

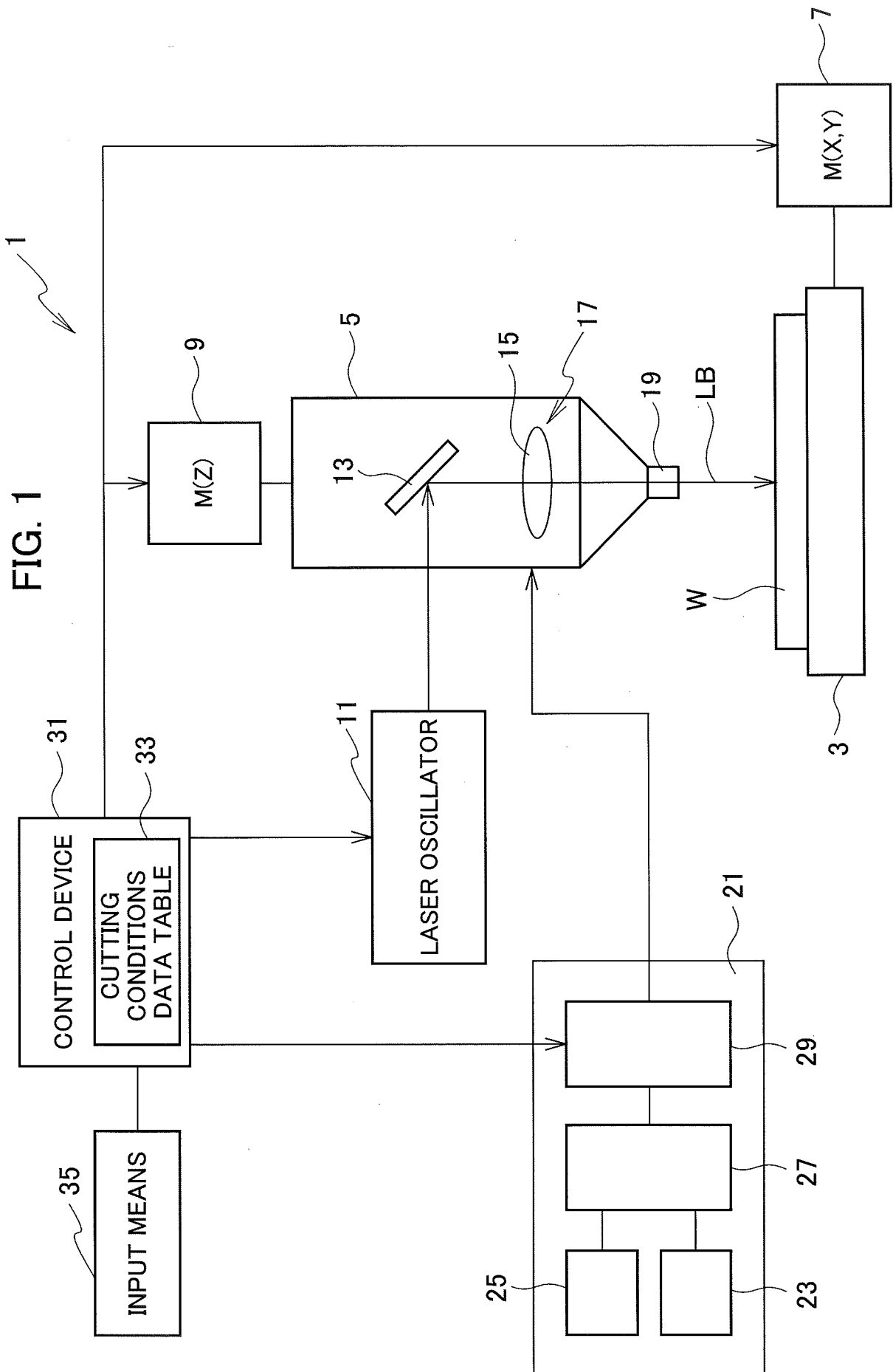


FIG. 2

Plated steel plates are laser cut and machined under different cutting conditions and cut end faces are subjected to "EPMA #1" analysis.

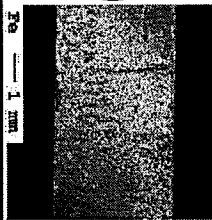
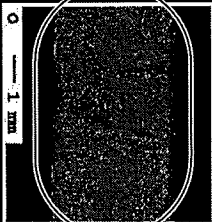
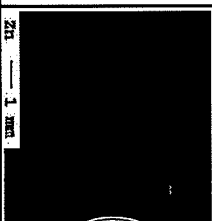
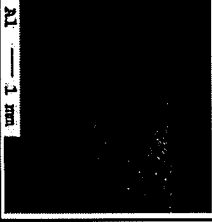
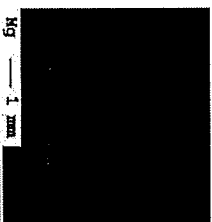
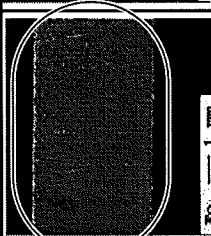
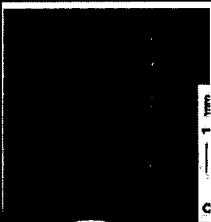
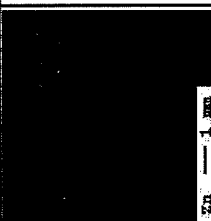
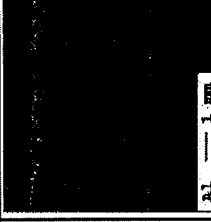
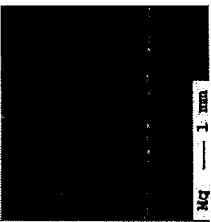
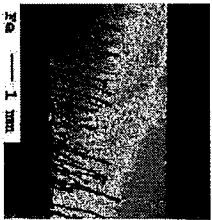
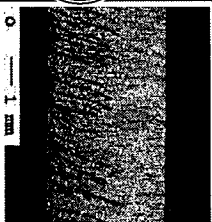
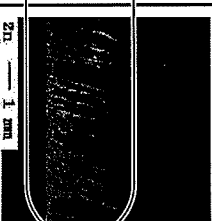
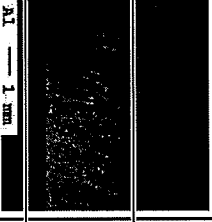
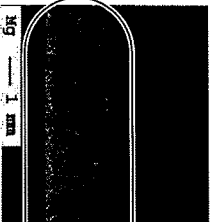
PROCESSING METHOD	Fe	O	Zn	Al	Mg	NOTE
OXYGEN CUTTING						Cut end face is entirely covered with oxide film.
CLEAN CUTTING						Cut end face has no oxide film or the like and shows only raw material component.
EASY CUTTING						Cut end face shows thin oxide film, and at upper part, plating components.

FIG. 3

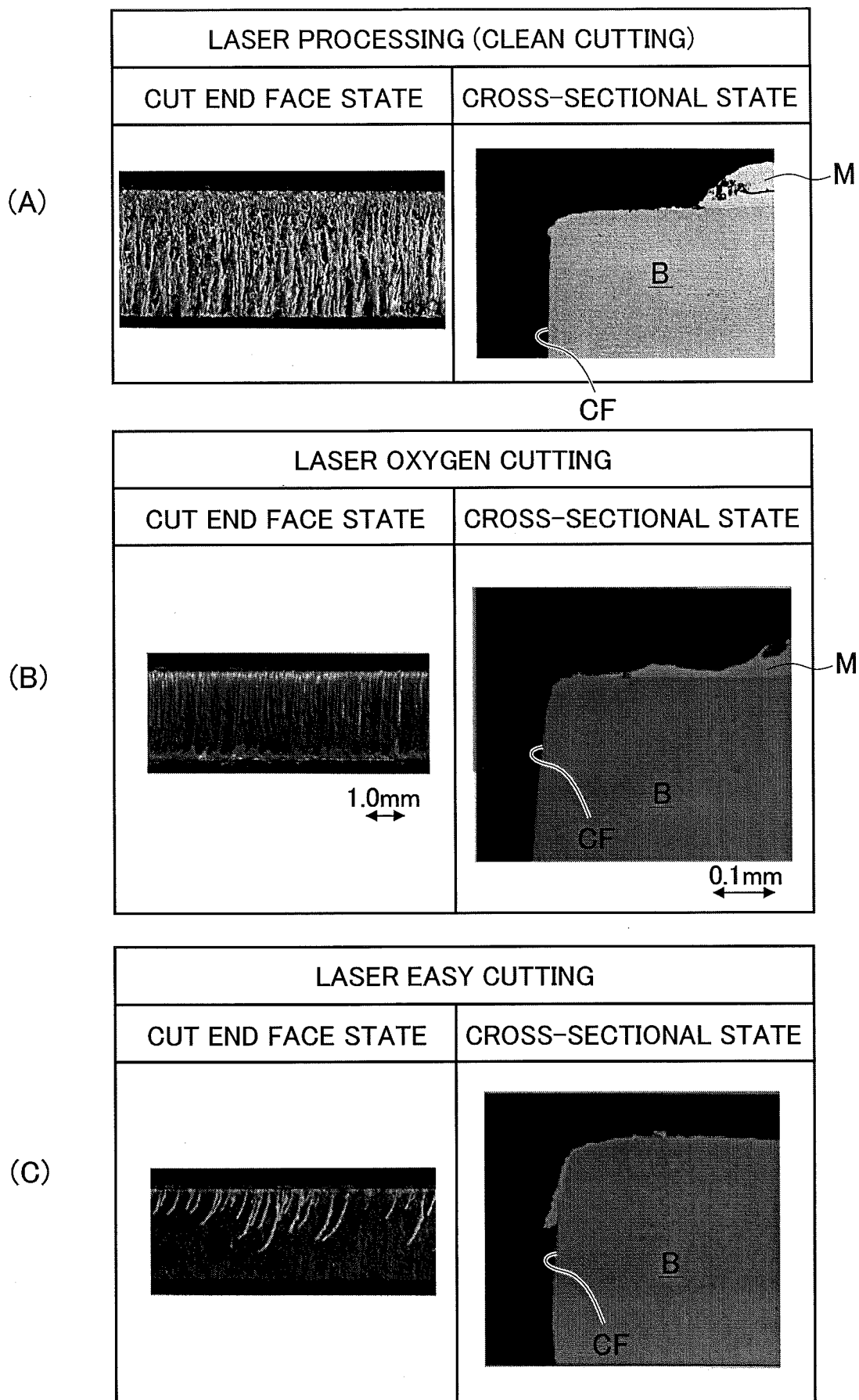
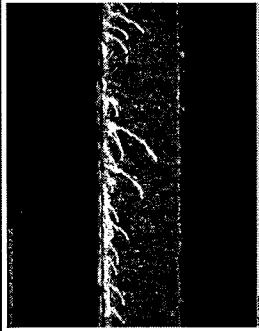
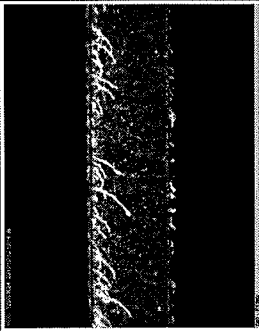
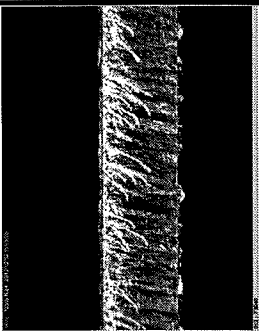
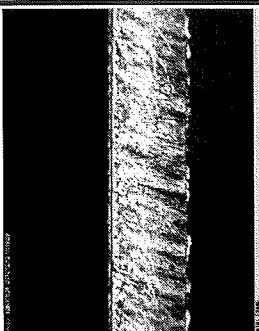


FIG. 4

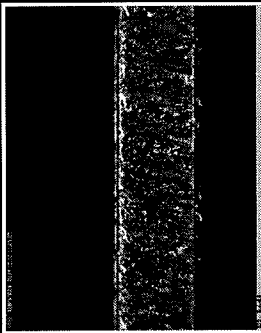
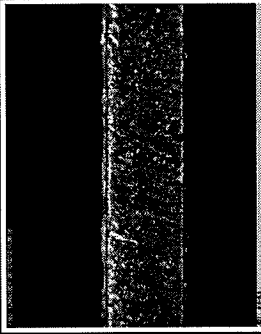
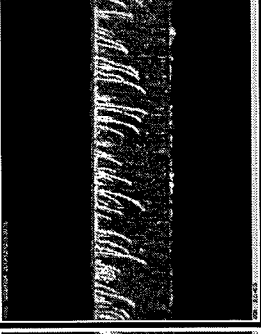
● ASSIST GAS: EZ NOZZLE: ϕ 4.0 CUTTING SPEED: 1120~3840 ASSIST GAS PRESSURE: 0.9MPa
NOZZLE GAP: 0.3mm FOCUS: -4.5mm

PARAM- ETER	SLOW <					FAST >
CUTTING SPEED	F=1120	F=1280	F=1600	F=3040	F=3840	
PHOTO						

● Speeding up cutting speed increases coating quantity of plating-layer-containing metal on cut end face.

FIG. 5

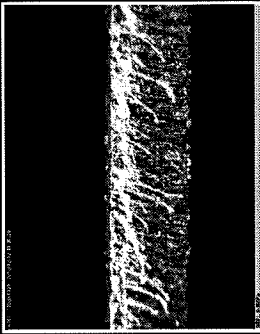
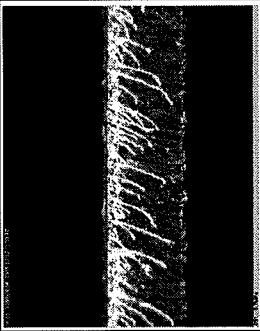
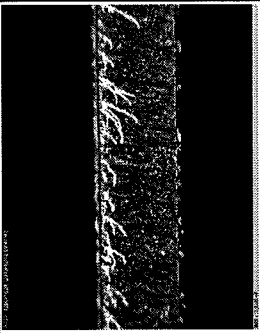
● ASSIST GAS: EZ NOZZLE: ϕ 4.0 CUTTING SPEED: 1600 ASSIST GAS PRESSURE: 0.9MPa NOZZLE GAP: 0.3mm
FOCUS: -6.5~+0.5mm

PARAM- ETER	LOW ←	→ HIGH			
CUTTING SPEED	-6.5	-5.5	-4.5	-1.5	+0.5
PHOTO					

● Bringing focus toward plus side increases coating quantity of plating-layer-containing metal on cut end face.

FIG. 6

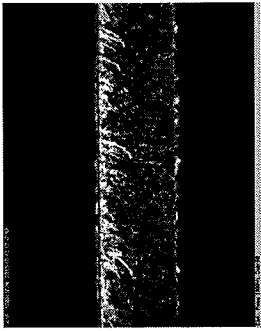
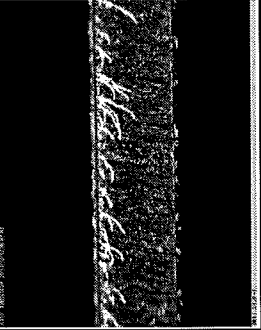
● ASSIST GAS: EZ NOZZLE: ϕ 4.0 CUTTING SPEED: 1600 ASSIST GAS PRESSURE: 0.5~0.95MPa
NOZZLE GAP: 0.3mm FOCUS: -4.5mm

PARAMETER	LOW	HIGH		
GAS PRESSURE	0.5MPa	0.7MPa	0.9MPa	-
PHOTO				

● Lowering assist gas pressure increases coating quantity of plating-layer-containing metal on cut end face.

FIG. 7

- ASSIST GAS: EZ NOZZLE: ϕ 4.0 CUTTING SPEED: 1600 ASSIST GAS PRESSURE: 0.9MPa
NOZZLE GAP: 0.3mm FOCUS: -4.5mm FREQUENCY: 800Hz~CW

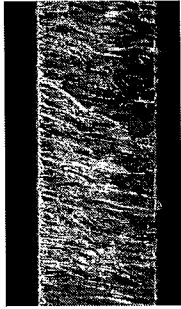
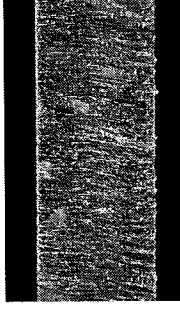
PARAMETER	LOW 	 HIGH
PULSE	800Hz	-
PHOTO		

- Changing pulse frequency causes no significant change in coating quantity of plating-layer-containing metal on cut end face.

FIG. 8

STATE	MARK	PLASMA STATE
NO PLASMA GENERATION	NIL	
WEAK PLASMA GENERATION	p	
PLASMA GENERATION	P	

FIG. 9

STATE	MARK	PHOTO
NO RUSTING	O	
RUSTING	x	

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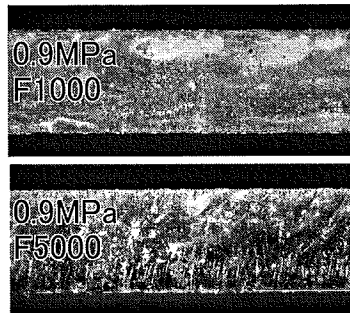
FIG. 10

ONE-MONTH EXPOSURE, PLATE THICKNESS $t = 2.3\text{mm}$,
FOCAL POSITION: -0.5mm

PLATING QUANTITY			K14								
NOZZLE DIAMETER (mm)			S2.0			D4.0			D7.0		
ASSIST GAS PRESSURE (MPa)			0.9	0.7	0.5	0.9	0.7	0.5	0.9	0.7	0.5
PLATE $t = 2.3$	CUTTING SPEED mm/min	1000	NIL ×	NIL ×	NIL ×	NIL ×	NIL ×	NIL ×	p ×	p ×	p ×
		2000	NIL ×	NIL ×	NIL ×	NIL ×	NIL ×	NIL ×	p ×	p ×	p ×
		3000	P ×	P ×	PO	PO	PO	PO	pO	pO	pO
		4000	P ×	PO	PO	PO	PO	PO	PO	PO	PO
		5000	P ×	PO	PO	PO	PO	PO	PO	PO	PO

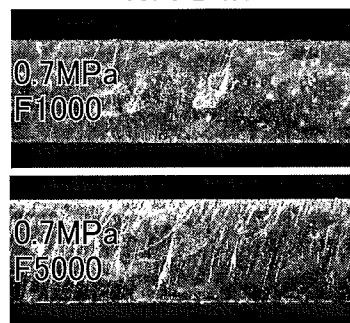
(A)

K14 S2.0



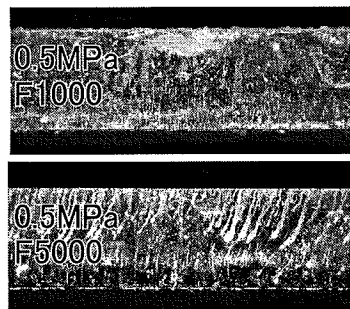
(B)

K14 D4.0



(C)

K14 D7.0



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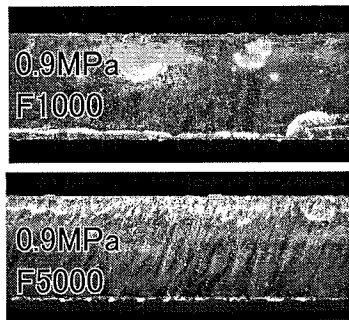
FIG. 11

ONE-MONTH EXPOSURE, PLATE THICKNESS $t = 2.3\text{mm}$,
 FOCAL POSITION: -0.5mm

PLATING QUANTITY			K27								
NOZZLE DIAMETER (mm)			S2.0			D4.0			D7.0		
ASSIST GAS PRESSURE (MPa)			0.9	0.7	0.5	0.9	0.7	0.5	0.9	0.7	0.5
PLATE $t = 2.3$	CUTTING SPEED mm/min	1000	NIL X	NIL X	NIL X	NIL X	NILO	NIL X	pO	pO	p X
		2000	p X	p X	p X	p X	pO	pO	pO	pO	pO
		3000	PO	PO	PO	PO	PO	PO	PO	PO	PO
		4000	PO	PO	PO	PO	PO	PO	PO	PO	PO
		5000	PO	PO	PO	PO	PO	PO	PO	PO	PO

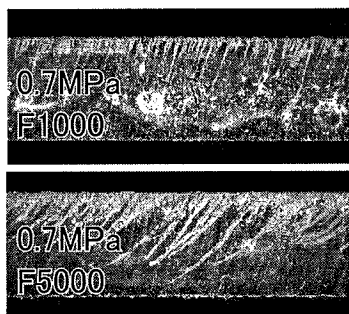
(A)

K27 S2.0



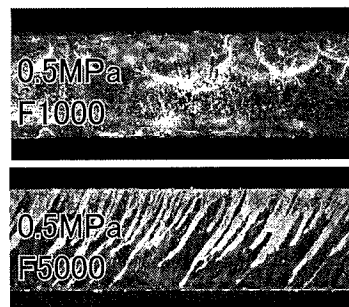
(B)

K27 D4.0



(C)

K27 D7.0



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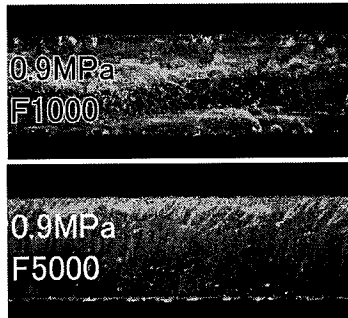
FIG. 12

ONE-MONTH EXPOSURE, PLATE THICKNESS $t = 2.3\text{mm}$,
FOCAL POSITION: -0.5mm

PLATING QUANTITY			K35								
NOZZLE DIAMETER (mm)			S2.0			D4.0			D7.0		
ASSIST GAS PRESSURE (MPa)			0.9	0.7	0.5	0.9	0.7	0.5	0.9	0.7	0.5
PLATE $t = 2.3$	CUTTING SPEED mm/min	1000	NIL x	NIL x	NIL x	P x	p x	p x	p x	p x	p x
		2000	P x	P x	P x	P x	PO	PO	PO	PO	PO
		3000	PO	PO	PO	PO	PO	PO	PO	PO	PO
		4000	PO	PO	PO	PO	PO	PO	PO	PO	PO
		5000	PO	PO	PO	PO	PO	PO	PO	PO	PO

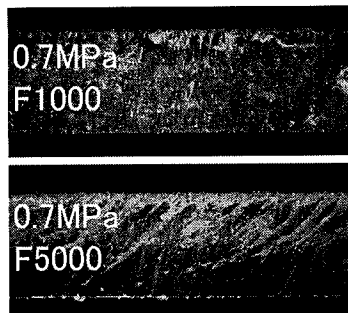
(A)

K35 S2.0



(B)

K35 D4.0



(C)

K35 D7.0

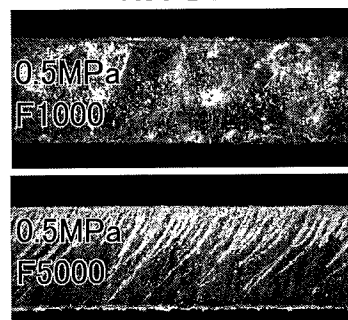
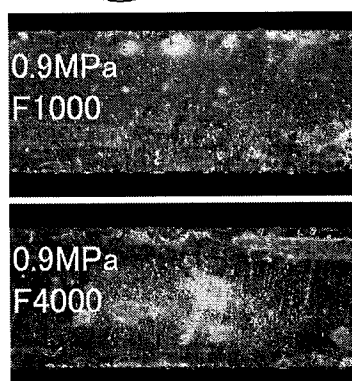


FIG. 13 ONE-MONTH EXPOSURE, PLATE THICKNESS $t = 3.2\text{mm}$,
FOCAL POSITION: -0.5mm

PLATING QUANTITY			K14							
NOZZLE DIAMETER (mm)			S2.0		D4.0			D7.0		
ASSIST GAS PRESSURE (MPa)			0.9	0.7	0.9	0.7	0.5	0.9	0.7	0.5
PLATE t = 3.2	CUTTING SPEED mm/min	1000	NIL x	NIL x	NIL x	NIL x	NIL x	p x	p x	NIL x
		1500	NIL x	NIL x	NIL x	NIL x	NIL x	p x	p x	p x
		2000	NIL x	NIL x	NIL x	NIL x	NIL x	p x	p x	p x
		2500	NIL x	NIL x	NIL x	NIL x	NIL x	P x	P x	p x
		3000	NIL x	NIL x	NIL x	NIL x	p x	P x	P x	NG
		3500	NIL x	NIL x	NIL x	NG	NG	NG	NG	NG
		4000	NIL x	p x	NG	NG	NG	NG	NG	NG

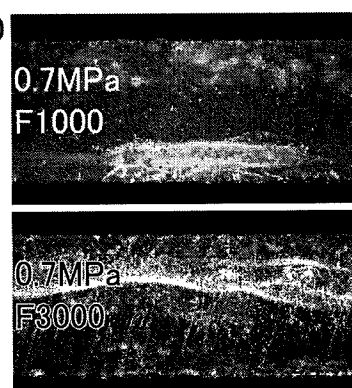
(A)

K14 S2.0



(B)

K14 D4.0



(C)

K14 D7.0

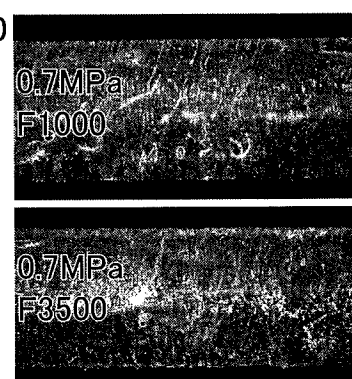
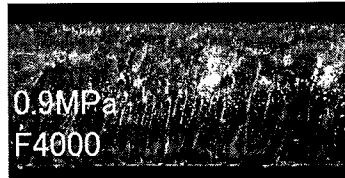
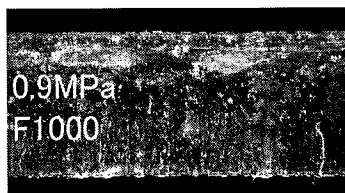


FIG. 14 ONE-MONTH EXPOSURE, PLATE THICKNESS $t = 3.2\text{mm}$,
FOCAL POSITION: -0.5mm

PLATING QUANTITY			K27							
NOZZLE DIAMETER (mm)			S2.0		D4.0			D7.0		
ASSIST GAS PRESSURE (MPa)			0.9	0.7	0.9	0.7	0.5	0.9	0.7	0.5
PLATE t = 3.2	CUTTING SPEED mm/min	1000	NIL ×	NIL ×	NIL ×	NIL ×	NIL ×	p ×	pO	pO
		1500	NIL ×	NIL ×	NIL ×	NIL ×	NIL ×	p ×	pO	pO
		2000	NIL ×	NIL ×	p ×	p ×	p ×	pO	pO	pO
		2500	p ×	p ×	p ×	pO	pO	PO	PO	PO
		3000	P ×	PO	PO	PO	PO	PO	PO	PO
		3500	PO	PO	PO	PO	PO	PO	PO	PO
		4000	PO	PO	NG	NG	NG	NG	NG	NG

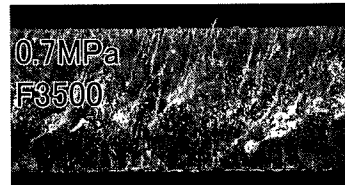
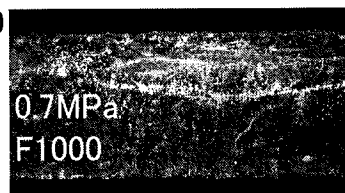
(A)

K27 S2.0



(B)

K27 D4.0



(C)

K27 D7.0

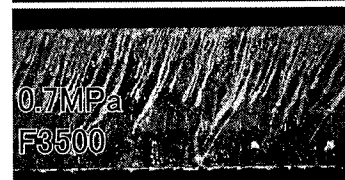
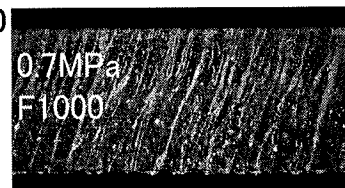
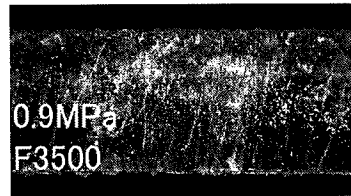
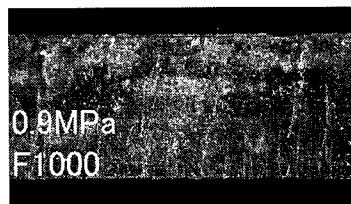


FIG. 15

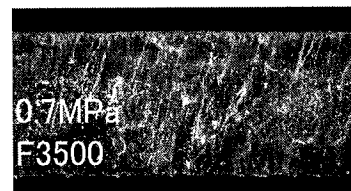
ONE-MONTH EXPOSURE, PLATE THICKNESS $t = 3.2\text{mm}$,
FOCAL POSITION: -0.5mm

PLATING QUANTITY			K35							
NOZZLE DIAMETER (mm)			S2.0		D4.0			D7.0		
ASSIST GAS PRESSURE (MPa)			0.9	0.7	0.9	0.7	0.5	0.9	0.7	0.5
PLATE t = 3.2	CUTTING SPEED mm/min	1000	NIL x	NIL x	NIL x	NIL x	NIL x	p x	pO	pO
		1500	NIL x	NIL x	NIL x	NIL x	NIL x	pO	pO	p x
		2000	p x	p x	p x	p x	p x	PO	PO	PO
		2500	P x	p x	PO	PO	PO	PO	PO	PO
		3000	P x	PO	PO	PO	PO	PO	PO	PO
		3500	PO	PO	PO	PO	PO	NG	NG	NG
		4000	NG	NG	NG	NG	NG	NG	NG	NG

(A) K35 S2.0



(B) K35 D4.0



(C) K35 D7.0

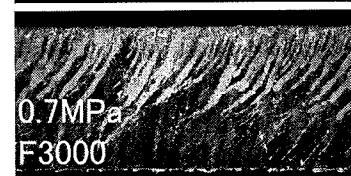
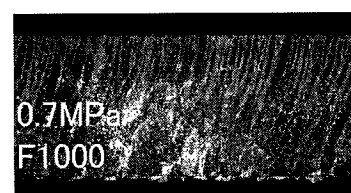


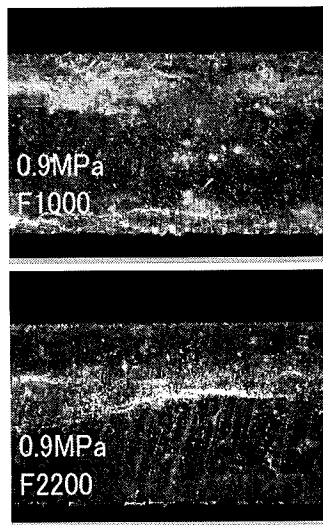
FIG. 16

ONE-MONTH EXPOSURE, PLATE THICKNESS $t = 4.5\text{mm}$,
FOCAL POSITION: -0.5mm

PLATING QUANTITY			K27						K35					
NOZZLE DIAMETER (mm)			D4.0			D7.0			D4.0			D7.0		
ASSIST GAS PRESSURE (MPa)			0.9	0.7	0.5	0.9	0.7	0.5	0.9	0.7	0.5	0.9	0.7	0.5
PLATE $t = 4.5$	CUTTING SPEED mm/min	1000	(NIL x)	NIL x	x	P x	(P x)	D x	(NIL x)	NIL x	D x	PO	(PO)	D x
		1500	NIL x	NIL x	x	PO	PO	NG	p x	NIL x	x	PO	PO	NG
		2000	p x	p x	x	PO	PO	DO	p x	NIL x	x	PO	PO	DO
		2200	(p x)	p x	NG	NG	(PO)	NG	(P x)	p x	x	PO	(PO)	NG
		2500	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG

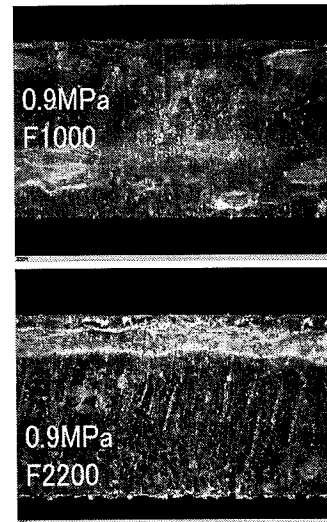
(A)

K27 D4.0



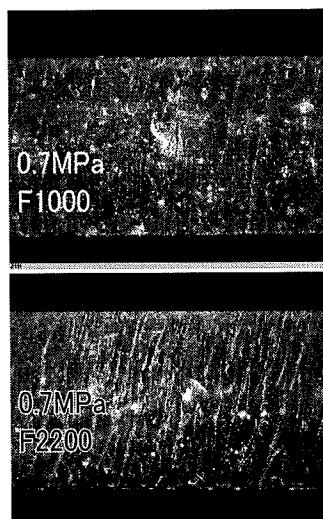
(C)

K35 D4.0



(B)

K27 D7.0



(D)

K35 D7.0

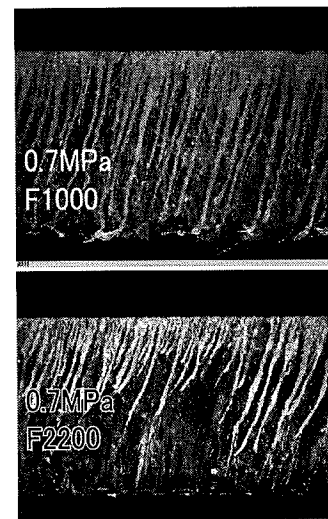


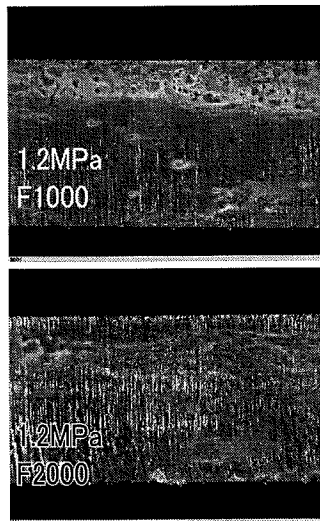
FIG. 17

ONE-MONTH EXPOSURE, PLATE THICKNESS $t = 6.0\text{mm}$,
FOCAL POSITION: -2.0mm

PLATING QUANTITY			K27					K35				
NOZZLE DIAMETER (mm)			D4.0			D7.0		D4.0			D7.0	
ASSIST GAS PRESSURE (MPa)			1.2	0.9	0.7	1.2	0.9	1.2	0.9	0.7	1.2	0.9
PLATE $t = 6.0$	CUTTING SPEED mm/min	1000	(NIL x)	NIL x	D x	(P x)	D x	(NIL x)	NIL x	D x	(P x)	DO
		1500	NIL x	NIL x	D x	(P x)	D x	P x	NIL x	D x	(PO)	DO
		1800	NG	NIL x	NG	NG	NG	(P x)	NIL x	x	NG	NG
		2000	(NIL x)	NG	NG	NG	NG	NG	NG	NG	NG	NG

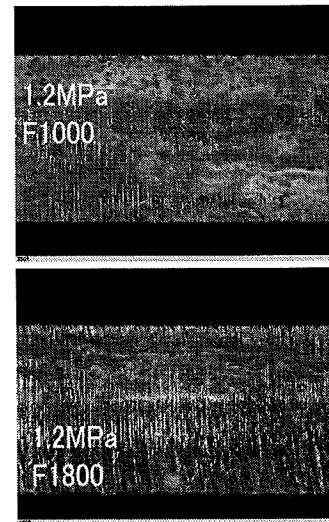
(A)

K27 D4.0



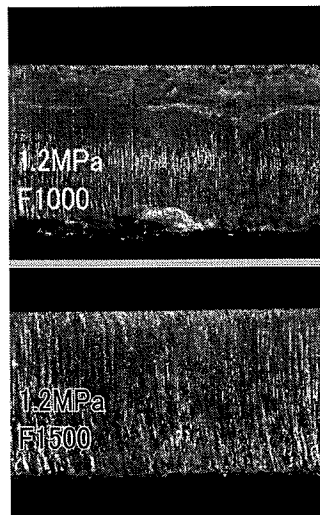
(C)

K35 D4.0



(B)

K27 D7.0



(D)

K35 D7.0

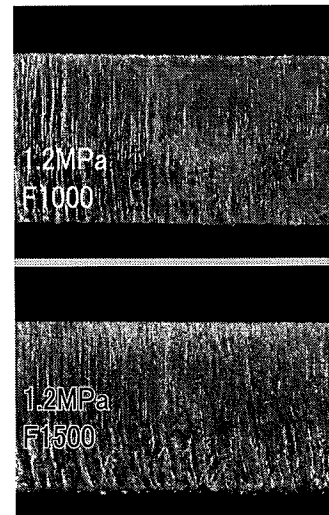


FIG. 18

PLATE THICKNESS $t = 2.3\text{mm}$

PROCESS- ING SPEED	ASSIST GAS : N ₂			ASSIST GAS : N ₂ +O ₂		
	K35、D7.0、 0.5MPa	K27、D4.0 0.7MPa	K14、D4.0、 0.7MPa	K35、D7.0、 0.5MPa	K27、D4.0 0.7MPa	K14、D4.0、 0.7MPa
F1000	pO	O	x	PO	PO	p x
F2000	PO	p x	x	PO	PO	P x
F3000	PO	PO	PO	PO	PO	PO
F4000	PO	PO	PO	PO	PO	PO
F5000	PO	PO	PO	PO	PO	PO

FIG. 19

PROCESSING VOLTAGE : 3kV t = 2.3 K14

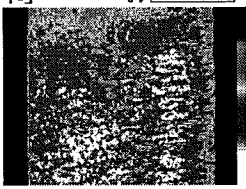
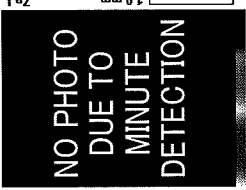
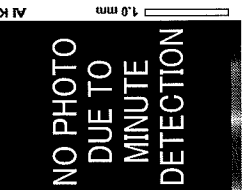
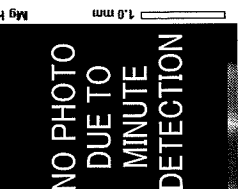
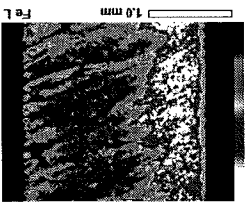
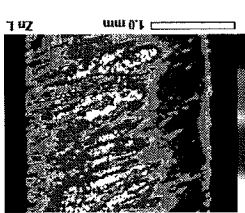
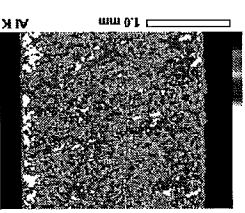
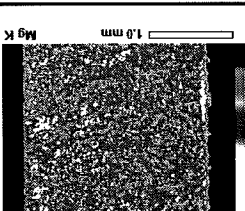
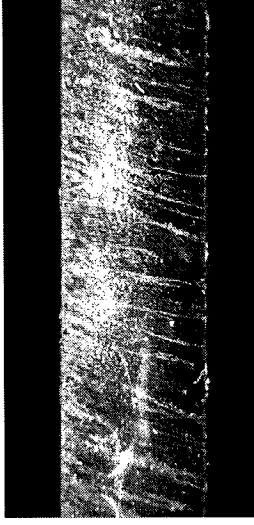
PROCESSING SPEED	Fe	Zn	Al	Mg	EXPOSURE TEST RESULT (AFTER 4 WEEKS)
2200 (mm/min)	 Fe L 1.0 mm % BY WEIGHT : 89.16	 Zn L 1.0 mm NO PHOTO DUE TO MINUTE DETECTION	 Al K 1.0 mm NO PHOTO DUE TO MINUTE DETECTION	 Mg K 1.0 mm NO PHOTO DUE TO MINUTE DETECTION	
	 Fe L 1.0 mm % BY WEIGHT : 32.48	 Zn L 1.0 mm % BY WEIGHT : 43.57	 Al K 1.0 mm % BY WEIGHT : 4.02	 Mg K 1.0 mm % BY WEIGHT : 2.19	

FIG. 20

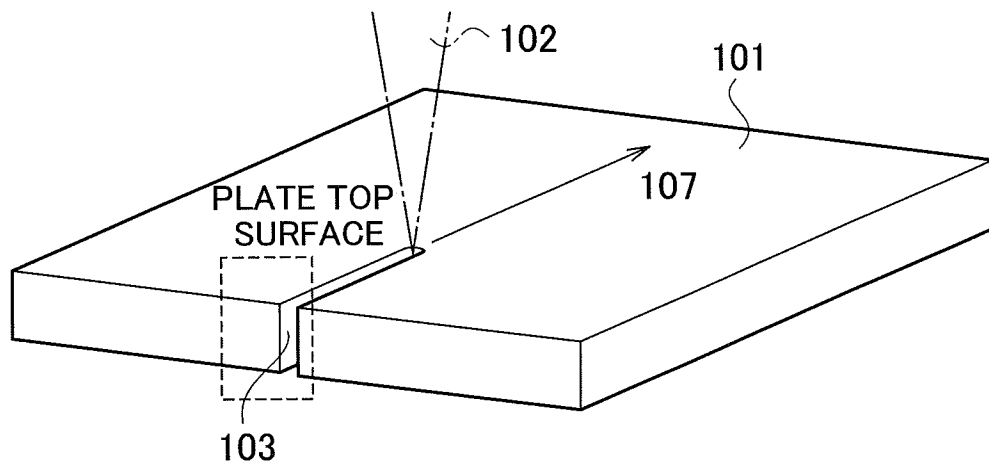


FIG. 21

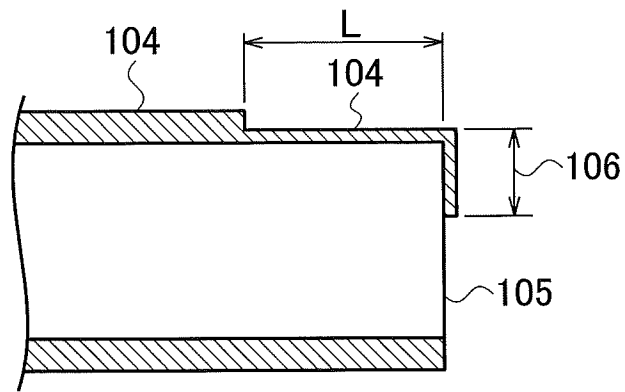


FIG. 22

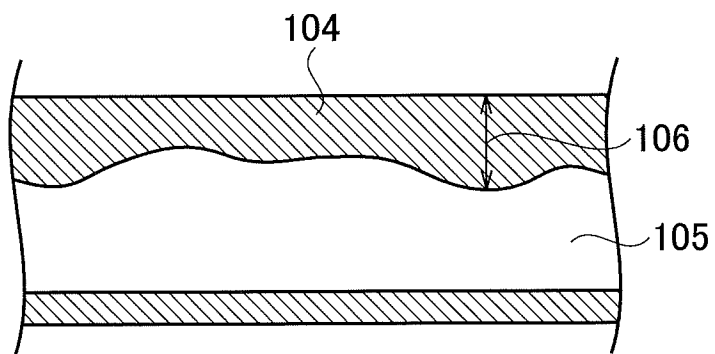


FIG. 23

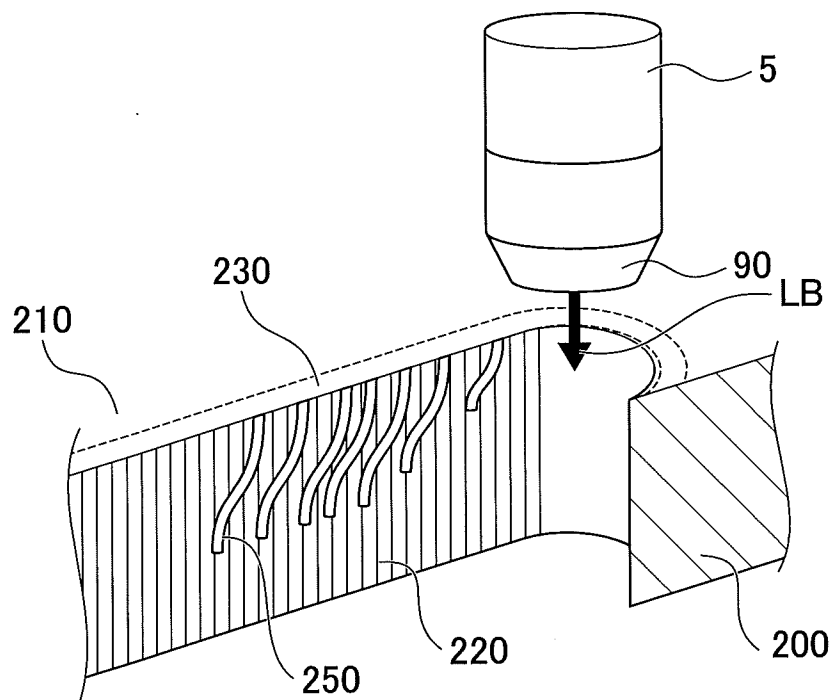


FIG. 24

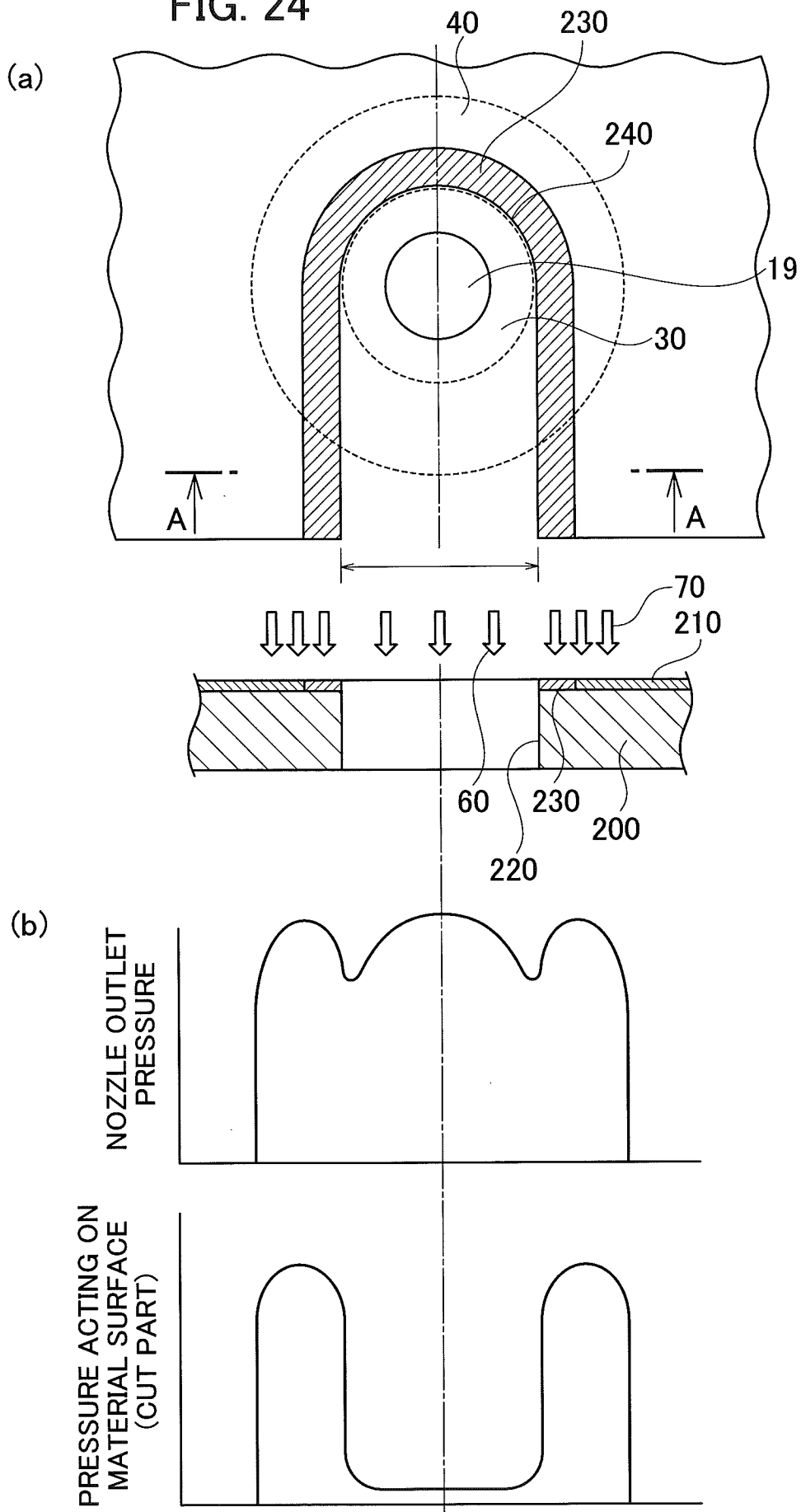


FIG. 25

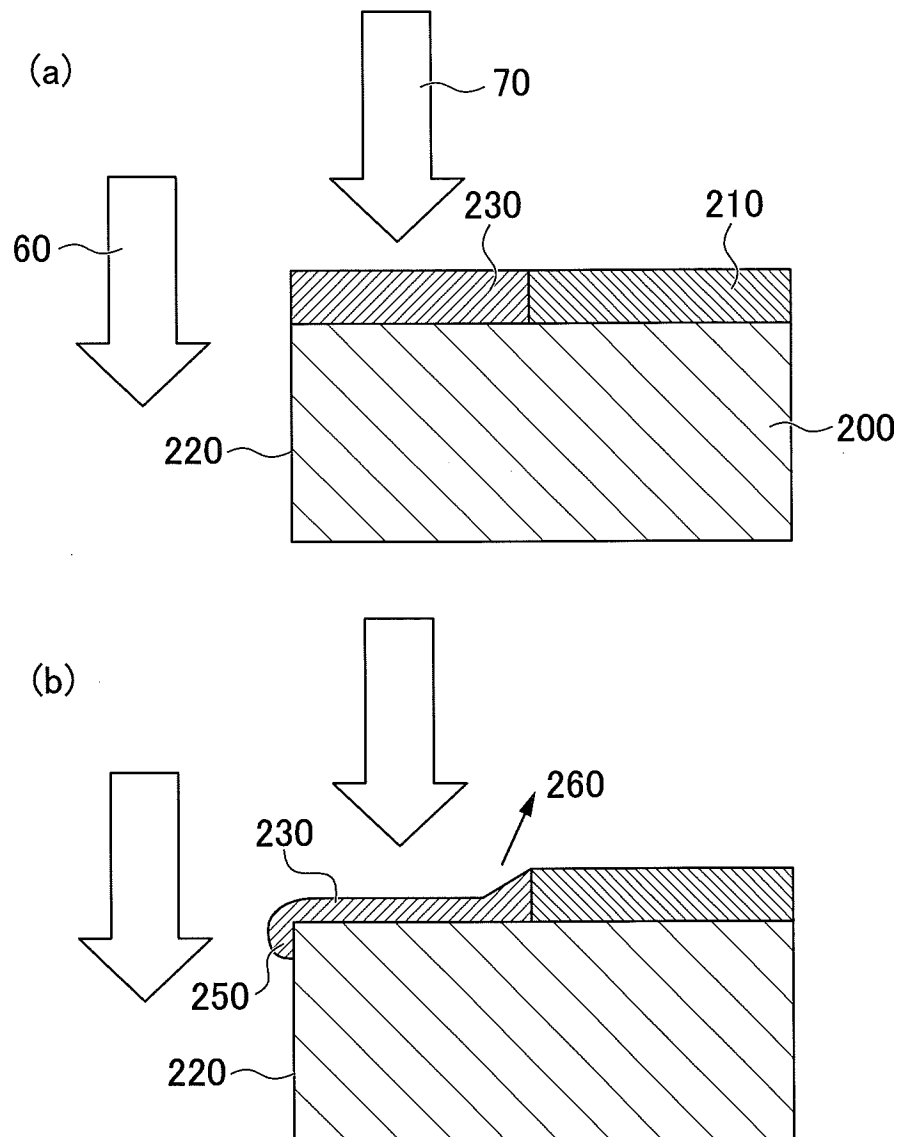


FIG. 26

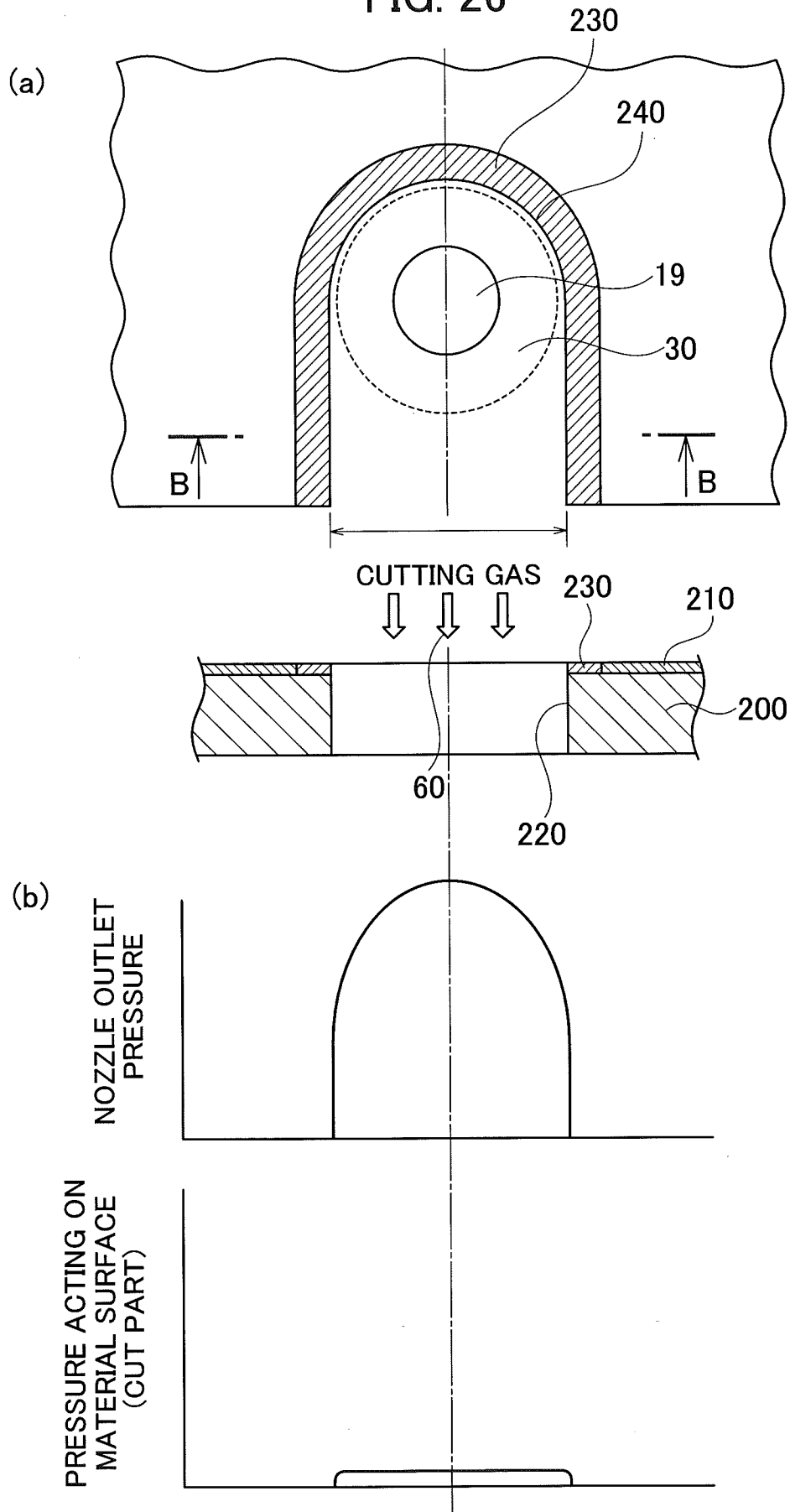
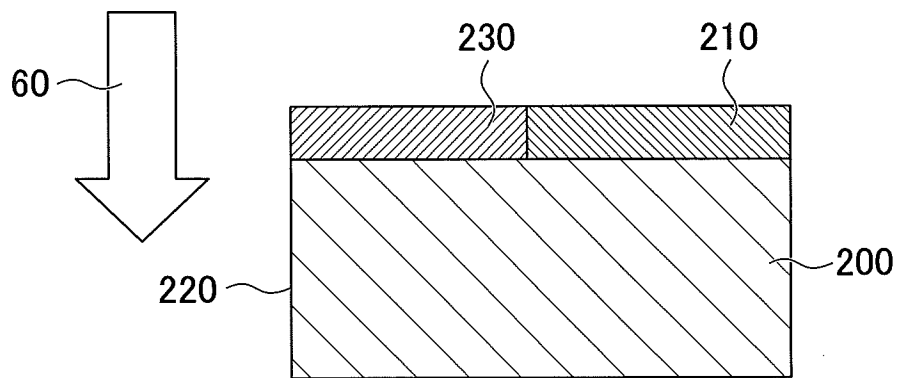


FIG. 27

(a)



(b)

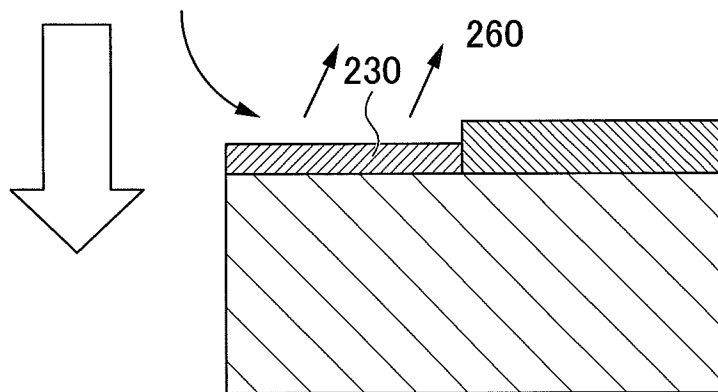


FIG. 28

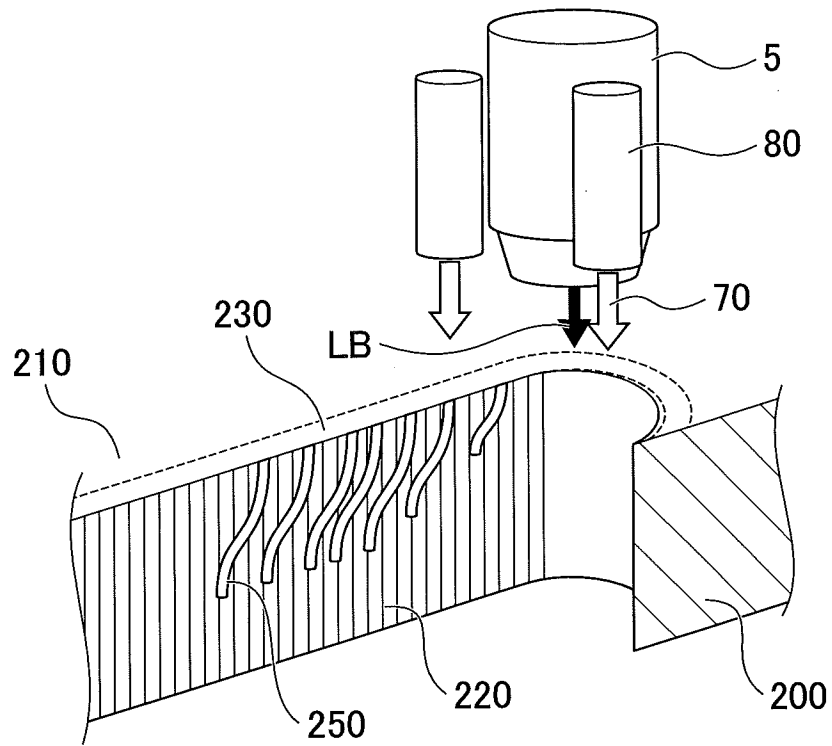


FIG. 29

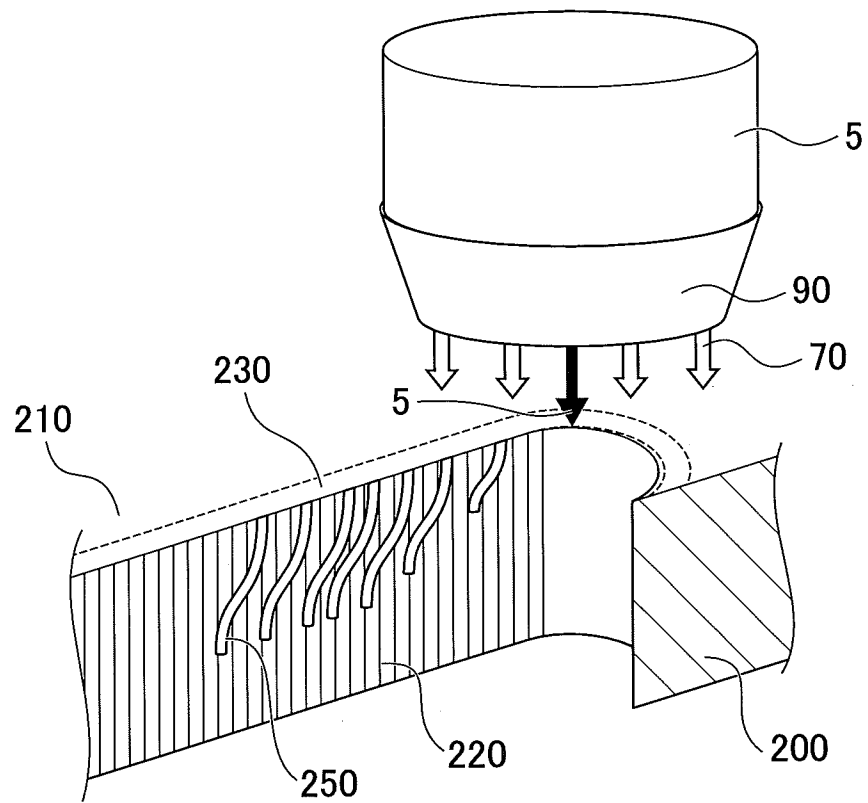


FIG. 30

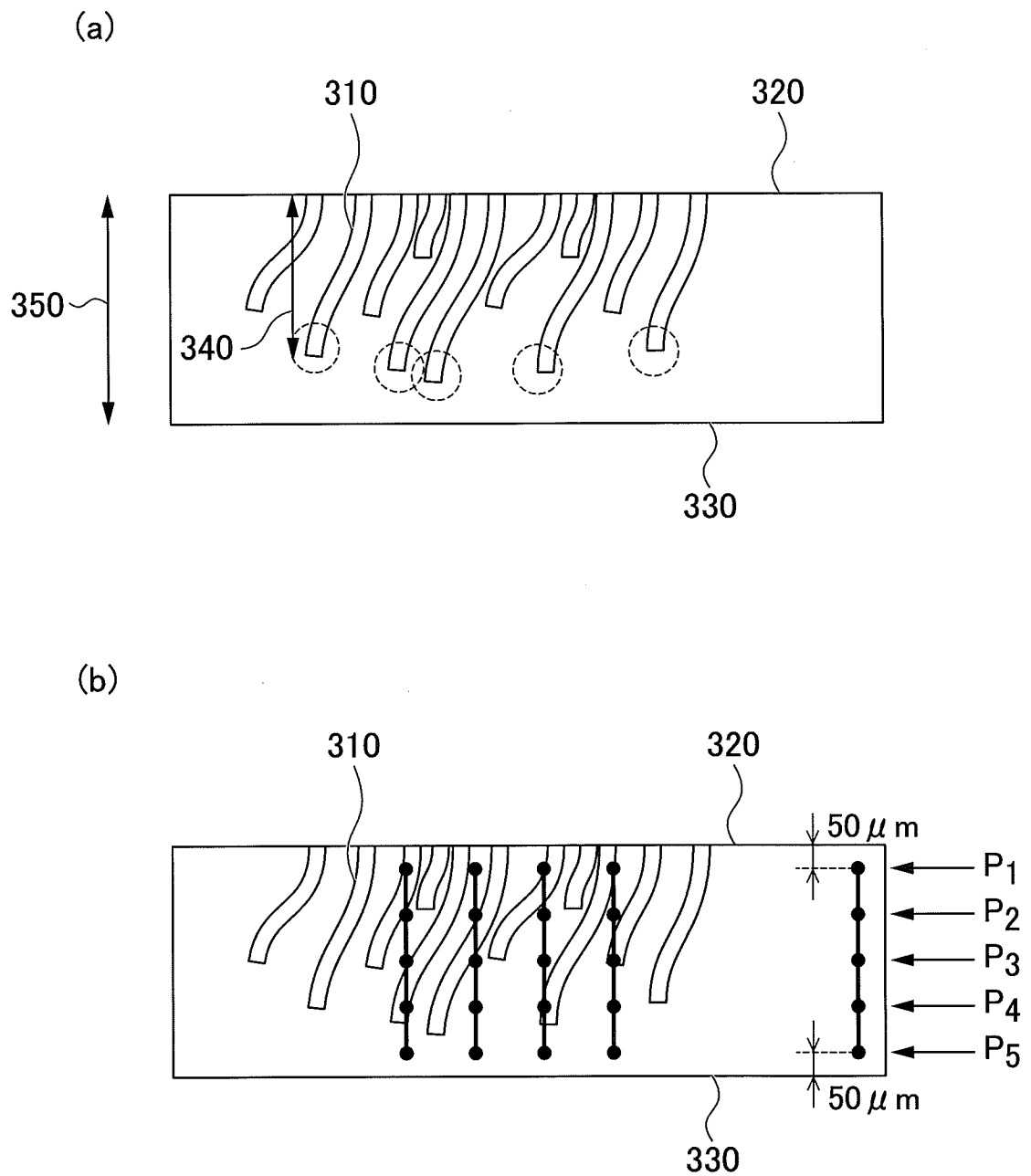


FIG. 31

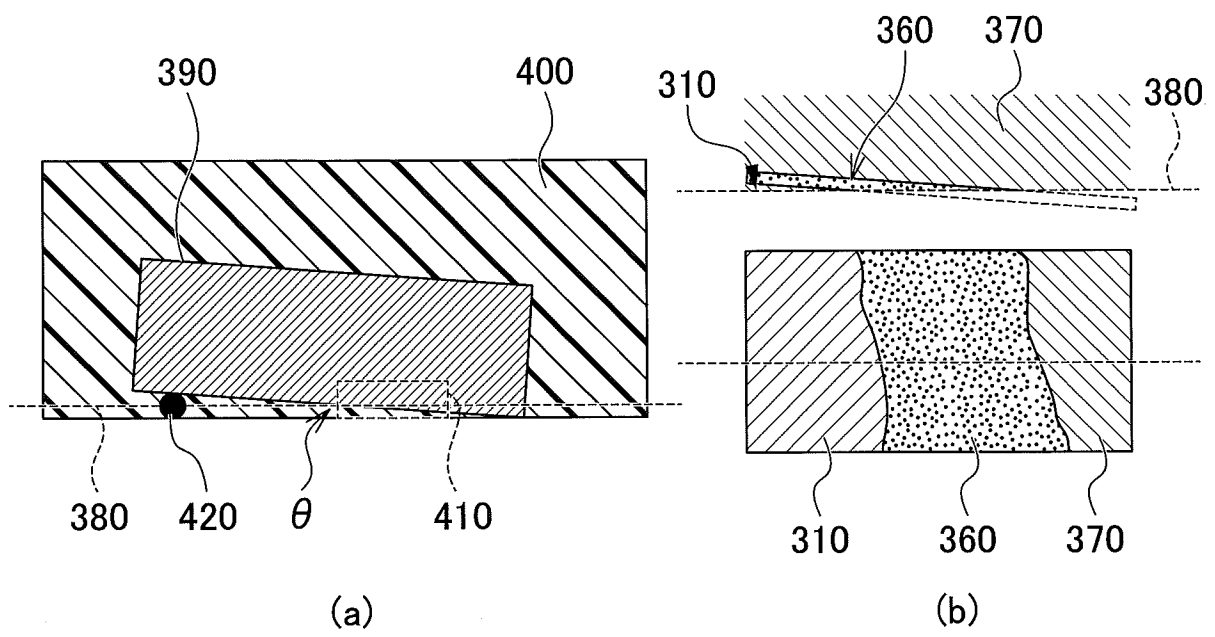


FIG. 32

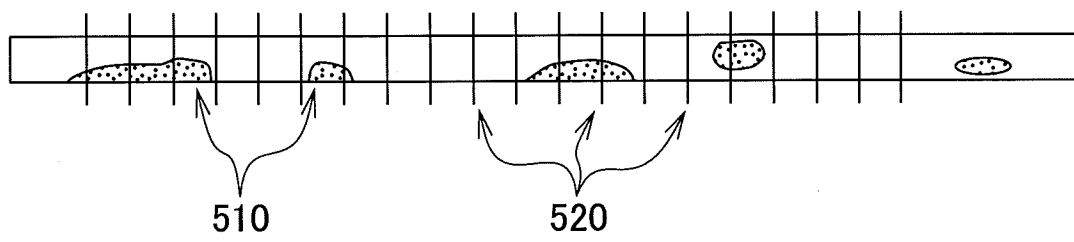


FIG. 33

