CONFORMED COPY

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Attorneys for Plaintiff
Sony Corporation

UNITED STATES DISTRICT COURT
CENTRAL DISTRICT OF CALIFORNIA

SONY CORPORATION, a Japanese corporation,

Plaintiff,

v.

LG ELECTRONICS U.S.A., INC., a Delaware corporation and LG ELECTRONICS MOBILECOMM U.S.A., INC., a California corporation,

Defendants.

CV10-09967 CAS (PJWx)

Case No.

COMPLAINT FOR PATENT INFRINGEMENT

DEMAND FOR JURY TRIAL

DATE: December 28, 2010

Plaintiff Sony Corporation ("Sony") hereby alleges for its Complaint against LG Electronics U.S.A., Inc. ("LGEUS"), and LG Electronics Mobilecomm U.S.A., Inc. ("LGEMU") (collectively "Defendants"), on personal knowledge as to its own activities and on information and belief as to the activities of others, as follows:

THE PARTIES

1. Sony is a corporation organized and existing under the laws of Japan with offices at 1-7-1 Konan, Minato-ku, Tokyo, 108-0075, Japan.

2. On information and belief, LGEUS is a corporation organized and existing under the laws of New Jersey with offices at 1000 Sylvan Avenue, Englewood Cliffs, New Jersey 07632. Upon information and belief, LGEUS, directly or indirectly through its wholly owned subsidiaries, imports into the United States and distributes and sells and/or offers to sell throughout the United States, including in the State of California, mobile telephone handsets, Blu-ray players with Wi-Fi functionality, and Wi-Fi adaptors. Such products include, but are not limited to, BX580 Blu-ray player, BD570 Blu-ray player, AN-WF100 Wi-Fi USB adapter, Accolade (VX5600), Cosmos (VN250), Encore (GT550), enV Touch (VX11000), Fathom (VS750), Quantum (C900), Glance (VX7100), GU295, Lotus Elite (LX610), LX370, Neon (GT365), Remarq (LN240), Rumor 2 (VM265), Rumor Touch (LN510), Vu Plus (GR700), and Xenon (GR500).

3. On information and belief, LGEMU is a corporation organized and existing under the laws of California with offices at 10101 Old Grove Road, San Diego, California 92131. Upon information and belief, LGEMU is a wholly owned subsidiary of LGEUS. Upon information and belief, LGEMU imports, markets, distributes, and sells the LG mobile telephone handset products in the United States, including in the State of California. Such mobile telephone handset products include, but are not limited to, Accolade (VX5600), Cosmos (VN250), Encore (GT550), enV Touch (VX11000), Fathom (VS750), Quantum (C900), Glance (VX7100), GU295, Lotus Elite (LX610), LX370, Neon (GT365), Remarq

(LN240), Rumor 2 (VM265), Rumor Touch (LN510), Vu Plus (GR700), and Xenon (GR500).

JURISDICTION AND VENUE

4. This is an action for patent infringement arising under the patent laws of the United States, Title 35 of the United States Code. Accordingly, this Court has subject matter jurisdiction pursuant to 28 U.S.C. §§ 1331 and 1338(a).

5. Personal jurisdiction is proper in this district pursuant to 28 U.S.C. §§ 1391 and 1400 because, on information and belief, Defendants transact business in this district, including the sale and offering for sale of their mobile telephone handset products, and Defendants have sufficient contacts with this district to subject themselves to the jurisdiction of this Court.

6. Venue is proper in this district pursuant to 28 U.S.C. §§ 1391(b), (c), and (d), and 1400(b).

CAUSES OF ACTION

COUNT I

Infringement of U.S. Patent No. 6,222,921

7. Sony repeats and re-alleges the allegations of paragraphs 1 through 6 of this Complaint as if fully set forth herein.

8. United States Patent No. 6,222,921, entitled "Method and apparatus for displaying an electronic phonebook" (the "'921 patent"), was duly and legally issued on April 24, 2001 naming Katzuto Maugura, Bryan Lew Fong, and Chris Shi-Chai Liu as inventors. A true and correct copy of the '921 patent is attached hereto as Exhibit A.

9. Sony owns by assignment the entire right, title, and interest in and to the '921 patent, including the right to sue for past, present, and future infringements thereof.

10. Sony has provided and Defendants have received actual notice of the '921 patent.

11. Defendants have directly infringed, and/or have induced others to infringe, and/or have committed acts of contributory infringement of one or more claims of the '921 patent in violation of 35 U.S.C. § 271, *et seq*. Defendants have committed acts of infringement by making, using, selling, and/or offering to sell products within the United States, and/or importing products into the United States, including, but not limited to, the following LG products: Lotus Elite (LX610), LX370, Neon (GT365), Remarq (LN240), Rumor 2 (VM265), and Xenon (GR500).

12. Defendants' activities have been without express, or implied, license by Sony.

13. Defendants will continue to infringe the '921 patent unless enjoined by this Court. As a result of the infringing conduct of each Defendant, Sony has suffered, and will continue to suffer, irreparable harm for which there is no adequate remedy at law. Accordingly, Sony is entitled to temporary, preliminary, and/or permanent injunctive relief against such infringement pursuant to 35 U.S.C. § 283.

14. As a result of the infringement of the '921 patent by each Defendant, Sony has been damaged, and will be further damaged, and is entitled to be compensated for such damages pursuant to 35 U.S.C. § 284 in an amount that presently cannot be ascertained, but that will be determined at trial.

15. Sony believes that each Defendant's past infringement and/or continuing infringement has been deliberate and willful, and that this case is therefore an exceptional case, which warrants an award of treble damages and attorneys' fees to Sony in accordance with 35 U.S.C. § 285.

COUNT II

Infringement of U.S. Patent No. 7,580,006

16. Sony repeats and re-alleges the allegations of paragraphs 1 through 6 of this Complaint as if fully set forth herein.

17. United States Patent No. 7,580,006, entitled "Portable telephone" (the

"'006 patent"), was duly and legally issued on August 25, 2009 naming Ryosuke Takeuchi as inventor. A true and correct copy of the '006 patent is attached hereto as Exhibit B.

18. Sony owns by assignment the entire right, title, and interest in and to the '006 patent, including the right to sue for past, present, and future infringements thereof.

19. Sony has provided and Defendants have received actual notice of the '006 patent.

20. Defendants have directly infringed, and/or have induced others to infringe, and/or have committed acts of contributory infringement of one or more claims of the '006 patent in violation of 35 U.S.C. § 271, *et seq*. Defendants have committed acts of infringement by making, using, selling, and/or offering to sell products within the United States, and/or importing products into the United States, including, but not limited to, the following LG products: Accolade (VX5600), Cosmos (VN250), Encore (GT550), enV Touch (VX11000), Fathom (VS750), Glance (VX7100), GU295, Lotus Elite (LX610), LX370, Neon (GT365), Remarq (LN240), Rumor 2 (VM265), Rumor Touch (LN510), Vu Plus (GR700) and Xenon (GR500).

21. Defendants' activities have been without express, or implied, license by Sony.

22. Defendants will continue to infringe the '006 patent unless enjoined by this Court. As a result of the infringing conduct of each Defendant, Sony has suffered, and will continue to suffer, irreparable harm for which there is no adequate remedy at law. Accordingly, Sony is entitled to temporary, preliminary, and/or permanent injunctive relief against such infringement pursuant to 35 U.S.C. § 283.

23. As a result of the infringement of the '006 patent by each Defendant, Sony has been damaged, and will be further damaged, and is entitled to be

compensated for such damages pursuant to 35 U.S.C. § 284 in an amount that presently cannot be ascertained, but that will be determined at trial.

24. Sony believes that each Defendant's past infringement and/or continuing infringement has been deliberate and willful, and that this case is therefore an exceptional case, which warrants an award of treble damages and attorneys' fees to Sony in accordance with 35 U.S.C. § 285.

COUNT III

Infringement of U.S. Patent No. RE40,568

25. Sony repeats and re-alleges the allegations of paragraphs 1 through 6 of this Complaint as if fully set forth herein.

26. United States Patent No. RE40,568 entitled "Synchronization symbol structure using OFDM based transmission method" (the "'568 patent"), was duly and legally issued on November 11, 2008 naming Ralf Böhnke, Thomas Dölle, and Tino Puch as inventors. A true and correct copy of the '568 patent is attached hereto as Exhibit C.

27. Sony owns by assignment the entire right, title, and interest in and to the '568 patent, including the right to sue for past, present, and future infringements thereof.

28. Sony has provided and Defendants have received actual notice of the '568 patent.

29. Defendants have directly infringed, and/or have induced others to infringe, and/or have committed acts of contributory infringement of one or more claims of the '568 patent in violation of 35 U.S.C. § 271, *et seq*. Defendants have committed acts of infringement by making, using, selling, and/or offering to sell products within the United States, and/or importing products into the United States, including, but not limited to, the following LG products: BX580 Blu-ray player, BD570 Blu-ray player, AN-WF100 Wi-Fi USB adapter, Fathom (VS750), and Quantum (C900).

30. Defendants' activities have been without express, or implied, license by Sony.

31. Defendants will continue to infringe the '568 patent unless enjoined by this Court. As a result of the infringing conduct of each Defendant, Sony has suffered, and will continue to suffer, irreparable harm for which there is no adequate remedy at law. Accordingly, Sony is entitled to temporary, preliminary, and/or permanent injunctive relief against such infringement pursuant to 35 U.S.C. § 283.

32. As a result of the infringement of the '568 patent by each Defendant, Sony has been damaged, and will be further damaged, and is entitled to be compensated for such damages pursuant to 35 U.S.C. § 284 in an amount that presently cannot be ascertained, but that will be determined at trial.

33. Sony believes that each Defendant's past infringement and/or continuing infringement has been deliberate and willful, and that this case is therefore an exceptional case, which warrants an award of treble damages and attorneys' fees to Sony in accordance with 35 U.S.C. § 285.

COUNT IV

Infringement of U.S. Patent No. 7,120,137

34. Sony repeats and re-alleges the allegations of paragraphs 1 through 6 of this Complaint as if fully set forth herein.

35. United States Patent No. 7,120,137 entitled "Method and apparatus for assigning codes" (the "'137 patent"), was duly and legally issued on October 10, 2006 naming Keijiro Take as inventor. A true and correct copy of the '137 patent is attached hereto as Exhibit D.

36. Sony owns by assignment the entire right, title, and interest in and to the '137 patent, including the right to sue for past, present, and future infringements thereof.

37. Sony has provided and Defendants have received actual notice of the

'137 patent.

38. Defendants have directly infringed, and/or have induced others to infringe, and/or have committed acts of contributory infringement of one or more claims of the '137 patent in violation of 35 U.S.C. § 271, *et seq*. Defendants have committed acts of infringement by making, using, selling, and/or offering to sell products within the United States, and/or importing products into the United States, including, but not limited to, the following LG products: Encore (GT550), Fathom (VS750), GU295, Vu Plus (GR700), and Xenon (GR500).

39. Defendants' activities have been without express, or implied, license by Sony.

40. Defendants will continue to infringe the '137 patent unless enjoined by this Court. As a result of the infringing conduct of each Defendant, Sony has suffered, and will continue to suffer, irreparable harm for which there is no adequate remedy at law. Accordingly, Sony is entitled to temporary, preliminary, and/or permanent injunctive relief against such infringement pursuant to 35 U.S.C. § 283.

41. As a result of the infringement of the '137 patent by each Defendant, Sony has been damaged, and will be further damaged, and is entitled to be compensated for such damages pursuant to 35 U.S.C. § 284 in an amount that presently cannot be ascertained, but that will be determined at trial.

42. Sony believes that each Defendant's past infringement and/or continuing infringement has been deliberate and willful, and that this case is therefore an exceptional case, which warrants an award of treble damages and attorneys' fees to Sony in accordance with 35 U.S.C. § 285.

COUNT V

Infringement of U.S. Patent No. 6,829,489

43. Sony repeats and re-alleges the allegations of paragraphs 1 through 6 of this Complaint as if fully set forth herein.

44. United States Patent No. 6,829,489, entitled "Communication system, transmitter, receiver, and communication method" (the "'489 patent"), was duly and legally issued on December 7, 2004 naming Kazushi Yamamoto, Hideshi Murai, and Yasuhiro Yano as inventors. A true and correct copy of the '489 patent is attached hereto as Exhibit E.

45. Sony owns by assignment the entire right, title, and interest in and to the '489 patent, including the right to sue for past, present, and future infringements thereof.

46. Sony has provided and Defendants have received actual notice of the '489 patent.

47. Defendants have directly infringed, and/or have induced others to infringe, and/or have committed acts of contributory infringement of one or more claims of the '489 patent in violation of 35 U.S.C. § 271, *et seq*. Defendants have committed acts of infringement by making, using, selling, and/or offering to sell products within the United States, and/or importing products into the United States, including, but not limited to, the following LG products: Encore (GT550), Fathom (VS750), GU295, Vu Plus (GR700), and Xenon (GR500).

48. Defendants' activities have been without express, or implied, license by Sony.

49. Defendants will continue to infringe the '489 patent unless enjoined by this Court. As a result of the infringing conduct of each Defendant, Sony has suffered, and will continue to suffer, irreparable harm for which there is no adequate remedy at law. Accordingly, Sony is entitled to temporary, preliminary, and/or permanent injunctive relief against such infringement pursuant to 35 U.S.C. § 283.

50. As a result of the infringement of the '489 patent by each Defendant, Sony has been damaged, and will be further damaged, and is entitled to be compensated for such damages pursuant to 35 U.S.C. § 284 in an amount that

presently cannot be ascertained, but that will be determined at trial.

51. Sony believes that each Defendant's past infringement and/or continuing infringement has been deliberate and willful, and that this case is therefore an exceptional case, which warrants an award of treble damages and attorneys' fees to Sony in accordance with 35 U.S.C. § 285.

COUNT VI

Infringement of U.S. Patent No. 7,242,769

52. Sony repeats and re-alleges the allegations of paragraphs 1 through 6 of this Complaint as if fully set forth herein.

53. United States Patent No. 7,242,769, entitled "Enciphering apparatus and method, deciphering apparatus and method as well as information processing apparatus and method" (the "'769 patent"), was duly and legally issued on July 10, 2007 naming Ryuji Ishiguro, Yoshitomo Osawa, Yoshio Osakabe, Makoto Sato, Hisato Shima, and Tomoyuki Asano as inventors. A true and correct copy of the '769 patent is attached hereto as Exhibit F.

54. Sony owns by assignment the entire right, title, and interest in and to the '769 patent, including the right to sue for past, present, and future infringements thereof.

55. Sony has provided and Defendants have received actual notice of the '769 patent.

56. Defendants have directly infringed, and/or have induced others to infringe, and/or have committed acts of contributory infringement of one or more claims of the '769 patent in violation of 35 U.S.C. § 271, *et seq*. Defendants have committed acts of infringement by making, using, selling, and/or offering to sell products within the United States, and/or importing products into the United States, including, but not limited to, the following LG products: Encore (GT550), GU295, Vu Plus (GR700), and Xenon (GR500).

57. Defendants' activities have been without express, or implied, license by

Sony.

58. Defendants will continue to infringe the '769 patent unless enjoined by this Court. As a result of the infringing conduct of each Defendant, Sony has suffered, and will continue to suffer, irreparable harm for which there is no adequate remedy at law. Accordingly, Sony is entitled to temporary, preliminary, and/or permanent injunctive relief against such infringement pursuant to 35 U.S.C. § 283.

59. As a result of the infringement of the '769 patent by each Defendant, Sony has been damaged, and will be further damaged, and is entitled to be compensated for such damages pursuant to 35 U.S.C. § 284 in an amount that presently cannot be ascertained, but that will be determined at trial.

60. Sony believes that each Defendant's past infringement and/or continuing infringement has been deliberate and willful, and that this case is therefore an exceptional case, which warrants an award of treble damages and attorneys' fees to Sony in accordance with 35 U.S.C. § 285.

COUNT VII

Infringement of U.S. Patent No. 6,510,208

61. Sony repeats and re-alleges the allegations of paragraphs 1 through 6 of this Complaint as if fully set forth herein.

62. United States Patent No. 6,510,208, entitled "Telephone apparatus with audio recording function and audio recording method telephone apparatus with audio recording function" (the "'208 patent"), was duly and legally issued on January 21, 2003 naming Kozo Komiya as inventor. A true and correct copy of the '208 patent is attached hereto as Exhibit G.

63. Sony owns by assignment the entire right, title, and interest in and to the '208 patent, including the right to sue for past, present, and future infringements thereof.

64. Sony has provided and Defendants have received actual notice of the

'208 patent.

65. Defendants have directly infringed, and/or have induced others to infringe, and/or have committed acts of contributory infringement of one or more claims of the '208 patent in violation of 35 U.S.C. § 271, *et seq*. Defendants have committed acts of infringement by making, using, selling, and/or offering to sell products within the United States, and/or importing products into the United States, including, but not limited to, the following LG products: Glance (VX7100), Accolade (VX5600), Cosmos (VN250), enV Touch (VX11000), Lotus Elite (LX610), LX370, Remarq (LN240), and Rumor Touch (LN510).

66. Defendants' activities have been without express, or implied, license by Sony.

67. Defendants will continue to infringe the '208 patent unless enjoined by this Court. As a result of the infringing conduct of each Defendant, Sony has suffered, and will continue to suffer, irreparable harm for which there is no adequate remedy at law. Accordingly, Sony is entitled to temporary, preliminary, and/or permanent injunctive relief against such infringement pursuant to 35 U.S.C. § 283.

68. As a result of the infringement of the '208 patent by each Defendant, Sony has been damaged, and will be further damaged, and is entitled to be compensated for such damages pursuant to 35 U.S.C. § 284 in an amount that presently cannot be ascertained, but that will be determined at trial.

69. Sony believes that each Defendant's past infringement and/or continuing infringement has been deliberate and willful, and that this case is therefore an exceptional case, which warrants an award of treble damages and attorneys' fees to Sony in accordance with 35 U.S.C. § 285.

COUNT VIII

Infringement of U.S. Patent No. 6,374,121

70. Sony repeats and re-alleges the allegations of paragraphs 1 through 6 of

this Complaint as if fully set forth herein.

71. United States Patent No. 6,374,121, entitled "System and method for enabling automatic performance of instrument functions" (the "'121 patent"), was duly and legally issued on April 16, 2002 naming Kazuto Mugura, Eduardo Sciammarella, and Scott Kravitz as inventors. A true and correct copy of the '121 patent is attached hereto as Exhibit H.

72. Sony owns by assignment the entire right, title, and interest in and to the '121 patent, including the right to sue for past, present, and future infringements thereof.

73. Defendants have directly infringed, and/or are inducing others to infringe, and/or have committed acts of contributory infringement of one or more claims of the '121 patent in violation of 35 U.S.C. § 271, *et seq*. Defendants have committed acts of infringement by making, using, selling, and/or offering to sell products within the United States, and/or importing products into the United States, including, but not limited to, the following LG products: Xenon (GR500), and Quantum (C900).

74. Defendants' activities have been without express, or implied, license by Sony.

75. Defendants will continue to infringe the '121 patent unless enjoined by this Court. As a result of the infringing conduct of each Defendant, Sony has suffered, and will continue to suffer, irreparable harm for which there is no adequate remedy at law. Accordingly, Sony is entitled to temporary, preliminary, and/or permanent injunctive relief against such infringement pursuant to 35 U.S.C. § 283.

76. As a result of the infringement of the '121 patent by each Defendant, Sony has been damaged, and will be further damaged, and is entitled to be compensated for such damages pursuant to 35 U.S.C. § 284 in an amount that presently cannot be ascertained, but that will be determined at trial.

PRAYER FOR RELIEF

WHEREFORE, Sony respectfully requests that the Court enter judgment:

(a) That each Defendant has infringed the '921 patent, '006 patent, '568 patent, '137 patent, '489 patent, '769 patent, '208 patent, and '121 patent under 35 U.S.C. §§ 271 *et seq.*;

(b) That injunctions, preliminary and permanent, be issued by this Court restraining each Defendant, their respective officers, agents, servants, directors, and employees, and all persons in active concert or participation with each, from directly or indirectly infringing, or inducing or contributing to the infringement by others of the '921 patent, '006 patent, '568 patent, '137 patent, '489 patent, '769 patent, '208 patent, and '121 patent;

(c) That each Defendant be required to provide to Sony an accounting of all gains, profits, and advantages derived by each Defendant's infringement of the '921 patent, '006 patent, '568 patent, '137 patent, '489 patent, '769 patent, '208 patent, and '121 patent, and that Sony be awarded damages adequate to compensate Sony for the wrongful infringing acts by each Defendant, in accordance with 35 U.S.C. § 284;

(d) That the damages awarded to Sony with regard to the '921 patent, '006 patent, '568 patent, '137 patent, '489 patent, '769 patent, and '208 patent be increased up to three times, in view of Defendants' willful infringement, in accordance with 35 U.S.C. § 284;

(e) That this case be declared to be exceptional in favor of Sony under 35 U.S.C. § 285, and that Sony be awarded its reasonable attorneys' fees and other expenses incurred in connection with this action;

(f) That Sony be awarded its interest and costs of suit incurred in this action; and

(g) That Sony be awarded such other and further relief as this Court deems just and proper.

DATED: December 28, 2010

Respectfully submitted,

QUINN EMANUEL URQUHART & SULLIVAN, LLP

By STEVEN M. ANDERSON J.L.
Steven M. Anderson
Attorneys for Plaintiff Sony Corporation

Of Counsel:

John Flock
Marcia H. Sundeen
Jeffrey S. Gerchick
Paul T. Qualey

DEMAND FOR JURY TRIAL

Pursuant to Rule 38 of the Federal Rules of Civil Procedure, Plaintiff hereby demands a trial by jury as to all issues so triable.

DATED: December 28, 2010

Respectfully submitted,

QUINN EMANUEL URQUHART & SULLIVAN, LLP

By STEVEN M. ANDERSON J.L.
Steven M. Anderson
Attorneys for Plaintiff Sony Corporation

Of Counsel:

John Flock
Marcia H. Sundeen
Jeffrey S. Gerchick
Paul T. Qualey

Name & Address:

UNITED STATES DISTRICT COURT
CENTRAL DISTRICT OF CALIFORNIA

SONY CORPORATION, a Japanese Corporation PLAINTIFF(S) v. LG ELECTRONICS U.S.A., INC., a Delaware corporation and LG ELECTRONICS MOBILECOMM U.S.A., INC., a California corporation DEFENDANT(S).	CASE NUMBER CV10-09967 CAS (PJWx) **SUMMONS**

TO: DEFENDANT(S): LG Electronics U.S.A., Inc., LG Electronics Mobilecomm U.S.A., Inc.

A lawsuit has been filed against you.

Within 21 days after service of this summons on you (not counting the day you received it), you must serve on the plaintiff an answer to the attached ☑ complaint ☐ _____ amended complaint ☐ counterclaim ☐ cross-claim or a motion under Rule 12 of the Federal Rules of Civil Procedure. The answer or motion must be served on the plaintiff's attorney, Steven M. Anderson, whose address is 865 S. Figueroa St., 10th Floor, Los Angeles, CA 90017. If you fail to do so, judgment by default will be entered against you for the relief demanded in the complaint. You also must file your answer or motion with the court.

Clerk, U.S. District Court

Dated: DEC 28 2010

By: JULIE PRADO
Deputy Clerk

(Seal of the Court)

[Use 60 days if the defendant is the United States or a United States agency, or is an officer or employee of the United States. Allowed 60 days by Rule 12(a)(3)].

UNITED STATES DISTRICT COURT
CENTRAL DISTRICT OF CALIFORNIA

NOTICE OF ASSIGNMENT TO UNITED STATES MAGISTRATE JUDGE FOR DISCOVERY

This case has been assigned to District Judge Christina A. Snyder and the assigned discovery Magistrate Judge is Patrick J. Walsh.

The case number on all documents filed with the Court should read as follows:

CV10- 9967 CAS (PJWx)

Pursuant to General Order 05-07 of the United States District Court for the Central District of California, the Magistrate Judge has been designated to hear discovery related motions.

All discovery related motions should be noticed on the calendar of the Magistrate Judge

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NOTICE TO COUNSEL

A copy of this notice must be served with the summons and complaint on all defendants (if a removal action is filed, a copy of this notice must be served on all plaintiffs).

Subsequent documents must be filed at the following location:

[X] Western Division
312 N. Spring St., Rm. G-8
Los Angeles, CA 90012

[ ] Southern Division
411 West Fourth St., Rm. 1-053
Santa Ana, CA 92701-4516

[ ] Eastern Division
3470 Twelfth St., Rm. 134
Riverside, CA 92501

Failure to file at the proper location will result in your documents being returned to you.

UNITED STATES DISTRICT COURT, CENTRAL DISTRICT OF CALIFORNIA

CONFORMED COP

CIVIL COVER SHEET

(a) PLAINTIFFS (Check box if you are representing yourself ☐)

:ONY CORPORATION, a Japanese Corporation

DEFENDANTS

LG ELECTRONICS U.S.A., INC., A Delaware corporation and LG ELECTRONICS MOBILECOMM U.S.A., INC., a California corpo

(b) Attorneys (Firm Name, Address and Telephone Number. If you are representing yourself, provide same.)

Steven M. Anderson
Quinn Emanuel Urquhart & Sullivan LLP
865 S. Figueroa Street
10th Floor
Los Angeles, CA 90017
213-443-3000

Attorneys (If Known)

II. BASIS OF JURISDICTION (Place an X in one box only.)

☐ 1 U.S. Government Plaintiff
☒ 3 Federal Question (U.S. Government Not a Party)
☐ 2 U.S. Government Defendant
☐ 4 Diversity (Indicate Citizenship of Parties in Item III)

III. CITIZENSHIP OF PRINCIPAL PARTIES - For Diversity Cases Only (Place an X in one box for plaintiff and one for defendant.)

	PTF	DEF		PTF	DEF
Citizen of This State	☐ 1	☐ 1	Incorporated or Principal Place of Business in this State	☐ 4	☐ 4
Citizen of Another State	☐ 2	☐ 2	Incorporated and Principal Place of Business in Another State	☐ 5	☐ 5
Citizen or Subject of a Foreign Country	☐ 3	☐ 3	Foreign Nation	☐ 6	☐ 6

IV. ORIGIN (Place an X in one box only.)

☒ 1 Original Proceeding ☐ 2 Removed from State Court ☐ 3 Remanded from Appellate Court ☐ 4 Reinstated or Reopened ☐ 5 Transferred from another district (specify): ☐ 6 Multi-District Litigation ☐ 7 Appeal to District Judge from Magistrate Judge

REQUESTED IN COMPLAINT: JURY DEMAND: ☒ Yes ☐ No (Check 'Yes' only if demanded in complaint.)

LASS ACTION under F.R.C.P. 23: ☐ Yes ☒ No ☒ **MONEY DEMANDED IN COMPLAINT: $** Unspecified

I. CAUSE OF ACTION (Cite the U.S. Civil Statute under which you are filing and write a brief statement of cause. Do not cite jurisdictional statutes unless diversity.)

5 U.S.C. 271 - Patent infringement (All counts)

II. NATURE OF SUIT (Place an X in one box only.)

OTHER STATUTES
☐ 400 State Reapportionment
☐ 410 Antitrust
☐ 430 Banks and Banking
☐ 450 Commerce/ICC Rates/etc.
☐ 460 Deportation
☐ 470 Racketeer Influenced and Corrupt Organizations
☐ 480 Consumer Credit
☐ 490 Cable/Sat TV
☐ 810 Selective Service
☐ 850 Securities/Commodities/ Exchange
☐ 875 Customer Challenge 12 USC 3410
☐ 890 Other Statutory Actions
☐ 891 Agricultural Act
☐ 892 Economic Stabilization Act
☐ 893 Environmental Matters
☐ 894 Energy Allocation Act
☐ 895 Freedom of Info. Act
☐ 900 Appeal of Fee Determination Under Equal Access to Justice
☐ 950 Constitutionality of State Statutes

CONTRACT
☐ 110 Insurance
☐ 120 Marine
☐ 130 Miller Act
☐ 140 Negotiable Instrument
☐ 150 Recovery of Overpayment & Enforcement of Judgment
☐ 151 Medicare Act
☐ 152 Recovery of Defaulted Student Loan (Excl. Veterans)
☐ 153 Recovery of Overpayment of Veteran's Benefits
☐ 160 Stockholders' Suits
☐ 190 Other Contract
☐ 195 Contract Product Liability
☐ 196 Franchise

REAL PROPERTY
☐ 210 Land Condemnation
☐ 220 Foreclosure
☐ 230 Rent Lease & Ejectment
☐ 240 Torts to Land
☐ 245 Tort Product Liability
☐ 290 All Other Real Property

TORTS PERSONAL INJURY
☐ 310 Airplane
☐ 315 Airplane Product Liability
☐ 320 Assault, Libel & Slander
☐ 330 Fed. Employers' Liability
☐ 340 Marine
☐ 345 Marine Product Liability
☐ 350 Motor Vehicle
☐ 355 Motor Vehicle Product Liability
☐ 360 Other Personal Injury
☐ 362 Personal Injury-Med Malpractice
☐ 365 Personal Injury-Product Liability
☐ 368 Asbestos Personal Injury Product Liability

IMMIGRATION
☐ 462 Naturalization Application
☐ 463 Habeas Corpus-Alien Detainee
☐ 465 Other Immigration Actions

TORTS PERSONAL PROPERTY
☐ 370 Other Fraud
☐ 371 Truth in Lending
☐ 380 Other Personal Property Damage
☐ 385 Property Damage Product Liability

BANKRUPTCY
☐ 422 Appeal 28 USC 158
☐ 423 Withdrawal 28 USC 157

CIVIL RIGHTS
☐ 441 Voting
☐ 442 Employment
☐ 443 Housing/Accommodations
☐ 444 Welfare
☐ 445 American with Disabilities - Employment
☐ 446 American with Disabilities - Other
☐ 440 Other Civil Rights

PRISONER PETITIONS
☐ 510 Motions to Vacate Sentence Habeas Corpus
☐ 530 General
☐ 535 Death Penalty
☐ 540 Mandamus/ Other
☐ 550 Civil Rights
☐ 555 Prison Condition

FORFEITURE/ PENALTY
☐ 610 Agriculture
☐ 620 Other Food & Drug
☐ 625 Drug Related Seizure of Property 21 USC 881
☐ 630 Liquor Laws
☐ 640 R.R. & Truck
☐ 650 Airline Regs
☐ 660 Occupational Safety/Health
☐ 690 Other

LABOR
☐ 710 Fair Labor Standards Act
☐ 720 Labor/Mgmt. Relations
☐ 730 Labor/Mgmt. Reporting & Disclosure Act
☐ 740 Railway Labor Act
☐ 790 Other Labor Litigation
☐ 791 Empl. Ret. Inc. Security Act

PROPERTY RIGHTS
☐ 820 Copyrights
☒ 830 Patent
☐ 840 Trademark

SOCIAL SECURITY
☐ 861 HIA (1395ff)
☐ 862 Black Lung (923)
☐ 863 DIWC/DIWW (405(g))
☐ 864 SSID Title XVI
☐ 865 RSI (405(g))

FEDERAL TAX SUITS
☐ 870 Taxes (U.S. Plaintiff or Defendant)
☐ 871 IRS - Third Party 26 USC 7609

OR OFFICE USE ONLY: Case Number: CV10-09967

AFTER COMPLETING THE FRONT SIDE OF FORM CV-71, COMPLETE THE INFORMATION REQUESTED BELOW.

UNITED STATES DISTRICT COURT, CENTRAL DISTRICT OF CALIFQRNIA
CIVIL COVER SHEET

III(a). IDENTICAL CASES: Has this action been previously filed in this court and dismissed, remanded or closed? [X] No [ ] Yes

yes, list case number(s):

III(b). RELATED CASES: Have any cases been previously filed in this court that are related to the present case? [X] No [ ] Yes

yes, list case number(s):

ivil cases are deemed related if a previously filed case and the present case:

:heck all boxes that apply)

- [ ] A. Arise from the same or closely related transactions, happenings, or events; or
- [ ] B. Call for determination of the same or substantially related or similar questions of law and fact; or
- [ ] C. For other reasons would entail substantial duplication of labor if heard by different judges; or
- [ ] D. Involve the same patent, trademark or copyright, and one of the factors identified above in a, b or c also is present.

. VENUE: (When completing the following information, use an additional sheet if necessary.)

) List the County in this District; California County outside of this District; State if other than California; or Foreign Country, in which **EACH** named plaintiff resides.

[ ] Check here if the government, its agencies or employees is a named plaintiff. If this box is checked, go to item (b).

County in this District:*	California County outside of this District; State, if other than California; or Foreign Country
	Sony Corporation - Japan

) List the County in this District; California County outside of this District; State if other than California; or Foreign Country, in which **EACH** named defendant resides.

[ ] Check here if the government, its agencies or employees is a named defendant. If this box is checked, go to item (c).

County in this District:*	California County outside of this District; State, if other than California; or Foreign Country
	LG Electronics U.S.A., Inc. - New Jersey LG Mobilecomm U.S.A., Inc. - San Diego

) List the County in this District; California County outside of this District; State if other than California; or Foreign Country, in which **EACH** claim arose.

Note: In land condemnation cases, use the location of the tract of land involved.

County in this District:*	California County outside of this District; State, if other than California; or Foreign Country
Los Angeles (All counts)	

Los Angeles, Orange, San Bernardino, Riverside, Ventura, Santa Barbara, or San Luis Obispo Counties

ote: In land condemnation cases, use the location of the tract of land involved

. SIGNATURE OF ATTORNEY (OR PRO PER): STEVEN M. ANDERSON J.L. Date 12-28-10

Steven M. Anderson

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ey to Statistical codes relating to Social Security Cases:

Nature of Suit Code	Abbreviation	Substantive Statement of Cause of Action
861	HIA	All claims for health insurance benefits (Medicare) under Title 18, Part A, of the Social Security Act, as amended. Also, include claims by hospitals, skilled nursing facilities, etc., for certification as providers of services under the program. (42 U.S.C. 1935FF(b))
862	BL	All claims for "Black Lung" benefits under Title 4, Part B, of the Federal Coal Mine Health and Safety Act of 1969. (30 U.S.C. 923)
863	DIWC	All claims filed by insured workers for disability insurance benefits under Title 2 of the Social Security Act, as amended; plus all claims filed for child's insurance benefits based on disability. (42 U.S.C. 405(g))
863	DIWW	All claims filed for widows or widowers insurance benefits based on disability under Title 2 of the Social Security Act, as amended. (42 U.S.C. 405(g))
864	SSID	All claims for supplemental security income payments based upon disability filed under Title 16 of the Social Security Act, as amended.
865	RSI	All claims for retirement (old age) and survivors benefits under Title 2 of the Social Security Act, as amended. (42 U.S.C. (g))

EXHIBIT A

US006222921B1

(12) **United States Patent**
Mugura et al.

(10) **Patent No.: US 6,222,921 B1**
(45) **Date of Patent: Apr. 24, 2001**

(54) **METHOD AND APPARATUS FOR DISPLAYING AN ELECTRONIC PHONEBOOK**

(75) Inventors: **Katzuto Mugura**, Kawasaki (JP); **Bryan Lew Fong**, San Diego; **Chris Shi-Chai Liu**, San Jose, both of CA (US)

(73) Assignees: **Sony Corporation**, Tokyo (JP); **Sony Electronics Inc.**, Park Ridge, NJ (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/133,070**

(22) Filed: **Aug. 12, 1998**

(51) **Int. Cl.**[7] **H04M 1/00**
(52) **U.S. Cl.** **379/354**; 379/355; 379/356; 379/216
(58) **Field of Search** 379/354, 355, 379/356, 216, 201, 202

(56) **References Cited**

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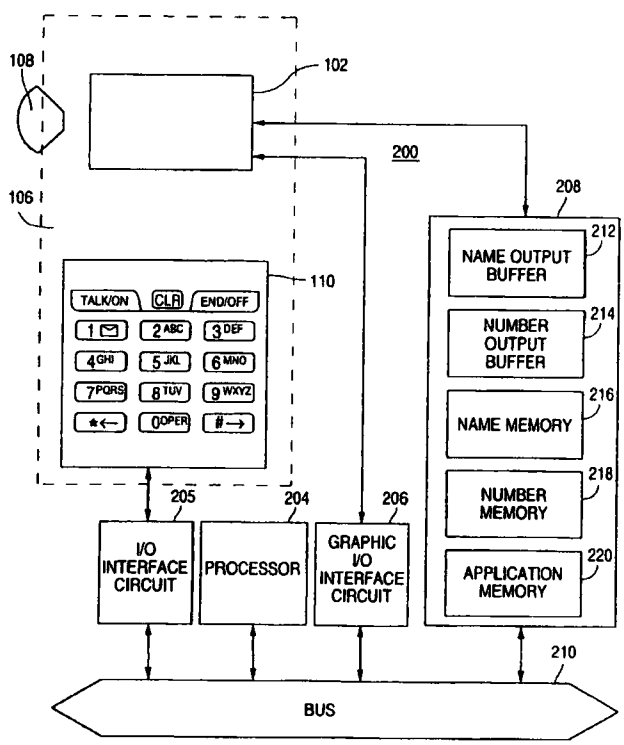
Primary Examiner—David Hudspeth
Assistant Examiner—Susan Wieland
(74) *Attorney, Agent, or Firm*—Crosby, Heafey, Roach & May

(57) **ABSTRACT**

An apparatus and method for displaying a telephone directory. A main menu is used to display the names of a telephone directory, and each of the names is associated with a primary number. A sub menu is used to display the numbers associated with each of the names in the main menu. The primary number is denoted and automatically selected in the second menu.

47 Claims, 5 Drawing Sheets



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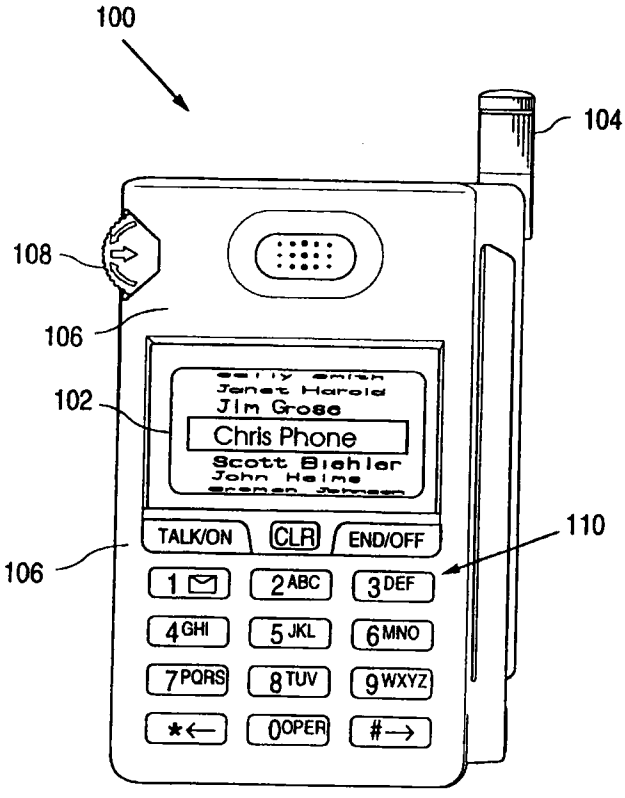

FIG. 1A

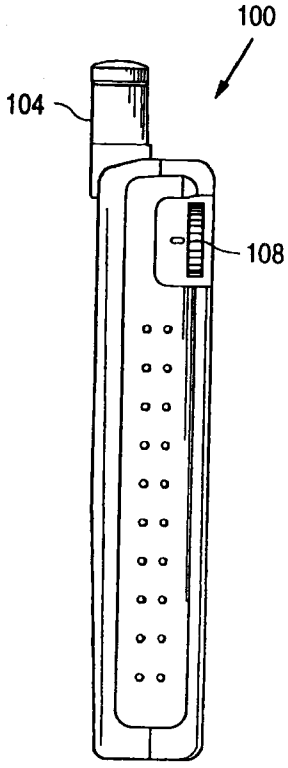

FIG. 1B

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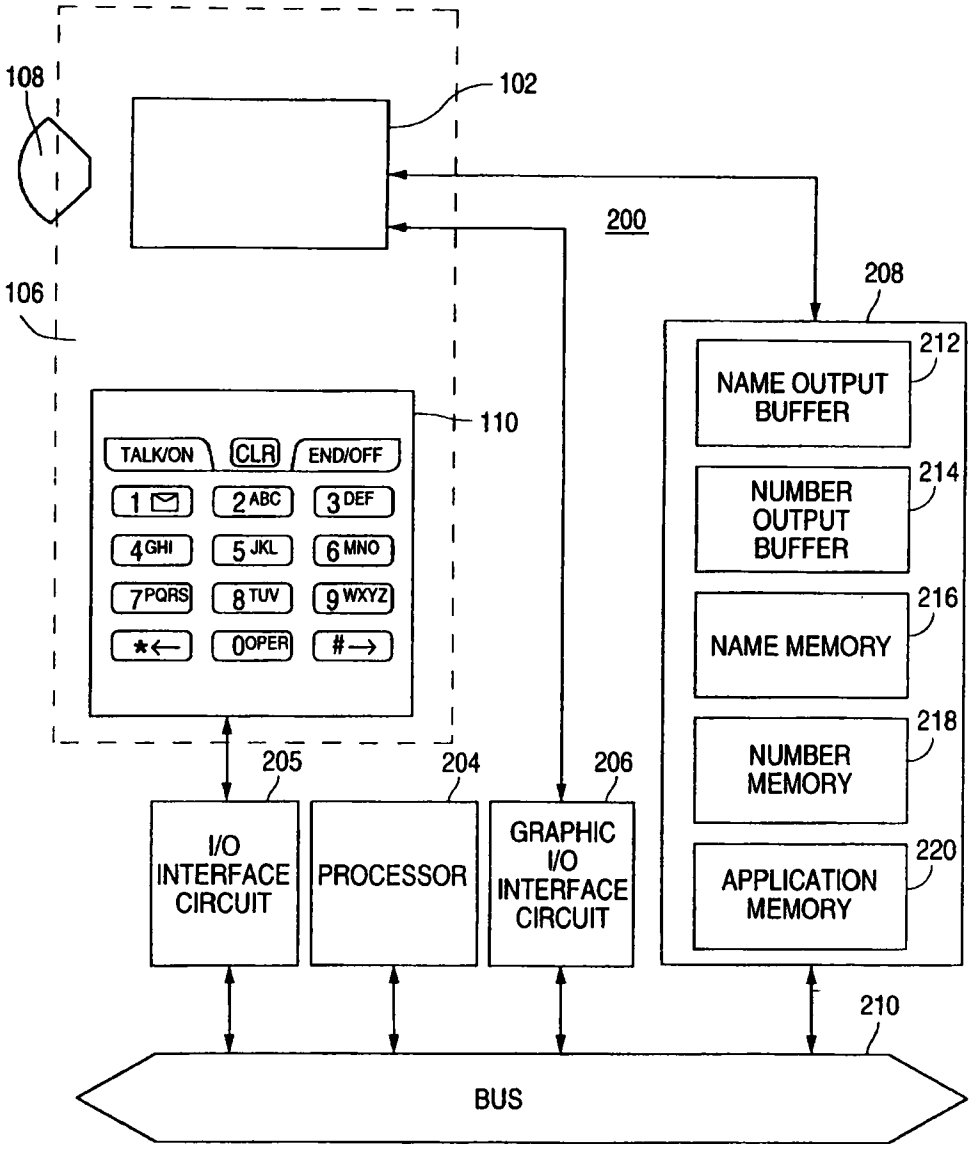

FIG. 2

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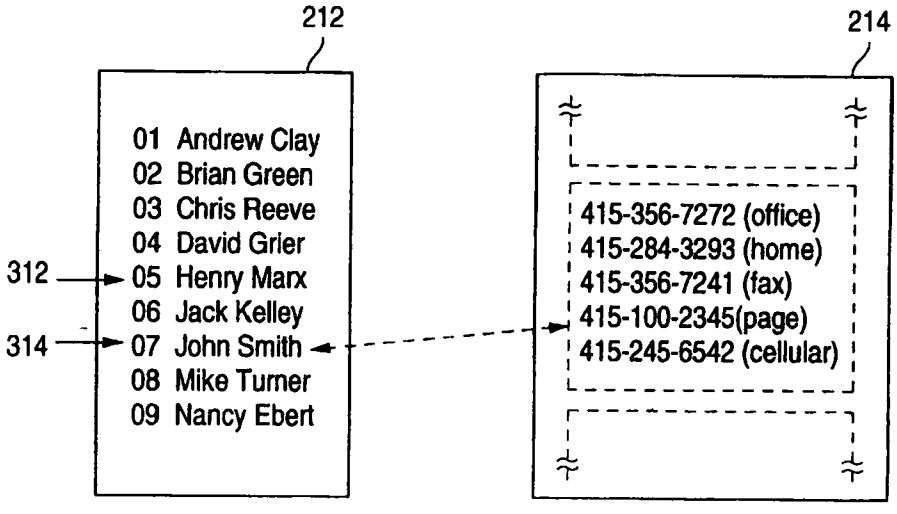

FIG. 3

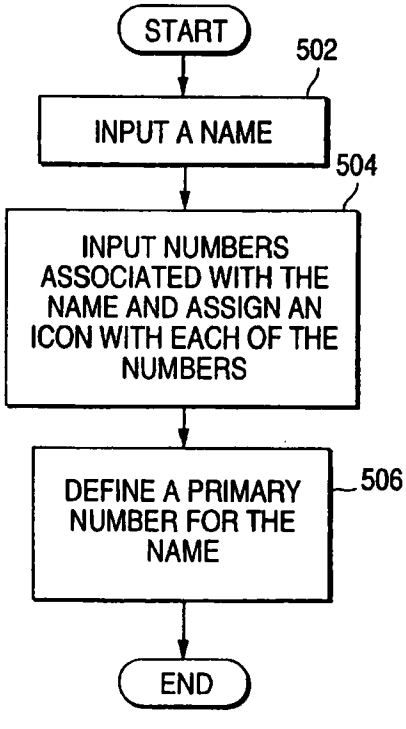

FIG. 5

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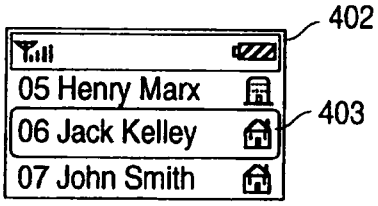

FIG. 4A

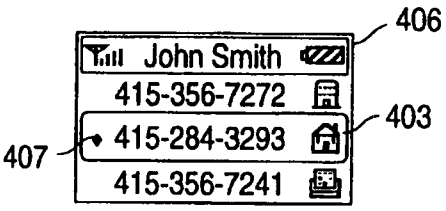

FIG. 4C

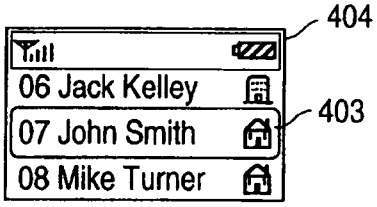

FIG. 4B

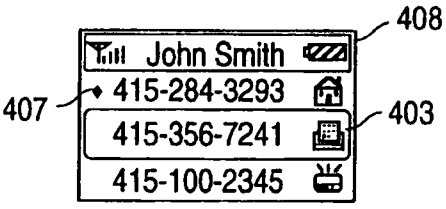

FIG. 4D

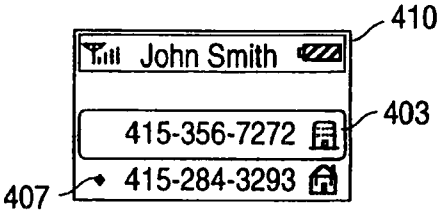

FIG. 4E

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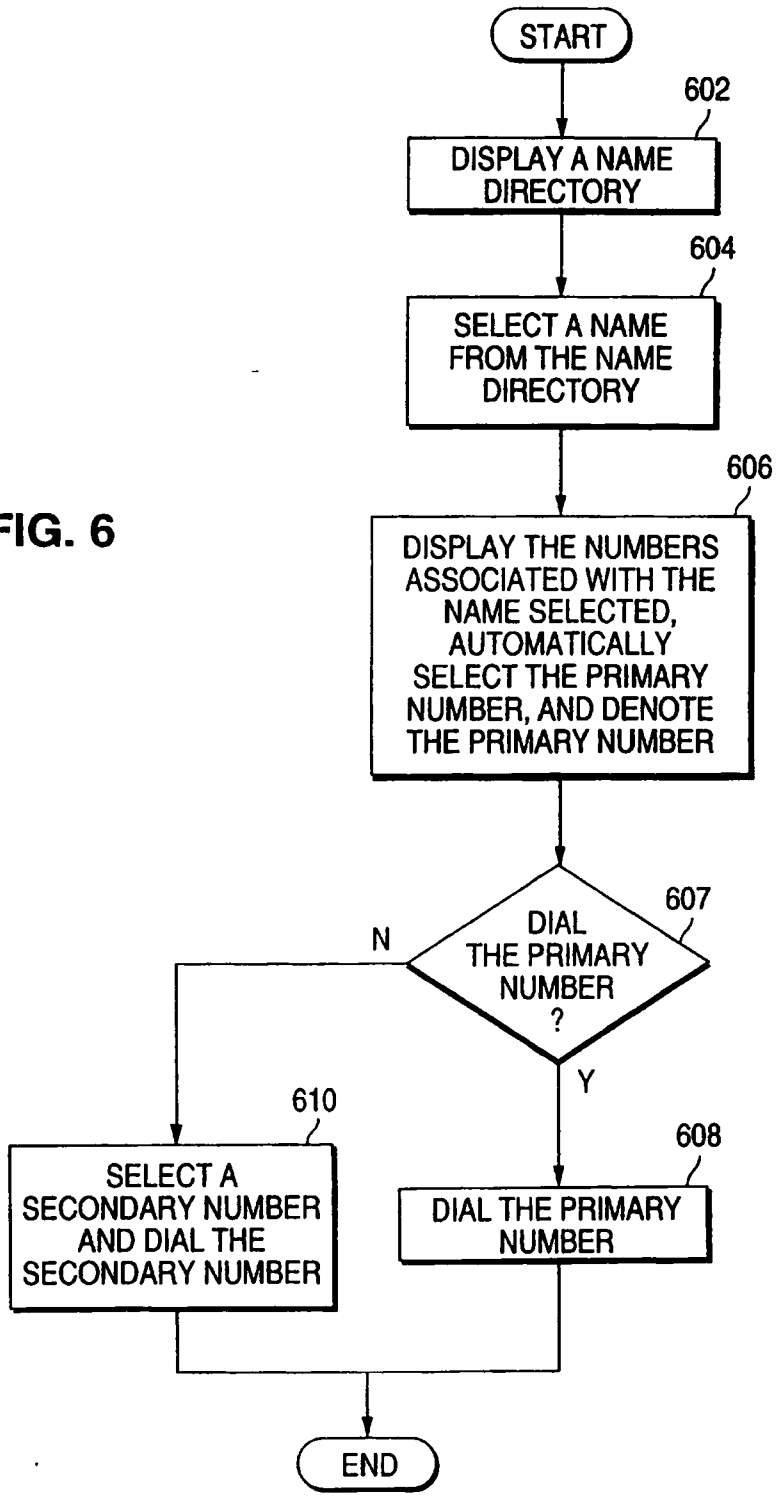
FIG. 6



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METHOD AND APPARATUS FOR DISPLAYING AN ELECTRONIC PHONEBOOK

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to displaying a name directory on a screen, and, more specifically, to displaying a name directory containing a plurality of directory names with each of them being associated with a plurality of numbers.

2. Related Art

A state of art telephone has the capability of storing a telephone directory containing a plurality of names, and displaying these names on the display screen of the telephone. Frequently, a name in a telephone directory may contain several numbers (including a home number, an office number, a fax number, a page number, and a cellular number, for example). Using control buttons on the control panel of a telephone, a user can select a number from a telephone directory to dial the selected number.

Conventionally, a typical available telephone displays all names and the associated numbers of a telephone directory together on a display screen. Such an approach makes it difficult for a user to locate a number of interest from the display screen, because the user may see several numbers under an identical name. Furthermore, when a telephone directory is displayed on a relatively small region, such as an LCD screen on a cellular telephone, it is even more difficult for a user to locate a particular number of interest.

There is, therefore, a need for a method and apparatus to display a plurality of names, which facilitates a user to select a specific number from the multiple numbers associated with the names.

There is another need for a method and apparatus to display a plurality of names on a relatively small display region, which facilitates a user to select a specific number from the multiple numbers associated with the names.

The present invention provides a method to meet these two needs.

SUMMARY OF THE INVENTION

The present invention provides a novel method and a corresponding apparatus to display a telephone directory.

To address the shortcomings of the available art, the present invention provides a novel method for displaying a telephone directory. The method comprises the steps of: on a first display screen, displaying a plurality of names, each of the names being associated with a primary number; from the first display screen, selecting one of the names; on a second display screen, displaying a primary number associated with the selected name and at least one secondary number; and on the second display screen, automatically selecting the primary number.

The present invention also provides an apparatus capable of performing the steps in the method described above.

The foregoing and other features and advantages of the invention will be more readily understood upon consideration of the following detailed description of certain preferred embodiments of the invention, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is the front view of a cellular telephone, which can be used to implement the present invention;

FIG. 1B is the side view of the cellular telephone shown in FIG. 1A;

FIG. 2 is a block diagram illustrating some components of the cellular telephone shown in FIG. 1A;

FIG. 3 shows the steps illustrating a sequence of displays on a display region, in accordance with one embodiment of the present invention;

FIGS. 4A–E show the steps illustrating a sequence of displays on a display region, in accordance with another embodiment of the present invention;

FIG. 5 shows a flowchart illustrating the steps of entering a name and the numbers that are associated with the name into the cellular telephone, in accordance with the present invention; and

FIG. 6 shows a flowchart illustrating the steps of displaying the numbers that are associated with a name in a name directory, in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1A, there is shown the front view of a cellular telephone **100**, which can be used to implement the present invention.

As shown in FIG. 1A, the cellular telephone **100** includes a display screen **102**, an antenna **104**, and a control panel **106**. The control panel **106** includes a jog dial wheel **108** and a key panel **110** including twelve alpha/numeric keys (1, 2, 3, 4, 5, 6, 7, 8, 9, *, 0, and #). The jog dial wheel **108** can be moved in three directions (turn-up, turn-down, and press-in) as indicated by the three arrows. The menu items displayed on the display screen **102** can be scrolled up and down by turning the jog dial wheel **108** up and down, respectively. And a selected menu item displayed on the display screen **102** can be activated by pressing in the jog dial wheel **102**.

Referring to FIG. 1B, there is shown the side view of the cellular telephone **100** to illustrate the side view of the jog dial wheel **108**.

Referring to FIG. 2, there is shown a block diagram **200**, illustrating some components of the cellular telephone **100** shown in FIG. 1A, in accordance with the present invention.

As shown in FIG. 2, the block diagram **200** includes a processor **204**, an I/O (input and output) interface circuit **205**, a graphic I/O interface circuit **206**, a memory **208**, and a bus **210**.

The processor **204**, the I/O interface circuit **205**, the graphic I/O interface circuit **206**, and the memory **208** are all coupled to the bus **210**.

The memory **208** includes: (1) a name output buffer **212** for storing directory names to be displayed, (2) a number output buffer **214** for storing the numbers to be displayed, (3) a name memory **216** for storing the directory names, (4) a number memory **218** for storing the numbers associated with the directory names, and (5) an application memory **220** for storing an application that includes a data entry routine, a display routine, and a dialing routine.

The processor **204** controls the operations of the I/O interface circuit **205**, the graphic the I/O interface circuit **206**, the memory **208**, and the display region **102**. More specifically, the processor **204** is able to: (1) get access to the data stored in the name output buffer **212**, the number output buffer **214**, the name memory **216**, and the number memory **218**, (2) execute the application stored in the application memory **220**, (3) interact with the control panel **106** via the I/O interface circuit **205**, and (4) display the data stored in

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the output buffers **212** and **214** on the display region **102** via the graphic I/O interface circuit **206**. All these operations are performed in a conventional manner, except as otherwise described herein.

Since to the cellular system **100**, the display screen **102** is an output mechanism, the name output buffer **212** and the number output buffer **214** are especially set to store the data to be displayed on the display screen **102**.

Using the jog dial wheel **108**, a user can invoke the data entry routine (stored in the application memory **20**). And using the nine alpha/numeric keys on the key panel **110**, a user can input names to the name memory **216** and numbers to the number memory **218**. The names and numbers can then be loaded from the name memory **216** and the number memory **218** to the name output buffer **212** and the number output buffer **214**, respectively. A name may associate with several numbers. Among the several numbers, the user can define a primary number for the name.

Referring to FIG. **3**, there is shown a name directory stored in the name output buffer **212** and the number output buffer **214**, in accordance with the present invention.

As shown in FIG. **3**, the name output buffer **212** stores nine names. The number output buffer **214** stores the numbers associated with each of the nine names stored in the name output buffer **212**. In particular, FIG. **3** shows that the number output buffer **214** stores five numbers that are associated with the seventh name (07 John Smith) stored in the name output buffer **212**.

Since the display screen **102** has a relatively small area, not all the data items stored in the name output buffer **212** or the number output buffer **214** can be displayed on the display screen **102** at a certain point of time. Hence, a start pointer and an end pointer are set to mark an active section in the name output buffer **212** (or in the number output buffer **214**). Even though all the data items stored in the name output buffer **212** (or in the number output buffer **214**) are linked with the display screen **102**, only the data items contained in the active section are being displayed on the display screen at a certain point of time. In the embodiment shown in FIG. **3**, for the name output buffer **212**, a start pointer **312** points to the fifth name (05 Henry Marx), and an end pointer **314** points to the seventh name (07 John Smith). Hence, the active region of the name output buffer **212** contains three names (05 Henry Marx, 06 Jack Kelley, and 07 John Smith). When the start and end pointers **312** and **314** are moved down or up by turning up or down the jog dial wheel **108**, the active section of the name output buffer **212** is also being moved up or down, causing the names stored in the name output buffer **212** to scroll up or down on the displaying screen **102** accordingly.

Referring to FIGS. **4A–E**, there are shown the screen displays on display screen **102**, in accordance with the present invention.

FIG. **4A** shows a screen display **402** on the display screen on **102**, corresponding to the active region marked by the start pointer **312** and the end pointer **314** shown in FIG. **3**. As shown in FIG. **4A**, the screen display **402** includes three names (05 Henry Marx, 06 Jack Kelley, and 07 John Smith). An icon is displayed beside each of the names, denoting a primary number for a respective name. Specifically, the building icon beside "**05** Henry Marx" denotes that the office number is the primary number for Henry Marx. The house icons beside "06 Jack Kelley" and "07 John Smith" denote that the home numbers are the primary numbers for Jack Kelley and John Smith. The rectangle in the middle of the display screen **102** indicates a selecting region **403**, meaning that the name displayed in the selecting region **403** is currently selected. In FIG. **4A**, the screen display **402** indicates that "06 Jack Kelley" is selected.

FIG. **4B** shows a screen display **404** time sequentially to the screen display **402** of FIG. **4A**. To select the name "07 John Smith", a user turns up the jog dial wheel **108** while the screen display **402** is being displayed on display screen **102**. In response, the control panel **106** sends a request to the processor **204** via the I/O interface circuit **205**. In response to the request, the processor **204** executes the display routine (stored in the application memory **220**) to move the start pointer **312** from "05 Henry Marx" to "06 Jack Kelley", and the end pointer **314** from "**07** John Smith" to "**08** Mike Turner". Consequently, the name entry "05 Henry Marx" is moved out and the name entry "08 Mike Turner" is moved into the active section of the name output buffer **212**. Via the graphic I/O interface circuit **206**, the processor **204** then displays the names currently contained in the active section of the name output buffer **212**, as shown in the display screen **404**.

FIG. **4C** shows a screen display **406** time sequentially to the screen display **404** of FIG. **4B**. To retrieve the numbers associated with the name "07 John Smith", the user presses in the jog dial wheel **108** while the screen display **404** is being displayed on the display screen **102**. In response, the control panel **106** sends a request to the processor **204** via the I/O interface circuit **205**. In response to the request, the processor **204** executes the display routine (stored in the application memory **220**) to retrieve the numbers associated with the name entry "07 John Smith" from number output memory **214**. Since the home number of John Smith has been defined as a primary number, the processor **204** automatically displays the home telephone number (510-284-3292) in the selecting region **403** without requiring any interaction from the user. As shown in the screen display **406**, a dot **407** denotes that the home telephone number is the primary number. To dial the primary number, the user simply presses in the jog dial wheel **108** on the control panel **106**. In response, the processor **204** executes the dialing routine (stored in the application memory **220**) to generate a dialing signal for the primary number.

FIG. **4D** shows a screen display **408** time sequentially to the screen display **406** of FIG. **4C**. To select the fax number "415-356-7241", a user turns up the jog dial wheel **108** while the screen display **406** is being displayed on display screen **102**. In response, the control panel **106** sends a request to the processor **204** via the I/O interface circuit **205**. In response to the request, the processor **204** executes the display routine (stored in the application memory **220**) to move the fax number "415-356-7241" to the selecting region **403**. To dial the fax number, the user then presses in the jog dial wheel **108** on the control panel **106**. In response, the processor **204** executes the dialing routine (stored in the application memory **220**) to generate a dialing signal for the fax number.

FIG. **4E** shows a screen display **410** time sequentially to the screen display **406** of FIG. **4C**. To select the office number "415-356-7272", a user turns down the jog dial wheel **108** while the screen display **406** is being displayed on the display screen **102**. In response, the control panel **106** sends a request to the processor **204** via the I/O interface circuit **205**. In response to the request, the processor **204** executes the display routine (stored in the application memory **220**) to move the office number "415-356-7272" to the selecting region **403**. To dial the office number, the user then presses in the jog dial wheel **108** on the control panel **106**. In response, the processor **204** executes the dialing

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routine (stored in the application memory **220**) to generate a dialing signal for the office number.

Referring to FIG. **5**, there is shown a flowchart illustrating the steps of entering a name and the numbers that are associated with the name into the cellular telephone **100**, in accordance with the present invention.

As shown in FIG. **5**, at step **502**, in response to a data entry menu selection from the display screen **102**, the processor **204** executes the data entry routine (stored in the application memory **220**) to display a prompt on the display screen **102**, instructing a user to enter a name to the cellular telephone **100**. Upon receiving the name entered by the user using the alpha/numeric keys on the key panel **110**, the processor **204** stores the name to the name memory **216**.

At step **504**, the processor **204** executes the data entry routine (stored in the application memory **220**) to display a prompt on the display screen **102**, repeatedly instructing the user to input the numbers that are associated with the name. Upon receiving a number, the processor **204** also display a prompt on the display screen **102**, instructing the user to input the title for the number (such as home, office, fax, pager, or cellular). Upon receiving the title of the number, the processor **204** assigns a pre-designed icon (that matches the title) to the number. Upon receiving all the numbers that are associated with the name, the processor **204** stores the number into the number memory **218**.

At step **506**, in response to a display menu selection from the display screen **102**, the processor **204** executes the data entry routine (stored in the application memory **220**) to display a prompt on the display screen **102**, instructing the user to defme a primary number for the name. Upon receiving a definition input from the user, the processor **204** associates the primary number and the associated icon with the name.

Referring to FIG. **6**, there is shown a flowchart illustrating the steps of displaying the numbers that are associated with a name in a name directory, in accordance with the present invention.

As shown in FIG. **6**, at step **602**, the processor **204** executes the display routine (stored in the application memory **220**) to present a screen display for a name directory on the display screen **102**. The screen display contains a selecting region and a plurality of name entries. As an exemplary screen display **404**, FIG. **4B** shows a name directory containing a selecting region **403** and three names (06 Jack Kelley, 07 John Smith, and 08 Mike Turner). The name "07 John Smith" is displayed within the selecting region **403**.

At step **604**, a user activates the name entry "07 John Smith" by pressing in the jog dial wheel **108**.

At step **606**, in response to the activation, the processor **204** executes the display routine (stored in the application memory **220**) to retrieve the number entries associated with the name entry "**07** John Smith" from the number output memory **214** and display them on a screen display. As an example, FIG. **4C** shows the screen display **406** containing a selecting region **403** and three number entries (415-365-7272 (office), 415-284-3293 (home), and 415-327-7241 (fax)). Each of the three number entries is associated with an icon, and the dot **407** displayed beside the number entry "415-284-3293" denotes that the number entry is a primary number. Since the home number is defined as the primary number for the name entry "07 John Smith", the processor **204** automatically displays it in the selecting region **403** without requiring any interaction from the user. Following the step **606**, the user has two options. If the user wishes to dial the primary number, the operation is led to step **608**; if the user wishes to dial a secondary number, the operation is led to step **610**.

At step **608**, to dial the primary number, the user simply presses in the jog dial wheel **108** on the control panel **106**, which in turn sends a request to the processor **204**. In response to the request, the processor **204** executes the dialing routine (stored in the application memory **220**) to generate a dialing signal for the primary number.

At step **610**, to dial the fax number (415-356-7241), the user first turns up the jog dial wheel **108** to move the fax number into the selecting region **403** (as shown in FIG. **4D**). The user then presses in the jog dial wheel **108**, which in turn generates a request to the processor **204**. In response to the request, the processor **204** executes the dialing routine (stored in the application memory **220**) to generate a dialing signal for the fax number.

As an alternative, at step **610**, to dial the office number (415-356-7272), the user first turns down the jog dial wheel **108** to move the office number into the selecting region **403** (as shown in FIG. **4E**). The user then presses in the jog dial wheel **108**, which in turn generates a request to the processor **204**. In response to the request, the processor **204** executes the dialing routine (stored in the application memory **220**) to generate a dialing signal for the office number.

Although the present invention has been shown and described with respect to preferred embodiments, various changes and modifications are deemed to lie within the spirit and scope of the invention as claimed.

What is claimed is:

1. A method for displaying a directory, comprising the steps of:

(a) displaying a plurality of names on a first screen display, each of the names being associated with a primary number;

(b) selecting one of the names from the first screen display;

(c) displaying a primary number associated with the selected name and at least one secondary number on a second screen display; and

(d) automatically selecting the primary number from the second screen display.

2. The method of claim **1**, including the further step of:

displaying a primary number icon for each of the names.

3. The method of claim **1**, including the further step of:

highlighting the primary number.

4. The method of claim **1**, including the further step of:

activating the primary number to cause a dialing of the primary number.

5. The method of claim **1**, including the further steps of:

selecting the secondary number; and

activating the selected secondary number to cause a dialing of the secondary number.

6. The method of claim **1**, the second screen display having a title region and a content region, the method further including the step

displaying the selected name in the title region, and displaying the primary number and the secondary number in the content region.

7. An apparatus for displaying a directory, comprising:

(a) means for displaying a plurality of names on a first screen display each of the names being associated with a primary number;

(b) means for selecting one of the names from the first screen display;

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(c) means for displaying on a second screen display a primary number associated with the selected name and at least one secondary number; and

(d) means for automatically selecting the primary number from the second screen display.

8. The apparatus of claim **7**, further comprising:

means for displaying a primary number icon for each of the names.

9. The apparatus of claim **7**, further comprising:

means for highlighting the primary number.

10. The apparatus of claim **7**, further comprising:

means for activating the primary number to cause a dialing of the primary number.

11. The apparatus of claim **7**, further comprising:

means for selecting the secondary number; and

means for activating the selected secondary number to cause a dialing of the secondary number.

12. The apparatus of claim **7**, the second screen display having a title region and a content region, the apparatus further including:

means for displaying the selected name in the title region, and displaying the primary number and the secondary number in the content region.

13. A storage device for storing a program, which is readable and executable by a processing circuit to perform the steps of:

(a) displaying a plurality of names on a first screen display, each of the names having associated with it a primary number;

(b) selecting one of the names from the first screen display;

(c) displaying a primary number associated with the selected name and at least one secondary number on a second screen display screen; and

(d) automatically selecting the primary number from the second screen display.

14. The memory device of claim **13**, the codes capable of further performing the step of:

displaying a primary number icon for each of the names.

15. The memory device of claim **13**, the codes capable of further performing the step of:

highlighting the primary number.

16. The memory device of claim **13**, the codes capable of further performing the step of:

activating the primary number to cause a dialing of the primary number.

17. The memory device of claim **13**, the codes capable of further performing the steps of:

selecting the secondary number; and

activating the selected secondary number to cause a dialing of the secondary number.

18. The memory device of claim **13**, the second screen display having a title region and a content region, the codes capable of further performing the step of:

displaying the selected name in the title region; and

displaying the primary number and the secondary number in the content region.

19. A method of operating a telephone, comprising the steps of:

(a) displaying a plurality of names on a first screen display, each of the names having associated with a primary number;

(b) selecting one of the names from the first screen display;

(c) displaying a primary number associated with the selected name and at least one secondary number on a second screen display; and

(d) automatically selecting the primary number from the second screen display.

20. The method of claim **19**, including the further step of:

displaying a primary number icon for each of the names.

21. The method of claim **19**, including the further step of:

highlighting the primary number.

22. The method of claim **19**, including the further step of:

activating the primary number to cause a dialing of the primary number.

23. The method of claim **19**, including the further step of:

selecting the secondary number; and

activating the selected secondary number to cause a dialing of the secondary number.

24. The method of claim **19**, the second screen display having a title region and a content region, the method including the further step of:

displaying the selected name in the title region; and

displaying the primary number and the secondary number in the content region.

25. An apparatus for displaying a directory, comprising:

(a) a display screen for displaying a first screen display containing a plurality of names, each of the names having associated with it a primary number; and

(b) a processing circuit, in response to a first selection signal, for selecting one of the names from the first screen display;

wherein the displaying screen displays a second screen display containing a primary number associated with the selected name and at least one secondary number; and

wherein the processing circuit, in response to a second selection signal, automatically selects the primary number from the second screen display.

26. The apparatus of claim **25**, the first screen display further containing:

a region for displaying a primary number icon for each of the names.

27. The apparatus of claim **25**, wherein the processing circuit also highlights the primary number.

28. The apparatus of claim **25**,

wherein the first and second screen displays are displayed on a telephone, and

wherein the processing circuit, in response to an activating signal activates the primary number to cause a dialing of the primary number.

29. The apparatus of claim **25**,

wherein the first and second screen displays are displayed on a telephone;

wherein the processing circuit, in response to a third selection signal, selects the secondary number; and

wherein the processing circuit, in response to an activating signal, activates the selected secondary number to cause a dialing of the secondary number.

30. The apparatus of claim **25**,

wherein the second screen display has a title region and a content region; and

wherein the processing circuit displays the selected name in the title region, and displays the primary number and the secondary number in the content region.

31. A method of operating a telephone that includes a screen for displaying a first screen display screen and a

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second screen display, and a processing circuit, the method comprising the steps of:

(a) invoking the first screen display that displays a plurality of names, each of the names being associated with a primary number;

(b) generating a first selection signal to instruct the processing circuit to select one of the names from the first screen display;

(c) invoking the second screen display that displays a primary number associated with the selected name and at least one secondary number; and

(d) instructing the processing circuit to automatically select the primary number from the second screen display.

32. The method of claim **31**, including the further step of:

displaying a primary number icon for each of the names.

33. The method of claim **31**, including the further step of:

highlighting the primary number.

34. The method of claim **31**, including the further step of:

generating an activating signal to instruct the processing circuit to activate the primary number to cause a dialing of the primary number.

35. The method of claim **31**, including the further steps of:

generating a third signal to instruct the processing circuit to select the secondary number; and

generating an activating signal to instruct the processing circuit to activate the selected secondary number to cause a dialing of the secondary number.

36. The method of claim **31**, including the further step of:

instructing the processing circuit to display the selected name in the title region, and displaying the primary number and the secondary number in the content region.

37. A telephone comprising:

means for storing a plurality of names;

means for storing a primary number and additional numbers for each of the names;

a display screen;

means for selecting and displaying a sub-set of the plurality of names;

means for selecting one of the sub-set names;

means for displaying the primary number and additional numbers; and

means for automatically selecting the primary number for dialing of the primary number.

38. The telephone of claim **37**, further comprising:

means for displaying an icon with each of the primary number and with each of the additional number.

39. The telephone of claim **37**, further comprising:

means for highlighting the primary number when it is automatically selected.

40. The telephone of claim **37**, further comprising:

means for dialing the primary number when it is automatically selected.

41. The telephone of claim **37**, further comprising:

means for selecting one of the additional numbers instead of the primary one.

42. The telephone of claim **37**, further comprising:

means for dialing the additional number when it is selected.

43. A telephone comprising:

a display screen;

a memory to allow a user to enter names and associated numbers into the memory, including a primary number for each name;

a dial wheel to enable the user to display on the display screen a limited number of names entered into the memory; and

wherein the dial wheel is used to select a single name among the displayed names, the primary and additional numbers are displayed, and the primary number is automatically selected for dialing.

44. The telephone of **43**,wherein the dial wheel is also used to select a number other than the primary one.

45. A telephone comprising:

a display screen;

a memory to allow a user to enter names and associated numbers into the memory, including a primary number for each name;

means to enable the user to display on the display screen a limited number of names entered into the memory;

means to select a signal name among the displayed names; and

means to display the primary and additional numbers and for automatically selecting the primary number for dialing.

46. The telephone of claim **45**, further comprising:

means to select a number other than the primary one.

47. The telephone of claim **46**, further comprising:

means to display an icon with each of the numbers.

* * * * *

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,222,921 B1
DATED : April 24, 2001
INVENTOR(S) : Mugura et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 5,
Line 31, delete "defme" and insert therefor -- define --.

Column 6,
Line 58, after "step", insert -- of: --.

Signed and Sealed this

Thirtieth Day of October, 2001

Attest:

Nicholas P. Godici

Attesting Officer

NICHOLAS P. GODICI
Acting Director of the United States Patent and Trademark Office

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,222,921 B1
APPLICATION NO. : 09/133070
DATED : April 24, 2001
INVENTOR(S) : Mugura et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the CLAIMS:

Claim 14, column 7, line 39, delete "memory device" and insert --storage device--.
Claim 14, column 7, line 39, delete "codes" and insert --program--.
Claim 15, column 7, line 42, delete "memory device" and insert --storage device--.
Claim 15, column 7, line 42, delete "codes" and insert --program--.
Claim 16, column 7, line 45, delete "memory device" and insert --storage device--.
Claim 16, column 7, line 45, delete "codes" and insert --program--.
Claim 17, column 7, line 49, delete "memory device" and insert --storage device--.
Claim 17, column 7, line 49, delete "codes" and insert --program--.
Claim 18, column 7, line 54, delete "memory device" and insert --storage device--.
Claim 18, column 7, line 55, delete "codes" and insert --program--.
Claim 45, column 10, line 39, delete "signal" and insert --single--.

Signed and Sealed this

Twenty-ninth Day of June, 2010

David J. Kappos

David J. Kappos
Director of the United States Patent and Trademark Office

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EXHIBIT B

US007580006B2

(12) **United States Patent**
Takeuchi

(10) **Patent No.: US 7,580,006 B2**
(45) **Date of Patent: *Aug. 25, 2009**

(54) **PORTABLE TELEPHONE**

(75) Inventor: **Ryosuke Takeuchi**, Saitama (JP)

(73) Assignee: **Sony Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 101 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/788,439**

(22) Filed: **Apr. 20, 2007**

(65) **Prior Publication Data**

US 2007/0218943 A1 Sep. 20, 2007

Related U.S. Application Data

(63) Continuation of application No. 09/927,050, filed on Aug. 9, 2001, now Pat. No. 7,405,722.

(30) **Foreign Application Priority Data**

Aug. 11, 2000 (JP) 2000-245401

(51) **Int. Cl.**
G09G 5/00 (2006.01)
H04H 40/00 (2006.01)

(52) **U.S. Cl.** **345/2.1**; 345/2.3; 345/184; 455/3.03; 455/78; 455/344

(58) **Field of Classification Search** 345/1.1–1.3, 345/2.1–2.3, 156, 157, 160, 161, 163, 168, 345/173, 184; 715/764, 810, 856–858, 861, 715/817, 819–824, 864; 455/575, 566, 90, 455/3.06, 78, 344

See application file for complete search history.

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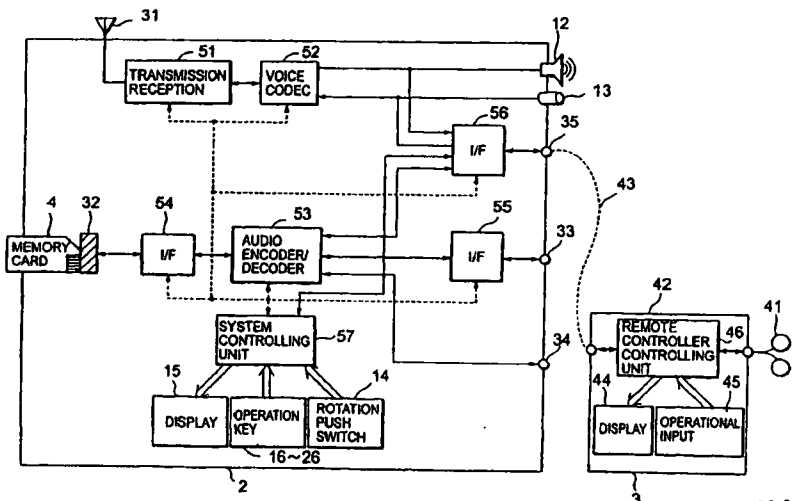
Primary Examiner—Henry N Tran
(74) *Attorney, Agent, or Firm*—Frommer Lawrence & Haug LLP; William S. Frommer; Thomas F. Presson

(57) **ABSTRACT**

In a portable telephone according to the present invention, a display displays a block indicative of an operator, predetermined information and a pointer; the operator can be operated in directions opposite to each other; and the controller controls the display so as to shift the pointer to a desirable position within a predetermined information on a screen of the display in accordance with an operation of the operator and also display a mark indicative of a direction to which the pointer can be shifted and in which the predetermined information exists, adjacently to the block along a shift direction through the operator.

6 Claims, 22 Drawing Sheets



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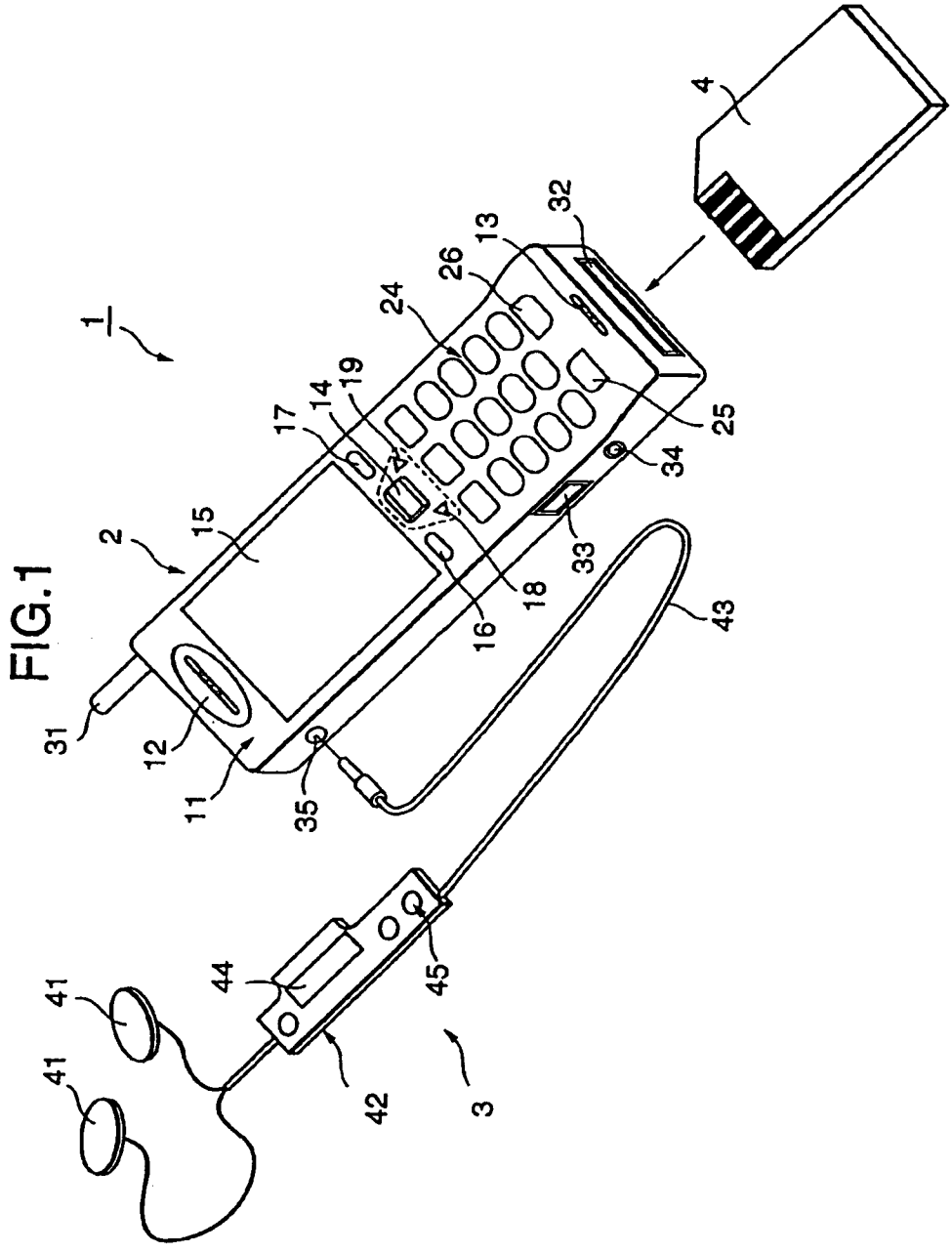

FIG.1

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FIG.2

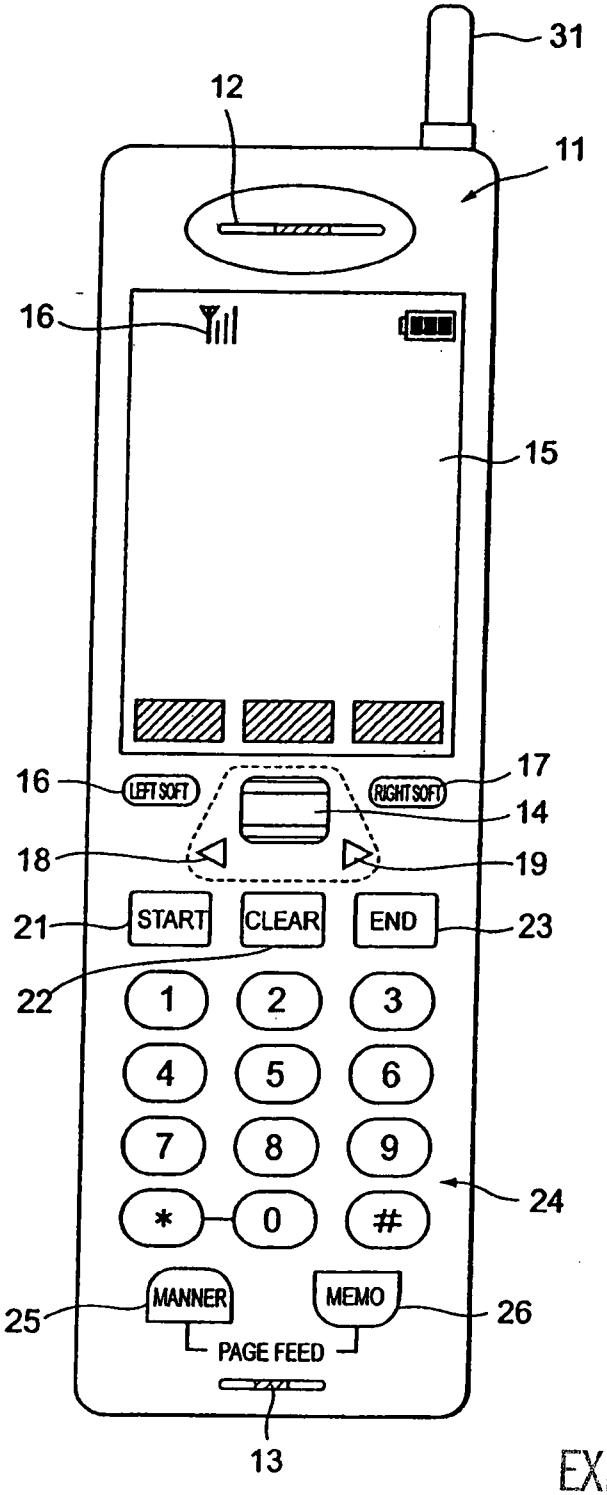

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FIG.3

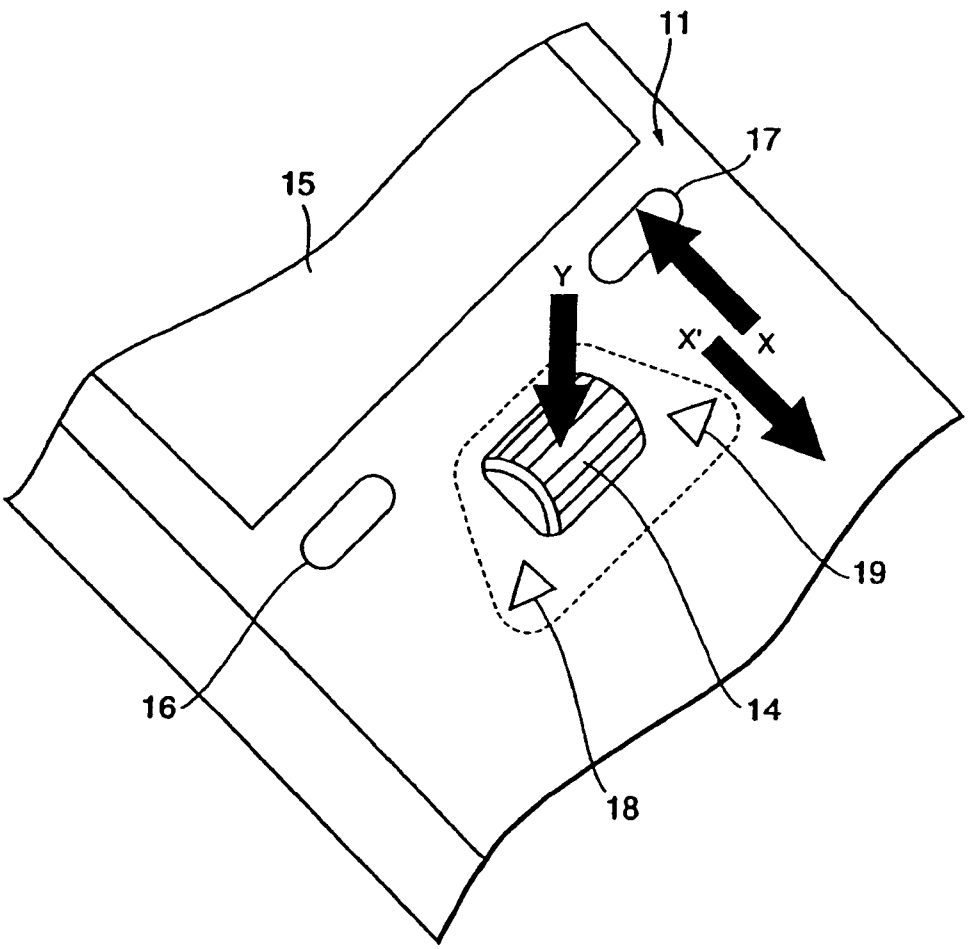

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FIG.4

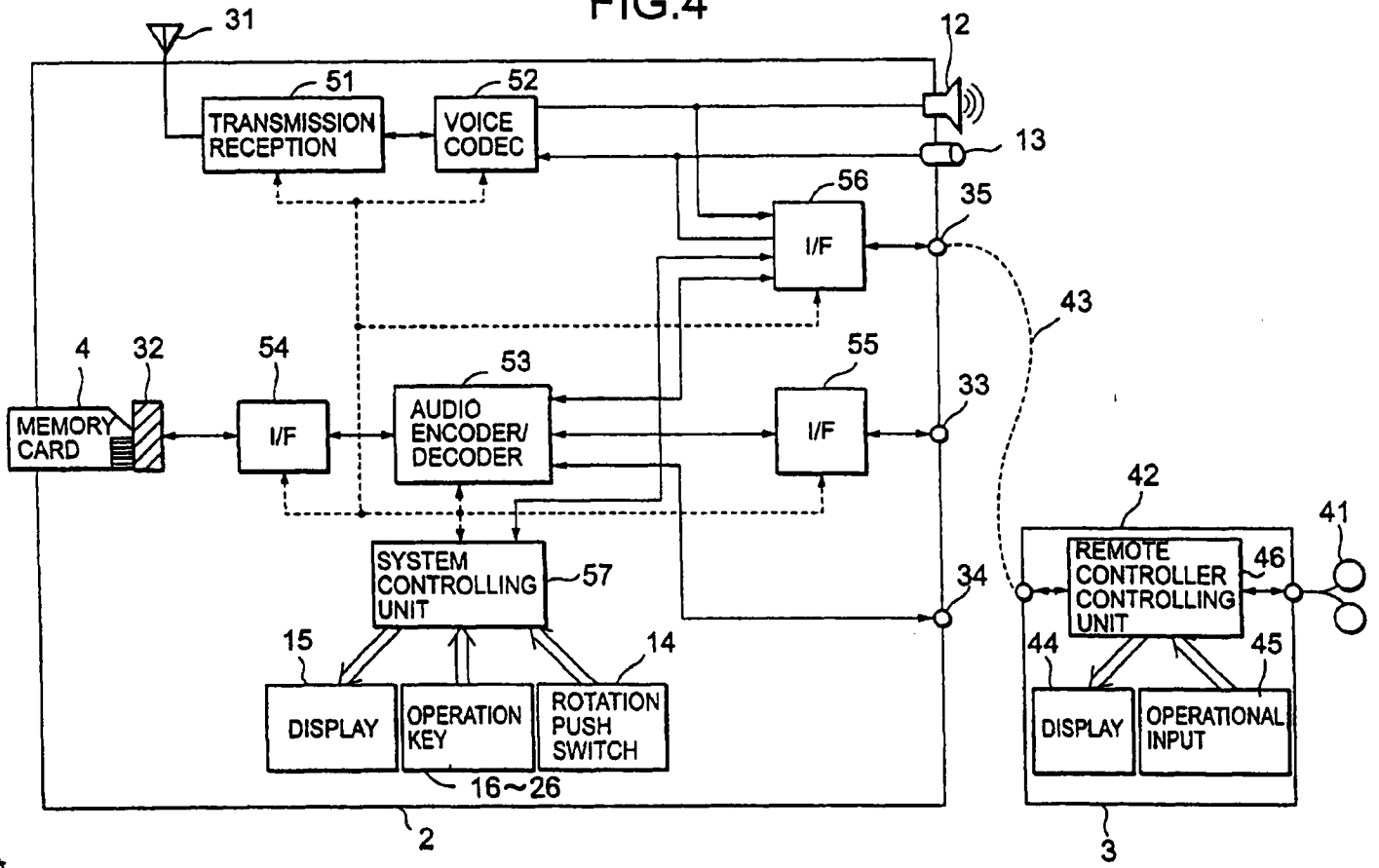

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FIG.5

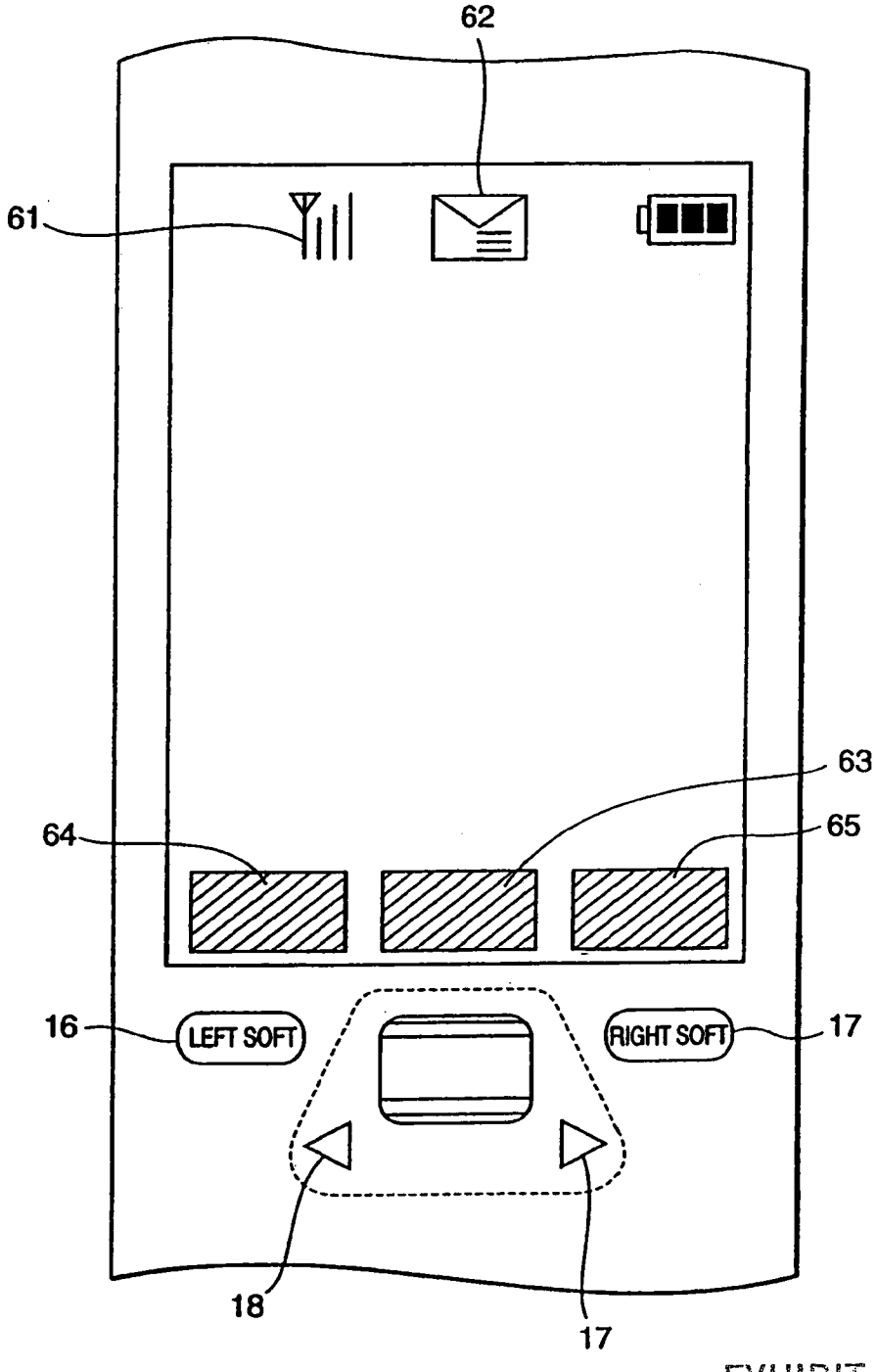

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FIG.6A

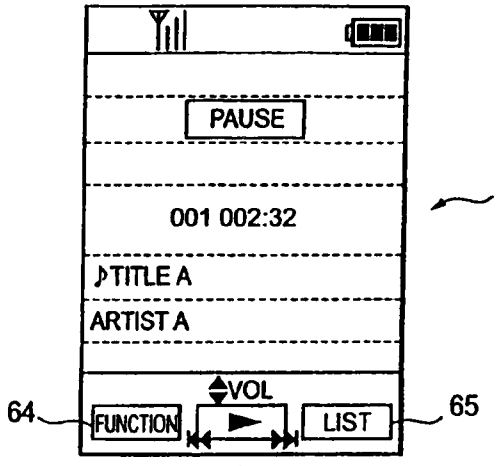

FIG.6B

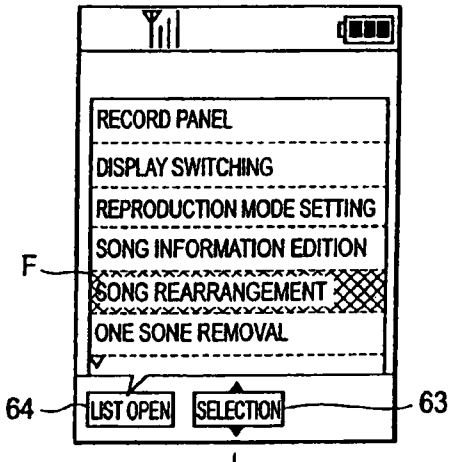

FIG.6C

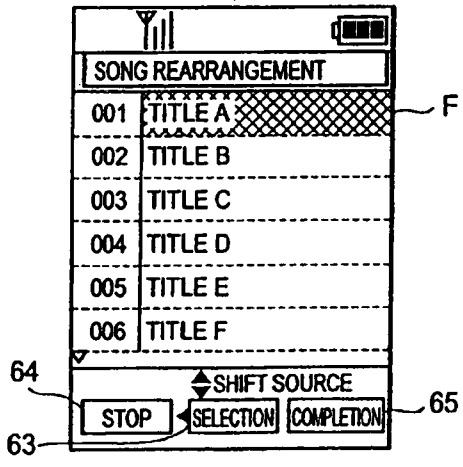

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FIG.7A

FIG.7B

FIG.7C

FIG.7D

FIG.7E

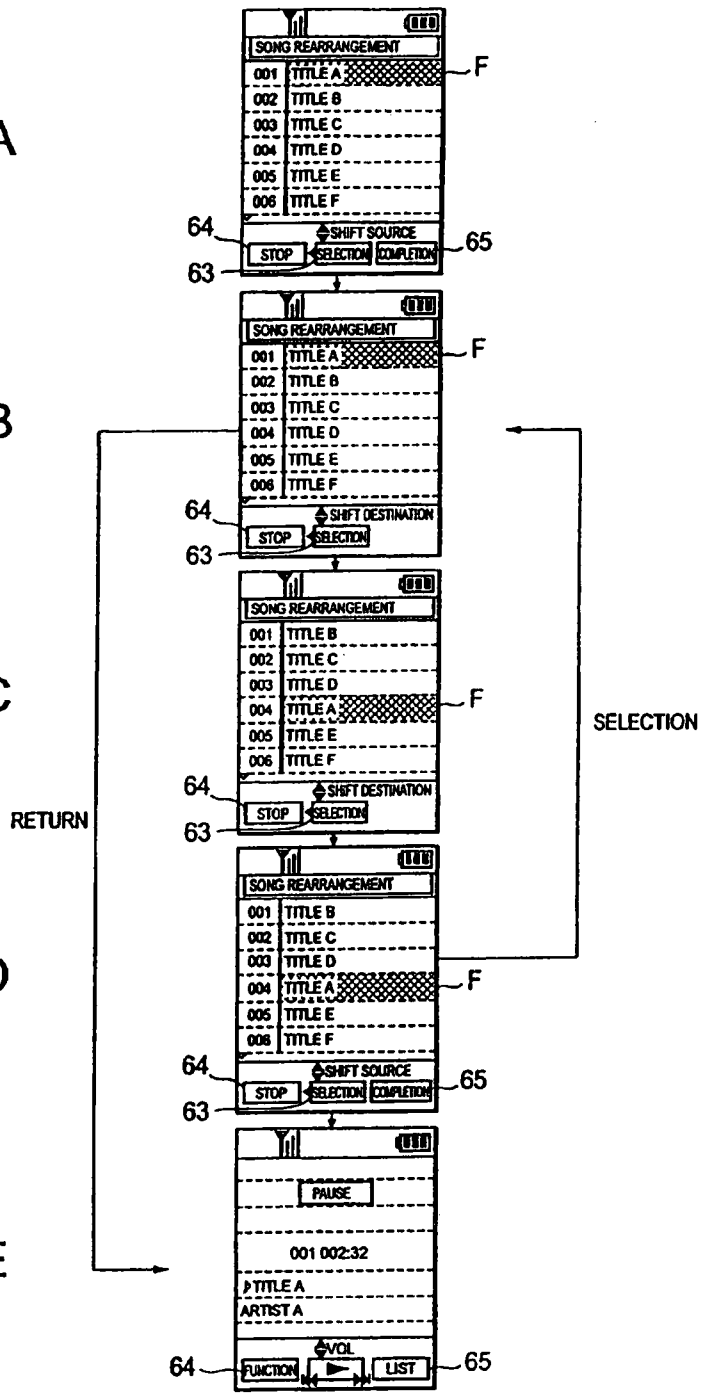

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FIG.8

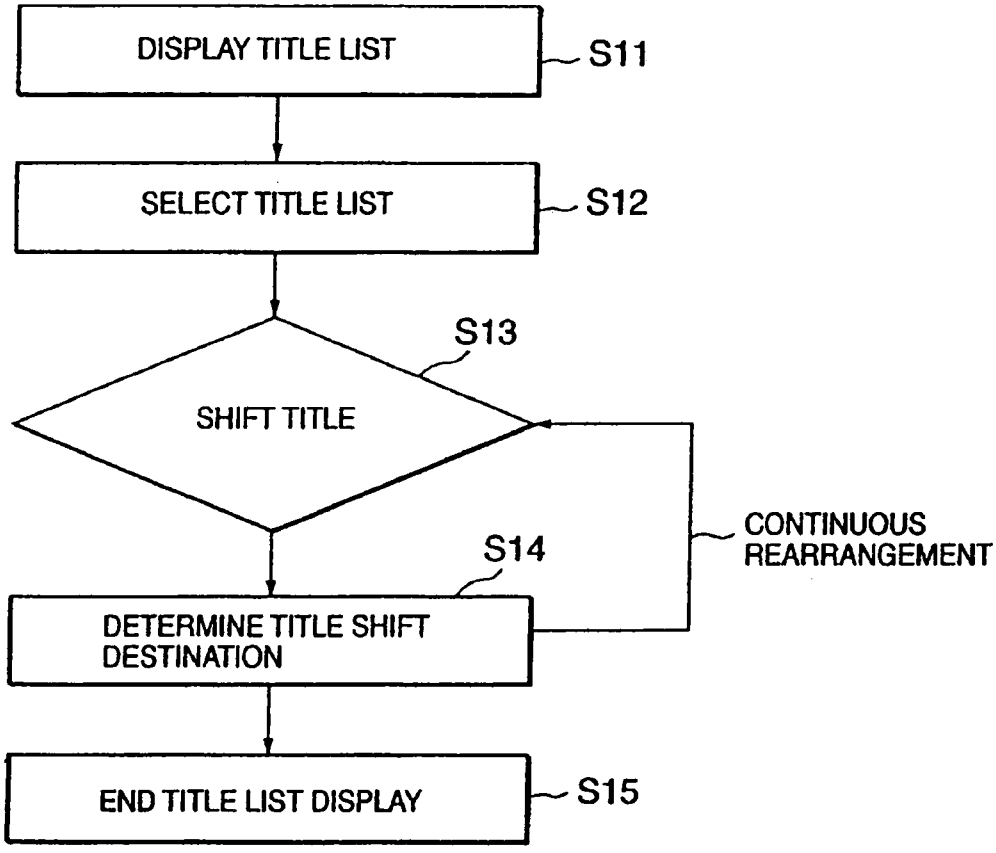

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FIG.9A

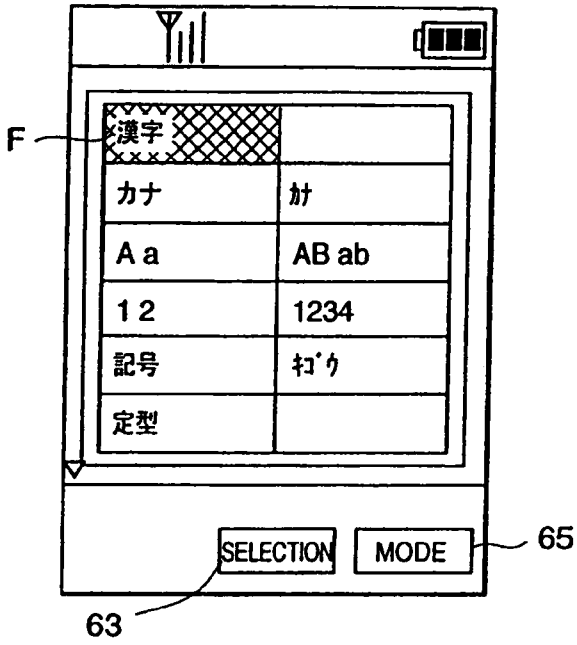

FIG.9B

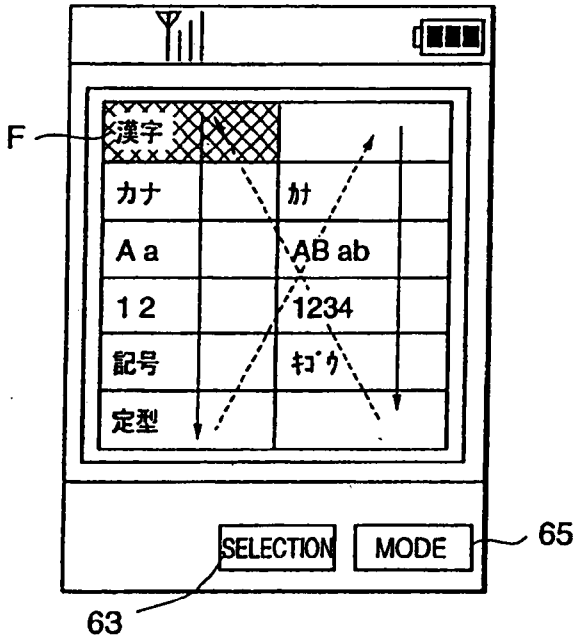

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FIG.10

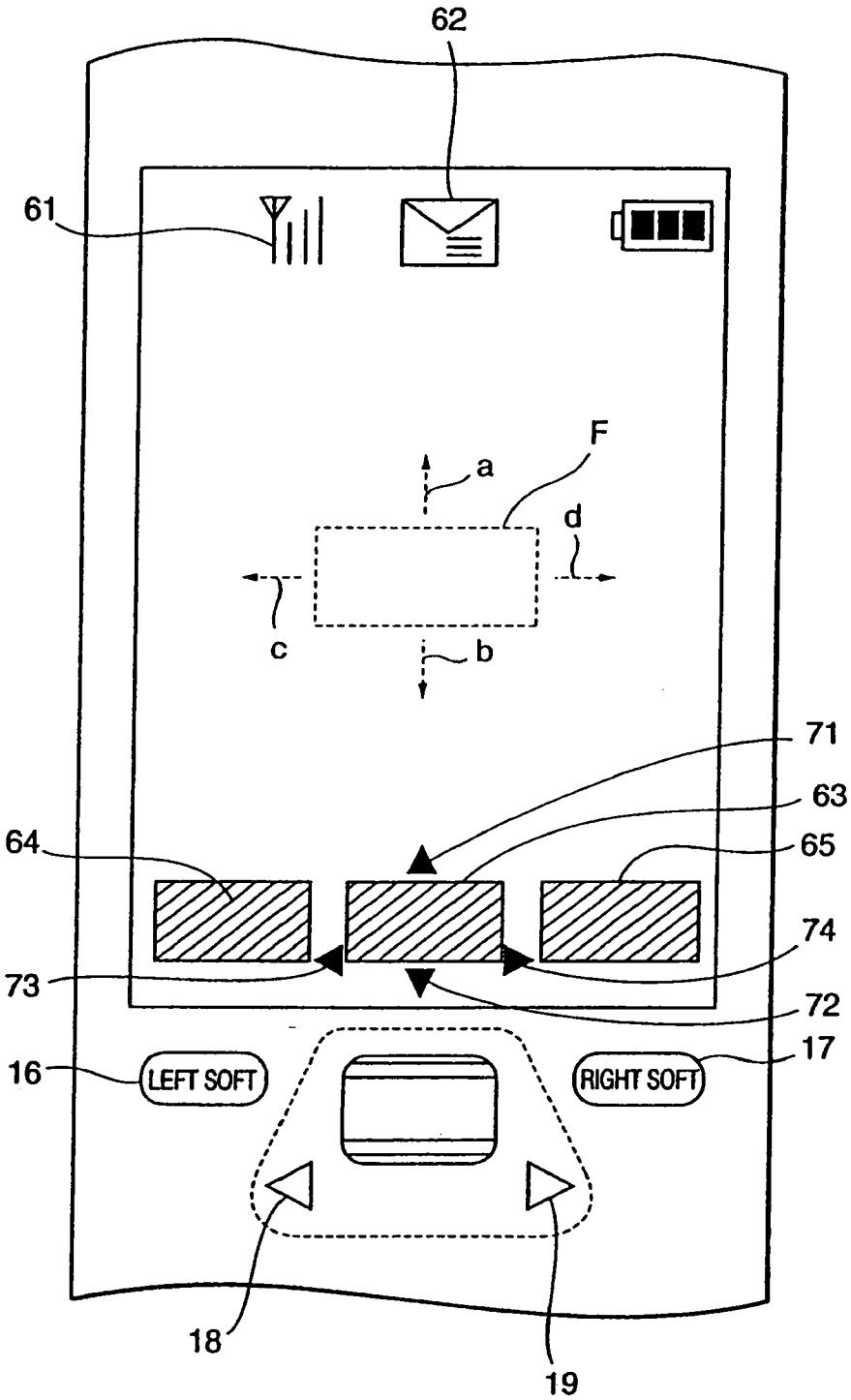

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FIG.11A

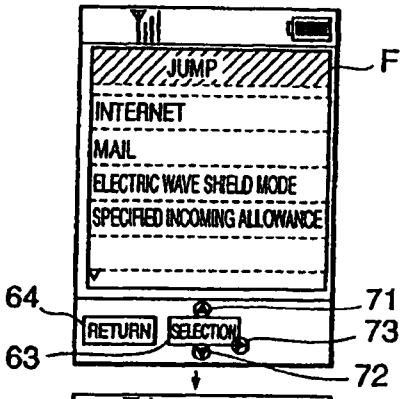

FIG.11B

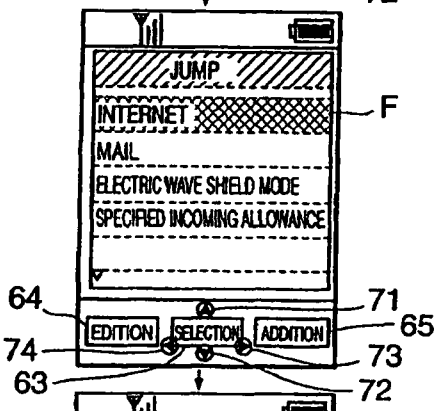

FIG.11C

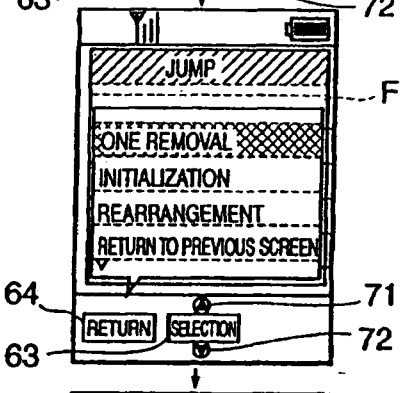

FIG.11D

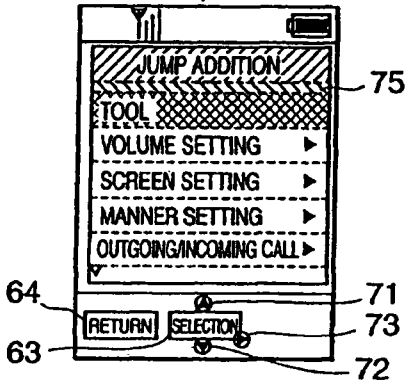

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FIG.12A

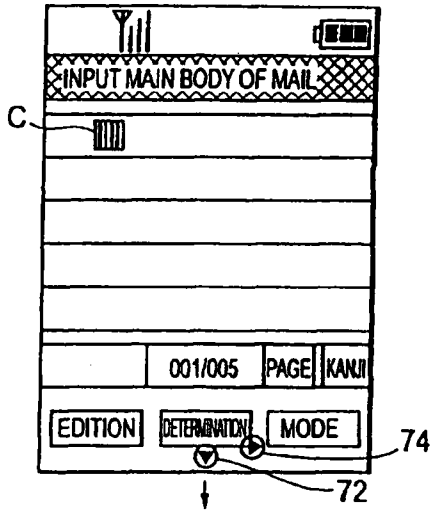

FIG.12B

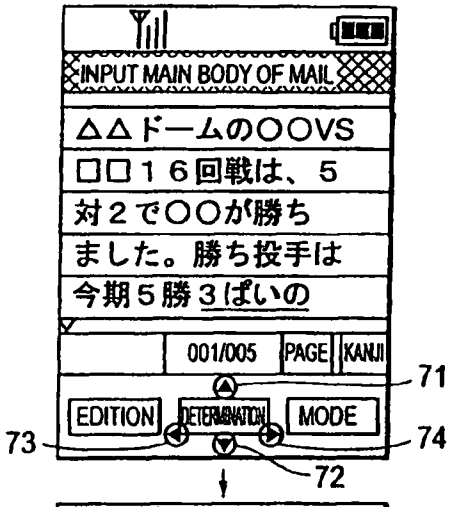

FIG.12C

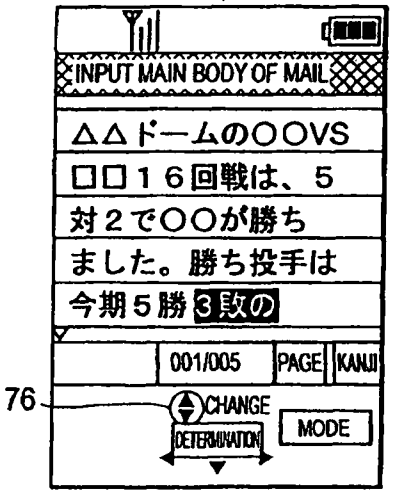

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FIG.13

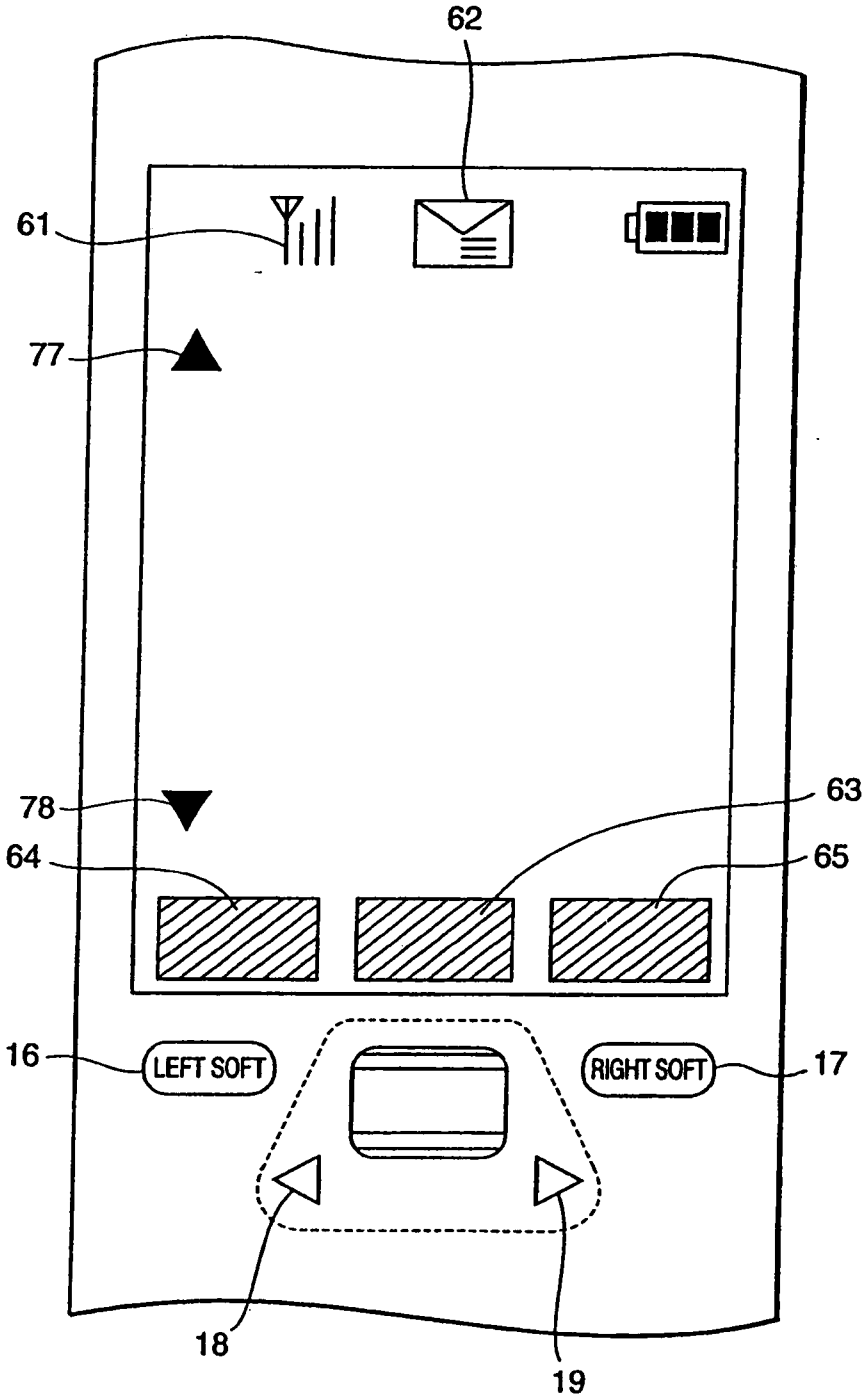

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FIG.14A

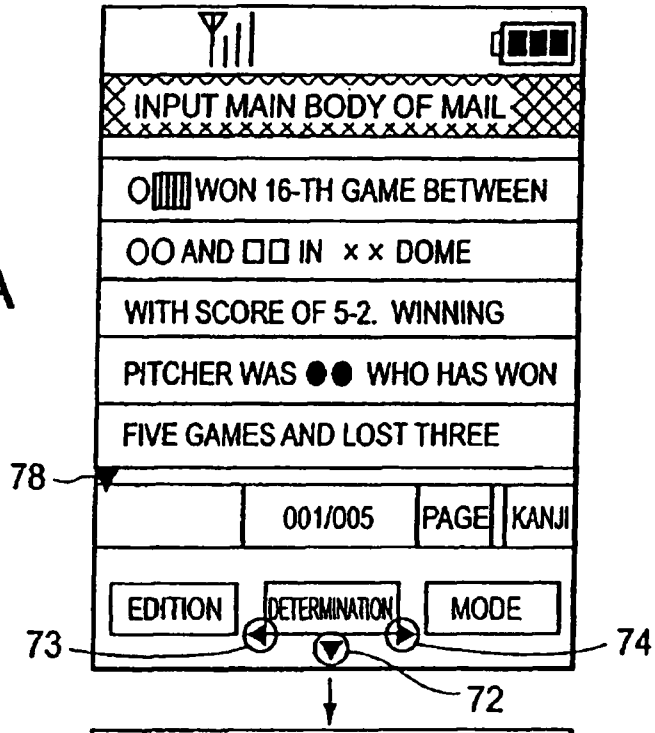

FIG.14B

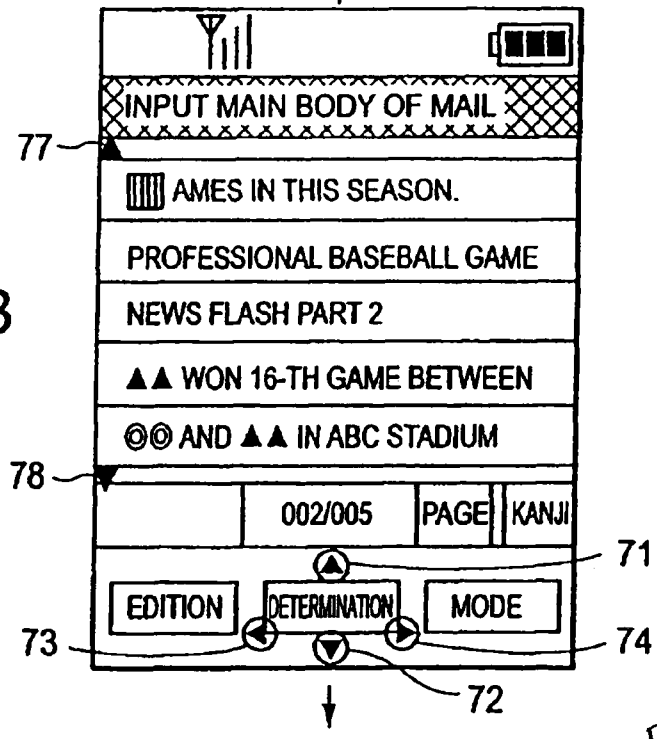

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FIG.15A

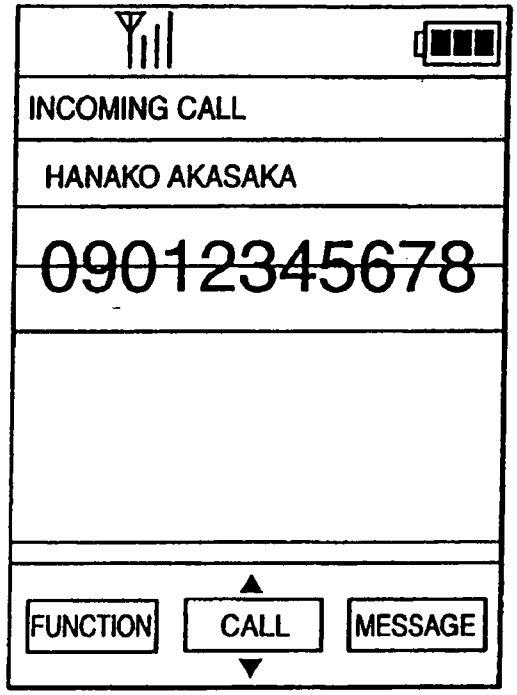

FIG.15B

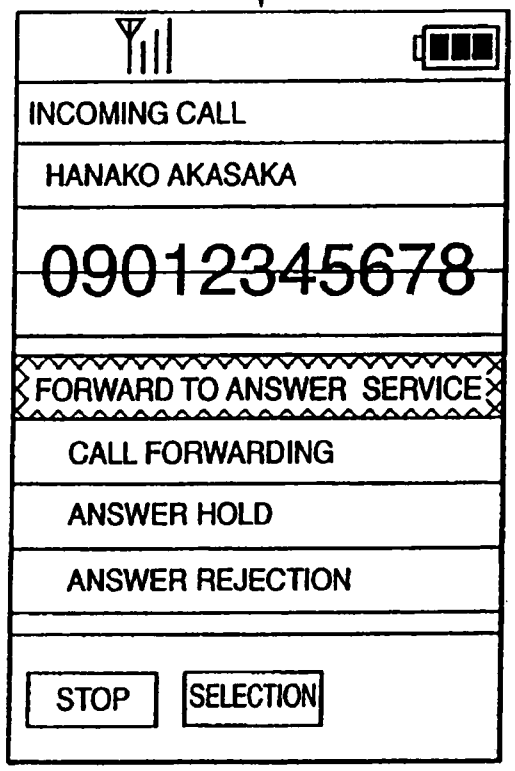

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FIG.16

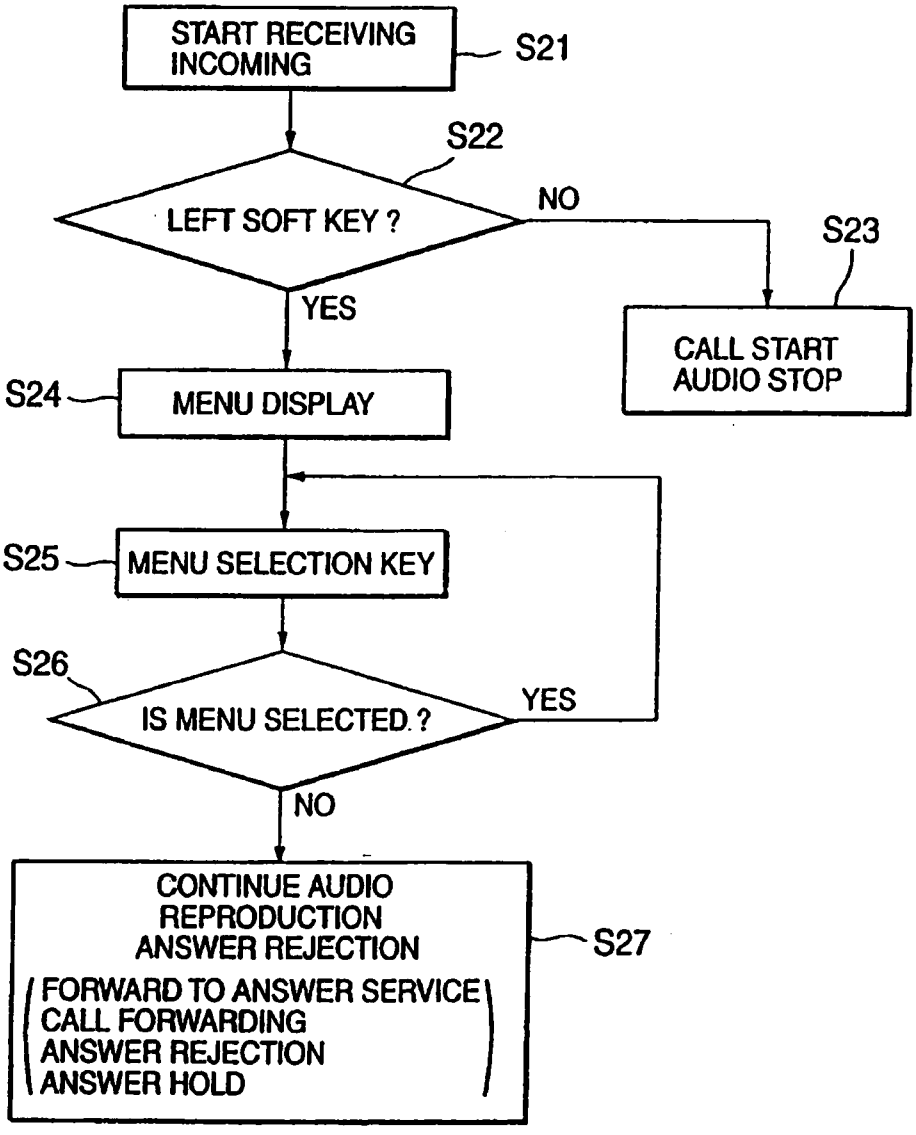

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FIG.17

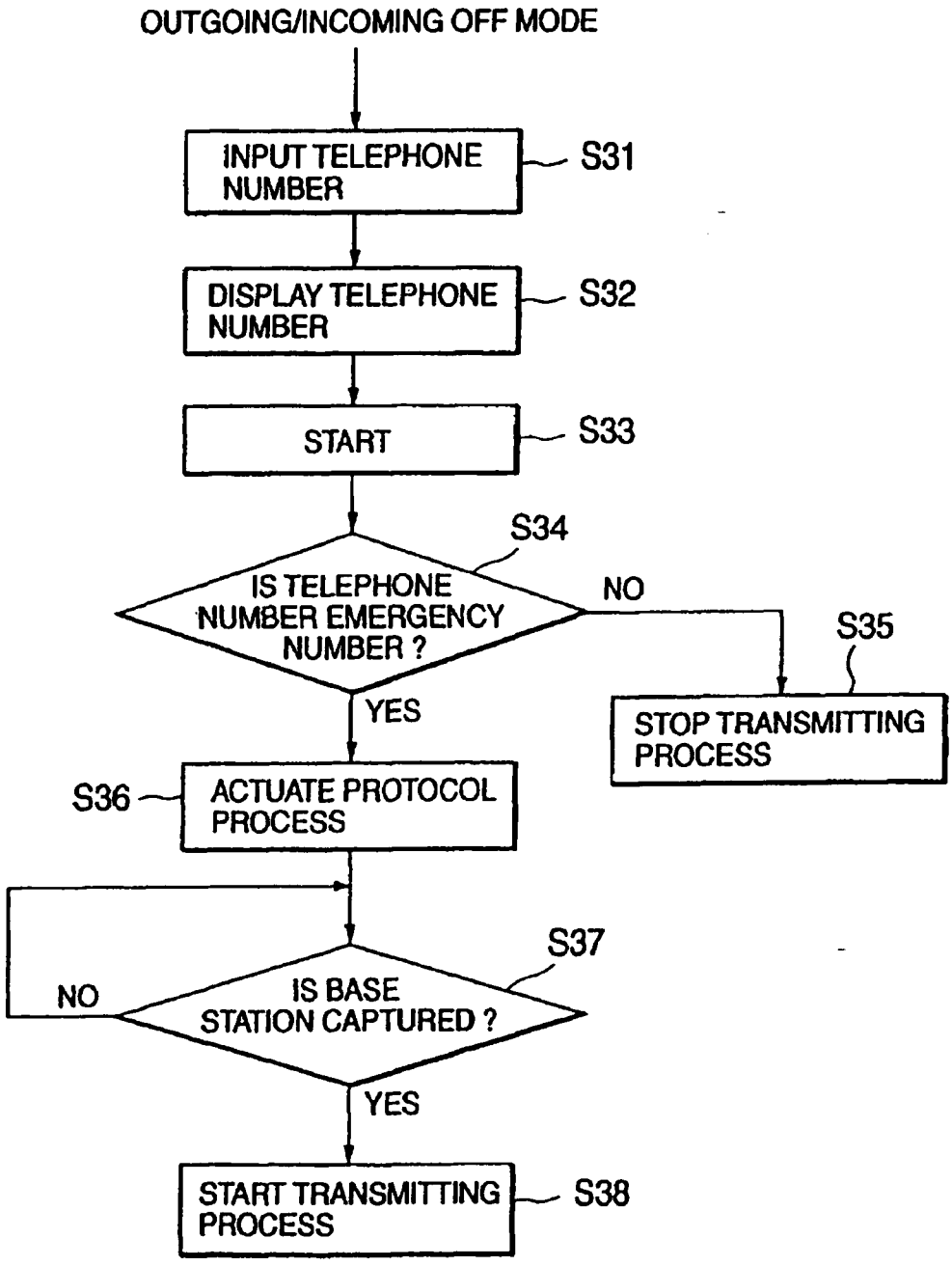

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FIG.18

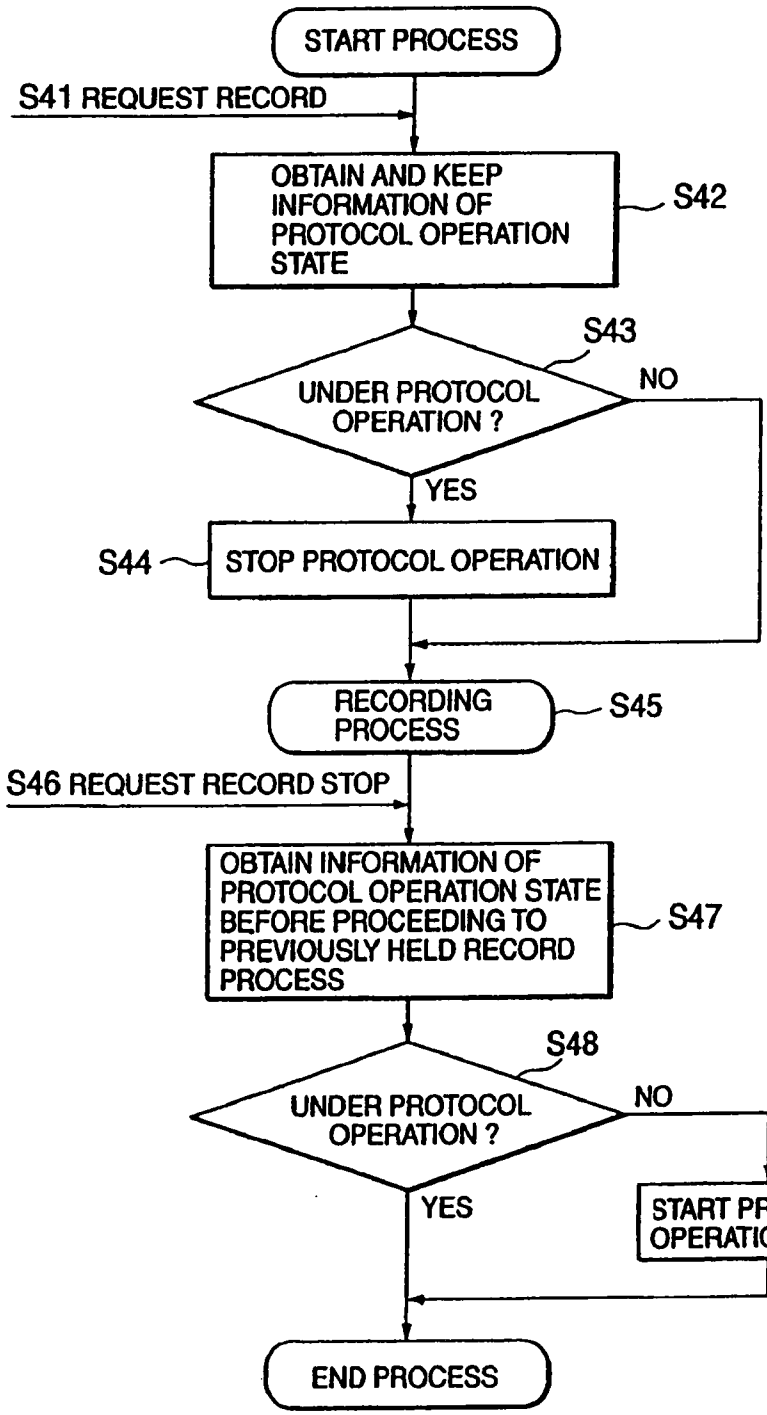

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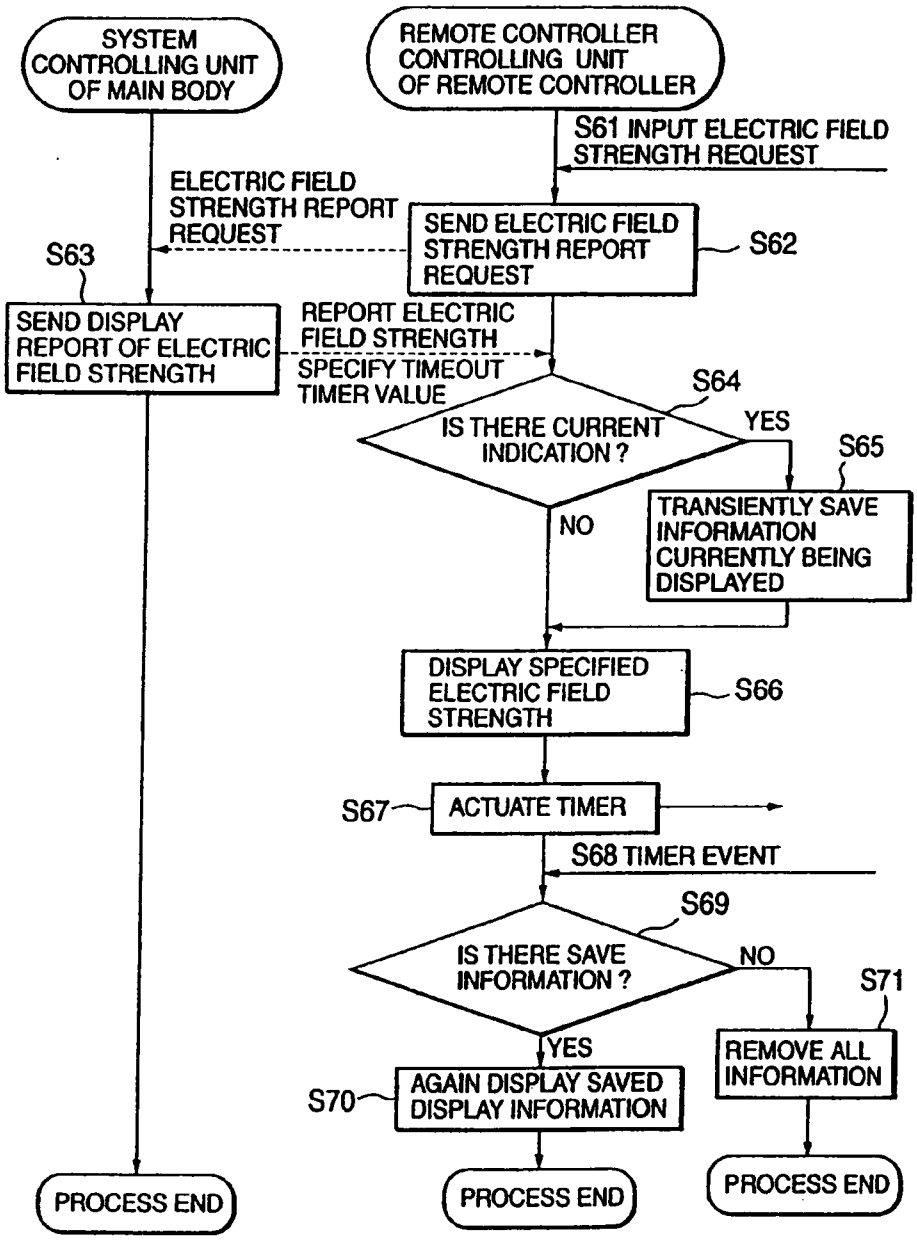
FIG.19



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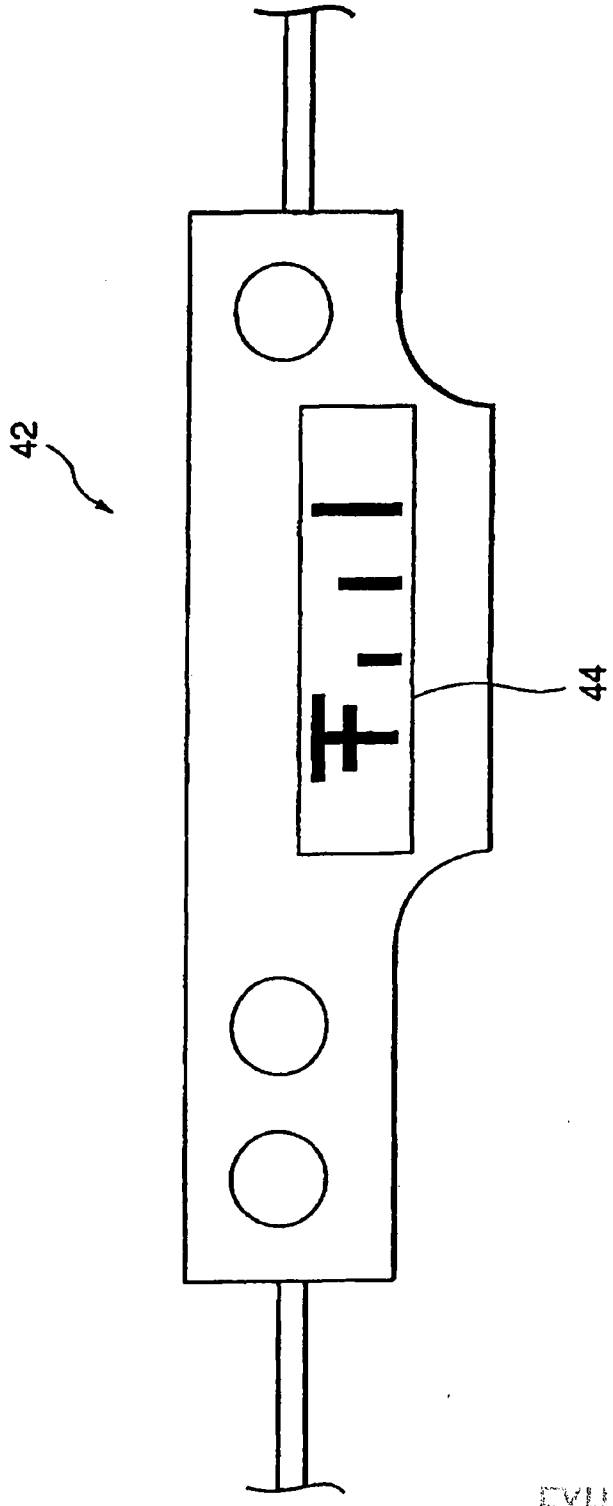

FIG.20

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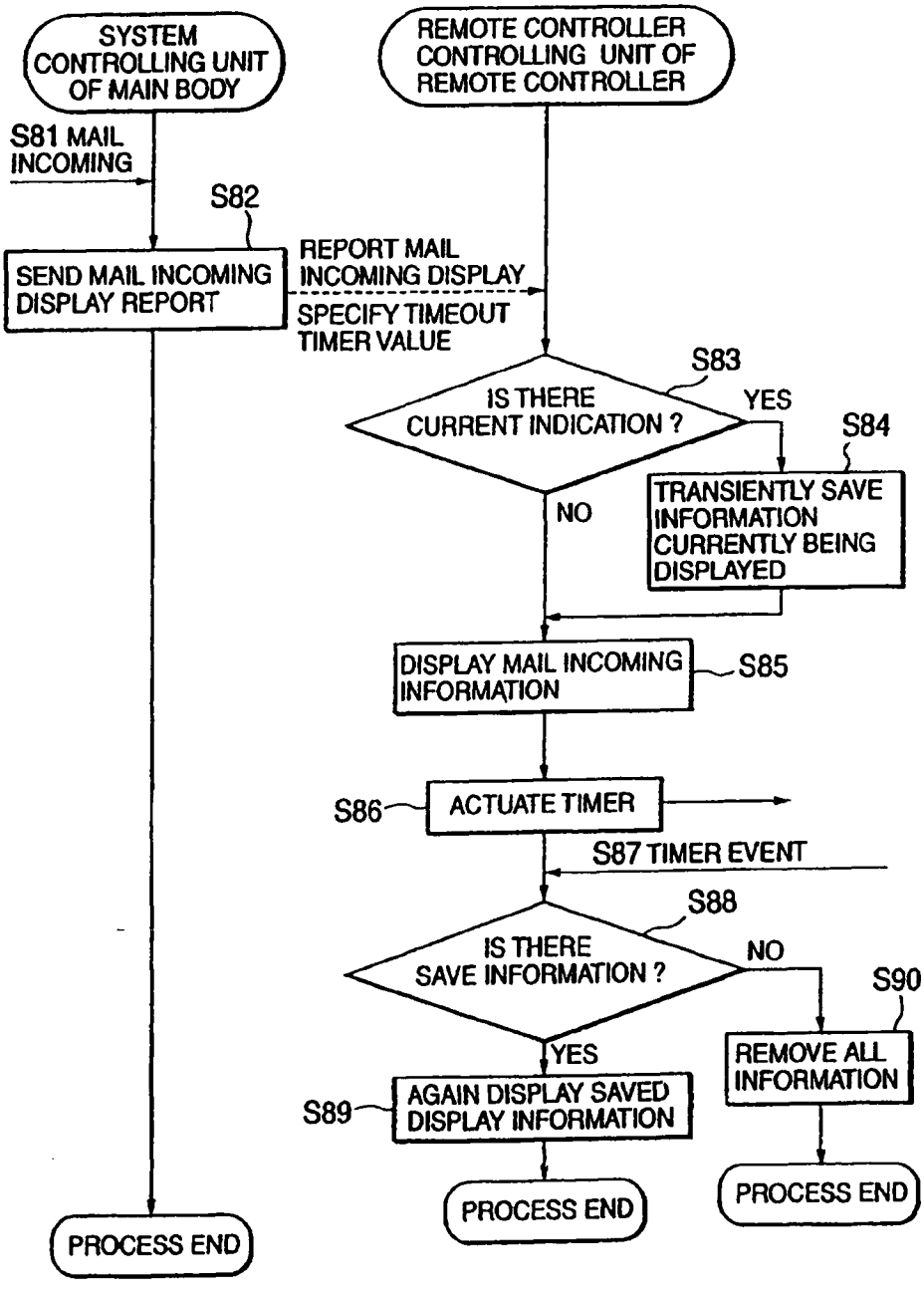
FIG.21



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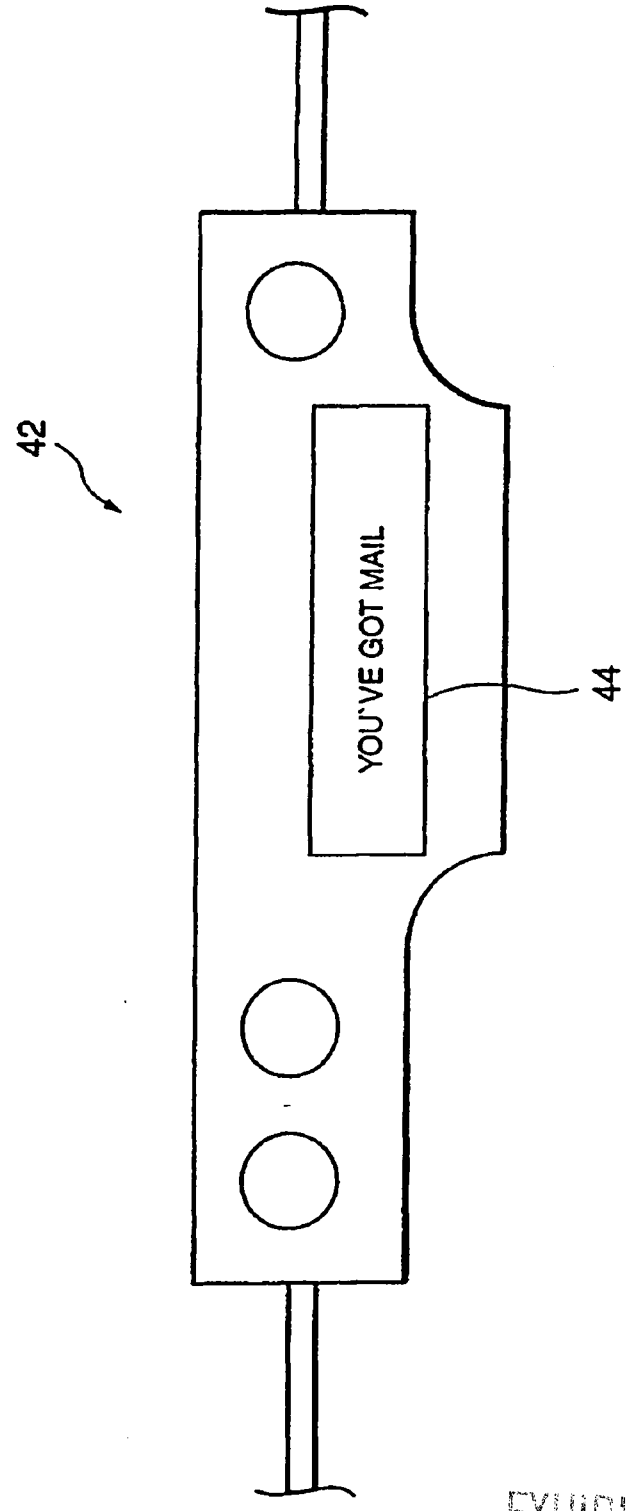

FIG.22

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PORTABLE TELEPHONE

This application is a Continuation of U.S. application Ser. No. 09/927,050, filed Aug. 9, 2001, now U.S. Pat. No. 7,405,722, which claims priority to Japanese Patent Application No. 2000-24501, filed in Japan on Aug. 11, 2000, which is hereby incorporated by reference in its entirety.

CROSS REFERENCES TO RELATED APPLICATIONS

The present document is based on Japanese Priority Document JP 2000-245401, filed in the Japanese Patent Office on Aug. 11, 2000, the entire contents of which being incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a portable telephone.

2. Description of Related Art

In recent years, not only a telephone call function but also additional functions, such as an electronic mail function for sending and receiving an electronic mail by using an Internet protocol or another unique network protocol and an Internet function so as to read even WEB have been added to a portable telephone. Also, the inclusion of a memory card serving as a small memory medium in a portable telephone can attain a portable telephone in which an audio signal and a picture signal can be recorded and reproduced as the additional functions. In this way, not only the original telephone function but also the various additional functions are added to the portable telephone. It is tried to develop the portable telephone having multiple functions.

A relatively large display is typically mounted in the portable telephone having the thus attained multiple functions. Also, a direction key and a page scroll key are also mounted for retrieving or selecting information displayed on this display.

By the way, even if it is tried to make the display larger, there is also the limit of the size of the portable telephone itself. For example, if an electronic mail is displayed, if WEB is displayed, or if information stored on a memory card is displayed, the display becomes relatively narrow with respect to the information to be displayed.

In such a case, it is necessary to find out a target information or select the information by operating a direction key for shifting a focus position placed as an operation key of the portable telephone in an upper, lower, leftward or rightward direction, or a page scroll key for scrolling upwardly or downwardly displayed information correspondingly to one page.

However, only from the information displayed on the display, a user cannot find out whether or not the information is located outside a display range or whether or not the focus can be shifted from a current position. Thus, as a first step, the user operates the direction key or operates the page scroll key, and thereby checks the existence of the information existing outside the display range. However, such an operation is very troublesome and difficult.

SUMMARY OF THE INVENTION

Accordingly, there has been a need to provide a portable telephone in which the operational performances of the direction keys and the like and the convenience for the user are improved.

In order to solve the above-mentioned problems, a portable telephone according to the present invention is characterized in that it is provided with: a first operating portion that can be operated in directions opposite to each other; a display for displaying a block indicative of the first operating portion, predetermined information and a pointer; and a controller for controlling the display so as to shift the pointer to a desirable position within the predetermined information on a screen of the display in accordance with an operation of the operating portion and also display a mark indicative of a direction to which the pointer can be shifted and in which the predetermined information exists, adjacently to the block along a shift direction through the first operating portion.

A portable telephone according to the present invention further comprises a second operating portion for shifting the pointer in a direction vertical to a shift direction of the pointer through the first operating portion, wherein the controller controls the display so as to display a mark indicative of a direction to which the pointer can be shifted by the second operating portion and in which the predetermined information exists, adjacently to the block along a shift direction through the second operating portion.

The first operating portion is a rotatable dial, and the second operating portion is two keys, which are arranged closely to each other, on both sides of the rotatable dial.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an appearance perspective view of a portable telephone in an embodiment of the present invention;

FIG. **2** is a plan view of the portable telephone;

FIG. **3** is an enlarged view of a main portion of the portable telephone;

FIG. **4** is an inner configuration view of the portable telephone;

FIG. **5** is a view explaining an electric field strength display, an incoming mail indicating display and a soft key function display to be displayed on a display of the portable telephone;

FIG. **6** includes views explaining a procedure for displaying a title list of a song recorded on a memory card; in which FIG. **6**A is a view showing a state where reproduction of audio data is suspended, FIG. **6**B is a view showing a state where an edit mode is selected, and FIG. **6**C is a view showing a title list display screen;

FIGS. **7**A to **7**E are views explaining a rearranging procedure for songs recorded on a memory card;

FIG. **8** is a flowchart explaining the rearranging procedure;

FIGS. **9**A to **9**B are views showing a character input mode selection screen;

FIG. **10** is a view explaining a configuration of a direction key guidance display;

FIGS. **11**A to **11**D are views showing a jump menu screen;

FIGS. **12**A to **12**C are views explaining a direction key guidance display by indicating a mail input screen;

FIG. **13** is a view explaining a configuration of a page feeding guidance display;

FIGS. **14**A to **14**B are views explaining a page feeding guidance display by indicating a mail input screen;

FIGS. **15**A and **15**B are views showing a display screen when there is an incoming call during music reproduction;

FIG. **16** is a flowchart showing a processing procedure when there is an incoming call during music reproduction;

FIG. **17** is a flowchart showing a processing procedure when a telephone number is inputted in a case of a setting at an outgoing/incoming call off mode;

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FIG. **18** is a flowchart showing a processing procedure when there is a recording request of an audio data;

FIG. **19** is a flowchart showing a processing procedure when an electric field strength display is performed on a remote controller;

FIG. **20** is a flowchart showing charge strength information to be displayed on a display of a remote controller;

FIG. **21** is a flowchart showing a processing procedure when an incoming mail indicating display is performed on a remote controller; and

FIG. **22** is a view showing incoming mail information to be displayed on a display of a remote controller.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A portable telephone having a function of recording and reproducing an audio data (hereafter, referred to as a portable telephone) is described as an embodiment to which the present invention is applied. The following portable telephone has a function of an electronic mail and searching for WEB through the Internet and a function of recording and reproducing an audio data since a memory card is mounted, as well as a normal telephone call function.

FIG. **1** shows an exterior perspective view of a portable telephone **1** in the embodiment of the present invention. FIG. **2** shows a plan view of this portable telephone **1**. And, FIG. **3** shows an enlarged view of the main portion of this portable telephone **1**.

The portable telephone **1** is provided with a main body **2** which is substantially rectangular parallelepiped having main functions such as a telephone function and the like, and a remote controller unit **3** that has a remote operation function and an earphone microphone function of the main body **2** and can be disposed in the main body **2**.

At first, the main body **2** is described.

A voice output speaker **12** is mounted at one end in a longitudinal direction on an operation surface **11** of the main body **2**, and a voice input microphone **13** is mounted at the other end in the longitudinal direction. By the way, from the viewpoint of the positional relation between the speaker **12** and the microphone **13**, the direction in which the speaker **12** is mounted is referred to as an upper portion, and the direction in which the microphone **13** is mounted is referred to as a lower direction.

A rotation push switch **14** is mounted at a substantial center in a short side direction of the operation surface **11**, between the speaker **12** and the microphone **13** on the operation surface **11** of the main body **2**. This rotation push switch **14** is the switch that can be actuated by a rotating operation and also actuated by a pushing operation. This rotation push switch **14** is designed such that its rotating operation direction is the upper and lower directions of the operation surface **11** (X and X' directions shown in FIG. **3**) and its pushing direction is the direction pushed vertically to the operation surface **11** (Y-direction shown in FIG. **3**).

A display **15** constituted by, for example, a liquid crystal display panel is mounted between the main body **2** and the rotation push switch **14** on the operation surface **11** of the main body **2**.

A left soft key **16** and a right soft key **17** are mounted between the display **15** and the rotation push switch **14** on the operation surface **11** of the main body **2**. The left soft key **16** is mounted on a left side in a short side direction towards the operation surface **11**, and the right soft key **17** is mounted on a right side in the short side direction towards the operation surface **11**. Also, on the operation surface **11** of the main body **2**, a leftward direction key **18** is mounted on a left adjacent side of the rotation push switch **14**, and a rightward direction key **19** is mounted on a right adjacent side thereof.

A start key **21** to carry out a call start and the like, a clear key **22**, an end key **23** to carry out an end of a telephone outgoing and the like and twelve dial keys (0 to 9 and * and #) **24** are mounted between the rotation push switch **14** and the microphone **13** on the operation surface **11** of the main body **2**.

A manner key **25** to set a so-called manner mode for removing an incoming tone via a sound, and a memo key **26** to be used when a telephone number and the like are stored during a call are mounted between the dial keys (0 to 9, and * and #) **24** and the microphone **13** on the operation surface **11** of the main body **2**.

An antenna **31** for sending and receiving an electric wave to and from a base station for the portable telephone is disposed on a side plane of an upper end of the main body **2**.

An insertion slot **32** into which a memory card **4** is inserted is mounted on a side plane of a lower end of the main body **2**.

A data input/output terminal **33** to send and receive data to and from a computer and the like, a line input terminal **34** to receive an audio data from an external audio apparatus, such as MD, CD, DVD or the like, and a remote controller unit terminal **35** to establish a connection to the remote controller unit **3** are mounted on a side of a left side plane of the main body **2**.

The remote controller unit **3** will be described below.

The remote controller unit **3** is composed of an earphone microphone **41**, a remote controller **42** and a connection cable **43**.

The earphone microphone **41** is the unit into which an earphone and a microphone are integrated. The usage of this earphone microphone **41** enables a call to be carried out, for example, while the main body **2** is kept in a bag. The earphone microphone **41** is also used when audio data recorded on the memory card **4** is heard. This earphone microphone **41** is configured so as to be detachable from the remote controller **42**.

A display unit **44** and an operation input unit **45** are mounted in the remote controller **42**. The remote controller **42** is intended to remotely operate the main body **2**.

Such a remote controller unit **3** can be operated when the remote controller **42** is connected through the connection cable **43** to the main body **2**. For example, the remote controller unit **3** can carry out the remote operations such as an incoming of a telephone, a reproduction, a stop and a fast forward of an audio signal, and the like. By the way, the main body **2** and the remote controller unit **3** may send and receive a data through a wireless communication such as infrared rays and the like without any connection via a cable.

The inner configuration of this portable telephone **1** will be described below.

FIG. **4** is a functional block diagram of the portable telephone **1**.

The main body **2** of the portable telephone **1** is provided with the speaker **12**, the microphone **13**, the rotation operation switch **14**, the display **15**, the various operation keys **16** to **26**, the antenna **31**, the insertion slot **32**, the data input output terminal **33**, the line input terminal **34** and the remote controller unit terminal **35**. Moreover, this main body **2** is composed of a transmission/reception unit **51**, a voice codec **52**, an audio encoder/decoder **53**, a memory card interface (memory card I/F) **54**, a digital data interface (digital I/F) **55**, a remote controller interface (remote controller I/F) **56** and a system controlling unit **57**.

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The remote controller unit **3** is composed of the earphone microphone **41**, the remote controller **42** and the connection cable **43**. The remote controller **42** of the remote controller unit **3** has the display **44**, the operation input unit **45** and a remote controller controlling unit **46**.

The transmission/reception unit **51** of the main body **2** carries out a process for transmitting an electric wave to the base station, and a process for receiving an electric wave from the base station. The transmission/reception unit **51** demodulates the received electric wave through the antenna **31**, and sends the demodulated data to the voice codec **52**. Also, the transmission/reception unit **51** modulates the data sent from the voice codec **52**, and sends it through the antenna **31**.

The voice codec **52** encodes and decodes the voice data. The voice codec **52** performs a voice decoding process on the demodulated data sent from the transmission/reception unit **51**. The voice signal on which the voice decoding process is performed is outputted from the speaker **12**, or sent through the remote controller I/F **56** to the remote controller unit **3** and outputted from the earphone microphone **41**. Also, the voice codec **52** receives the voice signal from the microphone **13** or the earphone microphone **41**, and encodes this voice signal and then sends to the transmission/reception unit **51**.

The audio encoder/decoder **53** performs an audio encoding/decoding process on audio data to be recorded on the memory card **4**. The audio data recorded on the memory card **4** inserted into the insertion slot **32** is sent through the memory card I/F **54** to the audio encoder/decoder **53**. The audio encoder/decoder **53** performs the decoding process, such as an encryption decoding process, a voice expanding process or the like, on the audio data. The audio data on which the decoding process is performed is sent through the remote controller I/F **56** to the remote controller unit **3**, and outputted from the earphone microphone **41**. Also, the audio data inputted from an external portion is inputted through the data input output terminal **33** or the line input terminal **34** to the audio encoder/decoder **53**. The audio encoder/decoder **53** performs the encoding process, such as a voice compressing process, an encryption decoding process or the like, on the inputted audio data. The audio data on which the encoding process is performed is recorded through the memory card I/F **54** on the memory card **4** inserted into the insertion slot **32**.

The system controlling unit **57** carries out the controls of each of the above-mentioned units.

On the other hand, the remote controller controlling unit **46** in the remote controller **42** of the remote controller unit **3** transmits and receives the data to and from the main body **2**, transmits and receives the signal to and from the earphone microphone **41**, controls the display on the display unit **44**, and controls the operational input from the operation input unit **45**.

The main configuration and the main operation of the portable telephone **1** having the above-mentioned configuration will be described below.

This portable telephone **1** is the telephone of a wirelessly communicating system, and it is carried by a user. When this portable telephone **1** is located at a position at which the electric wave transmitted from the base station can be received, it becomes at a communicable state. At this communicable state, after any telephone number is pushed by using the dial keys **24**, the start key **21** is pushed to start a call and then call out a partner. Also, at this time of the communicable state, an incoming call from the partner can be received. If there is the incoming call from the partner, any key is pushed to thereby start the call.

Here, in this portable telephone **1**, in order to provide a current state of a call quality to the user, as shown in FIG. **5**, an electric field strength indication **61** indicative of a level of an electric field strength of a received electric wave from the base station is displayed at a predetermined position on a left upper side of the display **15**. The electric field strength is detected by, for example, the transmission/reception unit **51**. The detected electric field strength information is periodically read by the system controlling unit **57**. The system controlling unit **57** carries out the display control of the display **15** on the basis of the read electric field strength information, and provides the electric field strength information to the user. In this embodiment, this electric field strength indication **61** is represented at approximately four stage levels, such as an excellent level, a usual level, a bad level and an incommunicable level, for example.

Also, this portable telephone **1** has an electronic mail function of communicating with the base station and sending and receiving an electronic mail by using an Internet protocol.

For example, mail data is sent by displaying a predetermined mail input screen, and entering a sentence to be transmitted, and then selecting a mail transmission button when it is at the communicable state. Actually, the system controlling unit **57** encodes the inputted electronic mail, and the transmission/reception unit **51** once sends the encoded mail data to the base station, and the mail data is transferred from the base station to a mail server of a partner. Also, when an electronic mail is transferred from the partner to an address of the user, the base station sends the mail data to the portable telephone **1**. The portable telephone **1**, when receiving the mail data at the time of the communicable state, automatically carries out an incoming mail process, and stores the mail data in an inner memory. Then, the system controlling unit **57** of the portable telephone **1**, when obtaining the mail data from the base station, displays a mail incoming indication **62** at a predetermined position on the display **15**, as shown in FIG. **5**.

Also, this portable telephone **1** has an Internet browsing function of communicating with the base station and viewing or a WEB site on the Internet.

For example, by displaying a browser screen of the Internet and then entering URL (Uniform Resource Locator) on this screen, communication with the base station is carried out, and a data provided through a predetermined URL is downloaded. When an input operation or a selection operation is carried out on the basis of the downloaded data, a predetermined data is further downloaded on the basis of the information.

In this portable telephone **1**, the memory card **4** on which audio data is recorded can be attached and detached as necessary. It has a function of recording and reproducing the audio data, such as an operation for reproducing the audio data recorded on the memory card **4** and an operation for recording the audio data on this memory card **4**.

When the audio data is reproduced, the memory card **4** is inserted into the insertion slot **32**, and a reproduction button is selected. When the reproduction button is selected, the audio data recorded on the memory card **4** in the insertion slot **32** is decoded by the audio encoder/decoder **53**, and outputted through the remote controller I/F **56** from the earphone microphone **41**.

Also, this portable telephone **1** can record audio data received from an external computer or an external audio reproduction apparatus.

When audio data is recorded through the external computer, the data input output terminal **33** and the external computer are connected to each other by using, for example, an IEEE 1394 interface and the like. Then, an application software on the external computer is used to carry out an operation for transferring desirable audio data to the memory

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card **4** (a so-called check-in operation). Accordingly, new audio data can be written on the memory card **4**. By the way, even an operation for editing the audio data recorded on the memory card **4** (for example, a deletion of data, a rearrangement of a reproducing order or the like) can be carried out by the external computer.

Also, when audio data is recorded through the external audio reproduction apparatus, the line input terminal **34** and the external audio reproduction apparatus are connected through a cable to each other. Desirable audio data is reproduced by the audio reproduction apparatus, and a recording start command is given to the portable telephone **1**. Thus, a so-called dubbing is started. Then, new audio data can be written on the memory card **4**. The transfer of the signal to the line input terminal **34** may be performed in a form of an analog signal or digital data. In a case of the analog signal being inputted, the audio encoder/decoder **53** carries out an A/D conversion, and converts the audio signal into the digital data. Then, the execution of the voice encoding process enables the audio data to be written on the memory card **4**.

As mentioned above, this portable telephone **1** has the electronic mail function, the Internet browsing function and the function of recording and reproducing the audio data by using the memory card **4**, in addition to the usual telephone call function. In this way, there is provided the portable telephone intended to have multiple function.

The respective operation keys and switches will be described below.

When a user operates each of the respective operation keys described below, its control command is sent to the system controlling unit **57**. Then, the system controlling unit **57** carries out a control corresponding to a function of each key, as described below.

The rotation push switch **14** is the switch that can be operated by a rotating operation and can be operated by a pushing operation.

The rotating operation of the rotation push switch **14** functions as, for example, the direction key for shifting upwardly and downwardly the pointer, such as the focus, the cursor or the like, which is displayed on the display **15**. The focus is, for example, the display to specify one piece of information (one icon, one menu title, one song title or the like) from information groups (for example, a plurality of icons, menu displays, list displays or the like) displayed on the display **15**. Usually, the display of the specified information is highlighted or reversing displayed. This rotation push switch **14** is mounted at the center in the short side direction on the operation surface **11**. Moreover, the direction of the rotating operation is the upper and lower directions (the longitudinal direction) of the operation surface **11**. Thus, when the focus is shifted upwardly or downwardly, the shift of the focus on the display screen is parallel to the operation of an operating finger. Also, the operating finger is located oppositely to the display screen. Hence, the coincident feeling between the operational feeling and the screen operation is given to the user. Moreover, the buttons such as the upper and lower keys and the like make the operation easy.

The pushing operation of the rotation push switch **14** has the function as the so-called soft key. The soft key is a key in which an action when the button is pushed is changed in a programmable manner on the basis of the menu content and the information displayed on the display **15**. This soft key is designed such that a content of a function selected when the button is pushed is displayed on the display **15** and the user can recognize the actual content of the action when this button is currently pushed. Concretely, the function selected when this rotation push switch **14** is pushed is displayed as a central soft key function indication **63**, at a center on a lower side of the display screen of the display **15**, as shown in FIG. **5**.

The left soft key **16** functions as the above-mentioned soft key. A function selected when this left soft key **16** is pushed is displayed as a left soft key function indication **64**, at a left hand position on a lower side of the display screen of the display **15**, as shown in FIG. **5**.

The right soft key **17** also functions as the above-mentioned soft key. A function selected when this right soft key **17** is pushed is displayed as a right soft key function indication **65**, at a right hand position on a lower side of the display screen of the display **15**, as shown in FIG. **5**.

The leftward direction key **18** functions as a shift key to shift the focus and the cursor displayed on the display **15** to a leftward direction.

The rightward direction key **19** functions as a shift key to shift the focus and the cursor displayed on the display **15** to a rightward direction.

The start key **21** functions as a key to start a telephone call.

The clear key **22** functions as a key to switch a display state of the display screen to an initial display menu screen, or to clear input information.

The end key **23** functions as a key for terminating a call or a power supply unit key to carry out an end function of a telephone outgoing and turn on and off a power supply of the portable telephone **1**.

The dial keys (0 to 9, and * and #) **24** function as the input keys for numerals 0 to 9 and symbols * and #. In addition, various characters are allocated thereto. Each of them functions as a character input key at a time of a character input of an electronic mail or the like. The kind of the allocated character is switched depending on a later-described character input mode setting screen. The kinds of the allocated characters include, for example, a kanji (Chinese character), a double-byte (full size) kana (Japanese character), a double-byte (full size) alphabet, a double-byte (full size) numeral, a double-byte (full size) symbol (character letter or pictorial letter), a standard sentence format, a single-byte (half size) kana, a single-byte (half size) alphabet, a single-byte (half size) numeral, a single-byte (half size) of symbol (character letter or pictorial letter) and the like.

The manner key **25** functions as a key to set the manner mode of removing an incoming tone via a voice or sound.

The memo key **26** functions as a key to store a telephone number and the like during a call service.

By the way, the manner key **25** and the memo key **26** also have a page feed function of scrolling information displayed on the display **15**, correspondingly to one page. In a case of other than making a call, for example, writing an electronic mail or browsing a WEB, the manner key **25** functions as an upward page feed key, and the memo key **26** functions as a downward page feed key. Hereafter, the manner key **25** is referred to as an upward page feed key **25**, and the memo key **26** is referred to as a downward page feed key **26**.

(Rearrangement of Song Order)

An operation for rearranging an order of songs (music pieces) of audio data recorded on the memory card **4** will be described below.

In this portable telephone **1**, it is possible to rearrange and edit the order of songs (music pieces) of the audio data recorded on the memory card **4**. By the way, the music order described here implies the number order of the numbers given to respective information units, for example, such as the numbers of tracks or the numbers of files recorded in a management information of a record medium. Typically, it corresponds to a reproducing order in a case of a continuous

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reproduction. Thus, even if the song order is rearranged, the actual content (audio data) recorded on the memory card **4** is not rewritten. The file number and the track number managed as the management information, or a link relation between songs (music pieces) or the like are rewritten.

At first, in the portable telephone **1**, the audio data is reproduced. Once it is interrupted, a display screen is displayed as shown in FIG. **6**A. If the left soft key **16** is pushed while this screen is displayed and "Function" is selected, an edition mode selection screen is displayed as shown in FIG. **6**B.

On this edition mode selection screen, the rotation push switch **14** is rotationally operated to shift a focus F upwardly and downwardly so that the focus F is located at a position of "Song Rearrangement". In succession, when the rotation push switch **14** is pushed and operated to select "Selection", a title list display screen is displayed as shown in FIG. **6**C.

On this title list display screen, the titles and the title numbers to specify the songs (pieces of music) recorded on the memory card **4** are arranged in the upward and downward directions based on a song order currently being registered, and displayed in a form of list.

The focus F is firstly shifted from this state of the title list display screen to a position of a title of a song (music piece) desired to be shifted. At this time, the focus F is shifted by rotationally operating the rotation push switch **14** since the title list is arranged in the upward and downward directions. Here, as shown in FIG. **7**A, it is assumed that the focus F is shifted to a position of "Title A". In succession, if the rotation push switch **14** is pushed and operated to select "Selection", "Title A" is selected as shown in FIG. **7**B.

Here, in a case where the left soft key **16** is pushed when the screen shows the state at which this "Title A" is selected, and "Return" is selected, the operational flow returns back to a display screen in which the reproduction of the audio data is once stopped, as shown in FIG. **7**E.

On the other hand, in a case where the rotation push switch **14** is rotationally operated when the screen shows the state at which this "Title A" is selected, the title character letters of "Title A" together with the focus F are shifted upwardly and downwardly on the title list. Then, the focus F and the title character letters of "Title A" are shifted to a position at which the rearrangement on the title list is desired. Here, as shown in FIG. **7**C, it is assumed that they are shifted to a position between "Title D" and "Title E". In succession, the rotation push switch **14** is pushed and operated to select "Determination". Then, as shown in FIG. **7**D, this leads to the state that the selected title is shifted to the desired position, which results in the completion of the rearrangement of the title list. Moreover, if another title is further desired to be shifted, the focus F is shifted from this screen to a position of a title of a song (music piece) desired to be shifted. At that position, the rotation push switch **14** is pushed and operated to select "Selection". Such operations enable the plurality of titles to be continuously shifted.

When the shifts of the titles are all completed, "Completion" is selected by pushing the right soft key **17** from a state of FIG. **7**D. When this "Completion" is selected, the system controlling unit **57** rewrites the management information of the memory card **4** in accordance with the order of the title list currently being displayed, and also returns the display screen back to the screen in which the reproduction of the audio data is once stopped, as shown in FIG. **7**E.

The above-mentioned processing procedure will be described below with reference to a flowchart in FIG. **8**.

The title list in which the plurality of titles to specify the songs or music pieces recorded on the memory card **4** are arranged in accordance with the recording order is displayed (Step S11). In succession, by operating the rotation push switch **14** in the rotating direction, the focus is shifted to a title position of a song desired to be shifted. At the title position, the rotation push switch **14** is operated in the pushing direction, and its title is selected (Step S12). Next, the title selected by operating the rotation push switch **14** in the rotating direction is shifted to any position on the list (Step S13). Then, at the title position, the rotation push switch **14** is operated in the pushing direction to thereby determine the shift destination of the title (Step S14). After the determination of the shift destination of the title, it is possible to operate the rotation push switch **14** in the rotating direction to thereby select a title of a next song or music piece desired to be shifted. When the shifts of the titles are all completed, the display of the title list is ended, and the order of recording the songs recorded on the memory card **4** is rewritten in accordance with the title list order (Step S15).

As mentioned above, in the portable telephone **1**, the editing work can be very easily carried out by rearranging the recording order of the audio data recorded on the memory card **4** in accordance with such an operational procedure.

By the way, the example of rearranging the audio data recorded on the memory card **4** has been described as mentioned above. However, in this procedure, the target for the rearrangement is not limited to the audio data. It may be applied to any information, if it is the information to define a recording order, for example, such as a picture data, a computer data, a telephone number list, an address list and the like. Also, the memory card **4** is exemplified as a recording medium. However, it may be any medium if it is a rewritable recording medium, such as the inner memory of the portable telephone **1**, MD, and DVD-RAM.

(Switching of Character Input Mode)

An operation for switching a character input mode will be described below.

In the portable telephone **1**, a plurality of character kinds are assigned to the dial keys **24**. Any character kind of a character can be entered by switching the character input mode.

In the portable telephone **1**, when the right soft key **17** is pushed to select "Mode" when a character input screen is displayed at the time of writing an electronic mail or the like, a character input mode selection screen is displayed as shown in FIG. **9**A.

On this character input mode selection screen, all the character kinds assigned to the dial keys **24** are displayed on a list of two columns. The character kinds assigned to the dial keys **24** include, for example, a kanji (Chinese character), a double-byte (full size) kana, a double-byte (full size) alphabet, a double-byte (full size) numeral, a double-byte (full size) symbol (character letter or pictorial letter), a standard sentence format, a single-byte (half size) kana, a single-byte (half size) alphabet, a single-byte (half size) numeral, and a single-byte (half size) symbol (character letter of pictorial letter). On this character input selection screen as shown in FIG. **9**A and FIG. **9**B, a kanji (Chinese character) (top column), a double-byte kana (second upper column), a double-byte alphabet (third upper column), a double-byte numeral (third lower column), a double-byte symbol (character letter or pictorial letter) (second lower column), a standard sentence format (bottom column) are displayed in the left column of the list, and a single-byte kana (second upper column), a single-byte alphabet (third upper column), a single-byte numeral (third lower column), and a single-byte symbol (character letter of pictorial letter) (second lower column) are displayed in the right column of the list.

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On this character input mode selection screen, the rotating operation of the rotation push switch **14** enables the focus F to be cyclically shifted in an order of a kanji→a double-byte kana→a double-byte alphabet→a double-byte numeral→a double-byte symbol (character)→a standard sentence format→a single-byte kana→a single-byte alphabet→a single-byte numeral→a single-byte symbol (character)→a kanji→a double-byte kana and so on, as shown in FIG. **9**B. Also, pushing the leftward direction key **18** or the rightward direction key **19** causes the focus F to be shifted between the left and right columns.

When this character input mode selection screen is displayed, the rotation push switch **14** and the direction keys **18**, **19** that are operated as mentioned above are used to shift the focus to the character kind desired to be used. Then, when the rotation push switch **14** is pushed and operated to select "Selection", the operational flow returns back to the screen to write the electronic mail or the like. Thus, it is possible to enter the character set of the selected character kind.

As mentioned above, in the portable telephone **1**, when the character input mode is operationally set on a character write screen, the character input mode selection screen in which all the character kinds are displayed is displayed. The selection of a character kind based on this character input mode selection screen enables the character of any character kind assigned to the dial keys **24** to be entered.

For this reason, in the portable telephone **1**, the character input mode can be easily selected without any troublesome work such as an operation for pushing the mode set buttons, one by one, and then switching the character input mode.

By the way, on the character input mode selection screen, it may be designed to display only the character kind that can be entered at that time or select only the character kind that can be entered at that time. For example, when an electronic mail address or URL is entered, it is possible to design the character input mode selection screen so that only a half size of alphabet and a half size of numeral can be selected.

(Guidance Display)

A guidance display of a shiftable direction of a focus or the like and a guidance display of a page feed key will be described below.

In this portable telephone **1**, a direction key guidance display is carried out for indicating whether or not the rotation push switch **14** can be rotationally operated and whether or not the leftward direction key **18** and the rightward direction key **19** can be operated. That is, the direction key guidance display indicates whether or not the pointer such as the focus, the cursor and the like can be effectively shifted upwardly and downwardly by rotationally operating the rotation push switch **14** and whether or not the pointer such as the focus, the cursor and the like can be effectively shifted in the leftward and rightward directions by operating the leftward direction key **18** and the rightward direction key **19**.

This direction key guidance display is constituted by an upwardly shiftable mark **71**, a downwardly shiftable mark **72**, a leftwardly shiftable mark **73** and a rightwardly shiftable mark **74**, as shown in FIG. **10**. Those direction key guidance displays are displayed as respective arrow marks around a central soft key function indication **63**. That is, the upwardly shiftable mark **71** is displayed as an upward arrow mark at an upper position of the central soft key function indication **63**. The downwardly shiftable mark **72** is displayed as a downward arrow mark at a lower position of the central soft key function indication **63**. The leftwardly shiftable mark **73** is displayed as a left arrow mark at a left position of the central soft key function indication **63**. And, the rightwardly shiftable mark **74** is displayed as a rightward arrow mark at a right position of the central soft key function indication **63**.

The upwardly shiftable mark **71** is displayed if the rotation push switch **14** can be upwardly operated, and it is not displayed if the rotation push switch **14** cannot be upwardly operated. In other words, the upwardly shiftable mark **71** is displayed, for example, if the focus F can be shifted in a direction of an arrow man in FIG. **10** (i.e., for example, if a selectable information exists at a further upper position of the focused information), and it is not displayed if the focus F can not be shifted in the direction of the arrow "a" in FIG. **10** (i.e., for example, if the selectable information does not exist at the further upper position of the focused information.

The downwardly shiftable mark **72** is displayed if the rotation push switch **14** can be downwardly operated, and it is not displayed if the rotation push switch **14** cannot be downwardly operated. In other words, the downwardly shiftable mark **72** is displayed, for example, if the focus F can be shifted in a direction of an arrow "b" in FIG. **10** (i.e., for example, if a selectable information exists at a further lower position of the focused information), and it is not displayed if the focus F cannot be shifted in the direction of the arrow "b" in FIG. **10** (i.e., for example, if the selectable information does not exist at the further lower position of the focused information).

The leftwardly shiftable mark **73** is displayed if the leftward direction key **18** can be operated in the leftward direction, and it is not displayed if the leftward direction key **18** cannot be operated in the leftward direction. The leftwardly shiftable mark **73** is displayed, for example, if the focus F can be shifted in a direction of an arrow "c" in FIG. **10** (i.e., for example, if a selectable information exists at a further leftward position of the focused information or if there is a screen of an upper hierarchy of the selected information), and it is not displayed if the focus F can not be shifted in the direction of the arrow "c" in FIG. **10** (i.e., for example, if the selectable information does not exist at the further leftward position of the focused information or if there is not the screen of the upper hierarchy of the selected information).

The rightwardly shiftable mark **74** is displayed if the rightward direction key **19** can be operated in the rightward direction, and it is not displayed if the rightward direction key **19** cannot be operated in the rightward direction. That is, the rightwardly shiftable mark **74** is displayed, for example, if the focus F can be shifted in a direction of an arrow "d" in FIG. **10** (i.e., for example, if a selectable information exists at a further rightward position of the focused information or if there is a screen of a lower hierarchy of the selected information), and it is not displayed if the focus F can not be shifted in the direction of the arrow "d" in FIG. **10** (i.e., for example, if the selectable information does not exist at the further rightward position of the focused information or if there is not the screen of the lower hierarchy of the selected information).

An actual display example of the direction key guidance display will be described below with reference to the display screen of the portable telephone **1**.

FIGS. **11**A to **11**D are views showing a jump menu that is a short cut screen to each display menu.

FIG. **11**A is a display screen of a state at which when a jump menu screen is displayed, the focus F points out a character string of "Jump" of its menu title. The upwardly shiftable mark **71**, the downwardly shiftable mark **72** and the leftwardly shiftable mark **73** are displayed at the state of this display screen. At this time, it is possible to shift the focus F upwardly and downwardly using the rotation push switch **14**. Moreover, at this time, it is also possible to display the lower hierarchy on the screen by pushing the rightward direction key **19**.

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Pushing the rightward direction key **19** on the display screen of FIG. **11**A results in a display screen of FIG. **11**B. This display screen of FIG. **11**B is a selection screen showing an individual menu within the jump menu, and it is a screen of a state at which the focus F points out a selection position of "Internet". The upwardly shiftable mark **71**, the downwardly shiftable mark **72**, the leftwardly shiftable mark **73** and the rightwardly shiftable mark **74** are displayed on this display screen. At this time, it is possible to shift the focus F upwardly and downwardly by rotating the rotation push switch **14**. Moreover, at this time, it is also possible to display the upper hierarchy (the screen of FIG. **11**A) on the screen by pushing the leftward direction key **18**, and to display the lower hierarchy on the screen by pushing the rightward direction key **19**.

Pushing the left soft key **16** on the display screen of FIG. **11**B results in a display screen of FIG. **11**C. This display screen of FIG. **11**C is an edition screen showing an individual menu within the jump menu. The upwardly shiftable mark **71** and the downwardly shiftable mark **72** are displayed on this display screen. At this time, it is possible to shift the focus F upwardly and downwardly by rotating the rotation push switch **14**.

Pushing the right soft key **17** on the display screen of FIG. **11**B results in a display screen of FIG. **11**D. This display screen of FIG. **11**D is an addition screen of an individual menu display within the jump menu. The upwardly shiftable mark **71**, the downwardly shiftable mark **72** and the leftwardly shiftable mark **73** are displayed on this display screen. At this time, it is possible to shift the focus F upwardly and downwardly by rotating the rotation push switch **14**. Moreover, at this time, it is also possible to display the lower hierarchy on the screen by pushing the rightward direction key **19**.

Here, a division line **75** indicative of a head of a list is displayed on this display screen of FIG. **11**D. The division line **75** indicative of the head of this list is used in the following manner, for example. That is, there is a case that although the number of displayed lists is definite, the focus is desired to be cyclically shifted by the rotating operation of the rotation push switch **14**, namely, there is a case that the focus is desired to be shifted in order to make the focus coincide with the lowest portion of the list by instructing the further upward direction even if the focus coincides with the uppermost portion of the list. If the cyclic focus shift is carried out as mentioned above, a portion at which the head of the list is located cannot be evidently provided to the user. Accordingly, this portable telephone **1** is designed such that the division line **75** is displayed at the uppermost division position of the list.

FIGS. **12**A to **12**C are views showing an input screen of an electronic mail.

FIG. **12**A is a display screen when even one character is not still written to a main body of a mail, and a cursor C is located on a left upper portion. The downwardly shiftable mark **72** and the rightwardly shiftable mark **74** are displayed on this display screen. At this time, it is possible to shift the cursor C downwardly by rotating the rotation push switch **14** downwardly. Moreover, at this time, it is also possible to shift the cursor C in the rightward direction by pushing the rightward direction key **19**.

FIG. **12**B is a display screen under a condition that the main body of the mail is written to a certain degree. The characters on the display shown in FIG. **12**B and FIG. **12**C are in Japanese in order to explain the character conversion function of the portable telephone of the present embodiment. The sentences shown in these figures means "○○ won 16-the game between ○○ and □□ in ΔΔ dome with score of 5-2. Winning pitcher was XX (not shown) who has won five games and lost three games in this season." The last word in the fifth row, which is shown with an underline, has just been currently inputted to be converted into a word with kanji. The upwardly shiftable mark **71**, downwardly shiftable mark **72**, the leftwardly shiftable mark **73** and the rightwardly shiftable mark **74** are displayed on this display screen. After the conversion, the cursor C will appear after the converted word. At this time, it is possible to shift the cursor C upwardly and downwardly by rotating the rotation push switch. Moreover, at this time, it is also possible to shift the cursor C in the leftward direction by pushing the leftward direction key **18**, and to shift the cursor C in the rightward direction by pushing the rightward direction key **19**.

FIG. **12**C is a display screen when the word underlined in FIG. **12**B has been converted into one of word with kanji (Chinese character). On this display screen, a conversion candidate display **76** is displayed for indicating that a conversion candidate is outputted by rotationally operating the rotation push switch **14**.

In this portable telephone **1**, a page feed guidance display is also carried out for indicating whether or not a previous page feed can be done by using the upward page feed key **25** or whether or not a next page feed can be done by using the downward page feed key **26**.

That is, the page feed guidance display is the information to indicate whether or not the operation of the upward page feed key **25** or the downward page feed key **26** enables a page to be fed, namely, whether or not there is further information, currently invisible, beyond the display screen.

This page feed guidance display is constituted by an upwardly feedable page mark **77** and a downwardly feedable page mark **78**, as shown in FIG. **13**. Those page feed guidance displays are displayed at upper and lower positions on the left side of the display screen, respectively.

The upwardly feedable page mark **77** is displayed if the page feed can be upwardly done by using the upward page feed key **25**, and it is not displayed if the operation is impossible.

The downwardly feedable page mark **78** is displayed if the page feed can be downwardly done by using the downward page feed key **26**, and it is not displayed if the operation is impossible.

An actual display example of the page feed guidance display will be described below with reference to the display screen of the portable telephone **1**.

FIGS. **14**A to **14**B are views showing an input screen of an electronic mail.

FIG. **14**A is a display screen when the cursor is located at the position of the second character on the first row, under a condition that the main body of the mail is written to a certain degree. The downwardly feedable page mark **78** is displayed on this display screen. At this time, it is possible to scroll the page downwardly by pushing the downward page feed key **26**.

FIG. **14**B is a display screen when the page is downwardly scrolled correspondingly to one page from the state of FIG. **14**A. The upwardly feedable page mark **77** and the downwardly feedable page mark **78** are displayed on this display screen. At this time, it is possible to scroll the page upwardly by pushing the upward page feed key **25**. Also, it is possible to scroll the page downwardly by pushing the downward page feed key **26**.

In the portable telephone **1**, such executions of the direction key guidance display and the page feed key guidance display can improve the operational performances of the

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direction keys and the page feed keys and accordingly improve the convenience of the user.

(Answer Rejection During Music Reproduction)

The process of the portable telephone **1** when there is an incoming call from a partner during an audio reproduction will be described below with reference to display screens of FIGS. **15A**, **15B** and a flowchart of FIG. **16**.

When the portable telephone **1** receives an incoming call from a partner during an audio reproduction (Step **S21**), a display screen is displayed as shown in FIG. **15A**. At this time, if any key except the left soft key **16** is pushed (Step **S22**), the incoming call is received to start a call. Here, if the call is started, the audio reproduction is transiently suspended (Step **S23**). Also, when there is the incoming call, and the left soft key **16** is pushed (Step **S22**), a menu is displayed as shown in FIG. **15B** (Step **S24**).

At this step **S24**, a menu display is carried out for indicating "Forward to Answer Service", "Incoming Call Forwarding", "Answer Holding" and "Answer Rejection".

In succession, in accordance with this menu display, the rotation push switch **14** is rotationally operated to then select any one of the menus (Steps **S25**, **S26**).

Here, if "Forward to Answer Service" is selected, a process is carried out for forwarding the telephone call from the partner to a telephone answer service station installed in the base station. If "Incoming Call Forwarding" is selected, a process is carried out for forwarding the telephone call from the partner to another telephone number. Also, if "Answer Holding" is selected, a state at which the incoming call from the partner is held is maintained (namely, the calling state is held). And, if "Answer Rejection" is selected, a process is carried out for disconnecting the telephone call from the partner.

In the portable telephone **1**, if such a menu selection is done, an operation for rejecting a call is carried out correspondingly to the selection. At this time, the audio reproduction is continued (Step **S27**).

As mentioned above, in the portable telephone **1**, if there is the incoming call during the audio reproduction, the rejection of the call is done depending on the operational input. Due to this mechanism, in the portable telephone **1**, the simple operation enables the reproduction to be continued if there is the incoming call during the audio reproduction.

(Emergent Telephone Call in Case of Outgoing/Incoming Call Off Mode)

In this portable telephone **1**, an outgoing/incoming call off mode can be set so as not to transmit and receive an electric wave by stopping the operation of the transmission/reception unit **51**. When this outgoing/incoming call off mode is selected, for example, on the menu screen, the system controlling unit **57** stops a protocol operation of the transmission/reception unit **51**, and perfectly stops transmitting and receiving the electric wave to and from the base station. Such setting of the outgoing/incoming call off mode can stop only the transmission and reception of the electric wave without turning off the power supply of the main body. Thus, it can be set at the state that the functions except the telephone function can be used. Hence, for example, although the telephone function cannot be used at this outgoing/incoming call off mode, it is possible to carry out the input operation of the character of the electronic mail, the recording and the reproduction of the music, and the like other operations.

Here, a process when a telephone number input is carried out in a case of this outgoing/incoming call off mode is set being described with reference to FIG. **17**.

If the outgoing/incoming call off mode is set, when the dial key **24** is pushed and a telephone number is inputted (Step **S31**), the system controlling unit **57** displays the pushed telephone number on the display **15** (Step **S32**).

In succession, when the start key **33** is pushed (Step **S33**), the system controlling unit **57** judges whether or not its telephone number inputted is one of emergency phone call numbers (for example, in a case of Japan, 110 for police, 118 for coast guard and 119 for fire station and/or ambulance) or a pre-registered predetermined telephone number (Step **S34**). By the way, the registered telephone number is desired to be different from a usual address registration, and it is desired to be a telephone number specially registered for an emergency.

If the telephone number inputted is not one of the emergency phone call numbers or the pre-registered telephone number, the outgoing call is stopped, and the outgoing/incoming call off mode is maintained in its original state (Step **S35**). That is, a phone call cannot be made.

On the other hand, if it is one of the emergency phone call numbers or the pre-registered telephone number, the system controlling unit **57** cancels the outgoing/incoming call off mode, and then actuates the protocol process of the operation of the transmission reception unit **51** (Step **S36**).

In succession, when the protocol process of the operation of the transmission/reception unit **51** is started, the transmission/reception unit **51** starts an operation for capturing a base station.

When the transmission/reception unit **51** captures the base station, the transmission/reception unit **51** starts a process for transmitting an input telephone number (Step **S38**).

As mentioned above, in this portable telephone **1**, even if it is set at the outgoing/incoming call off mode at which the transmission/reception of the electric wave is stopped and the outgoing/incoming of a call is not done, if a phone call of emergency or a preliminarily registered phone call is made, a call can be started without canceling operation of the outgoing/incoming call off mode by the user. Thus, it is possible to immediately make a report or make a call.

(Automatic Outgoing/Incoming Call Off During Recording Audio Data)

As mentioned above, in the portable telephone **1**, the audio data inputted from the line input terminal **34** or the data input/output terminal **33** can be recorded on the memory card **4**. A process when there is a request for recording audio data in the portable telephone **1** is described with reference to FIG. **18**.

At first, when the power supply of the portable telephone **1** is turned on and there is the request for recording the audio data (Step **S41**), the system controlling unit **57** obtains information of a protocol operation state of the transmission/reception unit **51**, and stores it in a memory (Step **S42**).

The system controlling unit **57** judges whether or not the protocol for the transmission/reception of the transmission/reception circuit **51** is currently operated (Step **S43**). If the protocol is operated, the operational flow proceeds to step **S44**. If it is not operated, the operational flow proceeds to step **S45**.

The system controlling unit **57**, if the protocol of the transmission/reception circuit **51** is operated, stops the operation of the protocol of this transmission reception circuit **51**, and sets at the portable phone **1** at the outgoing/incoming call off mode in which the outgoing/incoming of the telephone call is not carried out.

The system controlling unit **57** starts the operation for recording the audio data (Step **S45**). Thus, the operation for

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recording the audio data at this step S45 is always carried out at the state at which it is set at the outgoing/incoming call off mode.

The system controlling unit **57**, if there is a record stop request (Step S46), obtains a protocol operation state of the transmission/reception circuit **51** prior to the actuation of the recording operation stored in the memory at the previous step S42 (Step S47).

It judges whether or not the protocol is under operation, from the information read out at the step S47 (Step S48). If the protocol is under operation, the operational flow proceeds to step S49. If it is not under operation, the process, is ended.

Next, the system controlling unit **57**, if the protocol of the transmission/reception circuit **51** is under operation, starts the operation of the protocol of the transmission/reception circuit **51** (Step S49). Then, the series of audio recording processes is ended.

As mentioned above, in the portable telephone **1**, the interference in the recording operation caused by the incoming call can be avoided by automatically setting it at the outgoing/incoming call off mode, if there is the recording operation request.

(Display of Electric Field Strength in Remote Controller)

In the portable telephone **1**, the remote controller unit **3** is mounted as mentioned above. The remote controller **42** in this remote controller unit **3** carries out a remote control for reproducing the audio data recorded on the memory card **4** and a remote control for the function of the main body of the portable telephone.

Such process for displaying electric field strength through the remote controller **42** will be described below with reference to a flowchart shown in FIG. **19**.

If the user requests a display of electric field strength (Step S61), the remote controller controlling unit **46** of the remote controller **42** sends a report request of the electric field strength to the system controlling unit **57** (Step S62).

The system controlling unit **57** of the main body **2** sends electric field strength information currently being held (the information for displaying the electric field strength indication **61**) and a timeout timer value to the remote controller **42** (Step S63).

When receiving the report from the system controller **57**, the remote controller controlling unit **46** of the remote controller **42** judges whether or not any indication is currently displayed on the display unit **44** of the remote controller **42** (Step S64). If any indication is displayed on the display unit **44**, the operational flow proceeds to step S65. If it is not displayed, the operational flow proceeds to step S66.

The remote controller controlling unit **46** of the remote controller **42** transiently saves the information currently being displayed on the display unit **44** (Step S65).

The remote controller controlling unit **46** of the remote controller **42** displays the electric field strength on the display unit **44**, based on the electric field strength information sent out from the system controlling unit **57** of the main body **2** (Step S66). In the embodiment, the electric field strength information is displayed on the display unit **44** at approximately four stage levels, for example, such as an excellent level, a usual level, a bad level and an impossible communication. However, the indication is not limited to such four-stage-level display, and any other way for indicating the electric field strength may be employed.

The remote controller controlling unit **46** of the remote controller **42** actuates a timer (Step S67). The actuated timer carries out counting until a counted value reaches the timeout timer value sent out from the system controlling unit **57** of the main body **2**. If the counting is ended, a timer event is generated.

If the timer event is generated from the timer (Step S68), The remote controller controlling unit **46** of the remote controller **42** judges whether or not there is the save information transiently saved at the step S65 (Step S69). If there is the save information, the operational flow proceeds to step S70. If there is not the save information, the operational flow proceeds to step S71.

In succession, if there is the save information, the remote controller controlling unit **46** of the remote controller **42** again displays the save information, and ends the process (Step S70). Also, the remote controller controlling unit **46** of the remote controller **42**, if there is not the save information, removes the indication on the display unit **44**, and ends the process (Step S71).

By the way, it may be designed that the timeout timer value is not sent out from the main body **2** and that it is set in advance on the remote controller side.

As mentioned above, the portable telephone **1** has the remote controller unit **3** separately mounted from the main body **2**, and the electric field strength information is displayed on this remote controller unit **3**. This mechanism of the portable telephone **1** enables the electric field strength of the received electric wave to be simply and conveniently checked by the user. For example, even if the main body **2** of the portable telephone is kept in a bag or the like, the electric field strength information is displayed on, for example, the remote controller unit **3**. Thus, the user can check a current electric wave reception state very simply without especially taking out the main body **2** from the bag or the like to check the status. Also, the electric field strength information is not always displayed on the remote controller unit **3**. That is, it is displayed, as necessary, in accordance with the operation from the user. Hence, it is possible to effectively use the display region placed on the remote controller unit **3**.

(Display of Incoming Call on Remote Controller)

In the portable telephone **1**, the remote controller unit **3** is disposed as mentioned above. The remote controller **42** of this remote controller unit **3** carries out the remote control for reproducing the audio data recorded on the memory card **4** and the remote control to the function of the main body **2** of the portable telephone.

A process for displaying a mail incoming by using such a remote controller **42** will be described below with reference to a flowchart shown in FIG. **21**.

When automatically receiving a mail data from the base station (Step S81), the system controlling unit **57** of the main body **2** sends out a mail incoming display report and a timeout timer value to the remote controller **42** (Step S82).

When receiving the report from the system controller **57**, the remote controller controlling unit **46** of the remote controller **42** judges whether or not any indication is currently displayed on the display unit **44** of the remote controller **42** (Step S83). If any indication is displayed on the display unit **44**, the operational flow proceeds to step S84. If it is not displayed, the operational flow proceeds to step S85.

The remote controller controlling unit **46** of the remote controller **42** transiently saves the information currently being displayed on the display unit **44** (Step S84).

In accordance with a mail incoming report sent out from the system controlling unit **57** of the main body **2**, the remote controller controlling unit **46** of the remote controller **42** displays the mail incoming indicative of the presence of the

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mail incoming (Step S85). This incoming indication is displayed, for example, such as "You've Got Mail", as shown in FIG. 22.

The remote controller controlling unit 46 of the remote controller 42 actuates the timer (Step S86). Then, the actuated timer carries out counting until a counted value reaches the timeout timer value sent out from the system controlling unit 57 of the main body 2. When the count is ended, the timer event is generated.

When the timer event is generated from the timer (Step S87), the remote controller controlling unit 46 of the remote controller 42 judges whether or not there is the save information transiently saved at the step S84 (Step S88). If there is the save information, the operational flow proceeds to step S89. If there is not the save information, the operational flow proceeds to step S90.

In succession, when there is the save information, again displays the save information, the remote controller controlling unit 46 of the remote controller 42, and ends the process (Step S89). Also, the remote controller controlling unit 46 of the remote controller 42, when there is not the save information, removes the indication on the display unit 44, and ends the process (Step S90).

By the way, it may be designed that the timeout timer value is not sent out from the main body 2 and that it is set in advance on the remote controller side.

As mentioned above, the portable telephone 1 has the remote controller unit 3 separately mounted from the main body 2, and the fact of the incoming of the electronic mail is displayed on this remote controller unit 3.

This mechanism of the portable telephone 1 which is a characteristic feature of the invention enables the fact of the incoming of the electronic mail to be quickly reported to the user. Also, the user can easily recognize the fact of the incoming of the electronic mail. In the portable telephone 1, for example, even if the main body 2 is kept in a bag or the like, the mail incoming is displayed on, for example, the display of the remote controller unit 3. Thus, the user can recognize the fact of the incoming of the electronic mail quickly and easily without especially checking the main body 2.

What is claimed is:

1. A communication apparatus comprising:

a communication unit configured to transmit an outgoing call and to respond to an incoming call to communicate with at least another device;

a reproduction unit configured to reproduce music data; and

a controller unit configured to stop communicating with the other device and continue reproduction of said music data when an outgoing/incoming call off mode is selected.

2. The communication apparatus according to claim 1, wherein said controller unit is operable to input electronic mail characters even when said outgoing/incoming call off mode is selected.

3. The communication apparatus according to claim 1, further comprising:

a memory operable to record music data, and wherein

said controller unit sets said outgoing/incoming call off mode when said memory is operated to record music data.

4. A method of operating a communication device comprising the steps of:

transmitting an outgoing call and responding to an incoming call to communicate with at least another device;

reproducing music data; and

stopping communicating with the other device and continuing the reproduction of said music data when an outgoing/incoming call off mode is selected.

5. The method according to claim 4, further comprising the step of inputting electronic mail characters in said communication device even when said outgoing/incoming call off mode is selected.

6. The method according to claim 4, further comprising the steps of:

recording music data in a memory of said communication device; and

setting said outgoing/incoming call off mode upon recording music data in said memory.

* * * * *

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EXHIBIT C

US00RE40568E

(19) **United States**
(12) **Reissued Patent**
Böhnke et al.

(10) **Patent Number: US RE40,568 E**
(45) **Date of Reissued Patent: Nov. 11, 2008**

(54) **SYNCHRONIZATION SYMBOL STRUCTURE USING OFDM BASED TRANSMISSION METHOD**

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(73) Assignee: **Sony Corporation**, Tokyo (JP)

(21) Appl. No.: **11/286,440**

(22) Filed: **Nov. 23, 2005**

Related U.S. Patent Documents

Reissue of:

(64) Patent No.: **6,654,339**
Issued: **Nov. 25, 2003**
Appl. No.: **09/479,281**
Filed: **Jan. 6, 2000**

(51) **Int. Cl.**
H04J 11/00 (2006.01)

(52) **U.S. Cl.** **370/203**; 370/208; 370/350; 375/355

(58) **Field of Classification Search** 370/203, 370/208, 350; 375/355
See application file for complete search history.

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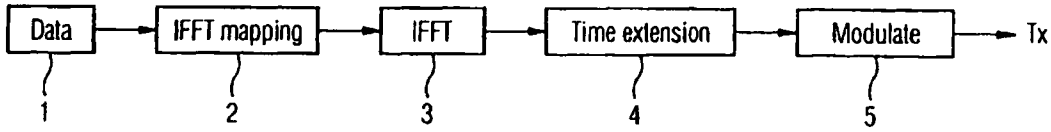
Primary Examiner—Frank Duong
(74) *Attorney, Agent, or Firm*—Frommer Lawrence & Haug LLP; William S. Frommer

(57) **ABSTRACT**

The present invention proposes a method for generating synchronization bursts for OFDM transmission systems. The symbols of a predefined symbol sequence are mapped according to a predefined mapping scheme on subcarriers of the OFDM systems by a mapping unit (2), wherein the symbols of the predefined symbol sequence represent subcarriers of the OFDM system with nonzero amplitudes. A synchronization burst is generated by a inverse fast Fourier transforming unit (3) transforming the subcarriers of the OFDM system mapped to said predefined symbol sequence. The mapping (2) of the symbols of the predefined symbol sequence is set such that the resulting time domain signal of the synchronization burst represents a periodic nature. According to the invention the predefined symbol sequence is set such that the envelope fluctuation of the time domain signal of the synchronization burst is minimized. Therefore advantageous symbol sequences reducing said the envelope fluctuation of the time domain signal are proposed.

34 Claims, 9 Drawing Sheets



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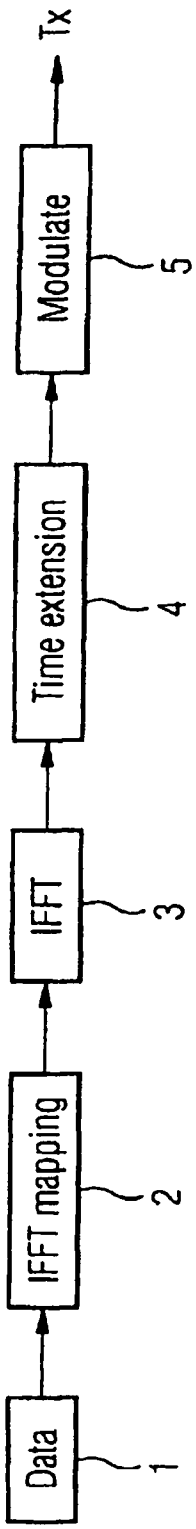

FIG 1

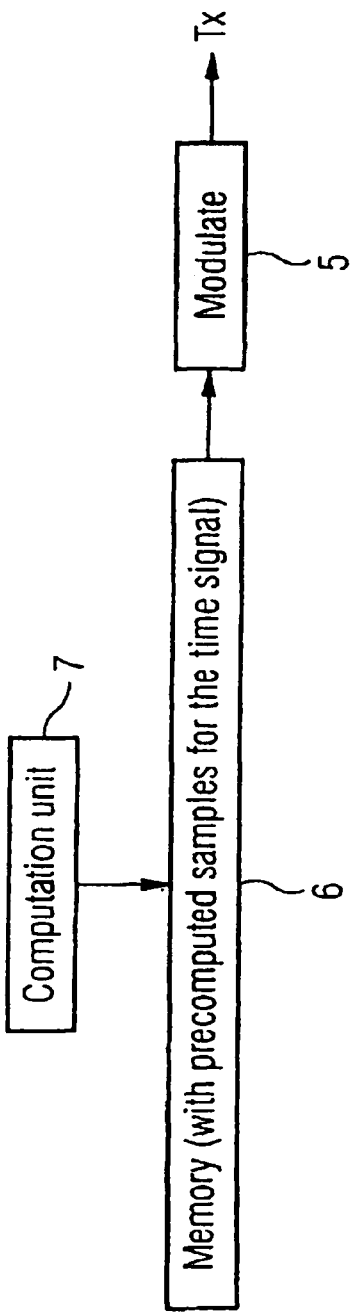

FIG 2

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FIG 3

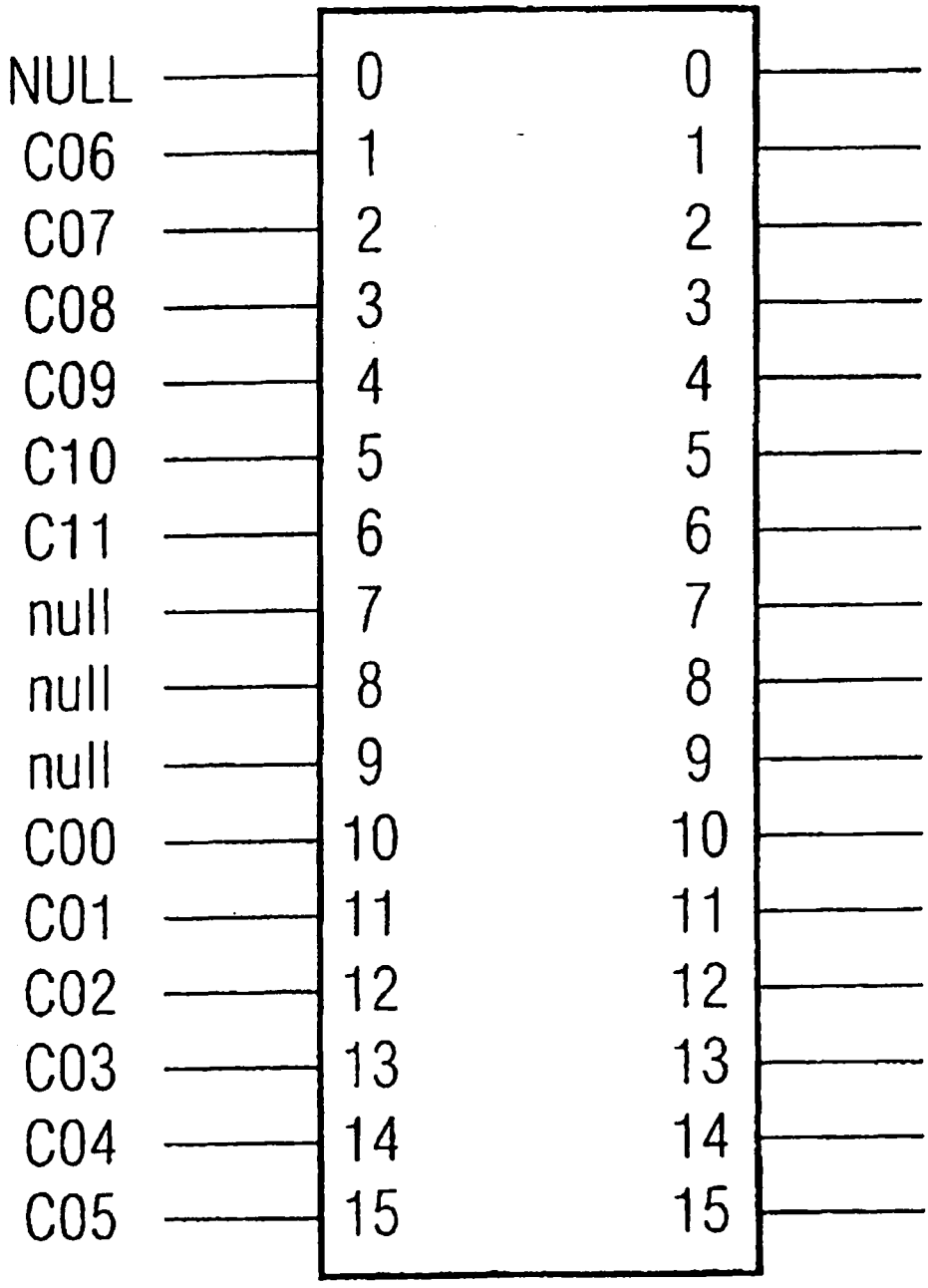


EXHIBIT B C
PAGE 65

FIG 4a

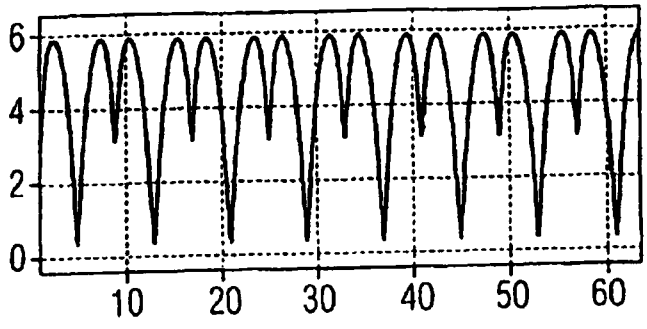


FIG 4b

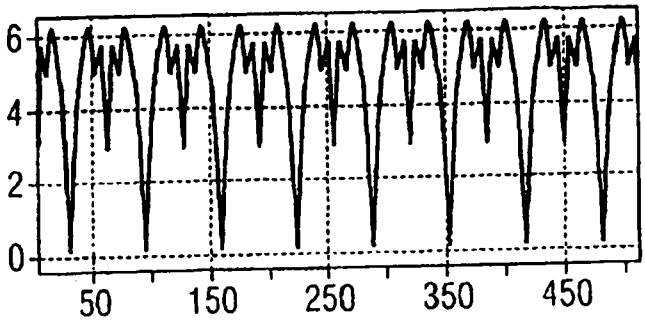


FIG 4c

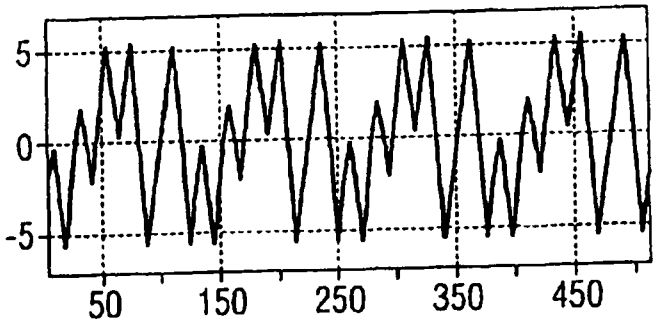
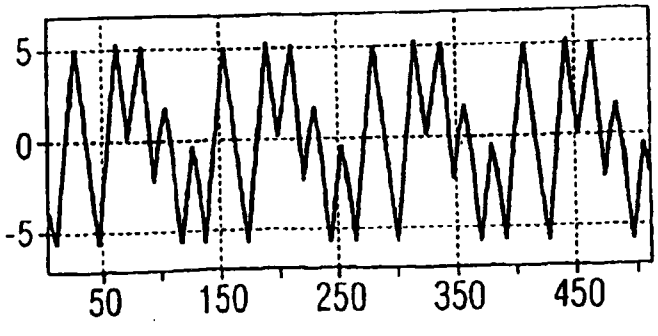


FIG 4d



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PAGE 66

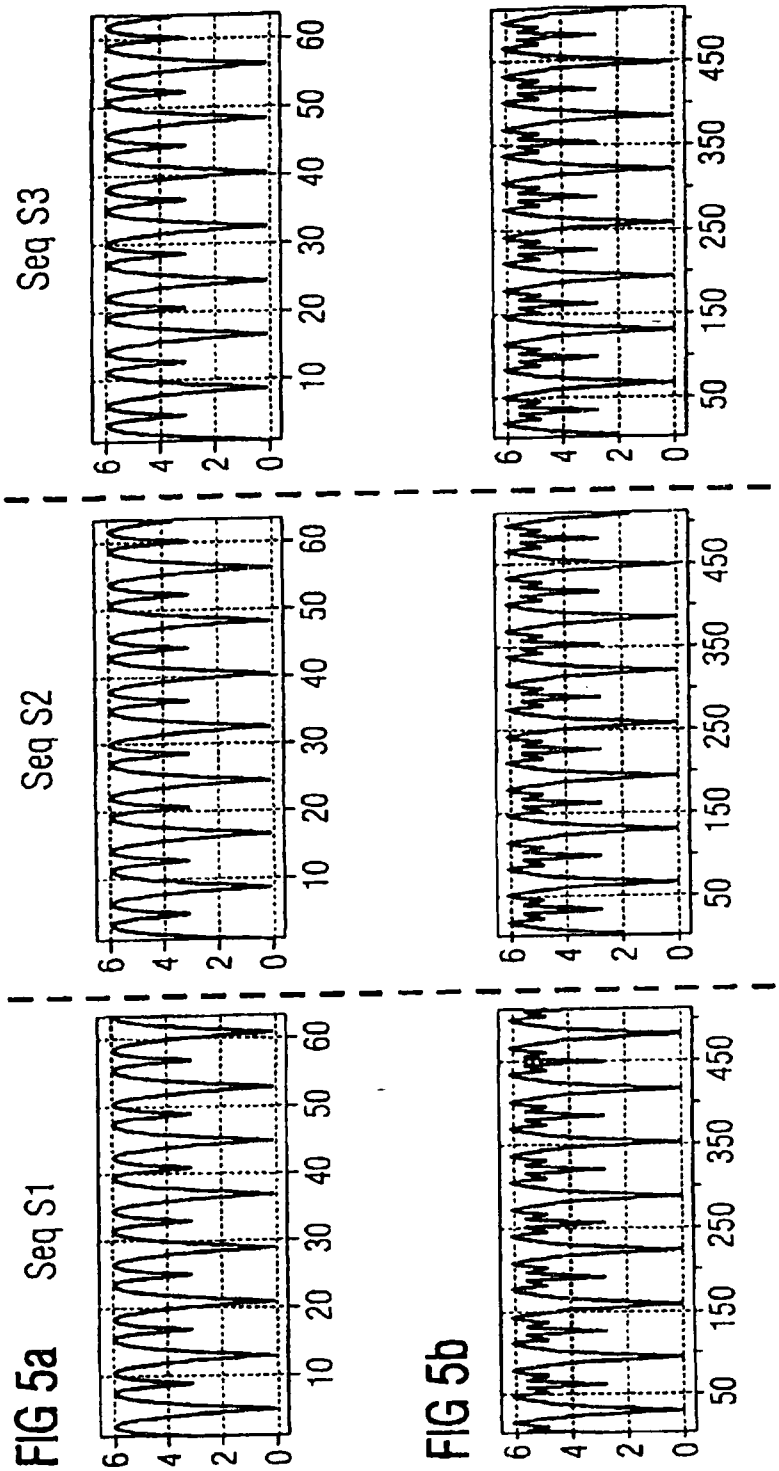

FIG 5a FIG 5b

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FIG 5c

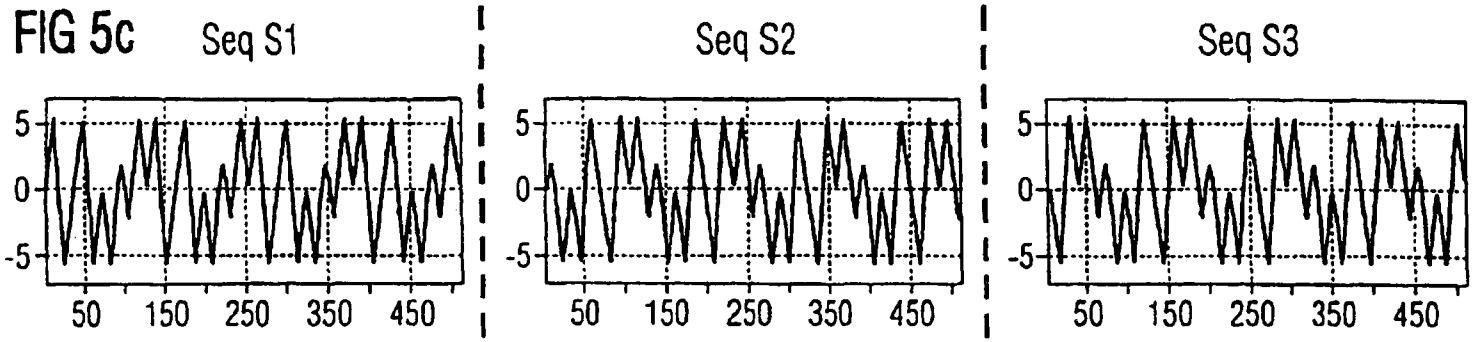
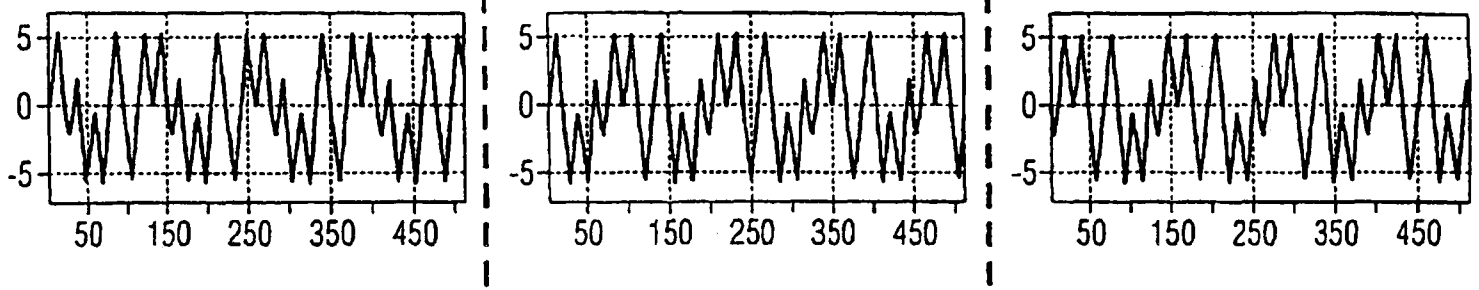


FIG 5d



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6X

FIG 6

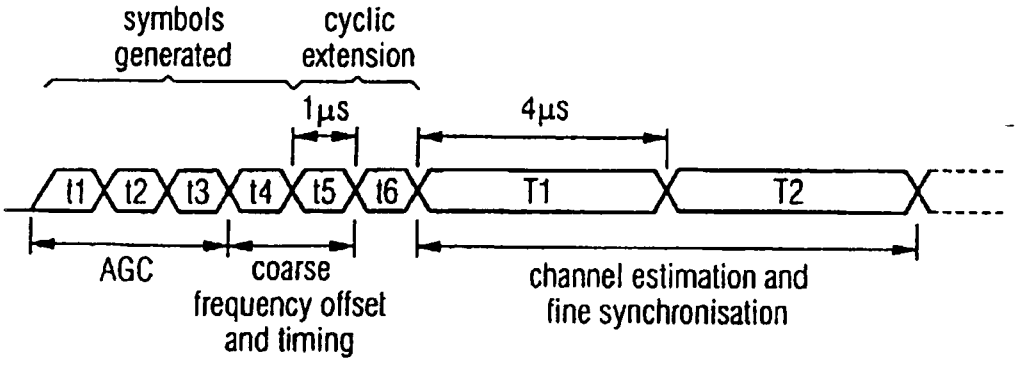

FIG 7

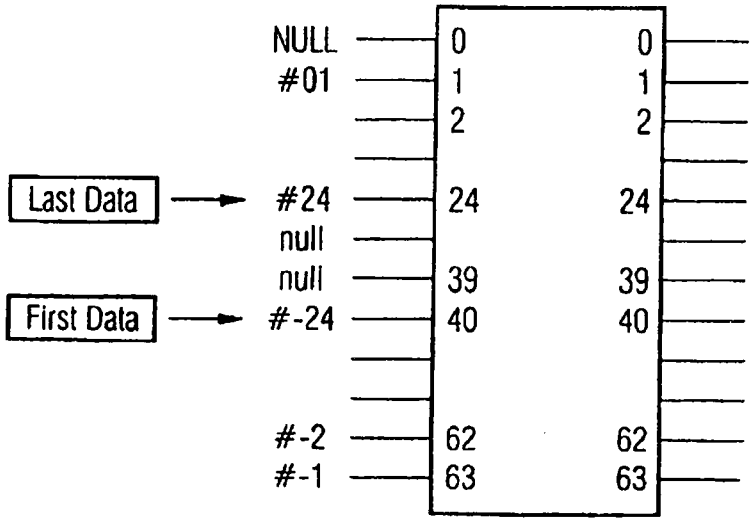

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FIG 8a

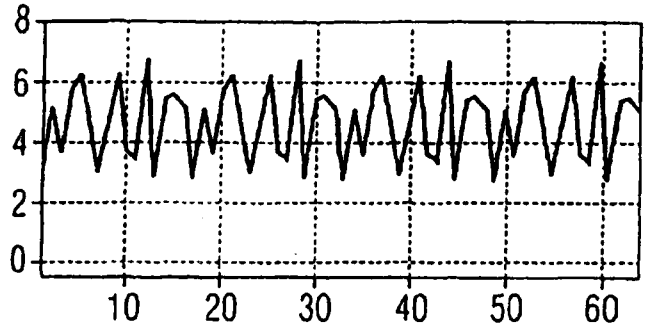

FIG 8b

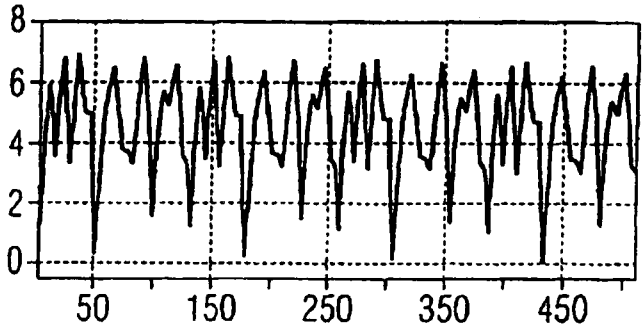

FIG 8c

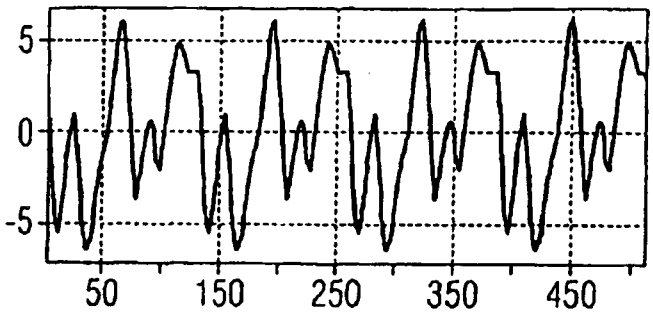

FIG 8d

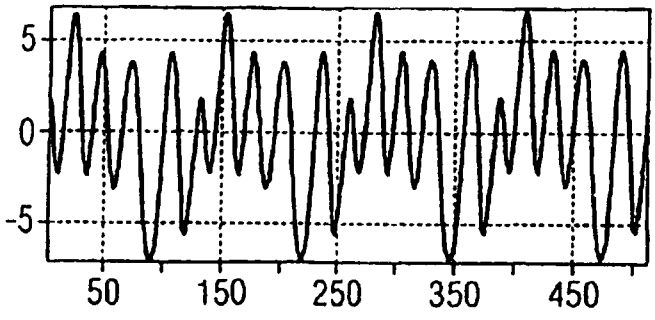

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FIG 9a

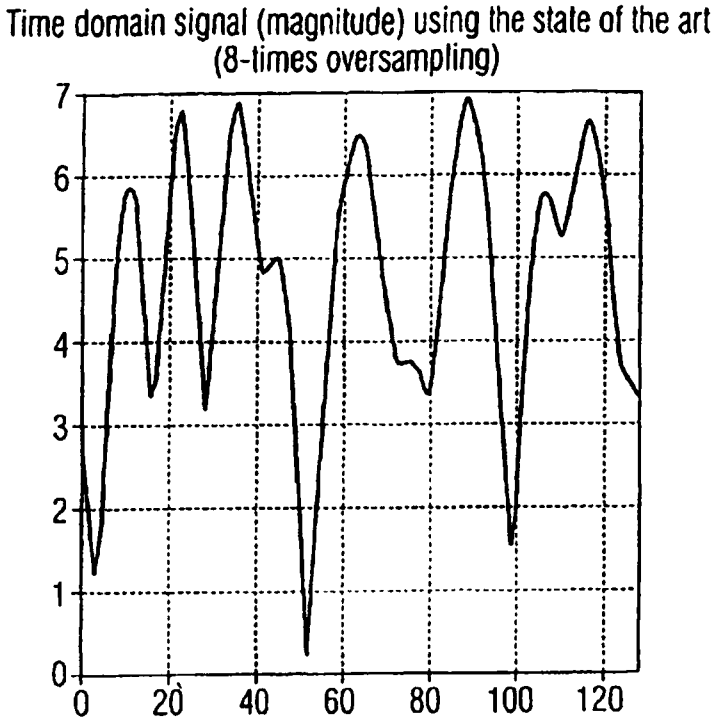

FIG 9b

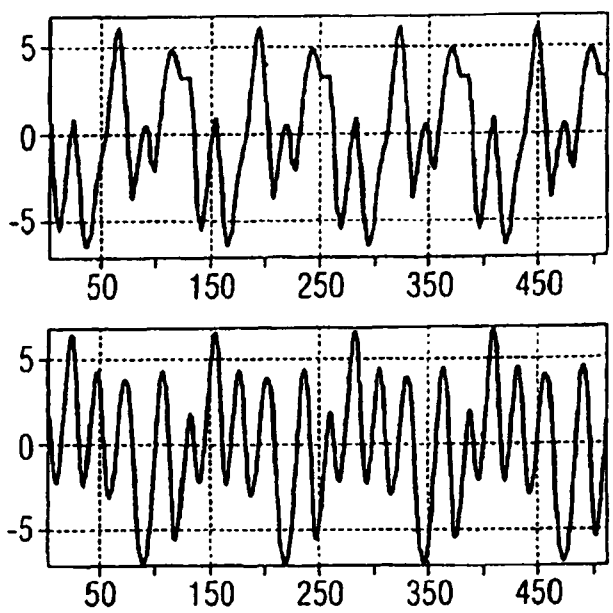

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FIG 10a

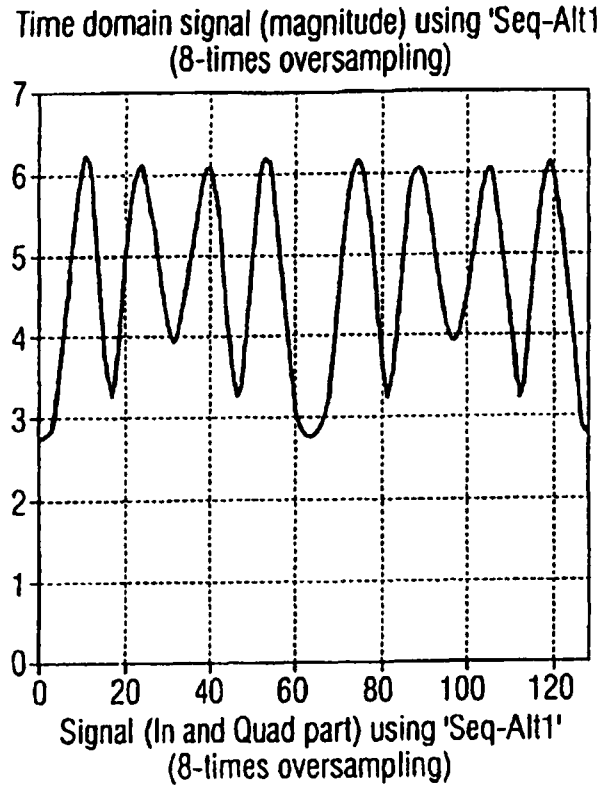
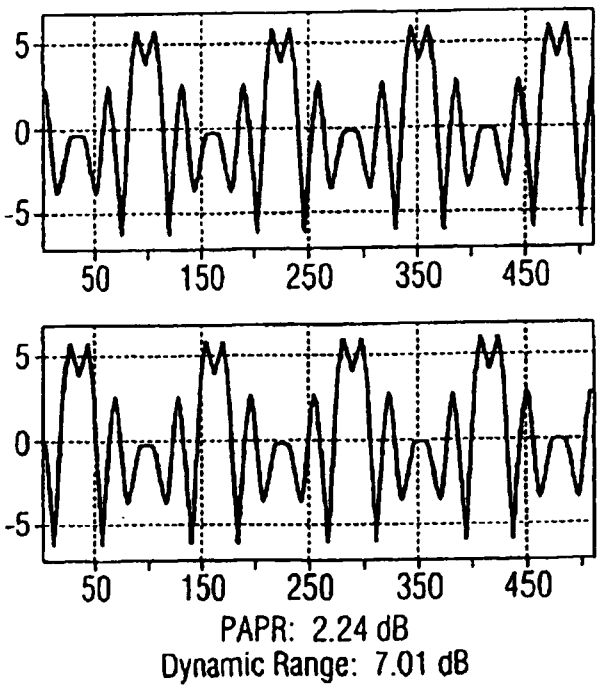


FIG 10b



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SYNCHRONIZATION SYMBOL STRUCTURE USING OFDM BASED TRANSMISSION METHOD

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.

The present invention relates to a method for generating synchronization bursts for OFDM transmission systems, a method for synchronizing wireless OFDM systems, an OFDM transmitter as well as to a mobile communications device comprising such a transmitter.

The present invention relates generally to the technical field of synchronizing wireless OFDM (orthogonal frequency division multiplexing) systems. Thereby it is known to use a synchronization burst constructed using especially designed OFDM symbols and time domain repetitions.

Particularly from the document IEEE P802.11a/d2.0 "Draft supplement to a standard for telecommunications and information exchange between systems—LAN/MAN specific requirements—part 1: wireless medium access control (MAC) and physical layer (PHY) specifications: high-speed physical layer in the 5 GHz band" a synchronization scheme for OFDM systems is proposed. This document is herewith included by reference as far as it concerns the synchronization including the proposed implementation. Said known scheme will now be explained with reference to FIG. 6 to 8 of the enclosed drawings.

FIG. 6 shows the structure of the known synchronization field. As shown in FIG. 6 the synchronization field consists of so-called short symbols t1, t2, . . . t6 and two long symbols T1, T2. In view of the present invention particularly the short symbols t1, t2 . . . t6 are of interest. Among the short symbols t1, t2, . . . t6 used for the amplifier gain control (t1, t2, t3) and the course frequency offset and timing control only the symbols t1, t2, t3 and t4 are actually generated, whereas the symbols t5, t6 are cyclic extensions (copies of the symbols t1 and t2, respectively). It is to be noted that FIG. 5 shows only the synchronization preamble structure as the structure of the following signal field indicating the type of baseband modulation and the coding rate as well as the structure of further following data fields are not of interest in view of the present invention. For further details reference is made to said prior art document.

The symbols t1, t2, t3, t4 are generated by means of an OFDM modulation using selected subcarriers from the entire available subcarriers. The symbols used for the OFDM modulation as well as the mapping to the selected subcarriers will now be explained with reference to FIG. 6.

Each of the short OFDM symbols t1, . . . t6 is generated by using 12 modulated subcarriers phase-modulated by the elements of the symbol alphabet:

$S=\overline{2}(\pm 1 \pm j)$

The full sequence used for the OFDM modulation can be written as follows:

$$S_{-24,24}=\sqrt{2}*\{1+j,0,0,0,1+j,0,0,0,-1-j,0,0,0,-1-j,0,0,0,1-j,0,0,0,-1-j,0,0,0,0\ 0,0,0,1+j,0,0,0,1+j,0,0,0,-1-j,0,0,0,1+j,0,0,0,-1+j,0,0,0,1+j\}$$

The multiplication by a factor of $\sqrt{2}$ is in order to normalize the average power of the resulting OFDM symbol.

The signal can be written as:

$$s_{SHORT}(t) = w_{SHORT1}(t) \sum_{k=-N_2/2}^{N_2/2} S_k \exp(j2\pi k \Delta_F t)$$

The fact that only spectral lines of $S_{-24,\ 24}$ with indices which are a multiple of 4 have nonzero amplitude results in a periodicity of $T_{FFT}/4$=0.8 μsec. The interval $T_{TSHORT1}$ is equal to nine 0.8 μsec periods, i.e. 7.2 μsec.

Applying a 64-point IFFT to the vector S, where the remaining 15 values are set to zero, four short training symbols t1, t2, t3, t4 (in the time domain) can be generated. The IFFT output is cyclically extended to result in 6 short symbols t1, t2, t3, . . . t6. The mapping scheme is depicted in FIG. 7. The so called virtual subcarriers are left unmodulated.

The way to implement the inverse Fourier transform is by an IFFT (Inverse Fast Fourier Transform) algorithm. If, for example, a 64 point IFFT is used, the coefficients 1 to 24 are mapped to same numbered IFFT inputs, while the coefficients −24 to −1 are copied into IFFT inputs 40 to 63. The rest of the inputs, 25 to 39 and the 0 (DC) input, are set to zero. This mapping is illustrated in FIG. 7. After performing an IFFT the output is cyclically extended to the desired length.

With the proposed inverse fast Fourier transform (IFFT) mapping as shown in FIG. 7 the resulting time domain signal consists of 4 periodically repeated short symbols t1, t2, t3, t4, and cyclically extended by a copy of t1, t2, which copy is depicted in FIG. 5 as t5, t6. Note that in the present case only spectral lines with indices which are a multiple of 4 have nonzero amplitude. Other periodic natures can be generated by setting other multiples of the spectral lines to nonzero amplitudes.

Though the known synchronization scheme is very effective, it provides for disadvantage regarding the time domain signal properties.

For OFDM (or in general multicarrier signals) the signal envelope fluctuation (named Peak-to-Average-Power-Ratio=PAPR) is of great concern. A large PAPR results in poor transmission (due to nonlinear distortion effects of the power amplifier) and other signal limiting components in the transmission system (e.g. limited dynamic range of the AD converter).

For synchronization sequences it is even more desirable to have signals with a low PAPR in order to accelerate the receiver-AGC (automatic gain control) locking and adjusting the reference signal value for the A/D converter (the whole dynamic range of the incoming signal should be covered by the A/D converter resolution without any overflow/underflow).

FIGS. 8a, 8b show the "absolute" (sqrt{In*+Quad*Quad}) value of the resulting time domain signal waveform with the sequences proposed by Lucent Technologies. Oversampling (8*) was considered in order to ensure the peak was captured correctly using the limited 64-point IFFT.

FIGS. 8c, 8d show the real and imaginary part of the resulting transmitted time domain waveform. The resulting PAPR is 2.9991 dB (no oversampling) and 3.0093 dB (with 8 times oversampling).

Therefore it is the object of the present invention to provide for a synchronization technique which bases on the known synchronization technique but which presents improved time domain signal properties to reduce the requirements for the hardware.

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The above object is achieved by means of the features of the independent claims. The dependent claims develop further the central idea of the present invention.

According to the present invention therefore a method for generating synchronization bursts for OFDM transmission systems is provided. Symbols of a predefined symbol sequence are mapped according to a predefined mapping scheme on subcarriers of the OFDM system wherein the symbols of the predefined symbol sequence represent subcarriers with nonzero amplitudes. A synchronization burst is generated by inverse fast Fourier transforming the subcarriers mapped with a predefined symbol sequence. According to the present invention the predefined symbol sequence is optimized such that the envelope fluctuation of the time domain signal (Peak-to-average-power-ratio) is minimized.

The predefined symbol sequence can be chosen such that the following equations are satisfied for all symbols of the predefined symbol sequence:

$$n=2m,$$

$$C_{i-1}=\pm C_{1-i},$$

n being the number of symbols of the predefined symbol sequence,

m being an integer larger than one,

C being the symbol value, and

i being an integer running from 1 to m.

The mapping of the symbols of the predefined symbol sequence and the Inverse Fast Fourier Transform can be set such that the resulting time domain signal of the synchronization burst represents a periodic nature.

Alternatively the mapping of the symbols of the predefined symbol sequence and the Inverse Fast Fourier Transform is set such that one burst part of the synchronization burst in the time domain is generated and the periodic nature of the synchronization burst in the time domain is achieved by copying the one burst part.

The number of symbols of a symbol sequence (n) can for example be 12.

The above equations define generally the symbol sequences according to the present invention. The predefined symbol sequence can therefore be for example:

A A A –A –A –A –A A –A –A A –A,

wherein A is a complex value.

Alternatively the predefined symbol sequence can be:

A –A A A –A A A A A –A –A –A,

wherein A is a complex value.

Alternatively the following predefined symbol sequence can be used:

A B –A B –A –B B A –B A –B –A,

wherein A, B are complex values.

As a further alternative the following sequence can be used:

A –B –A –B –A B –B A B A B –A,

wherein A, B are complex values.

According to the present invention furthermore a method for synchronizing wireless OFDM systems is provided, wherein a synchronization burst is generated according to a method as set forth above and the synchronization burst is transmitted respectively before the transmission of data fields.

Thereby the time domain signals of the synchronization burst can be precomputed and stored in a memory, such that the computation of the time domain signal of the burst is only effected once.

According to the present invention furthermore a OFDM transmitter is provided comprising a mapping unit for mapping the symbols of a predefined symbols sequence according to a predefined mapping scheme on subcarriers of the OFDM system, wherein the symbols of a predefined symbols sequence represent the subcarriers of the OFDM system with nonzero amplitudes. Furthermore an inverse fast Fourier transforming unit is provided for generating a synchronization burst by inverse fast Fourier transforming the subcarriers of the OFDM mapped with said predefined symbols sequence. The mapping unit thereby is designed such that the resulting time domain signal of the synchronization burst represents a periodic nature. The mapping unit according to the present invention uses a predefined symbol sequence which is such that the envelope fluctuation of the time domain signal of the synchronization burst is minimized.

According to the present invention furthermore a mobile communications device such as set forth above is used.

With reference to the figures of the enclosed drawings referred embodiments of the present invention will now be explained.

FIG. **1** shows schematically a transmitter according to the present invention,

FIG. **2** shows an alternative embodiment for a transmitter according to the present invention,

FIG. **3** shows an alternative mapping scheme according to the present invention,

FIGS. **4**a to **4**d show the time domain signal properties achieved with the synchronization symbol structure using OFDM based transmission according to the present invention,

FIGS. **5**a to **5**d show the time domain signal properties of synchronization symbol structures according to alternative embodiments of the present invention,

FIG. **6** shows a synchronization preamble structure known from the prior art,

FIG. **7** shows an IFFT mapping according to the prior art, and

FIGS. **8**a to **8**d show the time domain properties of the synchronization symbol structure according to the prior art,

FIGS. **9**a and **9**b show the time domain properties, particularly the dynamic range of the synchronization symbol structure according to the prior art, and

FIGS. **10**a and **10**b show the time domain properties of the synchronization symbol structure according to further alternative embodiments of the present invention,

According to the present invention the time domain synchronization burst structure as shown in FIG. **6** is maintained. The IFFT mapping as shown in FIG. **7** can be maintained or alternatively the IFFT mapping according to FIG. **3** can be used. The symbol sequences mapped to the subcarriers are optimized to sequences which result in a lower PAPR.

According to the present invention a short OFDM symbol (**t1**, . . . **t6**) consists of 12 phase-modulated subcarriers.

	C00	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11
Seq0	A	A	A	–A	–A	–A	–A	A	–A	–A	A	–A
Seq1	A	–A	A	A	–A	A	A	A	A	–A	–A	–A

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-continued

	C00	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11
Seq2	A	B	-A	B	-A	-B	B	A	-B	A	-B	-A
Seq3	A	-B	-A	-B	-A	B	-B	A	B	A	B	-A

with

$$A = \exp(j*2+\pi*\varphi_A) \text{ and}$$

$$B = A*\exp\left(j\frac{\pi}{2}\right) = \exp\left(j2\pi*\varphi_A + j\frac{\pi}{2}\right) \text{ and } 0.0 \le \varphi_A < 1.0.$$

Generally the predefined symbol sequence therefore is chosen such that the envelope fluctuation of the time domain signal of the synchronization burst is minimized.

Therefore generally the predefined symbol sequence is set such that the following equations are satisfied for all symbols for the predefined symbol sequence:

$$n=2m,$$

$$C_{i-1}=\pm C_{n-i}$$

wherein n is a number of symbols of the predefined symbol sequence,

m is an integer larger than 1,

c is the symbol value, and

i is an integer value running from 1 to m.

In the following the time domain signal properties of the new sequences according to the present invention will be shown with reference to FIGS. 4a to 4d and FIGS. 5a to 5d.

For simplicity we use in our demonstration the classical quadriphase symbol alphabet,

$$S = \sqrt{\frac{1}{2}}(\pm 1 \pm j).$$

(this corresponds to ϕ_A=0.125)

Symbol		
A	$\exp\left(j\frac{\pi}{4}\right)$	$\sqrt{\frac{1}{2}}(+1+j)$
-A	$-\exp\left(j\frac{\pi}{4}\right) = \exp\left(j\frac{5\pi}{4}\right)$	$\sqrt{\frac{1}{2}}(-1-j)$
B	$\exp\left(j\frac{\pi}{4}+j\frac{\pi}{2}\right) = \exp\left(j\frac{3\pi}{4}\right)$	$\sqrt{\frac{1}{2}}(-1+j)$
-B	$-\exp\left(j\frac{3\pi}{4}\right) = \exp\left(j\frac{7\pi}{4}\right)$	$\sqrt{\frac{1}{2}}(+1-j)$

Table 1: Complex symbol mapping

FIGS. 5a and 5b thereby show the time domain signal (magnitude) when using the optimized sequence according to the present invention in the case of no oversampling/8-times oversampling is effected.

PAPR (in decibel) is limited to 2.059 (even when using a time domain oversampling to capture the actual peak).

FIGS. 5c and 5d show the in-phase and quadrature-phase component, respectively, of the resulting wave form. It is clearly visible that the full symbol consists of four repetitions of a short sequence.

FIGS. 5a to 5d show graphics corresponding to FIGS. 4a to 4d for the other proposed sequences S1, S2 and S3.

Further simulations have shown that not only the PAPR can be optimized but also the dynamic range of the signal should be minimized. Therefore another four sequences, with achieve a small PAPR and at the same time a small overall dynamic range are proposed further below.

Using the sequence as proposed in the state of the art the PAPR is 3.01 dB and the dynamic range (defined as the ratio of the peak power to the minimum power) is 30.82 dB (see FIGS. 9a and 9b).

Using the sequences according to the present invention and as described above the PAPR is reduced to 2.06 dB, however, the dynamic range is increased as the signal power is '0' at some points.

Therefore the following four sequences are proposed as a further embodiment of the present invention:

The symbol sequence is C0, C1, . . . C11 and the mapping is:

S=2*{C00, 0, 0, 0, C01, 0, 0, 0, C02, 0, 0, 0, C03, 0, 0, 0, C04, 0, 0, 0, C05, 0, 0, 0, 0, 0, 0, C06, 0, 0, 0, C07, 0, 0, 0, C08, 0, 0, 0, C09, 0, 0, 0, C10, 0, 0, 0, C11}

	C00	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11
Seq-Alt0	A	A	A	A	-A	-A	A	-A	-A	A	-A	A
Seq-Alt1	A	-A	A	-A	-A	A	-A	-A	A	A	A	A
Seq-Alt2	A	B	-A	-B	-A	-B	-B	-A	-B	-A	B	A
Seq-Alt3	A	-B	-A	B	-A	B	B	-A	B	-A	-B	A

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with A=exp (i*2*π*ϕ_A) and

$$B = A * \exp(j\frac{\pi}{2}) = \exp(j2\pi * \varphi_A + j\frac{\pi}{2})$$

and $0.0 \leqq \phi_A < 1.0$.

Using these sequences the PAPR is reduced to 2.24 dB and the dynamic range is limited to 7.01 dB as it is shown in FIGS. **10**a and **10**b.

The advantages are the same as described before, however, the clipping problem is further reduced due to the very limited dynamic range of the signal.

With reference to FIG. **1** and **2** possible implementations of a transmitter according to the present invention will now be explained.

In the transmitter the sync symbol data **1** are prepared and mapped in a IFFT mapping unit **2** to the appropriate IFFT points. The subcarriers of the OFDM system are transformed by a IFFT unit **3** and then the time domain signal is extended in a time extension unit **4** by copying parts of the signals (for example, t1, t2 are copied to t5, t6). The time extended signal is then sent to the I/Q modulator **5**.

As shown in FIG. **2** alternatively the time domain signal can be precomputed once in a computation unit **7** and then be stored in a memory **6** for the precomputed sample for the time signal. Then the time domain signal of the synchronization burst can be sent to the modulator **5** directly from the memory **6**.

With reference to FIG. **3** a modified IFFT mapping scheme will now be explained.

According to this scheme, the principle of setting only every fourth subcarrier of the OFDM system to a non-zero amplitude (see FIG. **7**) is abandoned. Therefore the time domain signal achieved according to the mapping scheme of FIG. **3** will not present a periodic nature.

The IFFT size is now only 16 (instead of 64 as it is the case in FIG. **7**). Only one of the bursts t1, t2, . . . t6 will be generated. The other bursts can be generated by copying to retain the periodic nature of the synchronization time domain signal necessary for the correlation and synchronization on the receiving side. Therefore for example the time extension unit **4** can perform the copying of the 16-sample burst t1 generated by the IFFT **16** according to FIG. **7** to the other burst t2, t3, . . . t6. Obviously the mapping scheme according to FIG. **3** reduces the computing effort necessary for the IFFT. The periodic nature of the time domain signal of the SYNCH bursts is therefore no longer achieved by the IFFT step, but by copying the burst t1 generated with the simplified IFFT mapping scheme.

The mapping scheme shown in FIG. **3** is also advantageous in combination with the precomputing technique shown in FIG. **2**.

According to the present invention therefore a synchronization burst structure to be used in high speed wireless transmission systems is proposed. The synchronization burst is constructed using especially designed OFDM symbols and time domain repetitions. The resulting synchronization burst achieves a high timing detection and frequency offset estimation accuracy. Furthermore the burst is optimized to achieve a very low envelope fluctuation (Low peak-to-average-power-ratio) to reduce the complexity on the receive and to reduce time and frequency acquisition time at the receiver.

Therefore the synchronization performance can further be improved. As with the scheme according to the present invention the envelope of the OFDM based synchronization burst in the time domain is reduced, the AGC pool-in speed at the receiver can be improved and an accurate time and frequency synchronization can be achieved. Furthermore the synchronization complexity on the receiver side can be reduced due to the reduced resolution requirements necessary due to reduced envelope fluctuation.

The advantages of the present invention can be set forth as following:

- An OFDM based SYNCH symbol with a reduced Peak-to-Average-Power-Ratio (PARP) is proposed,
- Improved synchronization performance (compared to the state of the art proposal),
- Reduced AGC (automatic gain control) pull-in time due to reduced dynamic range of the SYNCH burst,
- Improved AGC settlement (AGC has to adjust to a incoming signal level that later on now overflow/underflow in the AD happens. The reduced dynamic range of the SYNCH burst help to find this reference level more accurate),
- Reduced synchronization detection complexity on the receiver (reduced resolution necessary due to reduced envelope fluctuation).

What is claimed is:

1. A method for generating synchronization bursts for OFDM transmission systems, comprising the following steps:

mapping the symbols of a predefined symbol sequence according to a predefined mapping scheme on subcarriers S of the OFDM system, wherein the symbols of the predefined symbol sequence represent subcarriers of the OFDM system with non-zero-amplitude, and

generating a synchronization burst by Inverse Fourier Transforming the subcarriers S of the OFDM system mapped with the symbols of said predefined symbol sequence,

characterized in that

the predefined symbol sequence is set such that the envelope fluctuation of the time domain signal of the synchronization burst is minimized and the symbols of the predefined symbols sequence can be expressed as

A –A A –A –A A –A –A A A A A

A being a complex value.

2. A method for synchronizing wireless OFDM systems, characterized by the steps of

generating a synchronization burst according to a method according to claim **1**, and

transmitting the synchronization burst.

3. A method according to claim **2**, characterized in that

the time domain signal of the synchronization burst is precomputed and stored in a memory.

4. An OFDM transmitter, comprising:

a unit for mapping the symbols of a predefined symbol sequence according to a predefined mapping scheme on subcarriers of the OFDM system, wherein the symbols of the predefined symbol sequence represent subcarriers of the OFDM system with non-zero-amplitude, and

a unit for generating a synchronization burst by Inverse Fourier Transforming the subcarriers of the OFDM system mapped with the symbols of said predefined symbol sequence,

characterized in that

the mapping unit is designed to modulate the subcarriers such that the envelope fluctuation of the time domain signal of the synchronization burst is minimized by using the following predefined symbol sequence:

A –A A –A –A A –A –A A A A A

A being a complex value.

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5. An OFDM transmitter according to claim 4, characterized by

a time extension unit copying the burst part to achieve a periodic nature of the time domain signal.

6. An OFDM transmitter according to claim 4, characterized by

a processing unit for precomputing the time domain signal of the synchronization burst

and a memory for storing the precomputed time domain signal of the synchronization burst.

7. A mobile communications device, comprising a transmitter according to claim 4.

8. A synchronization burst signal for synchronizing OFDM systems generated by a method according to claim 1.

9. A method for generating a synchronization signal by using a plurality of subcarriers for an OFDM transmission system, comprising the steps of:

mapping symbols of a predefined symbol sequence in accordance with a predefined mapping scheme on said plurality of subcarriers, wherein pre-selected twelve symbols of the predefined symbol sequence have non-zero values, and

generating a synchronization signal by Inverse Fourier Transforming said plurality of subcarriers mapped with the symbols of said predefined symbol sequence,

wherein the symbols of the predefined symbols sequence are expressed as

A –A A –A –A A –A –A A A A A

A being a complex value.

10. A method for generating a synchronization signal by using a plurality of subcarriers in an OFDM transmission system, comprising the steps of:

generating a predefined symbol sequence having at least twelve symbols corresponding to respective pre-selected ones of said plurality of subcarriers, and

generating said synchronization signal in time domain by performing Inverse Fourier Transforming on said pre-selected ones of said plurality of subcarriers,

wherein said twelve symbols are set to nonzero having complex values and others of said symbols are set to zero, such that said twelve symbols are arranged periodically in said predefined symbol sequence in the frequency domain, and

wherein said symbol sequence of said twelve symbols is A –A A –A –A A –A –A A A A A, where A is a complex value.

11. A method for generating a synchronization signal by using a plurality of subcarriers in an OFDM transmission system, comprising the steps of:

generating a predefined symbol sequence having twelve symbols each set to a non-zero value and a plurality of further symbols each set to a zero value, wherein each of said symbols is mapped respectively on a predefined subcarrier of said plurality of subcarriers, and

generating said synchronization signal in time domain by performing Inverse Fourier Transforming on said plurality of subcarriers mapped with said predefined symbol sequence,

wherein said twelve symbols of the predefined symbol sequence is expressed as

A –A A –A –A A –A –A A A A A

A being a complex value.

12. A method for transmitting OFDM data signals in an OFDM transmission system, comprising the steps of:

receiving a plurality of subcarriers on which a predefined symbol sequence is mapped, said predefined symbol sequence having twelve symbols set to non-zero values and other symbols set to zero values, and wherein said twelve symbols of said predefined symbols sequence are expressed as

A –A A –A –A A –A –A A A A A

A being a complex value,

generating a synchronization signal in time domain by performing Inverse Fourier Transforming on said plurality of subcarriers, and

transmitting said synchronization signals and said OFDM data signals.

13. A method for transmitting OFDM data signals in an OFDM transmission system, comprising the steps of:

receiving a plurality of subcarriers on which a predefined symbol sequence is mapped,

generating a synchronization signal in time domain by performing Inverse Fourier Transforming on said plurality of subcarriers, and

transmitting said synchronization signals and said OFDM data signals,

wherein said predefined symbol sequence has twelve symbols having complex value and said twelve symbols of said predefined symbols sequence can be expressed as

A –A A –A –A A –A –A A A A A

wherein twelve symbols are arranged in said predefined symbol sequence such that every fourth subcarrier among said plurality of subcarriers has non-zero amplitude.

14. A method for transmitting OFDM data signals in an OFDM transmission system, comprising the steps of:

generating synchronization signals in time domain by performing Inverse Fourier Transforming on a plurality of subcarriers on which a predefined symbol sequence is mapped in accordance with a predefined mapping scheme, and

transmitting said synchronization signals and said OFDM data signals,

wherein said predefined symbol sequence contains the following symbol sequence comprising twelve complex values:

A –A A –A –A A –A –A A A A A

wherein said twelve symbols are mapped on every fourth subcarriers of said plurality of subcarriers.

15. Apparatus for generating a synchronization signal by using a plurality of subcarriers for an OFDM transmission system, comprising:

a unit mapping symbols of a predefined symbol sequence in accordance with a predefined mapping scheme on said plurality of subcarriers, wherein pre-selected twelve symbols of the predefined symbol sequence have non-zero values, and

a unit for generating a synchronization signal by Inverse Fourier Transforming said plurality of subcarriers mapped with the symbols of said predefined symbol sequence,

wherein the symbols of the predefined symbols sequence are expressed as

A –A A –A –A A –A –A A A A A

A being a complex value.

16. Apparatus for generating a synchronization signal by using a plurality of subcarriers in an OFDM transmission system, comprising

a unit for generating a predefined symbol sequence having at least twelve symbols corresponding to respective pre-selected ones of said plurality of subcarriers, and

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a unit for generating said synchronization signal in time domain by performing Inverse Fourier Transforming on said preselected ones of said plurality of subcarriers,

wherein said twelve symbols are set to nonzero having complex values and others of said symbols are set to zero, such that said twelve symbols are arranged periodically in said predefined symbol sequence in the frequency domain, and

wherein said symbol sequence of said twelve symbols is A −A A −A −A A −A −A A A A A, where A is a complex value.

17. Apparatus for generating a synchronization signal by using a plurality of subcarriers in an OFDM transmission system, comprising:

a unit for generating a predefined symbol sequence having twelve symbols each set to a non-zero value and a plurality of further symbols each set to a zero value, wherein each of said symbols is mapped respectively on a predefined subcarrier of said plurality of subcarriers, and

a unit for generating said synchronization signal in time domain by performing Inverse Fourier Transforming on said plurality of subcarriers mapped with said predefined symbol sequence,

wherein said twelve symbols of the predefined symbol sequence is expressed as

A −A A −A −A A −A −A A A A A

A being a complex value.

18. Apparatus for transmitting OFDM data signals in an OFDM transmission system, comprising:

a unit for receiving a plurality of subcarriers on which a predefined symbol sequence is mapped, said predefined symbol sequence having twelve symbols set to non-zero values and other symbols set to zero values, and wherein said twelve symbols of said predefined symbols sequence are expressed as

A −A A −A −A A −A −A A A A A

A being a complex value,

a unit for generating a synchronization signal in time domain by performing Inverse Fourier Transforming on said plurality of subcarriers, and

a transmitter for transmitting said synchronization signals and said OFDM data signals.

19. Apparatus for transmitting OFDM data signals in an OFDM transmission system, comprising:

a unit for receiving a plurality of subcarriers on which a predefined symbol sequence is mapped,

a unit for generating a synchronization signal in time domain by performing Inverse Fourier Transforming on said plurality of subcarriers, and

a transmitter for transmitting said synchronization signals and said OFDM data signals,

wherein said predefined symbol sequence has twelve symbols having complex value and said twelve symbols of said predefined symbols sequence can be expressed as

A −A A −A −A A −A −A A A A A

wherein twelve symbols are arranged in said predefined symbol sequence such that every fourth subcarrier among said plurality of subcarriers has non-zero amplitude.

20. Apparatus for transmitting OFDM data signals in an OFDM transmission system, comprising:

a unit for generating synchronization signals in time domain by performing Inverse Fourier Transforming on

a plurality of subcarriers on which a predefined symbol sequence is mapped in accordance with a predefined mapping scheme, and

a transmitter for transmitting said synchronization signals and said OFDM data signals,

wherein said predefined symbol sequence contains the following symbol sequence comprising twelve complex values:

A −A A −A −A A −A −A A A A A

wherein said twelve symbols are mapped on every fourth subcarriers of said plurality of subcarriers.

21. A method for synchronizing a wireless communication device in an OFDM communication system, comprising the steps of:

receiving data signals and a synchronization signal exhibiting periodicity, the data signals and synchronization signal being transmitted from a transmitter side by using a plurality of subcarriers, said synchronization signal being based on a predefined symbol sequence having twelve complex value symbols with the symbol sequence

A −A A −A −A A −A −A A A A A

wherein A is a complex value, and

wherein said twelve symbols are mapped on every fourth subcarrier of said plurality of subcarriers so that said periodic nature of synchronization signal contains four repetitions of one synchronization signal in time domain; and

performing time and frequency synchronization in accordance with said periodicity of synchronization signal.

22. A method for synchronizing a wireless communication device in an OFDM communication system, comprising the steps of:

receiving data and synchronization signals transmitted from a transmitter side by using a plurality of subcarriers, and

performing time and frequency synchronization in accordance with said synchronization signal;

wherein said synchronization signal is generated based on a predefined symbol sequence comprising twelve symbols having complex values and a sequence of said twelve symbols is expressed as

A −A A −A −A A −A −A A A A A

wherein A is a complex value.

23. A method for synchronizing a wireless communication device in an OFDM communication system, comprising the steps of:

receiving data and synchronization signals transmitted from a transmitter side by using a plurality of subcarriers, and

performing time and frequency synchronization in accordance with said synchronization signal;

wherein said synchronization signal is generated based on a predefined symbol sequence comprising twelve non-zero symbols having complex value and other symbols being set to zero so that said twelve symbols are arranged with periodicity in said predefined symbol sequence in the frequency domain, and

wherein a sequence of said twelve symbols in the frequency domain is

A −A A −A −A A −A −A A A A A

wherein A is a complex value.

24. A method for synchronizing a wireless communication device in an OFDM communication system, comprising the steps of:

receiving data and synchronization signals transmitted from a transmitter side by using a plurality of subcarriers, and

performing time and frequency synchronization in accordance with said synchronization signal;

wherein said synchronization signal is based on a predefined symbol sequence comprised of twelve symbols having complex value, said twelve symbols being expressed as

A −A A −A −A A −A −A A A A A

wherein A is a complex value and

wherein the twelve symbols are arranged such that every fourth subcarrier among said plurality of subcarriers has non-zero amplitude.

25. A method for transmitting data signals in an OFDM transmission system, comprising the steps of:

generating a predefined symbol sequence comprised of a plurality of complex value symbols mapped on a plurality of subcarriers,

generating a synchronization signal by supplying said plurality of subcarriers having non-zero amplitude to an inverse Fourier Transform unit, such that said plurality of subcarriers mapped with said predefined symbol sequence are transformed into a time domain signal to generate only one synchronization signal,

copying said one synchronization signal to generate other synchronization signals in the time domain; and

transmitting said generated synchronization signals and said data signals.

26. The method according to claim 25,

wherein the symbols of said predefined symbol sequence are expressed by C_{i-1} or C_{n-i}, wherein:

n is the number of symbols of said predefined symbol sequence,

m is a half value of n,

i is an integer running from 1 to m

wherein said symbols expressed by C_{i-1} are supplied to one set of inputs of said inverse Fourier transform unit, and said symbols expressed by C_{n-i} are supplied to another set of said inputs of said inverse Fourier transform unit.

27. A method for transmitting data signals in an OFDM transmission system, comprising the steps of:

receiving a plurality of subcarriers on which a predefined symbol sequence is mapped, said predefined symbol sequence being formed of a plurality of symbols set to complex values,

transforming said plurality of subcarriers, of non-zero amplitude, mapped with said predefined symbol sequence into a time domain signal using inverse Fourier transformation, so as to generate only one synchronization signal,

copying said one synchronization signal in the time domain to provide a synchronization signal with periodicity, and

transmitting said provided synchronization signal and said data signals.

28. A method for transmitting data signals in an OFDM transmission system, comprising the steps of:

receiving a plurality of subcarriers on which a predefined symbol sequence is mapped, said predefined symbol sequence being formed of a plurality of symbols set to complex values,

transforming said plurality of subcarriers, set to non-zero amplitude, mapped with said predefined symbol sequence into a time domain signal by using Inverse

Fourier Transformation, to generate only one synchronization signal,

copying said one synchronization signal to generate other synchronization signals in the time domain; and

transmitting said generated synchronization signals and said data signals.

29. A method for transmitting OFDM data signals in an OFDM transmission system, comprising the steps of:

generating one synchronization signal in the time domain by performing Inverse Fourier Transformation on a plurality of subcarriers on which a predefined symbol sequence is mapped in accordance with a predefined mapping scheme, wherein all symbols of said predefined symbol sequence are set to complex values,

generating a synchronization signal of periodicity by copying said one synchronization signal in the time domain, and

transmitting said synchronization signal of periodicity and said OFDM data signals.

30. A method for transmitting OFDM data signals in an OFDM transmission system, comprising the steps of:

generating a predefined symbol sequence having at least twelve non-zero complex value symbols, each of said twelve symbols being mapped in a periodic manner on a plurality of pre-selected subcarriers in the frequency domain,

generating a time domain signal by performing Inverse Fourier transformation on said plurality of pre-selected subcarriers mapped with said predefined symbol sequence,

said predefined symbol sequence conforming with the following equations for all symbols of said predefined symbol sequence:

$$n=2m,$$

$$C_{i-1}=\pm C_{n-i}$$

wherein:

n is the number of symbols of said predefined symbol sequence,

m is an integer larger than one,

C is the symbol value, and

i is an integer from 1 to m.

31. A method for transmitting OFDM data signals by using a plurality of subcarriers in an OFDM transmission system, comprising the steps of:

generating a predefined symbol sequence having at least twelve symbols corresponding to respective pre-selected ones of said plurality of subcarriers,

generating a time domain signal by performing Inverse Fourier transformation on said plurality of pre-selected subcarriers corresponding to the symbols of said predefined symbol sequence,

wherein each of twelve symbols is set to a nonzero complex value and said predefined symbol sequence has a binary symbol sequence expressed by A and −A, where A is a complex value, and wherein said predefined symbol sequence satisfies the following equations for all symbols of said predefined symbol sequence:

$$n=2m,$$

$$C_{i-1}=\pm C_{n-i}$$

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wherein:

n is the number of symbols of said predefined symbol sequence,

m is an integer larger than one,

C is the symbol value, and

i is an integer from 1 to m.

32. A method for transmitting OFDM data signals by using a plurality of subcarriers in an OFDM transmission system, comprising the steps of:

generating a predefined symbol sequence having at least twelve symbols corresponding to respective pre-selected subcarriers of said plurality of subcarriers,

generating a time domain signal by performing Inverse Fourier transformation on said plurality of pre-selected subcarriers corresponding to the symbols of said predefined symbol sequence,

wherein each of said twelve symbols has a nonzero complex value expressed by A or −A, and wherein said predefined symbol sequence satisfies the following equations for all symbols of said predefined symbol sequence:

$$n=2m,$$

$$C_{i-1}=\pm C_{n-i}$$

wherein:

n is the number of symbols of said predefined symbol sequence,

m is an integer larger than one,

C is the symbol value, and

i is an integer from 1 to m.

33. A method for transmitting OFDM data signals by using a plurality of subcarriers in an OFDM transmission system, comprising the steps of:

generating a predefined symbol sequence having predefined symbols, each of said symbols being mapped on a respective predefined subcarrier, and

generating a time domain signal by Inverse Fourier Transforming said plurality of subcarriers mapped with the symbols of said predefined symbol sequence,

wherein said predefined symbols are set to nonzero complex values and have a binary sequence of symbol values expressed by A or −A,

wherein said predefined symbol sequence satisfies the following equations for all symbols of said predefined symbol sequence:

$$n=2m,$$

$$C_{i-1}=\pm C_{n-i}$$

wherein:

n is the number of symbols of said predefined symbol sequence,

m is an integer larger than one,

C is the symbol value, and

i is an integer from 1 to m.

34. A method for transmitting OFDM data signals in an OFDM transmission system, comprising the steps of:

mapping symbols of a predefined symbol sequence in accordance with a predefined mapping scheme on said plurality of subcarriers, wherein pre-selected symbols of the predefined symbol sequence have non-zero values, and

generating a time domain signal by Inverse Fourier Transforming said plurality of subcarriers mapped with the symbols of said predefined symbol sequence,

wherein said predefined symbol sequence satisfies the following equations for all symbols of said predefined symbol sequence:

$$n=2m,$$

$$C_{i-1}=\pm C_{n-i}$$

wherein:

n is the number of symbols of said predefined symbol sequence,

m is an integer larger than one,

C is the symbol value, and

i is an integer from 1 to m.

* * * * *

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EXHIBIT D

US007120137B2

(12) **United States Patent**
Take

(10) **Patent No.: US 7,120,137 B2**
(45) **Date of Patent: Oct. 10, 2006**

(54) **METHOD AND APPARATUS FOR ASSIGNING CODES**

(75) Inventor: **Keijiro Take**, Tokyo (JP)

(73) Assignee: **Mitsubishi Denki Kabushiki Kaisha**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/796,092**

(22) Filed: **Mar. 10, 2004**

(65) **Prior Publication Data**

US 2004/0170146 A1 Sep. 2, 2004

Related U.S. Application Data

(60) Division of application No. 10/013,451, filed on Dec. 13, 2001, which is a continuation of application No. 09/156,703, filed on Sep. 18, 1998, now Pat. No. 6,477,158.

(30) **Foreign Application Priority Data**

Mar. 16, 1998 (JP) 10-065434

(51) **Int. Cl.**
H04B 7/216 (2006.01)
H04J 3/06 (2006.01)

(52) **U.S. Cl.** **370/335**; 370/342; 370/350

(58) **Field of Classification Search** 370/320, 370/335, 342, 441, 479, 203, 350, 332, 508–510; 375/200

See application file for complete search history.

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Primary Examiner—Chi Pham
Assistant Examiner—Tri H. Phan
(74) *Attorney, Agent, or Firm*—Oblon, Spivak, McClelland, Maier & Neustadt, P.C.

(57) **ABSTRACT**

A base station controller selects codes corresponding to rate information included in a new starting call message from a mobile station, and further selects codes assignable to the mobile station out of the selected codes as candidate codes. Then, the base station controller detects codes which meet both the characteristics of being at upper level of the candidate codes in the tree structure and being assignable to other mobile station, and further detects levels of the detected codes. Detected levels for all the candidate codes are compared to find a candidate code whose level is the lowest and to assign the candidate code to the mobile station sending the new starting call message.

4 Claims, 17 Drawing Sheets

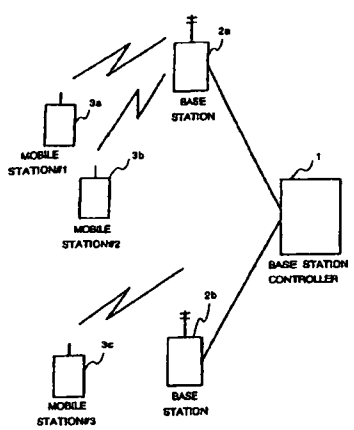

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Fig.1

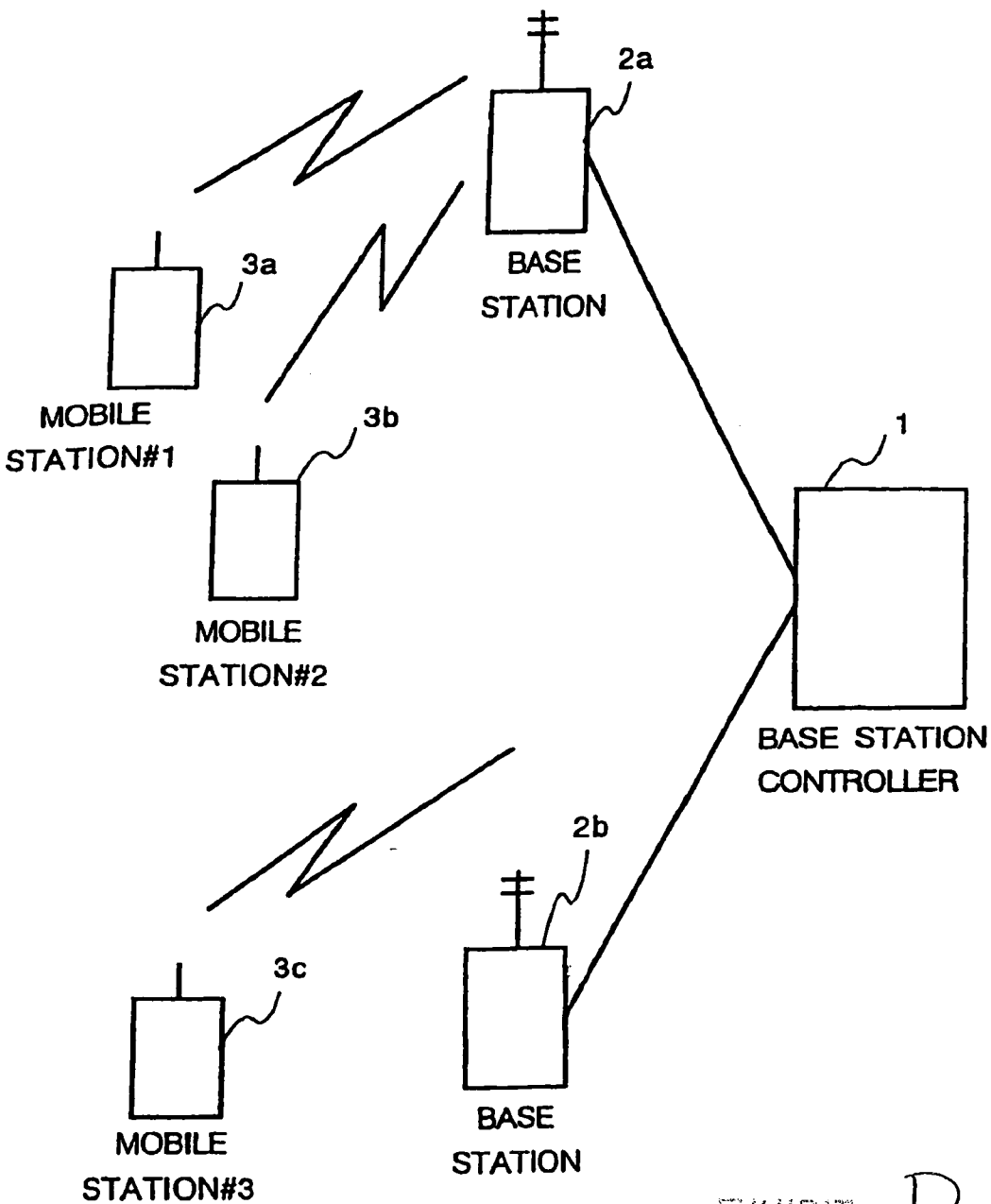

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Fig.2

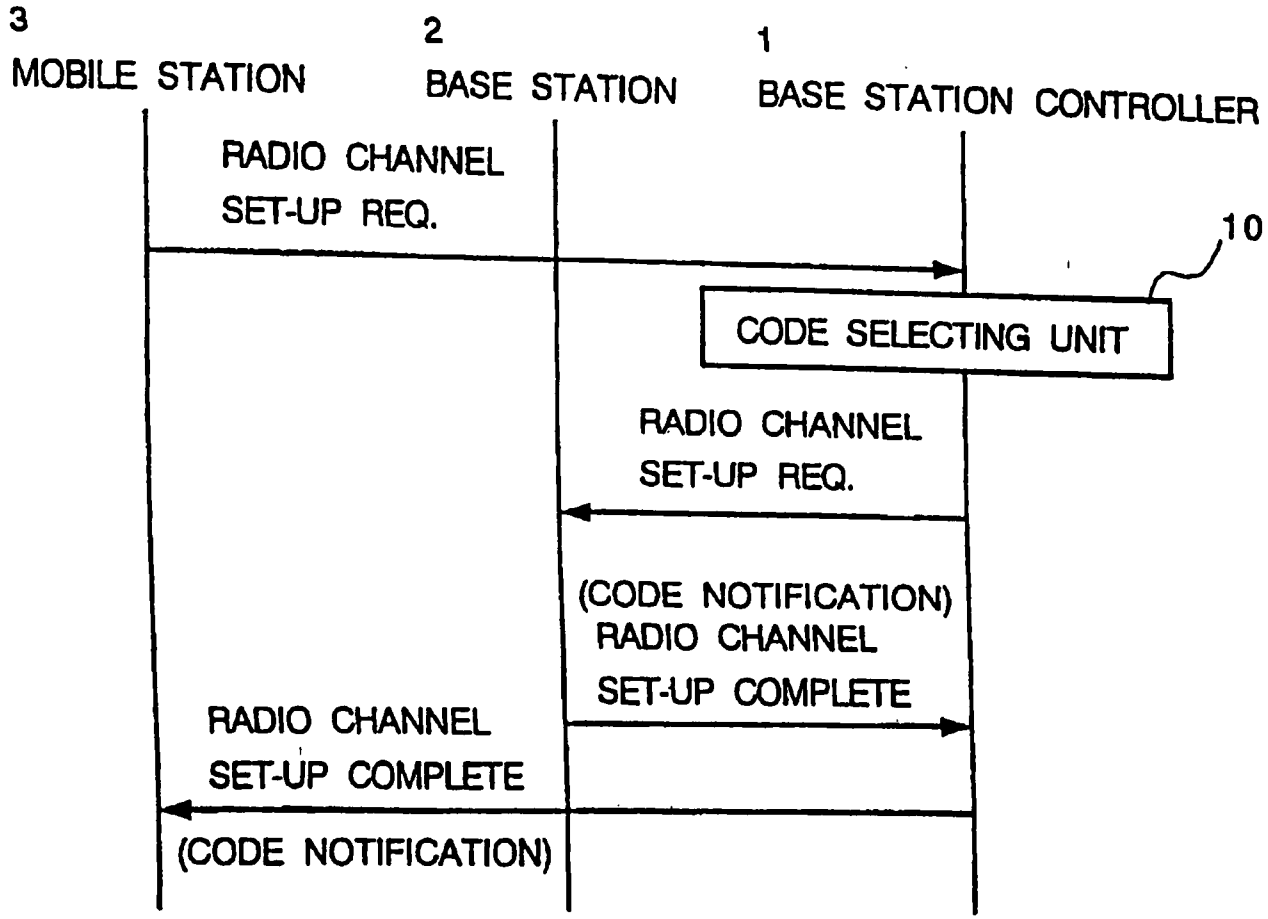

Fig.3

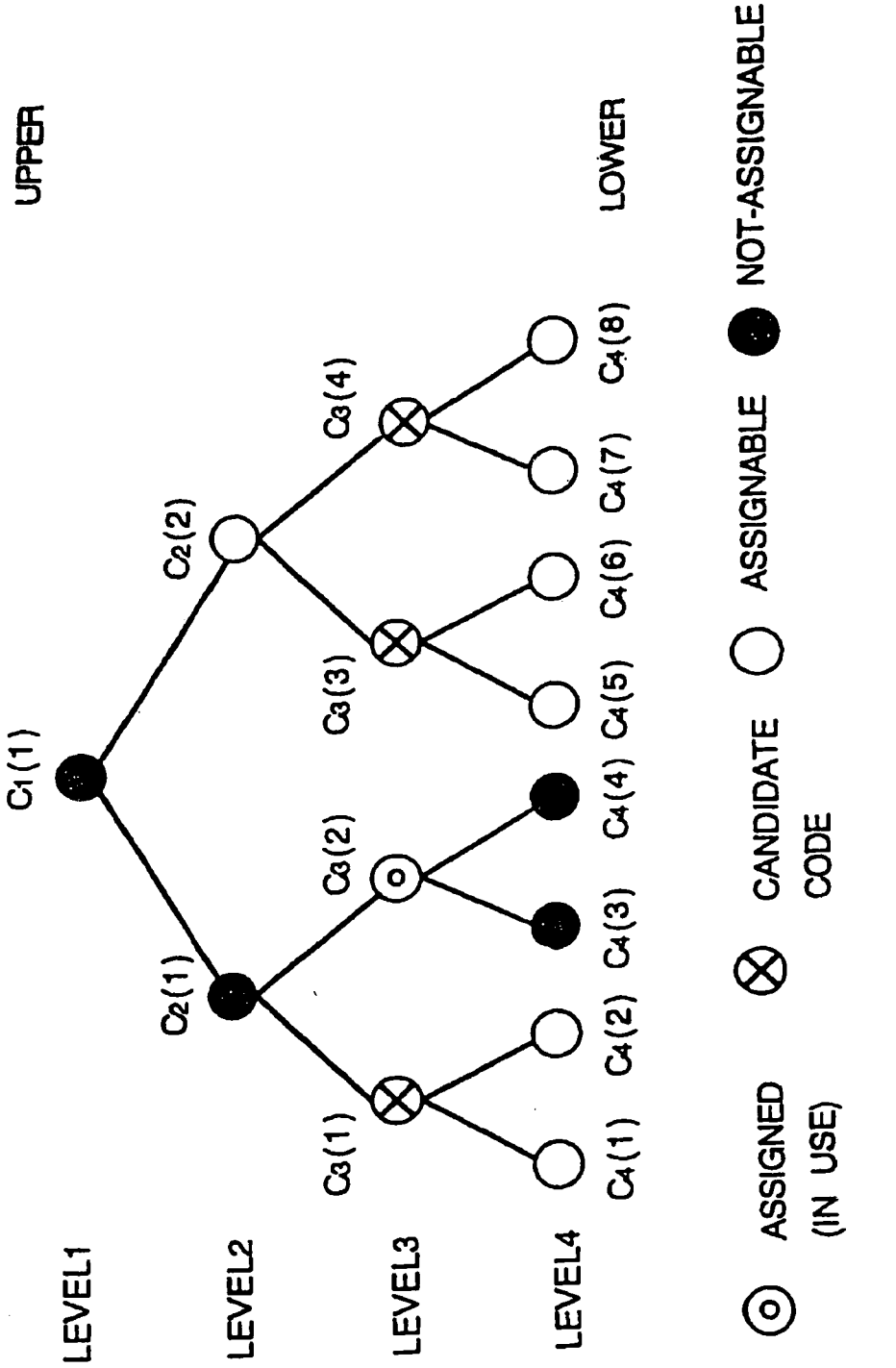

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Fig.4

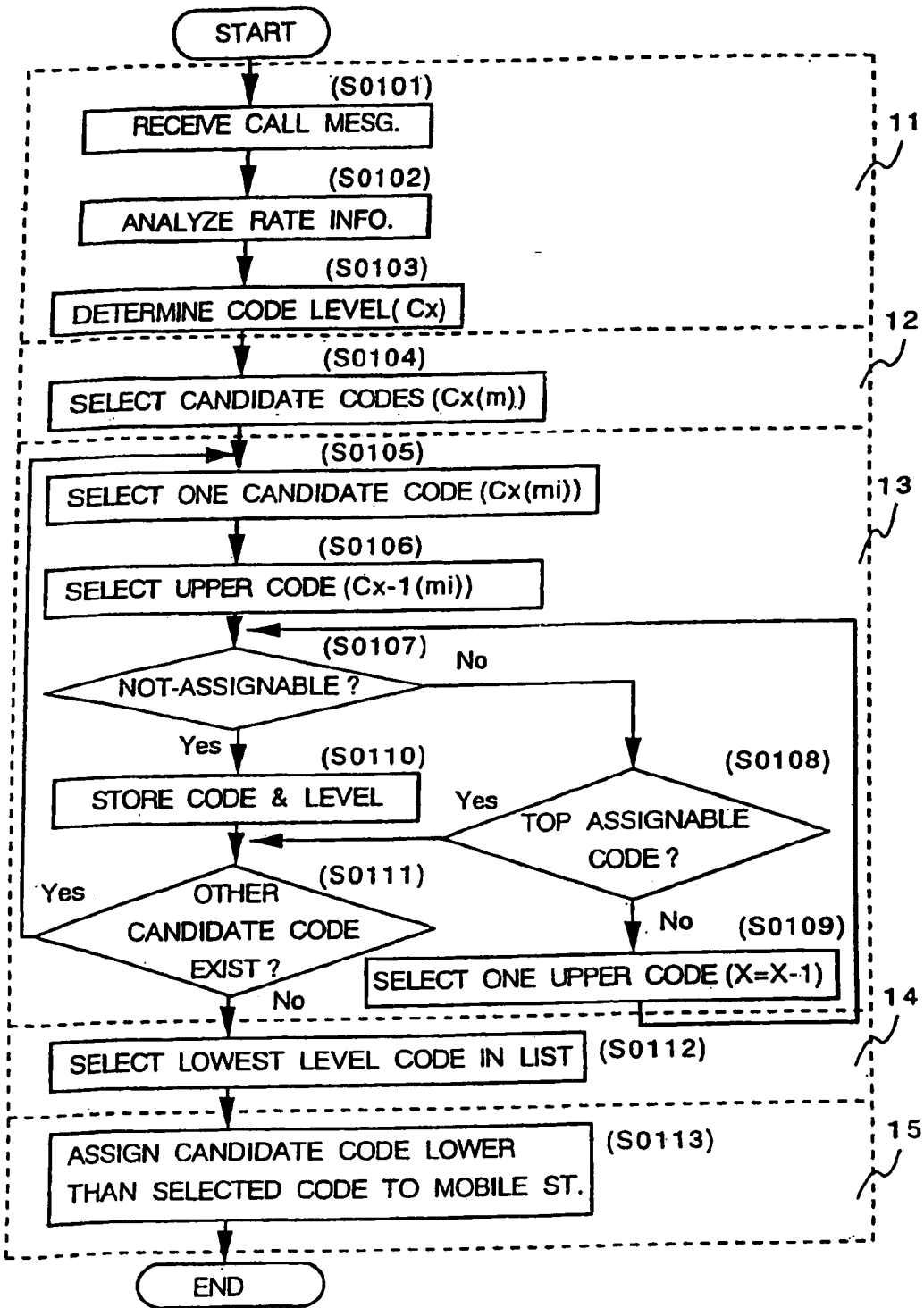

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Fig.5

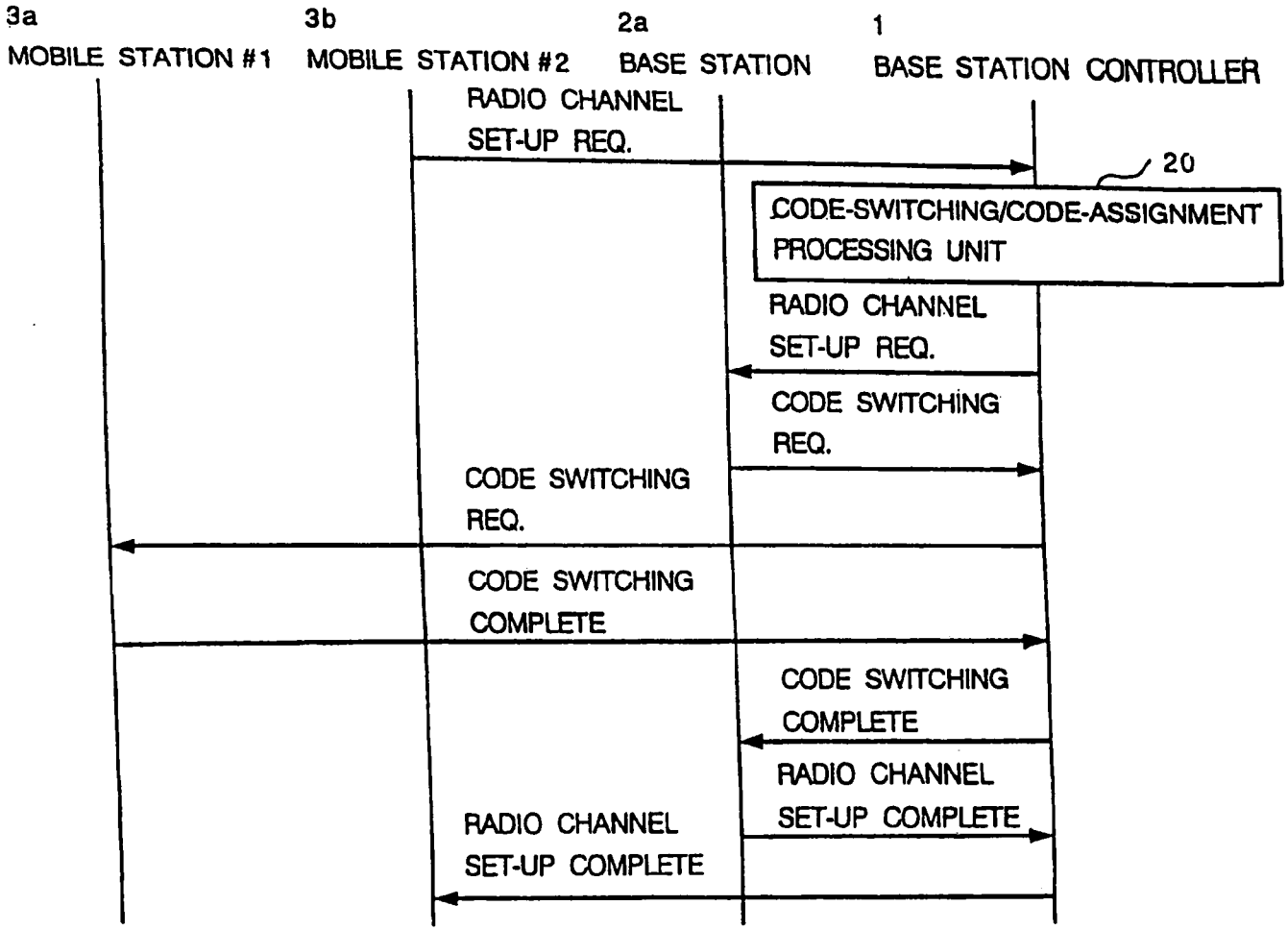
3a
MOBILE STATION #1
3b
MOBILE STATION #2
2a
BASE STATION
1
BASE STATION CONTROLLER
RADIO CHANNEL SET-UP REQ.
20
CODE-SWITCHING/CODE-ASSIGNMENT PROCESSING UNIT
RADIO CHANNEL SET-UP REQ.
CODE SWITCHING REQ.
CODE SWITCHING REQ.
CODE SWITCHING COMPLETE
CODE SWITCHING COMPLETE
RADIO CHANNEL SET-UP COMPLETE
RADIO CHANNEL SET-UP COMPLETE

Fig.6

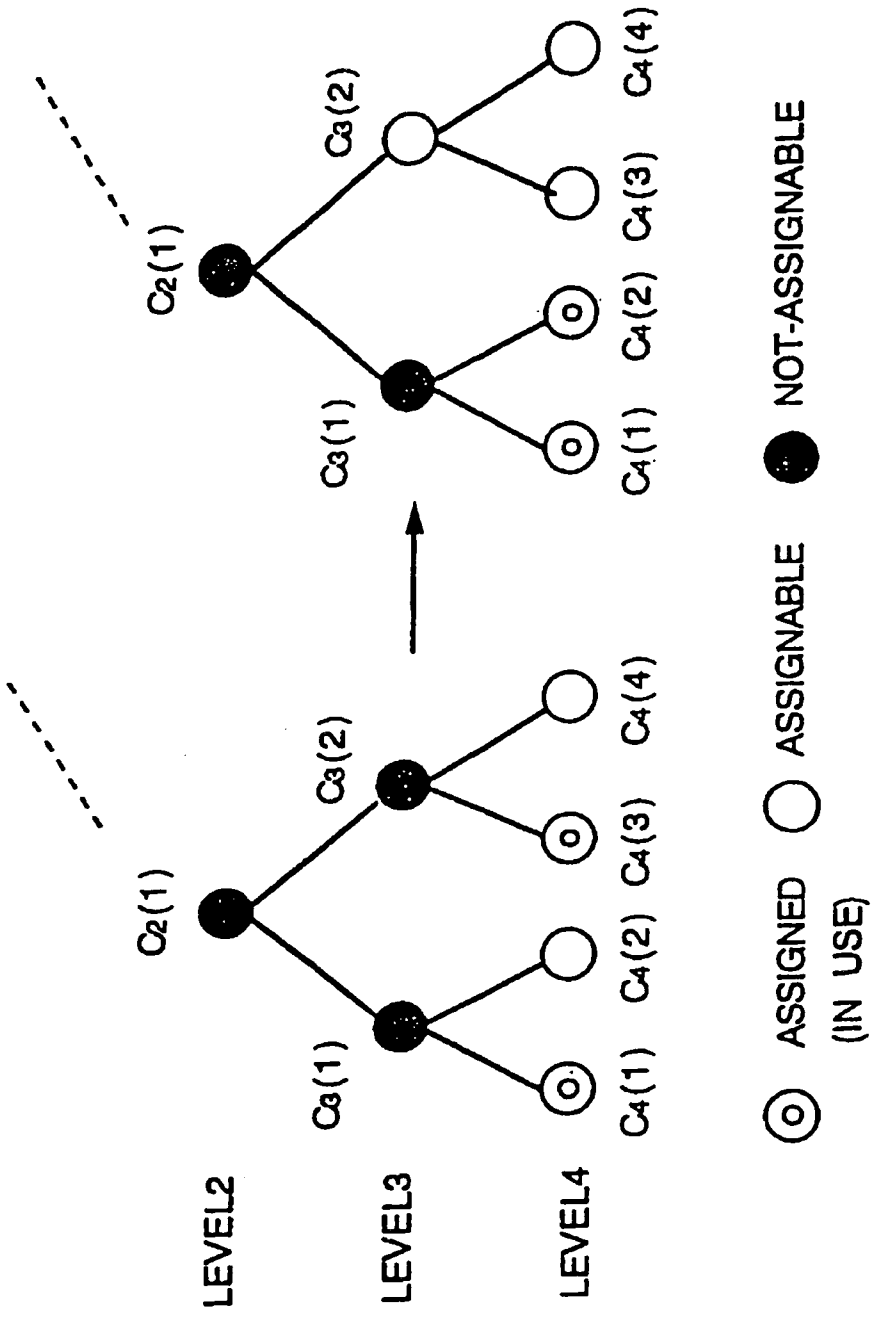

Fig.8

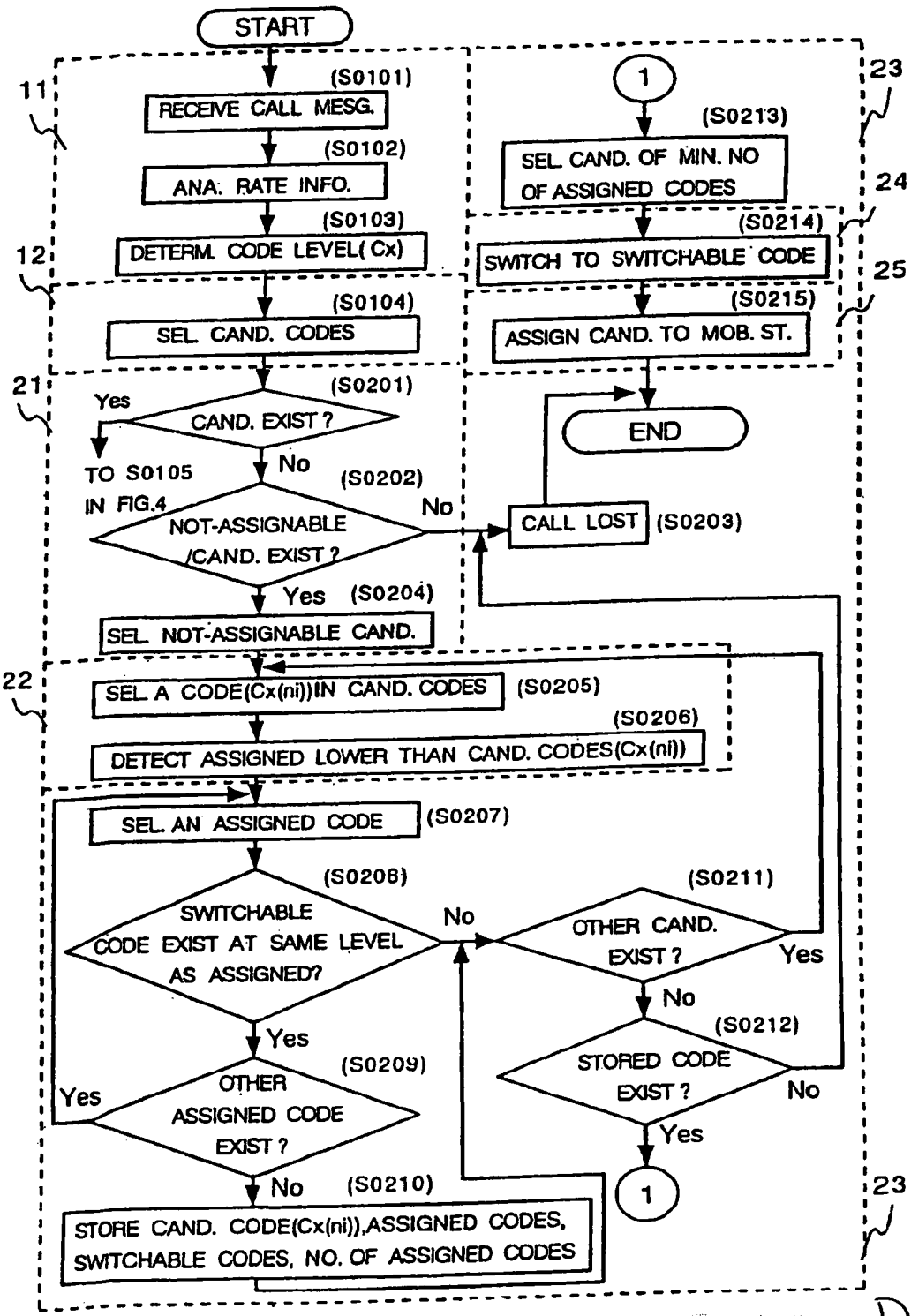

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Fig.9

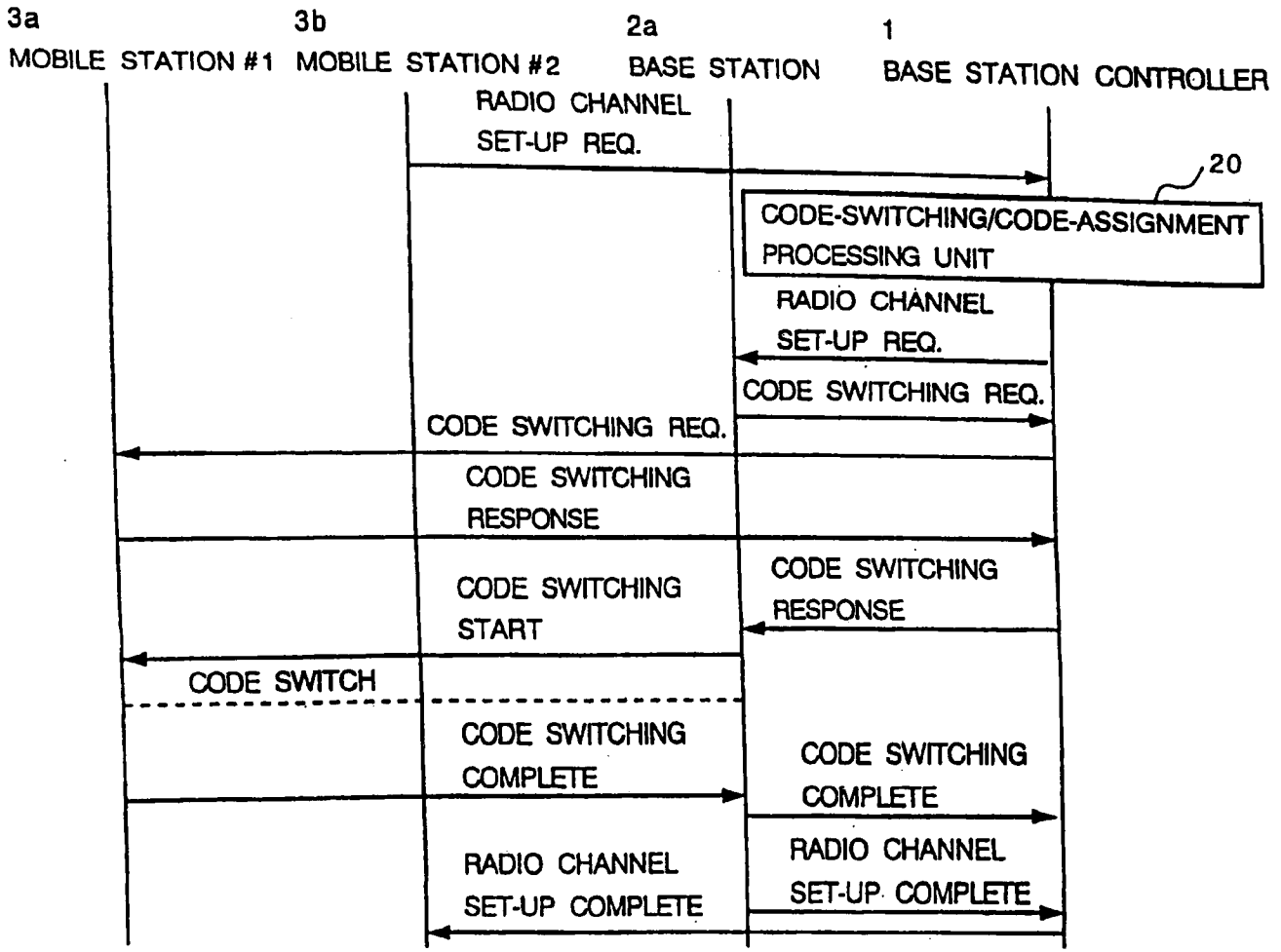
3a
MOBILE STATION #1
3b
MOBILE STATION #2
2a
BASE STATION
1
BASE STATION CONTROLLER
RADIO CHANNEL SET-UP REQ.
20
CODE-SWITCHING/CODE-ASSIGNMENT PROCESSING UNIT
RADIO CHANNEL SET-UP REQ.
CODE SWITCHING REQ.
CODE SWITCHING REQ.
CODE SWITCHING RESPONSE
CODE SWITCHING START
CODE SWITCHING RESPONSE
CODE SWITCH
CODE SWITCHING COMPLETE
CODE SWITCHING COMPLETE
RADIO CHANNEL SET-UP COMPLETE
RADIO CHANNEL SET-UP COMPLETE

Fig.10

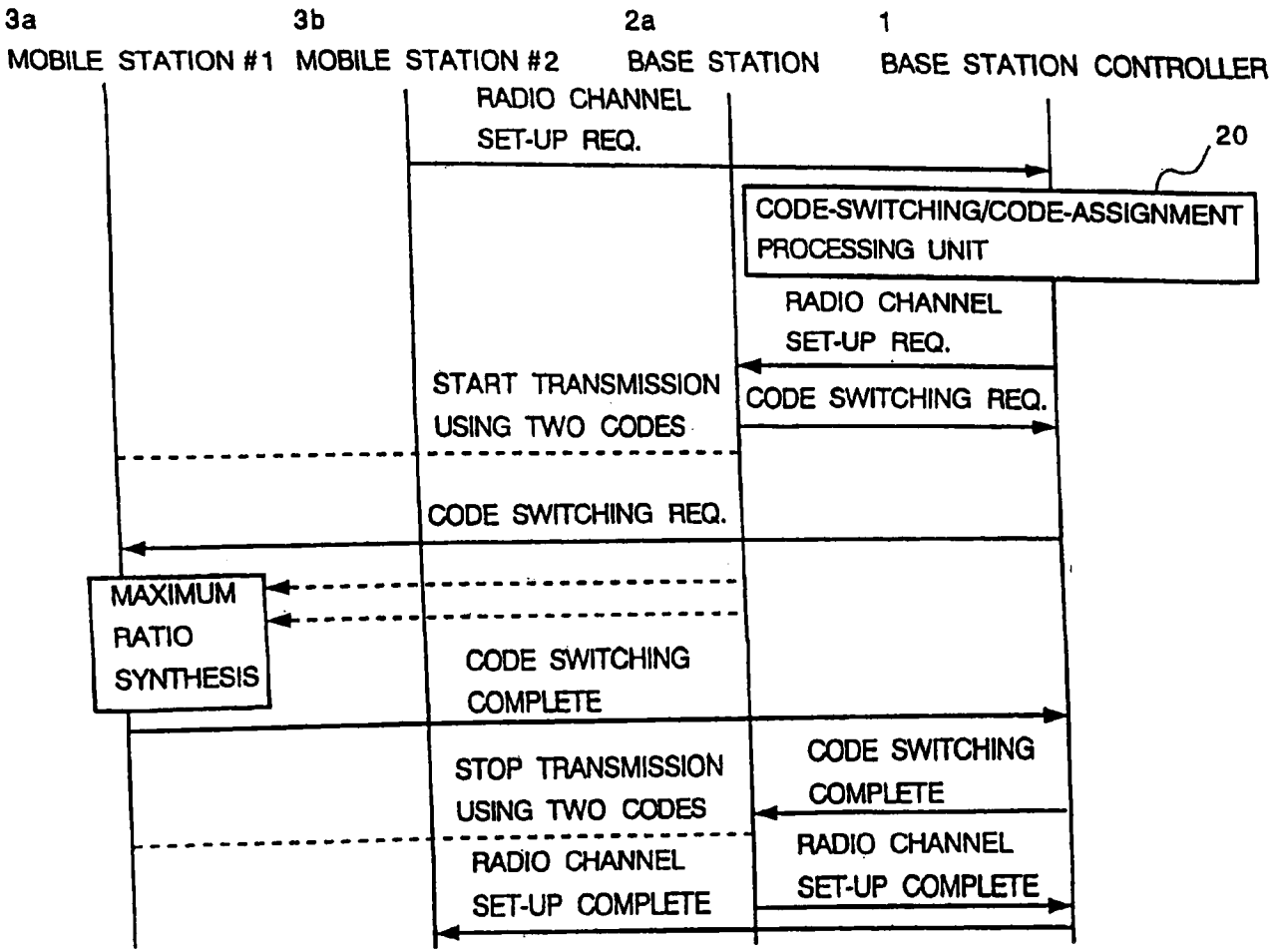

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Fig.11 RELATED ART

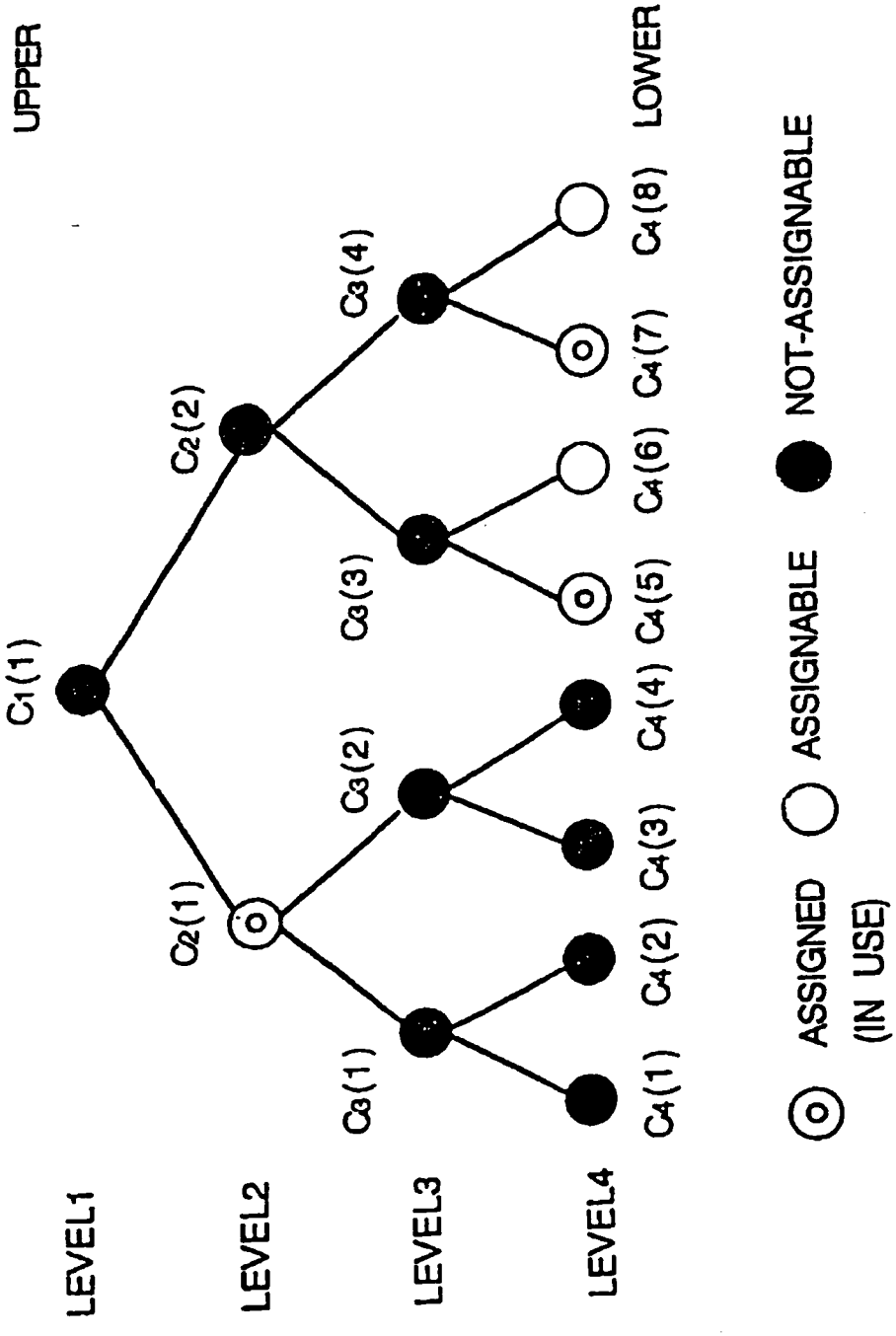

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Fig.12

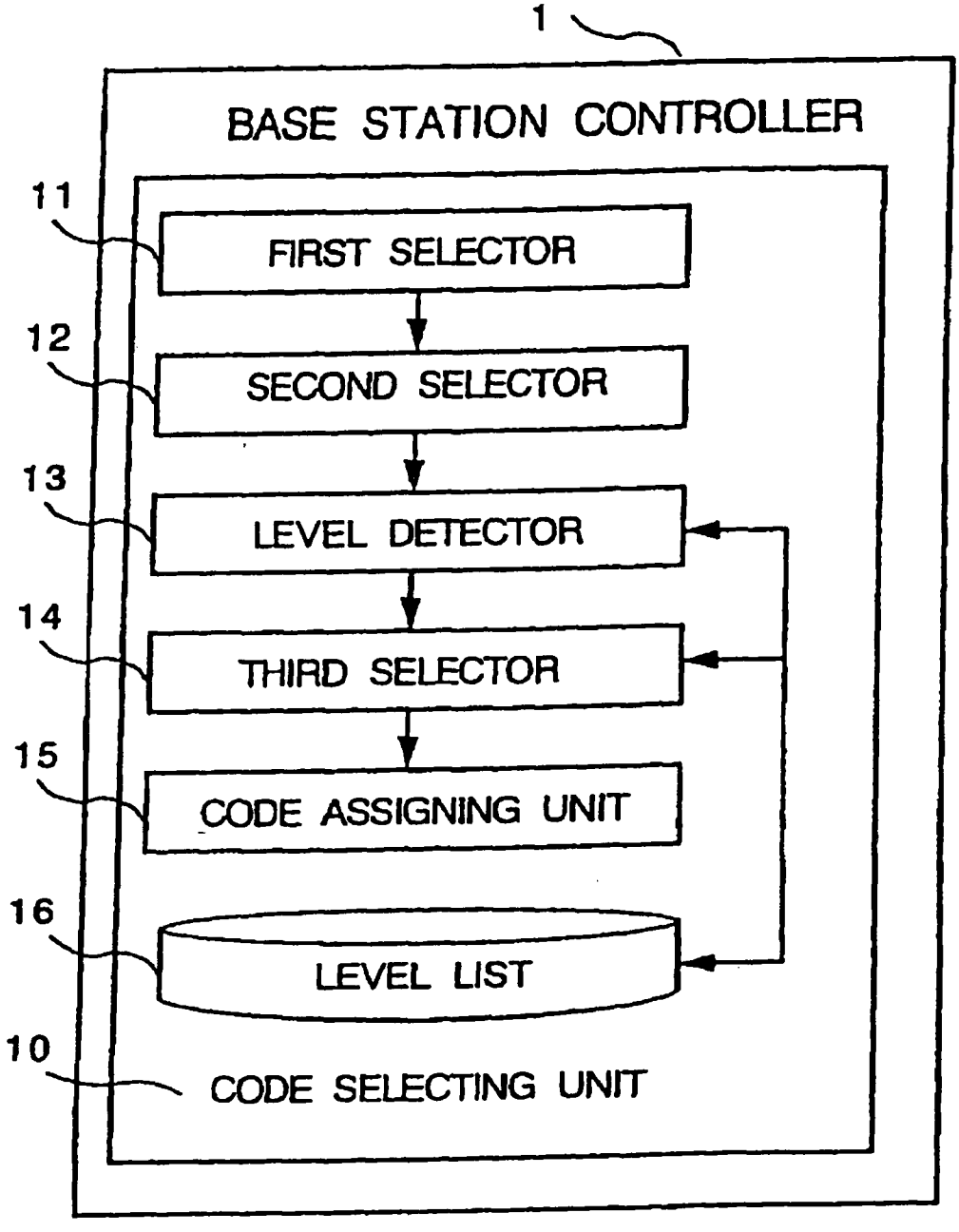

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Fig.13

16 : LEVEL LIST

CANDIDATE CODE	UPPER NOT-ASSIGNABLE CODE	LEVEL
$C_3(1)$	$C_2(1)$	LEVEL2
$C_3(3)$	$C_1(1)$	LEVEL1
$C_3(4)$	$C_1(1)$	LEVEL1

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Fig.14

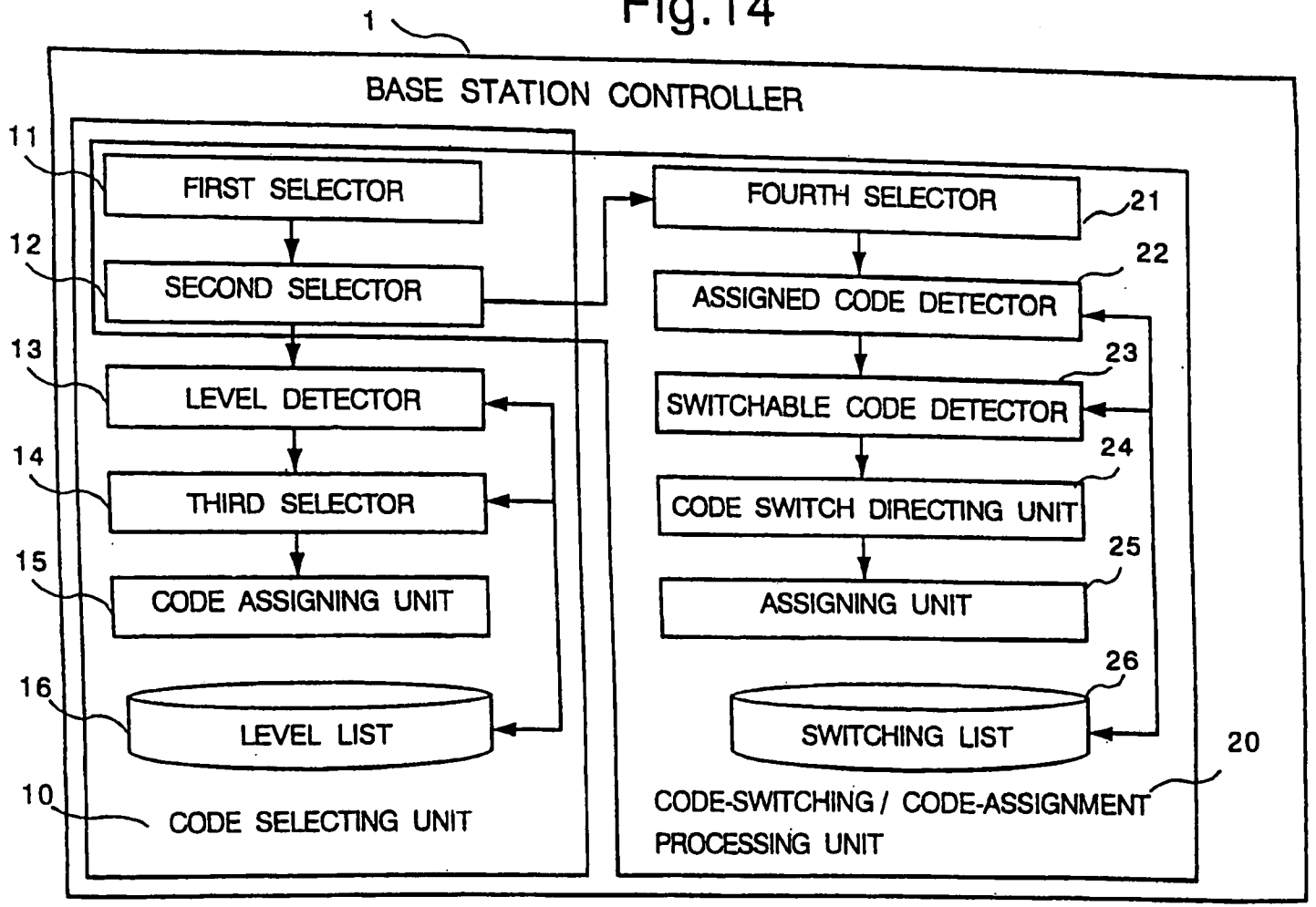

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Fig.15

26 : SWITCHING LIST

CANDIDATE CODE	ASSIGNED CODE	SWITCHABLE CODE
$C_3(2)$	$C_4(3)$	$C_4(2)$
$C_3(1)$	$C_4(1)$	$C_4(4)$

Fig.16

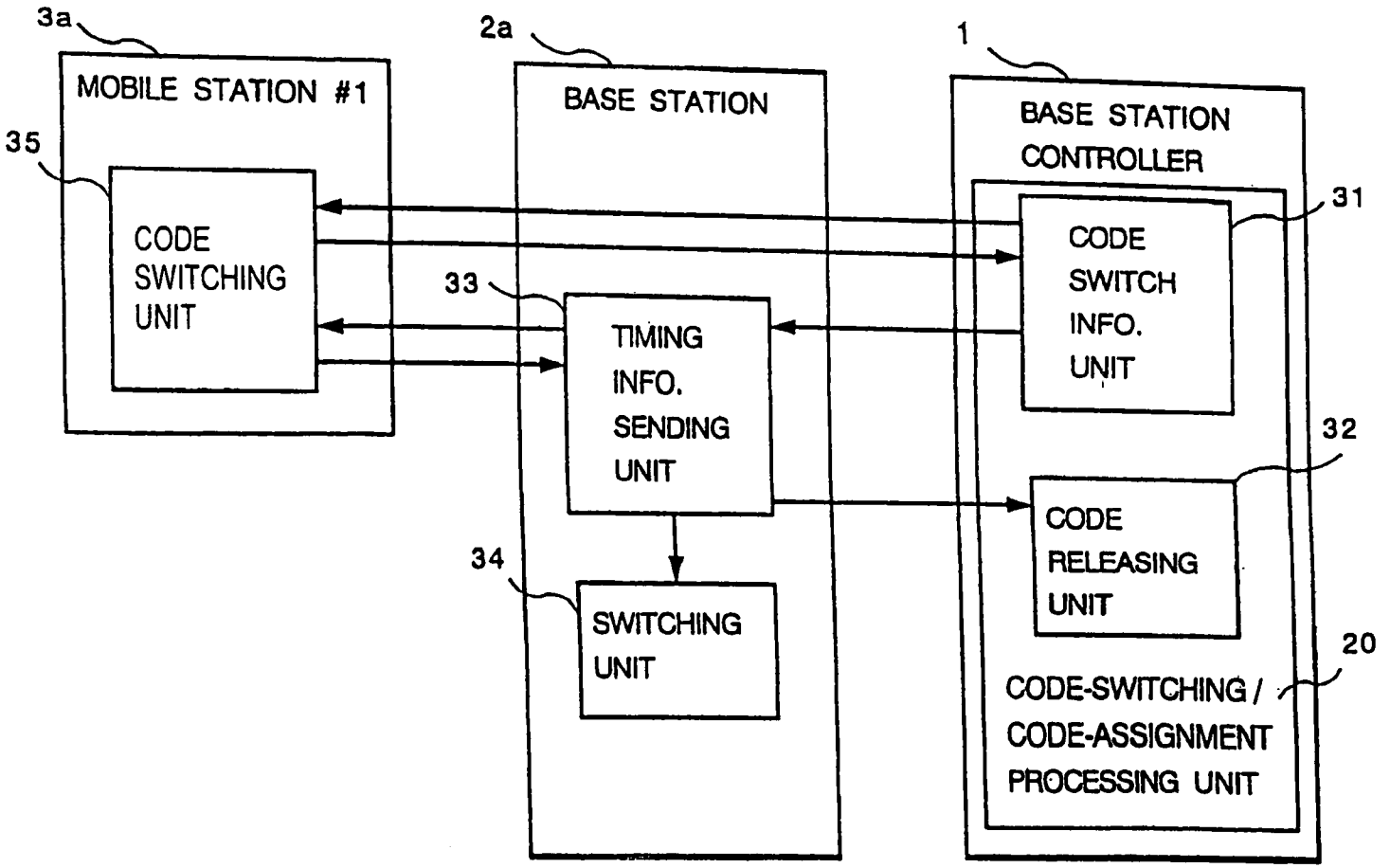
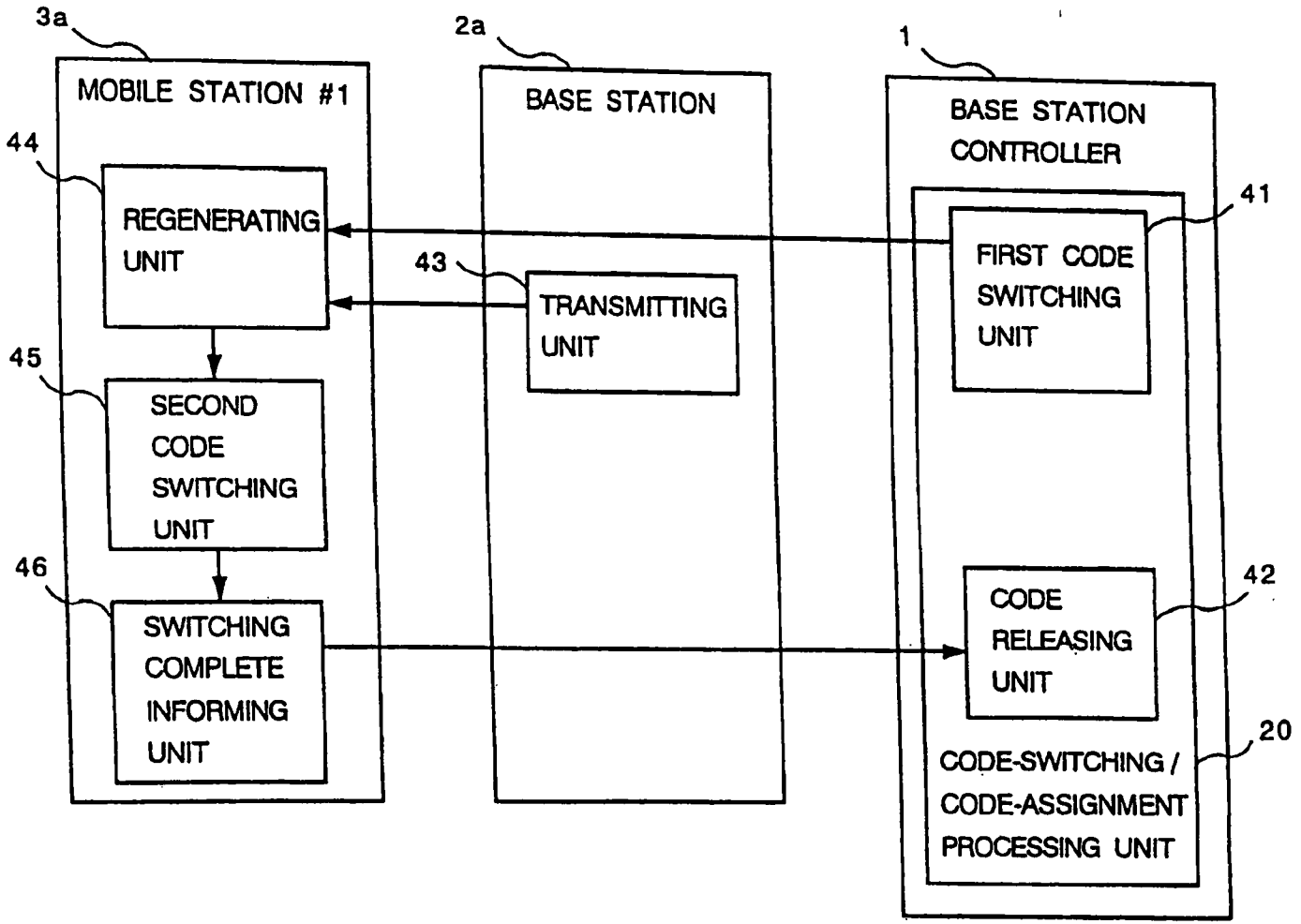


Fig.17



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METHOD AND APPARATUS FOR ASSIGNING CODES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to code assignment in multi-rate communications of the radio communication system employing Code Division Multiple Access (CDMA) system, where codes having tree structured orthogonal multi-spreading factor sequence are used as spreading codes.

2. Description of the Related Art

The system utilizing coherent multi code and the system utilizing tree structured multi-spreading factor sequence code have been introduced as a multi-rate transmission system in the radio communication system employing DS-CDMA (Direct Sequence-CDMA). In the multi-rate transmission utilizing the coherent multi code, plural codes are simultaneously used to perform multi-code-multiplexing. In the multi-rate transmission utilizing the tree structured multi-spreading factor sequence code, orthogonal codes having equivalent spreading factors are multiplexed in parallel. Receivers for receiving plural codes are needed for a mobile station used for the multi-rate transmission utilizing the coherent multi code. On the other hand, only one receiver is needed for the system utilizing the tree structured multi-spreading factor sequence code.

The conventional CDMA system using tree structured orthogonal multi-spreading factor sequences is disclosed in, for example, a technical report entitled "Multi-rate Wideband DS-CDMA Radio Access For Next Generation Mobile Radio Systems", the Institute of Electronics, Information and Communication Engineers, RCS-97-86, 1997. The conventional system will be explained with reference to FIG. **11**.

FIG. **11** shows a configuration of the conventional tree structured orthogonal multi-spreading factor sequences.

The tree structure is composed of four levels: level **1** at the top through level **4** at the bottom, defined just for convenience. As there are four levels in this case, the channel transmission rate using the top level (level **1**) code is eight times as fast as that of the channel using the lowest level (level **4**) code. The channel transmission rate using level **2** code is four times the rate of channel using the level **4** code. The channel transmission rate using level **3** code is twice the rate of channel using the level **4** code. Cx(y) in FIG. **11** represents a kind of codes, x stands for a code level, y stands for an identification number in the same code level, and .smallcircle. stands for a code.

In FIG. **11**, a code in the level **1** can be used for communication of twice the transmission rate of level **2**. Now, a concrete example will be explained referring to the case of tree structure as shown in FIG. **11**. When C.sub.2(1) is assigned to a user of four times the transmission rate of the lowest rate (C.sub.4(x) level in FIG. **11**), the codes C.sub.4(1), C.sub.4(2), C.sub.4(3), C.sub.4(4), C.sub.3(1), and C.sub.3(2) can not be assigned to other users because of keeping the code orthogonality. Due to this characteristic, all the lower level codes connected with an assigned code through branches and all the upper level codes connected with the assigned code through only upward branches are not-assignable. When C.sub.2(1) is the assigned code, all the lower codes C.sub.4(1), C.sub.4(2), C.sub.4(3), C.sub.4(4), C.sub.3(1) and C.sub.3(2) connected with the assigned code by branches are not-assignable, and the upper code C.sub.1(1) connected with the assigned code by the shortest branch is not-assignable, either.

As stated above, in CDMA system using codes of tree structured orthogonal multi-spreading factor sequences, the code assignment for a mobile station is restricted because of the characteristic. Accordingly, in the case of FIG. **11**, if C.sub.4(5) and C.sub.4(7) are assigned to calls of the lowest rate (level **4**), it is impossible to assign a call having the rate of level **3** or upper than level **3**. However, on the supposition that C.sub.4(6) is assigned to the call of level **4** instead of C.sub.4(7), it is possible to assign C.sub.3(4) to the call of level **3**, consequently channels are effectively utilized.

OBJECTS OF THE PRESENT INVENTION

In the multi-rate transmission of the conventional radio communication system employing Code Division Multiple Access (CDMA) system where codes having tree structured orthogonal multi-spreading factor sequence are used, when a code has been already assigned (in use), it is impossible to assign all the codes upper than the code. This causes a problem that the channel utilization is deteriorated. It is an object of the present invention to utilize all the system (all the branches) of the tree structure for assigning a code to be responsive to a new call, in order to enhance the channel utilization.

In the conventional art, a channel mismatch would occur at the call ending, even if a channel match was kept at the code assigning time of a new call starting. This sometimes causes a problem that selecting a code to be assigned to a new call is impossible. It is another object of the present invention is to avoid the channel mismatch by switching a code being used in communication. Consequently, call loss rate can be reduced.

In the code assignment of the conventional radio communication system employing CDMA system, it is necessary for a base station and a mobile station to simultaneously switch codes in order not to stop the communication under way. However, as the base station does not have means for judging a code switch timing over the mobile station, the base station is troublesomely needed to simultaneously perform reception and transmission using both the codes used before and after switching. It is another object of the present invention to reduce the stop time caused by code switching and the hardware needed for reception/transmission using both the codes between the base station and the mobile station, by means of sending the code switching timing from the base station.

In the code assignment of the conventional radio communication system employing CDMA system, there is a problem that much process is needed for synchronizing the code switch timings in the base station and the mobile station. It is another object of the present invention to reduce the code switching process by means of depending on mobile station's own timing.

Namely, it is a general object of the present invention to provide an apparatus and a method for effectively utilizing the channel, comprising means in the base station to judge a code switch timing over the mobile station, and reducing the synchronization process.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, a code assigning apparatus used in a radio communication system including a base station controlling apparatus, a plurality of base stations, and a plurality of mobile stations, employing CDMA (Code Division Multiple Access) method, which uses codes of tree structured orthogonal multi-spreading

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factor sequences as spreading codes, for radio access between the plurality of base stations and the plurality of mobile stations, and providing multi-rate transmission between the plurality of mobile stations and the plurality of base stations, the code assigning apparatus comprises

a code selecting unit for selecting an assignable code which suits specifications requested by a new starting call and exists in a location as close to a not-assignable code as possible and in a level lower than the not-assignable code in the tree structure.

According to another aspect of the present invention, the code selecting unit of the code assigning apparatus comprises

a first selecting unit for selecting one or more than one codes corresponding to rate information included in a message from one of the plurality of mobile stations, as first codes,

a second selecting unit for selecting one or more than one first codes if they are assignable to the one of the plurality of mobile stations, as second codes,

a level detecting unit for retrieving codes upper than the second codes one by one, detecting not-assignable codes, which are assigned to another of the plurality of mobile stations, out of the codes upper than the second codes, as third codes, and detecting each level of the third codes,

a third selecting unit for selecting one of the second codes whose upper third code is in a lowest level in the tree structure, and

a code assigning unit for assigning the one of the second codes selected by the third selecting unit to the one of the plurality of mobile stations.

According to another aspect of the present invention, the code assigning apparatus comprises

a code-switching/code-assignment processing unit,

when there is no assignable code which suits specifications requested by a new starting call, for making a code which is not-assignable and suits the specifications requested by the new starting call assignable by way of switching an assigned code being used to another code connected by a branch different from a branch used for the assigned code in the tree structure.

According to another aspect of the present invention, the code-switching/code-assignment processing unit of the code assigning apparatus comprises

a first selecting unit for selecting one or more than one codes corresponding to rate information included in a message from the second mobile station, as first codes,

a second selecting unit for selecting one or more than one first codes if they are assignable to the second mobile station, as second codes,

a fourth selecting unit, when there is no second code, for selecting one or more than one first codes if their lower codes have been assigned to the first mobile station, as fifth codes,

an assigned code detecting unit for detecting a code lower than the fifth codes and assigned to the first mobile station as a fourth code,

a switchable code detecting unit for detecting a code to which switchable from the fourth code, for the first mobile station, as a sixth code,

a code switch directing unit for directing the first mobile station to switch from the fourth code to the sixth code, and

an assigning unit for assigning a fifth code to the second mobile station after switching all the fourth codes to other codes.

According to another aspect of the present invention,

the code-switching/code-assignment processing unit includes a code switch informing unit for informing that the fourth code having been used by the first mobile station can be switched to a sixth code,

one of the plurality of base stations includes a timing information sending unit for sending timing information of switching from the fourth code to the sixth code to the first mobile station,

the first mobile station includes a code switching unit for switching the fourth code to the sixth code based on the informing of the code-switching/code-assignment processing unit and the timing information of the one of the base stations,

the one of the plurality of base stations includes a switching unit for switching downlink transmission codes at time when the timing information is sent to the first mobile station, and the code-switching/code-assignment processing unit includes

a code releasing unit for releasing the fourth code used by the first mobile station, at the time when the timing information is sent to the first mobile station.

According to another aspect of the present invention, the code-switching/code-assignment processing unit includes a first code switching unit for informing the first mobile station that a fourth code being used by the first mobile station is to be switched to a sixth code,

one of the plurality of base stations includes a transmitting unit for performing transmission using both the fourth code and the sixth code to the first mobile station,

the first mobile station includes a regenerating unit for receiving both the fourth code and the sixth code and generating reception information by performing maximum ratio combination, a second code switching unit for switching a state of synthesizing maximum ratio to a state of receiving only the sixth code based on own timing, and a switching complete informing unit for informing that code switching has been completed in the first mobile station, and

the code-switching/code-assignment processing unit includes a code releasing unit for releasing the fourth code used by the first mobile station, based on the informing from the first mobile station.

According to another aspect of the code assigning apparatus of the present invention, the code selecting unit is provided in either one of the plurality of base stations or the base station controlling unit.

According to another aspect of the code assigning apparatus of the present invention, the code-switching/code-assignment processing unit is provided in either one of the plurality of base stations or the base station controlling unit.

According to one aspect of a method of assigning codes of the present invention, used in a radio communication system including a base station controlling apparatus, a plurality of base stations, and a plurality of mobile stations, employing CDMA (Code Division Multiple Access) which uses codes of tree structured orthogonal multi-spreading factor sequences as spreading codes, for radio access between the plurality of base stations and the plurality of mobile stations, and providing multi-rate transmission between the plurality of mobile stations and the plurality of base stations, the method of assigning codes comprises the steps of

selecting one or more than one codes corresponding to rate information included in a message from one of the plurality of mobile stations, as first codes,

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selecting one or more than one first codes if they are assignable to the one of the plurality of mobile stations, as second codes,

retrieving codes upper than the second codes one by one,

detecting not-assignable codes, which are assigned to another of the plurality of mobile stations, out of the codes upper than the second codes, as third codes,

detecting each level of the third codes,

selecting one of the second codes whose upper third code is in a lowest level in the tree structure, and

assigning the one of the second codes selected by the above step to one of the plurality of mobile stations.

According to another aspect of the method of assigning codes of the present invention comprises the steps of

selecting one or more than one codes corresponding to rate information included in a message from the second mobile station as first codes,

selecting one or more than one first codes if they are assignable to the second mobile station as second codes,

when there is no second code, selecting one or more than one first codes if their lower codes have been assigned to the first mobile station, as fifth codes,

detecting a code lower than the fifth codes and assigned to the first mobile station, as a fourth code,

detecting a code to which switchable from the fourth code for the first mobile station, as a sixth code,

directing the first mobile station to switch from the fourth code to the sixth code, and

assigning a fifth code to the second mobile station after switching all the fourth codes to other codes.

According to another aspect of the method of assigning codes of the present invention comprises the steps of

informing that a fourth code having been used by the first mobile station can be switched to a sixth code,

sending timing information of switching from the fourth code to the sixth code to the first mobile station,

switching the fourth code to the sixth code based on the informing of the informing step and the timing information of the sending timing information step,

switching downlink transmission codes based on the timing information sent to the first mobile station, and

releasing the fourth code used by the first mobile station, based on the timing information.

According to another aspect of the method of assigning codes of the present invention comprises the steps of

informing the first mobile station that a fourth code being used by the first mobile station is to be switched to a sixth code,

performing downlink transmission using both the fourth code and the sixth code to the first mobile station,

receiving both the fourth code and the sixth code,

generating reception information by performing maximum ratio combination,

switching a state of synthesizing maximum ratio to a state of receiving only the sixth code based on own timing,

informing that code switching has been completed in the first mobile station, and

releasing the fourth code used by the first mobile station, based on the informing from the first mobile station.

The above and other objects and features of the invention will appear more fully hereinafter from a consideration of the following description taken in connection with the accompanying drawing wherein one example is illustrated by way of example.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** shows a configuration of radio communication system applying a code assignment method according to the present invention;

FIG. **2** illustrates sequence of a code assignment procedure according to the present invention;

FIG. **3** shows a code structure used for the code assignment procedure of FIG. **2**;

FIG. **4** is a flowchart showing a process of the code assignment procedure of FIG. **2**;

FIG. **5** illustrates sequence of another code assignment procedure according to the present invention;

FIG. **6** shows a code structure used for a code switching procedure of FIG. **5**;

FIG. **7** shows a code structure used for selecting a code-switching candidate code;

FIG. **8** is a flowchart showing a process of the code assignment procedure of FIG. **5**;

FIG. **9** illustrates sequence of another code assignment procedure according to the present invention;

FIG. **10** illustrates sequence of another code switching procedure according to the present invention;

FIG. **11** shows a tree structure of codes having tree structured orthogonal multi-spreading factor sequence, used in a conventional art;

FIG. **12** shows a configuration of a code selecting unit in a base station controller according to the present invention;

FIG. **13** shows a level list according to the present invention;

FIG. **14** shows configurations of a code selecting unit and a code-switching/code-assignment processing unit, in a base station controller according to the present invention;

FIG. **15** shows a switching list according to the present invention;

FIG. **16** shows a system structure according to the present invention; and

FIG. **17** shows a system structure according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiment 1

FIG. **1** shows a configuration of radio communication system applying a code assignment method according to the present embodiment. FIG. **2** illustrates sequence of a code assignment procedure according to the present embodiment. FIG. **3** shows a code structure example of the code assignment procedure of FIG. **2**. FIG. **4** is a flowchart showing a process of the code assignment procedure of FIG. **2**. FIG. **12** shows a configuration of a base station controller **1**. Referring to FIGS. **1**, **2**, **3**, **4**, and **12**, one embodiment of code assignment performed in a base station **2** and the base station controller **1** according to the present invention will be described.

FIG. **1**, showing a configuration of radio communication system of the present embodiment and other embodiments, is composed of plural mobile stations **3***a*, **3***b* and **3***c*, plural base stations **2***a*, and **2***b*, and the base station controller **1** which controls the plural base stations **2***a* and **2***b*. The mobile stations **3***a*, **3***b* and **3***c* are just called as a "mobile station **3**" in the case of describing each mobile station being unnecessary. The base stations **2***a* and **2***b* are also called as a "base station **2**" in the case of describing each base station

being unnecessary. The mobile station **3** is connected to the base station **2** via a radio channel. The radio channel utilizes the Code Division Multiple Access (CDMA) system as a radio access system, and uses spreading codes having tree structured orthogonal multi-spreading factor sequences. According to the radio communication system of the present embodiment, it is possible to set up multiple rates. Namely, the base station **2** and the mobile station **3** can set up channels of plural-kinds rates for each call, using the radio channel. As orthogonal multi spreading codes are used, a channel having a double transmission rate can be set up in proportion as a code level goes up one by one.

FIG. **2** illustrates sequence of a code assignment procedure in responsive to a call from the mobile station **3**. Referring to FIGS. **1** and **2**, the code assignment procedure regarding the base station controller **1**, the base station **2** and the mobile station **3** will now be explained. First, a radio channel set-up request message is transmitted from the mobile station **3** to the base station controller **1** via the base station **2**. The base station controller **1** analyzes the message in order to detect a transmission rate requested by the mobile station **3**. The base station controller **1** determines a pair of codes for transmission to be used by the mobile station **3** and the base station **2**, based on the code assignment process stated later. Then, the base station controller **1** transmits the radio channel set-up request message to the base station **2**.

The radio channel set-up request message includes information of the code pair. Receiving the message, the base station **2** begins to prepare for reception/transmission based on an appointed code, and transmits a radio channel set-up complete message to the base station controller **1**. On receiving the radio channel set-up complete message, the base station controller **1** transmits the radio channel set-up complete message appointing the pair of codes to the mobile station **3**. After receiving the message, the mobile station **3** starts communication with the base station **2**, based on the appointed code.

As stated above, the communication channel between the mobile station **3** and the base station **2** is set up based on the request from the mobile station **3**. A code selection process, performed in the base station controller **1** for the mobile station **3** and the base station **2** is explained with reference to FIGS. **3**, **4** and **12**. FIG. **3** shows a tree structure of codes having orthogonal multi-spreading factor sequence. In FIG. **3**, the tree structure is composed of four levels; level **1** at the top through level **4** at the bottom, defined just for convenience. As there are four levels in this case, the channel transmission rate using the top level (level **1**) code is eight times as fast as that of channel using the lowest level (level **4**) code. The channel transmission rate using level **2** code is four times the rate of channel using level **4** code. The channel transmission rate using level **3** code is twice the rate of channel using level **4** code.

Cx(y) in FIG. **3** represents a kind of codes; x stands for a code level, y stands for an identification number in the same code level, and .smallcircle. stands for a code. In the tree structured orthogonal multi spreading sequence codes, codes lower than a specific code being used (that is, larger number level codes connected with the specific code by branches in FIG. **3**) can not be used because of keeping the orthogonality characteristic.

In addition, codes upper than the specific code being used (that is, smaller number level codes connected with the specific code through only upward branches) also can not be utilized. When C.sub.3(2) is being used in FIG. **3**, C.sub.1(1), C.sub.2(1), C.sub.4(3) and C.sub.4(4) can not be used. Therefore, it is necessary to appropriately assign a code to a new call from the mobile station **3**.

FIG. **12** shows a configuration of a code selecting unit **10** in the base station controller **1**. FIG. **4** is a flowchart showing code assignment processes, for the mobile station **3** and the base station **2**, performed in the code selecting unit **10**. When a first selector **11** of the base station controller **1** receives the radio channel set-up request message from the mobile station **3** (**S0101**), the first selector **11** analyses rate information in the message (**S0102**), and determines a code level needed for the mobile station **3** and the base station **2** (**S0103**). In FIG. **3**, for instance, the code level requested by the mobile station **3** is level **3**. Secondly, a second selector **12** of the base station controller **1** selects candidate codes which can be used in the determined level (**S0104**). In FIG. **3**, C.sub.3(1), C.sub.3(3) and C.sub.3(4) are selected as the candidate codes.

A level detector **13** of the base controller **1** selects a code out of the candidate codes (**S0105**), selects another code in a level one more upper than the selected code (**S0106**), and judges whether or not the one more upper level code can be assigned (**S0107**). In FIG. **3**, if the candidate code is C.sub.3(1), the one more upper level code is C.sub.2(1). Then, when the one more upper level code is able to be assigned, the judging procedure is repeated upwards along the branches until it comes to a code which can not be assigned (**S1018**, **S0109**). If a code that is not assignable is detected, the code and its level are memorized in a level list **16** for each of the candidate codes (**S0107**, **S0110**). When C.sub.3(1) in FIG. **3** is the candidate code, one more upper code C.sub.2(1) is not assignable. Then, C.sub.3(1), C.sub.2(1) and the level **2** are stored in the level list **16** as shown in FIG. **13**. This procedure is performed for each candidate code to complete the level list **16** shown in FIG. **13** (**S0111**).

A third selector **14** selects a candidate code whose upper not-assignable code has the lowest level, in the level list **16** (**S0112**). Then, the candidate code is selected to be assigned to the mobile station **3** (**S0113**). If there are several candidate codes whose upper not-assignable codes have the same code level, any of the candidate codes can be selected. If a candidate code has no upper not-assignable code, the top level code is regarded as the upper not-assignable code. As shown in FIG. **13**, C.sub.2(1) being the upper not-assignable code and level **2** are selected for the candidate code C.sub.3(1) in FIG. **3**. C.sub.1(1) and level **1** are for the candidate code C.sub.3(3), and C.sub.1(1) and level **1** are for the candidate code C.sub.3(4). Therefore, C.sub.3(1), whose upper not-assignable code is C.sub.2(1), is selected as a code to be assigned. According to this assigning method, C.sub.3(3) and C.sub.3(4) in FIG. **3** are not selected. The code C.sub.3(1) is assigned to the mobile station **3** by a code assigning unit **15**. If a new call corresponding to level **2** is requested after the call corresponding to level **3** has been in use as shown in FIG. **3**, C.sub.2(2) can be assigned to the new call.

According to the present assigning method, a channel mismatch at the code assigning time of a new call starting, caused by the tree structure characteristic, is avoided. Therefore, a code assignment for multi-rate transmission can be performed without deteriorating the channel utilization efficiency. It is also acceptable to provide the code selecting unit **10** of FIG. **12** in the base station **2** instead of the base station controller **1**.

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Embodiment 2

FIG. **5** illustrates a code assignment sequence showing a code switching procedure, according to the present embodiment. FIG. **6** shows a code structure applied for the code switching procedure of FIG. **5**. FIG. **7** shows a code structure used in selecting a candidate code for the code switching. FIG. **8** is a procedure flowchart for the code assignment sequence of FIG. **5**. FIG. **14** shows a configuration of the base station controller according to the present embodiment. Referring to FIGS. **1**, **5**, **6**, **7**, **8** and **14**, the code assignment according to the present embodiment will now be described.

The code switching is explained with reference to FIG. **6** showing a code assignment state change. The same code definition as FIG. **3** is used in FIG. **6**. As stated in Embodiment 1, when a code has been already assigned to the mobile station **3**, it is impossible to newly assign a code in upper level than the assigned code to another mobile station **3**, because of the characteristic of spreading codes having tree structured orthogonal multi-spreading factor. In the left of FIG. **6**, as C.sub.4(1) and C.sub.4(3) have been already assigned, it is impossible to assign C.sub.3(1) and C.sub.3 (2) to another mobile station **3**. Accordingly, if there is a call requesting a transmission rate corresponding to level **3** at this time, the call is to be lost. By switching the code from C.sub.4(3) to C.sub.4(2), however, C.sub.3(2) can be assigned, so that the call requesting the transmission rate corresponding to level **3** is accepted.

Referring to FIGS. **1** and **5**, the code assignment procedure and the code switching procedure regarding the base station controller **1**, the base station **2**, and the mobile station **3** will now be explained. In FIG. **1**, a mobile station #1 (*3a*) has been already used, and a mobile station #2 (*3b*) newly makes a call. As shown in FIG. **5**, the mobile station #2 (*3b*) transmits a radio channel set-up request message indicating a transmission rate, to the base station controller **1** as stated in Embodiment 1.

When there is no assignable code as shown in the left of FIG. **6**, it is necessary to perform code switching. Therefore, the mobile station #1 (*3a*) and a code are selected for the code switching, based on a method stated later. The radio channel set-up request message is transmitted to a base station *2a* in order to assign the selected code to the mobile station #2 (*3b*).

The base station *2a* judges whether the code appointed in the radio channel set-up request message can be used or not. In this case, as the code is being used by the mobile station #1 (*3a*), it is judged to be not usable. Then, a code switching request is transmitted to the base station controller **1**. On receiving the code switching request from the base station *2a*, the base station controller **1** transmits a code switching request message including information of code after switching to the mobile station #1 (*3a*). In the case of FIG. **6**, the base station controller **1** defines C.sub.4(2) as the code after-switching in the code switching request message.

When the mobile station #1 (*3a*) receives the code switching request message, the mobile station #1 (*3a*) switches the original code to the target code (code after switching) (C.sub.4(2) in FIG. **6**), and transmits a code switching complete message to the base station controller **1**. The base station controller **1** judges, by receiving the code switching complete message, that the code has been switched in the mobile station #1 (*3a*). (The state has been changed from the left side to the right side in FIG. 6.) Then, the base station controller **1** transmits the code switching complete message to the base station *2a*. After receiving the code switching complete message, the base station *2a* transmits a radio channel set-up complete message to the base station controller **1**. The base station controller **1** transmits the radio channel set-up complete message to the mobile station #2 (*3b*) in order to assign an assignable and requested-level code whose level is corresponding to the transmission rate requested by the mobile station #2 (*3b*) (that is, C.sub.3(2) in FIG. **6**).

By performing the above procedures, a new radio channel requested by the mobile station **3** has been set up between the mobile station **3** and the base station **2**. Now, the code switching procedure, for the mobile station #1 (*3a*) and the base station *2a*, performed in the base station controller **1**, and the code assigning procedure, for the mobile station #2 (*3b*) and the base station *2a*, performed in the controller **1** are explained with reference to FIGS. **7**, **8** and **14**. Similar to FIG. **3**, FIG. **7** shows a tree structure of codes having orthogonal multi-spreading factor sequence. The candidate code/not-assignable in the figure represents an unused code which is corresponding to a requested transmission rate and whose lower level code has been already assigned. FIG. **14** shows a configuration of a code-switching/code-assignment processing unit **20** in the base station controller **1**. FIG. **8** is a flowchart showing a code switching and a code assigning process performed in the code-switching/code-assignment processing unit **20**.

Similar to Embodiment 1, when the first selector **11** of the base station controller **1** receives the radio channel set-up request message from the mobile station #2 (*3b*) (**S0101**), the first selector **11** analyzes rate information in the message (**S0102**) and determines a code level in the tree structure corresponding to the rate information (**S0103**). In FIG. **7**, for instance, the code level corresponding to the rate information is level **3**. The second selector **12** of the base station controller **1** retrieves an assignable code of the determined level (**S0104**). When there is no assignable candidate code of the determined level (**S0201**), a fourth selector **21** selects a code which is not assignable and has not been itself assigned, as a candidate code (**S0204**). In FIG. **7**, C.sub.3(1) and C.sub.3(2) are such codes. In the case of there being no code which is not assignable and has not been itself assigned yet (**S0202**: No), the original call becomes lost (**S0203**).

An assigned code detector **22** selects a code out of candidate codes (C.sub.3(2) in FIG. **7**) (**S0205**), and detects an assigned code in lower level than the selected candidate code. (In FIG. **7** case, C.sub.4(3)) (**S0206**). A switchable code detector **23** retrieves codes to see whether there is a switchable code at the same level as the above assigned code or not. (**S0208**). When there is a switchable code in the same level as the assigned code (C.sub.4(2) in FIG. **7**), the candidate code (C.sub.3(2)), the assigned code (C.sub.4(3)) and the switchable code (C.sub.4(2)) are stored in a switching list **26** as shown in FIG. **15** (**S0210**). This procedure is performed for every candidate code and every assigned code at the lower level than the candidate code. (**S0207**, **S0209**, **S0211**). In the case of there being candidate codes, the switchable code detector **23** selects one candidate code having the least number of assigned codes at its lower level, as an assignment target code (**S0213**).

In the above case, all the assigned codes have their switchable codes in the same level. In FIG. **7**, there are two candidate codes: C.sub.3(1) and C.sub.3(2). As shown in FIG. **15**, either of C.sub.3(1) and C.sub.3(2) has one assigned code (C.sub.4(1) is for C.sub.3(1), and C.sub.4(3s) is for C.sub.3(2)), and both the candidate codes C.sub.3(1) and C.sub.3(2) have their switchable codes (C.sub.4(4) for C.sub.3(**1**) and C.sub.4(2) for C.sub.3(2)) in the same level

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(level **4**). Therefore, either of C.sub.3(1) and C.sub.3(2) can be selected as the assignment target code.

A code switch directing unit **24** switches the assigned code at the lower level of the selected assignment target code to the stored switchable code (**S0214**). In the case of selecting C.sub.3(2) as the assignment target code in FIG. **7**, C.sub.4(3) is switched to C.sub.4(2). The code used by the mobile station #**1** (**3***a*) in FIG. **5** is corresponding to the assigned code. An assigning unit **25** assigns the selected assignment target code to the mobile station #**2** (**3***b*) (**S0215**).

The switching possibility is checked for all the assigned codes at the lower level of all the candidate codes, in the present embodiment. The checking process, however, can be completed at the first time of detecting a candidate code which has an assigned code to be switched at the lower level.

Even when a channel mismatch exists, according to the present embodiment, the call loss rate is reduced because a new high rate call can be achieved by switching a code being used in the mismatch channel. It is also acceptable to provide the code selecting unit **10** and the code-switching/code-assignment processing unit **20** of FIG. **14** in the base station **2** instead of the base station controller **1**.

Embodiment 3

FIG. **9** illustrates a code assignment sequence showing a code switching procedure, according to the present embodiment. FIG. **16** shows a system structure. Referring to FIGS. **1**, **9**, and **16**, the code switching according to the present embodiment will be explained below.

As stated in Embodiment 2, it is sometimes necessary to switch codes during the communication. The code switching during the communication should be simultaneously performed at the base station **2** and the mobile station **3** in order not to stop the communication and so as to reduce interfering in other communication. The simultaneous switching is performed based on code switch timing information sent from a timing information sending unit **33** in the base station **2** to the mobile station **3**. FIG. **9** illustrates procedures of sending the code switch timing information from the base station **2** to the mobile station **3**.

The procedures, from transmitting a radio channel set-up request message by the mobile station #**2** (**3***b*) up to transmitting a code switching request message to the mobile station #**1** (**3***a*) by the base station controller **1**, are the same as Embodiment 2 shown in FIG. **5**. Therefore, procedures after the above will now be described in the present embodiment. A code switch informing unit **31** of the base station controller **1** transmits a code switching request message indicating a target code (code after switching) to the mobile station #**1** (**3***a*). On receiving the code switching request message, a code switching unit **35** of the mobile station #**1** (**3***a*) starts preparing for the code switching and transmits a code switching response message to the code switch informing unit **31** of the base station controller **1**.

After receiving the code switching response message, the code switch informing unit **31** transmits the message indicating that the code of the mobile station #**1** (**3***a*) can be switched, to the base station **2***a*. Receiving the code switching response message, the timing information sending unit **33** of the base station **2***a* transmits a code switching start message to the mobile station #**1** (**3***a*). This code switching start message includes start timing information for the code switching. Then, if the radio channel is composed of frames, the code switching start message can be time information per frame.

It is acceptable to switch at the time of frame N (N is equal to **1** or an integer more than **1**) after receiving the code switching start message. It is also acceptable for the timing information to use a code period of the spreading code. Thus, a switching unit **34** is synchronized with the code switching unit **35** in order to switch the code.

Receiving the code switching start message, the code switching unit **35** of the mobile station #**1** (**3***a*) switches the original code (code before switching) to the target code (code after switching) based on the time prescription specified in advance, using the timing information in the message. Then, the code switching unit **35** transmits a code switching complete message to the timing information sending unit **33** in the base station **2***a* using the target code. By receiving the code switching complete message, the timing information sending unit **33** judges that the code switching has been properly completed, and transmits the code switching complete message to the base station controller **1**. By receiving the code switching complete message, a code releasing unit **32** of the base station controller **1** judges that the code used by the mobile station #**1** (**3***a*) has been released, and transmits a radio channel set-up complete message for assigning the code used by the mobile station #**1** (**3***a*) to the mobile station #**2** (**3***b*).

As the code switch timing between the mobile station **3** and the base station **2** can be set up according to the present embodiment, it is not necessary for the base station **2** to simultaneously perform reception and transmission using both the original code and the target code. Consequently, interfering with other communications is reduced.

Embodiment 4

FIG. **10** illustrates a code assignment sequence showing a code switching procedure using the maximum ratio combination of the mobile station **3**, according to the present embodiment. FIG. **17** shows a system structure. Referring to FIGS. **10** and **17**, the code switching according to the present embodiment will now be described.

The procedures, from transmitting the radio channel set-up request message by the mobile station #**2** (**3***b*) up to transmitting the code switching request message by the base station **2***a* to the base station controller **1**, are the same as Embodiment 2 shown in FIG. **5**. Therefore, procedures after the above will now be described in the present embodiment.

As shown in FIG. **10**, after the base station **2***a* sends the code switching request message to the base station controller **1**, a transmitting unit **43** of the base station **2***a* performs reception and transmission with a regenerating unit **44** of the mobile station #**1** (**3***a*) using both the original code (code before switching) and the target code (code after switching). When the base station controller **1** receives the code switching request message from the base station **2***a*, a first code switching unit **41** of the base station controller **1** transmits the message to the mobile station #**1** (**3***a*), and instructs the regenerating unit **44** of the mobile station #**1** (**3***a*) to switch the code. On receiving the code switching request message, the regenerating unit **44** begins to receive signals based on the maximum ratio combination, using both the original code (code just in use) and the target code appointed by the code switching request message.

Regarding the transmission, either of the following methods is acceptable. One is to independently switch the code by using a second code switching unit **45** of the mobile station #**1** (**3***a*). The other is to transmit signals from the mobile station #**1** (**3***a*) with using both the original code in use and the target code. In this case of transmitting with

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using both the codes, it is also acceptable to perform the maximum ratio combination at the base station **2**.

When the second code switching unit **45** of the mobile station #1 (*3a*), in which the reception has been performed by the regenerating unit **44** based on the maximum ratio combination, begins to independently receive signals using the target code only, a switching complete informing unit **46** of the mobile station #1 (*3a*) transmits a code switching complete message to a code releasing unit **42** of the base station controller **1** with using the target code. Then, the code releasing unit **42** judges that the code having been used in the mobile station #1 (*3a*) until this time is released and the code switching is completed. The code releasing unit **42** transmits the code switching complete message to the base station *2a*. On receiving the code switching complete message from the base station controller **1**, the base station *2a* stops transmitting signals to the mobile station #1 (*3a*) using the original code, releases the original code, prepares for the reception and the transmission with the mobile station #2 (*3b*) using the original code, and transmits a radio channel set-up complete message to the base station controller **1**.

After receiving the radio channel set-up complete message from the base station *2a*, the base station controller **1** transmits the message indicating to set up the original code, having been used in the mobile station #1 (*3a*), for the mobile station #2 (*3b*). As stated above, the code switching process using the maximum ratio combination has been performed.

According to the present embodiment procedures, the code switch timing can be achieved based on own timing of the mobile station **3** without deteriorating the channel quality. Namely, the time needed for code switching can be reduced.

In addition, it is also acceptable that the code assignment is controlled by the base station **2** instead of the base station controller **1**.

Having thus described several particular embodiments of the invention, various alterations, modifications, and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements are intended to be part of this disclosure, and are intended to be within the spirit and scope of the invention. Accordingly, the foregoing description is by way of example only, and not intended to be limiting. The invention is limited only as defined in the following claims and the equivalents thereto.

What is claimed is:

1. A radio communication method of a mobile station used for a radio communication system employing CDMA (Code Division Multiple Access) for radio access and providing multi-rate transmission, the radio communication system including a base station controlling apparatus, a plurality of base stations, and a plurality of mobile stations, the mobile station being one of said plurality of mobile stations, the radio communication method comprising steps of:

receiving code information by message from the base station controlling apparatus or from one of said plurality of base stations, said code information for switching a first code being used to a second code;

receiving timing information by message, said timing information including an integer representing a frame at which the first code is switched to the second code;

switching from the first code to the second code based on the code information and the timing information received, said step of switching performed in synchronization with switching from the first code to the second code at the one of the plurality of base stations; and

transmitting a completion message from said mobile station to the base station controlling apparatus or to the one of said plurality of base stations to indicate completion of the step of switching from the first code to the second code, wherein

the timing information is used to synchronize the switching at the mobile station with the switching at the one of plurality of base stations.

2. A mobile station used for a radio communication system employing CDMA (Code Division Multiple Access) for radio access and providing multi-rate transmission, the radio communication system including a base station controlling apparatus, a plurality of base stations, and a plurality of mobile stations, the mobile station being one of said plurality of mobile stations, the mobile station comprising:

a switching unit configured to receive code information by message from the base station controlling apparatus or from one of said plurality of base stations, said code information for switching a first code being used to a second code, said switching unit further configured to receive timing information by message, said timing information including an integer representing a frame at which the first code is switched to the second code, said switching unit further configured to switch from the first code to the second code based on the code information and the timing information received and in synchronization with a switching from the first code to the second code at one of a plurality of base stations, said switching unit further configured to transmit a completion message to the base station controlling apparatus or to the one of said plurality of base stations to indicate completion switching from the first code to the second code, wherein

the timing information is used to synchronize the switching at the mobile station with the switching at the one of plurality of base stations.

3. A radio communication method of a mobile station used for a radio communication system employing CDMA (Code Division Multiple Access) for radio access and providing multi-rate transmission, the radio communication system including a base station controlling apparatus, a plurality of base stations, and a plurality of mobile stations, the mobile station being one of said plurality of mobile stations, the radio communication method comprising steps of:

receiving code information by message from the base station controlling apparatus or from one of said plurality of base stations, said code information for switching a first code being used to a second code;

receiving timing information by message, said timing information including an integer representing a frame at which the first code is switched to the second code at said mobile station;

switching from the first code to the second code at said frame represented by said integer; and

transmitting from said mobile station a completion message to the base station controlling apparatus or to the one of said plurality of base stations to indicate completion of the step of switching from the first code to the second code, wherein

the timing information is further configured to enable the one of a plurality of base stations to switch from the first code to the second code at said frame represented by said integer.

4. A mobile station used for a radio communication system employing CDMA (Code Division Multiple Access) for radio access and providing multi-rate transmission, the radio communication system including a base station con-

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trolling apparatus, a plurality of base stations, and a plurality of mobile stations, the mobile station being one of said plurality of mobile stations, the mobile station comprising:

a switching unit configured to receive code information by message from the base station controlling apparatus or from one of said plurality of base stations, said code information for switching a first code being used to a second code, said switching unit further configured to receive timing information by message, said timing information including an integer representing a frame at which the first code is switched to the second code at said mobile station, said switching unit further configured to switch from the first code to the second code

at said frame represented by said integer, said switching unit further configured to transmit a completion message to the base station controlling apparatus or to the one of said plurality of base stations to indicate completion switching from the first code to the second code, wherein

the timing information is further configured to enable the one of a plurality of base stations to switch from the first code to the second code at said frame represented by said integer.

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EXHIBIT E

US006829489B2

(12) **United States Patent**
Yamamoto et al.

(10) **Patent No.: US 6,829,489 B2**
(45) **Date of Patent: Dec. 7, 2004**

(54) **COMMUNICATION SYSTEM, TRANSMITTER, RECEIVER, AND COMMUNICATION METHOD**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 407 days.

(21) Appl. No.: **09/843,101**

(22) Filed: **Apr. 27, 2001**

(65) **Prior Publication Data**

US 2002/0013156 A1 Jan. 31, 2002

Related U.S. Application Data

(63) Continuation of application No. PCT/JP00/04288, filed on Jun. 29, 2000.

(30) **Foreign Application Priority Data**

Aug. 27, 1999 (JP) 11-241217

(51) **Int. Cl.**[7] **H04Q 7/20**
(52) **U.S. Cl.** **455/522**; 455/13.4; 370/318
(58) **Field of Search** 455/69, 522, 552.1, 455/13.4, 62, 71, 72, 70, 131, 139; 375/326, 338, 221, 358; 342/357.05; 370/318, 320, 335, 441

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(74) *Attorney, Agent, or Firm*—Oblon, Spivak, McClelland, Maier & Neustadt, P.C.

(57) **ABSTRACT**

The communication system comprises a transmitter (1A) and a receiver (2A). Both, the transmitter (1A) and the receiver (2A) are capable of operating in a normal mode or a compressed mode in which setting of a predetermined idle time is allowed. The transmitter (1A) effects transmission power control to a frame in each mode. When operating in the compressed mode, the transmitter (1A) inserts of the idle time in such a manner so as to reduce adverse affect of a transmission power control error that occurs after the idle time.

19 Claims, 23 Drawing Sheets

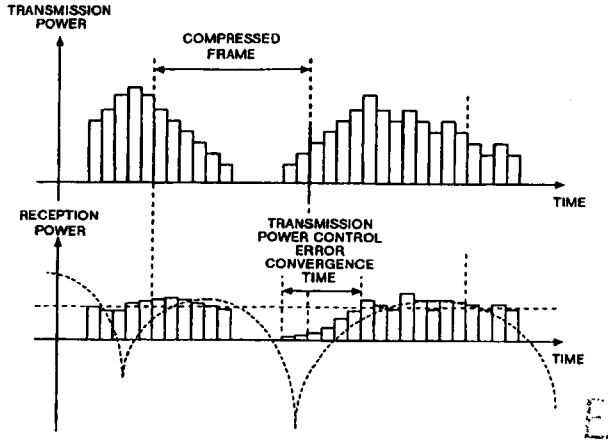

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FIG.1

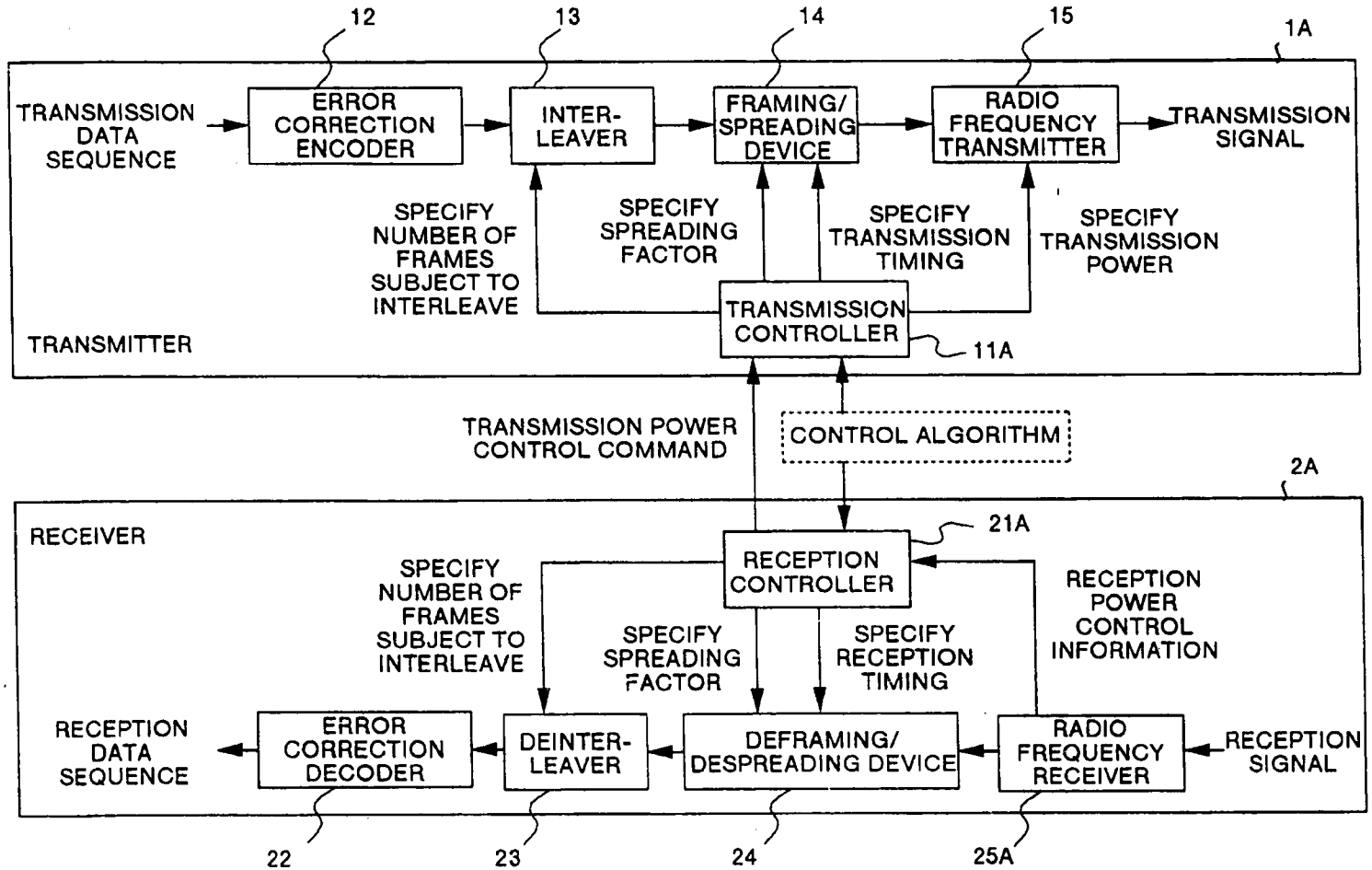

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FIG.2

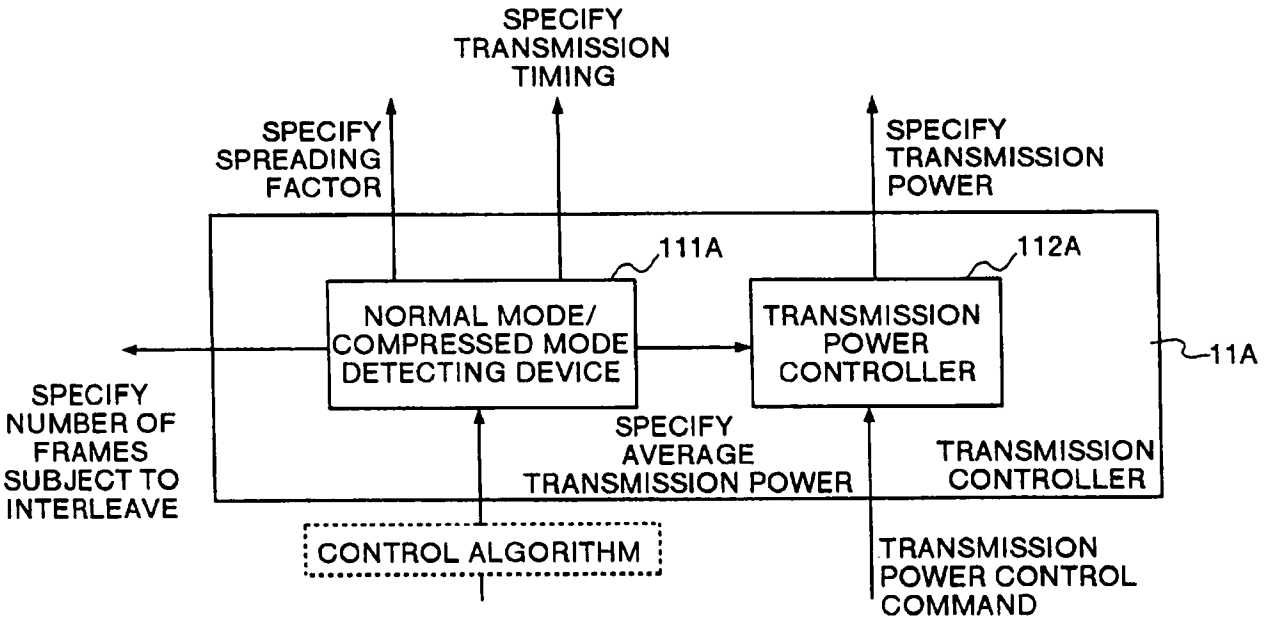

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FIG.3

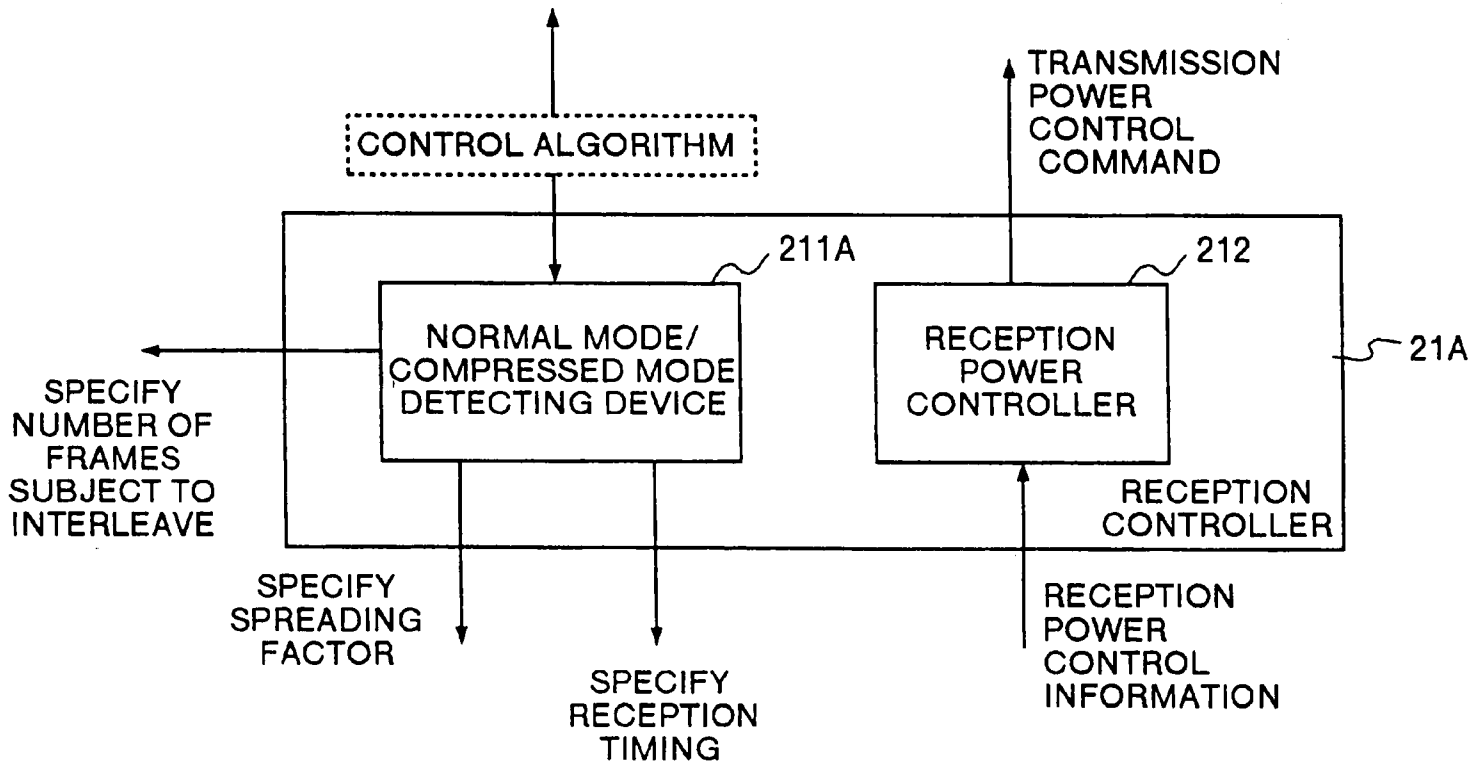

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FIG.4

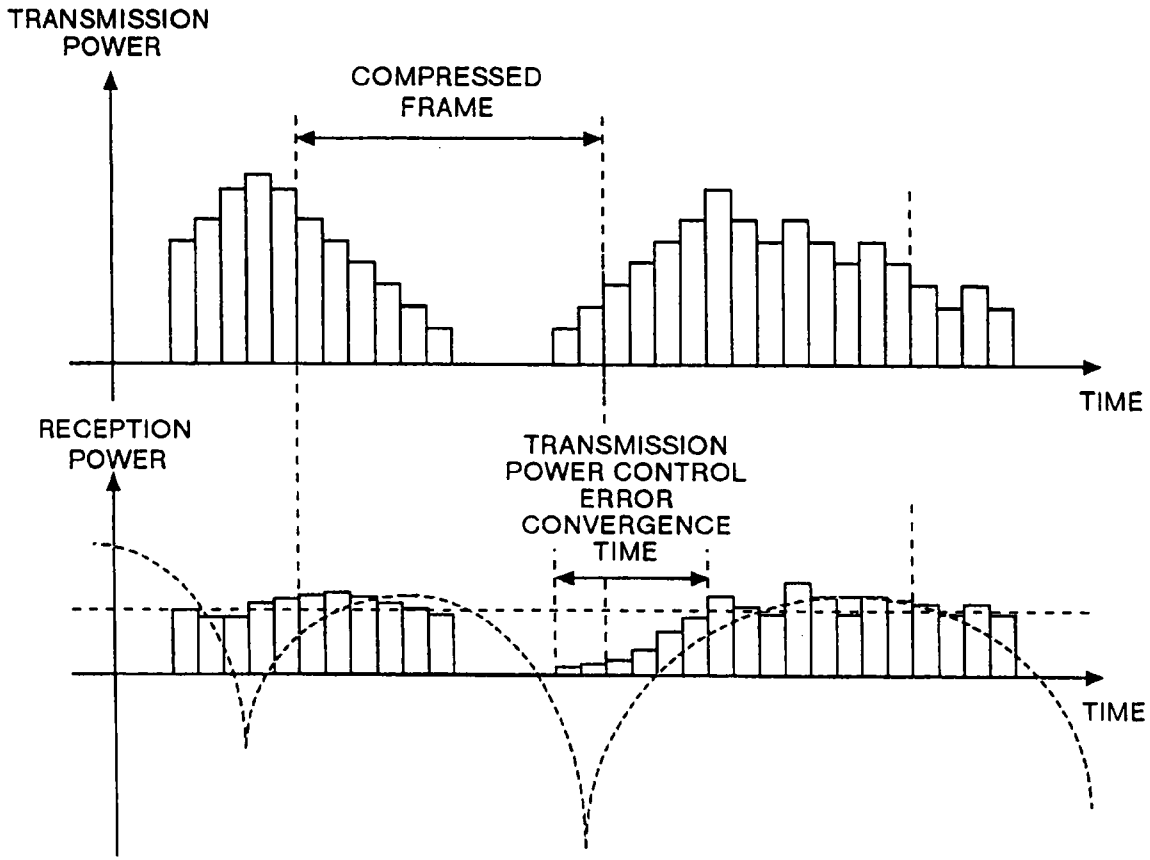
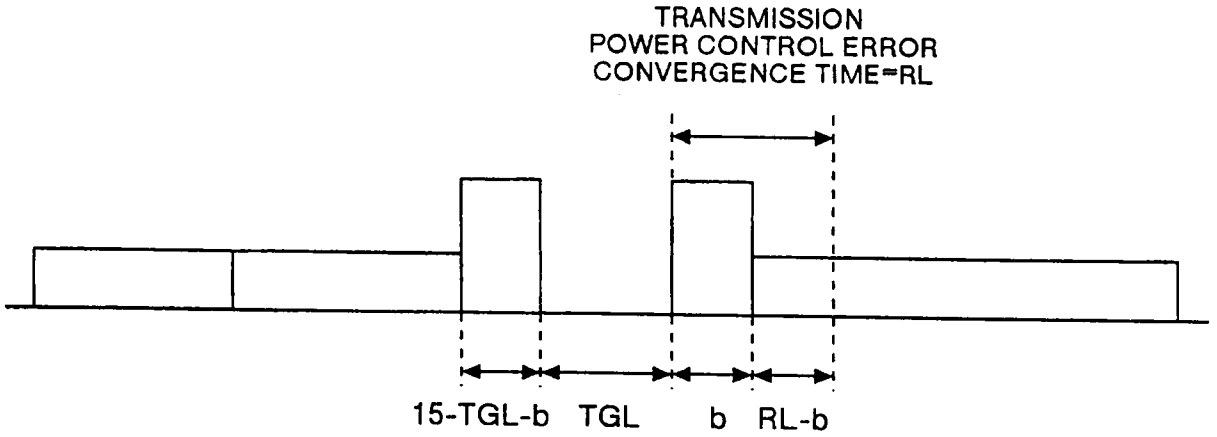


FIG.5

(a)



(b) WHEN TGL=7, RL=7

b	c=b/(15-TGL)
4	4/8
3	3/8
2	2/8
1	1/8
0	0/8

FIG.6

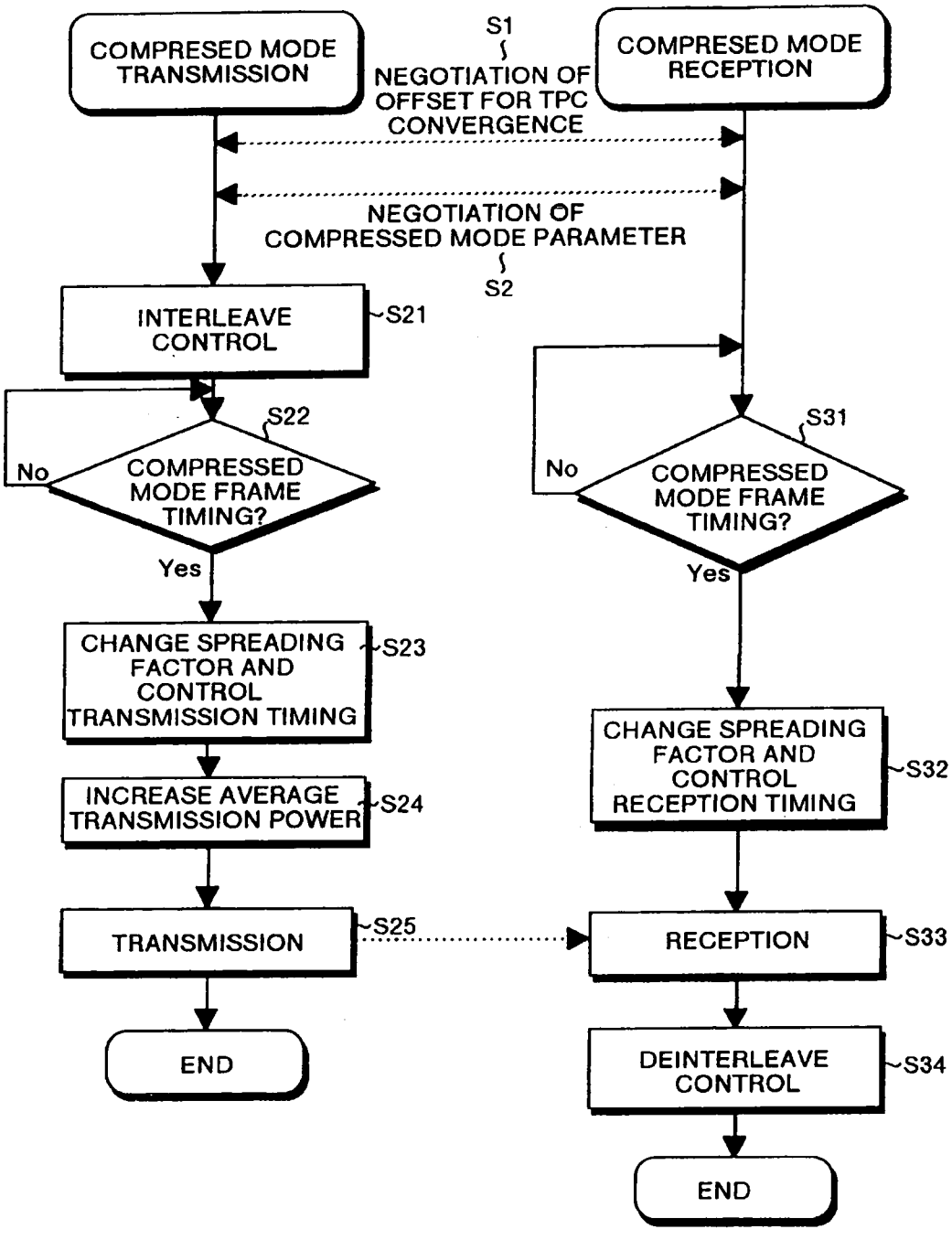


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FIG.7

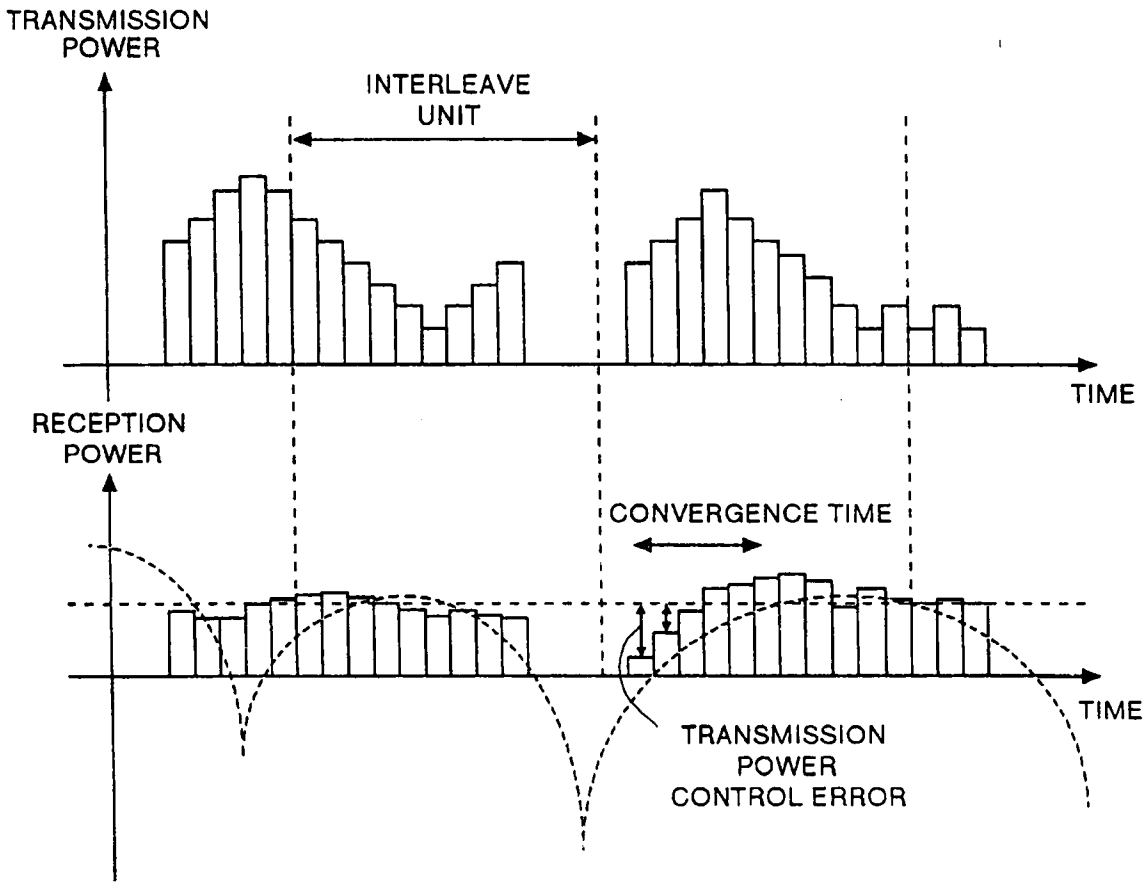

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FIG.8

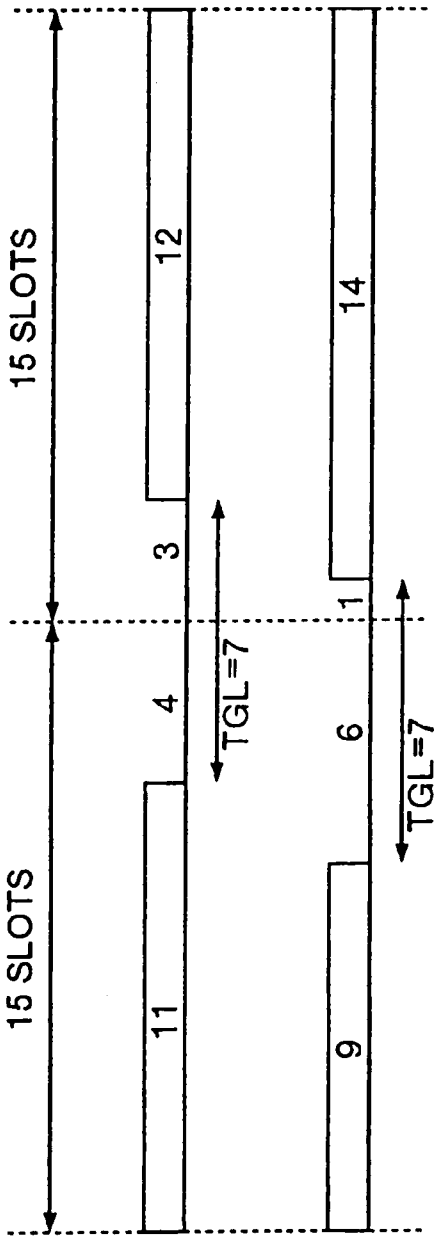

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FIG.9

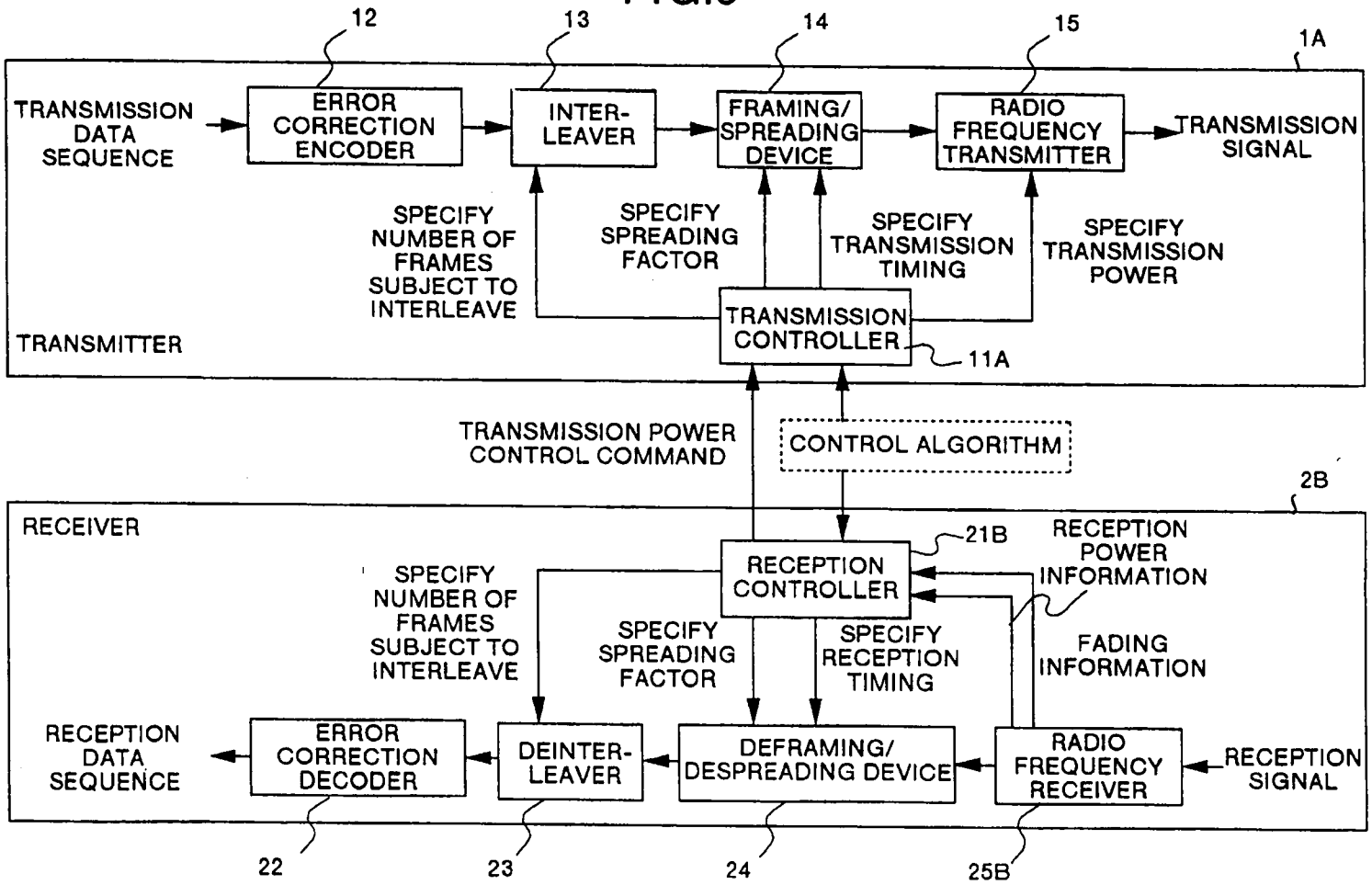
12
13
14
15
1A
TRANSMISSION DATA SEQUENCE
ERROR CORRECTION ENCODER
INTER-LEAVER
FRAMING/ SPREADING DEVICE
RADIO FREQUENCY TRANSMITTER
TRANSMISSION SIGNAL
SPECIFY NUMBER OF FRAMES SUBJECT TO INTERLEAVE
SPECIFY SPREADING FACTOR
SPECIFY TRANSMISSION TIMING
SPECIFY TRANSMISSION POWER
TRANSMISSION CONTROLLER
11A
TRANSMITTER
TRANSMISSION POWER CONTROL COMMAND
CONTROL ALGORITHM
2B
RECEIVER
21B
RECEPTION CONTROLLER
RECEPTION POWER INFORMATION
SPECIFY NUMBER OF FRAMES SUBJECT TO INTERLEAVE
SPECIFY SPREADING FACTOR
SPECIFY RECEPTION TIMING
FADING INFORMATION
RECEPTION DATA SEQUENCE
ERROR CORRECTION DECODER
DEINTER-LEAVER
DEFRAMING/ DESPREADING DEVICE
RADIO FREQUENCY RECEIVER
RECEPTION SIGNAL
22
23
24
25B

FIG.10

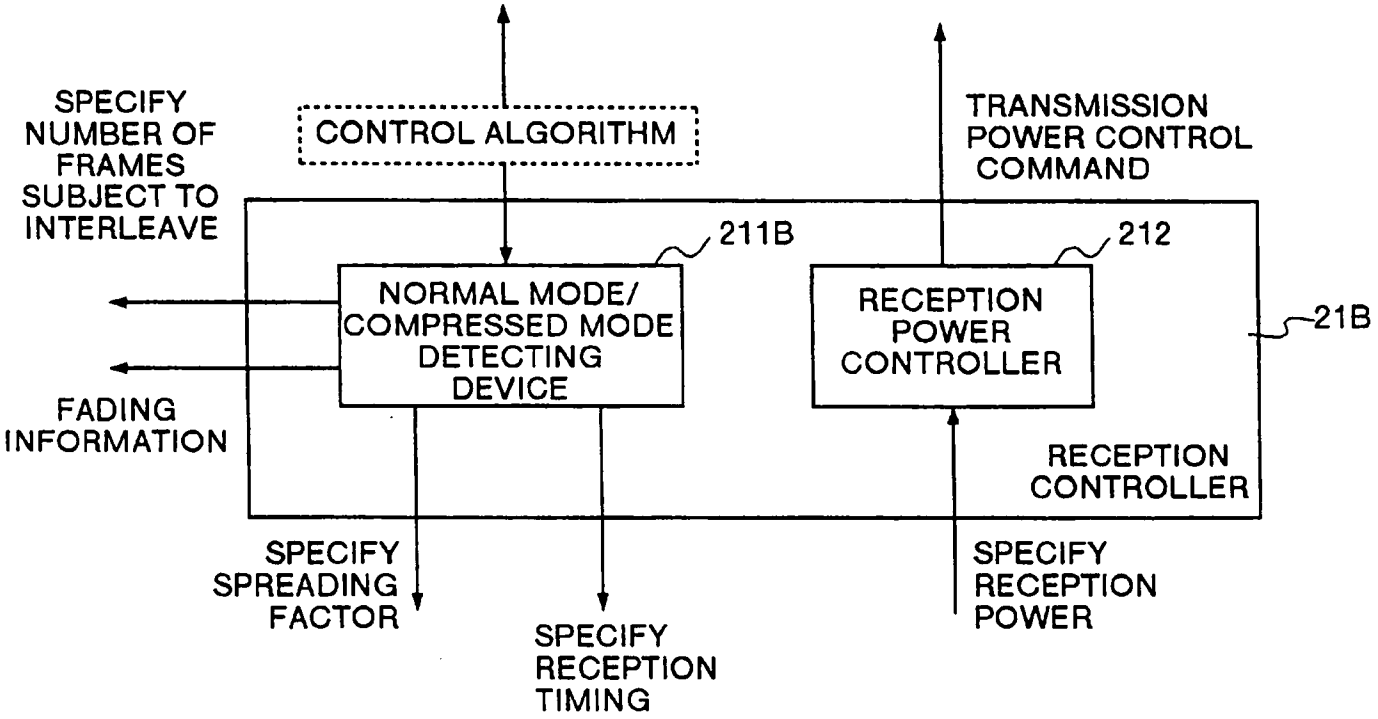

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FIG.11

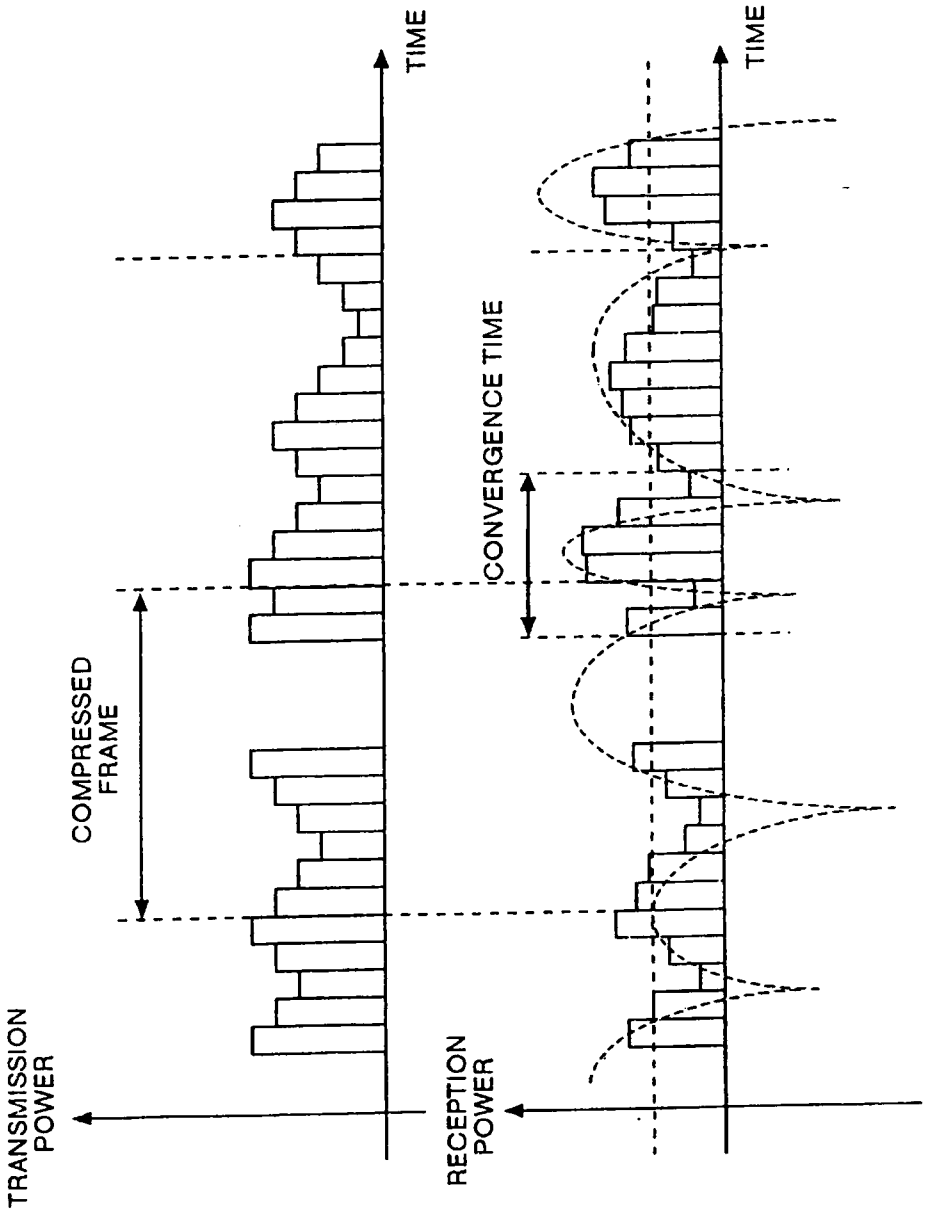

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FIG.12

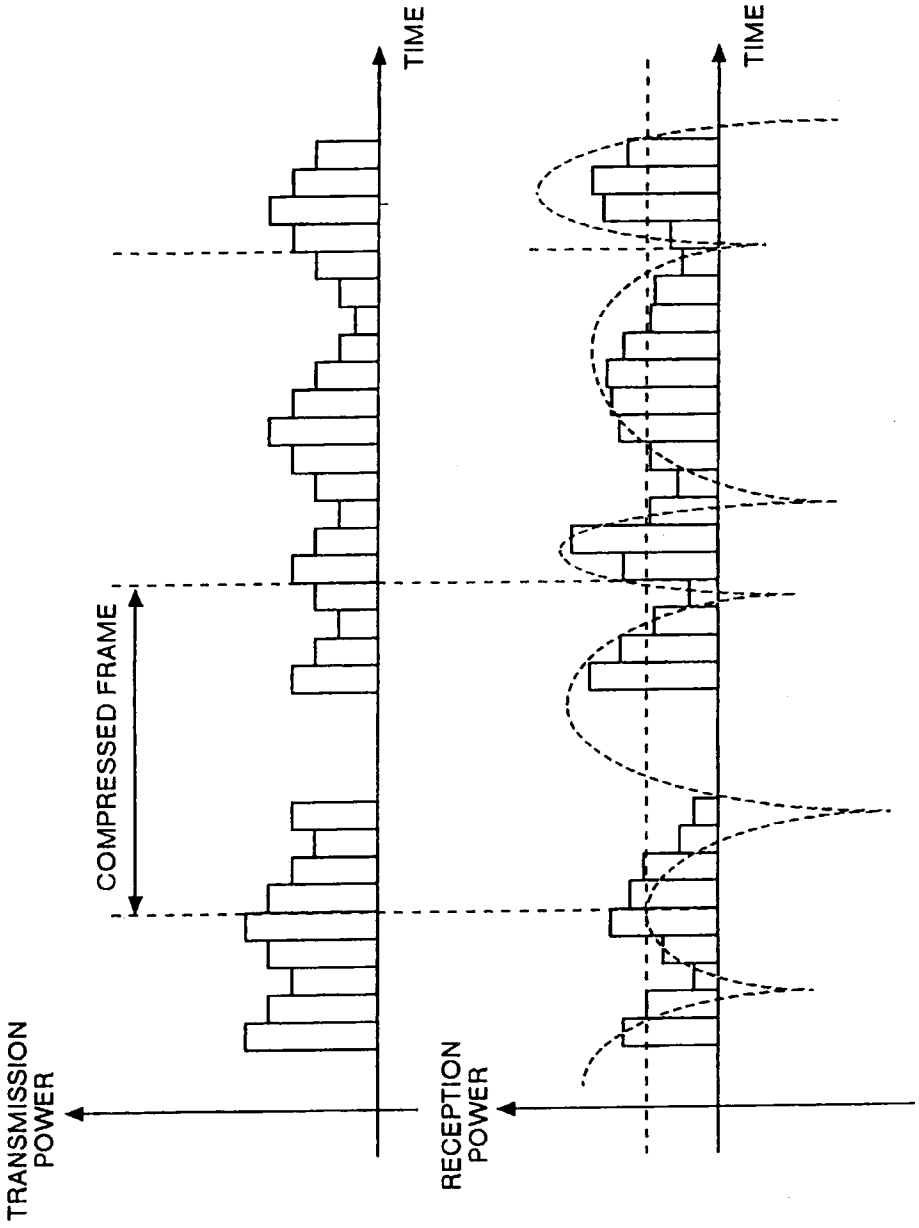

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FIG.13

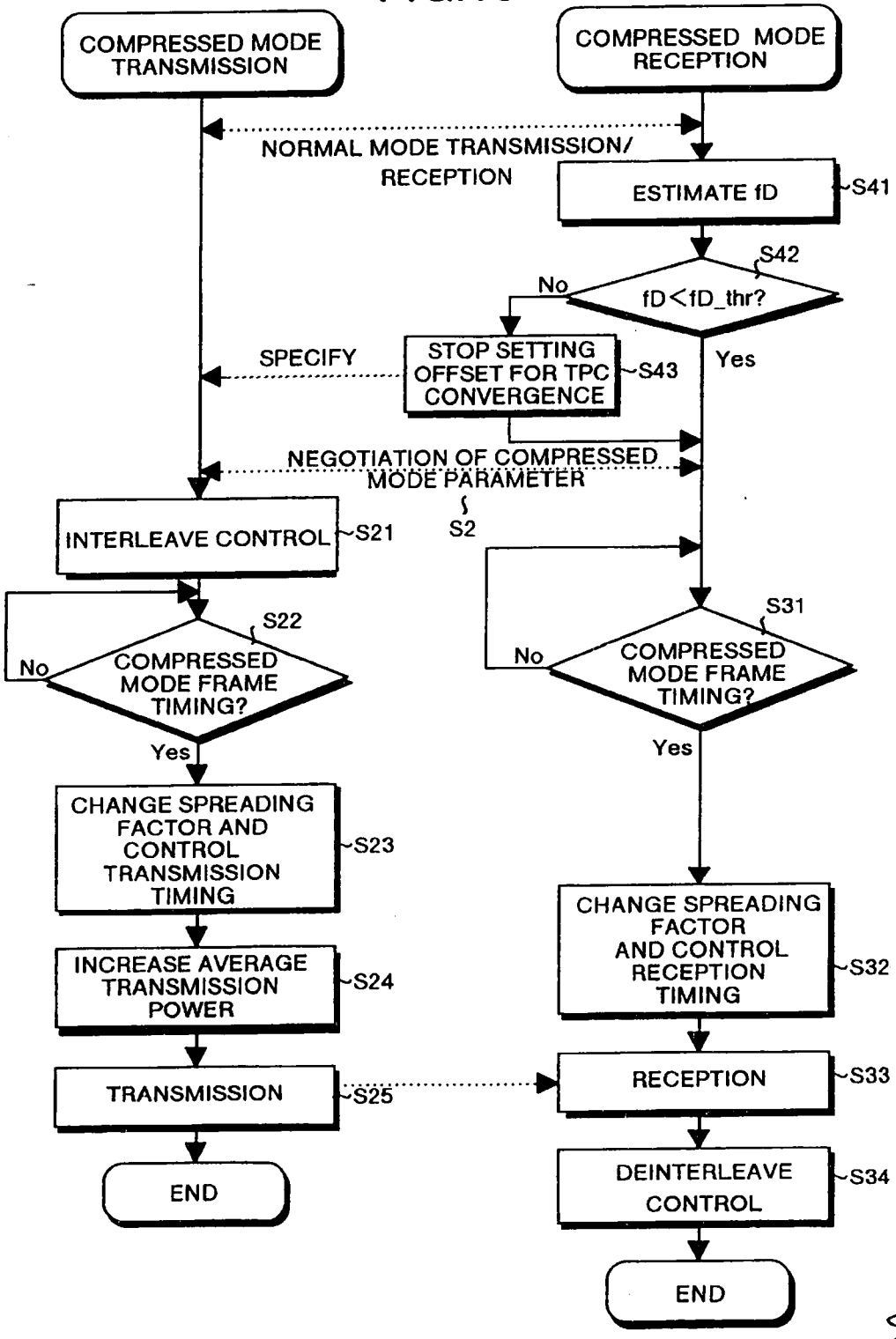

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FIG.14

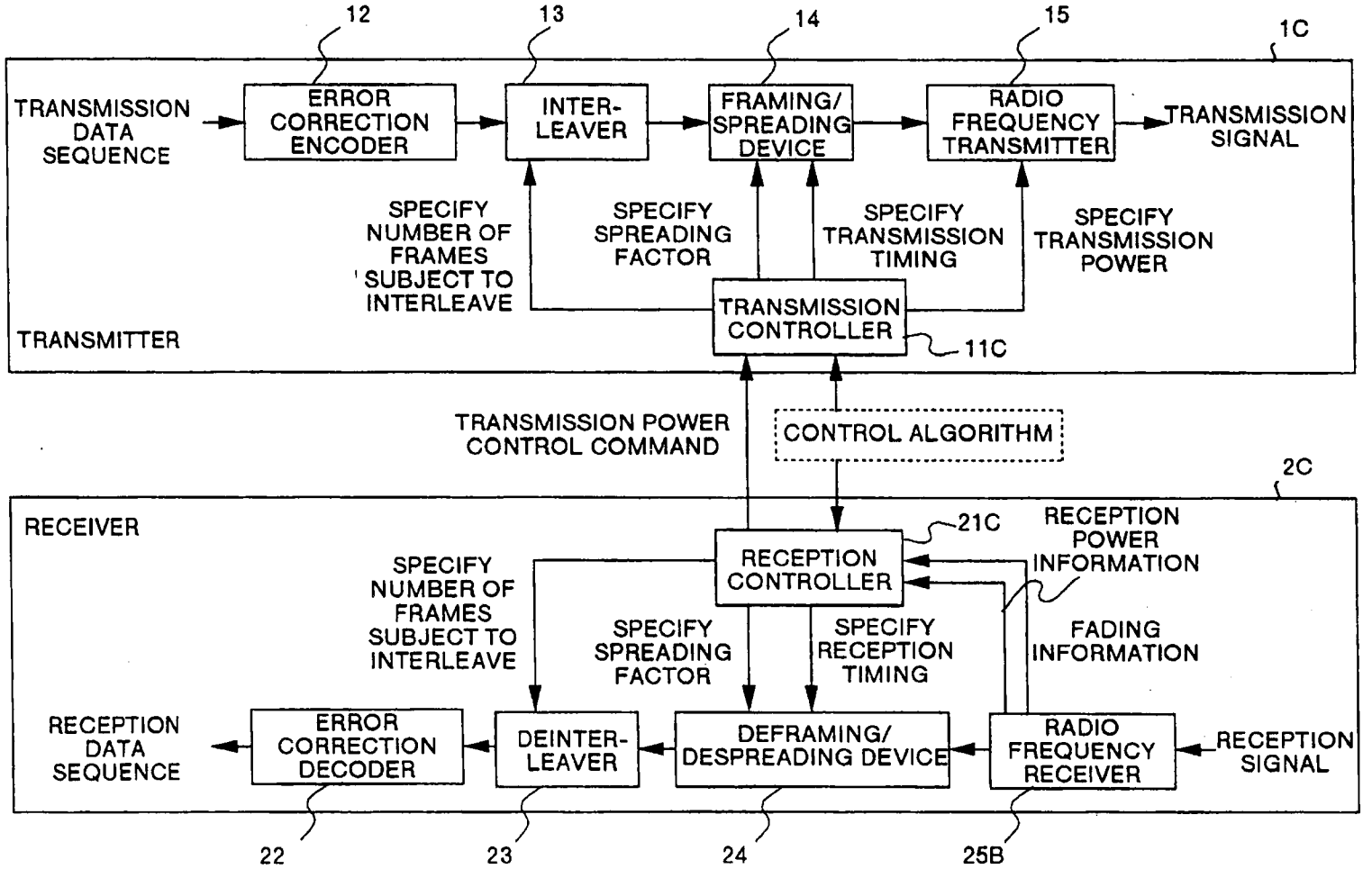

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FIG.15

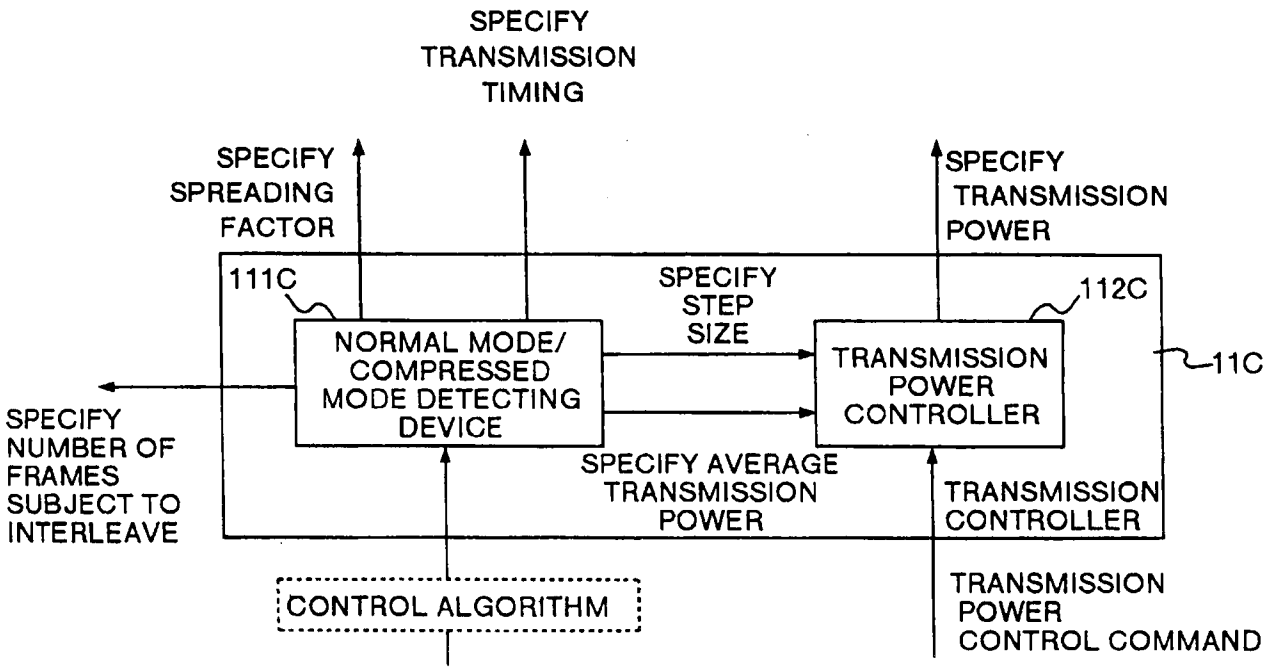

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FIG.16

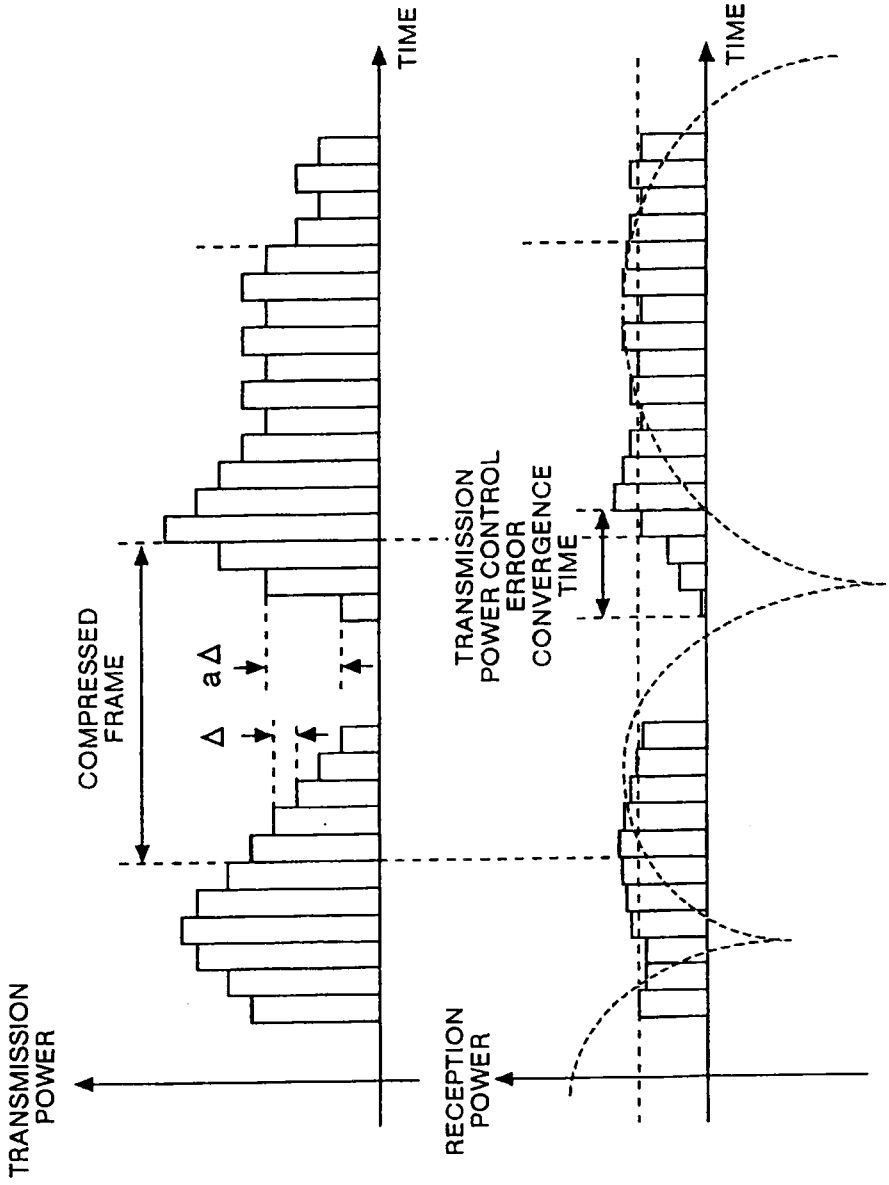

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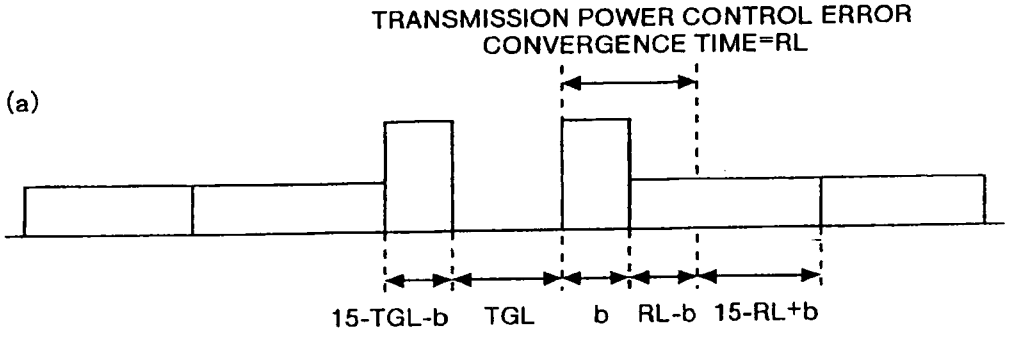
FIG.17

(a)



(b)

TGL=7, RL=7

b	c=b/(15-TGL)
4	4/8
3	3/8
2	2/8
1	1/8
0	0/8

(c)

TGL=7, RL=6

b	c=b/(15-TGL)
4	4/8
3	3/8
2	2/8
1	1/8
0	0/8

(d)

TGL=7, RL=5

b	c=b/(15-TGL)
4	4/8
3	3/8
2	2/8
1	1/8
0	0/8

(e)

TGL=7, RL=4

b	c=b/(15-TGL)
4	4/8
3	3/8
2	2/8
1	1/8
0	0/8

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FIG.18

(a)

TGL=7,RL=3

b	c=b/(15-TGL)
4	3/8
3	3/8
2	2/8
1	1/8
0	0/8

(b)

TGL=7,RL=2

b	c=b/(15-TGL)
4	2/8
3	2/8
2	2/8
1	1/8
0	0/8

(c)

TGL=7,RL=1

b	c=b/(15-TGL)
4	1/8
3	1/8
2	1/8
1	1/8
0	0/8

FIG.19

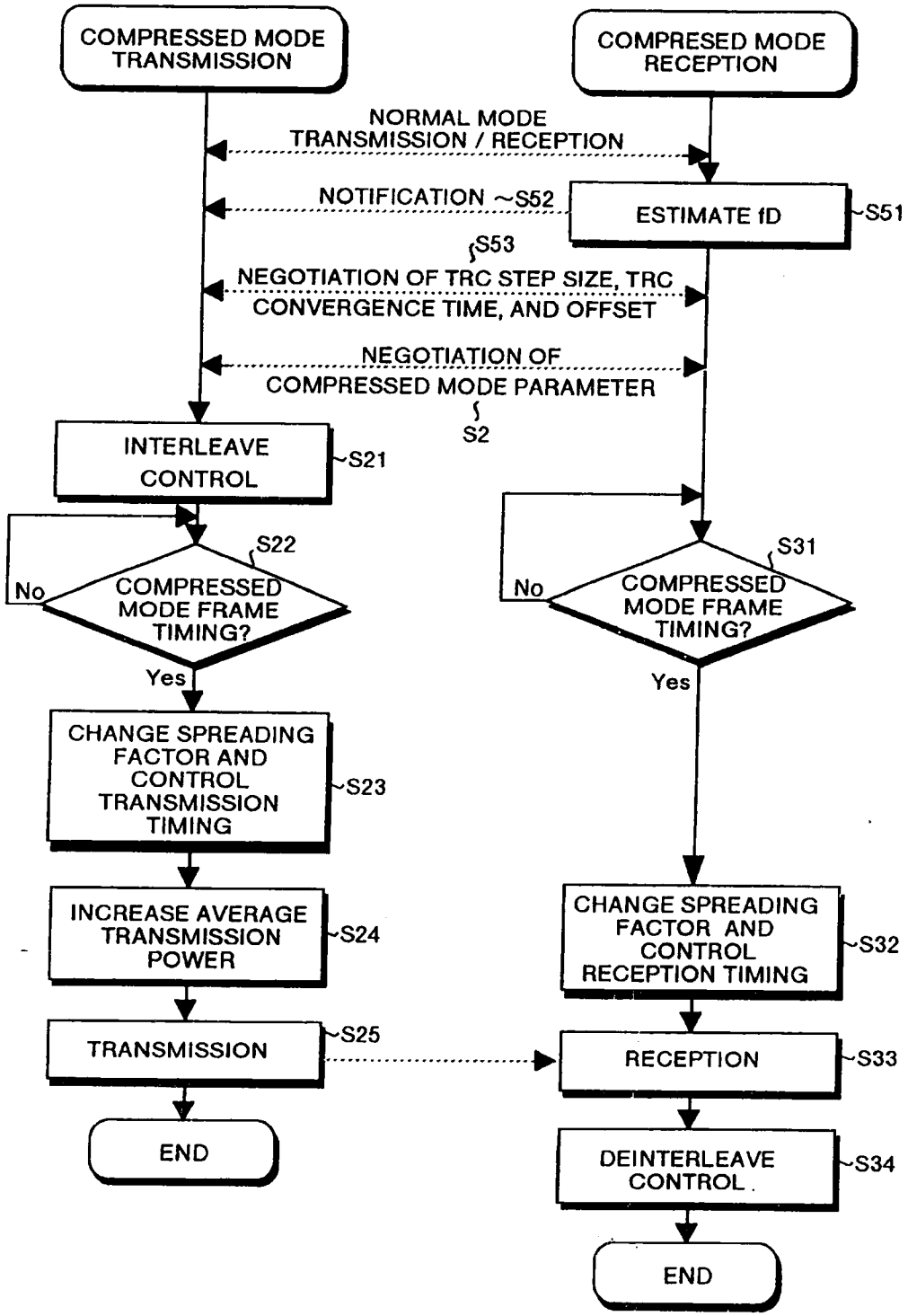

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FIG.20

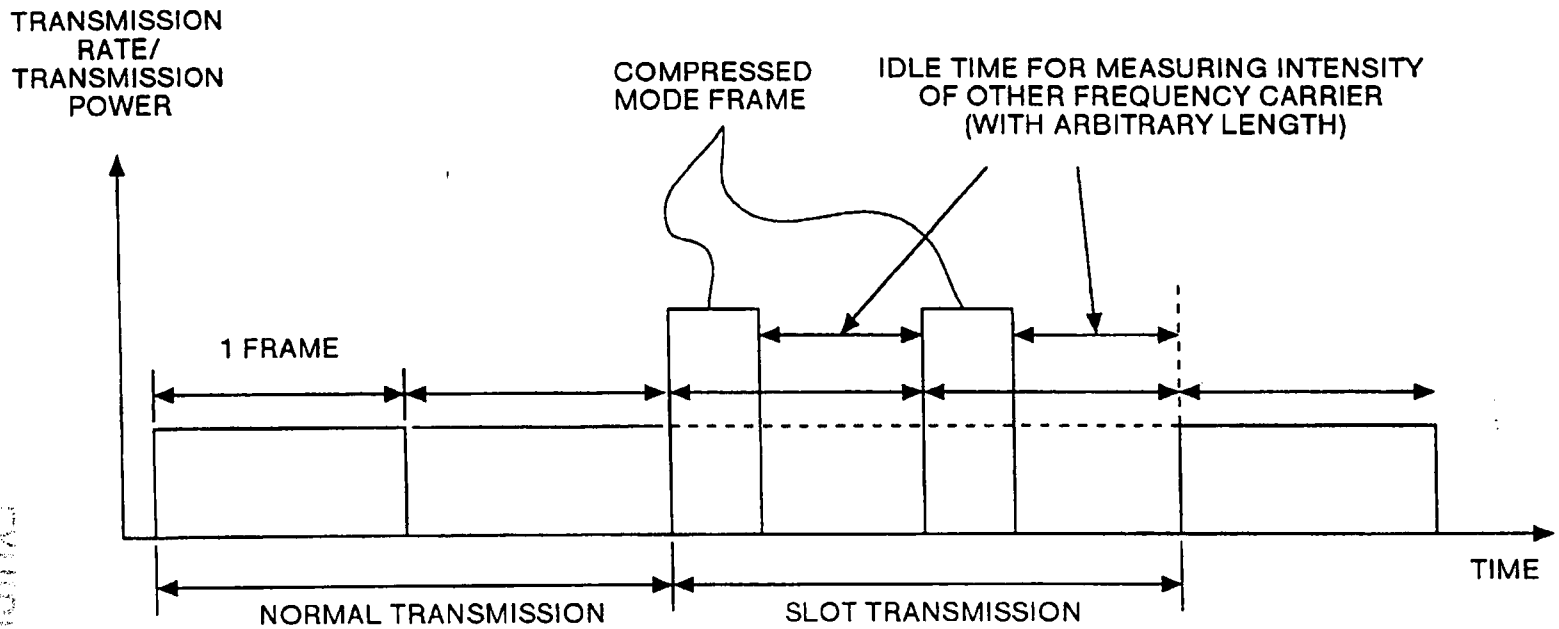

FIG.21

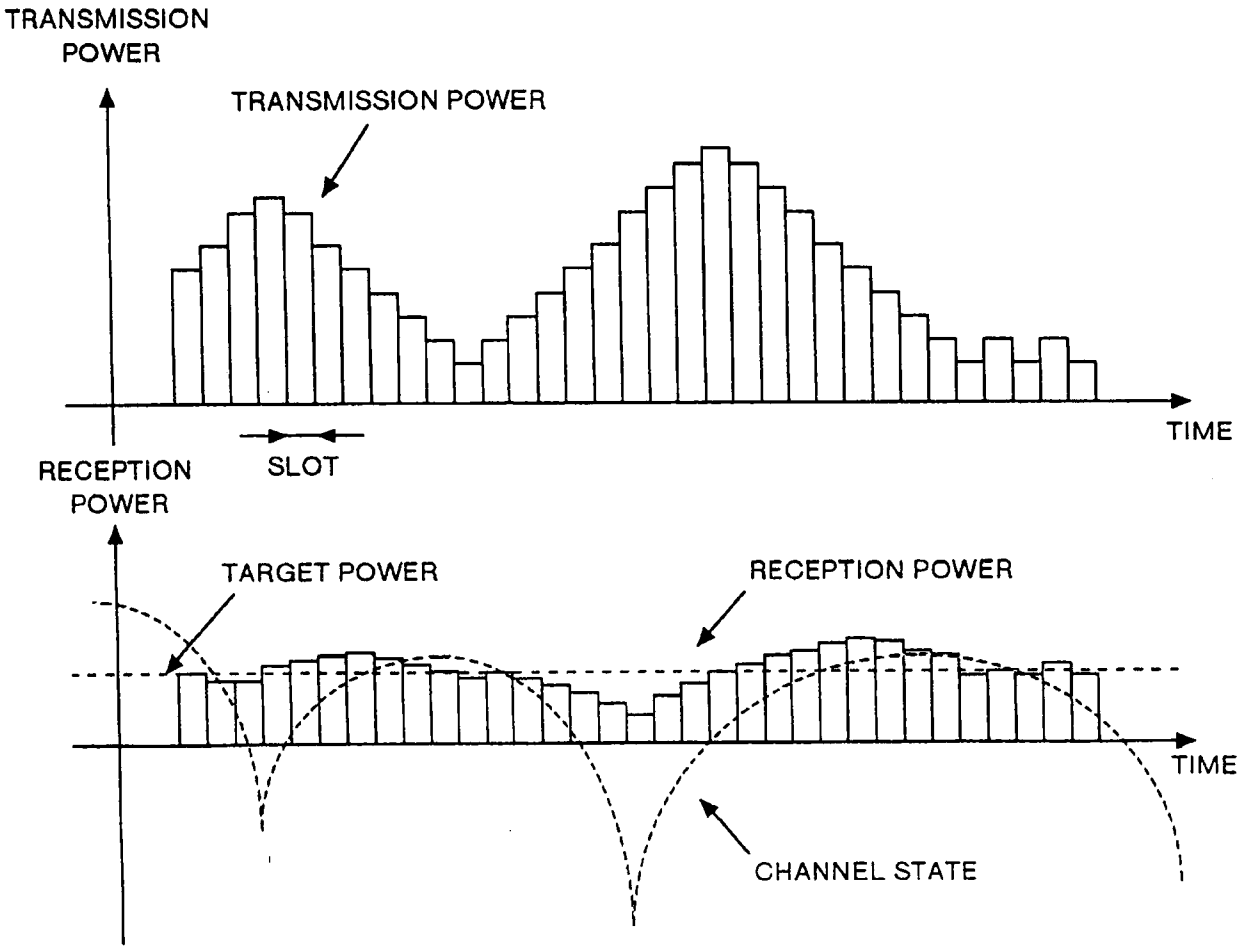

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FIG.22

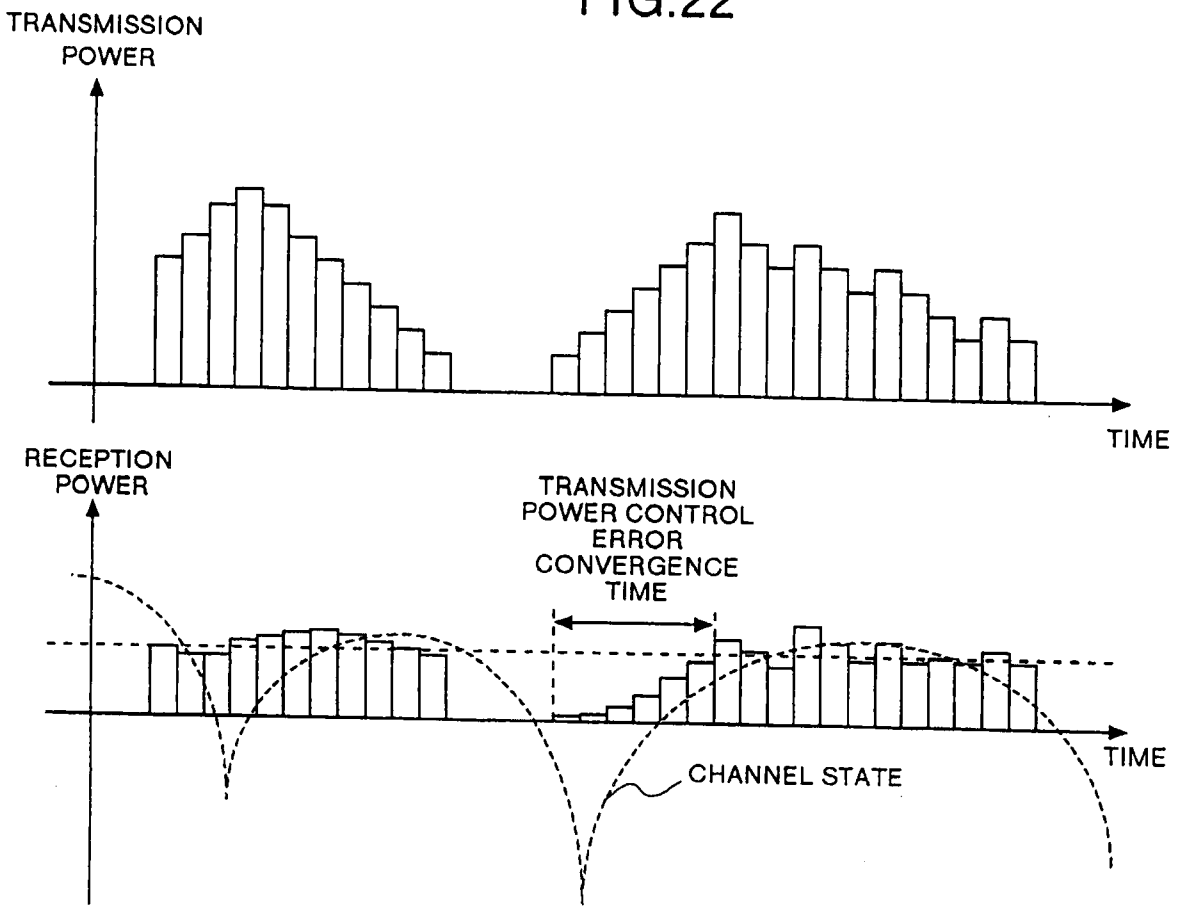
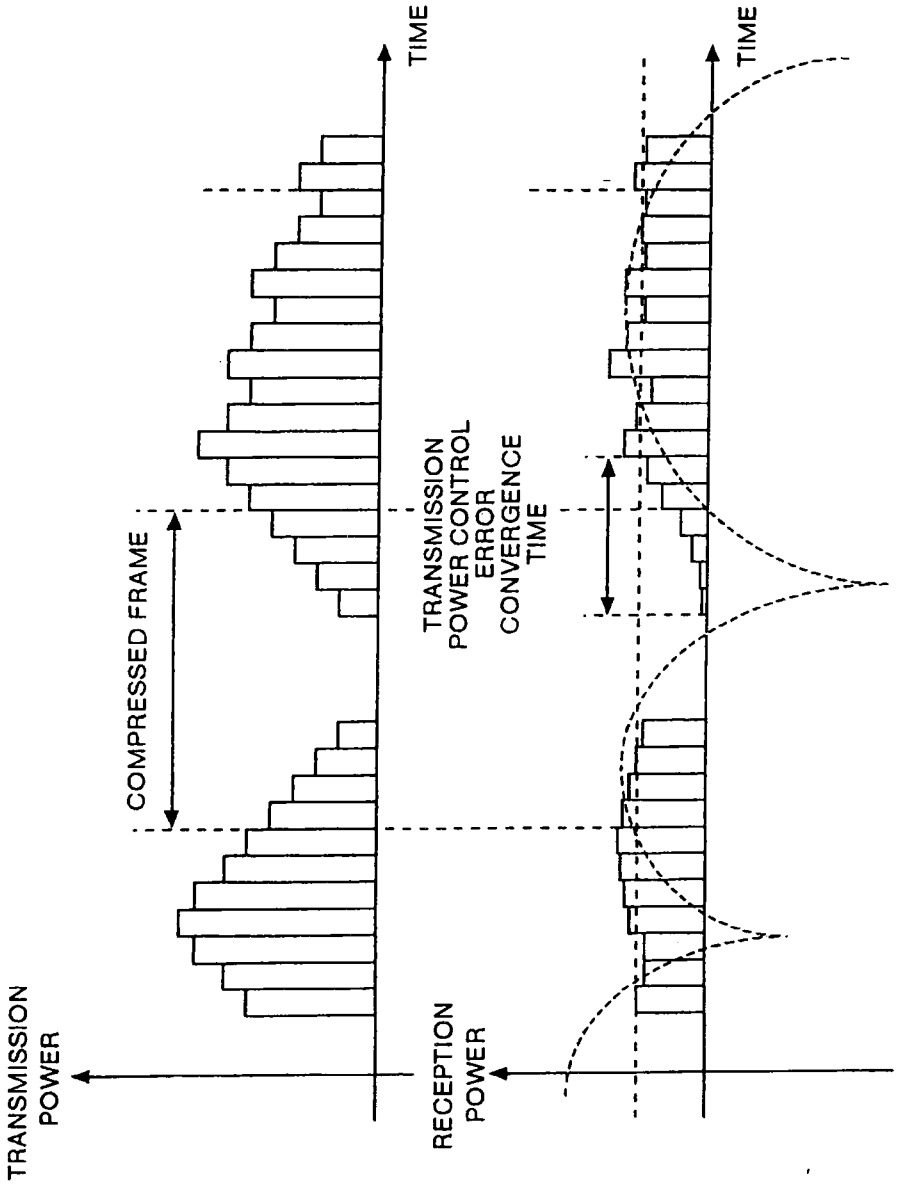


FIG.23



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COMMUNICATION SYSTEM, TRANSMITTER, RECEIVER, AND COMMUNICATION METHOD

CROSS REFERENCES

This application is a Continuation of co-pending International Application PCT/JP00/04288, which has not been published in English, has an International filing date of Jun. 29, 2000, and has a priority date of Aug. 27, 1999, based on Japanese-Laid-Open-Document No. JP11-241217. The entire disclosure of both of these documents is hereby incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to a communication system adaptable to a radio communication, such as a mobile communication and a satellite communication. More particularly, this invention relates to a communication system, a transmitter, a receiver, and a communication method capable of reducing characteristics deterioration at compressed mode transmission in a CDMA (Code Division Multiple Access) communication system.

BACKGROUND ART

A conventional communication system will be explained here. For example, in the CDMA cellular system, the same carrier frequency is repetitively used within a cell, and handover between the frequencies is not necessary within the same cell. However, when the CDMA cellular system coresides with the existing system, handover between different carrier frequencies becomes necessary. Three concrete examples of handover between different carrier frequencies are given below.

The first example is the handover of the frequency between adjacent cells. When different carrier frequencies are assigned to adjacent cells, because the traffic is heavy due to of an increase of the number of subscribers, handover becomes necessary between such cells. The second example is the handover of the frequency between cells of the umbrella structure. For example, when the umbrella structure is formed, different carrier frequencies are assigned to large and small cells, and the handover is necessary between these cells. The third example is the handover of the frequency between the third generation system represented by the W(Wide)-CDMA system and the second generation system represented by the current cellular phone system.

When the handover takes place under the foregoing conditions, it is necessary to detect the power of different frequency carriers. In order to perform such detection, the receiver must be able to detect two frequencies. However, if the receiver is to detect two frequencies, the necessary structure makes the arrangement of the receiver either larger in size or complex in structure.

The handover method includes two types: handover led by a mobile station (Mobile Assisted Handover: MAHO) and handover led by a network (Network Assisted Handover: NAHO). In NAHO, the load on the mobile station is less as compared to MAHO, however, synchronization with each mobile station becomes necessary in the base station. Furthermore, in NAHO, in order to trace each mobile station separately, the arrangement of the base station/network becomes complex and huge.

Thus, MAHO is preferable from the point of view from the mobile station. However, in order to judge whether the handover should take place or not, intensities of two different frequency carriers have to be observed. Different from the TDMA (Time Division Multiple Access) system used in the second generation, the CDMA cellular system generally uses continuous transmission for both transmission and reception. Hence, in order to observe the intensities of two different frequency carriers, the transmission or reception timing has to be suspended to observe the other frequency unless a receiving device capable of handling two frequencies is prepared.

Accordingly, in the conventional communication system, a technique related to a compressed mode has been proposed, in which transmission information in the normal mode is time compressed, so that the compressed information is transmitted in a shorter time and the other frequency carrier is observed in the remaining time. One example is described in PCT Unexamined patent Publication No. 8-500475 entitled as "Discrete Transmission for Seamless Handover in DS-CDMA System". This publication discloses means to attain a compressed mode for cutting a data transmission time shorter by reducing a spreading factor of used spreading codes.

The compressed mode disclosed in the above publication will be explained in brief. FIG. **20** is a view showing a transmission example in the normal mode and compressed mode in the conventional CDMA cellular system. Vertical axis represents the power rate/transmission power and horizontal axis represents time. Compressed mode transmission is interposed between normal transmission frames. For example, in case of transmission in the compressed mode, a non-transmission time is set within a descending frame (compressed frame). The time length can be set arbitrarily. The non-transmission time is used as an idle time during which the intensity of the other frequency carrier is measured. As has been discussed, in the conventional CDMA cellular system, interposing the idle time between the compressed mode frame transmissions allows slot transmission.

Also, at the foregoing compressed mode transmission, the transmission power increases with a time ratio between the idle time and frame (compressed mode frame) transmission time. Thus, as is shown in FIG. **20**, the compressed mode frame is transmitted at higher transmission power than the normal transmission frame. Consequently, it is possible to maintain the transmission quality at the frame transmission in the compressed mode.

Besides the foregoing publication, the references as to the compressed mode include Gustafsson, M. et. al., "Compressed Mode Techniques for Inter-Frequency Measurements in a Wide-band DS-CDMA System", Proc. of 8th IEEE PIMRC, '97. The latter publication discloses means to attain the compressed mode in case of increasing a coding rate, using multi-code transmission, or using multi-bit transmission modulation system, such as 16 QAM, besides the case of reducing the spreading factor.

On the other hand, in the conventional CDMA cellular system, in order to solve the "perspective (near-and-far) problem" that an undesired signal from a nearby station interferes with a desired signal from a remote station, transmission power control to the mobile station is effected so that the reception power in each base station will be equal. Hence, in the conventional CDMA cellular system, the channel state that is changed with time by adverse affect, such as fading, is corrected, so that not only can the required communication quality be secured at the receiver station, but also the line capacity can be utilized efficiently. The following description will describe the transmission power control in the conventional communication system with reference to the accompanying drawings.

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FIG. **21** is a view showing the transmission power control at the normal mode transmission in the conventional communication system. To begin with, the receiver station determines reception power on the target such that meets the required communication quality, that is, target power. Here, the required communication quality on the target is not limited to the reception power, and may be a power ratio (SIR: Signal-to-Interference Ratio) between a desired signal and an interference signal instead. Then, the receiver station compares the power of the received desired signal with the target power, and if the former is greater than the latter, the receiver station sends a transmission power control command (TPC) to the transmitter station to lower the transmission power, and if the former is smaller than the latter, the receiver station sends a TPC command to the transmitter station to increase the transmission power. Upon receipt of the TPC command, the transmitter station changes the transmission power by using prescribed power amplitude: Δ in accordance with the content in the TPC command. Here, the transmission power control is performed per time unit called as a slot to follow a change in the channel state (channel state) shown in the drawing. Either a fixed value or a value that varies in accordance with a certain rule is given as the value of Δ.

FIG. **22** is a view showing the transmission power control at the compressed mode transmission in the conventional communication system. The target power is not changed between the normal mode transmission and compressed mode transmission for ease of explanation. However, in general, there is a case that the set value of the target power is changed so as to ensure the required quality at the compressed mode transmission. Basic operations at the compressed mode transmission, such as following a change in the channel state, are the same as those at the normal mode transmission. However, at the compressed mode transmission, the receiver station does not receive a signal during the idle time in the compressed mode, and therefore, the receiver station cannot send a transmission power control command (TPC) to the transmitter station properly. This disables the transmission side to follow a change in the channel state, and when the transmission is resumed, a signal is sent on the transmission power immediately before shifting to the compressed mode as is shown in the drawing, thereby causing a "transmission power control error". Accordingly, in the conventional communication system, the transmission power control error caused by the compressed mode transmission is converged as soon as possible by employing a method of increasing the power amplitude Δ, for example. Hereinafter, a period since the transmission is resumed until the transmission power control error is converged (that is, a period until the reception power is restored in the vicinity of the target power) is referred to as a transmission power control convergence time.

Furthermore, in the conventional communication system, in order to achieve an interleave effect, the setting position of the idle time (non-transmission time) in the compressed mode is placed near the center of the frame formed by a plurality of slots as shown in FIG. **23**, so that interleave is effected per base unit of a frame. In order to achieve a satisfactory interleave effect, it is more preferable to place the idle time near the center of the frame where bits within the frame can be dispersed with time than to place the idle time at the end of the frame to narrow the bits region after the interleave.

However, in the foregoing conventional communication system, a data volume within one frame is compensated with the actual transmitting time being compressed at the compressed mode transmission, and for this reason, a method of increasing a transmission rate by lowering the spreading factor or a method of increasing the transmission rate by reducing a coding rate is employed. Hence, as was discussed above as the prior art, in case that the idle time is placed near the center of the frame, slots with a lower spreading factor or slots with a reduced coding rate are placed in the transmission power control convergence time as shown in FIG. **23**, which results in considerable deterioration in signal decoding accuracy. In short, the conventional communication system has a problem that adverse affect of the transmission power control error caused by the idle time is much greater than in the normal frame.

In addition, in the conventional communication system, in order to reduce the transmission power control error caused by the idle time, there has been proposed a method, in which the idle time is dispersed to more than one position so as to be placed discretely with time. However, according to the proposed method, each idle time is short, and when consideration is given to processing time or the like, there arises a problem that efficiency is reduced when observing the intensity of a different frequency carrier.

The present invention is devised to solve the above problems. It is an object of the present invention to obtain a communication system, a transmitter and a receiver, and a communication method capable of reducing adverse affect of the transmission power control error caused by the idle time without dispersing the idle time at the compressed mode transmission within a frame.

DISCLOSURE OF THE INVENTION

A communication system of the present invention, including a transmitter and a receiver both capable of operating in a normal mode or a compressed mode in which setting of a predetermined non-transmission time is allowed, the transmitter effecting transmission power control to a frame in each mode, wherein, when operating in the compressed mode, the transmitter changes a position of the non-transmission time in such a manner so as to minimize adverse affect of a transmission power control error that occurs after the non-transmission time.

According to the above-mentioned aspect, the position of the non-transmission time (idle time) in the compressed mode is changed in such a manner so as to minimize adverse affect of a transmission power control error that occurs after the non-transmission time, for example, with consideration given to the adverse affect of the transmission power control error and the interleave effect. Thus, different from the conventional method, it is not necessary to adapt a method of dispersing the non-transmission time at the compressed mode transmission within a frame.

According to the communication system of another aspect of the present invention, when the unit of interleaving is set to one frame, the transmitter places the non-transmission time in the compressed mode rearward from a center of a compressed frame.

According to the above-mentioned aspect, adverse affect of the transmission power control error is taken into consideration, and the position of the non-transmission time in the compressed mode is determined so as to be placed rearward from the center of the compressed frame, for example, thereby allowing observation of a different frequency carrier within the non-transmission time.

According to the communication system of another aspect of the present invention, the transmitter places data of at least one slot after the non-transmission time within the compressed frame, so that a satisfactory interleave effect is achieved.

According to the above-mentioned aspect, the position of the non-transmission time in the compressed mode is determined so as to be placed rearward from the center of the compressed frame, for example, with consideration given to the adverse affect of the transmission power control error and the interleave effect, and further, data of at least one slot is placed after the non-transmission time within the compressed frame, thereby allowing observation of a different frequency carrier within the non-transmission time.

According to the communication system of another aspect of the present invention, when the unit of interleaving is set to one frame and the non-transmission time extends over two frames, the transmitter places the non-transmission time in the compressed mode longer in a first frame and set relatively shorter in a second frame.

According to the above-mentioned aspect, the non-transmission time is set relatively longer in a first frame and set relatively shorter in a second frame, so that a satisfactory interleave effect can be achieved even when the non-transmission time extends over first and following second frames with consideration given to adverse affect of the transmission power control error to the second frame.

According to the communication system of another aspect of the present invention, the receiver estimates maximum Doppler frequency, compares the estimated maximum Doppler frequency with a preset threshold of the maximum Doppler frequency, and when the estimated maximum Doppler frequency is higher than the threshold, negotiates with the transmitter not to effect control as to a change of the position of the non-transmission time and when the estimated maximum Doppler frequency is lower than the threshold, the transmitter places the non-transmission time in the compressed mode rearward from the center of the compressed frame.

According to the above-mentioned aspect, the estimated value of the maximum Doppler frequency is compared with the preset threshold of the maximum Doppler frequency, and when a frequency of the estimated value is lower than the threshold, the non-transmission time is placed rearward in the compressed frame. On the other hand, when the frequency of the estimated value is higher than the threshold, negotiation is made so as not to adjust the non-transmission time, and the non-transmission time is placed near the center of the compressed frame. In other words, the position of the non-transmission time in the compressed frame is changed in response to the pitch of the fading frequency.

According to the communication system of another aspect of the present invention, the transmitter and receiver set a step size of power in transmission power control larger than a predetermined value set as a reference value through negotiation, and reduce a number of slots needed for the transmission power control error convergence that occurs after the non-transmission time.

According to the above-mentioned aspect, the step size of the transmission power control is determined in response to the fading frequency, and further, by estimating the transmission power control error convergence time based on the step size, the non-transmission time is set with consideration given to the adverse affect of the transmission power control error caused by the non-transmission time and the interleave effect.

According to the communication system of another aspect of the present invention, in an area where moving at a high speed is expected, the control as to a change of the position of the non-transmission time is not effected, and in an area where moving at a high speed is not expected, the non-transmission time in the compressed mode is placed rearward from the center of the compressed frame.

According to the above-mentioned aspect, by estimating the fading frequency based on the largeness of the cell radius, the non-transmission time is set with consideration given to the adverse affect of the transmission power control error caused by the non-transmission time and the interleave effect.

A transmitter of another aspect of the present invention for operating in a normal mode or a compressed mode in which setting of a predetermined non-transmission time is allowed and effecting transmission power control to a frame in each mode wherein, when operating in the compressed mode, changing a position of the non-transmission time in such a manner so as to minimize adverse affect of a transmission power control error that occurs after the non-transmission time.

According to the above-mentioned aspect, the position of the non-transmission time in the compressed mode is changed in such a manner so as to minimize the adverse affect of the transmission power control error that occurs after the non-transmission time, for example, with consideration given to the adverse affect of the transmission power control error and the interleave effect.

According to the transmitter of another aspect of the present invention, when the unit of interleaving is set to one frame, placing the non-transmission time in the compressed mode rearward from a center of a compressed frame.

According to the above-mentioned aspect, adverse affect of the transmission power control error is taken into consideration, and the position of the non-transmission time in the compressed mode is determined so as to be placed rearward from the center of the compressed frame, for example, thereby allowing observation of a different frequency carrier.

According to the transmitter of another aspect of the present invention, placing data of at least one slot after the non-transmission time within the compressed frame, so that a satisfactory interleave effect is achieved.

According to the above-mentioned aspect, the position of the non-transmission time in the compressed mode is determined so as to be placed rearward from the center of the compressed frame, for example, with consideration given to the adverse affect of the transmission power control error and the interleave effect, and further, data of at least one slot is placed after the non-transmission time within the compressed frame, thereby allowing observation of a different frequency carrier.

According to the transmitter of another aspect of the present invention, when the unit of interleaving is set to one frame and the non-transmission time extends over two frames, placing the non-transmission time in the compressed mode longer in a first frame and set relatively shorter in a second frame.

According to the above-mentioned aspect, the non-transmission time is set relatively longer in a first frame and set relatively shorter in a second frame, so that a satisfactory interleave effect can be achieved even when the non-transmission time extends over first and following second frames with consideration given to the adverse affect of the transmission power control error to the second frame.

According to the transmitter of another aspect of the present invention, through negotiation with a receiver, setting a step size of power in transmission power control larger than a predetermined value set as a reference value, and

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reducing a number of slots needed for the transmission power control error convergence that occurs after the non-transmission time.

According to the above-mentioned aspect, the step size of the transmission power control is determined in response to the fading frequency, and further, by estimating the transmission power control error convergence time based on the step size, the non-transmission time is set with consideration given to the adverse affect of the transmission power control error caused by the non-transmission time and the interleave effect.

A receiver of another aspect of the present invention estimates maximum Doppler frequency, compares the estimated maximum Doppler frequency with a preset threshold of the maximum Doppler frequency, and when the estimated maximum Doppler frequency is higher than the threshold, negotiates with a transmitter not to effect control as to a change of the position of the non-transmission time.

According to the above-mentioned aspect, the estimated value of the maximum Doppler frequency is compared with the preset threshold of the maximum Doppler frequency, and when a frequency of the estimated value is higher than the threshold, negotiation is made so as not to adjust the non-transmission time, and the non-transmission time is placed near the center of the compressed frame.

According to the receiver of another aspect of the present invention, through negotiation with a transmitter, setting a step size of power in transmission power control larger than a predetermined value set as a reference value, and reducing a number of slots necessary for a transmission power control error that occurs after the non-transmission time to converge.

According to the above-mentioned aspect, the step size of the transmission power control is determined in response to the fading frequency, and further, by estimating the transmission power control error convergence time based on the step size, the non-transmission time is set with consideration given to the adverse affect of the transmission power control error caused by the non-transmission time and the interleave effect.

A communication method of another aspect of the present invention comprises a transmission step and a reception step operating in a normal mode or a compressed mode in which setting of a predetermined non-transmission time is allowed, the transmission step including effecting of transmission power control, wherein, when operating in the compressed mode, a position of the non-transmission time is changed in the transmission step in such a manner so as to minimize adverse affect of a transmission power control error that occurs after the non-transmission time.

According to the above-mentioned aspect, the position of the non-transmission time in the compressed mode is changed in such a manner so as to minimize adverse affect of a transmission power control error that occurs after the non-transmission time, for example, with consideration given to the adverse affect of the transmission power control error and the interleave effect.

According to the communication method of another aspect of the present invention, when the unit of interleaving is set to one frame, in the transmission step, the non-transmission time in the compressed mode is placed rearward from a center of a compressed frame.

According to the above-mentioned aspect, adverse affect of the transmission power control error is taken into consideration, and the position of the non-transmission time in the compressed mode is determined so as to be placed rearward from the center of the compressed frame, for example, thereby allowing observation of a different frequency carrier.

According to the communication method of another aspect of the present invention, in the transmission step, data of at least one slot is placed after the non-transmission time within the compressed frame, so that a satisfactory interleave effect is achieved.

According to the above-mentioned aspect, the position of the non-transmission time in the compressed mode is determined so as to be placed rearward from the center of the compressed frame, for example, with consideration given to the adverse affect of the transmission power control error and the interleave effect, and further, data of at least one slot is placed after the non-transmission time within the compressed frame, thereby allowing observation of a different frequency carrier.

According to the communication method of another aspect of the present invention, when the unit of interleaving is set to one frame and the non-transmission time extends over two frames, in the transmission step, the non-transmission time in the compressed mode is set relatively longer in a first frame and set relatively shorter in a second frame.

According to the above-mentioned aspect, the non-transmission time is set relatively longer in a first frame and set relatively shorter in a second frame, so that a satisfactory interleave effect can be achieved even when the non-transmission time extends over first and following second frames with consideration given to adverse affect of the transmission power control error to the second frame.

According to the communication method of another aspect of the present invention, in the reception step, a maximum Doppler frequency is estimated, and the estimated maximum Doppler frequency is compared with a preset threshold of the maximum Doppler frequency, and when the estimated maximum Doppler frequency is higher than the threshold, a negotiation is made with a transmitter not to effect control as to a change of the position of the non-transmission time; and in the transmission step, when the frequency of the estimated maximum Doppler frequency is lower than the threshold, the non-transmission time in the compressed mode is placed rearward from the center of the compressed frame.

According to the above-mentioned aspect, the estimated value of the maximum Doppler frequency is compared with the preset threshold of the maximum Doppler frequency, and when a frequency of the estimated value is lower than the threshold, the non-transmission time is placed rearward in the compressed frame. On the other hand, when the frequency of the estimated value is higher than the threshold, negotiation is made so as not to adjust the non-transmission time, and the non-transmission time is placed near the center of the compressed frame.

According to the communication method of another aspect of the present invention, in the transmission step and reception step, a step size of power in transmission power control is set larger than a predetermined value set as a reference value through negotiation, and a number of slots needed for the transmission power control error convergence that occurs after the non-transmission time is reduced.

According to the above-mentioned aspect, the step size of the transmission power control is determined in response to the fading frequency, and further, by estimating the transmission power control error convergence time based on the step size, the non-transmission time is set with consideration

given to the adverse affect of the transmission power control error caused by the non-transmission time and the interleave effect.

According to the communication method of another aspect of the present invention, in an area where moving at a high speed is expected, the control as to a change of the position of the non-transmission time is not effected, and in an area where moving at a high speed is not expected, the non-transmission time in the compressed mode is placed rearward from the center of the compressed frame.

According to the above-mentioned aspect, by estimating the fading frequency based on the largeness of the cell radius, the non-transmission time is set with consideration given to the adverse affect of the transmission power control error caused by the non-transmission time and the interleave effect.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view depicting an arrangement of a first embodiment of a communication system of the present invention;

FIG. **2** is a view depicting an arrangement as to transmission power control by a transmission controller **11**A in the first embodiment;

FIG. **3** is a view depicting an arrangement as to transmission power control by a reception controller **21**A in the first embodiment;

FIG. **4** is a view showing a setting position of an idle time at compressed mode transmission in the first embodiment;

FIG. **5** is a view showing an optimal position of the idle time when consideration is given to adverse affect of a transmission power control error;

FIG. **6** shows a flowchart of the various steps in this communication method according to the first embodiment;

FIG. **7** is a view showing a setting position of an idle time at compressed mode transmission in a second embodiment;

FIG. **8** is a view showing adverse affect of a transmission power control error that occurs after the idle time to a second frame;

FIG. **9** is a view depicting an arrangement of a third embodiment of the communication system of the present invention;

FIG. **10** is a view depicting an arrangement as to transmission power control by a reception controller **21**B in the third embodiment;

FIG. **11** is a view showing a setting position of an idle time at compressed mode transmission in the third embodiment (when the fading frequency is low);

FIG. **12** is a view showing another setting position of an idle time at compressed mode transmission in the third embodiment (when the fading frequency is high);

FIG. **13** shows a flowchart of the various steps in this communication method according to the third embodiment;

FIG. **14** is a view depicting an arrangement of a fourth embodiment of the communication system of the present invention;

FIG. **15** is a view depicting an arrangement as to transmission power control by a transmission controller **11**C in the fourth embodiment;

FIG. **16** is a view showing a setting position of an idle time at compressed mode transmission in the fourth embodiment;

FIG. **17** is a view showing an optimal position of an idle time when the number of slots in a transmission power control error convergence time is reduced;

FIG. **18** is a view showing another optimal position of an idle time when the number of slots in a transmission power control error convergence time is reduced;

FIG. **19** shows a flowchart of the various steps in this communication method according to the fourth embodiment;

FIG. **20** is a view showing a transmission example in a normal mode and a compressed mode in a conventional CDMA cellular system;

FIG. **21** is a view showing transmission power control at normal mode transmission in a conventional communication system;

FIG. **22** is a view showing transmission power control at compressed mode transmission in a conventional communication system; and

FIG. **23** is a view showing a position of an idle time at compressed mode transmission in a conventional communication system.

BEST MODE FOR CARRYING OUT THE INVENTION

Preferred embodiments of a communication system and a communication method of the present invention are described in detail below with reference to accompanying drawings. It should be appreciated, however, that the present invention is not limited to the embodiments described below.

FIG. **1** is a view depicting an arrangement of a first embodiment of the communication system of the present invention. In the present embodiment, the CDMA (Code Division Multiple Access) system will be explained as an example of the communication system. However, the communication system is not limited to the CDMA system, and can be any radio communication system (mobile communication, satellite communication, etc.) adapting the communication method of the present invention.

As shown in FIG. **1**, the communication system of the present invention comprises a transmitter **1**A and a receiver **2**A. Such a transmitter **1**A and receiver **2**A are provided to the base station and each of the mobile station forming the system. The base station and each mobile station communicate wirelessly by means of the CDMA communication system.

Configuration of the transmitter **1**A will be explained here. The transmitter **1**A includes a transmission controller **11**A, an error correction encoder **12**, an interleaver **13**, a framing/spreading device **14**, and a radio frequency transmitter **15**. The transmission controller **11**A chiefly controls the operations of the interleaver **13**, framing/spreading device **14**, and radio frequency transmitter **15** through negotiation with the receiver **2**A. For example, the transmission controller **11**A specifies the number of frames subject to interleave in each of the normal mode (non-compressed mode) and compressed mode through negotiation with the receiver **2**A. Also, in the compressed mode, the transmission controller **11**A specifies a change of the spreading factor and transmission timing for transmitting a frame in the compressed mode to the framing/spreading device **14**. Further, the transmission controller **11**A directs the radio frequency transmitter **15**A to increase/decrease transmission power.

The error correction encoder **12** generates coding data by effecting the error correction coding to a transmission data sequence. The interleaver **13** interleaves the time sequential orders per bit unit of the coding data, so that should sequential bits of a transmission signal be lost by fading during transmission (in case that a burst data error occurs),

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adverse affect of a transmission error can be minimized. The interleaver **13** can interleave more than one frame, and when specified the number of frames subject to interleave by the transmission controller **11A**, the interleaver **13** effects the interleave to that number of frames.

The framing/spreading device **14** spreads the normal mode and compressed mode by using a user-specific spreading code into a broad band, and forms a frame suitable to each mode. When specified the transmission timing for each mode by the transmission controller **11A**, the framing/spreading device **14** transmits the frame to the radio frequency transmitter **15** at that transmission timing. Further, when a change of the spreading factor is specified by the transmission controller **11A** in the compressed mode, the framing/spreading device **14** generates a transmission signal by using a spreading factor lower than that in the normal mode as per instruction.

The radio frequency transmitter **15** converts the transmission signal obtained in the framing/spreading device **14** into a radio frequency and transmits the same. The radio frequency transmitter **15** outputs the transmission signal by increasing/decreasing the transmission power under the control of the transmission controller **11A**. For example, the radio frequency transmitter **15** outputs the transmission signal in the compressed mode by increasing average transmission power from that in the normal mode.

Next, configuration of the receiver **2A** will be explained. The receiver **2A** includes a reception controller **21A**, an error correction decoder **22**, a deinterleaver **23**, a deframing/despreading device **24**, and a radio frequency receiver **25A**. The reception controller **21A** chiefly controls the operation of the deinterleaver **23** and deframing/despreading device **24** through negotiation with the transmitter **1A**. For example, the reception controller **21A** specifies the number of frames subject to deinterleave suitable in each of the normal mode and compressed mode through negotiation with the transmitter **1A**. Also, in the compressed mode, the reception controller **21A** specifies a change of the spreading factor and reception timing for receiving a frame in the compressed mode to the deframing/despreading device **24**.

The radio frequency receiver **25A** decodes a reception signal sent from an unillustrated antenna. The deframing/despreading device **24** generates a frame for each of the normal mode and compressed mode by means of despreading with a spreading code allocated to the user of the receiver **2A**. Also, when specified the reception timing for each mode by the reception controller **21A**, the deframing/despreading device **24** takes in the reception signal from the radio frequency receiver **25A** at that reception timing. Further, when specified a change of the spreading factor by the reception controller **21A** in the compressed mode, the deframing/despreading device **24** generates a reception signal by using a spreading factor lower than that in the normal mode as per instruction.

The deinterleaver **23** deinterleaves the time sequential orders per bit unit for the frame generated in the deframing/despreading device **24** in an inverse order in the interleaver **13** in the transmitter **1A**. Like the interleaver **13**, the deinterleaver **23** can also deinterleave more than one frame, and effects the deinterleave to that number of frames subject to deinterleave specified by the reception controller **21A**. In addition, the error correction decoder **22** generates decoding data, that is, a reception data sequence, by effecting the error correction decoding to a signal to which the deinterleave has been effected.

The transmission controller **11A** and reception controller **21A** operate in the following manner. FIG. **2** is a view depicting an arrangement as to transmission power control by the transmission controller **11A** of the present embodiment. Legend **111A** denotes a normal mode/compressed mode detecting device and legend **112A** denotes a transmission power controller. The normal mode/compressed mode detecting device **111A** determines timing at which the normal mode shifts to the compressed mode through negotiation with the receiver **2A**, and specifies a change of the spreading factor and transmission timing to the framing/spreading device **14**. Similarly, the normal mode/compressed mode detecting device **111A** directs the transmission power controller **112A** to increase average transmission power to suppress deterioration of a communication quality caused when compressing data in the compressed mode. When directed to increase the average transmission power, the transmission power controller **112A** determines transmission power per slot unit based on the average transmission power and a transmission power control command (TPC command) from the receiver **2A**, and specifies the determination result to the radio frequency transmitter **15**.

FIG. **3** is a view depicting an arrangement as to transmission power control by the reception controller **21A** of the present embodiment. Legend **211A** denotes a normal mode/compressed mode detecting device and Numeral **212** denotes a reception power controller. The normal mode/compressed mode detecting device **211A** determines timing at which the normal mode shifts to the compressed mode through negotiation with the transmitter **1A**, and specifies a change of spreading factor and reception timing to the deframing/despreading device **24**. In the normal mode and compressed mode, the reception power controller **212** compares the target power set so as to meet the required communication quality with power of the reception signal based on reception power control information notified by the radio frequency receiver **25B**. When the latter is greater than the former, the reception power controller **212** notifies the transmitter **1A** of a transmission power control command directing to lower the transmission power by predetermined power amplitude Δ. On the other hand, when the latter is smaller than the former, the reception power controller **212** notifies the transmitter **1A** of a transmission power control command directing to increase the transmission power by predetermined power amplitude Δ.

Next, how and where (hereafter referred to as 'setting position') the ideal time is set will be explained. FIG. **4** is a view showing an example of the setting position of the idle time at the compressed mode transmission. Herein, one frame is given as an interleave unit. For example, in the compressed mode, because data is compressed for transmission, if the transmission power control error convergence time is the same, decoding characteristics are deteriorated more by adverse affect of the transmission power control error compared with the frame in the normal mode. For this reason, the normal mode/compressed mode detecting device **111A** of the present embodiment controls the idle time to be placed rearward from the center of the compressed frame by specifying the transmission timing shown in FIG. **2**. Upon receipt of the specification, the framing/spreading device **14** places the idle time at the desired position within the compressed frame.

If the number of slots after the idle time within the compressed frame decreases, so does the interleave effect within the compressed frame. Thus, in order to achieve a satisfactory interleave effect, at least one slot is set after the idle time within the compressed frame. In the present embodiment, because one frame is given as the interleave

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unit, the number of slots after the idle time within the compressed frame is set at least one. However, in case that the interleave unit extends over more than one frame, the number of slots after the idle time may be 0 (nil).

When the idle time is placed rearward from the center of the compressed frame as has been discussed, the number of slots after the idle time, that is, the number of slots given with a lowered spreading factor or the slots given with a reduced coding rate to be placed in the transmission power control convergence time, is smaller than the conventional number of slots. Accordingly, the signal decoding accuracy is upgraded significantly. In other words, in the communication system of the present embodiment, adverse affect of the transmission power control error caused by the idle time can be reduced markedly compared with the prior art. In addition, when the number of slots after the idle time within the compressed frame is set to one or more, the transmission power control convergence time is divided into the first and following second frames, that is, extends over two frames. Consequently, deterioration in decoding accuracy in the following second frame can be decreased.

When the number of slots after the idle time is set to 0 (nil), adverse affect of the transmission power control error is minimized. However, in this case, most of the slots are placed forward in the compressed frame, and there may be a case where a satisfactory interleave effect cannot be obtained. Thus, in the present embodiment, consideration is given to both the interleave effect and the adverse affect of the transmission power control error, and the idle time is placed rearward in the compressed frame and the number of slots after the idle time within the compressed frame is at least one.

FIGS. 5(*a*) and 5(*b*) are views showing an optimal position of the idle time when consideration is given to adverse affect of the transmission power control error. In the present embodiment, the explanation is given for a case where one typical frame includes 15 slots for ease of explanation. TGL (transmission Gap Length) denotes the number of slots in the idle time in the compressed mode; a small letter b denotes the number of slots after the idle time in the compressed frame; 15-TGL-b denotes the number of slots before the idle time in the compressed frame; and RL (Recover Length) denotes the transmission power control error convergence time. In FIG. 5, 7 slots are given as the number TGL of idle slots in the compressed mode and also 7 slots are given as the transmission power control error convergence time RL.

For example, given TGL=7 in the idle time in the compressed mode, then the transmitter 1A has to transmit all the data (bits) in (15-TGL)=8 slots. Here, given RL=7 as the transmission power control error convergence time caused when adversely affected by the idle time, a ratio of being adversely affected by the transmission power control error when the number b of slots is varied (0 to 4), that is, a ratio c of the number of slots (b slots) after the idle time to the number of slots (8 slots) used in transmitting data, can be illustrated as FIG. 5. It is understood that the smaller the number b of the slots after the idle time, the less the adverse affect of the transmission power control error caused by the idle time become. However, in order to achieve a satisfactory interleave effect such that attains the error correction coding effect by randomizing errors that occur continuously, consideration has to be given to the number of slots after the idle time to some extent.

Next, a concrete example of the communication method between the transmitter 1A and receiver 2A will be explained. It is assumed that the idle time in the compressed mode is placed at the above-explained optimal position in the communication system shown in FIG. 1. FIG. 6 shows a flowchart of the various steps in this communication method.

To begin with, the transmission controller 11A in the transmitter 1A and the reception controller 21A in the receiver 1A determine the offset of frame timing for the transmission power control error convergence through negotiation at the normal mode transmission before the compressed mode transmission starts (Step S1). Then, the normal mode/compressed mode detecting device 111A and normal mode/compressed mode detecting device 211A determine the interleave method (the number of frames subject to interleave, etc.), transmission/reception timing related to the compressed frame, and parameters, such as spreading factor and average transmission power based on the idle time necessary to observe a different carrier frequency (Step S2). Then, the transmitter 1A and receiver 1B use the specified interleave method (Step S21) and carry out transmission/reception in the normal mode until the compressed frame timing thus determined comes (No in Step S22 and No in Step S31).

When the compressed frame timing comes under these conditions (Yes in Step S22 and Yes in Step S31), the transmission controller 11A in the transmitter 1A specifies a change of the spreading factor and transmission timing to the framing/spreading device 14. Then, upon receipt of these specifications, the framing/spreading device 14 generates, out of the data to which the interleave has been effected, a transmission data frame in which the idle time is placed rearward within the compressed frame (Step S23). Then, with the specified average transmission power under the control of the transmission controller 11A (Step S24), the radio frequency transmitter 15 outputs a transmission signal in the compressed mode (Step S25).

On the other hand, the reception controller 21A in the receiver 2A specifies a change of the spreading factor and reception timing to the deframing/despreading device 24 (Step S32). Upon receipt of these specifications, the deframing/despreading device 24 generates a reception data frame out of a reception signal received through the radio frequency receiver 25A (Step S33). Further, the deinterleaver 23 effects the deinterleave by a predetermined method (Step S34), whereby data with high decoding accuracy can be obtained as a result.

In this manner, in the present embodiment, consideration is given to the adverse affect of the transmission power control error and the interleave effect, and the position of the idle time in the compressed mode is determined so as to be placed rearward from the center of the compressed frame. Consequently, it is possible to prevent deterioration of the communication quality caused when observing a different frequency carrier.

As discussed above, in the present embodiment, by placing the idle time rearward from the center of the compressed frame by using the above method, it is possible to reduce the adverse affect of the transmission power control error caused by the idle time without dispersing the idle time within the frame at the compressed mode transmission as was in the conventional method. In the present embodiment, the position of the idle time was determined when one frame is given as an interleave unit. However, in case that more than one frame is given as the interleave unit, the position of the idle time in the compressed mode is also determined by giving consideration to the adverse affect of the transmission power control error and the interleave effect.

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FIG. 7 is a view showing a setting position of the idle time at the compressed mode transmission in a second embodiment. In the present embodiment, assume that the idle time in the compressed mode extends over two frames and one frame is given as the interleave unit. The arrangement of the communication system, arrangement of the transmission controller, and arrangement of the reception controller are identical with those explained in the first embodiment with reference to FIG. 1, FIG. 2, and FIG. 3. Thus, like components are labeled with like legends and the explanation of these components is not repeated for ease of explanation. Also, because the communication method in the compressed mode in the communication system of the present embodiment is identical with the one detailed with reference to the flowchart in FIG. 6, the explanation thereof is not repeated, either.

For example, on the foregoing assumption, the transmission power control error after the idle time adversely affects only the second frame as shown in FIG. 7. More specifically, as shown in FIG. 8, given TGL=7, RL=4, and 30 slots as the compressed frame in which the idle time extends over two frames (when 15 slots are given as one frame in the normal mode), if the idle time is placed at the position (a), the adversely affect given to the second frame by the transmission power control error convergence time is 4 slots/12 slots. On the other hand, if the idle time is placed at the position (b), the adversely affect given to the second frame by the transmission power control error convergence time is 4 slots/14 slots.

Here, if the idle time extends over the first and following second frames, the normal mode/compressed mode detecting device 111A in the transmission controller 11A of the present embodiment considers the adverse affect of the transmission power control error to the second frame, and places the idle time more in the first frame and less in the following second frame, so that a satisfactory interleave effect can be achieved (see FIG. 7).

As has been discussed, in the present embodiment, even when the idle time extends over two frames, consideration is given to the adverse affect of the transmission power control error and the idle time is placed so that a satisfactory interleave effect is achieved in the second frame. Consequently, it is possible to suppress deterioration of the communication quality in the compressed mode.

FIG. 9 is a view depicting an arrangement of a third embodiment in the communication system of the present invention. In the present embodiment, like components with respect to the first embodiment discussed with reference to FIG. 1 are labeled with like legends, and the explanation of these components is not repeated for ease of explanation. Also, in the present embodiment, the CDMA system will be explained as an example of the communication system. However, the communication system is not limited to the CDMA system and can be any radio communication system (mobile communication, satellite communication, etc.) adapting the communication method of the present invention.

The communication system of the present invention comprises a transmitter 1A and a receiver 2B. The transmitter 1A and receiver 2B are provided to the base station and each mobile station forming the system. The base station and each mobile station communicate wirelessly by means of the CDMA communication system. The transmitter 1A is identical with its counterpart in the first embodiment, and the explanation thereof is not repeated herein for ease of explanation. The following description will describe the arrangement of the receiver 2B as to the difference from its counterpart in the first embodiment alone.

The receiver 2B includes a reception controller 21B, an error correction decoder 22, a deinterleaver 23, a deframing/despreading device 24, and a radio frequency receiver 25B. The reception controller 21B chiefly controls the operations of the deinterleaver 23 and deframing/despreading device 24 through negotiation with the transmitter 1A. The reception controller 21B specifies a change of the spreading factor and reception timing for receiving a compressed frame to the deframing/despreading device 24 in the compressed mode. Further, the reception controller 21B compares an estimated value of the maximum Doppler frequency (fading frequency) notified as fading information by the radio frequency receiver 25B with a preset threshold of the maximum Doppler frequency, and when a frequency of the estimated value is higher than the threshold, the reception controller 21B negotiates with the transmitter 1A not to control the position of the idle time, that is, to set the idle time near the center of the frame.

The radio frequency receiver 25B decodes a reception signal sent from an unillustrated antenna. The radio frequency receiver 25B estimates the maximum Doppler frequency based on the reception signal, and notifies the same to the reception controller 21B as the fading information.

The following description will describe operations of the reception controller 21B of the present embodiment as to differences from those of the reception controller 21A with reference to the accompanying drawings. FIG. 10 is a view depicting an arrangement as to transmission power control by the reception controller 21B of the present embodiment. Legend 211B denotes a normal mode/compressed mode detecting device. The normal mode/compressed mode detecting device 211B determines timing to shift to the compressed mode through negotiation with the transmitter 1A, and specifies a change of the spreading factor and reception timing to the deframing/despreading device 24. The normal mode/compressed mode detecting device 211B compares the fading information notified by the radio frequency receiver 25B with the preset threshold of the maximum Doppler frequency, and when a frequency of the estimated value related to the maximum Doppler frequency notified as the fading information is higher than the threshold, the normal mode/compressed mode detecting device 211B negotiates with the transmitter 1A not to adjust the idle time.

Next, the following description will describe a setting position of the idle time at the compressed mode transmission in the present embodiment. FIGS. 11 and 12 are views showing an example of the setting position of the idle time at the compressed mode transmission. It should be noted that the present embodiment is applicable to a case where the maximum Doppler frequency is higher than that in the first embodiment.

For example, when the fading (the illustrated channel state) is high, a relatively short time is given as a time interval during which the reception power drops, thereby dispersing the occurrence of errors with time. Hence, the effect of improving the communication quality by means of the transmission power control is reduced with deterioration following the channel state, and conversely, the effect of improving the communication quality by means of the error correction coding/interleave is increased. Therefore, for example, when the fading frequency is high, if the idle time is placed rearward in the compressed frame in the same manner as the first embodiment, the compressed data bits are

distributed unevenly forward within the compressed frame, thereby possibly impairing the randomizing effect attained by means of interleave.

Accordingly, in the present embodiment, the reception controller **21B** compares the fading information notified by the radio frequency receiver **25B** with the preset threshold of the maximum Doppler frequency, and when a frequency of the estimated value of the maximum Doppler frequency notified as the fading information is lower than the threshold, as is shown in FIG. **11**, the reception controller **21B** places the idle time rearward in the compressed frame in the same manner as the first embodiment.

On the other hand, when the reception controller **21B** compares the fading information notified by the radio frequency receiver **25B** with the preset threshold of the maximum Doppler frequency and a frequency of the estimated value of the maximum Doppler frequency notified as the fading information is higher than the threshold, the reception controller **21B** negotiates with the transmitter **11A** not to adjust the idle time, so that, as is shown in FIG. **12**, the idle time is placed near the center of the compressed frame.

In this manner, by changing the position of the idle time in the compressed frame in response to the pitch of the fading frequency, it is possible to effect the control such that does not deteriorate the interleave effect when the fading frequency is high and the transmission power control effect when the fading frequency is low. In addition, for example, a similar effect can be achieved by placing the idle time rearward in the compressed frame in the same manner as the first embodiment in an area where moving at a high speed is not expected (when the fading frequency is low), and by placing the idle time near the center of the compressed frame when moving at a high speed is expected (when the fading frequency is high).

Next, a concrete example of the communication method between the transmitter **1A** and receiver **2B** will be explained. It is assumed that the idle time in the compressed mode is placed at the above-explained optimal position in the communication system shown in FIG. **8**. FIG. **13** shows a flowchart of the various steps in this communication method. The steps same as those in the above-described first embodiment are labeled with like step numbers, and the explanation of these steps is not repeated for ease of explanation.

To begin with, at the normal mode transmission before shifting to the compressed mode transmission, the radio frequency receiver **25B** in the receiver **2B** estimates the maximum Doppler frequency based on the received reception signal, and notifies the same to the reception controller **21B** as the fading information (Step **S41**). Upon receipt of the fading information, the reception controller **21B** compares the fading information with the preset threshold of the maximum Doppler frequency, and when a frequency of the estimated value is higher than the threshold (No in Step **S42**), the reception controller **21B** stops the setting of the offset of the idle time fot the transmission power control error convergance (Step **S43**), and places the idle time near the center of the compressed frame. When the frequency of the estimated value of the frequency is lower than the threshold (Yes in Step **S42**), the reception controller **21B** places the idle time rearward in the compressed frame in the same manner as the first embodiment in the following steps.

As discussed above, in the present embodiment, a similar effect as that in the first embodiment can be achieved. Further, by changing the position of the idle time in the compressed frame in response to the pitch of the fading frequency, it is possible to effect the control such that does deteriorate the interleave effect when the fading frequency is high and the transmission power control effect when the fading frequency is low.

The maximum Doppler frequency is not necessarily estimated by measuring the reception signal. For example, in the cellular communication, a large radius is given to the cells that provide a communication service by the base location for the service to a mobile station having a higher moving rate, such as use in an automobile or a train, whereas a smaller radius is given to the cells that provide a service to a quasi-station mobile station in use at a walking pace or in a semi-fixed station. Thus, in general, it can be said that when the cell radius is large, the fading frequency is high, and when the cell radius is small, the fading frequency is low. Hence, in this case, a similar effect can be achieved by estimating the Doppler frequency (fading frequency) based on the largeness of the cell radius and carrying out the above control.

FIG. **14** is a view depicting an arrangement of a fourth embodiment of the communication system of the present invention. In the present embodiment, the components identical with those explained in the first embodiment with reference to FIG. **1** and those explained in the second embodiment with reference to FIG. **9** are labeled with like legends, and explanation of these components is not repeated for ease of explanation. In the present embodiment also the CDMA system will be explained as an example of the communication system. However, the communication system is not limited to the CDMA system, and can be any radio communication system (mobile communication, satellite communication, etc.) adapting the communication method of the present invention.

As shown in FIG. **14**, the communication system of the present invention comprises a transmitter **1C** and a receiver **2C**. The transmitter **1C** and receiver **2C** are provided to the base station and each mobile station forming the system, and the base station and each mobile station communicate wirelessly by means of the CDMA communication system. Herein, the explanation of the transmitter **1C** and receiver **2C** will be given as to the differences from their counterparts in the first and second embodiments alone.

To begin with, the transmitter **1C** forming the communication system will be explained. In FIG. **14**, the transmitter **1C** includes a transmission controller **11C**, an error correction encoder **12**, an interleaver **13**, a framing/spreading device **14**, and a radio frequency transmitter **15**.

FIG. **15** is a view depicting an arrangement as to the transmission control by the transmission controller **11C** of the present embodiment. Legend **111C** denotes a normal mode/compressed mode detecting device, and legend **112C** denotes a transmission power controller. The normal mode/compressed mode detecting device **111C** negotiates with the receiver **2C** based on the fading information notified by the receiver **2C** to determine a transmission power control step size, and notifies a step size specifying signal to the transmission power controller **112C**. At the same time, the normal mode/compressed mode detecting device **111C** estimates a convergence time for a transmission power control error that occurs after the idle time in the compressed mode based on the fading information and transmission power control step size. Then, with the consideration given to the adverse affect of the transmission power control error and the interleave effect, the normal mode/compressed mode detecting device **111C** determines the position of the idle time. The other operations of the normal mode/compressed mode detecting device **111C** are the same as those explained in the first embodiment.

The transmission power controller **112C** controls power amplitude in the transmission power control in accordance with the step size specifying signal sent from the normal mode/compressed mode detecting device **111C**. The other operations of the transmission power controller **112C** are the same as those explained in the first embodiment.

Next, configuration of the receiver **2C** forming the communication system will be explained. The receiver **2C** includes a reception controller **21C**, an error correction decoder **22**, a deinterleaver **23**, a deframing/despreading device **24**, and a radio frequency receiver **25B**.

The reception controller **21C** chiefly controls the operations of the deinterleaver **23** and deframing/despreading device **24** through negotiation with the transmitter **1C**. The reception controller **21C** specifies a change of the spreading factor and reception timing for receiving a compressed frame to the deframing/despreading device **24** in the compressed mode. Further, the reception controller **21C** notifies an estimated value of the maximum Doppler frequency notified as the fading information by the radio frequency receiver **25B** to the receiver **1C**, and estimates a transmission power control error convergence time through negotiation with the transmitter **1C** to determine the transmission power control step size and an offset quantity of the idle time.

FIG. **16** is a view showing an example of the setting position of the idle time at the compressed mode transmission and the transmission control step size set by the foregoing operations. In FIG. **16**, Δ denotes the step size before the idle time in the compressed frame, and a Δ (a>1) denotes the step size after the idle time. For example, in the present embodiment, by setting the transmission control step size larger than that in the first embodiment, the number of the slots necessary to converge the transmission power control error that occurs after the idle time is reduced.

FIGS. **17**(*a*) to **17**(*e*) and FIGS. **18**(*a*) to **18**(*c*) are views showing an optimal position of the idle time in the compressed mode when the number of the slots in the transmission power control error convergence time after the idle time is reduced by changing the transmission control step size by the foregoing operations. These drawings reveal that the smaller the number b of the slots after the idle time, the less the adverse affect of the transmission power control error caused by the idle time. It should be noted, however, that, in order to achieve a satisfactory interleave effect that attains the error correction coding effect by randomizing errors that occur continuously, consideration has to be given to the number of slots after the idle time to some extent.

Next, a concrete example of the communication method between the transmitter **1C** and receiver **2C** will be explained. It is assumed that the idle time in the compressed mode is placed at the above-explained optimal position in the communication system shown in FIG. **14**. FIG. **19** shows a flowchart of the various steps in this communication method. The steps identical with those explained in the first embodiment are labeled with like step numbers, and the explanation of these steps is not repeated for ease of explanation.

To begin with, the radio frequency receiver **15B** of the receiver **2C** estimates the maximum Doppler frequency based on a received reception signal at the normal mode transmission before shifting to the compressed mode transmission, and notifies the estimated value to the reception controller **21C** as the fading information (Step S51). The receiver **2C** notifies the estimated maximum Doppler frequency further to the transmission controller **11C** in the transmitter **1C** (Step S52). Then, the transmission controller **11C** and reception controller **21C** determine the step size in the transmission power control based on the notified Doppler frequency, and estimate a time necessary for the transmission power control error to converge, while making negotiation to determine the idle time position (Step S53). The operations afterwards are the same as those explained in the first embodiment.

As has been discussed, in the present embodiment, the step size in the transmission power control is determined in response to the fading frequency and further the transmission power control error convergence time is estimated from the step size. Thus, it is possible to set the idle time in the compressed mode with consideration given to the adverse affect of the transmission power control error caused by the idle time and the interleave effect, and also to suppress deterioration of the communication quality in the compressed mode.

The maximum Doppler frequency is not necessarily estimated by measuring the reception signal. For example, in the cellular communication, a large radius is given to the cells that provide a communication service by the base location for the service to a mobile station having a higher moving rate, such as use in an automobile or a train, whereas a smaller radius is given to the cells that provide a service to a quasi-station mobile station in use at a walking pace or in a semi-fixed station. Thus, in general, it can be the that when the cell radius is large, the fading frequency is high, and when the cell radius is small, the fading frequency is low. Hence, in this case, a similar effect can be achieved by estimating the Doppler frequency (fading frequency) based on the largeness of the cell radius and carrying out the above control.

As explained above, according to one aspect of the present invention, the position of the non-transmission time (idle time) in the compressed mode is changed in such a manner so as to minimize adverse affect of a transmission power control error that occurs after the non-transmission time, for example, with consideration given to the adverse affect of the transmission power control error and the interleave effect. Consequently, there can be offered an effect that it is possible to obtain a communication system capable of reducing adverse affect of the transmission power control error caused by the non-transmission time without adapting a conventional method, by which the non-transmission time at the compressed mode transmission is dispersed within a frame.

According to the another aspect of the present invention, adverse affect of the transmission power control error is taken into consideration, and the position of the non-transmission time in the compressed mode is determined so as to be placed rearward from the center of the compressed frame, for example. Consequently, there can be offered an effect that it is possible to obtain a communication system capable of preventing deterioration of a communication quality occurred when observing a different frequency carrier.

According to the another aspect of the present invention, the position of the non-transmission time in the compressed mode is determined so as to be placed rearward from the center of the compressed frame, for example, with consideration given to the adverse affect of the transmission power control error and the interleave effect, and further, data of at least one slot is placed after the non-transmission time within the compressed frame. Consequently, there can be offered an effect that it is possible to obtain a communication system capable of improving a communication quality in association with observation of a different frequency carrier.

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According to the another aspect of the present invention, the non-transmission time is set relatively longer in a first frame and set relatively shorter in a second frame, so that a satisfactory interleave effect can be achieved even when the non-transmission time extends over first and following second frames with consideration given to adverse affect of the transmission power control error to the second frame. Consequently, there can be offered an effect that it is possible to obtain a communication system capable of suppressing deterioration of a communication quality in the compressed mode.

According to the another aspect of the present invention, the estimated value of the maximum Doppler frequency is compared with the preset threshold of the maximum Doppler frequency, and when a frequency of the estimated value is lower than the threshold, the non-transmission time is placed rearward in the compressed frame. On the other hand, when the frequency of the estimated value is higher than the threshold, negotiation is made so as not to adjust the non-transmission time, and the non-transmission time is placed near the center of the compressed frame. By changing the position of the non-transmission time in the compressed frame in response to the pitch of the fading frequency in this manner, there can be offered an effect that it is possible to obtain a communication system capable of effecting control such that does not deteriorate the interleave effect when the fading frequency is high and the transmission power control effect when the fading frequency is low.

According to the another aspect of the present invention, the step size of the transmission power control is determined in response to the fading frequency, and further, the transmission power control error convergence time is estimated based on the step size. Consequently, there can be offered an effect that it is possible to obtain a communication system capable of setting non-transmission time with consideration given to the adverse affect of the transmission power control error caused by the non-transmission time and the interleave effect, and suppressing deterioration of a communication quality in the compressed mode.

According to the another aspect of the present invention, the fading frequency is high when the cell radius is large and the fading frequency is low when the cell radius is small. Consequently, by estimating the fading frequency based on the largeness of the cell radius, there can be offered an effect that it is possible to obtain a communication system capable of setting the non-transmission time with consideration given to the adverse affect of the transmission power control error caused by the non-transmission time and the interleave effect, and suppressing deterioration of a communication quality in the compressed mode.

According to the another aspect of the present invention, the position of the non-transmission time in the compressed mode is changed in such a manner so as to minimize the adverse affect of the transmission power control error that occurs after the non-transmission time, for example, with consideration given to the adverse affect of the transmission power control error and the interleave effect. Consequently, there can be offered an effect that it is possible to obtain a transmitter capable of reducing adverse affect of the transmission power control error caused by the non-transmission time without adapting a conventional method, by which the non-transmission time at the compressed mode transmission is dispersed within a frame.

According to the another aspect of the present invention, adverse affect of the transmission power control error is taken into consideration, and the position of the non-transmission time in the compressed mode is determined so as to be placed rearward from the center of the compressed frame, for example. Consequently, there can be offered an effect that it is possible to obtain a transmitter capable of preventing deterioration of a communication quality occurred when observing a different frequency carrier.

According to the another aspect of the present invention, the position of the non-transmission time in the compressed mode is determined so as to be placed rearward from the center of the compressed frame, for example, with consideration given to the adverse affect of the transmission power control error and the interleave effect, and further, data of at least one slot is placed after the non-transmission time within the compressed frame. Consequently, there can be offered an effect that it is possible to obtain a transmitter capable of improving a communication quality in association with observation of a different frequency carrier.

According to the another aspect of the present invention, the non-transmission time is set relatively longer in a first frame and set relatively shorter in a second frame, so that a satisfactory interleave effect can be achieved even when the non-transmission time extends over first and following second frames with consideration given to adverse affect of the transmission power control error to the second frame. Consequently, there can be offered an effect that it is possible to obtain a transmitter capable of suppressing deterioration of a communication quality in the compressed mode.

According to the another aspect of the present invention, the step size of the transmission power control is determined in response to the fading frequency, and further, the transmission power control error convergence time is estimated based on the step size. Consequently, there can be offered an effect that it is possible to obtain a transmitter capable of setting the non-transmission time with consideration given to the adverse affect of the transmission power control error caused by the non-transmission time and the interleave effect, and suppressing deterioration of a communication quality in the compressed mode.

According to the another aspect of the present invention, the estimated value of the maximum Doppler frequency is compared with the preset threshold of the maximum Doppler frequency, and when a frequency of the estimated value is higher than the threshold, negotiation is made so as not to adjust the non-transmission time, and the non-transmission time is placed near the center of the compressed frame. Consequently, by changing the position of the non-transmission time in the compressed frame in response to the fading frequency, there can be offered an effect that it is possible to obtain a receiver capable of effecting control such that does not deteriorate the interleave effect when the fading frequency is high.

According to the another aspect of the present invention, the step size of the transmission power control is determined in response to the fading frequency, and further, the transmission power control error convergence time is estimated based on the step size. Consequently, there can be offered an effect that it is possible to obtain a receiver capable of setting the non-transmission time with consideration given to the adverse affect of the transmission power control error caused by the non-transmission time and the interleave effect, and suppressing deterioration of a communication quality in the compressed mode.

According to the another aspect of the present invention, the position of the non-transmission time in the compressed mode is changed in such a manner so as to minimize adverse affect of a transmission power control error that occurs after

the non-transmission time, for example, with consideration given to the adverse affect of the transmission power control error and the interleave effect. Consequently, there can be offered an effect that it is possible to obtain a communication method capable of reducing adverse affect of the transmission power control error caused by the non-transmission time without adapting a conventional method, by which the non-transmission time at the compressed mode transmission is dispersed within a frame.

According to the another aspect of the present invention, adverse affect of the transmission power control error is taken into consideration, and the position of the non-transmission time in the compressed mode is determined so as to be placed rearward from the center of the compressed frame, for example. Consequently, there can be offered an effect that it is possible to provide a communication method capable of preventing deterioration of a communication quality occurred when observing a different frequency carrier.

According to the another aspect of the present invention, the position of the non-transmission time in the compressed mode is determined so as to be placed rearward from the center of the compressed frame, for example, with consideration given to the adverse affect of the transmission power control error and the interleave effect, and further, data of at least one slot is placed after the non-transmission time within the compressed frame. Consequently, there can be offered an effect that it is possible to obtain a communication method capable of improving a communication quality in association with observation of a different frequency carrier.

According to the another aspect of the present invention, the non-transmission time is set relatively longer in a first frame and set relatively shorter in a second frame, so that a satisfactory interleave effect can be achieved even when the non-transmission time extends over first and following second frames with consideration given to adverse affect of the transmission power control error to the second frame. Consequently, there can be offered an effect that it is possible to obtain a communication method capable of suppressing deterioration of a communication quality in the compressed mode.

According to the another aspect of the present invention, the estimated value of the maximum Doppler frequency is compared with the preset threshold of the maximum Doppler frequency, and when a frequency of the estimated value is lower than the threshold, the non-transmission time is placed rearward in the compressed frame. On the other hand, when the frequency of the estimated value is higher than the threshold, negotiation is made so as not to adjust the non-transmission time, and the non-transmission time is placed near the center of the compressed frame. By changing the position of the non-transmission time in the compressed frame in response to the pitch of the fading frequency in this manner, there can be offered an effect that it is possible to obtain a communication method capable of effecting control such that does not deteriorate the interleave effect when the fading frequency is high and the transmission power control effect when the fading frequency is low.

According to the another aspect of the present invention, the step size of the transmission power control is determined in response to the fading frequency, and further, the transmission power control error convergence time is estimated based on the step size. Consequently, there can be offered an effect that it is possible to obtain a communication method capable of setting the non-transmission time with consideration given to the adverse affect of the transmission power control error caused by the non-transmission time and the interleave effect, and suppressing deterioration of a communication quality caused in the compressed mode.

According to the another aspect of the present invention, the fading frequency is high when the cell radius is large and the fading frequency is low when the cell radius is small. Consequently, by estimating the fading frequency based on the largeness of the cell radius, there can be offered an effect that it is possible to obtain a communication method capable of setting the non-transmission time with consideration given to the adverse affect of the transmission power control error caused by the non-transmission time and the interleave effect, and suppressing deterioration of a communication quality in the compressed mode.

Industrial Applicability

As explained above, the communication system, transmitter and receiver, and communication method of the present invention are useful in a radio communication, such as a mobile communication and a satellite communication, and particularly suitable to the CDMA communication system, in which the other frequency carrier is observed in the compressed mode and handover is effected based the observation result.

What is claimed is:

1. A communication system including a transmitter and a receiver both capable of operating in at least one of a normal mode and a compressed mode in which setting of a predetermined non-transmission time is allowed,

wherein said transmitter effects transmission power control to maintain a received target power on a frame in each mode, and, when operating in the compressed mode, said transmitter changes a position of the non-transmission time to minimize adverse effect of a transmission power control error that occurs after the non-transmission time.

2. The communication system according to claim 1,

wherein, when a unit of interleaving is set to one frame, said transmitter places the non-transmission time in the compressed mode rearward from a center of a compressed frame, and

said transmitter places data of at least one slot after the non-transmission time within the compressed frame, so that a satisfactory interleave effect is achieved.

3. The communication system according to claim 1,

wherein, when the unit of interleaving is set to one frame and the non-transmission time extends over two frames, said transmitter places the non-transmission time in the compressed mode longer in a first frame and set relatively shorter in a second frame.

4. The communication system according to claim 2,

wherein said receiver estimates maximum Doppler frequency, compares the estimated maximum Doppler frequency with a preset threshold of the maximum Doppler frequency, and when the estimated maximum Doppler frequency is higher than the threshold, negotiates

with said transmitter not to effect control as to a change of the position of the non-transmission time; and

when the estimated maximum Doppler frequency is lower than the threshold, said transmitter places the non-transmission time in the compressed mode rearward from the center of the compressed frame; and

in an area where moving at a high speed is expected, the control as to a change of the position of the non-

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transmission time is not effected, and in an area where moving at a high speed is not expected, the non-transmission time in the compressed mode is placed rearward from the center of the compressed frame.

5. The communication system according to claim 2,

wherein said transmitter and receiver set a step size of power in transmission power control larger than a predetermined value set as a reference value through negotiation, and reduce a number of slots needed for the transmission power control error convergence that occurs after the non-transmission time.

6. A transmitter that operates in at least one of a normal mode and a compressed mode in which setting of a predetermined non-transmission time is allowed,

wherein said transmitter effects transmission power control to maintain a received target power on a frame in each mode, and, when operating in the compressed mode, said transmitter changes a position of the non-transmission time to minimize adverse effect of a transmission power control error that occurs after the non-transmission time.

7. The transmitter according to claim 6,

wherein, when a unit of interleaving is set to one frame, said transmitter places the non-transmission time in the compressed mode rearward from a center of a compressed frame; and

said transmitter places data of at least one slot after the non-transmission time within the compressed frame, so that a satisfactory interleave effect is achieved.

8. The transmitter according to claim 6,

wherein when a unit of interleaving is set to one frame and the non-transmission time extends over two frames, said transmitter places the non-transmission time in the compressed mode longer in a first frame and set relatively shorter in a second frame.

9. The transmitter according to claim 7,

wherein, through negotiation with a receiver, said transmitter sets a step size of power in transmission power control larger than a predetermined value set as a reference value, and reduces a number of slots needed for the transmission power control error convergence that occurs after the non-transmission time.

10. A receiver that communicates with a transmitter that changes a position of a non-transmission time,

wherein said receiver estimates maximum Doppler frequency, compares the estimated maximum Doppler frequency with a preset threshold of the maximum Doppler frequency, and when a frequency of the estimated maximum Doppler frequency is higher than the threshold, negotiates with the transmitter not to effect control as to a change of a position of a non-transmission time.

11. A receiver,

wherein said receiver, through negotiation with a transmitter, sets a step size of power in transmission power control to maintain a received target power, said step size being larger than a predetermined value set as a reference value, and reduces a number of slots necessary for a transmission power control error convergence that occurs after a non-transmission time.

12. A communication method comprising:

a transmission step and a reception step operating in at least one of a normal mode and a compressed mode in which setting of a predetermined non-transmission time is allowed, the transmission step including effecting of transmission power control to maintain a received target power on a frame in each mode,

wherein, in the transmission step, when operating in the compressed mode, a position of the non-transmission time is changed to minimize adverse effect of a transmission power control error that occurs after the non-transmission time.

13. The communication method according to claim 12,

wherein, in the transmission step, when a unit of interleaving is set to one frame, the non-transmission time in the compressed mode is placed rearward from a center of a compressed frame; and

in the transmission step, data of at least one slot is placed after the non-transmission time within the compressed frame, so that a satisfactory interleave effect is achieved.

14. The communication method according to claim 12,

wherein, in the transmission step, when a unit of interleaving is set to one frame and the non-transmission time extends over two frames, the non-transmission time in the compressed mode is set relatively longer in a first frame and set relatively shorter in a second frame.

15. The communication method according to claim 13,

wherein, in the reception step, a maximum Doppler frequency is estimated, and the estimated Doppler frequency is compared with a preset threshold of the maximum Doppler frequency, and when the estimated maximum Doppler frequency is higher than the threshold, a negotiation is made with a transmitter not to effect control as to a change of the position of the non-transmission time; and

in the transmission step, when a frequency of the estimated maximum Doppler frequency is lower than the threshold, the non-transmission time in the compressed mode is placed rearward from the center of the compressed frame; and

in an area where moving at a high speed is expected, the control as to a change of the position of the non-transmission time is not effected, and in an area where moving at a high speed is not expected, the non-transmission time in the compressed mode is placed rearward from the center of the compressed frame.

16. The communication method according to claim 13,

wherein in the transmission step and reception step, a step size of power in transmission power control is set larger than a predetermined value set as a reference value through negotiation, and a number of slots needed for the transmission power control error convergence that occurs after the non-transmission time is reduced.

17. A communication system including a transmitter and a receiver both capable of operating in at least one of a normal mode and a compressed mode in which setting of a predetermined non-transmission time is allowed, wherein the transmitter effects transmission power control on a frame in each mode, and comprises:

a transmission power control unit controlling a transmission power after the non-transmission time in the compressed mode; and

a frame generation unit placing a center of the non-transmission time rearward from a center of a compressed frame.

18. A transmitter operating in at least one of a normal mode and a compressed mode in which setting of a predetermined non-transmission time is allowed, effecting transmission power control on a frame in each mode, and comprising:

a transmission power control unit controlling a transmission power after the non-transmission time in the compressed mode; and

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a frame generation unit placing a center of the non-transmission time rearward from a center of a compressed frame.

19. A communication method including the steps of transmitting and receiving, the steps both operating in at least one of a normal mode and a compressed mode in which setting of a predetermined non-transmission time is allowed, wherein the step of transmitting effects transmission power control, and comprises:

a transmission power control step of controlling a transmission power after the non-transmission time in the compressed mode; and

a frame generation step of placing a center of the non-transmission time rearward from a center of a compressed frame.

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US007242769B2

(12) **United States Patent**
Ishiguro et al.

(10) **Patent No.: US 7,242,769 B2**
(45) **Date of Patent: *Jul. 10, 2007**

(54) **ENCIPHERING APPARATUS AND METHOD, DECIPHERING APPARATUS AND METHOD AS WELL AS INFORMATION PROCESSING APPARATUS AND METHOD**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/359,928**

(22) Filed: **Feb. 22, 2006**

(65) **Prior Publication Data**

US 2006/0140402 A1 Jun. 29, 2006

Related U.S. Application Data

(63) Continuation of application No. 09/872,509, filed on Jun. 1, 2001, now abandoned, which is a continuation of application No. 09/059,776, filed on Apr. 14, 1998, now Pat. No. 6,256,391.

(30) **Foreign Application Priority Data**

Apr. 23, 1997 (JP) P09-106136

(51) **Int. Cl.**
H04L 9/00 (2006.01)
H04L 9/32 (2006.01)

(52) **U.S. Cl.** **380/44**; 713/189

(58) **Field of Classification Search** 380/44–46, 380/203, 239, 277–278; 713/189; 705/59
See application file for complete search history.

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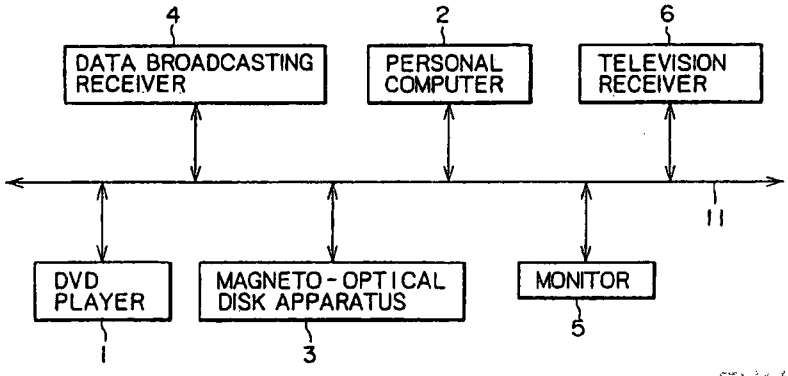
Primary Examiner—Hosuk Song
(74) *Attorney, Agent, or Firm*—Frommer Lawrence & Haug LLP; William S. Frommer

(57) **ABSTRACT**

The invention provides an enciphering apparatus and method, a deciphering apparatus and method and an information processing apparatus and method by which illegal copying can be prevented with certainty. Data enciphered by a 1394 interface of a DVD player is transmitted to a personal computer and a magneto-optical disk apparatus through a 1394 bus. In the magneto-optical disk apparatus with which a change to a function is open to a user, the received data is deciphered by a 1394 interface. In contrast, in the personal computer with which a change to a function is open to a user, the enciphered data is deciphered using a time variable key by a 1394 interface, and a result of the decipherment is further deciphered using a session key by an application section.

18 Claims, 22 Drawing Sheets



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Stream Ciphers , 20060726, pp. 1-6.

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FIG. 1

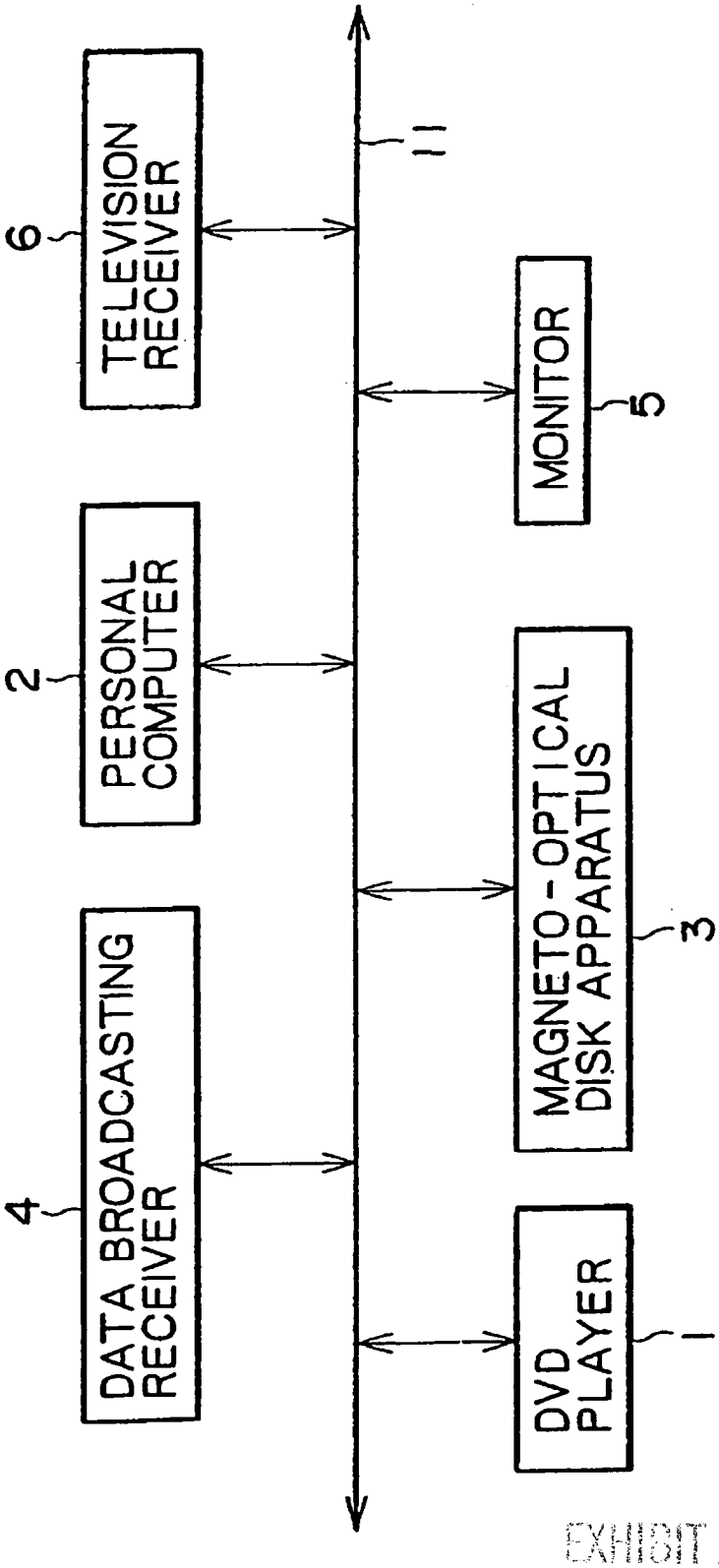

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FIG. 2

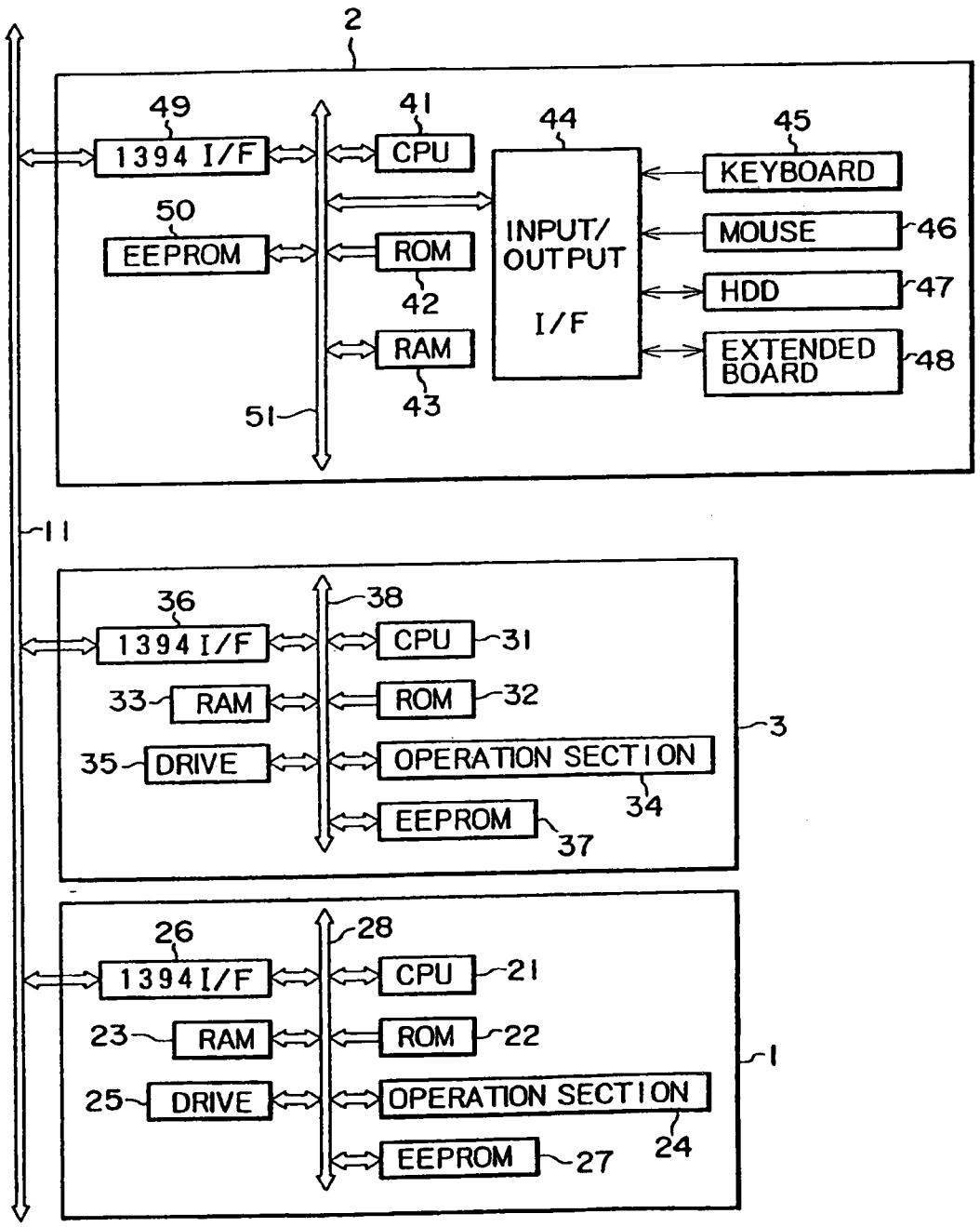

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FIG. 3

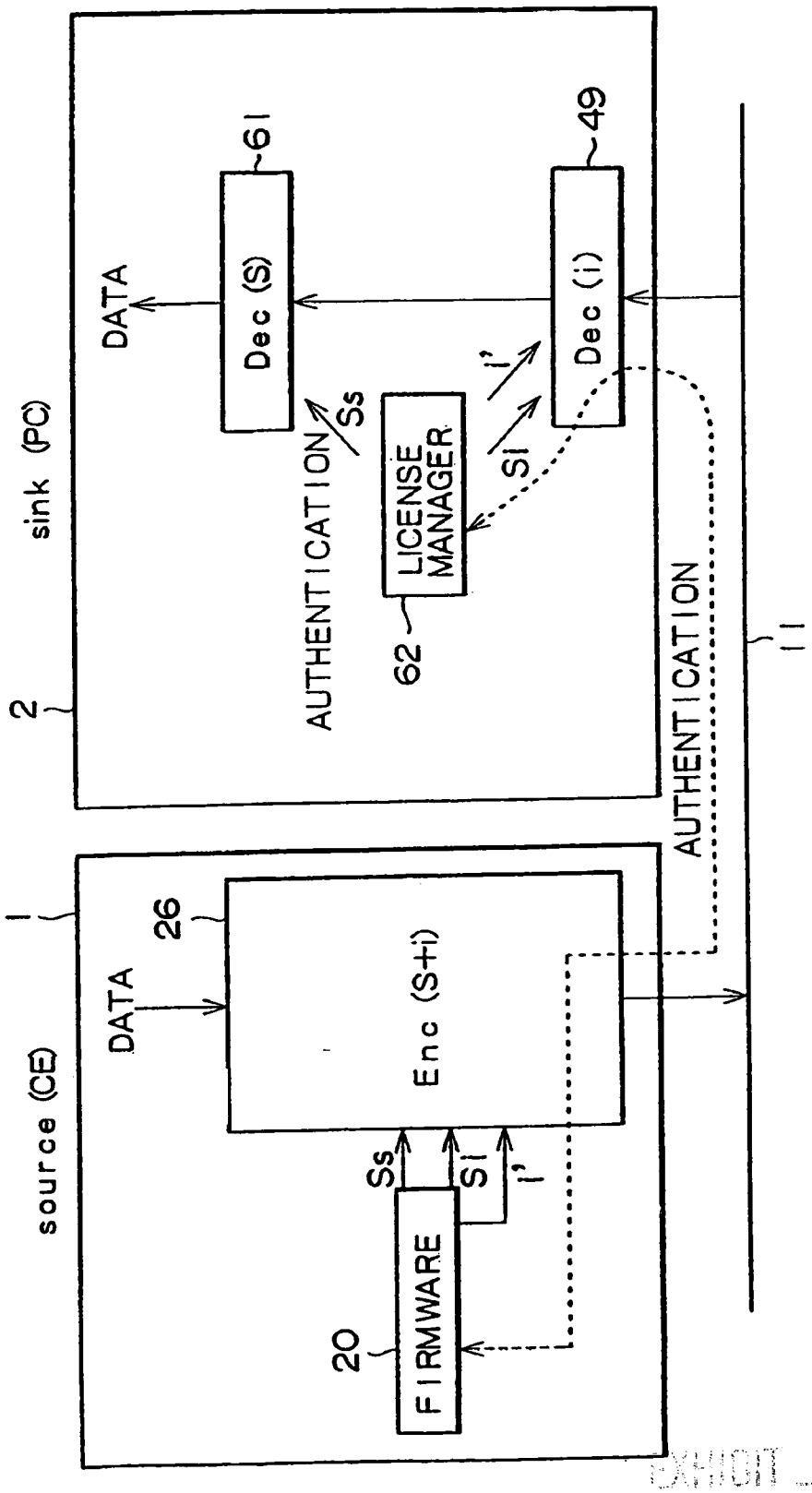

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FIG. 4

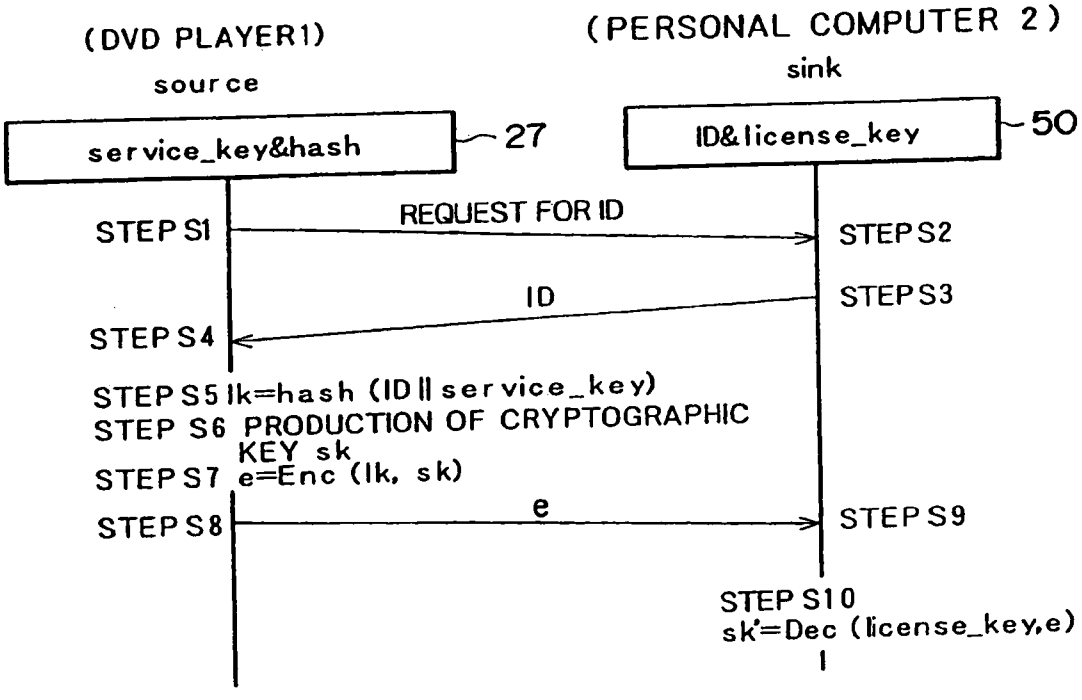

FIG. 5

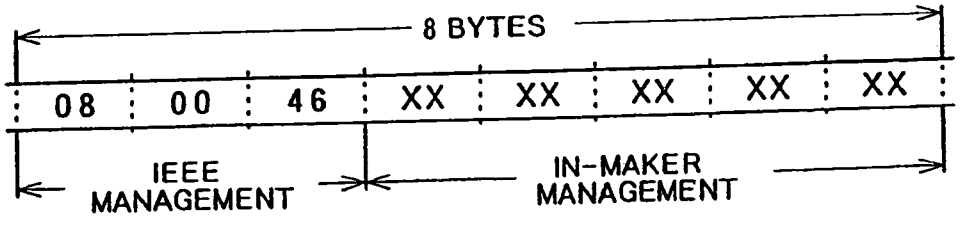

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FIG. 6

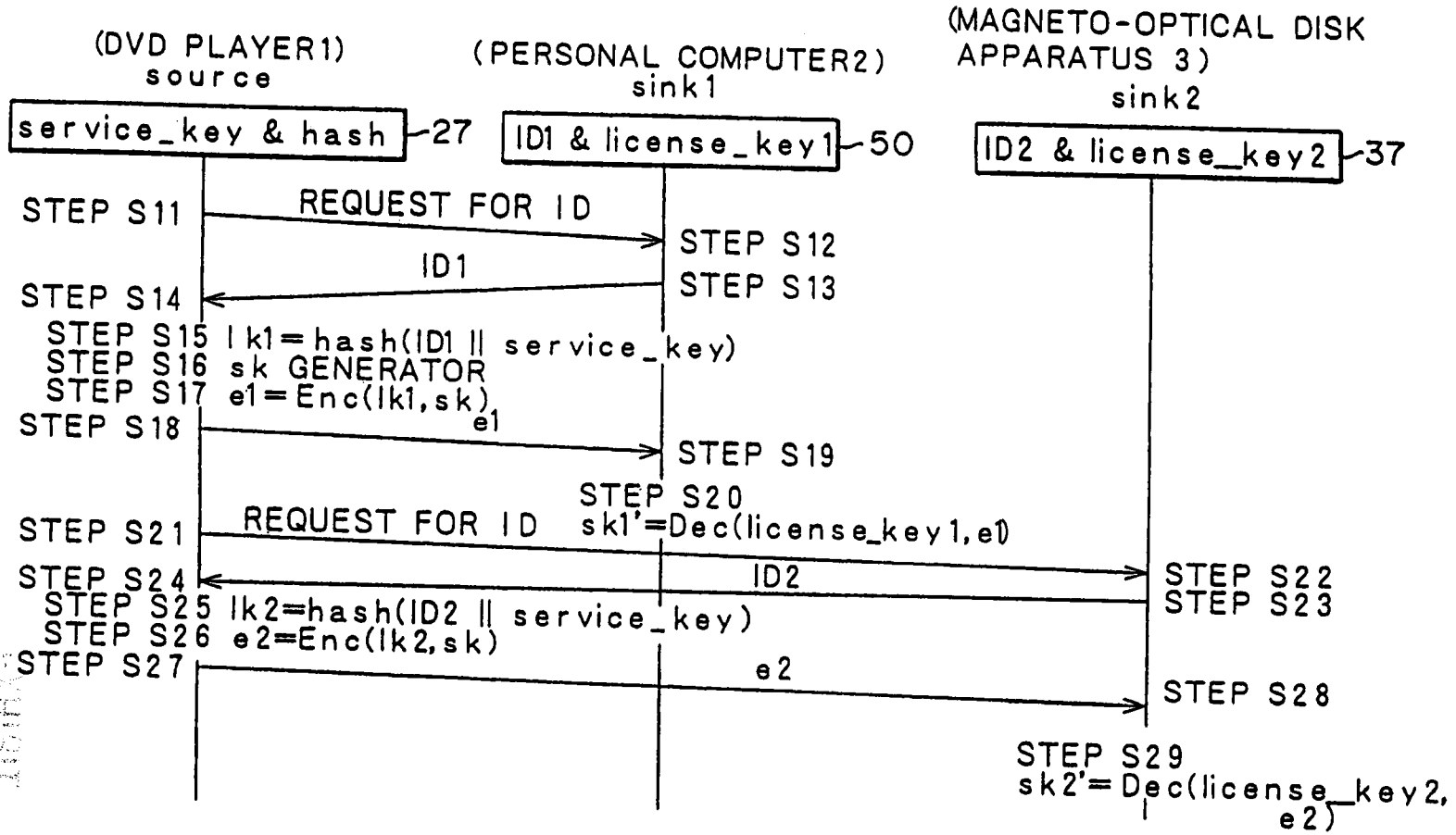
(DVD PLAYER1)
source
(PERSONAL COMPUTER2)
sink1
(MAGNETO-OPTICAL DISK APPARATUS 3)
sink2
service_key & hash
27
ID1 & license_key1
50
ID2 & license_key2
37
STEP S11
REQUEST FOR ID
STEP S12
ID1
STEP S13
STEP S14
STEP S15 Ik1=hash(ID1 || service_key)
STEP S16 sk GENERATOR
STEP S17 e1=Enc(Ik1,sk)
STEP S18
e1
STEP S19
STEP S20
sk1'=Dec(license_key1,e1)
STEP S21
REQUEST FOR ID
STEP S22
STEP S24
ID2
STEP S23
STEP S25 Ik2=hash(ID2 || service_key)
STEP S26 e2=Enc(Ik2,sk)
STEP S27
e2
STEP S28
STEP S29
sk2'=Dec(license_key2, e2)

FIG. 7

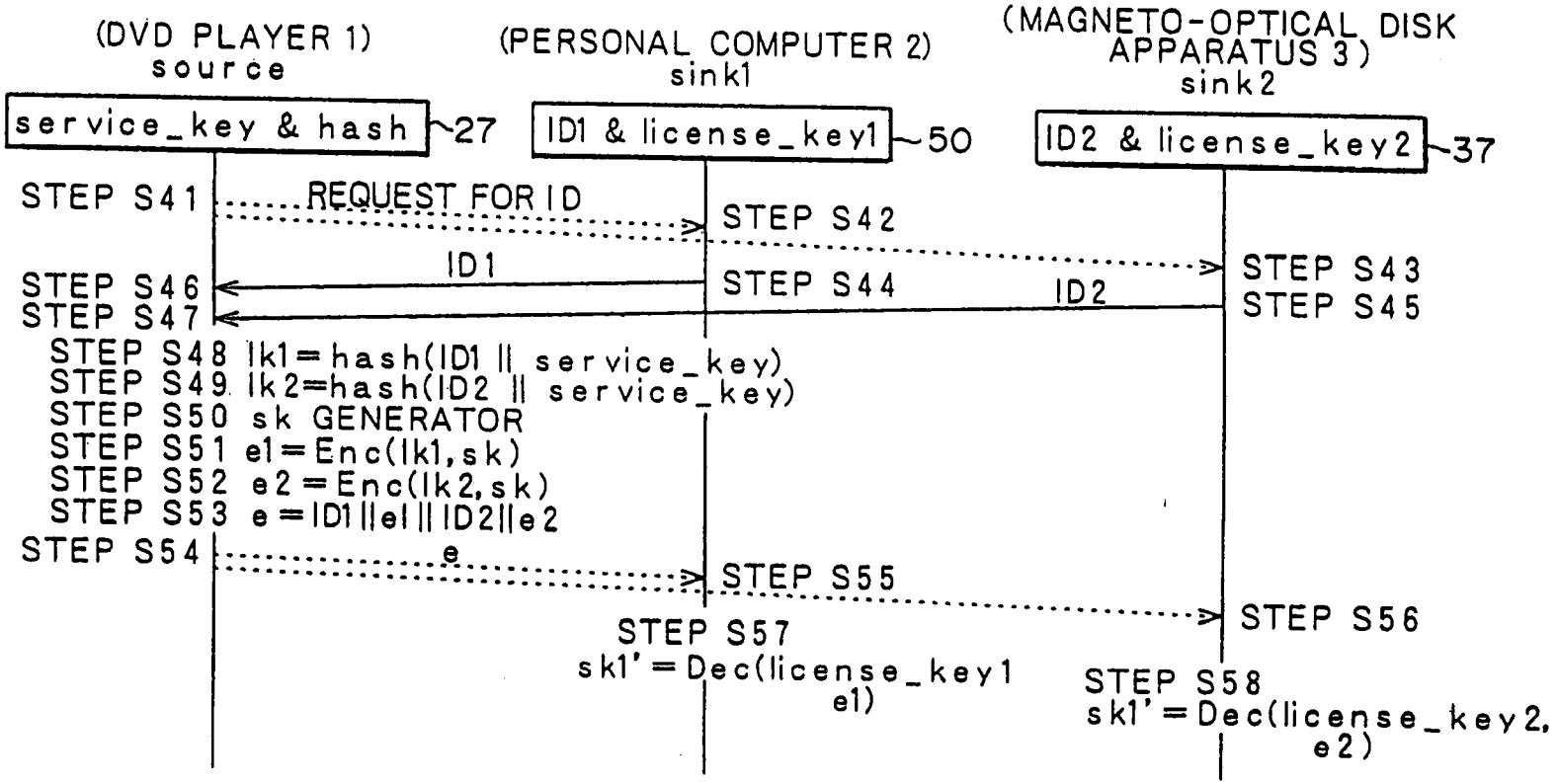

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FIG. 8

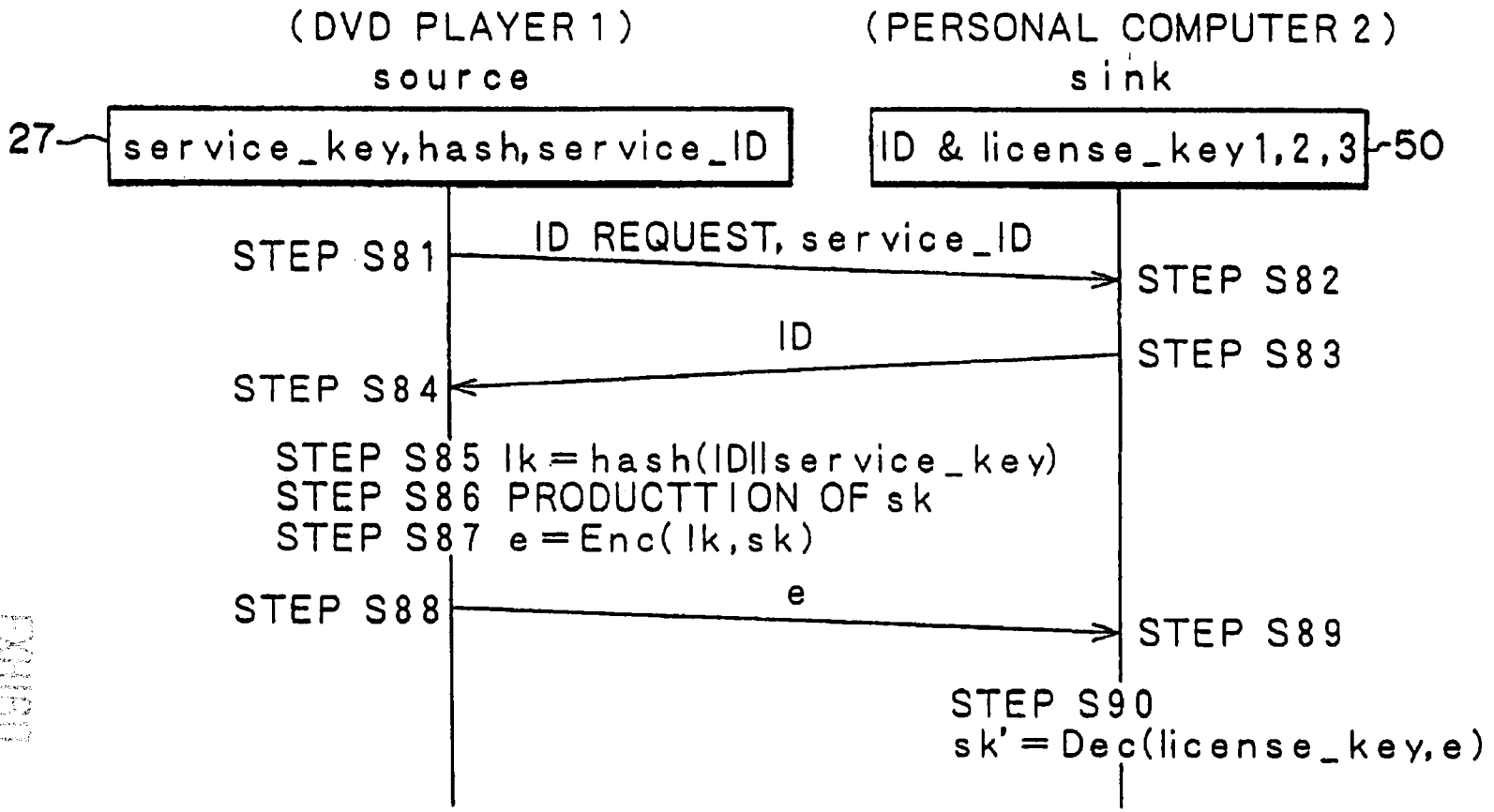
(DVD PLAYER 1)
source
(PERSONAL COMPUTER 2)
sink
27
service_key,hash,service_ID
ID & license_key1,2,3
50
STEP S81
ID REQUEST, service_ID
STEP S82
ID
STEP S83
STEP S84
STEP S85 lk=hash(ID||service_key)
STEP S86 PRODUCTTION OF sk
STEP S87 e=Enc(lk,sk)
STEP S88
e
STEP S89
STEP S90
sk'=Dec(license_key,e)

FIG. 9

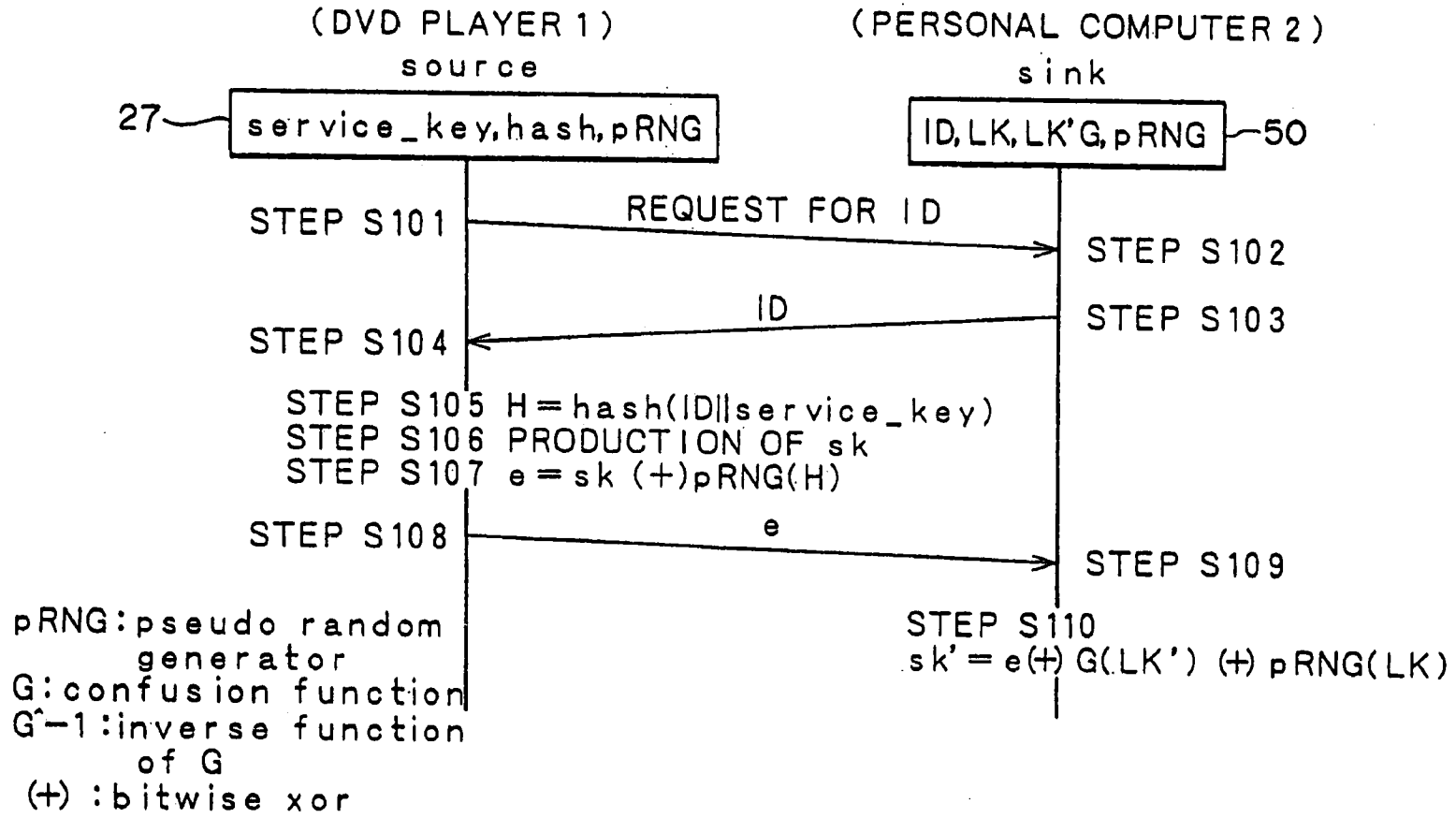
(DVD PLAYER 1)
source
27
service_key, hash, pRNG
(PERSONAL COMPUTER 2)
sink
ID, LK, LK'G, pRNG
50
STEP S101
REQUEST FOR ID
STEP S102
ID
STEP S103
STEP S104
STEP S105 H=hash(ID||service_key)
STEP S106 PRODUCTION OF sk
STEP S107 e=sk (+)pRNG(H)
STEP S108
e
STEP S109
STEP S110
sk'=e(+) G(LK') (+) pRNG(LK)
pRNG: pseudo random generator
G: confusion function
G^-1: inverse function of G
(+) : bitwise xor

FIG. 10

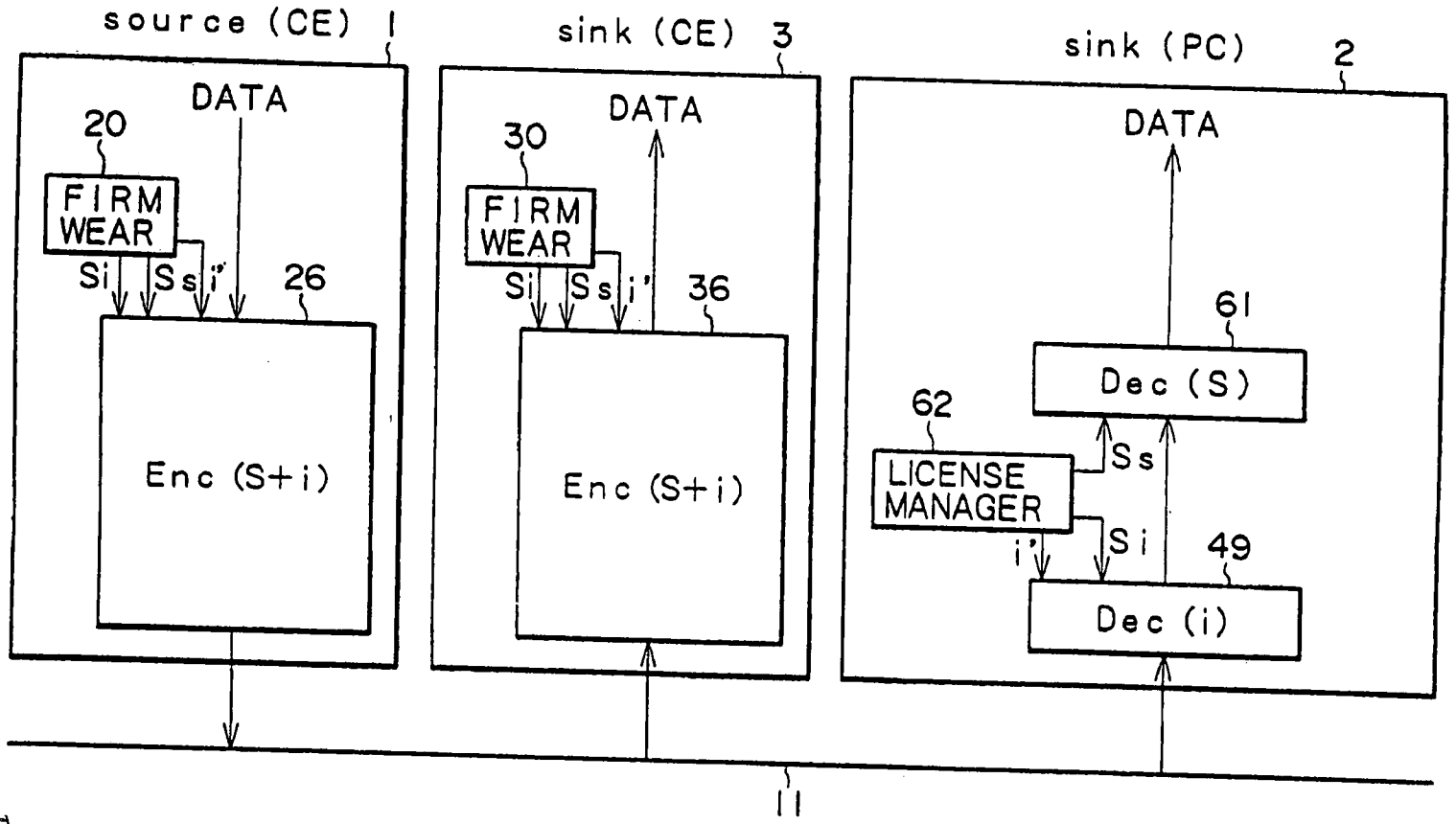

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FIG. 11

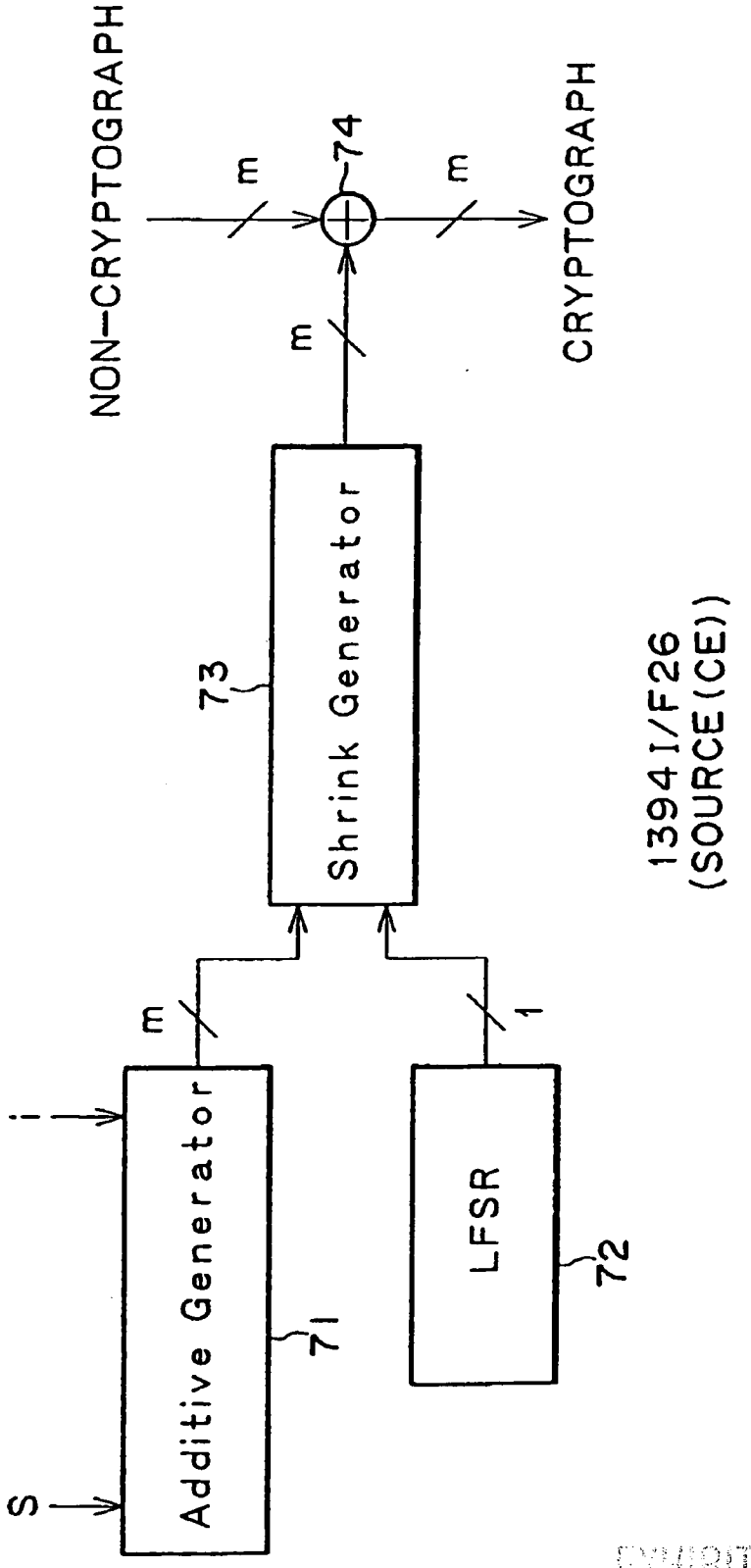

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FIG. 12

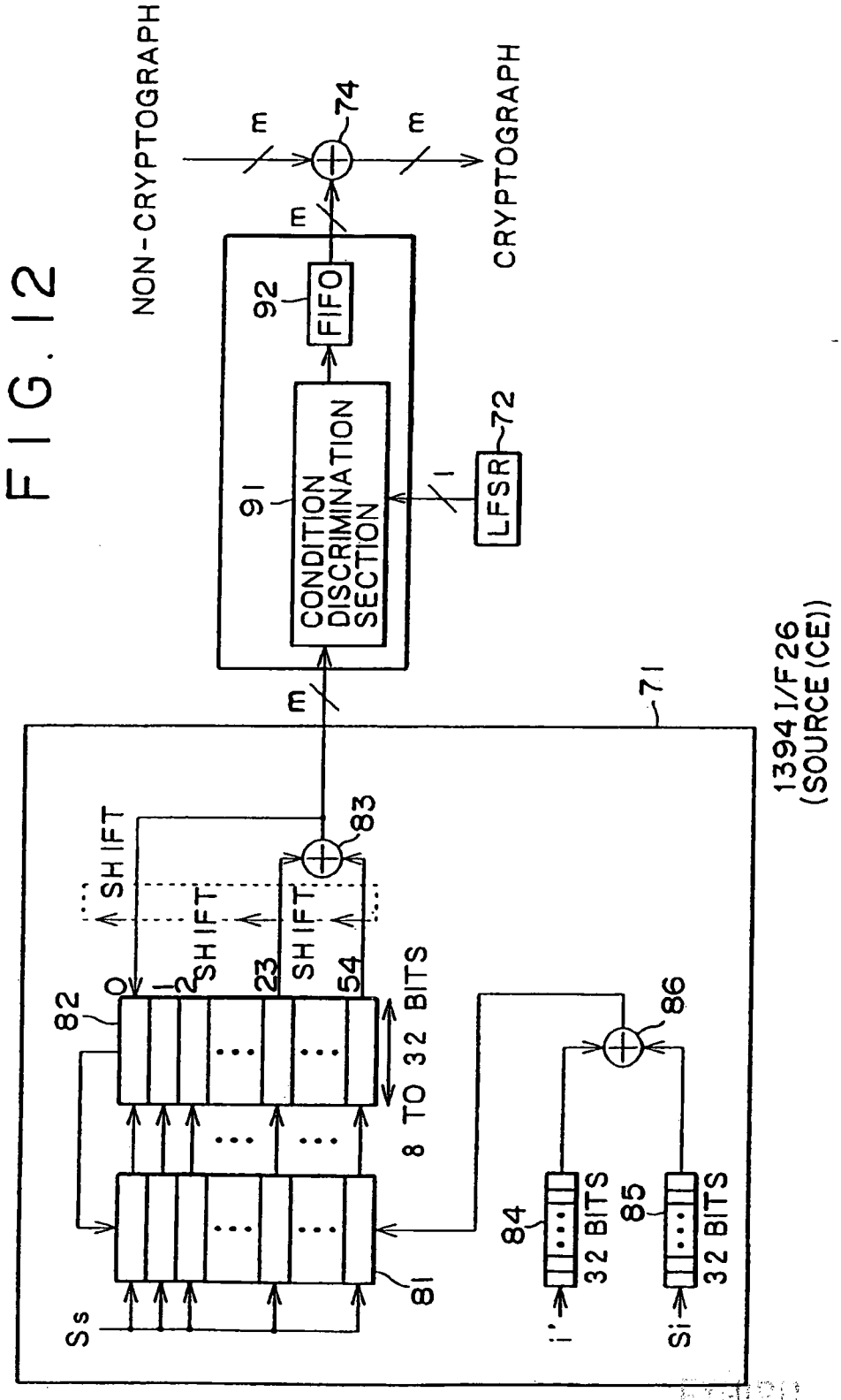

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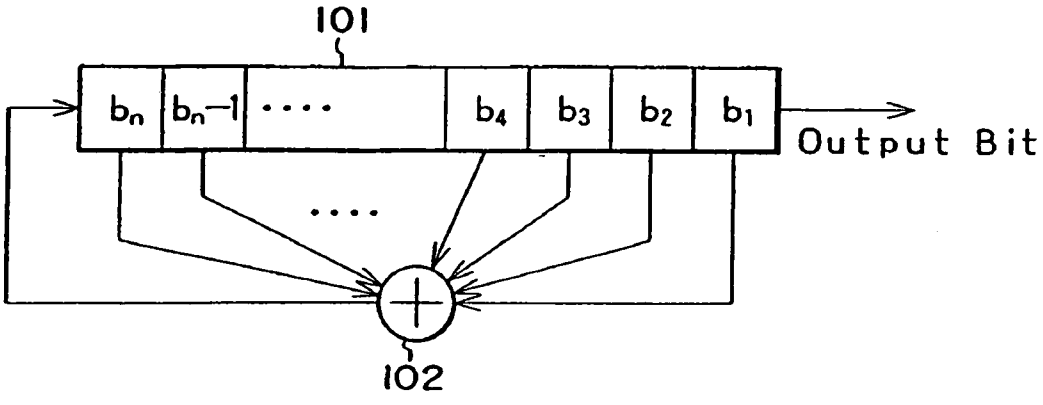
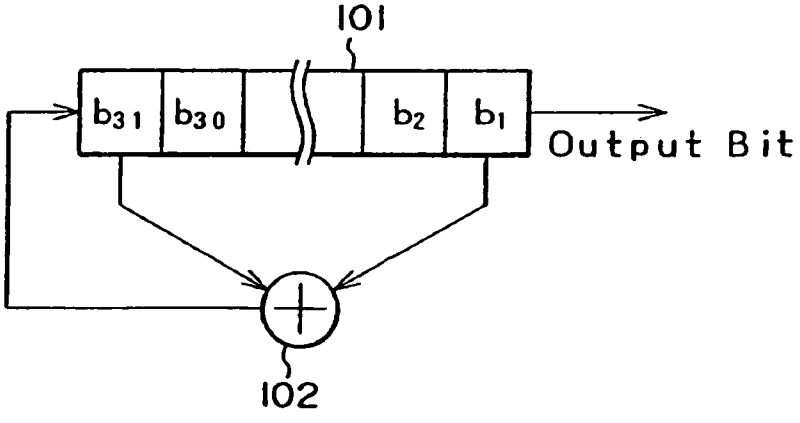
FIG. 13



LFSR72

FIG. 14



LFSR72

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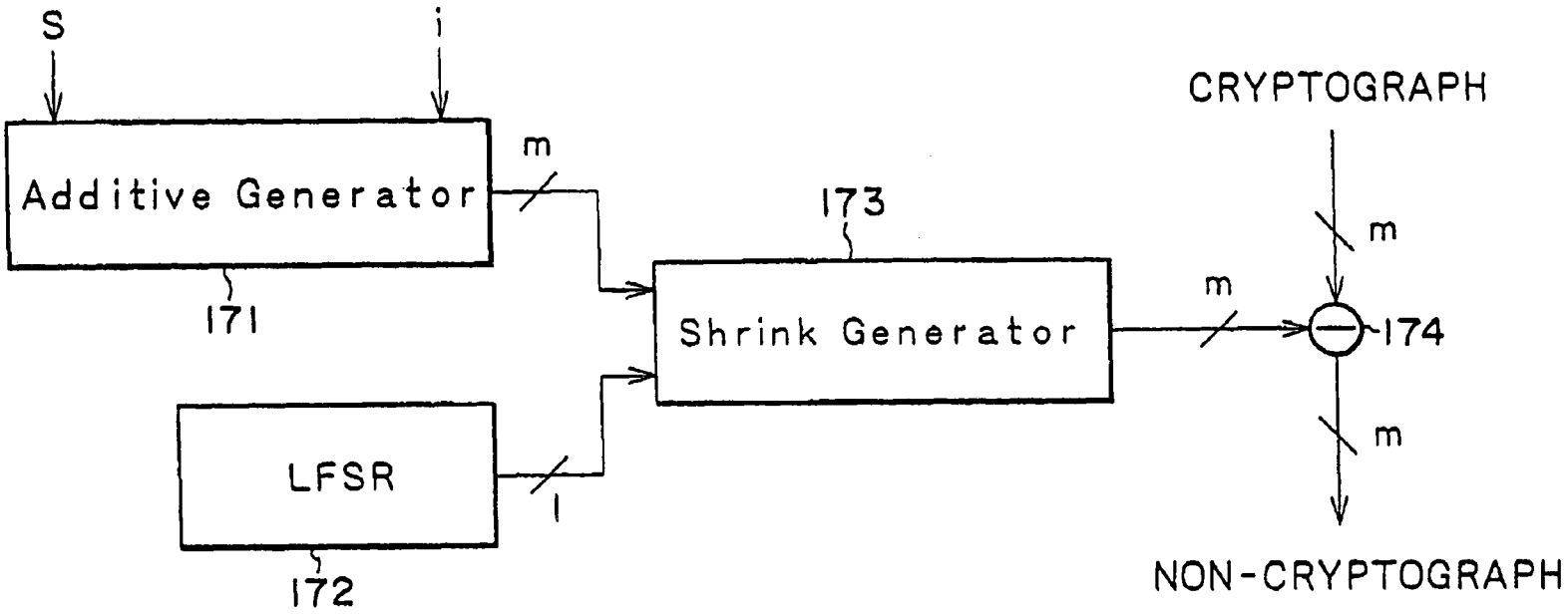
FIG. 15



13941/F36
(SINK (CE))

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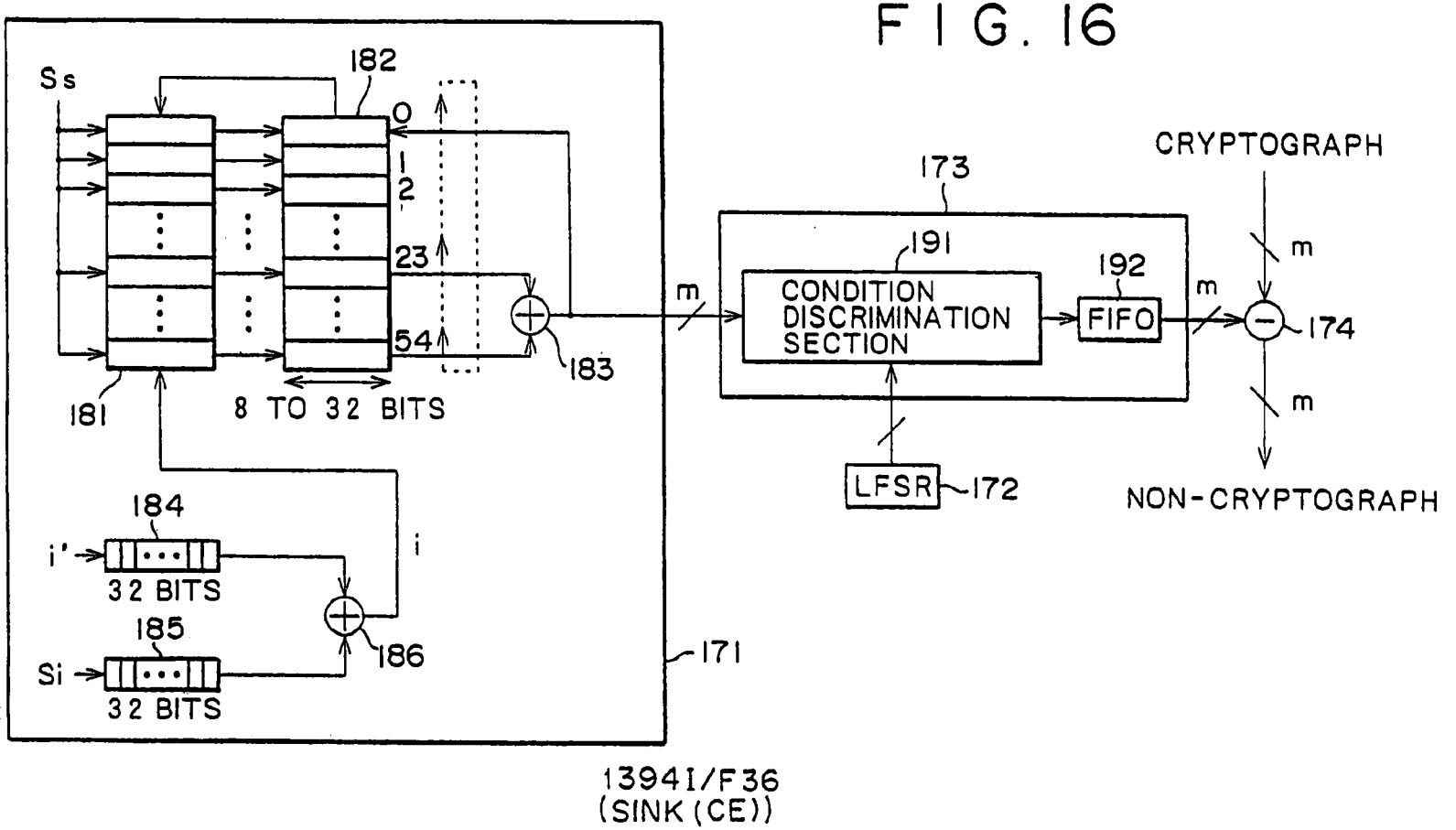
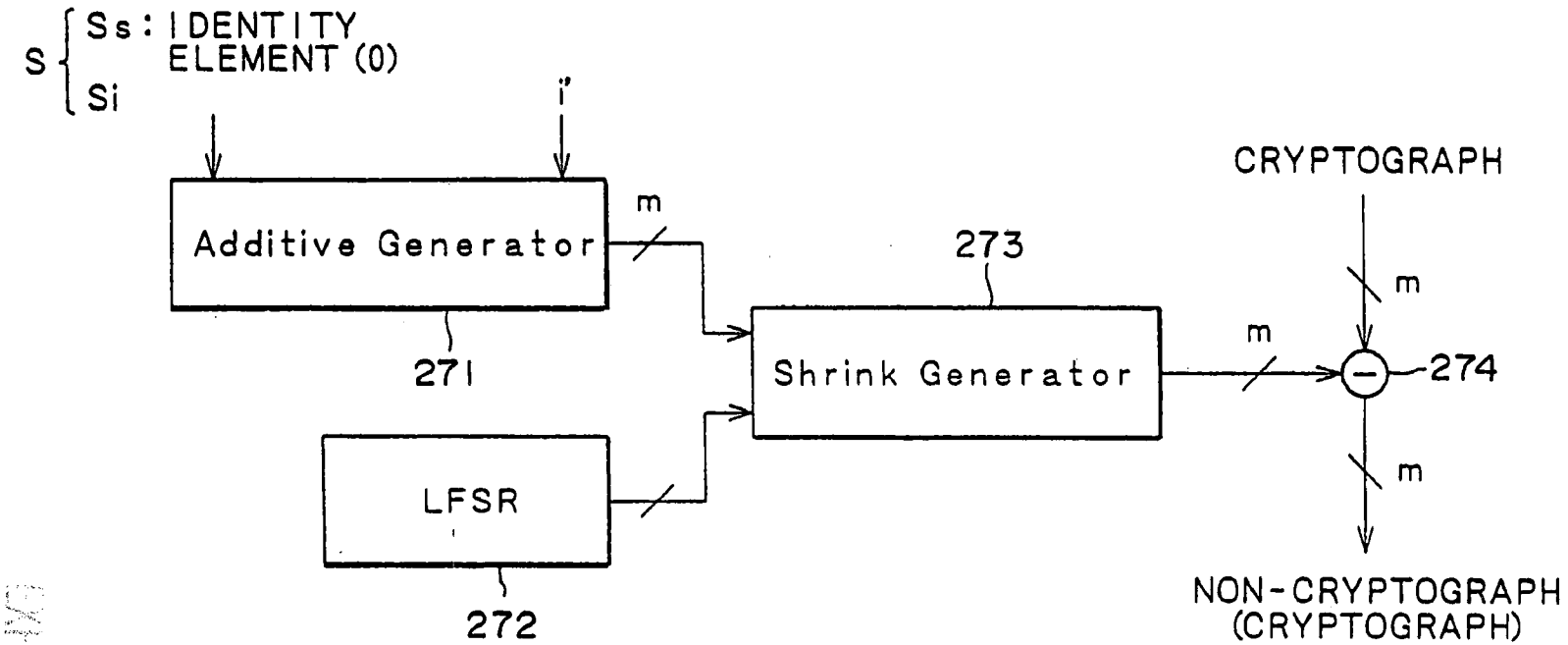
FIG. 16



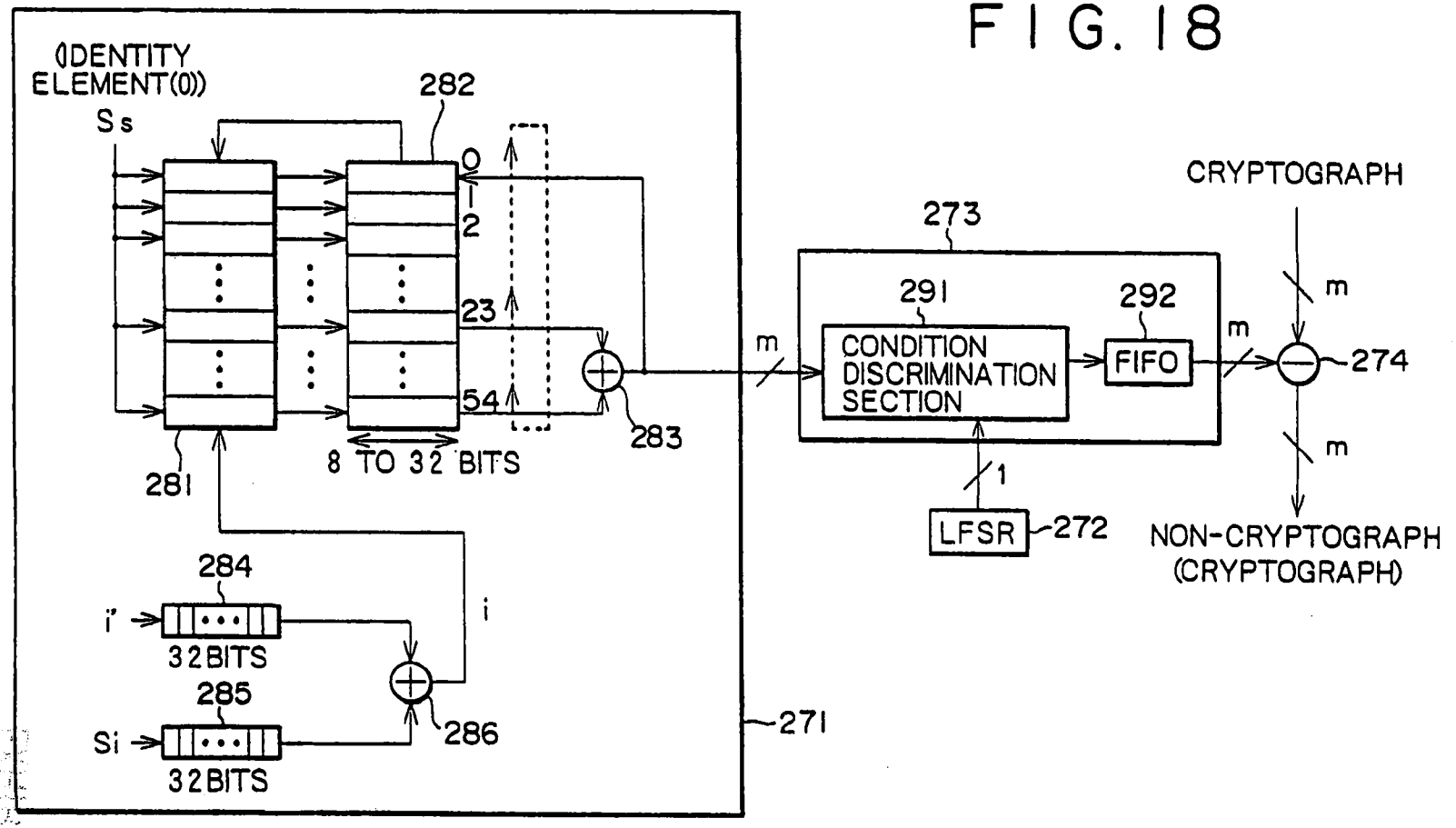
13941/F36
(SINK (CE))

FIG. 17



13941/F49
(LINK PORTION OF SINK(PC))

FIG. 18



13941/F49
(LINK PORTION OF SINK(PC))

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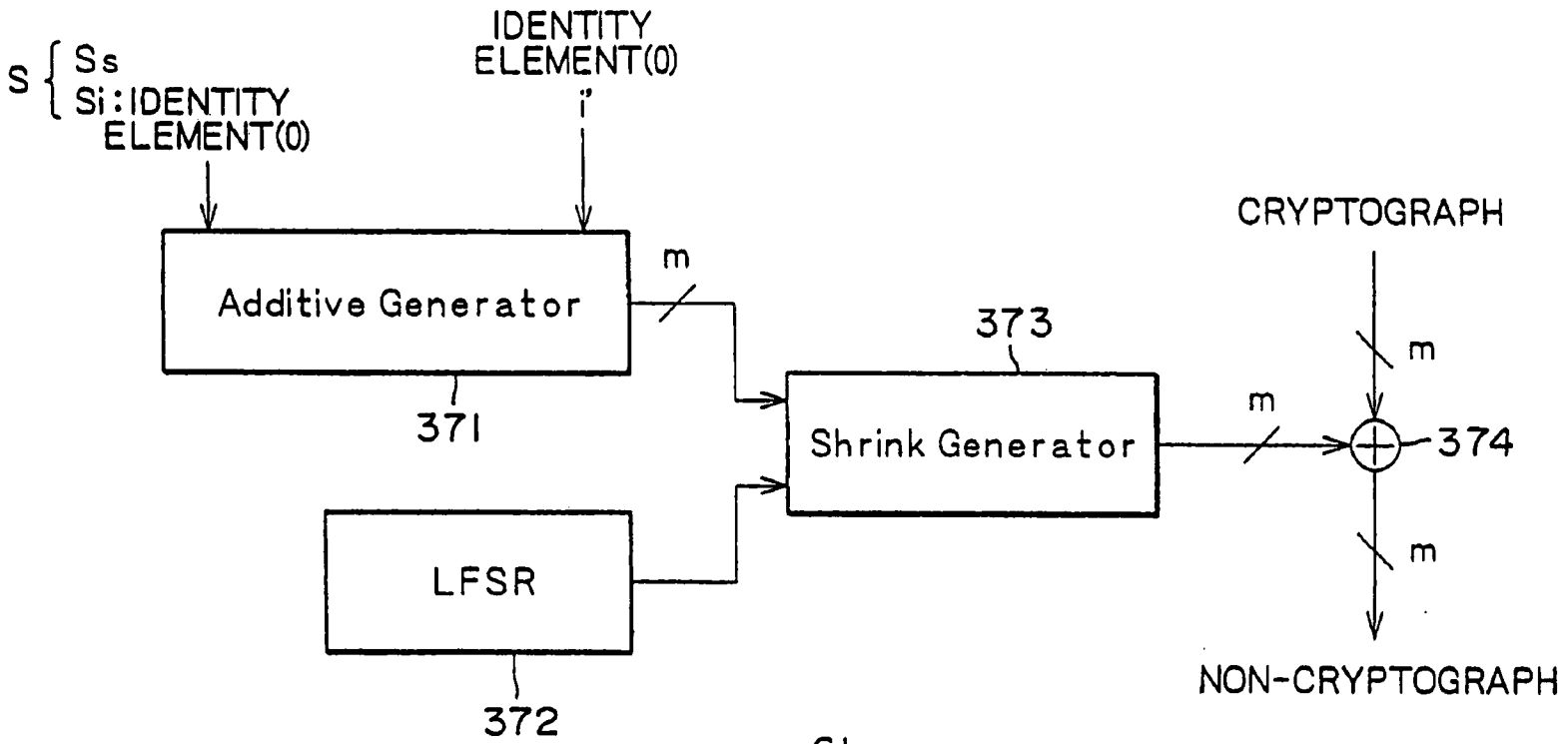
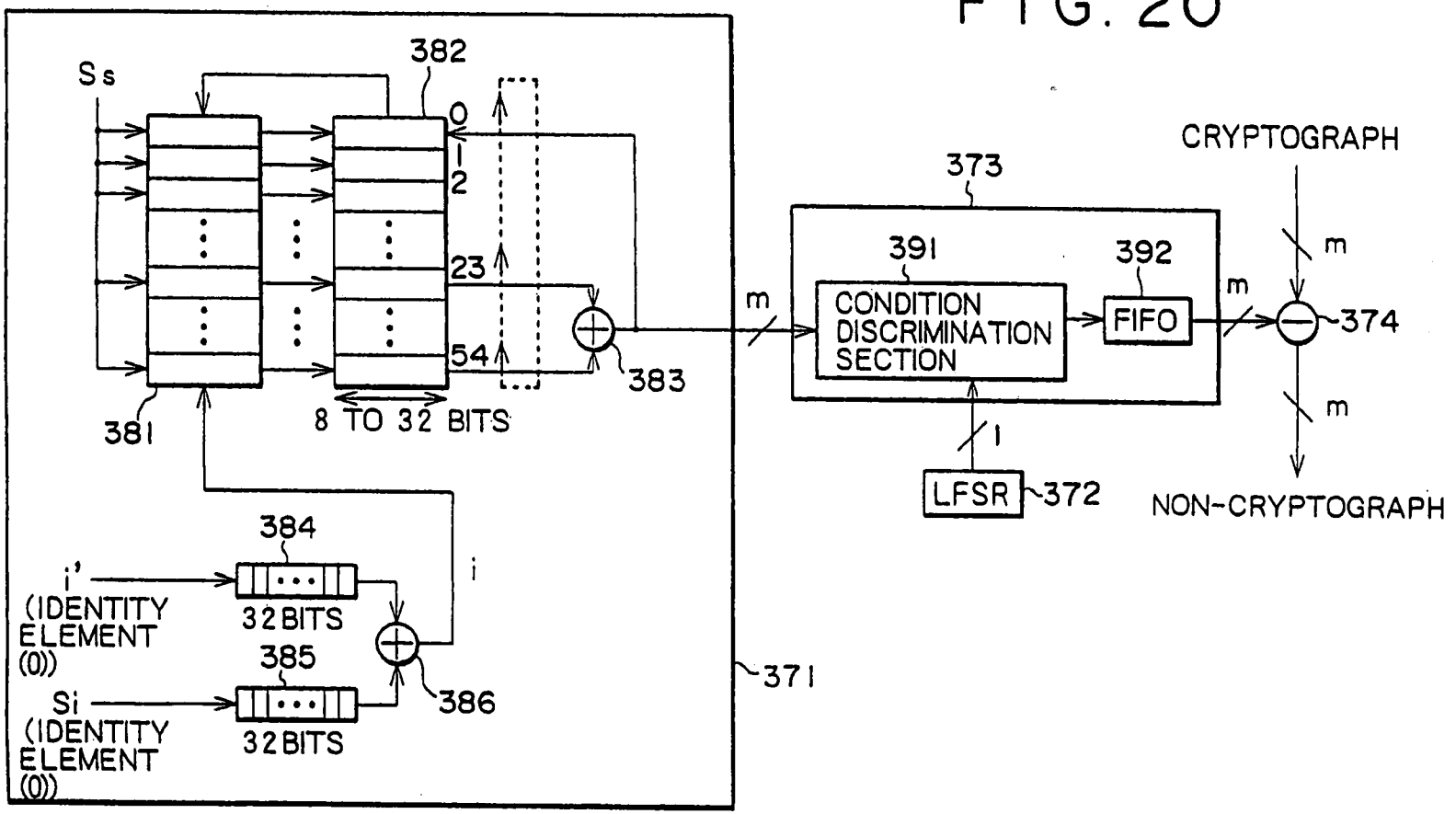
FIG. 19


S { Ss
Si : IDENTITY ELEMENT(0)
IDENTITY ELEMENT(0)
i
Additive Generator
371
m
373
Shrink Generator
LFSR
372
m
CRYPTOGRAPH
m
374
m
NON-CRYPTOGRAPH

61

FIG. 20


Ss
382
0
2
23
54
381
8 TO 32 BITS
383
m
373
391
CONDITION DISCRIMINATION SECTION
392
FIFO
m
CRYPTOGRAPH
m
374
m
NON-CRYPTOGRAPH
1
LFSR
372
384
i'
(IDENTITY ELEMENT (0))
32BITS
i
385
Si
(IDENTITY ELEMENT (0))
32BITS
386
371

61

FIG. 21

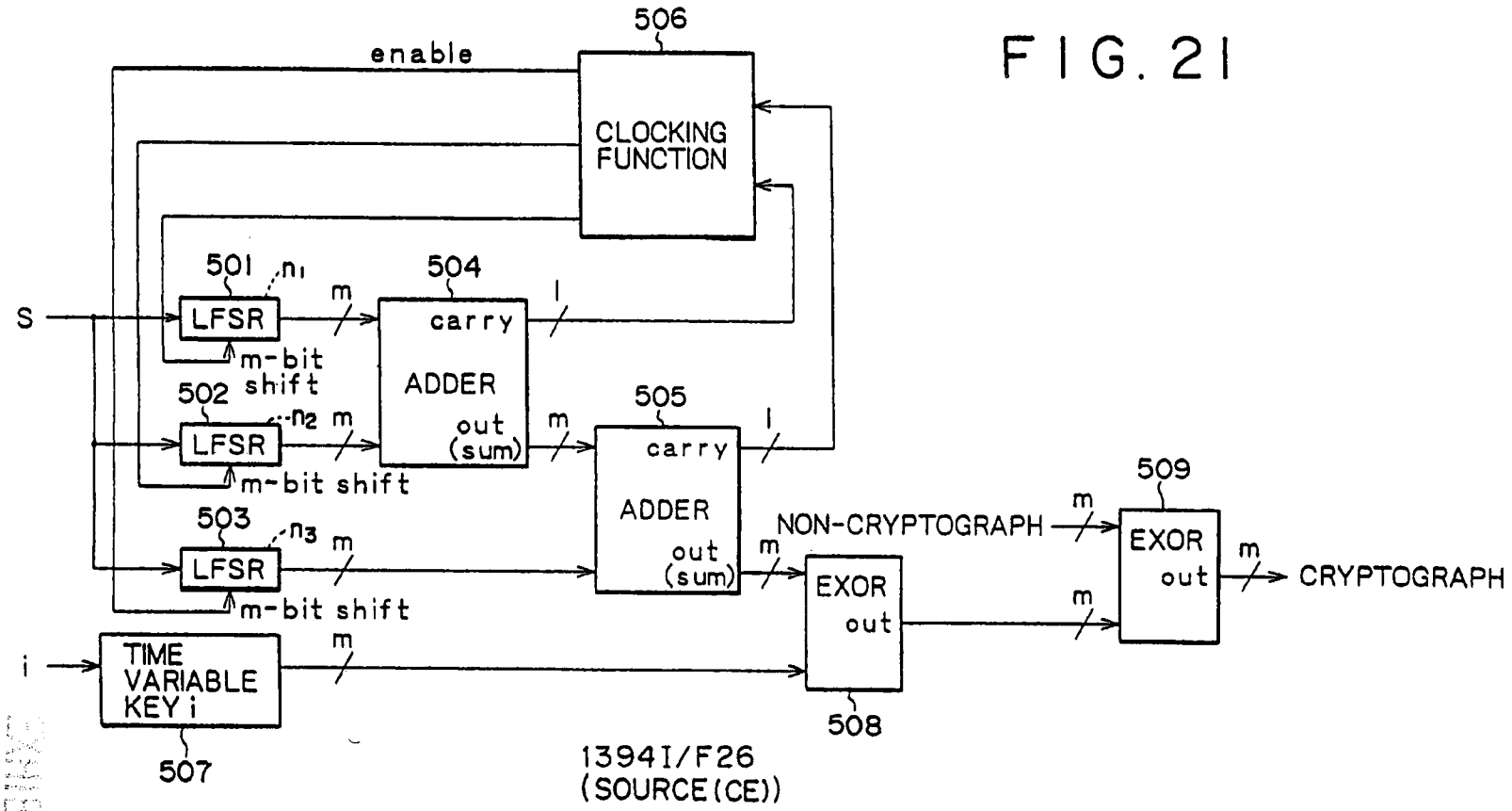

506
enable
CLOCKING FUNCTION
501
n1
504
S
LFSR
m
carry
ADDER
out (sum)
l
m-bit shift
502
n2
505
LFSR
m-bit shift
carry
ADDER
out (sum)
509
503
n3
NON-CRYPTOGRAPH
EXOR out
CRYPTOGRAPH
LFSR
m-bit shift
EXOR out
i
TIME VARIABLE KEY i
507
508
1394I/F26 (SOURCE(CE))

FIG. 22

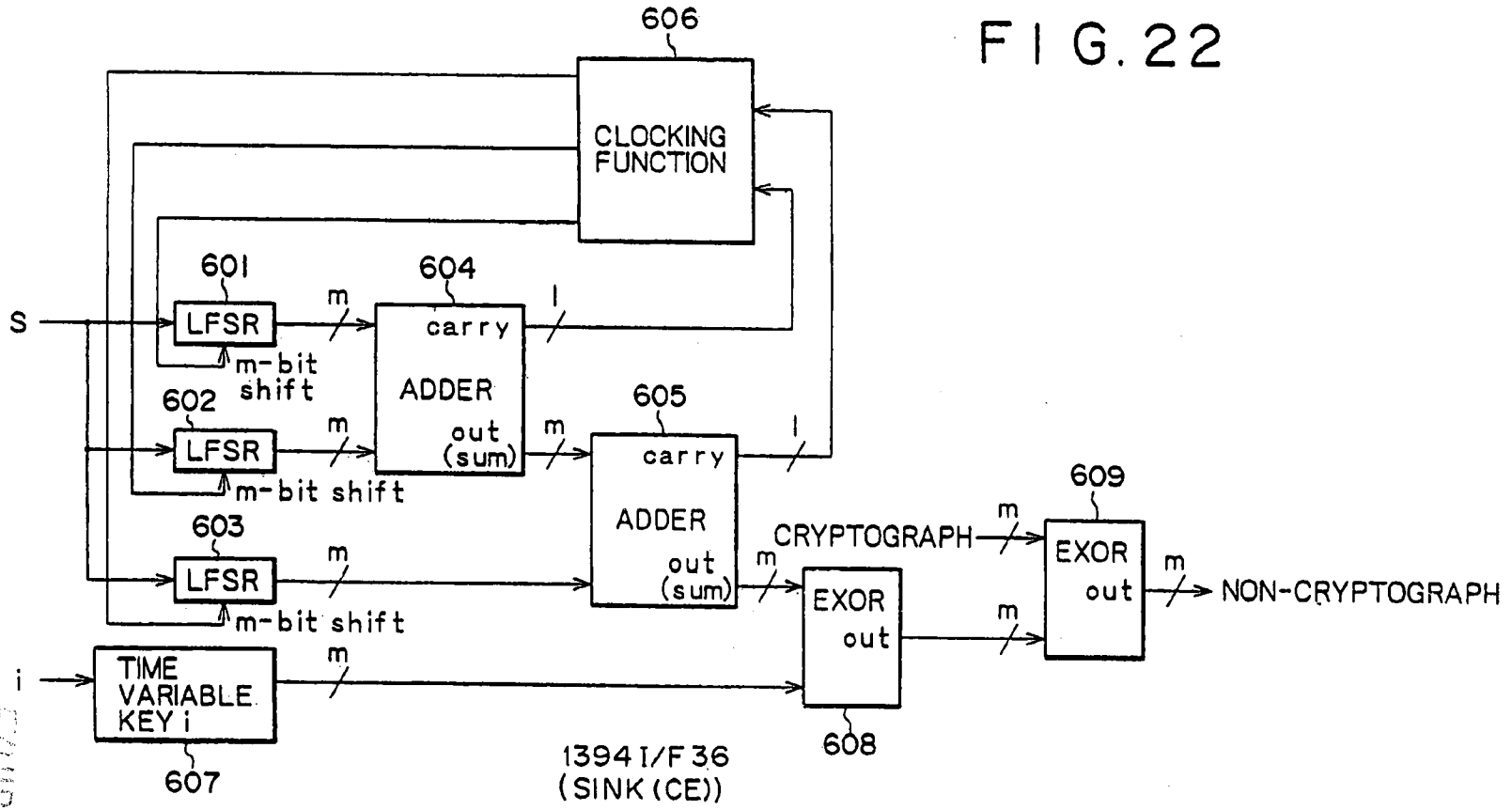

606
CLOCKING FUNCTION
601
604
S
LFSR
m
carry
ADDER
out (sum)
l
m-bit shift
602
605
LFSR
m
carry
ADDER
out (sum)
m
l
m-bit shift
609
603
CRYPTOGRAPH
m
EXOR
out
m
LFSR
m
EXOR
out
m
m-bit shift
NON-CRYPTOGRAPH
i
TIME VARIABLE KEY i
m
607
1394 I/F 36 (SINK (CE))
608

FIG. 23

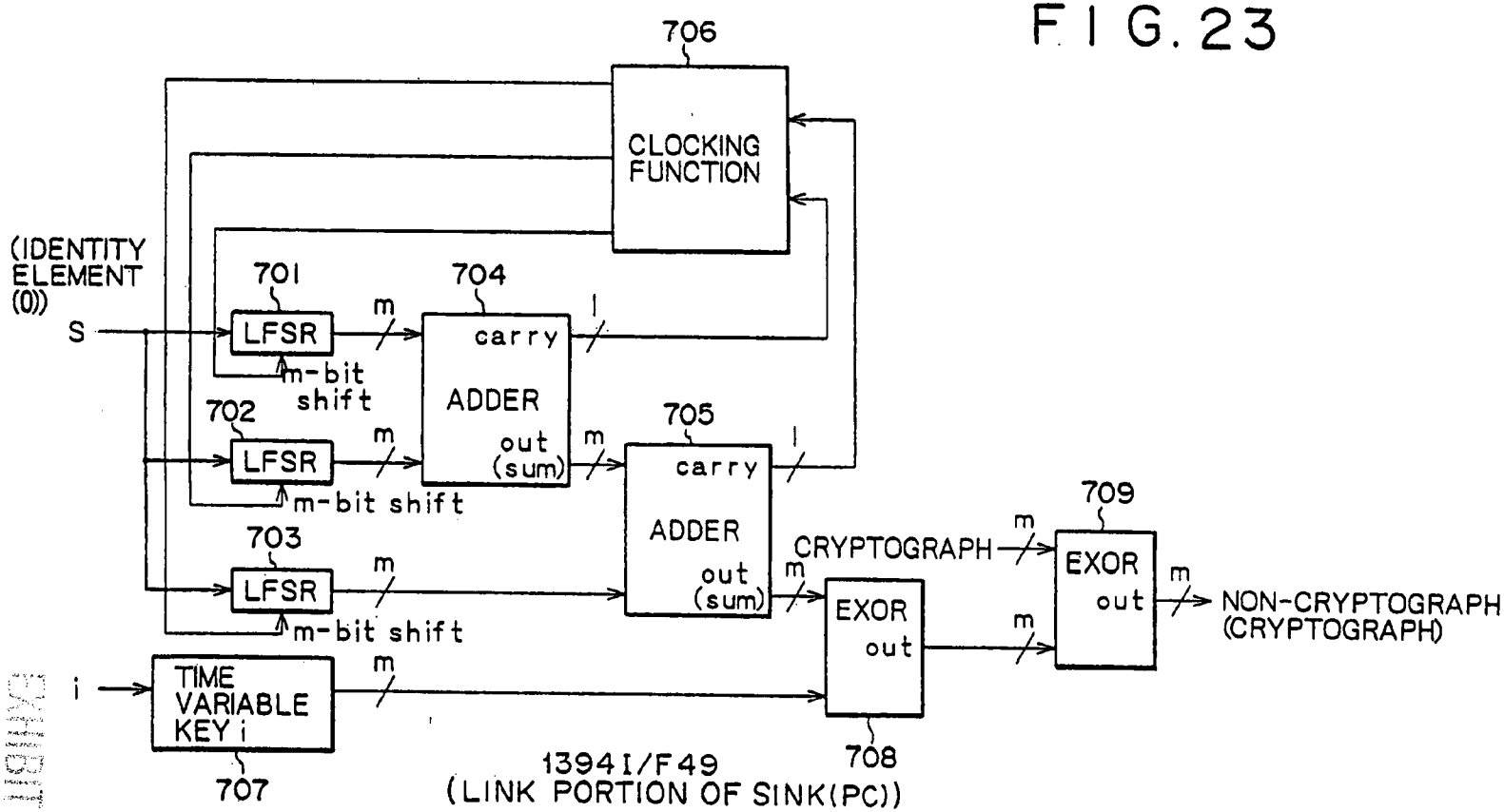
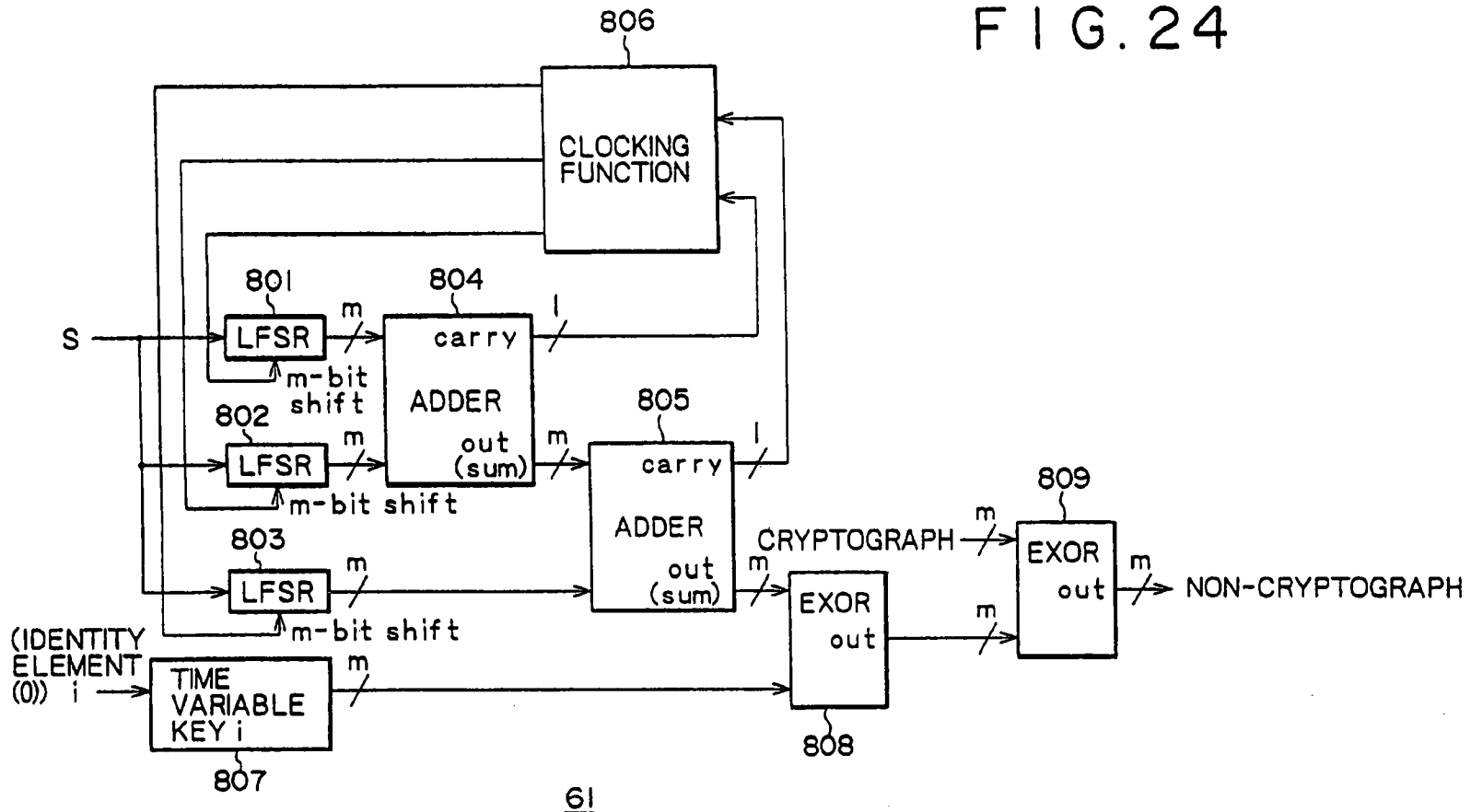

706
CLOCKING FUNCTION
(IDENTITY ELEMENT (0))
S
701
LFSR
m-bit shift
704
carry
ADDER
out (sum)
l
702
LFSR
m-bit shift
705
carry
ADDER
out (sum)
703
LFSR
m-bit shift
CRYPTOGRAPH
709
EXOR
out
NON-CRYPTOGRAPH (CRYPTOGRAPH)
EXOR
out
i
TIME VARIABLE KEY i
707
1394I/F49 (LINK PORTION OF SINK(PC))
708
m

FIG. 24



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ENCIPHERING APPARATUS AND METHOD, DECIPHERING APPARATUS AND METHOD AS WELL AS INFORMATION PROCESSING APPARATUS AND METHOD

This is a continuation of application Ser. No. 09/872,509 filed Jun. 1, 2001 now abandoned, which is a continuation of application Ser. No. 09/059,776, filed Apr. 14, 1998, now U.S. Pat. No. 6,256,391, the entirety thereof being incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an enciphering apparatus and method, a deciphering apparatus and method and an information processing apparatus and method, and more particularly to an enciphering apparatus and method, a deciphering apparatus and method and an information processing apparatus and method by which high security is assured.

2. Description of the Related Art

Recently, a network is available which is composed of a plurality of electronic apparatus represented by AV apparatus, computers and so forth which are connected to each other by a bus so that various data may be communicated between them.

Where a network of the type mentioned is employed, for example, data of a movie reproduced from a DVD (Digital Video Disk or Digital Versatile Disk) by a DVD player connected to the network can be transferred through the bus to and displayed by a display unit such as a television receiver or a monitor. Usually, it is licensed from the proprietor of copyright at a point of time when a DVD is purchased to display and enjoy a movie reproduced from the DVD on a display unit.

However, it is not usually licensed from the proprietor of copyright to copy data reproduced from the DVD onto another recording medium and utilize the same. Thus, in order to prevent data sent out through the bus (network) from being copied illegally, it is a possible idea to encipher the data on the sending side and decipher the data on the receiving side.

However, consumer electronics apparatus (CE apparatus) such as DVD players and television receivers are normally designed and produced for predetermined objects and are each produced such that it is impossible for a user to modify it or incorporate a different part into it to acquire or alter internal data (change of functions) of the apparatus. On the other hand, for example, in regard to personal computers, the architecture or circuitry is open to the public, and it is possible to add a board or install various application software to add or alter various functions.

Accordingly, in regard to a personal computer, it can be performed comparatively readily to directly access or alter data on an internal bus of the personal computer by adding predetermined hardware or applying a software program. This signifies that, by producing and applying application software, it can be performed readily, for example, to receive data transmitted as ciphered data from a DVD player to a television receiver and decipher or copy the received data by a personal computer.

In other words, a personal computer has a weak connection between a link portion which effects communication via a bus and an application portion which prepares data to be transmitted and utilizes received data, and includes many portions which can be modified physically and logically by

a user. In contrast, a CE apparatus has a strong connection between them and includes little portion which allows intervention of a user.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an enciphering apparatus and method, a deciphering apparatus and method and an information processing apparatus and method by which illegal copying of data can be prevented with a higher degree of certainty.

In order to attain the object described above, according to an aspect of the present invention to provide an enciphering apparatus, comprising enciphering means for enciphering data using a cryptographic key, first generating means for generating a first key, second generating means for generating a second key which is changed at a predetermined timing while the data is enciphered, and producing means for producing the cryptographic key using the first key and the second key.

According to another aspect of the present invention, there is provided an enciphering method, comprising the steps of enciphering data using a cryptographic key, generating a first key, generating a second key which is changed at a predetermined timing while the data are enciphered, and producing the cryptographic key using the first key and the second key.

With the enciphering apparatus and the enciphering method, since a cryptographic key is produced using a first key and a second key which is changed at a predetermined timing while data is enciphered, encipherment can be performed with a high degree of security.

According to a further aspect of the present invention, there is provided a deciphering apparatus, comprising receiving means for receiving enciphered data, deciphering means for deciphering the received data using a cryptographic key, first generating means for generating a first key, second generating means for generating a second key which is changed at a predetermined timing while the data is deciphered, and producing means for producing the cryptographic key using the first key and the second key.

According to a still further aspect of the present invention, there is provided a deciphering method, comprising the steps of receiving enciphered data, deciphering the received data using a cryptographic key, generating a first key, generating a second key which is changed at a predetermined timing while the data is deciphered, and producing the cryptographic key using the first key and the second key.

With the deciphering apparatus and the deciphering method, since a cryptographic key is produced using a first key and a second key which is changed at a predetermined timing while data is deciphered, enciphered data can be deciphered with a higher degree of security.

According to a yet further aspect of the present invention, there is provided an information processing system, comprising a plurality information processing apparatus connected to each other by a bus, the information processing apparatus including first information processing apparatus each having a function whose change is not open to a user, and second information processing apparatus each having a function whose change is open to a user, each of the first information processing apparatus including first receiving means for receiving enciphered data, first deciphering means for deciphering the data received by the first receiving means using a cryptographic key, first generating means for generating a first key, second generating means for generating a second key which is changed at a predetermined

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timing while the data is deciphered, and first producing means for producing the cryptographic key using the first key generated by the first generating means and the second key generated by the second generating means, each of the second information processing apparatus including second receiving means for receiving enciphered data, third generating means for generating the first key, fourth generating means for generating the second key which is changed at a predetermined timing while the data is deciphered, second producing means for producing a first cryptographic key using one of the first key generated by the third generating means and the second key generated by the fourth generating means, third producing means for producing a second cryptographic key using the other of the first key generated by the third generating means and the second key generated by the fourth means, second deciphering means for deciphering the enciphered data received by the receiving means using the first cryptographic key, and third deciphering means for further deciphering the data deciphered by the second deciphering means using the second cryptographic key.

According to a yet further aspect of the present invention, there is provided an information processing method for an information processing system composed of a plurality information processing apparatus connected to each other by a bus, the information processing apparatus including first information processing apparatus each having a function whose change is not open to a user, and second information processing apparatus each having a function whose change is open to a user, comprising the steps performed by each of the first information processing apparatus of receiving enciphered data, deciphering the data received in the receiving step using a cryptographic key, generating a first key, generating a second key which is changed at a predetermined timing while the data is deciphered, and producing the cryptographic key using the first key generated in the first generating step and the second key generated in the second generating step, and the steps performed by each of the second information processing apparatus of receiving enciphered data, generating the first key, generating the second key which is changed at a predetermined timing while the data is deciphered, producing a first cryptographic key using one of the first key and the second key, producing a second cryptographic key using the other of the first key and the second key, deciphering the enciphered data received in the receiving step using the first cryptographic key, and deciphering the deciphered data further using the second cryptographic key.

With the information processing system and the information processing method, since, in the first information processing apparatus which have functions whose change is not open to a user, a cryptographic key is produced using a first key and a second key which is changed at a predetermined timing while data is deciphered, but in the second information processing apparatus which have functions whose change is open to a user, a first cryptographic key is produced using one of a first key and a second key which is changed at a predetermined timing while data is deciphered, and then a second cryptographic key is produced using the other, whereafter the enciphered data is deciphered using the first cryptographic key, and the deciphered data is further deciphered using the second cryptographic key, the information processing apparatus and method has a higher degree of reliability than ever.

According to a yet further aspect of the present invention, there is provided an information processing apparatus, comprising receiving means for receiving data transmitted thereto through a bus, producing means composed of a software program for producing a first cryptographic key and a second cryptographic key which is changed at a predetermined timing while the data is deciphered from the data received by the receiving means, first deciphering means for deciphering the enciphered data received by the receiving means using one of the first cryptographic key and the second cryptographic key produced by the producing means, and second deciphering means for deciphering and processing the data deciphered by the first deciphering means further using the other of the first cryptographic key and the second cryptographic key produced by the producing means.

According to a yet further aspect of the present invention, there is provided an information processing method, comprising the steps of receiving data transmitted thereto through a bus, producing, from the received data, a first cryptographic key and a second cryptographic key which is changed at a predetermined timing while the data is deciphered, deciphering the received enciphered data using one of the first cryptographic key and the second cryptographic key, and deciphering the deciphered data further using the other of the first cryptographic key and the second cryptographic key.

With the information processing apparatus and the information processing method, since a first cryptographic key and a second cryptographic key which is changed at a predetermined timing while data is deciphered are produced based on a software program, decipherment can be performed for each application program, and illegal copying can be prevented with a higher degree of accuracy.

The above and other objects, features and advantages of the present invention will become apparent from the following description and the appended claims, taken in conjunction with the accompanying drawings in which like parts or elements are denoted by like reference characters.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram showing an example of a construction of an information processing system to which the present invention is applied;

FIG. **2** is a block diagram showing an example of internal constructions of a DVD player, a personal computer and a magneto-optical disk apparatus shown in FIG. **1**;

FIG. **3** is a block diagram illustrating an authentication procedure performed in the information processing system of FIG. **1**;

FIG. **4** is a timing chart illustrating the authentication procedure illustrated in FIG. **3**;

FIG. **5** is a diagrammatic view illustrating a format of a node_unique_ID;

FIG. **6** is a timing chart illustrating another authentication procedure;

FIG. **7** is a similar view but illustrating a further authentication procedure;

FIG. **8** is a similar view but illustrating a still further authentication procedure;

FIG. **9** is a similar view but illustrating a yet further authentication procedure;

FIG. **10** is a block diagram illustrating an enciphering procedure;

FIG. **11** is a block diagram showing an example of a construction of a 1394 interface used in the enciphering procedure of FIG. **10**;

FIG. **12** is a block diagram showing an example of a more detailed construction of the 1394 interface of FIG. **11**;

FIG. **13** is a block diagram showing an example of a more detailed construction of a linear feedback shift register shown in FIG. **12**;

FIG. **14** is a block diagram showing an example of a more detailed construction of the linear feedback shift register of FIG. **13**;

FIG. **15** is a block diagram showing an example of a construction of a 1394 interface used in the enciphering procedure of FIG. **10**.

FIG. **16** is a block diagram showing an example of a more detailed construction of the 1394 interface of FIG. **15**;

FIG. **17** is a block diagram showing an example of a construction of a 1394 interface used in the enciphering procedure of FIG. **10**;

FIG. **18** is a block diagram showing an example of a more detailed construction of the 1394 interface of FIG. **17**;

FIG. **19** is a block diagram showing an example of a construction of an application section used in the enciphering procedure of FIG. **10**;

FIG. **20** is a block diagram showing an example of a more detailed construction of the application section of FIG. **19**;

FIG. **21** is a block diagram showing another example of the construction of the 1394 interface used in the enciphering procedure of FIG. **10**:

FIG. **22** is a block diagram showing another example of the construction of the 1394 interface used in the enciphering procedure of FIG. **10**;

FIG. **23** is a block diagram showing another example of the construction of the 1394 interface used in the enciphering procedure of FIG. **10**; and

FIG. **24** is a block diagram showing another example of the construction of the application section used in the enciphering procedure of FIG. **10**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. **1**, there is shown an exemplary information processing system to which the present invention is applied. The information processing system shown includes a DVD player **1**, a personal computer **2**, an magneto-optical disk apparatus **3**, a data broadcasting receiver **4**, a monitor **5** and a television receiver **6** all connected to each other by an IEEE 1394 serial bus **11**.

Referring now FIG. **2**, there are shown more detailed internal constructions of the DVD player **1**, personal computer **2** and magneto-optical disk apparatus **3** of the information processing system shown in FIG. **1**. The DVD player **1** is connected to the 1394 bus **11** by a 1394 interface **26**. The DVD player **1** includes a CPU **21** which executes various processes in accordance with programs stored in a ROM **22**. A RAM **23** is used to suitably stores data, programs and so forth necessary for the CPU **21** to execute various processes. An operation section **24** is formed from buttons, switches, a remote controller and so forth, and when it is operated by a user, it outputs a signal corresponding to the operation. A drive **25** drives a DVD not shown to reproduce data recorded on the DVD. An EEPROM (Electrically Erasable Programmable Read Only Memory) **27** stores information such as key information which must remain stored also after the power supply to the apparatus is turned off. An internal bus **28** connects the components to each other.

The magneto-optical disk apparatus **3** includes a CPU **31**, a ROM **32**, a RAM **33**, an operation section **34**, a drive **35**, a 1394 interface **36**, an EEPROM **37** and an internal bus **38** which have similar functions to those of the DVD player **1** described above. Here, description of the similar components is omitted to avoid redundancy. It is to be noted, however, that the drive **35** drives not a DVD but a magneto-optical disk not shown to record or reproduce data onto or from the magneto-optical disk.

The personal computer **2** is connected to the 1394 bus **11** via a 1394 interface **49**. The personal computer **2** includes a CPU **41** which executes various processes in accordance with programs stored in a ROM **42**, and a RAM **43** into which data, programs and so forth necessary for the CPU **41** to execute various processes are stored suitably. A keyboard **45** and a mouse **46** are connected to an input/output interface **44**, and the input/output interface **44** outputs signals inputted thereto from the keyboard **45** and the mouse **46** to the CPU **41**. Further, a hard disk drive (HDD) **47** is connected to the input/output interface **44** so that data, programs and so forth can be recorded onto and reproduced from a hard disk not shown by the hard disk driver **47**. Further, an extended board **48** can be suitably mounted onto the input/output interface **44** so that a necessary function can be additionally provided to the personal computer **2**. An EEPROM **50** is used to store information which must remain stored also after the power supply to the personal computer **2** is turned off such as information of various keys. An internal bus **51** is formed from, for example, a PCI (Peripheral Component Interconnect) bus, a local bus or the like and connects the components mentioned above to each other.

It is to be noted that the internal bus **51** is open to the user so that the user can suitably receive data transmitted by the internal bus **51** by suitably connecting a predetermined board to the extended board **48** or by producing and installing a predetermined software program.

In contrast, in any of consumer electronics (CE) apparatus such as the DVD player **1** and the magneto-optical disk apparatus **3**, the internal bus **28** or the internal bus **38** is not open to a user and the user cannot acquire data transmitted in it unless special alteration is performed for it.

Subsequently, a procedure of authentication performed between a source and a sink is described. Here, the authentication procedure is performed, for example, as seen in FIG. **3**, between firmware **20** as one of software programs stored in advance in the ROM **22** of the DVD player **1** serving as a source and a license manager **62** as one of software programs stored in the ROM **42** of the personal computer **2** serving as a sink and processed by the CPU **41**.

FIG. **4** illustrates a procedure of authentication performed between the source (DVD player **1**) and the sink (personal computer **2**). A service key (service_key) and a function (hash) are stored in advance in the EEPROM **27** of the DVD player **1**. They are both provided to the user of the DVD player **1** from the proprietor of copyright, and the user stores them in the EEPROM **27** secretly.

The service key is provided for each information provided by the proprietor of copyright and is common to systems which are constructed using the 1394 bus **11**. It is to be noted that the system in the present specification signifies a general apparatus formed from a plurality of apparatus.

The hash function is a function for outputting data of a fixed length such as 64 bits or 128 bits in response to an input of an arbitrary length, and is a function with which, when y(=hash(x)) is given, it is difficult to determine x, and also it is difficult to determine a set of x1 and x2 with which hash(x1)=hash(x2) is satisfied. As representative ones of one-directional hash functions, MD5, SHA and so forth are known. The one-directional hash function is explained in detail in Bruce Schneier, "Applied Cryptography (Second Edition), Wiley".

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Meanwhile, for example, the personal computer **2** as a sink stores an identification number (ID) and a license key (license_key) given from the proprietor of copyright and peculiar to the personal computer **2** itself secretly in the EEPROM **50**. The license key is a value obtained by applying the hash function to data (ID||service_key) of n+m bits obtained by connecting the ID of n bits and the service key of m bits. In particular, the license key is represented by the following expression:

license_key=has(ID || service_key)

For the ID, for example, a node_unique_ID prescribed in the standards for a 1394 bus can be used. The node_unique_ID is composed of, as seen from FIG. **5**, **8** bytes (64 bits), wherein the first 3 bytes are managed by the IEEE and given from the IEEE to the individual maker of electronic apparatus. Meanwhile, the lower 5 bytes can be given by each maker to each apparatus provided to any user by the maker itself. Each maker applies, for example, numbers of the lower 5 bytes serially to individual apparatus with a single number applied to one apparatus, and if all available numbers for the 5 bytes are used up, then another node_unique_ID whose upper 3 bytes are different is given to the maker whereas a single number is applied to one apparatus with the lower 5 bytes. Accordingly, the node_unique_ID is different among different units irrespective of its maker and is unique to each unit.

In step **S1**, the firmware **20** of the DVD player **1** controls the 1394 interface **26** to request the personal computer **2** for an ID through the 1394 bus **11**. The license manager **62** of the personal computer **2** receives the request for an ID in step **S2**. In particular, the 1394 interface **49** outputs, when it receives the signal of the request for an ID transmitted thereto from the DVD player **1** through the 1394 bus **11**, the signal to the CPU **41**. The license manager **62** of the CPU **41** reads out, when the request for an ID is received, the ID stored in the EEPROM **50** and transmits the ID from the 1394 bus **11** to the DVD player **1** through the 1394 interface **49** in step **S3**.

In the DVD player **1**, the ID is received by the 1394 interface **26** in step **S4** and supplied to the firmware **20** which is being operated by the CPU **21**.

The firmware **20** couples, in step **S5**, the ID transmitted thereto from the personal computer **2** and the service key stored in the EEPROM **27** to produce data (ID || service_key) and applies a hash function as given by the following expression to the data to produce a key lk:

lk=hash(ID || service_key)

Then, in step **S6**, the firmware **20** produces a cryptographic key sk which is hereinafter described in detail. The cryptographic key sk is utilized as a session key in the DVD player **1** and the personal computer **2**.

Then, in step **S7**, the firmware **20** enciphers the cryptographic key sk produced in step **S6** using the key lk produced in step **S5** as a key to obtain enciphered data (enciphered key) e. In other words, the firmware **20** calculates the following expression:

e=Enc (lk,sk)

where Enc(A, B) represents to encipher data B using a key A in a common key cryptography.

Then, in step **S8**, the firmware **20** transmits the enciphered data e produced in step **S7** to the personal computer **2**. In particular, the enciphered data e is transmitted from the 1394 interface **26** of the DVD player **1** to the personal computer **2** through the 1394 bus **11**. In the personal computer **2**, the enciphered data e is received by the 1394 interface **49** in step **S9**. The license manager **62** deciphers the enciphered data e received in this manner using the license key stored in the EEPROM **50** in accordance with the following expression to produce a deciphering key sk':

sk'=Dec (license_key,e)

where Dec(A, B) represents to decipher data B using a key A in a common key cryptography.

It is to be noted that, as an algorithm for encipherment in the common key cryptography, the DES is known. Also the common key cryptography is explained in detail in "Applied Cryptography (Second Edition)" mentioned hereinabove.

The key lk produced in step **S5** by the DVD player **1** has a value equal to that (license_key) stored in the EEPROM **50** of the personal computer **2**. In other words, the following expression is satisfied:

lk=license_key

Accordingly, the key sk' obtained by the decipherment in step **S10** by the personal computer **2** has a value equal to that of the cryptographic key sk produced in step **S6** by the DVD player **1**. In other words, the following expression is satisfied:

sk'=sk

In this manner, the keys sk and sk' which are equal to each other can be possessed commonly by both of the DVD player **1** (source) and the personal computer **2** (sink). Thus, either the key sk can be used as it is as a cryptographic key, or a pseudo-random number may be produced based on the key sk and used as a cryptographic key by both of the source and the sink.

Since the license key is produced based on the ID peculiar to the apparatus and the service key corresponding to information to be provided as described above, another apparatus cannot produce the key sk or sk'. Further, any apparatus which is not authorized by the proprietor of copyright cannot produce the sk or sk' since it does not have a license key. Accordingly, when the DVD player **1** thereafter enciphers reproduction data using the cryptographic key sk and transmits resulting data to the personal computer **2**, where the personal computer **2** has the license key obtained legally, since it has the cryptographic key sk', it can decipher the enciphered reproduction data transmitted thereto from the DVD player **1**. However, where the personal computer **2** is not legal, since it does not have the cryptographic key sk', it cannot decipher the enciphered reproduction data transmitted thereto. In other words, since only a legal apparatus can produce the common cryptographic keys sk and sk', authentication is performed as a result.

Even if the license key of the single personal computer **2** is stolen, since the ID is different among different units, it is impossible for another apparatus to decipher enciphered data transmitted thereto from the DVD player **1** using the license key. Accordingly, the security is augmented.

FIG. **6** illustrates an exemplary procedure when not only the personal computer **2** but also the magneto-optical disk apparatus **3** function as a sink with respect to a source (DVD player **1**).

In this instance, an ID1 is stored as an ID and a license_key1 is stored as a license key in the EEPROM **50** of the personal computer **2** which serves as a sink1, but in the magneto-optical disk apparatus **3** which serves as a sink2, an ID2 is stored as an ID and a license_key2 is stored as a license key in the EEPROM **37**.

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Processes in steps S11 to S20 performed between the DVD player 1 (source) and the personal computer 2 (sink1) are substantially similar to the processes in steps S1 to S10 illustrated in FIG. 4. Therefore, description of the processes in steps S11 to S20 is omitted to avoid redundancy.

After the DVD player 1 cooperates with the personal computer 2 to perform an authentication procedure in such a manner as described above, it requests, in step S21, the magneto-optical disk apparatus 3 for an ID. When the ID requesting signal is received via the 1394 interface 36 in step S22 by the magneto-optical disk apparatus 3, firmware 30 (FIG. 10) in the magneto-optical disk apparatus 3 reads out the ID (ID2) stored in the EEPROM 37 in step S23 and transmits the ID from the 1394 interface 36 to the DVD player 1 through the 1394 bus 11. The firmware 20 of the DVD player 1 receives the ID2 via the 1394 interface 26 in step S24 and produces a key lk2 based on the following expression in step S25:

lk2=hash(ID2 || service_key)

Further, the firmware 20 calculates the following expression in step S26 to encipher the key sk produced in step S16 using the key lk2 produced in step S25 to produce enciphered data e2:

e2=Enc(lk2,sk)

Then, in step S27, the firmware 20 transmits the enciphered data e2 from the 1394 interface 26 to the magneto-optical disk apparatus 3 through the 1394 bus 11.

The magneto-optical disk apparatus 3 receives the enciphered data e2 via the 1394 interface 36 in step S28, and calculates the following expression in step S29 to produce a cryptographic key sk2':

sk2'=Dec(license_key2, e2)

The cryptographic keys sk1' and sk2' are obtained by the personal computer 2 and the magneto-optical disk apparatus 3, respectively, in such a manner as described above. The values of them are an equal value to the cryptographic key sk of the DVD player 1.

While, in the procedure of FIG. 6, the DVD player 1 requests the personal computer 2 and the magneto-optical disk apparatus 3 individually for an ID and processes the received IDs, where a request for an ID can be delivered by broadcast communication, such a procedure as illustrated in FIG. 7 can be performed.

In particular, in the procedure of FIG. 7, the DVD player 1 as a source requests all sinks, which are, in the present procedure, the personal computer 2 and the magneto-optical disk apparatus 3, for an ID by broadcast communication. After the personal computer 2 and the magneto-optical disk apparatus 3 receive the signal of the request for transfer of an ID in steps S42 and S43, respectively, each of them reads out the ID1 or the ID2 stored in the EEPROM 50 or the EEPROM 37 and transfers it to the DVD player 1 in step S44 or step S45. The DVD player 1 receives the IDs in steps S46 and S47.

The DVD player 1 produces a cryptographic key lk1 based on the following expression in step S48:

lk1=hash(ID1 || service_key)

Further, in step S49, a cryptographic key lk2 is produced based on the following expression:

lk2=has(ID2 || service_key)

In the DVD player 1, a cryptographic key sk is produced further in step S50, and in step S51, the cryptographic key sk is enciphered as given by the following expression using the key lk1 as a key:

e1=Enc(lk1,sk)

Further, in step S52, the cryptographic key sk is enciphered in accordance with the following expression using the key lk2 as a key:

e2=Enc(lk2,sk)

Furthermore, in step S53, the values ID1, e1, ID2 and e2 thus obtained are coupled as given by the following expression to produce enciphered data e:

e=ID1 || e1 || ID2 || e2

The enciphered data e produced in the DVD player 1 in such a manner as described above is transmitted to the personal computer 2 and the magneto-optical disk apparatus 3 by broadcast communication further in step S54.

The personal computer 2 and the magneto-optical disk apparatus 3 receive the enciphered data e in steps S55 and S56, respectively. Then, in the personal computer 2 and the magneto-optical disk apparatus 3, calculation indicated by the following expressions is performed in steps S57 and S58 so that cryptographic keys sk1' and sk2' are produced, respectively:

sk1'=Dec(license_key1,e1)

sk2'=Dec(license_key2,e2)

FIG. 8 illustrates an example of a procedure where one sink can enjoy a plurality of services (decipherment of a plurality of kinds of information). Referring to FIG. 8, in the present procedure, for example, the personal computer 2 serving as a sink has a plurality of license keys (license_key1, license_key2, license_key3 and so forth) stored in the EEPROM 50 thereof. The DVD player 1 serving as a source has a plurality of service keys (service_key1, service_key2, service_key3 and so forth) stored in the EEPROM 27 thereof. In this instance, when the DVD player 1 requests the personal computer 2 as a sink for an ID in step S81, it transfers a service_ID for identification of information (a service) to be transferred subsequently from the DVD player 1. When the personal computer 2 receives the service_ID in step S82, it selects one of the plurality of license keys stored in the EEPROM 50 which corresponds to the service_ID and performs deciphering processing in step S90 using the selected license key. The other operations are similar to those illustrated in FIG. 4.

FIG. 9 illustrates a further example of a procedure. In the present procedure, the DVD player 1 serving as a source has a service_key, a hash function and a pseudo-random number generation function pRNG stored in the EEPROM 27 thereof. They have been given from the proprietor of copyright and are stored secretly. Meanwhile, in the EEPROM 50 of the personal computer 2 serving as a sink, an ID, LK, LK', function G and pseudo-random number generation function pRNG given thereto from the proprietor of copyright are stored.

LK is a unique random number produced by the proprietor of copyright, and LK' is produced so that it may satisfy the following expressions:

$$LK'=G^{-1}(R)$$

$$R=pRNG(H)(+)pRNG(LK)$$

H=hash(ID || service_key)

It is to be noted that G^−1 signifies an inverse function of G. G^−1 has such a characteristic that it can be calculated simply if a predetermined rule is known, but if the rule is not known, it is difficult to calculate. For such a function, a function which is used for a public key cryptography can be used.

Further, the pseudo-random function generation function may be provided as hardware.

The firmware **20** of the DVD player **1** first requests the license manager **62** of the personal computer **2** for an ID in step S**101**. The license manager **62** of the personal computer **2** reads out, when it receives the ID requesting signal in step S**102**, the ID stored in the EEPROM **50** and transfers it to the DVD player **1** in step S**103**. The firmware **20** of the DVD player **1** receives this ID in step S**104** and calculates the following expression in step S**105**:

$$H=\text{hash}(\text{ID} \,||\, \text{service\_key})$$

Further, the firmware **20** produces a key sk in step S**106** and calculates the following expression in step S**107**:

$$e=sk(+)pRNG(H)$$

It is to be noted that A (+) B represents operation of exclusive ORing of A and B.

In other words, the key sk is enciphered by operating exclusive ORing, for each bit, of a result pRNG (H) obtained by inputting H calculated in step S**105** to the pseudo-random generation key pRNG and the key sk produced in step S**106**.

Then, in step S**108**, the firmware **20** transmits e to the personal computer **2**.

In the personal computer **2**, this e is received in step S**109**, and the following expression is calculated in. step S**110**:

$$sk'=e(+)G(LK')(+)pRNG(LK)$$

In particular, exclusive ORing of e transmitted from the DVD player **1**, the value G(LK') obtained by applying LK' stored in the EEPROM **50** to the function G also stored in the EEPROM **50** and the result pRNG(LK) obtained by applying LK' stored in the EEPROM **50** to the pseudo-random number generation function pRNG also stored in the EEPROM **50** is calculated to obtain a key sk'.

Here, as seen from the following expression, sk=sk':

$$\begin{aligned} sk' &= e(+)G(LK')(+)pRNG(LK) \\ &= sk(+)pRNG(H)(+)R(+)pRNG(LK) \\ &= sk(+)pRNG(H)(+)pRNG(H)+pRNG(LK)(+)pRNG(LK) \\ &= sk \end{aligned}$$

In this manner, the DVD player **1** as a source and the personal computer **2** as a sink can possess the cryptographic keys sk and sk', which are equal to each other, commonly. Since only the proprietor of copyright can produce LK and LK', even if the source tries to produce LK or LK' illegally, it cannot produce the same, and consequently, the security can be further promoted.

While, in the description above, authentication is performed between a source and a sink, for example, the personal computer **2** can normally use an arbitrary application program as a load. Further, as such application program, an application program produced illegally may be used. Accordingly, for each application program, it must be discriminated whether or not it is licensed from the proprietor of copyright. Therefore, as shown in FIG. **3**, also between each application section **61** and the license manager **62**, authentication processing may be performed in such a manner as described above. In this instance, the license manager **62** serves as a source, and the application section **61** serves as a sink.

Subsequently, operation when, after authentication is performed (after common possession of a cryptographic key is performed), enciphered data is transferred from a source using a cryptographic key to a sink and the enciphered data is deciphered by the sink is described.

In an apparatus whose internal functions are not open to an ordinary user such as the DVD player **1** or the magneto-optical disk apparatus **3**, processing of encipherment and decipherment of data communicated through the 1394 bus **11** is performed by the 1394 interface **26** or the 1394 interface **36**. While, for the encipherment and the decipherment, a session key S and a time variable key i are used, the session key S and the time variable key i (more accurately, a key i' to be used for production of the time variable key i) are supplied from the firmware **20** or the firmware **30** to the 1394 interface **26** or the 1394 interface **36**, respectively. The session key S is composed of an initial value key Ss to be used as an initial value and a disturbance key Si to be used for disturbing the time variable key i. The initial value key Ss and the disturbance key Si can be composed of upper bits and lower bits of predetermined bit numbers of a cryptographic key sk (=sk') produced in the authentication described above, respectively. The session key S is suitably updated for each session, for example, for information of each one movie or for each reproduction. In contrast, the time variable key i produced from the disturbance key Si and the key i' is updated frequently in one session, and for example, time information at a predetermined timing or the like can be used.

Now, it is assumed that video data reproduced by and outputted from the DVD player **1** service as a source is transmitted to the magneto-optical disk apparatus **3** and the personal computer **2** through the 1394 bus **11** so that it is deciphered by the magneto-optical disk apparatus **3** and the personal computer **2**. In this instance, in the DVD player **1**, enciphering processing is performed using the session key S and the time variable key i by the 1394 interface **26**. In the magneto-optical disk apparatus **3**, deciphering processing is performed using the session key S and the time variable key i by the 1394 interface **36**.

In contrast, in the personal computer **2**, the license manager **62** supplies the initial value key Ss of the session key S to the application section **61** and supplies the disturbance key Si and the time variable key i (more accurately, the key i' for production of the time variable key i) to the 1394 interface **49** (link portion). Then, by the 1394 interface **49**, a time variable key i is produced from the disturbance key Si and the key i' and decipherment is performed using the time variable key i, and the deciphered data is further deciphered using the session key S (more accurately, the initial value key Ss) by the application section **61**.

In this manner, in the personal computer **2**, since the internal bus **51** is open to a user, only decipherment in the first stage is performed by the 1394 interface **49** so that resulting data still remains in a condition of a cryptograph. Then, further decipherment in the second stage is performed by the application section **61** to produce a non-cryptograph. By this, the personal computer **2** is inhibited from adding a function suitably to the same to copy data (a non-cryptograph) communicated by the internal bus **51** onto the hard disk **47** or any other apparatus.

In this manner, in the present system, while, in a CE apparatus whose internal bus is not open, an enciphering or

deciphering procedure is performed once using a session key S and a time variable key i, in another apparatus (the personal computer **2** or the like) whose internal bus is open, a deciphering procedure is performed separately as a deciphering procedure in which the time variable key i is used and another deciphering procedure in which the session key S is used. In order to allow both of the deciphering procedure by one stage and the deciphering procedure by two separate stages to be performed in this manner, the following expression must be satisfied:

$$Dec(S,Dec(i,Enc(algo(S+i),Data)))=Data$$

where algo(S+i) represents a result obtained by inputting the session key S and the time variable key i to a predetermined algorithm.

FIG. **11** shows an example of a construction of the 1394 interface **26** which satisfies the expression above. Referring to FIG. **11**, in the 1394 interface **26** shown, data of m bits produced by an additive generator **71** is supplied to a shrink generator **73**. Meanwhile, a linear feedback shift register (LFSR) **72** outputs data of 1 bit and supplies it to the shrink generator **73**. The shrink generator **73** selects the output of the additive generator **71** in response to the output of the linear feedback shift register **72** and outputs the selected data as a cryptographic key to an adder **74**. The adder **74** adds an inputted non-cryptograph (data of m bits to be transmitted to the 1394 bus **11**) and the data of m bits (cryptographic key) supplied from the shrink generator **73** and outputs a result of the addition as a cryptograph (enciphered data) to the 1394 bus **11**.

The addition processing of the adder **74** is addition of the output of the shrink generator **73** and a non-cryptogr aph by mod 2^m (^ signifies a power exponent). In other words, data of m bits are added to each other, and a sum with a carry-over ignored is outputted.

FIG. **12** shows an example of a more detailed construction of the 1394 interface **26** shown in FIG. **11**. Of the session key S outputted from the firmware **20**, the initial value key Ss is transferred via an adder **81** to and stored into a register **82**. The initial value key Ss is composed of, for example, 55 words (one word has a width from 8 bits to 32 bits). Further, of the session key S supplied from the firmware **20**, the disturbance key Si composed of, for example, 32 bits of the LSB (Least Significant Bit) side is stored into another register **85**.

A key i' is stored into a further register **84**. Here, for example, each time one packet is transmitted through the 1394 bus **11**, a key 1' of 2 bits is supplied to the register **84**, and when a key 1' for 16 packets (32 bits) is stored into the register **84**, it is added to the disturbance key Si of 32 bits stored in the register **85** by an adder **86** and is supplied as a final time variable key i to the adder **81**. The adder **81** adds the value currently stored in the register **82** and the time variable key i supplied from the adder **86** and supplies a result of the addition to the register **82** so that it is stored into the register **82**.

Where the number of bits of a word of the register **82** is, for example, **8**, since the time variable key i outputted from the adder **86** is 32 bits, the time variable key i is divided into four parts of 8 bits, and each 8 bits are added to the word of a predetermined address (0 to 54) of the register **82**.

After the initial value key Ss is first stored into the register **82** in this manner, it is updated with the time variable key i each time a non-cryptograph for 16 packets is transmitted.

An adder **83** selects predetermined 2 words (in the case of a timing illustrated in FIG. **12**, the words at the address **23** and the address **54**) of the 55 words stored in the register **82**, and adds the two selected words and outputs a resulting word to the shrink generator **73**. Further, the output of the adder **83** is transferred, at the timing illustrated in FIG. **12**, to the address **0** of the register **82** so that it is stored in place of the preceding stored value at the address **0**.

Then, at the next timing, the addresses of the two words to be supplied to the adder **83** are shifted upwardly by one word in FIG. **12** from the address **54** and the address **23** to the address **53** and the address **22**, respectively, and also the address to be updated with the output of the adder **83** is shifted to a higher address in the figure. However, since an address higher than the address **0** is not present, in this instance, the address is shifted to the address **54**.

It is to be noted that the adders **81**, **83** and **86** may otherwise operate exclusive ORing.

The linear feedback shift register **72** is composed of, for example, as shown in FIG. **13**, a shift register **101** of n bits, and an adder **102** for adding values of predetermined bits (registers) of the n bits of the shift register **101**. The shift register **101** stores a bit supplied from the adder **102** into the register b_n leftmost in FIG. **13** and shifts data which has been stored there till then to the next register b_{n-1} on the right side. Also the registers b_{n-1}, b_{n-2}, . . . perform similar processing. Then, at a further next timing, a value obtained by addition of the values of the bits by the adder **102** is stored into the leftmost bit b_n in FIG. **13**. The operations described above are successively repeated while an output is successively outputted one by one bit from the rightmost register b_1 in FIG. **13**.

While FIG. **13** shows an example of an ordinary construction, more particularly the linear feedback shift register **72** may be constructed in such a manner as shown, for example, in FIG. **14**. In the linear feedback shift register **72** shown in FIG. **14**, the shift register **101** is composed of 31 bit, and the value of the register b_1 at the right end in FIG. **14** and the register b_{31} at the left end in FIG. **14** are added by the adder **102**, and a result of the addition is fed back to the register b_{31}.

When the data of 1 bit outputted from the linear feedback shift register **72** has the logical value 1, a condition discrimination section **91** transfers data of m bits supplied from the adder **83** of the additive generator **71** as it is to a FIFO (first-in first-out) memory **92** so as to be stored into the FIFO **92**. On the other hand, when the data of 1 bit supplied from the linear feedback shift register **72** has the logic value 0, the condition discrimination section **91** does not accept the data of m bits supplied from the CPU **31** but interrupts the enciphering processing. In this manner, only those of data of m bits produced by the additive generator **71** which are outputted at timings at which the linear feedback shift register **72** outputs the logical value 1 are selected and stored into the FIFO **92** of the shrink generator **73**.

The data of m bits stored in the FIFO **92** is supplied as a cryptographic key to the adder **74**, by which it is added to data of a non-cryptograph to be transmitted (reproduction data from a DVD) to produce a cryptograph.

The enciphered data is supplied from the DVD player **1** to the magneto-optical disk apparatus **3** and the personal computer **2** through the 1394 bus **11**.

The 1394 interface **36** of the magneto-optical disk apparatus **3** has such a construction as shown in FIG. **15** in order to decipher data received from the 1394 bus **11**. Referring to FIG. **15**, in the 1394 interface **36** shown, data of m bits outputted from an additive generator **171** and data of 1 bit outputted from a linear feedback shift register **172** are supplied to a shrink generator **173**. Then, a key of m bits

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outputted from the shrink generator **173** is supplied to a subtractor **174**. The subtractor **174** subtracts the key supplied from the shrink generator **173** from a cryptograph to decipher the cryptograph into a non-cryptograph.

In particular, the 1394 interface **36** shown in FIG. **15** has a basically similar construction to the 1394 interface **26** shown in FIG. **11**, but is different only in that the adder **74** shown in FIG. **11** is replaced by the subtractor **174**.

FIG. **16** shows an example of a more detailed construction of the 1394 interface **36** shown in FIG. **15**. Referring to FIG. **16**, while also the 1394 interface **36** has a basically similar construction to the 1394 interface **26** shown in FIG. **12**, the adder **74** shown in FIG. **12** is replaced by the subtractor **174**. The other components of the additive generator **171**, the linear feedback shift register **172**, the shrink generator **173**, an adder **181**, a register **182**, another adder **183**, registers **184** and **185**, a further adder **186**, a condition discrimination section **191** and a FIFO **192** correspond to the additive generator **71**, linear feedback shift register **72**, shrink generator **73**, adder **81**, register **82**, adder **83**, registers **84** and **85**, adder **86**, condition discrimination section **91** and FIFO **92** shown in FIG. **12**, respectively.

Accordingly, since operation of the 1394 interface **36** is basically same as that of the 1394 interface **26** shown in FIG. **12**, overlapping description of it is omitted here to avoid redundancy. However, in the 1394 interface **36** of FIG. **16**, a key of m bits outputted from the FIFO **192** of the shrink generator **173** is subtracted from a cryptograph by the subtractor **174** to decipher the cryptograph into a non-cryptograph.

As described above, in the 1394 interface **36**, enciphered data are deciphered at a time using the session key S (initial value key Ss and disturbance key-Si) and the time variable key i.

In contrast, as described above, in the personal computer **2**, decipherment is performed in two stages individually by the 1394 interface **49** and the application section **61**.

FIG. **17** shows an exemplary construction of the 1394 interface **49** where decipherment is performed by hardware. Referring to FIG. **17**, the 1394 interface **49** shown has a basic construction similar to that of the 1394 interface **36** shown in FIG. **15**. In particular, also the present 1394 interface **49** is composed of an additive generator **271**, a linear feedback shift register **272**, a shrink generator **273** and a subtractor **274**, and those components have basically similar constructions to those of the additive generator **171**, linear feedback shift register **172**, shrink generator **173** and subtractor **174** shown in FIG. **15**, respectively. However, while, in the 1394 interface shown in FIG. **17**, similar keys to those of the 1394 interface **36** shown in FIG. **15** are supplied as the key i' to be for production of the time variable key i and the disturbance key Si of the session key S for disturbing the time variable key i from the license manager **62** to the additive generator **271**, as the initial value key Ss, an identity element wherein all bits are 0 is supplied.

In particular, as shown in FIG. **18**, since all of the bits of the initial value key Ss are 0, substantially similarly to the alternative case wherein no initial value key Ss is present, a cryptographic key is produced based only on the time variable key i. As a result, the subtractor **274** performs only decipherment based on the time variable key i of a cryptograph. Further, since decipherment based on the initial value key Ss is not performed, data obtained as a result of the decipherment does not make a complete non-cryptograph, but remains in a condition of a cryptograph. Accordingly, even if the data is fetched from the internal bus **51** and recorded onto the hard disk **47** or some other recording medium, it cannot be utilized as it is.

Then, the construction of the application section **61** which deciphers data deciphered once based on the time variable key i by hardware in the 1394 interface **49** in such a manner as described above further by software is composed of, as shown in FIG. **19**, an additive generator **371**, a linear feedback shift register **372**, a shrink generator **373** and a subtractor **374**. The basic constructions of the components are similar to those of the additive generator **171**, linear feedback shift register **172**, shrink generator **173** and subtractor **174** shown in FIG. **15**, respectively.

However, while, as the initial value key Ss of the session key S, an ordinary initial value key is supplied in a similar manner as in the case of FIG. **15**, each of the disturbance key Si and the key i' to be used for production of the time variable key i is data of an identity element wherein all bits are 0.

As a result, as particularly shown in FIG. **20** (the elements **371** to **392** correspond to the elements **171** to **192** shown in FIG. **16**, respectively), since the key i' stored in the register **384** and the disturbance key Si stored in the register **385** are 0 at all bits thereof, also the time variable key i outputted from the adder **386** is 0 at all bits, and operation substantially similar to that of the alternative case wherein the time variable key i is not present is performed. In other words, a cryptographic key based only on the initial value key Ss is produced. Then, by the subtractor **374**, a cryptograph is deciphered into a non-cryptograph based on the cryptographic key produced in such a manner as described above. Since this cryptograph has been obtained by the decipherment in the first stage based on the time variable key i by the 1394 interface **49** as described above, a complete non-cryptograph can be obtained by performing decipherment in the second stage based on the initial value key Ss here.

In the magneto-optical disk apparatus **3**, when a cryptograph is deciphered in such a manner as described above, the CPU **31** supplies the deciphered data to the drive **35** so that it may be recorded onto a magneto-optical disk.

Meanwhile, in the personal computer **2**, the CPU **41** (application section **61**) supplies the data deciphered in such a manner as described above, for example, to the hard disk drive **47** so as to be recorded. In the personal computer **2**, while a predetermined board can be connected as the extended board **48** to monitor data communicated by the internal bus **51**, since the element which can finally decipher data transmitted to the internal bus **51** is the application section **61**, even if the extended board **48** can monitor the data for which the decipherment based on the time variable key i has been performed by the 1394 interface **49** (the data for which decipherment based on the session key S has not been performed as yet), data deciphered completely to a non-cryptograph cannot be monitored. Therefore, illegal copying can be prevented.

It is to be noted that common possession of a session key may be performed using, for example, the Diffie-Hellman method or the like.

It is to be note that, in some other case such as, for example, where the 1394 interface **49** or the application section **61** of the personal computer **2** has such a comparatively low processing capacity that it cannot perform deciphering processing, if one or both of the session key and the time variable key are formed from an identity element on the source side while they are used with the identity element also on the sink side, then communication of data is possible substantially without using the session key and the time

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variable key. However, where this method is employed, the possibility that data may be illegally copied increases.

If the application section **61** itself originates from illegal copying, then there is the possibility that deciphered data may be copied illegally. However, this can be prevented if the application section **61** is authenticated by the license manager **62** in such a manner as described above.

As the authentication method in this instance, in addition to a common key cryptography, a digital autograph for which a public key cryptography is used can be utilized.

The 1394 interfaces shown in FIGS. **11**, **12** and **15** to **20** described above satisfy a relationship of a homomorphism (homomorphism). In particular, when keys K_1 and K_2 are elements of a Galois field G, a result $K_1 \cdot K_2$ of a group operation of them makes an element of the Galois field G. Further, the following expression is satisfied with regard to a predetermined function H:

$$H(K_1 \cdot K_2) = H(K_1) \cdot H(K_2)$$

FIG. **21** shows a further exemplary construction of the 1394 interface **26**. In the 1394 interface **26**, a session key S is supplied to linear feedback shift registers **501** to **503** so that initialization is performed with it. The widths n_1 to n_3 of the linear feedback shift registers **501** to **503** are individually approximately 20 bits, and the individual widths n_1 to n_3 are constructed so as to be relatively prime. Accordingly, for example, of the session key S, for example, the upper n_1 bits are initially set to the linear feedback shift register **501**, and the next upper n_2 bits are initially set to the linear feedback shift register **502** while the further next upper n_3 bits are initially set to the linear feedback shift register **503**.

Each of the linear feedback shift registers **501** to **503** performs a shifting operation by m bits when an enable signal of, for example, the logical value 1 is inputted from a clocking function **506**, and outputs data of m bits. The value of m may be, for example, 8, 16, 32, 40 or the like.

Outputs of the linear feedback shift register **501** and the linear feedback shift register **502** are inputted to an adder **504**, by which they are added. Of the addition value of the adder **504**, a carry component is supplied to the clocking function **506** while a sum component is supplied to an adder **505**, by which it is added to an output of the linear feedback shift register **503**. A carry component of the adder **505** is supplied to the clocking function **506** while a sum component is supplied to an exclusive OR circuit **508**.

The clocking function **506** outputs, since the combination of the data supplied from the adder **504** and the adder **505** is one of 00, 01, 10 and 11, data of one of 000 to 111 in accordance with the combination of the data to the linear feedback shift registers **501** to **503**. Each of the linear feedback shift registers **501** to **503** performs a shifting operation of m bits and outputs new data of m bits when the logical value 1 is inputted, but when the logical value 0 is inputted, it outputs data of m bits same as that outputted in the preceding cycle.

The exclusive OR circuit **508** operates exclusive ORing of the sum component outputted from the adder **505** and a time variable key i stored in a register **507** and outputs a result of the calculation to an exclusive OR circuit **509**. The exclusive OR circuit **509** operates exclusive ORing of a non-cryptograph inputted and the cryptographic key inputted from the exclusive OR circuit **508** and outputs a result of the calculation as a cryptograph.

FIG. **22** shows another exemplary construction of the 1394 interface **36** of the magneto-optical disk apparatus **3**. Referring to FIG. **22**, the 1394 interface **36** shown includes elements **601** to **609** which are similar to the elements **501** to **509** described hereinabove with reference to FIG. **21**, respectively. Therefor, overlapping description of the similar components is omitted here to avoid redundancy. The 1394 interface **36** of FIG. **22**, however, is different from the 1394 interface **26** of FIG. **21** in that, while, in the 1394 interface **26**, enciphering processing is performed, deciphering processing is performed in the 1394 interface **36**.

FIG. **23** shows another exemplary construction of the 1394 interface **49** of the magneto-optical disk apparatus **3**. Referring to FIG. **23**, the 1394 interface **36** shown includes elements **701** to **709** which are similar to the elements **601** to **609** described hereinabove with reference to FIG. **22**, respectively. However, the session key S initially set to the linear feedback shift registers **701** to **703** is an identify element wherein all bits are 0. Accordingly, in the present instance, deciphering processing is performed substantially only with the time variable key i stored in the register **707**.

FIG. **24** shows an exemplary construction of the application section **61** of the personal computer **2**. Referring to FIG. **24**, the application section **61** shown includes elements **801** to **809** which have basically similar constructions to those of the elements **601** to **609** described hereinabove with reference to FIG. **22**, respectively. The application section **61** is different from the 1394 interface **36** of FIG. **22** only in that the time variable key i to be inputted to the register **807** is an identity element wherein all bits are 0. Accordingly, in the application section **61**, a cryptographic key is produced and deciphering processing is performed based only on the session key S.

It is to be noted that, since the processing illustrated in FIGS. **19**, **20** and **24** is performed by the application section **61**, it is processed by software.

While, in the foregoing description, the DVD player **1** serves as a source and the personal computer **2** and the magneto-optical disk apparatus **3** serve as sinks, any apparatus can serve as a source or a sink.

Further, also the external bus for interconnecting the different apparatus is not limited to the 1394 bus, but various buses can be utilized, and also the electronic apparatus to be connected to the external bus are not limited to those described above, but an arbitrary apparatus can be connected.

Having now fully described the invention, it will be apparent to one of ordinary skill in the art that many changes and modifications can be made thereto without departing from the spirit and scope of the invention as set forth herein.

What is claimed is:

1. An enciphering apparatus for enciphering data using a cryptographic key, comprising:

first providing means for providing first information;

second providing means for providing second information which is changed during a session;

producing means for producing a cryptographic key based on the first information and the second information; and

enciphering means for enciphering data using said cryptographic key, wherein said cryptographic key is changed at a predetermined timing during the session in accordance with a change in said second information.

2. An enciphering apparatus according to claim **1**, further comprising transmission means for transmitting data enciphered with the cryptographic key to another apparatus via a bus.

3. An enciphering method for enciphering data using a cryptographic key, comprising the steps of:

providing first information;

providing second information which is changed during a session;

producing a cryptographic key based upon the first information and the second information; and

enciphering data using said cryptographic key, wherein said cryptographic key is changed at a predetermined timing during the session in accordance with a change in said second information.

4. A deciphering apparatus for deciphering data using a cryptographic key, comprising:

receiving means for receiving enciphered data;

first providing means for providing first information;

second providing means for providing second information which is changed during a session;

producing means for producing a cryptographic key based upon the first information and the second information; and

deciphering means for deciphering said received enciphered data using said cryptographic key, wherein said cryptographic key is changed at a predetermined timing during the session in accordance with a change in said second information.

5. A deciphering method for deciphering data using a cryptographic key, comprising the steps of:

receiving enciphered data;

providing first information;

providing second information which is changed during a session;

producing a cryptographic key based upon the first information and the second information; and

deciphering said received enciphered data using said cryptographic key, wherein said cryptographic key is changed at a predetermined timing during the session in accordance with a change in said second information.

6. An enciphering apparatus for enciphering data using a cryptographic key, comprising:

an encipherer;

a first information provider;

a second information provider; and

a cryptographic key producer coupled with said encipherer, whereby said encipherer enciphers data using a cryptographic key produced by said cryptographic key producer based upon first information provided by said first information provider and second information provided by said second information provider and changed at a predetermined timing during a session.

7. The enciphering apparatus according to claim 6, further comprising a transmitter coupled with said encipherer; said transmitter transmitting data enciphered with a cryptographic key to another apparatus via a bus.

8. A deciphering apparatus for deciphering data using a cryptographic key, comprising:

a receiver;

a decipherer coupled with said receiver;

a first information provider;

a second information provider; and

a cryptographic key producer coupled with said decipherer, whereby said decipherer deciphers data received by said receiver using a cryptographic key produced by said cryptographic key producer based upon first information provided by said first information provider and second information provided by said second information provider and changed at a predetermined timing during a session.

9. An enciphering method according to claim 3, further comprising the step of transmitting data enciphered with the cryptographic key to another apparatus via a bus.

10. An enciphering apparatus for enciphering data using a cryptographic key, comprising:

first providing means for providing first information which is held in common with another device in an authentication process by communication between the two devices;

second providing means for providing second information which is changed at a predetermined timing;

producing means for producing the cryptographic key based on the first information held in common with the other device and the second information which is used for changing the cryptographic key; and

enciphering means for enciphering data using said cryptographic key, wherein said cryptographic key is changed at a predetermined timing in accordance with a change in said second information.

11. An enciphering apparatus according to claim 10, further comprising transmission means for transmitting the data enciphered with the cryptographic key to another apparatus via a bus.

12. An enciphering method for enciphering data using a cryptographic key, comprising the steps of:

providing first information which is held in common with another device in an authentication process by communication between the two devices;

providing second information which is changed at a predetermined timing;

producing a cryptographic key based upon the first information held in common with the other device and the second information which is used for changing the cryptographic key; and

enciphering data using said cryptographic key, wherein said cryptographic key is changed at a predetermined timing in accordance with a change in said second information.

13. A deciphering apparatus for deciphering data using a cryptographic key, comprising:

receiving means for receiving enciphered data;

first providing means for providing first information which is held in common with another device in an authentication process by communication between the two devices;

second providing means for providing second information which is changed at a predetermined timing;

producing means for producing a cryptographic key based upon the first information held in common with the other device and the second information which is used for changing the cryptographic key; and

deciphering means for deciphering said received enciphered-data using said cryptographic key, wherein said cryptographic key is changed at a predetermined timing in accordance with a change in said second information.

14. A deciphering method for deciphering data using a cryptographic key, comprising the steps of:

receiving enciphered data;

providing first information which is held in common with another device in an authentication process by communication between the two devices;

providing second information which is changed at a predetermined timing;

producing a cryptographic key based upon the first information held in common with the other device and the second information which is used for changing the cryptographic key; and

deciphering said received enciphered data using said cryptographic key, wherein said cryptographic key is changed at a predetermined timing in accordance with a change in said second information.

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15. An enciphering apparatus for enciphering data using a cryptographic key, comprising:

an encipherer;

a first information provider;

a second information provider; and

a cryptographic key producer coupled with said encipherer, whereby said encipherer enciphers data using a cryptographic key produced by said cryptographic key producer based upon first information provided by said first information provider and held in common with another device in an authentication process by communication between the two devices, and second information provided by said second information provider and changed at a predetermined timing.

16. The enciphering apparatus according to claim 15, further comprising a transmitter coupled with said encipherer; said transmitter transmitting data enciphered with a cryptographic key to another apparatus via a bus.

17. A deciphering apparatus for deciphering data using a cryptographic key, comprising:

a receiver;

a decipherer coupled with said receiver;

a first information provider;

a second information provider; and

a cryptographic key producer coupled with said decipherer, whereby said decipherer deciphers data received by said receiver using a cryptographic key produced by said cryptographic key producer based upon first information provided by said first information provider and held in common with another device in an authentication process by communication between the two devices and second information provided by said second information provider and changed at a predetermined timing.

18. An enciphering method according to claim 12, further comprising the step of transmitting data enciphered with the cryptographic key to another apparatus via a bus.

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US006510208B1

(12) **United States Patent**
Komiya

(10) **Patent No.: US 6,510,208 B1**
(45) **Date of Patent: Jan. 21, 2003**

(54) **TELEPHONE APPARATUS WITH AUDIO RECORDING FUNCTION AND AUDIO RECORDING METHOD TELEPHONE APPARATUS WITH AUDIO RECORDING FUNCTION**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/009,237**

(22) Filed: **Jan. 20, 1997**

(30) **Foreign Application Priority Data**

Jan. 20, 1997 (JP) 9-007674

(51) **Int. Cl.**[7] **H04M 1/65**
(52) **U.S. Cl.** **379/88.1**; 455/412
(58) **Field of Search** 379/88.1, 88.28, 379/93.08, 88.16, 88.22, 88.08; 455/412, 413; 704/220, 221, 222, 223, 229, 230

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(57) **ABSTRACT**

A memory for voice memo is provided. A digital audio signal is stored into the memory in a form in which the signal was compression encoded by a variable length code. Thus, a data amount which is required for the voice memo is reduced and the improvement of the recording time and the reduction of the memory capacity can be realized without deteriorating the sound quality. The audio signal is compressed by a system similar to a compression system of a CDMA system and stored into the memory. Thus, there is no need to add any special circuit and a circuit scale and costs are not increased.

4 Claims, 2 Drawing Sheets

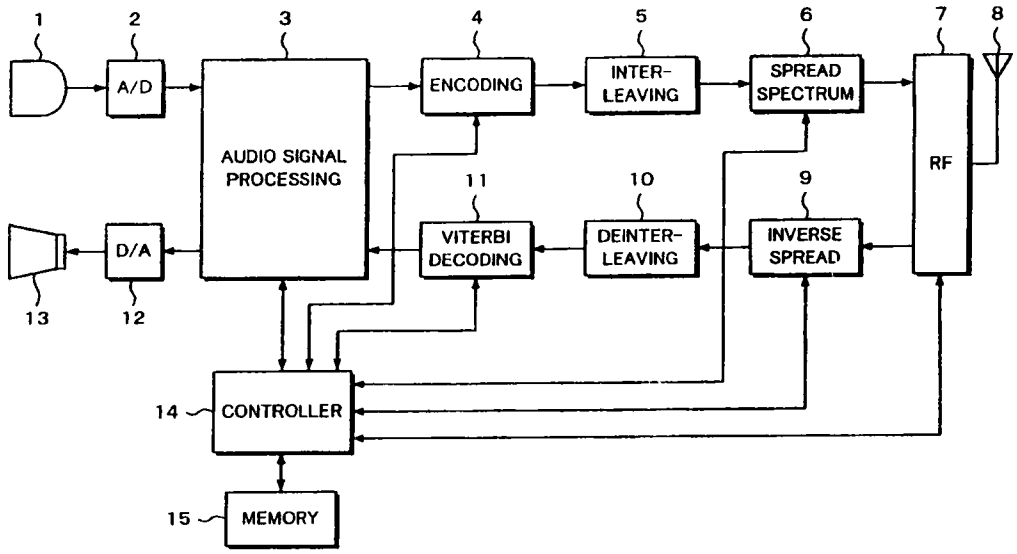

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Fig. 1

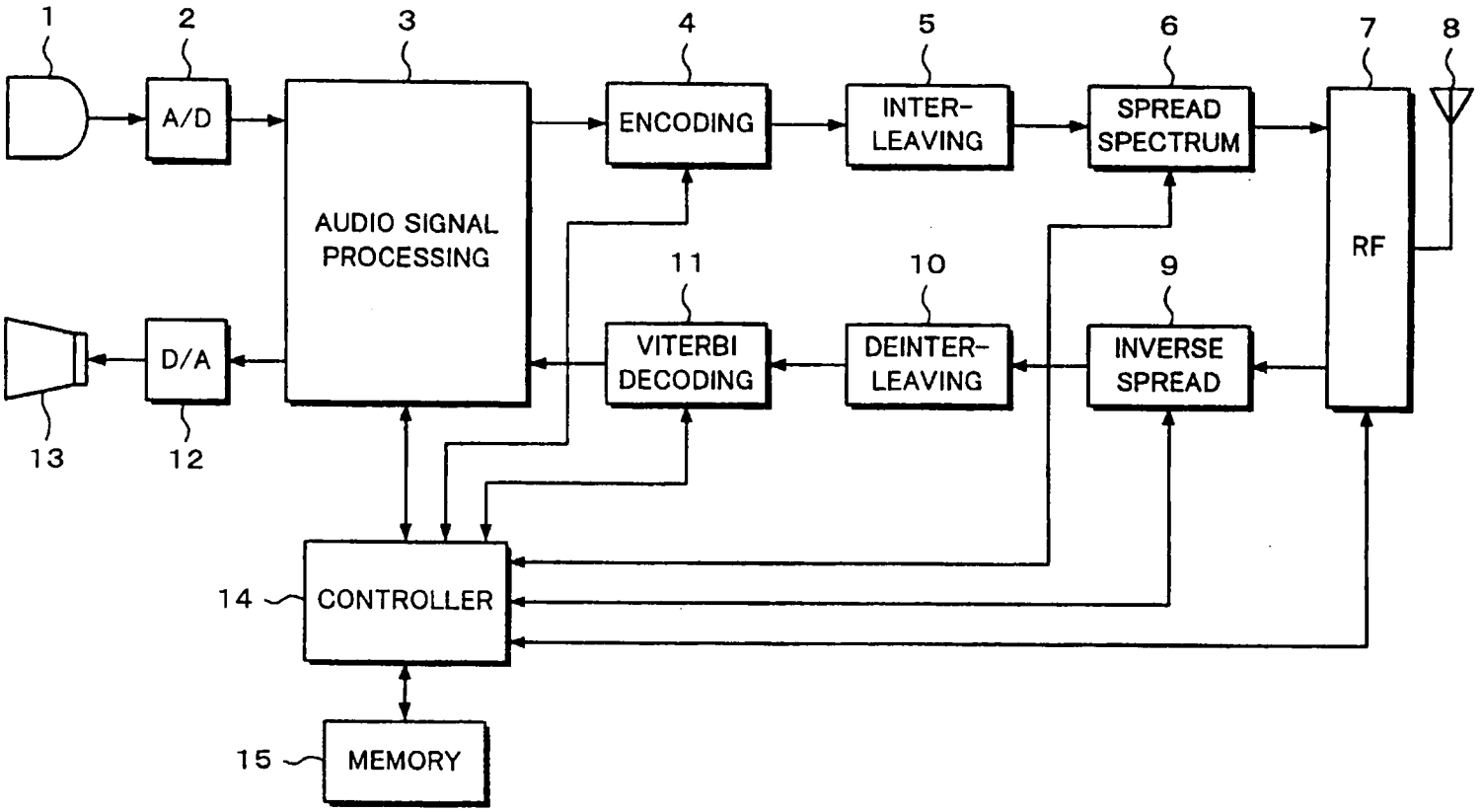

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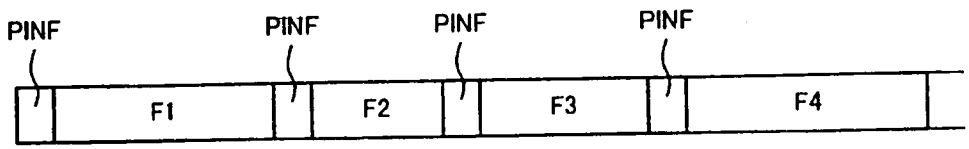
Fig. 2

PACKET TYPE	BITS/PACKET
Rate 1	171
Rate 1/2	80
Rate 1/4	40
Rate 1/8	16
Blank	0
Rate 1 with bit errors	171
Insufficient frame quality(erasure)	0

Fig. 3



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TELEPHONE APPARATUS WITH AUDIO RECORDING FUNCTION AND AUDIO RECORDING METHOD TELEPHONE APPARATUS WITH AUDIO RECORDING FUNCTION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a telephone apparatus with an audio recording function and its audio recording method which can preserve a response to a partner side and a message from the partner side. More particularly, the invention relates to a telephone apparatus with an audio recording function and its audio recording method which are suitable for use in a cellular phone of a cellular telephone system of the CDMA (Code Division Multiple Access) system.

2. Description of the Related Art

In recent years, many telephones having a voice memorandum function (simply referred to as a voice memo function hereinbelow) for enabling a response of an answer-phone to be informed from this side to the partner side when the user is absent or enabling a message from the partner side to be left have been brought to market. In the telephone having the voice memo function, a response of the answer-phone from the partner side can be previously recorded in case of absence. When there is a reception call from the partner side, a voice of the response of the answer-phone is reproduced and is sent to the partner side. Thus, the absence can be notified to the partner side and it is promoted to decide whether the message should be left or not as necessary. When there is a message from the partner side, the message from the partner side is accumulated in the telephone having the voice memo function. When the message from the partner side remains, the user of the telephone reproduces the message when he comes home. Thus, the user of the telephone can confirm the contents of the remaining message from the partner side in case of absence.

As such a telephone with the voice memo function, hitherto, for example, there has been known a telephone such that a drive unit of a small tape cassette is provided, a small magnetic tape cassette is set into the tape cassette drive unit of the telephone main body, and a response of an answer-phone or a voice of a message of the partner side is recorded in the small magnetic tape cassette. Hitherto, there has also been known a telephone such that a semiconductor memory is provided, a response of an answer-phone or a voice of a message of the partner side is converted into a digital signal, and the response of the answer-phone or the voice of the message of the partner side is recorded as a digital signal into the semiconductor memory.

A construction such that the voice memo function is installed in a cellular phone of a cellular telephone system is considered. As mentioned above, as telephones having the voice memo function, the telephone in which a voice is recorded in the small tape cassette and the telephone in which a voice is recorded as a digital signal into the semiconductor memory have been known. However, in the cellular phone of the cellular telephone system, it is difficult to use a magnetic tape cassette in order to realize a small size and a light weight. Therefore, in a case such that the voice memo function is installed in the cellular phone of the cellular telephone system, a construction such that the response of the answer-phone or the message of the partner side is recorded in the semiconductor memory is considered.

However, in the voice memo function using the semiconductor memory, a semiconductor memory of a large capacity is necessary in order to record for a long time. When the memory of the large capacity is installed, it becomes an obstacle for realization of a small size and a light weight and the costs rise.

OBJECTS AND SUMMARY OF THE INVENTION

It is, therefore, an object of the invention to provide a telephone apparatus with an audio recording function which can record and reproduce a voice for a long time without using a memory of a large capacity and an audio recording method of such a telephone apparatus with the audio recording function.

To accomplish the above object, according to one aspect of the invention, there is provided an audio recording method of recording a voice into a storage device, comprising: an audio processing step of compressing a non-compressed audio signal when such a signal is inputted and keeping a compressed audio signal as it is when such a compressed signal is inputted; and a storing step of storing an output derived in the audio processing step into the storage device.

According to another aspect of the invention, there is provided an audio reproducing method of reproducing a voice from a storage device, comprising: a reading step of reading a compressed signal which was stored and recorded in the storage device; and an audio processing step of receiving an output derived in the reading step, decompressing the output derived in the reading step when an output of a non-compressed audio signal is required, and keeping the output derived in the reading step as it is when an output of the compressed audio signal is required.

According to still another aspect of the invention, there is provided a transmitting method having a step of recording and reproducing a voice to/from a storage device, comprising: a compressing step of receiving a non-compressed audio signal and compressing it; a storing step of storing an output derived in the compressing step into the storage device; a reading step of reading out a compressed signal which was stored and recorded in the storage device; a modulating step of receiving an output derived in the reading step and modulating it; a high frequency signal processing step of converting an output derived in the modulating step into a high frequency signal; and a transmitting step of transmitting an output derived in the high frequency signal processing step.

According to further another aspect of the invention, there is provided a receiving method having a step of recording and reproducing a voice to/from a storage device, comprising: a receiving step of receiving a high frequency signal; a demodulating step of demodulating an output derived in the receiving step; a storing step of storing a previously compressed audio signal which is obtained from an output derived in the demodulating step into the storage device as it is; a reading step of reading out the compressed signal which was stored and recorded in the storage device; and a decompressing step of decompressing an output derived in the reading step.

According to the invention, an audio recording apparatus, an audio reproducing apparatus, a transmitting apparatus, and a receiving apparatus to accomplish the above methods are also provided, respectively.

The above and other objects and features of the present invention will become apparent from the following detailed description and the appended claims with reference to the accompanying drawings.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing an example of a cellular phone of the CDMA system to which the present invention is applied;

FIG. 2 is a schematic diagram for use in explanation of QCELP; and

FIG. 3 is a schematic diagram for use in explanation of an example of a cellular phone of the CDMA system to which the invention is applied.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment of the present invention will now be described hereinbelow with reference to the drawings. The invention is suitable when it is used in, for example, a cellular phone of a cellular telephone system of the CDMA system.

The CDMA system is a system in which a carrier wave of a transmission signal is spectrum spread by using a pseudo random noise code (PN code) as a spread code and is transmitted and a pattern and a phase of a code sequence of a spread code are made different, thereby enabling a multiple access.

According to the CDMA system, a spread spectrum system is used as a communication system. In the spread spectrum system, the PN (Pseudo random Noise) code is multiplied to the carrier wave upon transmission and the carrier wave is modulated by the PN code. Since the PN code is a random code, by modulating the carrier wave by the PN code as mentioned above, its frequency spectrum is widened. Upon reception, the same PN code as that on the transmitting side is multiplied. Upon reception, when the same PN code as that upon transmission is used and their phases coincide, an inverse spread is performed.

According to the spread spectrum system, in order to inversely spread the signal upon reception, the same PN code as that on the transmitting side is necessary with respect to not only the pattern but also the phase. By changing the pattern or phase of the PN code, therefore, the multiple access can be performed. A system in which the multiple access is enabled by making the pattern or phase of the code sequence of the spread code different as mentioned above is called a CDMA system.

FIG. 1 shows an example of a cellular phone of a cellular telephone system of the CDMA system to which the invention can be applied. In FIG. 1, an audio signal is inputted to a microphone 1 upon transmission. The audio signal is supplied to an A/D converter 2 and an analog audio signal is converted into a digital audio signal by the A/D converter 2. An output signal of the A/D converter 2 is supplied to an audio signal processing circuit 3.

The inputted digital audio signal is compressed by the audio signal processing circuit 3. The audio signal processing circuit 3 is controlled by a controller 14. As a compression encoding system, various systems have been proposed. For example, a system such as QCELP (Qualcomm Code Excited Linear Prediction) such that a plurality of coding speeds can be selected in accordance with a nature of a voice of a speaker or a busy situation of a communication path can be used. According to the QCELP, four kinds of coding speeds can be selected in accordance with the nature of the voice of the speaker or the busy situation of the communication path.

An output signal of the audio signal processing circuit 3 is supplied to an error correction encoding circuit 4. An error correction code of a convolution code is added to transmission data. An output of the error correction encoding circuit 4 is supplied to an interleaving circuit 5. The transmission data is interleaved by the interleaving circuit 5. An output signal of the interleaving circuit 5 is supplied to a spread spectrum circuit 6.

A carrier signal is modulated by the spread spectrum circuit 6 and the spectrum of the signal is spread by the PN code. Since the PN code is a random code, by multiplying the PN code as mentioned above, a frequency width of the carrier signal is widened and a spread spectrum is performed. For example, a BQPSK modulation is used as a modulation system of the transmission data.

An output signal of the spread spectrum circuit 6 is supplied to an RF circuit 7. The RF circuit 7 is controlled by the controller 14. A frequency of a transmission signal is converted to a predetermined frequency. An output signal of the RF circuit 7 is power amplified and, thereafter, is supplied to an antenna 8. A radio wave from the antenna 8 is transmitted toward a base station.

Upon reception, a radio wave from the base station is received by the antenna 8. A reception signal from the antenna 8 is supplied to the RF circuit 7. The reception signal is converted into an intermediate frequency signal of a predetermined frequency by the RF circuit 7.

An output signal of the RF circuit 7 is supplied to an inverse spread spectrum circuit 9. The signal which was spectrum spread and transmitted is inversely spread by the inverse spread spectrum circuit 9 and the data is demodulated. An output signal of the inverse spread spectrum circuit 9 is supplied to a deinterleaving circuit 10.

The reception data is deinterleaved by the deinterleaving circuit 10 in correspondence to the interleaving process on the transmitting side. An output of the deinterleaving circuit 10 is supplied to a Viterbi decoding circuit 11. The Viterbi decoding circuit 11 decodes the convolution code by a soft decision and a maximum likelihood decoding. An error correcting process is executed by the Viterbi decoding circuit 11. An output signal of the Viterbi decoding circuit 11 is supplied to the audio signal processing circuit 3.

The audio signal which was compressed by, for example, the QCELP and was transmitted is decompressed by the audio signal processing circuit 3 and the digital audio signal is decoded. The digital audio signal is supplied to a D/A converter 12. The digital audio signal is converted to the analog audio signal by the D/A converter 12. The analog audio signal is supplied to a speaker 13.

A semiconductor memory 15 is provided for the cellular phone of the cellular telephone system to which the invention is applied. The memory 15 is used for a voice memo. The digital audio signal from the audio signal processing circuit 3 is stored in the memory 15 in a compression encoded form by the control of the controller 14.

A response of an answer-phone from the partner side can previously be recorded in the memory 15 in case of absence. When there is a reception call from the partner side, a voice of the response of the answer-phone is read out from the memory 15 and the voice of the response of the answer-phone is sent to the partner side. Thus, a situation that the user is absent at present is informed to the partner side and a judgment about whether a message should be left or not is promoted to the partner side a s necessary. When there is a message from the partner side, the message from the partner side is stored in the memory 15. When the message from the partner side remains, the message in the memory 15 is reproduced after the user returns home. Thus, the user of the

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telephone can confirm the contents of the message left from the partner side in case of absence.

If the user wants to leave a response on this side to the partner side in case of absence, an audio signal of the response on this side to the partner side is inputted from the microphone **1**, is converted into a digital signal by the A/D converter **2**, is compressed by the audio signal processing circuit **3**, and is stored in the memory **15**. As mentioned above, the response on this side to the partner side is converted into the digital signal, is compressed, and is stored into the memory **15**. When there is a reception call, the data in the memory **15** is read out and is sent to the RF circuit **7** through the encoding circuit **4**, interleaving circuit **5**, and spread spectrum circuit **6**, is transmitted from the antenna **8**, and is sent to the partner side. Thus, the response on this side is transmitted to the partner side.

In case of leaving the message from the partner side in case of absence, the signal from the partner side is received by the antenna **8** and is supplied to the audio signal processing circuit **3** through the RF circuit **7**, inverse spread spectrum circuit **9**, deinterleaving circuit **10**, and Viterbi decoding circuit **11**. The audio signal from the audio signal processing circuit **3** is stored as it is in the memory **15** in a compression encoded form.

In case of reproducing the message stored in the memory **15**, the output data of the memory **15** is supplied to the audio signal processing circuit **3**. The audio signal which was compressed by the QCELP and stored is decompressed by the audio signal processing circuit **3** and the digital audio signal is decoded. The digital audio signal is supplied to the D/A converter **12**. The digital audio signal is converted to the analog audio signal by the D/A converter **12**. The analog audio signal is supplied to the speaker **13**.

In the QCELP, the audio signal is divided into audio signals on a 20-msec unit basis and is compressed to packets of four kinds of coding rates (for example, four kinds of rates of 9.6 kbps, 4.8 kbps, 2.4 kbps, and 1.2 kbps) in a range from the coding rate **1** to the coding rate ⅛ as shown in FIG. **2** in accordance with an audio energy. As mentioned above, in the QCELP, a frame of a small audio energy can be compressed-into a short packet. Therefore, if the audio signal compressed by the QQELP is stored into the memory **15**, a memory capacity occupied can be reduced and a time for the voice memo can be extended as compared with the case where the audio signal is converted into the digital signal and is stored as it is into the memory **15**.

Since the QCELP is based on the variable rate, in case of storing the audio signal compressed by the QCELP into the memory **15**, packet identification information to identify the kind of packet is necessary. In the QCELP, there are four kinds of coding rates and, further, as packet types, there are three kinds (Blank, Rate **1** with bit errors, Insufficient frame quality) which are used in the case where a receiving state in the demodulator is bad and a frame error occurs. Thus, there are total seven kinds of rates. Consequently, at least three bits are needed as packet ID information.

As shown in FIG. **3**, the audio data is divided into frames F1, F2, F3, . . . of the packet data of a variable length and packet ID information PINF indicative of the kind of packet of each frame is arranged at the head of each of the frames F1, F2, F3, ... A size of each of the frames F1, F2, F3, . . . is set to a variable length. As packet ID information PINF, information corresponding to at least three bits is prepared. In case of reproducing the voice stored in the memory **15**, the output data of the memory **15** is supplied to the audio signal processing circuit **3**. The audio signal which was compressed by the QCELP and stored is decompressed by the audio signal processing circuit **3**. In this instance, the audio signal is decompressed by using the packet ID information PINF added to each of the frames F1, F2, F3, ...

As mentioned above, in the cellular phone to which the invention is applied, the digital audio signal from the audio signal processing circuit **3** is stored in the memory **15** for voice memo in the compression encoded form. In case of reproducing the audio signal which was compressed and stored in the memory **15**, the compressed and stored audio signal is decompressed by the audio signal processing circuit **3**. As mentioned above, since the audio signal is compressed by the variable length encoding and stored into the memory **15** for voice memo, the memory capacity can be reduced without deteriorating a sound quality and a recording time. Since the audio signal is compressed by a system similar to the compression system of the CDMA system and is stored into the memory **15** for voice memo, there is no need to add any special circuit and a circuit scale and costs are not increased.

In the above embodiment, although the audio signal has been compressed and decompressed by using the QCELP, the compressing system is not limited to the QCELP but the invention can be also similarly applied to other compressing systems.

According to the invention, the digital audio signal is stored into the memory for voice memo in the compression encoded form. Therefore, the data amount which is required for the voice memo is reduced and the improvement of the recording time and the reduction of the memory capacity can be realized without deteriorating the sound quality. Since the audio signal is compressed by the system similar to the compressing system of the CDMA system and is stored into the memory for voice memo, there is no need to add any special circuit and the circuit scale and costs are not increased.

The present invention is not limited to the foregoing embodiments but many modifications and variations are possible within the spirit and scope of the appended claims of the invention.

What is claimed is:

1. An audio recording method in a portable cellular telephone for recording an audio signal into a storage device, comprising the steps of:

receiving said audio signal transmitted in a Code Division Multiple Access (CDMA) system, wherein said audio signal is compressed using a Qualcomm Code Excited Linear Prediction (QCLEP) system into a plurality of variable size packets using a plurality of coding speeds in response to an audio energy of said audio signal;

demodulating said audio signal to generate a demodulated audio signal; and

storing said demodulated audio signal into said storage device in said QCELP compressed form.

2. An audio reproducing method in a portable cellular telephone for reproducing an audio signal from a storage device, comprising the steps of:

reading said audio signal out of said storage device, wherein said audio signal was transmitted to said portable cellular telephone in a Code Division Multiple Access (CDMA) system and compressed using a Qualcomm code Excited Linear Prediction (QCELP) system into a plurality of variable size packets using a plurality of coding speeds in response to an audio energy of said audio signal and stored in said QCELP compressed form;

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supplying said audio signal read from said storage device to a QCELP decoder for decompressing processing; and

decompressing and reproducing said audio signal.

3. An audio recording apparatus in a portable cellular telephone for recording an audio signal into a storage device, comprising:

a receiver for receiving said audio signal transmitted in a Code Division Multiple Access (CDMA) system, wherein said audio signal is compressed using a Qualcomm Code Excited Linear Prediction (QCLEP) system into a plurality of variable size packets using a plurality of coding speeds in response to an audio energy of said audio signal;

a demodulator for demodulating said audio signal to generate a demodulated audio signal; and

a controller for storing said demodulated audio signal into said storage device in said QCELP compressed form.

4. An audio reproducing apparatus in a portable cellular telephone for reproducing an audio signal from a storage device, comprising:

a controller for reading said audio signal out of said storage device, wherein said audio signal was transmitted to said portable cellular telephone in a Code Division Multiple Access (CDMA) system and was compressed using a Qualcomm code Excited Linear Prediction (QCELP) system into a plurality of variable size packets using a plurality of coding speeds in response to an audio energy of said audio signal and stored in said QCELP compressed form, wherein said controller

supplies said audio signal read from said storage device to a QCELP decoder for decompressing processing, and

decompresses and reproduces said audio signal.

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(12) **United States Patent**
Mugura et al.

(10) **Patent No.: US 6,374,121 B1**
(45) **Date of Patent: Apr. 16, 2002**

(54) **SYSTEM AND METHOD FOR ENABLING AUTOMATIC PERFORMANCE OF INSTRUMENT FUNCTIONS**

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(73) Assignees: **Sony Corporation** (JP); **Sony Electronics, Inc.**

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/590,597**

(22) Filed: **Jun. 9, 2000**

Related U.S. Application Data

(63) Continuation of application No. 09/006,550, filed on Jan. 13, 1998.

(51) **Int. Cl.**[7] **H04B 1/38**
(52) **U.S. Cl.** **455/550**; 455/426; 455/564; 455/566; 340/7.24; 340/7.51
(58) **Field of Search** 455/31.1, 31.2, 455/31.3, 403, 426, 550, 556, 564, 566, 575; 379/355, 356; 340/825.44, 7.1, 7.24, 7.25, 7.51, 7.55

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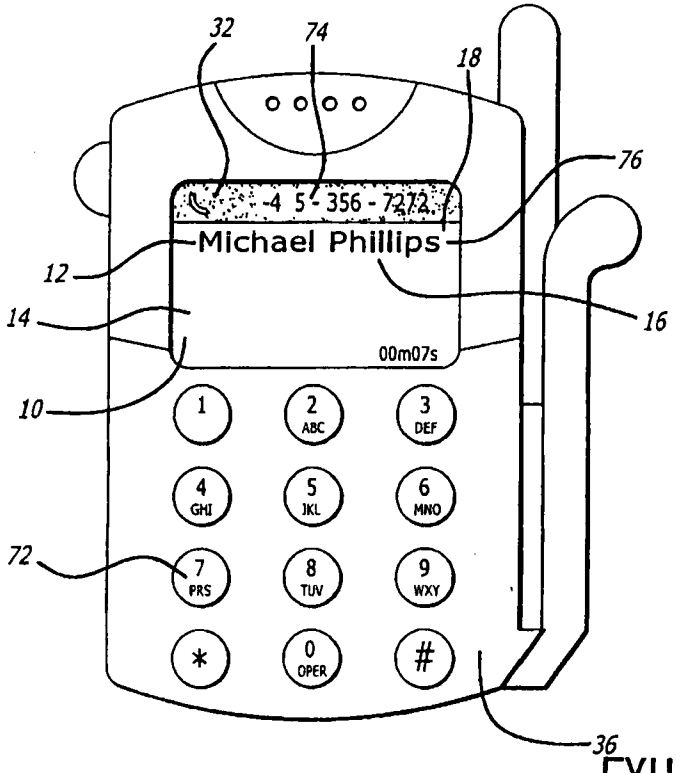
(57) **ABSTRACT**

An instrument includes a display screen which includes a bitmap graphical user interface including an on-screen menu, and a control element which enables movement of the on-screen menu corresponding to movement of the control element, enables the user to manipulate and select graphic images for executing selected instrument functions. The instrument is adapted to enable automatic performance of instrument functions.

10 Claims, 1 Drawing Sheet



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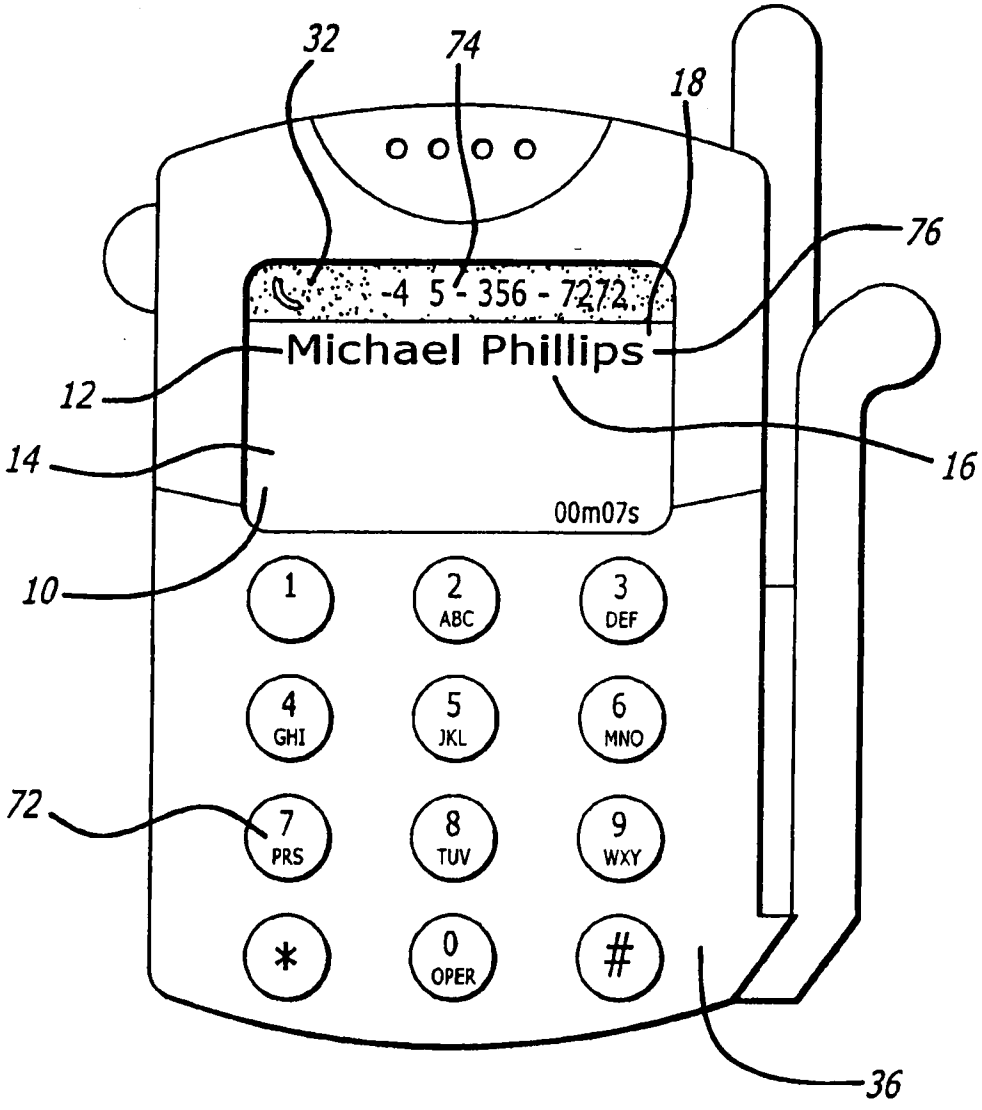

FIG. 1

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SYSTEM AND METHOD FOR ENABLING AUTOMATIC PERFORMANCE OF INSTRUMENT FUNCTIONS

This application is a con of Ser. No. 09/006,550 filed Jan. 13, 1998.

BACKGROUND OF THE INVENTION

The present invention relates generally to an interface for a display screen and, more particularly, to a graphical user interface which, with a control device, enables manipulation of graphic images on a display screen.

In an instrument which includes a display screen, an on-screen menu, and a control device, a user may interact with the on-screen menu by viewing the on-screen menu, deciding to select a menu item, and manipulating the control device to generate menu movement and to enable entry of the menu selection.

The instrument may comprise a hand-held wireless telephone which includes an on-screen menu displayed in a text text-based interface on a small liquid-crystal display screen, and a jog dial control device for scrolling through the menu and for entry of a menu selection and execution of an instrument function thereby.

In an instrument which includes a display screen and control element, and which is adapted to enable selection of and connection to a telephone number, a user may wish to view the name of the party called or transmit a code for enabling connection to a service.

Therefore, there has been a need existing for a system which enables the user of an instrument to view the name of a party called or transmit a code required to connect with a service. The present invention fulfills these needs.

SUMMARY OF THE INVENTION

Briefly, and in general terms, the present invention provides an on-screen menu in an interactive graphical user interface, which provides for enabling display of the name of a party called or transmission of a code for connection to a service.

The system enables automatic performance of functions of an instrument. It includes means for enabling entry in the instrument of information relating to a party, and information associated with the related information. It further includes means for performing automatically an instrument function in connection with the related information and the associated information.

One aspect of the present invention is that a system enables the user to view and manipulate graphic images in an on-screen menu in an intuitive graphical user interface in a display screen.

Another aspect of the present invention is that a system enables the user to enter information related to a party and associated with the party, and automatically execute a function in connection with the related information and the associated information through an on-screen menu in a display screen in an instrument.

Other features and advantages of the invention will become apparent from following detailed description taken in conjunction with the accompanying drawings, which illustrate, by way of example, the features of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The FIGURE is an elevational view of a display in an instrument which includes an on-screen menu in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, there are shown preferred embodiments of a system **10** for enabling manipulation of a plurality of graphic images **12** on a display screen **14**. A graphical user interface **18** which comprises a bitmap display includes the graphic image **12** therein. In the screen **14** shown in the FIGURE, a header graphic image **32** is also presented.

In a preferred embodiment, as shown in FIGURE, system **10** is adapted to enable automatic performance of functions of an instrument **36**. For example, instrument **36** may comprise a wireless telephone, which includes elements **72**, such as a keypad, for enabling entry of information **74** relating to a party, such as the telephone number of the party, and information **76** associated with the party, such as the name of the party. Instrument **36** further includes a display screen **14**, for displaying related information **74** and associated information **76**. Instrument **36** is adapted to automatically display the name of the party associated with the telephone number of the party, upon entry of the telephone number of the party.

Instrument **36** may further or alternatively comprise a pager, which is adapted to connect instrument **36** to the telephone number entered, wherein related information **36** may comprise the telephone number of a paging service. Associated information **76** may comprise a personal identification number. Instrument **36** may then be adapted to automatically transmit the personal identification number to the paging service, upon connection of the entered telephone number with the paging service, for enabling connection of instrument **36** to the paging service.

From the foregoing it will be appreciated that the system of the present invention provides advantages in enabling automatic performance of instrument functions. While particular forms of the invention have been illustrated and described, it will be apparent that various modifications can be made without departing from the spirit and scope of the invention. Accordingly, the invention is not to be limited, except as by the following claims.

What is claimed is:

1. A system for enabling automatic performance of functions of an instrument which comprises a wireless telephone which includes a display screen, and means for displaying the telephone number on the display screen, comprising:

means for enabling entry and storage in the instrument of information relating to a party which comprises a telephone number, and information associated with the telephone number which comprises the name of the party associated with the telephone number; and

means for performing automatically a function in connection with the associated information upon subsequent entry of the telephone number in the instrument to access the telephone number from storage and to automatically perform the associated information function, which comprises automatically accessing from storage and displaying the name of the party associated with the telephone number along with the entered telephone number on the display upon subsequent entry and access from storage of the telephone number.

2. A system for enabling automatic performance of functions of an instrument, which comprises a paging instrument, comprising:

means for enabling entry and storage in the instrument of information relating to a party, which comprises the

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telephone number of a paging service, and information associated with the telephone number, which comprises a personal identification number;

means for performing automatically a function in connection with the associated information, to access the telephone number from storage and transmit the telephone number, and to automatically perform the associated information function, which comprises automatically accessing from storage and transmitting the personal identification number to the paging service telephone number upon subsequent entry and access from storage of the telephone number in the instrument; and

means for connecting the paging instrument to the paging service telephone number.

3. The system of claim **2**, further comprising a display screen, and means for displaying the entered paging service telephone number on the display.

4. The system of claim **2** wherein the displaying means are further adapted to display the personal identification number.

5. A system for enabling automatic performance of functions of an instrument which comprises a wireless telephone which includes a display screen, and an element for displaying the telephone number on the display screen, comprising:

an element for enabling entry and storage in the instrument of information relating to a party which comprises a telephone number, and information associated with the telephone number which comprises the name of the party associated with the telephone number; and

an element for performing automatically a function in connection with the associated information upon subsequent entry of the telephone number in the instrument to access the telephone number from storage and to automatically perform the associated information function, which comprises automatically accessing from storage and displaying the name of the party associated with the telephone number along with the entered telephone number on the display upon subsequent entry and access from storage of the telephone number.

6. A system for enabling automatic performance of functions of an instrument, which comprises a paging instrument, comprising:

an element for enabling entry and storage in the instrument of information relating to a party, which comprises the telephone number of a paging server, and information associated with the telephone number, which comprises a personal identification number;

an element for performing automatically a function in connection with the associated information, to access the telephone number from storage and transmit the telephone number, and to automatically perform the associated information function, which comprises automatically accessing from storage and transmitting the personal identification number to the paging service telephone number upon subsequent entry and access from storage of the telephone number in the instrument; and

an element for connecting the paging instrument to the paging service telephone number.

7. A method of enabling automatic performance of functions of an instrument which comprises a wireless telephone which includes a display screen, and an element for displaying the telephone number on the display screen, in a system which comprises an element for enabling entry and storage

in the instrument of information relating to a party which comprises a telephone number, and information associated with the telephone number which comprises the name of the party associated with the telephone number, and an element for performing automatically a function in connection with the associated information upon subsequent entry of the telephone number in the instrument to access the telephone number from storage and to automatically perform the associated information function, which comprises automatically accessing from storage and displaying the name of the party associated with the telephone number along with the entered telephone number on the display upon subsequent entry and access from storage of the telephone number, wherein the method comprises:

entering the telephone number, and the name of the party associated with the telephone number, in the wireless telephone;

subsequently entering the telephone number in the wireless telephone; and

automatically accessing from storage and displaying the name of the party associated with the telephone number along with the entered telephone number upon subsequent entry and access from storage of the telephone number.

8. A method of enabling automatic performance of functions of an instrument which comprise a paging instrument, in a system which comprises an element for enabling entry and storage in the instrument of information relating to a party which comprises a telephone number of a paging service, and information associated with the telephone number which comprises a personal identification number, and an element for performing automatically a function in connection with the associated information upon subsequent entry of the telephone number in the instrument to access the telephone number from storage and to automatically perform the associated information function which comprises automatically accessing from storage and transmitting the personal identification number to the paging service telephone number upon subsequent entry and access from storage of the telephone number in the instrument, and an element for connecting the instrument to the telephone number, wherein the method comprises:

entering the telephone number of a paging service, and a personal identification number, in the paging instrument;

subsequently entering the telephone number of the paging service in the paging instrument, accessing the paging service telephone number from storage, and connecting the paging instrument to the paging service telephone number; and

automatically transmitting the personal identification number to the connected paging service telephone number upon subsequent entry and access from storage of the paging service telephone number an connection with the paging service.

9. The method of claim **8**, wherein the instrument further comprises a display screen, and means for displaying the entered paging service telephone number on the display screen, further comprising the step of displaying the entered paging service number on the display screen.

10. The method of claim **8**, wherein the displaying means are further adapted to display the personal identification number, further comprising the step of displaying the entered personal identification number on the display screen.

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