

(19)
(12)(KR)
(A)(51) 。 Int. Cl. ⁷
H01T 13/38(11)
(43)2001 - 0109196
2001 12 08(21) 10 - 2001 - 0030333
(22) 2001 05 31(30) 2000 - 163846 2000 05 31 (JP)
2001 - 099528 2001 03 30 (JP)

(71) 가 14 18

(72) 14 18

14 18

14 18

(74)

:

(54)

PbO 1 % Pb ; SiO₂ 25 45 % Si ; B₂O₃
 20 40 % B ; ZnO 5 25 % Zn; BaO SrO 0.5 15
 % Ba / Sr ; Na₂O, K₂O Li₂O 5 10 % Na, K Li (
 K가) 1 ; MoO₃, WO₃, Ni₃O₄, Co₃O₄, Fe₂O₃ MnO₂
 0.5 5 % 1 2 Mo, W, Ni, Co, Fe Mn
 (2d) .

1

1

2 (glaze)

3A 3B

4 가

5 가

6

7

8A 8D

9A 9B 8A 8D

< >

1:

2:

2d:

2d':

3:

4:

S:

()

가

가 .

가 , 가 , 가 가
가 가 , . 가 가
가 . , .
가 .

PbO

, Pb
가

가

Pb

(leadless)

가 Pb
가

11 - 43351

가

11 - 106234

Zn

(joint) 가

, 가 가 가 , 가 ,
가 가 가 . 가 ,
11 - 106234
() .

가

11 - 106234

Si B

가

(cancellation)

1 Pb , 가 ,
가

2

가 가 가 가

,
 .
 1 , PbO 1 % Pb ; SiO₂ 25 4
 5 % Si ; B₂O₃ 20 40 % B ; ZnO 5 25 % Zn; BaO
 SrO 0.5 15 % Ba / Sr ,
 Na₂O, K₂O Li₂ 5 10 % Na, K Li (K가) 1
 ,
 MoO₃, WO₃, Ni₃O₄, Co₃O₄, Fe₂O₃ MnO₂ 0.5 5 % 1 2
 Mo, W, Ni, Co, Fe Mn .
 1 .
 A A
 PbO 1.0 % Pb
 (" " Pb
 가가 (, Pb²⁺) , 가).
 (, Pb³⁺) . ,
 , Pb가 . Pb 0.1 % ,
 . Pb (가) 가 가
 .
 B B
 Pb , , Pb
 (, B (B₂O₃)
 Si B 가 ,
 , 1 2 Mo, W, Ni, Co, Fe Mn 가
 , 가
 , 1
 .
 C C
 , Pb ,
 , Si
 ,
 , 가 .

, 가
가 ,
.

D D

가 , 1 K .

가 , K 가
Na Li .
K가 .

$25 \sim 45\%$ Zn ; BaO $2 \sim 5\%$ Si ; B_2O_3 $0.5 \sim 1.5\%$ PbO $1 \sim 2\%$ Pb ; SiO_2 $20 \sim 40\%$ B ; ZnO $5 \sim 25\%$ Ba / Sr ,

Na_2O, K_2O Li_2O $5 \sim 10\%$ Na, K Li 1 ,

TiO_2, ZrO_2 HfO_2 $0.5 \sim 5\%$ 1 2 Ti, Zr Hf,

$MoO_3, WO_3, Ni_3O_4, Co_3O_4, Fe_2O_3$ MnO_2 $0.5 \sim 5\%$ 1 2
Mo, W, Ni, Co, Fe Mn .

$2 \sim 5\%$ K , 1 2
Ti, Zr Hf가
A C , 1 2 Ti, Zr Hf
가 .

E E

Ti, Zr Hf 가 , Zr Hf , 가
" "
 ,
가 가
 ,
가
 ,
가 $0.5 \sim 1\%$,
가 .

, 1 2 가 . A E
가 .

; $3 \sim 5\%$ PbO $1 \sim 2\%$ Pb Na, K L
i 3 , .

$NNa_2O < NLi_2O < NK_2O$

[illegible]

가

"

가

10

8 10,

" 4.

JIS - Z8721

9 10

" 4.3

Cs 0 6 , Vs 7.5

가 6

가

Cs

JIS - Z8721

W, Mo Fe

Mo, Fe W

Mo가 50 %

5 10 % . 5 %

가 . 10 %

5 8 %

Na, K Li 2 가

2 가

가 (

Na, K Li K

가 가 . 0.4 K/(Na + K + Li) 0.8

, K/(Na + K + Li)가 0.4

, K/(Na + K + Li) 0.8

0.2 (0.6) 가 . K/(Na +

K + Li) 0.5 0.7

가 , Li 가 ,

가

Li (%) 0.2 Li/(Na + K + Li) 0.5 가

Li가 0.2 , 가

가 , Li가 0.5 , Li

가 K/(Na + K + Li)

0.3 0.45 가

가 , Na, K Li 3 .

Si , 25 % , . Si 30 40 %가 .

B 20 % , , , 40 % , , 가 , B 가 25 35 % .

Zn 5 % , , 가 , Zn , Zn . 25 % . Zn 10 20 % .

Ba Sr 가 . 0.5 % , , . 20 % , Ba Sr , Ba 0. 5 10 % . Ba Sr .

Ba Sr BaSO₄ Ba , S .

Zn Ba / Sr 8 30 % . 30 % , , , 가 . 8 & 10 20 % .

Al₂O₃ 1 10 % Al , CaO 1 10 % Ca MgO 0.1 10 % Mg 1 2 1 15 %가 . Al , Ca , Ba Zn , 가 , 가 .

가 , B₂O₃ RE (, RE Ba, Mg, Ca Sr R (, R Na, K Li N(B₂O₃ + ZnO))
 2 REO , 1 2
) R₂O N(REO + R₂O)가 1.5
 N(B₂O₃ + ZnO)/N(REO + R₂O) 3.0 , B₂O₃ ZnO
 , REO R₂O 가 ,
 가 1.5 , 가 ,
 , 가 ,
 , 가 3.0 , , 가
 , 1.7 N(B₂O₃ + ZnO)/N(REO + R₂O) 2.5 .

Bi, Sn, Sb, P, Cu, Ce Cr 1 2 Bi₂O₃ Bi, SnO₂
 Sn, Sb₂O₅ Sb, P₂O₅ P, CuO Cu, CeO₂
 Ce, Cr₂O₃ Cr 5 % 가
 (,) , 가
 () 가
 . Bi Sb가 .

, 가 , ,
 , ,
) EPMA () XPS (X -
 , EPMA ,
 X - , ,

500 ,
 가 ,
 200 MΩ , 400 MΩ .

8A 8D 가 , DC (, 1000 V) (100)
 (13) (1) , 가 (100)가 500
 가 가 , Im VS (Rm)
 가 , Rx (VS/Im) - Rm (, Im
).

Al₂O₃ 85 98 % Al
 가 20 350 5 × 10⁻⁶ / 8.5 × 10⁻⁶ / 가
 , 가 (skipping) 가
 , 가 6 × 10⁻⁶ / 8 × 10⁻⁶ /

가 .

7 50 μm

가

가

3

가

가 7 μm

가 50 μm

가

Ti, Zr Hf 가 ()

1,000 1,500 가

가

()

가

가

가

1 2 가
 $\text{Fe}_2\text{O}_3, \text{TiO}_2, \text{CaO}, \text{MgO}, \text{Na}_2\text{O}, \text{K}_2\text{O}$ 1 2
 ($\text{SiO}_2, \text{Al}_2\text{O}_3$)

(,)

:

950 : 800
 가 ,

가 :

가 .

800 950

950 가 520 700 700
 가 520 800
 가 가 가
 520 620

(sag point) 1 가 (, 2)

가

(1) (100) (1), (21)가 (1) (2) (3) (1) (2), (31)가 (4) (4) (31) (32) (1) (100) (7) 1e (1) 가 6 (2) (6) (13) (6) (3) (6) (15) (13) (16 17) (3) (13) (15) (16 17) (1) (15) (13) (3) 가 가 (15) (13) (3)

(2) (3) (6) , 가 (2) (3) Al Al₂O₃ 85 98 % (90 98 %)

Al

Si : SiO₂ 1.50 5.00 %;

Ca : CaO 1.20 4.00 %;

Mg : MgO 0.05 0.17 %;

Ba : BaO 0.15 0.50 %;

B : B₂O₃ 0.15 0.50 %.

(2) (2b), (2e) (2e), (2e) (2g), (2e) (2g) 1 (2g) 2 (2i) 1 (2g) (2b) (2c) 1 (2g) (2i) (21) 가 (2g) (2g) (2g)

(3) (15) (2) (6) (3) (6a)() , 1 (6a) 2 () (13) (15) 2 (6b) (3) 1 (6a) (3) (3c) ,

(6) 1 (6a) 2 (2b) 3A 1 (2g) ,
 , (6c) (3) (3c) 가
 .

(2) 1 (2g) 2 (2i) (2h) , (2)
 . (1) , (2h)가 가 (63) (1c)
 (2h) (1c) . 가 (62)
 (2e) (2) (1) , 가 (60) 가 (6
 2) . 2 가 (60, 62) (61)가 . (2)
 (1) , , 가 (60)
 (ld) , (1) (2) .

3A 3B (2) .

L1: 30 75 mm;

1 (2g) L2: 0 30 mm [(2f) (2e) , (2h)
 2 (2i)];

2 (2i) L3: 2 27 mm;

(2b) D1: 9 13 mm;

(2e) D2: 11 16 mm;

1 (2g) D3: 5 - 11 mm;

2 (2i) D4: 3 8 mm;

2 (2i) D5 [, 가
 , (O) 가]:
 2.5 7 mm;

(6) 2 (6b) D6: 2 5 mm;

(6) 1 (6a) D7: 1 3.5 mm;

1 (2g) t1: 0.5 4.5 mm;

2 (2i) t2 [(O)]: 0.3 3.5 mm;

2 (2i) t3 [(O) ,
 가 , (O)
 가]: 0.2 3 mm;

2 (2i) tA [(t2+t3)/2]: 0.25 3.25 mm.

1 , (1) (2) (2k) LQ 23 27 mm (, 25 mm) .
 (2) (2k) (2) (O) , (2)
 (2k) LP (2c) (1)
 (2) 26 32 mm (, 29 mm) .

3A (2) . L1 = 60 mm, L2 = 10 mm, L3 = 14 mm, D1 = 11 mm, D2 = 13 mm, D3 = 7.3 mm, D4 = 5.3 mm, D5 = 4.3 mm, D6 = 3.9 mm, D7 = 2.6 mm, t1 = 3.3 mm, t2 = 1.4 mm, t3 = 0.9 mm tA = 1.15 mm.

3B (2) 3A 1 (2g) 2 (2i) . L1 = 60 mm, L2 = 10 mm, L3 = 14 mm, D1 = 11 mm, D2 = 13 mm, D3 = 9.2 mm, D4 = 6.9 mm, D5 = 5.1 mm, D6 = 3.9 mm, D7 = 2.7 mm, t1 = 3.3 mm, t2 = 2.1 mm, t3 = 1.2 mm tA = 1.65 mm.

2 (2d) (2) , (2c)
 (2b) . (2d) 가 7 150 μ m, 10 50 μ m .
 1 , (2b) (2d)
 , (2b) .

(2d) , (2b)
 . (2d) [(1) - (2)
 c)] (tg) () 7 50 μ m . (2c) , (1b) L
 Q 50% (1) (2d) tg .

(3a) (4) Ni (3) (3a) 가
 Cu Cu (3b) 가 . (31) (32) Ir, Pt
 Rh 1 2 . (3) (3a)
 , , (W) (31)
 , (32) (31) (4) ,
 (W) .

1 (31) (32) .
 (100) (2) ,
 Si , Ca , Mg , Ba B ,
 (, PVA) . Si SiO₂ , Ca
 CaCO₃ , Mg MgO, Ba BaCO₃ B H₃BO₃ . H₃BO₃
 가 .
 , 가
 1 (2) 가 , 1,400 1,
 600 (2) .

Si, B, Zn, Ba (Na, K, Li) (, Si SiO₂ , B H
₃BO₃, Zn ZnO , Ba BaCO₃, Na Na₂CO₃ , K K₂CO₃, Li
 Li₂CO₃) , 1,000 1,500 가
 , (fritz) , 가
 , 가

7 , S N (2d')
 (2d')

(3) (13) (15) (2d') (2)
 , (16, 17) . 8a , (3)
 (6) 1 (6a) (H) 8B (6)
 (H) (28) 가 1 (26)
 1 (26), (25) 2 , 8D
 (6) (27) (3)()

9A (13) (6) PA가
 PA 가 , 800 950 가
 (25 27) 가 (13) (3) (6)
 가 . , 9B 가 (16), (15)
 (17) ()

(2d') 600 700 , 9A 9B
 가 가 (2d') (2d)
 가 800 950 , (3) (13)

가 가 (,) , 가
 . B 40 % ,

(1), (4) 1 (100)
 (PA) (100) (7) ,
 / (RC)(
 , (100) (RC) 0.5 1.0 mm (2
 b) D1(3) (2b)

, (RC) (2b)

, 1, 4, 5, (4) q (2) (3) 가 (3) (4)

1 1

(2) (95 %; Na (Na₂O) : 0.1 %; : 3.0 μm) SiO₂ (: 99.5%, : 1.5 μm), CaCO₃ (: 99.9%, : 2.0 μm), MgO(: 99.5%, : 2 μm), BaCO₃ (: 99.5%, : 1.5 μm), H₃BO₃ (: 99.0%, 1. 5 μm) ZnO(: 99.5%, 2.0 μm) . 100 3 PVA 103 가 ,

, 50 100 μm . 50 MPa 가 , 1,550 (2) . X - , (2) .

Al (Al₂O₃) : 94.9 %

Si (SiO₂) : 2.4 %;

Ca (CaO) : 1.9 %;

Mg (MgO) : 0.1 %;

Ba (BaO) : 0.4 %;

B (B₂O₃) : 0.3 %.

3A (2) . L1 = 60 mm, L2 = 8 mm, L3 = 14 mm, D1 = 10 mm, D2 = 13 mm, D3 = 7 mm, D4 = 5.5mm, D5 = 4.5 mm, D6 = 4 mm, D7 = 2.6 mm, t1 = 1.5 mm, t2 = 1. 45 mm, t3 = 1.25 mm tA = 1.35 mm. 1 , (1) (2) (2k) LQ 25 mm . (2) (2k) (2) O (2) , (1) (2c) (2) (2) (2k) LP 29 mm .

SiO₂ (: 99.5%), Al₂O₃ (: 99.5%), H₃BO₃ (: 98.5%), Na₂O₃ (: 99.5%), K₂C
O₃ (: 99%), Li₂CO₃ (: 99%), BaSO₄ (: 99.5%), SrCO₃ (: 99%), ZnO (:
: 99.5%), MoO₃ (: 99%), Fe₂O₃ (: 99%), WO₃ (: 99%), Ni₃O₄ (: 99%), C
o₃O₄ (: 99%), MnO₂ (: 99%), CaO (: 99.5%), TiO₂ (: 99.5%), ZrO₂ (:
: 99.5%), HfO₂ (: 99%), MgO (: 99.5%), Sb₂O₅ (: 99%), Bi₂O₃ (: 99%),
SnO₂ (: 99.5%), P₂O₅ (: 99%), CuO (: 99%), CeO₂ (: 99.5%) Cr₂O₃
(: 99.5%) . 1,000 1,500 , , 2 PVA

3

100

50 μm

100

7

(2)

가

100 μm

(2d')

11

12

(2)

(100)

(7)

14 mm

(15)

B₂O₃- SiO₂ - BaO - LiO₂, ZrO₂, TiO₂

Al

(16,17)

B₂O₃ - SiO₂ - Na₂O

, Cu

, Fe

Fe - B

가

900

X -

()

(1)

X -

(2d)

EPMA

() 1 6

(2)

5 mm × 5 mm × 5 mm

, 20 350

(2)

, 73 × 10⁻⁷ /

(3)

50 mg

, 가

2

500

8A

8D

가

1,0

00 V

가 , (2)

(2d)

SEM

(), 가

가

()

1

6

[1]

		1	2	3	4	5	6	7
Com. (mol%)	SiO ₂	36.0	36.0	36.0	36.0	36.0	36.0	36.0
	Al ₂ O ₃	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	B ₂ O ₃	28.0	28.0	28.0	28.0	28.0	28.0	28.0
	Na ₂ O	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	K ₂ O	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	Li ₂ O	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	BaO	4.5	4.5	2.5	—	4.5	4.5	4.5
	SrO	—	—	2.0	4.5	—	—	—
	ZnO	16.0	16.0	16.0	16.0	16.0	16.0	16.0
	MoO ₃	1.0	1.0	1.0	1.0	—	—	—
	Fe ₂ O ₃	—	—	—	—	—	1.0	—
	WO ₃	—	—	—	—	1.0	—	—
	Ni ₃ O ₄	—	—	—	—	—	—	0.5
	Co ₃ O ₄	—	—	—	—	—	—	0.5
	MnO ₂	—	—	—	—	—	—	—
	CaO	4.0	5.0	4.0	4.0	4.0	4.0	4.0
	ZrO ₂	1.0	—	1.0	1.0	1.0	1.0	1.0
	TiO ₂	—	—	—	—	—	—	—
	HfO ₂	—	—	—	—	—	—	—
	MgO	—	—	—	—	—	—	—
	Sb ₂ O ₅	—	—	—	—	—	—	—
	Bi ₂ O ₃	—	—	—	—	—	—	—
	SnO ₂	—	—	—	—	—	—	—
	P ₂ O ₅	—	—	—	—	—	—	—
	CuO	—	—	—	—	—	—	—
	CeO ₂	—	—	—	—	—	—	—
	Cr ₂ O ₃	—	—	—	—	—	—	—
		100	100	100	100	100	100	100
	K/(Na+Li+K)	0.60	0.60	0.60	0.60	0.60	0.60	0.60
	Li/(Na+Li+K)	0.27	0.27	0.27	0.27	0.27	0.27	0.27
	ZnO+BaO+SrO	20.5	20.5	20.5	20.5	20.5	20.5	20.5
	Al ₂ O ₃ +CaO+MgO	6.0	7.0	6.0	6.0	6.0	6.0	6.0
(× 10 ⁻⁶)		7.0	7.0	7.0	7.0	7.0	7.0	7.0
()		570	570	570	570	570	570	570
500	(MΩ)	800	400	900	800	800	800	800
		00	00	00	00	00	00	00
(μm)		40	60	20	40	30	40	20

[2]

		8	9	10	11	12	13	14
Com. (mol%)	SiO ₂	36.0	36.0	36.0	38.0	36.0	36.0	36.0
	Al ₂ O ₃	2.0	2.0	2.0	—	2.0	2.0	2.0
	B ₂ O ₃	28.0	28.0	28.0	28.0	28.0	28.0	28.0
	Na ₂ O	1.0	2.5	3.5	3.5	2.0	0.5	0.5
	K ₂ O	4.5	2.5	—	—	4.5	2.5	2.5
	Li ₂ O	2.0	2.5	3.0	3.0	1.0	4.5	4.5
	BaO	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	SrO	—	—	—	—	—	—	—
	ZnO	16.0	16.0	16.0	16.0	16.0	16.0	16.0
	MoO ₃	—	1.0	1.0	1.0	1.0	1.0	1.0
	Fe ₂ O ₃	—	—	—	—	—	—	—
	WO ₃	—	—	—	—	—	—	—
	Ni ₃ O ₄	—	—	—	—	—	—	—
	Co ₃ O ₄	—	—	—	—	—	—	—
	MnO ₂	1.0	—	—	—	—	—	—
	CaO	4.0	4.0	4.0	4.0	4.0	4.0	5.0
	ZrO ₂	1.0	1.0	1.5	1.5	1.0	1.0	—
	TiO ₂	—	—	0.5	0.5	—	—	—
	HfO ₂	—	—	—	—	—	—	—
	MgO	—	—	—	—	—	—	—
	Sb ₂ O ₅	—	—	—	—	—	—	—
	Bi ₂ O ₃	—	—	—	—	—	—	—
	SnO ₂	—	—	—	—	—	—	—
	P ₂ O ₅	—	—	—	—	—	—	—
	CuO	—	—	—	—	—	—	—
	CeO ₂	—	—	—	—	—	—	—
	Cr ₂ O ₃	—	—	—	—	—	—	—
		100	100	100	100	100	100	100
	K/(Na+Li+K)	0.60	0.33	0.00	0.00	0.60	0.33	0.33
	Li/(Na+Li+K)	0.27	0.33	0.46	0.46	0.13	0.60	0.60
	ZnO+BaO+SrO	20.5	20.5	20.5	20.5	20.5	20.5	20.5
	Al ₂ O ₃ +CaO+MgO	6.0	6.0	6.0	4.0	6.0	6.0	7.0
(× 10 ⁻⁶)		7.0	6.8	7.0	6.9	7.2	6.6	6.6
()		570	560	550	545	575	550	545
500	(MΩ)	700	450	350	350	900	300	100
		00	00	0	0	0	00	00
(μm)		50	30	20	20	50	20	60

[3]

		15	16	17*	18*	19	20	21
Com. (mol%)	SiO ₂	38.0	36.0	30.0	36.0	36.0	37.0	37.0
	Al ₂ O ₃	–	2.0	2.0	2.0	2.0	2.0	2.0
	B ₂ O ₃	28.0	28.0	33.0	30.0	25.0	28.0	30.0
	Na ₂ O	0.5	1.0	4.0	0.5	1.0	1.0	1.0
	K ₂ O	2.5	6.5	2.0	1.0	4.5	4.5	4.5
	Li ₂ O	4.5	2.0	5.5	3.0	2.0	2.0	2.0
	BaO	4.5	7.5	4.5	4.5	2.0	7.0	7.0
	SrO	–	–	–	–	–	–	–
	ZnO	16.0	11.0	16.0	16.0	23.0	7.0	9.0
	MoO ₃	1.0	1.0	1.0	1.5	0.5	2.0	–
	Fe ₂ O ₃	–	–	–	–	–	–	–
	WO ₃	–	–	–	–	–	–	–
	Ni ₃ O ₄	–	–	–	–	–	–	–
	Co ₃ O ₄	–	–	–	–	–	–	–
	MnO ₂	–	–	–	–	–	–	–
	CaO	5.0	4.0	–	–	3.0	4.5	4.5
	ZrO ₂	–	1.0	2.0	2.0	1.0	1.0	–
	TiO ₂	–	–	–	–	–	1.0_	–
	HfO ₂	–	–	–	3.5_	–	3.0_	3.0_
	MgO	–	–	–	–	–	–	–
	Sb ₂ O ₅	–	–	–	–	–	–	–
	Bi ₂ O ₃	–	–	–	–	–	–	–
	SnO ₂	–	–	–	–	–	–	–
	P ₂ O ₅	–	–	–	–	–	–	–
	CuO	–	–	–	–	–	–	–
	CeO ₂	–	–	–	–	–	–	–
	Cr ₂ O ₃	–	–	–	–	–	–	–
		100	100	100	100	100	100	100
	K/(Na+Li +K)	0.33	0.68	0.17	0.22	0.60	0.60	0.60
	Li/(Na+Li+K)	0.60	0.21	0.48	0.67	0.27	0.27	0.27
	ZnO+BaO+SrO	20.5	18.5	20.5	20.5	20.5	14.0	16.0
	Al ₂ O ₃ + CaO + MgO	5.0	6.0	2.0	5.5	5.0	9.5	9.5
(× 10 ⁻⁶)		6.5	8.0	8.5	6.4	6.5	7.7	7.7
()		540	555	540	590	550	590	590
500	(MΩ)	700	450	350	350	900	300	100
		0	00	A	B	00	00	00
(μm)		60	40	30	40	50	40	65

[4]

		22	23*	24*	25	26	27	28
Com. (mol%)	SiO ₂	39.0	30.0	35.0	35.0	35.0	35.0	35.0
	Al ₂ O ₃	—	1.5	2.0	2.0	2.0	2.0	2.0
	B ₂ O ₃	30.0	26.0	22.0	27.0	27.0	27.0	27.0
	Na ₂ O	1.0	2.0	4.5	1.0	1.0	1.0	1.0
	K ₂ O	4.5	1.0	2.0	4.5	4.5	4.5	4.5
	Li ₂ O	2.0	4.5	1.0	2.0	2.0	2.0	2.0
	BaO	7.0	3.0	20.0	13.0	13.0	13.0	13.0
	SrO	—	—	—	—	—	—	—
	ZnO	9.0	30.0	11.0	10.0	10.0	10.0	10.0
	MoO ₃	—	1.0	1.0	1.0	1.0	1.0	1.0
	Fe ₂ O ₃	—	—	0.5	—	—	—	—
	WO ₃	—	—	—	—	—	—	—
	Ni ₃ O ₄	—	—	—	—	—	—	—
	Co ₃ O ₄	—	—	—	—	—	—	—
	MnO ₂	—	—	—	—	—	—	—
	CaO	4.5	—	—	2.0	2.0	2.0	2.0
	ZrO ₂	—	—	1.0	2.0	2.0	2.0	2.0
	TiO ₂	—	1.0	—	—	—	—	—
	HfO ₂	—	—	—	—	—	—	—
	MgO	3.0	—	—	—	—	—	—
	Sb ₂ O ₅	—	—	—	0.5_	—	—	—
	Bi ₂ O ₃	—	—	—	—	0.5_	—	—
	SnO ₂	—	—	—	—	—	0.5_	—
	P ₂ O ₅	—	—	—	—	—	—	0.5_
	CuO	—	—	—	—	—	—	—
	CeO ₂	—	—	—	—	—	—	—
	Cr ₂ O ₃	—	—	—	—	—	—	—
		100	100	100	100	100	100	100
	K/(Na+Li+K)	0.60	0.13	0.27	0.60	0.60	0.60	0.60
	Li/(Na+Li+K)	0.27	0.60	0.13	0.27	0.27	0.27	0.27
	ZnO+BaO+SrO	16.0	33.0	31.0	23.0	23.0	23.0	23.0
	Al ₂ O ₃ +CaO+MgO	7.5	1.5	2.0	4.0	4.0	4.0	4.0
(× 10 ⁻⁶)		7.6	6.0	8.7	7.9	7.9	7.9	7.9
()		585	530	560	560	550	565	565
500	(MΩ)	400	350	1000	900	900	1000	800
		0	D	A	00	00	00	00
(μm)		65	50	30	40	20	20	50

[5]

		29	30	31	32*	33*	34	35
Com. (mol%)	SiO ₂	35.0	35.0	35.0	36.0	36.0	36.0	28.0
	Al ₂ O ₃	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	B ₂ O ₃	27.0	27.0	27.0	28.0	27.0	28.0	33.5
	Na ₂ O	1.0	1.0	1.0	4.5	4.5	-	2.0
	K ₂ O	4.5	4.5	4.5	2.0	2.0	-	4.5
	Li ₂ O	2.0	2.0	2.0	1.0	1.0	7.5	1.0
	BaO	13.0	13.0	13.0	4.5	4.5	4.5	10.0
	SrO	-	-	-	-	-	-	-
	ZnO	10.0	10.0	10.0	16.0	12.0	16.0	16.0
	MoO ₃	1.0	1.0	1.0	-	4.0	1.0	1.0
	Fe ₂ O ₃	-	-	-	-	2.0	0.5	-
	WO ₃	-	-	-	-	-	-	-
	Ni ₃ O ₄	-	-	-	-	-	-	-
	Co ₃ O ₄	-	-	-	-	-	-	-
	MnO ₂	-	-	-	-	-	-	-
	CaO	2.0	2.0	2.0	4.0	4.0	-	1.0
	ZrO ₂	2.0	2.0	2.0	1.0	1.0	-	1.0
	TiO ₂	-	-	-	-	-	-	-
	HfO ₂	-	-	-	-	-	-	-
	MgO	-	-	-	-	-	3.5	-
	Sb ₂ O ₅	-	-	-	1.0	-	1.0	-
	Bi ₂ O ₃	-	-	-	-	-	-	-
	SnO ₂	-	-	-	-	-	-	-
	P ₂ O ₅	-	-	-	-	-	-	-
	CuO	0.5	-	-	-	-	-	-
	CeO ₂	-	0.5	-	-	-	-	-
	Cr ₂ O ₃	-	-	0.5	-	-	-	-
		100	100	100	100	100	100	100
	K/(Na+Li+K)	0.60	0.60	0.60	0.27	0.27	0.00	0.60
	Li/(Na+Li+K)	0.27	0.27	0.27	0.13	0.13	1.00	0.13
	ZnO+BaO+SrO	23.0	23.0	23.0	20.5	16.5	20.5	26.0
	Al ₂ O ₃ +CaO+MgO	4.0	4.0	4.0	6.0	6.0	5.5	3.0
(× 10 ⁻⁶)		7.9	7.9	7.9	7.2	7.2	6.4	7.5
()		565	535	565	570	580	540	550
500	(MΩ)	800	800	800	800	800	50	600
		00	00	00	E*	D*	00	00
(μm)		40	20	10	30	30	80	40

[6]

		36*	37	38*	39*	40	41	42*
Com.(mol%)	SiO ₂	20.0	40.0	48.0	38.0	38.0	38.0	30.0
	Al ₂ O ₃	4.0	1.0	1.0	2.0	2.0	2.0	1.0
	B ₂ O ₃	38.0	28.0	25.0	18.0	22.0	22.0	41.0
	Na ₂ O	4.5	1.0	5.5	4.5	1.0	1.0	2.0
	K ₂ O	2.0	5.0	3.0	2.0	4.5	4.5	4.5
	Li ₂ O	1.0	3.0	1.0	1.0	2.0	2.0	1.0
	BaO	5.5	4.5	4.5	7.5	6.5	6.5	4.5
	SrO	–	–	–	–	–	–	–
	ZnO	16.0	15.0	10.0	16.0	16.0	16.0	12.0
	MoO ₃	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Fe ₂ O ₃	–	–	–	–	–	–	–
	WO ₃	–	–	–	–	–	–	–
	Ni ₃ O ₄	–	–	–	–	–	–	–
	Co ₃ O ₄	–	–	–	–	–	–	–
	MnO ₂	–	–	–	–	–	–	–
	CaO	4.0	–	–	4.0	4.0	4.0	2.0
	ZrO ₂	2.0	1.0	1.0	1.0	1.0	–	1.0
	TiO ₂	2.0	0.5	–	2.0	2.0	2.0	–
	HfO ₂	–	–	–	–	–	1.0	–
	MgO	–	–	–	3.0	–	–	–
	Sb ₂ O ₅	–	–	–	–	–	–	–
	Bi ₂ O ₃	–	–	–	–	–	–	–
	SnO ₂	–	–	–	–	–	–	–
	P ₂ O ₅	–	–	–	–	–	–	–
	CuO	–	–	–	–	–	–	–
	CeO ₂	–	–	–	–	–	–	–
	Cr ₂ O ₃	–	–	–	–	–	–	–
		100	100	100	100	100	100	100
	K/(Na+Li +K)	0.27	0.56	0.32	0.27	0.60	0.60	0.60
	Li/(Na+Li+K)	0.13	0.33	0.11	0.13	0.27	0.27	0.13
	ZnO+BaO+SrO	21.5	19.5	14.5	23.5	22.5	22.5	16.5
	Al ₂ O ₃ + CaO + MgO	8.0	1.0	1.0	9.0	6.0	6.0	3.0
(× 10 ⁻⁶)		7.7	6.9	6.5	7.7	7.5	7.5	6.5
()		520	610	640	620	590	590	510
500	(MΩ)	500	650	600	800	850	850	800
		F	00	B	B	00	00	G
(μm)		30	30	20	40	40	10	50

1

com : , *

2

com : *

3

A : , B : , * :

4

A : , D : , * :

5

com : , D* : , E* : , * :

6

B : , F : , G :

*

가 , Pb가 ,

(57)

1.

; ; , ,

PbO 1 % Pb ; SiO₂ 25 45 % Si ; B₂O₃
 20 40 % B ; ZnO 5 25 % Zn; BaO SrO 0.
 5 15 % Ba / Sr 1 ; Na₂O, K₂O Li₂O 5 10 % N
 a, K Li (K가) 1 ; MoO₃, WO₃, Ni₃O₄, Co₃O₄, Fe
₂O₃ MnO₂ 0.5 5 % 1 Mo, W, Ni, Co, Fe Mn

2.

1 , K 1 .

3.

1 , TiO₂, ZrO₂ HfO₂ 0.5 5 % Ti, Zr Hf 1

4.

； ； ， ， ，

PbO 1 % Pb ; SiO₂ 25 45 % Si ; B₂O₃
 20 40 % B ; ZnO 5 25 % Zn; BaO SrO 0.
 5 15 % Ba / Sr 1 ; Na₂O, K₂O Li₂O 5 10 % N
 a, K Li (K가) 1 ; TiO₂, ZrO₂ HfO₂
 0.5 5 % Ti, Zr Hf 1 ; MoO₃, WO₃, Ni₃O₄, Co₃O₄, Fe₂O₃ MnO₂
 0.5 5 % 1 Mo, W, Ni, Co, Fe Mn 1 .

5.

1 4 , 1 Li, Na K 3
 , NNa₂O Na₂O , NLi₂O Na NK₂O [, NLi₂O Li₂O Li
 , NK₂O K₂O K
] .

6.

； ； ， ， ，

PbO 1 % Pb ; 1 Si B ;
 Li, Na K 3 , NNa₂O Na₂O NLi₂O < NK₂O [, NLi₂
 O Li₂O , NNa₂O Na₂O Na , N
 K₂O K₂O K] .

7.

1 , K , Li, Na K 2 , 2
 R , NR₂O가 R₂O 2 , NK₂
 O K₂O K 0.4 < NK₂O/NR₂O < 0.8 .

8.

4 , K , Li, Na K 2 , 2
 R , NR₂O가 R₂O 2 , NK₂
 O K₂O K 0.4 < NK₂O/NR₂O < 0.8 .

9.

6 , K , Li, Na K 2 , 2
 R , NR₂O가 R₂O 2 , NK₂
 O K₂O K 0.4 < NK₂O/NR₂O < 0.8 .

10.

1 , Li , Li, Na K 2 , 2
 R , NR₂O가 R₂O 2 , NLi
 2O Li₂O Li 0.2 < NLi₂O/NR₂O < 0.5
 .

11.

4 , R Li , Li, Na K 2 , 2
₂O Li₂O , NR₂O₇ R₂O 2 , NLi
 Li 0.2 < NLi₂O/NR₂O < 0.5

12.

6 , R Li , Li, Na K 2 , 2
₂O Li₂O , NR₂O₇ R₂O 2 , NLi
 Li 0.2 < NLi₂O/NR₂O < 0.5

13.

1 , Zn , Ba Sr 1 ZnO, BaO SrO 10
 30 %

14.

4 , Zn , Ba Sr 1 ZnO, BaO SrO 10
 30 %

15.

6 , Zn , Ba Sr 1 ZnO, BaO SrO 10
 30 %

16.

1 , Al₂O₃ 0.1 10 % Al , CaO 0.1 10 %
 Ca MgO 0.1 10 % Mg 1 0.1 15 %

17.

4 , Al₂O₃ 0.1 10 % Al , CaO 0.1 10 %
 Ca MgO 0.1 10 % Mg 1 0.1 15 %

18.

6 , Al₂O₃ 0.1 10 % Al , CaO 0.1 10 %
 Ca MgO 0.1 10 % Mg 1 0.1 15 %

19.

1, Bi₂O₃, SnO₂, Sb₂O₅, P₂O₅, CuO, CeO₂, Cr₂O₃, Bi, Sn, Sb, P, Cu, Ce, Cr 1 5 %.

20.

4, Bi₂O₃, SnO₂, Sb₂O₅, P₂O₅, CuO, CeO₂, Cr₂O₃, Bi, Sn, Sb, P, Cu, Ce, Cr 1 5 %.

21.


6, Bi₂O₃, SnO₂, Sb₂O₅, P₂O₅, CuO, CeO₂, Cr₂O₃, Bi, Sn, Sb, P, Cu, Ce, Cr 1 5 %.

22.

23.

4, 7 50 μm

24.

6  7 50 μ m

25.

1. The first step is to identify the problem or question that needs to be answered. This involves understanding the context and the specific requirements of the task.

26.

4

27.

6 , ;
 , 500
 400 MΩ

28.

1 , Al_2O_3 85 98 % Al
 가 20 350 $5 \times 10^{-6} /$ $8.5 \times 10^{-6} /$. ,

29.

4 , Al_2O_3 85 98 % Al
 가 20 350 $5 \times 10^{-6} /$ $8.5 \times 10^{-6} /$. ,

30.

6 , Al_2O_3 85 98 % Al
 가 20 350 $5 \times 10^{-6} /$ $8.5 \times 10^{-6} /$. ,

31.

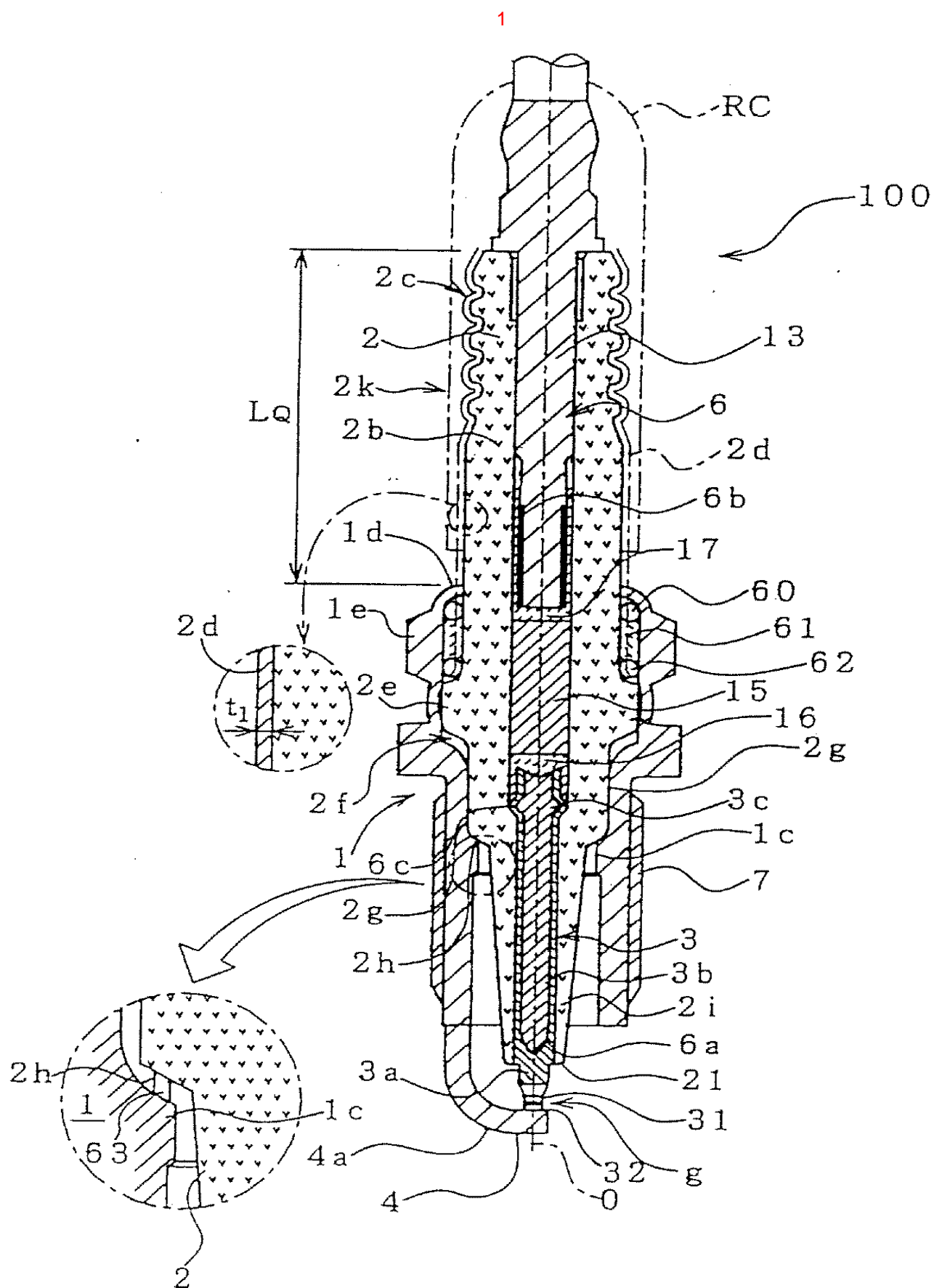
1 , 520 620 .

32.

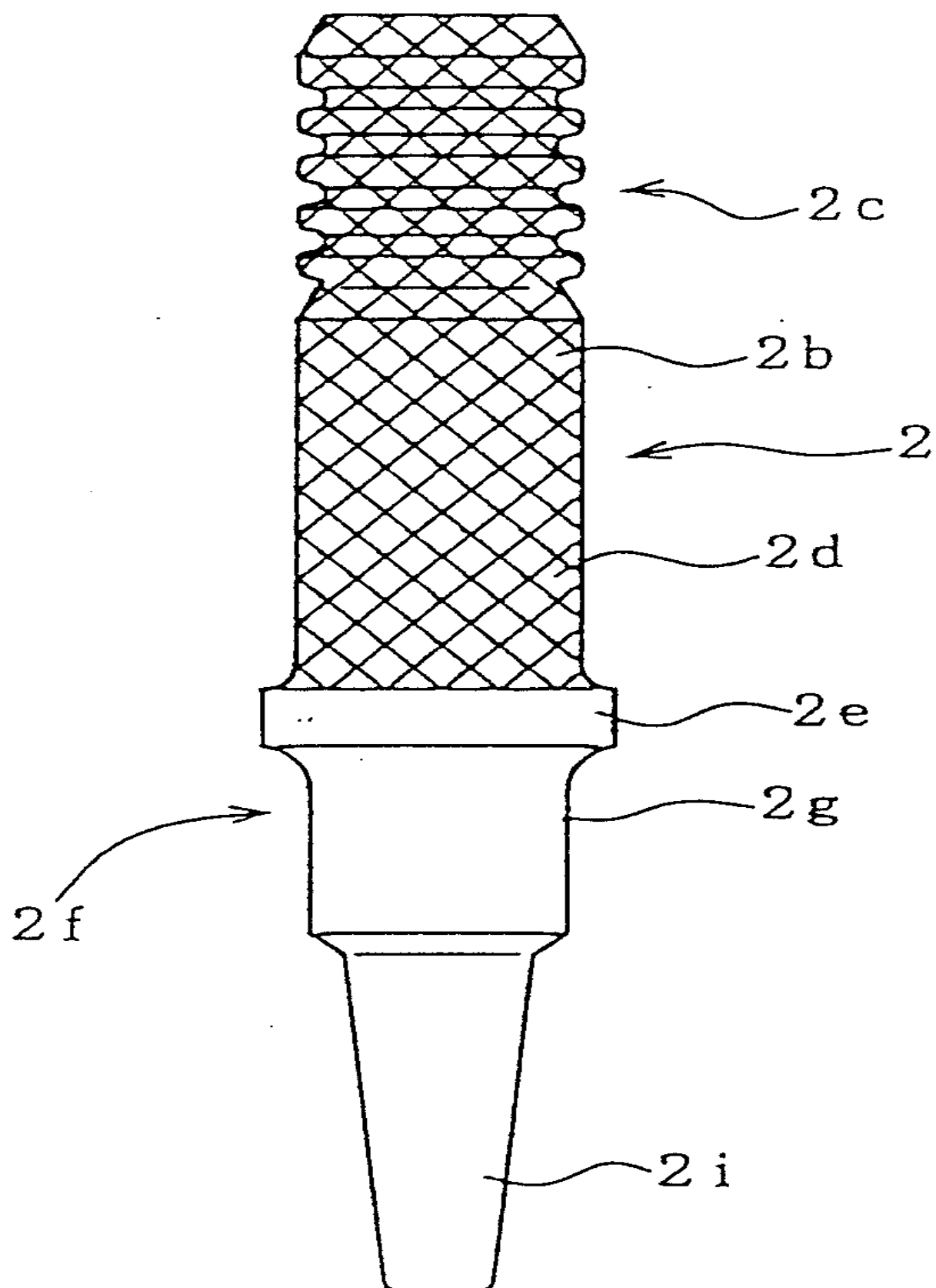
4 , 520 620 .

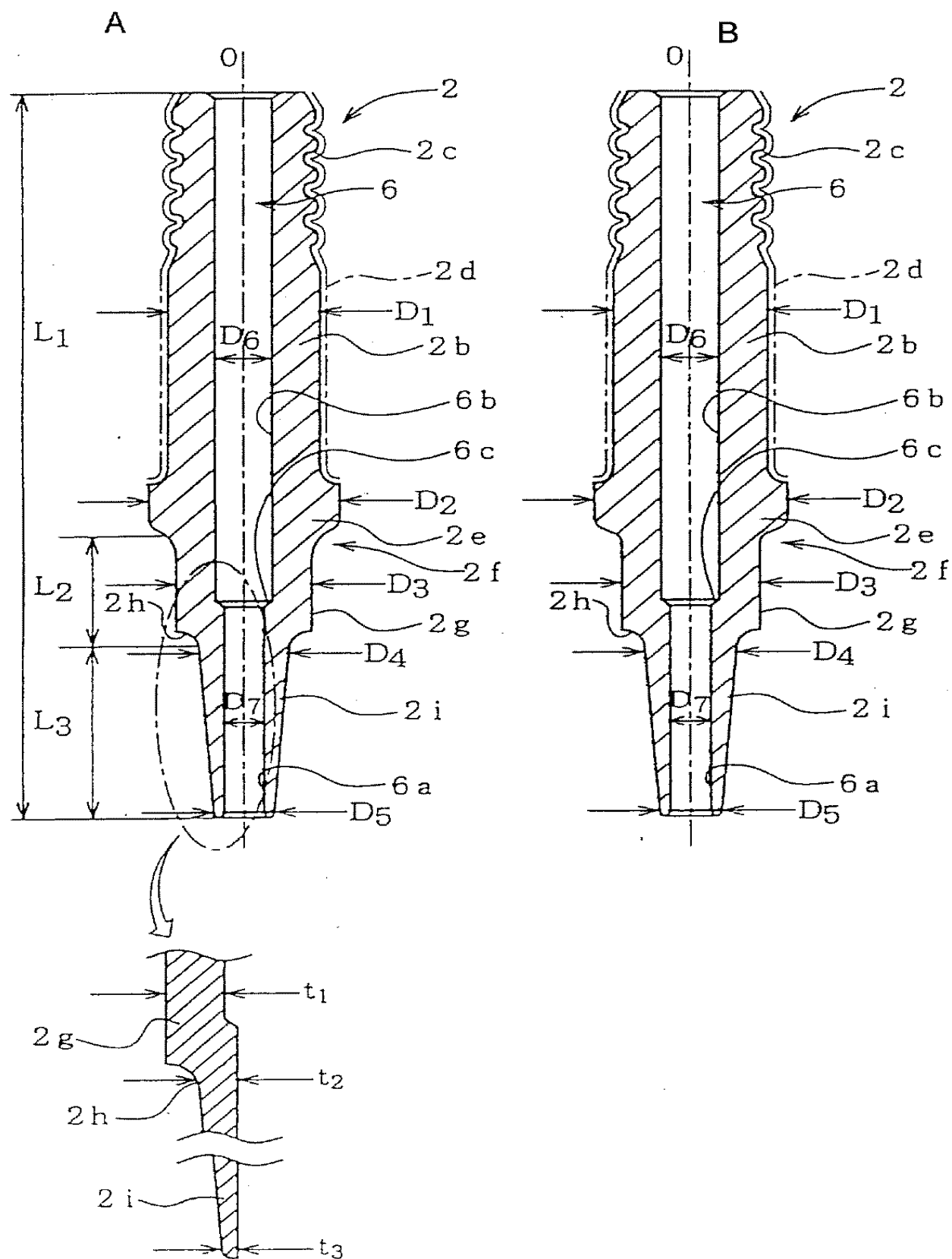
33.

6 , 520 620 .

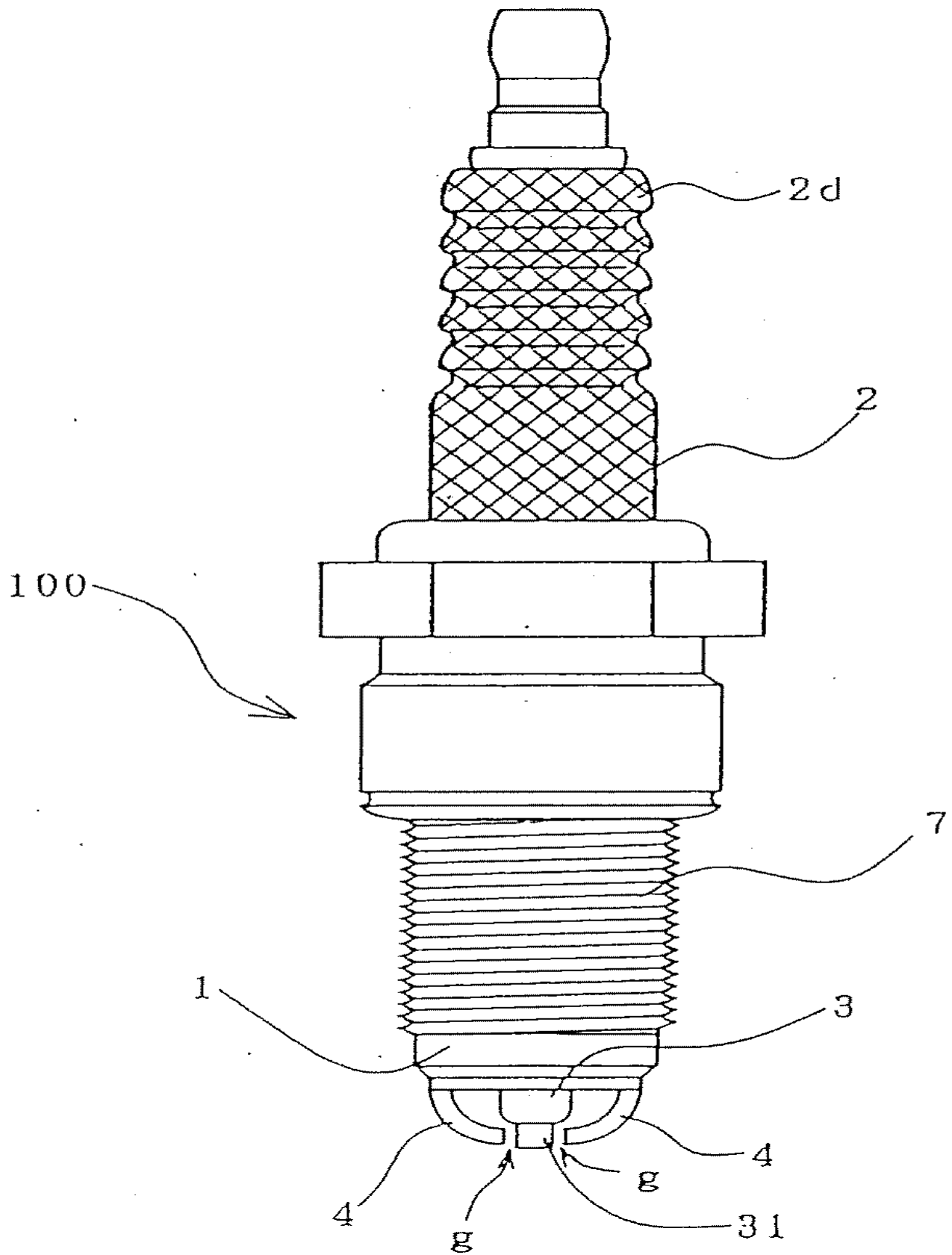


2

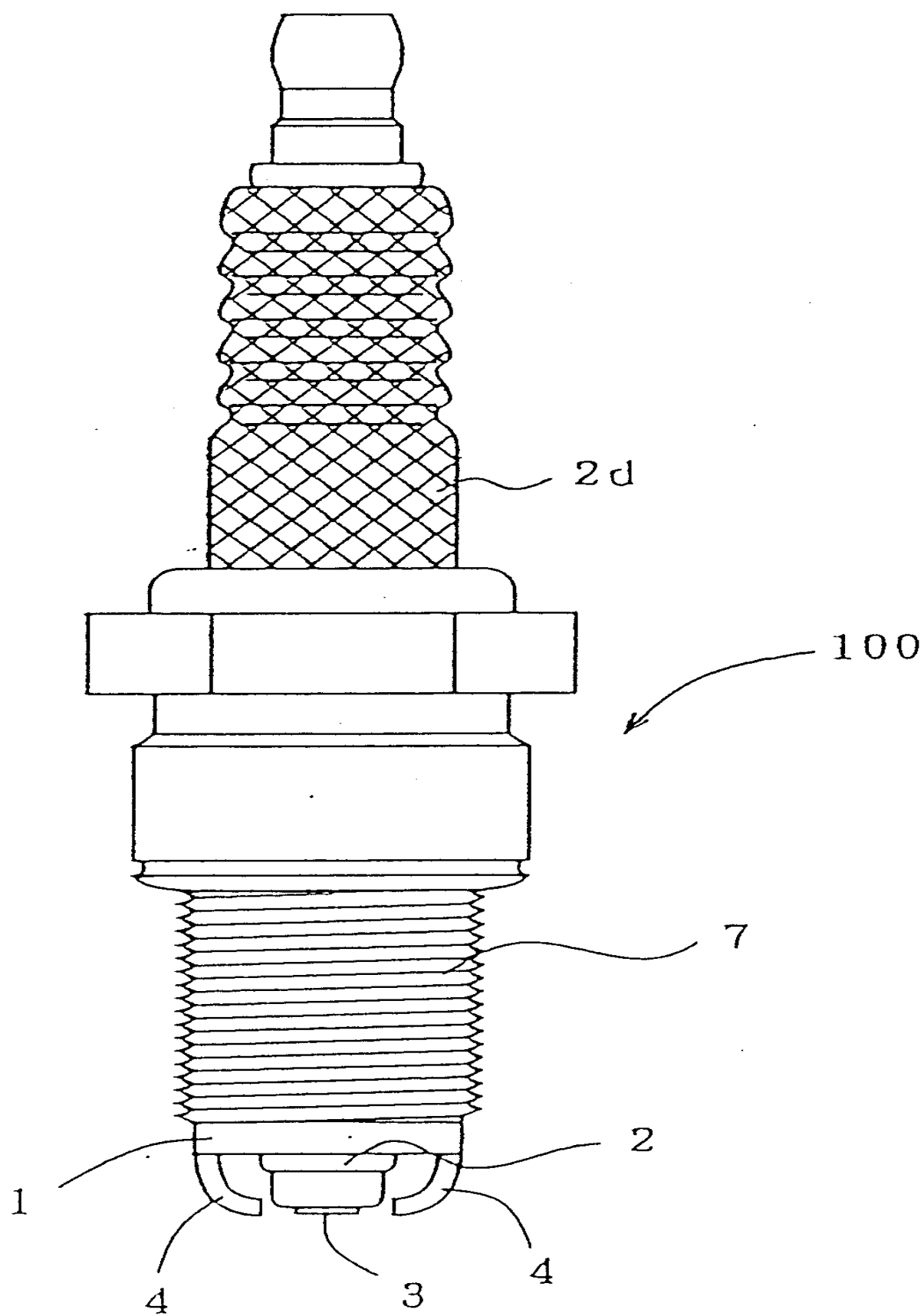


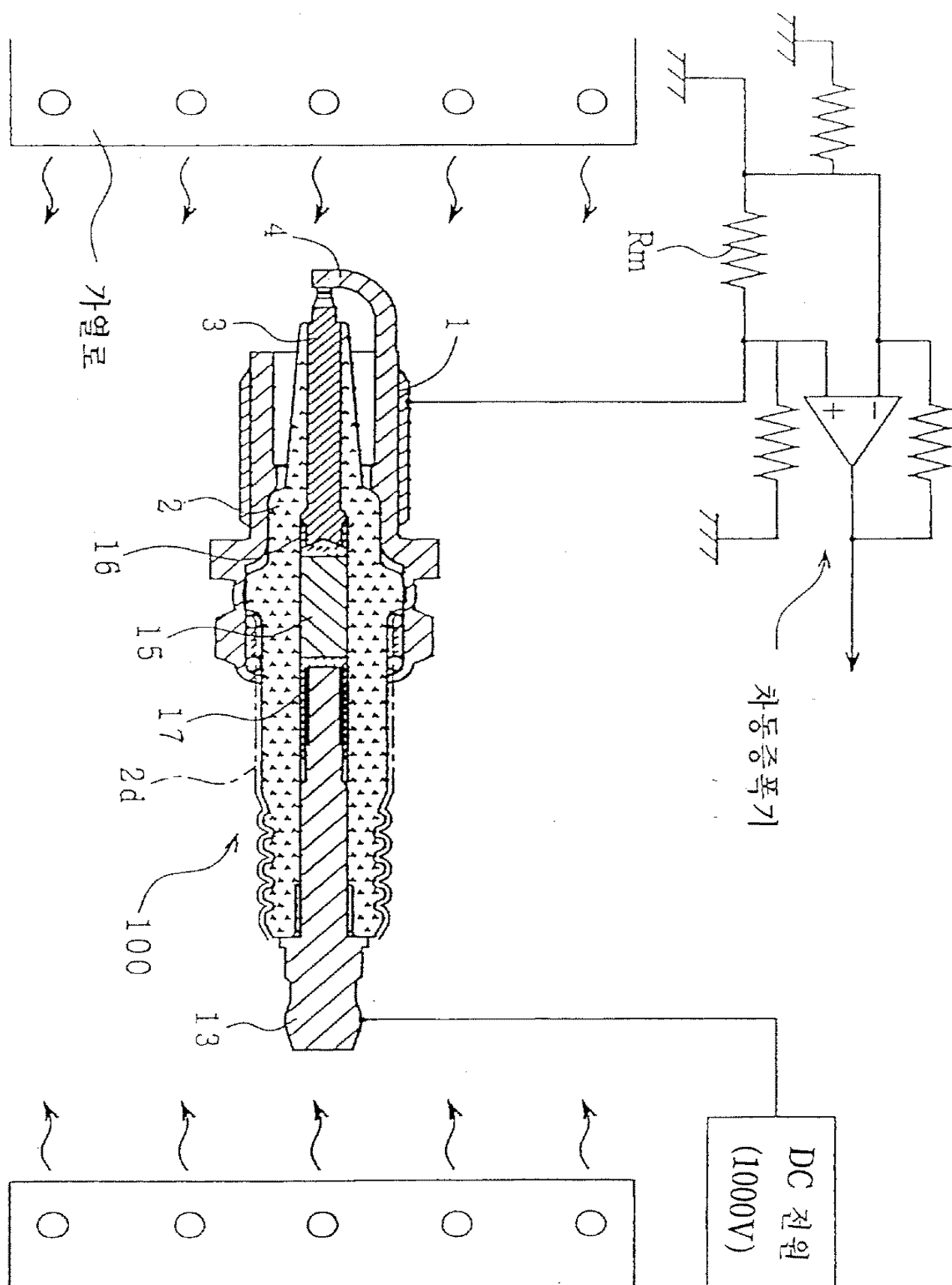


4

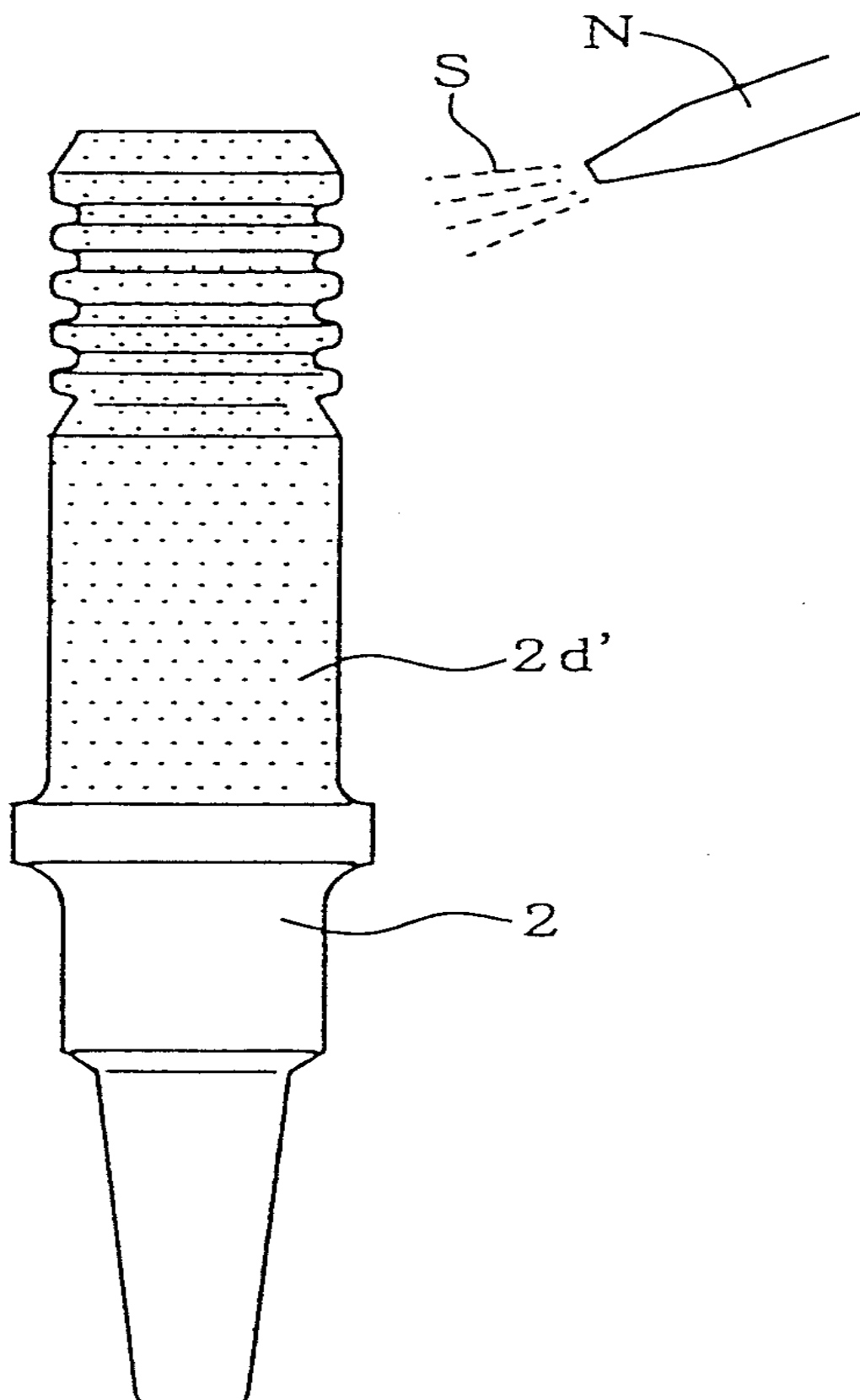


5





7



8

FIG. 8D

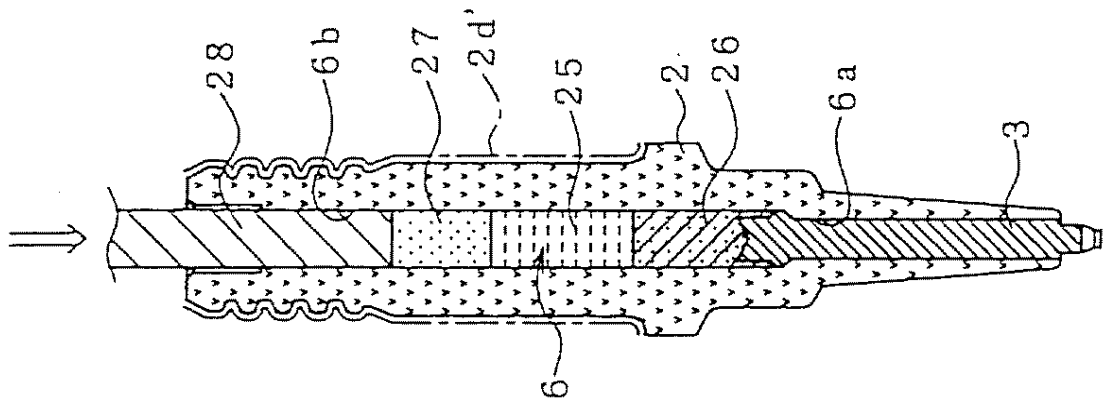


FIG. 8C

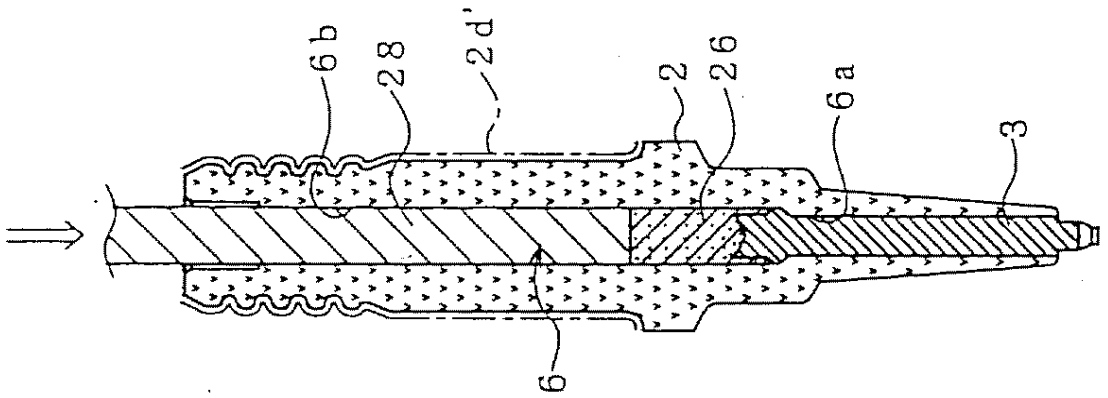


FIG. 8B

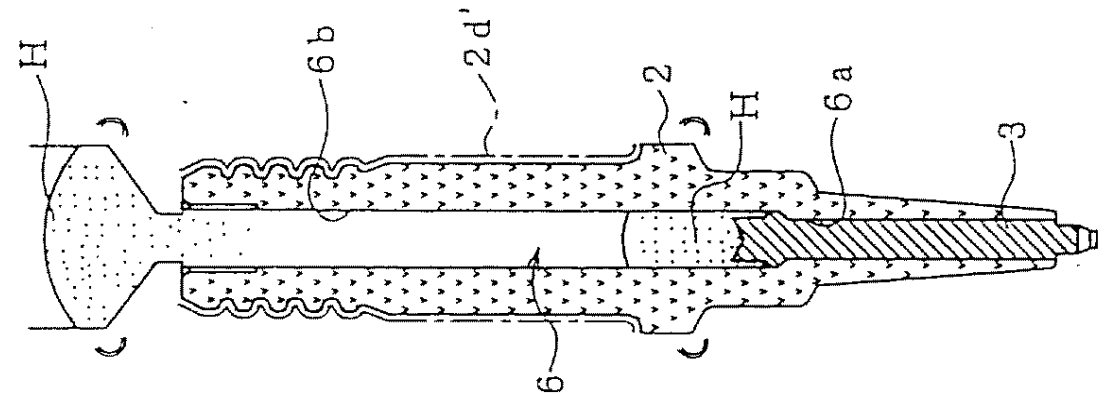


FIG. 8A

