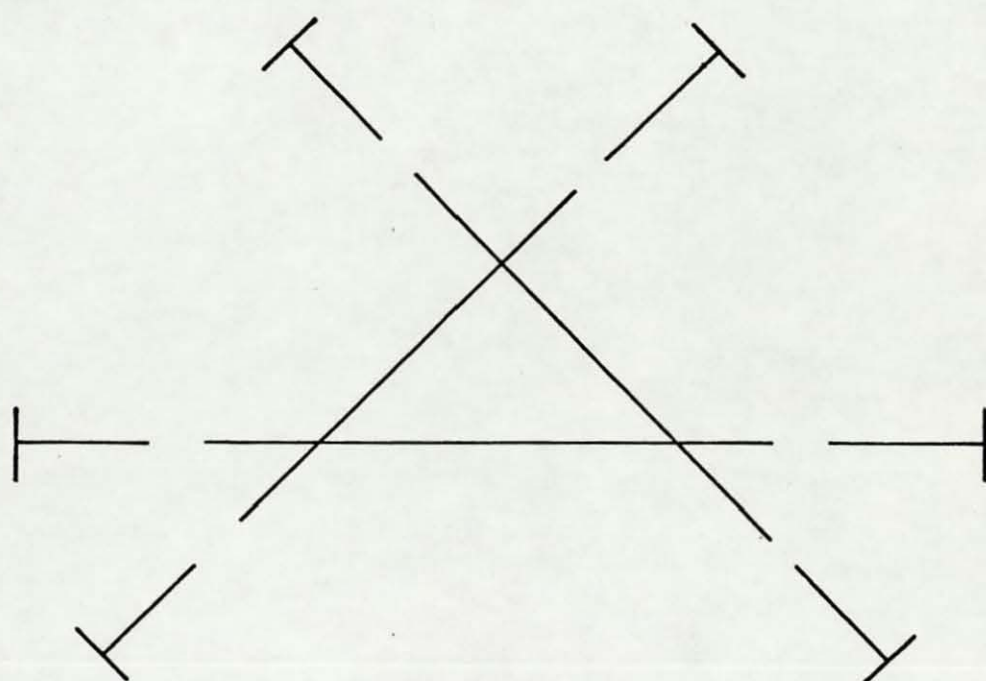


FIGURE 5.34

FIGURE 5.33 INGOT CASTINGS METALLOGRAPHIC SPECIMEN  
LOCATION AND DIMENSIONS

FIGURE 5.34 INTERCEPT LAYOUT FOR GRAIN SIZE  
DETERMINATION



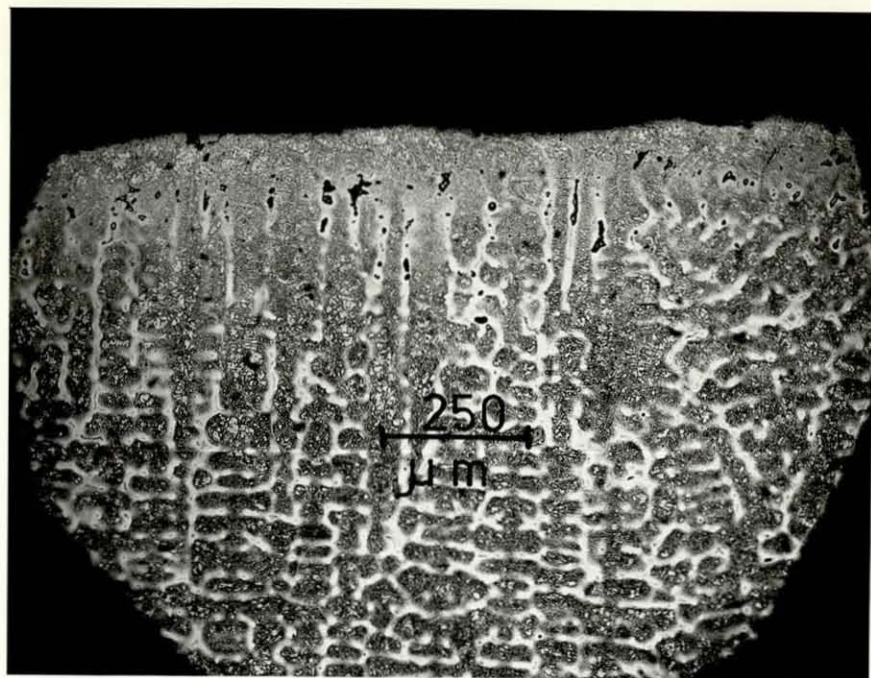


FIGURE 5.35

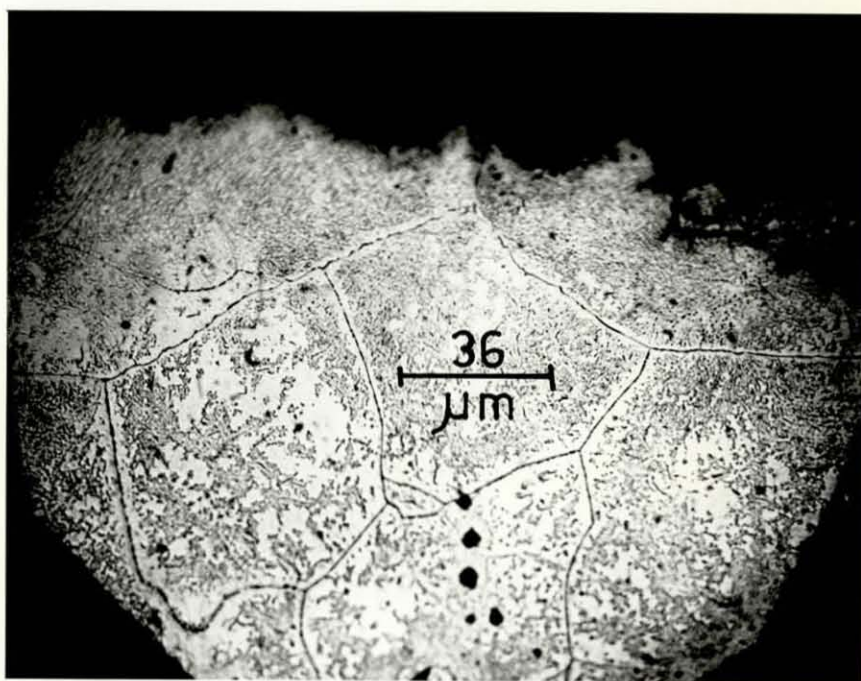


FIGURE 5.36

FIGURES 5.35 & 5.36 PHOTOMICROGRAPHS OF INGOT  
CASTING 3 EDGE STRUCTURE



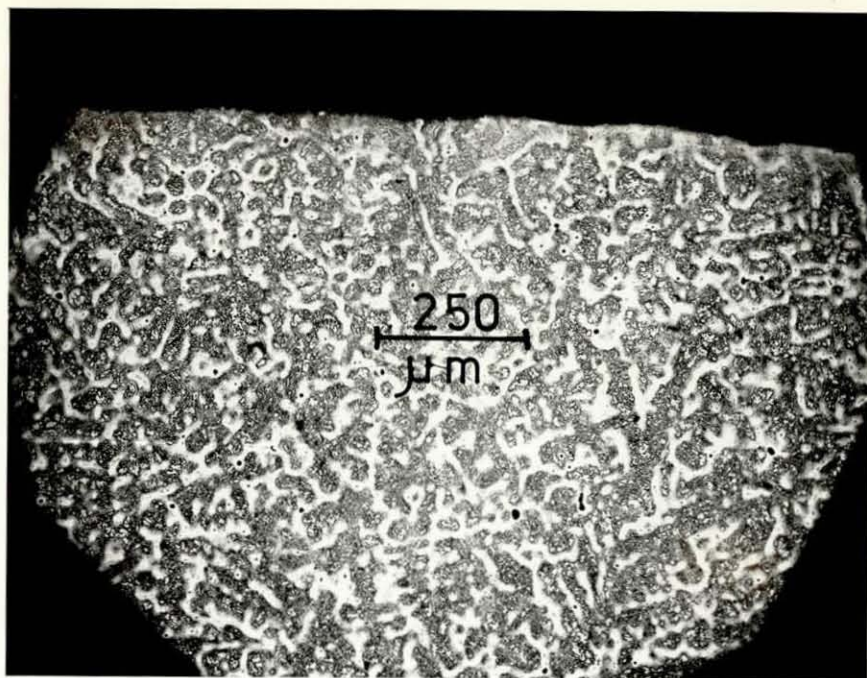


FIGURE 5.37



FIGURE 5.38

FIGURES 5.37 & 5.38 PHOTOMICROGRAPHS OF INGOT  
CASTING 34 EDGE STRUCTURE



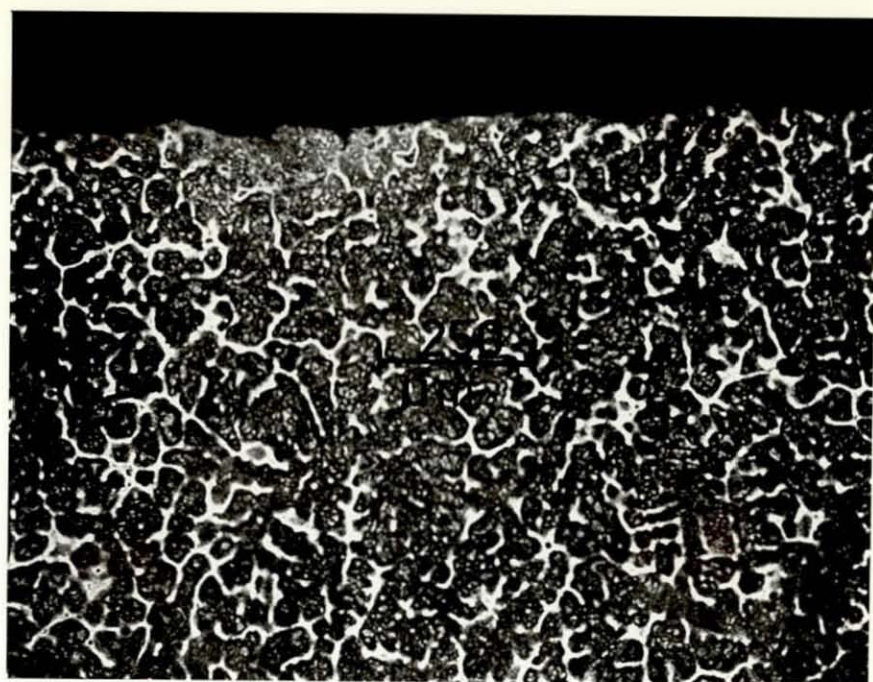


FIGURE 5.39



FIGURE 5.40

FIGURES 5.39 & 5.40 PHOTOMICROGRAPHS OF INGOT  
CASTING 35 EDGE STRUCTURE



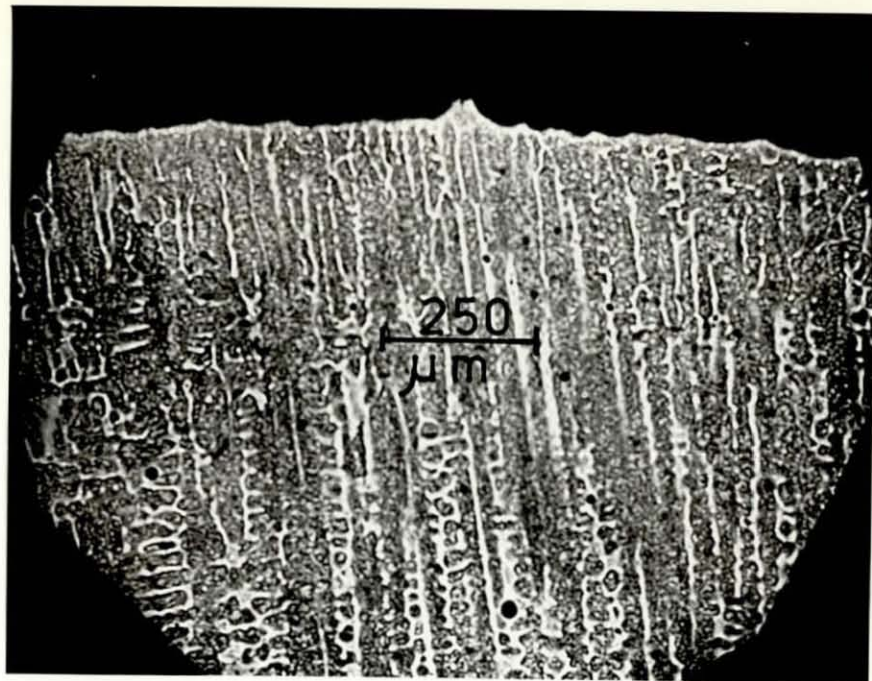


FIGURE 5.41

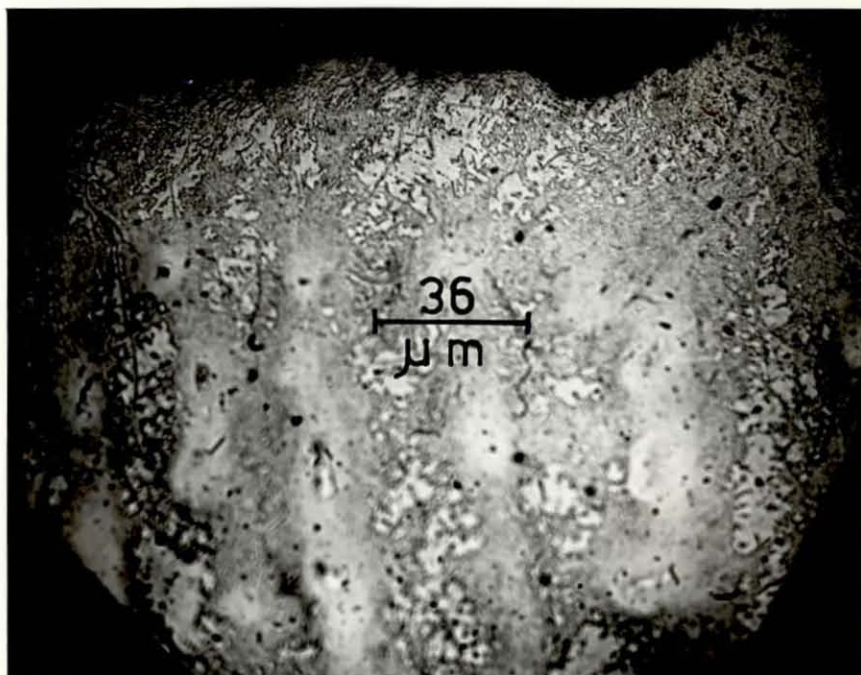


FIGURE 5.42

FIGURES 5.41 & 5.42 PHOTOMICROGRAPHS OF INGOT  
CASTING 43 EDGE STRUCTURE

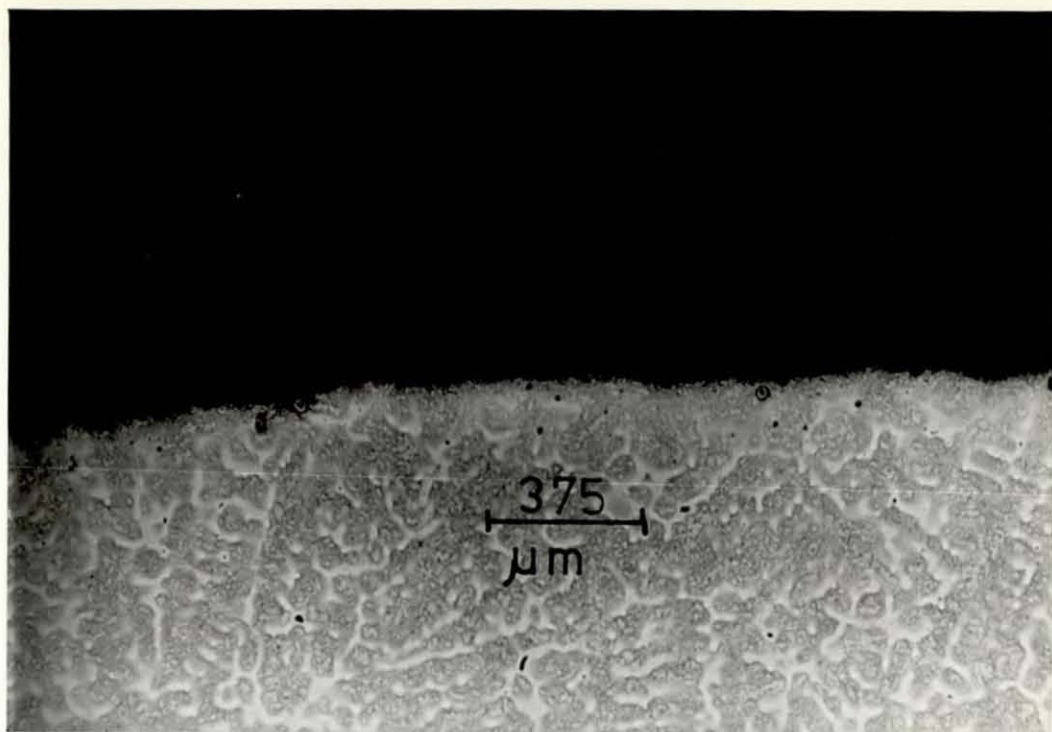


FIGURE 5.43

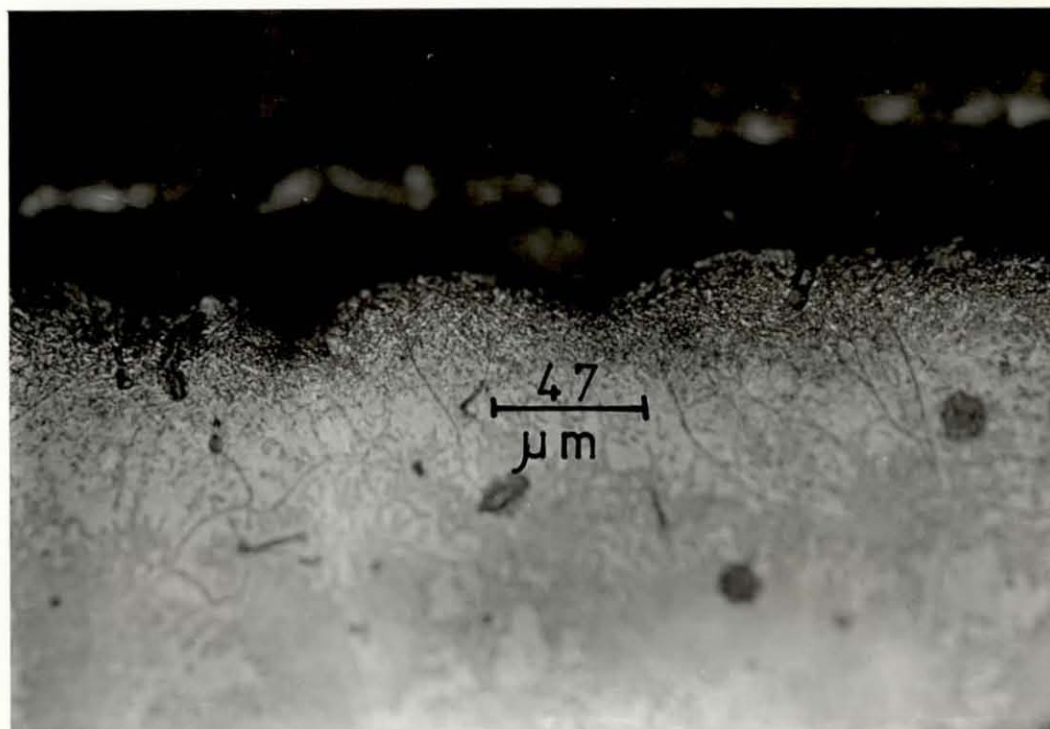


FIGURE 5.44

FIGURES 5.43 & 5.44 PHOTOMICROGRAPHS OF INGOT  
CASTING 58 EDGE STRUCTURE



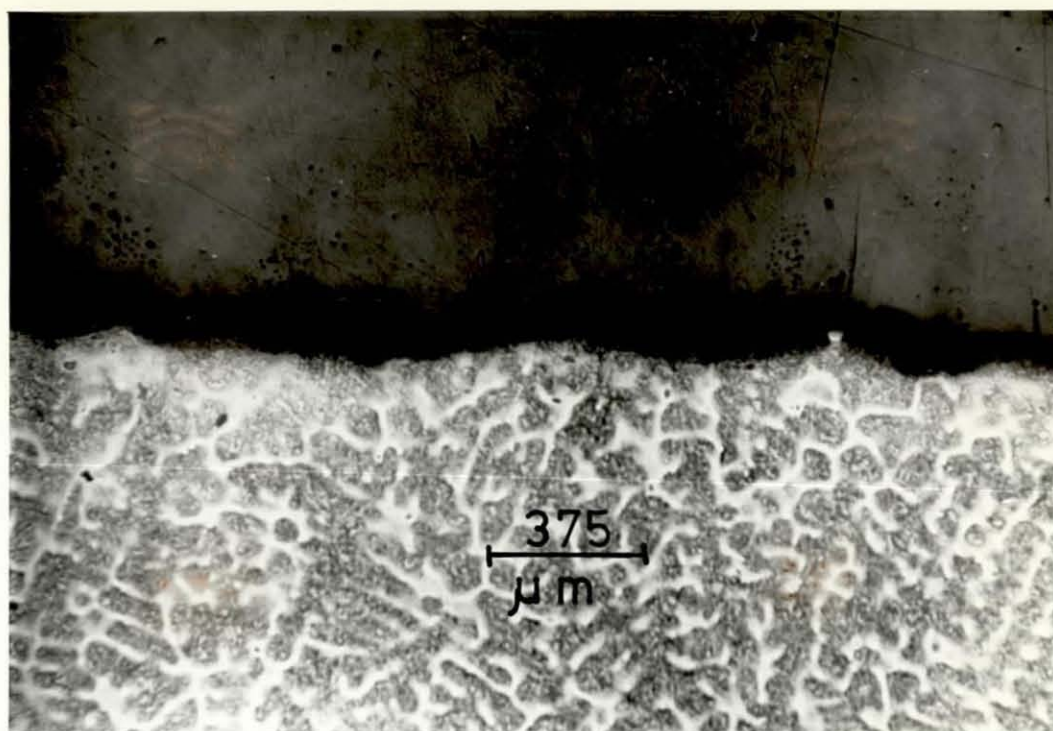


FIGURE 5.45



FIGURE 5.46

FIGURES 5.45 & 5.46 PHOTOMICROGRAPHS OF INGOT  
CASTING 59 EDGE STRUCTURE



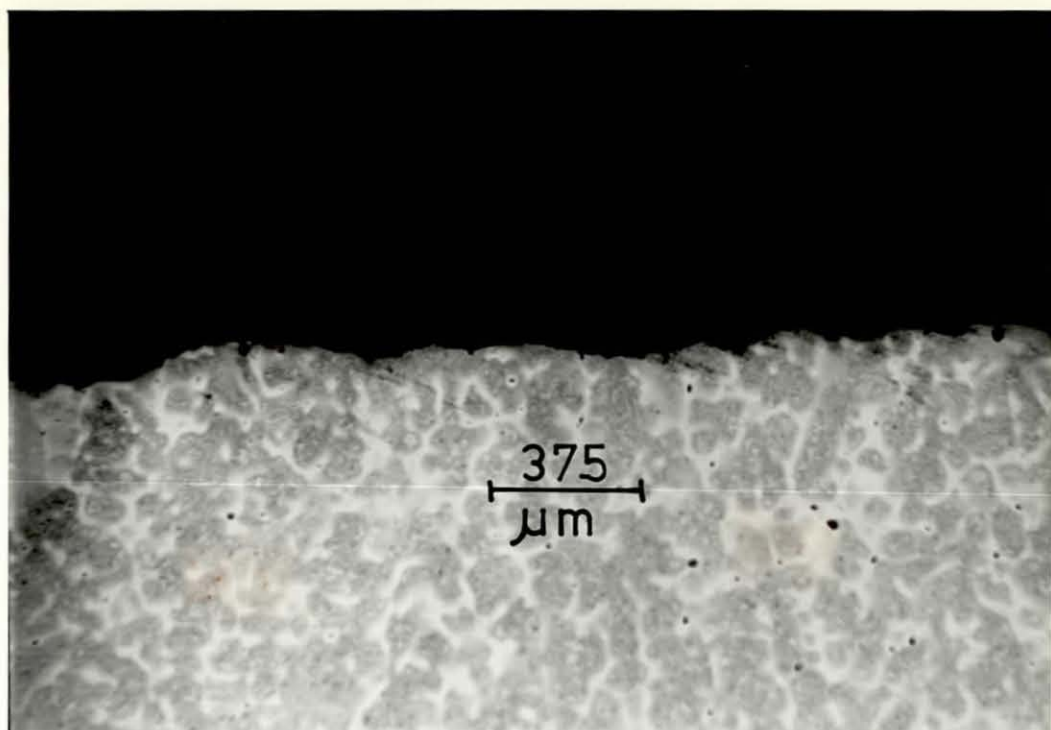


FIGURE 5.47

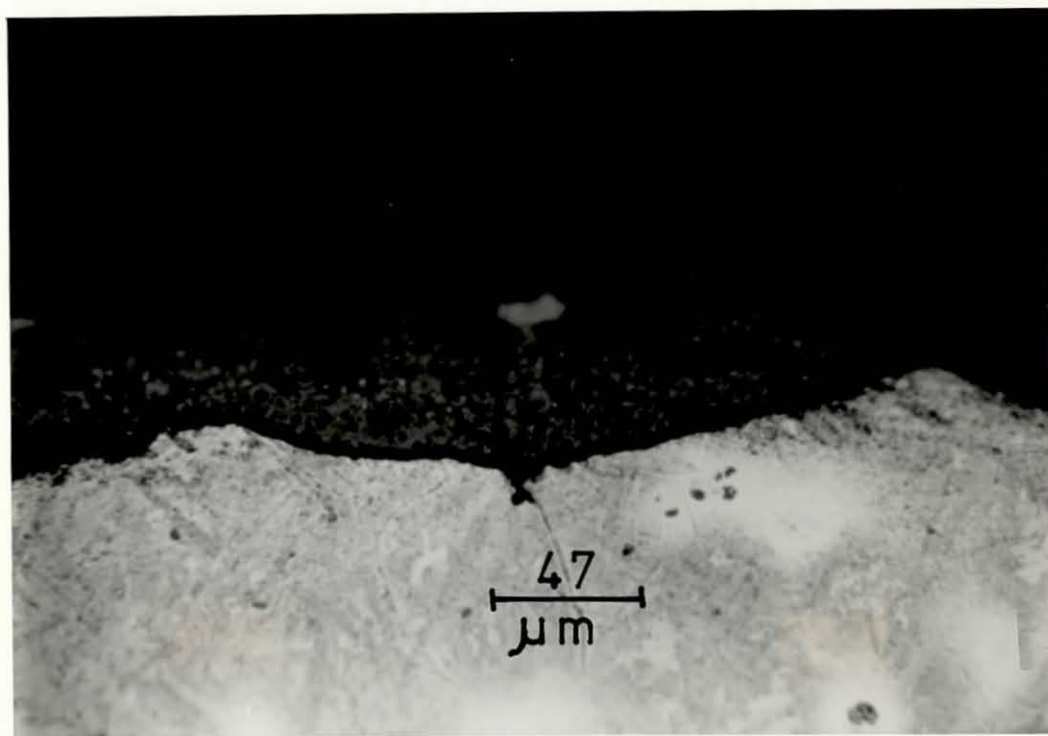


FIGURE 5.48

FIGURES 5.47 & 5.48 PHOTOMICROGRAPHS OF INGOT  
CASTING 63 EDGE STRUCTURE

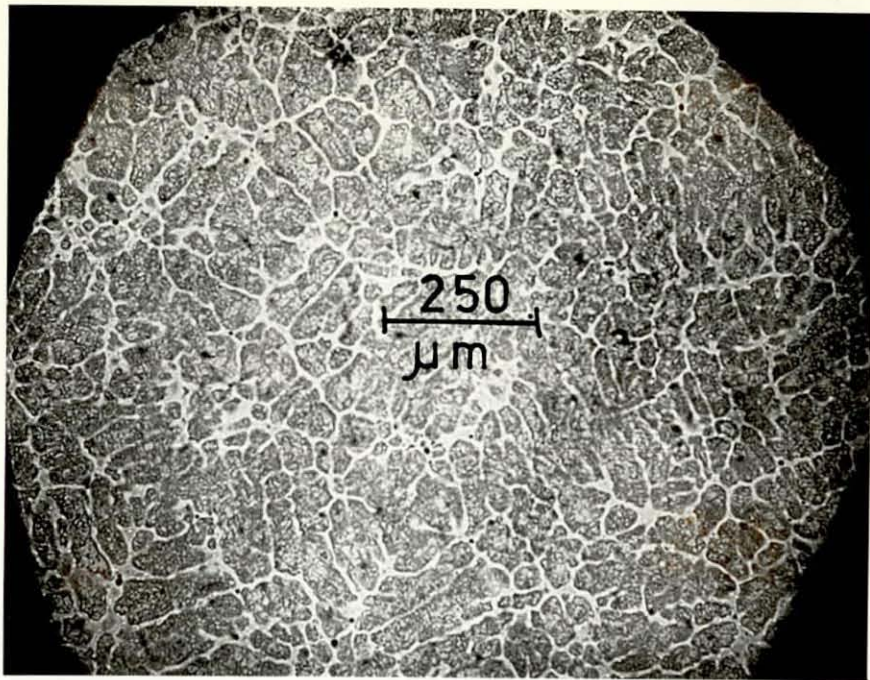


FIGURE 5.49a

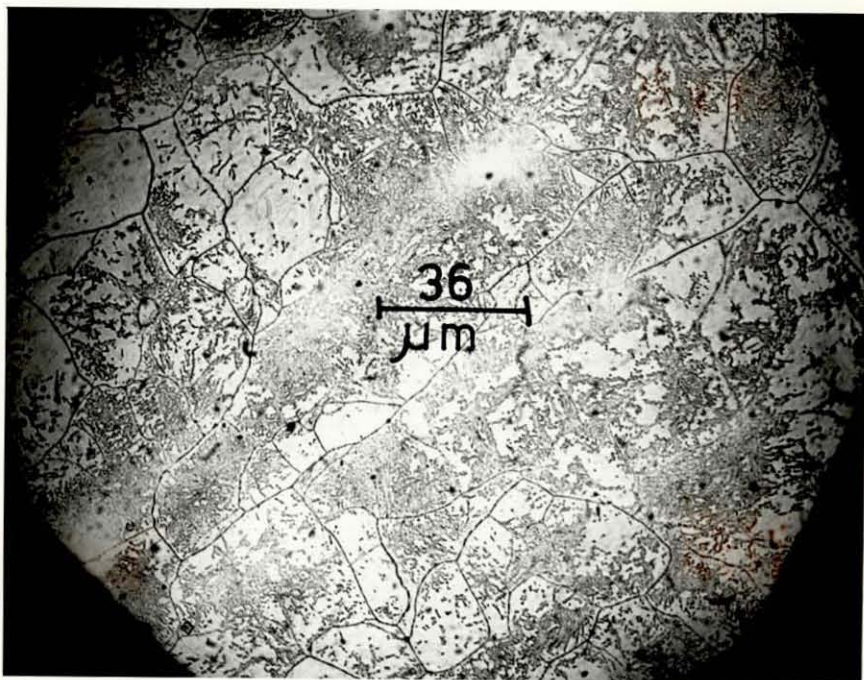
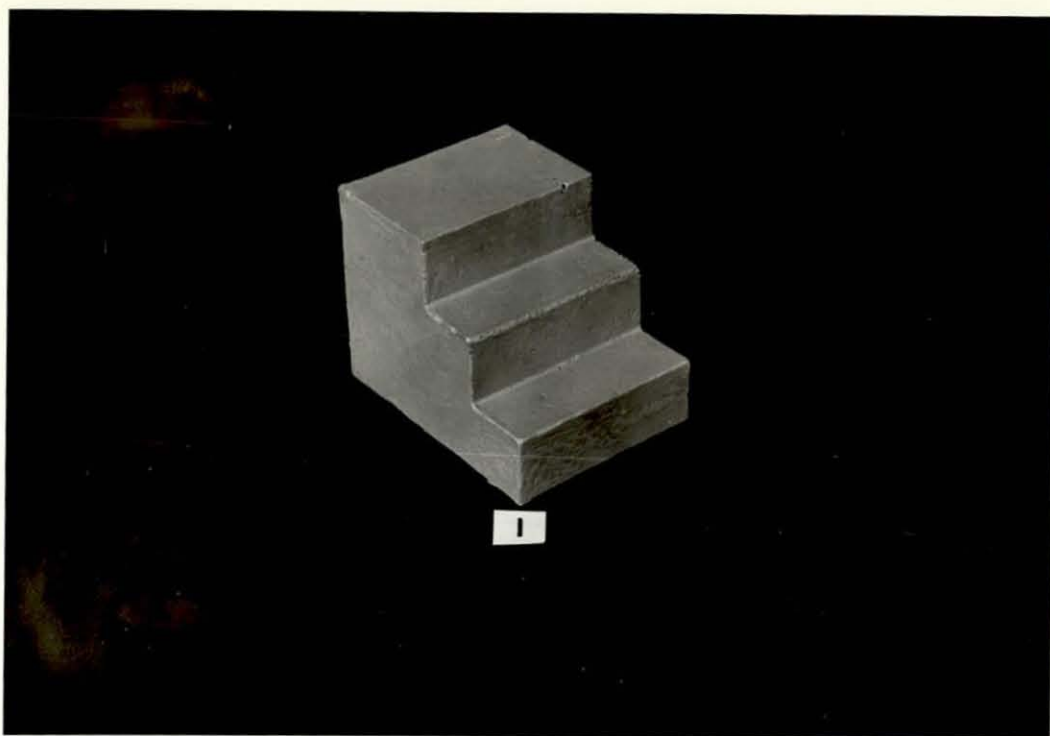


FIGURE 5.49b

FIGURES 5.49 a & b PHOTOMICROGRAPHS OF INGOT  
CASTING 37 CENTRE STRUCTURE

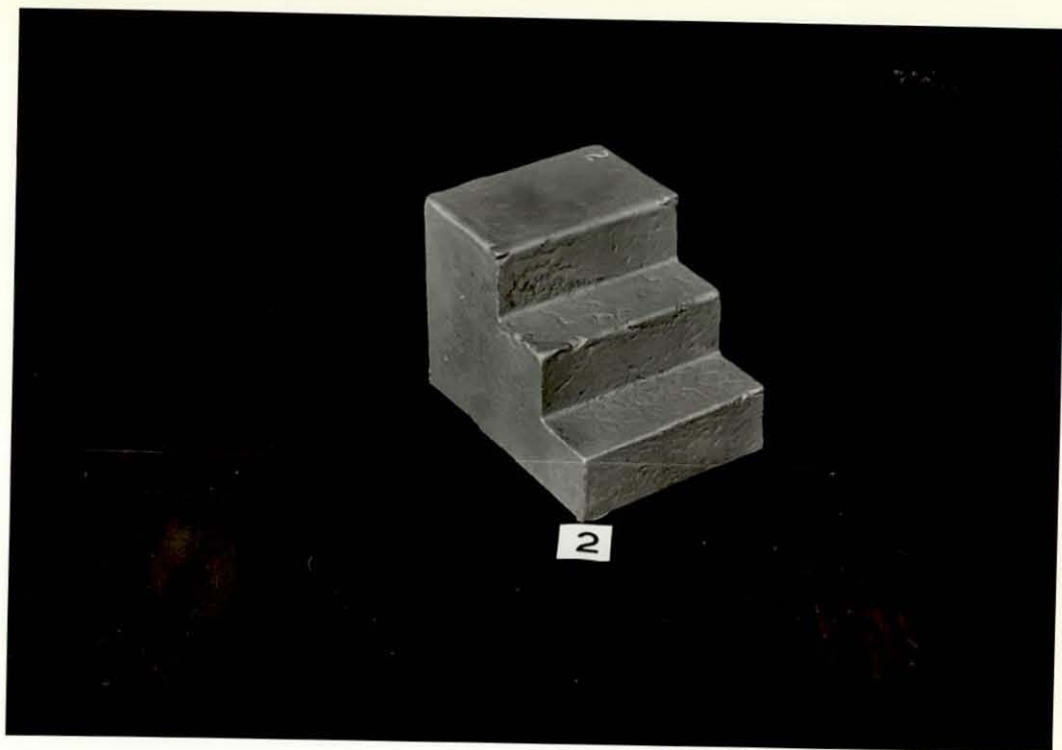




MELT WEIGHT	:	27.3 KG
MELT TIME	:	1 HR 40 MINS
LADLE PREHEAT TIME	:	1 HR 15 MINS
FURNACE TEMPERATURE	:	1650°C
STELLAGEN ADDITION	:	135 GMS
POURING TEMPERATURE	:	1523°C
MOULD ATMOSPHERE	:	NITROGEN

(CASTINGS 1 & 2 PRODUCED FROM THE SAME MELT)

FIGURE 5.50 STEPPED BLOCK CASTING 1

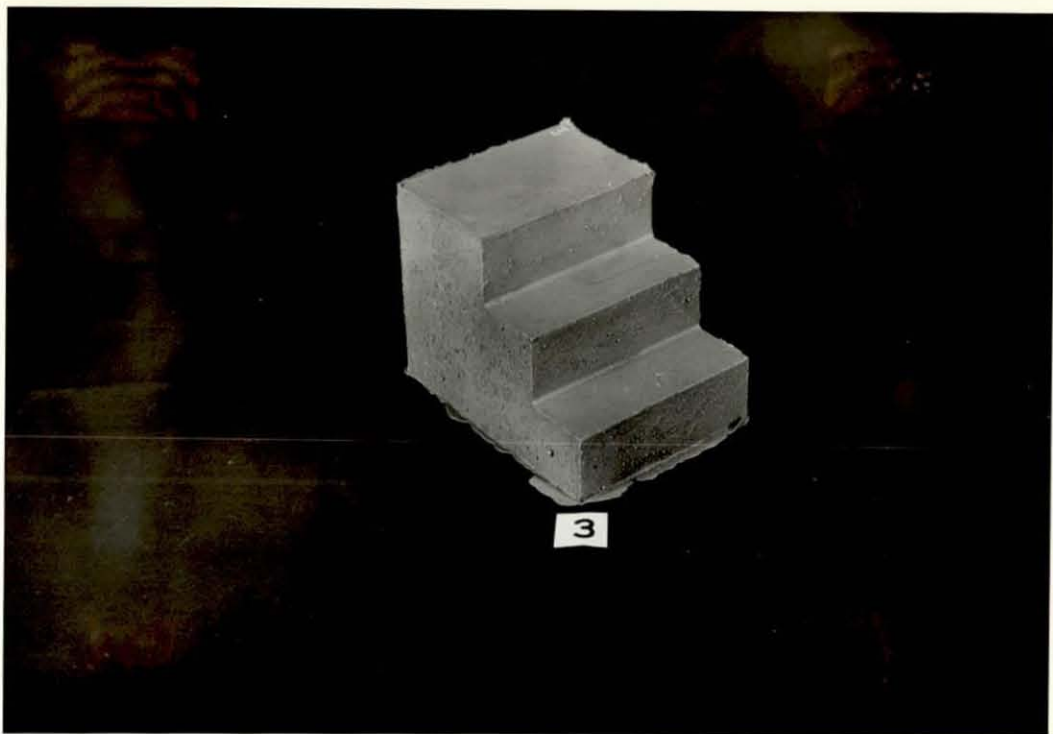


MELT WEIGHT	:	27.2 KG
MELT TIME	:	1 HR 40 MINS
LADLE PREHEAT TIME	:	1 HR 15 MINS
FURNACE TEMPERATURE	:	1650 <sup>o</sup> C
STELLAGEN ADDITION	:	135 GMS
POURING TEMPERATURE	:	1483 <sup>o</sup> C
MOULD ATMOSPHERE	:	AIR

(CASTINGS 1 & 2 PRODUCED FROM THE SAME MELT)

FIGURE 5.51 STEPPED BLOCK CASTING 2

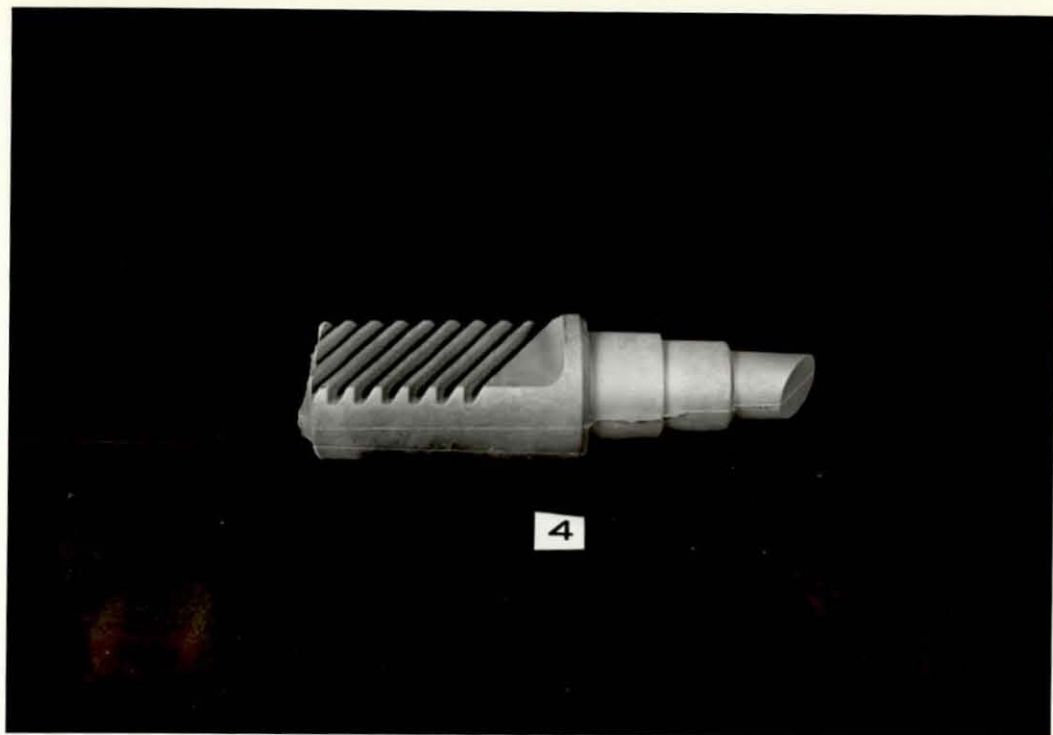




MELT WEIGHT	:	29.5 KG
MELT TIME	:	1 HR 40 MINS
LADLE PREHEAT TIME	:	1 HR 10 MINS
FURNACE TEMPERATURE	:	1650°C
STELLAGEN ADDITION	:	146 GMS
POURING TEMPERATURE	:	1586°C
MOULD ATMOSPHERE	:	AIR

(CASTINGS 3 & 4 PRODUCED FROM THE SAME MELT)

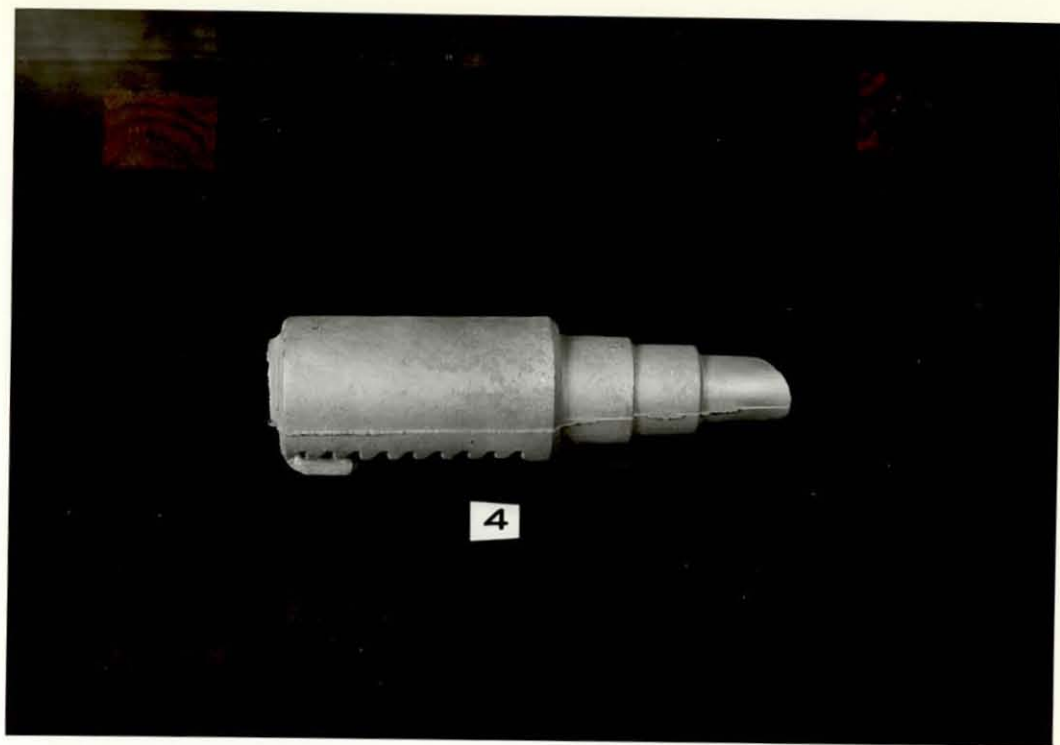
FIGURE 5.52 STEPPED BLOCK CASTING 3



MELT WEIGHT	:	29.5 KG
MELT TIME	:	1 HR 40 MINS
LADLE PREHEAT TIME	:	1 HR 10 MINS
FURNACE TEMPERATURE	:	1650 <sup>o</sup> C
STELLAGEN ADDITION	:	146 GMS
POURING TEMPERATURE	:	1555 <sup>o</sup> C
MOULD ATMOSPHERE	:	AIR

(CASTINGS 3 & 4 PRODUCED FROM THE SAME MELT)

FIGURE 5.53 RETRACTABLE DIE CORE 4 (i)

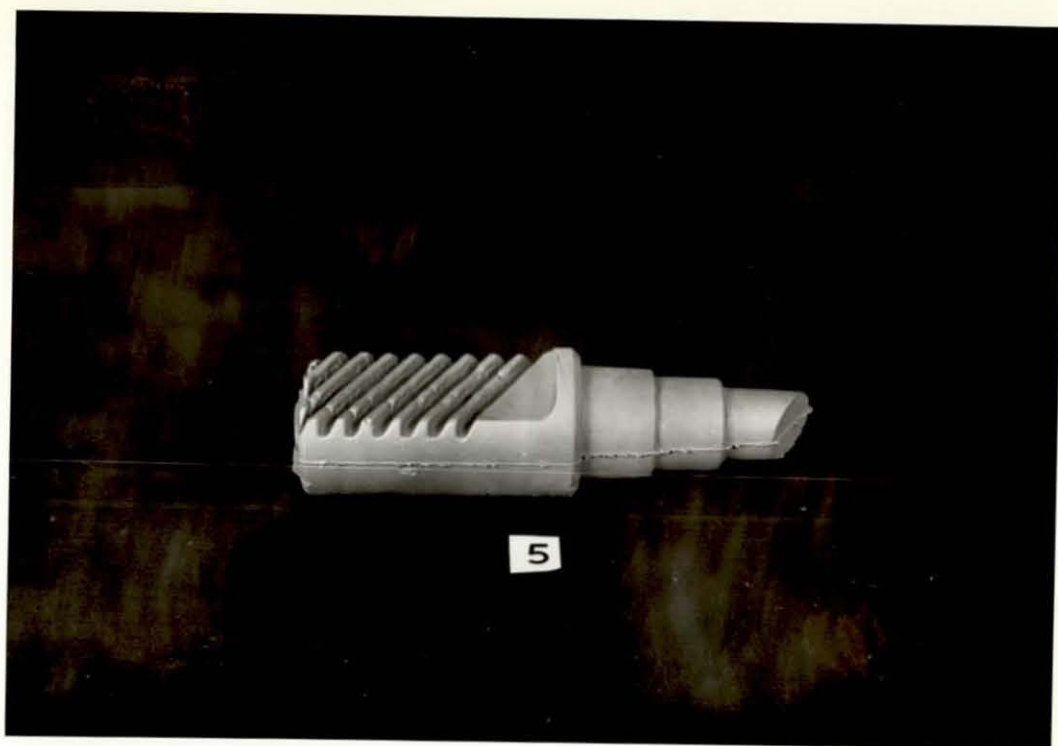


MELT WEIGHT	:	29.5 KG
MELT TIME	:	1 HR 40 MINS
LADLE PREHEAT TIME	:	1 HR 10 MINS
FURNACE TEMPERATURE	:	1650 <sup>o</sup> C
STELLAGEN ADDITION	:	146 GMS
POURING TEMPERATURE	:	1555 <sup>o</sup> C
MOULD ATMOSPHERE	:	AIR

(CASTINGS 3 & 4 PRODUCED FROM THE SAME MELT)

FIGURE 5.53 RETRACTABLE DIE CORE 4 (ii)



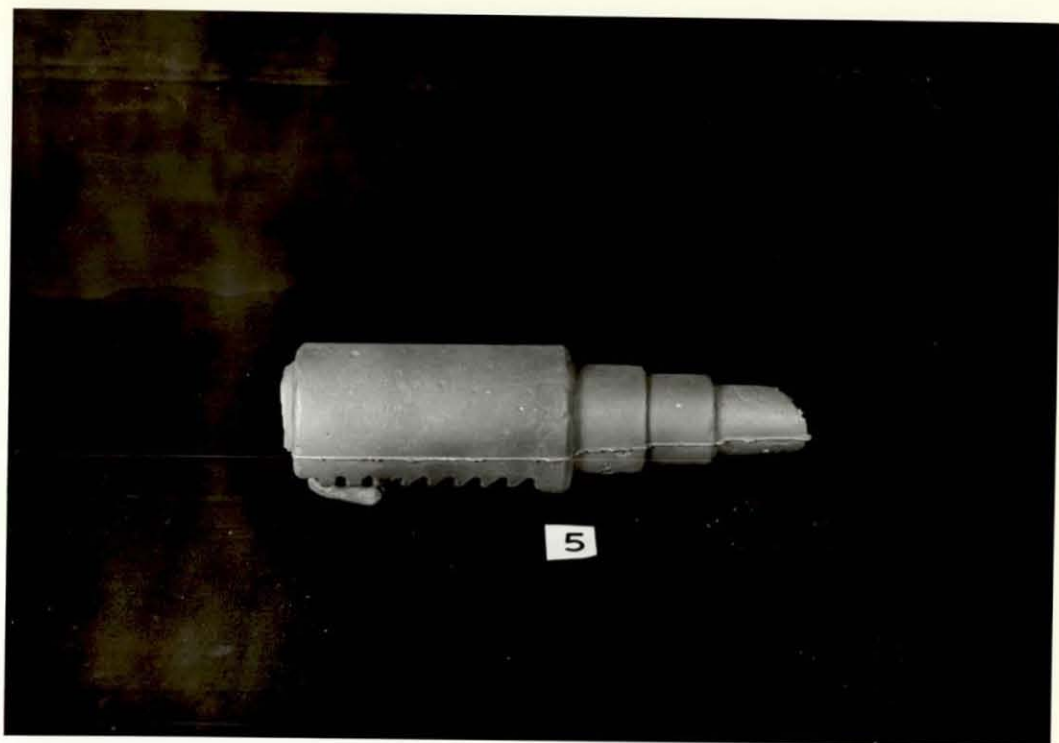


MELT WEIGHT	:	28.6 KG
MELT TIME	:	1 HR 30 MINS
LADLE PREHEAT TIME	:	45 MINS
FURNACE TEMPERATURE	:	1650°C
STELLAGEN ADDITION	:	140 GMS
POURING TEMPERATURE	:	1530°C
MOULD ATMOSPHERE	:	NITROGEN

(CASTINGS 5 & 6 PRODUCED FROM THE SAME MELT)

FIGURE 5.54 RETRACTABLE DIE CORE 5 (i)

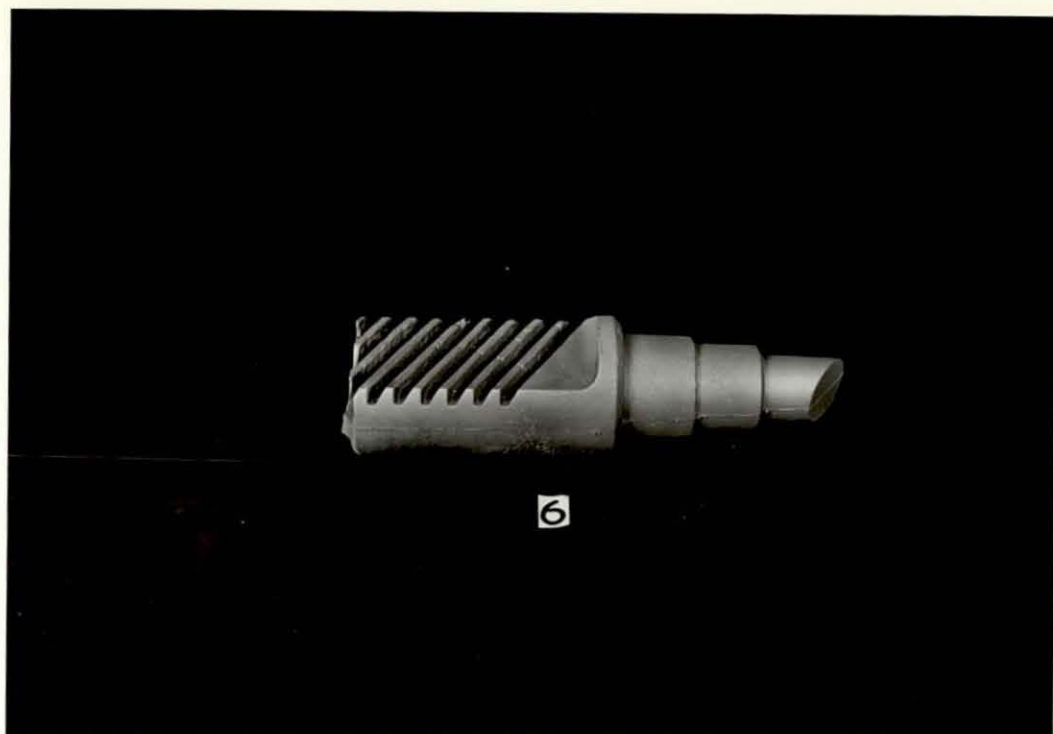




MELT WEIGHT	:	28.6 KG
MELT TIME	:	1 HR 30 MINS
LADLE PREHEAT TIME	:	45 MINS
FURNACE TEMPERATURE	:	1650°C
STELLAGEN ADDITION	:	140 GMS
POURING TEMPERATURE	:	1530°C
MOULD ATMOSPHERE	:	NITROGEN

(CASTINGS 5 & 6 PRODUCED FROM THE SAME MELT)

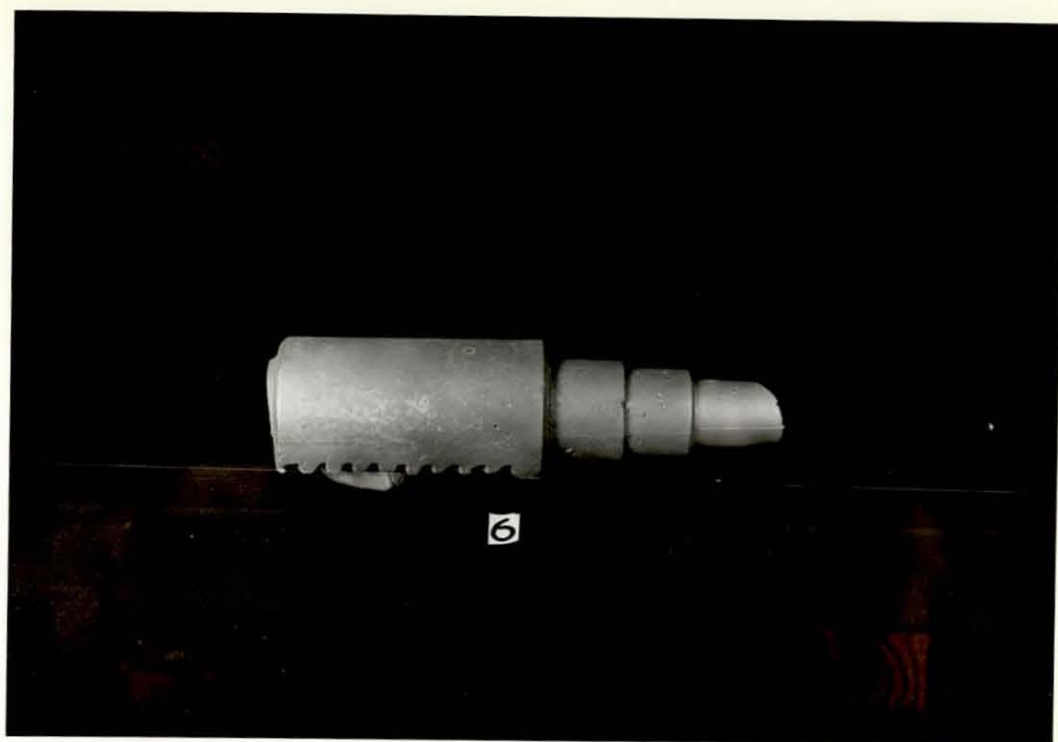
FIGURE 5.54 RETRACTABLE DIE CORE 5 (ii)



MELT WEIGHT	:	28.6 KG
MELT TIME	:	1 HR 30 MINS
LADLE PREHEAT TIME	:	45 MINS
FURNACE TEMPERATURE	:	1650° C
STELLAGEN ADDITION	:	140 GMS
POURING TEMPERATURE	:	1500° C
MOULD ATMOSPHERE	:	AIR

(CASTINGS 5 & 6 PRODUCED FROM THE SAME MELT)

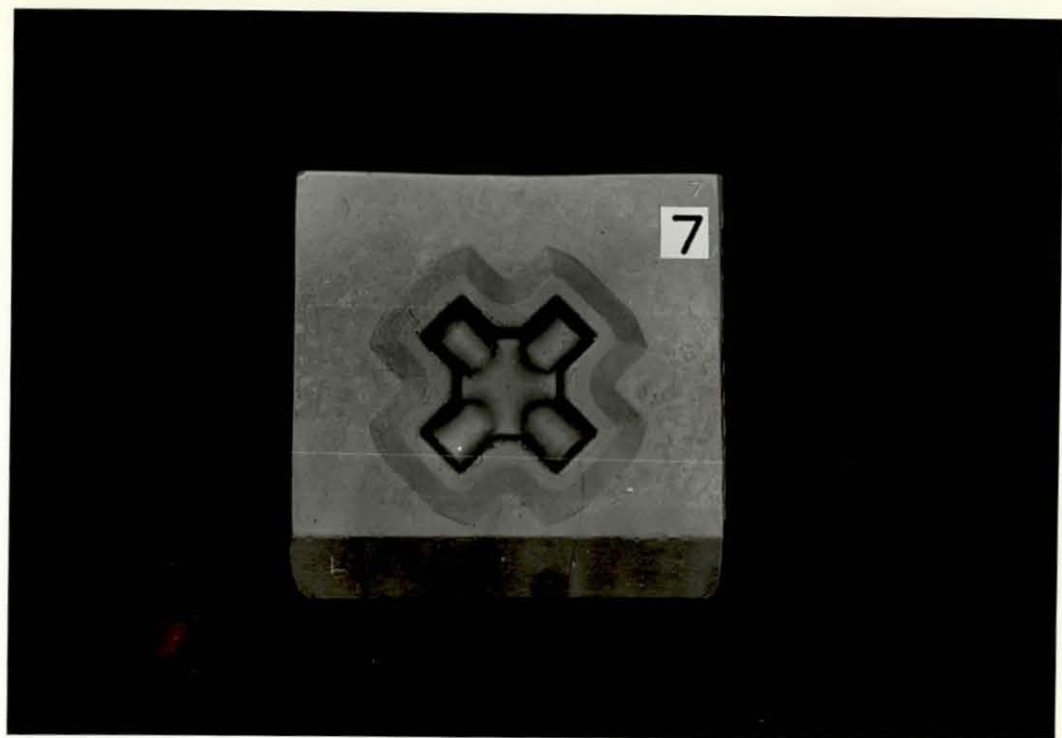
FIGURE 5.55 RETRACTABLE DIE CORE 6 (i)



MELT WEIGHT	:	28.6 KG
MELT TIME	:	1 HR 30 MINS
LADLE PREHEAT TIME	:	45 MINS
FURNACE TEMPERATURE	:	1650° C
STELLAGEN ADDITION	:	140 GMS
POURING TEMPERATURE	:	1500° C
MOULD ATMOSPHERE	:	AIR

(CASTINGS 5 & 6 PRODUCED FROM THE SAME MELT)

FIGURE 5.55 RETRACTABLE DIE CORE 6(ii)



MELT WEIGHT	:	20.4 KG
MELT TIME	:	1 HR 15 MINS
LADLE PREHEAT TIME	:	1 HR 15 MINS
FURNACE TEMPERATURE	:	1650°C
STELLAGEN ADDITION	:	102 GMS
POURING TEMPERATURE	:	1516°C
MOULD ATMOSPHERE	:	NITROGEN

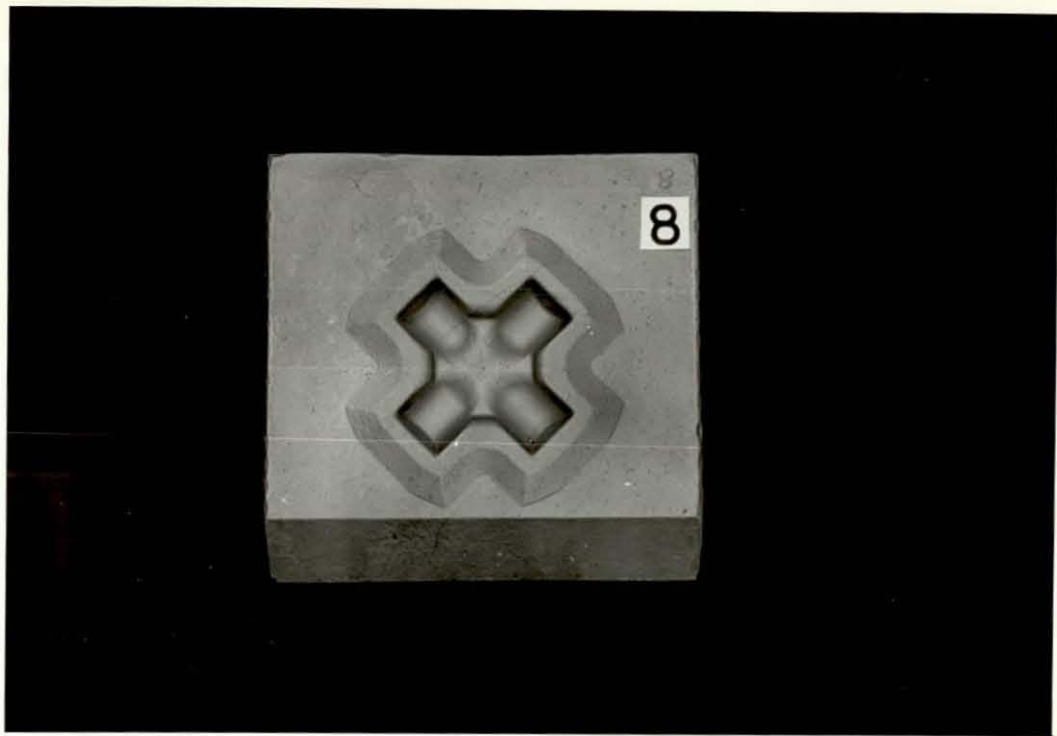
FIGURE 5.56 SPIDER FORGING DIE 7(i)





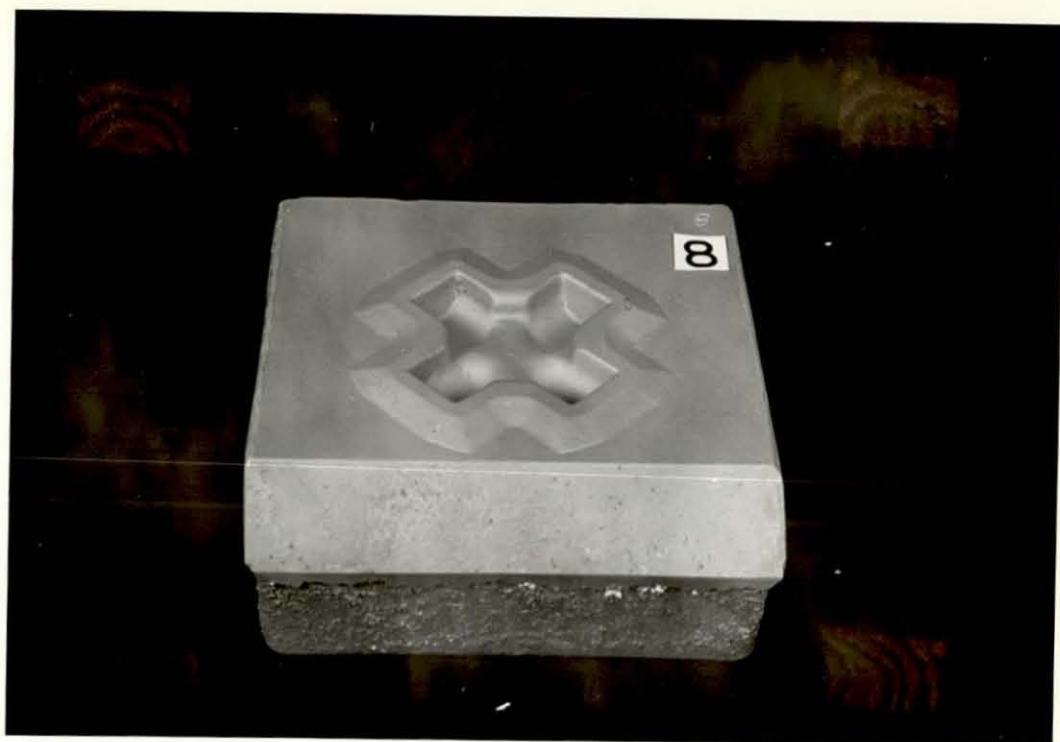
MELT WEIGHT	:	20.4 KG
MELT TIME	:	1 HR 15 MINS
LADLE PREHEAT TIME	:	1 HR 15 MINS
FURNACE TEMPERATURE	:	1650°C
STELLAGEN ADDITION	:	102 GMS
POURING TEMPERATURE	:	1516°C
MOULD ATMOSPHERE	:	NITROGEN

FIGURE 5.56 SPIDER FORGING DIE 7 (ii)



MELT WEIGHT	:	20.4 KG
MELT TIME	:	1 HR
LADLE PREHEAT TIME	:	1 HR
FURNACE TEMPERATURE	:	1665°C
STELLAGEN ADDITION	:	102 GMS
POURING TEMPERATURE	:	1550°C
MOULD ATMOSPHERE	:	AIR

FIGURE 5.57 SPIDER FORGING DIE 8 (i)



MELT WEIGHT	:	20.4 KG
MELT TIME	:	1 HR
LADLE PREHEAT TIME	:	1 HR
FURNACE TEMPERATURE	:	1665°C
STELLAGEN ADDITION	:	102 GMS
POURING TEMPERATURE	:	1550°C
MOULD ATMOSPHERE	:	AIR

FIGURE 5.57 SPIDER FORGING DIE 8 (ii)

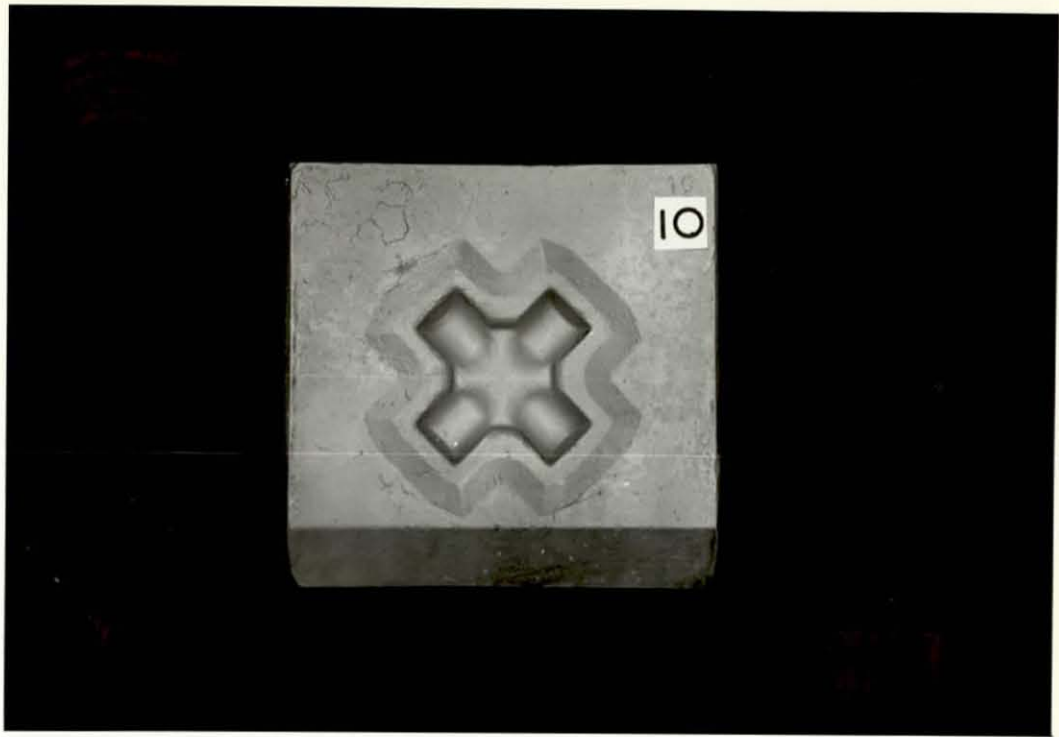




MELT WEIGHT	:	28.6 KG
MELT TIME	:	1 HR 45 MINS
LADLE PREHEAT TIME	:	1 HR 50 MINS
FURNACE TEMPERATURE	:	1650° C
STELLAGEN ADDITION	:	142 GMS
POURING TEMPERATURE	:	1545° C
MOULD ATMOSPHERE	:	AIR

FIGURE 5.58 FLANGE YOKE FORGING DIE 9





MELT WEIGHT	:	20.9 KG
MELT TIME	:	1 HR 5 MINS
LADLE PREHEAT TIME	:	1 HR 5 MINS
FURNACE TEMPERATURE	:	1650°C
STELLAGEN ADDITION	:	104 GMS
POURING TEMPERATURE	:	1540°C
MOULD ATMOSPHERE	:	AIR

FIGURE 5.59 SPIDER FORGING DIE 10 (i)



MELT WEIGHT	:	20.9 KG
MELT TIME	:	1 HR 5 MINS
LADLE PREHEAT TIME	:	1 HR 5 MINS
FURNACE TEMPERATURE	:	1650°C
STELLAGEN ADDITION	:	104 GMS
POURING TEMPERATURE	:	1540°C
MOULD ATMOSPHERE	:	AIR

FIGURE 5.59 SPIDER FORGING DIE 10(ii)



MELT WEIGHT	:	28.3 KG
MELT TIME	:	2 HRS 5 MINS
LADLE PREHEAT TIME	:	2 HRS 5 MINS
FURNACE TEMPERATURE	:	$> 1650^{\circ}\text{C}$
STELLAGEN ADDITION	:	140 GMS
POURING TEMPERATURE	:	$1550^{\circ}\text{C}$
MOULD ATMOSPHERE	:	NITROGEN

FIGURE 5.60 FLANGE YOKE FORGING DIE 11

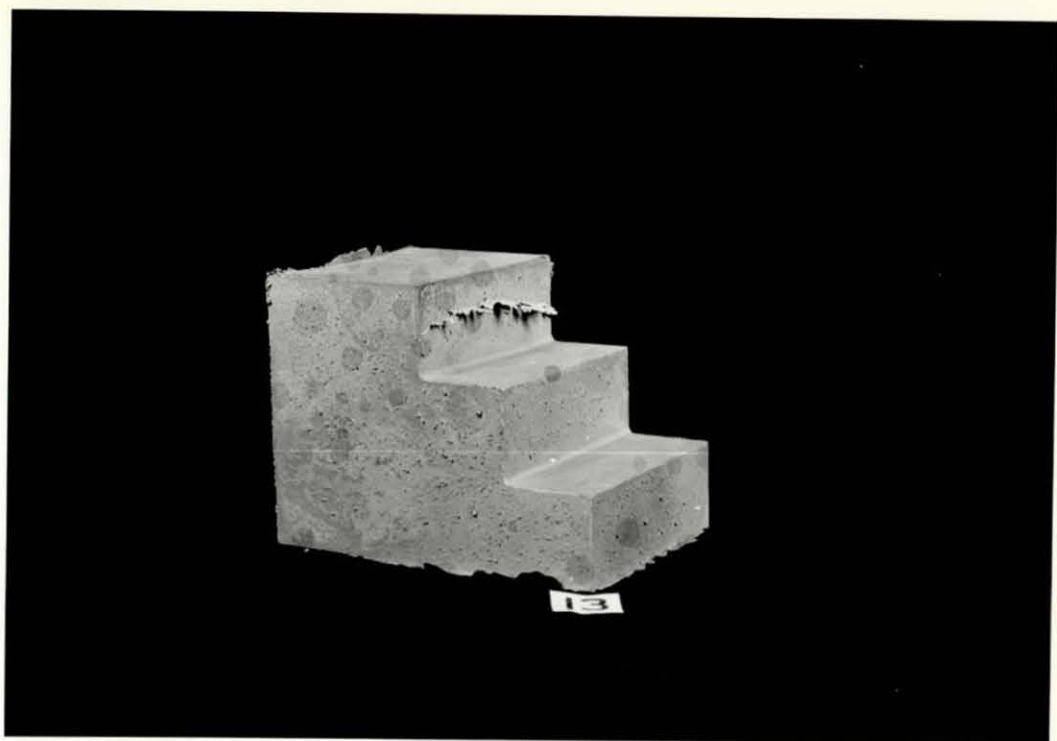




MELT WEIGHT	:	28.3 KG
MELT TIME	:	1 HR 40 MINS
LADLE PREHEAT TIME	:	1 HR 20 MINS
FURNACE TEMPERATURE	:	1650° C
STELLAGEN ADDITION	:	140 GMS
POURING TEMPERATURE	:	1545° C
MOULD ATMOSPHERE	:	AIR

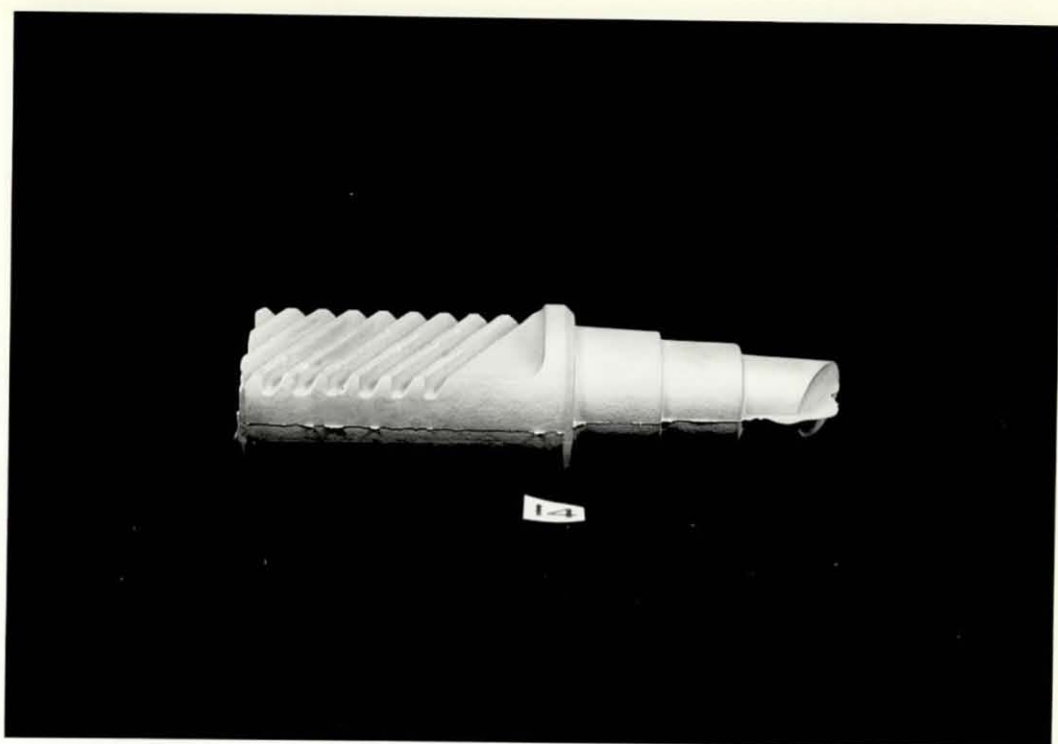
FIGURE 5.61 FLANGE YOKE FORGING DIE 12





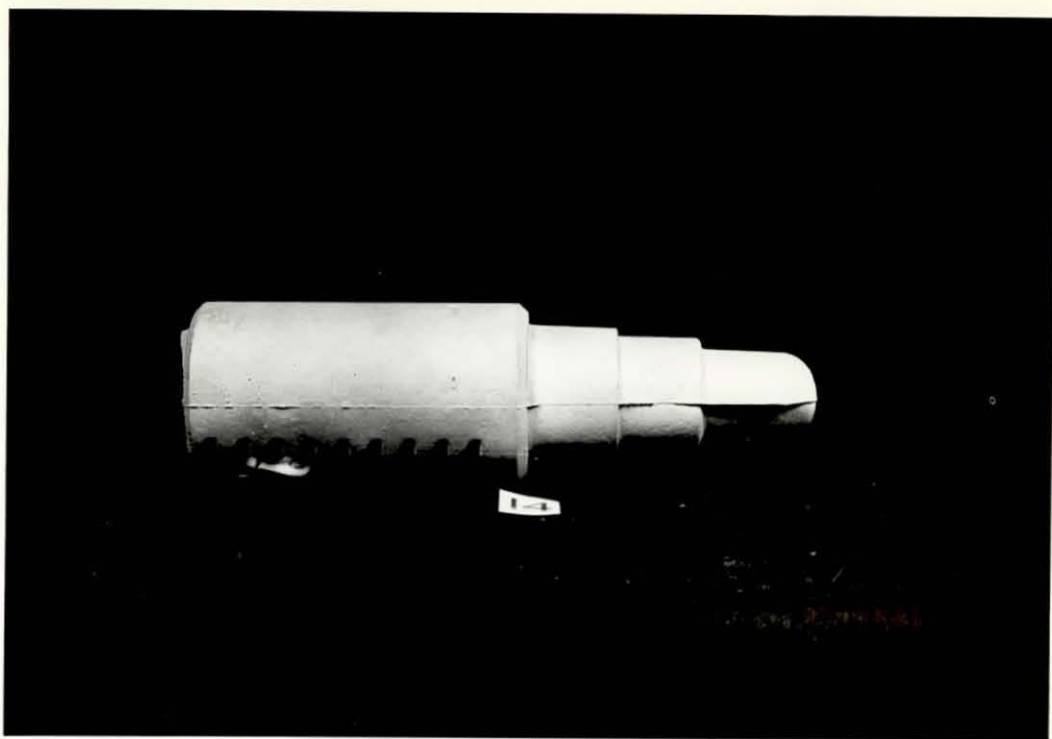
MELT WEIGHT	:	25.4 KG
MELT TIME	:	1 HR 40 MINS
LADLE PREHEAT TIME	:	1 HR
FURNACE TEMPERATURE	:	1670°C
STELLAGEN ADDITION	:	125 GMS
POURING TEMPERATURE	:	1555°C
MOULD ATMOSPHERE	:	AIR

FIGURE 5.62 STEPPED BLOCK CASTING 13



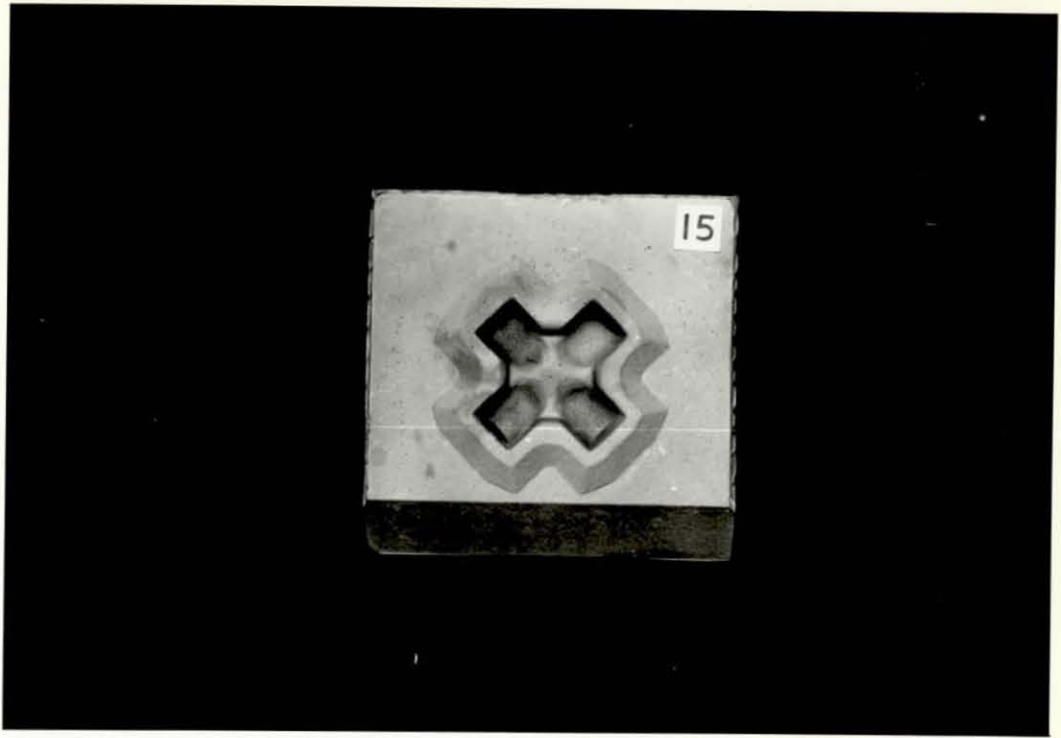
MELT WEIGHT	:	25.4 KG
MELT TIME	:	1 HR 5 MINS
LADLE PREHEAT TIME	:	40 MINS
FURNACE TEMPERATURE	:	1650°C
STELLAGEN ADDITION	:	125 GMS
POURING TEMPERATURE	:	1550°C
MOULD ATMOSPHERE	:	AIR

FIGURE 5.63 RETRACTABLE DIE CORE 14 (i)



MELT WEIGHT	:	25.4 KG
MELT TIME	:	1 HR 5 MINS
LADLE PREHEAT TIME	:	40 MINS
FURNACE TEMPERATURE	:	1650° C
STELLAGEN ADDITION	:	125 GMS
POURING TEMPERATURE	:	1550° C
MOULD ATMOSPHERE	:	AIR

FIGURE 5.63 RETRACTABLE DIE CORE 14 (ii)



MELT WEIGHT	:	25.4 KG
MELT TIME	:	1 HR 10 MINS
LADLE PREHEAT TIME	:	55 MINS
FURNACE TEMPERATURE	:	1700° C
STELLAGEN ADDITION	:	125 GMS
POURING TEMPERATURE	:	1540° C
MOULD ATMOSPHERE	:	AIR

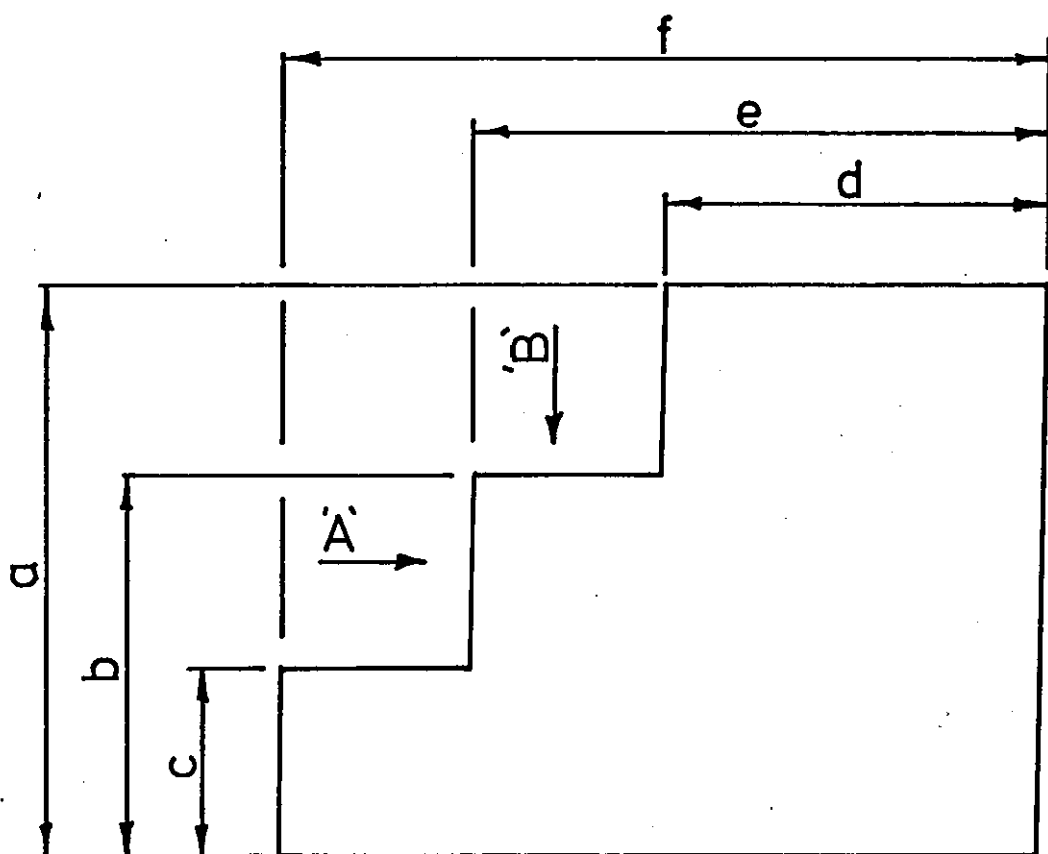
FIGURE 5.64 SPIDER FORGING DIE 15 (i)





MELT WEIGHT	:	25.4 KG
MELT TIME	:	1 HR 10 MINS
LADLE PREHEAT TIME	:	55 MINS
FURNACE TEMPERATURE	:	1700°C
STELLAGEN ADDITION	:	125 GMS
POURING TEMPERATURE	:	1540°C
MOULD ATMOSPHERE	:	AIR

FIGURE 5.64 SPIDER FORGING DIE 15 (ii)



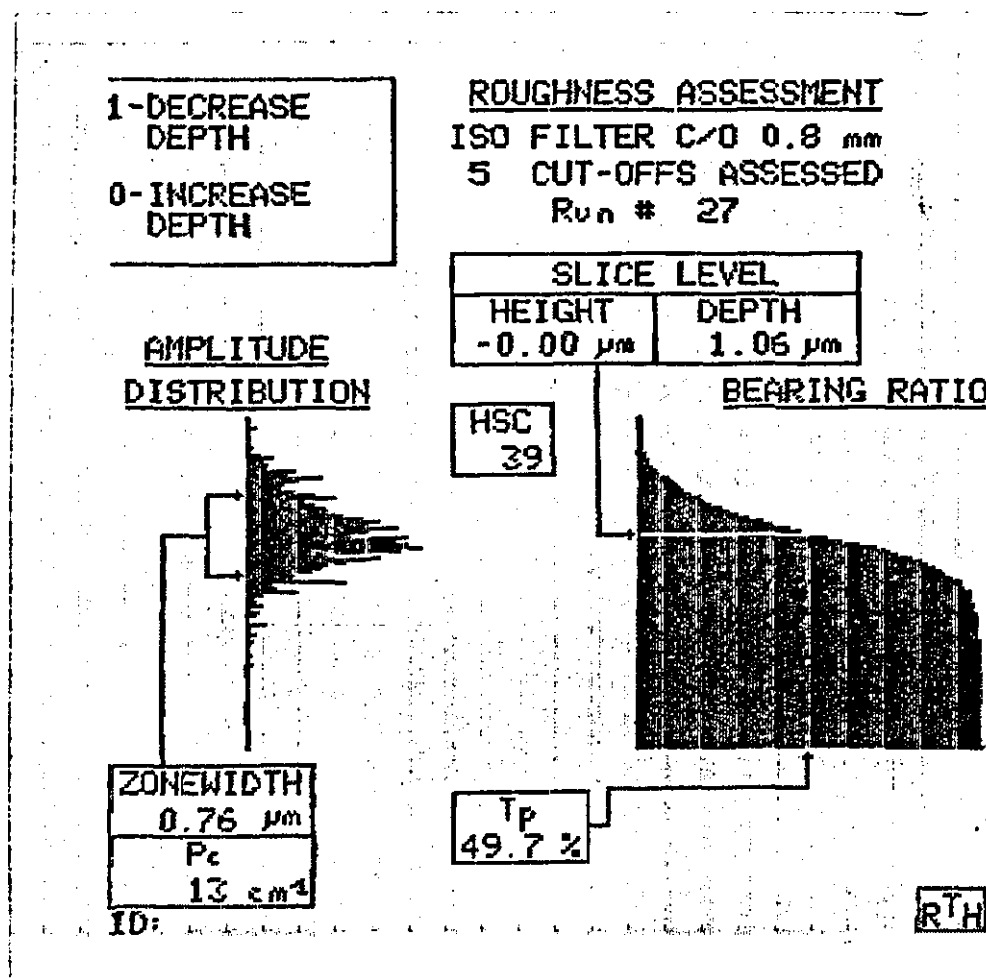
12	13	14
view on arrow 'A'		
15		16
17	18	19

1	2	3
4		
5		6
view on arrow 'B'		
7		8
9	10	11

DRAWING NO.

FIGURE 5.65

DESCRIPTION: SKETCH SHOWING DIMENSIONS MEASURED AND THEIR POINTS OF MEASUREMENT FOR THE STEPPED BLOCK CASTING



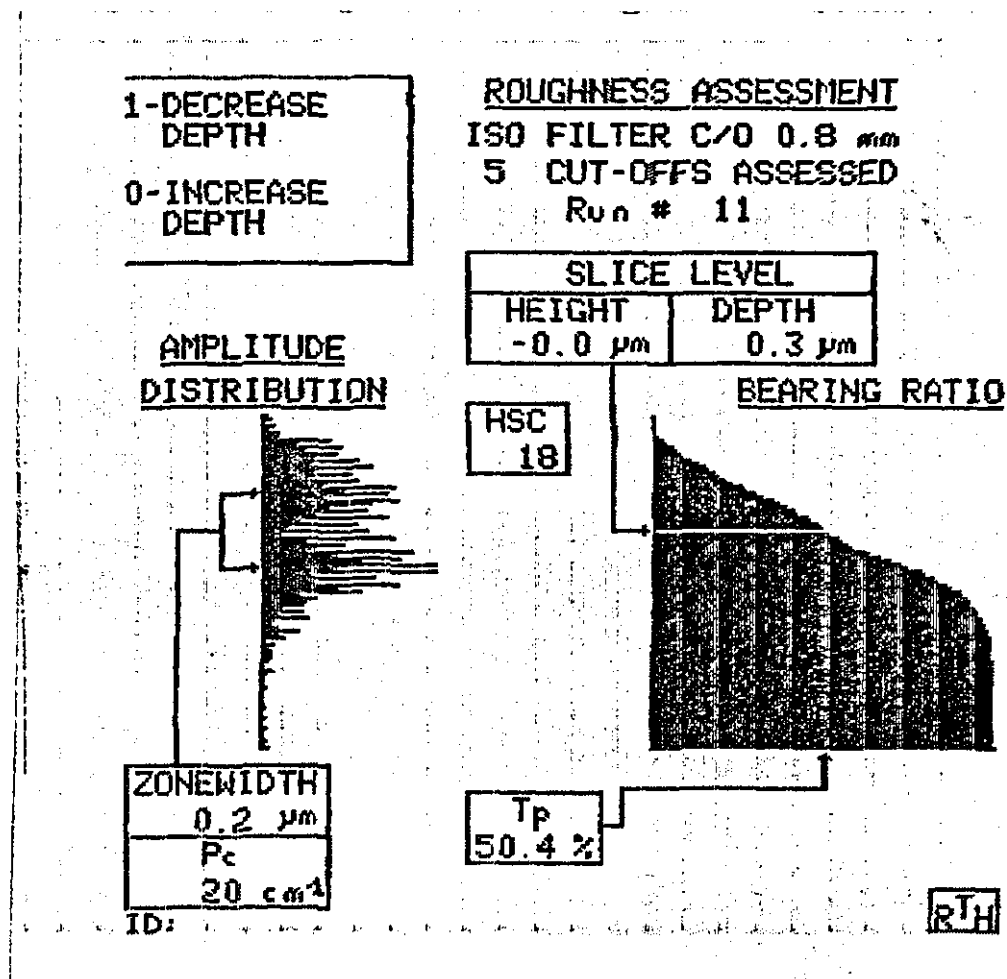
**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 27

Ra	.251 $\mu\text{m}$
Rq	.334 $\mu\text{m}$
Ry	2.94 $\mu\text{m}$
Rzm	1.79 $\mu\text{m}$
Rpm	0.67 $\mu\text{m}$

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 2.5 mm  
2 CUT-OFFS ASSESSED  
Run # 26

Ra	.268 $\mu\text{m}$
Rq	.300 $\mu\text{m}$
Ry	0.47 $\mu\text{m}$
Rp	0.61 $\mu\text{m}$

FIGURE 5.66 (1) SURFACE FINISH MEASUREMENTS STEPPED BLOCK PATTERN TOP STEP



**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 11

$R_a$	0.13 $\mu\text{m}$
$R_q$	0.15 $\mu\text{m}$
$R_y$	0.9 $\mu\text{m}$
$R_{tm}$	0.6 $\mu\text{m}$
$R_{pm}$	0.2 $\mu\text{m}$

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 12

$R_a$	0.23 $\mu\text{m}$
$R_q$	0.31 $\mu\text{m}$
$R_y$	0.8 $\mu\text{m}$
$R_{pm}$	0.4 $\mu\text{m}$

FIGURE 5.66 (ii) SURFACE FINISH MEASUREMENTS STEPPED BLOCK PATTERN MIDDLE STEP



1-DECREASE  
DEPTH

0-INCREASE  
DEPTH

AMPLITUDE  
DISTRIBUTION



ZONEDWIDTH	
	0.3 $\mu\text{m}$
Pc	
	20 $\text{cm}^{-1}$

ID:

### ROUGHNESS ASSESSMENT

ISO FILTER C/O 0.8 mm

5 CUT-OFFS ASSESSED

Run # 10

SLICE LEVEL

HEIGHT

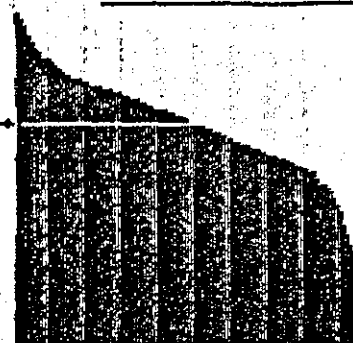
0.0  $\mu\text{m}$

DEPTH

0.5  $\mu\text{m}$

HSC  
22

BEARING RATIO



Tp  
53.1 %

RTI

### ROUGHNESS ASSESSMENT

ISO FILTER C/O 0.8 mm

5 CUT-OFFS ASSESSED

Run # 10

Ra 0.17  $\mu\text{m}$   
Rq 0.22  $\mu\text{m}$   
Ry 1.2  $\mu\text{m}$   
Rtm 1.0  $\mu\text{m}$   
Rpm 0.4  $\mu\text{m}$

### ROUGHNESS ASSESSMENT

ISO FILTER C/O 0.8 mm

5 CUT-OFFS ASSESSED

Run # 9

Ra 0.19  $\mu\text{m}$   
Rq 0.24  $\mu\text{m}$   
Ry 0.6  $\mu\text{m}$   
Rpm 0.4  $\mu\text{m}$

FIGURE 5.66 (iii) SURFACE FINISH MEASUREMENTS STEPPED BLOCK PATTERN BOTTOM STEP

0- INCREASE  
DEPTH

## ROUGHNESS ASSESSMENT

ISO FILTER C/D 0.8 mm

#### 4 CUT-OFFS ASSESSED

Run # 1

## SLICE LEVEL

**HEIGHT**

-0.3  $\mu\text{m}$

DEPTH

8.9  $\mu\text{m}$ 

AMPLITUDE  
DISTRIBUTION



**ZONEWIDTH**

6.7 Jan

PC

25 cm<sup>2</sup>

**HSC**

37

**BEARING RATIO**



**Tr**

49.1%

ETH

## ROUGHNESS ASSESSMENT

ISO FILTER C/O 0.8 mm

#### 4 CUT-OFFS ASSESSED

Run # 1

Ra 2.65  $\mu\text{m}$

**Rq 3.37  $\mu\text{m}$**

R<sub>4</sub> 19.3 μm

**Rt<sub>m</sub> 15.6 μm**

Rpms 7.2  $\mu$ m

NOVEMBER: DECEMBER: 11

EXHIBIT (25)-(87-0.3) 1000

5 (UFG-0173 00000000)

Run 3 7

4.91  $\mu\text{m}$

 $\lambda_{\text{ex}}$  5.57  $\mu\text{m}$ 

Idv 9.1 Jan

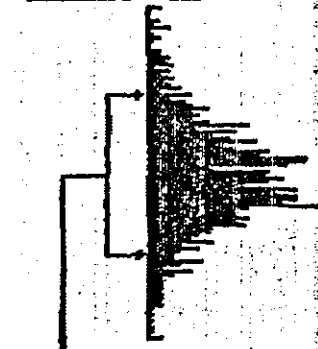
Id. 9.3 Jan

FIGURE 5.67 (i) SURFACE FINISH MEASUREMENTS STEPPED  
BLOCK CASTING 1 TOP STEP

1-DECREASE  
DEPTH

0-INCREASE  
DEPTH

AMPLITUDE  
DISTRIBUTION



ZONEWIDTH  
9.6  $\mu\text{m}$   
 $P_c$   
19  $\text{cm}^{-1}$

ID:

ROUGHNESS ASSESSMENT

ISO FILTER C/O 0.8 mm

4 CUT-OFFS ASSESSED

Run # 1

SLICE LEVEL

HEIGHT  
0.2  $\mu\text{m}$

DEPTH  
10.0  $\mu\text{m}$

HSC  
39

BEARING RATIO



$T_p$   
47.6 %

RTM

ROUGHNESS ASSESSMENT

ISO FILTER C/O 0.8 mm

4 CUT-OFFS ASSESSED

Run # 1

$R_a$  2.48  $\mu\text{m}$

$R_q$  3.19  $\mu\text{m}$

$R_y$  19.6  $\mu\text{m}$

$R_{tm}$  16.4  $\mu\text{m}$

$R_{pm}$  8.5  $\mu\text{m}$

ROUGHNESS ASSESSMENT

ISO FILTER C/O 0.8 mm

4 CUT-OFFS ASSESSED

Run # 11

$R_a$  4.00  $\mu\text{m}$

$R_q$  4.72  $\mu\text{m}$

$R_y$  8.7  $\mu\text{m}$

$R_{pm}$  10.9  $\mu\text{m}$

FIGURE 5.67 (11) SURFACE FINISH MEASUREMENTS STEPPED  
BLOCK CASTING 1 MIDDLE STEP

1-DECREASE  
DEPTH  
0-INCREASE  
DEPTH

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
4 CUT-OFFS ASSESSED  
Run # 2

AMPLITUDE  
DISTRIBUTION



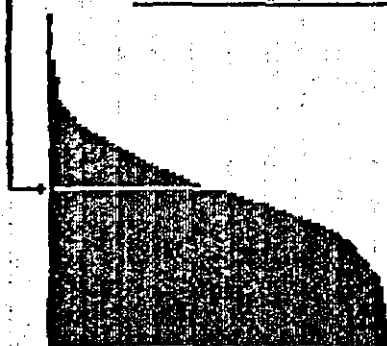
ZONewidth  
10.4  $\mu\text{m}$   
Pc  
9  $\text{cm}^2$

ID:

SLICE LEVEL  
HEIGHT  
0.3  $\mu\text{m}$   
DEPTH  
11.4  $\mu\text{m}$

HSC  
40

BEARING RATIO



Tp  
47.2 %

RTM

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
4 CUT-OFFS ASSESSED  
Run # 2

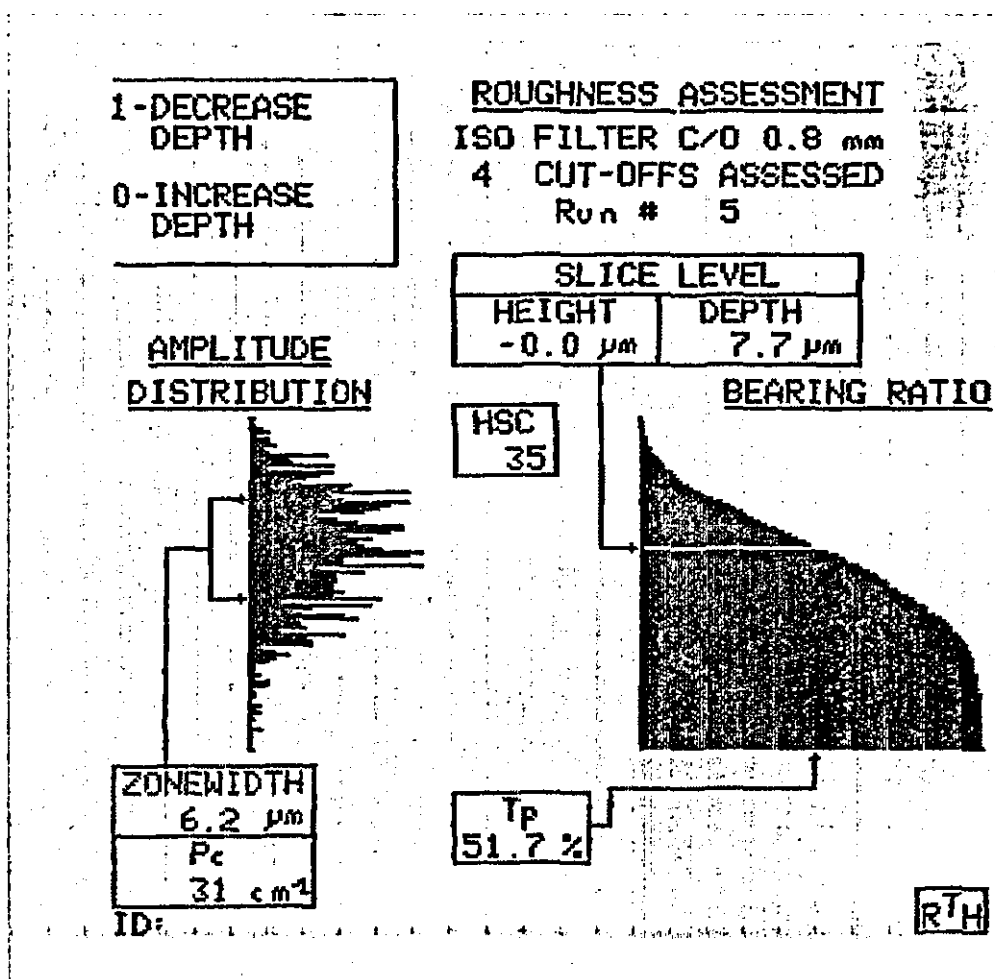
Ro 2.50  $\mu\text{m}$   
Rq 3.25  $\mu\text{m}$   
Ry 20.5  $\mu\text{m}$   
Rem 15.6  $\mu\text{m}$   
Rp 9.5  $\mu\text{m}$

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
4 CUT-OFFS ASSESSED  
Run # 12

Ro 4.23  $\mu\text{m}$   
Rq 5.31  $\mu\text{m}$   
Ry 15.8  $\mu\text{m}$   
Rp 8.1  $\mu\text{m}$

FIGURE 5.67 (iii) SURFACE FINISH MEASUREMENTS STEPPED  
BLOCK CASTING 1 BOTTOM STEP





**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
4 CUT-OFFS ASSESSED  
Run # 5

$R_a$	2.73 $\mu\text{m}$
$R_q$	3.35 $\mu\text{m}$
$R_s$	17.8 $\mu\text{m}$
$R_{tm}$	15.6 $\mu\text{m}$
$R_{pm}$	6.7 $\mu\text{m}$

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 17

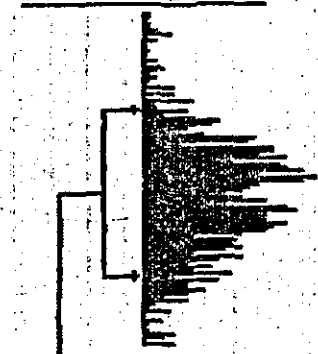
$R_a$	6.37 $\mu\text{m}$
$R_q$	8.43 $\mu\text{m}$
$R_s$	23.5 $\mu\text{m}$
$R_{pm}$	11.3 $\mu\text{m}$

FIGURE 5.68 (1) SURFACE FINISH MEASUREMENTS STEPPED  
BLOCK CASTING 2 TOP STEP

1-DECREASE  
DEPTH  
0-INCREASE  
DEPTH

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
4 CUT-OFFS ASSESSED  
Run # 4

AMPLITUDE  
DISTRIBUTION



ZONWIDTH  
14.0  $\mu\text{m}$   
Pc  
6  $\text{cm}^{-1}$

SLICE LEVEL  
HEIGHT  
-0.3  $\mu\text{m}$   
DEPTH  
15.2  $\mu\text{m}$

HSC  
23

BEARING RATIO



Tp  
49.8 %

RTH

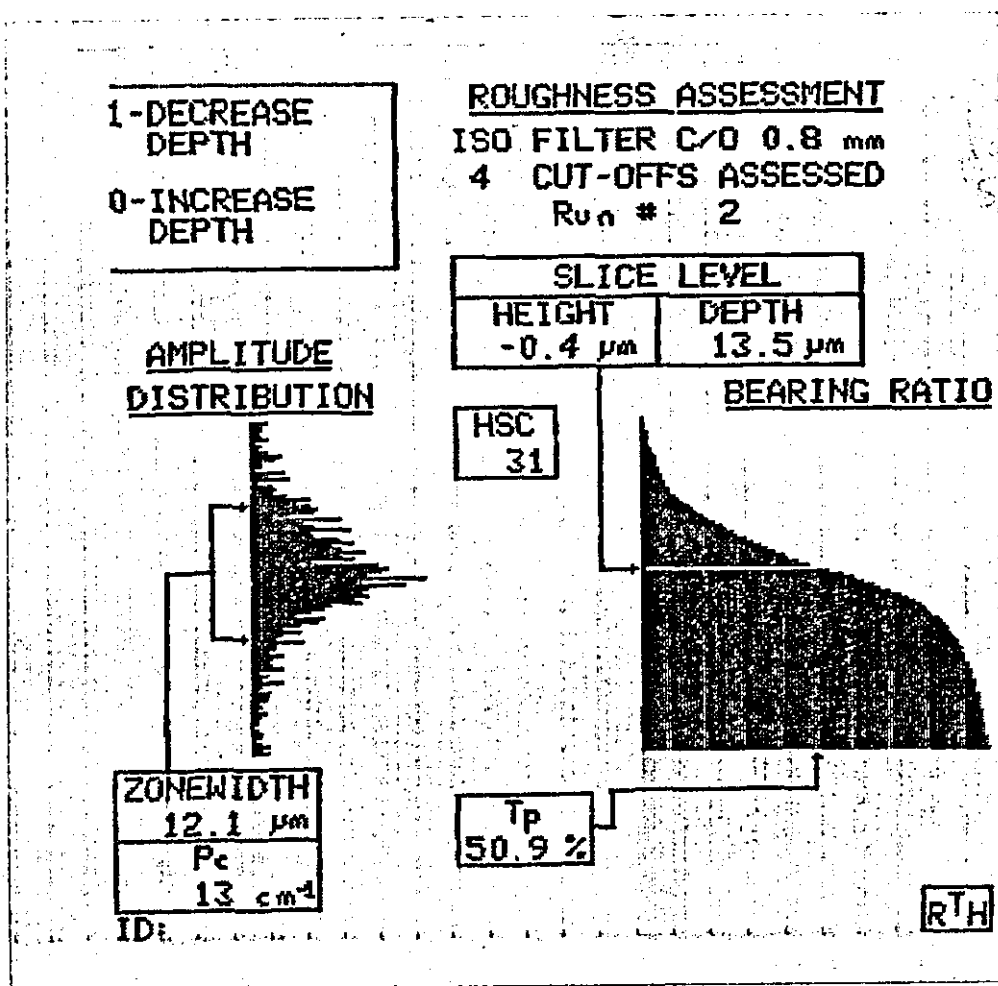
ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
4 CUT-OFFS ASSESSED  
Run # 4

Ra 3.81  $\mu\text{m}$   
Rq 4.76  $\mu\text{m}$   
Ry 27.6  $\mu\text{m}$   
Rtm 20.8  $\mu\text{m}$   
Rpm 9.8  $\mu\text{m}$

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 20

Ra 4.75  $\mu\text{m}$   
Rq 5.61  $\mu\text{m}$   
Ry 9.2  $\mu\text{m}$   
Rpm 12.8  $\mu\text{m}$

FIGURE 5.68 (11) SURFACE FINISH MEASUREMENTS STEPPED  
BLOCK CASTING 2 MIDDLE STEP



**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
4 CUT-OFFS ASSESSED  
Run # 2

$R_a$	3.82 $\mu\text{m}$
$R_q$	5.08 $\mu\text{m}$
$R_{t1}$	29.4 $\mu\text{m}$
$R_{t2}$	21.9 $\mu\text{m}$
$R_{pm}$	9.8 $\mu\text{m}$

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
4 CUT-OFFS ASSESSED  
Run # 27

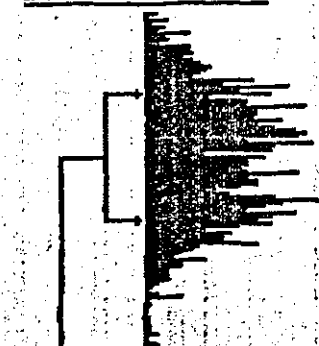
$W_a$	5.01 $\mu\text{m}$
$W_q$	5.82 $\mu\text{m}$
$W_v$	12.7 $\mu\text{m}$
$W_p$	11.6 $\mu\text{m}$

FIGURE 5.68 (iii) SURFACE FINISH MEASUREMENTS STEPPED BLOCK CASTING BOTTOM STEP

1-DECREASE  
DEPTH  
0-INCREASE  
DEPTH

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 2

**AMPLITUDE  
DISTRIBUTION**

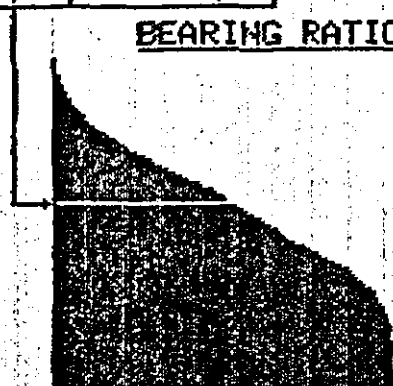


**ZONEWIDTH**  
9.4  $\mu\text{m}$   
**Pc**  
13  $\text{cm}^2$

**SLICE LEVEL**  
**HEIGHT**  
-0.1  $\mu\text{m}$   
**DEPTH**  
10.7  $\mu\text{m}$

**HSC**  
28

**BEARING RATIO**



**Tp**  
51.4 %

**RTI**

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 2

**Ra** 3.82  $\mu\text{m}$   
**Rq** 4.57  $\mu\text{m}$   
**Ry** 23.5  $\mu\text{m}$   
**Rtm** 19.2  $\mu\text{m}$   
**Rpm** 9.3  $\mu\text{m}$

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 30

**Wa** 5.55  $\mu\text{m}$   
**Wq** 6.95  $\mu\text{m}$   
**Wy** 15.8  $\mu\text{m}$   
**Wp** 15.2  $\mu\text{m}$

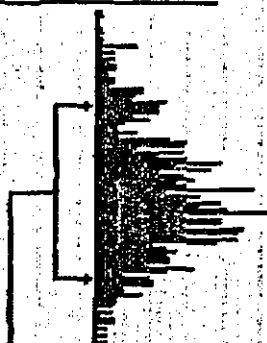
FIGURE 5.69 (1) SURFACE FINISH MEASUREMENTS STEPPED  
BLOCK CASTING 3 TOP STEP



1-DECREASE  
DEPTH

0-INCREASE  
DEPTH

AMPLITUDE  
DISTRIBUTION



ZONWIDTH  
12.2  $\mu\text{m}$   
 $P_c$   
9  $\text{cm}^4$

ID:

ROUGHNESS ASSESSMENT

ISO FILTER C/O 0.8  $\text{mm}$

4 CUT-OFFS ASSESSED

Run # 6

SLICE LEVEL

HEIGHT

-0.6  $\mu\text{m}$

DEPTH

12.8  $\mu\text{m}$

HSC

21

BEARING RATIO



$T_p$   
45.2 %

RTM

ROUGHNESS ASSESSMENT

ISO FILTER C/O 0.8  $\text{mm}$

4 CUT-OFFS ASSESSED

Run # 6

$R_a$  3.44  $\mu\text{m}$

$R_q$  4.27  $\mu\text{m}$

$R_y$  23.3  $\mu\text{m}$

$R_{em}$  16.8  $\mu\text{m}$

$R_{pm}$  8.3  $\mu\text{m}$

ROUGHNESS ASSESSMENT

ISO FILTER C/O 0.8  $\text{mm}$

5 CUT-OFFS ASSESSED

Run # 35

$R_a$  9.70  $\mu\text{m}$

$R_q$  11.4  $\mu\text{m}$

$R_y$  21.7  $\mu\text{m}$

$R_p$  22.5  $\mu\text{m}$

FIGURE 5.69 (ii) SURFACE FINISH MEASUREMENTS STEPPED  
BLOCK CASTING 3 MIDDLE STEP

1-DECREASE  
DEPTH

0-INCREASE  
DEPTH

# ROUGHNESS ASSESSMENT

ISO FILTER C/O 0.8 mm

4 CUT-OFFS ASSESSED

Run # 1

## SLICE LEVEL

HEIGHT

-0.8  $\mu\text{m}$

DEPTH

11.5  $\mu\text{m}$

## AMPLITUDE DISTRIBUTION



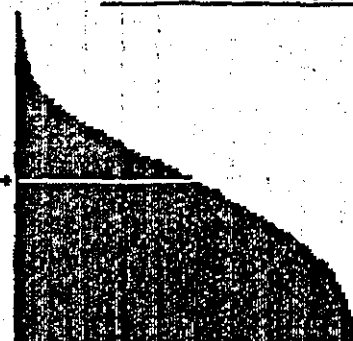
ZONWIDTH  
11.0  $\mu\text{m}$   
Pc  
19  $\text{cm}^2$

ID:

HSC

27

## BEARING RATIO



TP  
51.6 %

RTM

# ROUGHNESS ASSESSMENT

ISO FILTER C/O 0.8 mm

4 CUT-OFFS ASSESSED

Run # 1

Ra 3.52  $\mu\text{m}$

Rq 4.33  $\mu\text{m}$

Ry 21.6  $\mu\text{m}$

Rzm 19.4  $\mu\text{m}$

Rpm 9.3  $\mu\text{m}$

# ROUGHNESS ASSESSMENT

FILTER CUT-OFF 0.8 mm

5 CUT-OFFS ASSESSED

Run # 22

Wa 6.00  $\mu\text{m}$

Wq 7.82  $\mu\text{m}$

Wv 13.2  $\mu\text{m}$

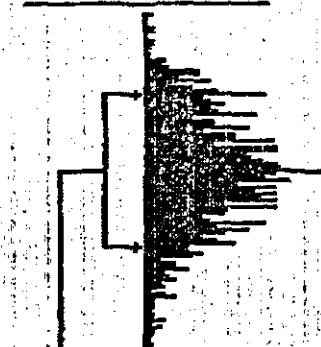
Wp 18.9  $\mu\text{m}$

FIGURE 5.69 (iii) SURFACE FINISH MEASUREMENTS STEPPED  
BLOCK CASTING 3 BOTTOM STEP

1-DECREASE  
DEPTH  
0-INCREASE  
DEPTH

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 40

AMPLITUDE  
DISTRIBUTION



ZDNEWIDTH  
11.4  $\mu\text{m}$   
Pc  
10  $\text{cm}^{-1}$

ID:

SLICE LEVEL  
HEIGHT 0.3  $\mu\text{m}$  DEPTH 11.6  $\mu\text{m}$

HSC  
40

BEARING RATIO



Tp  
49.9 %

RTM

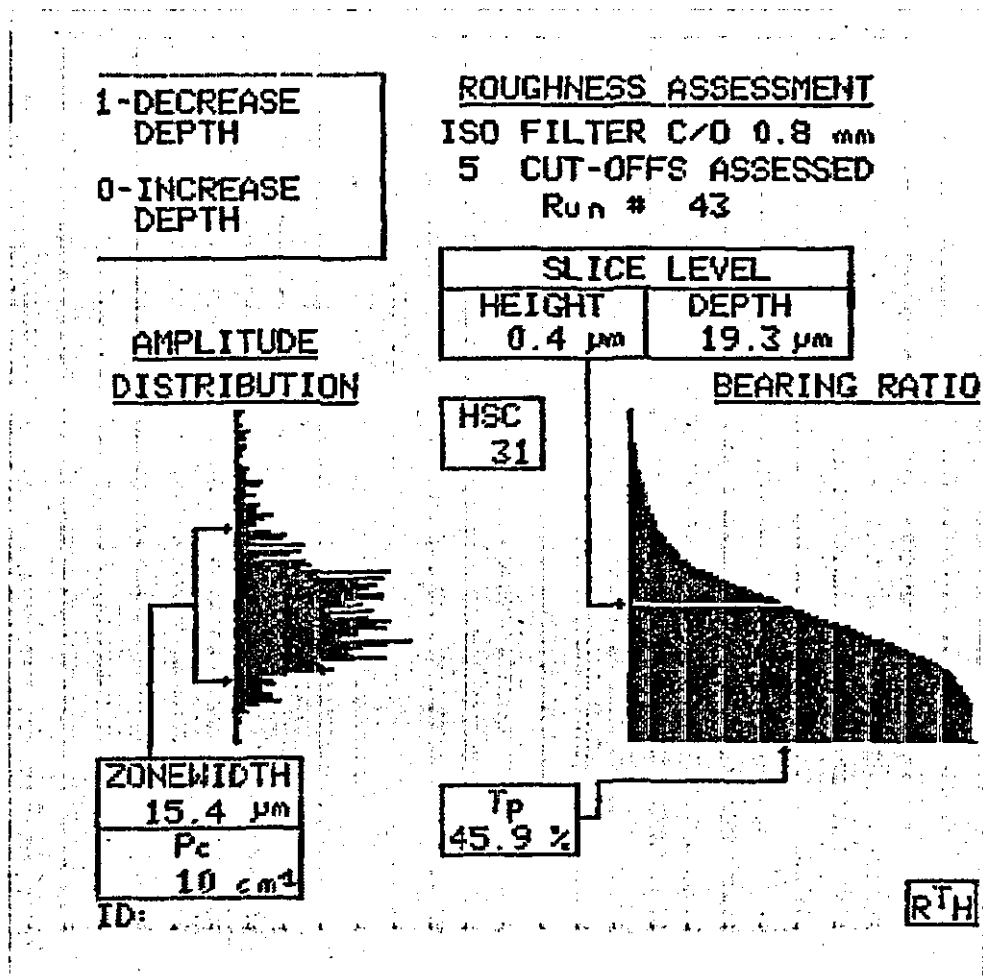
ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 40

Ra 3.42  $\mu\text{m}$   
Rq 4.28  $\mu\text{m}$   
Ry 24.1  $\mu\text{m}$   
Rtm 18.7  $\mu\text{m}$   
Rpm 8.9  $\mu\text{m}$

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
4 CUT-OFFS ASSESSED  
Run # 41

Ra 5.18  $\mu\text{m}$   
Rq 6.07  $\mu\text{m}$   
Ry 15.7  $\mu\text{m}$   
Rpm 8.1  $\mu\text{m}$

FIGURE 5.70 (1) SURFACE FINISH MEASUREMENTS STEPPED  
BLOCK CASTING 13 TOP STEP



**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 43

Ra	4.04 $\mu\text{m}$
Rq	5.18 $\mu\text{m}$
Ry	27.7 $\mu\text{m}$
Rt <sub>m</sub>	21.9 $\mu\text{m}$
Rpm	11.9 $\mu\text{m}$

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 44

Ra	6.31 $\mu\text{m}$
Rq	8.10 $\mu\text{m}$
Ry	16.1 $\mu\text{m}$
Rt <sub>m</sub>	27.6 $\mu\text{m}$

FIGURE 5.70 (ii) SURFACE FINISH MEASUREMENTS STEPPED BLOCK CASTING 13 MIDDLE STEP

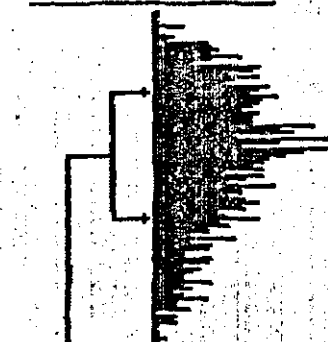


1-DECREASE  
DEPTH

0-INCREASE  
DEPTH

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 46

AMPLITUDE  
DISTRIBUTION



ZONEWIDTH  
6.5  $\mu\text{m}$   
Pc  
28  $\text{cm}^{-1}$

ID:

SLICE LEVEL	
HEIGHT	DEPTH
0.0 $\mu\text{m}$	7.4 $\mu\text{m}$

HSC  
42

BEARING RATIO



Tp  
54.7 %

RTM

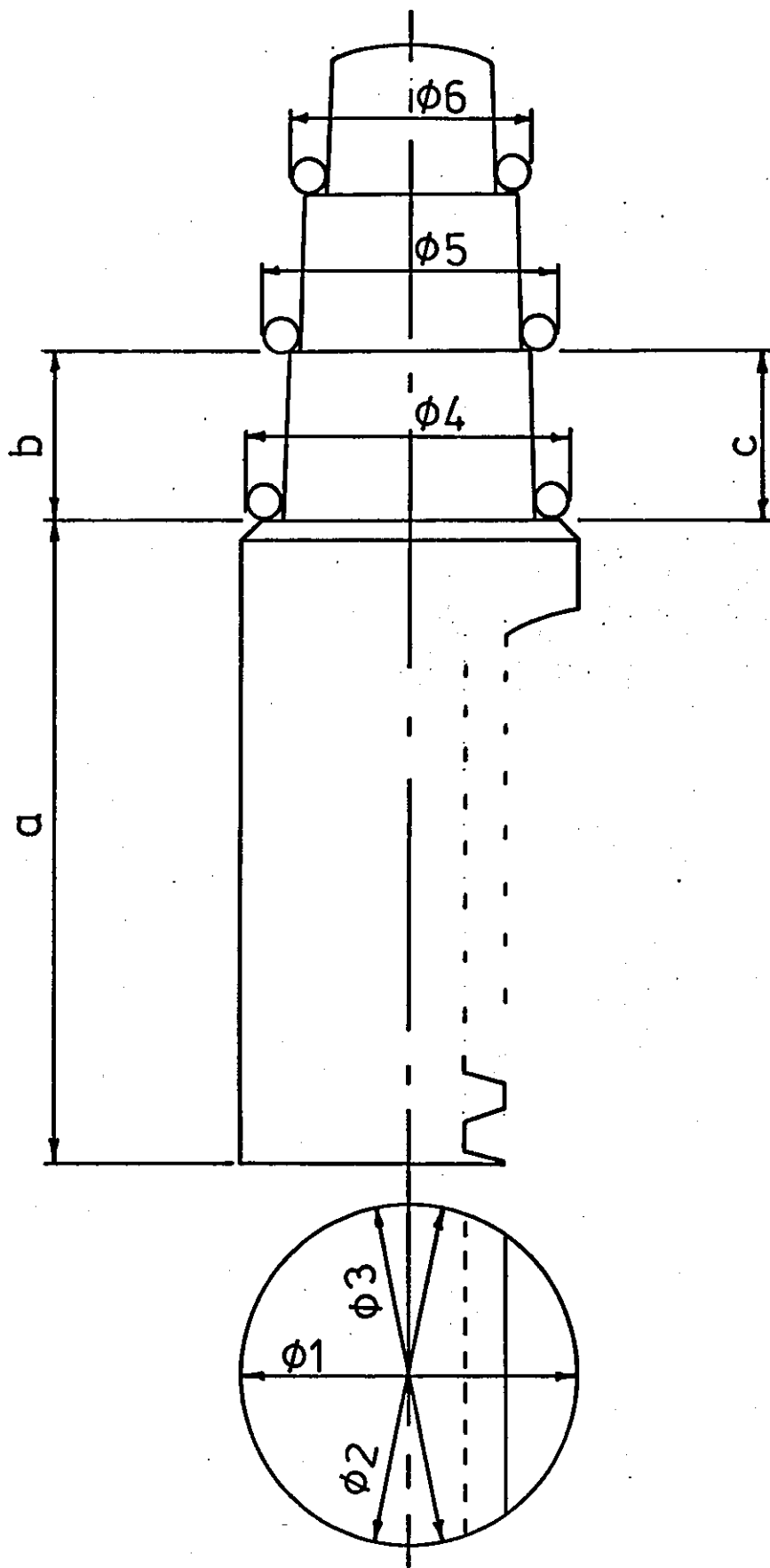
ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 46

Ra 2.86  $\mu\text{m}$   
Rq 3.49  $\mu\text{m}$   
Ry 16.3  $\mu\text{m}$   
Rzm 13.6  $\mu\text{m}$   
Rpm 6.6  $\mu\text{m}$

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 47

Ra 3.49  $\mu\text{m}$   
Rq 4.52  $\mu\text{m}$   
Ry 10.5  $\mu\text{m}$   
Rpm 12.3  $\mu\text{m}$

FIGURE 5.70 (iii) SURFACE FINISH MEASUREMENTS STEPPED  
BLOCK CASTING 13 BOTTOM STEP

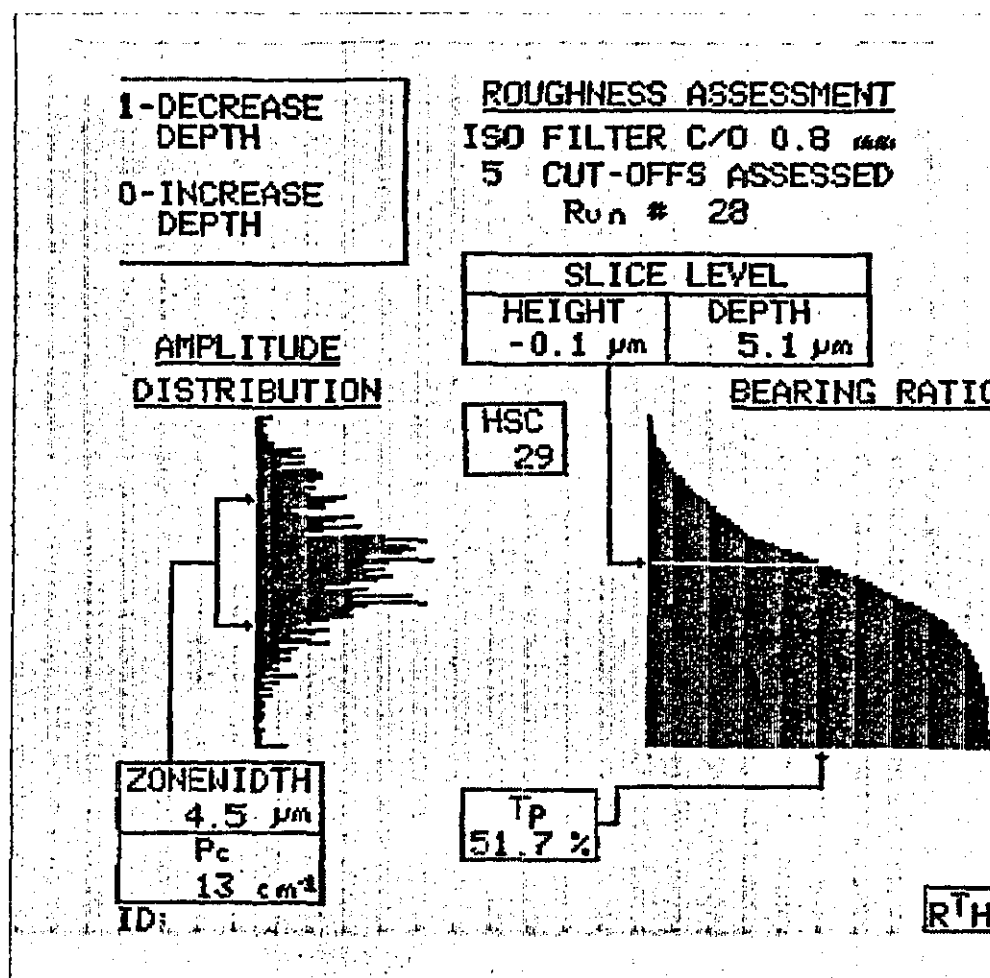


DRAWING NO.

FIGURE 5.71

DESCRIPTION:

SKETCH SHOWING DIMENSIONS MEASURED AND THEIR POINTS OF MEASUREMENT FOR THE RETRACTABLE DIE CORE



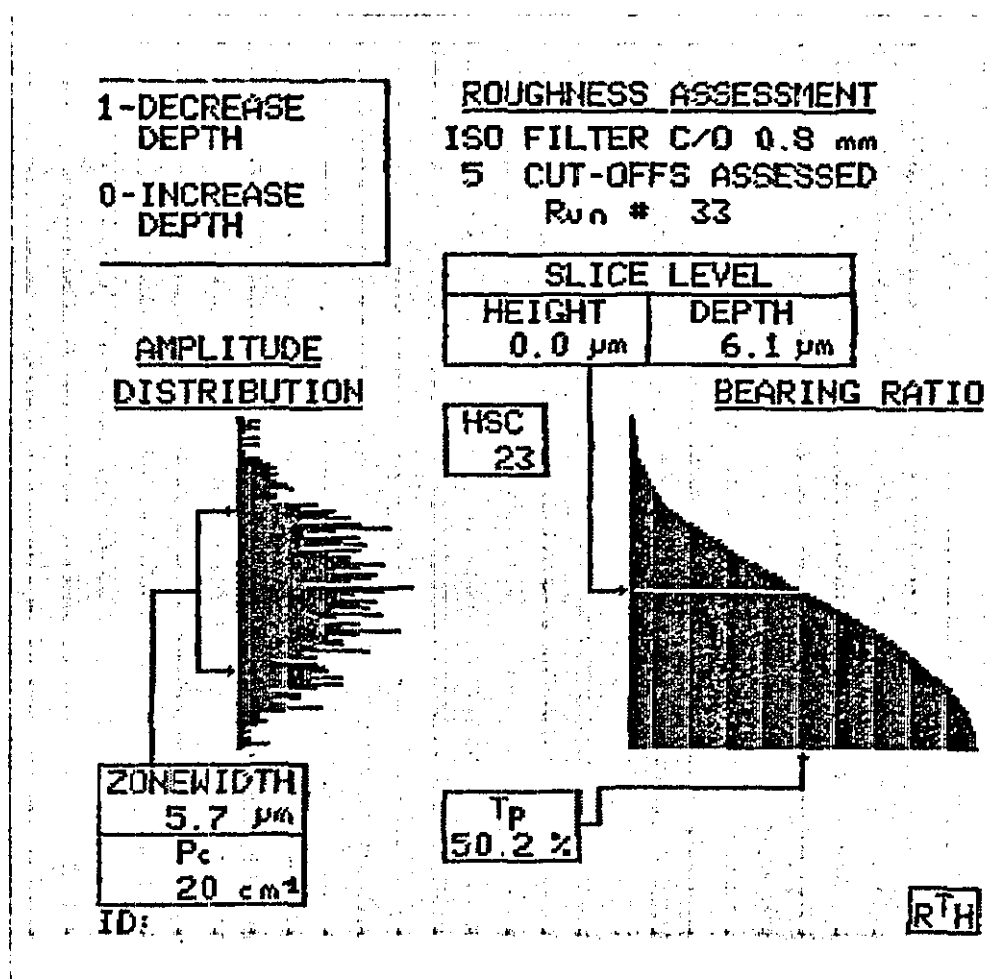
**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8  $\mu\text{m}$   
5 CUT-OFFS ASSESSED  
Run # 28

Ra	1.61 $\mu\text{m}$
Rq	2.05 $\mu\text{m}$
Ry	9.7 $\mu\text{m}$
Rz	8.1 $\mu\text{m}$
Rpm	4.0 $\mu\text{m}$

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 2.5  $\mu\text{m}$   
2 CUT-OFFS ASSESSED  
Run # 28

Ra	1.31 $\mu\text{m}$
Rq	1.65 $\mu\text{m}$
Ry	3.9 $\mu\text{m}$
Rz	2.2 $\mu\text{m}$

FIGURE 5.72 (i) SURFACE FINISH MEASUREMENTS RETRACTABLE DIE CORE PATTERN



**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 33

$R_a$	1.91 $\mu\text{m}$
$R_q$	2.32 $\mu\text{m}$
$R_y$	11.3 $\mu\text{m}$
$R_{tm}$	9.3 $\mu\text{m}$
$R_{pm}$	5.1 $\mu\text{m}$

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 2.5 mm  
2 CUT-OFFS ASSESSED  
Run # 34

$R_a$	1.23 $\mu\text{m}$
$R_q$	1.61 $\mu\text{m}$
$R_y$	3.8 $\mu\text{m}$
$R_{pm}$	2.2 $\mu\text{m}$

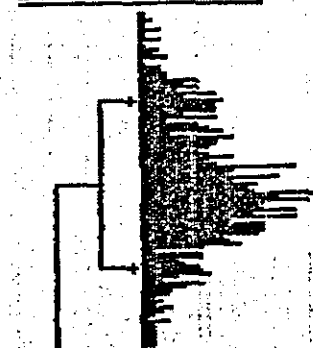
FIGURE 5.72 (11) SURFACE FINISH MEASUREMENTS RETRACTABLE DIE CORE PATTERN



1-DECREASE  
DEPTH

0-INCREASE  
DEPTH

AMPLITUDE  
DISTRIBUTION



ZONWIDTH  
11.2  $\mu\text{m}$   
Pc  
16  $\text{cm}^2$

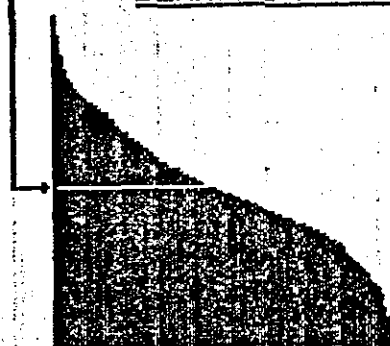
ID:

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
4 CUT-OFFS ASSESSED  
Run # 1

SLICE LEVEL  
HEIGHT  
-0.4  $\mu\text{m}$   
DEPTH  
11.2  $\mu\text{m}$

HSC  
30

BEARING RATIO



Tp  
45.3 %

RTM

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
4 CUT-OFFS ASSESSED  
Run # 1

Ra 3.27  $\mu\text{m}$   
Rq 4.09  $\mu\text{m}$   
Ry 21.3  $\mu\text{m}$   
Rtm 19.7  $\mu\text{m}$   
Rpm 9.5  $\mu\text{m}$

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 14

Ra 8.41  $\mu\text{m}$   
Rq 9.93  $\mu\text{m}$   
Ry 15.1  $\mu\text{m}$   
Rtm 20.4  $\mu\text{m}$

FIGURE 5.73 (1) SURFACE FINISH MEASUREMENTS RETRACTABLE  
DIE CORE CASTING 4

1-DECREASE  
DEPTH

0-INCREASE  
DEPTH

AMPLITUDE  
DISTRIBUTION



ZONWIDTH  
15.1  $\mu\text{m}$   
Pc  
8  $\text{cm}^2$

ID:

ROUGHNESS ASSESSMENT

ISO FILTER C/O 0.8 mm

5 CUT-OFFS ASSESSED

Run # 2

SLICE LEVEL

HEIGHT  
-0.5  $\mu\text{m}$

DEPTH  
16.0  $\mu\text{m}$

HSC  
38

BEARING RATIO



Tp  
51.7 %

RTM

ROUGHNESS ASSESSMENT

ISO FILTER C/O 0.8 mm

5 CUT-OFFS ASSESSED

Run # 2

Ra 3.84  $\mu\text{m}$

Rq 5.00  $\mu\text{m}$

Ry 32.6  $\mu\text{m}$

Rz 23.0  $\mu\text{m}$

Rpm 10.9  $\mu\text{m}$

ROUGHNESS ASSESSMENT

ISO FILTER C/O 0.8 mm

5 CUT-OFFS ASSESSED

Run # 51

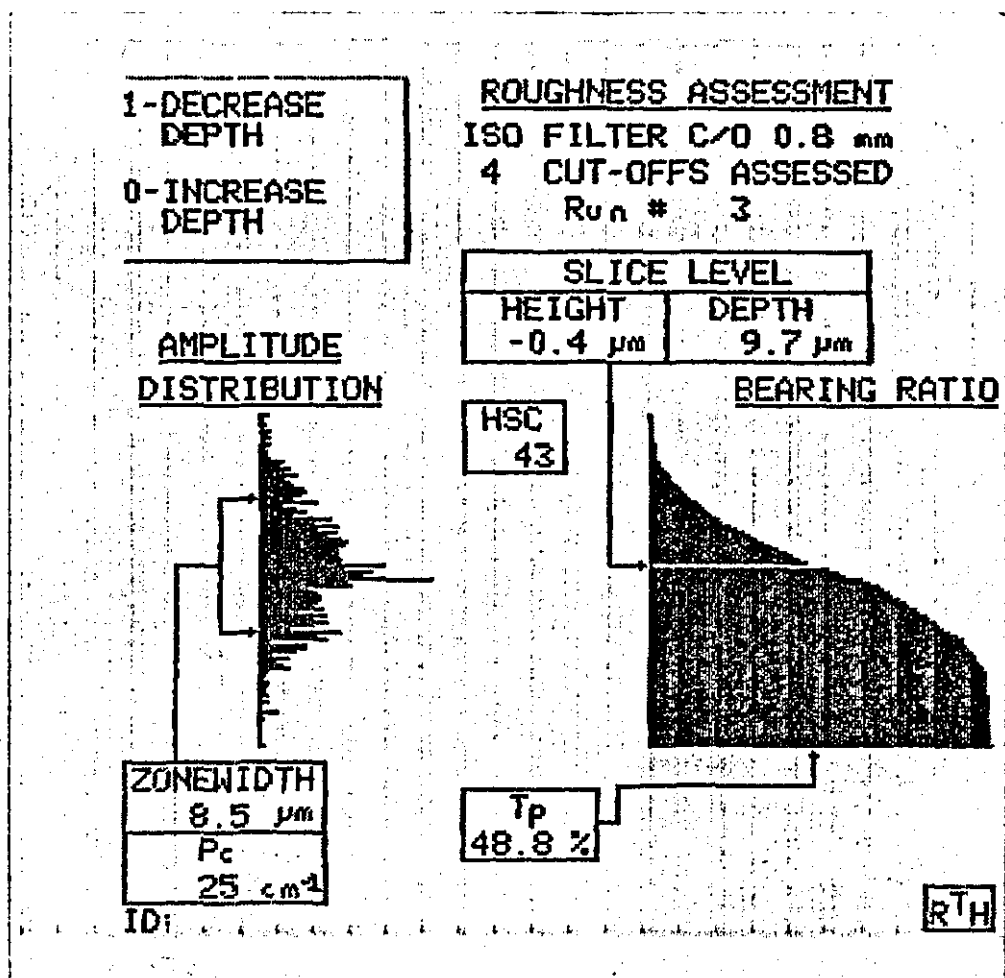
Ra 6.48  $\mu\text{m}$

Rq 7.57  $\mu\text{m}$

Ry 13.7  $\mu\text{m}$

Rz 16.0  $\mu\text{m}$

FIGURE 5.73 (ii) SURFACE FINISH MEASUREMENTS RETRACTABLE  
DIE CORE CASTING 4



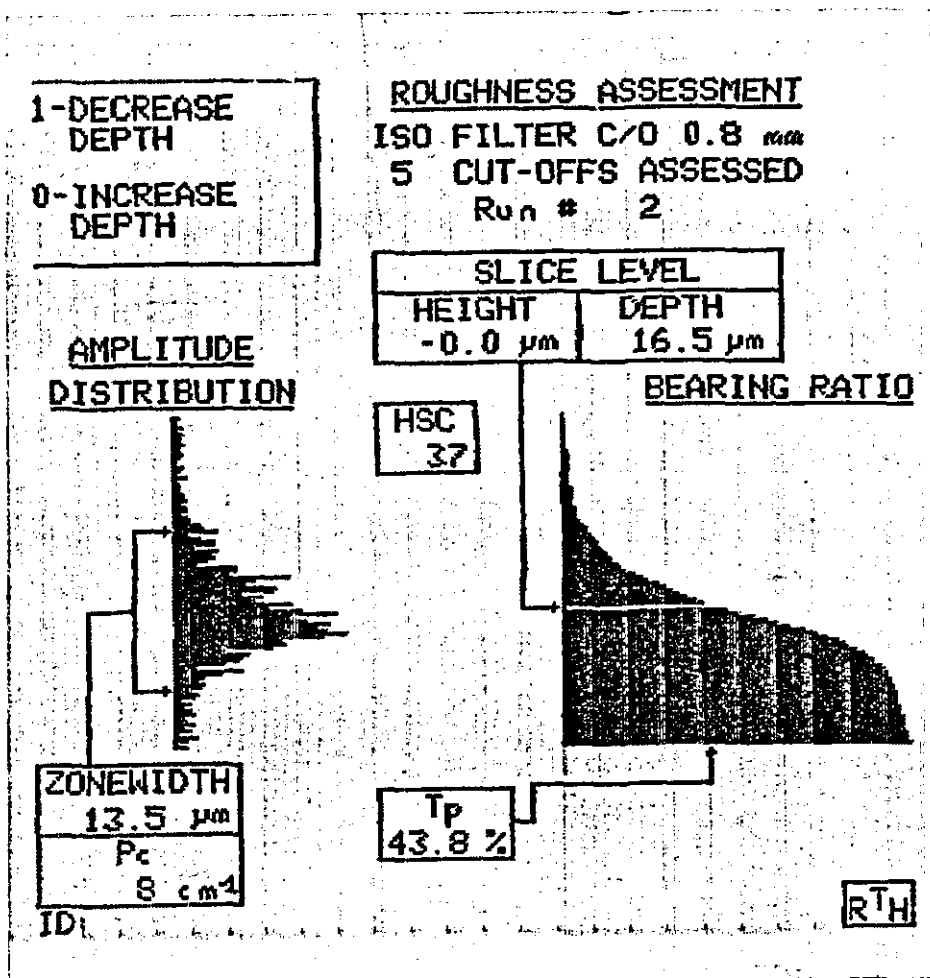
**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
4 CUT-OFFS ASSESSED  
Run # 3

Ra	2.73 $\mu\text{m}$
Rq	3.44 $\mu\text{m}$
Ry	21.1 $\mu\text{m}$
Rtm	16.9 $\mu\text{m}$
Rpm	8.1 $\mu\text{m}$

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 181

Ra	6.96 $\mu\text{m}$
Rq	8.61 $\mu\text{m}$
Ry	13.6 $\mu\text{m}$
Rp	21.6 $\mu\text{m}$

FIGURE 5.74 (1) SURFACE FINISH MEASUREMENTS RETRACTABLE DIE CORE CASTING 5



**ROUGHNESS ASSESSMENT**

ISO FILTER C/O 0.8 mm

5 CUT-OFFS ASSESSED

Run # 2

Ra	3.09 $\mu\text{m}$
Rq	4.15 $\mu\text{m}$
Ry	27.9 $\mu\text{m}$
Rzm	17.5 $\mu\text{m}$
Rpm	8.8 $\mu\text{m}$

**ROUGHNESS ASSESSMENT**

FILTER CUT-OFF 0.8 mm

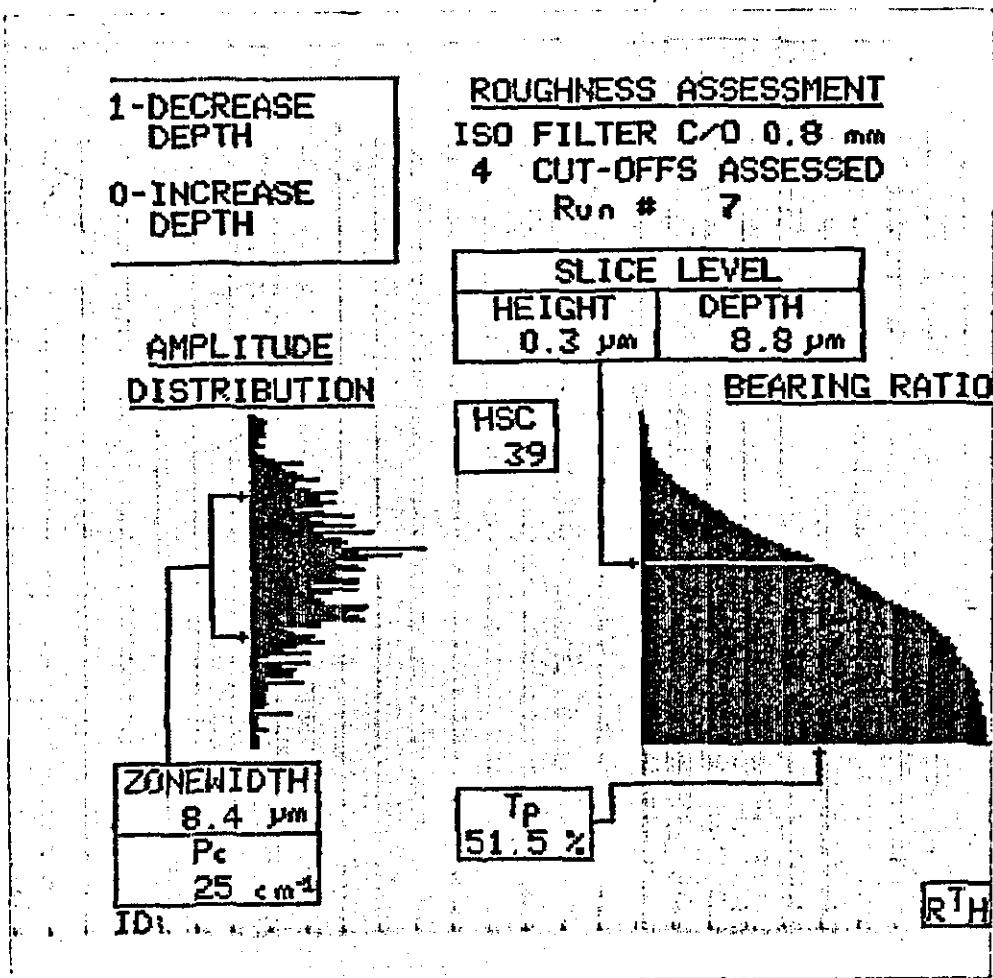
5 CUT-OFFS ASSESSED

Run # 1

Ra	9.23 $\mu\text{m}$
Rq	10.8 $\mu\text{m}$
Ry	23.8 $\mu\text{m}$
Rpm	14.2 $\mu\text{m}$

FIGURE 5.74 (ii) SURFACE FINISH MEASUREMENTS RETRACTABLE DIE CORE CASTING 5





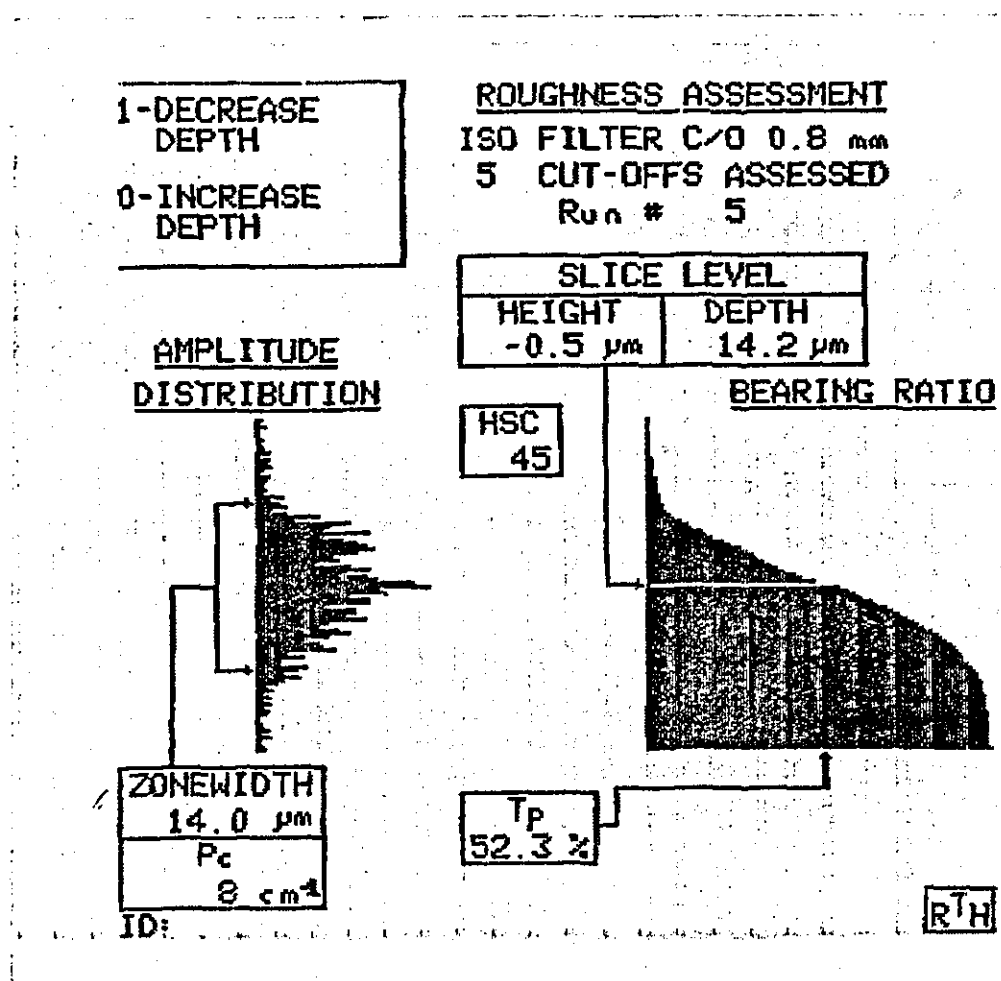
**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
4 CUT-OFFS ASSESSED  
Run # 7

$R_a$	2.93 $\mu\text{m}$
$R_q$	3.62 $\mu\text{m}$
$R_y$	19.0 $\mu\text{m}$
$R_{Sm}$	17.5 $\mu\text{m}$
$R_{pm}$	8.9 $\mu\text{m}$

**WAVINESS ASSESSMENT**  
FILTER CUT-OFF 0.8 mm  
4 CUT-OFFS ASSESSED  
Run # 9

$W_a$	5.29 $\mu\text{m}$
$W_q$	6.88 $\mu\text{m}$
$W_v$	12.6 $\mu\text{m}$
$W_p$	17.8 $\mu\text{m}$

FIGURE 5.75 (1) SURFACE FINISH MEASUREMENTS RETRACTABLE DIE CORE CASTING 6



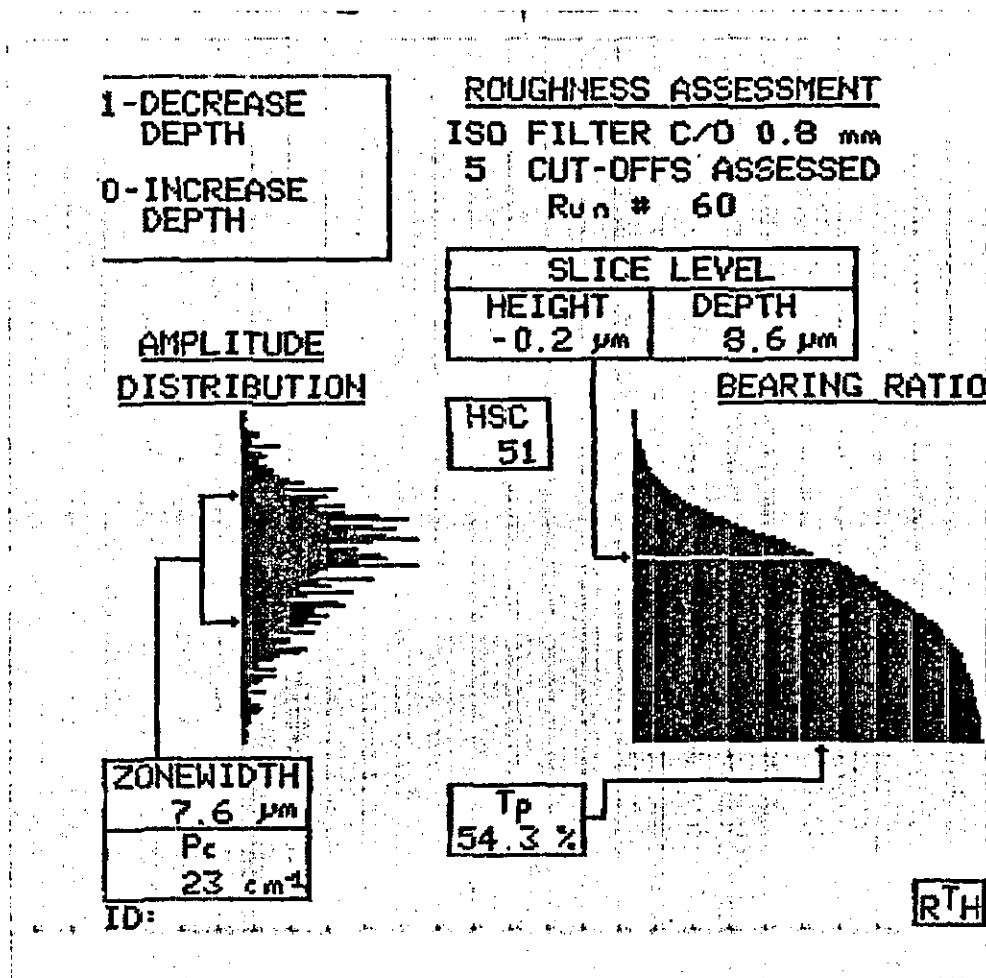
**ROUGHNESS ASSESSMENT**  
 ISO FILTER C/O 0.8 mm  
 5 CUT-OFFS ASSESSED  
 Run # 5

Ra	3.36 $\mu\text{m}$
Rq	4.27 $\mu\text{m}$
Ry	27.8 $\mu\text{m}$
Rzm	17.8 $\mu\text{m}$
Rpm	8.5 $\mu\text{m}$

**WAVINESS ASSESSMENT**  
 FILTER CUT-OFF 0.8 mm  
 4 CUT-OFFS ASSESSED  
 Run # 6

Wa	4.41 $\mu\text{m}$
Wq	5.48 $\mu\text{m}$
Wv	7.6 $\mu\text{m}$
Wp	12.4 $\mu\text{m}$

FIGURE 5.75 (ii) SURFACE FINISH MEASUREMENTS RETRACTABLE DIE CORE CASTING 6



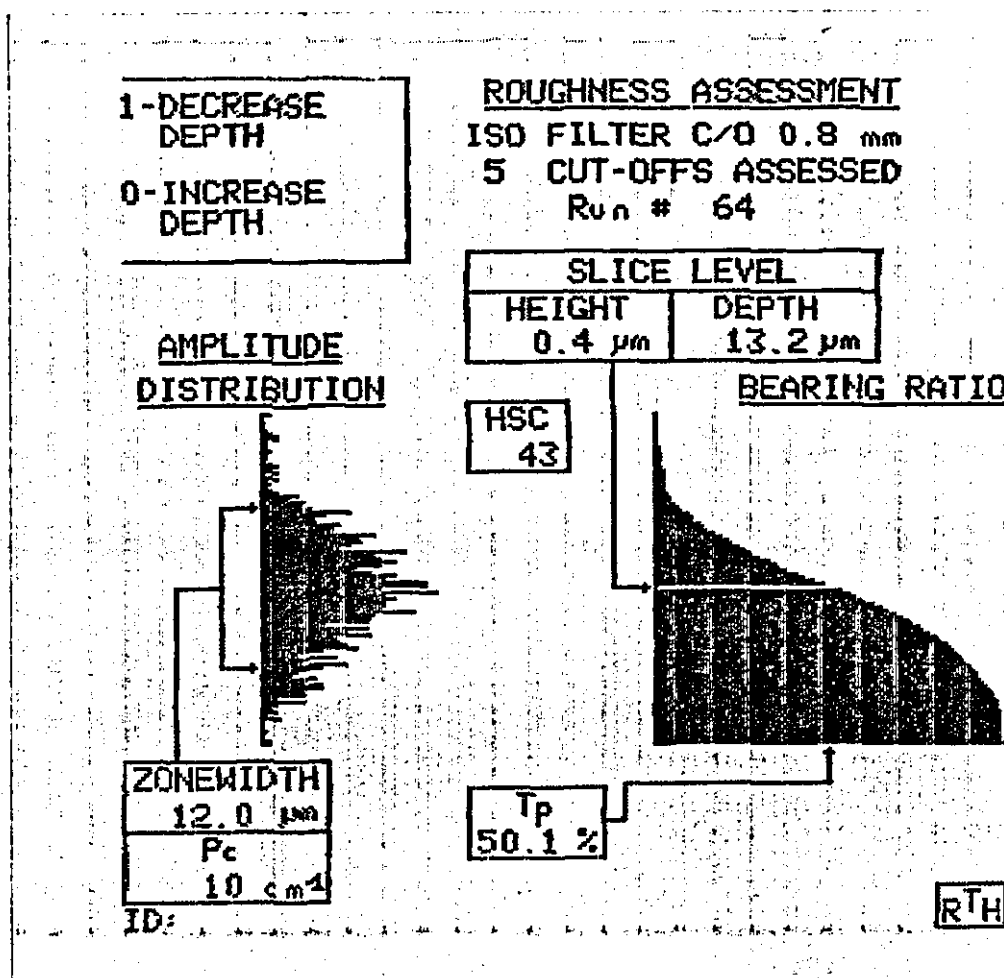
**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 60

Ra	2.69 μm
Rq	3.35 μm
Ry	18.0 μm
Rtm	15.8 μm
Rpm	7.1 μm

**NOVIMENS ASSESSMENT**  
FILTER CUT-OFF 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 61

Ma	6.23 μm
Me	7.27 μm
Mv	15.2 μm
Mp	11.6 μm

FIGURE 5.76 (i) SURFACE FINISH MEASUREMENTS RETRACTABLE DIE CORE CASTING 14



**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 64

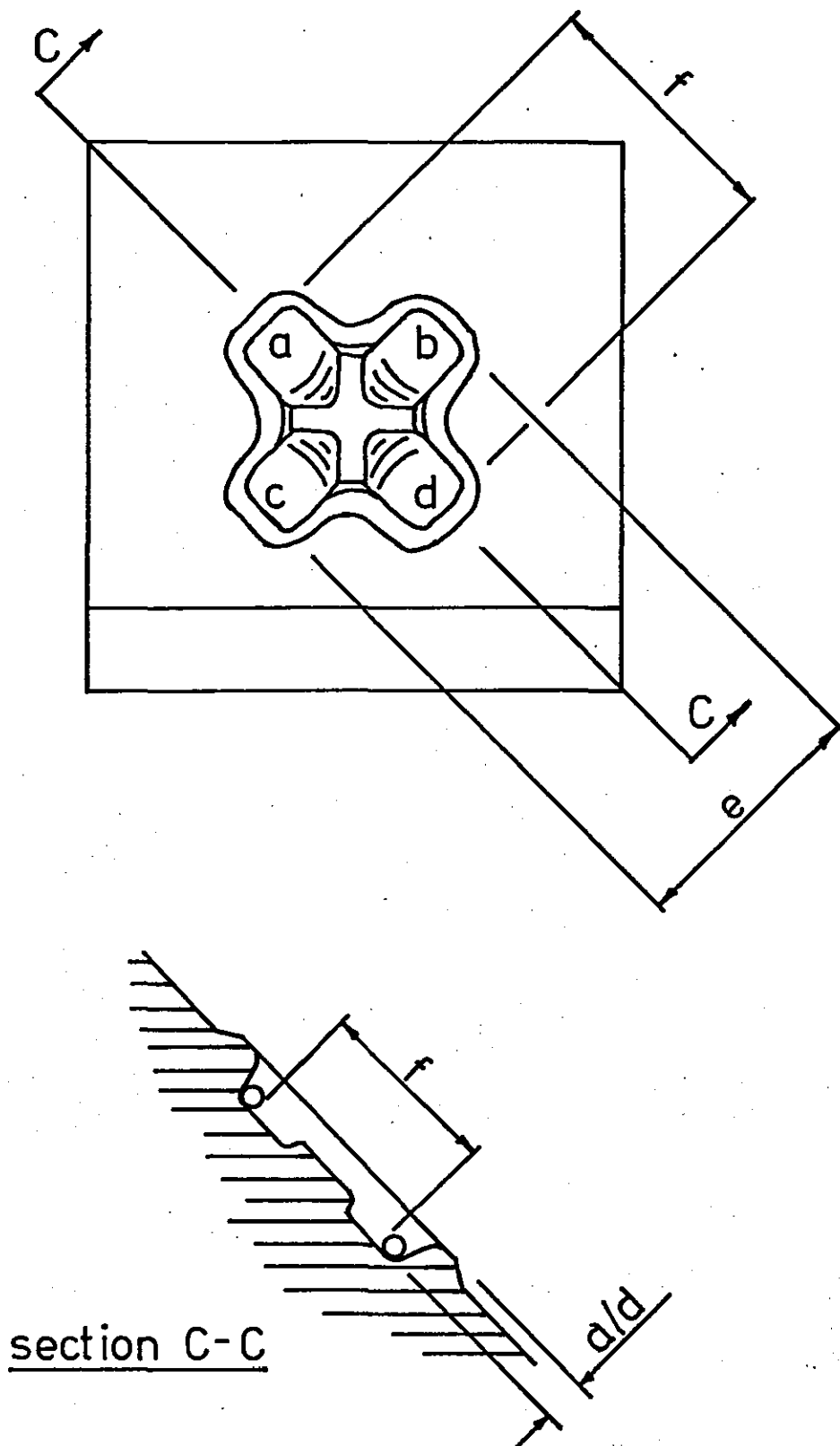
Ra	3.35 μm
Rq	4.20 μm
Rg	23.7 μm
Rem	19.1 μm
Rpm	10.0 μm

**WAVINESS ASSESSMENT**  
FILTER CUT-OFF 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 66

Wv	6.38 μm
Wq	7.45 μm
Wv	15.7 μm
Wp	15.2 μm

FIGURE 5.76 (ii) SURFACE FINISH MEASUREMENTS RETRACTABLE DIE CORE CASTING 14



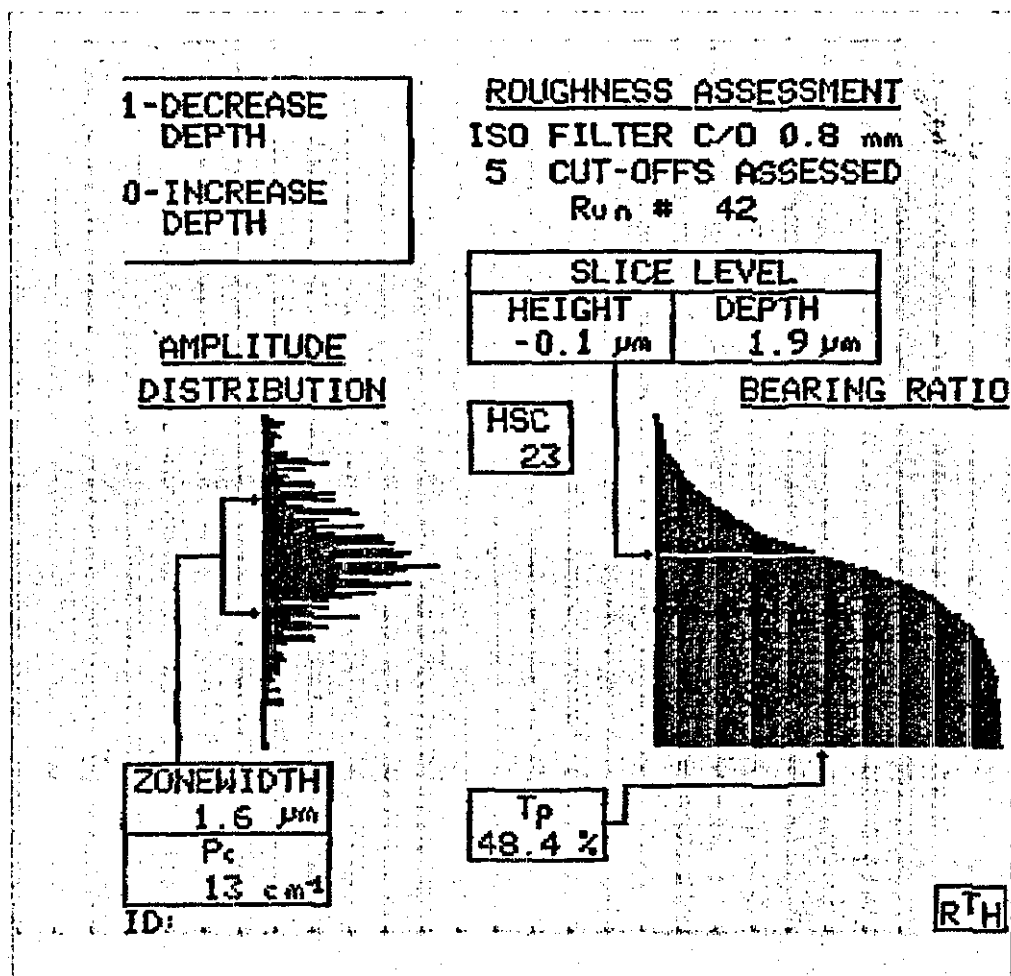


DRAWING NO.

FIGURE 5.77

DESCRIPTION:

SKETCH SHOWING DIMENSIONS MEASURED  
FOR THE SPIDER FORGING DIE



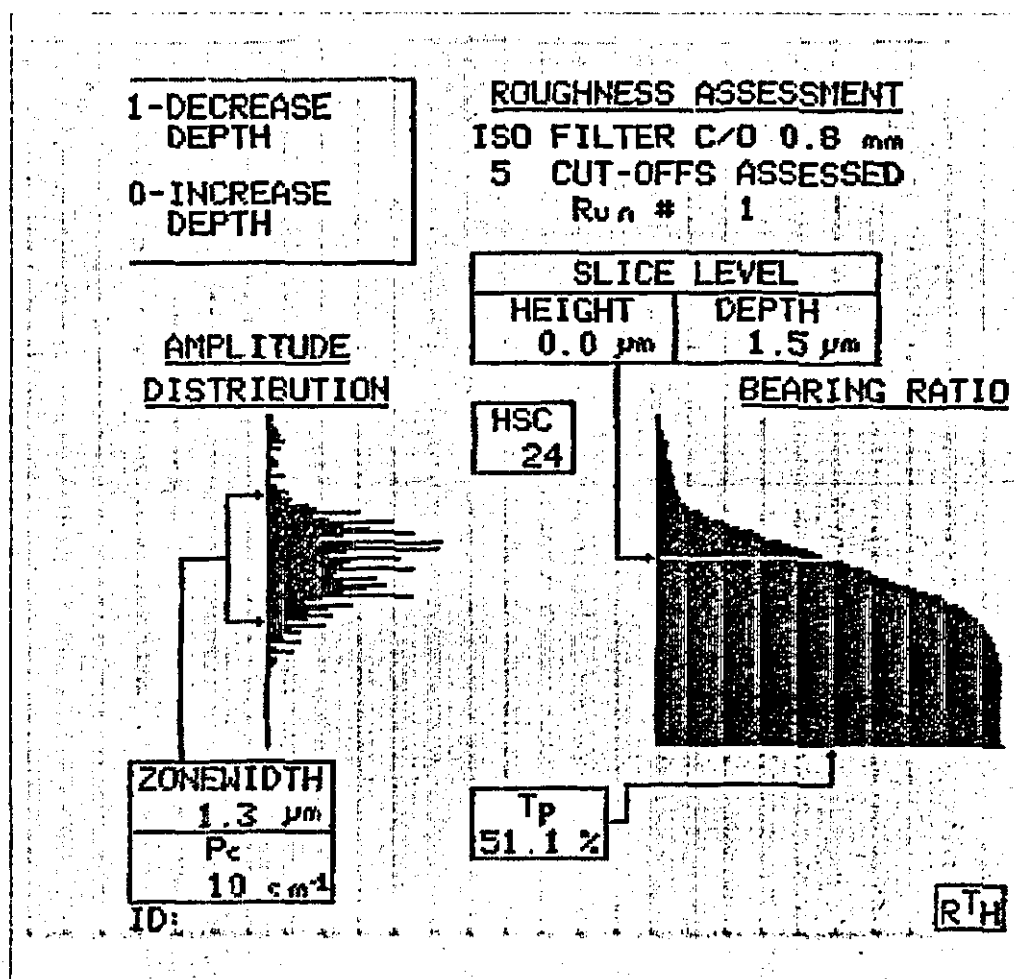
**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 42

Ra	0.56 $\mu\text{m}$
Rq	0.72 $\mu\text{m}$
Ry	3.9 $\mu\text{m}$
Rtm	3.2 $\mu\text{m}$
Rpm	1.5 $\mu\text{m}$

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 2.5 mm  
2 CUT-OFFS ASSESSED  
Run # 41

Ra	2.17 $\mu\text{m}$
Rq	2.70 $\mu\text{m}$
Ry	8.3 $\mu\text{m}$
Rpm	3.8 $\mu\text{m}$

FIGURE 5.78 (1) SURFACE FINISH MEASUREMENTS SPIDER FORGING DIE PATTERN



**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 1

$R_a$	0.35 $\mu\text{m}$
$R_q$	0.46 $\mu\text{m}$
$R_y$	3.4 $\mu\text{m}$
$R_{tm}$	1.9 $\mu\text{m}$
$R_{pm}$	0.9 $\mu\text{m}$

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 4

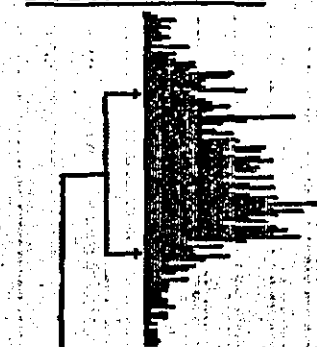
$R_a$	0.47 $\mu\text{m}$
$R_q$	0.61 $\mu\text{m}$
$R_y$	1.4 $\mu\text{m}$
$R_{tm}$	1.3 $\mu\text{m}$

FIGURE 5.78 (11) SURFACE FINISH MEASUREMENTS SPIDER FORGING DIE PATTERN

1-DECREASE  
DEPTH  
0-INCREASE  
DEPTH

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 29

AMPLITUDE  
DISTRIBUTION



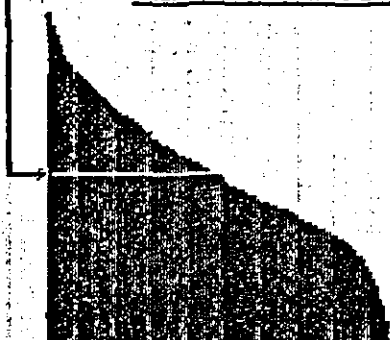
ZONEWIDTH  
12.5  $\mu\text{m}$   
Pc  
13  $\text{cm}^4$

ID:

SLICE LEVEL  
HEIGHT 0.1  $\mu\text{m}$  DEPTH 12.7  $\mu\text{m}$

HSC  
27

BEARING RATIO



Tp  
48.1 %

RTI

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 29

Ra 4.27  $\mu\text{m}$   
Rq 5.19  $\mu\text{m}$   
Ry 25.3  $\mu\text{m}$   
Rem 20.5  $\mu\text{m}$   
Rpm 10.5  $\mu\text{m}$

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 30

Wa 4.05  $\mu\text{m}$   
Wq 5.13  $\mu\text{m}$   
Wy 15.4  $\mu\text{m}$   
Wp 8.2  $\mu\text{m}$

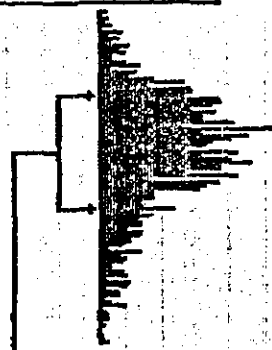
FIGURE 5.79 (1) SURFACE FINISH MEASUREMENTS SPIDER  
FORGING DIE CASTING 7



1-DECREASE  
DEPTH  
0-INCREASE  
DEPTH

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 32

AMPLITUDE  
DISTRIBUTION



ZONewidth  
8.4  $\mu\text{m}$   
Pc  
13  $\text{cm}^{-1}$

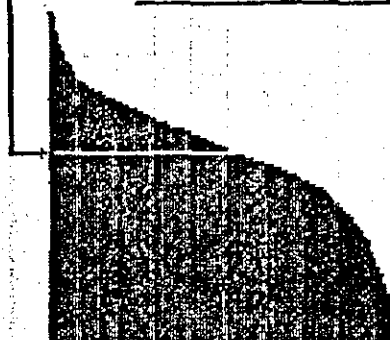
ID:

SLICE LEVEL

HEIGHT	DEPTH
-0.8 $\mu\text{m}$	10.6 $\mu\text{m}$

HSC  
25

BEARING RATIO



Tp  
54.4 %

RTM

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 32

Ra 3.40  $\mu\text{m}$   
Rq 4.34  $\mu\text{m}$   
Ry 21.8  $\mu\text{m}$   
Rem 18.4  $\mu\text{m}$   
Rpm 6.8  $\mu\text{m}$

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 31

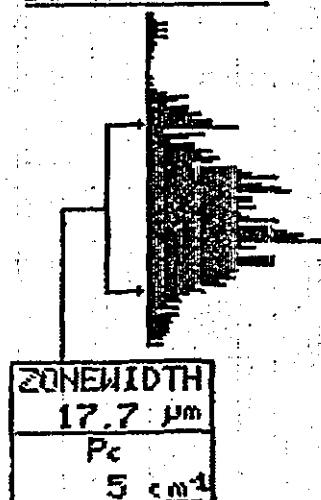
Ra 4.20  $\mu\text{m}$   
Rq 4.92  $\mu\text{m}$   
Ry 9.0  $\mu\text{m}$   
Rpm 10.5  $\mu\text{m}$

FIGURE 5.79 (11) SURFACE FINISH MEASUREMENTS SPIDER  
FORGING DIE CASTING 7

1-DECREASE  
DEPTH  
0-INCREASE  
DEPTH

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 24

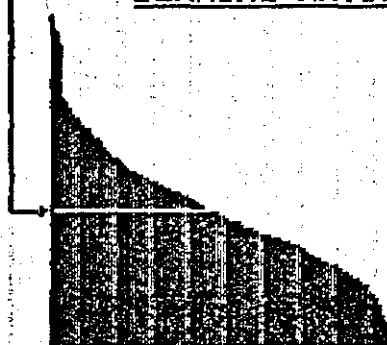
**AMPLITUDE  
DISTRIBUTION**



SLICE LEVEL	
HEIGHT	DEPTH
-0.6 $\mu\text{m}$	20.8 $\mu\text{m}$

HSC  
16

**BEARING RATIO**



RTH

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 24

Ra 5.12  $\mu\text{m}$   
Rq 6.40  $\mu\text{m}$   
Ry 34.3  $\mu\text{m}$   
Rtm 22.8  $\mu\text{m}$   
Rpm 11.8  $\mu\text{m}$

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 25

Ra 7.37  $\mu\text{m}$   
Rq 8.89  $\mu\text{m}$   
Ry 20.1  $\mu\text{m}$   
Rpm 14.2  $\mu\text{m}$

FIGURE 5.80 (1) SURFACE FINISH MEASUREMENTS SPIDER  
FORGING DIE CASTING 8

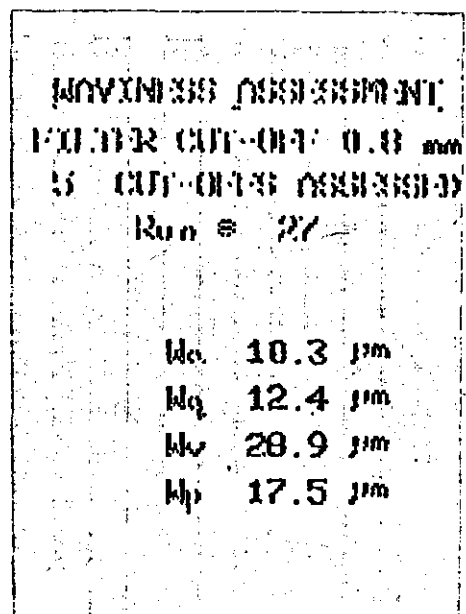
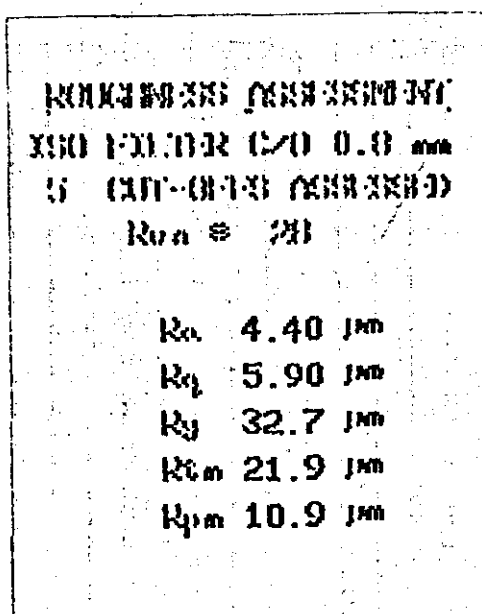
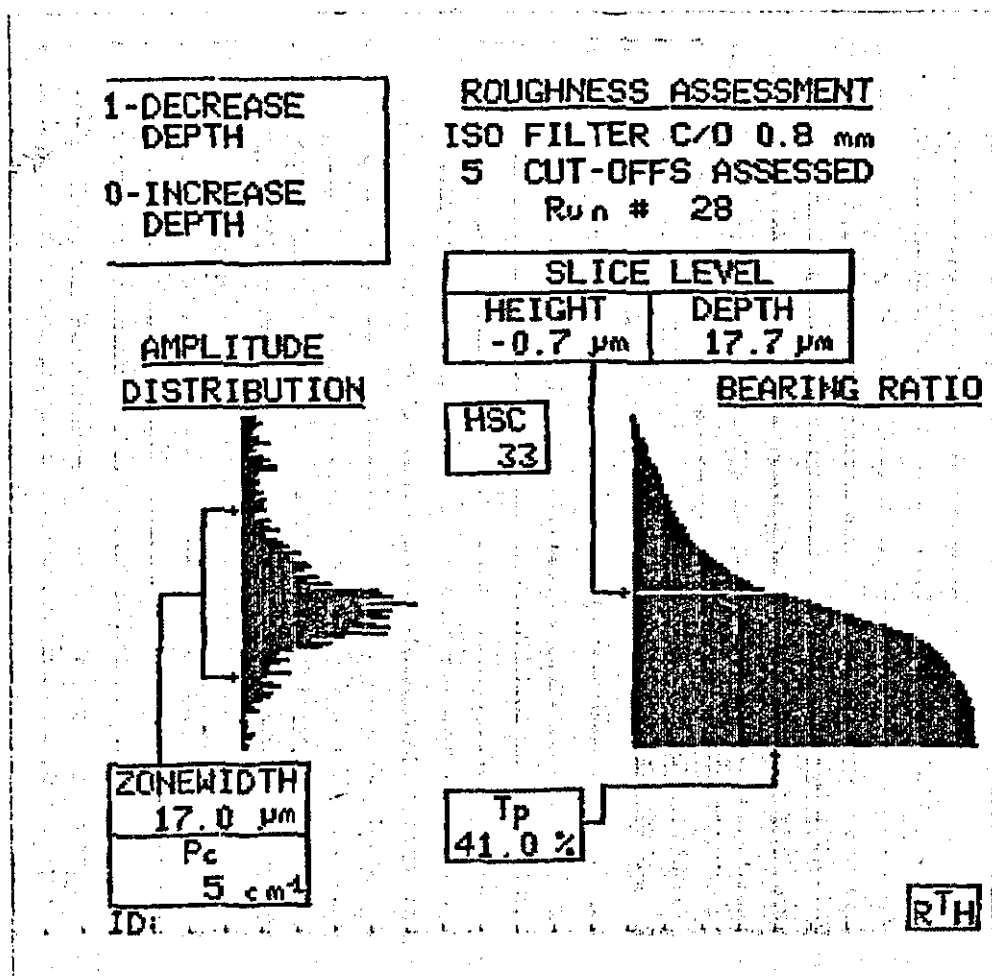
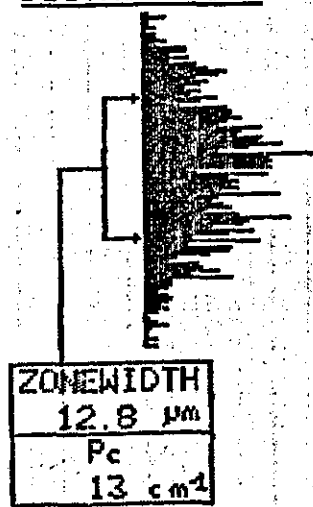


FIGURE 5.80 (11) SURFACE FINISH MEASUREMENTS SPIDER FORGING DIE CASTING 8

1-DECREASE  
DEPTH

0-INCREASE  
DEPTH

AMPLITUDE  
DISTRIBUTION



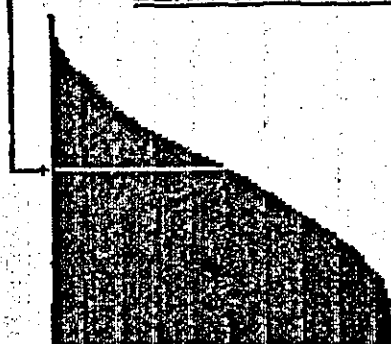
ID:

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 33

SLICE LEVEL	
HEIGHT	DEPTH
-0.2 $\mu\text{m}$	13.8 $\mu\text{m}$

HSC  
20

BEARING RATIO



RTM

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 33

Ra 4.82  $\mu\text{m}$   
Rq 5.85  $\mu\text{m}$   
Ry 29.4  $\mu\text{m}$   
Rtm 23.5  $\mu\text{m}$   
Rpm 11.0  $\mu\text{m}$

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 34

Ra 5.15  $\mu\text{m}$   
Rq 6.55  $\mu\text{m}$   
Ry 12.0  $\mu\text{m}$   
Rpm 19.8  $\mu\text{m}$

FIGURE 5.81 (i) SURFACE FINISH MEASUREMENTS SPIDER  
FORGING DIE CASTING 10



1-DECREASE  
DEPTH

0-INCREASE  
DEPTH

AMPLITUDE  
DISTRIBUTION



ZONEWIDTH  
25.6  $\mu\text{m}$   
Pc  
8  $\text{cm}^2$

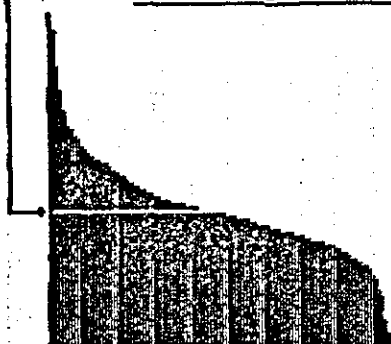
ID:

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 48

SLICE LEVEL	
HEIGHT	DEPTH
-0.4 $\mu\text{m}$	31.3 $\mu\text{m}$

HSC  
25

BEARING RATIO



TP  
46.3 %

RTM

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 48

Ra 5.77  $\mu\text{m}$   
Rq 7.96  $\mu\text{m}$   
Ry 52.2  $\mu\text{m}$   
Rzm 27.3  $\mu\text{m}$   
Rpm 14.2  $\mu\text{m}$

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 47

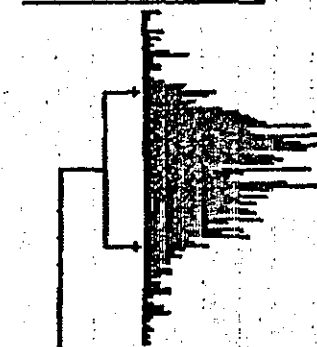
Ra 10.7  $\mu\text{m}$   
Rq 12.6  $\mu\text{m}$   
Ry 25.3  $\mu\text{m}$   
Rpm 28.3  $\mu\text{m}$

FIGURE 5.81 (11) SURFACE FINISH MEASUREMENTS SPIDER  
FORGING DIE CASTING 10

1-DECREASE  
DEPTH  
0-INCREASE  
DEPTH

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 4

AMPLITUDE  
DISTRIBUTION



ZONEWIDTH  
12.0  $\mu\text{m}$   
 $P_c$   
10  $\text{cm}^2$

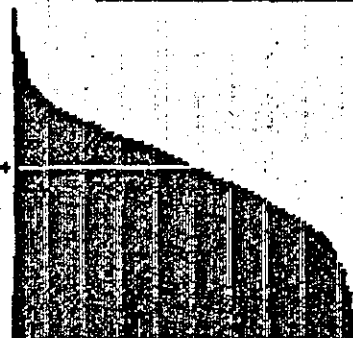
ID:

SLICE LEVEL  

HEIGHT	DEPTH
0.3 $\mu\text{m}$	12.3 $\mu\text{m}$

HSC  
30

BEARING RATIO



$T_p$   
53.2 %

RTM

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 4

$R_a$  3.41  $\mu\text{m}$   
 $R_q$  4.26  $\mu\text{m}$   
 $R_y$  24.0  $\mu\text{m}$   
 $R_{t_m}$  18.7  $\mu\text{m}$   
 $R_{p_m}$  9.6  $\mu\text{m}$

WAVINESS ASSESSMENT  
FILTER CUT-OFF 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 3

$W_a$  5.29  $\mu\text{m}$   
 $W_q$  6.20  $\mu\text{m}$   
 $W_v$  10.2  $\mu\text{m}$   
 $W_p$  13.0  $\mu\text{m}$

FIGURE 5.82 (i) SURFACE FINISH MEASUREMENTS SPIDER  
FORGING DIE CASTING 15

1-DECREASE  
DEPTH  
0-INCREASE  
DEPTH

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
3 CUT-OFFS ASSESSED  
Run # 4

AMPLITUDE  
DISTRIBUTION

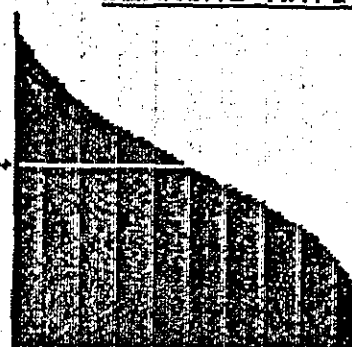


ZONWIDTH  
8.8  $\mu\text{m}$   
Pc  
29 cm<sup>2</sup>

SLICE LEVEL  
HEIGHT  
-0.4  $\mu\text{m}$   
DEPTH  
9.9  $\mu\text{m}$

HSC  
20

BEARING RATIO



TP  
50.3 %

RTH

ID:

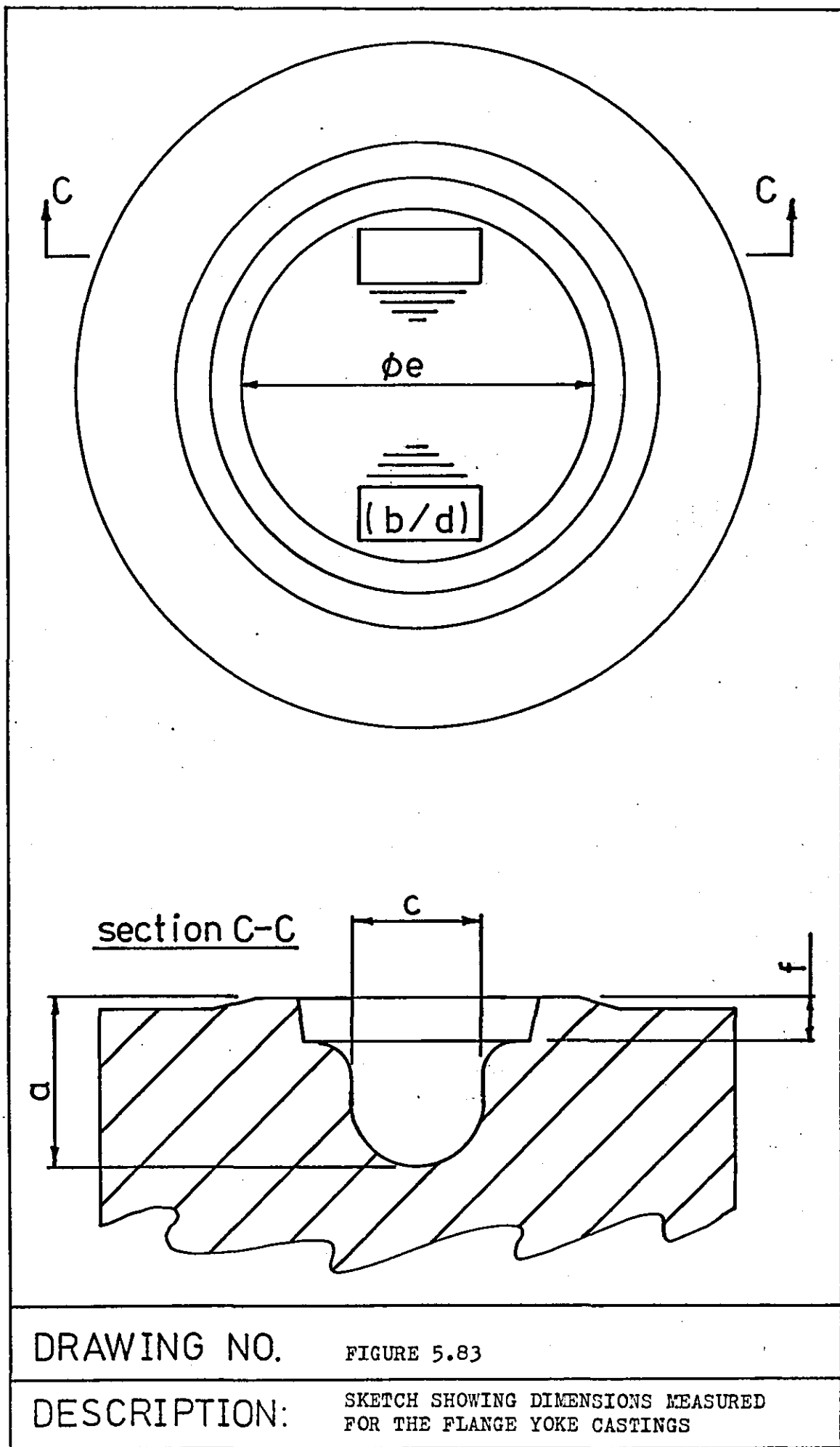
ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
3 CUT-OFFS ASSESSED  
Run # 4

Ra 3.39  $\mu\text{m}$   
Rq 4.12  $\mu\text{m}$   
Ry 21.6  $\mu\text{m}$   
Rzm 17.7  $\mu\text{m}$   
Rpm 8.7  $\mu\text{m}$

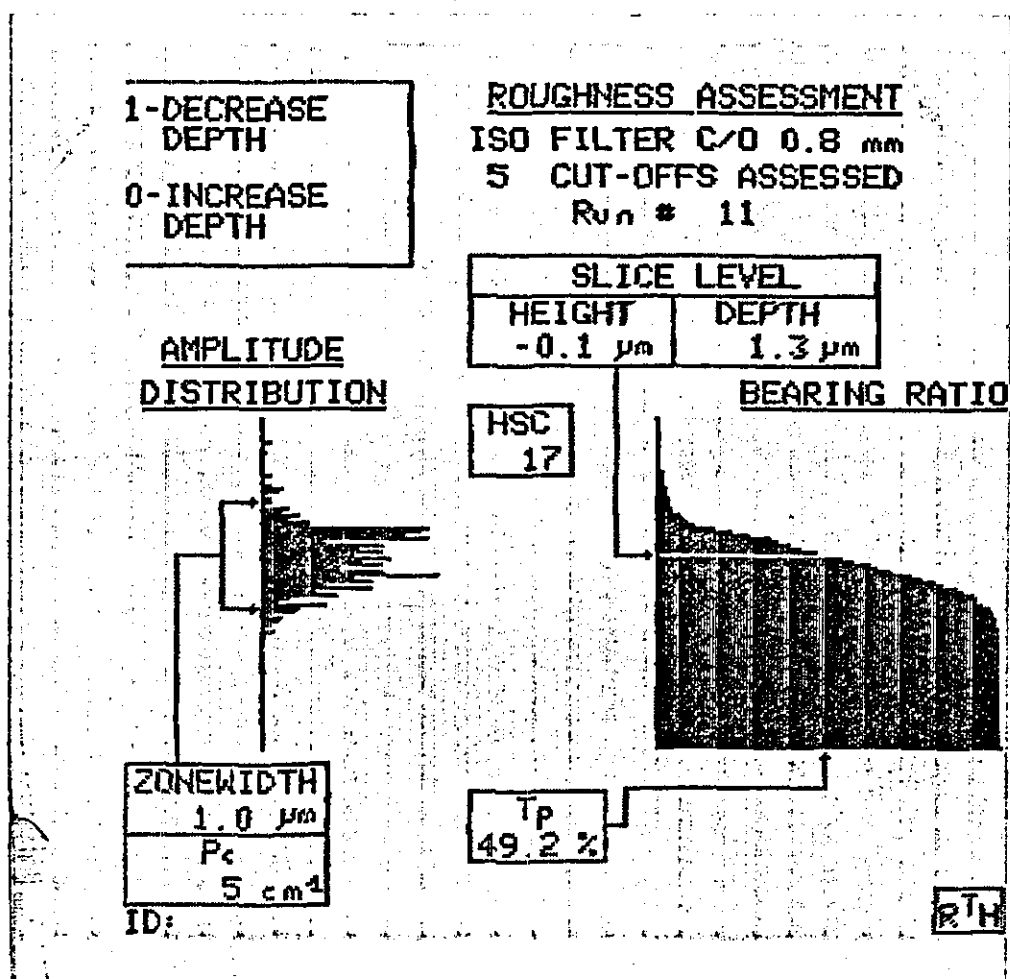
ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
4 CUT-OFFS ASSESSED  
Run # 5

Ra 4.57  $\mu\text{m}$   
Rq 6.11  $\mu\text{m}$   
Ry 8.7  $\mu\text{m}$   
Rpm 16.2  $\mu\text{m}$

FIGURE 5.82 (ii) SURFACE FINISH MEASUREMENTS SPIDER  
FORGING DIE CASTING 15







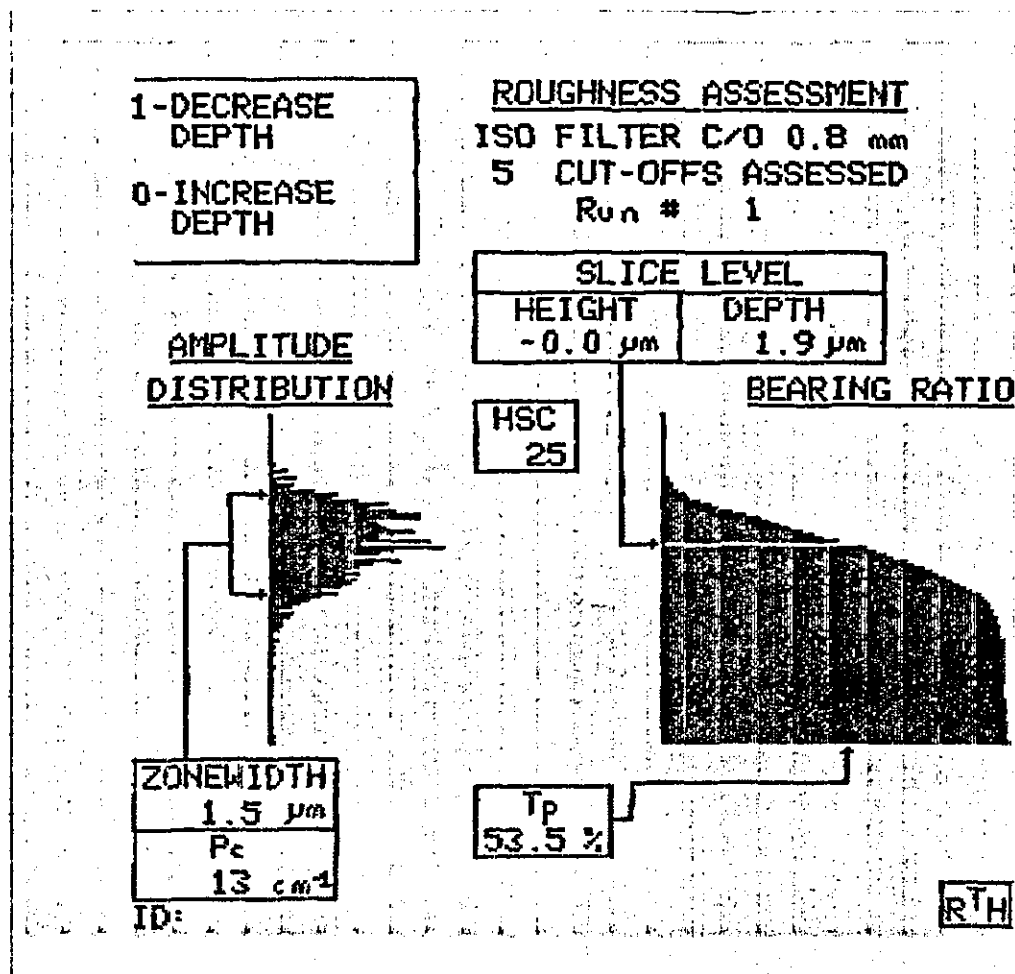
**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 11

Ra	0.23 μm
Rq	0.29 μm
Rg	2.4 μm
Rcm	1.3 μm
Rpm	0.5 μm

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 12

Wa	1.09 μm
Wq	1.25 μm
Wv	1.5 μm
Wp	2.4 μm

FIGURE 5.84 (i) SURFACE FINISH MEASUREMENTS FLANGE  
YOKE FORGING DIE PATTERN



**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 1

Ra	0.43 μm
Rq	0.57 μm
Ry	3.2 μm
Rtm	2.5 μm
Rpm	1.1 μm

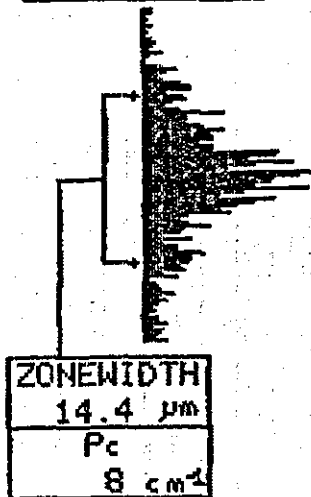
**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 1

Ra	0.96 μm
Rq	1.14 μm
Ry	2.3 μm
Rtm	2.1 μm

FIGURE 5.84 (ii) SURFACE FINISH MEASUREMENTS FLANGE YOKE FORGING DIE PATTERN

1-DECREASE  
DEPTH  
0-INCREASE  
DEPTH

### AMPLITUDE DISTRIBUTION



ID:

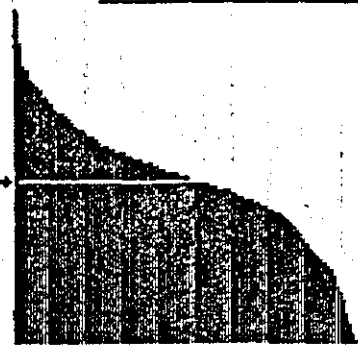
ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 5

### SLICE LEVEL

HEIGHT	DEPTH
-0.3 $\mu\text{m}$	14.7 $\mu\text{m}$

HSC  
37

### BEARING RATIO



Tp  
53.7 %

RTM

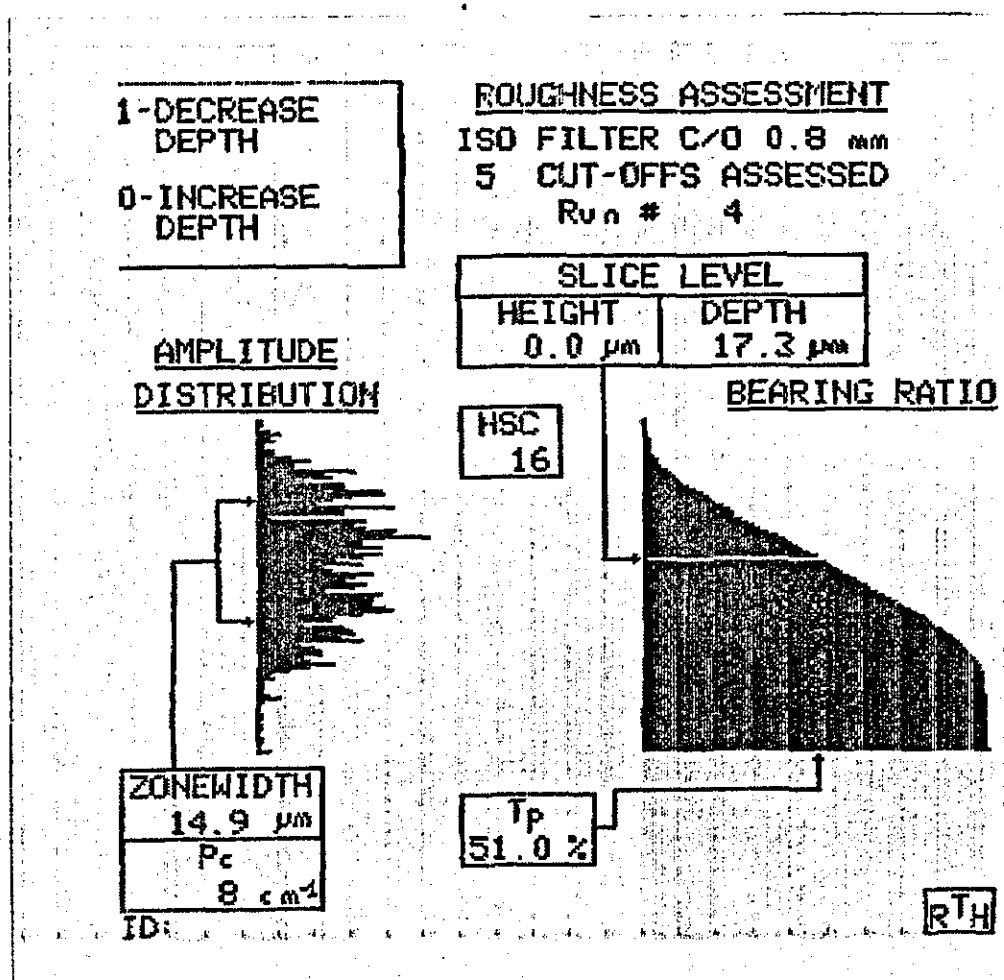
ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 5

Ra 3.87  $\mu\text{m}$   
Rq 5.09  $\mu\text{m}$   
Rg 28.3  $\mu\text{m}$   
Rm 18.3  $\mu\text{m}$   
Rp 9.3  $\mu\text{m}$

ROUGHNESS ASSESSMENT  
ISO FILTER C/O 0.8 mm  
4 CUT-OFFS ASSESSED  
Run # 6

Ra 5.17  $\mu\text{m}$   
Rq 6.46  $\mu\text{m}$   
Rg 11.7  $\mu\text{m}$   
Rp 13.9  $\mu\text{m}$

FIGURE 5.85 (1) SURFACE FINISH MEASUREMENTS FLANGE  
YOKE FORGING DIE CASTING 9



**ROUGHNESS ASSESSMENT**

ISO FILTER C/O 0.8 mm

5 CUT-OFFS ASSESSED

Run # 4

$R_a$	6.19 $\mu\text{m}$
$R_q$	7.36 $\mu\text{m}$
$R_y$	32.8 $\mu\text{m}$
$R_{z,m}$	20.4 $\mu\text{m}$
$R_{p,m}$	13.3 $\mu\text{m}$

**ROUGHNESS ASSESSMENT**

ISO FILTER C/O 0.8 mm

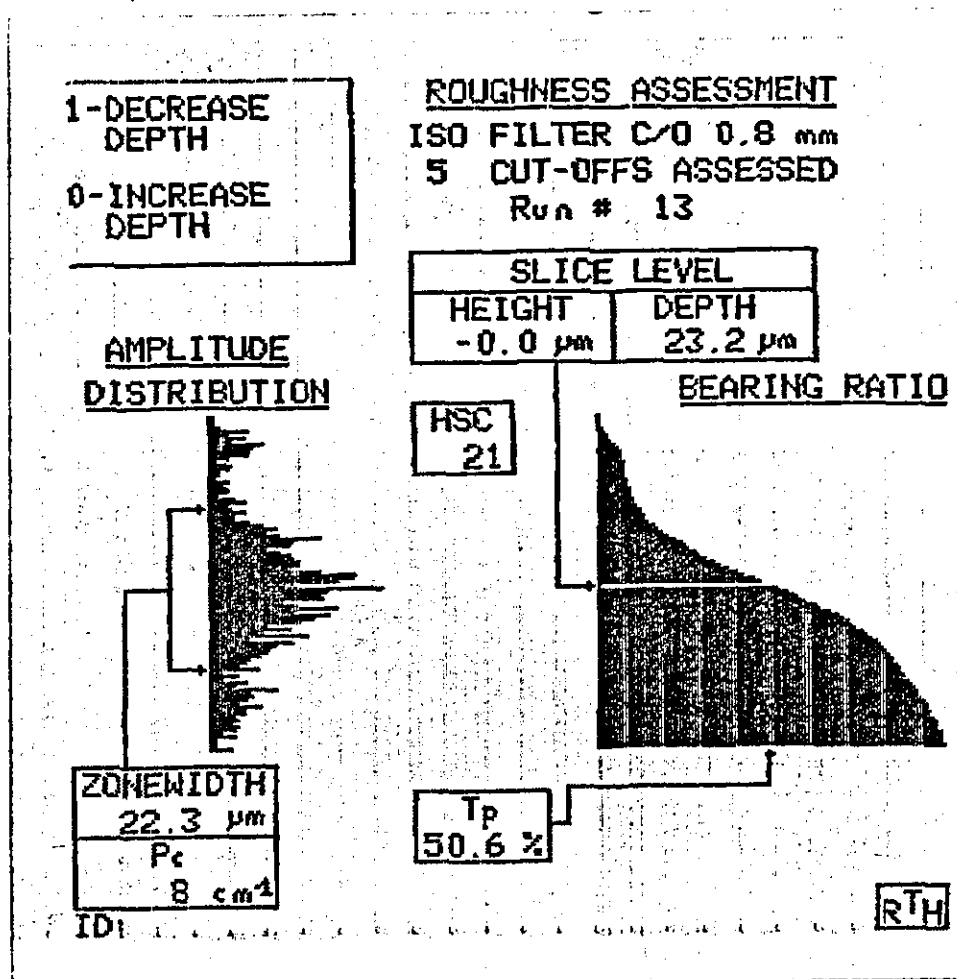
5 CUT-OFFS ASSESSED

Run # 6

$R_a$	10.5 $\mu\text{m}$
$R_q$	12.5 $\mu\text{m}$
$R_y$	26.2 $\mu\text{m}$
$R_p$	19.7 $\mu\text{m}$

FIGURE 5.85 (ii) SURFACE FINISH MEASUREMENTS FLANGE  
YOKE FORGING DIE CASTING 9





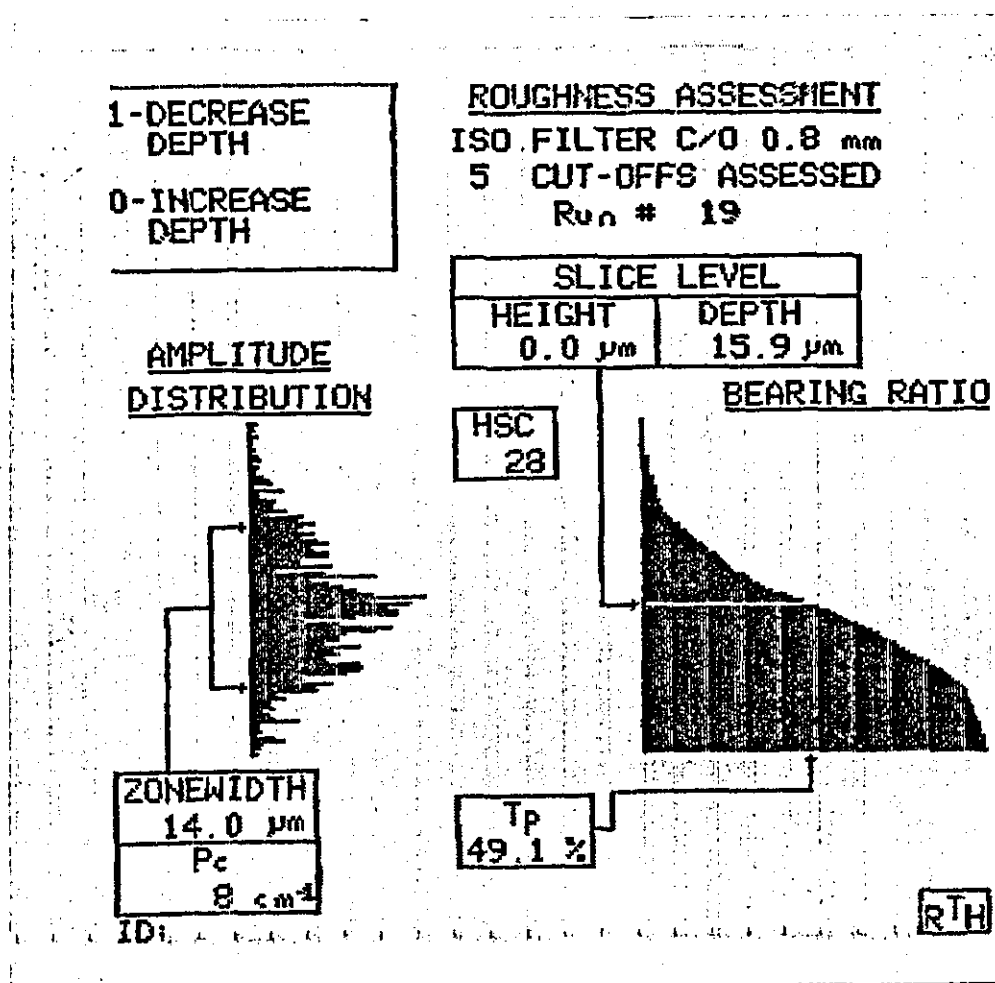
**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 13

Ra	7.20 $\mu\text{m}$
Rq	9.31 $\mu\text{m}$
Ry	44.7 $\mu\text{m}$
Rzm	30.6 $\mu\text{m}$
Rpm	14.1 $\mu\text{m}$

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 14

Ra	10.2 $\mu\text{m}$
Rq	14.0 $\mu\text{m}$
Ry	36.2 $\mu\text{m}$
Rzm	35.7 $\mu\text{m}$

FIGURE 5.86 (1) SURFACE FINISH MEASUREMENTS FLANGE  
YOKE FORGING DIE CASTING 11



**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 19

Ra	4.05 $\mu\text{m}$
Rq	5.08 $\mu\text{m}$
Ry	27.5 $\mu\text{m}$
Rzm	21.6 $\mu\text{m}$
Rpm	10.7 $\mu\text{m}$

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 16

Ra	6.97 $\mu\text{m}$
Rq	8.66 $\mu\text{m}$
Ry	24.4 $\mu\text{m}$
Rpm	15.0 $\mu\text{m}$

FIGURE 5.86 (ii) SURFACE FINISH MEASUREMENTS FLANGE  
YOKE FORGING DIE CASTING 11

1-DECREASE  
DEPTH  
0-INCREASE  
DEPTH

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 1

**AMPLITUDE  
DISTRIBUTION**

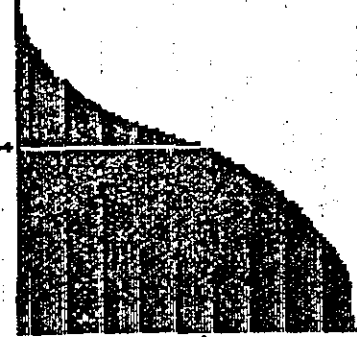


**ZONEMWIDTH**  
13.0  $\mu\text{m}$   
 $P_c$   
18  $\text{cm}^{-1}$

**SLICE LEVEL**  
HEIGHT  
-0.1  $\mu\text{m}$   
DEPTH  
14.6  $\mu\text{m}$

**HSC**  
28

**BEARING RATIO**



$T_p$   
55.6 %

**RTM**

**ROUGHNESS ASSESSMENT**

ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 1

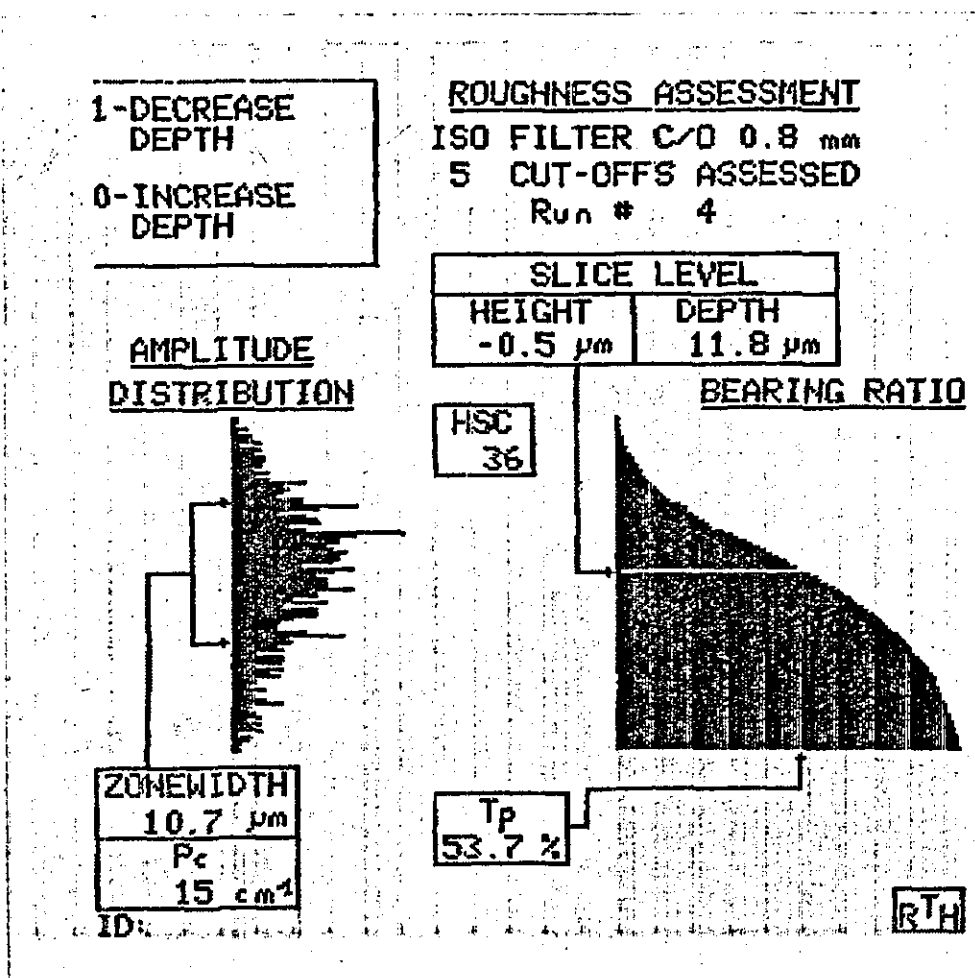
$R_a$  4.83  $\mu\text{m}$   
 $R_q$  6.15  $\mu\text{m}$   
 $R_y$  32.1  $\mu\text{m}$   
 $R_{tm}$  24.8  $\mu\text{m}$   
 $R_{pm}$  12.0  $\mu\text{m}$

**WAVINESS ASSESSMENT**

FILTER CUT-OFF 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 2

$W_a$  6.58  $\mu\text{m}$   
 $W_q$  8.37  $\mu\text{m}$   
 $W_v$  18.5  $\mu\text{m}$   
 $W_p$  19.5  $\mu\text{m}$

FIGURE 5.87 (i) SURFACE FINISH MEASUREMENTS FLANGE  
YOKE FORGING DIE CASTING 12



**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 4

Ra	4.21 $\mu\text{m}$
Rq	5.19 $\mu\text{m}$
Ry	25.2 $\mu\text{m}$
Rtn	20.1 $\mu\text{m}$
Rpm	9.5 $\mu\text{m}$

**ROUGHNESS ASSESSMENT**  
ISO FILTER C/O 0.8 mm  
5 CUT-OFFS ASSESSED  
Run # 3

Na	6.45 $\mu\text{m}$
Nq	7.81 $\mu\text{m}$
Ny	10.4 $\mu\text{m}$
Np	19.2 $\mu\text{m}$

FIGURE 5.87 (ii) SURFACE FINISH MEASUREMENTS FLANGE  
YOKE FORGING DIE CASTING 12



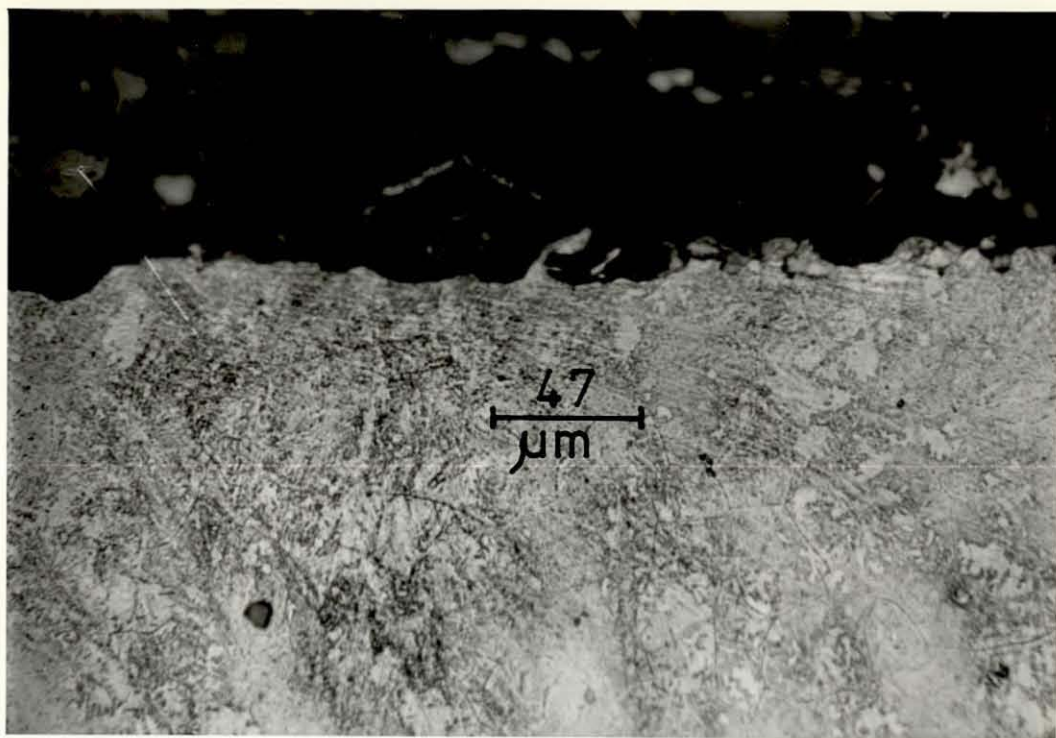


FIGURE 5.88

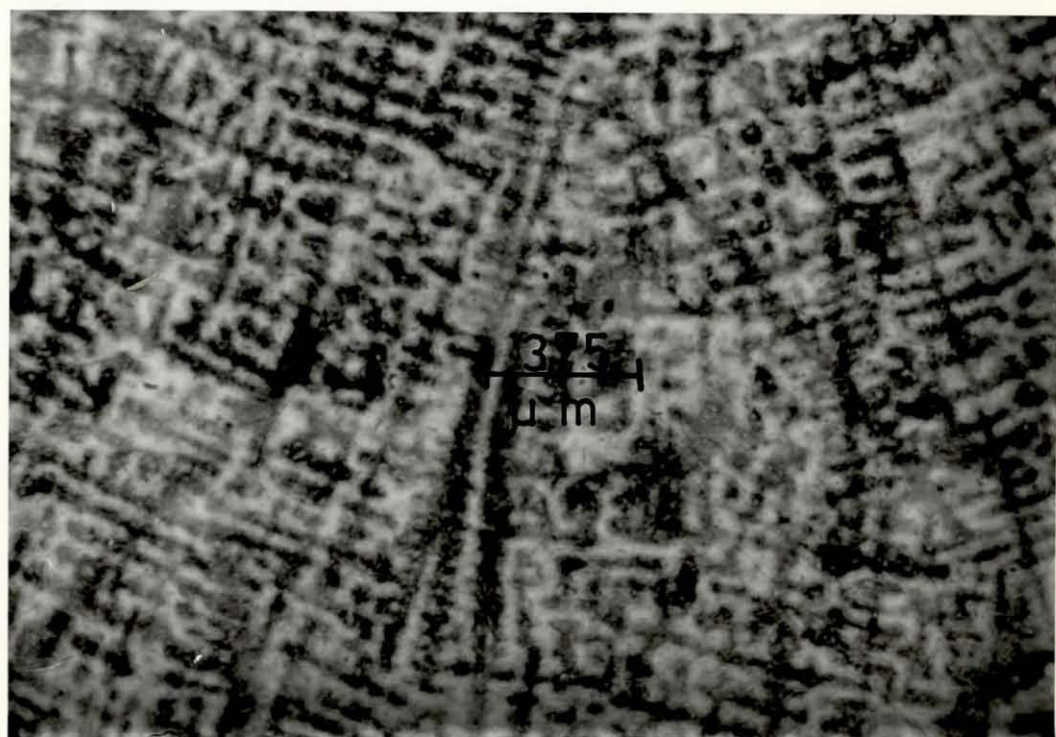


FIGURE 5.89

FIGURE 5.88 PHOTOMICROGRAPH OF THE AS CAST SURFACE STRUCTURE OF TEST CASTING SPECIMEN 13 A.

FIGURE 5.89 PHOTOMICROGRAPH OF THE CENTRE STRUCTURE OF TEST CASTING SPECIMEN 13 A.

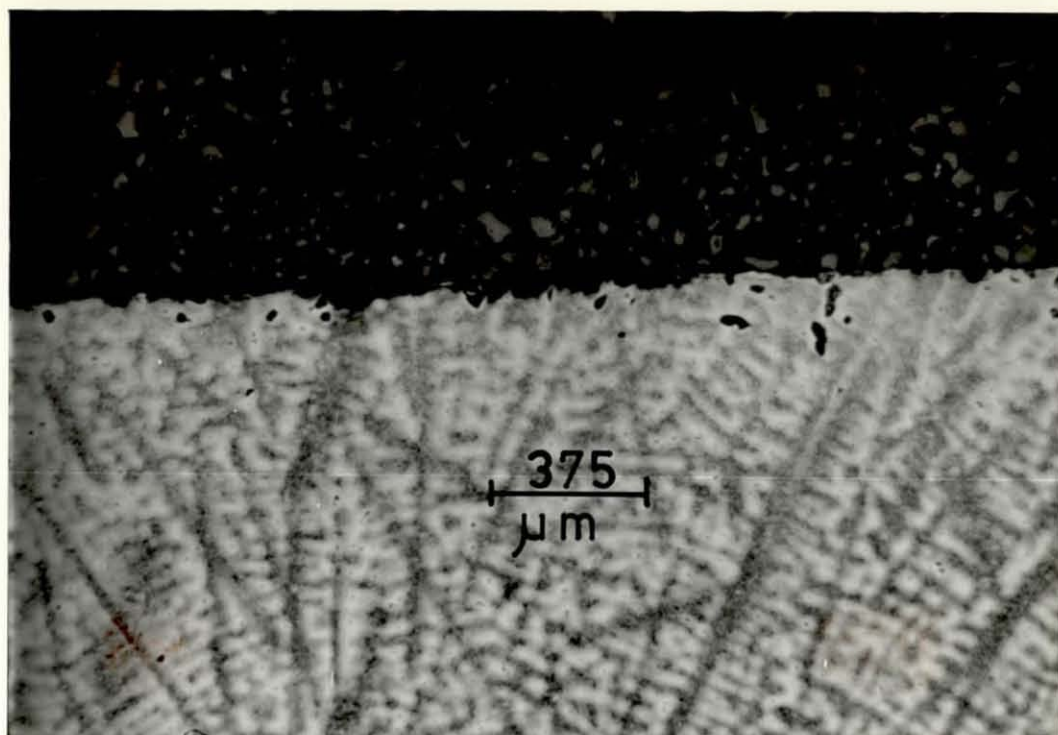


FIGURE 5.90

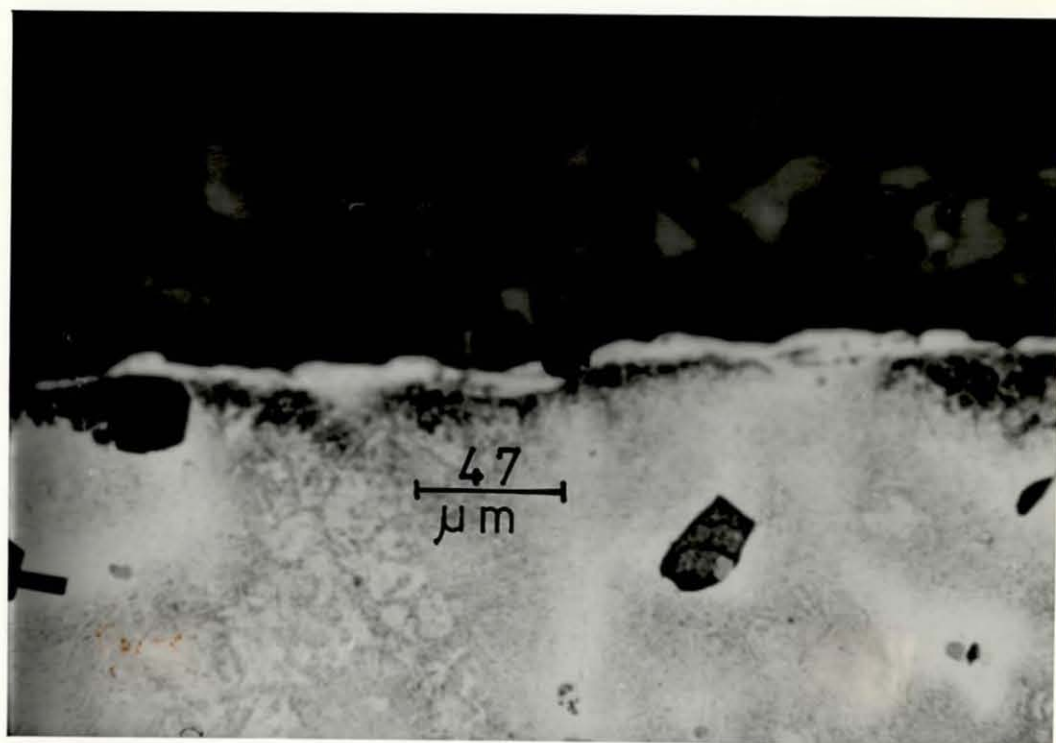


FIGURE 5.91

FIGURES 5.90 & 5.91 PHOTOMICROGRAPHS OF THE SURFACE  
STRUCTURE OF TEST CASTING SPECIMEN 13 C PRODUCED  
BY EDM.



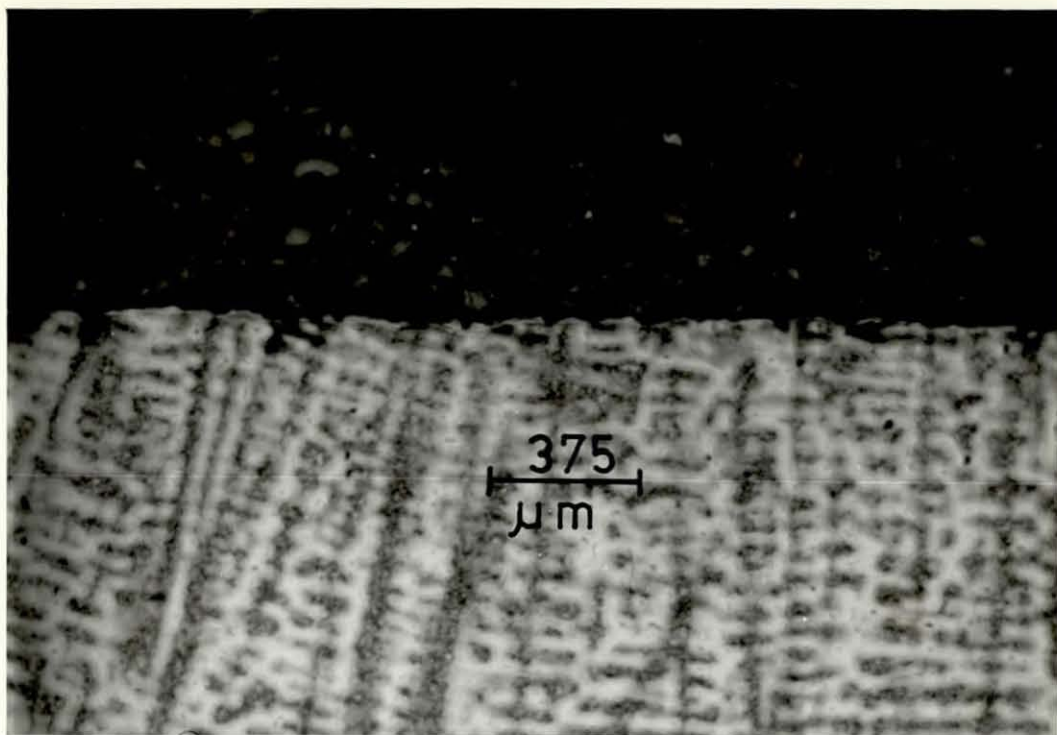


FIGURE 5.92

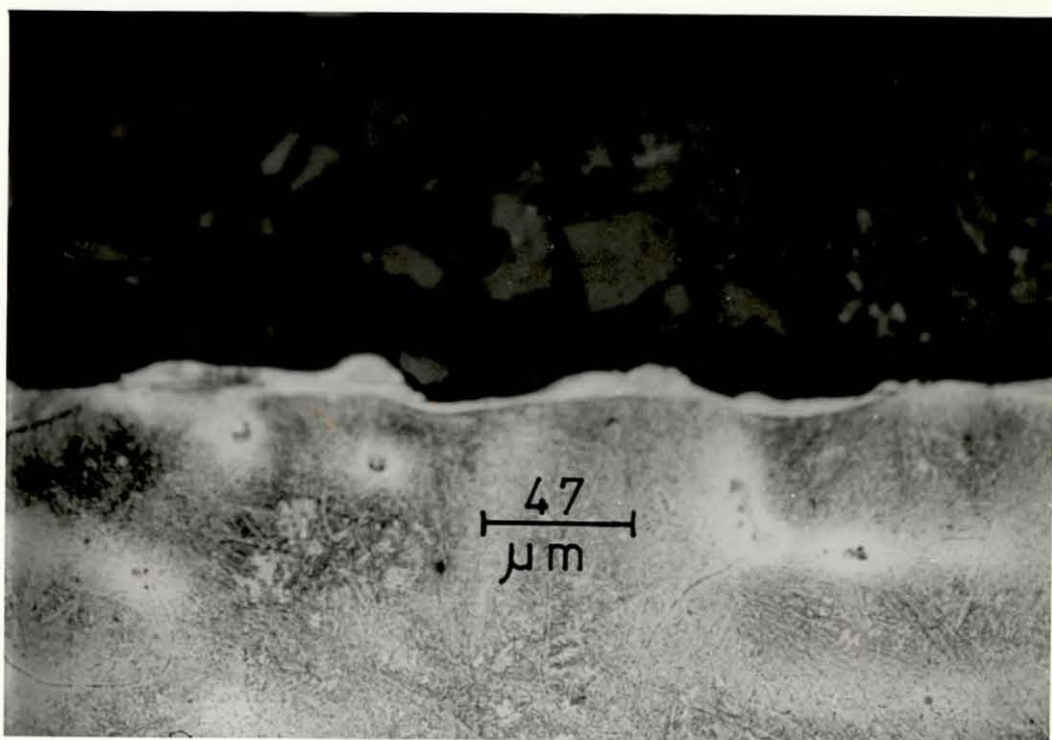


FIGURE 5.93

FIGURES 5.92 & 5.93 PHOTOMICROGRAPHS OF THE SURFACE  
STRUCTURE OF TEST CASTING SPECIMEN 13 B PRODUCED  
BY EDM.

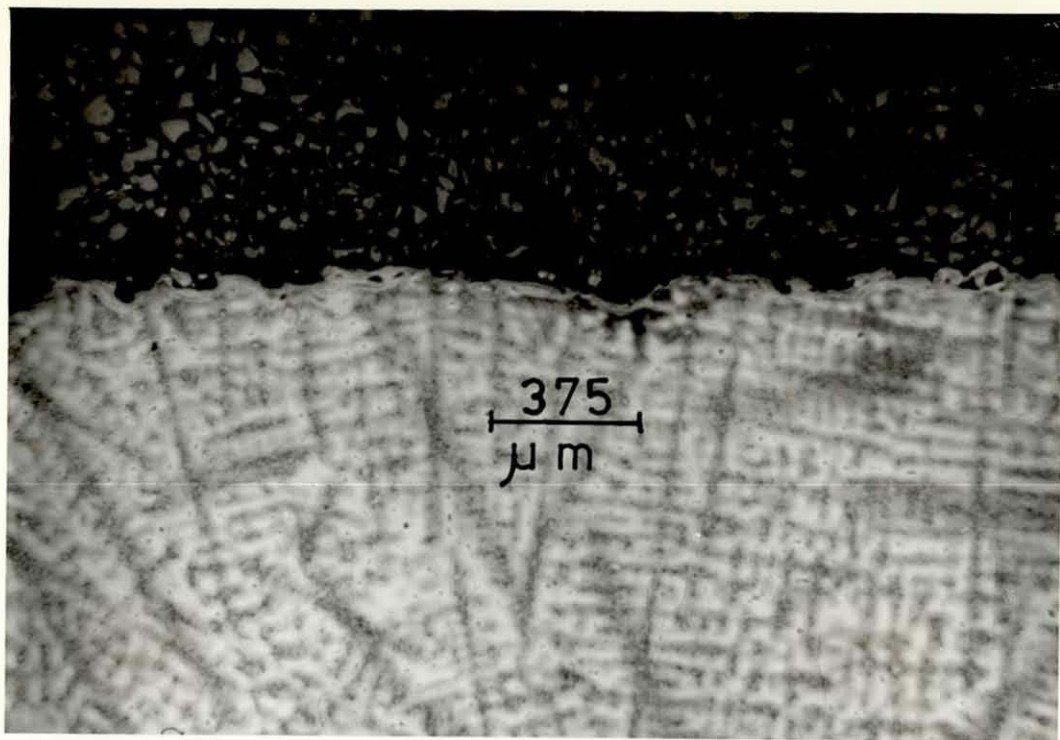


FIGURE 5.94

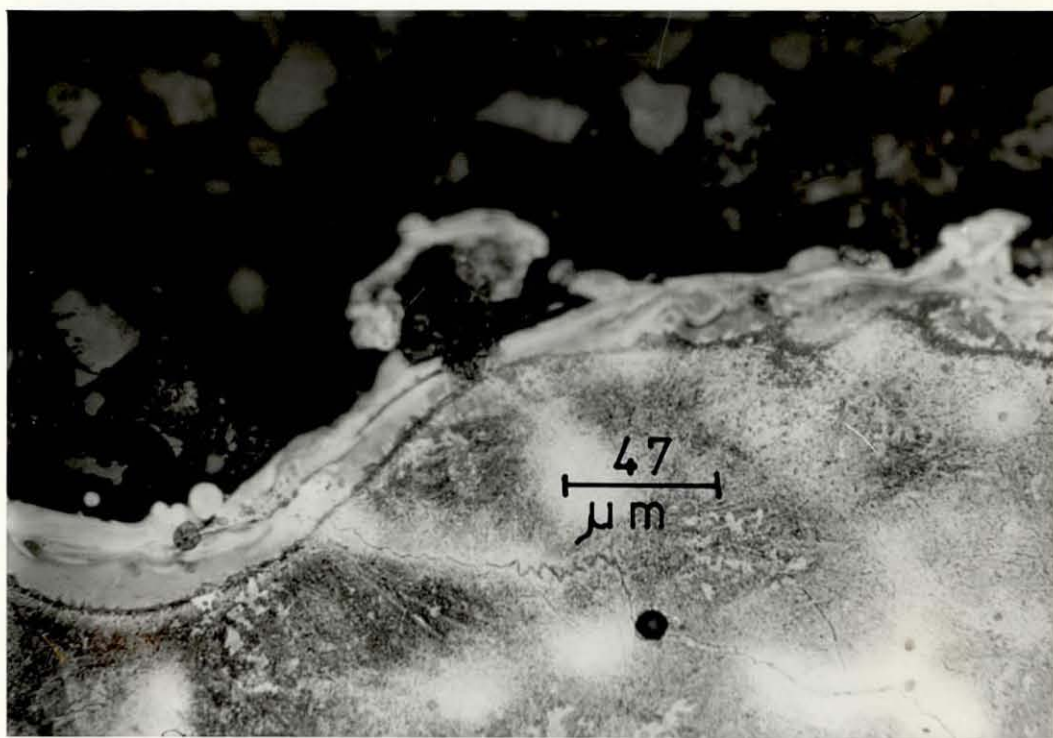


FIGURE 5.95

FIGURES 5.94 & 5.95 PHOTOMICROGRAPHS OF THE SURFACE  
STRUCTURE OF TEST CASTING SPECIMEN 13 D PRODUCED  
BY EDM.

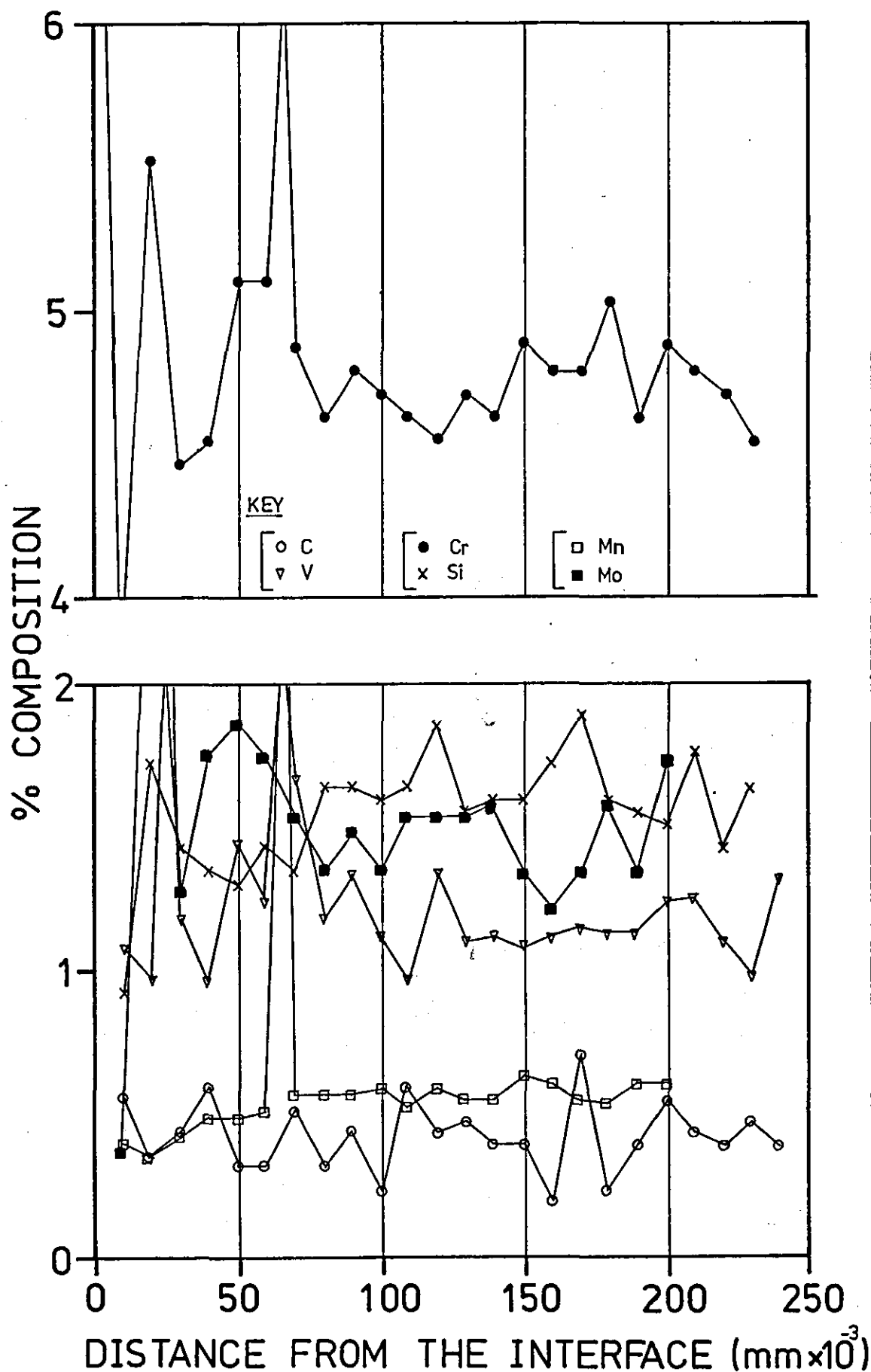


FIGURE 5.96 QUALITATIVE RELATIONSHIP BETWEEN  
% COMPOSITION AND DISTANCE FROM THE AS CAST SURFACE  
OF TEST CASTING SPECIMEN 1 A.



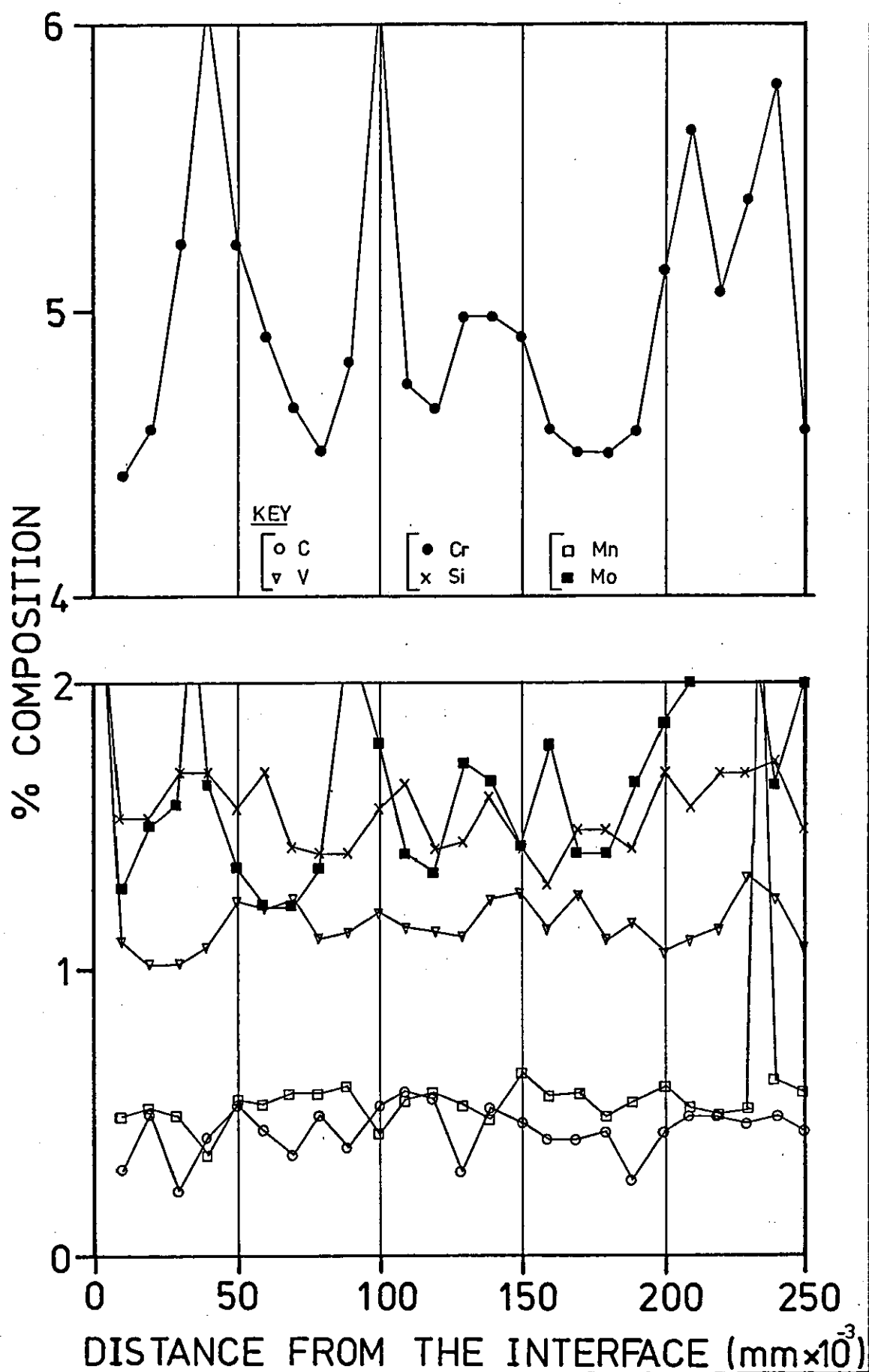


FIGURE 5.97 QUALITATIVE RELATIONSHIP BETWEEN  
% COMPOSITION AND DISTANCE FROM THE AS CAST SURFACE  
OF TEST CASTING SPECIMEN 2 A.

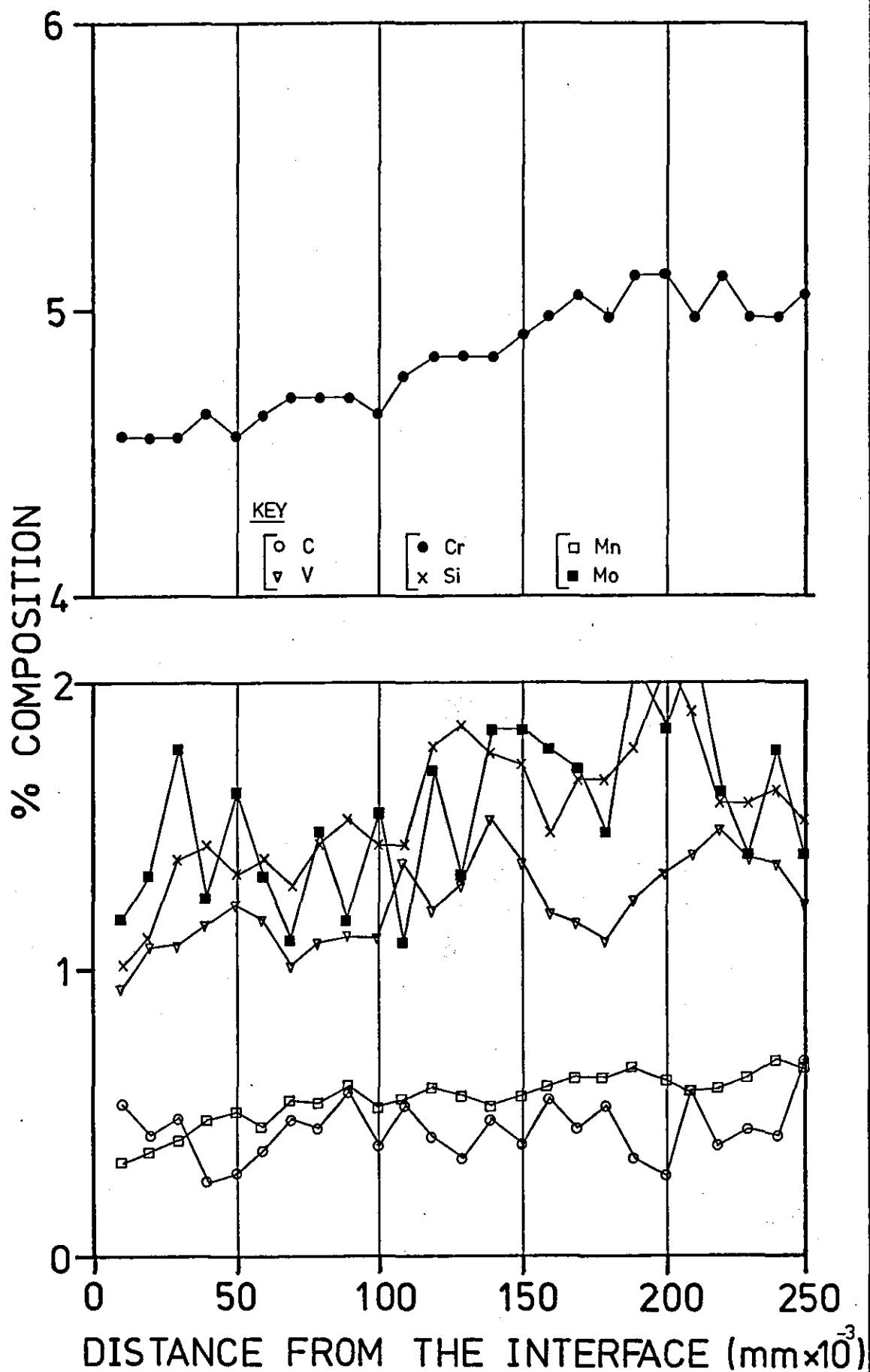


FIGURE 5.98 QUALITATIVE RELATIONSHIP BETWEEN  
% COMPOSITION AND DISTANCE FROM THE AS CAST SURFACE  
OF TEST CASTING SPECIMEN 13 A.

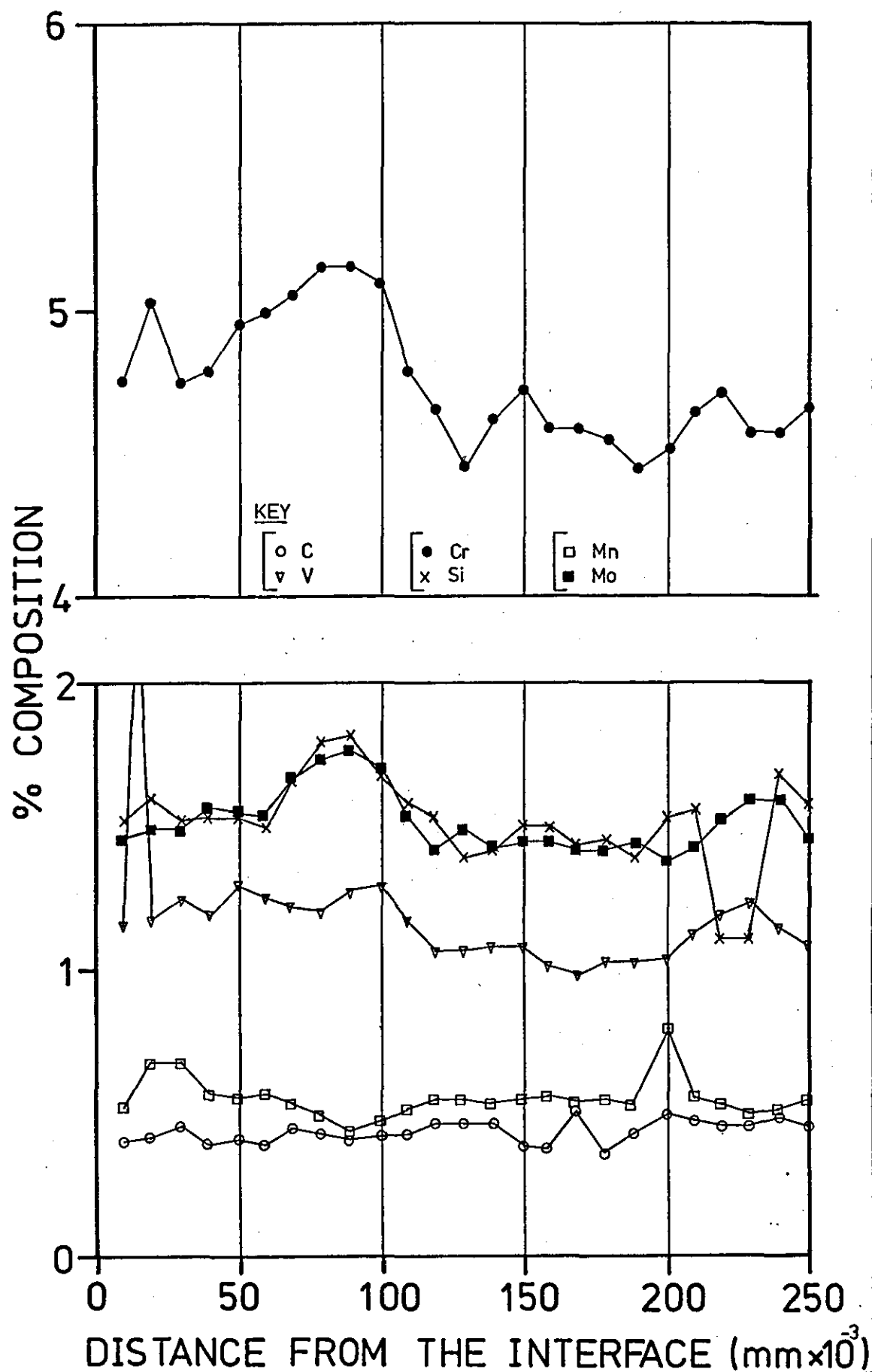


FIGURE 5.99 QUALITATIVE RELATIONSHIP BETWEEN  
% COMPOSITION AND DISTANCE FROM THE MACHINED ( EDM )  
SURFACE OF TEST CASTING SPECIMEN 13 C.

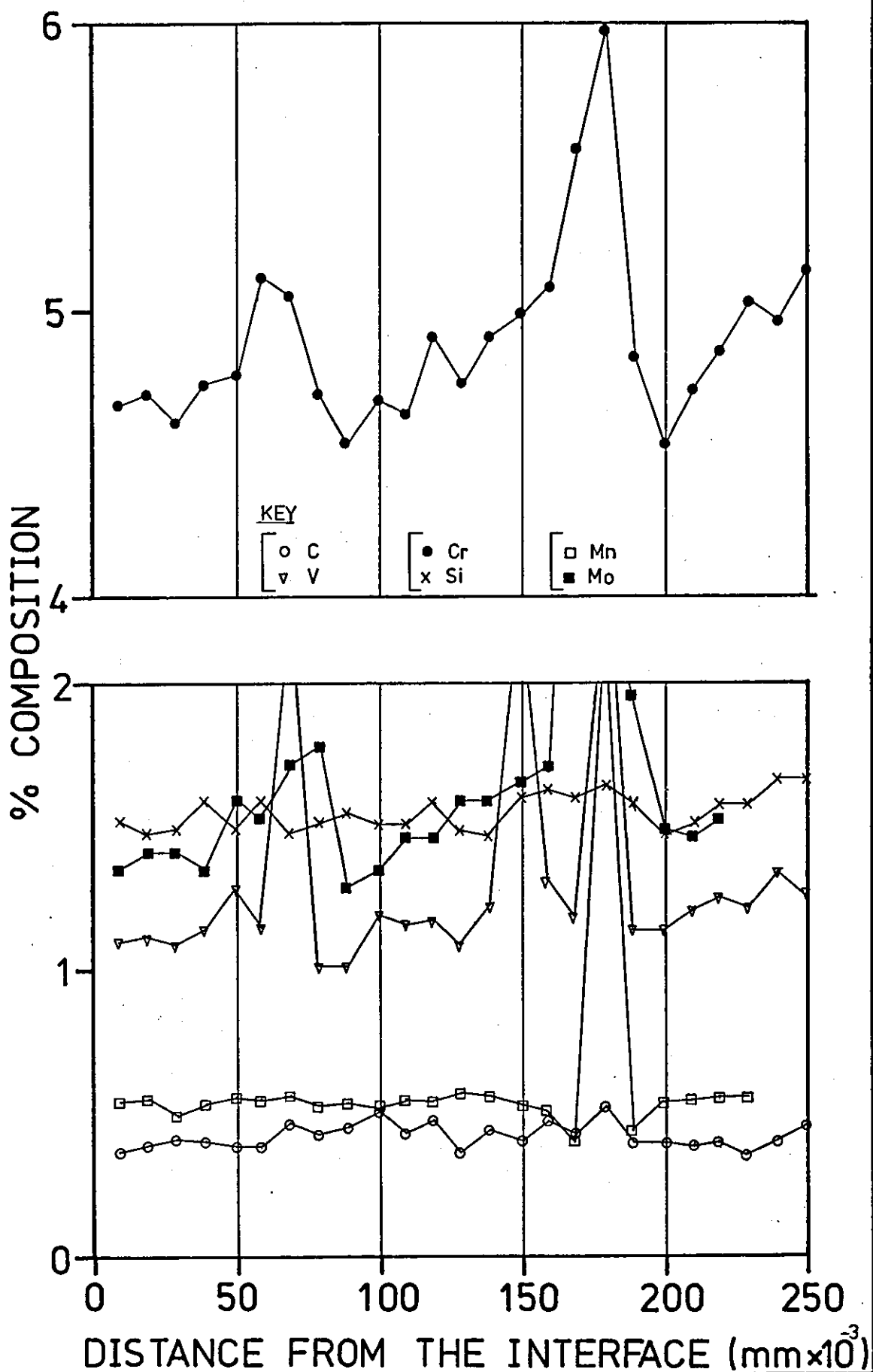


FIGURE 5.100 QUALITATIVE RELATIONSHIP BETWEEN  
% COMPOSITION AND DISTANCE FROM THE MACHINED ( EDM )  
SURFACE OF TEST CASTING SPECIMEN 13 B.



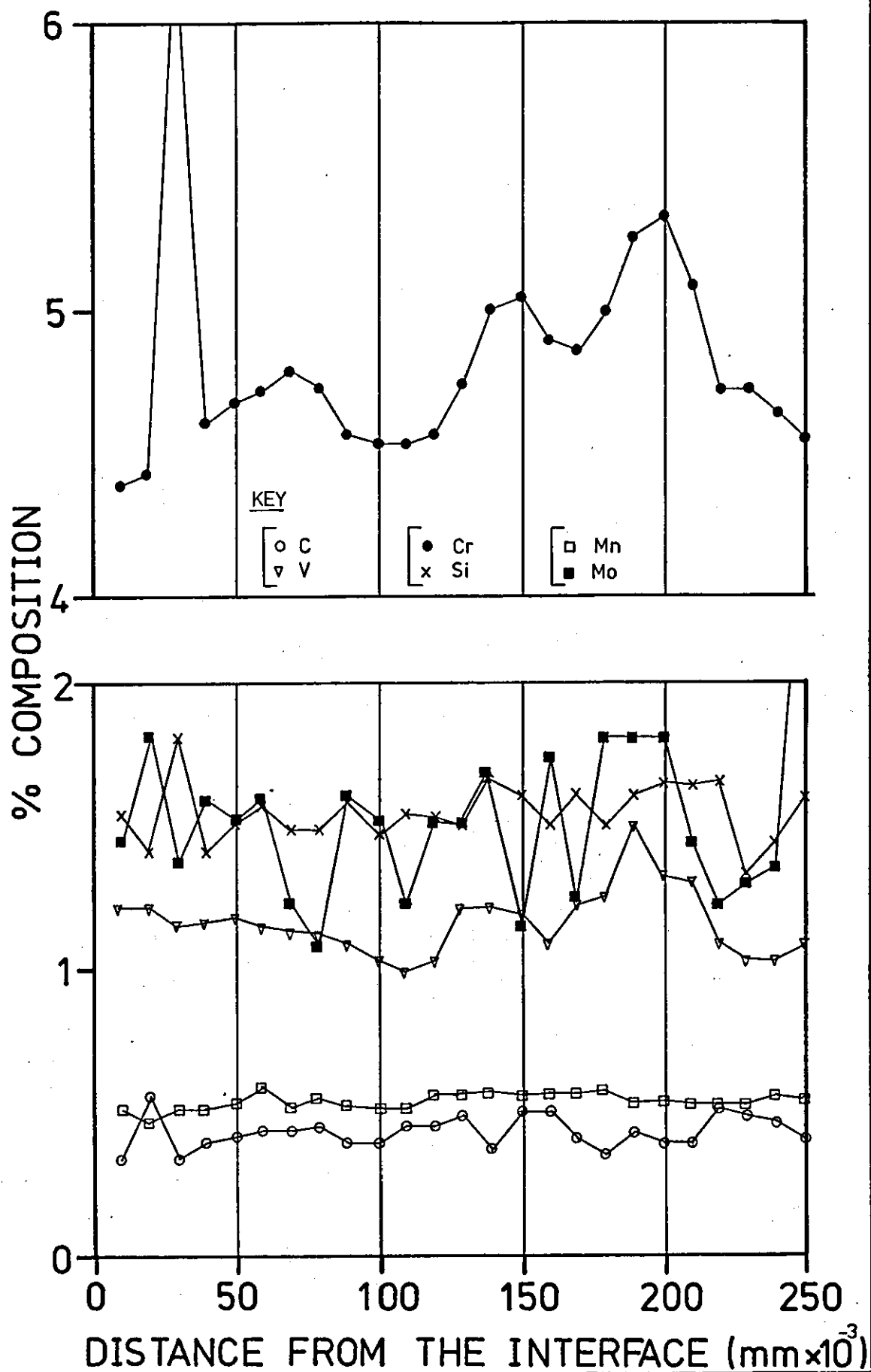


FIGURE 5.101 QUALITATIVE RELATIONSHIP BETWEEN  
% COMPOSITION AND DISTANCE FROM THE MACHINED ( EDM )  
SURFACE OF TEST CASTING SPECIMEN 13 D.

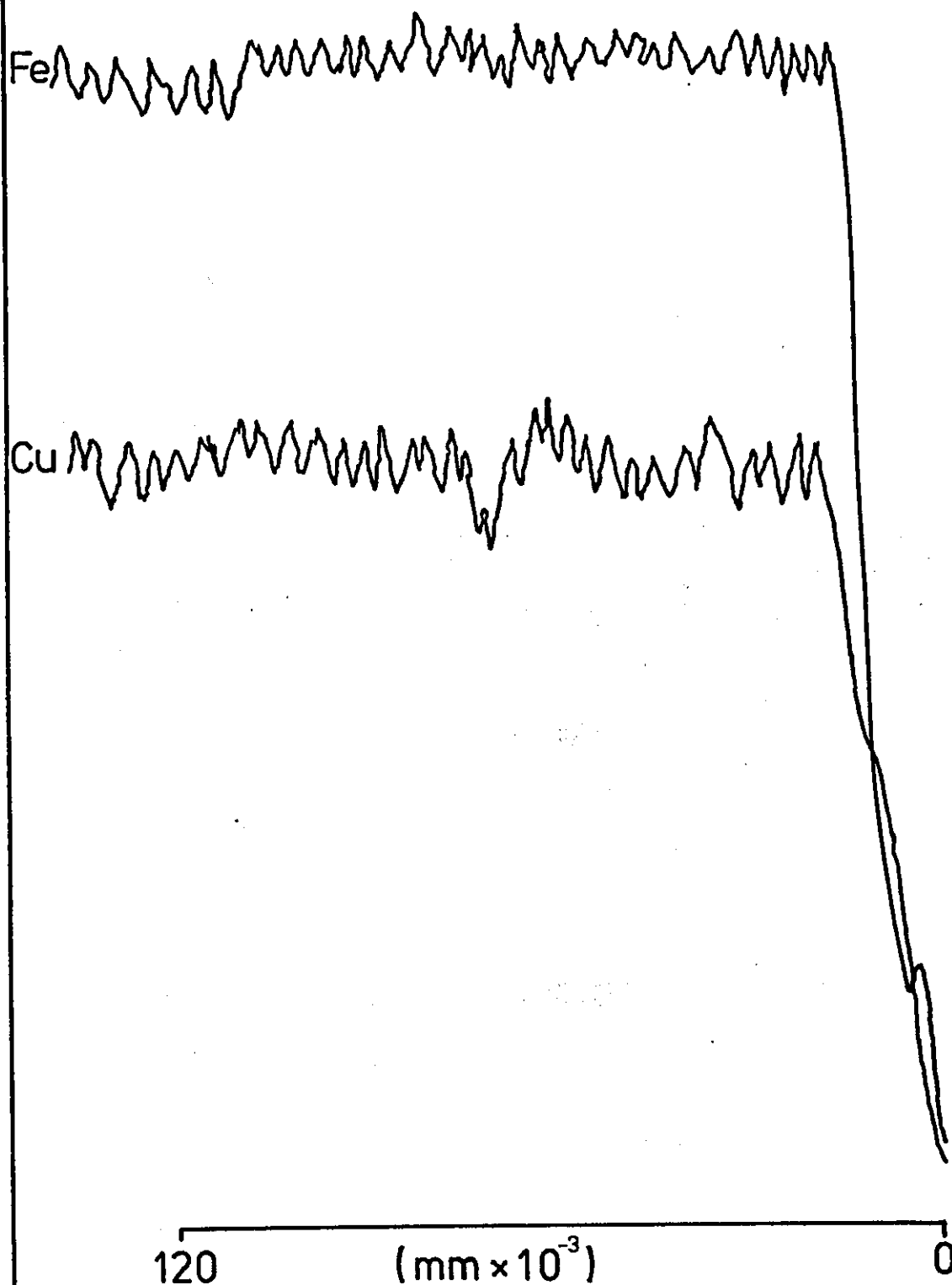


FIGURE 5.102 EPMA TRACE FOR COPPER AND IRON IN  
TEST CASTING SPECIMEN 13 A

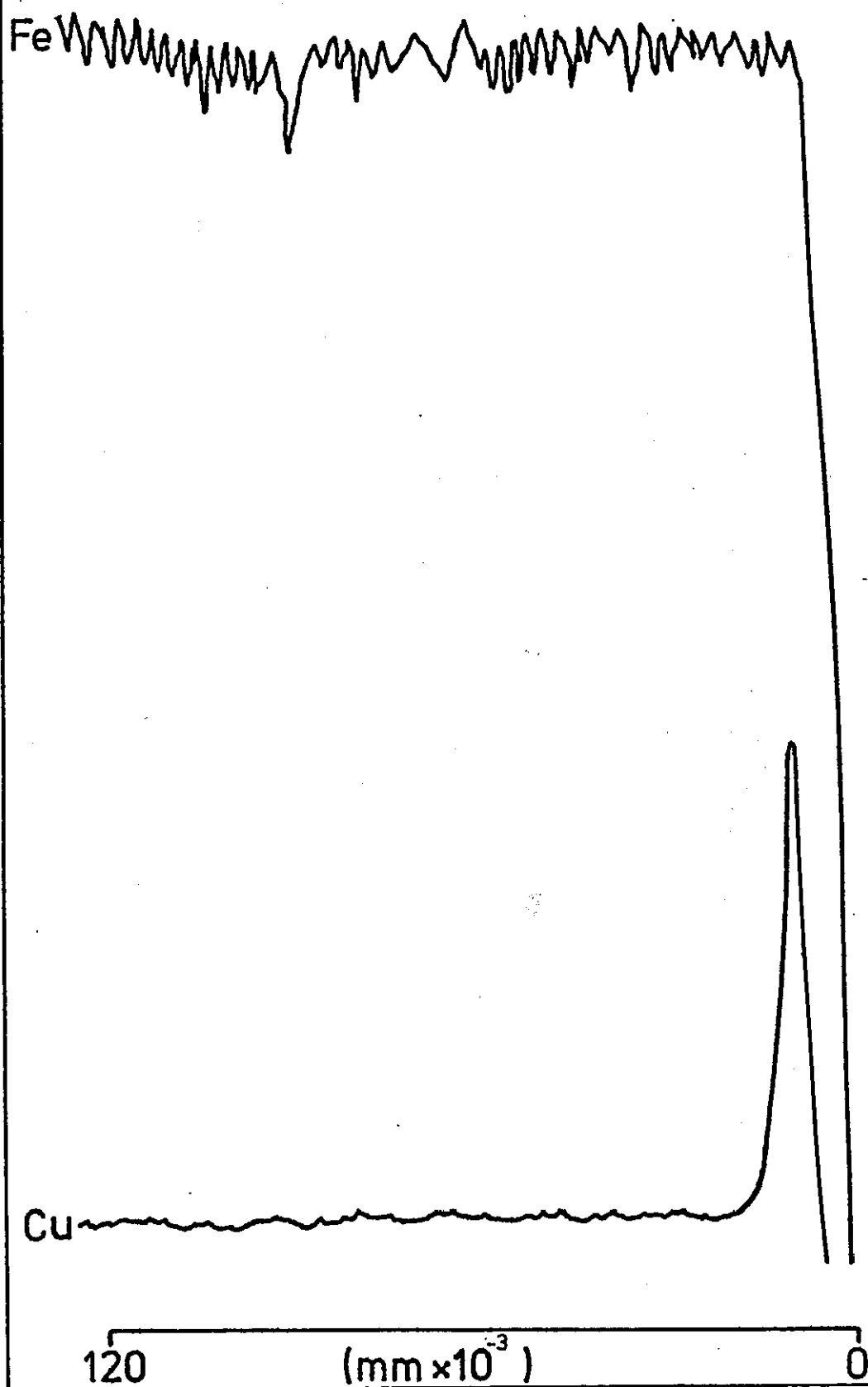


FIGURE 5.103 EPMA TRACE FOR COPPER AND IRON IN  
TEST CASTING SPECIMEN 13 C

Fe

Cu

120 (mm $\times 10^{-3}$ ) 0

FIGURE 5.104 EPMA TRACE FOR COPPER AND IRON IN  
TEST CASTING SPECIMEN 13 D

FIGURE 6.1 RELATIONSHIP BETWEEN % DEVIATION FROM THE  
PATTERN DIMENSIONS AND CASTING TYPE ( OR  
WEIGHT )

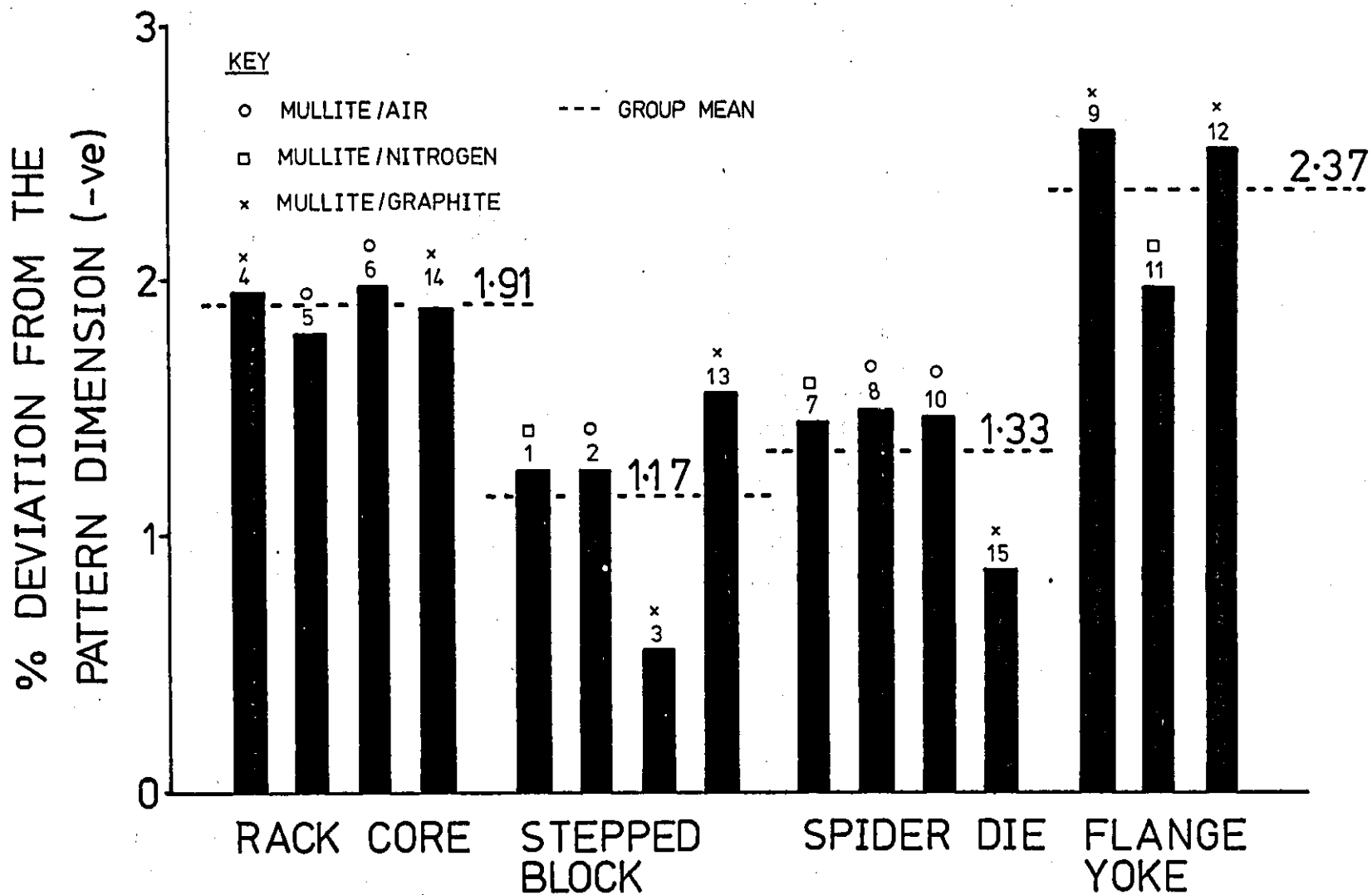




FIGURE 6.2 RELATIONSHIP BETWEEN % DEVIATION FROM THE  
PATTERN DIMENSIONS AND THE MOLD MATERIAL /  
ATMOSPHERE CONDITIONS

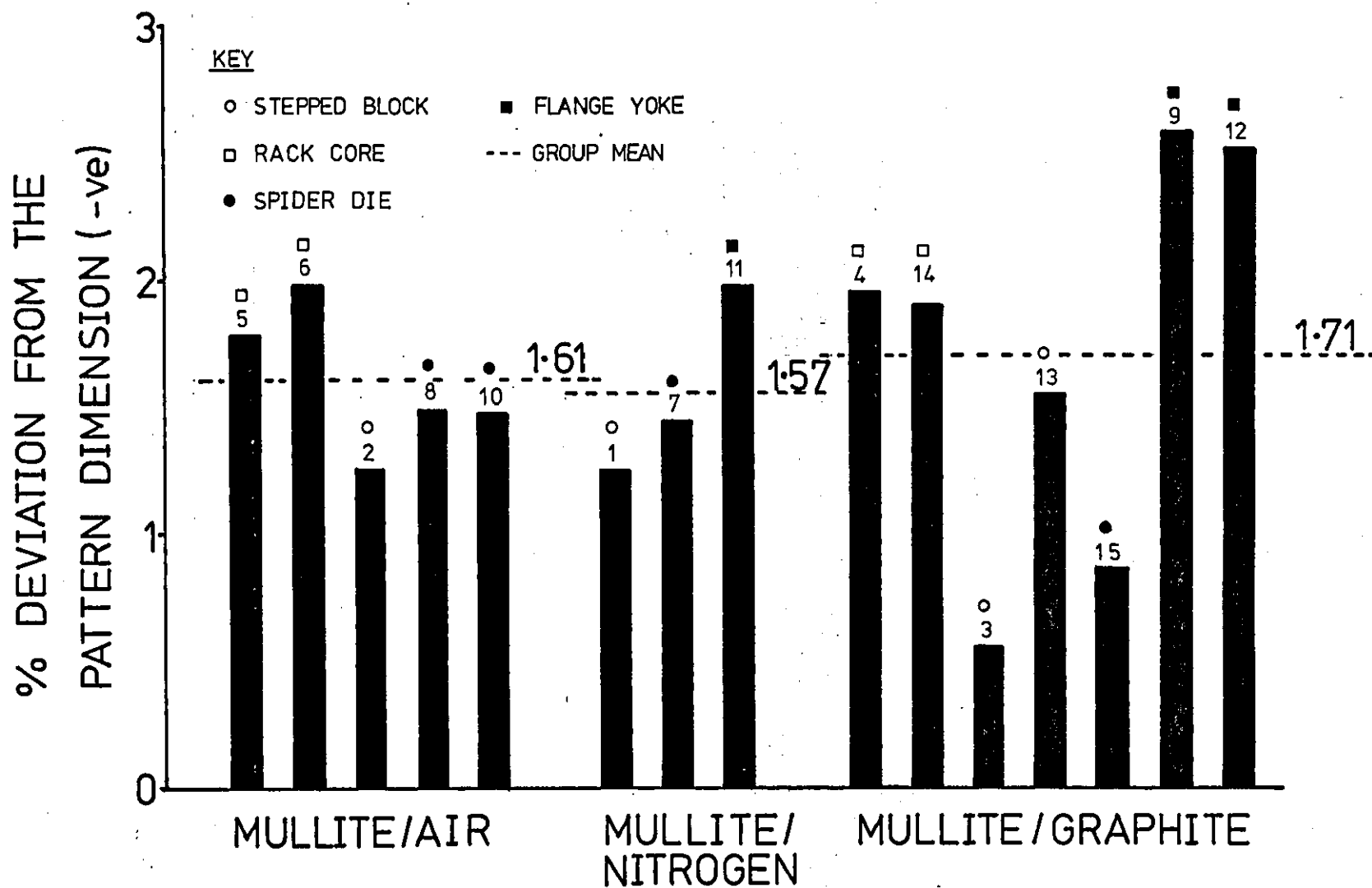


FIGURE 6.3 RELATIONSHIP BETWEEN % DEVIATION FROM THE  
PATTERN DIMENSIONS AND THE SIZE OF THE  
NOMINAL PATTERN DIMENSION

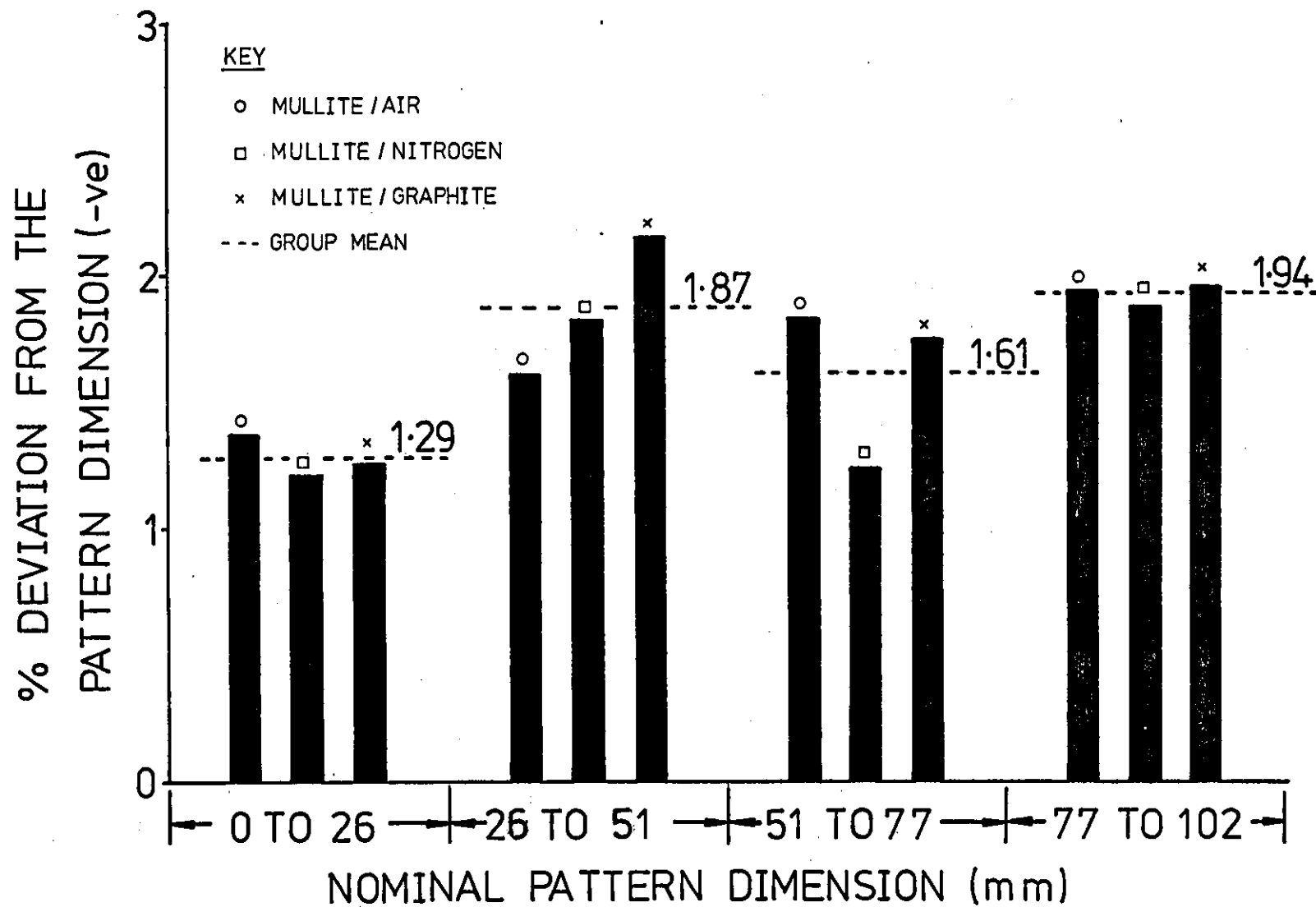


FIGURE 6.4 RELATIONSHIP BETWEEN THE MEAN Ra VALUES  
AND THE CASTING TYPE ( OR WEIGHT )

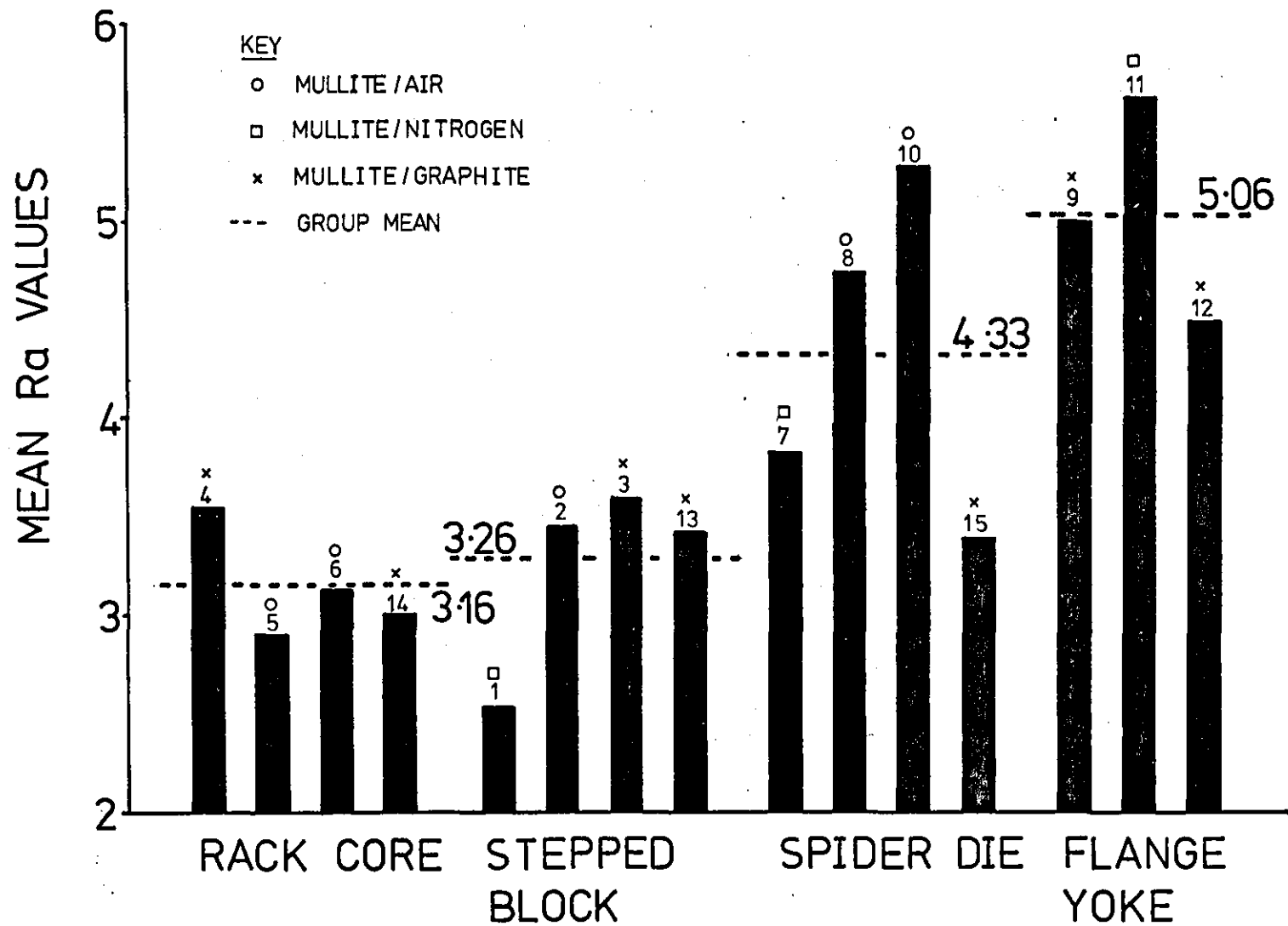


FIGURE 6.5 RELATIONSHIP BETWEEN THE MEAN  $W_a$  VALUES  
AND CASTING TYPE ( OR WEIGHT )

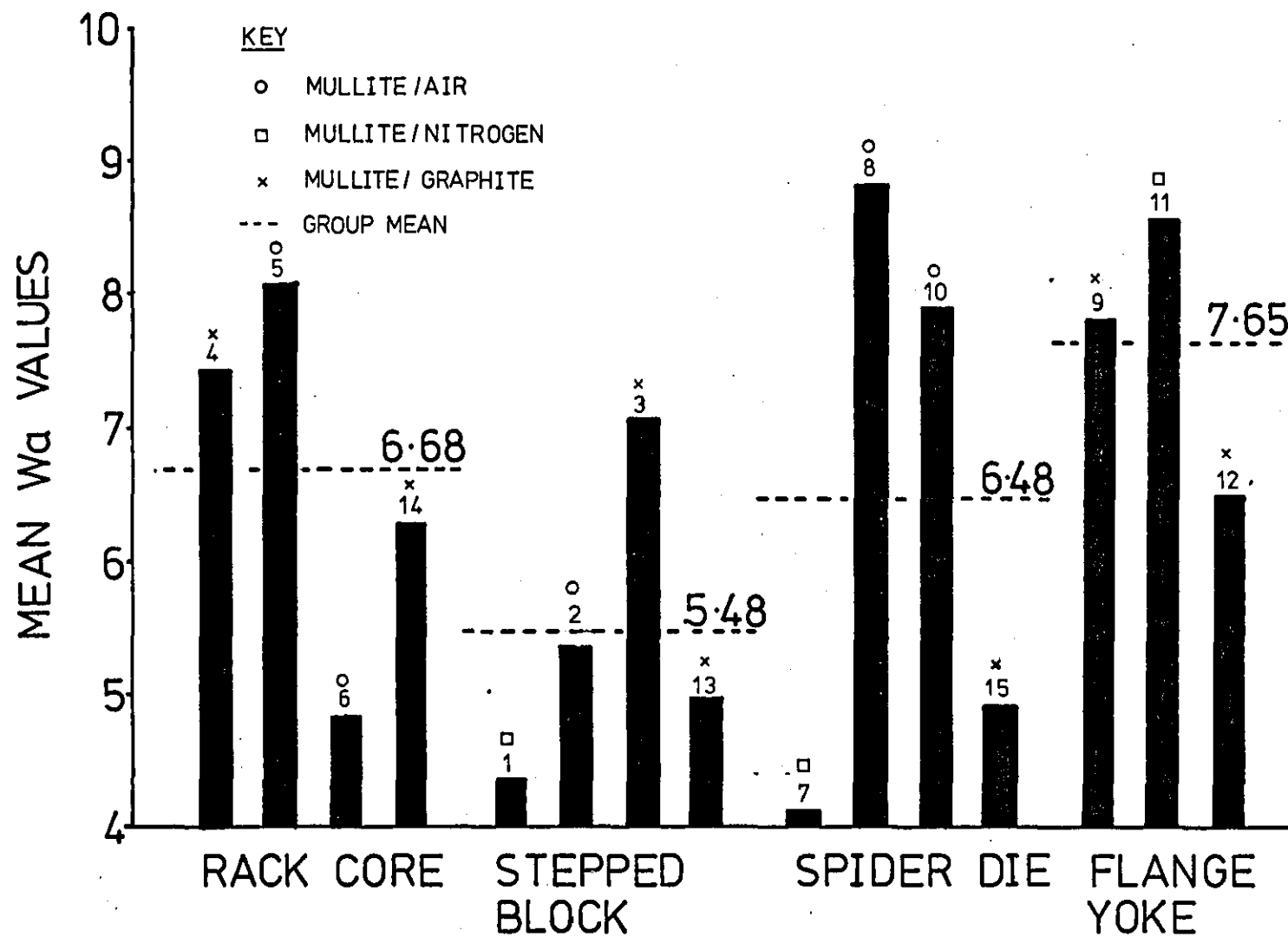


FIGURE 6.6 RELATIONSHIP BETWEEN THE MEAN Ra VALUES  
AND THE MOLD MATERIAL / ATMOSPHERE  
COMBINATION

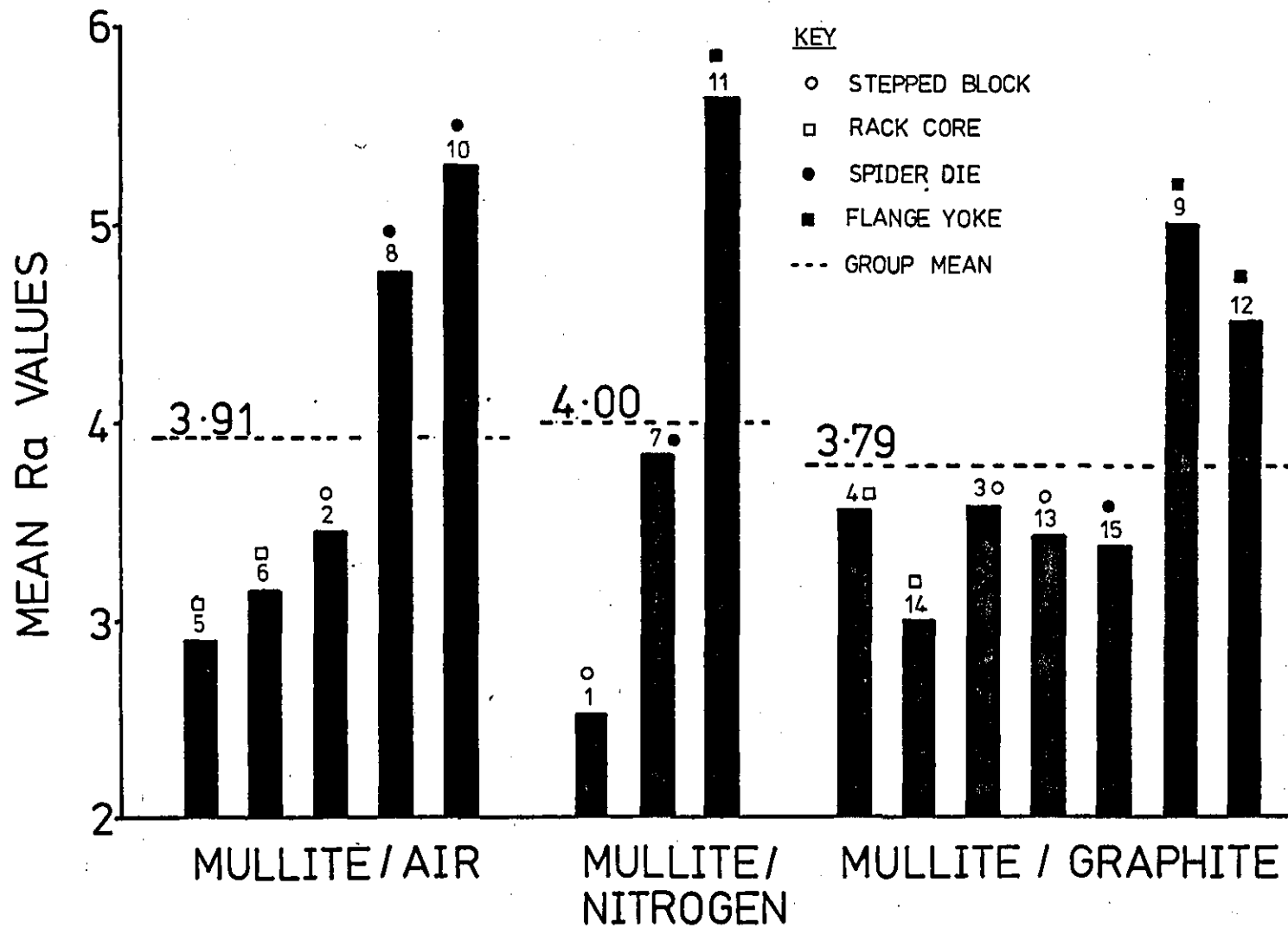




FIGURE 6.7 RELATIONSHIP BETWEEN THE MEAN  $W_a$  VALUES  
AND THE MOLD MATERIAL / ATMOSPHERE  
COMBINATION

