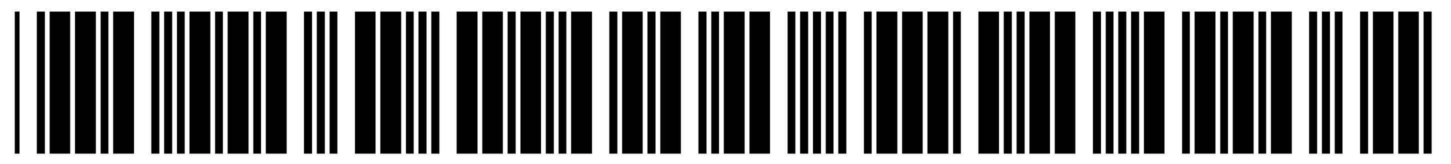

(19) **United States**

(12) **Reissued Patent**

Oguchi et al.

(10) **Patent Number:** **US RE37,539 E**

(45) **Date of Reissued Patent:** **Feb. 5, 2002**

(54) **SEALED STACKED ARRANGEMENT OF SEMICONDUCTOR DEVICES**

(75) Inventors: **Satoshi Oguchi**, Kodaira; **Masamichi Ishihara**, Fukuma-machi; **Kazuya Ito**, Hamura; **Gen Murakami**, Tama; **Ichiro Anjoh**, Koganei; **Toshiyuki Sakuta**, Tokyo; **Yasunori Yamaguchi**, Fussa; **Yasuhiro Kasama**, Kokubunji; **Tetsu Udagawa**, Iruma; **Eiji Momose**, Matsumoto; **Youichi Matsuno**, Kokubunji; **Hiroshi Satoh**, Takasaki; **Atsusi Nozoe**, Hino, all of (JP)

(73) Assignee: **Hitachi, Ltd.**, Tokyo (JP)

(21) Appl. No.: **09/471,000**

(22) Filed: **Dec. 23, 1999**

Related U.S. Patent Documents

Reissue of:

(64) Patent No.: **5,701,031**
Issued: **Dec. 23, 1997**
Appl. No.: **08/280,381**
Filed: **Jul. 25, 1994**

U.S. Applications:

(62) Division of application No. 07/691,985, filed on Apr. 26, 1991, now Pat. No. 5,332,922.

(30) **Foreign Application Priority Data**

Apr. 26, 1990 (JP) 2-108621
Mar. 31, 1991 (JP) 3-74530

(51) **Int. Cl.**[7] **H01L 23/28**; H01L 23/535; H01L 23/538; H01L 23/065

(52) **U.S. Cl.** **257/686**; 257/724; 257/786; 257/787

(58) **Field of Search** 257/686, 724, 257/786, 787

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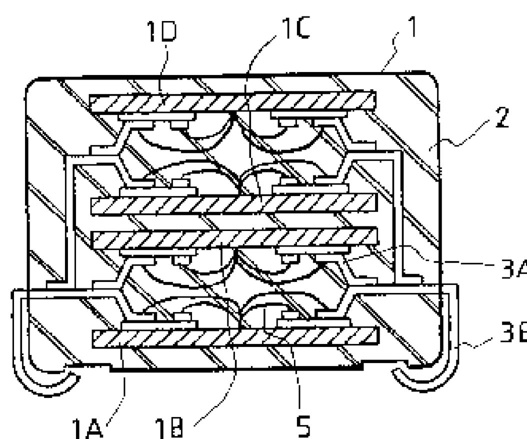
Primary Examiner—David E. Graybill

(74) *Attorney, Agent, or Firm*—Antonelli, Terry, Stout & Kraus, LLP

(57) **ABSTRACT**

A pair of DRAM chips **1A** and **1B** are mounted opposedly to each other with wiring means such as lead frames put therebetween, the lead frames being substantially integral with external terminals **3B**. Then, these DRAM chips and lead frames are connected together by the conventional wire bonding method. Plural pairs of the thus-connected DRAM chips and lead frames are stacked and corresponding leads of the lead frames are connected in common to form a laminate. The plural DRAM chips thus mounted are activated selectively in accordance with a predetermined chip selection signal. Additionally, partial DRAM chips capable of partially functioning normally are combined together by utilizing the above chip mounting method to constitute a single DRAM package.

40 Claims, 45 Drawing Sheets



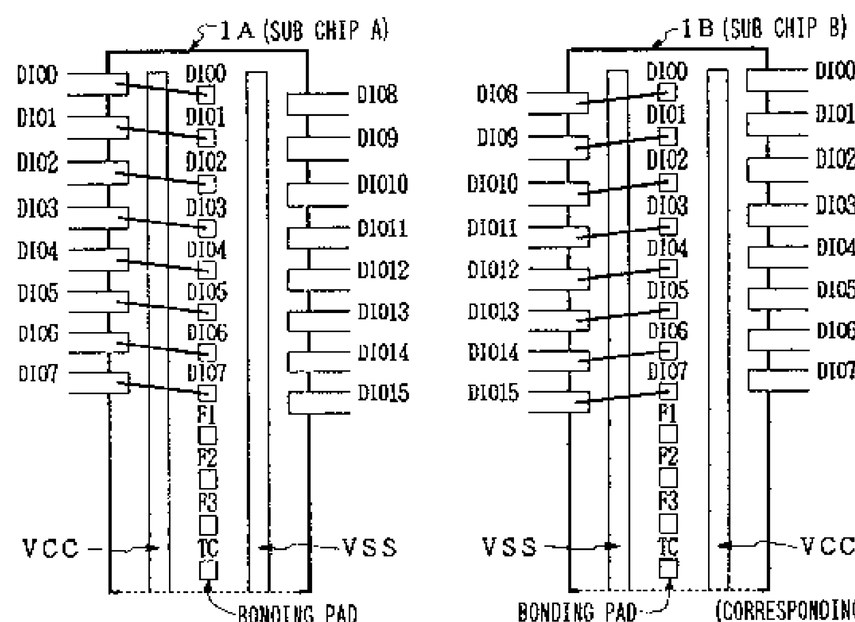


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FIG. 1

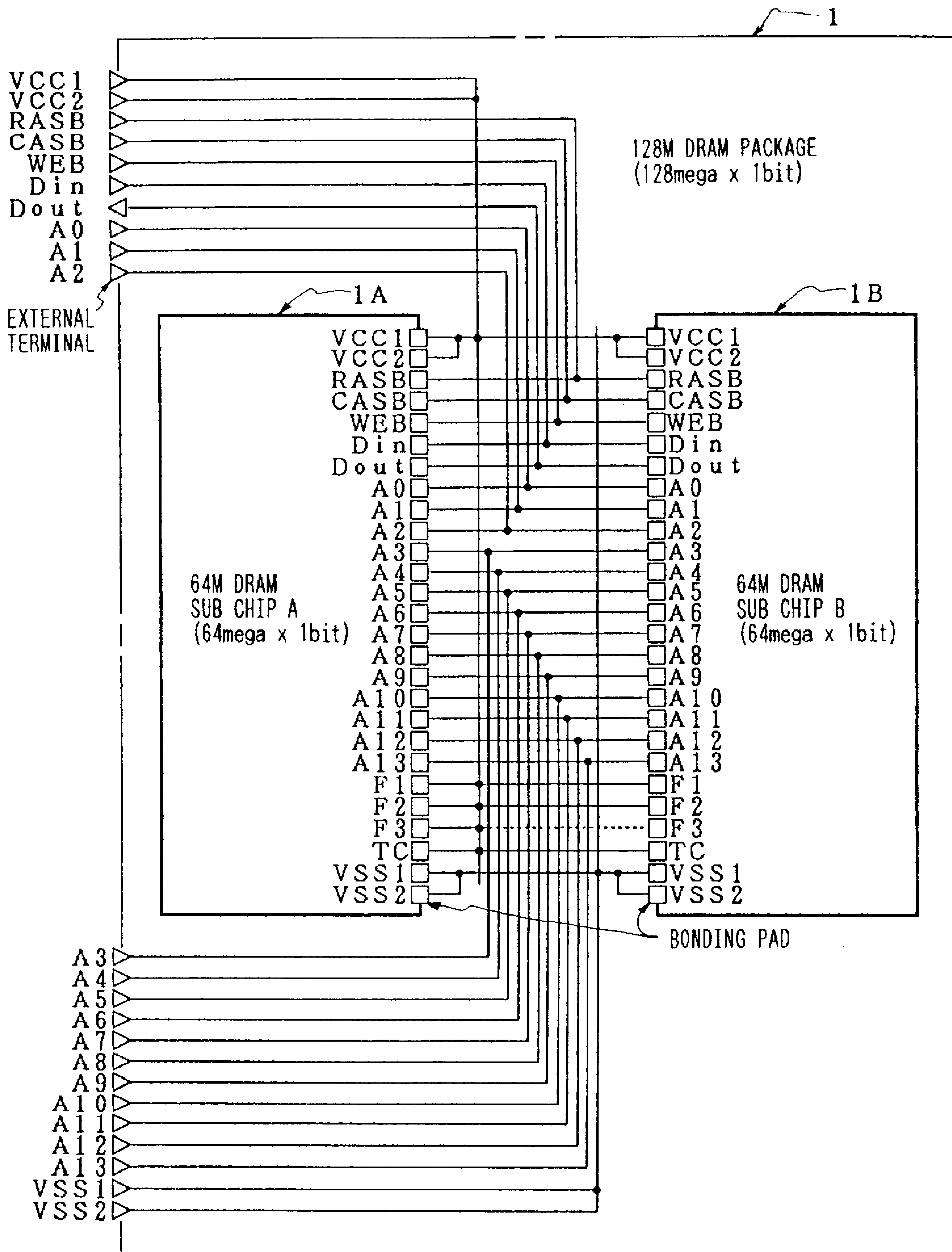


FIG. 2

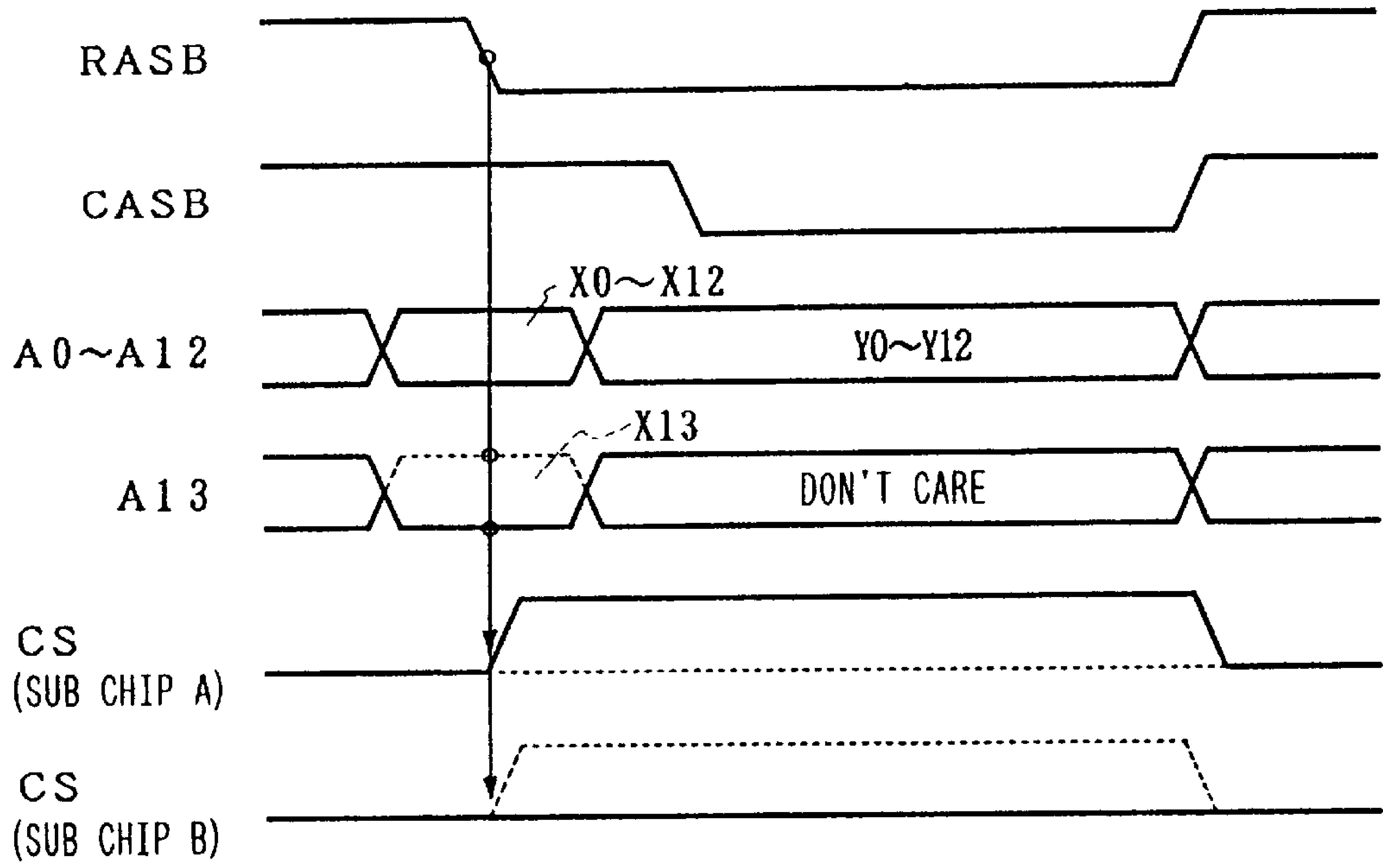


FIG. 3

STANDARD SPECIFICATION OF 64M DRAM SUB CHIP

ITEM		SPECIFIGURATION		
BIT CONFIGUCATION		64megaword x 1bit	16megaword x 4bits	8megaword x 8bits
ADDRESS	CHIP	X13	X13	X13
	ROW	X0~X12	X0~X12	X0~X12
	COLUMN	Y0~Y12	Y0~Y10	Y0~Y9
PACKAGE		32PINS SOJ 300 x 850 mil		
NUMBER OF PINS USED		23PINS	26PINS	32PINS
		CLOCK : 3 ADDRESS : 14 I/O : 2 POWER SOURCE: 4	CLOCK : 4 ADDRESS : 14 I/O : 4 POWER SOURCE: 4	CLOCK : 4 ADDRESS : 14 I/O : 8 POWER SOURCE: 6
REFRESH		8192 CYCLE / 64 ms		
STANDARD PARALLEL TEST		8-bit PARALLEL PROCESSING (ALL I/O SAME DATA OUTPUT)		
HIGH SPEED COLUMN MODE		FAST PAGE STATIC COLUMN NIBBLE	FAST PAGE STATIC COLUMN	FAST PAGE STATIC COLUMN
		THE COLUMNDEPTH IN FP AND SC MODES IS 8K bits AT MOST		

FIG. 4

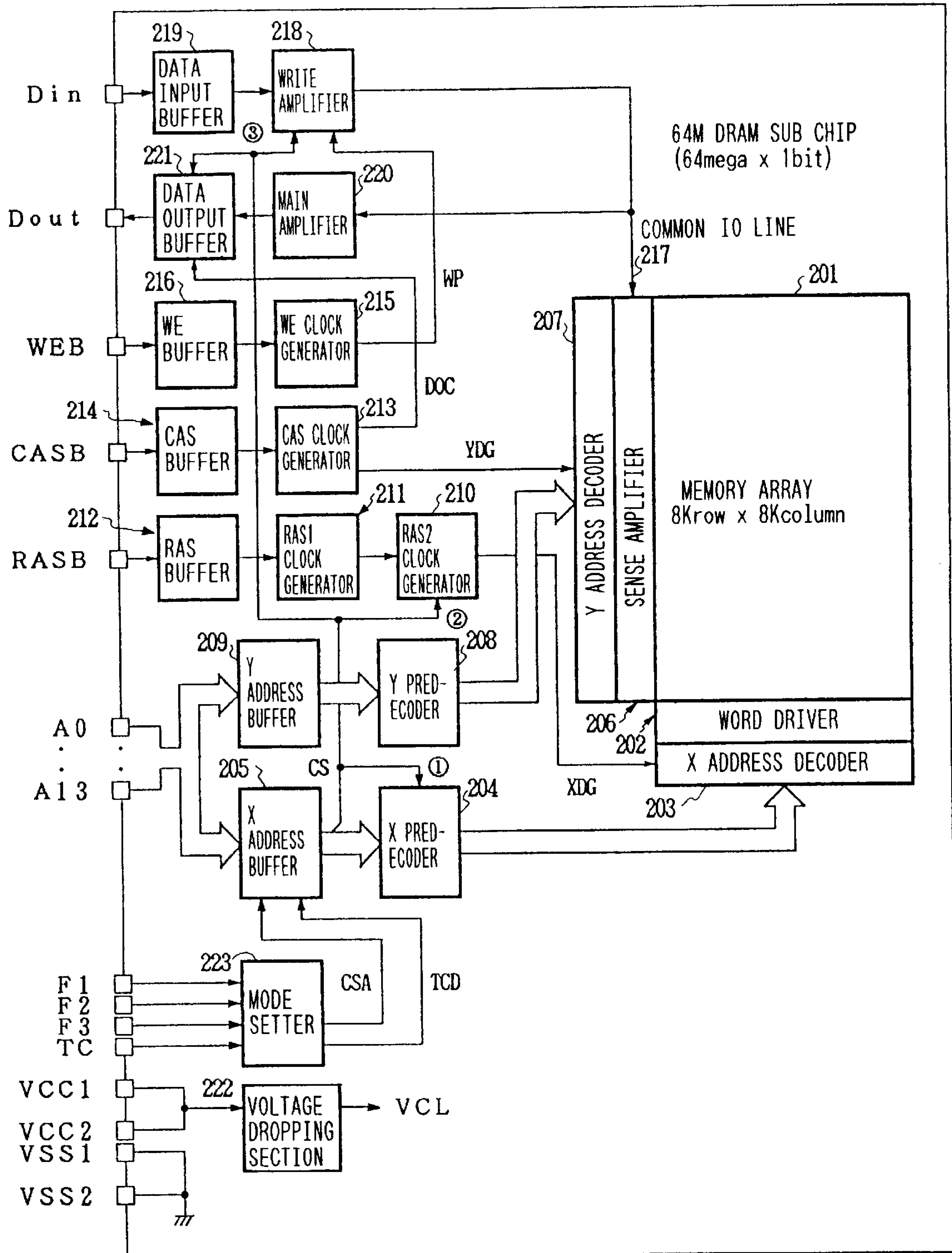


FIG. 5

BASIC LAYOUT OF 64M DRAM SUB CHIP

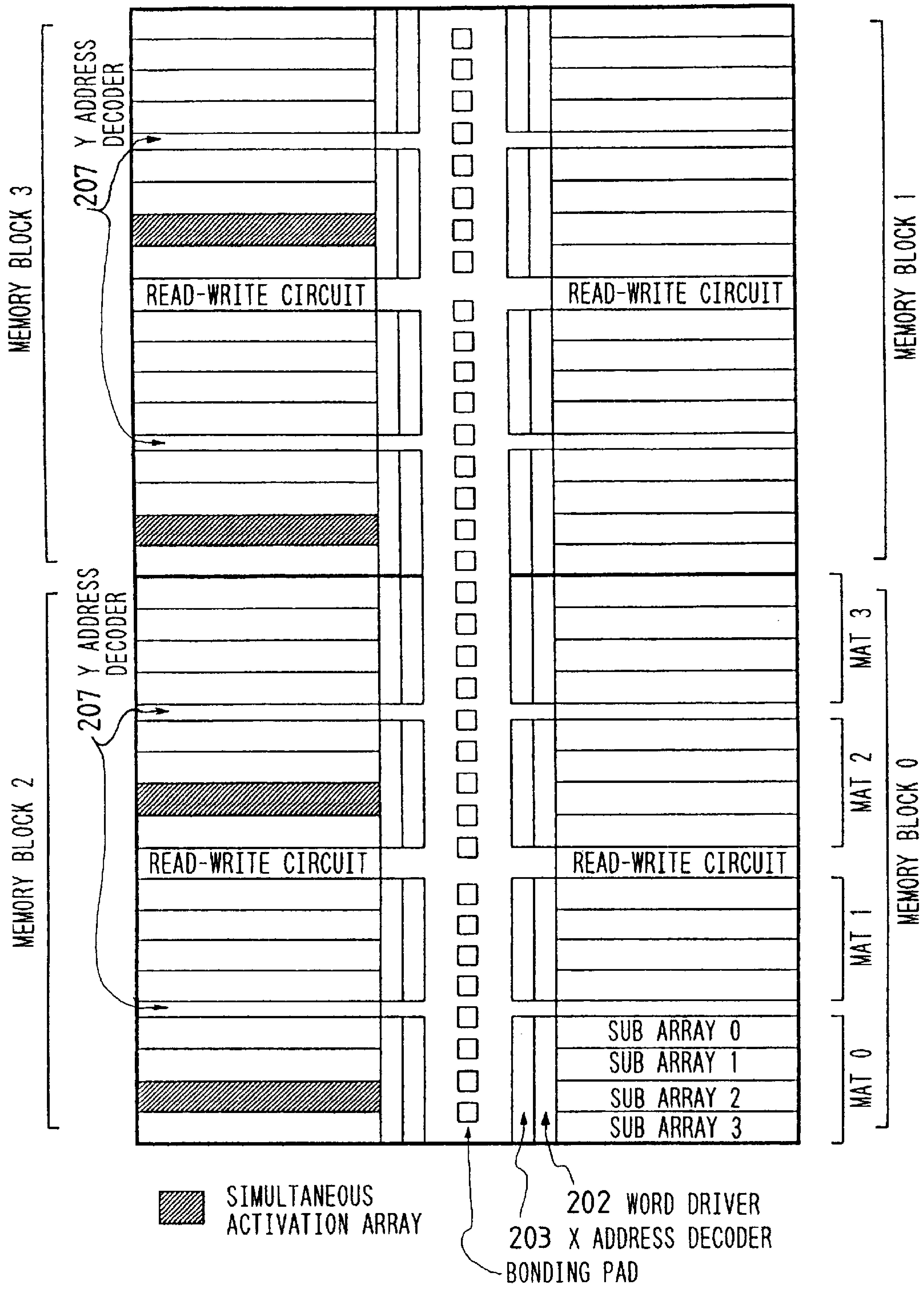


FIG. 6

CONCEPTUAL DIAGRAM OF 64M DRAM SUB CHIP SELECTION

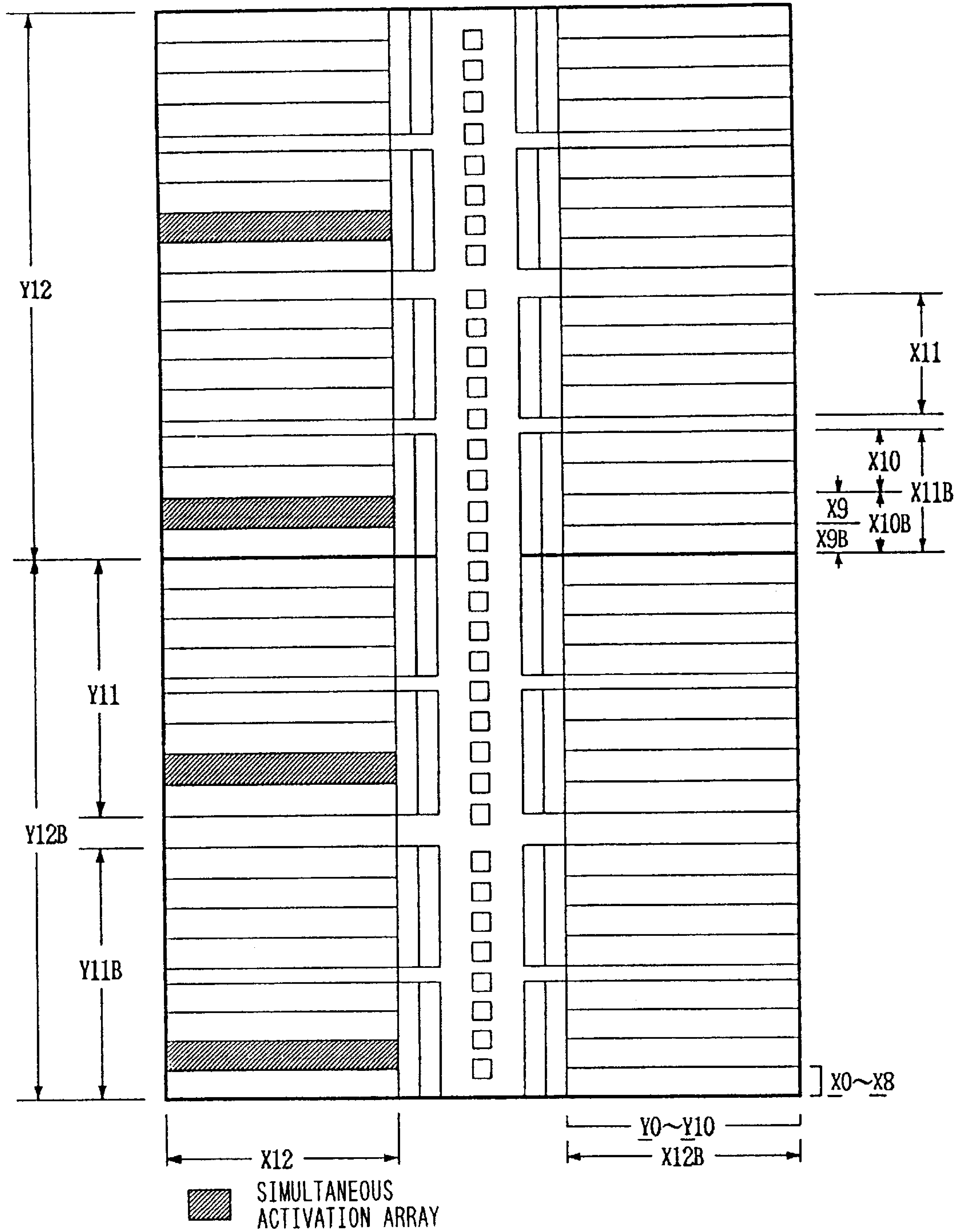


FIG. 7

VARIATIONS OF 128M DRAM PACKAGE

64M DRAM SUB CHIP			128M DRAM PACKAGE			REMARKS
WORD CONFIGURATION	BIT CONFIGURATION	ACCESS	WORD CONFIGURATION	BIT CONFIGURATION	CORRESPONDING DIAGRAM	
64mega	x 1	SELECTIVE	128mega	x 1	FIG. 1	
64mega	x 1	SIMULTANEOUS	64mega	x 2	FIG. 8	
16mega	x 4	SELECTIVE	32mega	x 4	FIG. 9	
16mega	x 4	SIMULTANEOUS	16mega	x 8	FIG. 10	
8mega	x 8	SELECTIVE	16mega	x 8	FIG. 11	
8mega	x 8	SIMULTANEOUS	8mega	x 16	FIG. 12	

FIG. 8

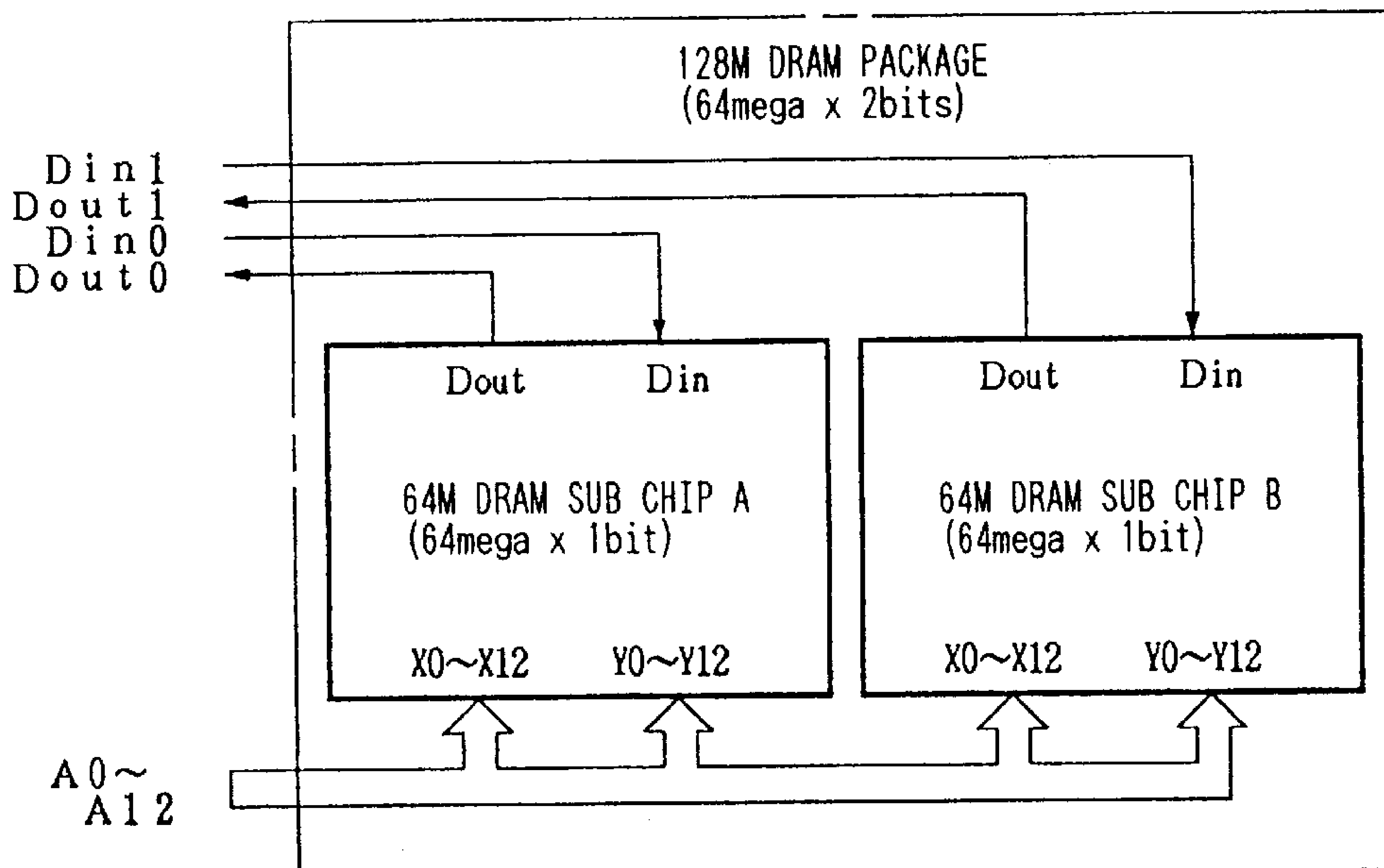


FIG. 9

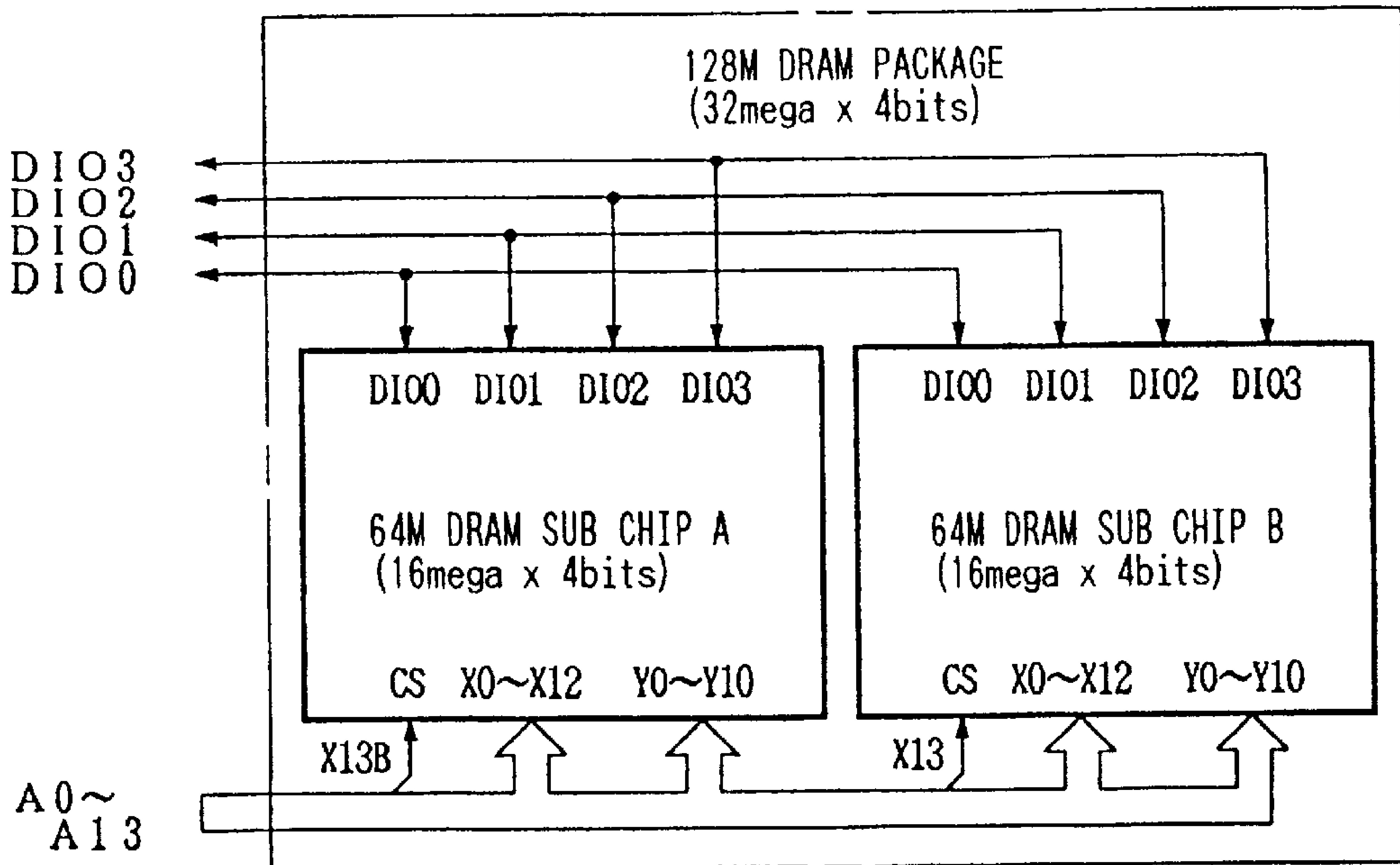


FIG. 10

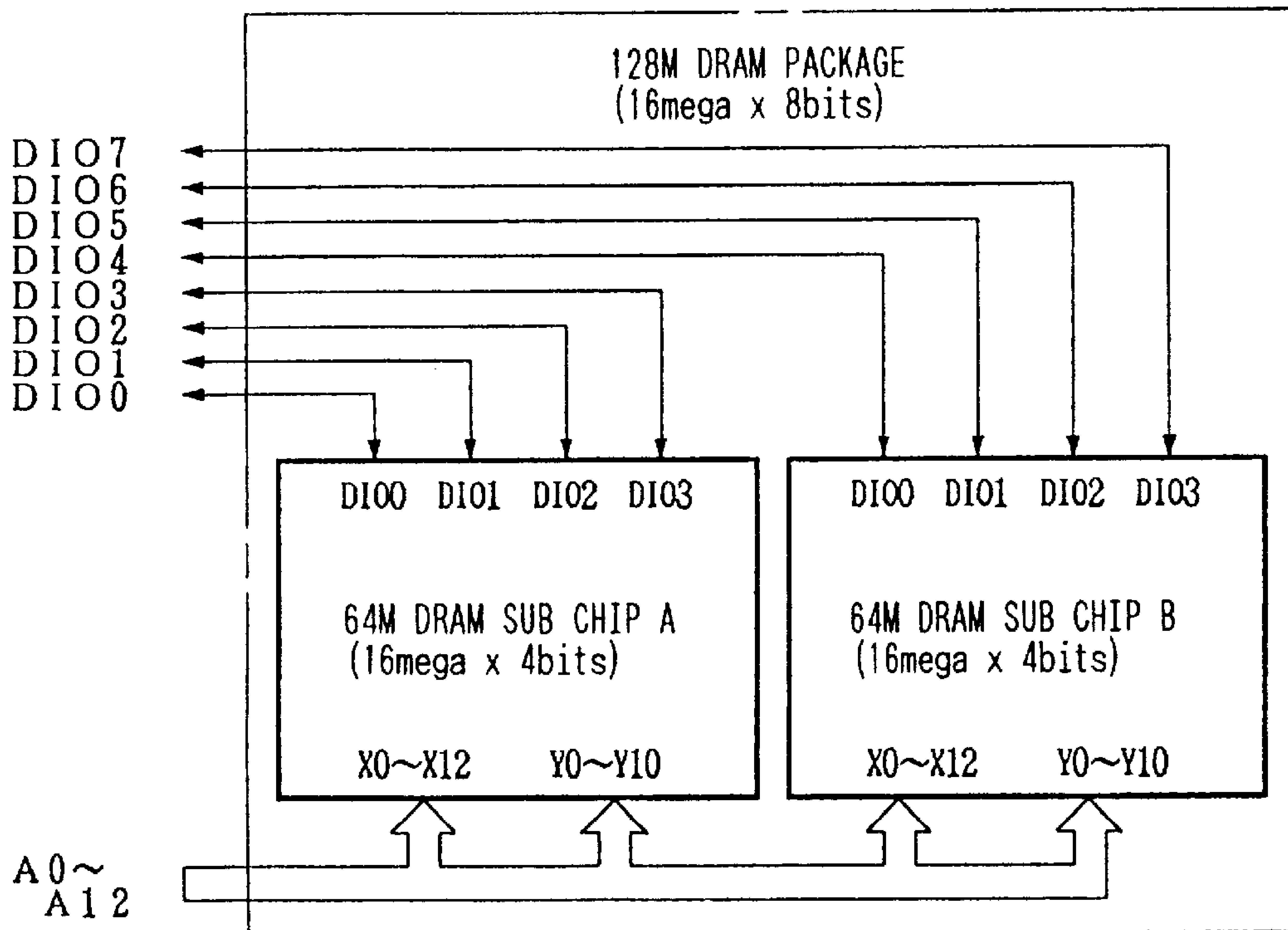


FIG. 11

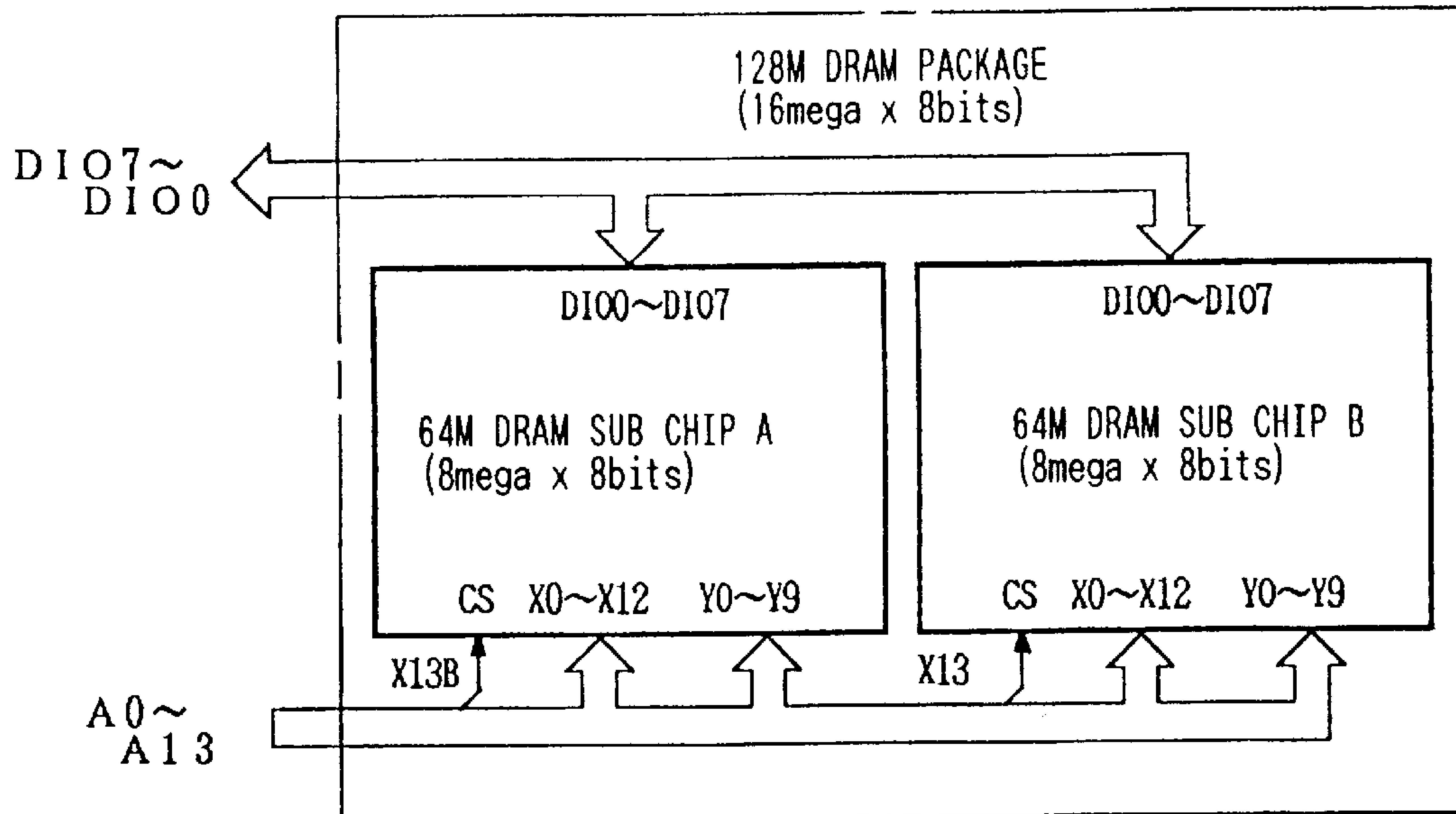


FIG. 12

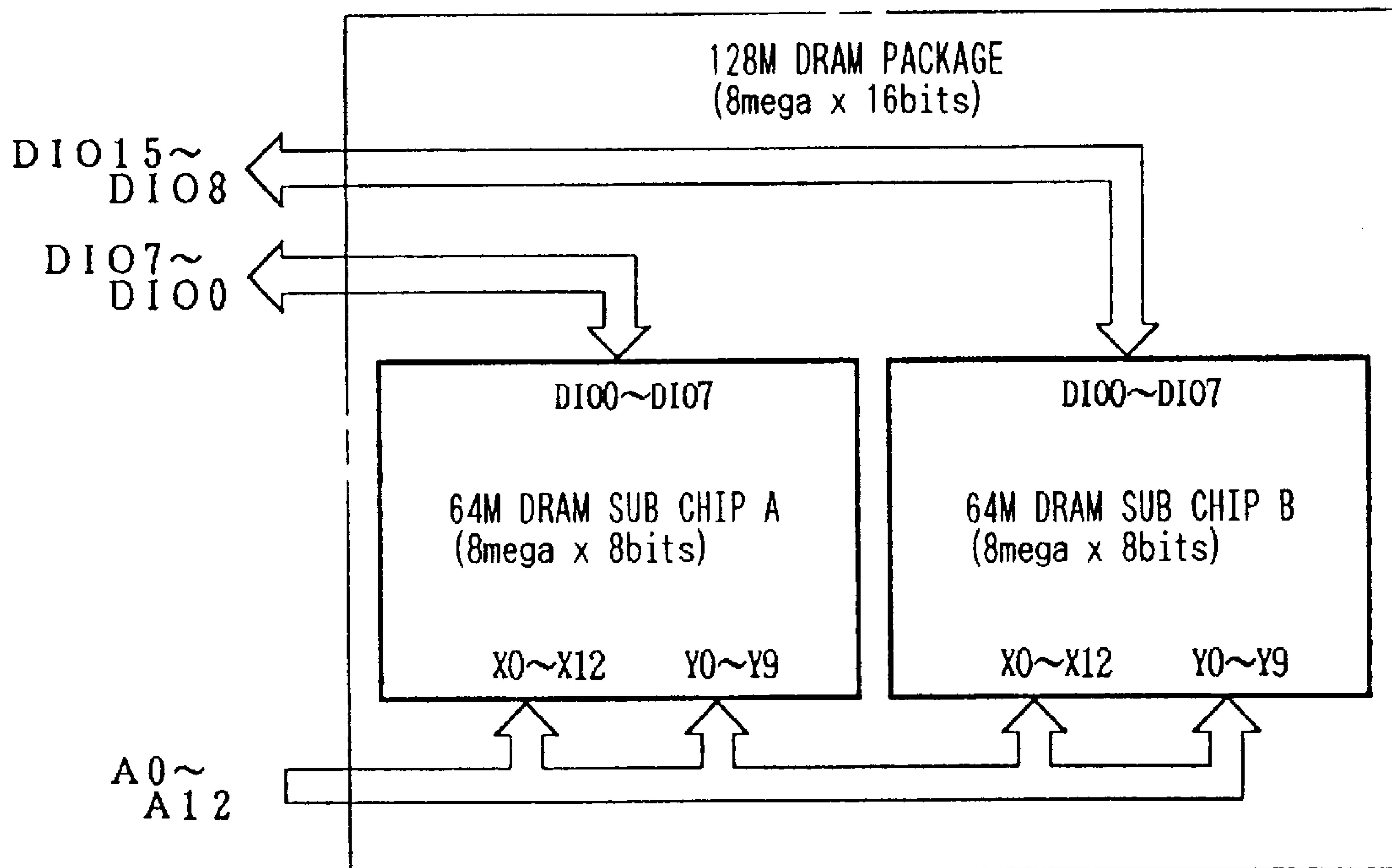


FIG. 13

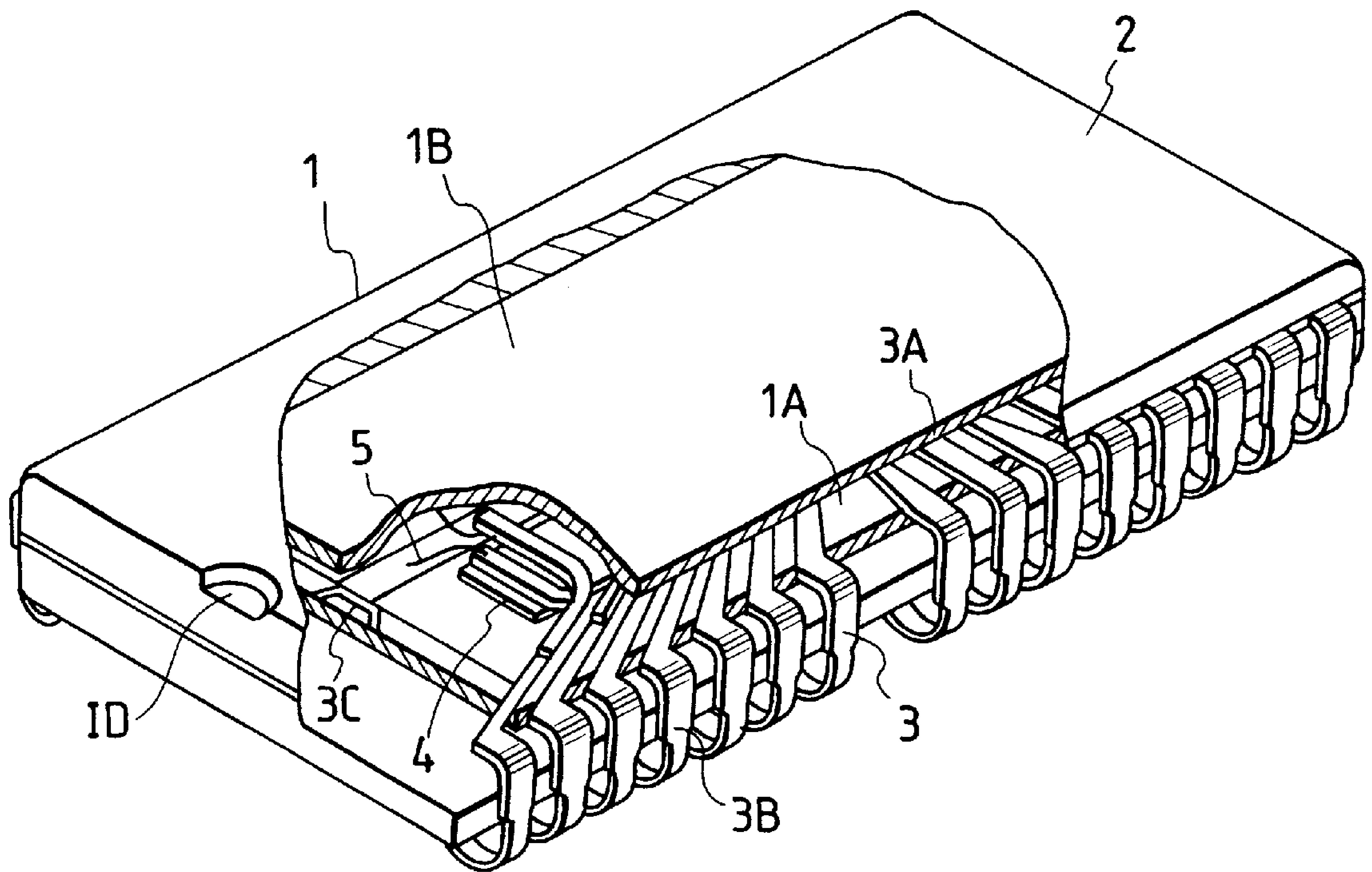


FIG. 14

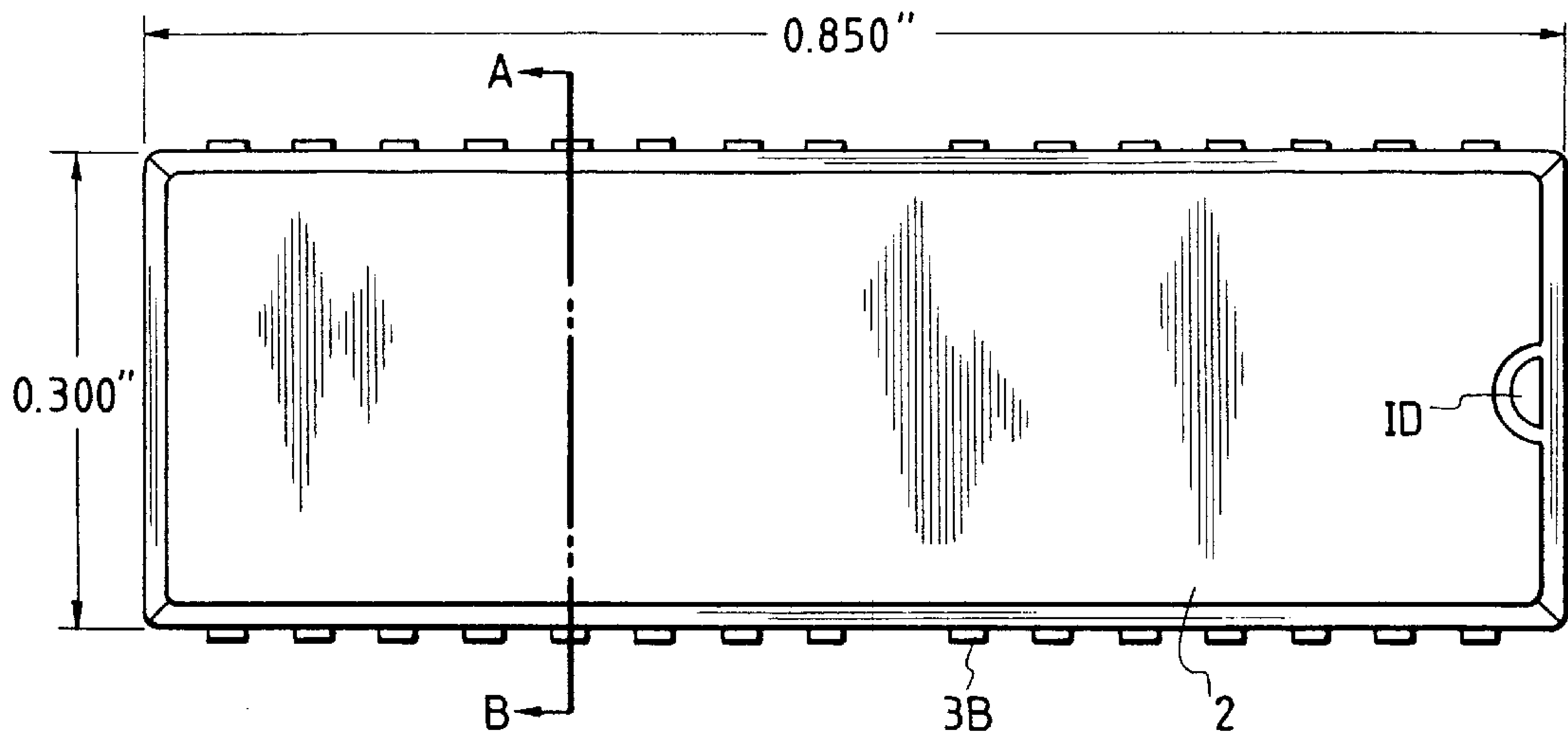


FIG. 15

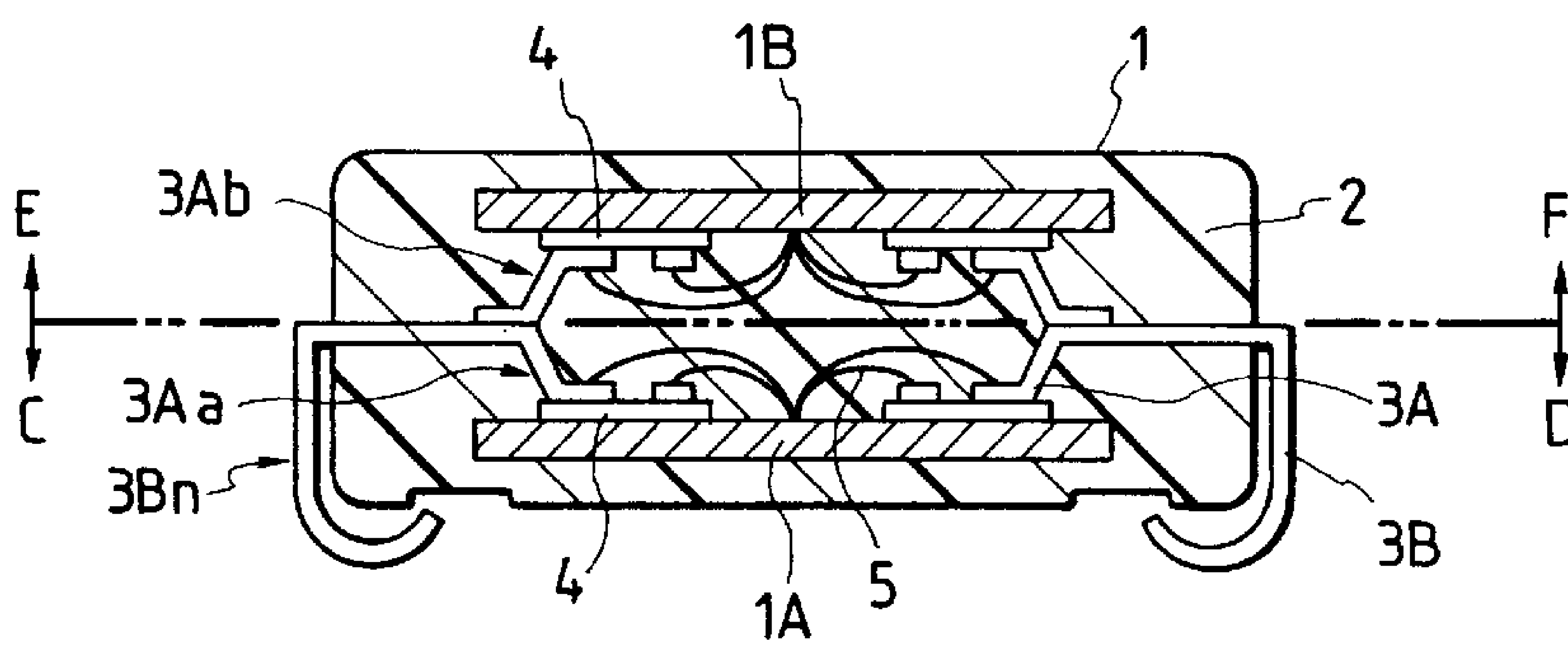


FIG. 16

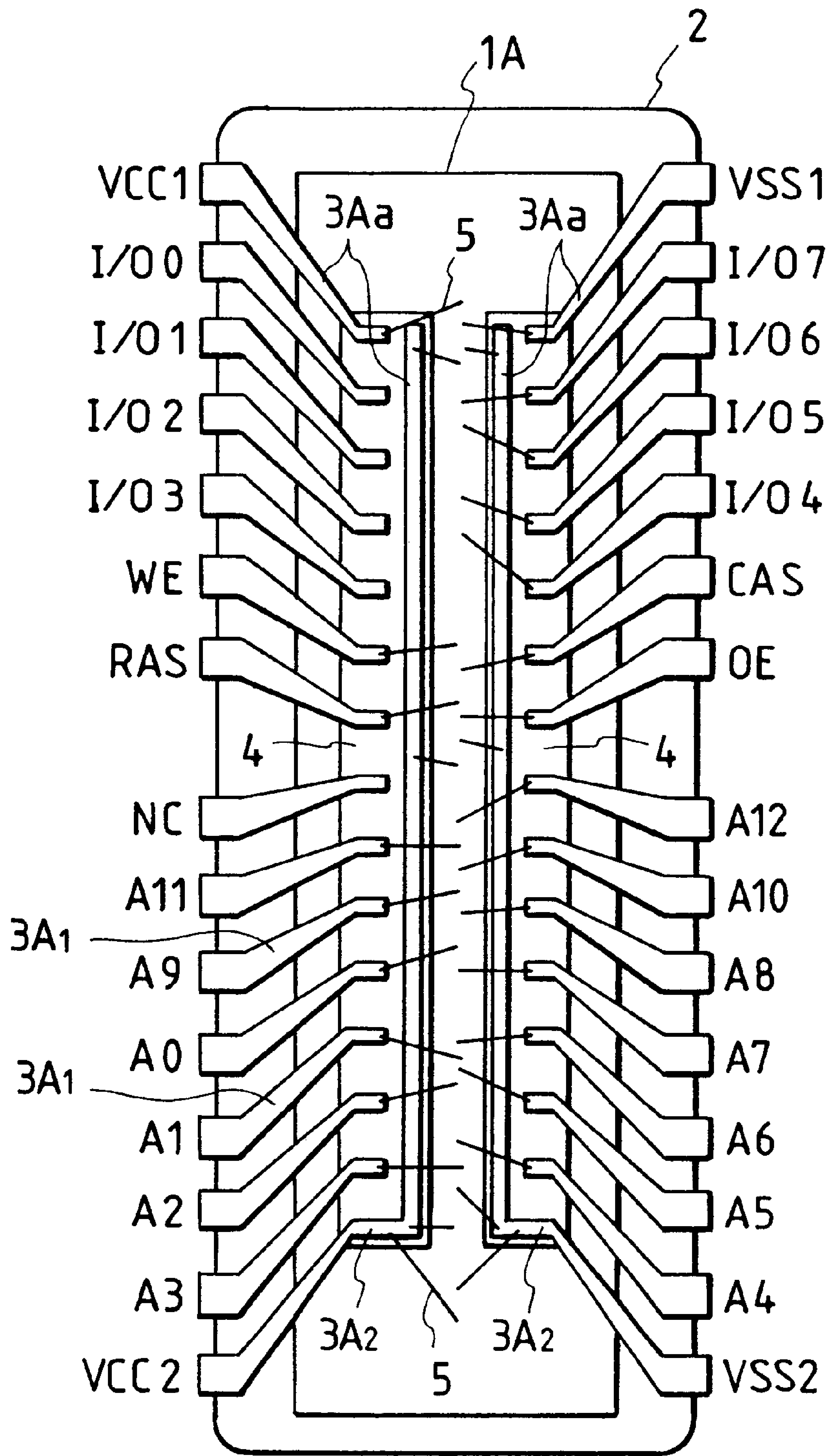


FIG. 17

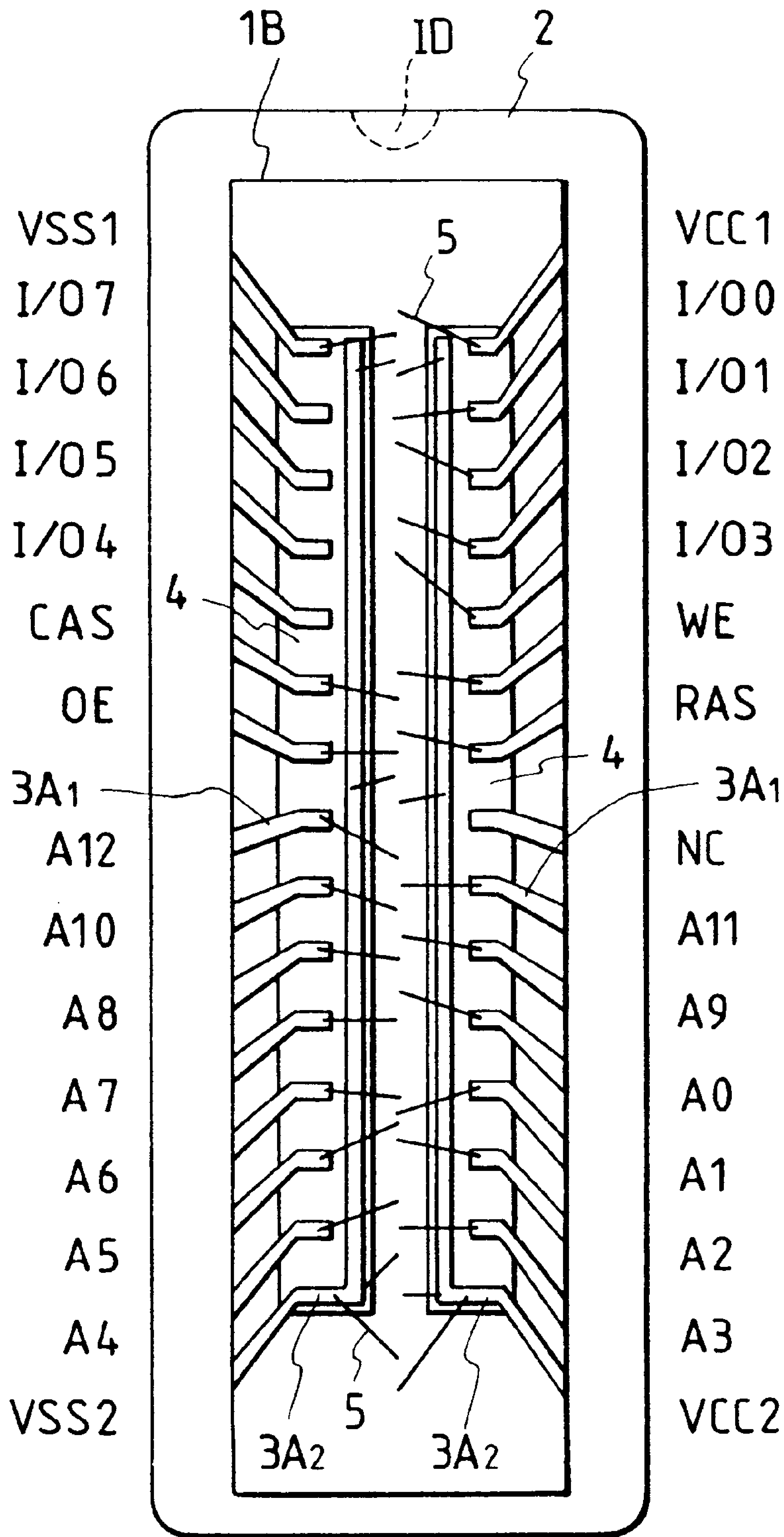


FIG. 18

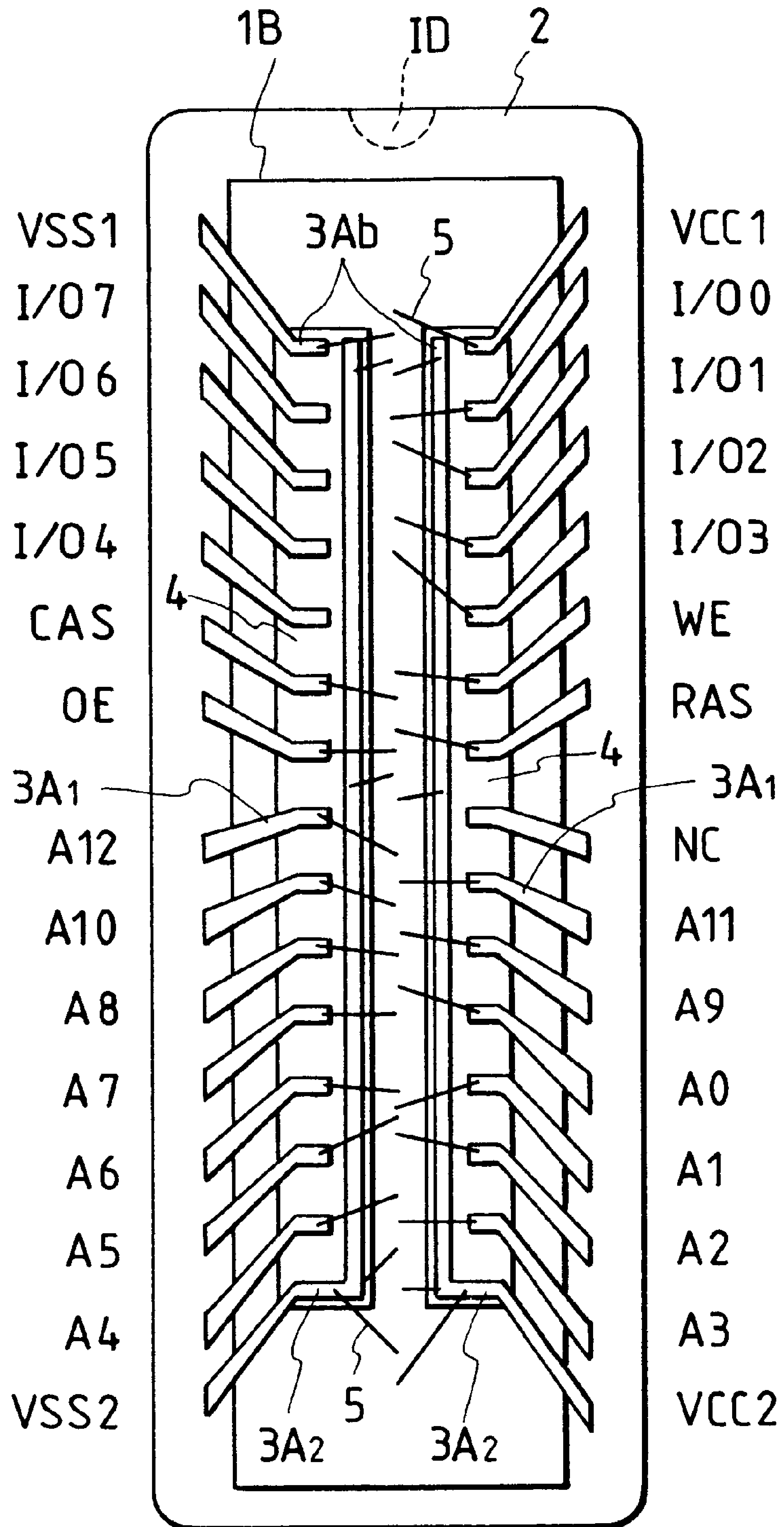


FIG. 19

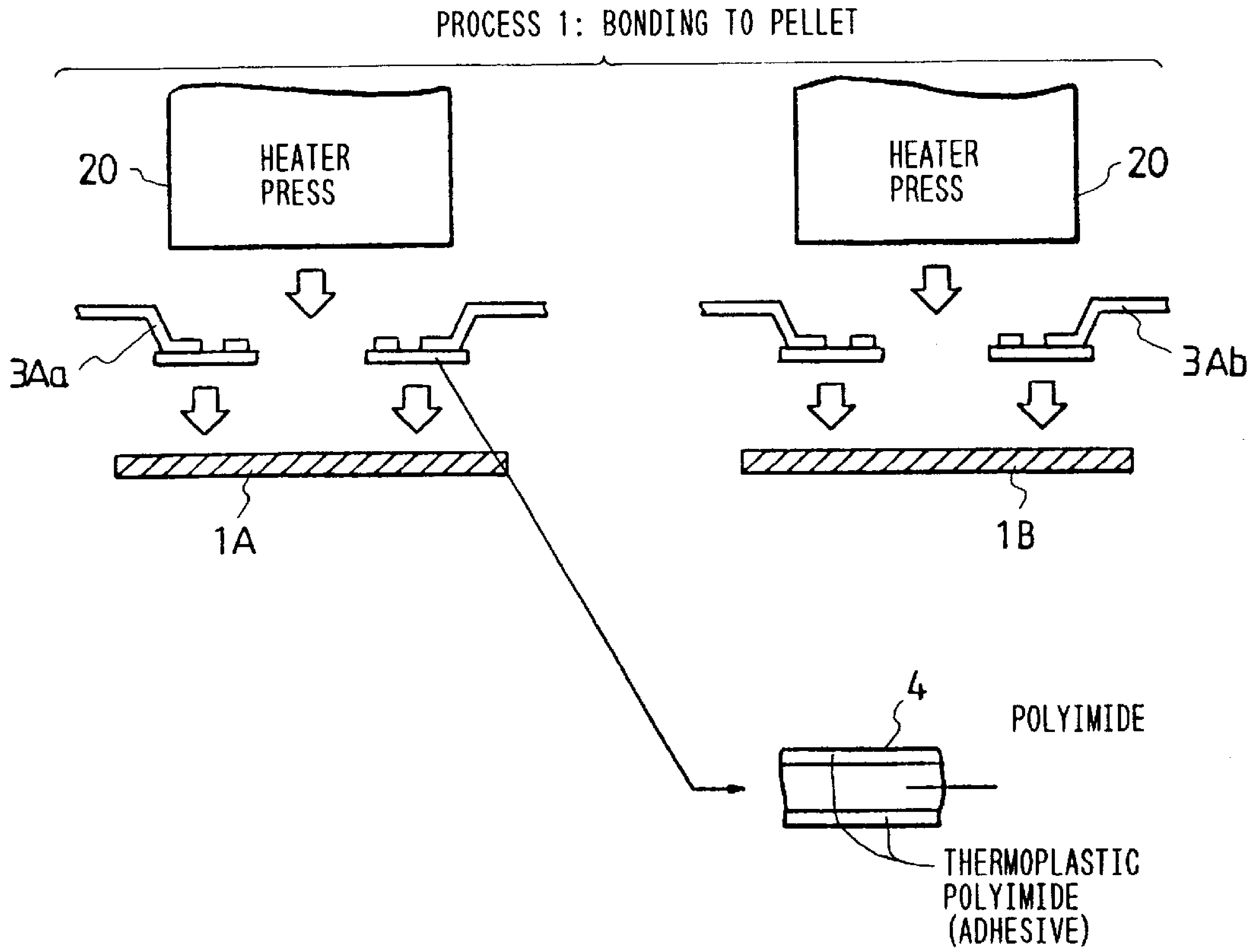


FIG. 20

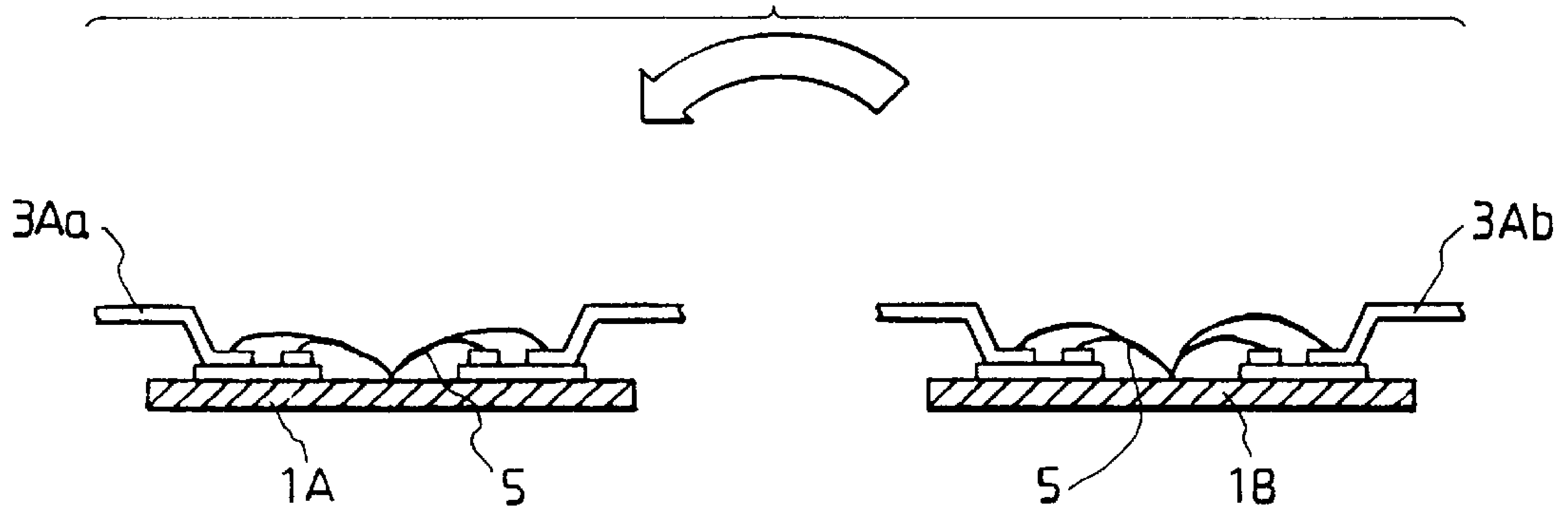


FIG. 21

PROCESS 3: LEAD CUTTING AND BONDING

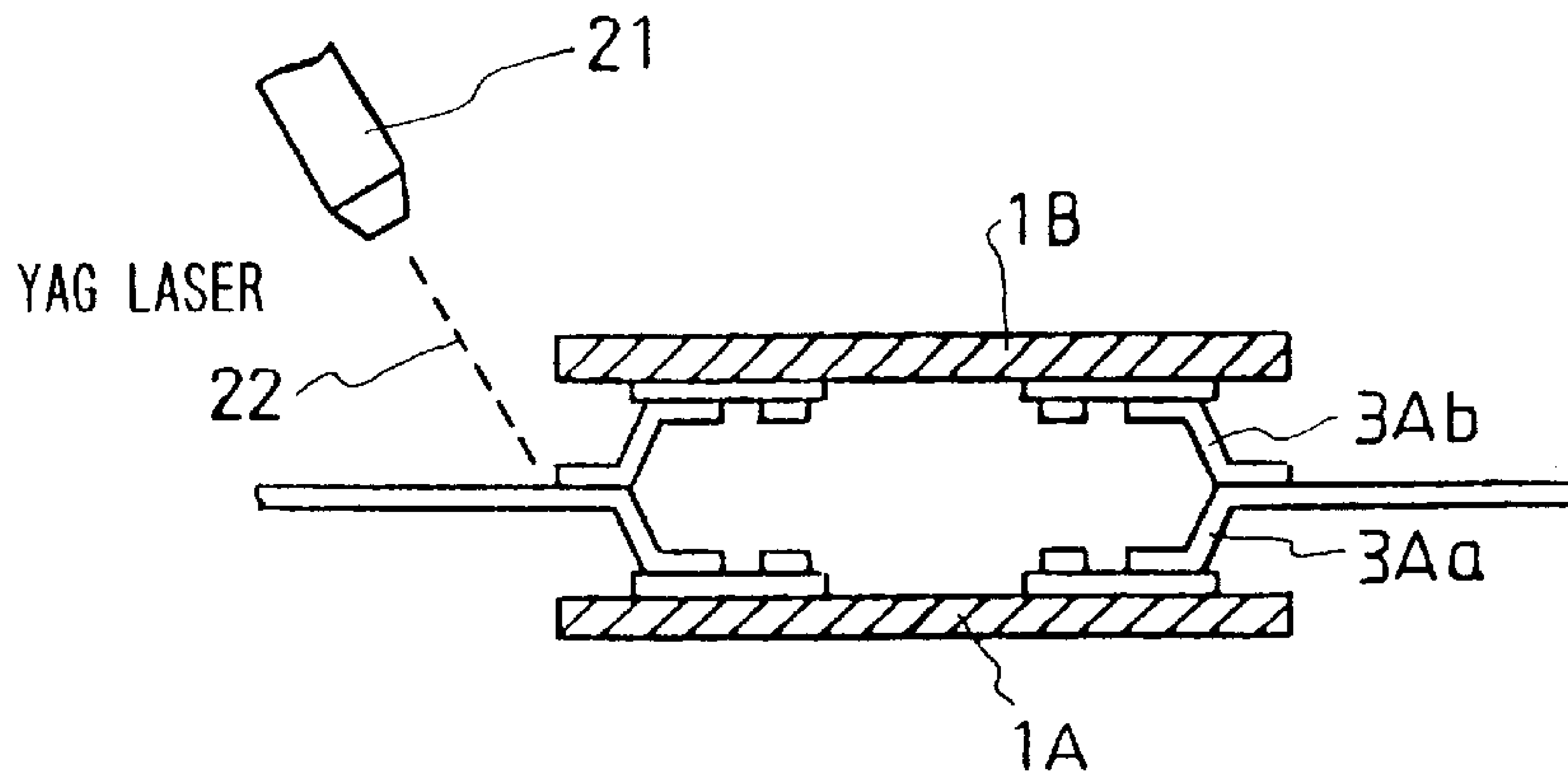


FIG. 22

PROCESS 4: SEALING (LEAD CUT AND BONDED PORTIONS ARE LOCATED WITHIN RESIN.)

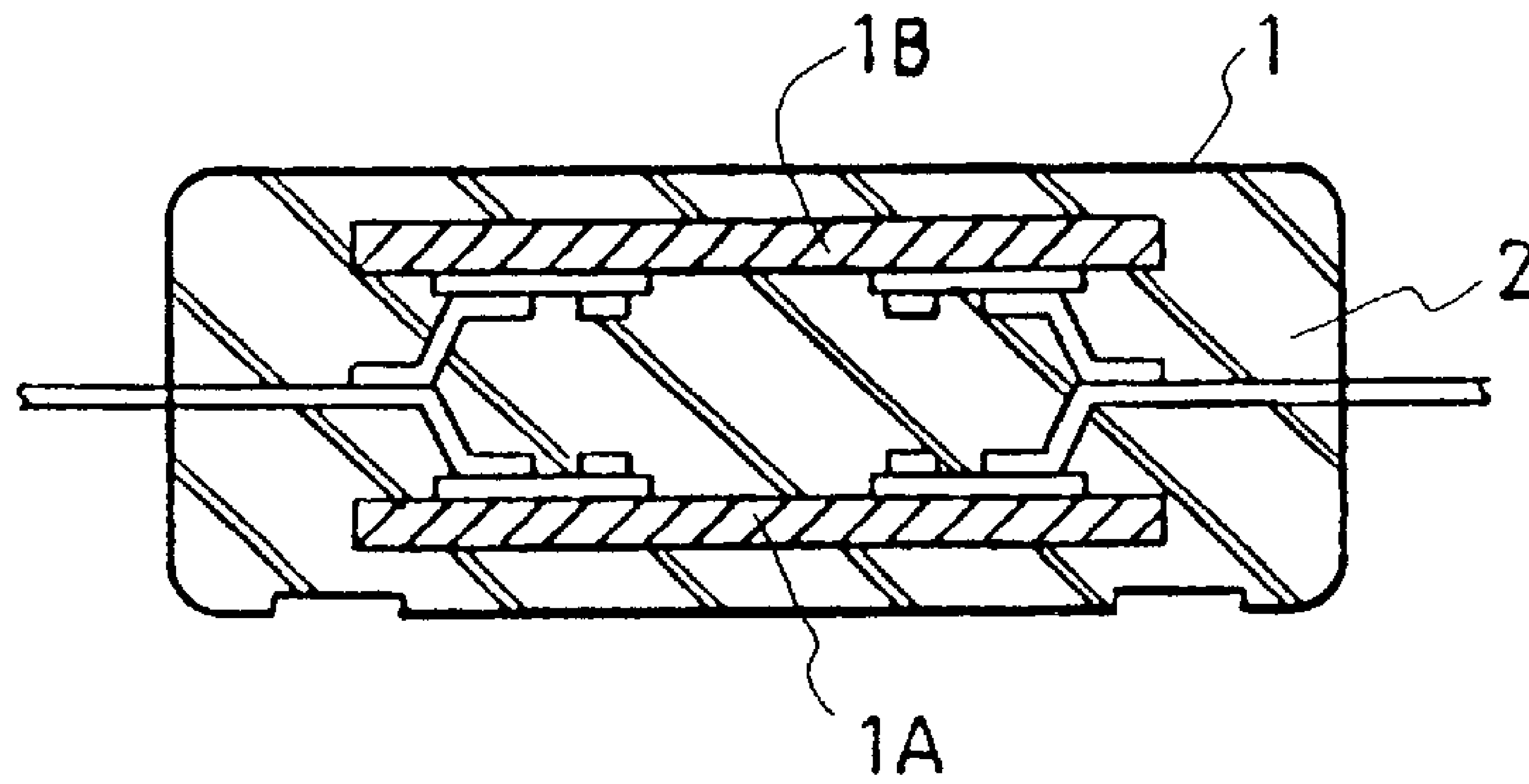


FIG. 23

PROCESS 5: LEAD FORMING

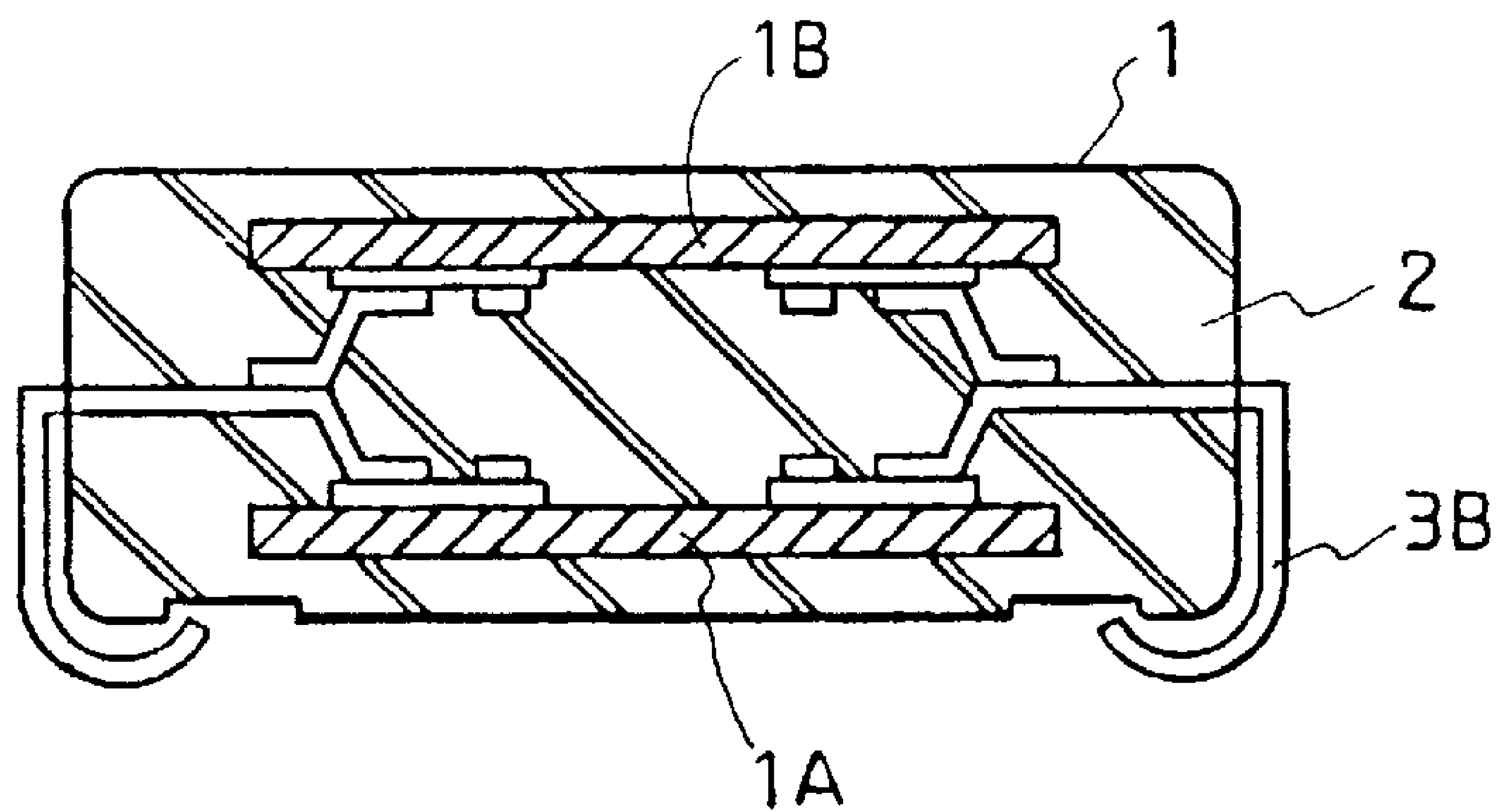


FIG. 24

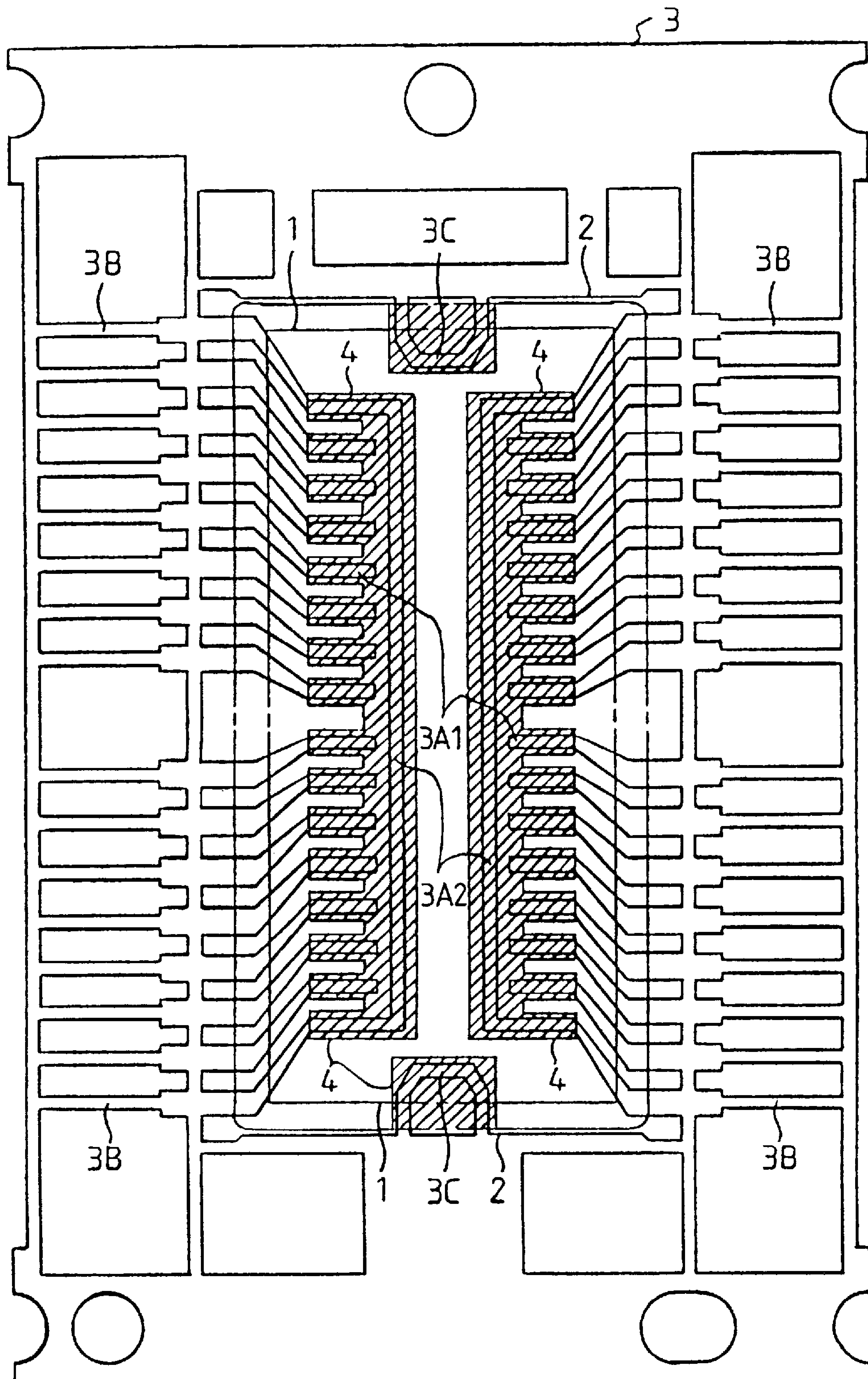


FIG. 25

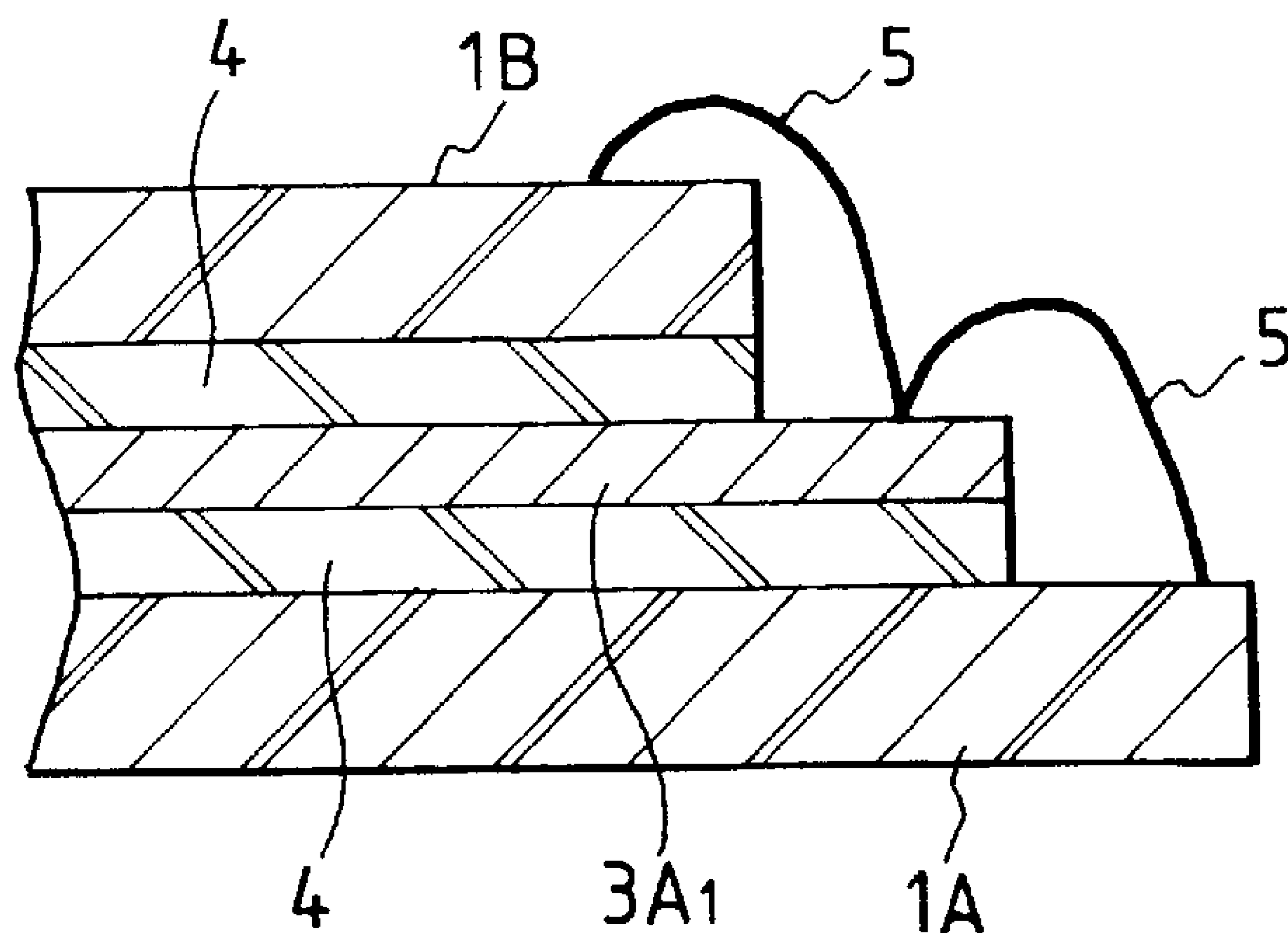


FIG. 26

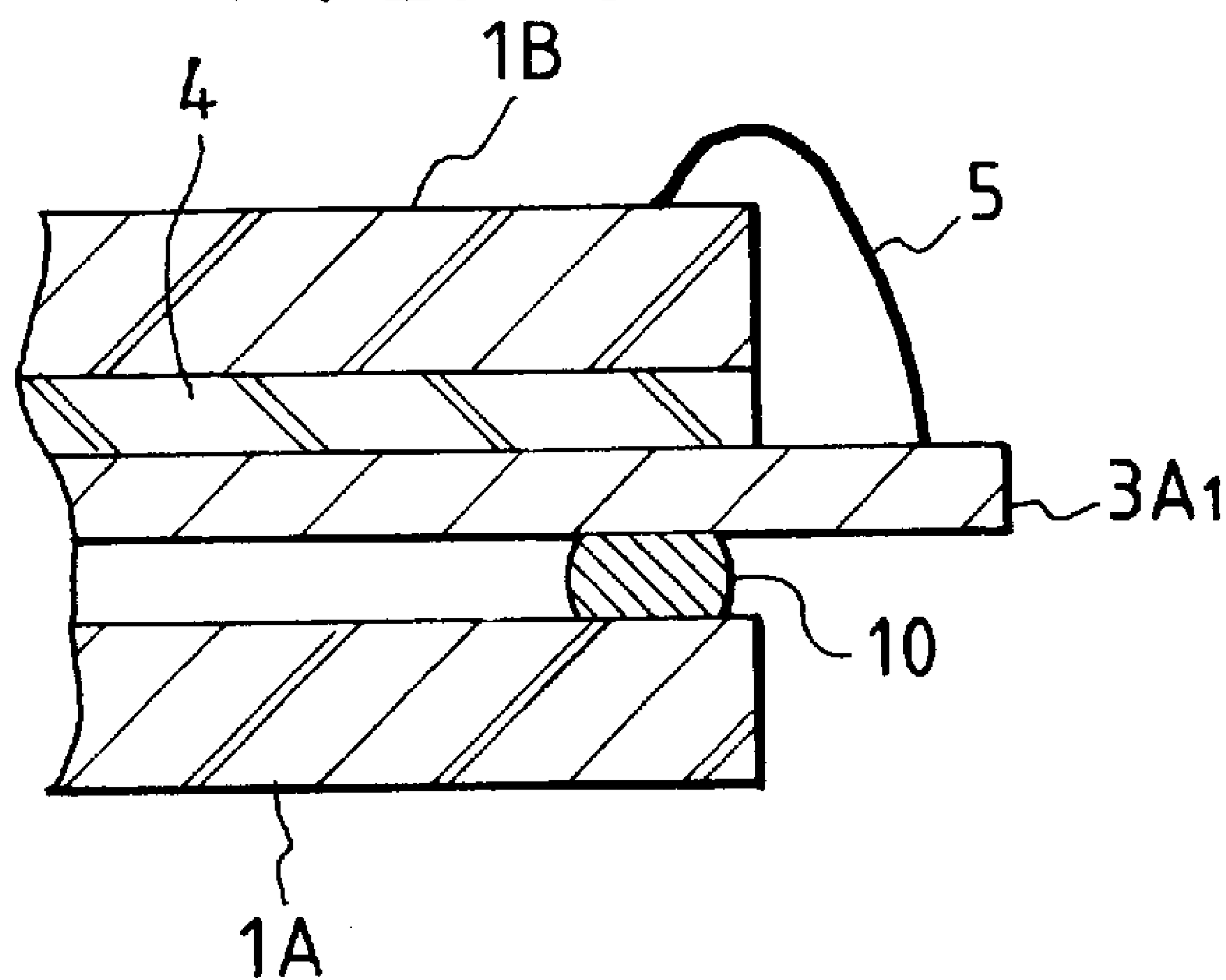
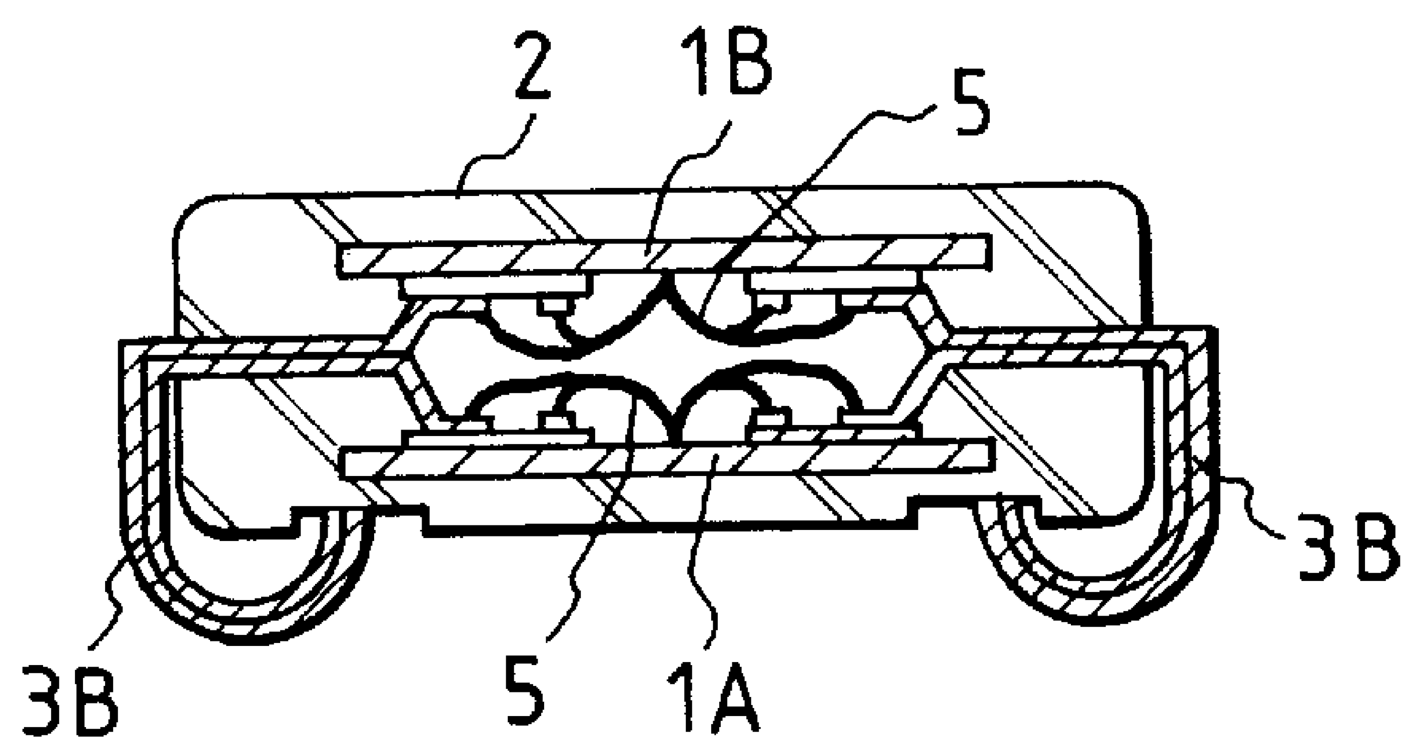


FIG. 27



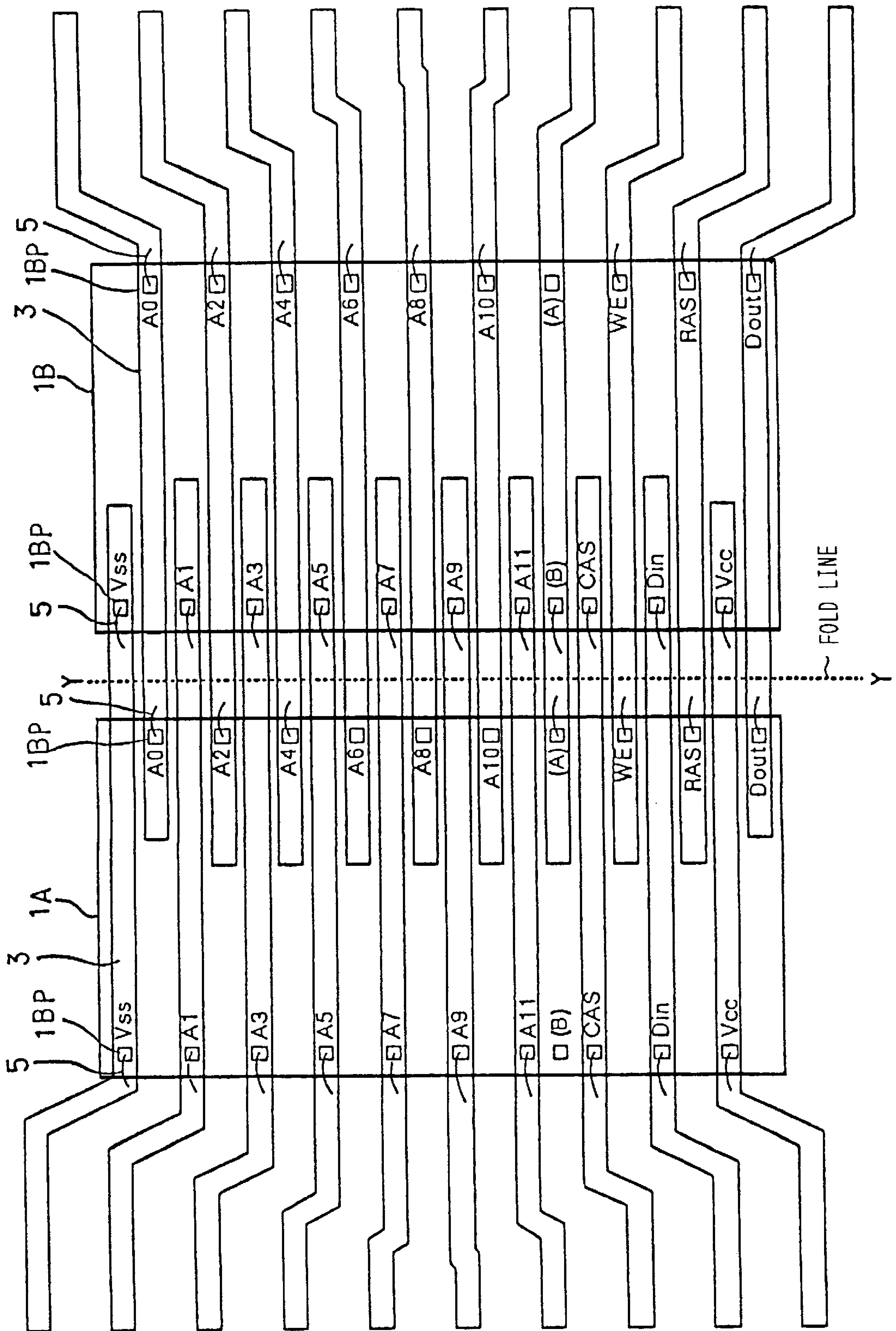


FIG. 28
1B
3
1BP
5
A0
A2
A4
A6
A8
A10
(A)
WE
RAS
Dout
Vss
A1
A3
A5
A7
A9
A11
(B)
CAS
Din
Vcc
FOLD LINE
Y
1A

FIG. 29

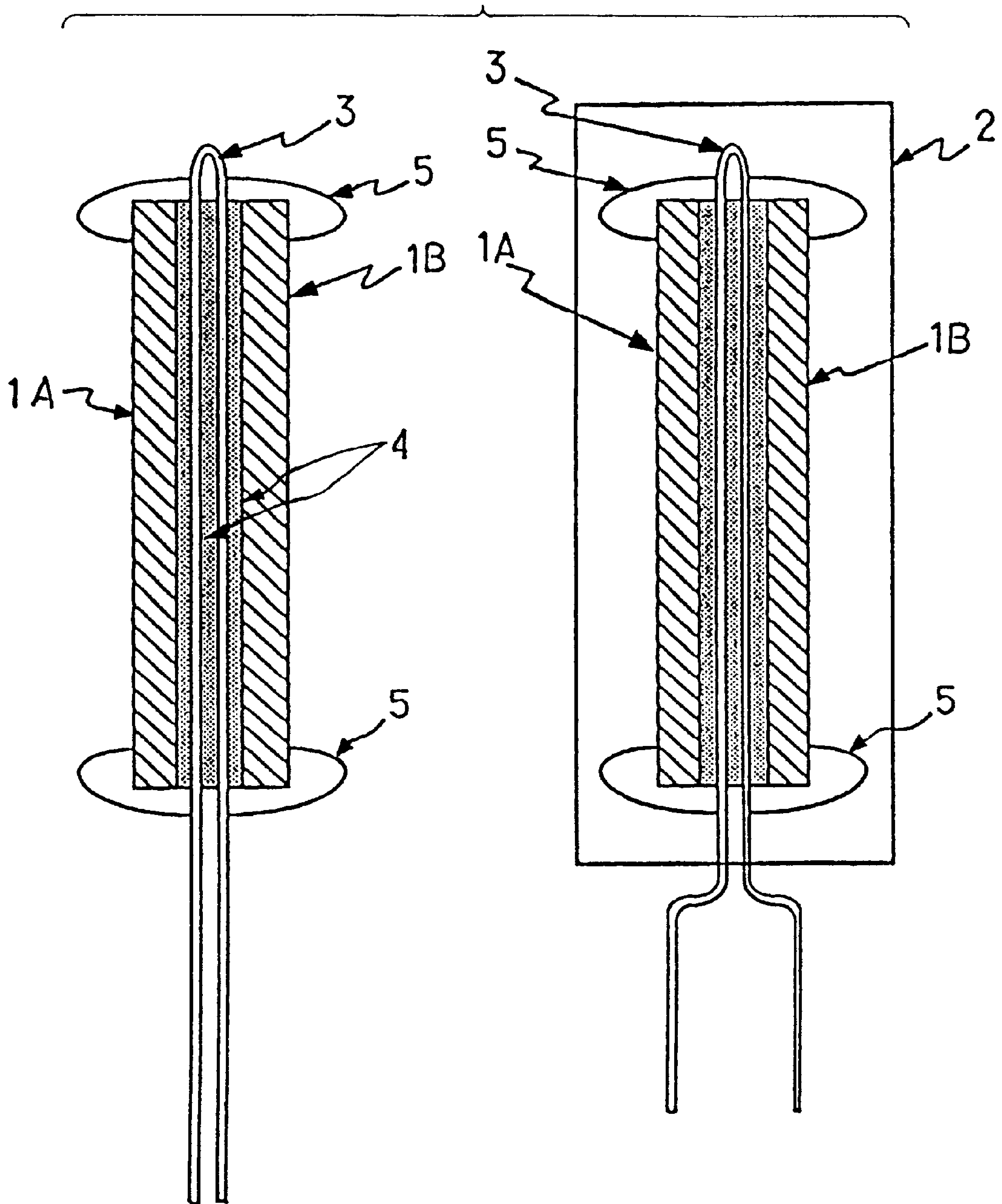


FIG. 30

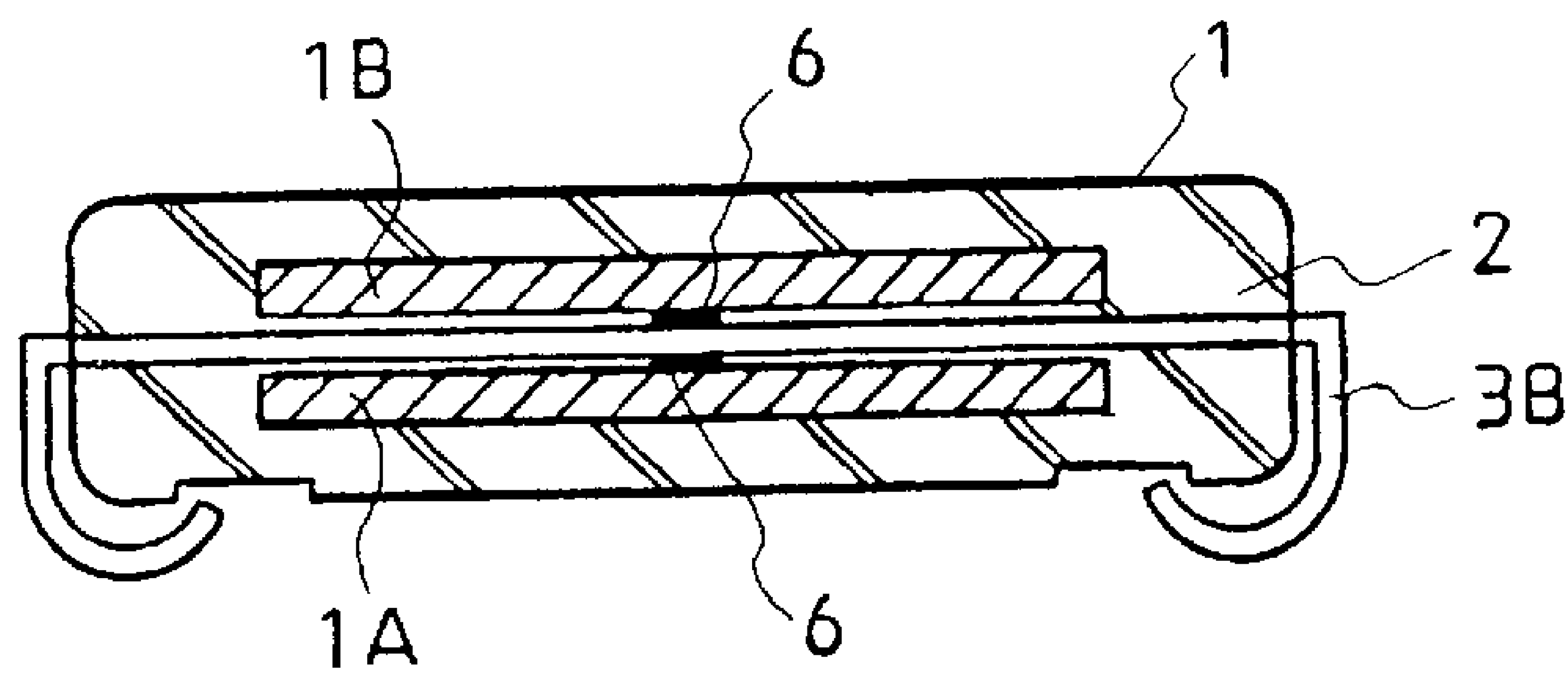


FIG. 31

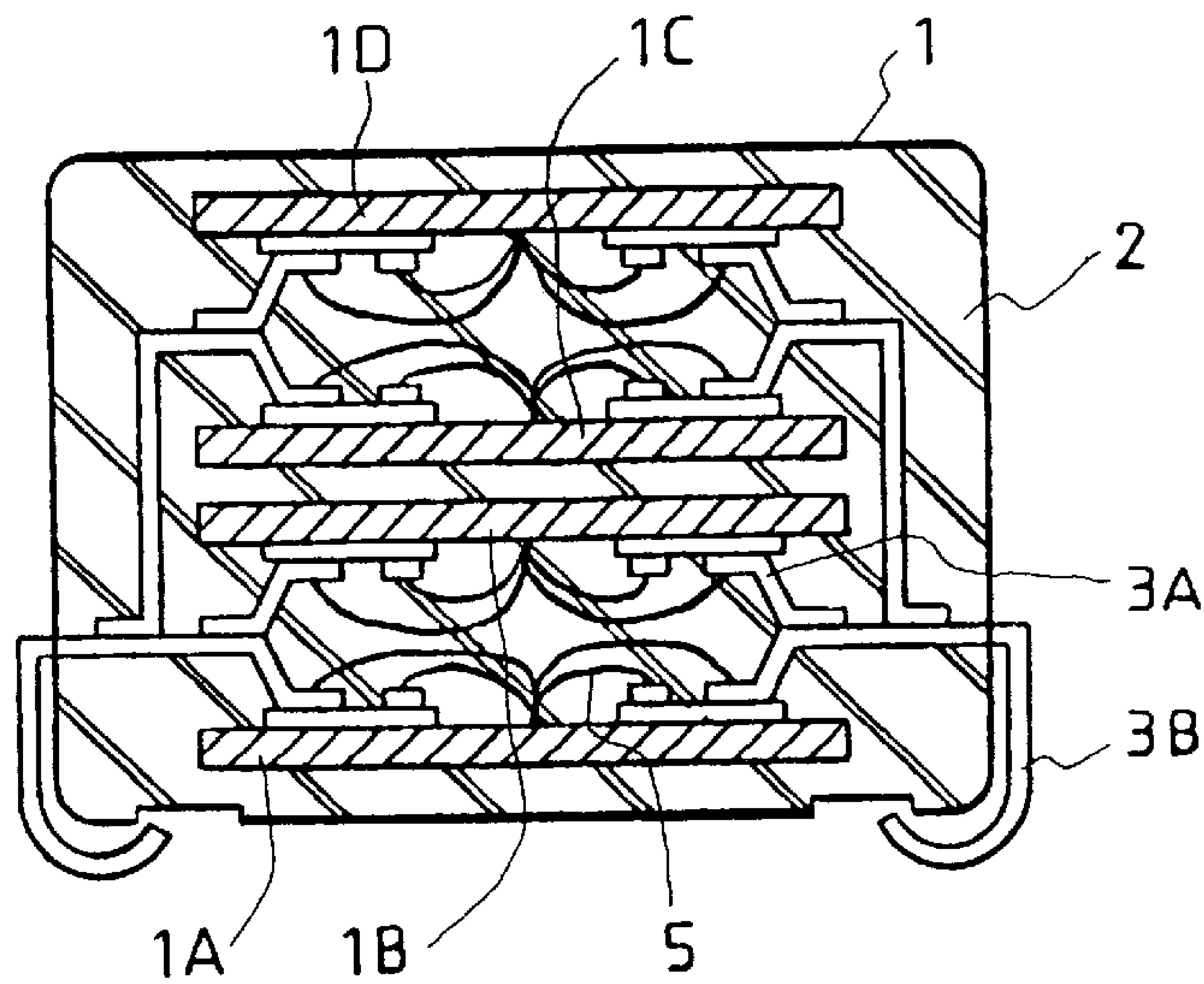


FIG. 32

BONDING OPTIONS OF 64M DRAM SUB CHIPS

F1	F2	F3	TC	BIT CONFIGURATION	CHIP SELECT	I/O TERMINAL
VCC	VCC	--	NC	x 1	NORMAL SELECT	Din/Dout
VCC	NC	--	NC	x 4	NORMAL SELECT	DI00~DI03
NC	NC	--	NC	x 8	NORMAL SELECT	DI00~DI07
--	--	NC	VCC	--	SELECT AT X13=H	--
--	--	VCC	VCC	--	SELECT AT X1L L	--

NC: NO SELECT
--: DON'T CARE

FIG. 33

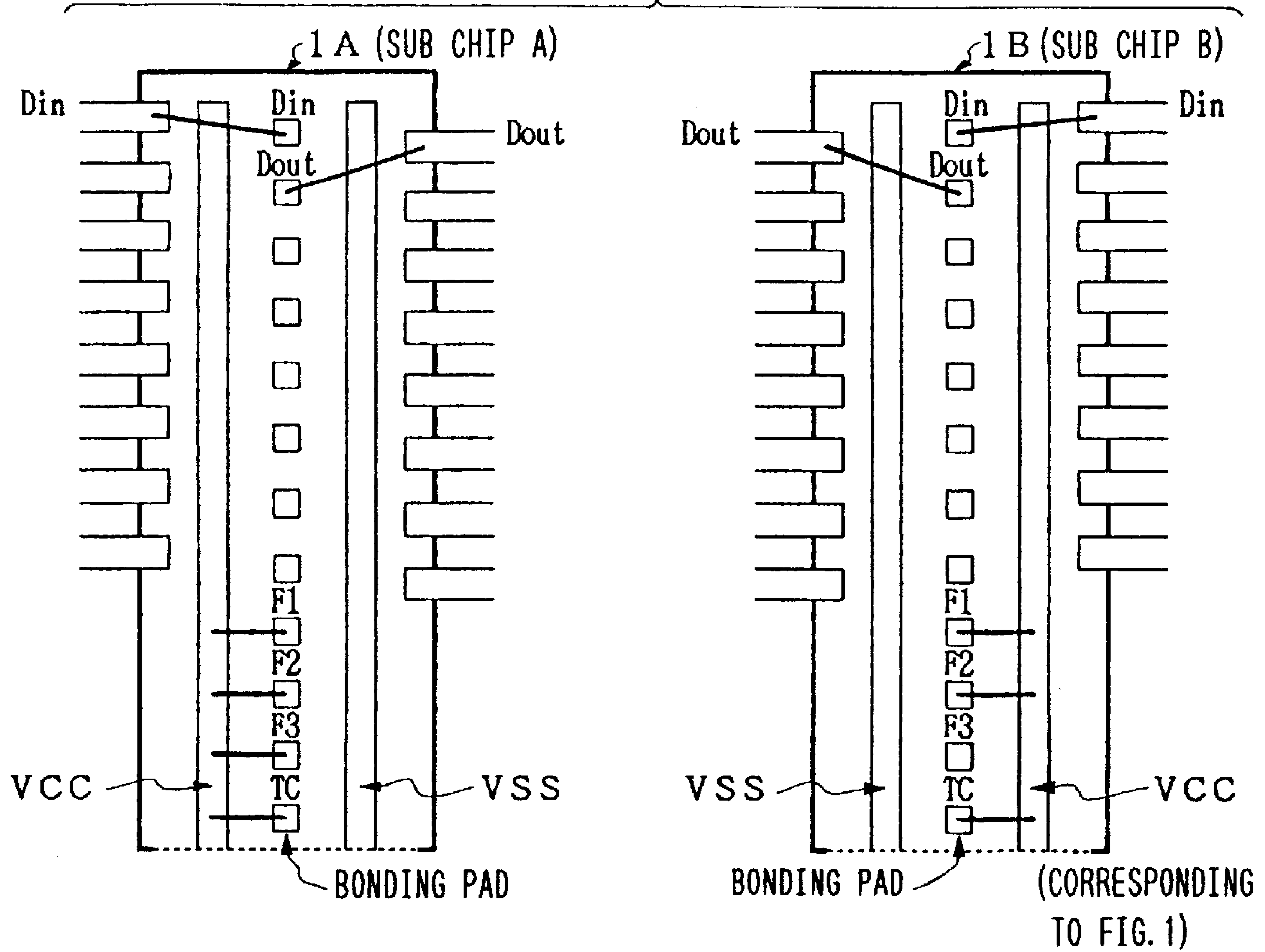


FIG. 34

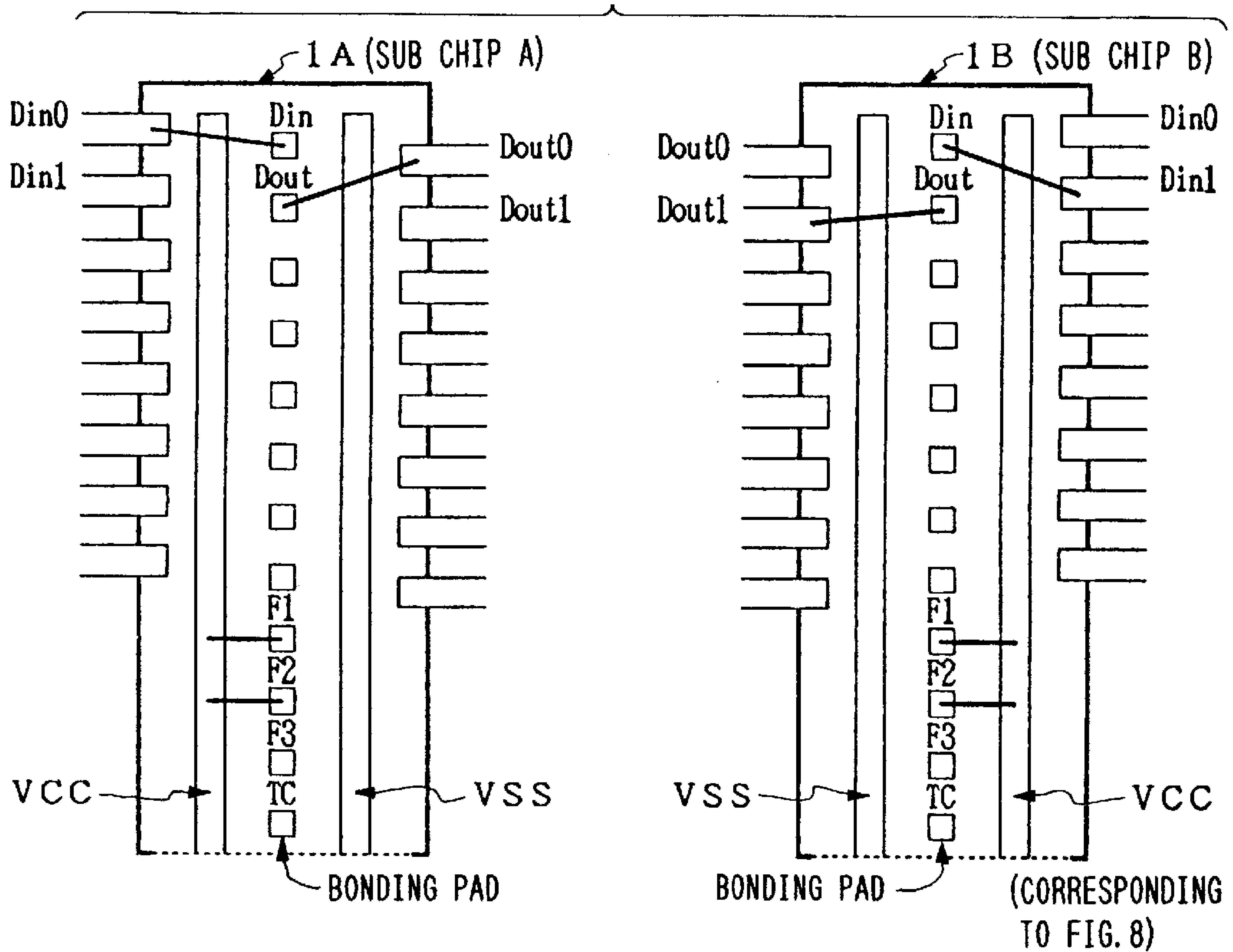


FIG. 35

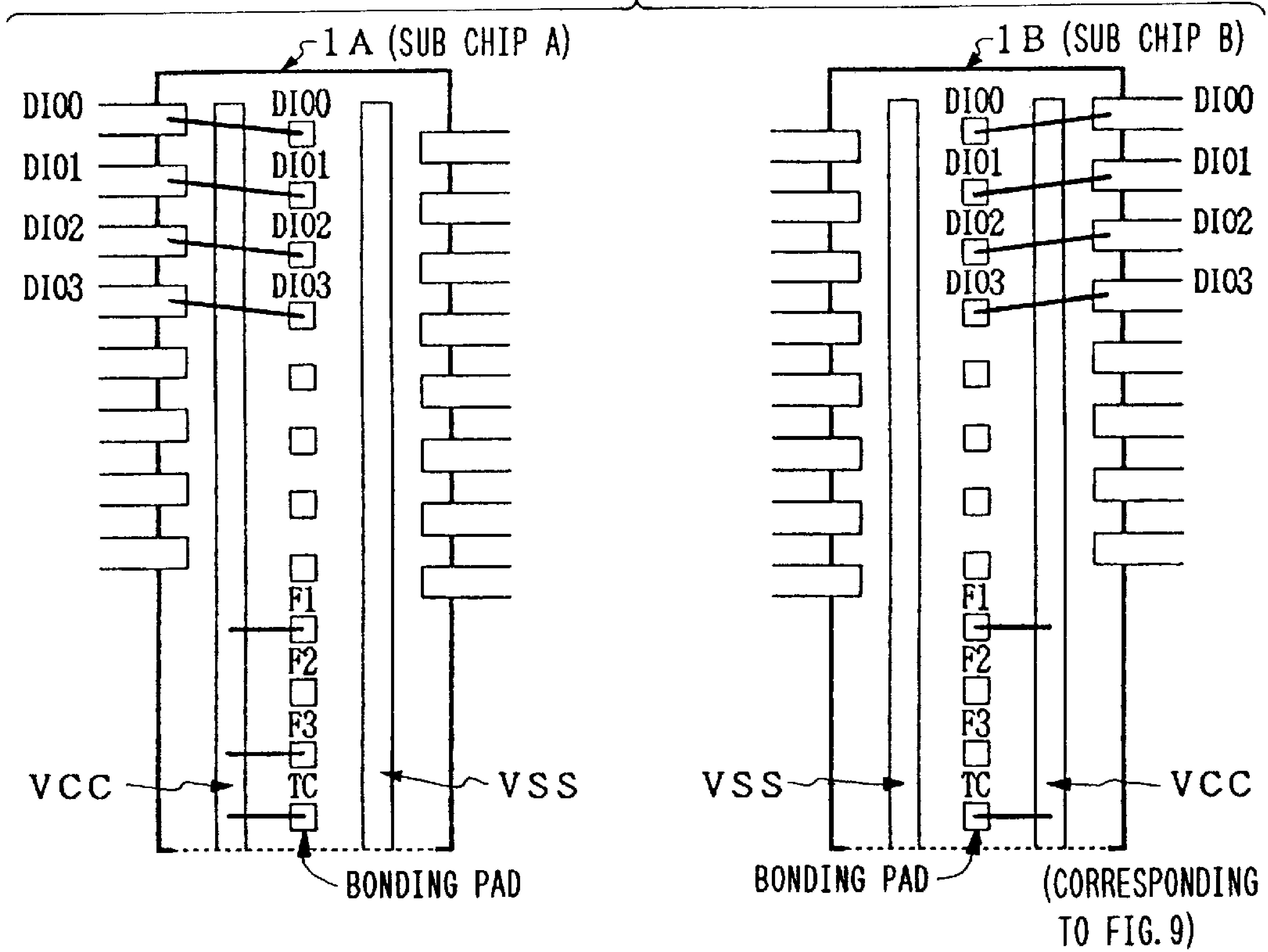


FIG. 36

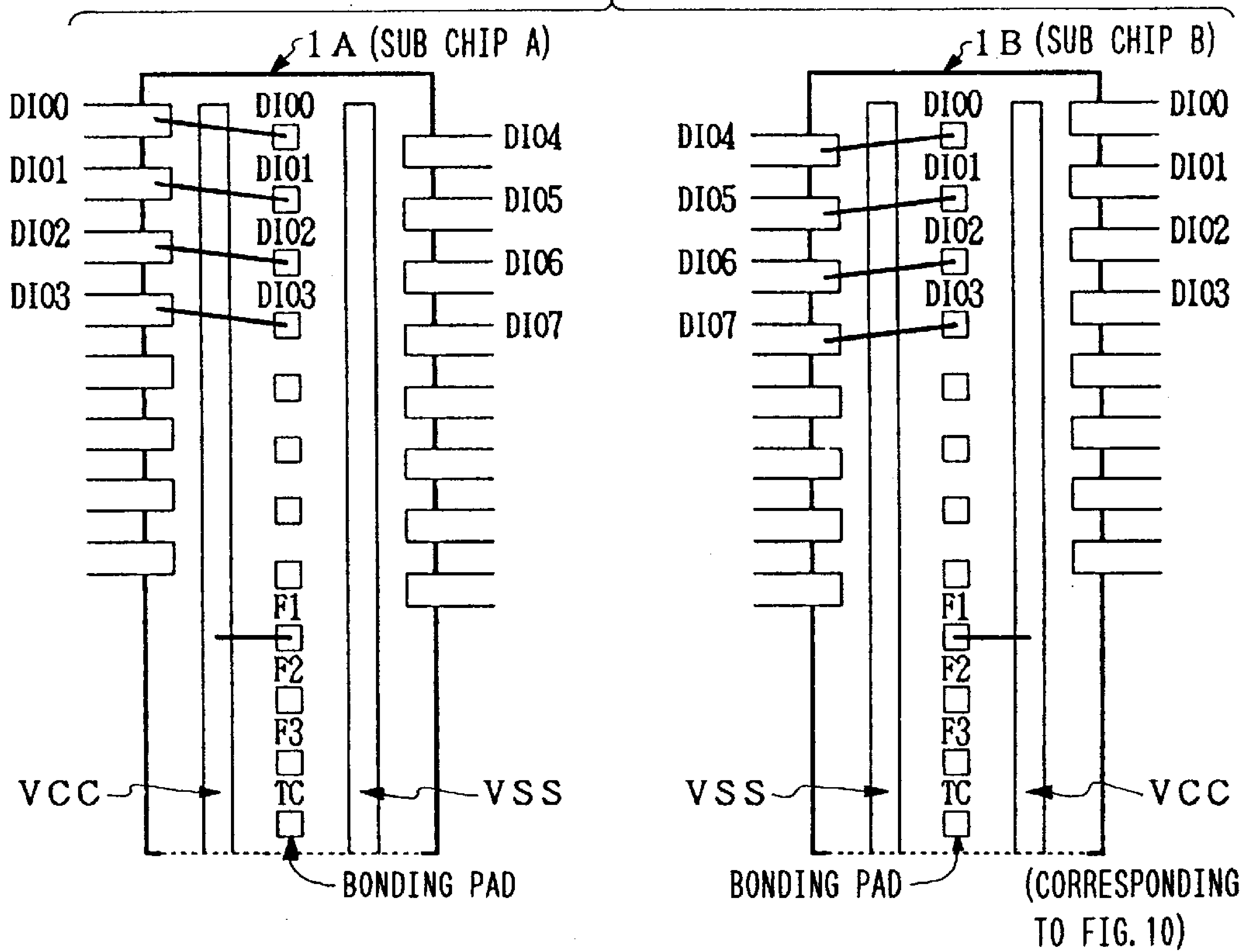


FIG. 37

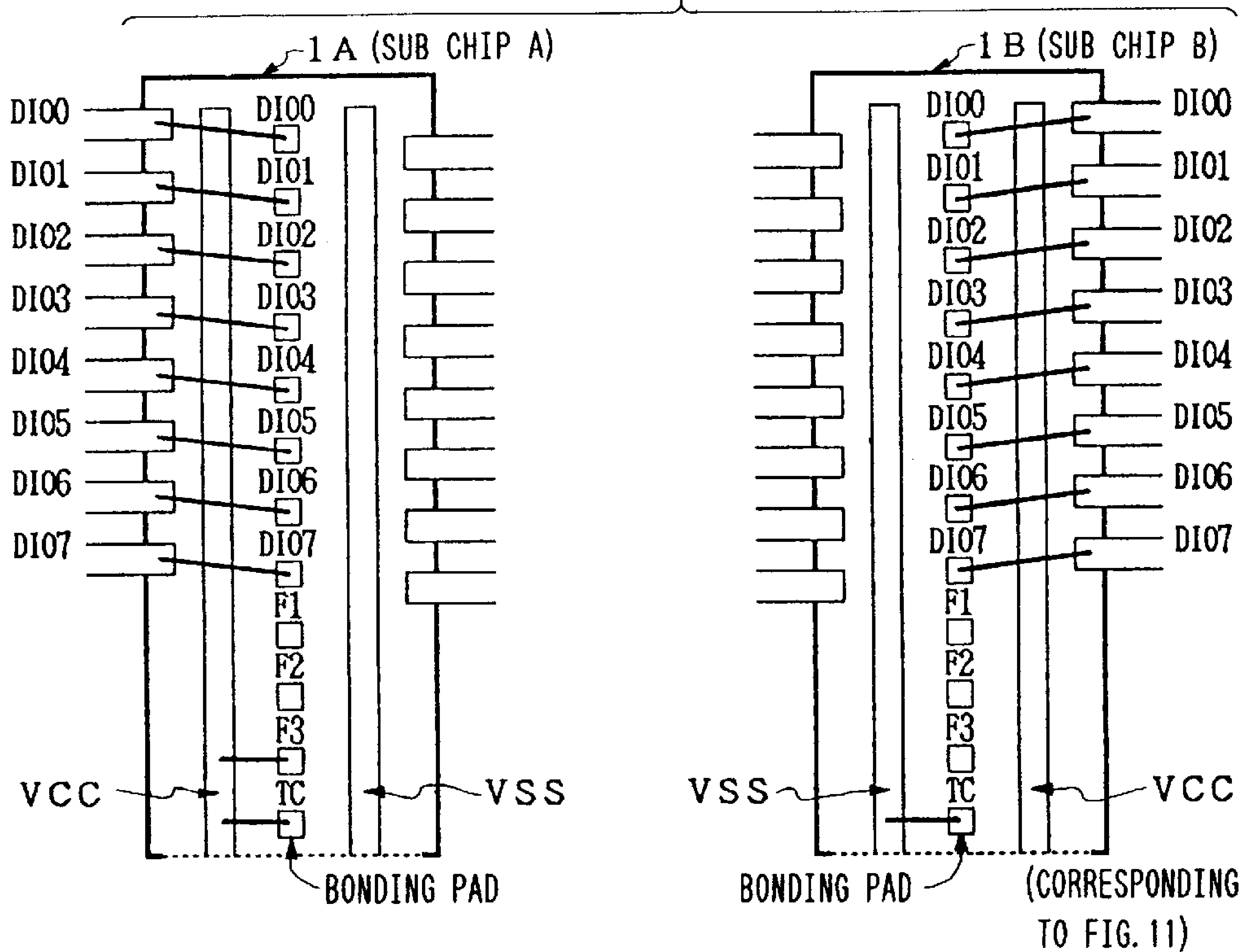


FIG. 38

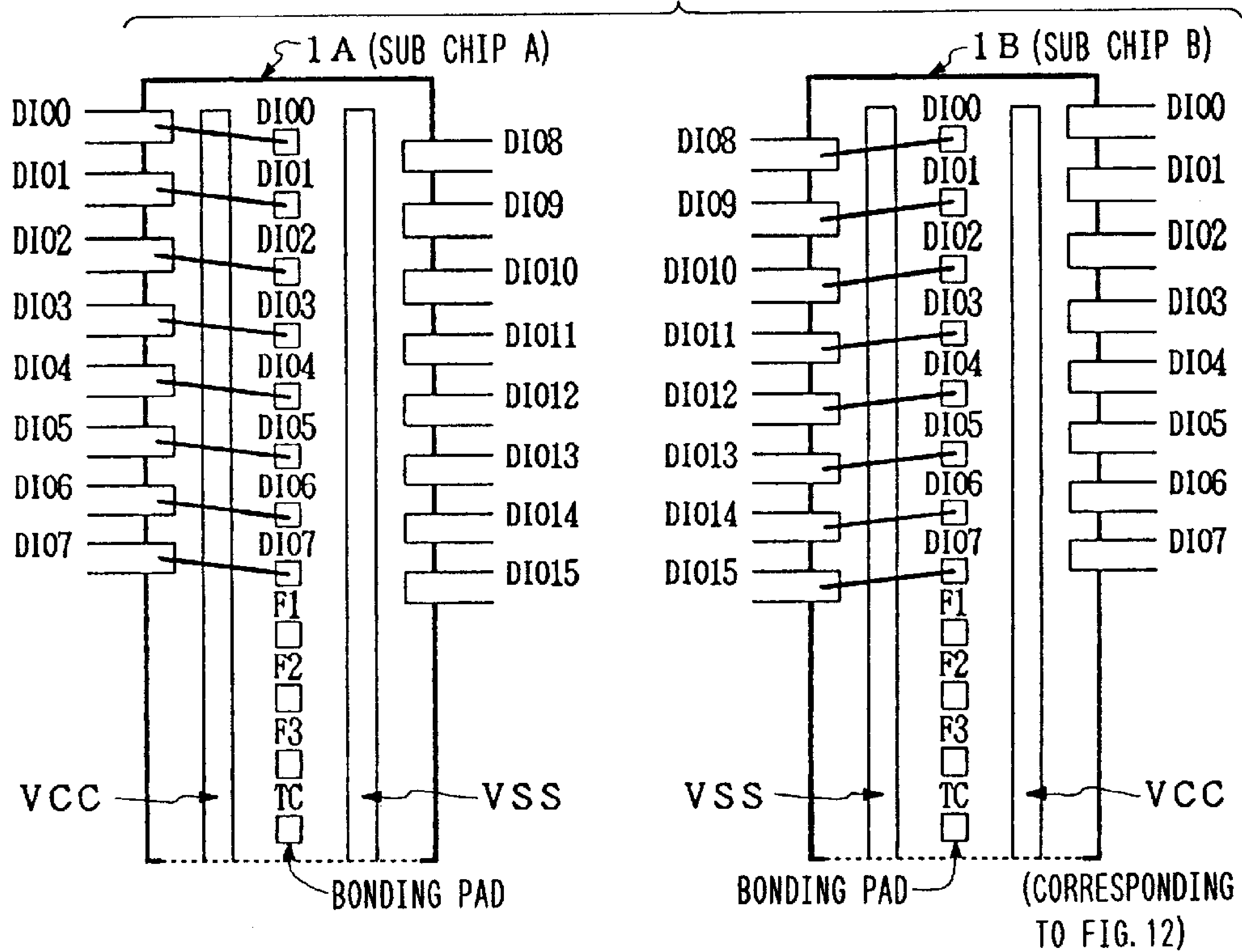


FIG. 39

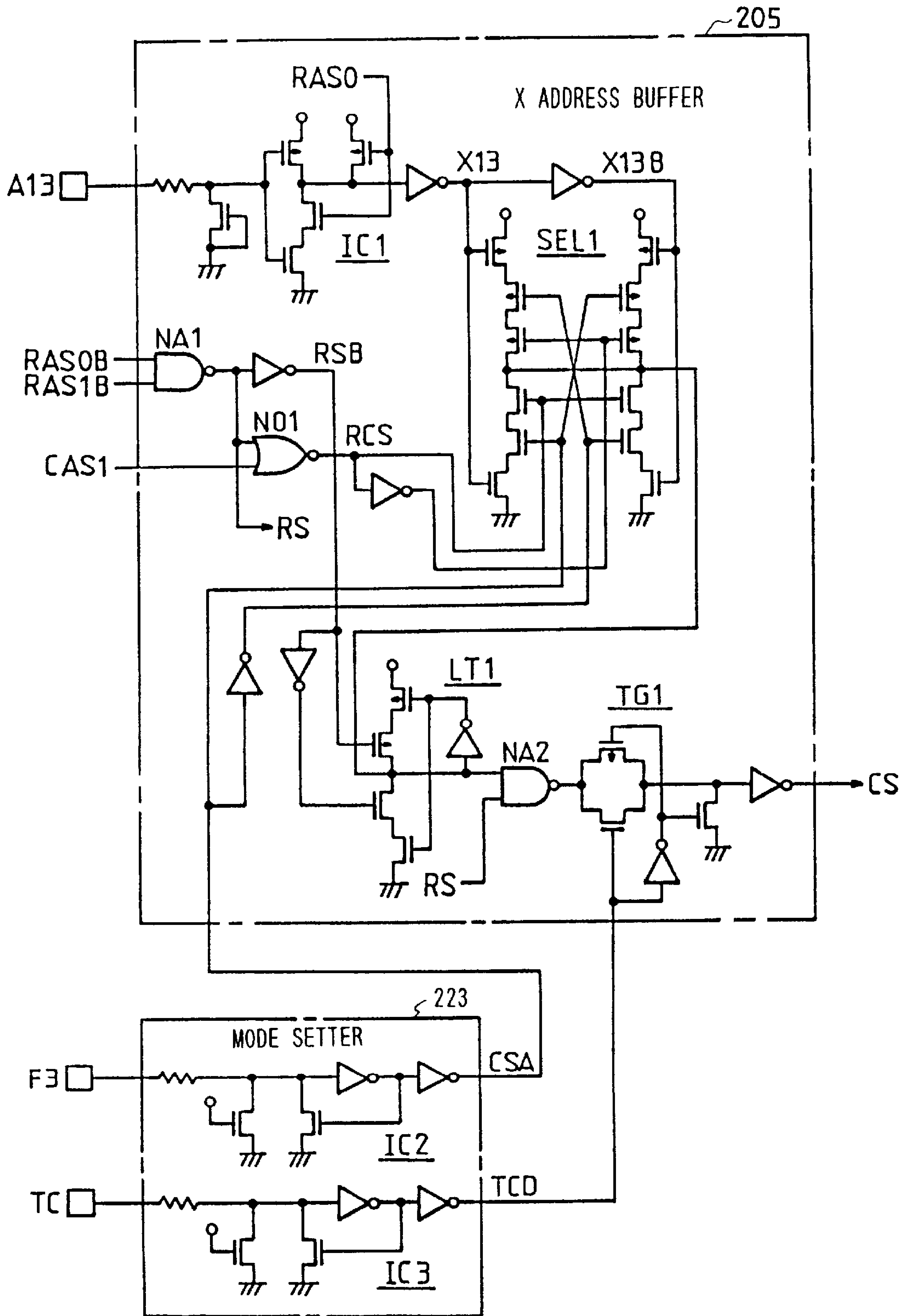


FIG. 40

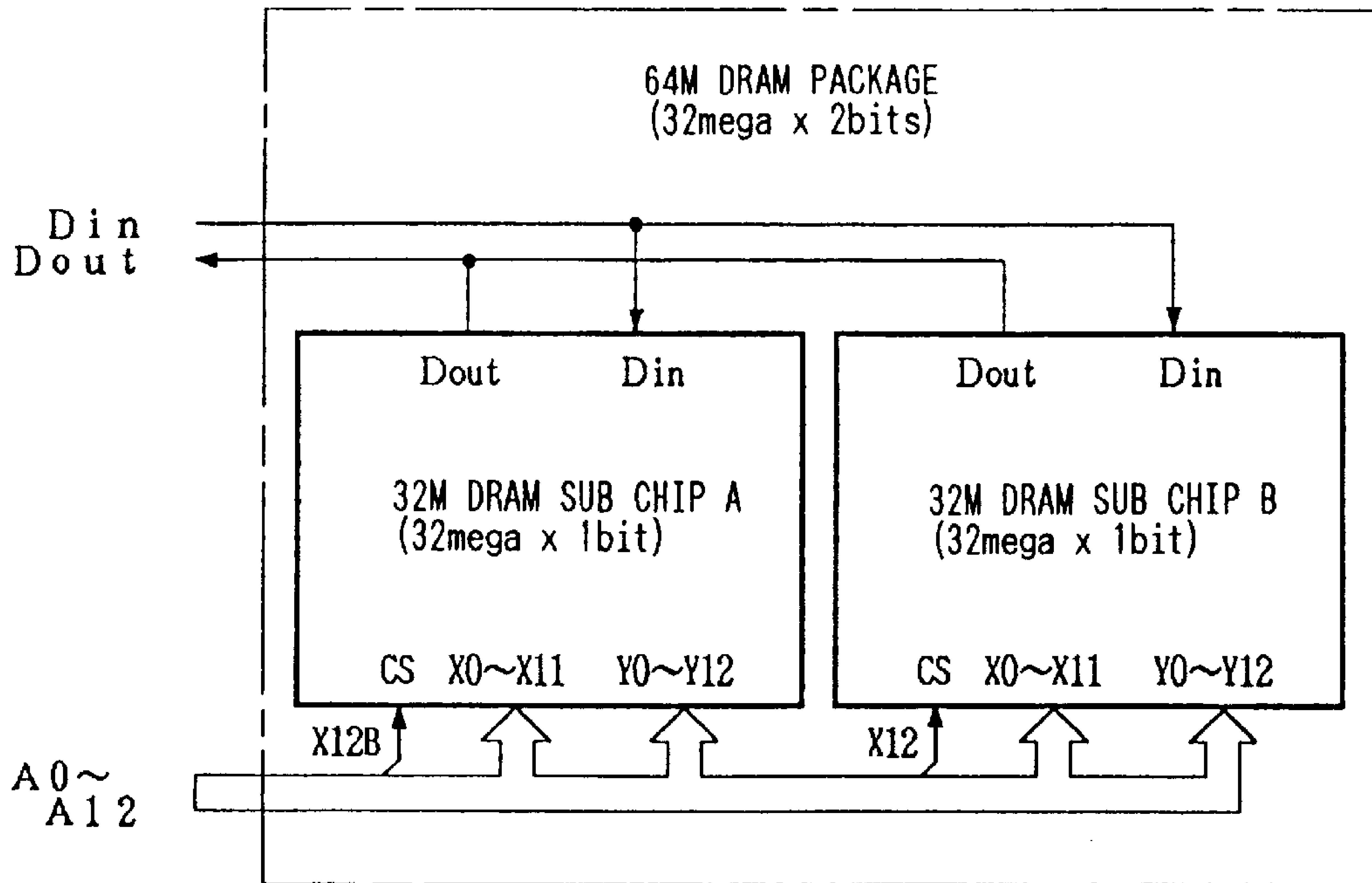


FIG. 41

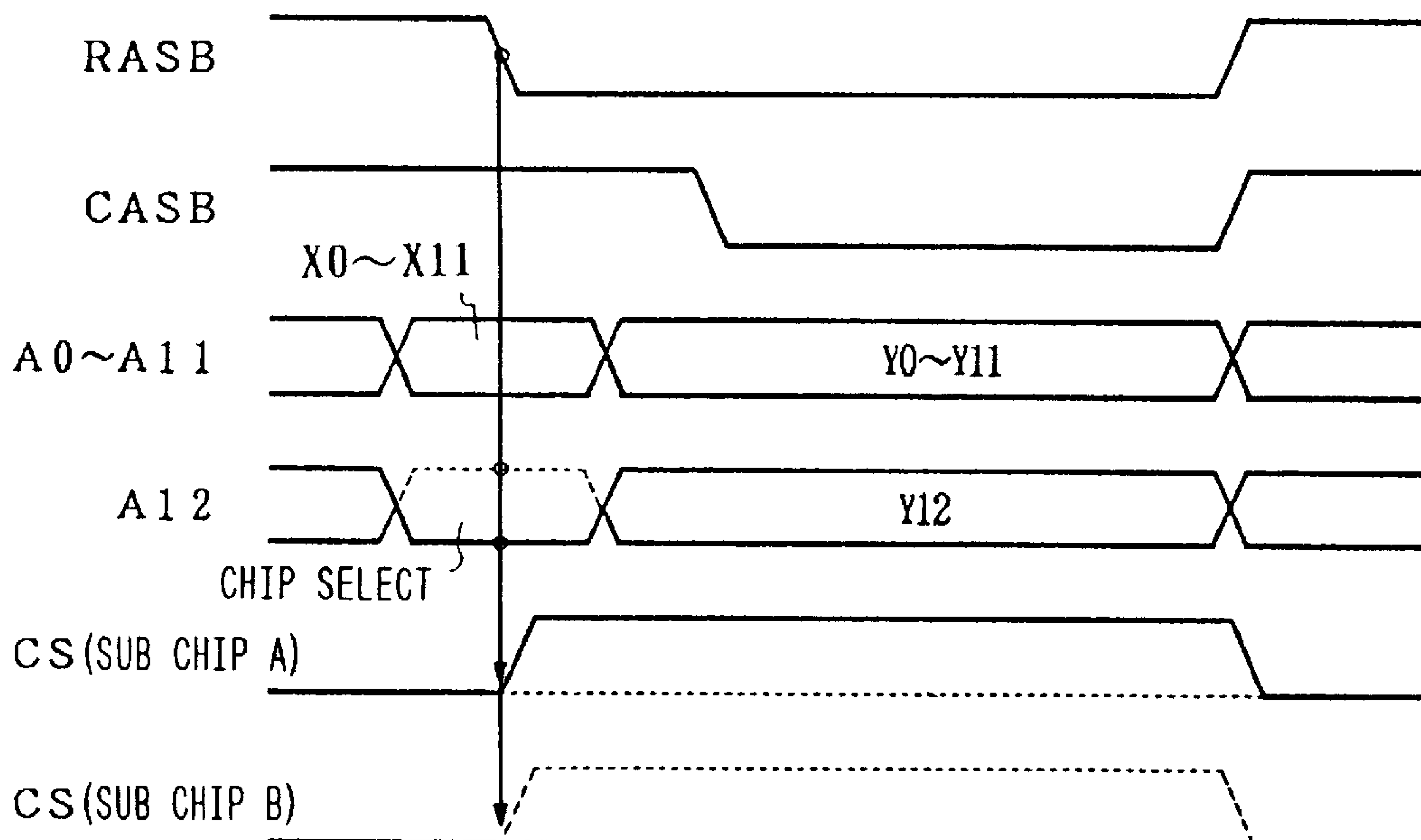
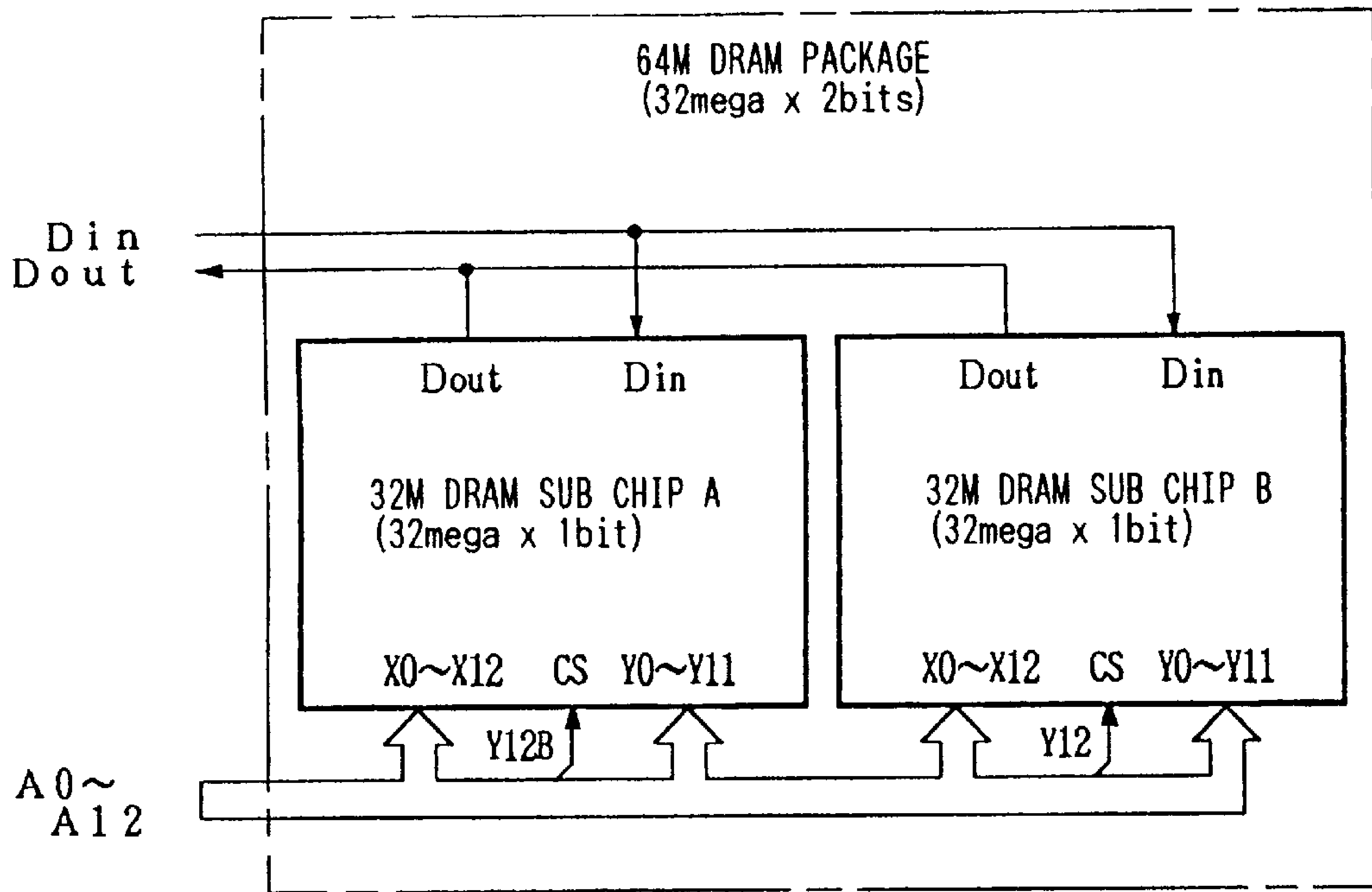


FIG. 42



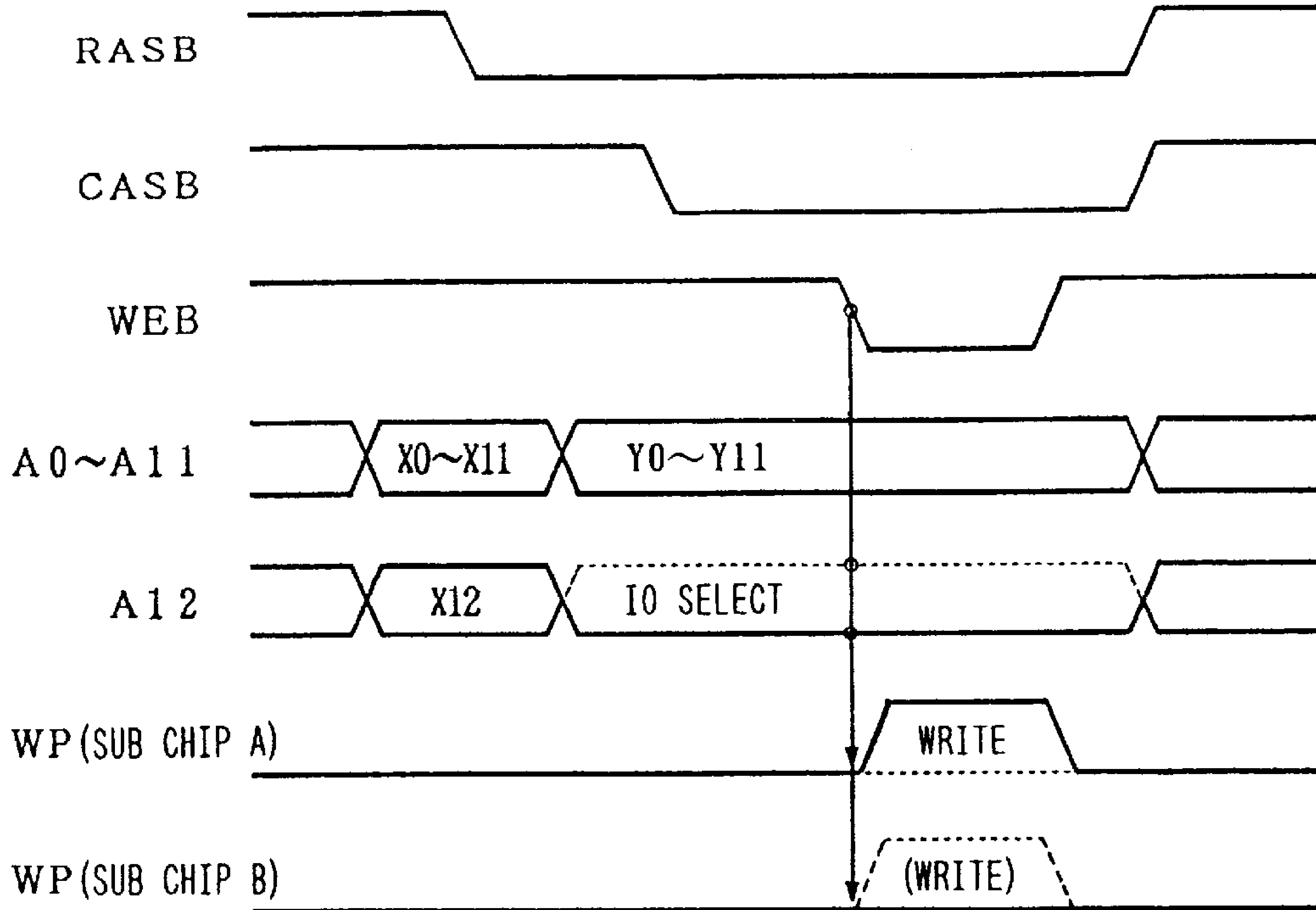


FIG. 43
RASB
CASB
WEB
A0~A11
X0~X11
Y0~Y11
A12
X12
IO SELECT
WP(SUB CHIP A)
WRITE
WP(SUB CHIP B)
(WRITE)

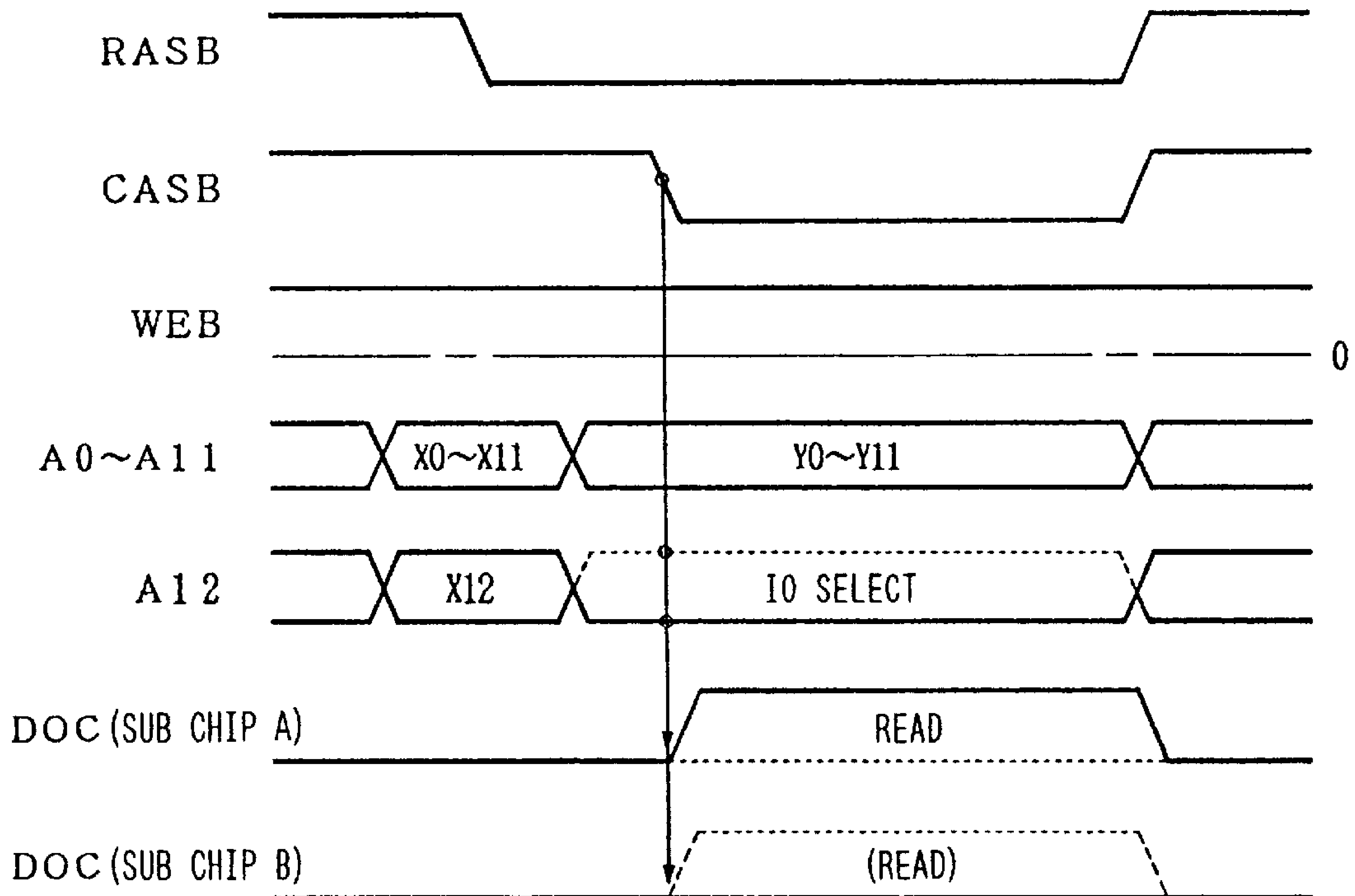


FIG. 44
RASB
CASB
WEB
0
A0~A11
X0~X11
Y0~Y11
A12
X12
IO SELECT
DOC(SUB CHIP A)
READ
DOC(SUB CHIP B)
(READ)

FIG. 45

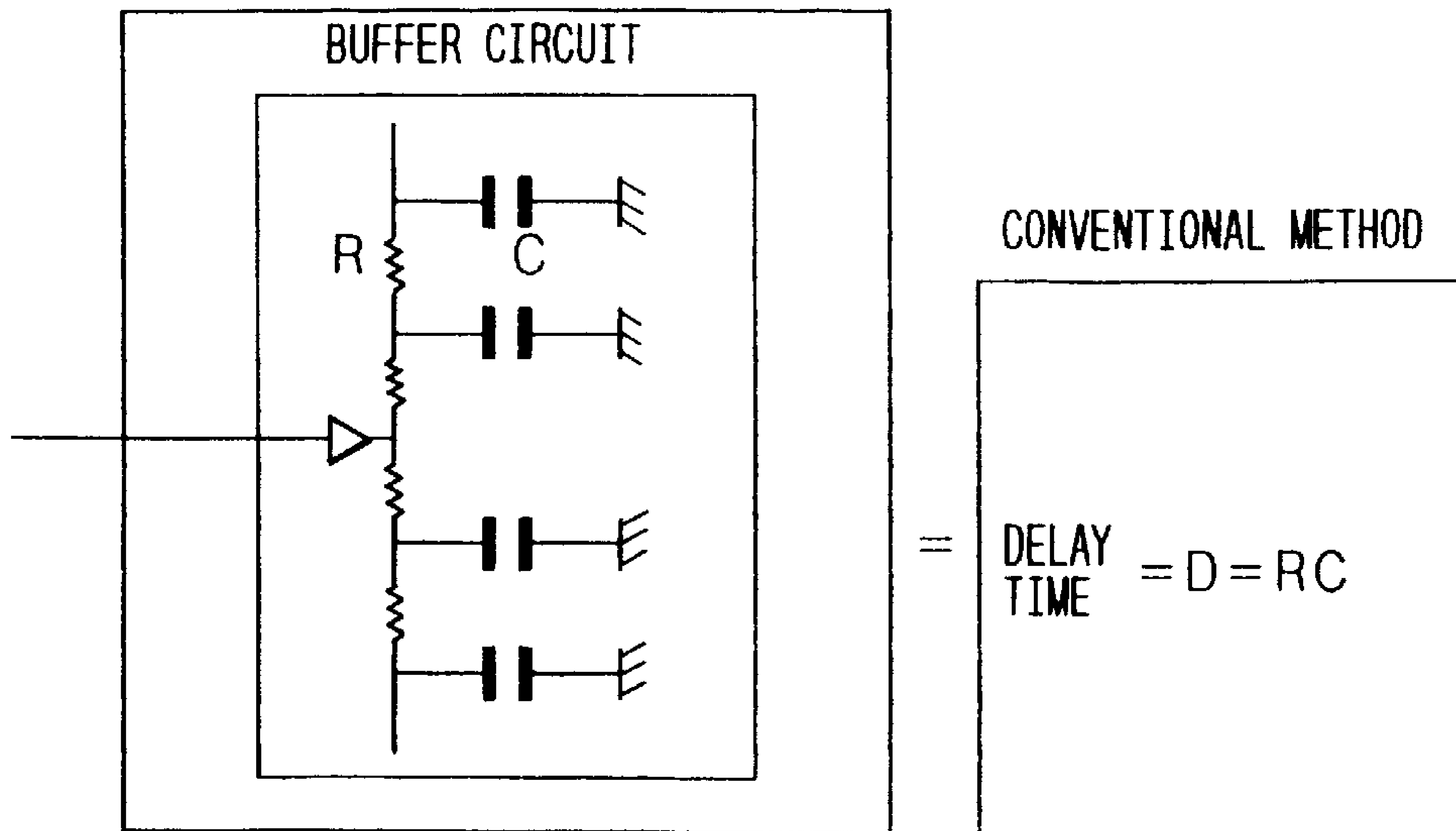


FIG. 46

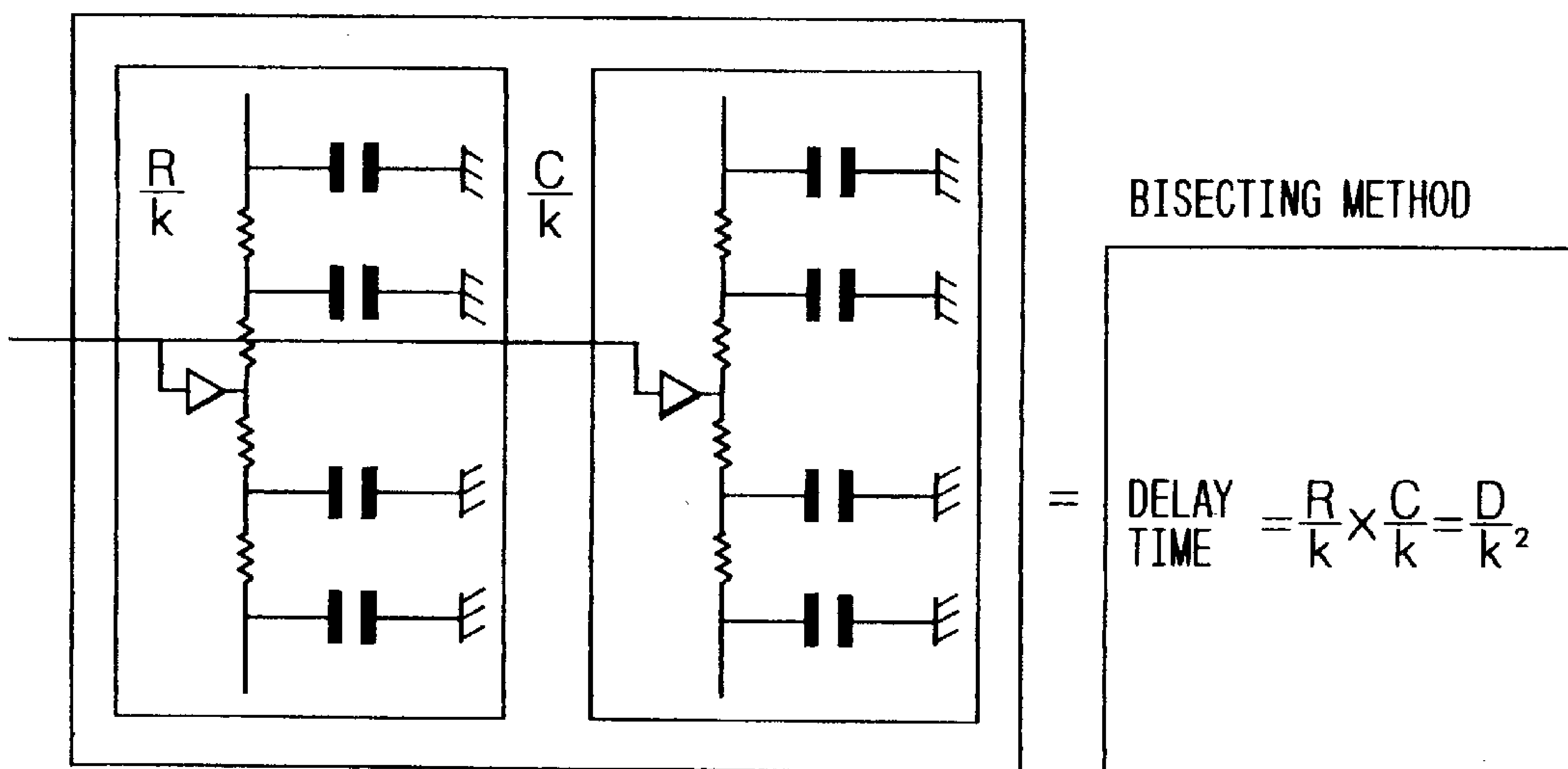


FIG. 47

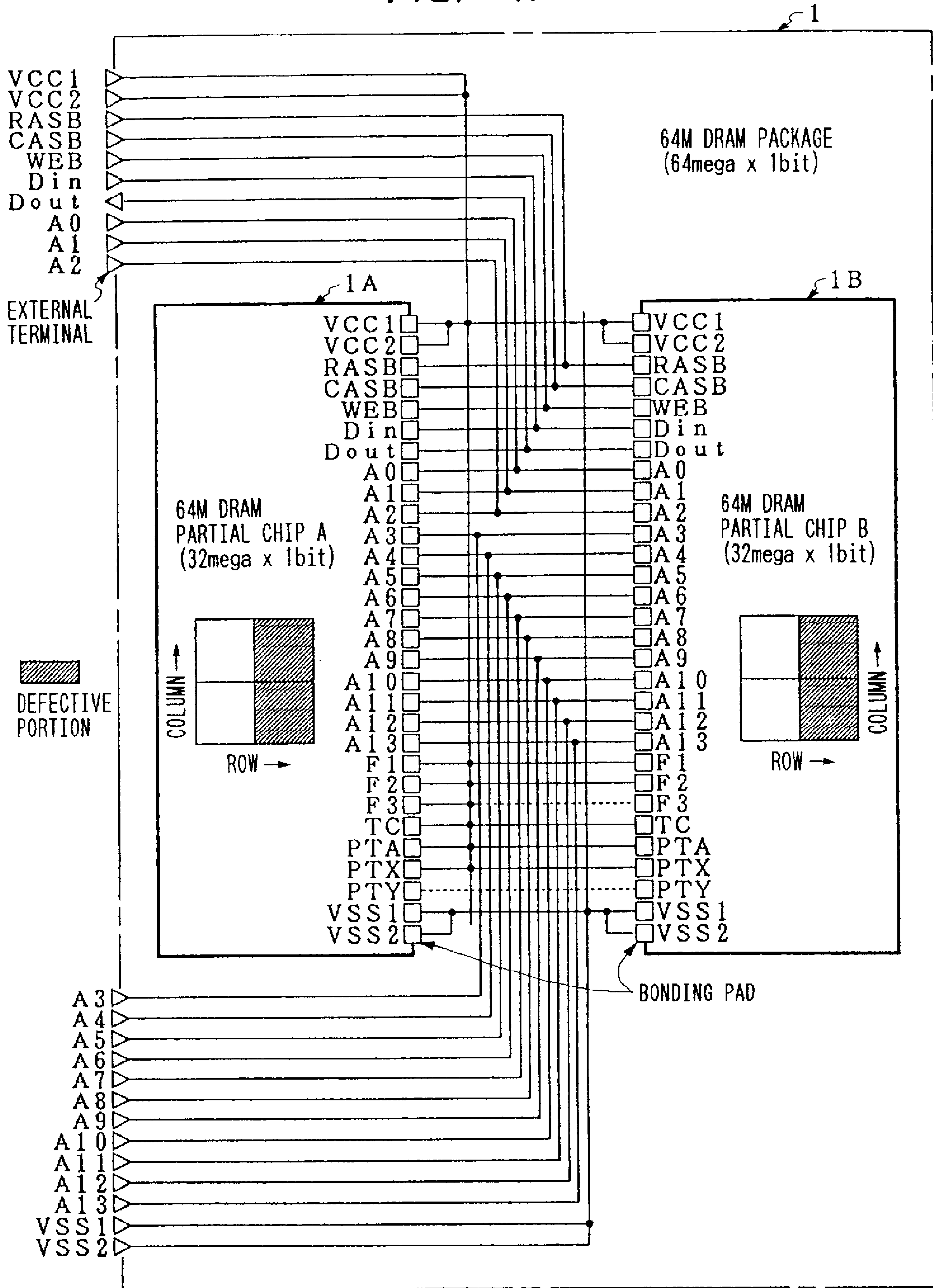


FIG. 48

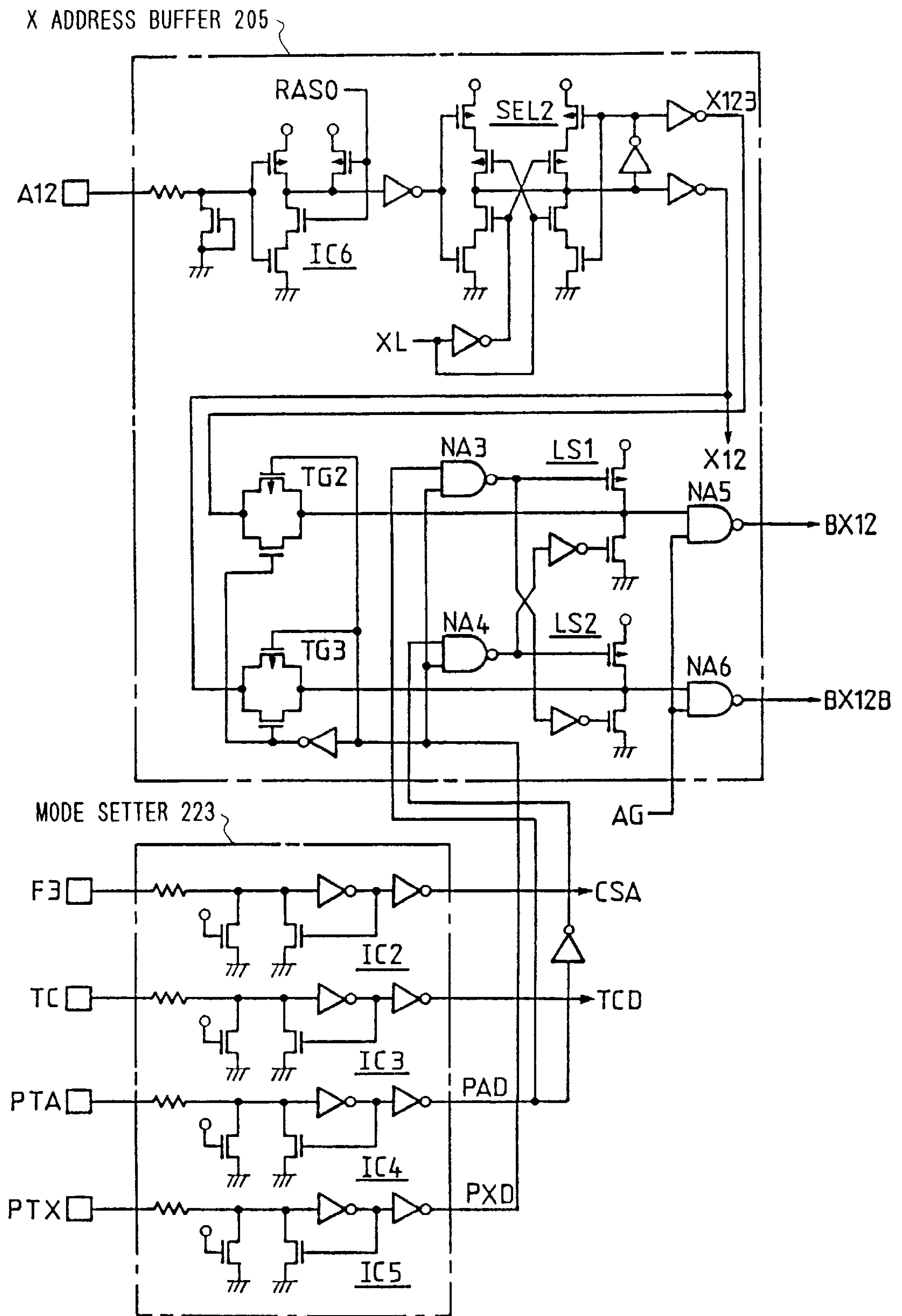


FIG. 49

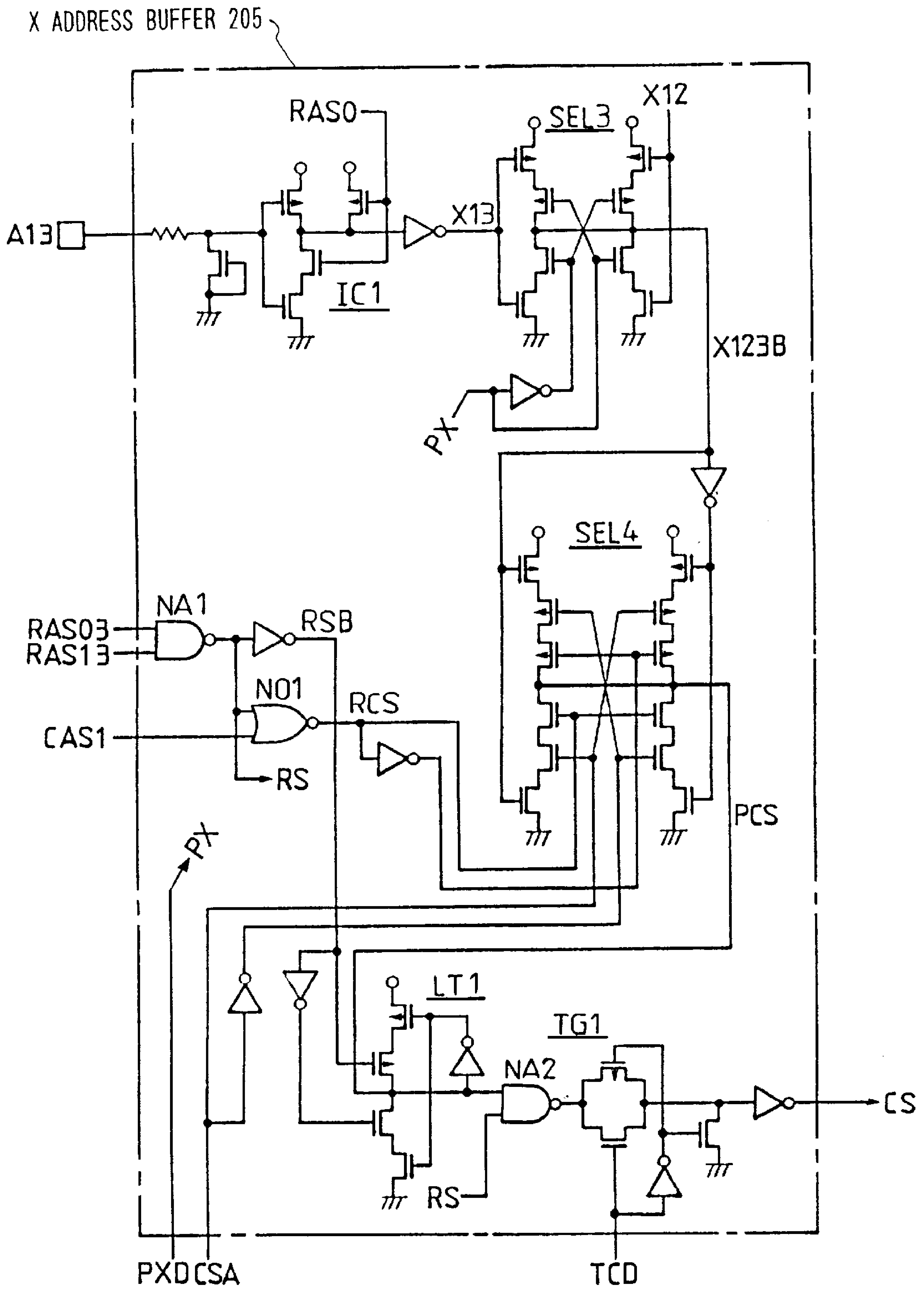


FIG. 50

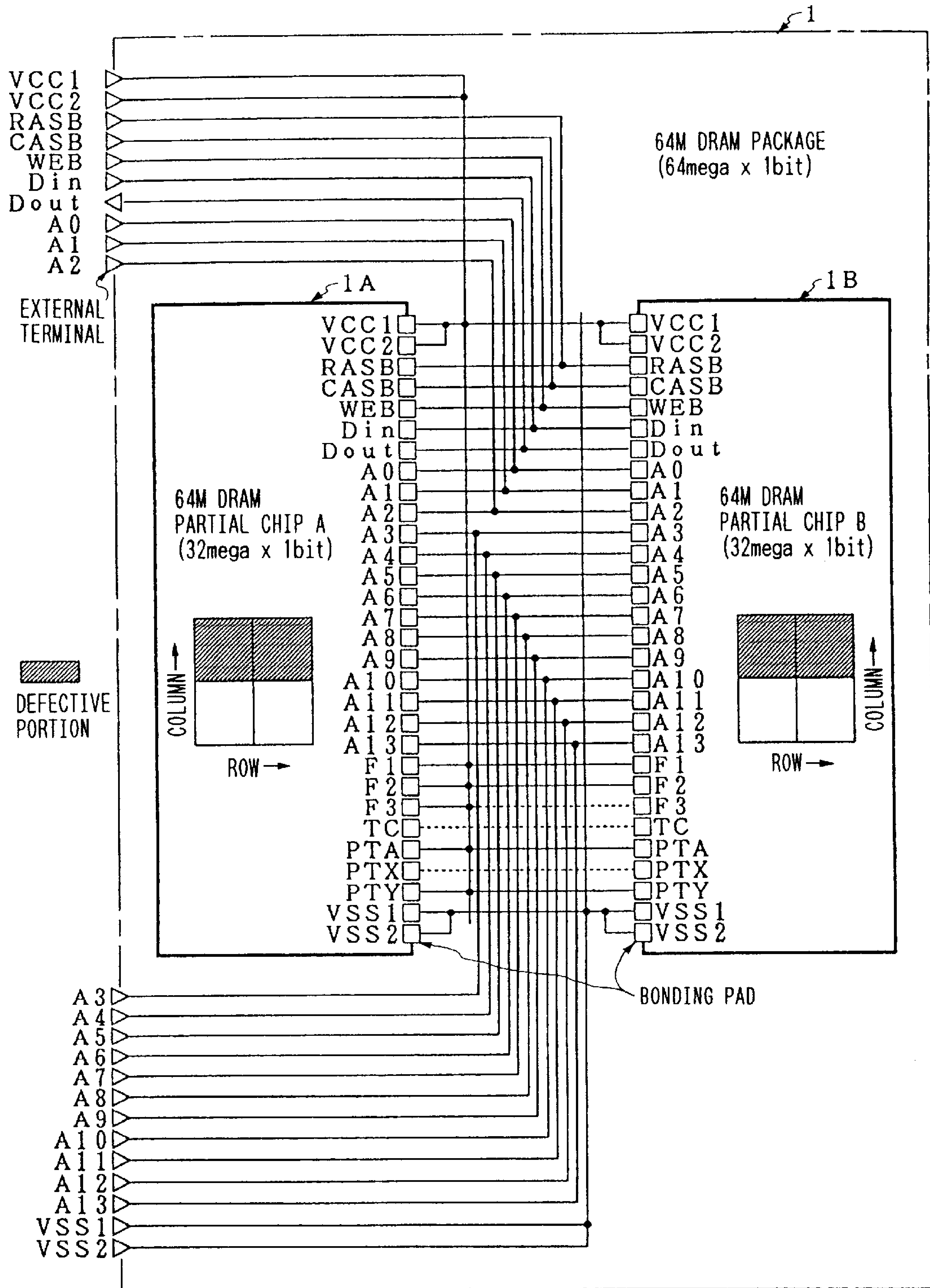


FIG. 51

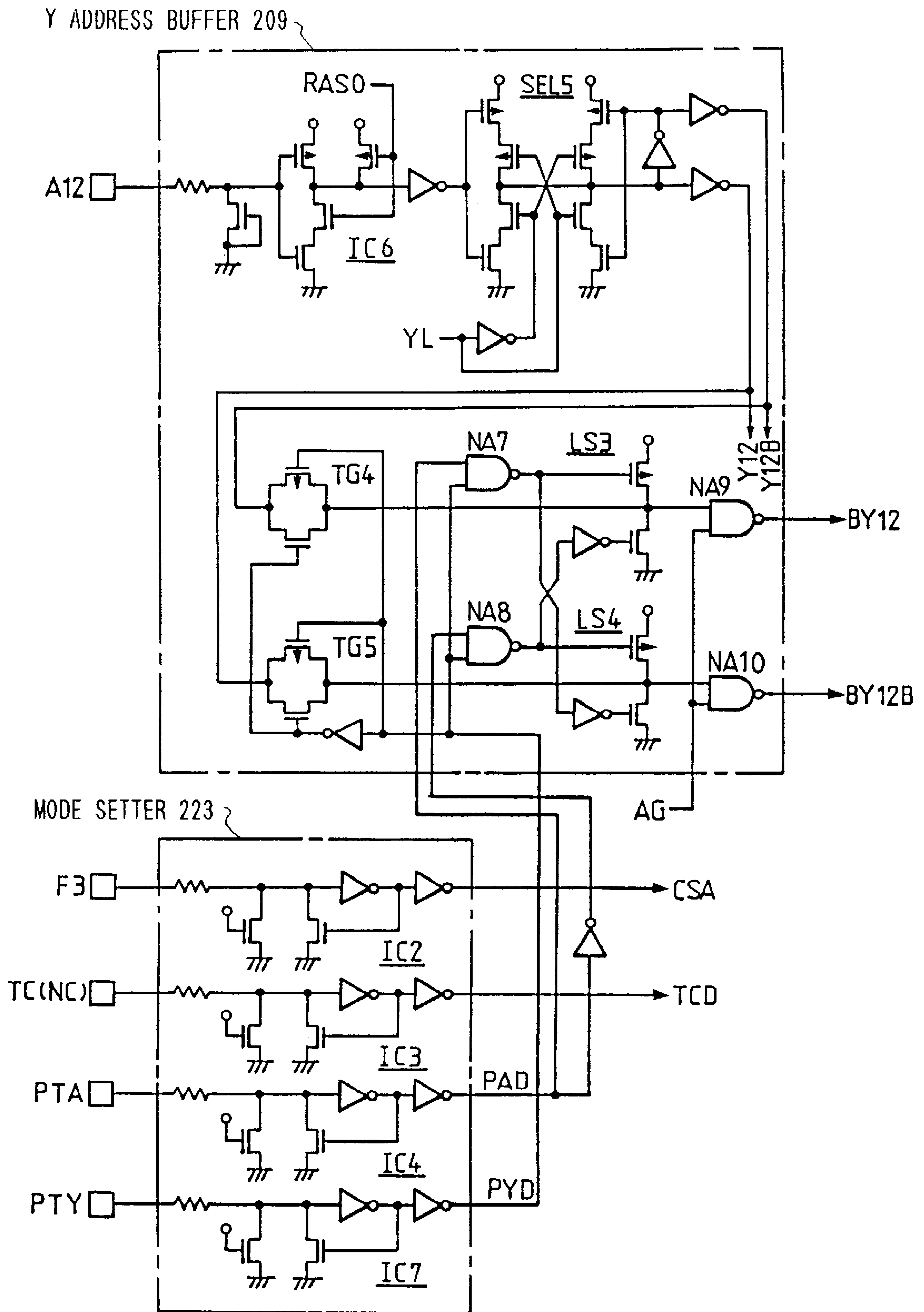


FIG. 52

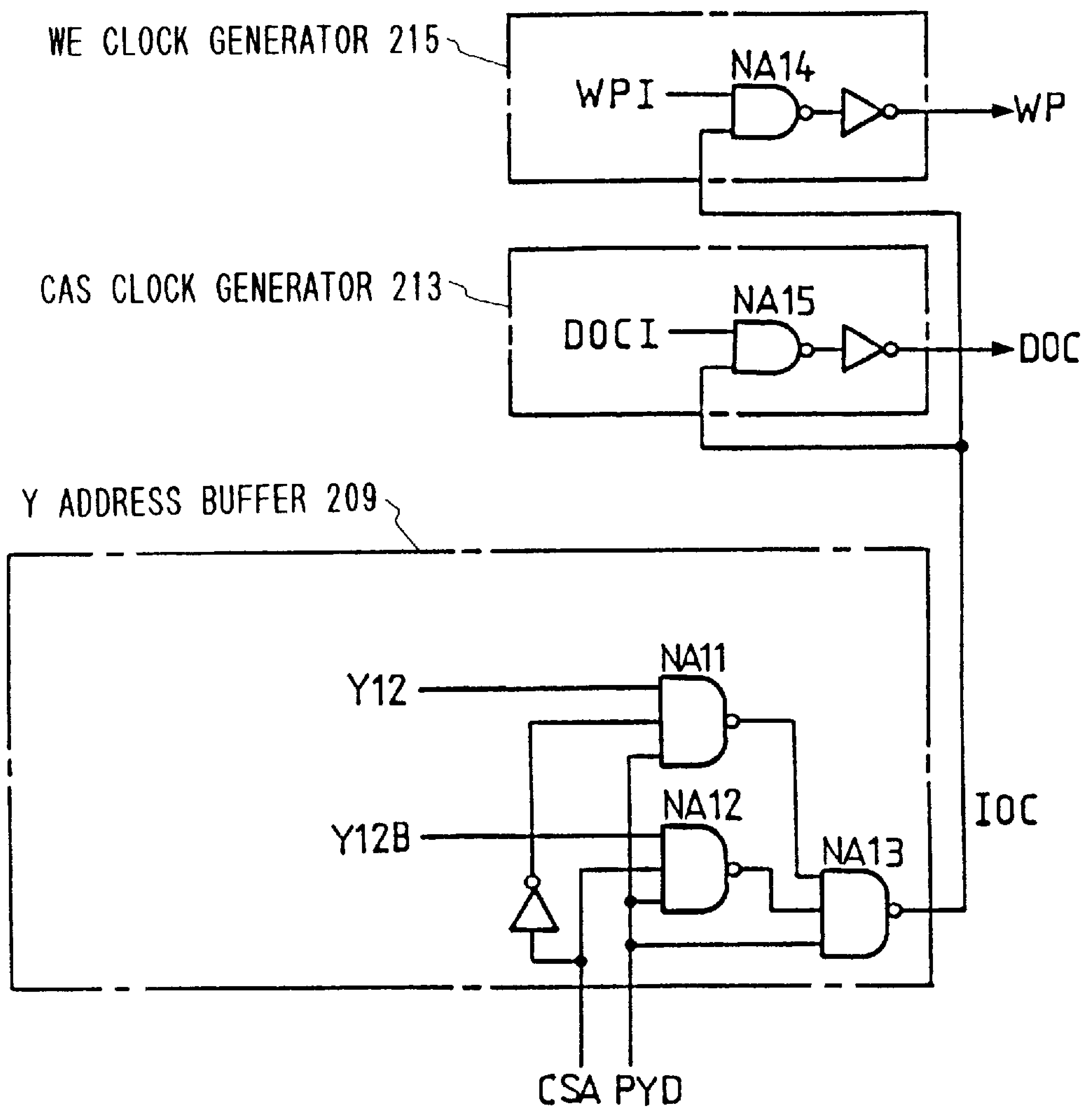


FIG. 53

BONDING OPTIONS OF 64M DRAM PARTIAL CHIPS

F3	TC	PTA	PTX	PTY	BX12	BY12	CHIP SELECT	IO OPERATION
--	NC	--	NC	NC	X12	Y12	NORMAL SELECT	NORMAL EXECUTE
NC	VCC	--	NC	NC	X12	Y12	SELECT AT X13=H	NORMAL EXECUTE
VCC	VCC	--	NC	NC	X12	Y12	SELECT AT X13=L	NORMAL EXECUTE
NC	VCC	NC	VCC	NC	H FIX	Y12	SELECT AT X12=H	NORMAL EXECUTE
NC	VCC	VCC	VCC	NC	L FIX	Y12	SELECT AT X12=H	NORMAL EXECUTE
VCC	VCC	NC	VCC	NC	H FIX	Y12	SELECT AT X12=L	NORMAL EXECUTE
VCC	VCC	VCC	VCC	NC	L FIX	Y12	SELECT AT X12=L	NORMAL EXECUTE
NC	NC	NC	NC	VCC	X12	H FIX	NORMAL SELECTH	EXECUTE AT Y12=H
NC	NC	VCC	NC	VCC	X12	L FIX	NORMAL SELECT	EXECUTE AT Y12=H
VCC	NC	NC	NC	VCC	X12	H FIX	NORMAL SELECT	EXECUTE AT Y12=L
VCC	NC	VCC	NC	VCC	X12	L FIX	NORMAL SELECT	EXECUTE AT Y12=L

FIG. 54

VARIATIONS OF 64M DRAM PACKAGE

64M DRAM PARTIAL CHIP				64M DRAM PACKAGE			REMARKS
WORD CON-FIGURATION	BIT CON-FIGURATION	NORMAL PORTION	ACCESS	WORD CON-FIGURATION	BIT CON-FIGURATION	CORRESPOND-ING DIAGRAM	
32mega	x 1	ROW 1/2	SELECTIVE	64mega	x 1	FIG. 47	
32mega	x 1	COLUMN 1/2	SIMULTANEOUS	64mega	x 1	FIG. 50	IO SELECTIVE EXECUTE
16mega	x 2	COLUMN 1/2	SIMULTANEOUS	16mega	x 4	FIG. 55	IO SIMULTANEOUS EXECUTE
8mega	x 4	ROW 1/2	SELECTIVE	16mega	x 4	FIG. 56	
8mega	x 4	COLUMN 1/2	SIMULTANEOUS	16mega	x 4	FIG. 57	IO SELECTIVE EXECUTE
8mega	x 4	COLUMN 1/2	SIMULTANEOUS	8mega	x 8	FIG. 58	IO SIMULTANEOUS EXECUTE
4mega	x 8	ROW 1/2	SELECTIVE	8mega	x 8	FIG. 59	

FIG. 55

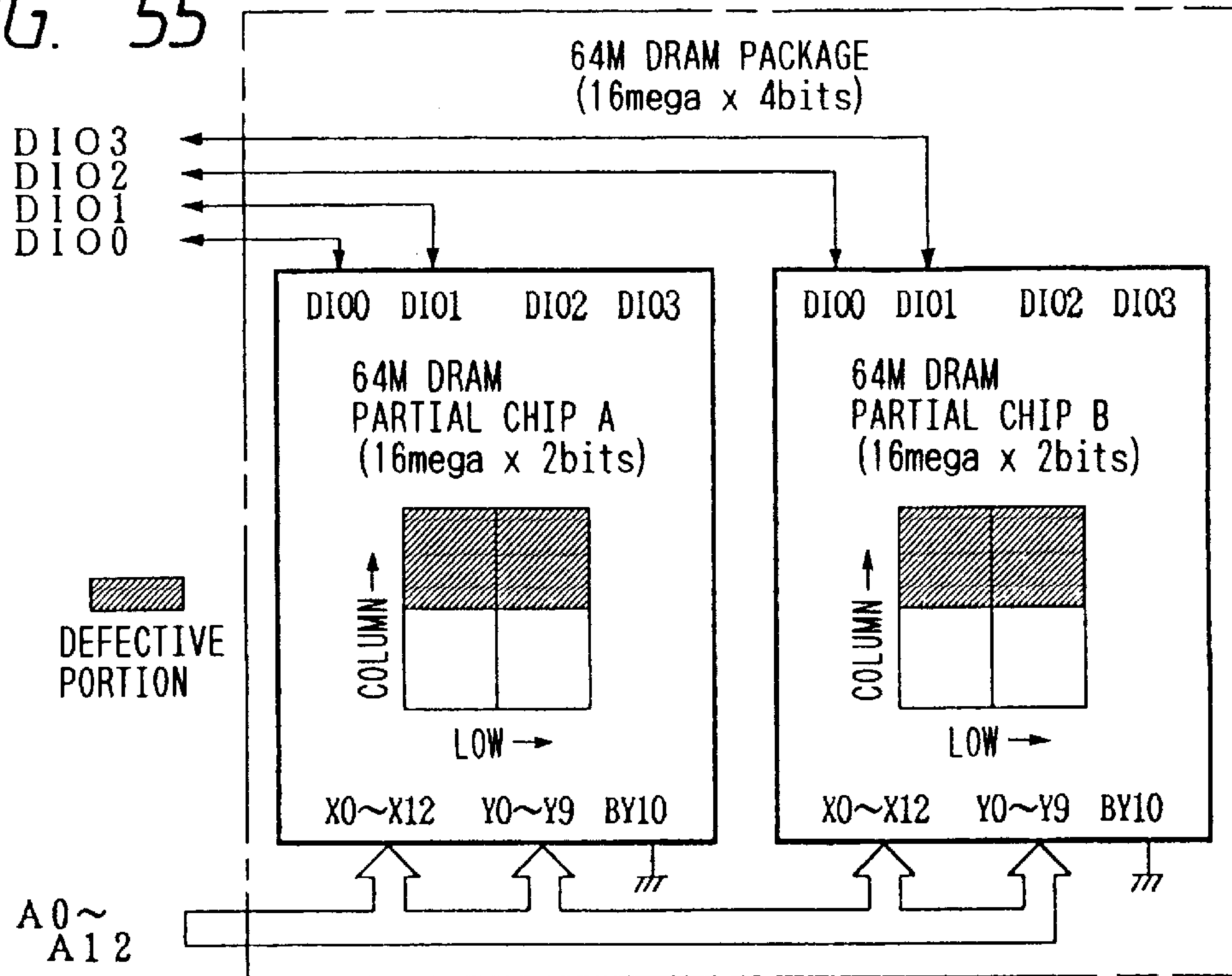


FIG. 56

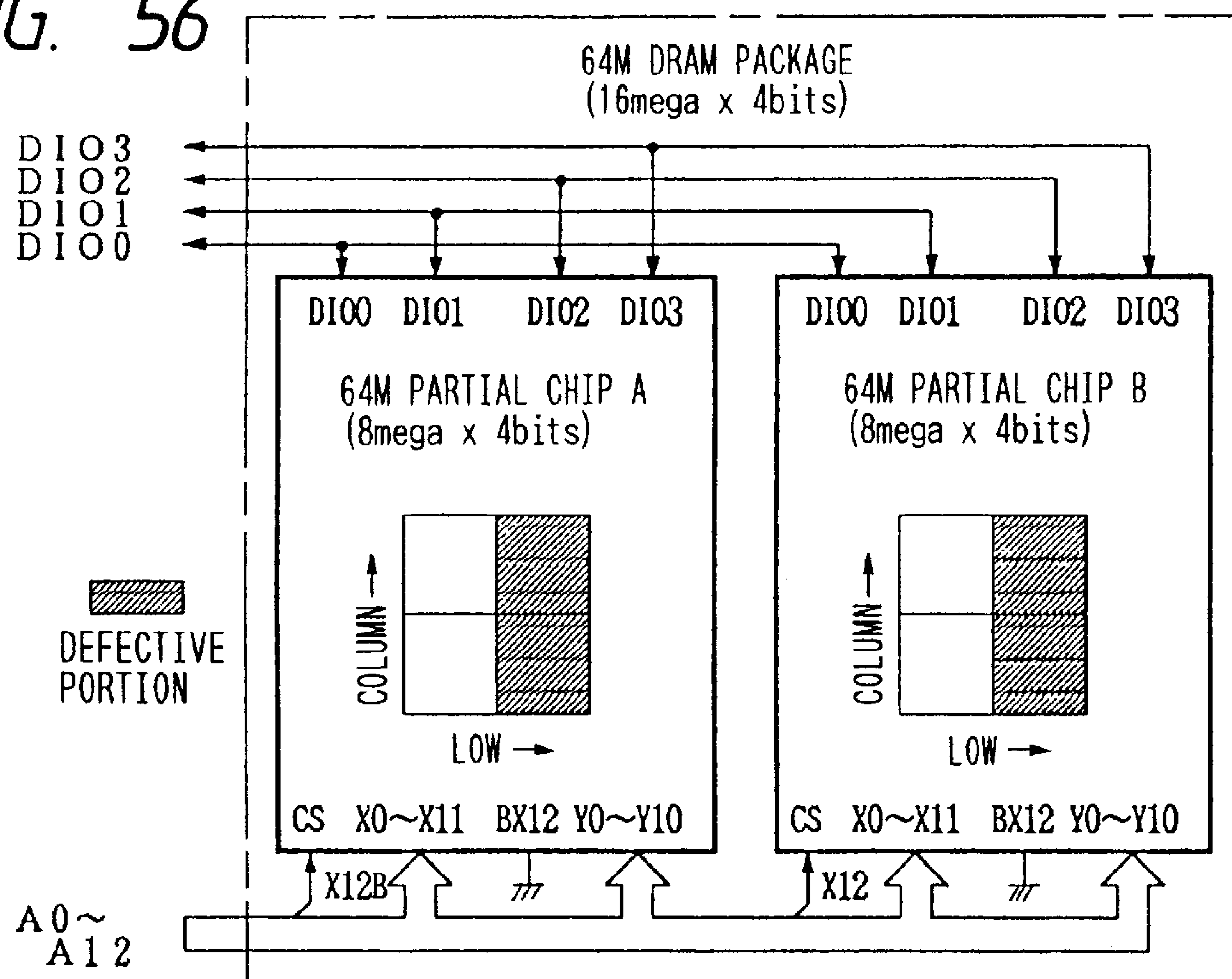


FIG. 57

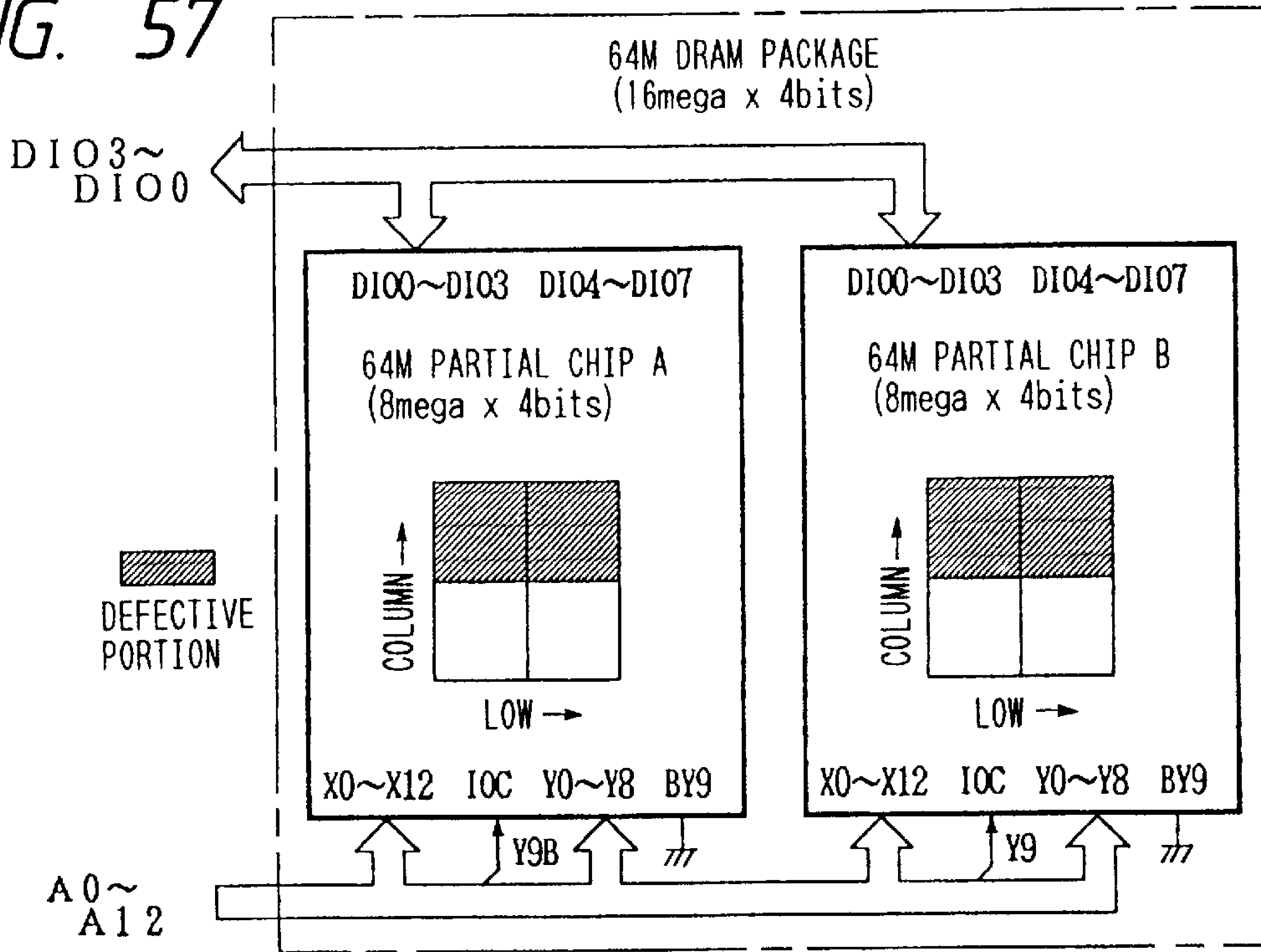


FIG. 58

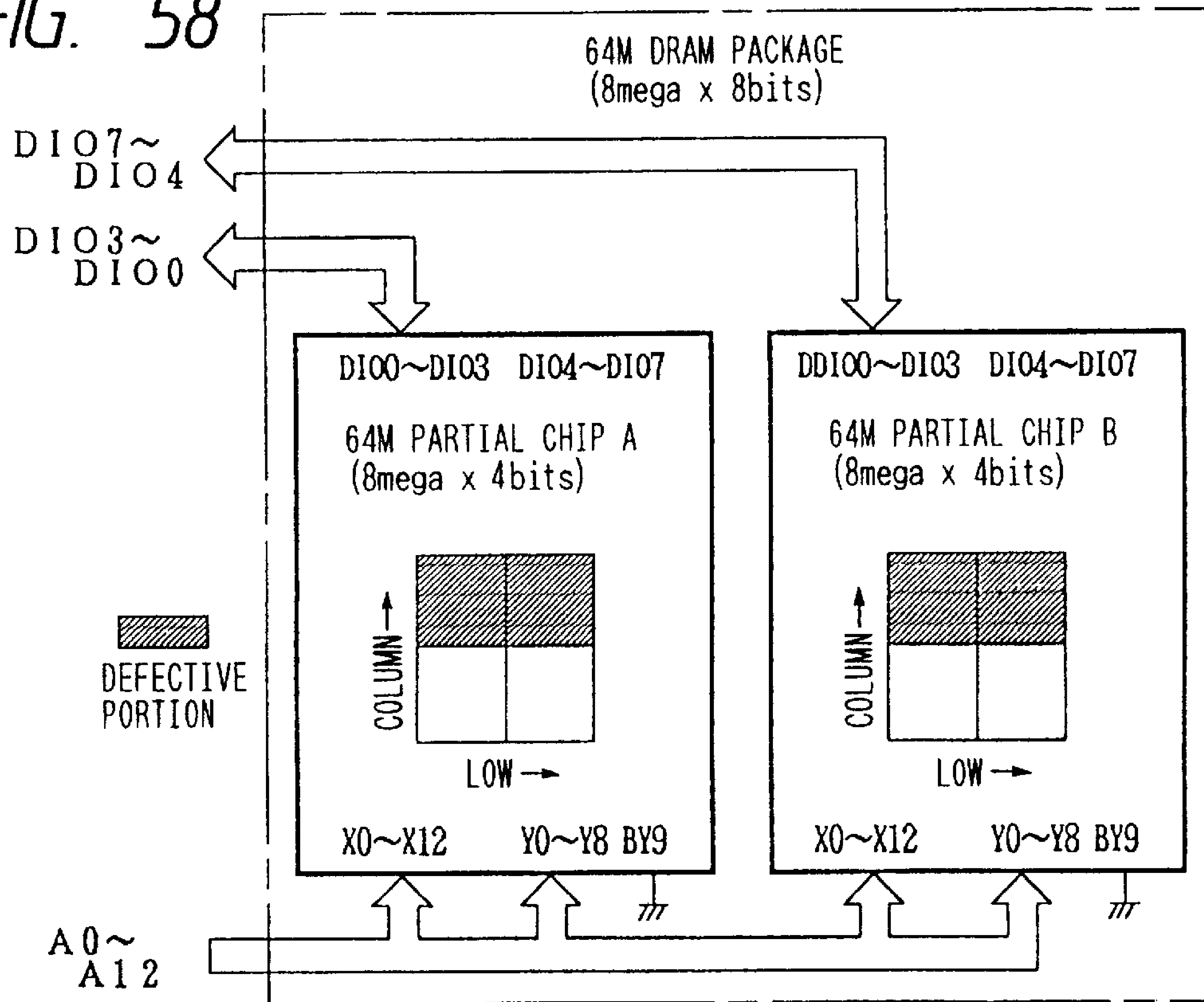


FIG. 59

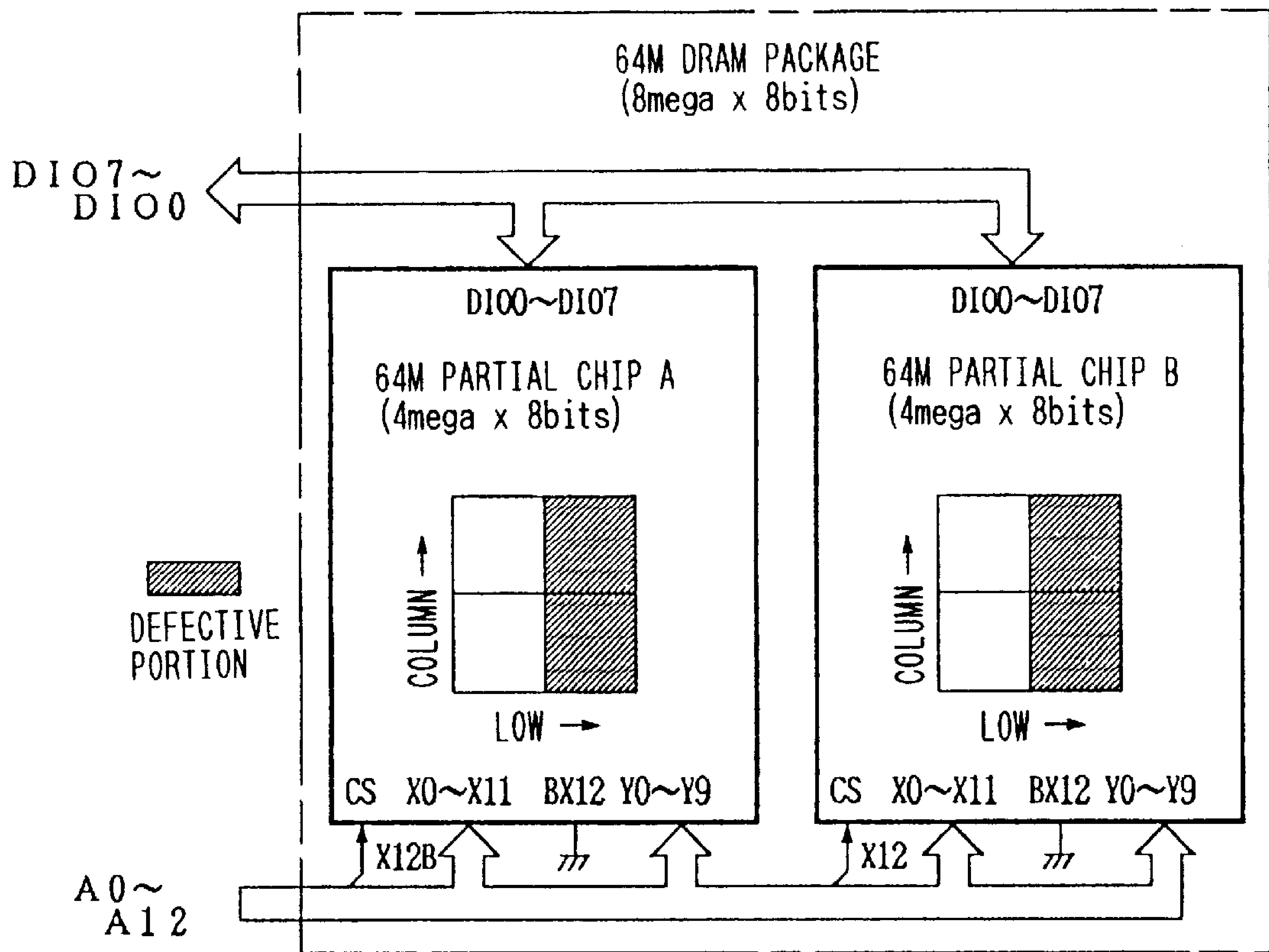
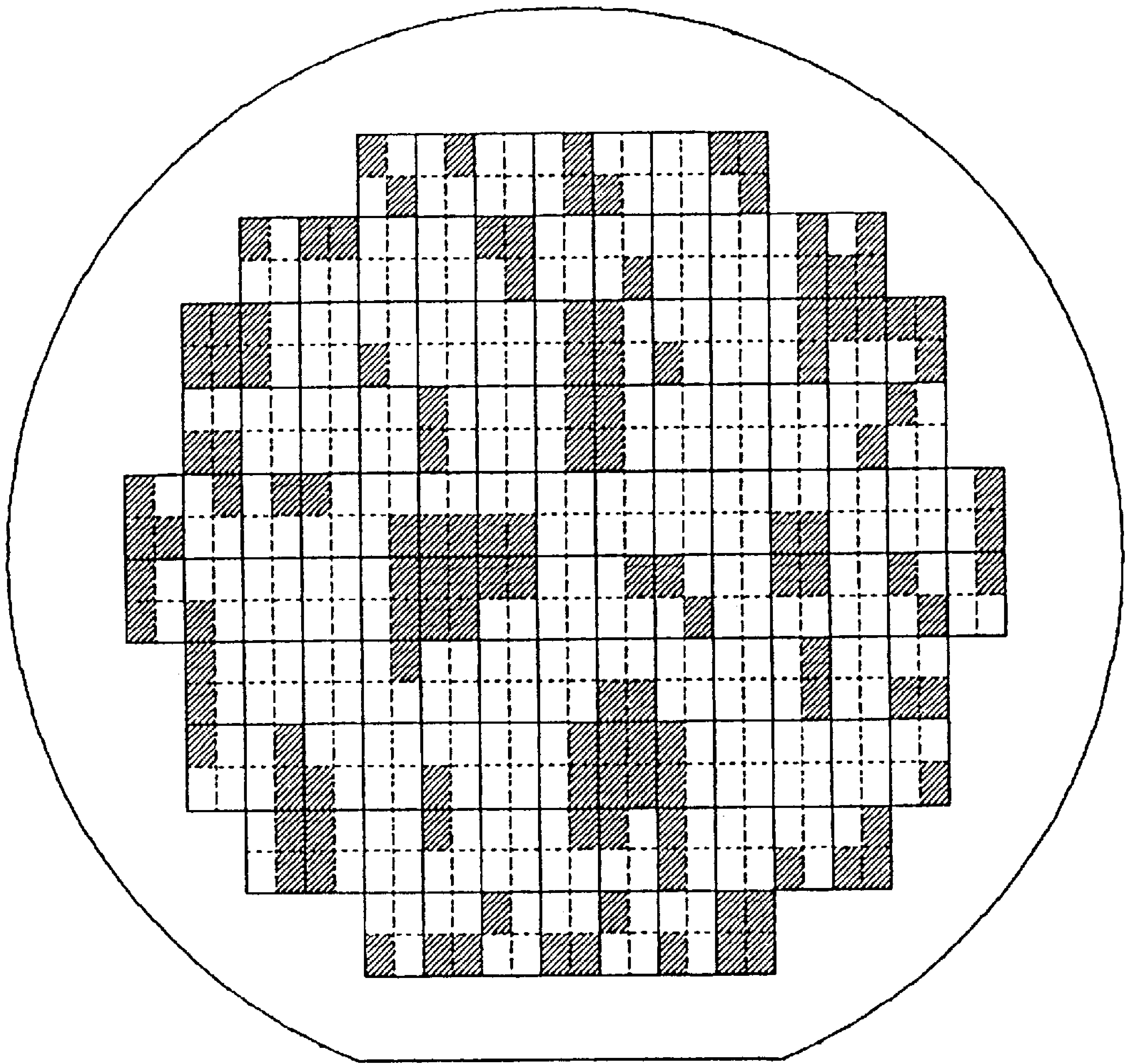


FIG. 60



NUMBER OF CONFORMING PRODUCTS (IN 64mega)

CONVENTIONAL METHOD: 45pcs

DOUBULE CHIP PACKAGE METHOD: 75pcs

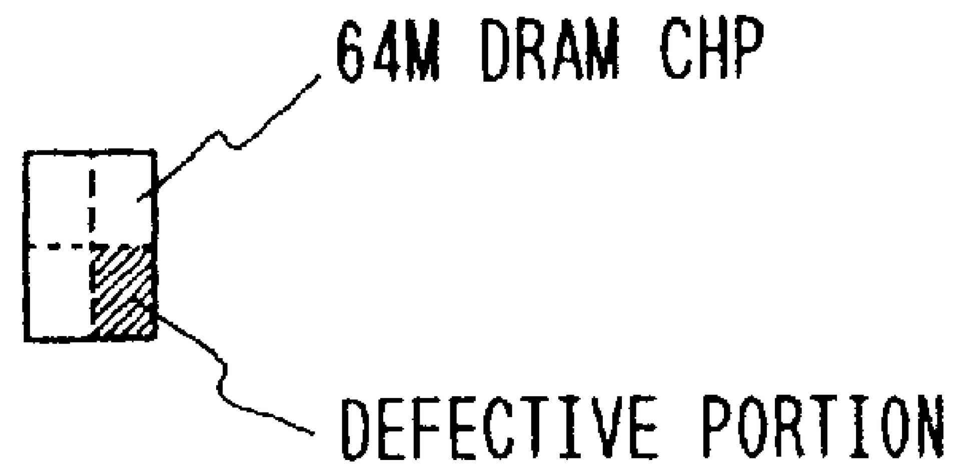


FIG. 61

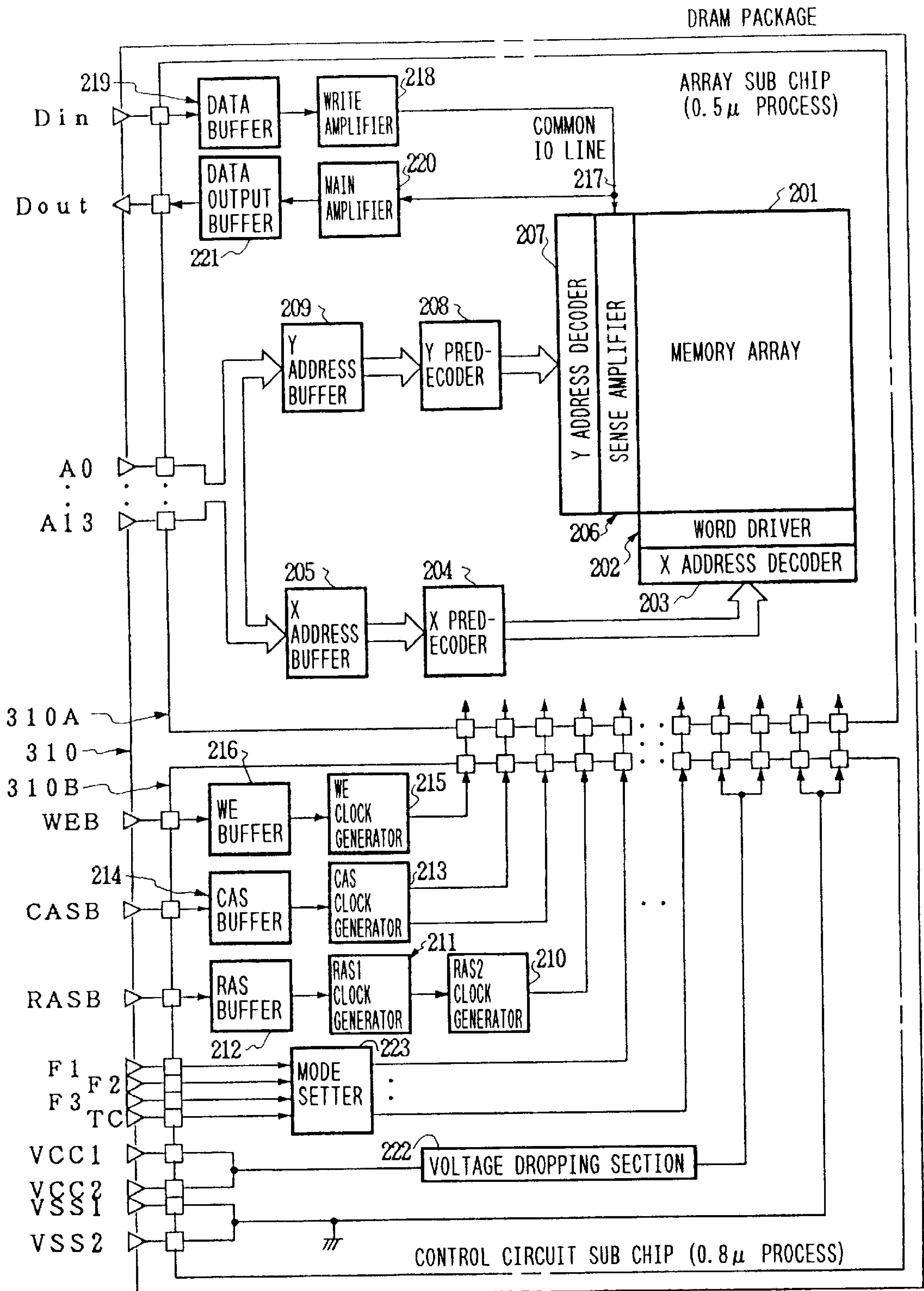


FIG. 62

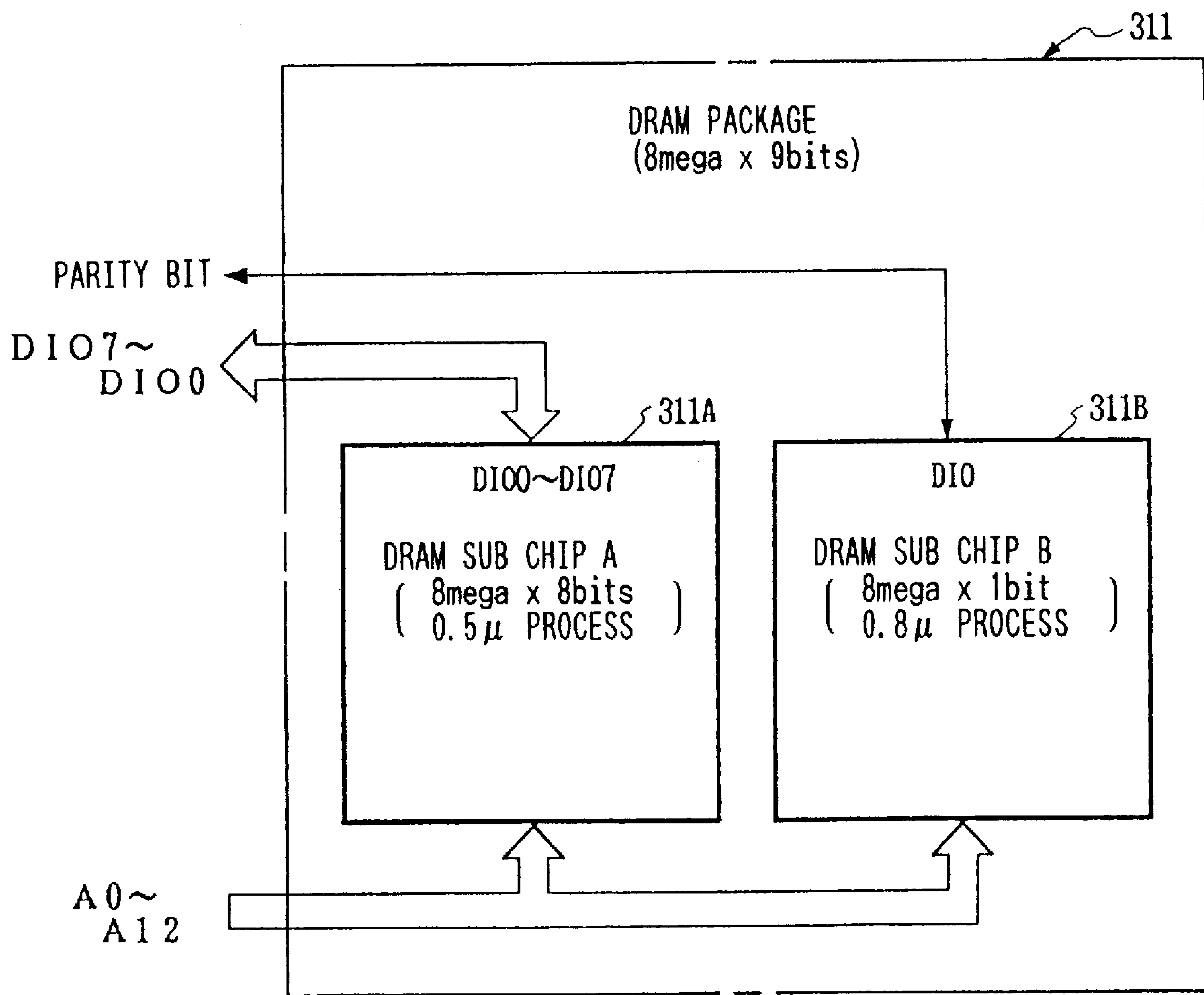
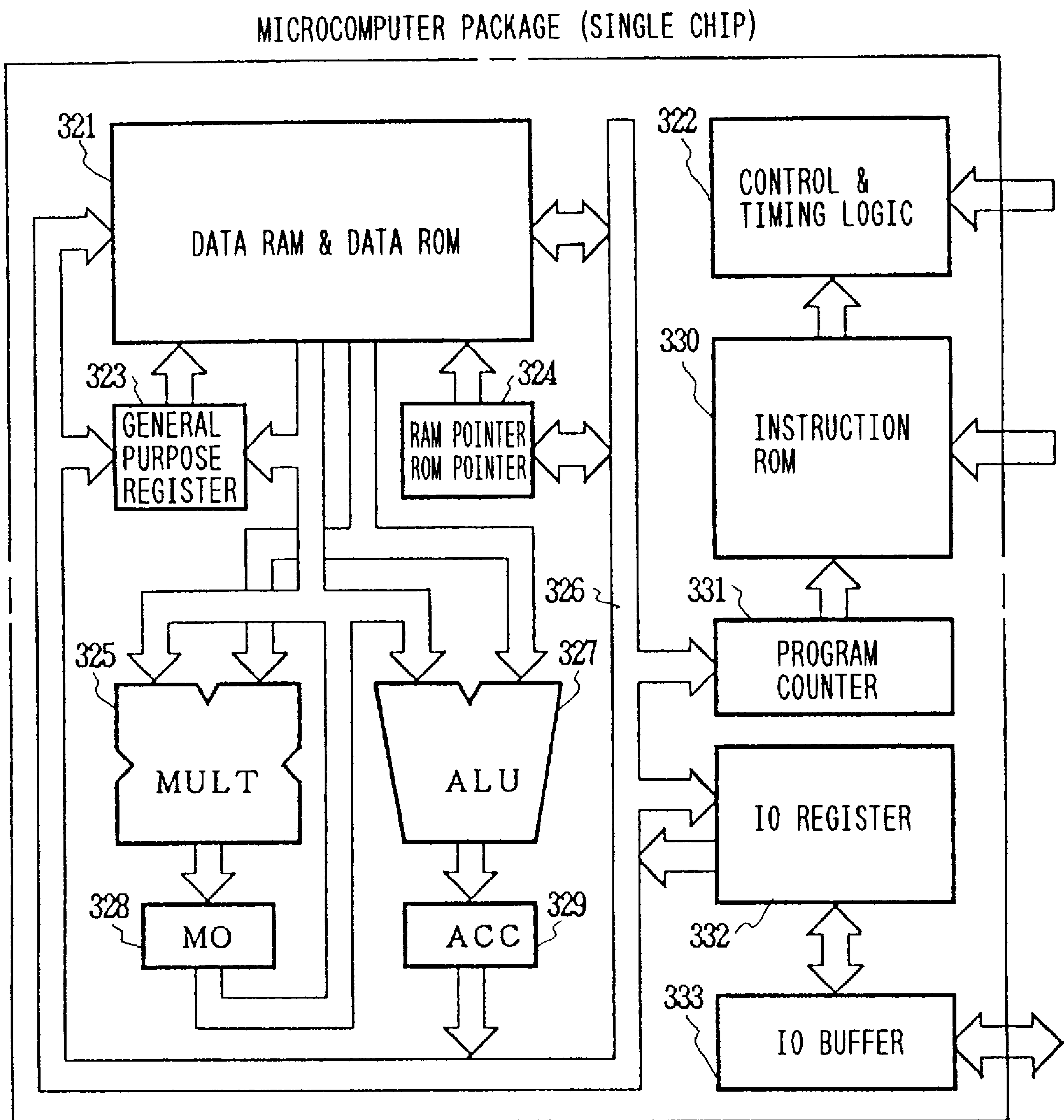


FIG. 63



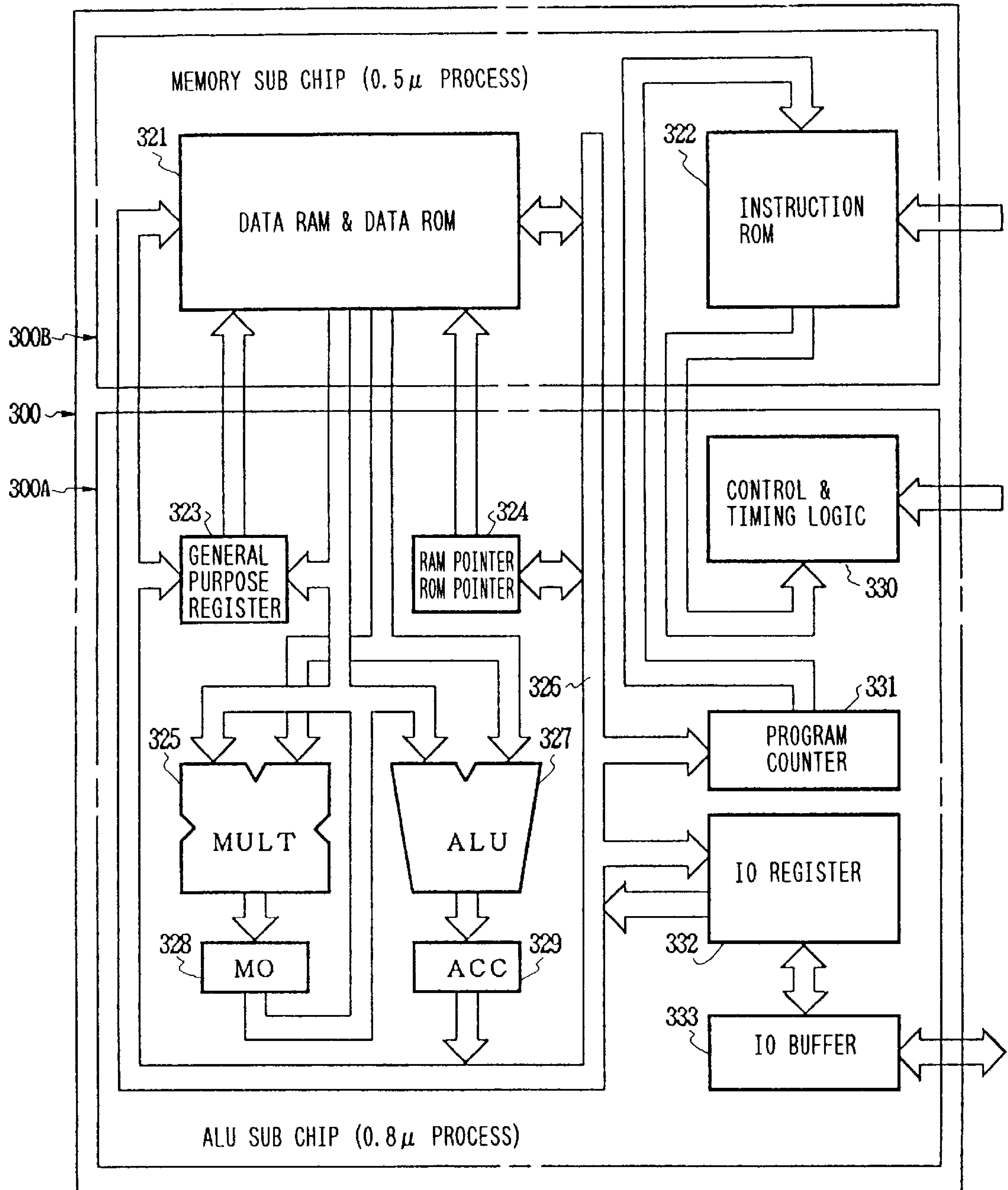


FIG. 64
MICROCOMPUTER PACKAGE (DOUBLE CHIP)
MEMORY SUB CHIP (0.5μ PROCESS)
321
DATA RAM & DATA ROM
322
INSTRUCTION ROM
300B
300
300A
CONTROL & TIMING LOGIC
330
323
GENERAL PURPOSE REGISTER
324
RAM POINTER ROM POINTER
326
331
PROGRAM COUNTER
325
327
MULT
ALU
IO REGISTER
328
MO
ACC
329
332
333
IO BUFFER
ALU SUB CHIP (0.8μ PROCESS)

FIG. 65

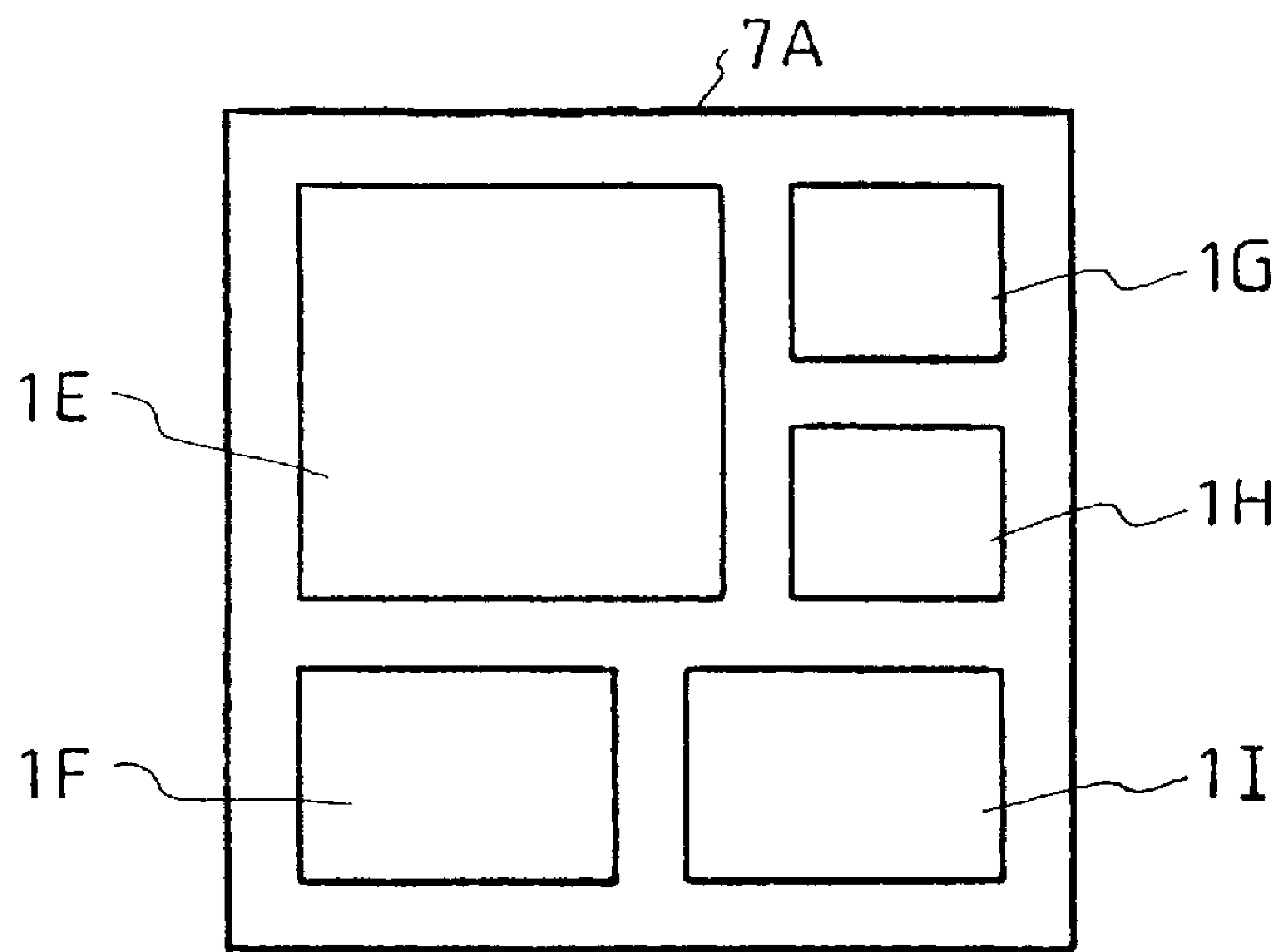


FIG. 66

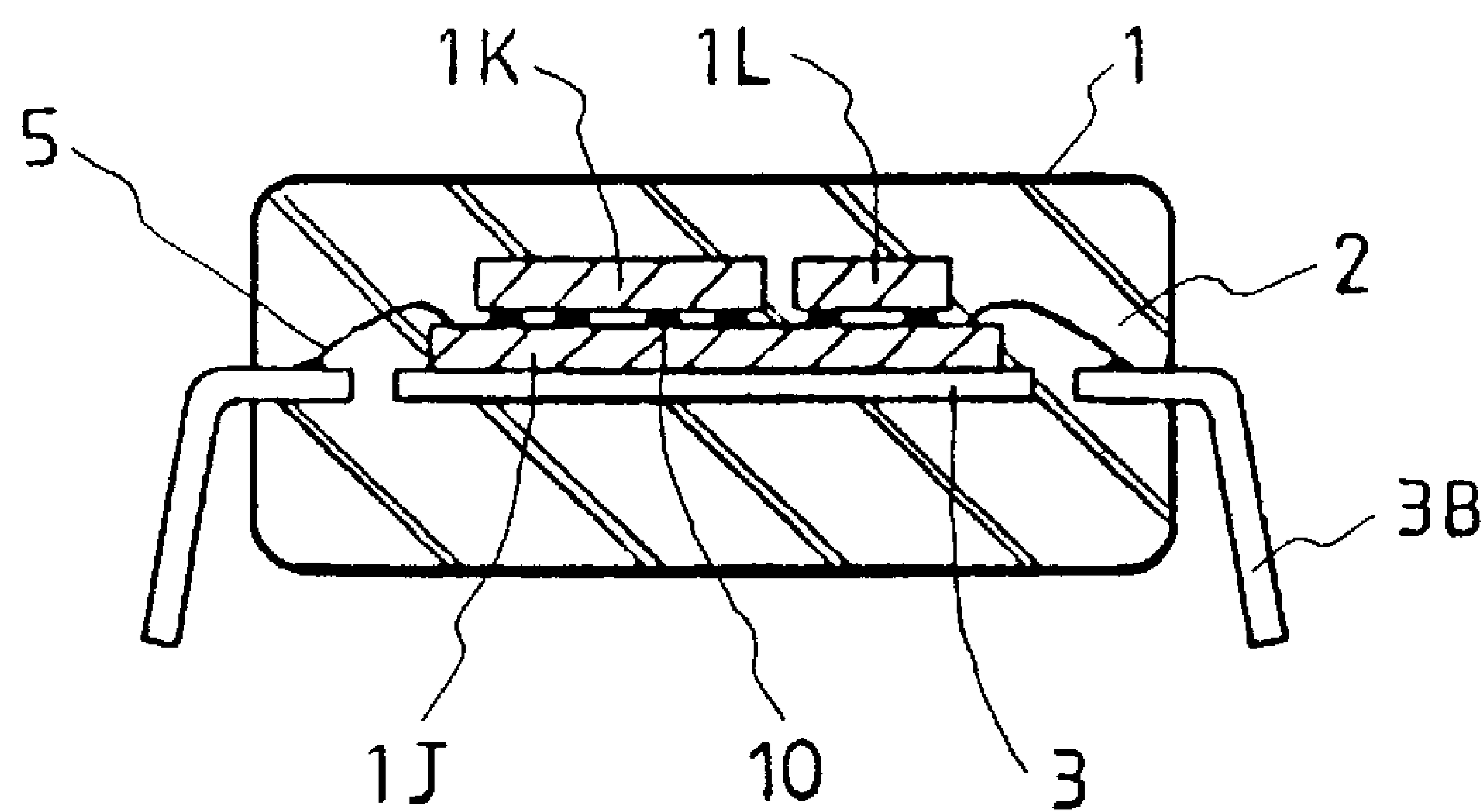
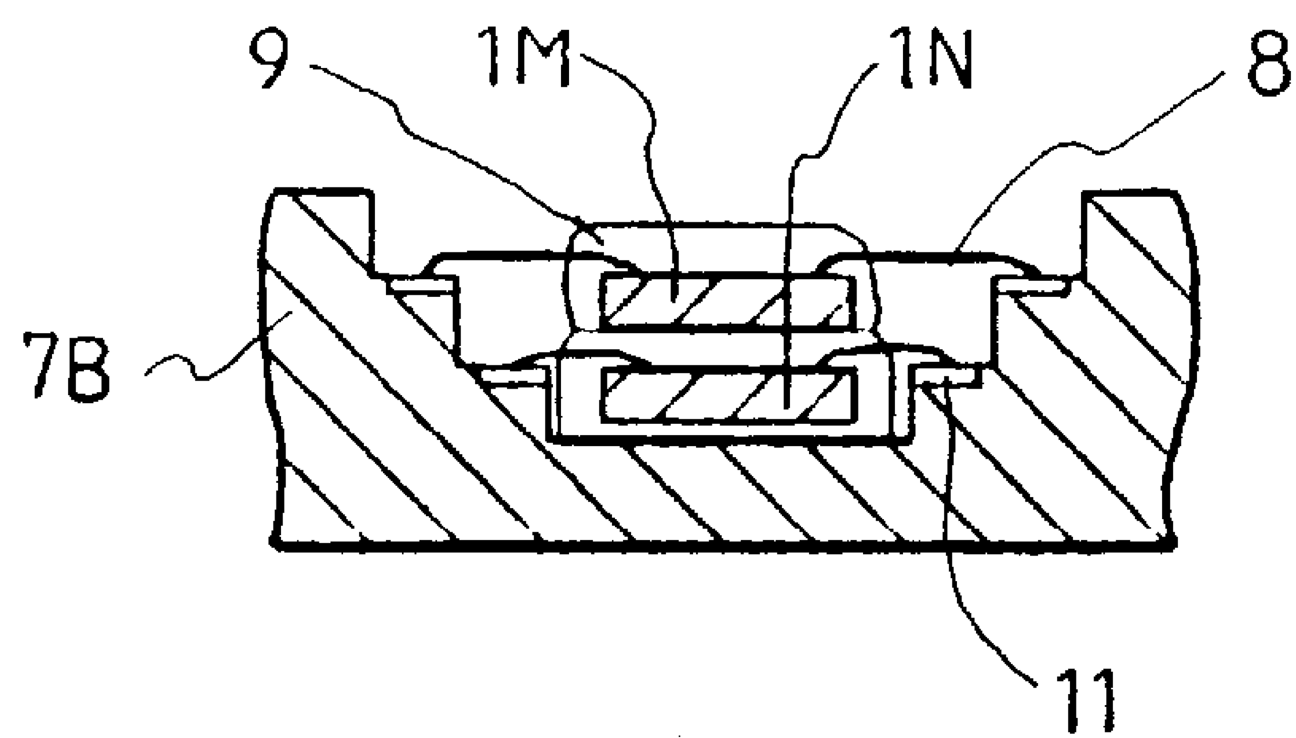


FIG. 67



SEALED STACKED ARRANGEMENT OF SEMICONDUCTOR DEVICES

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This is a divisional of application Ser. No. 07/691,985, filed Apr. 26, 1991, U.S. Pat. No. 5,332,922.

BACKGROUND OF THE INVENTION

The present invention relates to a semiconductor device and a method for manufacturing the same. For example, the present invention is concerned with a DRAM package (a semiconductor device with one or plural DRAM chips mounted thereon will hereinafter be referred to herein as "DRAM package") comprising plural DRAM (Dynamic Random Access Memory) chips (a semiconductor chip capable of functioning as DRAM will hereinafter be referred to herein as "DRAM chip"), as well as a technique which is particularly useful in producing such DRAM package.

A DRAM chip having as a basic configuration a memory array comprising lattice-like arranged dynamic memory cells as well as a DRAM package having such DRAM chip as a basic configuration are known. In the conventional DRAM package, usually, one DRAM chip is mounted thereon and bonding pads used therein are connected to corresponding leads of a lead frame integral with external terminals.

As to the DRAM package carrying a single DRAM chip thereon, it is described, for example, in U.S. Ser. No. 496,280 filed Mar. 20, 1990.

Recent success towards higher integration density and larger memory capacity of a DRAM chip has been remarkable and correspondingly the chip area has been increasing. At the same time, the DRAM package which carries a DRAM chip thereon also tends to become larger in size. As a result, there has developed a problem that the packaging efficiency of a memory system or the like comprising a DRAM package has not greatly improved.

To cope with the above problem, as shown in FIGS. **65** to **67**, there have been proposed several methods for mounting on a single package a plurality of sub chips (in the case where one package is composed of plural semiconductor chips, those plural constituent semiconductor chips will each be referred to herein as a "sub chip"). More particularly, in FIG. **65**, a plurality of sub chips **1E** to **1I** are mounted on the surface of a circuit board **7A**. In FIG. **66**, first a relatively large sub chip **1J** is mounted on a lead frame **3**, then two relatively small sub chips **1K** and **1L** are mounted as adjacently disposed sub chips on the sub chip **1J**. Corresponding pads of the sub chips **1J** and **1K**, **1L** are connected together through a solder bump **10**. Further, bonding pads of the sub chip **1J** are connected to corresponding external terminals, i.e., outer leads **3B**, through bonding wires **5**. On the other hand, in FIG. **67**, first a sub chip **1N** is die-bonded onto a circuit board **7B**, and pads provided on the sub chip **1N** are bonded to corresponding metallized portions **11** of the circuit board **7B** through bonding wires **8**. Then, the sub chip **1N** is coated with a molding resin **9**, and after the surface of the coating is flattened, a sub chip **1M** is laminated onto the thus-flattened surface of the coating.

The chip mounting methods illustrated in FIGS. **66** and **67** are described in Japanese Patent Laid Open Nos. 284951/86 and 283634/87, respectively.

SUMMARY OF THE INVENTION

However, with progress of higher integration density and larger capacity of semiconductor chips, the present inventors found out that the following problems were involved in the foregoing chip mounting methods. In FIG. **65**, since plural sub chips **1E–1I** are mounted on the same plane, the area of the circuit board **7A** increases with an increase in the number of semiconductor chips mounted thereon, and hence the package size also becomes larger. In FIG. **66**, the lower sub chip **1J** must be larger than the upper sub chips **1K** and **1L** by an amount corresponding to the pad portion required for drawing out the bonding wires **5**. Therefore, it is impossible to constitute a package using the same size of sub chips formed in the same manufacturing process, like a DRAM chip for example. In FIG. **67**, the heat radiation of the lower sub chip **1N** is obstructed, and restriction is placed on the reduction of the package size because it is necessary to use the circuit board **7B**. In all of these methods, moreover, the manufacturing process is complicated and the product yield is deteriorated in comparison with, for example, the conventional packaging method involving direct wire bonding to a lead frame.

It is the first object of the present invention to provide an effective chip mounting method capable of mounting plural sub chips of the same size without sacrificing the heat radiation characteristic of a package and the product yield.

It is the second object of the present invention to attain a large memory capacity and low power consumption of a DRAM package and simplify the manufacturing process for the same package while suppressing the increase in size of the package.

It is the third object of the present invention to realize a DRAM package having a memory capacity plural times that of a package of about the same size and comprising a single DRAM chip and thereby expand the limit of memory capacity of DRAM chips, etc.

It is the fourth object of the present invention to enhance the packaging efficiency of a memory system or the like having a DRAM package as a basic configuration and reduce the cost thereof.

It is the fifth object of the present invention to provide concrete means for an effective address system and a manufacturing process both suitable for the new chip mounting method and provide several application examples of this chip mounting method.

It is the sixth object of the present invention to provide an effective manufacturing method suitable for the new chip mounting method.

Of numerous improved aspects disclosed herein, a typical one will now be described briefly. A pair of DRAM chips are mounted oppositely to face each other and are provided on both sides of wiring means such as a lead frame which is substantially integrally formed with external terminals, and these DRAM chips and lead frame are connected together by a conventional wire bonding method for example. Plural pairs of such DRAM chips and lead frames thus connected are stacked and corresponding leads of the lead frames are connected in common to provide a laminate. Further, plural DRAM chips thus mounted are activated selectively in accordance with a predetermined chip select signal. Additionally, partial DRAM chips capable of normally functioning partially are combined, utilizing this chip mounting method, to constitute a single DRAM package.

According to the above means it is possible to provide an effective chip mounting method capable of mounting plural sub chips of the same size without sacrificing the heat radiation characteristic of the package and the product yield. Besides, it is possible to attain large memory capacity and low power consumption of the DRAM package and simplify

the manufacturing process for the package. Moreover, it is possible to realize a DRAM package having a memory capacity plural times that of a package comprising a single DRAM chip and thereby expand the limit of memory capacity of DRAM chips; at the same time it is possible to enhance the packaging efficiency of a memory system having a DRAM package as a basic configuration and reduce the cost thereof. Further, it is possible to utilize partial DRAM chips without waste and enhance a substantial product yield of DRAM chips, etc.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram showing a first example of a 128M DRAM package according to the present invention;

FIG. **2** is a timing chart in the DRAM package of FIG. **1**;

FIG. **3** is a standard specification table of 64M DRAM sub chips which constitute the DRAM package of FIG. **1**;

FIG. **4** is a block diagram showing an example of a DRAM sub chip of FIG. **3**;

FIG. **5** is a substrate layout diagram in the DRAM sub chip of FIG. **4**;

FIG. **6** is an address allocation diagram in the DRAM sub chip of FIG. **4**;

FIG. **7** is a product list showing variations of the 128M DRAM package;

FIG. **8** is a block diagram showing a second example of a 128M DRAM package according to the present invention;

FIG. **9** is a block diagram showing a third example of a 128M DRAM package according to the present invention;

FIG. **10** is a block diagram showing a fourth example of a 128M DRAM package according to the present invention;

FIG. **11** is a block diagram showing a fifth example of a 128M DRAM package according to the present invention;

FIG. **12** is a block diagram showing a sixth example of a 128M DRAM package according to the present invention;

FIG. **13** is a sectional perspective view of the DRAM package of FIG. **1**;

FIG. **14** is a plan view thereof;

FIG. **15** is a structural sectional view taken on line **15**—**15** in FIG. **14**;

FIG. **16** is a plan view cut away along line ≠—≠in FIG. **15**;

FIG. **17** is a plan view cut away along line ∫—∫in FIG. **15**, showing a first example of the DRAM package of FIG. **14**;

FIG. **18** is a plan view of a modification of FIG. **17**, showing a second example of the DRAM package of FIG. **14**;

FIG. **19** is a processing diagram showing a first manufacturing process for the DRAM package illustrated in FIG. **13**;

FIG. **20** is a processing diagram showing a second manufacturing process for the DRAM package illustrated in FIG. **13**;

FIG. **21** is a processing diagram showing a third manufacturing process for the DRAM package illustrated in FIG. **13**;

FIG. **22** is a processing diagram showing a fourth manufacturing process for the DRAM package illustrated in FIG. **13**;

FIG. **23** is a processing diagram showing a fifth manufacturing process for the DRAM package illustrated in FIG. **13**;

FIG. **24** is a plan view showing an example of a lead frame and an insulating film both used in the DRAM package of FIG. **13**;

FIG. **25** is a structural sectional view of a DRAM package further embodying the invention;

FIG. **26** is a structural sectional view of a DRAM package further embodying the invention;

FIG. **27** is a structural sectional view of a DRAM package further embodying the invention;

FIG. **28** is a plan view of a lead frame included in a DRAM package further embodying the invention;

FIG. **29** is a structural sectional view of the DRAM package referred to in FIG. **28**;

FIG. **30** is a structural sectional view of a DRAM package further embodying the invention;

FIG. **31** is a structural sectional view of a DRAM package further embodying the invention;

FIG. **32** is a list of connections, showing bonding options of the DRAM sub chips shown in FIG. **3**;

FIG. **33** is a connection diagram of pads in the DRAM package of FIG. **1**;

FIG. **34** is a connection diagram of pads in the DRAM package of FIG. **8**;

FIG. **35** is a connection diagram of pads in the DRAM package of FIG. **9**;

FIG. **36** is a connection diagram of pads in the DRAM package of FIG. **10**;

FIG. **37** is a connection diagram of pads in the DRAM package of FIG. **11**;

FIG. **38** is a connection diagram of pads in the DRAM package of FIG. **12**;

FIG. **39** is a partial circuit diagram of an X address buffer included in the DRAM sub chip of FIG. **4**;

FIG. **40** is a block diagram showing a seventh example of a 64M DRAM package according to the invention;

FIG. **41** is a timing chart in DRAM sub chips illustrated in FIG. **40**;

FIG. **42** is a block diagram showing an eighth example of a 64M DRAM package according to the invention;

FIG. **43** is a timing chart in a write mode of DRAM sub chips illustrated in FIG. **42**;

FIG. **44** is a timing chart in a read mode of the DRAM sub chips illustrated in FIG. **42**;

FIG. **45** is a partial signal system diagram in a conventional DRAM package;

FIG. **46** is a partial signal system diagram in the DRAM package of FIG. **1**;

FIG. **47** is a block diagram showing a first example of a 64M DRAM package consisting of two DRAM partial chips according to the invention;

FIG. **48** is a partial circuit diagram of an X address buffer included in the DRAM package of FIG. **47**;

FIG. **49** is another partial circuit diagram of the X address buffer included in the DRAM package of FIG. **47**;

FIG. **50** is a block diagram showing a second example of a 64M DRAM package consisting of two DRAM partial chips according to the invention;

FIG. **51** is a partial circuit diagram of a Y address buffer included in the DRAM package of FIG. **50**;

FIG. **52** is another partial circuit diagram of the Y address buffer included in the DRAM package of FIG. **50**;

FIG. **53** is a list of connections, showing bonding options of the DRAM partial chips shown in FIGS. **47** and **50**;

FIG. **54** is a list of products, showing variations of a 64M DRAM package consisting of two DRAM partial chips;

FIG. **55** is a block diagram showing a third example of a 64M DRAM package consisting of two DRAM partial chips according to the invention;

FIG. **56** is a block diagram showing a fourth example of a 64M DRAM package consisting of two DRAM partial chips according to the invention;

FIG. **57** is a block diagram showing a fifth example of a 64M DRAM package consisting of two DRAM partial chips according to the invention;

FIG. **58** is a block diagram showing a sixth example of a 64M DRAM package consisting of two DRAM partial chips according to the invention;

FIG. **59** is a block diagram showing a seventh example of a 64M DRAM package consisting of two DRAM partial chips according to the invention;

FIG. **60** is a plan view showing an example of a wafer from which a DRAM chip is formed;

FIG. **61** is a block diagram showing an example of a DRAM package consisting of two function-divided sub chips;

FIG. **62** is a block diagram showing an example of a DRAM package consisting of two bit-divided sub chips;

FIG. **63** is a block diagram showing an example of a conventional microcomputer package;

FIG. **64** is a block diagram showing an example of a microcomputer package consisting of two function-divided sub chips;

FIG. **65** is a plan view of a substrate in a conventional multi-chip module;

FIG. **66** is a structural sectional view showing another example of a conventional multi-chip module; and

FIG. **67** is a structural sectional view showing a further example of a conventional multi-chip module.

DESCRIPTION OF PREFERRED EMBODIMENTS

1. 128M DRAM Package according to Double Chip Packaging Method

1.1. Outline of DRAM Package

FIG. **1** is a block diagram showing an example of a 128M ("M" or "mega" is assumed equal to the twentieth power of 2 herein) DRAM package according to the present invention, and FIG. **2** is a timing chart in the said DRAM package. With reference to these figures, an outline of this DRAM package and an explanation of a chip selecting method will first be given below. The chip mounting method according to the present invention will herein be designated a double chip packaging method. For a specific description of the double chip packaging method and features thereof, see "1.4. Package Form of DRAM Package."

1.1.1. Block Configuration

A DRAM package **1** according to this embodiment includes two DRAM sub chips **1**A and **1**B. These sub chips each have a memory capacity of 64 mega. Write data and read data are inputted or outputted each in the unit of one bit through a data input terminal Din or a data output terminal Dout. The sub chips A and B adopt a so-called multiplex method, wherein the address space is designated alternatively in accordance with 13-bit X address signals (row address signals) X**0** to X**12** and Y address signals (column address signals) Y**0** to Y**12** which are fed time-sharingwise through thirteen address input terminals A**0** to A**12**. Data input pads Din and data output pads Dout of the sub chips A and B are connected in common to a data input terminal Din and a data output terminal Dout, respectively, of the DRAM package, and address input pads A**0** to A**13** are connected in common to address input terminals A**0** to A**13**, respectively, of the DRAM package.

As start control signals, a row address strobe signal RASB (as to an inversion signal or inversion signal line whose level is rendered low when it is made effective, the mark "B" is attached to the end of the name, and this will apply also in the following) and a column address strobe signal CASB, as well as a write enable signal WEB, are fed to the DRAM sub chips A and B from external terminals RASB and CASB as well as WEB through corresponding bonding pads. An X address signal X**13** as a chip selection signal is fed from an address input terminal A**13** through a corresponding bonding pad, and an external source voltage VCC is fed from two external terminals VCC**1** and VCC**2** through corresponding bonding pads VCC**1** and VCC**2**. Further, an earth potential of the circuit is fed from external terminals VSS**1** and VSS**2** through corresponding bonding pads VSS**1** and VSS**2**. The external source voltage VCC is set at a positive voltage like +5V for example, and as will be described later, it is lowered by a voltage dropping section of each of the sub chips A and B, then serves as a source voltage for the operation of each sub chip.

1.1.2. Chip Selecting Method

When the row address strobe signal RASB and the column address strobe signals CASB are made low in level, the sub chips A and B are selectively brought into a selected state, and the operation mode thereof is set in accordance with a logical level of the write enable signal WEB. To the address input terminals A**0**–A**12** are fed X address signals X**0**–X**12** in synchronism with the trailing edge of the row address strobe signal RASB, while Y address signals Y**0**–Y**12** are fed in synchronism with the trailing edge of the column address strobe signal CASB, as shown in FIG. **2**.

In this embodiment, moreover, the selected state of the sub chip A and that of the sub chip B are selectively designated in accordance with a logical level of the chip selection signal, i.e., the X address signal X**13**. More specifically, when the level of the X address signal X**13** is made low, the level of an internal control signal CS in the sub chip A is made high to select the sub chip A in the DRAM package, as indicated by solid line in FIG. **2**. On the other hand, when the level of the X address signal X**13** is made high, the level of an internal control signal CS in the sub chip B is rendered high to select the sub chip B, as indicated by dotted line in FIG. **2**. Thus, the 64M DRAM sub chips A and B are selected in an alternative manner, with the result that the DRAM package possesses a memory capacity twice that of each sub chip, namely, 128 mega×1 bit. Since the sub chips A and B are selected alternatively, the power consumption of the DRAM package is relatively small, corresponding to the power consumption of one of the two sub chips.

1.2. Outline of DRAM Sub Chips

FIG. **3** tabulates a standard specification of 64M DRAM sub chips which constitute the DRAM package of FIG. **1**; FIG. **4** is a block diagram showing an example thereof; FIG. **5** is a substrate layout view of the 64M DRAM sub chip shown in FIG. **4**; and FIG. **6** is an address allocation diagram in the same sub chip. With reference to these figures, the following description is now provided about a concrete configuration and specification of the 64M DRAM sub chips A and B which constitute the DRAM package of this embodiment as well as an address selecting method and an outline of operation. In the description of this chapter there

will be made no distinction between the sub chips A and B because both are basically of the same configuration.

1.2.1. Standard Specification

The 64M DRAM sub chips in this embodiment can each take three kinds of bit configurations which are 64 megawords×1 bit (hereinafter referred to simply as, for example, "64 mega×1 bit"), 16 mega×4 bits and 8 mega×8 bits because bonding to predetermined pads is executed selectively, as shown in FIG. **3**. When the sub chip has a bit configuration of 64 mega×1 bit, the address space thereof is designated alternatively by the 13-bit X address signals **X0**–**X12** and Y address signals **Y0**–**Y12** in the manner described above. On the other hand, when the sub chip has a bit configuration of 16 mega×4 bits, the address space thereof is designated alternatively by the 13-bit X address signals **X0**–**X12** and 11-bit Y address signal's **Y0**–**Y10**. Further, when the sub chip has a bit configuration of 8 mega×8 bits, the address space thereof is designated alternatively in accordance with the 13-bit X address signals **X0**–**X12** and 10-bit Y address signals **Y0**–**Y9**. Thus, in the 64M sub chips in this embodiment, a row address space is always designated by 13-bit X address signals, and a refresh cycle thereof is unified to 8 kilo ("kilo" is assumed equal to the tenth power of 2 herein) cycle with a period of 64 ms (millisecond=1/1000 second).

As the packaging form of the 64M DRAM sub chip there is adopted a so-called SOJ (Small Out-line J-bend) type package, and an external size thereof is set at 300 mil'850 mil (mil=1/1000 inch) though it is not specially limited. A maximum of 32 pins, or external terminals, are provided in the package. For the sub chip there is adopted an address multiplex method as mentioned previously, and a row address thereof is designated by 13-bit X address signals **X0**–**X12** irrespective of bit configuration. Therefore, the number of pins used as address input terminals is fourteen, including the X address signal **X13** serving as a chip selection signal, irrespective of the bit configuration of the sub chip. On the other hand, when the sub chip has a bit configuration of 64 mega×1 bit, write data and read data are inputted or outputted in the unit of one bit through the data input terminal Din or the data output terminal Dout, as noted previously. When the sub chip has a bit configuration of 16 mega×4 bits or 8 mega×8 bits, write data and read data are inputted or outputted in the unit of 4 or 8 bits through common data input-output terminals DIO**0** to DIO3 or DIO**0** to DIO7. At this time, an output enable signal OEB for setting an output timing of read data is fed to the sub chip, and the number of pins provided for the supply of start control signals or clocks is four. Consequently, the total number of pins used in each sub chip is 23 in the bit configuration of 64 mega×1 bit, 26 in the bit configuration of 16 mega×4 bits, 32 in the bit configuration of 8 mega×8 bits.

The 64M DRAM sub chips are each provided with a predetermined test mode and a parallel test function of comparing and collating 8-bit storage data read out simultaneously, with given expected value data in the said test mode. At this time, the results of the parallel test are outputted in common from all the output or input-output terminals. The sub chips are each provided with a high-speed column mode, or Fast Page mode, as well as Static Column mode and Nibble mode, for continuously inputting or outputting storage data with respect to plural memory cells connected to selected word lines. Nibble mode is made effective when the sub chip has a bit configuration of 64 mega×1 bit, and it inputs or outputs a maximum of 32 bits of storage data continuously. Fast Page mode and Static Column mode are made effective in any bit configuration and can input or output a maximum of 8 K bits, i.e., 8192 bits, continuously.

1.2.2. Block Configuration

The 64M DRAM sub chips in this embodiment have each a memory array **201** as a basic configuration wherein the address space comprises 8K, or 8192, row addresses and column addresses, as shown in FIG. **4**. This memory array includes 8192 word lines disposed substantially in parallel with the vertical direction in the same figure and corresponding to the row addresses and 8192 sets of complementary bit lines disposed in parallel with the horizontal direction and corresponding to the column addresses. At the intersecting points of these word lines and complementary bit lines there are disposed 8192×8192, or 67108864, i.e., 64M, dynamic memory cells in a lattice shape. Thus, the sub chip has a memory capacity of 64 megabits. As will be described later, a memory array in each DRAM sub chip of this embodiment is actually divided into four memory blocks, which are each further divided into four mats each consisting of four sub arrays. The following description on the block configuration will be made on the assumption that the memory array is a single memory array.

The word lines which constitute the memory array **201** are connected to an X address decoder **203** through a word driver **202**. Predetermined predecoded signals are fed to the X address decoder from an X predecoder **204**, and also fed thereto is an internal control signal XDG from a RAS**2** clock generator **210**. To the X predecoder are fed internal address signals BX**0**–BX**12** from an X address buffer **205**, and also fed thereto is an internal control signal CS which is formed on the basis of the X address signal **X13**. Further, X address signals **X0**–**X13** are fed to the X address buffer time-sharingwise through address input pads **A0**–**A13**, and also fed thereto are internal control signals TCD and CSA from a mode setter **223**.

The X address buffer **205** takes therein the X address signals **X0**–**X13** which are fed time-sharingwise through the address input pads **A0**–**A13**, and on the basis of these X address signals the X address buffer forms the internal address signals BX**0**–BX**12** and the internal control signal CS. The internal control signal CS is fed to the X predecoder **204**, RAS**2** clock generator **210**, write amplifier **218** and data output buffer **221** and is used as a so-called chip selection signal for operating these blocks selectively. In this embodiment, as will be described later, a logical condition for making the level of the internal control signal CS high is changed over selectively by selective execution of bonding to the internal control signals CSA and TCD, i.e., pads **F1** to **F3** and TC. As to these bonding options, see "1.5. Bonding Options of DRAM Sub Chips."

The X predecoder **204** decodes the internal address signals BX**0**–BX**12** fed from the X address buffer **205**, in combination of two or three bits at a time to form predetermined predecoded signals. These predecoded signals are fed to the X address decoder **203** and some of them are used for activating the memory blocks, mats and sub arrays selectively. The predecoder **204** is operated selectively in accordance with the internal control signal CS fed from the X address buffer, whereby the waste operating current is cut down when the sub chip is brought into an unselected state and thus the reduction in power consumption of the DRAM package is attained.

The X address decoder **203** combines the predecoded signals fed from the X predecoder **204** to form selection signals for selecting corresponding word lines of the memory array in an alternative manner. These selection

signals are transferred to corresponding word lines of the memory array through the word driver **202**, whereby the corresponding word lines are brought into a predetermined selection level. As well known, when the the word lines are brought into the selection level, the 8192 memory cells connected to the word lines are brought into the selected state all together, and the data held therein are outputted to the corresponding complementary bit lines. If these data are left as they are, they will be destroyed, but their signal amplitudes are amplified to a predetermined level by corresponding unit amplifier circuits of the sense amplifier **206**, whereby the data are rewritten into the corresponding memory cells. In the DRAM sub chips, when the 8192 unit amplifier circuits of the sense amplifier **206** are operated all together, a relatively large operating current is required. Therefore, whether each sub chip is activated or not is judged by whether the sense amplifier is brought into an operating state or not, in other words, whether the word line selecting operation is performed or not. Needless to say, it is important in reducing the power consumption that the sub chip which is brought into an unselected state not be activated. However, at some particular input timing of a chip selection signal there arises the case where the two sub chips which constitute the DRAM package must be activated at a time. In this case, only the storage data inputting or outputting operation is executed selectively by the write amplifier **218** or the data output buffer **221** in accordance with the internal control signal CS.

Next, the complementary bit lines of the memory array are connected to the corresponding unit amplifier circuits of the sense amplifier **206** and further connected to a common IO line **217** through corresponding MOSFET switches. The sense amplifier **206** includes **8192** unit amplifier circuits provided in corresponding relation to the complementary bit lines of the memory array and the same number of switch MOSFET pairs. The unit amplifier circuits of the sense amplifier are operated selectively and all together by a predetermined internal control signal (not shown) fed from the RAS2 clock generator **210**. In this operating state, the unit amplifier circuits amplify fine read signals which are outputted through the corresponding complementary bit lines of the memory array **201** from the 8192 memory cells connected to the selected word lines, to provide binary read signals of high or low level. On the other hand, to the switch MOSFET pairs of the sense amplifier are fed bit selection signals from the Y address decoder **207**. These MOSFET switches are turned ON selectively when the corresponding bit line selection signals are rendered high in level, to selectively connect the corresponding complementary bit lines of the memory array with the common IO line **217**.

To the Y address decoder **207** are fed predecoded signals from a Y predecoder **208** and also fed is an internal control signal YDG from a CAS clock generator **213**. To the Y predecoder **208** are fed internal address signals BY**0**–BY12 from a Y address buffer **209**, while to the Y address buffers **209** are fed Y address signals Y**0**–Y12 time-sharingwise through the address input pads A**0**–A12.

The Y address buffer **209** takes therein the Y address signals Y**0**–Y**12** which are fed time-sharingwise through the address input pads A**0**–A**12**, then on the basis of these Y address signals it forms internal address signals BY**0**–BY12 and supplies them to the Y predecoder **208**. The Y predecoder **208** decodes the internal address signals BY**0**–BY12 by combining them in the unit of two or three bits at a time to form predetermined predecoded signals and supplies these predecoded signals to the Y address decoder **207**, which in turn combines these predecoded signals to make the level of the corresponding bit line selection signals high in an alternative manner.

The common IO line **217** for connecting designated complementary bit lines of the memory array **201** selectively is connected to an output terminal of the write amplifier **218** and also connected to an input terminal of a main amplifier **220**. An input terminal of the write amplifier **218** is connected to an output terminal of a data input buffer **219**, while an input terminal of this data input buffer is connected to the data input pad Din. To the write amplifier **218** is fed the internal control signal CS and also fed is an internal control signal WP from a WP clock generator **215**. On the other hand, an output terminal of the main amplifier **220** is connected to an input terminal of the data output buffer **221**, and an output terminal of the data output buffer **221** is connected to the data output pad Dout. To the data output buffer **221** is fed to an internal control signal DOC from the CAS clock generator **213**.

When the DRAM sub chips are each brought into a selected state in the write mode, the data input buffer **219** transfers write data fed through the data input pad Din, to the write amplifier **218**. The write amplifier **218** is operated selectively when the DRAM sub chip is brought into a selected state in the write mode and the internal controls signals CS and WP are made high in level. In this operating state, the write amplifier forms a predetermined complementary write signal on the basis of the write data transferred from the data input buffer **219** and writes it into one selected memory cell in the memory array **201** through the common IO line **217**. On the other hand, when the DRAM sub chip is brought into a selected state in the read mode, the main amplifier **220** further amplifies a read signal which is outputted through the common IO line **217** from one selected memory cell in the memory array **201**, and transfers it as read data to the data output buffer **221**. The data output buffer **221** is operated selectively when the DRAM sub chip is brought into a selected state in the read mode and the level of the internal control signal DOC is made high. In this operating state, the data output buffer **221** transmits the read data provided from the main amplifier **220** to the exterior of the sub chip through the data output pad Dout. Thus, in the DRAM sub chip of this embodiment, the write amplifier **218** and the data output buffer **221** are operated selectively in accordance with the internal control signal CS serving as a chip selection signal, whereby the storage data inputting or outputting operation is executed selectively.

The DRAM sub chip is further provided with, as components of the control circuit, RAS buffer **212**, RAS1 clock generator **211**, RAS2 clock generator **210**, CAS buffer **214**, CAS clock generator **213**, WE buffer **216** and WE clock generator **215**, as well as mode setter **223** and voltage dropping section **222**. To the RAS buffer **212** is fed a row address strobe signal RASB through the input pad RASB, and an output signal from the RAS buffer **212** is fed to the RAS1 clock generator **211**. An output signal from the RAS1 clock generator is fed to the RAS2 clock generator **210** and also fed to predetermined portions of the sub chip. Further fed to the RAS2 clock generator **210** is the internal control signal CS, and an output signal from the RAS2 clock generator **210** is fed as an internal control signal XDG to the X address decoder **203** and also fed to predetermined portions of the sub chip. On the basis of the row address strobe signal RASB inputted through the RAS buffer **212** the RAS1 clock generator **211** and the RAS2 clock generator **210** form various internal control signals necessary for the word line selecting operation and the control of the sense amplifiers **206**. As mentioned previously, the operation of

the RAS2 clock generator **210** is controlled by the internal control signal CS. As a result, the operations of the X address decoder **203**, word driver **202** and sense amplifier **206** are executed selectively, whereby the sub chip is activated selectively.

On the other hand, to the CAS clock generator **213** is fed a column address strobe signal CASB through the input pad CASB, and an output signal from the CAS clock generator **213** is fed to the Y address decoder **207** and the data output buffer **221** as internal control signals YDG and DOC, respectively, and also fed to predetermined portions of the sub chip. On the basis of the column address strobe signal CASB inputted through the CAS buffer **214** the CAS clock generator **213** forms various internal control signals necessary for the complementary bit line selecting operation and for the control of the main amplifier **220** and data output buffer **221**. Likewise, to the WE buffer **216** is fed a write enable signal WEB through the input pad WEB, and an output signal from the WE buffer **216** is fed to the WE clock generator **215**. Further, an output signal from the WE clock generator **215** is fed as an internal control signal WP to the write amplifier **218** and also fed to predetermined portions of the sub chip. On the basis of the write enable signal WEB inputted through the WE buffer **216** the WE clock generator **215** forms an internal control signal WE, etc. necessary for the control of the write amplifier **218**.

To the mode setter **223** are fed a predetermined mode control signals through the pads F**1**–F**3** and TC, and output signals from the mode setter **223** are fed as internal control signals CSA and TCD to the X address buffer **205**. On the basis of the mode control signals fed through the pads F**1**–F**3** and TC the mode setter **223** forms various internal control signals for setting the bit configuration of the sub chip and chip selecting conditions. On the other hand, the voltage dropping section **222** forms a predetermined internal source voltage VCL on the basis of external source voltages VCC fed through the source voltage input pads VCC**1** and VCC**2**, and supplied it as an operating power to various portions of the sub chip. The internal source voltage VCL is set at a positive voltage of a relatively small absolute value such as +3.3 V for example.

1.2.3. Basic Layout

In each of the 64M DRAM sub chips according to this embodiment, the memory array **201** is divided into four memory blocks **0**–**3**, which are further divided into four mats **0**–**3** each consisting of four sub arrays **0**–**3**. The sub arrays **0**–**3** constituting each memory block and mat are disposed to extend the word lines in the direction of X axis of the semiconductor substrate surface, i.e., in the shorter side direction, as shown in FIG. **5**, and a sense amplifier (not shown) is disposed between two adjacent sub arrays **0** and **1** and also between sub arrays **2** and **3**. In corresponding relation to each of these sense amplifiers there are provided two sets of common IO lines **217**. Inside the sub arrays **0**–**3** there are disposed corresponding word driver **202** and X address decoder **203**. The mats **0**–**3** which constitute each memory block form pairs each consisting of two mats, and a Y address decoder **207** is disposed between the mats of each pair. These Y address decoders are used in common by two mats on both sides, namely, eight sub arrays. In an intermediate portion of each memory block there is disposed a read-write circuit including a write amplifier **218** and a main amplifier **220**. Centrally in the direction of Y axis, **1**.e., in the longer side direction, of the semiconductor substrate surface there are disposed a plurality of bonding pads, i.e. external terminals of the DRAM sub chip, in a straight line form. As will be described rarer, the paired sub chips A and B which constitute the DRAM package are mounted in opposed relation to each other. By this central, linear arrangement of the bonding pads, not only a planar symmetry of the bonding pads can be ensured but also the chip mounting method based on the conventional LOC (Lead On Chip) method can be applied. The basic layout of FIG. **5** does not restrict the layout size of each portion or an absolute number of bonding pads.

In this embodiment, though not specially limited, the sub arrays **0**–**3** substantially include 512 word lines and 2048 sets of complementary bit lines, each having a memory capacity of 1 megabits. That is, each mat has a memory capacity of 1M×4 bits, i.e., 4 megabits, and each memory block has a memory capacity of 4M×4, i.e., 16 megabits. Thus, the DRAM sub chips each have a memory capacity of 16M×4, i.e., 64 megabits. In this embodiment, as indicated by hatched lines in FIG. **5**, when the DRAM sub chip is brought into a selected state, four sub arrays are activated simultaneously and two sets, a total of eight sets, of complementary bit lines adjacent to the four sub arrays are connected selectively to two sets, a total of eight sets, of common IO lines. That is, each read-write circuit includes two, a total of eight, write amplifiers **218** and main amplifiers **220** which are provided in correspondence to those common IO lines. These write amplifiers and main amplifiers are operated in predetermined combinations, whereby the bit configuration of the DRAM sub chip is changed over selectively.

1.2.4. Address Assignment

To the DRAM sub chip are fed 13-bit X address signals X**0**–X**12** and Y address signals Y**0**–Y**12**, as mentioned above, and the address space of the sub chip is designated selectively. In this embodiment, though not specially limited, the 512 word lines which constitute the sub arrays **0**–**3** are designated in an alternative manner in accordance with 9-bit X address signals X**0**–X**8**, while the 2048 sets of complementary bit lines are designated in an alternative manner in accordance with 11-bit Y address signals Y**0**–Y**10**, as shown in FIG. **6**. The four sub arrays **0**–**3** which constitute each mat are designated in an alternative manner in accordance with 2-bit X address signals X**9** and X**10**, while the four mats **0**–**3** which constitute each memory block are designated in an alternative manner in accordance with 1-bit X address signal X**11** and Y address signal Y**11**. Further, the four memory blocks **0**–**3** are designated in an alternative manner in accordance with 1-bit X address signal X**12** and Y address signal Y**12**.

As to the 2048 sets of complementary bit lines which constitute each sub array, as mentioned above, two adjacent sets are brought into a selected state simultaneously, but are substantially designated in an alternative manner in accordance with Y address signals Y**0**–Y**8** because the two corresponding main amplifiers are selected in accordance with Y address signal Y**0**. Actually, the selection of memory blocks **0**–**3** by the most significant bit X and Y address signals X**12**, Y**12** is also realized by the selection of corresponding main amplifiers.

1.2. Variations of DRAM Package

In FIG. **7** there is illustrated a list of 128M DRAM package products comprising the 64M DRAM sub chips shown in FIGS. **3** to **6**. FIGS. **8** to **12** are block diagrams of the DRAM packages shown in the product list of FIG. **7**. With reference to these figures, the following description is now provided about the kind, configuration and outline of 128M DRAM packages each capable of being constituted by two 64M DRAM sub chips. In the block diagrams of FIGS. **8** to **12** there are shown only address signals and signal lines relating to input and output data.

1.3.1. Kind of 128M DRAM Packages Capable of Being Constituted

The 64M DRAM sub chips in this embodiment can each take three kinds of bit configurations of 64M×1 bit, 16M×4 bits and 8M×8 bits because prescribed bondings are executed selectively, as noted previously. By combining the two DRAM sub chips of the same bit configuration and accessing them simultaneously or selectively it is possible to configure a total of six kinds of 128M DRAM packages which are shown in FIG. **7**. The 128M×1 bit DRAM package constituted by combining two 64M×1 bit DRAM sub chips and accessing these sub chips selectively in accordance with a chip selection signal, i.e., X address signal **X13**, corresponds to the embodiment shown in FIG. **1**, will not be explained here.

1.3.2. Outline of Various DRAM Packages

(1) 64M×2 bit DRAM package wherein two 64M×1 bit DRAM sub chips are accessed simultaneously:

Such a 128M DRAM package of 64M×2 bits as shown in FIG. **8** can be constituted by combining two 64M DRAM sub chips A and B each having a bit configuration of 64M×1 bit and then accessing these sub chips simultaneously. In this variation, 13-bit X address signals **X0**–**X12** and Y address signals **Y0**–**Y12** are fed to address input pads **A0**–**A12** of the sub chips A and B in common and time-sharingwise, and data input and output pads Din, Dout are connected to corresponding data input terminals Din**1**, Din**2** and data output terminals Dout**1**, Dout**2** of the DRAM package. As a result, the sub chips A and B are brought into a selected state simultaneously and execute storage data inputting and outputting operations in the unit of 1 bit and in parallel. Thus, the DRAM package has a bit configuration of 64M×2 bits, wherein 2-bit storage data are inputted or outputted simultaneously. At this time, refresh operations for the sub chips are also executed in parallel, the refresh cycle of DRAM package becomes 8 K cycle/64 ms. It goes without saying that the power consumption of the DRAM package as a whole is about twice that of the 64M DRAM sub chips.

(2) 32M×4 bit DRAM package wherein two 16M×4 bit DRAM sub chips are accessed selectively:

By combining two 64M DRAM sub chips A and B each having a bit configuration of 16M×4 bits and then accessing these sub chips selectively there can be constituted such a 128M DRAM package of 32M×4 bits as shown in FIG. **9**. In this variation, 13-bit X address signals **X0**–**X12** and 11-bit Y address signals **Y0**–**Y10** are fed to address input pads **A0**–**A12** of the sub chips A and B in common and time-sharingwise, and further fed is an X address signal **X13** which serves as a chip selection signal through an address input pad A**13**. Data input-output pads DIO**0** to DIO3 of each sub chip are connected in common to corresponding data input-output terminals DIO0–DIO3 of the DRAM package. As a result, the such chip A is brought into a selected state selectively when the level of the X address signal **X13** is made low, and it executes alone a storage data inputting or outputting operation. On the other hand, the sub chip B is brought into a selected state selectively when the level of the X address signal X**13** is made high, and it executes alone a storage data inputting or outputting operation. Now, the DRAM package has a bit configuration of 32M×4 bits and inputs or outputs 4-bit storage data simultaneously. At this time, refresh operations for the sub chips A and B are executed selectively, so the refresh cycle of the DRAM package becomes 16 K cycle/64 ms. The power consumption of the DRAM package as a whole is almost equal to that of one sub chip because the 64M DRAM sub chips A and B are activated selectively, whereby the reduction of power consumption can be attained.

(3) 16M×8 bit DRAM package wherein two 16M×4 bit DRAM sub chips are accessed simultaneously:

By combining two 64M DRAM sub chips A and B each having a bit configuration of 16M×4 bits and then accessing these sub chips simultaneously there can be constituted such a 128M DRAM package of 16M×8 bits as shown in FIG. **10**. In this variation, 13-bit X address signals **X0**–**X12** and 11-bit Y address signals **Y0**–**Y10** are fed to address input pads **A0**–**A12** in common and time-sharingwise. Data input-output pads DIO**0**–DIO**3** of each sub chip are connected to corresponding input-output terminals DIO**0**–DIO**7** of the DRAM package. As a result, the sub chips A and B are brought into a selected state simultaneously and execute a 4-bit storage data inputting or outputting operation in a parallel manner. Now, the DRAM package has a bit configuration of 16M×8 bits and it inputs or outputs 8-bit storage data simultaneously. At this time, refresh operations for the sub chips A and B are also executed in parallel, so the refresh cycle as to the DRAM package becomes 8 K cycle/64 ms. The power consumption as to the entire DRAM package is about twice that of the sub chips.

(4) 16M×8 bit DRAM package wherein two 8M×8 bit DRAM sub chips are accessed selectively:

By combining two 64M DRAM sub chips A and B each having a bit configuration of 8M×8 bits and then accessing these sub chips selectively there can be constituted such a 128M DRAM package of 16M×8 bits as shown in FIG. **11**. In this variation, 13-bit X address signals **X0**–**X12** and 10-bit Y address signals **Y0**–**Y9** are fed to address input pads **A0**–A**12** of the sub chips A and B in common and time-sharingwise. Further, an X address signal **X13** which serves as a chip selection signal is fed through an address input pad A**13**. Data input-output pads DIO**0**–DIO**7** of each sub chip are connected in common to corresponding data input-output terminals DIO**0**–DIO**7** of the DRAM package. As a result, the sub chip A is brought into a selected state selectively when the level of the X address signal **X13** is made low, and it executes alone an 8-bit storage data inputting or outputting operation, while the sub chip B is brought into a selected state selectively when the level of the X address signal is rendered high, and it executes along an 8-bit storage data inputting or outputting operation. Now, the DRAM package has a bit configuration of 16M×8 bits and inputs or outputs 8-bit storage data simultaneously. At this time, the refresh cycle of the DRAM package is 16K cycle/64 ms and the power consumption as to the entire package is almost equal to that of one sub chip. Thus, the reduction of power consumption can be attained.

(5) 8M×16 bit DRAM package wherein two 8M×8 bit DRAM sub chips are accessed simultaneously:

By combining two 64M DRAM sub chips A and B each having a bit configuration of 8M×8 bits and then accessing these sub chips simultaneously there can be constituted such a 128M DRAM package of 8M×16 bits as shown in FIG. **12**. In this variation, 13-bit X address signals **X0**–**X12** and 10-bit Y address signals **Y0**–**Y9** are fed to address input pads **A0**–**A12** of the sub chips A and B in common and time-sharingwise. Input-output pads DIO**0**–DIO**7** of the sub chips are connected to corresponding data input-output terminals DIO**0**–DIO**7** and DIO**0**–DIO**15** of the DRAM package. As a result, the sub chips A and B are brought into a selected state simultaneously and executes an 8-bit storage data inputting or outputting operation in a parallel manner. Now, the DRAM package has a bit configuration of 8M×16 bits and inputs or outputs 16-bit storage data simultaneously. At this time, the refresh cycle of the DRAM package is 8K cycle/64 ms and the power consumption of the package as a whole is about twice that of the sub chips.

1.4. Package Form of DRAM Package and Manufacturing Method for Same

FIG. **13** is a structural perspective view of a 128M DRAM package embodying the invention and FIG. **14** is a plan view thereof. FIG. **15** is a structural sectional view of the DRAM package shown in FIGS. **13** and **14**, and FIGS. **16** to **18** are cut-away plan views thereof. Further, FIGS. **19** to **23** are processing diagrams relating to manufacturing processes for the DRAM package illustrated in FIGS. **13** and **14**, and FIG. **24** is a plan view showing an example of a lead frame used therein. FIGS. **25** to **31** are structural sectional views and plan view of other package forms of DRAM packages embodying the invention. With reference to these figures, the following description is provided about the package form, manufacturing method and features of the DRAM packages, including modifications. These examples place no limitation on concrete shape and size of the package as well as in what order the bonding pads are to be arranged.

1.4.1. Outline of Lead Laminated Type Package

This 128M DRAM package basically comprises two 64M DRAM sub chips A (**1**A: first semiconductor chip) and B (**1**B: second semiconductor chip), as mentioned previously. As shown in FIG. **15**, these sub chips are mounted opposedly to each other on both sides of a lead frame **3** which serves as wiring means. The lead frame **3** comprises inner leads **3**A in the interior of the package and outer terminals or leads **3**B in the exterior of the package. That is, the lead frame **3** as wiring means has a structure which is substantially integrally formed with the external terminals of the package. The DRAM package after sealing is a so-called SOJ type package, having outer dimensions of 300 mils in short side and 850 mils in long side, as shown in FIG. **14**. FIG. **15** corresponds to a structural sectional view taken on line **15**—**15** of the plan view of FIG. **14**, while FIGS. **16** and **17** correspond to cut-away plan views taken along lines **16**—**16** and **17**—∫in the structural sectional view of FIG. **15**. It goes without saying that in the following structural sectional views, including FIG. **15**, the sectional views of the sub chips **1**A and **1**B are taken in the short side direction of the sub chips.

In FIG. **15**, the sub chip **1**A is connected to inner leads **3**Aa of one lead frame (first lead frame) through an insulating film **4** of polyimide sandwiched in between adhesive layers of a thermoplastic polyimide. This lead frame is made integral with the external terminals or outer leads **3**B of the DRAM package without being cut. Plural bonding pads provided centrally of Y axis of the sub chip **1**A in a straight line form are connected to corresponding inner leads **3**Aa through bonding wires **5**. As shown in FIG. **16**, the inner leads are separated into relatively short inner leads **3A1** which are provided correspondingly to ordinary external terminals and relatively long inner leads **3A2** for the supply of source voltage and earth potential provided between externals VCC**1** and VCC**2** and between external terminals VSS**1** and VSS**2**. The inner leads **3A1** are used for bonding to inputting or outputting pads, while the inner leads **3A2** are used for the supply of source voltage and earth potential and for bonding to mode setting pads F1–F3 and TC. Thus, in this package, the source voltage and earth potential can be supplied in any desired positions through the inner leads **3A2**, so it is possible to shorten the source voltage or earth potential feed lines to suppress power source noises and attain speed-up of the operations of the DRAM sub chips **1**A and **1**B. As the bonding wires **5** there are used aluminum, gold or copper wires or coated wires obtained by coating the surfaces of such metal wires with an insulating resin. For the bonding between inner leads and pads there is adopted a conventional method used for LOC type packages, and the bonding is effected by a bonding method comprising both pressure bonding under heating and ultrasonic vibration. In a LOC type package, the inner leads **3**A can be extended freely without being restricted by the shape of the DRAM sub chips **1**A and **1**B, so the sub chip size can be increased accordingly; in other words, the package size can be reduced.

On the other hand, the sub chip **1**B is connected to inner leads **3**Ab of the other lead frame (second lead frame) also through the insulating film **4**. Though not specially limited, this lead frame is cut along the outer edges of the sub chips **1**A and **1**B and connected to corresponding inner leads **3**Aa of the lead frame which corresponds to the sub chip **1**A. Thus, according to the package form of this package, two opposed lead frames are cut and bonded, so this package is named a lead laminated type package. The inner leads **3**Ab may be cut outside the sub chips **1**A and **1**B and inside a resin sealed type package **2**, as shown in FIG. **18**. As mentioned previously, bonding pads of the sub chips **1**A and **1**B are arranged centrally thereon and along the Y axis, or the long side, in a straight line form. For the bonding of the sub chips **1**A and **1**B, therefore, predetermined external terminals of the sub chips are connected to left- and right-hand inner leads **3**Aa, **3**Ab, respectively, in the sub chips **1**A and **1**B for example. Such different bondings in the sub chips **1**A and **1**B permit overlapping of leads of corresponding functions when the sub chips **1**A and **1**B are lapped (or stacked) together in opposed relation to each other.

The sub chips **1**A and **1**B thus bonded together through the lead frames are sealed with a molding resin **2**. As the molding resin **2** there is used an epoxy resin incorporating therein a phenolic curing agent, a silicone rubber and a filler for attaining a reduced stress of the package. The silicone rubber functions to decrease the elastic modulus and the coefficient of thermal expansion of the epoxy resin. The filler, which is formed as spherical silicon oxide particles, also functions to decrease the thermal expansion coefficient. In a predetermined position of the package there is formed a cut-in portion serving as an index ID. The package is designed so that the cut portion of the lead frame corresponding to the sub chip **1**B and the portion thereof bonded to the lead frame corresponding to the sub chip **1**A are located in the interior of the resin-sealed package, i.e., the molding resin **2**, whereby the said lead frame cut portion and bonded portion can be protected and hence it is possible to enhance the durability of the DRAM package.

1.4.2. How to Produce Lead Laminated Type Package

The 128M DRAM package of this embodiment is produced through the following processes.

(1) Bonding to Pellet

The sub chips **1**A and **1**B are bonded to the corresponding inner leads **3**Aa and **3**Ab through the insulating film **4**. As shown in FIG. **19**, the insulating film **4** is of a three-layer structure wherein polyimide is sandwiched in between adhesive layers of a thermoplastic polyimide. The insulating film **4** is heated and pressurized in advance by means of a heater press, then bonded to the inner leads **3**Aa or **3**Ab and thereafter bonded to the sub chip **1**A or **1**B by a heat press **20**.

(2) Wire Bonding

Next, as shown in FIG. **20**, there is performed a bonding processing between the bonding pads arranged centrally of the Y axis or the long side of the sub chips **1**A, **1**B and the inner leads **3**Aa, **3**Ab. The inner leads **3**Aa and **3**Ab are each bent beforehand in a direction away from the corresponding sub chip. After completion of the bonding, the sub chip **1**B

bonded to the inner leads **3**Ab is inverted onto the sub chip **1**A bonded to the inner leads **3**Aa, whereby the two sub chips **1**A and **1**B are opposed to each other on both sides of the lead frames and the inner leads corresponding to each other come into contact with each other.

(3) Cutting and Bonding of Leads

For mutual contact of the corresponding leads, the inner leads **3**Ab superimposed on the inner leads **3**Aa are cut in the outer edge position of each sub chip by a YAG laser beam **22** emitted from a laser device **21** and at the same time they are welded to the inner leads **3**Aa. Now, the corresponding leads of the inner leads **3**Aa and **3**Ab are connected together electrically.

(4) Sealing

The sub chips **1**A and **1**B thus laminated together opposedly with the lead frames put therebetween are then sealed with the molding resin **2**, as shown in FIG. **22**. At this time, the cut portions of the inner leads **3**Ab and the bonded portions thereof to the inner leads **3**Aa are protected within the molding resin **2**, whereby the entry of water, etc. through the bonded portions is prevented and hence it is possible to enhance the durability of the DRAM package.

(5) Lead Forming

In the package thus sealed with the molding resin **2**, as shown in FIG. **23**, the outer leads **3**B of the lead frame corresponding to the sub chip **1**A are formed by a predetermined pressing machine to obtain a DRAM package **1** of the so-called SOJ structure.

1.4.3. Lead Frame and Insulating Film

The lead frames used in the lead laminated type package of this embodiment are designed so that the distance between adjacent inner and outer leads **3**A, **3**B is almost equal throughout the lead frames, as shown in FIG. **24**. As a result, the parasitic capacitance between leads is unified, the amount of noise induced between leads is suppressed, and the signal transfer time associated with the DRAM package is shortened accordingly.

On the other hand, the insulating film **4** used for bonding between the sub chips **1**A, **1**B and the inner leads **3**A is cut in the shape of a comb along the inner leads **3A1**, as indicated by oblique lines in FIG. **24**. The thermal expansion coefficient of the insulating film is relatively greatly different from that of the semiconductor substrate which forms each sub chip or the lead frame. Therefore, in the case where the substantial bonding area of the insulating film is large, the bonded portion of the insulating film may be peeled off by expansion and contraction caused by temperature changes over a long period. By cutting the insulating film **4** in the shape of a comb along the inner leads **3A1** to reduce its substantial bonding area, it is made possible to suppress the separation of the insulating film and enhance the durability and reliability of the DRAM package.

1.4.4. Other Package Forms

There may be adopted such modified forms of 128M DRAM packages as shown in FIGS. **25** to **31**. In FIG. **25**, the back side of a sub chip **1**B is bonded to the upper surface of a lead frame **3A1** coated with an insulating film **4** of a polyimide resin, while to the lower surface of the lead frame **3A1** is bonded the surface side of a sub chip **1**A. At this time, the sub chip **1**B and the inner leads **3A1**, as well as the inner leads **3A1** and the sub chip **1**A, are shifted from each other by a predetermined distance required for wire bonding. Thereafter, the inner leads **3A1** and the sub chip **1**A are wire-bonded together according to the LOC technique, and the inner leads **3A1** and the sub chip **1**B are wire-bonded by a conventional method.

On the other hand, as shown in FIG. **26**, when the lower sub chip **1**A and the inner leads **3A1** are bonded together using solder bumps **10**, it is not necessary to substantially shift the sub chips **1**A and **1**B in the manner described above.

In the foregoing lead laminated type package, the two lead frames corresponding to the sub chips **1**A and **1**B can be extended up to the outer leads **3**B without being cut, as shown in FIG. **27**. In this case, for retaining the durability of the DRAM package, it is necessary to prevent the ingress of water, etc. through the lead frame bonded portion.

In the case where it is possible to realize a lead frame which permits two sub chips **1**A and **1**B to be arranged side by side on the same plane, as shown in FIG. **28**, there can be formed such a DRAM package as shown in FIG. **29** by bending the lead frame along a fold line upon completion of bonding and wire bonding of those sub chips. In this case, the backs of the sub chips **1**A and **1**B are bonded and fixed using an insulating film **4** of a polyimide resin, followed by sealing with a molding resin **2**.

Further, as shown in FIG. **30**, the sub chips **1**A and **1**B can each be bonded to a lead frame as a circuit board through solder bumps **6**, as shown in FIG. **30**. As shown in FIG. **31**, moreover, it is also possible to realize a DRAM package comprising four sub chips by stacking two pairs of sub chips **1**A, **1**B and **1**C, **1**D bonded according to the lead laminated packaging method, in the direction perpendicular to the sub chip surfaces and then connecting corresponding leads of the lead frames in common. Also in this case, for enhancing the durability of the DRAM package it is desirable that the cut portion of the lead frame corresponding to the sub chip **1**C and the bonded portion thereof to the lead frame corresponding to the sub chip **1**A be located in the interior of the molding resin **2**.

1.5. Bonding Options of DRAM Sub Chips

FIG. **32** is a list relating to bonding options of 64M DRAM sub chips to which the invention is applied. FIGS. **33** to **38** are connection diagrams of pads of the 128M DRAM packages illustrated in FIG. **1** and FIGS. **8** to **12**. With reference to these figures, the following description is provided about bonding options of the DRAM sub chips and the connection of pads therein. The pad connection diagrams of FIGS. **33** to **38** are for explaining the relation of connection between pads and leads, placing no limitation on concrete arrangements and sizes of pads and leads.

In each of the 64M DRAM sub chips according to this embodiment there are provided four bonding pads F**1**–F**3** and TC for setting the bit configuration thereof and conditions for chip selection. As is apparent from FIG. **32**, the pads F**1** and F**2** are used for setting the bit configuration of each DRAM sub chip; the pad TC sets whether the DRAM sub chips are to be accessed selectively or simultaneously; and the pad F**3** is used for setting on which logical level of the X address signal X**13** as a chip selection signal the DRAM sub chips are to be brought into a selected state in the case where the sub chips are accessed selectively. In the initial state of the sub chips the pads F**1**–F**3** and TC are brought into a non-connected state NC (No Connect) not connected to any of the leads, and if necessary, they are wire-bonded selectively to an inner lead **3A2** for the supply of source voltage, or a source voltage supplying lead VCC.

When the pads F**1** and F**2** are both connected to the source voltage supplying lead VCC, the associated DRAM sub chip has a bit configuration of 64M×1 bit and inputs or outputs storage data in the unit of 1 bit through data input pad Din or data output pad Dout. At this time, as shown in FIG. **33**, when the pad TC is connected to the source voltage supplying lead VCC, the sub chip is activated selectively in accordance with the chip selection signal, i.e., X address signal **13**. Thus, the illustrated sub chips correspond to the

sub chips A (1A) and B (1B) which constitute the DRAM package of FIG. **1**. When the pad F3 is connected to the source voltage supplying lead VCC, the sub chip is brought into a selected state selectively on condition that the level of the X address signal **X13** is a low level, while when the pad **F3** is brought into the unconnected state NC, the sub chip is brought into the selected state selectively on condition that the level of the X address signal **X13** is a high level H. The data input pads Din of the sub chips A and B are connected in common to leads corresponding to data input terminals Din of the DRAM package, while the data output pads Dout are connected in common to leads corresponding to data output terminals Dout of the DRAM package.

On the other hand, as shown in FIG. **34**, when the pads F**1** and F**2** are both connected to the source voltage supplying leads VCC and the pad TC is brought into the non-connected state NC, the associated sub chip has a bit configuration of 64M×1 bit and is held in the selected state irrespective of the logical level of the X address signal **X13**. Thus, the sub chips correspond to the sub chips A and B which constitute the DRAM package shown in FIG. **8**. At this time, the data input and output pads Din, Dout of the sub chip A are connected respectively to leads corresponding to data input and output terminals Din**0**, Dout**0** of the DRAM package, while the data input and output pads Din, Dout of the sub chip B are connected respectively to leads corresponding to data input and output terminals Din**1**, Dout**1** of the DRAM package.

When the pad F**1** is connected to the source voltage supplying lead VCC and the pad F**2** is brought into the non-connected state NC, the associated DRAM sub chip has a bit configuration of 16M×4 bits and inputs or outputs storage data in the unit of 4 bits through data input-output pads DIO**0** to DIO3. At this time, as shown in FIG. **35**, once the pad TC is connected to the source voltage supplying lead VCC, the sub chip is activated selectively in accordance with the X address signal X13. Thus, the sub chips correspond to the sub chips A and B which constitute the DRAM package shown in FIG. **9**. Further, when the pad F3 is connected to the source voltage supplying lead VCC, the associated sub chip is brought into a selected state selectively on condition that the level of the X address signal X13 is a low level L, while when the pad F3 is brought into the non-connected state NC, the sub chip is brought into the selected state selectively on condition that the level of the X address signal **X13** is a high level H. The input-output pads DIO**0**–DIO**3** of the sub chips A and B are respectively connected in common to leads corresponding to the data input-output terminals DIO**0**–DIO**3** of the DRAM package.

On the other hand, as shown in FIG. **36**, when the pad F**1** is connected to the source voltage supplying lead VCC and the pads F**2** and TC are brought into the non-connected state NC, the associated sub chip has a bit configuration of 16M×4 bits and is held in the selected state. Now, the sub chips correspond to the sub chips A and B which constitute the DRAM package shown in FIG. **10**. At this time, the data input-output pads DIO**0**–DIO**3** of the sub chip A are connected respectively to leads corresponding to the data input-output terminals DIO**0**–DIO**3** of the DRAM package, while the data input-output pads DIO**0**–DIO**3** of the sub chip B are connected respectively to leads corresponding to the data input-output terminals DIO**4**–DIO**7** of the package.

Further, when the pads F**1** and F**2** are both brought into the non-connected state NC, the associated DRAM sub chip has a bit configuration of 8M×8 bits and inputs or outputs storage data in the unit of 8 bits through the input-output pads DIO**0**–DIO**7**. At this time, as shown in FIG. **37**, when the pad TC is connected to the source voltage supplying lead VCC, the sub chip is activated selectively in accordance with the X address signal **X13**. Now, the sub chips of this DRAM package correspond to the sub chips A and B which constitute the. DRAM package illustrated in FIG. **11**. Further, when the pad F3 is connected to the source voltage supplying lead VCC, the associated sub chip is brought into a selected state on condition that the level of the X address signal is a low level L, while when the pad F3 is brought into the non-connected state NC, the sub chip is brought into the selected state on condition that the level of the X address signal is a high level H. The data input-output pads DIO**0**–DIO**7** of the sub chips A and B are respectively connected in common to leads corresponding to the input-output terminals DIO**0**–DIO**7** of the DRAM package.

As shown in FIG. **38**, when the pads F**1**, F**2** and TC are brought into the non-connected state NC, the associated sub chip has a bit configuration of 8M×8 bits and is held in the selected state. Now, the sub chips of this package correspond to the sub chips A and B which constitute the DRAM package illustrated in FIG. **12**. At this time, the data input-output pads DIO**0**–DIO**7** of the sub chip A are connected respectively to leads corresponding to the data input-output terminals DIO**0**–DIO**7** of the DRAM package, while the data input-output pads DIO**0**–DIO**7** of the sub chip B are connected respectively to leads corresponding to the data input-output terminals DIO**8**–DI**15** of the package.

1.6. Concrete Methods for the Selection of Chip

FIG. **39** is a circuit diagram of the X address buffer **205** included in the 64M DRAM sub chip embodying the invention, and FIGS. **40** to **44** are block diagrams and timing charts illustrating other chip selecting methods in DRAM package. With reference to these figures, the following description is provided about concrete chip selecting methods in the 64M DRAM package. In each of the circuit diagrams of the figures which follow, the MOSFET (a metal oxide semiconductor type field effect transistor; the term "MOSFET" is used herein as a generic term for insulated gate type field effect transistors) with an arrow attached to the channel (back gate) portion is a P-channel type and is distinguished from an N-channel MOSFET with an arrow not attached thereto.

1.6.1. Selective Activation Method and Configuration of X Address Buffer

The chip selection for the 64M DRAM sub chip of this embodiment is substantially determined selectively in accordance with the logical level of the internal control signal CS which is outputted from the X address buffer **205**. The logical level of the internal control signal CS is set selectively in accordance with the logical level of the X address signal **X13** and whether the bonding relating to the bonding pads TA and F**3** is executed or not.

As shown in FIG. **39**, the pad TC is connected to a corresponding input circuit IC**3** of the mode setter **223**, and the level of an output signal, or an internal control signal TCD, from the input circuit IC**3** is made high or low selectively according to the state of bonding. More specifically, when the pad TC is brought into the non-connected state NC, the level of the internal control signal TCD is made low, while when the pad TC is connected to the source voltage supplying lead VCC, the level of the internal control signal TCD is made high. Likewise, the pad F3 is connected to a corresponding input circuit IC**2** of the mode setter **223**, and the level of an output signal, or an internal control signal CSA, from the input circuit IC**2** is made low when the pad F**3** is brought into the non-connected state NC, while when the pad F**3** is connected to the source voltage supplying lead VCC, the level of the internal control signal

CSA is rendered high. The internal control signals TCD and CSA are fed to the X address-buffer **205**.

The X address buffer **205** includes an input circuit **IC1** having an input terminal connected to an address input pad **A13**. The input circuit IC1 is brought into a transfer state selectively when the level of a row address strobe signal RASB and that of an internal control signals RASO are made high, and it takes in the chip selection signal, i.e., the X address signal **X13**, which is fed time-sharingwise through the address input pad **X13**. An output signal from the input circuit IC1 is fed as an internal signal **X13** to one input terminal of a selector **SEL1**, while at the same time, after being inverted by an inverter, the thus-inverted output signal is fed as an inverted internal signal **X13**B to the other input terminal of the selector **SEL1**. To a first control terminal of the selector **SEL1** is fed the internal control signal CSA from the mode setter **223**, while to a second control terminal thereof is fed an output signal, or an internal signal RCS, from a NOR gate NO**1**.

To one input terminal of the NOR gate NO**1** is fed an internal control signal CAS**1** which is formed in accordance with a column address strobe signal CASB, while to the other input terminal thereof is fed an output signal from a NAND gate NA**1**. To a pair of input terminals of the NAND gate NA**1** are fed inverted internal control signals RAS**0**B and RAS**1**B which are formed on the basis of the row address strobe signal RASB. As a result, the level of the output signal from the NAND gate NA**1** is rendered high selectively when the level of either the inverted internal control signal RAS**0**B or RAS**1**B is made low, while the level of the output signal from the NOR gate NO**1**, i.e. the internal signal RCS, is rendered low selectively when the level of the output signal from the NAND gate NA**1** or that of the internal control signal CAS**1** is made high. In other words, during the period in which the DRAM sub chips are held in an unselected state and also during the period from the time when the DRAM sub chips are brought into a selected state until when the level of the inverted internal control signal RAS**0**B or RAS**1**B is made low or that of the internal control signal CAS**1** is made high, the level of the internal control signal RCS is kept high, while it is rendered low while the DRAM sub chips are substantially held in a selected state.

When the level of the internal signal RCS is made high, the selector SEL**1** is brought into a transfer state, while when the level of the internal signal RCS is rendered low, the selector SEL**1** is brought into a non-transfer state. In the transfer state, when the level of the internal control signal CSA is low, the selector SEL**1** further inverts the inverted internal signal X13D and transfers the thus-inverted signal to a latch circuit LT**1** which follows, while when the level of the internal control signal CSA is high, the selector SEL**1** inverts the internal control signal X**13**B and transfers the thus-inverted signal to the latch circuit. Thus, when the pad **F3** is brought into the non-connected state NC, the selector SEL**1** further inverts the inverted internal signal X**13**B, i.e., an inverted signal of the X address signal X**13**, and transfers the thus-inverted signal to the latch circuit LT**1**; in other words, the X address signal **X13** is transferred to the latch circuit LT**1** directly without being inverted. When the pad **F3** is bonded to the source voltage supplying lead VCC, the selector SEL**1** inverts the internal signal X**13**, i.e., the X address signal X**13**, and transfers it to the latch circuit LT**1**. The X address signal X**13** transfer operation of the selector SEL**1** is stopped upon lapse of a predetermined time after the DRAM sub chips are brought into a selected state and when the level of the internal signal RCS is made low.

The latch circuit LT**1** is brought into a latch form selectively in accordance with an inverted signal of the output signal from the NAND gate NA**1**, i.e., an inverted internal signal RSB. More specifically, the latch circuit LT**1** is brought into a latch form selectively when the level of the inverted internal signal RSB is made low, in other words, upon lapse of a predetermined time after the DRAM sub chips were brought into a selected state. In this state the latch circuit LT**1** holds the internal signal X**13** or inverted internal signal X**13**B transferred through the selector SEL**1**. An output signal from the latch circuit LT**1** is fed to one input terminal of a NAND gate NA**2**. To the other input terminal of the NAND gate NA**2** is fed the output signal from the NAND gate NA**1**, i.e., internal signal RS. An output signal from the NAND gate NA**2** is outputted through a transfer gate TG**1** which receives the internal control signal TCD at a control terminal thereof and further through one inverter, and serves as an internal control signal CS. An output terminal of the trasnfer gate TG**1** is connected to an earth potential of the circuit through an N-channel MOSFET which receives at a gate thereof an inverted signal of the internal control signal TCD.

Thus, the internal signal X**13** or inverted internal control signal X**13**B held by the latch circuit LT**1** is transmitted to the transfer gate TG**1** on condition that the level of the internal signal RS and that of the internal control signal TCD are made high, in other words, on condition that the level of the row address strobe signal RASB is made low and the pad TC is bonded to the source voltage supplying lead VCC. The internal signal **X13** or inverted internal signal **X13**B thus transferred serves as the internal control signal CS. That is, the level of the internal control signal CS is kept low while the level of the row address strobe signal RASB is high, and upon lapse of a predetermined time after the level of the row address strobe signal RASB was made low, the level of the internal control signal CS is rendered high or low selectively in accordance with the X address signal **X13** on condition that the pad TC is bonded to the source voltage supplying lead VCC. That is, when the pad **F3** is in the unconnected state NC, the level of the internal control signal CS is rendered high on condition that the level of the inverted internal signal X**13**B is low, in other words, on condition that the level of the X address signal X**13** is high, while when the pad **F3** is bonded to the source voltage supplying lead VCC, the level of the internal control signal CS is rendered high selectively on condition that the level of the internal signal **X13** is low, in other words, on condition that the level of the X address signal **X13** is low. As a result, the internal control signal CS is formed in accordance with the conditions illustrated in FIG. **32** and can determine conditions for the selection of the paired sub chips which constitute the DRAM package.

In the DRAM sub chips of this embodiment, the internal control signal CS is formed selectively in accordance with the X address signal **X13**, as mentioned above, and this X address signal **X13** is fed at a relatively quick timing in synchronism with the trailing edge of the row address strobe signal RASB. As indicated at ② in FIG. **4**, the internal control signal CS can be utilized for causing the formation of the internal control signal XDG to be executed selectively by the RAS2 clock generator **210**, causing the selection of word lines to be executed selectively by the X address decoder **203** and thereby activating each sub chip selectively. In the case where there is a further margin in the input timing of the X address signal **X13**, it is also possible to operate the X predecoder **204** selectively in accordance with the internal control signal CS, as indicated at ① in FIG. **4**,

and cut down another 10% or so the power consumption of the sub chip which is rendered inactive. On the other hand, in the case where there is no margin in the input timing of the X address signal **X13** or when a chip selection signal is fed as part of the column address signal, i.e., Y address signal, the two sub chips which constitute the DRAM package must be activated simultaneously, and in this case either the storage data inputting operation of the write amplifier **218** or the outputting operation of the data output buffer **221** can merely be done selectively, as indicated at ③ in FIG. **4**.

1.6.2. Other Chip Selecting Methods

In the 64M DRAM package of the above embodiment, the chip selection signal for selectively accessing a pair of DRAM sub chips is fed as the X address signal **X12**, and the number of address input terminals is substantially increased by one. A method for coping with this increase may be optimizing the number of external terminals of the DRAM package by setting the number of bits of the X and Y address signals so as to be equal to each other, including the chip selection signal. In this case, it is necessary that the DRAM package should be constituted by the kth power of sub chips having an address space comprising i^{th} power of 2 of row addresses and the $i\text{-}k^{th}$ power of 2 of column addresses, or the $i\text{-}k^{th}$ power of 2 of row addresses and the ith power of 2 of column addresses. Thus, the sub chips are accessed selectively in accordance with the difference, k bit, between row and column address signals.

In the embodiment illustrated in FIG. **40**, the address space of the DRAM package comprises the first power of 2, namely, two 32M DRAM sub chips A and B which are selectively designated by X address signals **X0**–**X11** of i-1 bits or 12 bits and Y address signals **Y0**–**Y12** of i bits or 13 bits, and the chip selection signal is fed to the DRAM package as X address signal **X12** of the most significant bit. At this time, as shown in FIG. **41**, the X address signals **X0**–**X11** and the X address signal **X12** as the chip selection signal are fed in synchronism with the trailing edge of the row address strobe signal RASB, while the Y address signals **Y0**–**Y12** are fed in synchronism with the trailing edge of the column address strobe signal CASB. Since the internal control signal CS can be formed at a relatively quick timing, it becomes possible to activate the sub chips A and B selectively in accordance with the internal control signal CS. Consequently, it is possible to attain the reduction of power consumption of the DRAM package while optimizing the number of external terminals of the package.

On the other hand, in the embodiment illustrated in FIG. **42**, the address space of the DRAM package comprises the first power of 2, or two, 32M DRAM sub chips designated selectively by X address signals **X0**–**X12** of i bits or 13 bits and Y address signals **Y0**–**Y11** of i-1 bits or 12 bits, and the chip selection signal is fed to the DRAM package as Y address signal **Y12** of the most significant bit. At this time, as shown in FIGS. **43** and **44**, the X address signals **X0**–**X12** are fed in synchronism with the trailing edge of the row address strobe signal RASB, while the Y address signals **Y0**–**Y11** and the Y address signal **Y12** as the chip selection signal are fed in synchronism with the trailing edge of the column address strobe signal CASB. As a result, the internal control signal CS is formed selectively at a relatively slow timing and so it is impossible to activate the sub chips A and B selectively in accordance with the internal control signal CS. In this case, the storage data inputting and outputting operations can be executed selectively by forming the internal control signal WP fed to the write amplifier **218** or the internal control signal DOC fed to the data output buffer **221**, selectively in accordance with the chip selection signals i.e., Y address signal **Y12**.

1.7. Evaluation

In the DRAM package described above there is adopted a so-called double chip package method wherein a basic configuration comprises a pair of DRAM sub chips disposed opposedly on both sides of a lead frame serving as wiring means. These sub chips are activated selectively in accordance with the X or Y address signal of the most significant bit which is fed as a chip selection signal, or execute the storage data inputting or outputting operation selectively. As a result, the following effects can be attained.

(1) There can be realized an effective chip mounting method capable of mounting plural sub chips of the same size without sacrificing the heat radiation characteristic of the package and the product yield.

(2) It is possible to attain a large capacity and low power consumption of the DRAM package while suppressing the increase of the package size.

(3) As compared with a package comprising a single DRAM chip and of about the same package size, it is possible to realize a DRAM package having a memory capacity plural times that of such single chip package, and thus the limit of memory capacity in DRAM chips, etc. can be expanded.

(4) In the case where a package is constituted by a single semiconductor chip, a signal is transmitted with a relatively large delay time which is determined by resistor R and parasitic capacity C, as shown in FIG. **45**, while in the case where a package is constituted by k number of sub chips and these sub chips are activated selectively, as shown in FIG. **46**, the resistor R and parasitic capacity C can substantially be cut down to 1/k, so the delay time as the package can be substantially reduced to one per the second power of k and the operating speed thereof can be made high.

(5) Since the bonding pads of the paired sub chips are arranged centrally in a straight line form along the X or Y axis of the semiconductor substrate surface, a planar symmetry thereof can be realized easily and it is possible to utilize the bonding according to the conventional LOC technique.

(6) Since the paired sub chips are bonded to the corresponding lead frames and thereafter these sub chips and lead frames are laminated together, a double chip package system can be realized easily by using the conventional wire bonding technique.

(7) In the case of laminating the lead frames together, one lead frame is cut and bonded to the other lead frame and the cut and bonded portions are protected in the interior of a sealing resin, so it is possible to prevent the entry of water, etc. and thereby enhancing the durability of the package.

(8) Since plural pairs of sub chips each laminated through the lead frames are stacked in the direction perpendicular to the surface thereof and the corresponding leads of the lead frames are connected in common, it is possible to laminate plural pairs of sub chips easily and promote the attainment of a large package capacity.

(9) Since the address space of each memory package is constituted by k^{th} power of 2 of memory sub chips designated selectively in accordance with row address signals of i-k bits and column address signals of i bits, or row address signals of i bits and column address signals of i-k bits, and these sub chips are activated selectively in accordance with the differences k bit,

between the row and column address signals, it is possible to optimize the number of external terminals while promoting the reduction of power consumption of each memory package comprising plural sub chips.

(10) Since the insulating film for bonding a sub chip and a corresponding lead frame with each other is cut in the shape of a comb along the leads of the lead frame, it is possible to reduce the substantial bonding area and prevent the separation of the insulating film caused by changes of temperature. As a result, it is possible to enhance the packaging efficiency of a memory system or the like including a DRAM package as a basic configuration and thereby promote the reduction of cost thereof.

2. 64M DRAM Package using Partial Chips

Embodiments have been described above with respect to 128M DRAM packages wherein a large capacity as package and low power consumption are promoted by the combination of so-called full chips having address spaces all capable of functioning normally. The double chip package system according to the present invention can also be used as means for the relief partial chips by combining so-called partial chips each having an address space capable of partially functioning normally to constitute a DRAM package.

2.2. 64M DRAM Package Using Two 64M DRAM Partial Chips Accessed Selectively

FIG. **47** is a block diagram showing a first example of a 64M DRAM package according to the present invention. FIGS. **48** and **49** are partial circuit diagrams showing an X address buffer **205** and a mode setter **223** which are included in the DRAM package of FIG. **47**. FIG. **53** is a list of connections, showing bonding options of 64M DRAM partial chips which constitute the DRAM package of FIG. **47**. With reference to these figures, the following description is now provided about an outline of the DRAM package of this embodiment and a concrete chip selecting method. In these figures, the 64M DRAM partial chips which constitute the DRAM package basically follow the 64M DRAM sub chips which constitute the foregoing 128M DRAM package. Further, as in the case of the 128M DRAM package, a pair of partial chips constituting the DRAM package are mounted according to the double chip package method. In the block diagrams of these figures, moreover, the portions which are not normal are indicated by oblique lines.

2.1.1. Block Configuration

As shown in FIG. **47**, the 64M DRAM package of this embodiment is constituted basically by two 64M DRAM partial chips A and B wherein one half of each row address space can function normally. The portion of each partial chip capable of functioning normally is not specially limited, but it is a portion designated by a low address side, or X address signal **X12**, in the row address space when the level of the signal is made low. Address input pads **A0** to A**13** of the partial chips A and B are connected in common to corresponding address input terminals **A0** to A**13** of the DRAM package, and data input pads Din and data output pads Dout thereof are connected in common to a data input terminal Din and a data output terminal Dout of the DRAM package.

In addition of the mode setting pads of the 64M DRAM sub chips in the previous embodiment, the partial chips A and B are each provided with three mode setting pads PTA, PTX and PTY. As shown in FIG. **53**, the pads PTX and PTY are normally held in an unconnected state NC and are selectively bonded to a source voltage supplying lead VCC when the row or column address space of each partial chip partially functions normally. On the other hand, the pad PTA is bonded to the source voltage supplying lead VCC in a normal condition of the portion which is designated by a low address side, or X address signal **X12** or Y address signal **Y12**, in the row or column address space when the level of the signal is made low, and the pad PTA is brought into the non-connected state NC in a normal condition of the portion which is designated by a high address side, or X address signal **X12** or Y address signal **Y12**, when the level of the signal is rendered high. As in the foregoing 128M DRAM package, bonding pads TC and F**3** are used for selectively activating the partial chips A and B or for setting chip selecting conditions selectively.

In FIG. **47**, the pads PTA and PTX of each of the partial chips A and B are both bonded to the source voltage supplying lead VCC, while the pad PTY is brought into the non-connected state NC. In each partial chip, therefore, as will be described later, the level of an internal address signal **BX12** is rendered low forcibly and the row address space on the low address side capable of functioning normally is designated steadily. On the other hand, in the partial chips A and B, the pads TC are both bonded to the source voltage supplying lead VCC, and the pad F**3** on the partial chip A side is connected to the lead VCC, while the pad F**3** on the partial chip B side is brought into the non-connected state NC, whereby the level of an internal control signal CS in the partial chip A is rendered high on condition that the level of the X address signal **X12** is low, and the level of an internal control signal CS in the partial chip B is rendered high on condition that the level of the X address signal **X12** is high.

Thus, the partial chips A and B function substantially in the same manner as the 64M DRAM sub chips A and B which constitute the foregoing 128M DRAM package shown in FIG. **1** except that their memory capacity is halved to 32 megabits. As a result, the DRAM package of FIG. **47** function as a so-called 64M DRAM package. In this case, as is apparent from FIG. **47**, the DRAM package has an interface which is just the same as that of a 64M DRAM package constituted by a single 64M DRAM chip wherein all the address spaces can function normally. The refresh cycle is also 8K cycle/64 ms, and it is also possible to conduct a parallel test. This indicates that this DRAM package comprising two partial chips can be substituted for the 64M DRAM package comprising one full chip and that the double chip packaging method is effective in substantially improving the product yield of 64M DRAM chips.

2.1.2. Selectively Activating Method and Configuration of X Address Buffer

In FIG. **48**, the pads F**3**, TC, PTA and PTX of each partial chip are connected to input terminals of corresponding input circuits IC**2**–IC**5** in the mode setter **223**, and their output signals, or internal control signals CSA, TCD, PAD and PXD, are rendered high or low in level selectively. More specifically, the internal control signals CSA, TCD, PAD and PXD are made low in level when the corresponding pads F**3**, TC, PTA and PTX are brought into the non-connected state NC, and they are made high in level when the corresponding pads are bonded to the source voltage supplying lead VCC. The internal control signals CSA, TCD, PAD and PXD are fed to the X address buffer **205**. On the other hand, the address input pad **A12** is connected to an input terminal of an input circuit IC**6** of the X address buffer **205**, as shown in FIG. **48**. The input circuit IC**6** is brought into a transfer state selectively when the level of an internal control signal RAS**0** is made high, and it transmits the X address signal **X12** which is fed time-sharingwise through the address input pad **A12**, to one input terminal of a selector SEL**2**. The other input terminal of the selector SEL**2** is connected to an output terminal thereof through an inverter to form a latch circuit.

Further, an internal control signal XL is fed to a control terminal of the selector SEL2. As a result, the selector SEL2 is brought into a transfer state on condition that the level of the internal control signal XL is made low, and it is brought into a latch form when the level of the internal control signal XL is rendered high. An inverted output signal from this latch circuit is inverted by an inverter into an internal signal **X12**, while a non-inverted output signal from the latch circuit is inverted by an inverter into an inverted internal signal X**12**B.

The inverted internal signal X**12**B outputted from the selector SEL**2** is fed to one input terminal of a NAND gate NA**5** through a transfer gate TG**2**, while the internal signal X**12** is fed to the other input terminal of a selector SEL**3** which will be described later and is also fed to one input terminal of a NAND gate NA**6** through a transfer gate TG**3**. To control terminals of the trasnfer gates TG**2** and TG**3** is fed the internal control signal PXD. Further, an internal control signal AG is fed in common to the other input terminals of the NAND gates NA**5** and NA**6**. As a result, the internal signal X**12** and the inverted internal signal X**12**B are transmitted to one input terminals of the corresponding NAND gates NA**5** and NA**6** on condition that the level of the internal control signal PXD is made low, and further it becomes the inverted internal control signal BX**12**B or internal address signal BX**12** on condition that the level of the internal control signal AG is rendered high.

Between one input terminals of the NAND gates NA**5**, NA**6** and the source voltage and earth potential of the circuit there are provided level setting circuits LS**1** and LS**2** each comprising a pair of P and N channel MOSFETs which receive in a predetermined combination an output signal or an inverted signal thereof from a NAND gate NA**3** or NA**4**. To one input terminal of the NAND gate NA**3** is fed the internal control signal PAD, while an inverted signal thereof is fed to one input terminal of the NAND gate NA**4**. To the other input terminals of the NAND gates NA**3** and NA**4** is fed the internal control signal PXD in common. As a result, when the level of the internal control signal PXD is rendered low, one input terminals of the NAND gates NA**5** and NA**6** assume a level conforming to the level of the inverted internal signal X**12** or the internal signal X**12** which is fed through the transfer gate TG**2** or TG**3**, while when the level of the internal control signal PXD is rendered high, the said one input terminals are rendered high or low in level selectively and forcibly in accordance with the internal control signal PAD.

That is, when the level of the internal control signal PAD is made low, the level of the output signal from the NAND gate NA**4** becomes low and the N channel MOSFET of the level setting circuit LS**1** and the P channel MOSFET of the level setting circuit LS**2** are turned ON simultaneously. Consequently, the level of one input terminal of the NAND gate NA**5** is made low, while the level of one input terminal of the NAND gate NA**6** is made high. As a result, the level of the inverted internal address signal BX**12**B is made low, while the level of the internal address signal BX**12** is kept high. On the other hand, when the level of the internal control signal PAD is rendered high, the level of the output signal from the NAND gate NA**3** becomes low, and the P channel MOSFET of the level setting circuit LS**1** and the N channel MOSFET of the level setting circuit LS**2** are turned ON simultaneously. Therefore, the level of one input terminal of the NAND gate NA**5** is rendered high, while the level of one input terminal of the NAND gate NA**6** is rendered low. As a result, the level of the internal address signal BX**12** is made low forcibly, while the level of the inverted internal address signal BX**12**B is kept high. That is, in each partial chip, as shown in FIG. **53**, the level of the internal address signal BX**12** is rendered high forcibly on condition that the pad PTX is bonded to the source voltage supplying lead VCC and the pad PTA is brought into the non-connected state NC, while it is rendered low forcibly on condition that the pads PTX and PTA are both bonded to the source voltage supplying lead VCC. When the pad PTX is brought into the non-connected state NC, the level of the internal address signal BX**12** is rendered high or low in accordance with the X address signal X**12**.

Next, the address input pad A**13** is connected to an input circuit IC**1** of the X address buffer **205**, as shown in FIG. **49**. The input circuit IC**1** is brought into a transfer state selectively on condition that the level of the internal control signal RAS**0** is rendered high, and it transfers an X address signal X**13** which is fed time-sharingwise through the address input pad A**13**, to one input terminal of the selector SEL**3** as an internal signal X**13**. To the other input terminal of the selector SEL**3** is fed the internal signal X**12**, and to a control terminal of the selector SEL**3** is fed an internal signal PX, i.e., the internal control signal PXD. Consequently, when the level of the internal control signal PXD is made low, the selector SEL**3** transfers the internal signal X**13** as an inverted internal signal X**123**B to a selector SEL**4**, while when the level of the internal control signal PXD is rendered high, the selector SEL**3** transfers the internal signal X**12** as an inverted internal signal X**123**B to the selector SEL**4**.

The inverted internal signal X**123**B is fed to one input terminal of the selector SEL**4** and at the same time, after inversion by an inverter, it is fed to the other input terminal of the selector SEL**4**. To a first control terminal of the selector SET**4** is fed the internal control signal CSA from the mode setter **223**, while to a second control terminal thereof is fed an output signal or an internal signal RCS from a NOR gate NO**1**. Thus, the selector SEL**4** substantially fulfills the same function as the selector SEL**1** shown in FIG. **39** and transfers the inverted internal signal X**123**B or an inverted signal thereof to a latch circuit LT**1** selectively as an internal signal PCS in accordance with the internal control signals CSA and RCS. The NAND gates NA**1**, NA**2**, NOR gate NO**1**, latch circuit LT**1** and transfer gate TG**1** shown in FIG. **49** correspond directly to the NAND gates NA**1**, NA**2**, NOR gate NO**1**, latch circuit LT**1** and transfer gate TG**1**, respectively, illustrated in FIG. **39** and fulfill the same functions.

In the same manner as in FIG. **39**, when the level of the internal control signal PXD is rendered low, the level of the internal control signal CS is made high or low selectively in accordance with the X address signal X**13**, while when the level of the internal control signal PXD is rendered high, the level of the internal control signal CS is made high or low selectively in accordance with the X address signal X**12**. That is, when the internal control signals TCD and CSA are rendered high in level, the level of the internal control signal CS is brought into the same logical level as that of the X address signal X**12** and is rendered high selectively on condition that the level of the X address signal **12** is high. On the other hand, when the level of the internal control signal TCD and that of the internal control signal CSA are made high and low, respectively, the level of the internal control signal CS is brought into an inverted logical level of the X address signal X**12** and is rendered high selectively on condition that the level of the X address signal X**12** is low. Thus, as shown in FIG. **53**, when the pad TC is bonded to the source voltage supplying lead VCC and the pad PTX is in the non-connected state NC, each partial chip is brought

into a selected state selectively in accordance with the X address signal **X13**, while when the pads TC and PTX are both bonded to the source voltage supplying lead VCC, each partial chip is brought into the selected state according to the state of bonding of the pad PTA and upon receipt of the X address signal **X12** which is either high or low in level.

2.2. 64M DRAM Package Using Two 64M DRAM Partial Chips Accessed Simultaneously

FIG. **50** is a block diagram showing a second example of a 64M DRAM package according to the present invention. FIGS. **51** and **52** are partial circuit diagrams showing a Y address buffer **209** and a mode setter **223** which are included in the DRAM package of FIG. **50**. FIG. **53** is a list of connections, showing bonding options of 64M DRAM partial chips which constitute the DRAM package of FIG. **50**. With reference to these figures, the following description is now provided about an outline of the DRAM package of this embodiment and a concrete method for selective IO execution.

2.2.1. Block Configuration

As shown in FIG. **50**, the 64M DRAM package of this embodiment is constituted basically by two 64M DRAM partial chips A and B wherein one half of each column address space can function normally. The portion of each partial chip capable of functioning normally is not specially limited, but it is a portion designated by a low address side, or Y address signal **Y12**, in the column address space when the level of the signal is made low. Address input pads **A0** to **A13** of the partial chips A and B are connected in common to corresponding address input terminals **A0** to **A13** of the DRAM package, and data input pads Din and data output pads Dout thereof are connected in common to a data input terminal Din and a data output terminal Dout of the DRAM package.

In FIG. **50**, pads PTA and PTY of each of the partial chips A and B are both bonded to a source voltage supplying lead VCC, while a pad PTX is brought into a non-connected state NC. In each partial chip, therefore, as will be described later, the level of an internal address signal **BY12** is rendered low forcibly and the column address space on a low address side capable of functioning normally is designated steadily. On the other hand, in the partial chips A and B, pads TC are brought into the non-connected state NC, and a pad **F3** on the partial chip A side is bonded to the source voltage supplying lead VCC, while a pad **F3** on the partial chip B side is brought into the non-connected state NC. As a result, in the partial chip A, as will be described later, the level of an internal control signal WP for selectively executing a storage data outputting operation of a write amplifier **218** or the level of an internal control signal DOC for selectively executing a storage data outputting operation of a data output buffer **221** is rendered high on condition that the level of the Y address signal **Y12** is low, while in the partial chip B, it is rendered high on condition that the level of the Y address signal **Y12** is high.

Thus, the partial chips A and B function substantially in the same manner as the 64M DRAM sub chips A and B which constitute the foregoing 128M DRAM package shown in FIG. **1** except that their memory capacity is halved to 32 megabits. As a result, the DRAM package of FIG. **50** function as a so-called 64M DRAM package. In this case, as is apparent from FIG. **50**, the DRAM package has an interface which is just the same as that of a 64M DRAM package constituted by a single 64M DRAM chip wherein all the address spaces can function normally. The refresh cycle is also 8K cycle/64 ms. This indicates that this DRAM package can be substituted for the 64M DRAM package comprising one full chip and that the substantial product yield of the 64M DRAM chips can be improved. In this embodiment, a parallel test for the storage data in each sub chip is executed in the unit of four bits, so the time required for parallel test in the entire DRAM package is twice that required in the 64M DRAM package comprising one full chip.

2.2.2. Method for Selective IO Execution and Configuration of V Address Buffer

In FIG. **51**, the pads **F3**, TC, PTA and PTY of each partial chip are connected to input terminals of corresponding input circuits IC**2**–IC**4** and IC**7** in the mode setter **223**, and their output signals, or internal control signals CSA, TCD, PAD and PYD, are rendered high or low in level selectively. More specifically, the internal control signals CSA, TCD, PAD and PYD are made low in level when the corresponding pads are **F3**, TC, PTA and PTY are brought into the non-connected state NC, and they are made high in level when the corresponding pads are bonded to the source voltage supplying lead VCC. The internal control signals CSA, TCD, PAD and PYD are fed to the Y address buffer **209**.

On the other hand, the address input pad **A12** is connected to an input terminal of an input circuit IC**6** of the Y address buffer **209**. The input circuit IC**6** is brought into a transfer state selectively when the level of an internal control signal RAS**0** is rendered high, and it transmits the Y address signal **Y12** which is fed time-sharingwise through the address input pad **A12**, to one input terminal of a selector SEL**5**. The other input terminal of the SEL**5** is connected to an output terminal thereof through an inverter to form a latch circuit. Further, an internal control signal YL is fed to a control terminal of the selector SEL**5**. As a results the selector SEL**5** is brought into a transfer state on condition that the level of the internal control signal YL is rendered low, and it is brought into a latch Form when the level of the internal control signal YL is rendered high. An inverted output signal from the this latch circuit is inverted by an inverter into an internal signal **Y12**, while a non-inverted signal from the latch circuit is inverted by an inverter into an inverted internal signal **Y12**B.

The inverted internal signal **Y12**B outputted from the selector SRL**5** is fed to a first input terminal of a NAND gate NA**12** which will be described later and is also fed to one input terminal of a NAND gate NA**9** through a transfer gate TG**4**. Likewise, the internal signal **Y12** is fed to a first input terminal of a NAND gate NA**11** which will be described later and is also fed to one input terminal of a NAND gate NA**10** through a transfer gate TG**5**. To control terminals of the transfer gates TG**4** and TG**5** is fed the internal control signal PYD. Further, an internal control signal AG is fed in common to the other input terminals of the NAND gates NA**9** and HA**10**. As a result, the internal signal **Y12** and the inverted internal signal **Y12**B are transmitted to one input terminals of the corresponding NAND gates NA**9** and NA**10** on condition that the level of the internal control signal PYD is rendered lows and further it becomes an inverted internal address signal BY**12**B or internal address signal BY**12** on condition that the level of the internal control signal AG is rendered high.

Between one input terminals of the NAND gates NA**9**, NA**10** and the source voltage and earth potential of the circuit there are provided level setting circuits LS**3** and LS**4** each comprising a pair of P and N channel MOSFETs which receive in a predetermined combination an output signal or an inverted signal thereof from a NAND gate NA**7** or NA**8**. To one input terminal of the NAND gate NA**7** is fed the internal control signal PAD, while an inverted signal thereof

is fed to one input terminal of the NAND gate NA**8**. To the other input terminals of the NAND gates NA**7** and NA**8** is fed the internal control signal PYD in common. As a result, when the level of the internal control signal PYD is rendered low, one input terminals of the NAND gates NA**9** and NA**10** assume a level conforming to the level of the inverted internal signal Y**12**B or the internal signal Y**12**, while when the level of the internal control signal PYD is made high, the said one input terminals are rendered high or low in level selectively and forcibly in accordance with the internal control signal PAD.

That is, when the level of the internal control signal PAD is made low, the level of the NAND gate NA**8** becomes low and the N channel MOSFET of the level setting circuit LS**3** and the P channel MOSFET of the level setting circuit LS**4** are turned ON simultaneously. Consequently, the level of one input terminal of the NAND gate NA**9** is rendered low, while the level of one input terminal of the NAND gate NA**10** is made high. As a result, the level of the inverted internal address signal BY**12**B is rendered low forcibly, while the level of the internal address signal BY**12** is kept high. On the other hand, when the level of the internal control signal PAD is made high, the level of the output signal from the NAND gate NA**7** becomes low, and the P channel MOSFET of the level setting circuit LS**3** and the N channel MOSFET of the level setting circuit LS**4** are turned ON simultaneously. Therefore, the level of one input terminal of the NAND gate NA**9** is rendered high, while the level of one input terminal of the NAND gate NA**10** is rendered low. As a result, the level of the internal address signal BY**12** is made low forcibly, while the level of the invert internal address signal BY**12**B is kept high. That is, in each partial chip, as shown in FIG. **53**, the level of the internal address signal BY**12** is rendered high forcibly on condition that the pad PTY is bonded to the source voltage supplying lead VCC and the pad PTA is brought into the non-connected state NC, while it is rendered low forcibly on condition that the pads PTY and PTA are both bonded to the source voltage supplying lead VCC. When the pad PTY is brought into the non-connected state NC, the level of the internal address signal BY**12** is rendered high or low in accordance with the Y address signal Y**12**.

As shown in FIG. **52**, the Y address buffer **209** further includes three 3-input NAND gates NA**11**–NA**13**. To the first input terminals of the NAND gates NA**11** and NA**12** are fed the internal signal Y**12** and the inverted internal signal Y**12**B, respectively, as mentioned previously, while to the third input terminals thereof is fed the internal control signal PYD in common. Further, the internal control signal CSA is fed to the second input terminal of the NAND gate NA**12** and an inverted signal thereof is fed to the second input terminal of the NAND gate NA**11**. On the other hand, an output signal from the NAND gate NA**11** is fed to the first input terminal of the NAND gate NA**13**, and an output signal from the NAND gate NA**12** is fed to the second input terminal of the NAND gate NA**13**. To the third input terminal of the NAND gate NA**13** is fed the internal control signal PYD. An output signal from the NAND gate NA**13** is fed as an internal control signal IOC in common to one input terminal of a NAND gate NA**14** in a WE clock generator **215** and that of a NAND gate **15** in a CAS clock generator **213**. To the other input terminal of the NAND gate **14** is fed an internal control signal WPI which is formed by a front-stage circuit (not shown) in the WE clock generator **215**, while to the other input terminal of the NAND gate **15** is fed an internal control signal DOCI which is formed by a front-stage circuit (not shown) in the CAS clock generator **213**. An output signal from the NAND gate NA**14** is inverted by an inverter and then fed as the internal control signal WP to the write amplifier **218**. Likewise, an output signal from the NAND gate NA**15** is inverted by an inverter and then fed as the internal control signal DOC to the data output buffer **221**. The level of the internal control signal WPI is rendered high temporarily at a predetermined timing when the partial chips A and B are brought into a selected state in the write mode, while the level of the internal control signal DOC is rendered high at a predetermined timing when the partial chips are rendered into the selected state in the read mode.

Therefore, when the level of the internal control signal PYD is made high, the level of the internal control signal IOC is rendered high selectively on condition that the level of the internal control signal CSA and that of the internal signal Y**12** are rendered low and high, respectively, or it is rendered high selectively on condition that the level of the internal control signal CSA and that of the inverted internal signal Y**12**B are both made high. In the case where the level of the internal control signal PYD is made low, the level of the internal control signal IOC is made high steadily independently of the internal control signal CSA, internal signal Y**12** and inverted internal signal Y**12**B. Further, on condition that the level of the internal control signal IOC is made high, the level of the internal control signal WP is rendered high in accordance with an internal control signal WPI and the level of the internal control signal DOC is made high in accordance with the internal control signal DOCI. That is, as shown in FIG. **53**, when the pad PTY is brought into the non-connected state NC, the partial chips A and B execute the storage data inputting or outputting operation at a predetermined timing, but in the case where the pad PRY is bonded to the source voltage supplying lead VCC, the partial chips A and B execute the inputting or outputting operation selectively upon receipt of the Y address signal Y**12** of high level when the pad F**3** is brought into the non-connected state NC, while when the pad F**3** is bonded to the source voltage supplying lead VCC, the partial chips execute the inputting or outputting operation selectively upon receipt of the Y address signal Y**12** of low level.

2.3. Variations of 64M DRAM Package Using Partial Chips

In FIG. **54** there is illustrated a list of 64M DRAM package products capable of being constituted on the basis of two 64M DRAM partial chips. FIGS. **55** to **59** are block diagrams of the DRAM packages described in the product list of FIG. **54**. With reference to these figures, the following description is now provided about the kind, configuration and outline of 64M DRAM packages each capable of being constituted by two 64M DRAM partial chips. In the block diagrams of FIGS. **55** to **59** there are shown only normal portions of the partial chips as well as address signals and signal lines relating to input and output data.

2.3.1. Kind of 64M DRAM Packages Capable of Being Constituted

The 64M DRAM chips in this embodiment can take three kinds of bit configurations of 64M×1 bit, 16M×4 bits and 8M×8 bits because the bonding to pads F**1** and F**2** is executed selectively, as mentioned previously. Further, since the bonding to pads PTA and PTX or PTY is executed selectively, the row or column address space on the low or high address side can function selectively and partially in the unit of one half. Moreover, since the bonding to pad TC is executed selectively, the partial chips are accessed selectively or simultaneously, and since the bonding to pad F**3** is executed selectively, conditions for selective activation or for selective IO execution are designated selectively. By combining two partial chips of the same bit configuration

and accessing these partial chips selectively or simultaneously there can be constituted such seven kinds of 64M DRAM packages as shown in FIG. **54**. As to the two kinds of DRAM packages having a bit configuration of 64M×1 bit, an explanation thereof will be omitted because they correspond to the embodiments illustrated in FIGS. **47** and **50**. Although in all of these embodiments the row or column address space on the low address side is normal, there may be made a combination with the type wherein the row or column address space on the high address side is normal, or with the type wherein the row or column address space is normal on both low and high address sides.

2.3.2. Outline of Various DRAM Packages

(1) DRAM Package of 16M×45 bits wherein two partial chips of 16M×4 bits each having a column address space half of which is normal are accessed simultaneously:

Such a 64M DRAM package of 16M×4 bits as illustrated in FIG. **55** can be constituted by combining two 64M DRAM partial chips A and B of 16M×4 bits in each of which one half of the column address space can function normally and then by accessing these partial chips simultaneously. In this variation, 13-bit X address signals X**0**–X**12** and 11-bit Y address signals Y**0**–Y**10** are fed to address input pads A**0**–A**12** of the partial chips A and B in common and time-sharingwise, and data input-output pads DIO**0** and DIO**1** of the partial chips are connected to corresponding data input-output terminals DIO**0**–DIO**3** of the DRAM package. An internal address signal BY**10** in each partial chip is fixed to the earth potential of the circuit, and the Y address signal Y**10** is substantially ignored. As a result, the partial chips A and B are kept selected simultaneously and execute storage data inputting and outputting operations in parallel. Consequently, the DRAM package has a bit configuration of 16M×4 bits and inputs or outputs 4-bit storage data simultaneously. At this time, a refresh operation for the partial chips A and B is executed in a parallel manner and the refresh cycle as the DRAM package is 8K cycle/64 ms.

(2) DRAM Package of 16M×4 bits wherein two DRAM partial chips of 16M×4 bits each having a row address space half of which is normal are accessed selectively:

Such a 64M DRAM package of 16M×4 bits as shown in FIG. **56** can be constituted by combining two 64M DRAM partial chips A and B of 16M×4 bits in each of which one half of the row address space can function normally and then by accessing these partial chips selectively. In this variation, 13-bit X address signals X**0**–X**12** and 11-bit Y address signals Y**0**–Y**10** are fed to address input pads A**0**–A**12** of the partial chips A and B in common and time-sharingwise-Data input-output pads DIO**0**–DIO**3** of the partial chips are connected in common to corresponding data input-output terminals DIO**0**–DIO**3** of the DRAM package. The level of an internal control signal CS in the partial chip A is rendered high selectively on condition that the level of the X address signal is made low, while the level of an internal control signal CS in the partial chip B is rendered high on condition that the level of the X address signal X**12** is made high. The level of an internal address signal BX**12** in each partial chip is fixed to the earth potential of the circuit, i.e., low level. Thus, the partial chip A is brought into a selected state electively when the level of the X address signal X**12** is rendered low, and executes alone a storage data inputting or outputting operation in the unit of 4 bits. The partial chip B is brought into a selected state selectively when the level of the X address signal X**12** is rendered high, and executes alone a storage data inputting or outputting operation in the unit of 4 bits. As a result, the DRAM package has a bit configuration of 16M×4 bits and it inputs or outputs 4-bit storage data simultaneously. At this time, a refresh operation for the partial chips A and B is executed selectively, but since one half of the row address space of each partial chip is normal, the refresh cycle as the DRAM package is 8K cycle/64 ms.

(3) DRAM Package of 16M×4 bits wherein two DRAM partial chips of 8M×8 bits each having a column address space half of which is normal are accessed simultaneously:

Such a 64M DRAM package of 16M×4 bits as shown in FIG. **57** can be constituted by combining two 64M DRAM partial chips A and B in each of which one half of the column address space can function normally and then by accessing these partial chips simultaneously. In this variation, 13-bit X address signals X**0**–X**12** and 10-bit Y address signals Y**0**–Y**9** are fed to address input pads A**0**–A**12** of the partial chips A and B in common and time-sharingwise, and data input-output pads DIO**0**–DIO**3** of the partial chips are connected to corresponding data input-output terminals DIO**0**–DIO**3** of the DRAM package. The level of an internal controls signal IOC in the partial chip A is rendered high selectively on condition that the level of the Y address signal Y**9** is made low, while the level of an internal control signal IOC in the partial chip B is rendered high selectively on condition that the level of the Y address signal Y**9** is made high. The level of an internal address signal BY**9** in each partial chip is fixed to the earth potential of the circuit, i.e., low level. As a result, the partial chips A and B are kept selected simultaneously and execute 4-bit storage data inputting or outputting operation selectively in accordance with the Y address signal Y**9**. Consequently, the DRAM package has a bit configuration of 16M×4 bits and it inputs or outputs 4-bit storage data simultaneously. At this time, a refresh operation for the partial chips A and B is executed in a parallel manner, so the refresh cycle as the DRAM package is 8K cycle/64 ms.

(4) DRAM Package of 8M×8 bits wherein two DRAM partial chips of 8M×8 bits each having a column address space half of which is normal are accessed simultaneously:

Such a 64M DRAM package of 8M×8 bits as shown in FIG. **58** can be constituted by combining two 64M DRAM partial chips A and B of 8M×8 bits in each of which half of the column address space can function normally and then accessing these partial chips simultaneously. In this variation, 13-bit X address signals X**0**–X**12** and 10-bit Y address signals Y**0**–Y**9** are fed to address input pads A**0**–A**12** of the partial chips A and B in common and time-sharingwise, and data input-output pads DIO**0**–DIO**3** thereof are connected to corresponding data input-output terminals DIO**0**–DIO**3** and DIO**4**–DIO**7** of the DRAM package. The level of an internal address signal BY**9** in each partial chip is fixed to the earth potential of the circuit, i.e., low level, and the Y address signal Y**9** is substantially ignored. As a result, the partial chips A and B are brought into a selected state simultaneously and execute a 4-bit storage data inputting or outputting operation in a parallel manner. Consequently, the DRAM package has a bit configuration of 8M×8 bits and it inputs or outputs 8-bit storage data simultaneously. At this time, a refresh operation for the partial chips A and B is executed in a parallel manner, so the refresh cycle as the DRAM package is 8K cycle/64 ms.

(5) DRAM Package of 8M×8 bits wherein two DRAM partial chips of 8M×8 bits each having a row address space half of which is normal are accessed selectively:

Such a 64M DRAM package of 8M×8 bits as shown in FIG. **59** can be constituted by combining two 64M DRAM partial chips A and B of 8M×8 bits in each of which half of

the row address space can function normally and then by accessing these partial chips selectively. In this variation, 13-bit X address signals X0–X12 and 10-bit Y address signals Y0–Y9 are fed to address input pads A0–A12 of the partial chips A and B in common and time-sharingwise, and data input-output pads DIO0–DIO7 thereof are fed to corresponding data input-output terminals DIO0–DIO7 of the DRAM package in common. The level of an internal control signal CS in the partial chip A is rendered high on condition that the level of the X address signal X12 is made low, while the level of an internal control signal CS in the partial chip B is rendered high on condition that the level of the X address signal X12 is made high. The level of an internal address signal BX12 in each partial chip is fixed to the earth potential of the circuit, i.e., low level. As a result, the partial chip A is brought into a selected state selectively when the level of the X address signal X12 is made low and it executes alone a storage data inputting or outputting operation in the unit of 8 bits, while the partial chip B is brought into a selected state selectively when the level of the X address signal X12 is rendered high and it executes alone a storage data inputting or outputting operation in the unit of 8 bits. Consequently, the DRAM package has a bit configuration of 8M×8 bits and it inputs or outputs 8-bit storage data simultaneously. At this time, a refresh operation for the partial chips A and B is executed selectively, but since one half of the row address space in each partial chip is normal, the refresh cycle as the DRAM package is 8K cycle/64 ms.

2.4. Evaluation

Thus, the 64M DRAM package of this embodiment is constituted by mounting two 64M DRAM partial chips in each of which one half of the row or column address space can function normally, onto a single package according to the double chip packaging method. In the two partial chips which constitute the DRAM package, since predetermined bondings are executed selectively, the portion incapable of functioning normally are nullified selectively, while conditions for the selection of the portions capable of functioning normally are set selectively. As a result, there can be attained the following effects.

(1) By combining DRAM chips partially incapable of functioning normally there can be constituted a DRAM package having the same interface as that of a DRAM package constituted by one full chip in which all the address spaces can function normally, and also having interchangeability with such single chip DRAM package.

(2) As illustrated in FIG. 60, since DRAM chips partially incapable of functioning normally can be utilized and relieved as partial chips, it is possible to improve the product yield of DRAM chips. For example, in connection with FIG. 60, fourty five 64M DRAM packages can be obtained from one wafer according to the conventional method not utilizing DRAM chips partially incapable of functioning normally, but in the case where two partial chips are combined together according to the double chip packaging method, there can be obtained a total of seventy five 64M DRAM packages. As a result, it is possible to improve the product yield of DRAM chips and attain the reduction of cost of the DRAM package.

(3) Since predetermined bondings are executed selectively, it is possible to selectively nullify the portions of partial chips incapable of functioning normally and selectively set conditions for the selection of the portions capable of functioning normally, and hence it is possible to optionally combine and utilize partial chips having same portions incapable of functioning normally.

3. Application Examples of the Double Chip Packaging Method

In each of the embodiments described above, a single DRAM package is constituted by combining plural sub chips or partial chips having the same function and formed under the same conditions, but the plural semiconductor chips which constitute the package are not always required to have the same function, nor is it necessary for them to be fabricated under the same conditions. Application examples of the double chip packaging method wherein a plurality of different semiconductor chips are combined together will be outlined below.

3.1. Chip Division by Function in DRAM Package

FIG. 61 is a block diagram showing a first example of a DRAM package consisting of two different semiconductor chips. In FIG. 61, the DRAM package, indicated at 310, comprises two sub chips 310A (first sub chip) and 310B (second sub chip) as a basic configuration. Though not specially limited, the sub chip 310A is constituted by a block of a relatively high integration density, including memory array 201, word driver 202, X address decoder 203, X predecoder 204, X address buffer, sense amplifier 206, Y address decoder 207, Y predecoder 208, write amplifier 218, data input buffer 219, main amplifier 220, and data output buffer 221. Therefore, the sub chip 310A is named an array sub chip and is formed by a so-called 0.5 μm manufacturing process. On the other hand, the sub chip 310B is constituted by a block of a relatively low integration density, including so-called indirect peripheral circuits such as RAS2 clock generator 210, RAS1 clock generator 211, RAS buffer 212, CAS clock generator 213, CAS buffer 214, WE clock generator 215, WE buffer 216, voltage dropping section 222, and mode setter 223. Therefore, the sub chip 310B is named a control circuit sub chip and is formed by a so-called 0.8 μm manufacturing process.

The sub chips 310A and 310B are made integral with each other to constitute a single DRAM package according to the double chip packaging method. In this case, these sub chips are connected to external terminals of the DRAM package by wire bonding through plural pads, and are connected to each other by wire bonding through other plural pads.

Thus, by functionally dividing the plural constituent blocks of the DRAM package into plural sub chips according to their integration densities and manufacturing processes and by making these sub chips integral with each other according to the double chip packaging method, it is possible to simplify the manufacturing process while making an optimal functional division of the DRAM package. The sub chips 310A and 310B are different in the integration density and manufacturing process so are different in the product yield. If these blocks are accommodated in a single semiconductor chip as in the prior art, the product yield of the block included in the sub chip 310B and capable of being expected to be relatively high is lowered by a relatively low product yield of the block included in the sub chip 310A. As in this embodiment, by accommodating blocks different in product yield in two semiconductor chips and making these semiconductor chips integral with each other according to the double chip packaging method it is made possible to improve the product yield as the entire DRAM package.

3.2. Chip Division by Bit in DRAM Package

FIG. 62 is a block diagram showing a second example of a DRAM package consisting of two different semiconductor chips. In FIG. 61, the DRAM package 311, indicated at 311, comprises two sub chips 311A (third sub chip) and 311B (fourth sub chip) as a basic configuration. The sub chip 311A is a DRAM chip of a relatively high integration density

having a bit configuration of 8M×8 bits and is formed by the 0.5μ manufacturing process. On the other hand, the sub chip **311**B is a DRAM chip of a relatively low integration density having a bit configuration of 8M×1 bit and is formed by the 0.8 μm manufacturing process.

The sub chips **311**A and **311**B are rendered integral with each other to constitute a single DRAM package according to the double chip packaging method. In this case, address input pads A**0**–A**12** of these sub chips are connected in common to address input terminals A**0**–A**12** of the DRAM package. Data input-output pads DIO**0**–DIO**7** of the sub chip **311**A are connected to corresponding data input-output terminals DIO0–DIO7 of the DRAM package, while a data input-output pad DIO of the sub chip **311**B is connected to a data input-output terminal for parity bit of the DRAM package.

Thus, by dividing the plural constituent blocks of the DRAM package in correspondence to predetermined bits of storage data and making these sub chips integral with each other according to the double chip packaging method there can be easily realized a DRAM package having a non-general bit configuration. Further, the relief of a partial chip can be done by using a partial chip formed according to the same manufacturing process as that for the sub chip **311**A, in place of the sub chip **311**B.

3.3. Chip Division by Function in Microcomputer Package

FIG. **64** is a block diagram showing an example of a microcomputer package comprising two different semiconductor chips. In FIG. **64**, the microcomputer package, indicated at **320**, comprises two sub chips **320**A (fifth sub chip) and **320**B (sixth sub chip) as a basic configuration. The sub chip **320**A is constituted by a block of a relatively high integration density, including a data RAM (data ROM) **321** and an instruction ROM **322**. Therefore, the sub chip **320**A is named a memory sub chip and is formed by the 0.5 μm manufacturing process. On the other hand, the sub chip **320**B is constituted by a block of a relatively low integration density, including arithmetic logical operation unit **327**, multiplication unit **325**, general-purpose register **323**, RAM pointer (ROM pointer) **324**, internal bus **326**, multiplication unit output register **328**, accumulator **329**, control (timing) logic **330**, program counter **331**, IO register **332**, and IO buffer **333**. Therefore, the sub chip **320**B is named an ALU sub chip and is formed by the 0.8 μm manufacturing process.

The sub chips **320**A and **320**B are made integral with each other to constitute a single microcomputer package according to the double chip packaging method. In this case, these sub chips are connected to external terminals of the microcomputer package by wire bonding through plural pads and are connected to each other through other plural pads.

Thus, by functionally dividing the plural constituent blocks of the microcomputer package into plural sub chips according to their integration densities and manufacturing processes and by making these sub chips integral with each other according to the double chip packaging method, it is possible to simplify the manufacturing process while making an optimal functional division of the microcomputer package. The sub chips **320**A and **320**B are different in the integration density and manufacturing process so are different in the product yield. As shown in FIG. **63**, the product yield as the entire microcomputer package is improved in comparison with the conventional microcomputer package having such blocks accommodated in a single semiconductor chip.

The present invention has been described above concretely on the basis of plural embodiments thereof, but it goes without saying that the invention is not limited thereto and that various modifications may be made within the scope not departing from the gist of the invention. For example, in the DRAM package block diagrams of FIG. **1** and other figures, the memory capacity and bit configuration of each sub chip can be set optionally, and the memory capacity and bit configuration as DRAM package are also optional. For example, a 64M DRAM package can be constituted using two 32M DRAM sub chips, and a 256M DRAM package can be constituted using two 128M DRAM sub chips. Further, each sub chip and DRAM package can have a bit configuration of, say, ×16 bits or ×32 bits. In such a multi-bit DRAM package it is possible to considerably reduce the number of bonding pads formed on each sub chip by, for example, accessing two sub chips simultaneously and executing a storage data inputting or outputting operation in a parallel manner. The DRAM package and DRAM sub chips do not require the adoption of an address multiplex mode as an essential condition nor is their block configuration restricted by the above embodiments. Also as to the refresh cycle, parallel test and high-speed column mode for the DRAM package and DRAM sub chips, what method and kind are to be adopted is optional. In FIGS. **5** and **6**, the memory array dividing method for each DRAM sub chip can take various other modes, and this is also true of related layout and address allocation. As to the arrangement of bonding pads provided on the semiconductor substrate surface, various modes of arrangement may be adopted on condition that they are arranged in the form of planar symmetry. In FIGS. **13** to **18**, the DRAM package can take any other package form than SOJ, and concrete structures thereof are not restricted by the above embodiments. In FIGS. **19** to **23**, the DRAM package manufacturing processes using the double chip packaging method are mere examples and the present invention is not limited thereby at all. In the 64M DRAM package block diagrams of FIG. **47** and other figures, there may be used partial chips in each of which one fourth of the row or column address space can function normally. In this case, pads for designating the normal portion and for setting conditions for the selection must be provided accordingly. In the circuit diagrams of FIGS. **39**, **48**, **49**, **51** and **52**, the logical configurations of the X and Y address buffers are not restricted by those embodiments, and the combination and polarity of source voltages as well as the conductivity type of MOSFET can take various forms. In FIG. **61**, as to the functional division of DRAM package, for example the X address buffer **205** and the Y address buffer **209** may be included in the sub chip **310**B. In FIG. **64**, the block configuration of the microcomputer is not restricted by the illustrated embodiment and the functional division thereof is optional.

Although in the above description the present invention is applied to DRAM packages and microcomputer packages in the utilization field as the background field, the invention is not limited thereto. For example, the present invention is also applicable to various memory packages including a static type RAM, etc. as a basic configuration and various digital integrated circuit package including a gate array integrated circuit, etc. as a basic configuration. The present invention is widely applicable to semiconductor devices each comprising plural semiconductor chips and also to digital systems each including such semiconductor device.

A pair of DRAM chips are mounted opposedly to each other while wiring means such as lead frames substantially integral with external terminals are put therebetween, then these DRAM chips and lead frames are connected together by the conventional wire bonding pad method, for example. Further, plural pairs of DRAM chips and lead frames thus

bonded are stacked and corresponding leads of the lead frames are connected in common to form a laminate. Then, the plural DRAM chips thus mounted are activated selectively in accordance with a predetermined chip selection signal or are allowed to execute a storage data inputting or outputting operation selectively. Utilizing this chip mounting method, a single DRAM package is constituted by combining partial DRAM chips capable of partially functioning normally. Consequently, there can be realized an effective chip mounting method which permits the mounting of plural sub chips of the same size without sacrificing the heat radiation characteristic of package and the product yield; besides, it is possible to attain a large capacity of a DRAM package, etc., promote the reduction of power consumption thereof and simplify the manufacturing process, while suppressing the increase in size of the package. Moreover, it is possible to realize a DRAM package having a memory capacity which is plural times that of a package of the same size and constituted by a single DRAM sub chip, and thus the limit in memory capacity of a DRAM chip, etc. can be expanded. So it is possible to enhance the packaging efficiency of a memory system, etc. including a DRAM package as a basic configuration and reduce the cost thereof. Additionally, partial DRAM chips can be utilized effectively without waste and hence it is possible to improve the substantial product yield of DRAM chips, etc.

What is claimed is:

1. A stacked arrangement of semiconductor devices, comprising:

a first semiconductor device, including

(i) a first semiconductor substrate having a first main surface and a second main surface, opposing said first surface;

(ii) a first row of bonding pads provided in a central portion of said first main surface of said first semiconductor substrate, said first row of bonding pads consisting of at least a first and a second bonding pad; and

(iii) a first lead electrically connected to said first bonding pad and arranged over said first main surface at one side of said first row of bonding pads, and a second lead electrically connected to said second bonding pad and arranged over said first main surface at the other side of said first row of bonding pads, and

a second semiconductor device, including

(i) a second semiconductor substrate having a first main surface and a second main surface, opposing said first surface;

(ii) a second row of bonding pads having a same bonding pad arrangement as that of said first row of bonding pads and provided in a central portion of said first main surface of said second semiconductor substrate, said second row of bonding pads consisting of at least a third and a fourth bonding pad; and

(iii) a third lead electrically connected to said fourth bonding pad and arranged over said first main surface at one side of said second row of bonding pads, and a fourth lead electrically connected to said third bonding pad and arranged over said first main surface at the other side of said second row of bonding pads,

wherein said first and second semiconductor devices are stacked in a manner such that the second surfaces of said first and second semiconductor substrates are positioned to be facing toward each other, and

wherein said first lead is electrically connected to said fourth lead, and said second lead is electrically connected to said third lead.

2. A stacked arrangement of semiconductor devices according to claim **1**,

wherein said first and second semiconductor substrates are rectangular shaped and each has a first main surface area defined by a first pair of opposing edge sides and a second, relatively longer pair of opposing edge sides,

wherein said first row and said second row of bonding pads are arrayed along a direction of said second pair of opposing edge sides of said first and second semiconductor substrates, respectively, and

wherein said first and second leads and said third and fourth leads are extended in a direction of said first pair of opposing edge sides of said first and second semiconductor substrates, respectively.

3. A stacked arrangement of semiconductor devices according to claim **2**,

wherein the stacked arrangement of said first and second semiconductor devices is sealed in a molding resin package.

4. A stacked arrangement of semiconductor devices according to claim **2**,

wherein said first and second semiconductor substrates, said first and second rows of bonding pads and the electrical connections effected between the first and fourth leads and between the second and third leads are sealed within a molding resin package.

5. A stacked arrangement of semiconductor devices according to claim **4**,

wherein said molding resin package is rectangle-shaped and is provided with a first group of external leads and a second group of external leads, said first group of external leads and said second group of external leads protrude outwardly from different ones of a pair of opposing outer side surface thereof, said first group of external leads being contiguous with a first group of inner leads provided within the package and said second group of external leads being contiguous with a second of inner leads provided within said package, and

wherein each leads in said first and second group of inner leads is extended inwardly and is contiguous with one of the electrical connections made between one or more bonding pads of said first semiconductor substrate with that of one or more bonding pads of said second semiconductor substrate.

6. A stacked arrangement of semiconductor devices according to claim **5**,

wherein said pair of opposing outer side surfaces which have said external leads protruding therefrom correspond to those surfaces of the package which are substantially parallel to said second pair of opposing edge sides of said first and second semiconductor substrates in the stacked arrangement.

7. A stacked arrangement of semiconductor devices according to claim **6**,

wherein said first and second semiconductor substrates constitute first and second semiconductor chips, and

wherein said first row of bonding pads is aligned with said second row of bonding pads, in the stacked arrangement, such that similarly functioning bonding pads are located in the same relative position in both of said first and second semiconductor chips for facilitating an electrical connection between them.

8. A stacked arrangement of semiconductor devices according to claim **7**,

wherein said first and second semiconductor chips are memory chips.

9. A sealed stacked arrangement of semiconductor devices, comprising:

a first semiconductor device, including

(i) a first rectangle-shaped semiconductor chip having a front surface and a rear surface, and having a first pair of edge sides and a second, longer pair of edge sides;

(ii) a first row of bonding pads, provided at a central portion of said front surface of said first semiconductor chip, being arranged in a direction parallel to the longer edge sides of said first semiconductor chip and consisting of first bonding pads and second bonding pads;

(iii) first leads electrically connected to said first bonding pads, all of said first leads being arranged over said front surface of the first chip, at one side of said first row of bonding pads, and being extended toward one of the pair of longer edge sides thereof; and

(iv) second leads electrically connected to said second bonding pads, all of said second leads being arranged over said front surface of the first chip, at the other side of said first row of bonding pads, and being extended toward the other of the pair of longer edge sides thereof; and

a second semiconductor device, including

(i) a second rectangle-shaped semiconductor chip having a first, front surface and a second, rear surface, and having a first pair of edge sides and a second, longer pair of edge sides;

(ii) a second row of bonding pads having a same bonding pad arrangement as that of said first row of bonding pads and provided at a central portion of said front surface of said second semiconductor chip, said second row of bonding pads being directioned in parallel to the longer edge sides of said second semiconductor chip and consisting of third bonding pads and fourth bonding pads;

(iii) third leads electrically connected to said fourth bonding pads, all of said third leads being arranged over said front surface of the chip, at one side of said second row of bonding pads, and being extended toward one of the pair of longer edge sides thereof; and

(iv) fourth leads electrically connected to said third bonding pads, all of said fourth leads being arranged over said front surface of the second chip, at the other side of said second row of bonding pads, and being extended toward the other of the pair of longer edge sides,

wherein said first and second semiconductor devices are stacked in a manner such that the rear surfaces of said first and second semiconductor chips are positioned so as to be facing toward each other, and

wherein each of said first leads is electrically connected to one of said fourth leads, and each of said second leads is electrically connected to one of said third leads.

10. A sealed stacked arrangement of semiconductor devices according to claim **9**,

wherein the stacked arrangement of said first and second semiconductor devices is sealed in a molding resin package.

11. A sealed stacked arrangement of semiconductor devices according to claim **9**,

wherein said first and second semiconductor chips, said first and second rows of bonding pads and the electrical connections effected between said first leads and said fourth leads and between said second leads and said third leads are sealed within a rectangle-shaped molding resin package.

12. A sealed stacked arrangement of semiconductor devices according to claim **11**,

wherein said rectangle-shaped molding resin package is provided with a first group of external leads and a second group of external leads, said first group of external leads and said second group of external leads protrude outwardly from different ones of a pair of opposing outer side surfaces thereof, said first group of external leads being contiguous with a first group of inner leads provided within the package and said second group of external leads being contiguous with a second group of inner leads provided within said package, and

wherein each lead in said first and second groups of inner leads is extended inwardly and is contiguous with one of the electrical connections made between one or more bonding pads of said first semiconductor chip with that of one or more bonding pads of said second semiconductor chip.

13. A sealed stacked arrangement of semiconductor devices according to claim **12**,

wherein said pair of opposing outer side surfaces which have said external leads protruding therefrom correspond to those surfaces of the package which are substantially parallel to said second pair of opposing edge sides of said first and second semiconductor chips in the stacked arrangement.

14. A sealed stacked arrangement of semiconductor devices according to claim **13**,

wherein said first and second semiconductor chips have a similar function and are aligned back-to-back in a manner such that said first row of bonding pads is aligned with said second row of bonding pads, in the stacked arrangement, such that similarly functioning bonding pads are located in the same relative position in both of said first and second chips for facilitating electrical connection between them.

15. A sealed stacked arrangement of semiconductor devices according to claim **14**,

wherein said first and second semiconductor chips are memory chips.

16. A sealed stacked arrangement of semiconductor devices according to claim **9**,

wherein said first and second semiconductor chips are memory chips.

17. A semiconductor device, comprising:

a first semiconductor device, including

(i) a first semiconductor chip having a main surface and a rear surface, opposing said main surface, a plurality of bonding pads being arranged on said main surface;

(ii) a first lead crossing one side of said first semiconductor chip, a first end portion of said first lead being extended near to said plurality of bonding pads; and

(iii) a second lead crossing another pads, opposed to said one side of said first semiconductor chip, a first end portion of said second lead being extended near to said plurality of bonding pads;

wherein said first and second leads are electrically connected to corresponding ones of said plurality of bonding pads by wire, respectively,

a second semiconductor device, including

(i) a second semiconductor chip having a main surface and a rear surface, opposing said main surface, said second semiconductor chip having a same function and a same arrangement of bonding pads as said first semiconductor chip;

(ii) a third lead crossing one side of said second semiconductor chip, said one side thereof corresponding to said one side of said first semiconductor chip, and a first end portion of said third lead being extended near to said plurality of bonding pads; and

(iii) a fourth lead crossing another side, opposed to said one side of said second semiconductor chip, a first end portion of said fourth lead being extended near to said plurality of bonding pads,

wherein said third and fourth leads are electrically connected to corresponding ones of said plurality of bonding pads by wire, respectively, and

a molding resin sealing said first and second semiconductor chips which are stacked together,

wherein said first lead and said fourth lead are electrically connected to each other, and said second lead and said third lead are electrically connected to each other.

18. A semiconductor device according to claim 17, wherein said first semiconductor chip and said second semiconductor chip are stacked so that said main surfaces thereof are facing each other.

19. A semiconductor device according to claim 17, wherein said first semiconductor chip and said second semiconductor chip are stacked so that said rear surfaces thereof are facing each other.

20. A semiconductor device according to claim 17, further comprising:

insulating films, said first lead and said second lead being fixedly disposed on said main surface of said first semiconductor chip through one of said insulating films, said third lead and said fourth lead being fixedly disposed on said main surface of said second semiconductor chip through another one of said insulating films.

21. A semiconductor device according to claim 17,

wherein said plurality of bonding pads, formed on said first semiconductor chip, are arranged in a row in the spacing separating the first end portions of said first leads from the first end portions of said second leads, and

wherein said plurality of bonding pads, formed on said second semiconductor chip, are arranged in a row in the spacing separating the portion of said third leads from the first end portions of said fourth leads.

22. A semiconductor device according to claim 21,

wherein said plurality of bonding pads, formed on said first semiconductor chip, includes a first bonding pad and a second bonding pad, an electrical connection being effected between said first lead and said first bonding pad and between said second lead and said second bonding pad through individual wires, and

wherein said plurality of bonding pads, formed on said second semiconductor chip, includes a first bonding pad and a second bonding pad, said first and second bonding pads thereof having, respectively, the same function as said first and said second bonding pads of said first semiconductor chip, an electrical connection being effected between said third lead and said second bonding pad, of said second semiconductor chip, through said wires, respectively.

23. A semiconductor device according to claim 22, wherein a first address signal is supplied to said first lead and said fourth lead, and a second, different address signal is supplied to said second lead and said third lead.

24. A semiconductor device according to claim 23, wherein said first and said second semiconductor chips are memory chips.

25. A semiconductor device according to claim 17, wherein said first and second leads are protruded from said molding resin.

26. A semiconductor device according to claim 17, wherein said first, second, third and fourth leads are protruded from said molding resin.

27. A semiconductor device, comprising:

a first semiconductor chip and a second semiconductor chip, each having a plurality of bonding pads arranged on a main surface thereof;

a molding resin which seals a stacked arrangement of said first and said second semiconductor chips;

a plurality of leads, each lead including an inner portion and an outer portion, said outer portion protruding outwardly from said molding resin, and said inner portion branching into a first portion and a second portion in said molding resin; and

a first wire which electrically connects said first portion of the inner portion of a lead to a bonding pad of said first semiconductor chip, and a second wire which electrically connects said second portion of the inner portion of said lead to a bonding pad of said second semiconductor chip,

wherein said first portion of said lead is fixed to said main surface of said first semiconductor chip, and said second portion of said lead is fixed to said main surface of said second semiconductor chip.

28. A semiconductor device according to claim 27, wherein said first portion of said lead is fixed to said main surface of said first semiconductor chip through an insulating film, and said second portion of said lead is fixed to said main surface of said second semiconductor chip through another insulating film.

29. A semiconductor device according to claim 27, wherein said first semiconductor ship and said second semiconductor chip have the same bonding pad arrangement.

30. A semiconductor device according to claim 29, wherein said first semiconductor chip and said second semiconductor chip are stacked so that said main surfaces are facing each other.

31. A semiconductor device according to claim 29, wherein each of said first and second semiconductor chips has a front, said main surface and an opposing, rear surface, said first semiconductor chip and said second semiconductor chip are stacked so that the rear surfaces are facing each other.

32. A semiconductor device, comprising:

a rectangular-shaped first semiconductor chip having a pad line including a plurality of bonding pads arranged on a main surface thereof, said main surface comprising a first side which is extended along said pad line and a second side which is opposed to said first side,

a rectangular-shaped second semiconductor chip having a pad line including a plurality of bonding pads having the same arrangement, on a main surface thereof, and the same function as the bonding pads of said first semiconductor chip, said main surface comprising a first side and a second chip, corresponding to said first side and said second side of said first semiconductor chip, respectively;

a first lead having a first end portion, said first end portion extending across said first side and being positioned in an area between said pad line and said first side of said first semiconductor chip;

a second lead having a second end portion, said second end portion extending across said second side and being positioned in an area between said pad line and said second side of said second semiconductor chip;

a first bonding wire electrically connecting between said first lead to one of said plurality of bonding pads of said first semiconductor chip, and a second bonding wire electrically connecting said second lead to one of said plurality of bonding pads of said second semiconductor chip; and

a molding resin sealing said first and second semiconductor chips which are stacked to each other,

wherein said first lead and said second lead are electrically connected each other.

33. A semiconductor device according to claim 32, wherein said first semiconductor chip and said second semiconductor chip are stacked so that said main surfaces are facing each other.

34. A semiconductor device according to claim 32, wherein each of said first and second semiconductor chips has a front, said main surface and an opposing, rear surface, said first semiconductor chip and said second semiconductor chip are stacked so that said rear surfaces are facing each other.

35. A semiconductor device according to claim 32, wherein said first and second leads are protruded from said molding resin.

36. A semiconductor device according to claim 32, wherein one of said first and second leads are protruded from said molding resin.

37. A semiconductor device according to claim 32, wherein said first lead is fixed to said main surface of said first semiconductor chip through an insulating film, and said second lead is fixed to said main surface of said second semiconductor chip through another insulating film.

38. A composite structure of semiconductor devices, comprising:

a first semiconductor device, including

(i) a first semiconductor chip having a main surface and a rear surface, opposing said main surface, a plurality of bonding pads being arranged on said main surface;

(ii) a first lead crossing one side of said first semiconductor chip, a first end portion of said first lead being extended near to said plurality of bonding pads; and

(iii) a second lead crossing another side, opposed to said one side of said first semiconductor chip, a first end portion of said second lead being extended near to said plurality of bonding pads;

wherein said first and second leads are electrically connected to corresponding ones of said plurality of bonding pads by wire, respectively,

a second semiconductor device, including

(i) a second semiconductor chip having a main surface and a rear surface, opposing said main surface, said second semiconductor chip having a same function and a same arrangement of bonding pads as said first semiconductor chip;

(ii) a third lead crossing one side of said second semiconductor chip, said one side thereof corresponding to said one side of said first semiconductor chip, and a first end portion of said third lead being extended near to said plurality of bonding pads; and

(iii) a fourth lead crossing another side, opposed to said one side of said second semiconductor chip, a first end portion of said fourth lead being extended near to said plurality of bonding pads,

wherein said third and fourth leads are electrically connected to corresponding ones of said plurality of bonding pads by wire, respectively, and

a molding resin sealing said first and second semiconductor chips which are stacked together,

wherein said first lead and said fourth lead are electrically connected to each other, and said second lead and said third lead are electrically connected to each other.

39. A composite structure of semiconductors devices, comprising:

a first semiconductor chip and a second semiconductor chip, each having a plurality of bonding pads arranged on a main surface thereof;

a molding resin which seals a stacked arrangement of said first and said second semiconductor chips;

a plurality of leads, each lead including an inner portion and an outer portion, said outer portion protruding outwardly from said molding resin, and said inner portion branching into a first portion and a second portion in said molding resin; and

a first wire which electrically connects said first portion of the inner portion of a lead to a bonding pad of said first semiconductor chip, and a second wire which electrically connects said second portion of the inner portion of said lead to a bonding pad of said second semiconductor chip,

wherein said first portion of said lead is fixed to said main surface of said first semiconductor chip, and said second portion of said lead is fixed to said main surface of said second semiconductor chip.

40. A composite structure of semiconductor devices, comprising:

a rectangular-shaped first semiconductor chip having a pad line including a plurality of bonding pads arranged on a main surface thereof, said main surface comprising a first side which is extended along said pad line and a second side which is opposed to said first side,

a rectangular-shaped second semiconductor chip having a pad line including a plurality of bonding pads having the same arrangement, on a main surface thereof, and the same function as the bonding pads of said first semiconductor chip, said main surface comprising a first side and a second side, corresponding to said first side and said second side of said first semiconductor chip, respectively;

a first lead having a first end portion, said first end portion extending across said first side and being positioned in an area between said pad line and said first side of said first semiconductor chip;

a second lead having a second end portion, said second end portion extending across said second side and being positioned in an area between said pad line and said second side of said second semiconductor chip;

a first bonding wire electrically connecting between said first lead to one of said plurality of bonding pads of said first semiconductor chip, and a second bonding wire electrically connecting said second lead to one of said plurality of bonding pads of said second semiconductor chip; and

a molding resin sealing said first and second semiconductor chips which are stacked to each other,

wherein said first lead and said second lead are electrically connected each other.

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