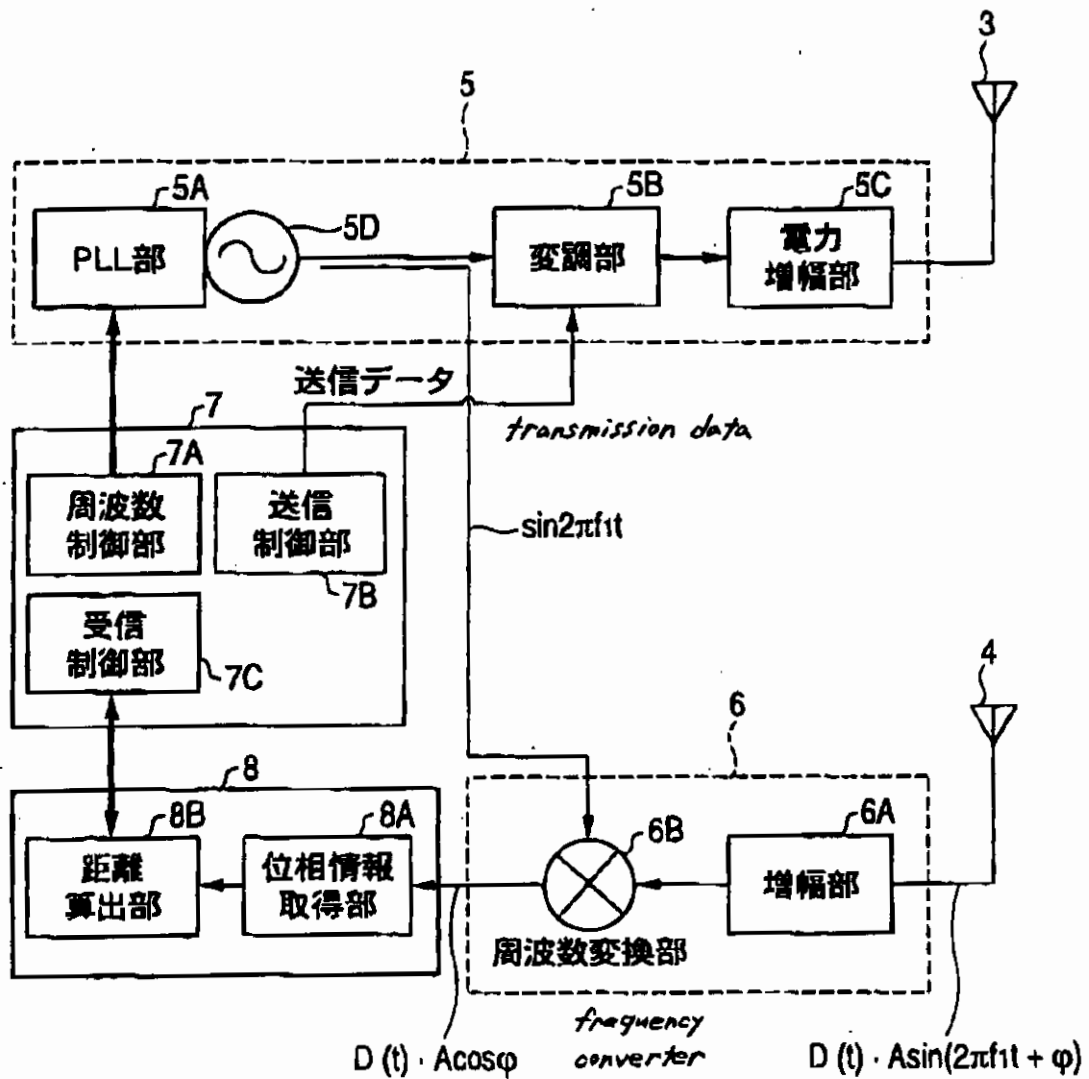


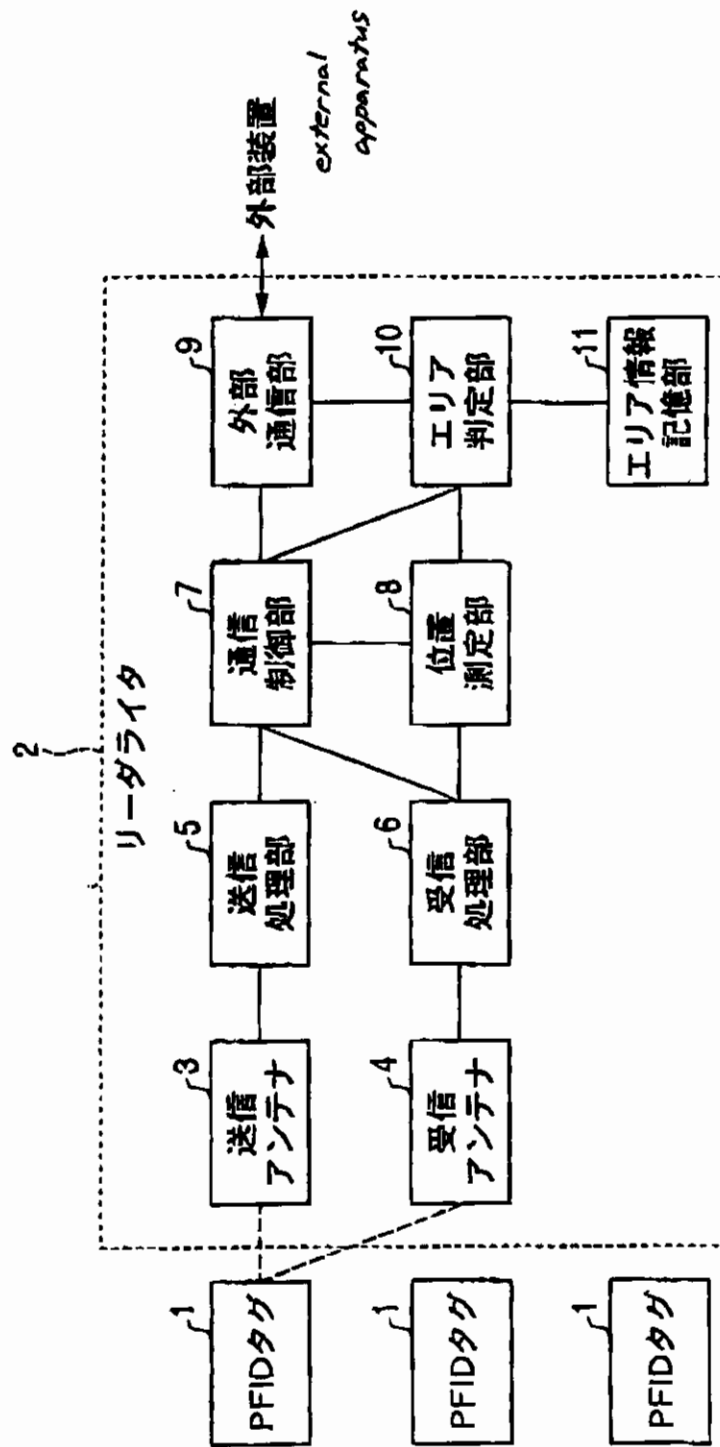
Fig. 1



5A: PLL SECTION
 5B: MODULATOR
 5C: POWER AMPLIFIER
 6A: AMPLIFIER

7A: FREQUENCY CONTROLLER
 7B: TRANSMISSION CONTROLLER
 7C: RECEPTION CONTROLLER
 8A: PHASE INFORMATION ACQUIRER
 8B: DISTANCE CALCULATOR

Fig. 2



1: RFID TAG

2: READERWRITER

3: TRANSMITTER ANTENNA

4: RECEIVER ANTENNA

5: RECEPTION PROCESSOR

6: TRANSMISSION PROCESSOR

7: COMMUNICATION CONTROLLER

8: LOCATION MEASURE

9: EXTERNAL COMMUNICATOR

10: AREA DETERMINANT

11: AREA INFORMATION STORAGE

Fig. 3A

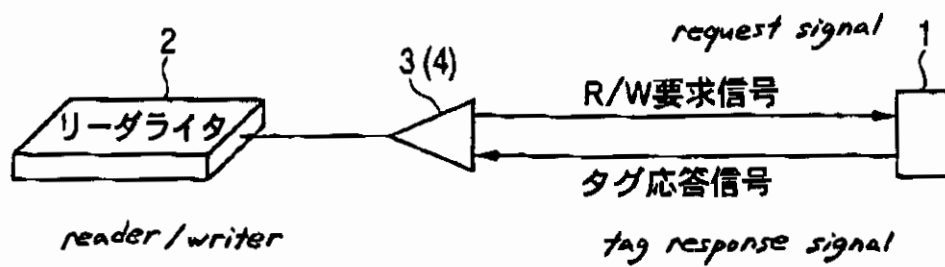


Fig. 3B

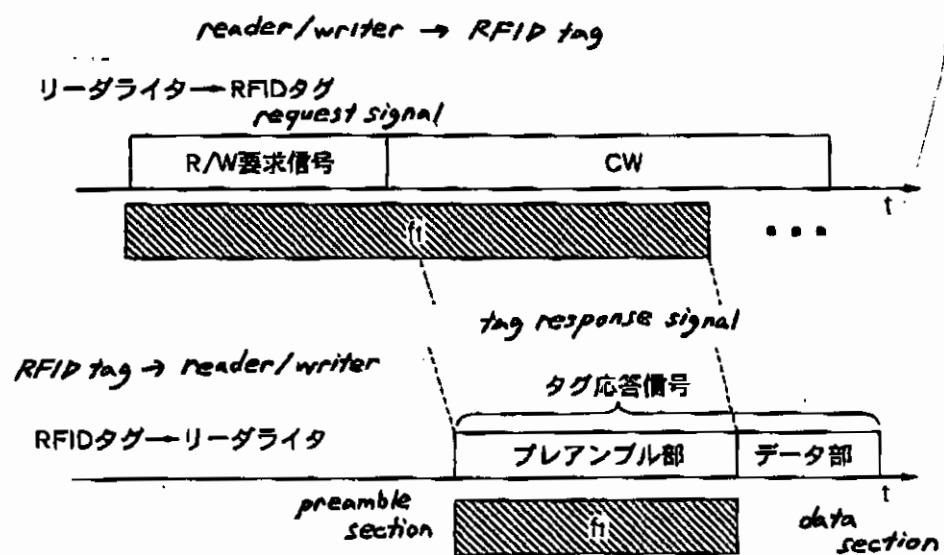


Fig. 3C

Fig. 4

5A: PLL SECTION

5B: MODULATOR

5C: POWER AMPLIFIER

7A: FREQUENCY CONTROLLER

7B: TRANSMISSION CONTROLLER

7C: RECEPTION CONTROLLER

8A: PHASE INFORMATION ACQUIRER

8B: DISTANCE CALCULATOR

6A1: AMPLIFIER

6A2: AMPLIFIER

6B3: 90-DEGREES PHASE SHIFTER

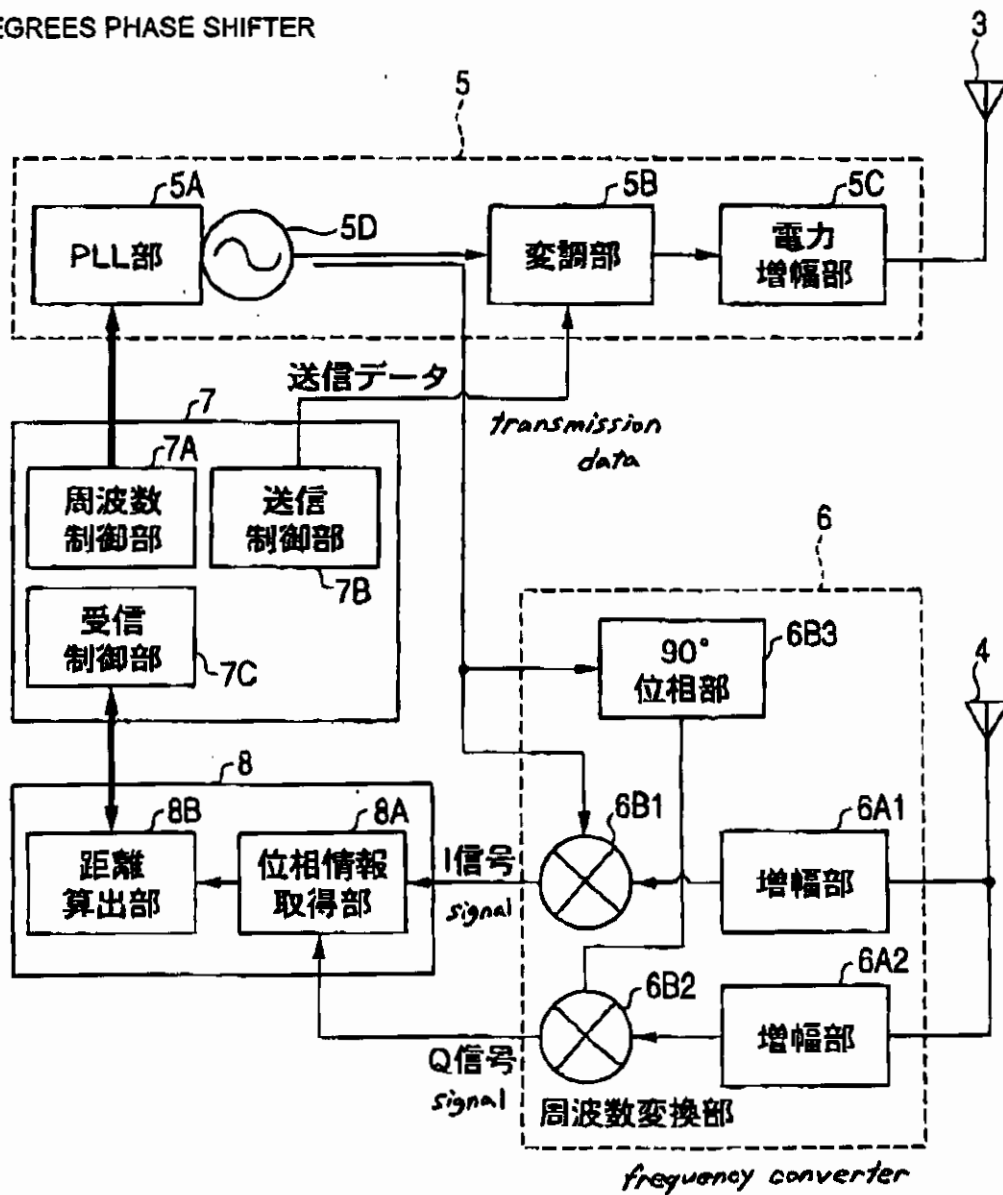
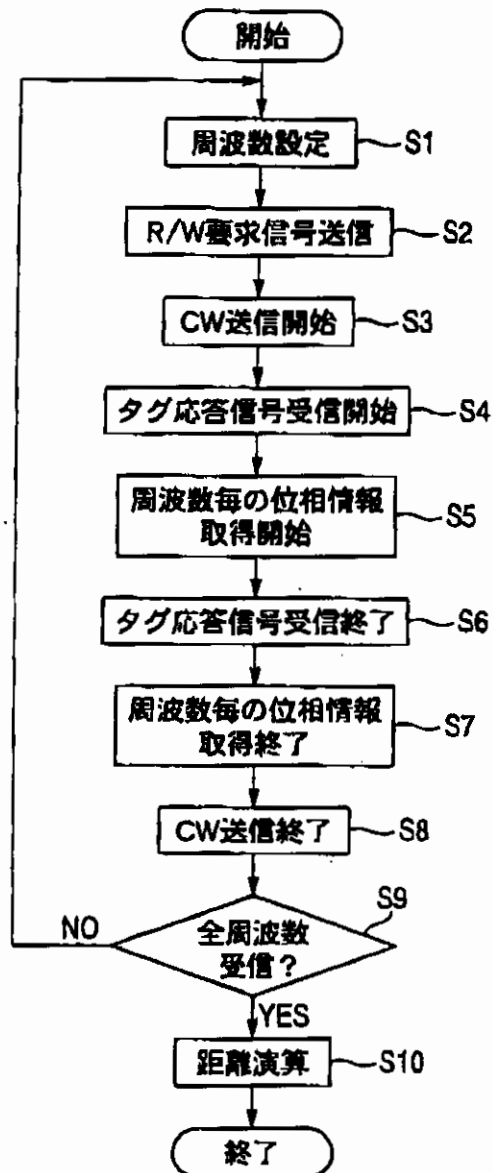


Fig. 5



START

S1: SET FREQUENCY

S2: TRANSMIT R/W REQUEST SIGNAL

S3: START CW TRANSMISSION

S4: START RECEPTION OF TAG RESPONSE SIGNAL

S5: START RECEPTION OF PHASE INFORMATION FOR EACH FREQUENCY

S6: FINISH RECEPTION OF TAG RESPONSE SIGNAL

S7: FINISH RECEPTION OF PHASE INFORMATION FOR EACH FREQUENCY

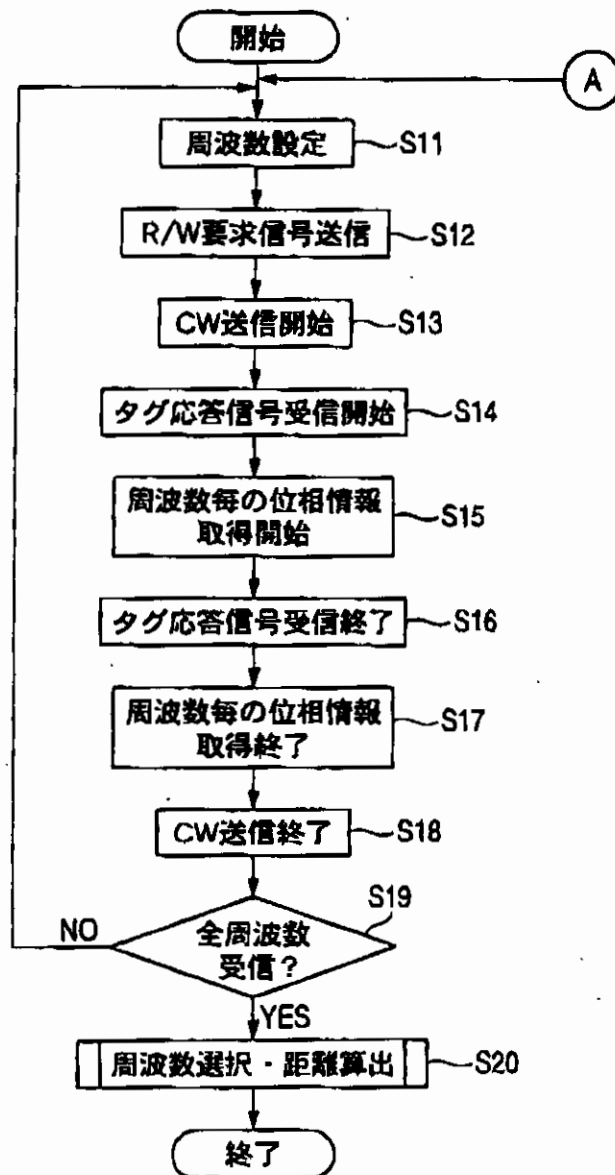
S8: FINISH CW TRANSMISSION

S9: ENTIRE FREQUENCIES ARE RECEIVED?

S10: CALCULATE DISTANCE

END

Fig. 6



START

S11: SET FREQUENCY

S12: TRANSMIT R/W REQUEST SIGNAL

S13: START CW TRANSMISSION

S14: START RECEPTION OF TAG RESPONSE SIGNAL

S15: START RECEPTION OF PHASE INFORMATION FOR EACH FREQUENCY

S16: FINISH RECEPTION OF TAG RESPONSE SIGNAL

S17: FINISH RECEPTION OF PHASE INFORMATION FOR EACH FREQUENCY

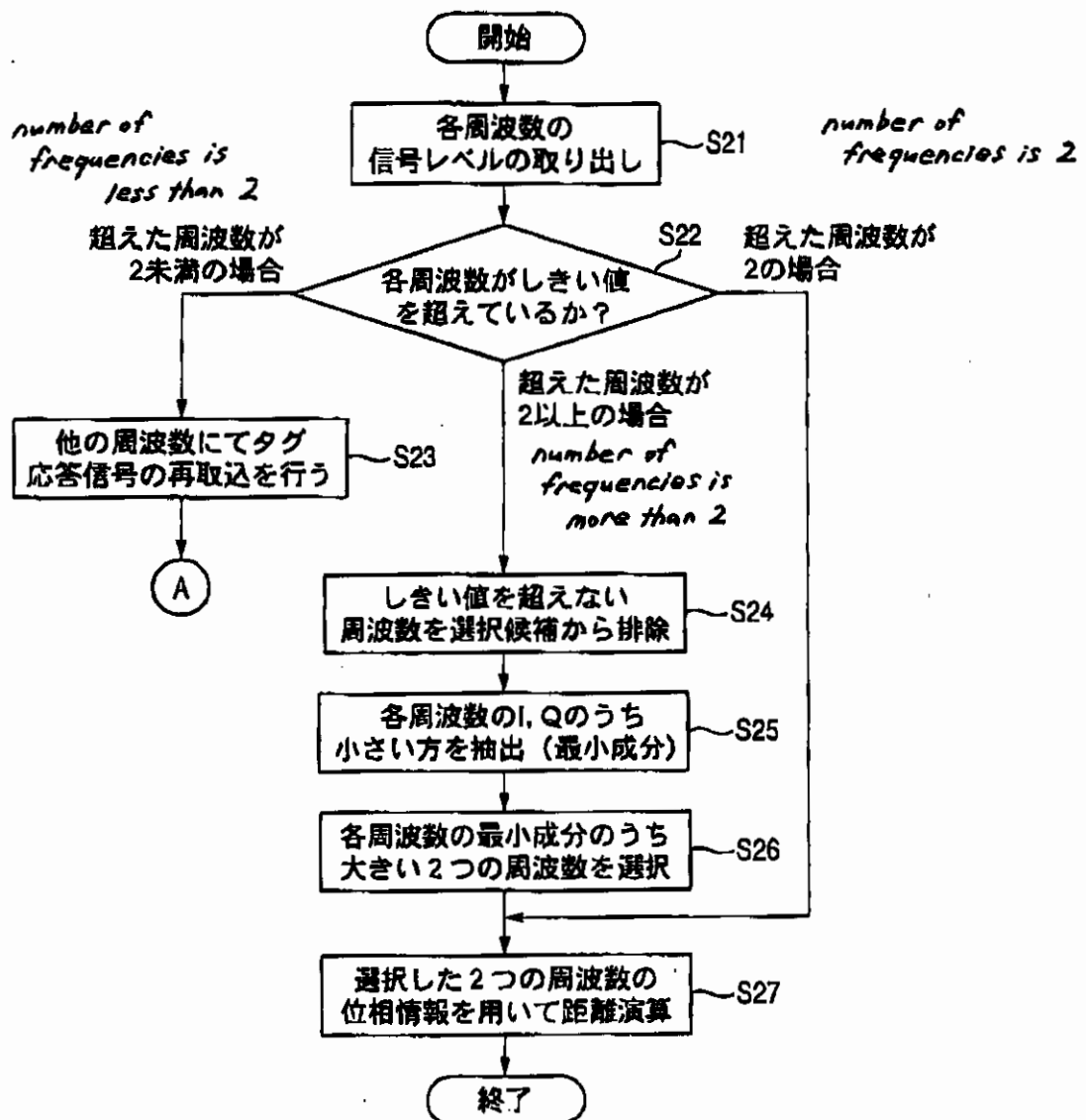
S18: FINISH CW TRANSMISSION

S19: ENTIRE FREQUENCIES ARE RECEIVED?

S20: FREQUENCY SELECTION / DISTANCE CALCULATION

END

Fig. 7



START

S21: EXTRACT SIGNAL LEVEL OF FREQUENCIES

S22: SIGNAL LEVEL IS GREATER THAN THERSHOLD?

S23: REACQUIRE TAG RESPONSE SIGNAL AT OTHER FREQUENCIES

S24: EXCLUDE FREQUENCIES HAVING SIGNAL LEVELS NOT GREATER THAN THRESHOLD FROM SELECTION CANDIDATES

S25: EXTRACT SMALLER ONE (MINIMAL COMPONENT) OF I AND Q SIGNALS FOR EACH FREQUENCY

S26: SELECT TWO FREQUENCIES HAVING MINIMAL COMPONENT LARGER THAN THAT OF OTHER FREQUENCIES

S27: CALCULATE DISTANCE ON THE BASIS OF PHASE INFORMATION OF TWO SELECTED FREQUENCIES

END

Fig. 8

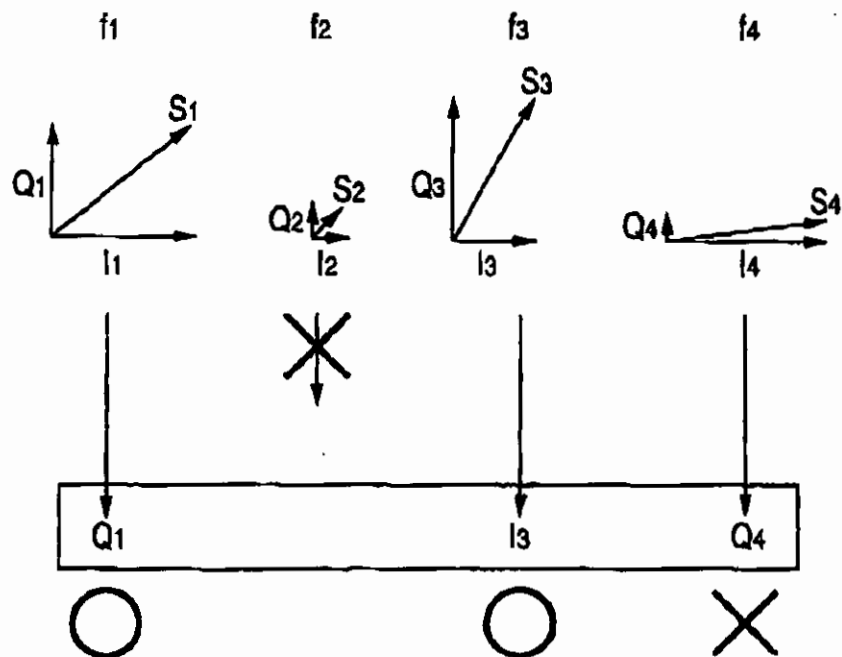


Fig. 9A

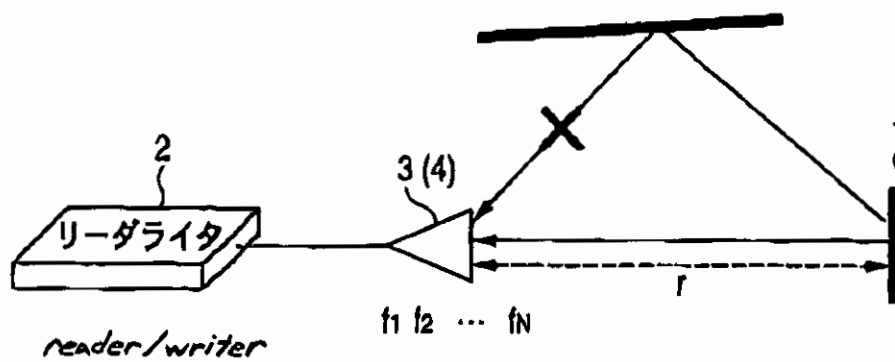


Fig. 9B

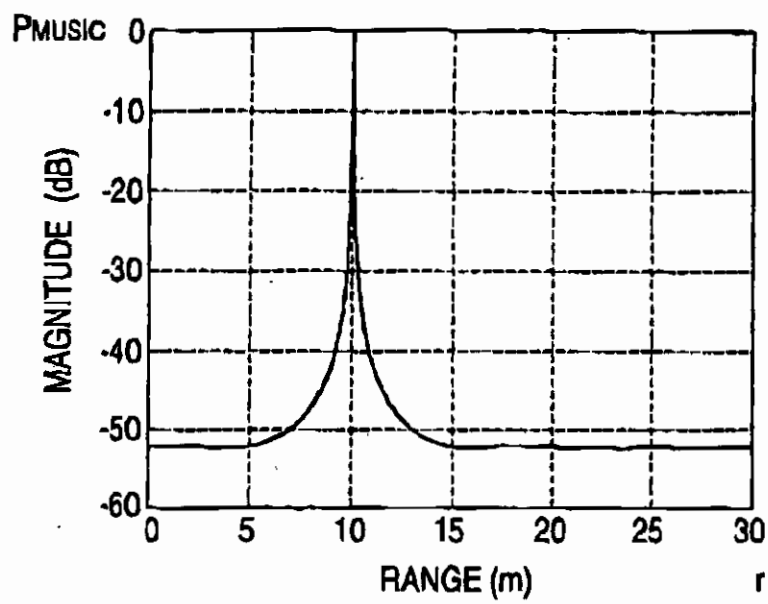


Fig. 9C

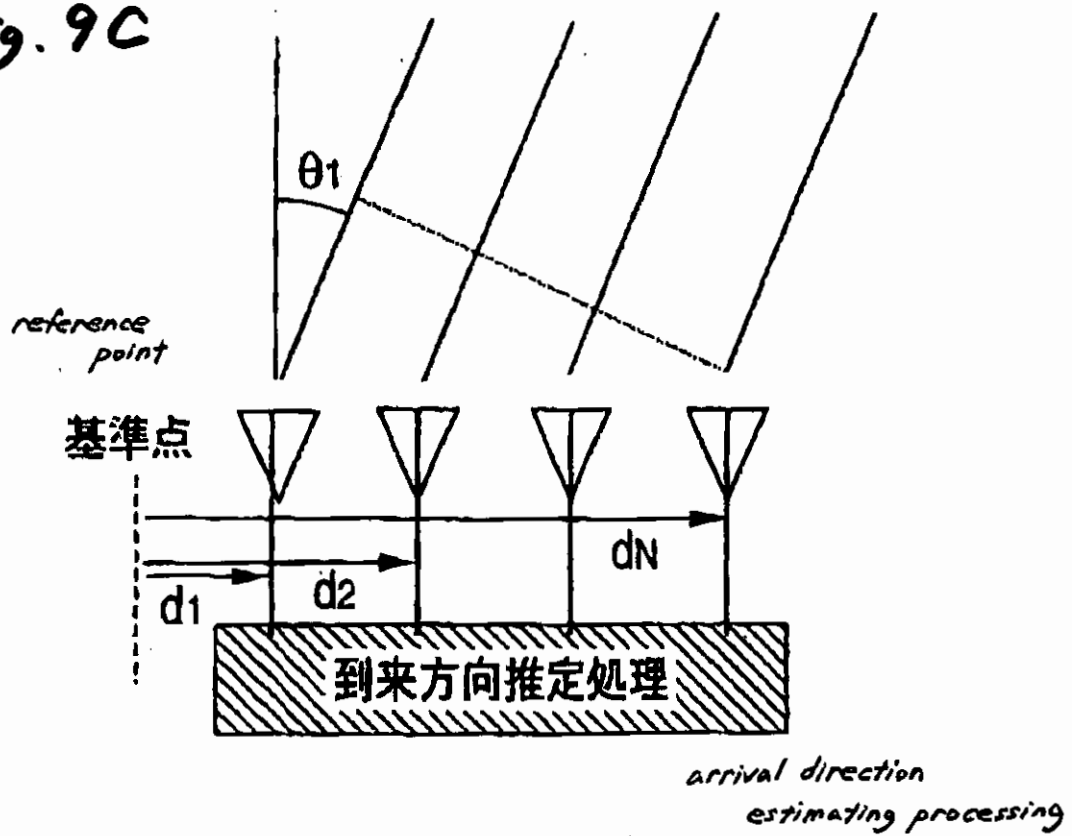
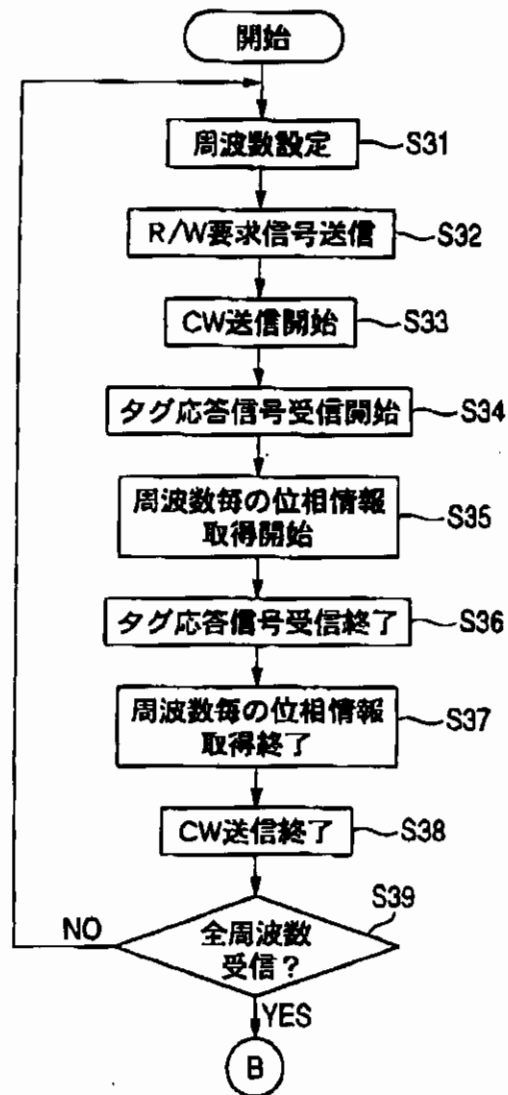


Fig. 10



START

S31: SET FREQUENCY

S32: TRANSMIT RW REQUEST SIGNAL

S33: START CW TRANSMISSION

S34: START RECEPTION OF TAG RESPONSE SIGNAL

S35: START RECEPTION OF PHASE INFORMATION FOR EACH FREQUENCY

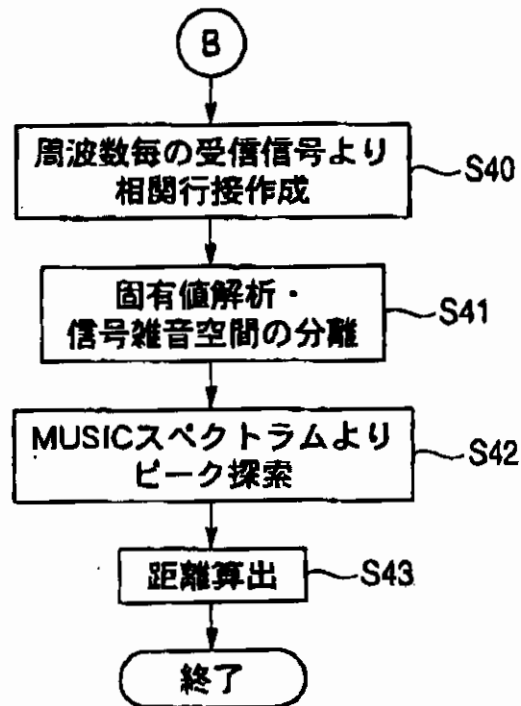
S36: FINISH RECEPTION OF TAG RESPONSE SIGNAL

S37: FINISH RECEPTION OF PHASE INFORMATION FOR EACH FREQUENCY

S38: FINISH CW TRANSMISSION

S39: ENTIRE FREQUENCIES ARE RECEIVED?

Fig. 11



S40: PREPARE CORRELATION MATRIX FOR EACH FREQUENCY FROM RECEPTION SIGNALS

S41: EIGENVALUE ANALYSIS / SPATIAL SEPARATION OF SIGNAL AND NOISE

S42: SEARCH PEAKS FROM MUSIC SPECTRUM

S43: CALCULATE DISTANCE

END

reader/writer → RFID tag

Fig. 12A

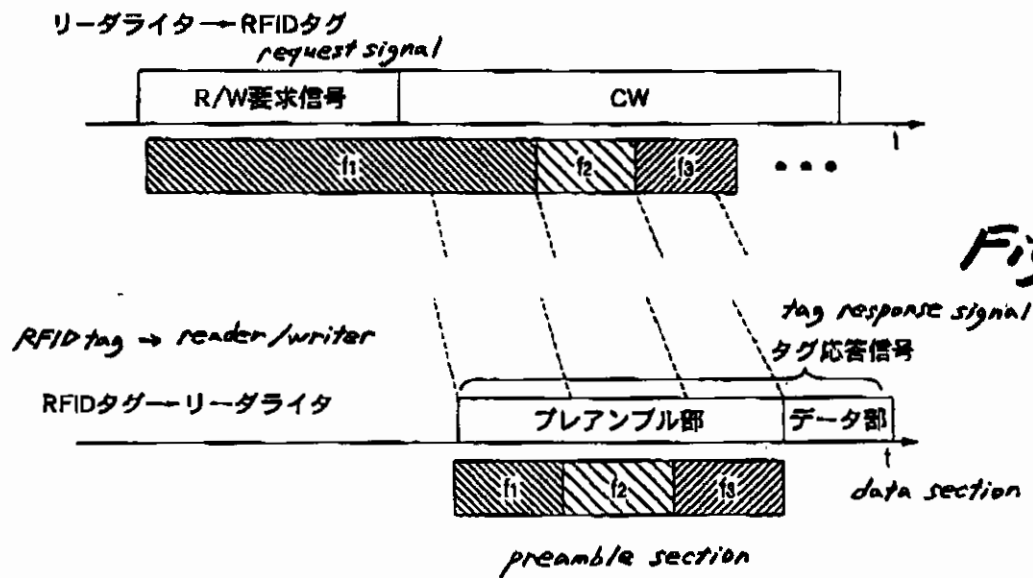
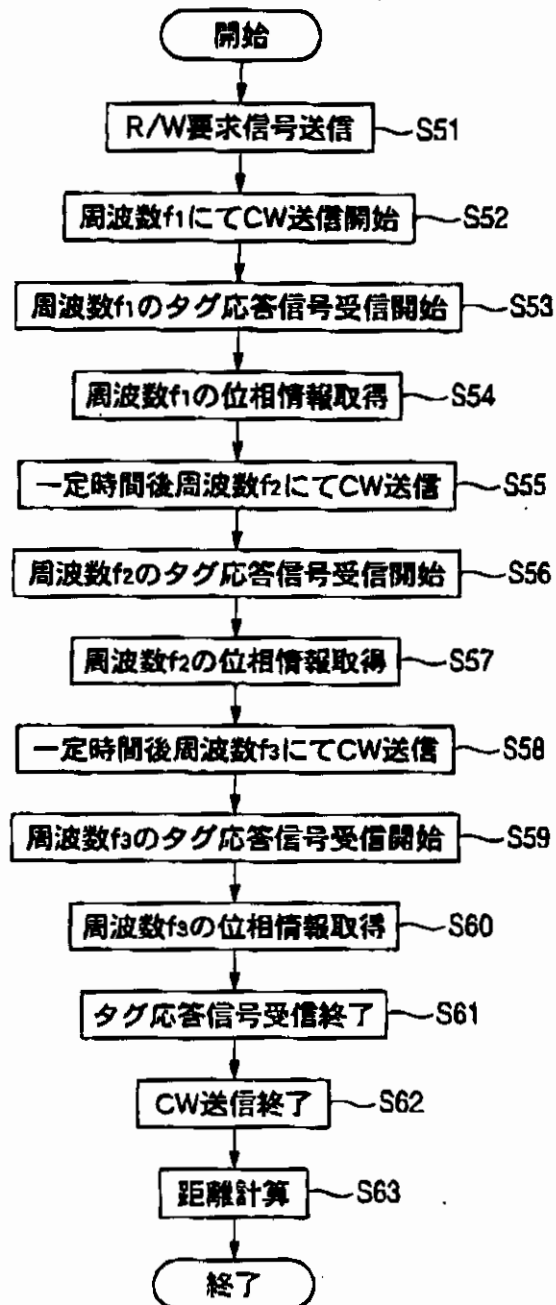


Fig. 12B

Fig. 13



START

S51: TRANSMIT R/W REQUEST SIGNAL

S52: START CW TRANSMISSION AT FREQUENCY f_1 S53: START RECEPTION OF TAG RESPONSE SIGNAL OF FREQUENCY f_1 S54: ACQUIRE PHASE INFORMATION OF FREQUENCY f_1 S55: TRANSMIT CW AT FREQUENCY f_2 AFTER PREDETERMINED DELAYS56: START RECEPTION OF TAG RESPONSE SIGNAL OF FREQUENCY f_2 S57: ACQUIRE PHASE INFORMATION OF FREQUENCY f_2 S58: TRANSMIT CW AT FREQUENCY f_3 AFTER PREDETERMINED DELAYS59: START RECEPTION OF TAG RESPONSE SIGNAL OF FREQUENCY f_3 S60: ACQUIRE PHASE INFORMATION OF FREQUENCY f_3

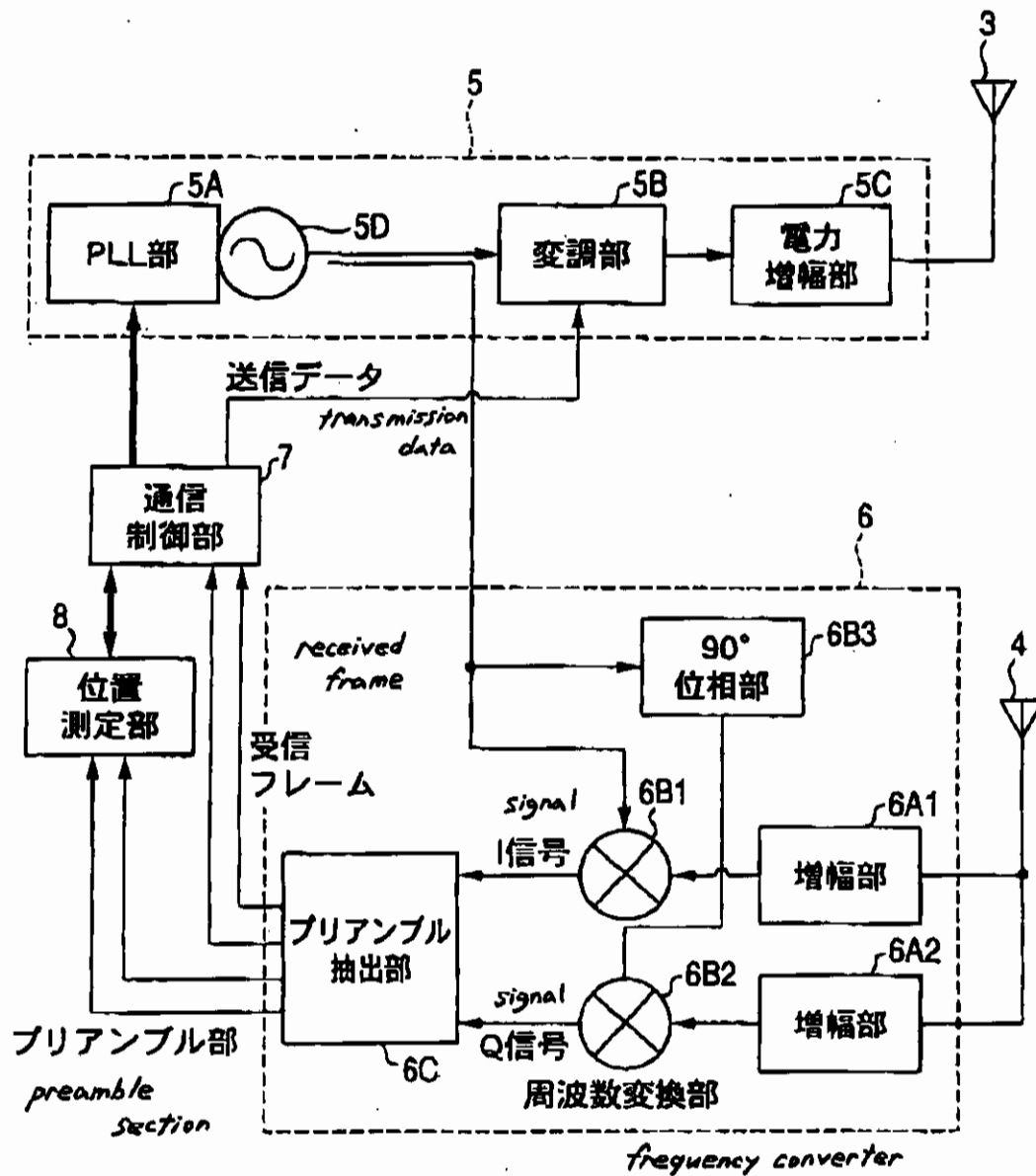
S61: FINISH RECEPTION OF TAG RESPONSE SIGNAL

S62: FINISH CW TRANSMISSION

S63: CALCULATE DISTANCE

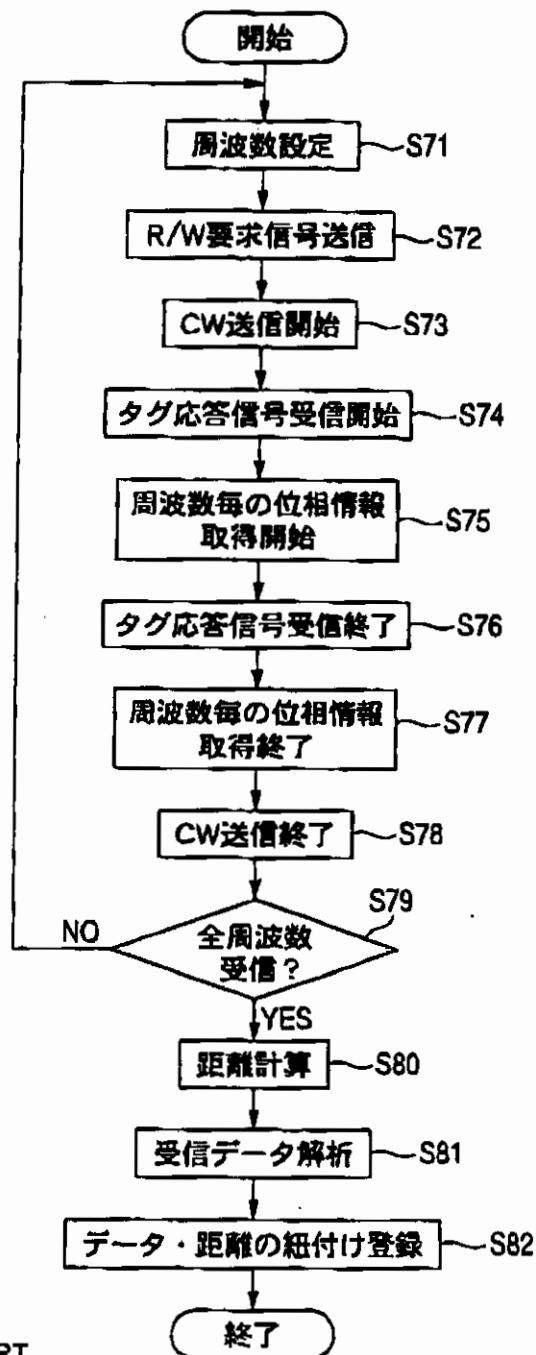
END

Fig. 14



- 5A: PLL SECTION
- 5B: MODULATOR
- 5C: POWER AMPLIFIER
- 7: COMMUNICATION CONTROLLER
- 8: LOCATION MEASURE
- 6A1: AMPLIFIER
- 6C: PREAMBLE EXTRACTER
- 6A2: AMPLIFIER
- 6B2: FREQUENCY CONVERTER
- 6B3: 90-DEGREES PHASE SHIFTER

Fig. 15



START

S71: SET FREQUENCY

S72: TRANSMIT R/W REQUEST SIGNAL

S73: START CW TRANSMISSION

S74: START RECEPTION OF TAG RESPONSE SIGNAL

S75: START RECEPTION OF PHASE INFORMATION FOR EACH FREQUENCY

S76: FINISH RECEPTION OF TAG RESPONSE SIGNAL

S77: FINISH RECEPTION OF PHASE INFORMATION FOR EACH FREQUENCY

S78: FINISH CW TRANSMISSION

S79: ENTIRE FREQUENCIES ARE RECEIVED?

S80: CALCULATE DISTANCE

S81: RECEPTION DATA ANALYSIS

S82: REGISTER DATA AND DISTANCE IN LINKED MANNER

END

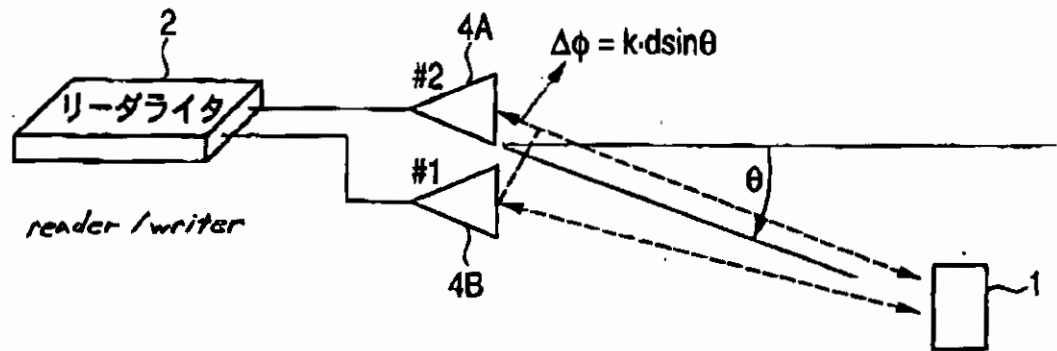
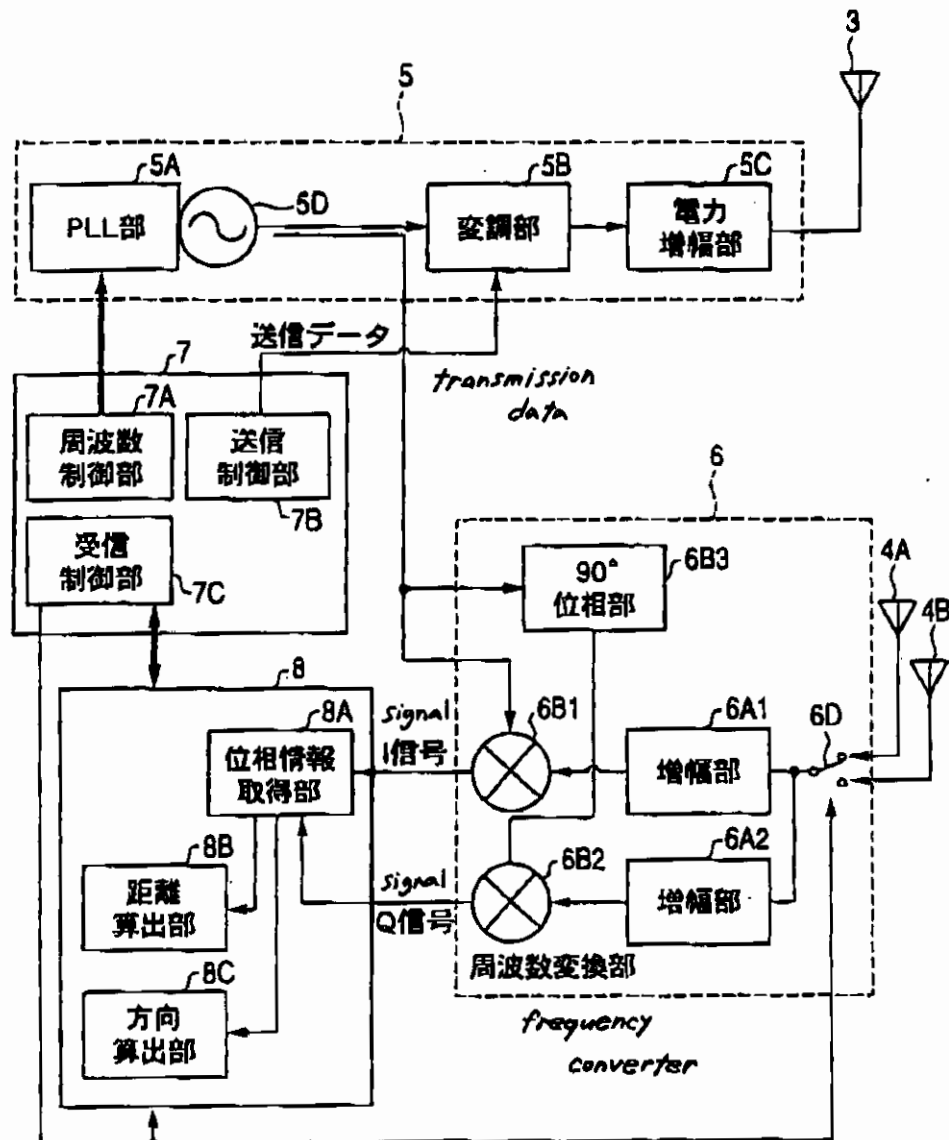
*Fig. 16*

Fig. 17



5A: PLL SECTION

5B: MODULATOR

5C: POWER AMPLIFIER

7A: FREQUENCY CONTROLLER

7B: TRANSMISSION CONTROLLER

7C: RECEPTION CONTROLLER

8A: PHASE INFORMATION ACQUIRER

8B: DISTANCE CALCULATOR

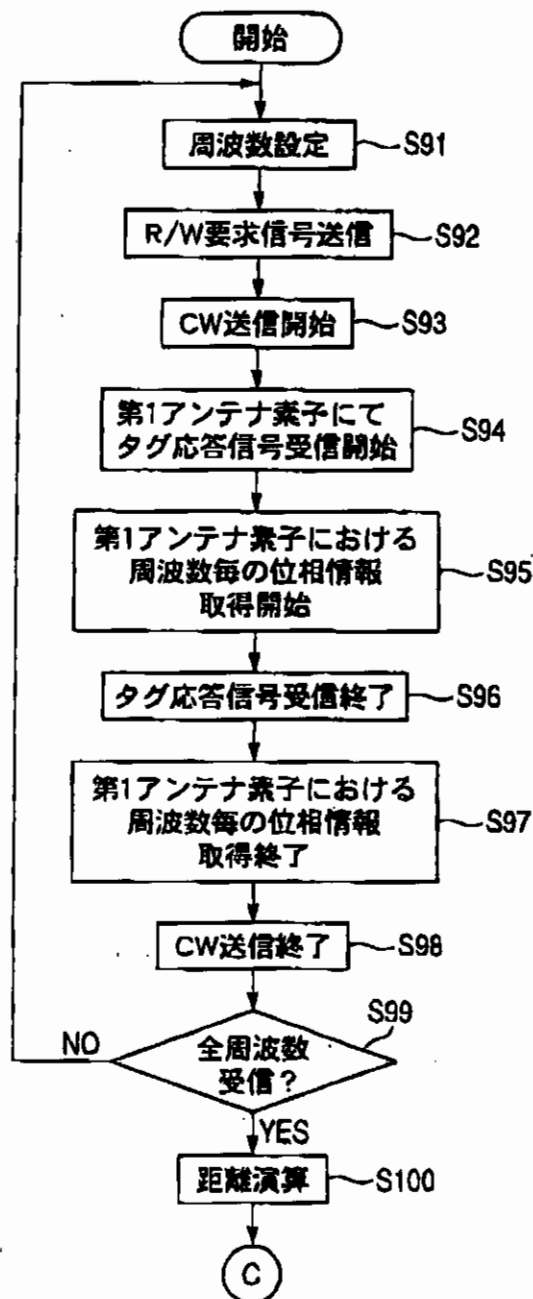
8C: DIRECTION CALCULATOR

6A1: AMPLIFIER

6A2: AMPLIFIER

6B3: 90-DEGREES PHASE SHIFTER

Fig. 18



START

S91: SET FREQUENCY

S92: TRANSMIT RW REQUEST SIGNAL

S93: START CW TRANSMISSION

S94: START RECEPTION OF TAG RESPONSE SIGNAL IN FIRST ANTENNA ELEMENT

S95: START ACQUISITION OF PHASE INFORMATION FOR EACH FREQUENCY IN FIRST ANTENNA ELEMENT

S96: FINISH RECEPTION OF TAG RESPONSE SIGNAL

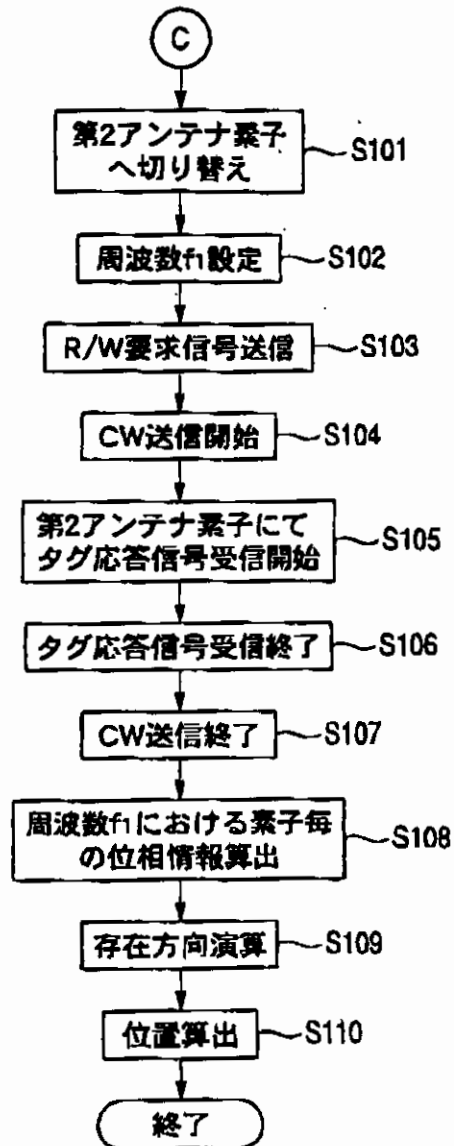
S97: FINISH ACQUISITION OF PHASE INFORMATION FOR EACH FREQUENCY IN FIRST ANTENNA ELEMENT

S98: FINISH CW TRANSMISSION

S99: ENTIRE FREQUENCIES ARE RECEIVED?

S100: CALCULATE DISTANCE

Fig. 19



S101: SWITCH TO SECOND ANTENNA ELEMENT

S102: SET FREQUENCY f_1

S103: TRANSMIT R/W REQUEST SIGNAL

S104: START CW TRANSMISSION

S105: START RECEPTION OF TAG RESPONSE SIGNAL IN SECOND ANTENNA ELEMENT

S106: FINISH RECEPTION OF TAG RESPONSE SIGNAL

S107: FINISH CW TRANSMISSION

S108: CALCULATE PHASE INFORMATION FOR EACH ELEMENT AT FREQUENCY f_1

S109: CALCULATE DIRECTION OF PRESENCE

S110: CALCULATE LOCATION

END

Fig. 20A

reader/writer $\rightarrow$ RFID tagリーダライタ $\rightarrow$ RFIDタグ

request signal

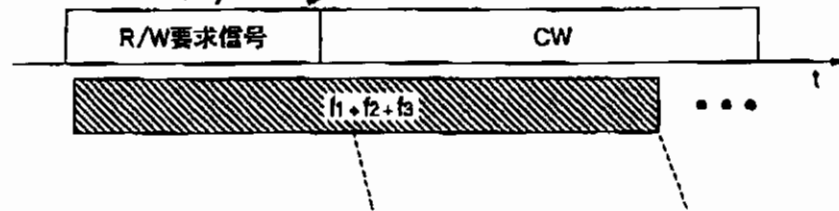


Fig. 20B

RFID tag $\rightarrow$ reader/writer

tag response signal

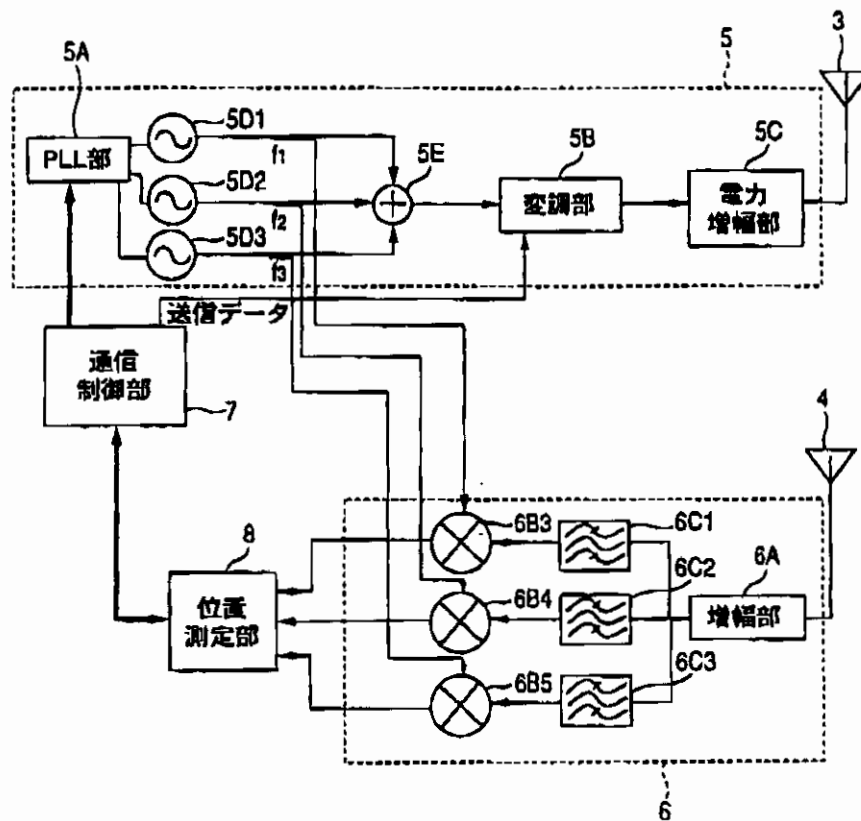
RFIDタグ $\rightarrow$ リーダライタ

preamble section

タグ応答信号



Fig. 21



5A: PLL SECTION

5B: MODULATOR

5C: POWER AMPLIFIER

7: COMMUNICATION CONTROLLER

8: LOCATION MEASURE

6A: AMPLIFIER

Fig. 22

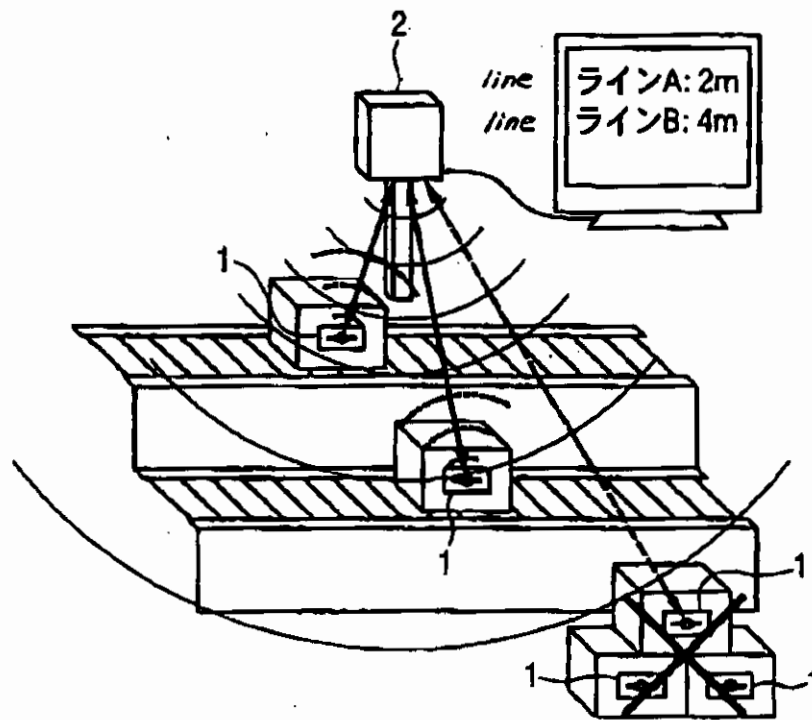


Fig. 23A

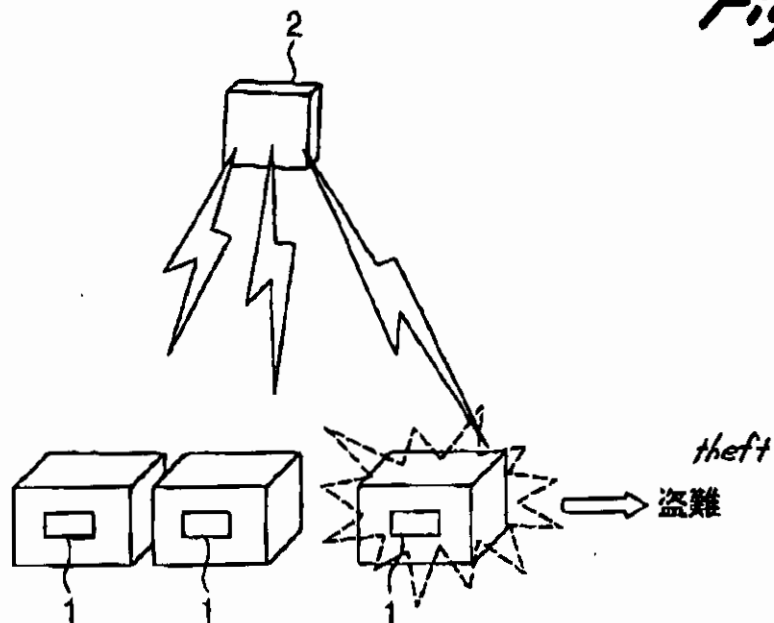


Fig. 23B

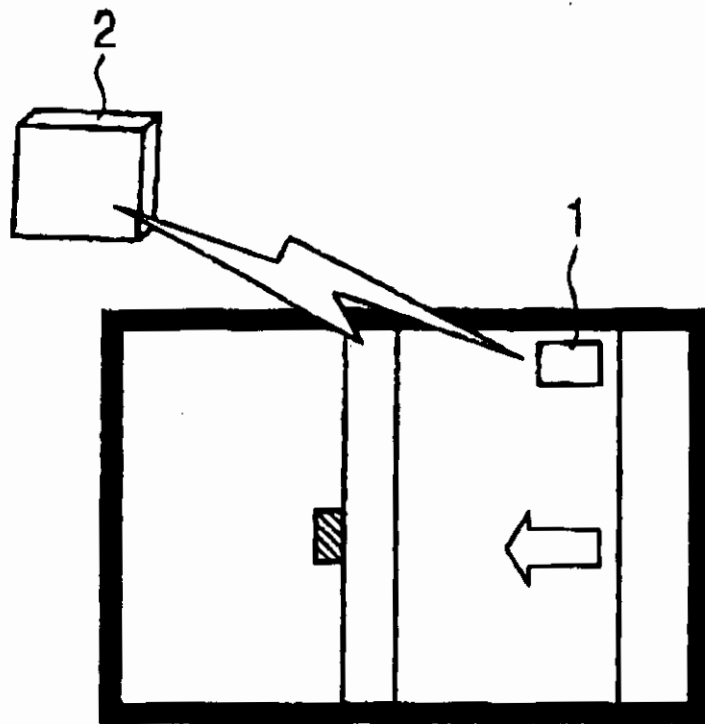


Fig. 24

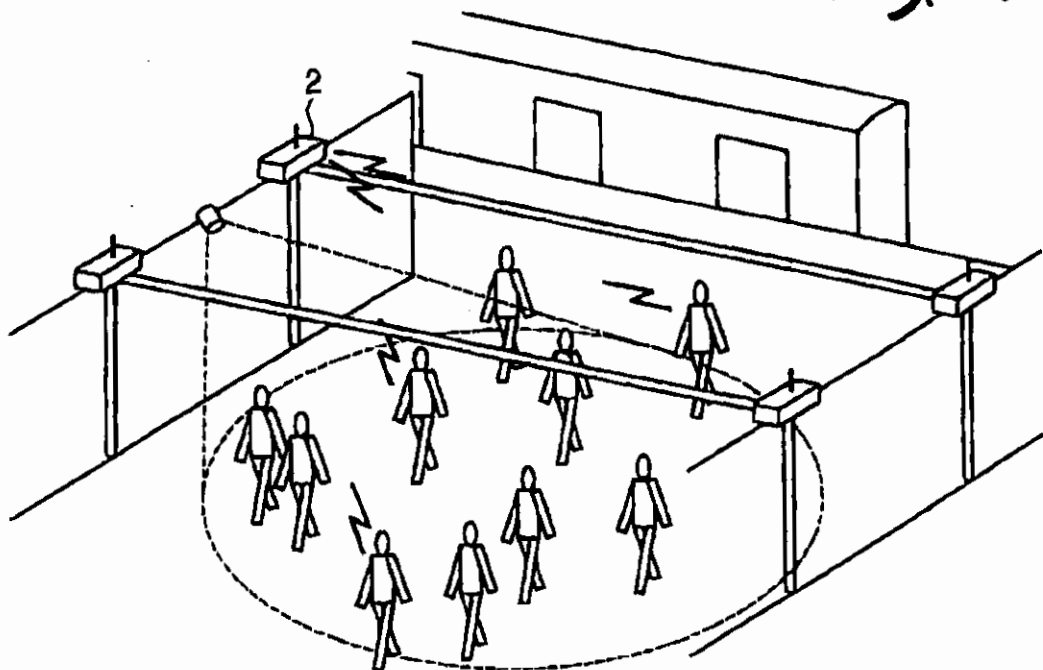
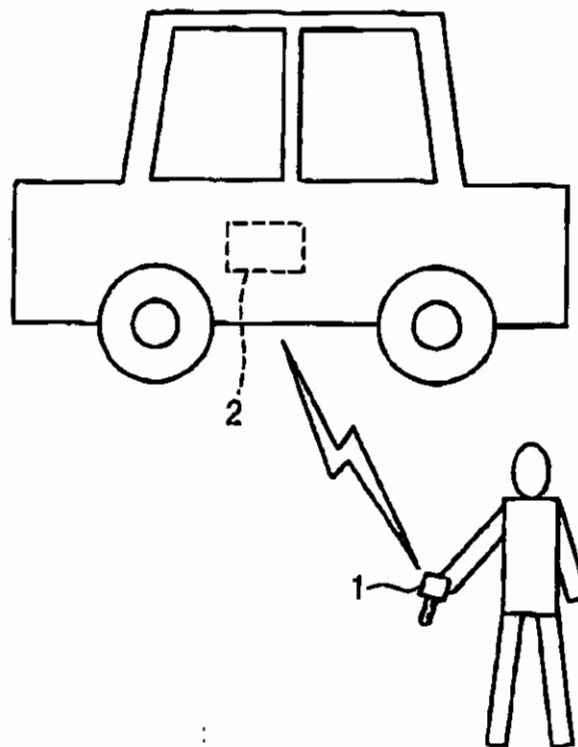


Fig. 25



- 44: CONTROLLER
 48: TAPPED TRANSMISSION LINE
 50: SIGNAL ANALYZER
 54: CONTROLLER
 56: MEMORY
 62: PHASE COMPARATOR CIRCUIT

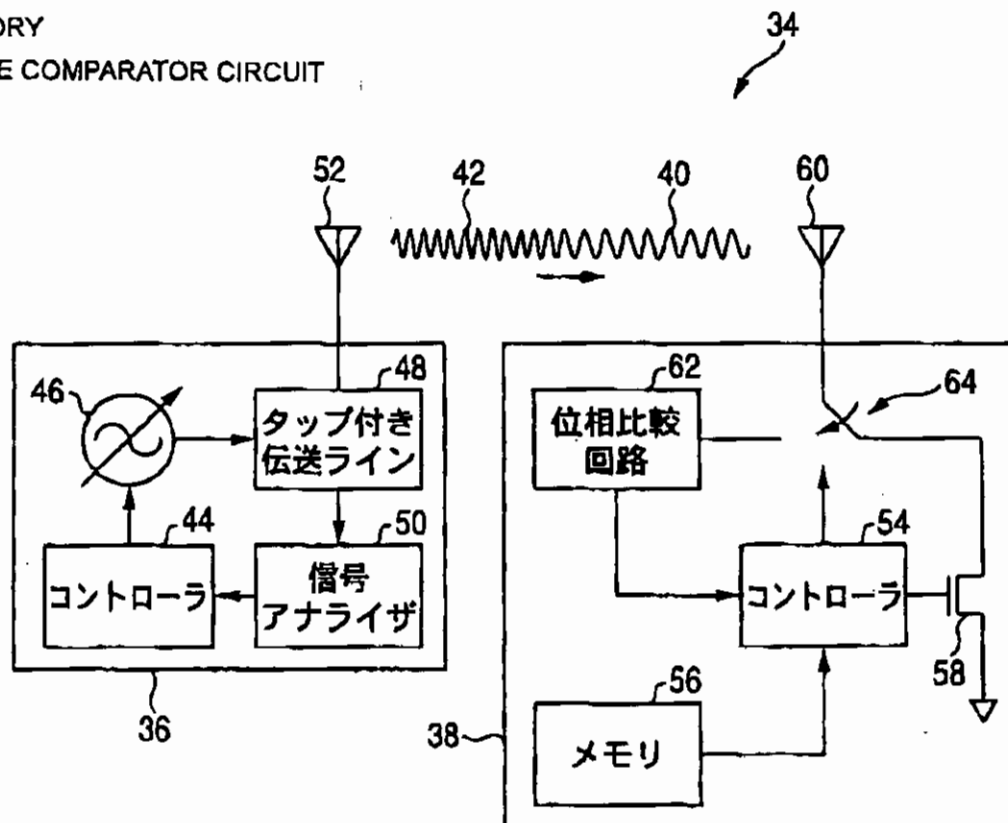


Fig. 26

