

Exhibit J



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Gollnick et al.

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[54] **SYSTEM FOR COUPLING HOST COMPUTER MEANS WITH BASE TRANSCIVER UNITS ON A LOCAL AREA NETWORK**

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[73] Assignee: **Norand Corporation**, Cedar Rapids, Iowa

[21] Appl. No.: **486,083**

[22] Filed: **Jun. 7, 1995**

Related U.S. Application Data

[63] Continuation of Ser. No. 277,944, Jun. 29, 1994, which is a continuation of Ser. No. 57,218, May 4, 1993, abandoned, which is a continuation of Ser. No. 700,704, May 14, 1991, abandoned.

[51] **Int. Cl.**⁶ **H04Q 7/00**; H04Q 7/24

[52] **U.S. Cl.** **370/329**; 370/331; 370/338; 370/328; 375/202

[58] **Field of Search** 370/95.1, 95.2, 370/95.3, 85.7, 84, 94.2, 85.2, 422, 431, 474, 414, 417, 346, 345, 349, 352, 331, 329, 338; 375/200, 202, 216; 379/61, 58; 455/17, 34.1, 33.1, 54.1, 54.2, 33.4, 38.1

[56] **References Cited**

U.S. PATENT DOCUMENTS

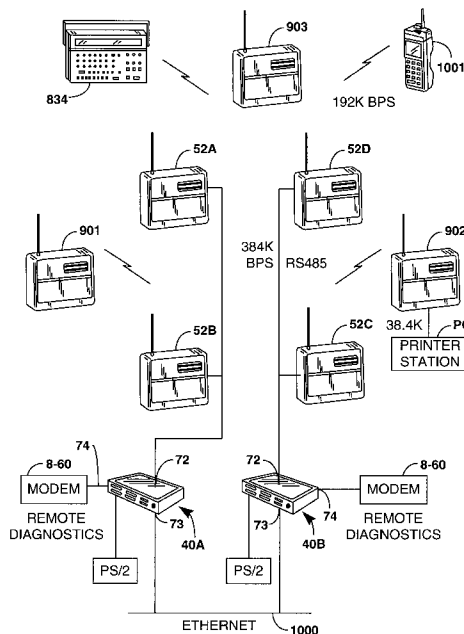
4,414,661	11/1983	Karlstrom	370/332
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4,940,974	7/1990	Sojka	340/825.08
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Assistant Examiner—Melissa Kay Carman
Attorney, Agent, or Firm—Akin, Gump, Strauss, Hauer & Feld, LLP

[57] **ABSTRACT**

Improved apparatus for a radio communication system having a multiplicity of mobile transceiver units selectively in communication with a plurality of base transceiver units which communicate with one or two host computers for storage and manipulation of data collected by bar code scanners or other collection means associated with the mobile transceiver units. A network controller provides selective interface means to be employed between the host computers and the base transceivers whereby low data rate base transceivers may be utilized with the network controller while spread spectrum or high data rate networked base transceivers may be also utilized. The network controller may allow selection of interface means for three of its ports from its front panel with use of three input keys. The network controller is entirely external to the host computer or computers, and can couple to a variety of commonly encountered host ports. Most preferable one- or two-network controller ports can each be software configured to match any needed host port, so that the host computer(s) need not be adapted to a radio network protocol accommodating the multiple base transceiver units.

14 Claims, 13 Drawing Sheets



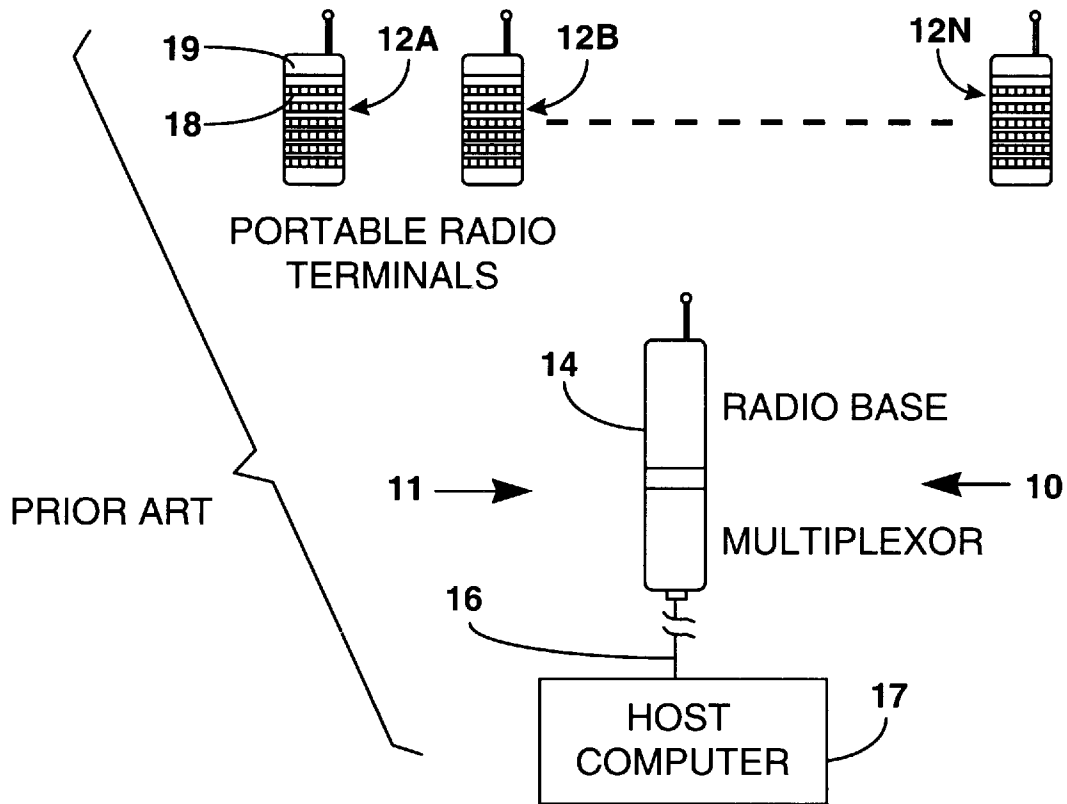


Fig. 1

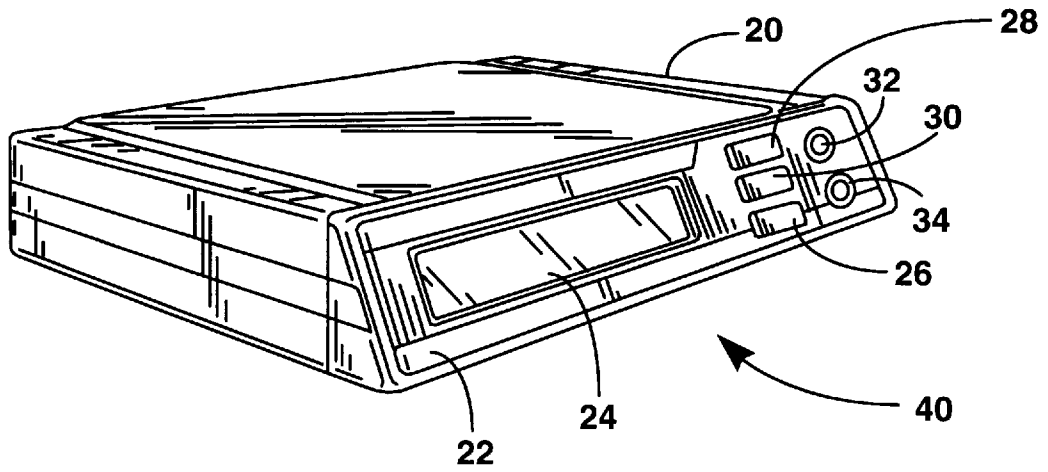


Fig. 2

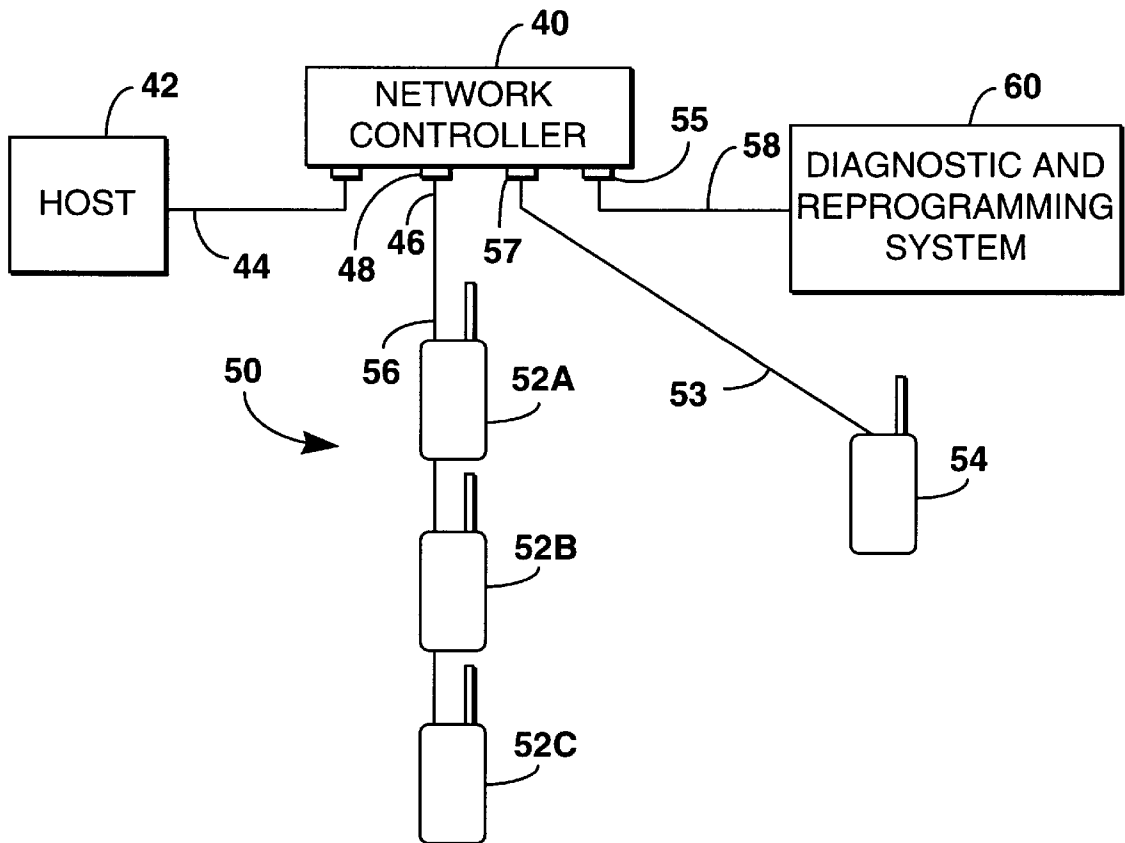


Fig. 3

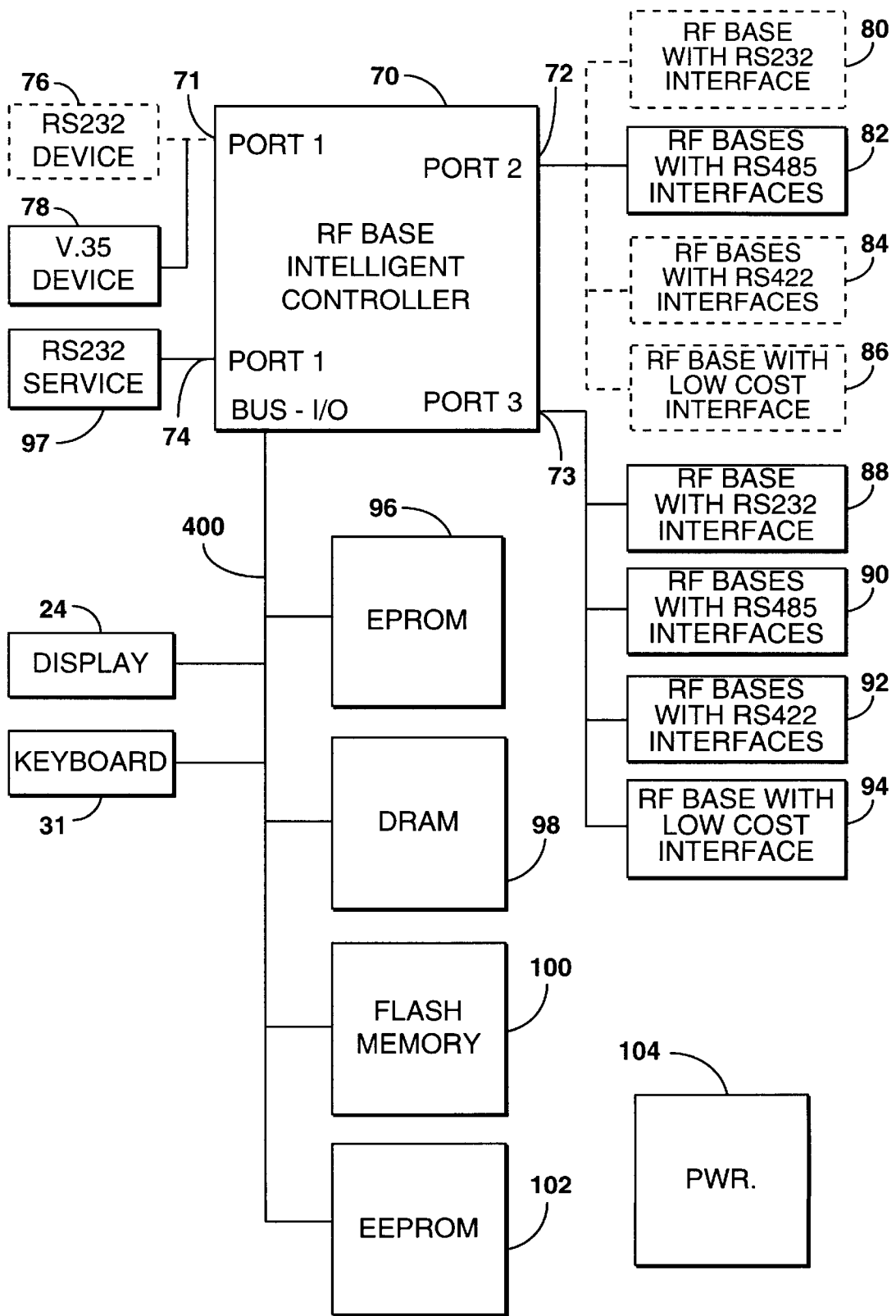


Fig. 4

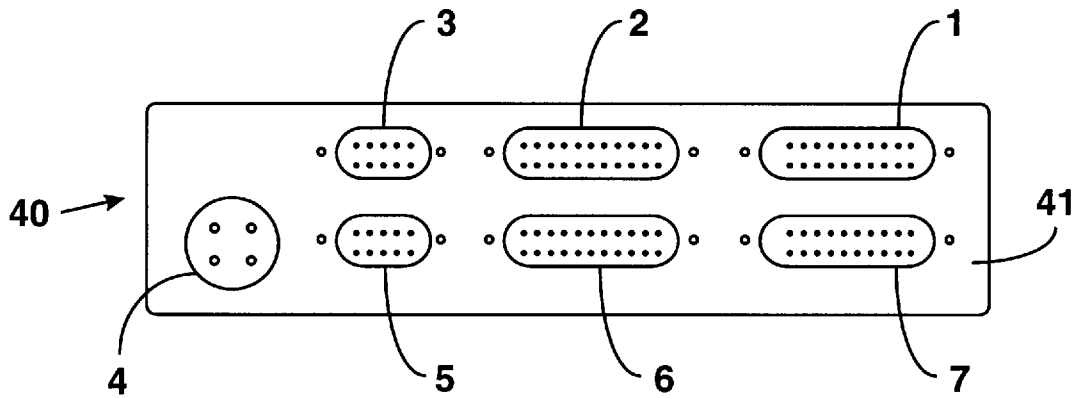


Fig. 5

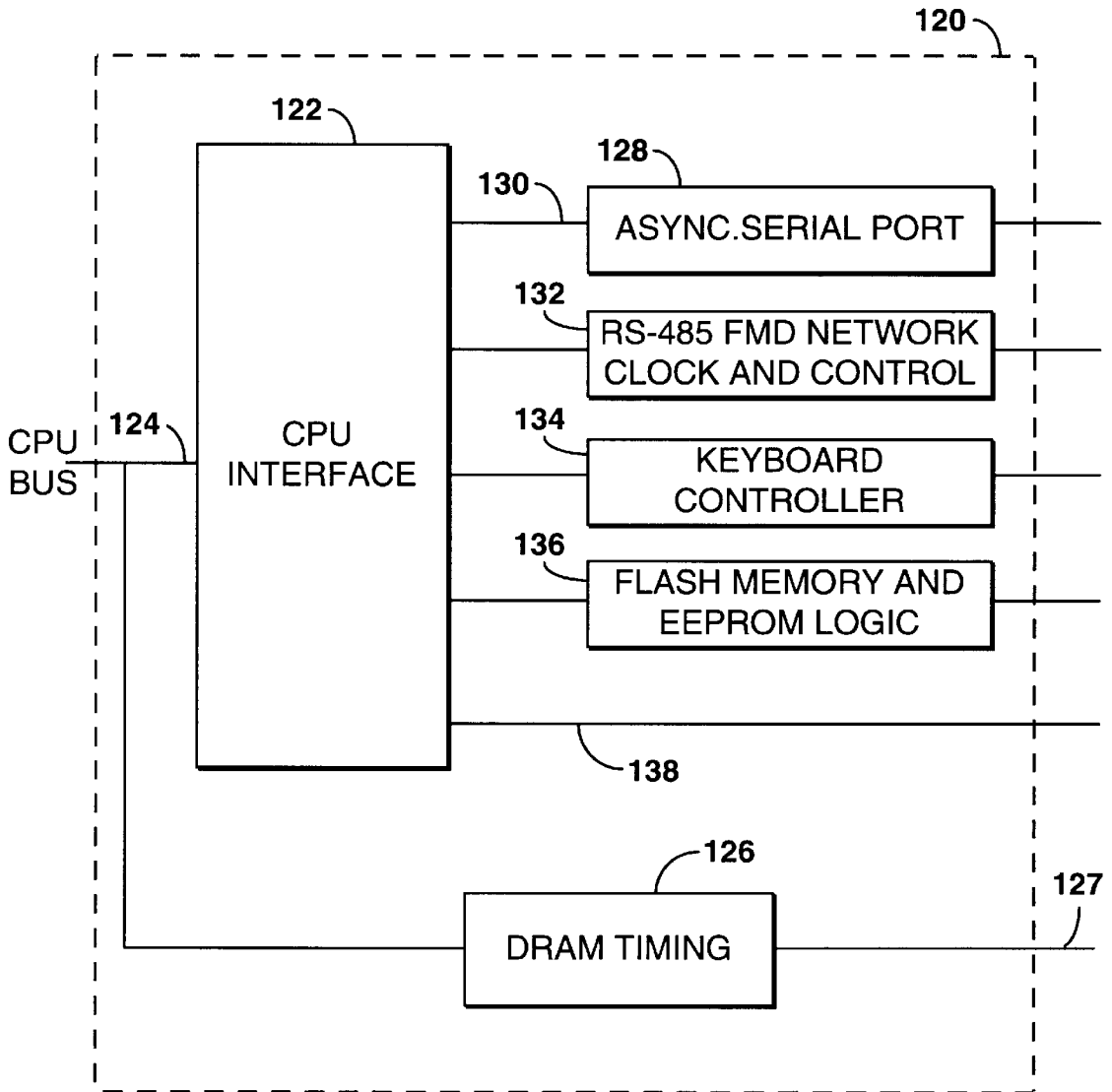


Fig. 6

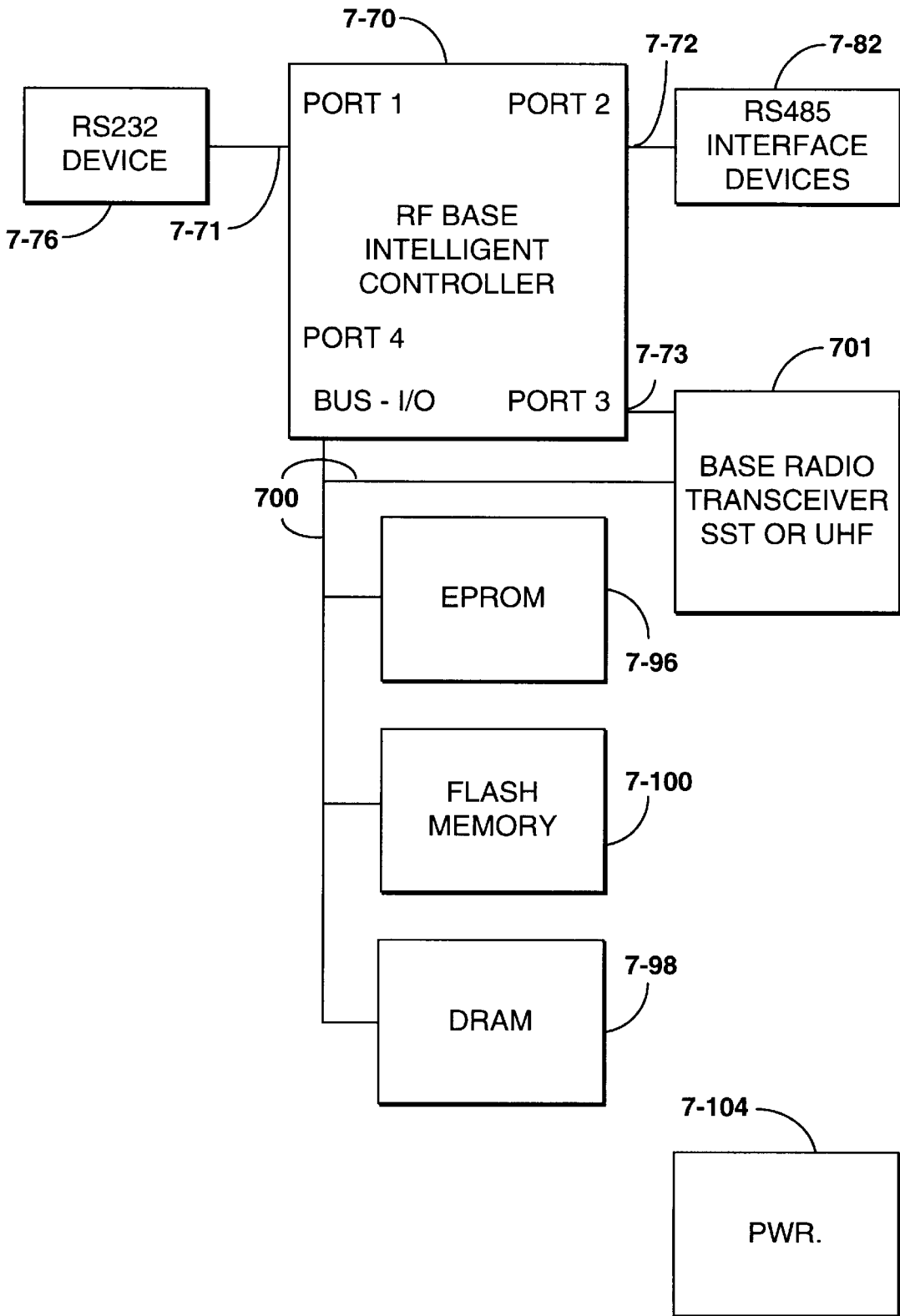


Fig. 7

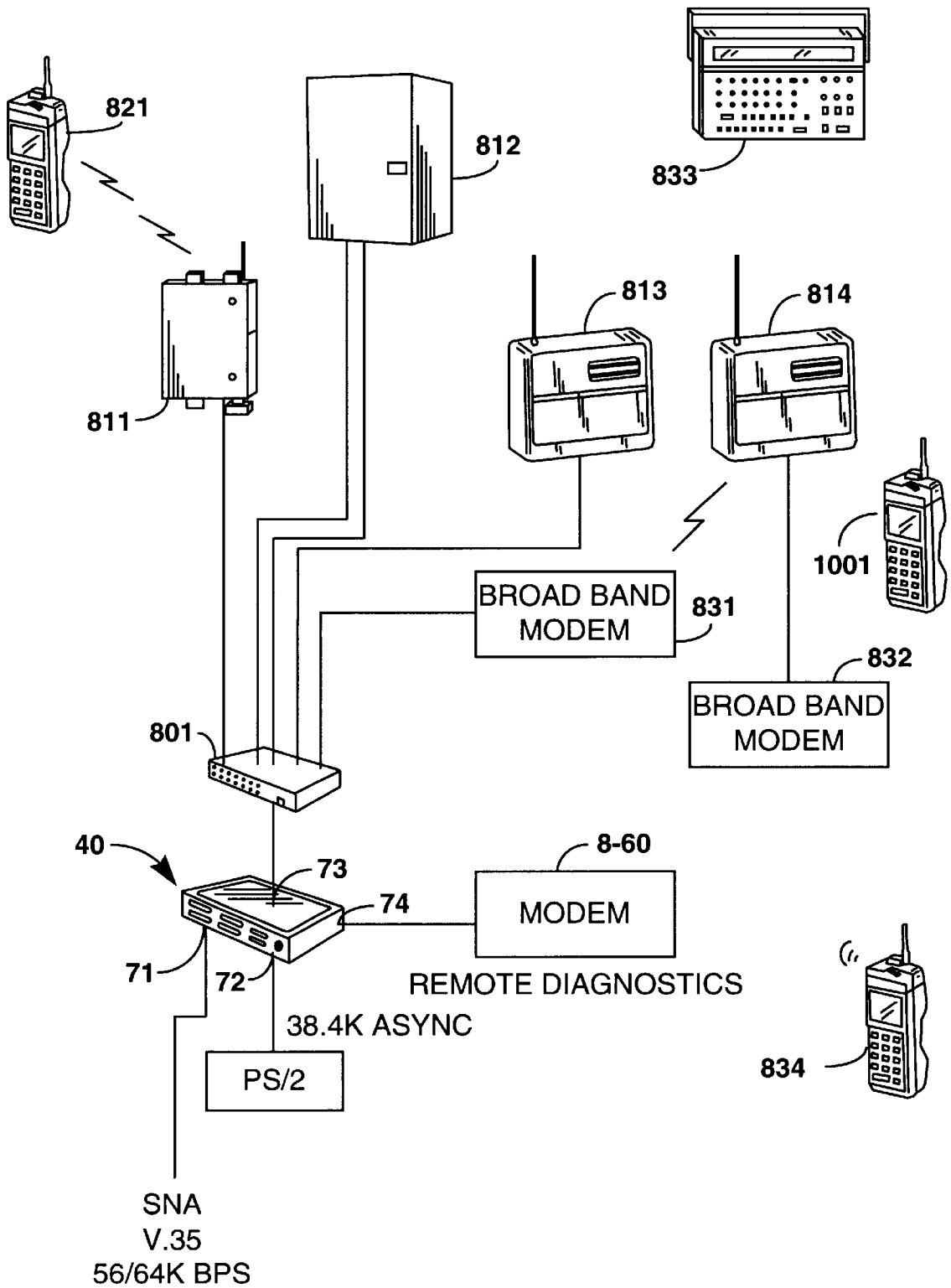


Fig. 8

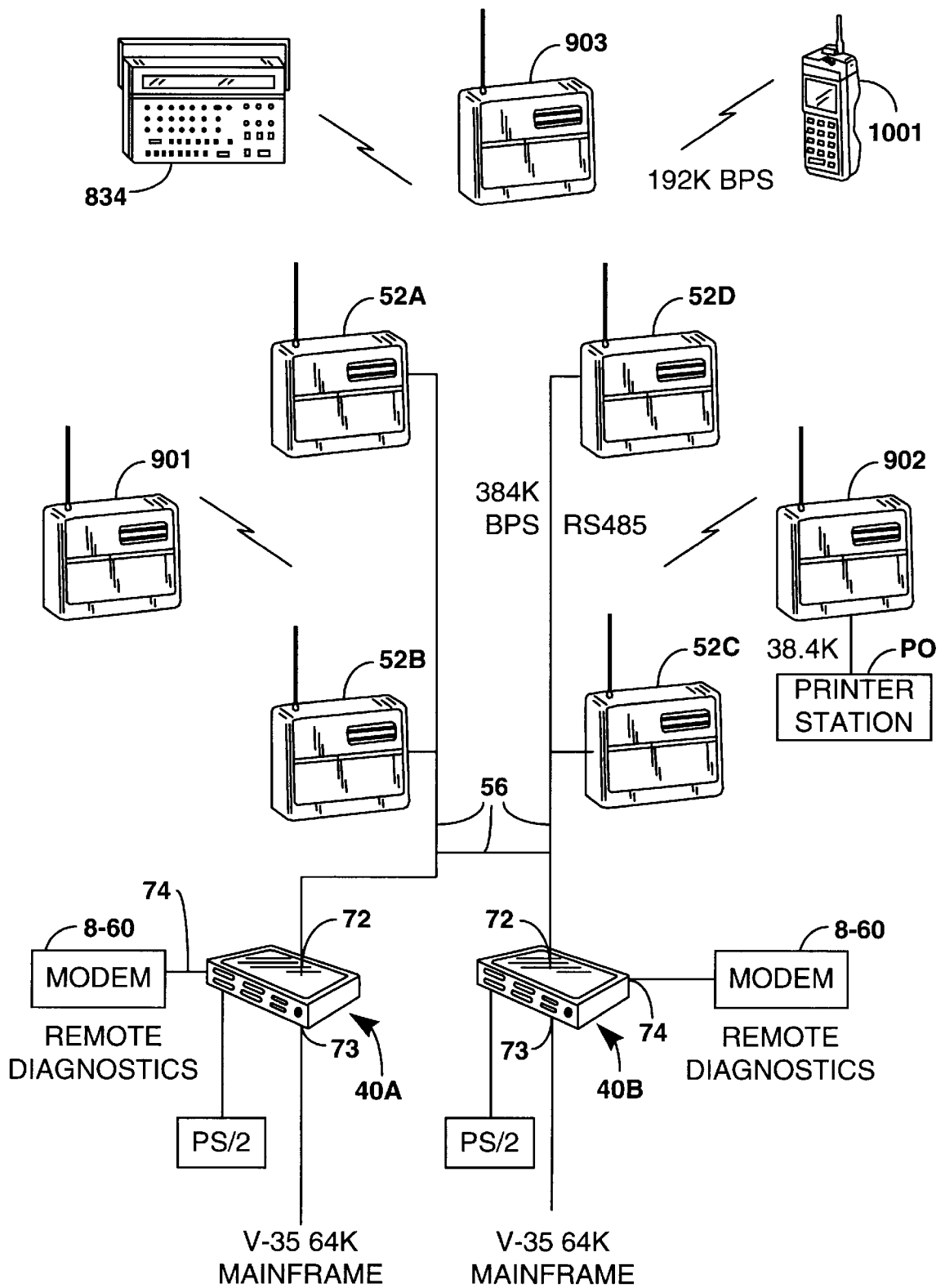


Fig. 9

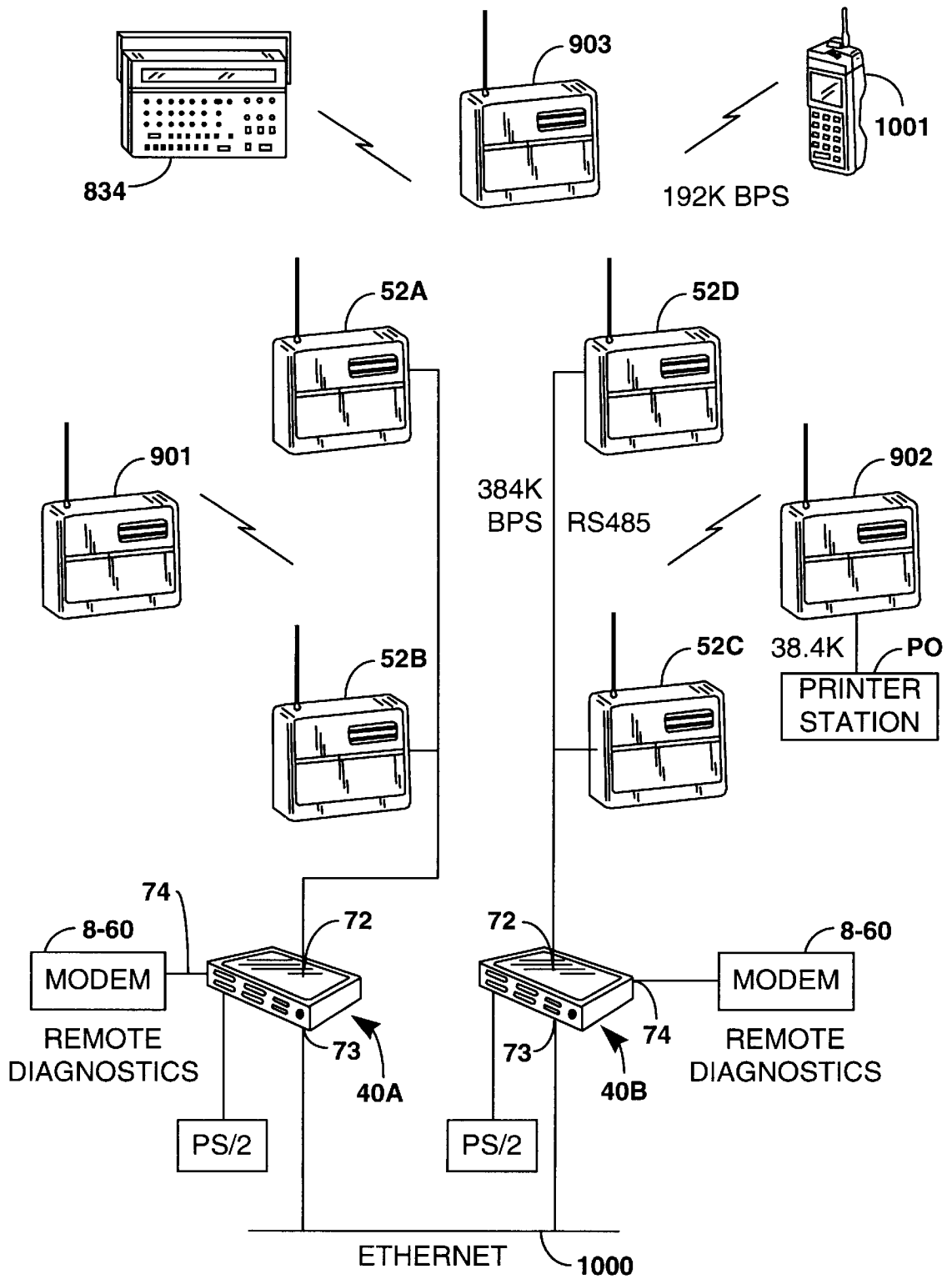


Fig. 10

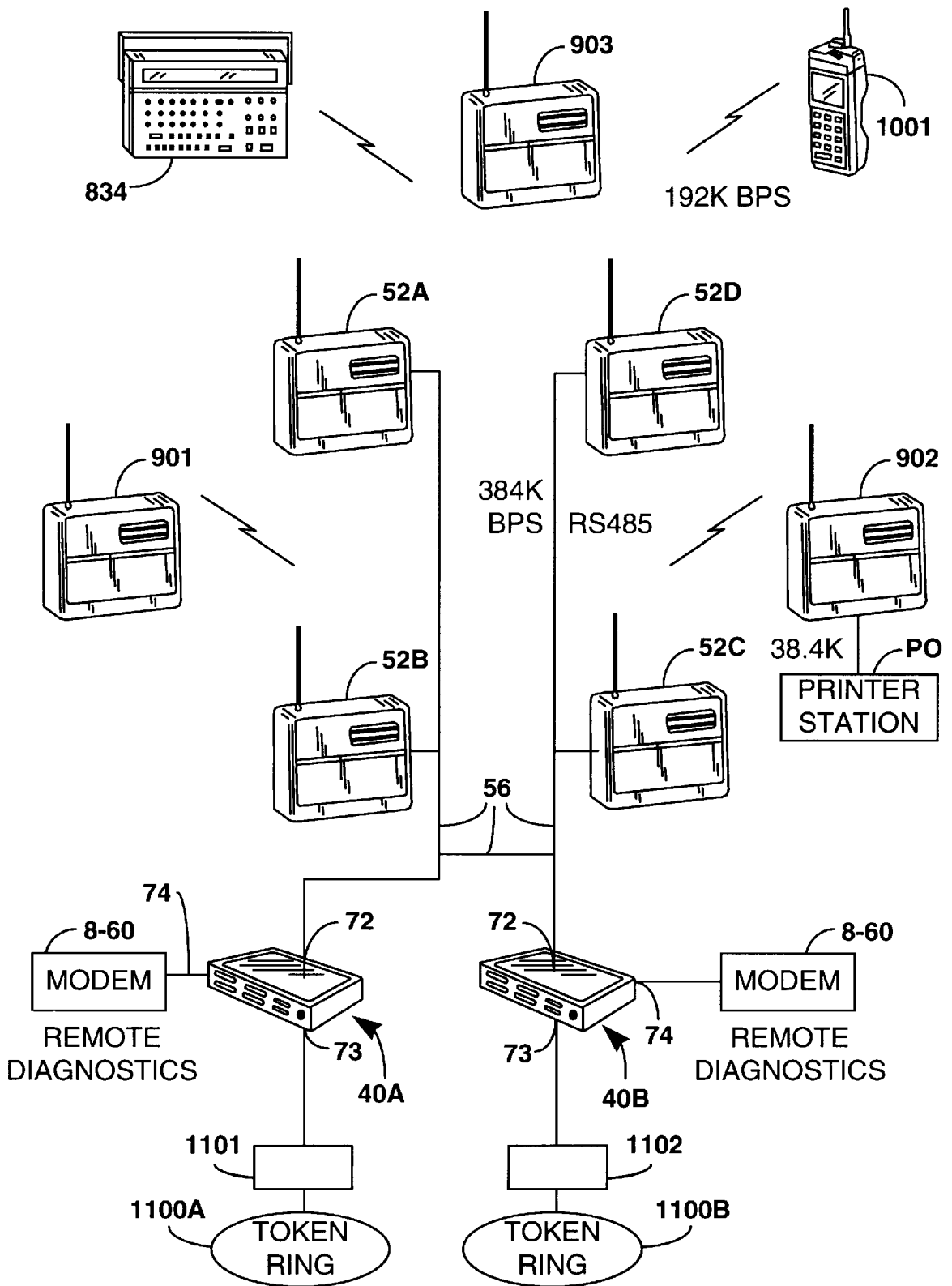


Fig. 11

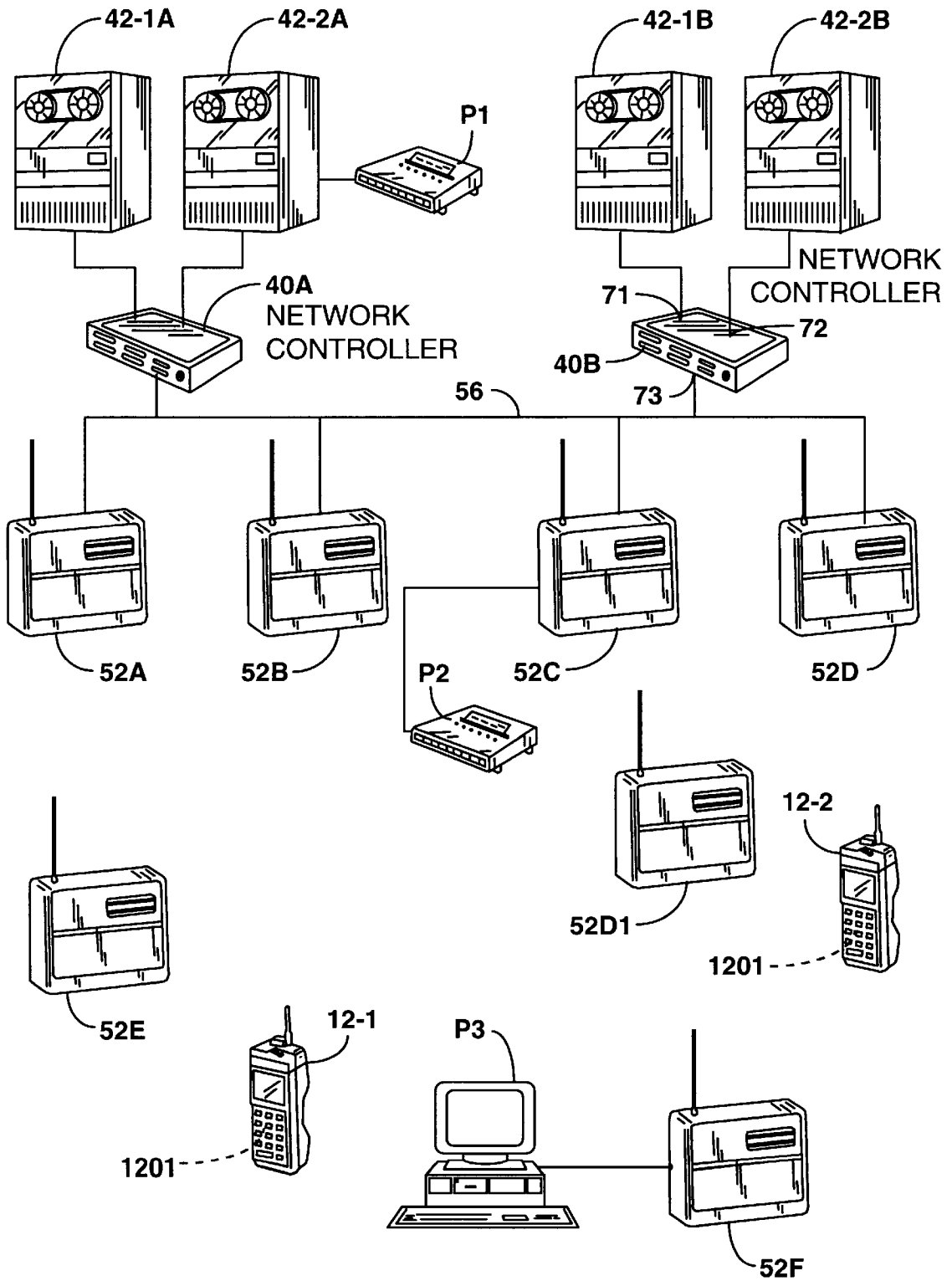


Fig. 12

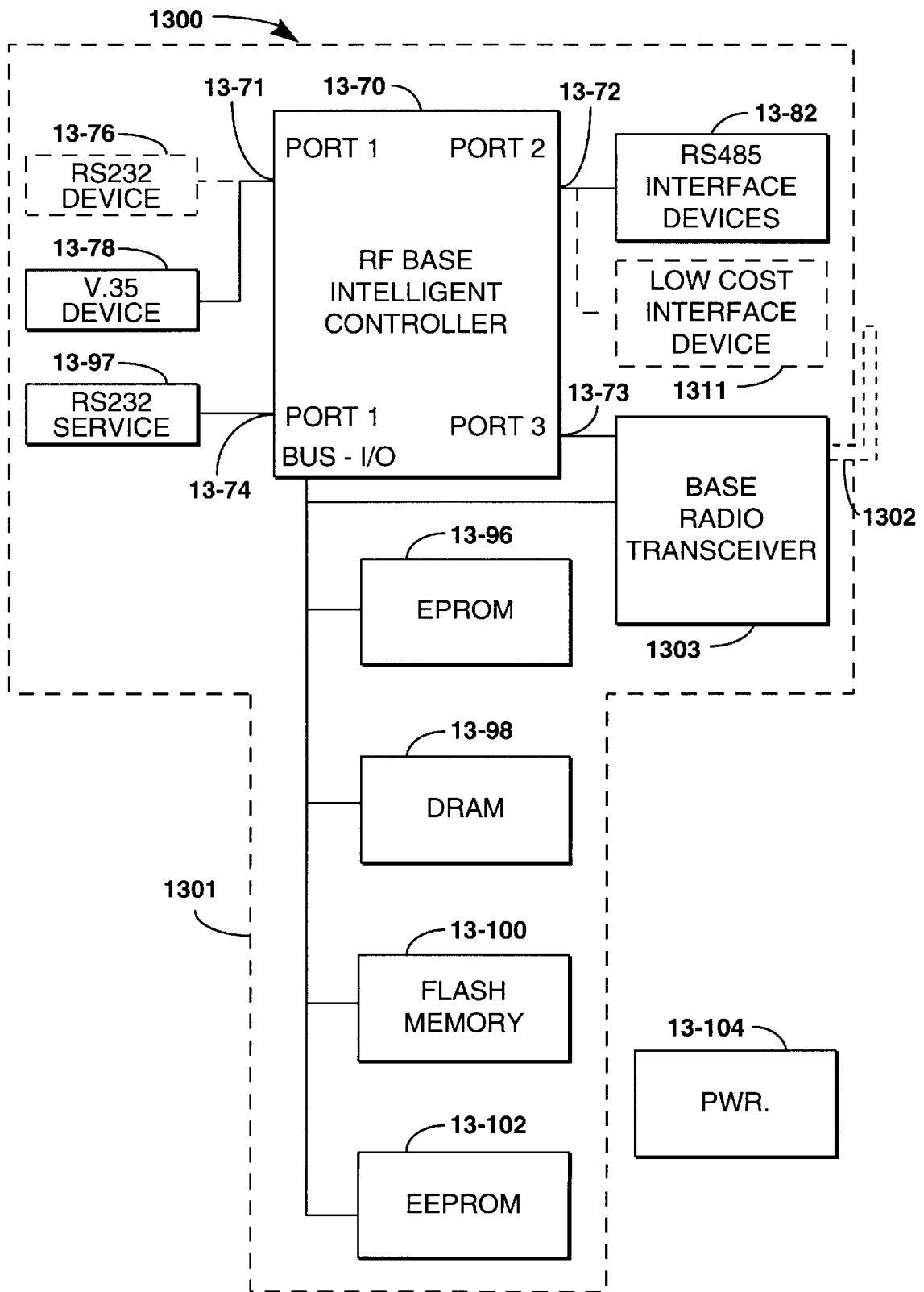


Fig. 13

**SYSTEM FOR COUPLING HOST
COMPUTER MEANS WITH BASE
TRANSCIVER UNITS ON A LOCAL AREA
NETWORK**

**CROSS-REFERENCE TO RELATED
APPLICATIONS**

This case is a continuation of application Ser. No. 08/277, 944, filed Jun. 29, 1994 which is a continuation of application Ser. No. 08/057,218, filed on May 4, 1993 and abandoned, which is a continuation of application Ser. No. 07/700,704, filed May 14, 1991 and abandoned.

BACKGROUND OF THE INVENTION

The present invention in a preferred implementation relates to improvements in radio data communication systems wherein a number of mobile transceiver units are to transmit data to a number of base stations under a wide range of operating conditions. The invention is preferably to be applicable as an upgrade of an existing data capture system wherein a number of hand-held transceiver units of an earlier design are already in the field representing a substantial economic investment in comparison to the cost of base stations, accessories and components. In installations spread over an extensive area, a large number of mobile portable transceiver units may be employed to gather data in various places and multiple base stations may be required. In a variety of such installations such as warehouse facilities, distribution centers, and retail establishments, it may be advantageous to utilize not only multiple bases capable of communication with a single host, but with multiple hosts as well.

An early RF data collection system is shown in Marvin L. Sojka, U.S. Pat. No. 4,924,462 assigned to the assignee of the present application. This patent illustrates (in the sixth figure) a NORAND® RC2250 Network Controller which supports one base transceiver for communication with multiple mobile portable transceivers. The exemplary prior art device is capable of communicating with a host computer through an RS232C interface at up to 19,200 baud in asynchronous mode. In order for an optional RS422 interface to be substituted for an RS232C interface, the unit must be opened and substitute circuitry components installed within it.

SUMMARY OF THE INVENTION

The present invention provides an improved network controller to serve as a consolidation link between one or more host computers and one or more base transceiver units, each of which may be communicative with many mobile portable transceiver units being moved about a warehouse complex for the collection of data. The network controller invention provides a front panel display with three operator-available control keys for selections of function and up or down scrolling through choices provided on the front panel display.

The invention will allow incorporation with existing base transceivers as well as with high-speed spread spectrum and synthesized radio networks at the same time. The invention allows the creation of a radio communication system with multiple host devices using differing communication protocols. Higher speed host device interfaces may be used as a result of the inclusion of the invention in an existing radio communication system. The invention provides means for the coupling of large networks of serially interconnected base transceivers over a single twisted pair of wires.

The invention provides a plurality of communication ports for interconnection to one or more host computers and one or more base transceiver systems or units. The communication ports available for connection with the host computers may be configured to provide selective interfaces without any requirement for rewiring or other hardware modification. A first port of the controller may be selected to interface with a host computer by either RS232 or V.35 means. The selection of interface means may be performed by the end user with choices made on the front panel control keys of the device.

A second port of the invention may be selected to provide interface means by a choice of RS232, RS422, or RS485 means or through a NORAND® Radio One Node Network proprietary interface. This second port may be communicative with a second host computer or with existing installed base units when RS232 means are selected, or with existing base units when RS422 means are selected. In addition, the second port may be configured to communicate with a network of new generation base units, either by RS485 interface protocol, or by the NORAND® Radio One Node Network proprietary interface.

The third port of the invention, like the second port hereof, may be selectively configured to communicate by RS232, RS422, RS485 or NORAND® Radio One Node Network proprietary interface means. For both the second and third ports, as well as for the host port, configuration of the port is accomplished by selection of the port on the front panel of the invention controller with the select key and then selection of the desired interface configuration through appropriate use of the up and down keys to scroll to the correct means to be selected. Because the invention permits internal, software-controlled, selection of the desired interface means for each port, the end user may easily self configure the unit for a particular use, thereby providing a highly versatile device. In addition the configuration choice means is simplified for the user, because the choices are conveniently displayed on the front panel display and a choice can be made from a scrollable list.

The introduction of the selectable RS485 interface in the present invention enables the controller to be interfaced to a network of new generation base station units which may comprise several base transceiver units configured on a single network circuit.

The inclusion of the selectable NORAND® Radio One Node Network proprietary interface means for the second and the third ports provides means for incorporation of new generation base transceiver units having particularized wiring and control requirements.

A diagnostic port configured for RS232 interface means is provided to provide selective communication, either remotely through modem means, or through direct coupling, with diagnostic and reprogramming apparatus.

The invention is provided with an application specific integrated circuit used in combination with a control processor unit capable of a speed of 16.667 mhz with direct memory access functionality available at its communication ports. Internal memory components to be coupled to the central processor unit and application specific integrated circuit will comprise nonvolatile electrically erasable programmable read only memory elements, dynamic random access memory elements, and nonvolatile FLASH memory elements which permit erasure by application of +12 VDC to prescribed pins.

Power supply means are supplied exteriorly to the invention in order to make the invention standardized for United

States, European and other countries' local power company output characteristics.

It is therefore an object of the invention to provide a radio communication system which permits the interconnection of one or two host computer devices to a multiplicity of base transceiver units which may include both prior art existing installed units and new generation units capable of spread spectrum or synthesized radio transmission.

It is a further object of the invention to provide a radio communication system network controller which may allow interconnection of a multiplicity of devices which are operating with non-uniform electrical interface characteristics.

It is a further object of the invention to provide a radio communication system network controller which may be configured for varying interface requirements by operation of a limited number of front panel keys.

It is a further object of the invention to provide a radio communication system network controller which will allow utilization of single twisted pair networks of serially networked base transceiver units, each of which being communicative with a large number of individual mobile data collection transceiver units.

These are other objects of the invention will be apparent from examination of the detailed description which follows.

DESCRIPTION OF THE DRAWING FIGURES

FIG. 1 is a block diagram of the prior art data communication system.

FIG. 2 is perspective view of the invention.

FIG. 3 is a schematic representation of an exemplary radio communication system utilizing the invention.

FIG. 4 is a diagrammatic illustration of the control circuitry elements of the invention.

FIG. 5 is a rear elevation view of the invention.

FIG. 6 is a diagrammatic illustration of the application specific integrated circuit of the invention.

FIG. 7 is a block diagram showing an exemplary implementation of intelligent network and router transceiver units such as the network transceiver units of FIG. 3.

FIG. 8 is a diagram of an RF system utilizing a network controller according to FIGS. 2-6, with one of its network ports configured for communication with a second host, and another of its ports coupled with a multiplicity of RF transceivers via an adapter unit.

FIG. 9 is a diagram illustrating the use of two network controllers according to FIGS. 2-6, configured for dual host computers each, and having their relatively high data rate extended distance network ports coupled with a multiplicity of intelligent network and router transceiver units implemented according to FIG. 7.

FIG. 10 is a diagram similar to FIG. 9 but showing the pair of coupled network controllers interfaced to a common relatively high data rate system having multiple hosts (e.g.) a local area network of the Ethernet type or equivalent (e.g. fiber optic type).

FIG. 11 is a diagram similar to FIG. 10 but indicating the network controllers being coupled to respective different high data rate multiple host systems (e.g. token ring type local area networks or other individual networks e.g. fiber optic loop networks of the collision-sense multiple-access type).

FIG. 12 is a view similar to FIG. 9 but intended to diagrammatically indicate a distribution of network and router transceivers and other elements of an on-line RF data

collection system over an extensive area of a facility e.g. of one of the types previously mentioned.

FIG. 13 shows an intelligent integrated controller and radio base unit which unifies controller and radio components such as shown in FIG. 7 into a single housing of the size represented in FIGS. 2 and 5.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows an existing radio frequency data transmission system 10 wherein a base station transceiver means 11 has a number of mobile transceiver units such as 12A, 12B, . . . , 12N in radio communication therewith.

By way of example, the base station may be comprised of a radio base unit 14 such as the model RB3021 of Norand Corporation, Cedar Rapids, Iowa, which forms part of a product family known as the RT3210 system. In this case, the radio base 14 may receive data from the respective mobile RF terminals, e.g. of type RT3210, and transmit the received data via a network controller and a communications link 16 (e.g. utilizing an RS-232 format) to a host computer 17.

The data capture terminals 12A, 12B, . . . , 12N may each be provided with a keyboard such as 18, a display as at 19, and a bar code scanning capability, e.g. via an instant bar code reader such as shown in U.S. Pat. No. 4,766,300 issued Aug. 23, 1988 and known commercially as the 20/20 High Performance Bar Code Reader of Norand Corporation.

FIG. 2 provides a perspective view of the invention 40 in the preferred embodiment case 20. Front panel 22 is provided with display 24 and select key 26, up key 28 and down key 30. Power indicator 32 comprises a low power green light emitting diode which is energized when power is supplied to the invention 10. Error condition indicator 34 is a yellow LED which is software controlled to be energized if the invention 10 is in error condition.

FIG. 3 discloses a diagrammatic illustration of a radio communication system in accordance with the present invention. Invention network controller 40 is coupled to host computer 42 such that data may be interchanged between the devices over host communications link 44, which may be either in an RS232C format or selectively in an RS422 format. The host communication link 44 couples to controller 40 at host port 46.

First communication port 48 of controller 40 provides means for coupling of network 50 to controller 40. Network 50 comprises a number of base RF transceiver units 52A, 52B and 53B, each of which may be selectively employed in the radio frequency communication of data from mobile transceiver units. It is to be understood that base transceiver units 52 are designed and equipped to be operable in the exchange of data with network controller 40 over network link 56 such that each base transceiver unit 52A, 52B, or 53C may independently exchange data with network controller 40 through first communication port 48. When first communication port 48 is intended for operation with a network such as network 50 of base transceiver units 52A, 52B and 53C, for example, network controller 40 is selectively operated to provide an RS485 interface at first communication port 48. First communication port 48 may be alternately selected to operate as an RS232C interface, as an RS422 interface, as a proprietary NORAND® Radio One Node Network interface or as a high speed V.35 interface. The selection of interface to be provided at first communication port 48 is front panel controlled, that is, the user may operate front panel keys 28, 30 and 26 (See FIG. 2) to direct the proper interface to be provided at first communication port 48.

Base transceiver units **52A**, **52B**, and **52C** are coupled to network link **56** by serial means, rather than parallel means, and each may be caused to transmit or to receive independently from the others while additionally being communicative with network controller **40** in a randomly chosen fashion.

It is further to be understood that interface translation is provided within controller **40** such that data communicated at first communication port **48** may be directed to host **42** at port **46** via properly chosen interface means as is required by the host **42** with which communication is intended.

Like first communication port **48**, second communication port **57** may be internally switched among interface choices of these types: RS232C, RS422, V.35, RS485 and proprietary NORAND® Radio One Node Network interface. In the illustrated arrangement of FIG. 3, for example, second communication port **57** is coupled over third link **53** to previously installed base transceiver **54**, which heretofore had been used in a prior art system as is illustrated in FIG. 1. Because of limitations of base transceiver **54**, it must communicate via RS232C interface format and therefore, second communication port **57** must be selected to operate in RS232C interface mode. However, when second communication port **57** is desired to communicate with a network via RS485 interface, front panel keys **26**, **28** and **30** may be manipulated by the user to provide the RS485 interface availability at second communication port **57**. Likewise, second communication port **57** may be selected to operate as an RS422 interface, as a V.35 interface, or as the proprietary NORAND® Radio One Node Network interface.

Diagnostic port **55** provides a fourth communication pathway for network controller **40**, providing an asynchronous port operable at 300 to 19,200 baud as an RS232C interface. When desirable, diagnostic port **55** may be coupled by diagnostic link **58** to diagnostic device **60** for purposes of error diagnosis of controller **40** by diagnostic device **60**, or for reprogramming of memory devices within controller **40** when desired. It is contemplated that diagnostic device **60** comprises a 16-bit microprocessor commonly known as a personal computer or "PC". The mode of coupling between diagnostic device **60** and network controller **40** may be direct or through remote means by use of a modem.

Referring now to FIG. 4, a central processing unit **70** is provided with at least four data communication ports, illustrated at numerals **71**, **72**, **73**, and **74**. First data communication port **71** may be selectively coupled to RS232 interface member **76** or V.35 interface member **78**. The choice of whether RS232 interface member **76** or V.35 interface member **78** is chosen is dependent upon the operating characteristics presented by the host computer, such as host computer **42** of FIG. 3, with which network controller **40** will communicate. The choice of whether first communication port **71** is coupled to interface member **76** or to interface member **78** depends on the front panel selection made by the user by keys **26**, **28**, and **30** shown in FIG. 2.

Second communication port **72** may be selectively coupled to RS232 member **80** or to RS485 interface member **82** or to RS422 interface member **84** or to NORAND® Radio One Node Network proprietary interface member **86**. By use of front panel keys **26**, **28**, and **30** of FIG. 2, the user may select second communication port **72** to be coupled to any one of interface members **80**, **82**, **84**, and **86**.

Third communication port **73** is identical to second communication, port **72** in functionality, being selectively coupleable to RS232 interface member **88**, to RS485 inter-

face member **90**, to RS422 interface member **92** or to NORAND® Radio One Node Network proprietary interface member **94**.

In the preferred embodiment of the invention **40**, central processing unit **70** of FIG. 4 comprises a Motorola™ 68302 integrated chip cooperative with an application specific integrated circuit. Central processing unit **70** employs novel features allowing the bidirectional use of a data communicative line of the Motorola™ 68302 chip and a single clock signal line to eliminate the need for coder-decoder members to be associated with the Motorola™ 68305 chip while allowing the use of only one pair of signal wires to be coupled to the RS485 interfaces **82** and **90** of FIG. 4.

Fourth communication port **74** of central processing unit is coupled to asynchronous RS232 interface member **97** to be available for interconnection of a diagnostic device therewith.

Also coupled to central processing unit **70** are display member **24** and keyboard member **31** with which keys **26**, **28**, and **30** of front panel **22** (FIG. 2) are interactive.

Memory elements including EPROM element **96**, DRAM unit **98**, FLASH memory unit **100** and EEPROM element **102** are intercoupled with each other and with central processing unit **70**.

Power supply member **104** is selectively attachable to invention network controller **40**. In order to avoid the necessity of different models of network controller **40** depending on the local electrical power utility's operating characteristics, power supply **104** is provided in optional models depending on the country in which it is to be used, power supply **104** being capable of providing satisfactory output power to network controller **40** regardless of the voltage or frequency of the input source provided to power supply **104**.

The application specific integrated circuit (ASIC) used in the invention network controller **40** is disclosed in FIG. 6 and is identified by the numeral **120**. ASIC **120** comprises a central processor unit interface **122** member which is coupled to the central processor unit bus by CPU bus link **124** which extends from ASIC **120**. Also coupled to the CPU bus link **124** is dynamic random access memory (DRAM) timing element **126**, which provides network controller **40** with timing signals for the DRAM member **98** illustrated in FIG. 4 when memory refresh of the DRAM **98** is indicated. DRAM timing element **126** is also coupled exteriorly to the ASIC **120** to DRAM member **98** by DRAM link **127**.

Central processing unit interface **122** is coupled to asynchronous signal processing element **128** by signal path **130**. Asynchronous signal processing element **128** comprises a baud rate generator cooperative with a universal asynchronous receiver-transmitter.

Also coupled to central processing unit interface **122** is network clock and control member **132** which comprises a programmable network clock generator which can be selectively programmed to generate an optional clock speed for a network to be coupled through RS485 interfaces **82** and **90** seen in FIG. 4. Network clock and control member **132** also provides detection means for detections of failure conditions on a linked network and provides control signals to system components in response thereto, including interrupt signals to programmable interrupt coordinator circuitry included in central processing interface **122**. Network clock and controller member **132** provides data encoding by the FMO standard, then the encoded data may be operated upon by RS485 interfaces **82** and **84** and transmitted and received by single twisted pair means to multiple serially networked

base transceiver units exemplified by base transceiver units **52A**, **52B**, and **52C** illustrated in FIG. 3.

Keyboard controller element **134** is coupled to central processing unit interface and provides a link exterior to ASIC **120** to keyboard **31** (See FIG. 3).

FLASH memory/EEPROM logic control member **136** is coupled to central processing unit interface **122** and comprises control functions for FLASH memory element **100** and EEPROM memory element **102** of FIG. 3.

Central processing unit interface **122** is also coupled by line **138** to latches exterior to ASIC **120**.

It is to be understood that the base transceiver units **52A**, **52B**, and **52C** illustrated in FIG. 3 are communicative with mobile transceiver units by electromagnetic radio means. The mobile transceiver units may be associated with bar code scanning devices such as the NORAND® 20/20 High Performance Bar Code Reader whereby the scanning devices scan an object having a bar code associated therewith and collect information stored in the bar code, which information is then transmitted through the mobile transceiver units to base transceiver units such as base transceiver units **52A**, **52B**, and **52C** or base transceiver unit **54** of FIG. 3. The bar code data received by said base transceiver units is then transmitted, in the example of FIG. 3, over network **50** by base transceiver units **52A**, **52B**, or **52C**, or over link **53** by base transceiver unit **54**, to network controller **40** which performs the routing and delivery of the data to the stationary data processor, or processors, such as shown for example, by host **42** of FIG. 3.

Description of FIGS. 7 through 11

FIG. 7 shows a block diagram of a particularly preferred intelligent base transceiver unit known as the RB4000. It will be observed that the components correspond with components of the network controller of FIG. 4, and similar reference numerals (preceded by 7-) have been applied in FIG. 7. Thus, the significance of components 7-70 through 7-73, 7-76, 7-82, 7-96, 7-98, 7-100 and 7-104 will be apparent from the preceding description with respect to FIG. 4 and 6, for example. I/O bus **700** may be coupled with a spread spectrum transmission (SST) or ultra high frequency (UHF) transceiver **701** which may correspond with any of the transceivers of units **52A**, **52B**, **52C** or **54** previously referred to. The network controller **70** could have a similar RF transceiver coupled with its data port **72** or **73** and controlled via input/output bus **400**, e.g. for direct RF coupling with router transceivers such as **901**, **901**, FIG. 9.

Referring to FIG. 8, a network controller **40** is shown with port **71** configured for interface with a host port type SNA V.35 56K/64K bits per second. Port **72** is shown as configured for communication with a personal computer of the PS/2 type operating asynchronously at 38.4K bits per second. Port **74** is coupled with a modem **8-60** providing for remote diagnostics and reprogramming of the network controller **40**.

Port **73** of network controller **40** is shown as being connected with an adapter component **801** known as the MBA3000. A specification for the MBA3000 is found in APPENDIX A following this detailed description. In the operating mode indicated in FIG. 8, the adapter **801** serves to couple controller **40** sequentially with four radio base transceiver units such as indicated at **811** through **814**. Component **811** is a commercially available radio base known as the RB3021 which utilizes features of Sojka U.S. Pat. No. 4,924,462 and of Mahany U.S. Pat. No. 4,910,794, both assigned to the present assignee, and the disclosures of which are hereby incorporated herein by reference in their entirety. Base station **811** may communicate with a multi-

licity of hand-held RF data terminals such as indicated at **821**. Details concerning base transceiver units **812** and **813**, **814** are found in the attached APPENDICES B and C, respectively. Base **814** is indicated as being coupled with the adaptor **801** via RF broadband modems **831** and **832**. Base units **813** and **814** may communicate with a variety of mobile transceiver units such as those indicated at **833**, **834** and **1001**, the first two being particularly described in APPENDICES D and E.

FIG. 9 shows two network controllers **40A** and **40B** each with its host ports configured as with the controller **40** of FIG. 8. In this example, the second ports **72** of the controllers **40A** and **40B** are configured for communication a relatively high data rate relatively along a distance network channel **56** which may have the characteristics of the serial channel **56** of FIG. 3, for example, an RS485 channel operating at 384 kilobits per second (384K bps). Network base transceivers **52A**, **52B** and **52C** may correspond with the correspondingly numbered transceiver units of FIG. 3, for example, and the network may have additional network transceivers such as **52D** which may support communication with the radio terminal **1001** for example. Furthermore, the network transceivers may have RF coupling with router transceiver units such as indicated at **901**, **902** and **903**. Router transceiver unit **902** is illustrated as a RB4000 intelligent transceiver such as represented in FIG. 7 and having its input/output bus **700** coupled with a peripheral.

FIG. 10 is entirely similar to FIG. 9, for example, except that ports **72** of the controllers **40A** and **40B** are coupled with separate serial type high data rate network channels, and ports **73** of the respective network controllers are coupled to a very high speed network e.g. in the megabit per second range such as an Ethernet local area network **1000**. Suitable interfaces are indicated at **1001** and **1002**.

FIG. 11 is entirely similar to FIG. 9 except that the ports **73** of the network controllers **40A** and **40B** are coupled with respective local area ring type networks which may be separate from each other and each have two or more hosts such as represented in FIG. 9 associated with the respective ring networks such as token rings **1100A** and **1100B**. Suitable interface means are indicated at **1101** and **1102**. Description of FIG. 12

FIG. 12 shows, for example, two network controllers **40A** and **40B**, each with two host computer units such as **42-1A**. Host **42-2A** is shown with a printer or other peripheral **P1** which may generate bar codes, for example, for replacement of damaged bar codes or the like. Another printer **P2** is shown associated with base **52C**, again for example, for producing bar code labels where those are needed in the vicinity of a base station. In a large warehouse, relatively large distances may be involved for a worker to return to a printer such as **P1** to obtain a new bar code label. Thus, it may be very advantageous to provide a printer **P2** at the base station **52C** which may be relatively close to a processing location which requires printed labels, e.g. a processing location in the vicinity of hand-held terminal **12-2** in FIG. 12. A base **52F** may have a peripheral **P3** associated therewith such as a large screen display, a printer or the like which may supplement the capabilities of a hand-held terminal, for example printing out new bar code labels at a convenient location, or providing a full screen display, rather than the more limited screen display area of the hand-held terminal **12-2**.

If, for example, a base radio **52D** which might be located at the ceiling level of a warehouse became inoperative at a time when qualified repair personnel were not immediately available, with the present system it would be feasible to

provide a substitute base radio or base radios, for example, as indicated at **52D1** located at table level or the like.

With the present system, the base radio stations do not necessarily forward data communications received from a given terminal to a particular host. For example, hand-held terminal **12-2** may request a path to printer **P2**, and such a path may be created via base stations **52D1** and **52C**. Station **52C** upon receipt of the message from terminal **12-2** would not transmit the message to a host but would, for example, produce the desired bar code label by means of printer **P2**. Further, terminal **12-2** may have provision for digitizing a voice message which might, for example, be addressed to terminal **12-1**. The system as illustrated would be operable to automatically establish a suitable path for example, via stations **52D1**, **52C**, **52B**, **52E** and **12-1** for the transmission of this voice message in digital form. Successive segments of such a voice message would be stored, for example, by the terminal **12-1**, and when the complete message was assembled, the segments would be synthesized into a continuous voice message for the user of terminal **12-1** e.g. by means of a speaker **1201** also useful for sending tone signals indicating valid bar code read, etc.

In accordance with the present invention, a hardware system such as illustrated in FIG. **12** may be physically laid out and then upon suitable command to one of the network controllers such as **42-2B**, the entire system would be progressively automatically self-configured for efficient operation. For example, controller **40B** could successively try its communications options with its output ports such as **71-73**, determining for example, that host processors were coupled with ports **71** and **72**, one operating on a 38.4 kilobit per second asynchronous basis and the other presenting a SNA port for the V.35 protocol at 64 kilobits per second. For example, one host, **42-1B** might be a main frame computer, while the other host **42-2B** might be a PS/2 type computer system. The controller **40B** having thus automatically configured itself so as to be compatible with the devices connected to ports **71** and **72**, could proceed to transmit via port **73** a suitable inquiry message to the network channel **56**. Each of the base stations could operate, for example, on a collision-sense multiple-access basis to respond to the inquiry message from the controller **40B**, until each of the successive bases on the network had responded and identified itself. Each base, for example, would have a respective unique address identification which it could transmit in response to the inquiry message so as to establish its presence on the network.

The controller **40B** could then transmit auto configure commands to the successive bases in turn, instructing the bases to determine what peripherals and router bases such as **52D1**, **52E** and **52F** were within the range of such base, and to report back to the controller. For example, bases such as **52C** and **52F** could determine the nature of peripherals **P2** and **P3** associated therewith so as to be able to respond to an inquiry from a terminal such as **12-2** to advise the terminal that a bar code printer, for example, was within direct RF range.

In the case of a breakdown of a component of the system such as **52D**, it would merely be necessary to place a router device such as **52D1** at a convenient location and activate the unit, whereupon the unit could send out its own broadcast inquiry which, for example, could be answered by the base stations **52C** and **52F**, station **52C** in turn, advising a relevant host or hosts of the activation of a substitute router station. Thus, the system is conveniently re-self-configured without the necessity for a technician familiar with the particular configuration procedure. As another example,

where the base stations are operating utilizing spread spectrum transmission, the introduction of barriers (such as a new stack of inventory goods) to such transmission between a given base such as **52A** and various terminals, could result in the base **52A** contacting router base **52E**, for example, with a request to become active with respect to the blocked terminals.

Description of FIG. **13**

FIG. **13** shows an intelligent integrated controller and radio base unit **1300** which is integrated into a single housing or case **1301** corresponding to the case or housing **20** of FIG. **2**. The housing **1301** may be provided with an external antenna as diagrammatically indicated at **1302** with suitable RF coupling to the radio circuitry indicated at **1303**. Components **13-70** through **13-74**, **13-76**, **13-78**, **13-96**, **13-97**, **13-98**, **13-100**, and **13-102** may correspond with the correspondingly numbered components described with reference to FIG. **4**.

SUPPLEMENTARY DISCUSSION

In accordance with the present disclosure, a network controller, or integrated network controller and radio unit is coupled to one or more host computers via a standard interface such as commonly encountered in practice (e.g. RS232, V.35, Ethernet, token ring, FDDI, and so on). In this way, no specialized interface or adapter is required for the host,

Since the preferred network controller can connect to two hosts, if one host is detected to have failed, or in the event of a system crash, loss of a communication link, or the like, the network controller can automatically switch to the second host. The second host may be a truly redundant system, or may be a simpler computer of the PC type (a so-called personal computer) that can simply store transactions until the main host is restored. As another example, a single host may have a second port coupled to a second port of the controller especially if a communication link failure may be a problem. For example, two ports of the network controller may be coupled by separate modems with separate phone lines, leading to separate ports of a single mainframe computer, for example an IBM3090. In a fully redundant system, two ports of a network controller may be connected respectively to two mainframe computers such as the IBM3090.

The disclosed network controller can also connect one radio network to two hosts using RS232 or V.35 ports or to many hosts using a local area network such as Ethernet, token ring, or FDDI. A number of the disclosed network controllers (for example, up to thirty-two) can be connected together to interface many hosts to a single radio network. The hand-held portable terminals in such a network can then talk to any of the hosts they choose.

For example where one port of the disclosed network controller is coupled via its RS232 interface to a mainframe computer such as the IBM3090, another of its ports may be coupled via an FDDI network with a super computer e.g. the Cray X-MP. Then mobile and/or portable terminals can access either the main frame or the super computer, or in general, any of the hosts that are connected to the network controller.

As indicated in FIG. **9**, four hosts can be on one network. Referring to FIGS. **10** and **11**, a multiplicity of hosts may be coupled with each local area network so as to be in communication with one or more of the disclosed network controllers. Furthermore, a single disclosed network controller can control two radio networks such as the one

indicated at **50** in FIG. **3**. Where each network such as **50** is limited to thirty-two devices, the number of devices is doubled with the use of two radio networks. Two such radio networks may also be utilized for the sake of redundancy, with a provision for automatic switch-over from one radio network to the second if a problem develops on the first. Two radio networks may also facilitate the use of different radio technologies in one installation.

The various multi-drop local area networks referred to herein, for example at **7-82** in FIG. **7** and as represented at **56, 56A, 56B, FIGS. 9 through 12**, and at **13-82** in FIG. **13** may comprise HDLC based local area networks operating at up to 2.5 megabits per second and using biphasic space encoding (FM0) for clock recovery from data.

The components **86** and **94**, FIG. **4**, and component **13-11**, FIG. **13**, provides a low-cost base radio interface using three pairs of twisted conductors. One pair provides a bidirectional RS485 data line. Another pair is used for the clock and has an RS422 electrical configuration, and is one directional from the radio to the controller. The third twisted pair is also RS422 and is used to communicate from the controller to the radio transceiver to effect mode selection.

Since it is advantageous to operate the network and router RF transceiver units so as to be compatible with existing mobile data collection terminals such as shown in APPENDIX D1 et seq., a preferred mode of operation is based on the RTC protocol as disclosed in the aforementioned incorporated Mahany and Sojka patents and the following pending applications:

- (1) U.S. Ser. No. 07/389,727 filed Aug. 4, 1989, now U.S. Pat. No. 5,070,536.
- (2) European Published Patent Application EPO 353759 published Feb. 7, 1990.
- (3) U.S. Ser. No. 07/485,313 filed Feb. 26, 1990, now abandoned.

The disclosures of applications (1), (2) and (3) are hereby incorporated herein by reference in their entirety.

An aspect of the invention resides in the provision of a network controller having port means selectively configurable for coupling in first mode with network RF transceiver units at a relatively high data rate such as 100 kilobits per second or higher, and for coupling in a second mode with network transceiver units at a relatively low data rate such as about twenty kilobits per second. Preferably a single port means such as **2, 3** or **5, 6**, FIG. **5**, can be software configured to interface selectively in the first mode or in the second mode. It is presently less expensive to use two connectors per port rather than a single 37-pin connector for example.

Where a network controller such as **40** operates two high data rate networks, for example, one network of RF base transceivers could operate with the RTC protocol, and the second network could operate according to a different protocol such as that disclosed in pending application Ser. No. 07/660,618 filed on or about Feb. 25, 1991, now abandoned, the disclosure of which being incorporated herein by reference in its entirety.

It will be apparent that many modifications and variations may be effected without departing from the scope of the teachings and concepts of the present disclosure.

Having described the invention, we claim:

1. In a data communication network having a plurality of mobile transceiver units selectively communicative with a plurality of base transceiver units, a method of automatically configuring the data communication network, executable by a network controller having a plurality of communication ports, comprising:

attempting communication on each of the plurality of communication ports;

determining what type of communication protocol is being utilized by devices or network channels connected to each of the plurality of communication ports; automatically configuring the plurality of communication ports to be communicatively compatible, according to the determined communication protocol, with devices or network channels connected to each of the plurality of communication ports;

transmitting over a network channel connected to one of the plurality of communication ports an inquiry message to the plurality of base transceiver units;

receiving from the plurality of base transceiver units a response message indicating an identification of each of the plurality of base transceiver units;

transmitting to each of the plurality of base transceiver units auto-configure commands instructing the base transceiver units to determine what devices such as peripherals and router bases are within range of each of the plurality of base transceiver units; and

receiving from each of the plurality of base transceiver units a report of the devices such as peripherals and router bases that are within range of each of the plurality of base transceiver units.

2. In a data communication system comprising a plurality of mobile transceiver units selectively communicative with a plurality of base transceiver units, a control system comprising:

switching circuitry that supports communication among the plurality of mobile transceiver units via the plurality of base transceiver units;

a plurality of host computers coupling with the switching circuitry; and

the switching circuitry selectively enables communication between the plurality of host computers and the plurality of mobile transceiver units.

3. The control system of claim 2, wherein communication between the plurality of host computers and the plurality of mobile transceiver units is selectively enabled to support redundancy.

4. The control system of claim 2, wherein communication between the plurality of host computers and the plurality of mobile transceiver units is selectively enabled in response to detected failure of one of the plurality of host computers.

5. The control system of claim 2, wherein the switching circuitry comprises at least one network controller, and wherein the plurality of host computers communicate with the plurality of base transceivers through multiple communication ports of the at least one network controller.

6. The control system of claim 5, wherein the multiple communication ports of the at least one network controller are automatically configured by the at least one network controller to be compatible with each of the plurality of host computers.

7. A data communication system comprising:

a first wireless transceiver that participates on a first wireless channel to support communication within a cell;

a first plurality of wireless devices that participate on the first wireless channel;

a second wireless transceiver that participates on a second wireless channel to support communication within the cell;

a second plurality of wireless devices that participate on the second wireless channel;

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the first and second wireless channels being communica-
tively incompatible with one another; and

a control circuit, communicatively coupled to both the
first and second wireless transceivers, that supports
communication among the first and second pluralities
of wireless devices. 5

8. The data communication system of claim **7** wherein the
first wireless channel supports a different radio technology
from that supported by the second wireless channel.

9. The data communication system of claim **7** at least one
of the first plurality of wireless devices roams through the
cell. 10

10. The data communication system of claim **7** further
comprising a wired link and a computing device, and the
control circuit communicatively couples the computing
device with the first and second pluralities of wireless
devices via the wired link. 15

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11. The data communication system of claim **10** wherein
the wired link comprises a wired network.

12. The data communication system of claim **10** further
comprising a redundant computing device coupled to the
control circuit.

13. The data communication system of claim **7** compris-
ing a third wireless transceiver that participates on a third
wireless channel to support communication outside of the
cell.

14. The data communication system of claim **12** further
comprising a remote wireless device, and the third wireless
transceiver participates to support longer distance commu-
nication with the remote wireless device than that supported
by the first and second wireless transceivers with the first
and second pluralities of wireless devices within the cell.

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