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United States Patent [19]

Stutman et al.

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[45] **Date of Patent: *Nov. 19, 1996**

[54] **MEDICAL ALERT DISTRIBUTION SYSTEM WITH SELECTIVE FILTERING OF MEDICAL INFORMATION**

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[73] Assignee: **Metriplex, Inc.**, Mass.

[*] Notice: The term of this patent shall not extend beyond the expiration date of Pat. No. 5,416,695.

[21] Appl. No.: **28,333**

[22] Filed: **Mar. 9, 1993**

[51] **Int. Cl.**[6] **G06F 17/30**; G06F 17/00

[52] **U.S. Cl.** **364/413.02**; 128/670; 128/700; 128/702; 364/413.03; 364/DIG. 1; 379/38; 395/200.03

[58] **Field of Search** 395/600, 148, 395/161, 575; 128/710, 677, 670, 702; 364/413.02, 413.03; 379/38

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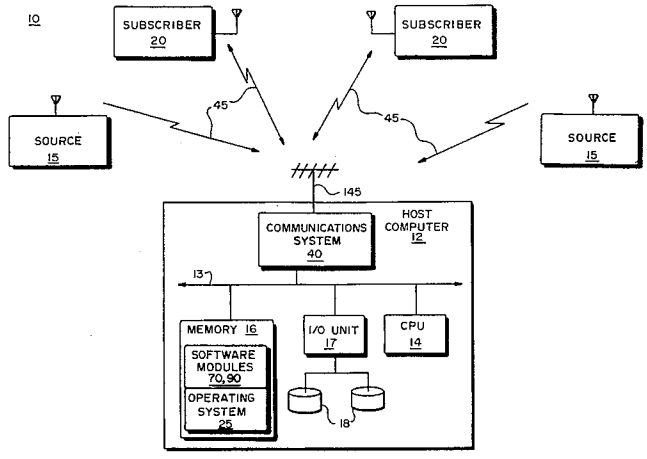
Primary Examiner—Wayne Amsbury
Assistant Examiner—Hosain T. Alam
Attorney, Agent, or Firm—Cesari & McKenna

[57] **ABSTRACT**

The present invention relates to a medical alert distribution system which receives medical information (e.g. blood pressure, blood chemistry test results, etc.) from monitoring units worn by ambulatory patients. The system also receives medical selection and limit parameters from remote system subscriber units (e.g., a unit accessed by a doctor). The system repeatedly compares the medical information received form the ambulatory patients to determine if a selected parameter, as indicated by an asserted in-alert flag, has exceeded the limit parameters received form the remote subscriber units. If exceeded, the system sends a message (e.g., via a wireless paging message) to the system subscriber unit(s) which requested that the particular parameter be continuously compared against the selected limit parameters. Thus, the system selectively filters information and distributes filtered information to a subscriber processing unit by way of communications network.

13 Claims, 15 Drawing Sheets



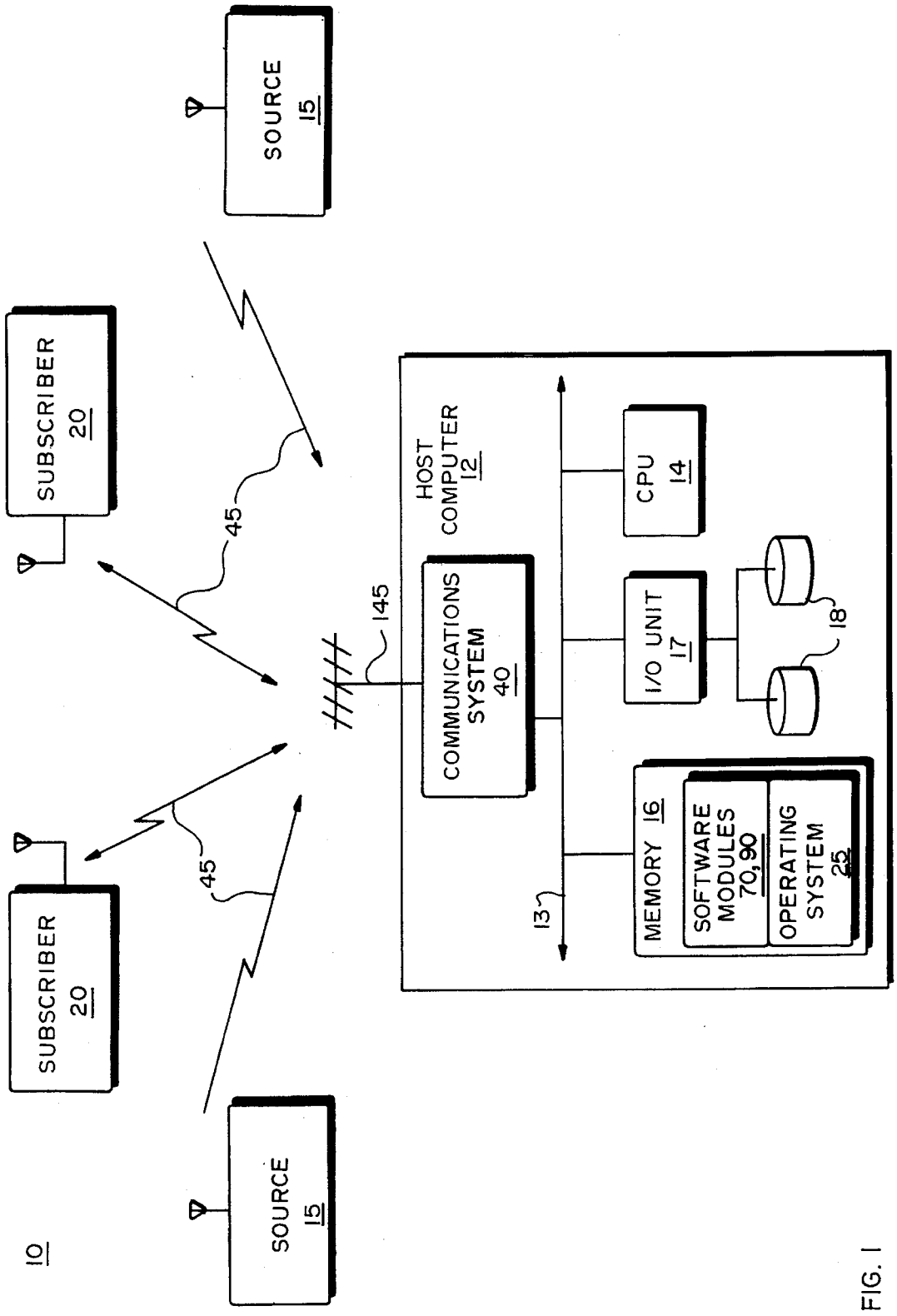

SOURCE 15
SUBSCRIBER 20
45
SUBSCRIBER 20
45
SOURCE 15
10
145
HOST COMPUTER 12
COMMUNICATIONS SYSTEM 40
CPU 14
I/O UNIT 17
18
13
MEMORY 16
SOFTWARE MODULES 70,90
OPERATING SYSTEM 25

FIG. 1

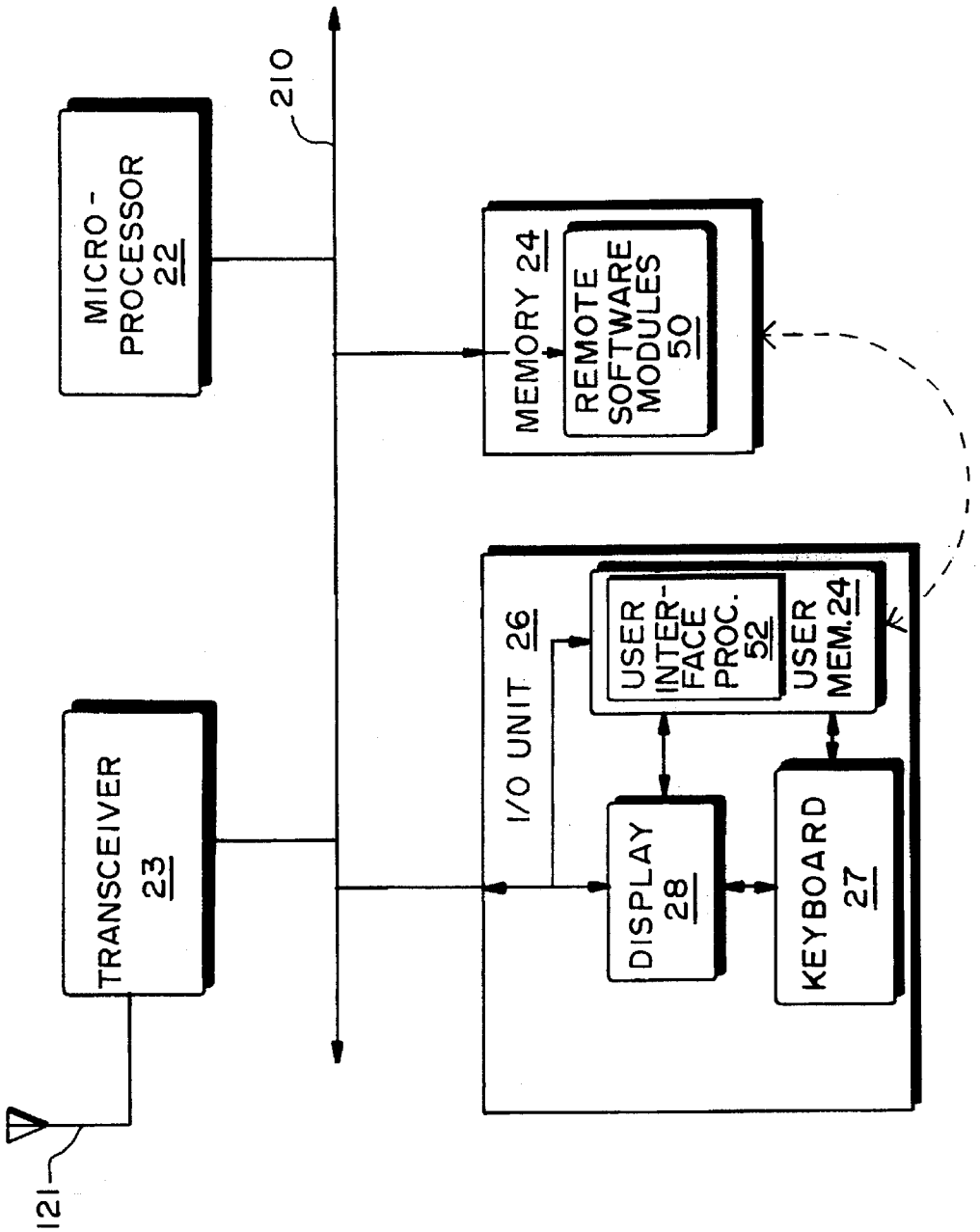

MICRO-PROCESSOR 22
210
MEMORY 24
REMOTE SOFTWARE MODULES 50
I/O UNIT 26
USER INTER-FACE PROC. 52
USER MEM. 24
DISPLAY 28
KEYBOARD 27
TRANSCEIVER 23
121
20

FIG. 2

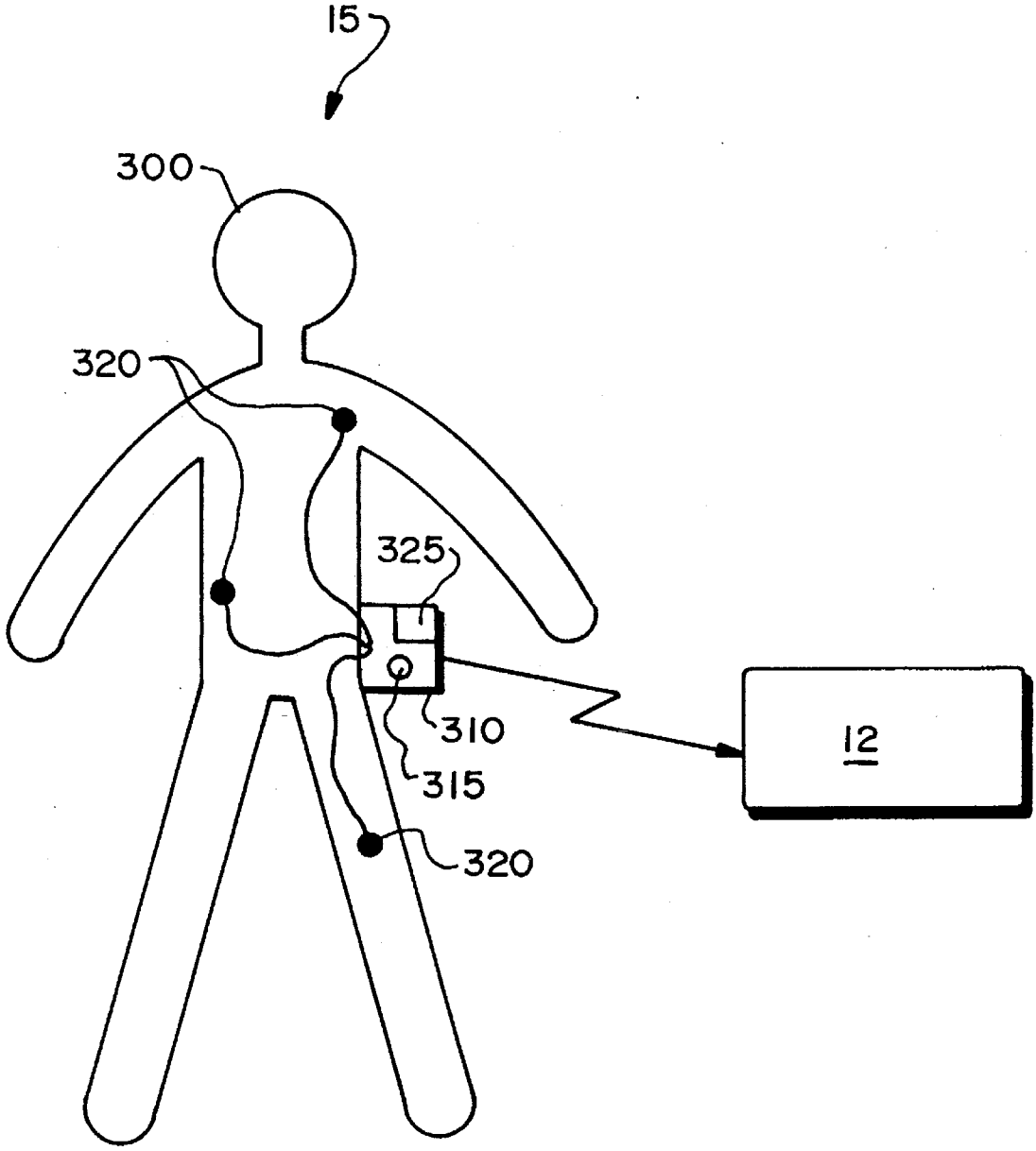


FIG. 3

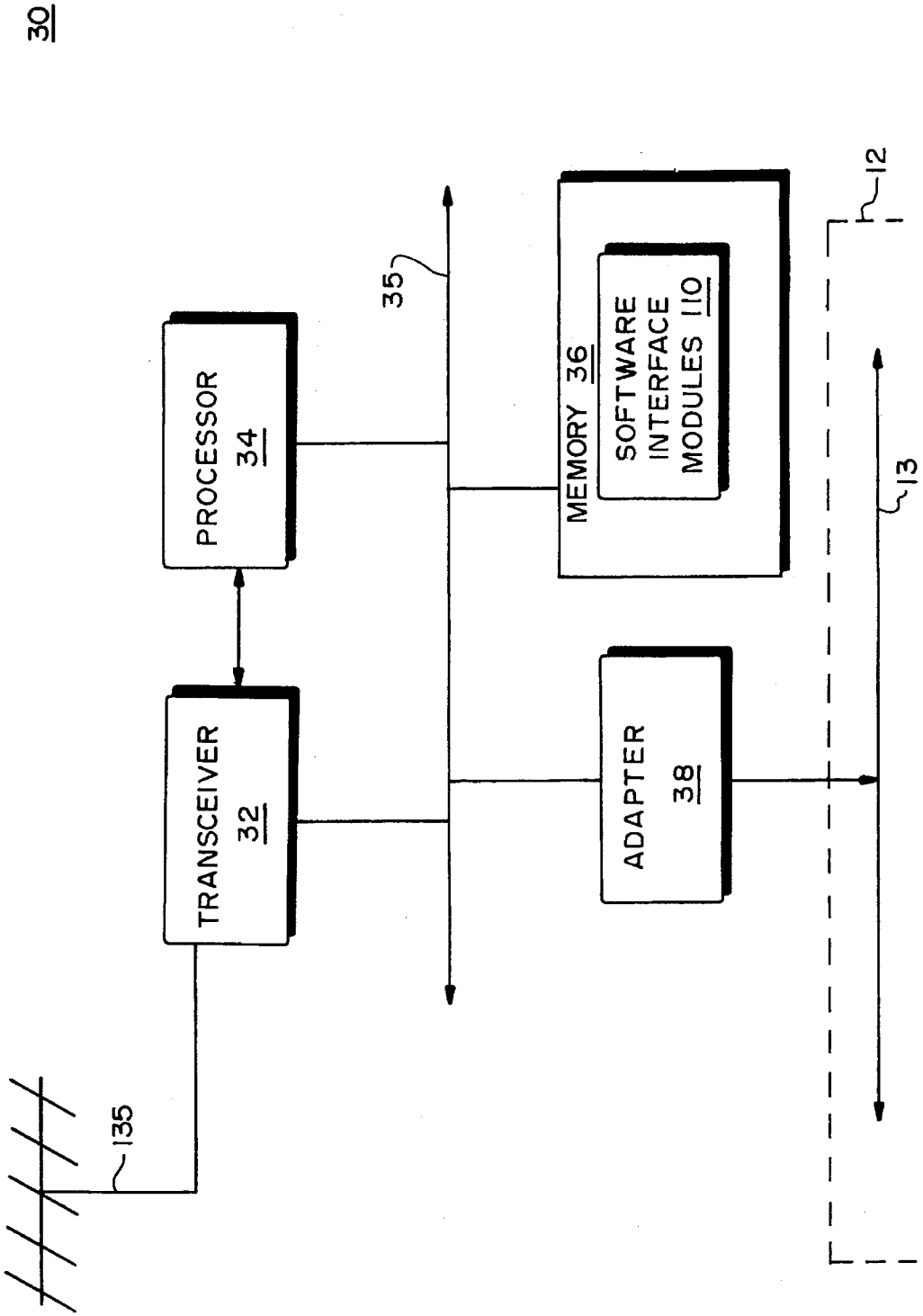

30
PROCESSOR 34
TRANSCEIVER 32
ADAPTER 38
MEMORY 36
SOFTWARE INTERFACE MODULES 110
35
12
13
135

FIG. 4

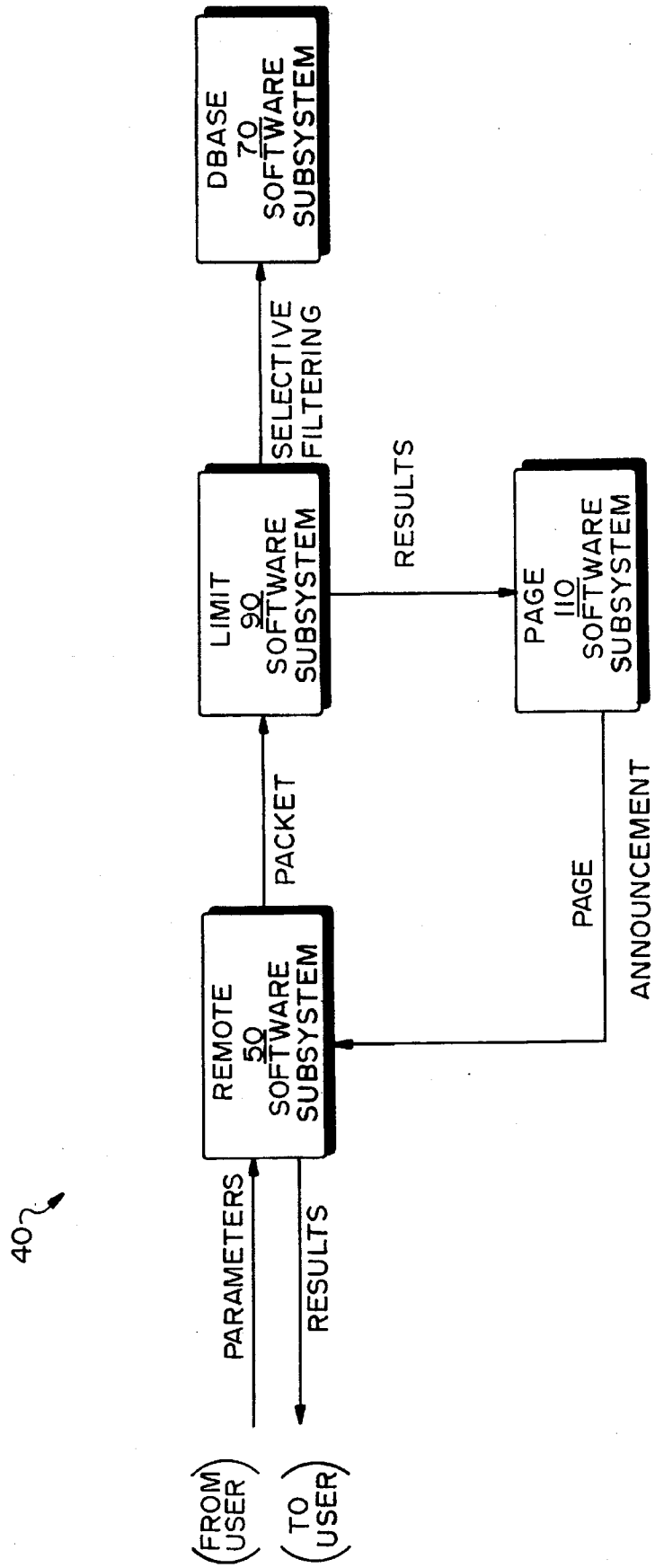

40
REMOTE 50 SOFTWARE SUBSYSTEM
LIMIT 90 SOFTWARE SUBSYSTEM
PAGE 110 SOFTWARE SUBSYSTEM
DBASE 70 SOFTWARE SUBSYSTEM
PARAMETERS
RESULTS
(FROM USER)
(TO USER)
PACKET
SELECTIVE FILTERING
RESULTS
PAGE
ANNOUNCEMENT

FIG. 5

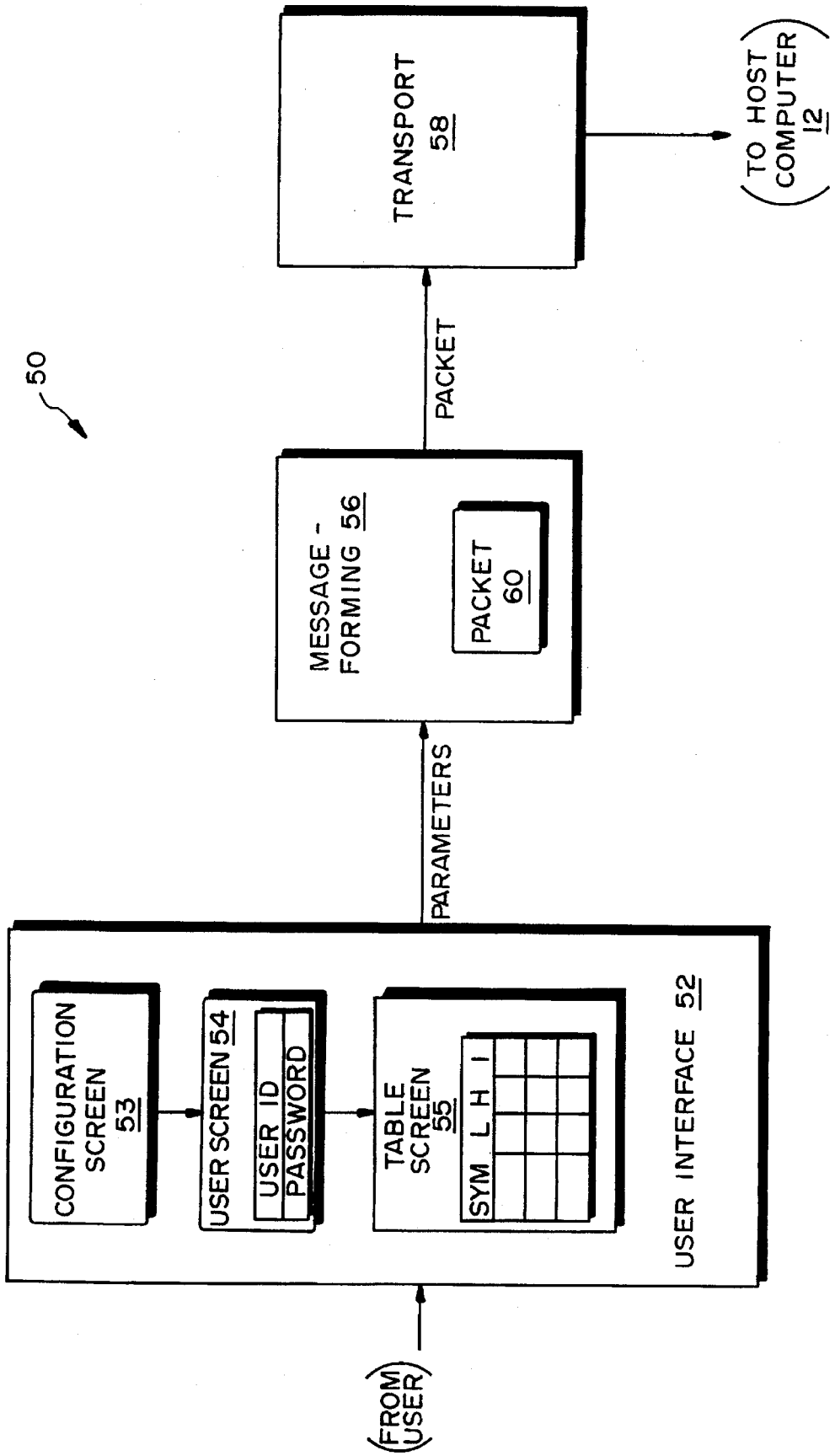

50
(FROM USER)
USER INTERFACE 52
CONFIGURATION SCREEN 53
USER SCREEN 54
USER ID
PASSWORD
TABLE SCREEN 55
SYM L H I
PARAMETERS
MESSAGE - FORMING 56
PACKET 60
PACKET
TRANSPORT 58
(TO HOST COMPUTER 12)

FIG. 6

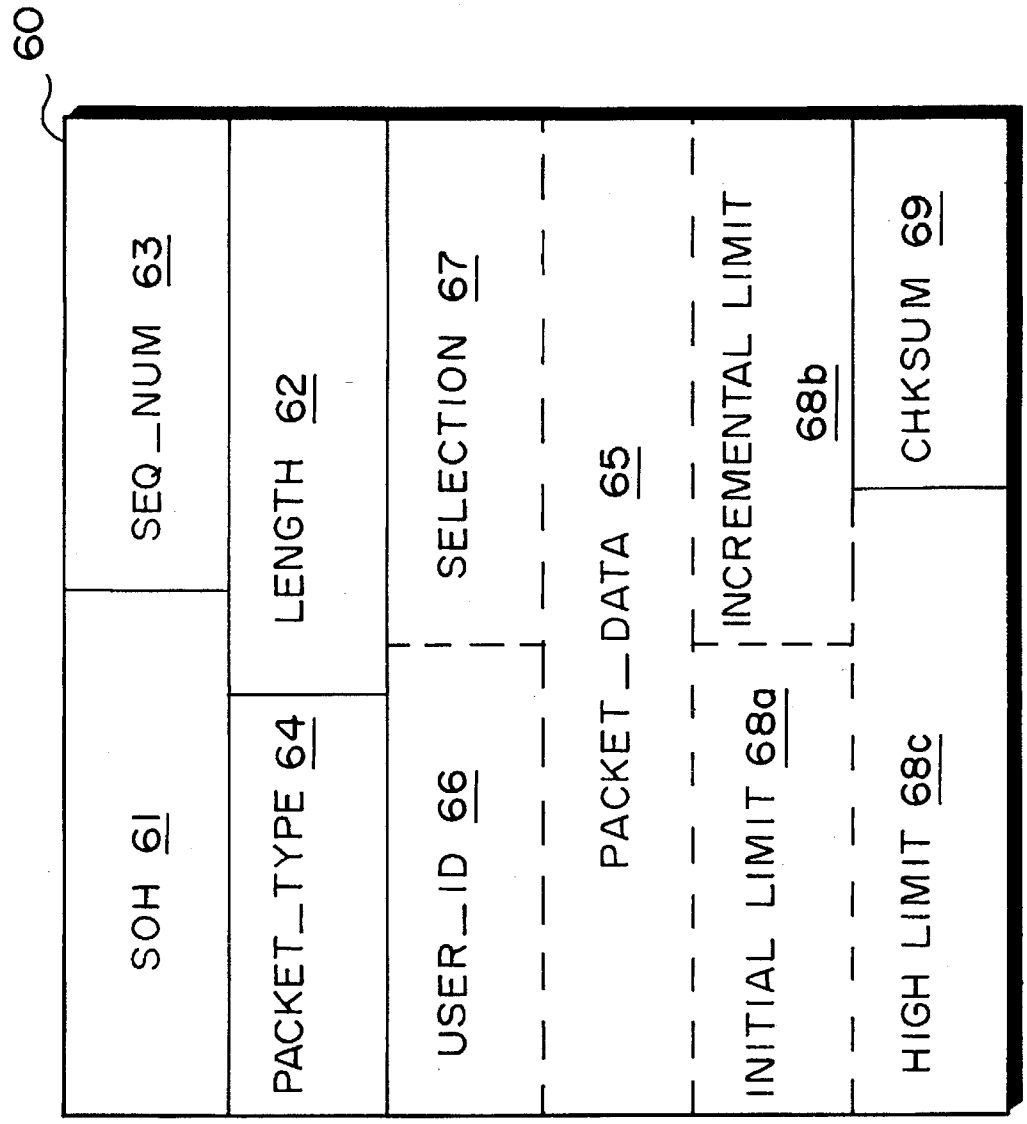

60
SOH 61
SEQ_NUM 63
PACKET_TYPE 64
LENGTH 62
USER_ID 66
SELECTION 67
PACKET_DATA 65
INITIAL LIMIT 68a
INCREMENTAL LIMIT 68b
HIGH LIMIT 68c
CHKSUM 69

FIG. 7

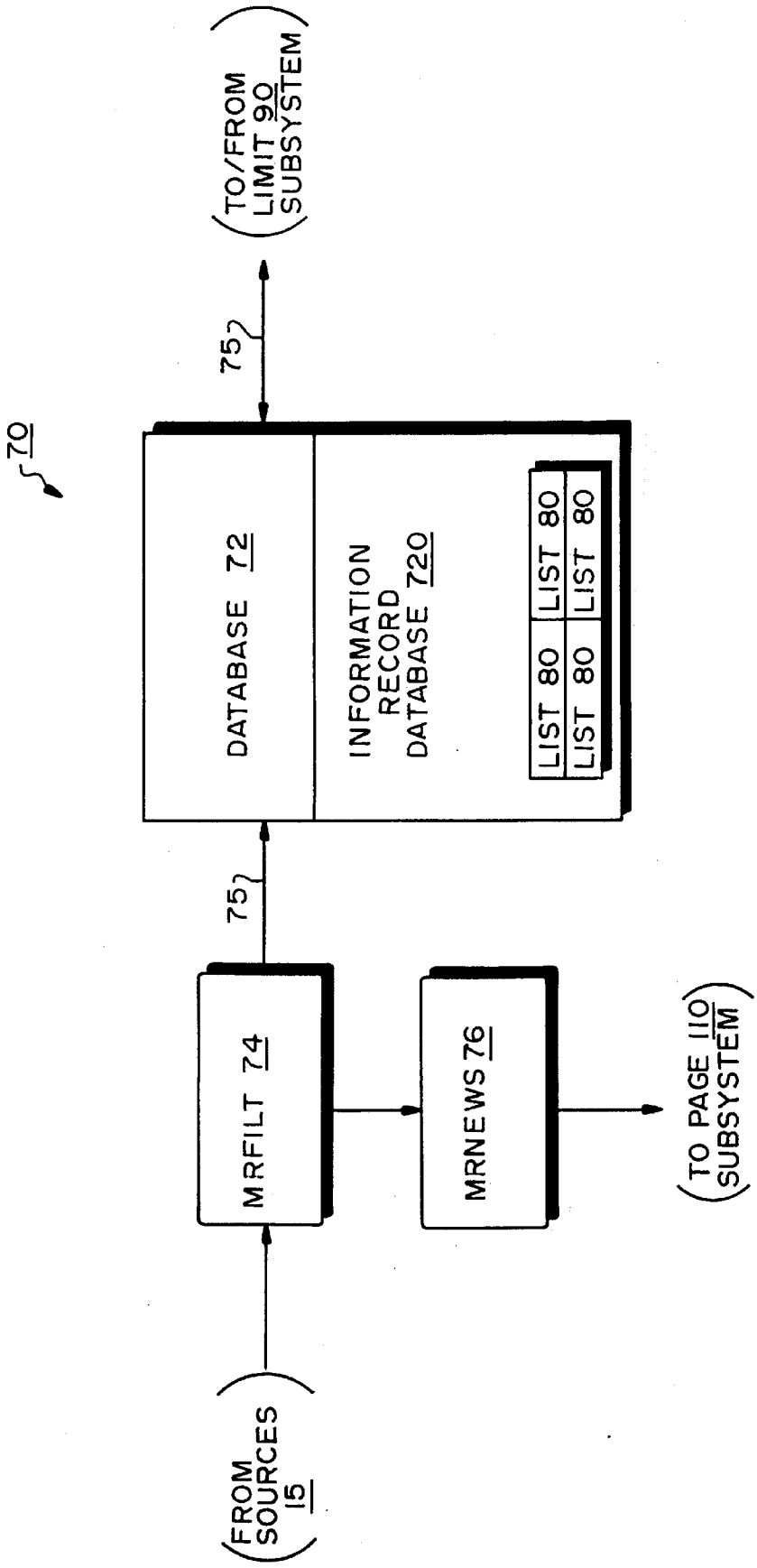

70
(TO/FROM LIMIT 90 SUBSYSTEM)
75
DATABASE 72
INFORMATION RECORD DATABASE 720
LIST 80
LIST 80
LIST 80
LIST 80
75
MRFILT 74
MRNEWS 76
(TO PAGE 110 SUBSYSTEM)
(FROM SOURCES 15)

FIG. 8

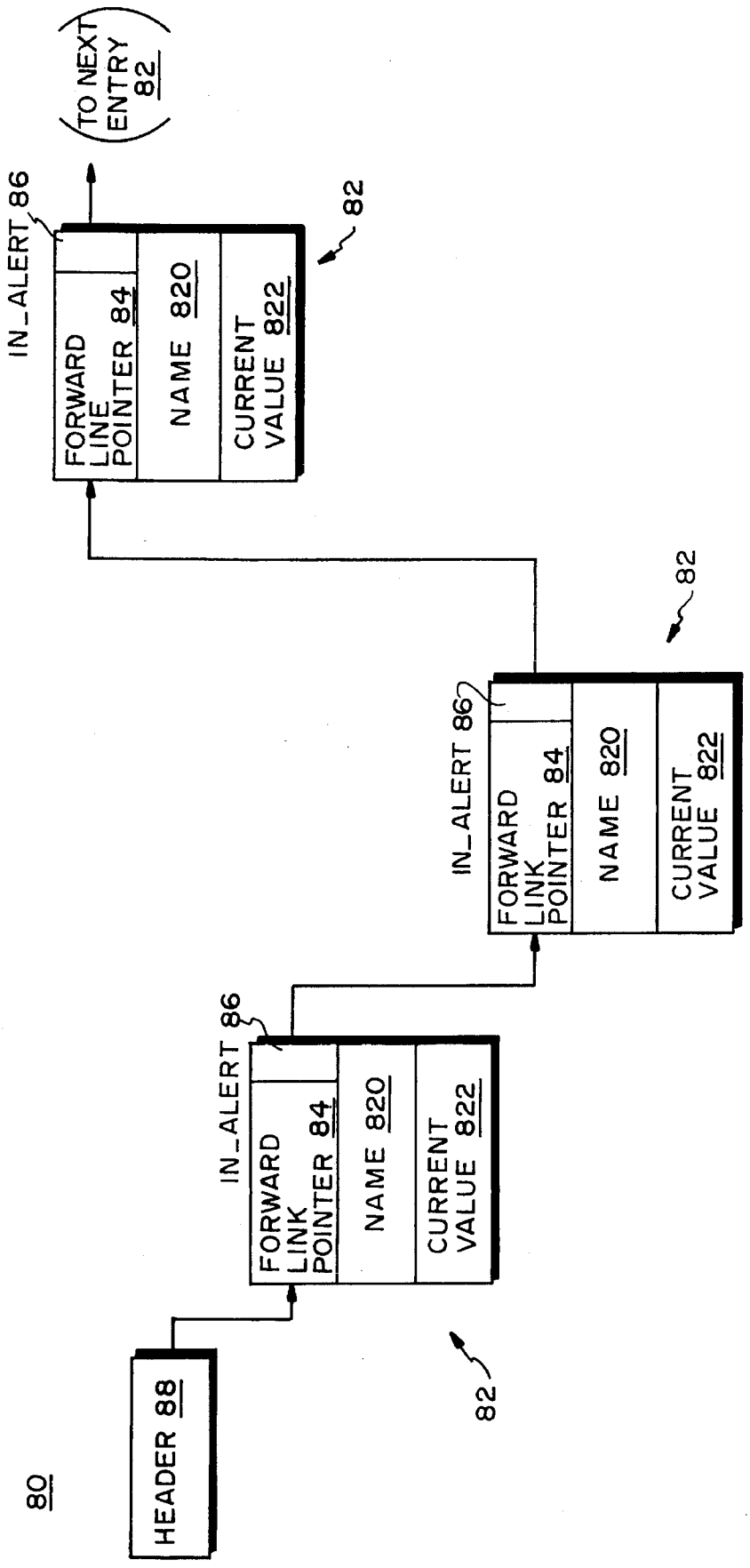

80
HEADER 88
82
IN_ALERT 86
FORWARD LINK POINTER 84
NAME 820
CURRENT VALUE 822
82
IN_ALERT 86
FORWARD LINK POINTER 84
NAME 820
CURRENT VALUE 822
82
IN_ALERT 86
FORWARD LINK POINTER 84
NAME 820
CURRENT VALUE 822
TO NEXT ENTRY 82

FIG. 9

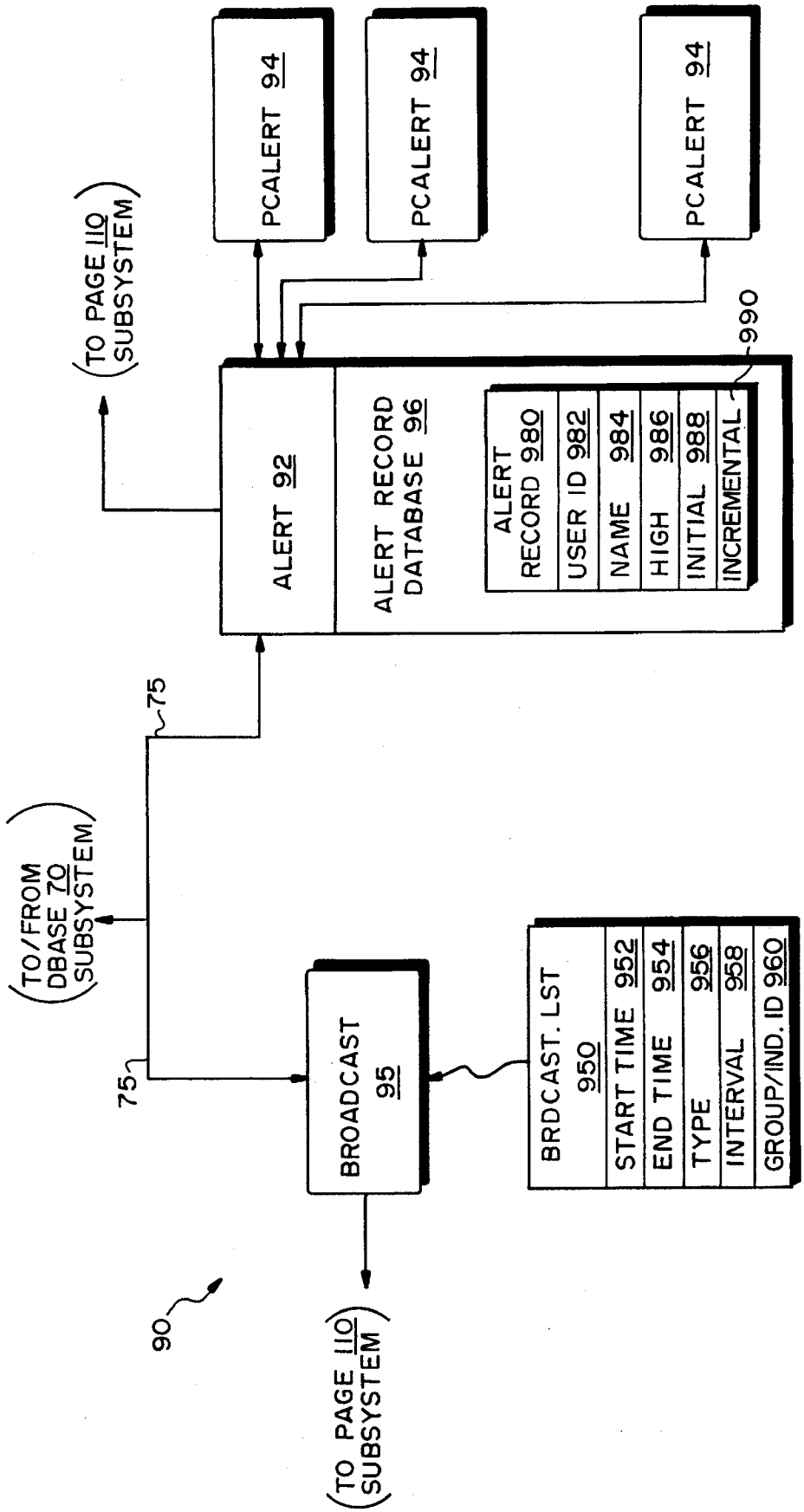

PCALERT 94
PCALERT 94
PCALERT 94
(TO PAGE 110 SUBSYSTEM)
990
ALERT 92
ALERT RECORD DATABASE 96
ALERT RECORD 980
USER ID 982
NAME 984
HIGH 986
INITIAL 988
INCREMENTAL
75
(TO/FROM DBASE 70 SUBSYSTEM)
75
BROADCAST 95
BRDCAST. LST 950
START TIME 952
END TIME 954
TYPE 956
INTERVAL 958
GROUP/IND. ID 960
90
(TO PAGE 110 SUBSYSTEM)

FIG. 10

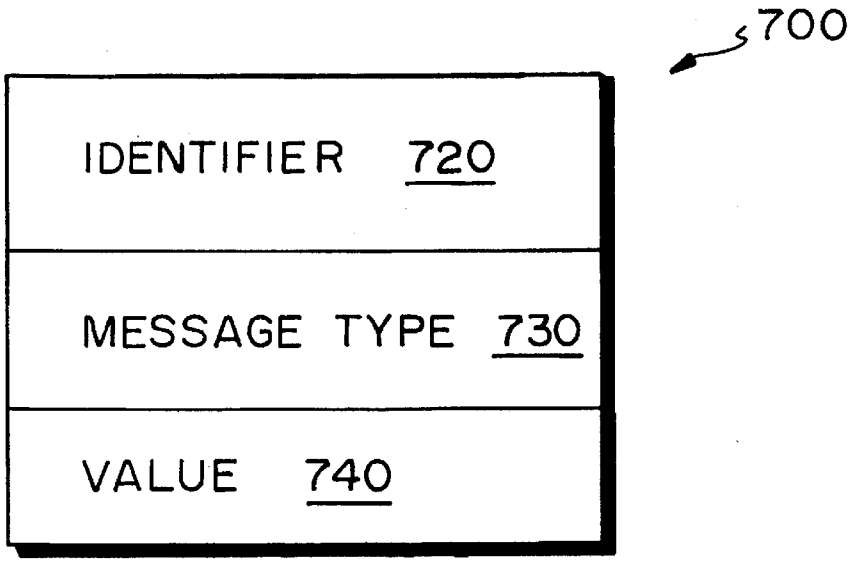


FIG. 11A

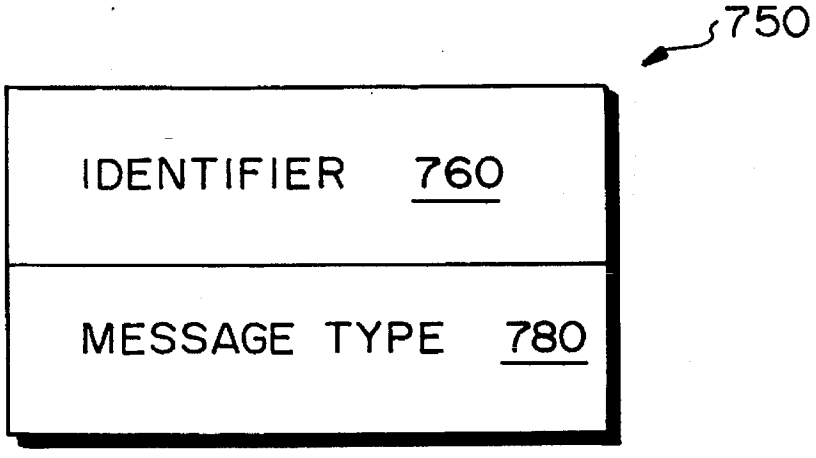


FIG. 11B

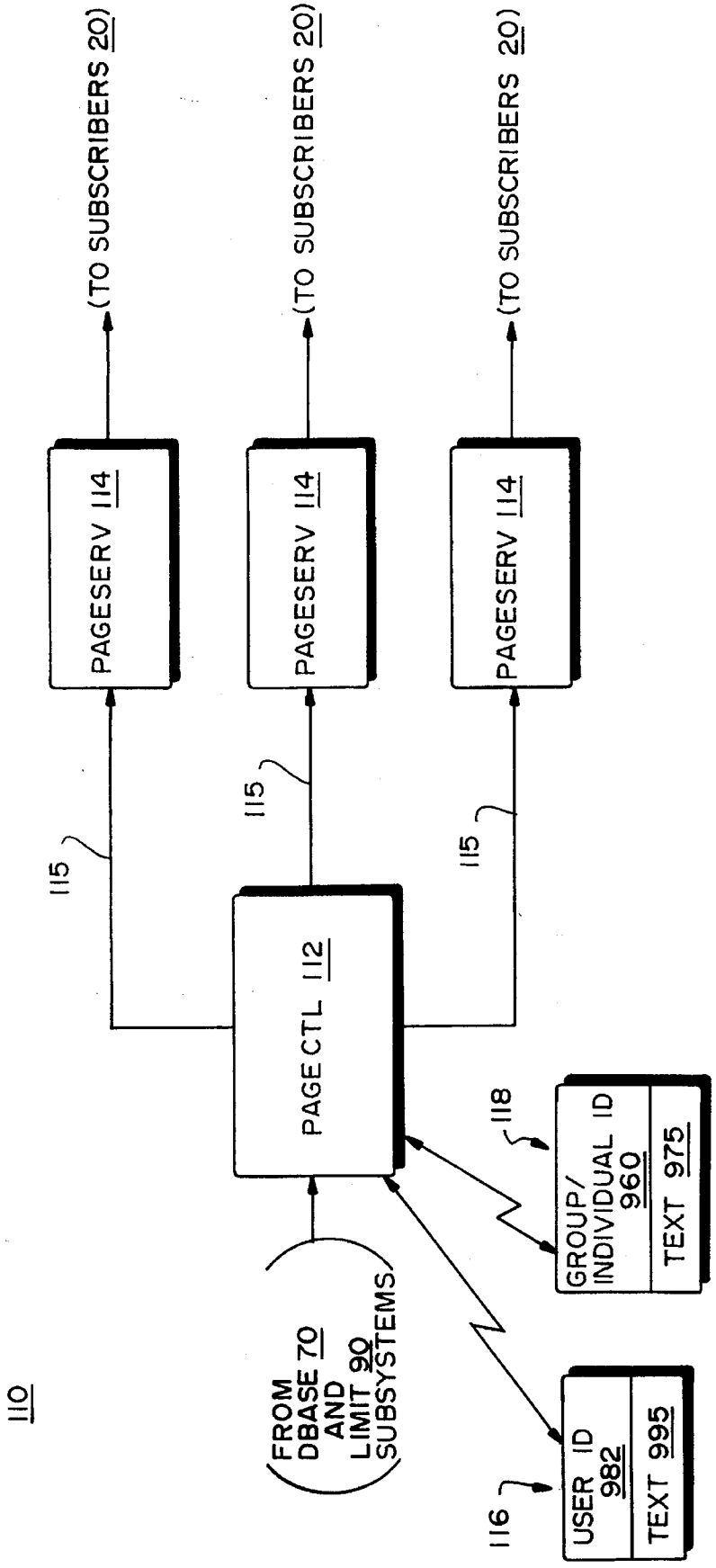

(TO SUBSCRIBERS 20)
(TO SUBSCRIBERS 20)
(TO SUBSCRIBERS 20)
PAGESERV 114
PAGESERV 114
PAGESERV 114
115
115
115
PAGE CTL 112
118
GROUP/ INDIVIDUAL ID 960
TEXT 975
FROM DBASE 70 AND LIMIT 90 SUBSYSTEMS
USER ID 982
TEXT 995
116
110

FIG. 12

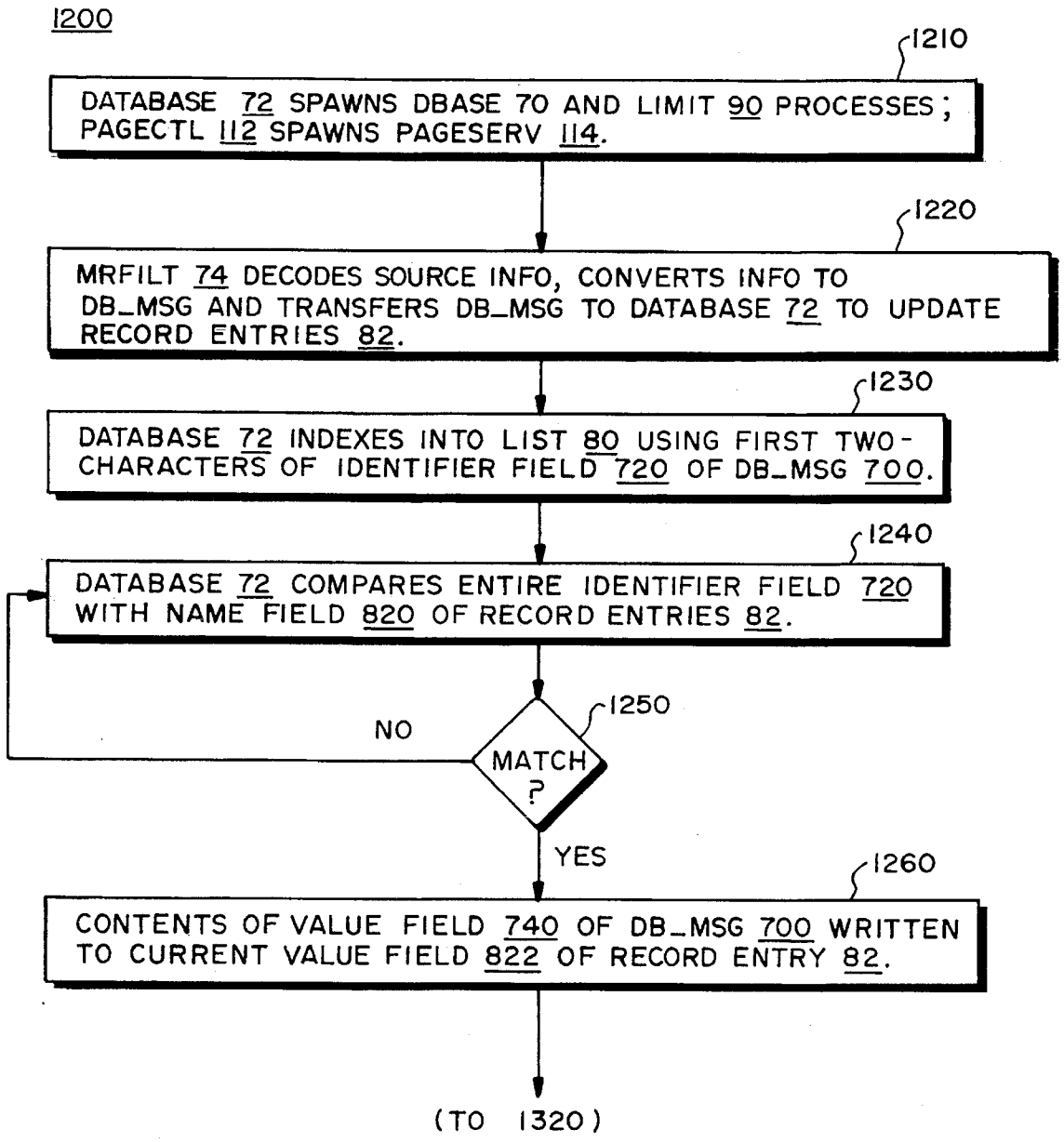

1200
1210
DATABASE 72 SPAWNS DBASE 70 AND LIMIT 90 PROCESSES; PAGECTL 112 SPAWNS PAGESERV 114.
1220
MRFILT 74 DECODES SOURCE INFO, CONVERTS INFO TO DB_MSG AND TRANSFERS DB_MSG TO DATABASE 72 TO UPDATE RECORD ENTRIES 82.
1230
DATABASE 72 INDEXES INTO LIST 80 USING FIRST TWO-CHARACTERS OF IDENTIFIER FIELD 720 OF DB_MSG 700.
1240
DATABASE 72 COMPARES ENTIRE IDENTIFIER FIELD 720 WITH NAME FIELD 820 OF RECORD ENTRIES 82.
1250
MATCH ?
NO
YES
1260
CONTENTS OF VALUE FIELD 740 OF DB_MSG 700 WRITTEN TO CURRENT VALUE FIELD 822 OF RECORD ENTRY 82.
(TO 1320)

FIG. 13A

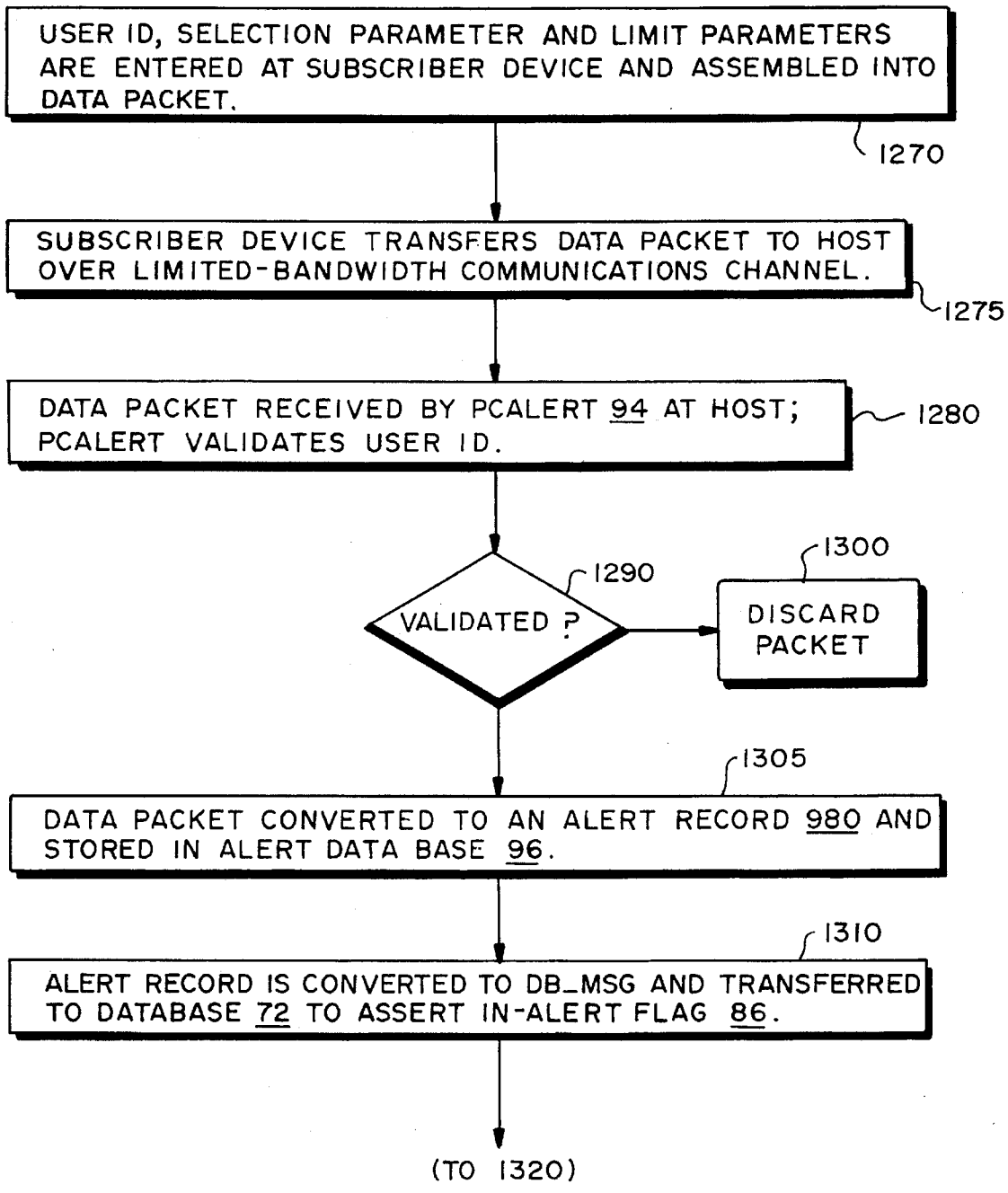

USER ID, SELECTION PARAMETER AND LIMIT PARAMETERS ARE ENTERED AT SUBSCRIBER DEVICE AND ASSEMBLED INTO DATA PACKET.
1270
SUBSCRIBER DEVICE TRANSFERS DATA PACKET TO HOST OVER LIMITED-BANDWIDTH COMMUNICATIONS CHANNEL.
1275
DATA PACKET RECEIVED BY PCALERT 94 AT HOST; PCALERT VALIDATES USER ID.
1280
VALIDATED ?
1290
DISCARD PACKET
1300
DATA PACKET CONVERTED TO AN ALERT RECORD 980 AND STORED IN ALERT DATA BASE 96.
1305
ALERT RECORD IS CONVERTED TO DB_MSG AND TRANSFERRED TO DATABASE 72 TO ASSERT IN-ALERT FLAG 86.
1310
(TO 1320)

FIG. 13B

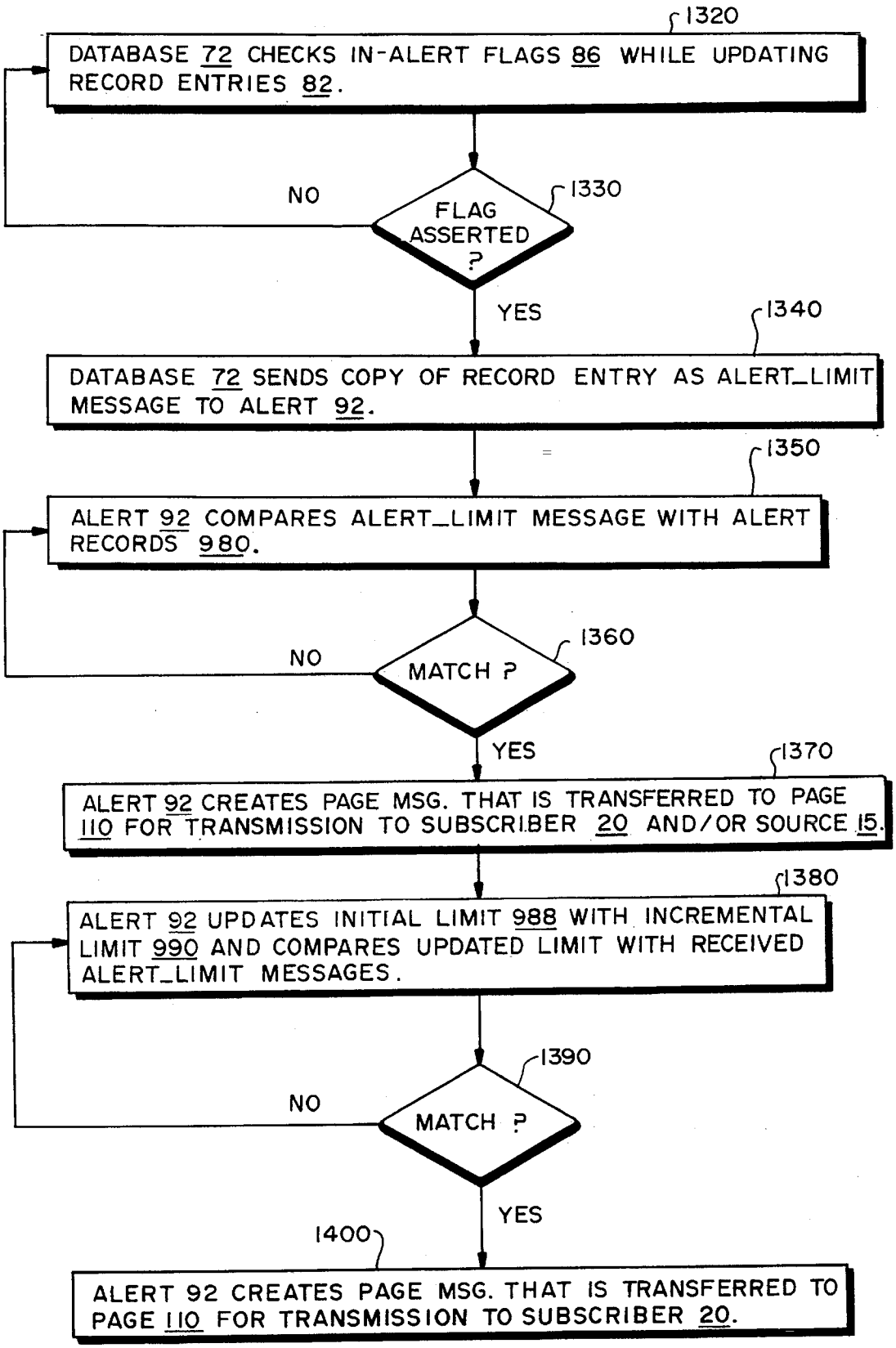

1320
DATABASE 72 CHECKS IN-ALERT FLAGS 86 WHILE UPDATING RECORD ENTRIES 82.
1330
FLAG ASSERTED ?
NO
YES
1340
DATABASE 72 SENDS COPY OF RECORD ENTRY AS ALERT_LIMIT MESSAGE TO ALERT 92.
1350
ALERT 92 COMPARES ALERT_LIMIT MESSAGE WITH ALERT RECORDS 980.
1360
MATCH ?
NO
YES
1370
ALERT 92 CREATES PAGE MSG. THAT IS TRANSFERRED TO PAGE 110 FOR TRANSMISSION TO SUBSCRIBER 20 AND/OR SOURCE 15.
1380
ALERT 92 UPDATES INITIAL LIMIT 988 WITH INCREMENTAL LIMIT 990 AND COMPARES UPDATED LIMIT WITH RECEIVED ALERT_LIMIT MESSAGES.
1390
MATCH ?
NO
YES
1400
ALERT 92 CREATES PAGE MSG. THAT IS TRANSFERRED TO PAGE 110 FOR TRANSMISSION TO SUBSCRIBER 20.

FIG. 13C

MEDICAL ALERT DISTRIBUTION SYSTEM WITH SELECTIVE FILTERING OF MEDICAL INFORMATION

CROSS-REFERENCE TO RELATED APPLICATION

This invention is related to U.S. patent applications Ser. No. 08/028,351, now U.S. Pat. No. 5,416,695 issued to Stutman et al, titled METHOD AND APPARATUS FOR ALERTING MEDICAL PERSONNEL OF EMERGENCY MEDICAL CONDITIONS, and Ser. No. 08/028,356, titled REMOTE LIMIT-SETTING INFORMATION DISTRIBUTION SYSTEM, each filed Mar. 9, 1993 and each assigned to the assignee of the present invention.

FIELD OF THE INVENTION

This invention relates generally to information retrieval and distribution systems and, more specifically, to a medical alert distribution system.

BACKGROUND OF THE INVENTION

Information retrieval and distribution systems are typically characterized by the efficiency with which they can retrieve, update and distribute large amounts of information to authorized subscribers in real time. These systems are commonly used in financial and securities market applications where data acquisition and distribution techniques permit each subscriber to access only the type of information for which it is authorized.

What is needed is an information and distribution system of the type discussed above, but for medical information applications. Such an information system should have the ability to collect medical information from both stationary and mobile sources, the latter being ambulatory patients. For the latter case, the system should have the capability to detect the geographic location of the patient. Moreover, the system should allow authorized subscribers, such as health care givers, to enter limits and conditions from a remote location, and have those limits and conditions operate on the collected information and report back the results to the health care givers.

SUMMARY OF THE INVENTION

The invention resides in a medical alert distribution system for selectively filtering information at a host computer prior to distributing the filtered information to a remote processing device or "subscriber" by way of a communications network. The information may be stored in a database residing in a subsystem of an independent device that is coupled to the host computer or it may be contained in a database subsystem within the host computer; alternatively, the information may be provided directly to the host computer from a source by way of high-speed streams of data or by data packets.

Software modules resident in a "limit" software subsystem of the host computer are organized to interface with software modules resident in the database subsystem to selectively filter the information in response to selection and limit parameters provided by an authorized user of the subscriber. The software modules of the limit and database subsystems embody a plurality of independent processes, each of which perform specific operations.

In an exemplary embodiment of the invention, a "database" software process maintains a primary database of information records received from the sources and transfers the contents of the records to other processes upon request. Each database record includes an alert flag which, when asserted, directs the database process to transfer the contents of the record to an "alert" process of the limit subsystem.

The alert process maintains its own database of "alert records". In one embodiment of the invention, each alert record includes a selection parameter and "initial" and "incremental" limit parameters; however, in the exemplary embodiment, the alert record also includes a "high" limit parameter as provided by the subscriber. When the contents of a record are received in response to an asserted alert flag, the second process compares the received contents with a specific limit of its records and if a match occurs, the subscriber is notified of the condition, preferably by paging transmission. For example, the record contents are compared with the initial limit and, upon a match condition, the second process updates the initial limit parameter with the incremental limit. This updated parameter is compared with the contents of records subsequently received by the alert process and the subscriber is again notified of a sailsifted limit condition.

One advantage provided by this arrangement involves the dynamic filtering of information at a host computer. That is, the inbound information feeds, which are typically high-speed streams of data or data packets transmitted either directly to the host computer or to an intervening database subsystem, are manipulated at the host computer in accordance with selection and limit parameters provided by a remote subscriber device. This obviates the need for expensive hardware and software components to power and outfit the subscriber's device.

Another advantage of the system is that the software modules of the database subsystem and limit subsystem are organized as a plurality of independent processes with each process configured to perform specific operations. Some of these operations require more time to complete than others. Accordingly, the arrangement of independent processes allows efficient operation of the alert distribution system because the processes may perform their functions in parallel within the host computer or on separate machines having additional resources.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and further advantages of the invention may be better understood by referring to the following description in conjunction with the accompanying drawings, in which:

FIG. **1** is a diagram of a remotely-configurable medical alert distribution system comprising a plurality of information sources and subscriber units coupled to a host computer;

FIG. **2** is a block diagram of a subscriber unit;

FIG. **3** is a diagram of an ambulatory patient with a conventional telemetry device coupled thereto;

FIG. **4** is a block diagram of a communications system of the host computer;

FIG. **5** is a flow diagram of the interaction between a REMOTE software section of the subscriber device, and LIMIT, DBASE and PAGE software sections of a software system of the host computer in accordance with the invention;

FIG. **6** is a block diagram of the processes constituting the REMOTE software section of FIG. **5**;

FIG. 7 is a diagram of the format of a data packet used to transfer parameters from a subscriber to the host computer;

FIG. 8 is a diagram of the processes constituting the DBASE section of FIG. 5;

FIG. 9 is a diagram of a linked list data structure including entries for storing information records;

FIG. 10 is a diagram of the processes constituting the LIMIT section of FIG. 5;

FIGS. 11A and 11B depict the formats of typical messages used for communication among the processes of the system;

FIG. 12 is a diagram of the processes constituting the PAGE section of FIG. 5; and

FIGS. 13A, 13B and 13C are flowcharts detailing the sequence for remotely configuring the medical alert distribution system of FIG. 1 in accordance with the invention.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

FIG. 1 depicts a medical alert distribution system **10** that includes a host computer **12** connected to a plurality of sources **15** and subscriber units **20**. The host computer **12** is preferably configured to perform functions that typically involve frequent accesses to secondary storage media and, for the exemplary embodiment described herein, incorporates a database for storing the information received from the sources **15**. However, in an alternate embodiment of the invention, the database may reside on another machine that is coupled to the host **12**. The sources **15** collect medical information pertaining to the health of various patients and geodetic information pertaining to their locations, and supply that information to the host computer. The subscriber units **20** are typically processing devices such as intelligent terminals and portable computers. The subscribers and sources are coupled to a communications system **30** of the host via a network **45** which may include wireless radio communication or wireline (telephone line) connections.

The host computer **12** includes a central processing unit (CPU **14**), an I/O unit **17** and associated storage devices **18**, such as magnetic disks and tape drives, a main memory **16** and the communications system **30** interconnected by a system bus **13**. An operating system **25**, portions of which are typically resident in main memory **16** and executed by the CPU **14**, functionally organizes the computer. The operating system **25** also includes, inter alia, software modules **110** (FIG. 4) executed by the communications system **30** to control the transfer of information to the other components of the computer **12**. These modules are, in turn, responsible for invoking operations in support of application programs executing in the computer.

For the exemplary embodiment disclosed herein, the application programs pertain to real-time data acquisition and transactional processing. Such applications require fast data access to and from storage devices **18** that are shared among the subscribers **20** and sources **15**. Instances of the software modules and application programs executing in the computer are called "processes". A process is an individually scheduable entity consisting of code and data, and characterized by dynamic states, as described below. The operating system **25** organizes the host computer **12** by tracking, suspending and resuming execution of the processes, while allocating to them the CPU **14** and other system resources.

The hardware and software components of the host computer **12** arrange related data items, i.e., records, into files and then organize the files in a manner that facilitates efficient and accurate inquiry and update. Specifically, host-based software modules **70**, **90** resident in the memory **16** operate to selectively extract, i.e.,"filter", the contents of the files in response to selection and limit parameters remotely provided by the subscribers **20**, thereby enabling efficient performance of the data acquisition and transactional processing operations that characterize the computer.

The subscriber unit **20** comprises a microprocessor **22**, a memory **24** and an I/O unit **26** interconnected by a bus **210**, as shown in FIG. 2. Buffering of selection and limit parameters in the memory **24** and subsequent transfer of these parameters to the host computer **12** are controlled by the microprocessor **22**. Remote software modules **50**, typically resident in the memory **24**, facilitate interpretation and organization of the selection and limit parameters entered by an authorized user.

As described further herein, a user interface process **52** of the remote software modules **50** presents a series of menus on a flat screen display **28** and provides for manipulation by a keyboard **27**. The menus allow a user to enter the selection and limit parameters in a user-recognizable format, where translations are performed locally by the microprocessor **22** during execution of the software modules **50** prior to arranging the parameters in a message or "data packet" format. The microprocessor **22** then transfers the data packet to a transceiver unit **23** and the packet is transmitted over the network **45** to the host computer **12**. For upload transmission of the packet to the host over a wireline medium, the transceiver unit **23** preferably comprises a wireline modem circuit configured to transmit the packet in accordance with conventional packet transfer protocols.

In the exemplary embodiment, the source **15** is an ambulatory patient **300** having a conventional telemetry device **310**, as shown in FIG. 3. The telemetry device **310** includes a panic button **315** located on the device, and includes various sensors **320** attached to parts of the patient's body. The sensors may include bioelectrical signal transducers with either direct contact electrodes or indirect contact, e.g., capacitive or magnetic field, electrodes; in addition, the sensors may be physiological transducers, including, but not limited to, photoelectric, optical, accoustic, thermal, mechanical, chemical or radiation sensitive transducers.

The sensors **320** collect body function data, e.g., blood pressure, blood chemistry, heart beat (arrhythmia), either transcutaneously using conventional non-invasive methods or intravenously. The data is assembled as a data packet at the telemetry device **310**, which includes a conventional microprocessor and transceiver unit (not shown), and the packet is transmitted to the host computer **12** as patient medical information.

The panic button **315** provides a means for signaling the host computer **12** at the patient's request; this arrangement enables the telemetry device to interact with the host computer in a manner other than the typical methods of providing information, e.g., CSMA/CD or periodic polling of all the sources **15** by the host computer **12**. The panic button **315** also provides the patient with a means for acknowledging receipt of a pre-programmed message from the host computer **12** when an alarm condition has been met.

The telemetry device **310** may also include a conventional radio positioning device **325**, such as a GPS or Loran, for collecting information pertaining to the geographic location of the ambulatory patient **300**. This information is provided to the host computer **12** as patient geodetic information.

The communications system **30**, shown in FIG. 4, provides a receiver/transmitter interface to the host computer

12. Accordingly, the communications system **30** includes a transceiver unit **32**, a processor unit **34** and a memory unit **36** interconnected by a "front-end" bus **35**. As noted, the processes of the software modules **110** are typically resident in the memory unit **36** and executed by the processor unit **34** to control the transfer of information between the communications system **30** and the other components of the computer. The transceiver **32** receives information from the sources **15** and transfers the information to the processor **34** for decoding in connection with known decoding algorithms. There, the information is converted to a message format for transfer to the memory **16** through an adapter **38** coupling the front-end bus **35** to the system bus **13** of the host computer **12**. The transceiver **32** also receives data packets from the subscribers **20** and forwards them to the processor **34** as described above; in addition, the transceiver may transmit messages to conventional paging services for distribution to the subscribers **20** and to the patients (sources **15**).

Communication to the subscribers **20** (and sources **15**) from the host computer **12** is effected by equipping each subscriber/source with a receiver, included within the respective transceiver units, that is capable of receiving messages from the host's transmitter, which is included within the transceiver unit **32**. The receiver may be a conventional FM radio receiver circuit adapted for non-interactive, limited-bandwith, wireless network communication, e.g., paging speeds of 1.2K bps, with a conventional FM radio transmitter at the host, although other receiver and transmitter arrangements, such as wireless modems, may be used. It is also understood that wide-bandwidth channels may be utilized; however, the method and apparatus described herein reduces the amount of bandwidth needed to accomplish the functions provided by the invention. In accordance with the exemplary embodiment of the invention, each subscriber/source has a radio receiver circuit for receiving paging information from the host **12** and a radio transmitter circuit for transmitting packets of parameter data to the host over wireless media.

One objective of the system according to the invention is to provide fast and efficient access to the information files provided by the sources **15**. Another objective is to provide selective filtering of the information in response to selection and associated limit parameters provided by the subscribers **20**. To achieve these objectives, the software modules of the subscriber **20** and the host computer **12** are organized as a software system **40** comprising four (4) software subsystems: the remote (REMOTE **50**) subsystem, the host (LIMIT **90**) subsystem, the database (DBASE **70**) subsystem and the transmission (PAGE **110**) subsystem. A flow diagram of the interaction between these portions of the software system **40** is illustrated in FIG. **5**.

In general, the REMOTE **50** software allows a user to accurately and efficiently enter selection and limit parameters at the subscriber device **20**. Further, the REMOTE **50** software organizes the parameters into a data packet format and controls the transfer of the packet to the LIMIT **90** software subsystem over the communications network. The LIMIT **90** software interfaces to the DBASE **70** software subsystem to perform selective filtering of the database information in response to the parameters of the packet. The results of the selective filtering process are then communicated back to the REMOTE **50** software by the PAGE **110** software subsystem, preferably by paging transmission. It should be noted that the DBASE **70** software architecture could be different from that of the LIMIT **90** software; only the interface between these processes need be defined. As described below in connection with FIGS. **11**A and **11**B, this interface consists of the exchange of messages between the processes.

Each of these subsystems comprise a plurality of independent processes for performing specific operations. Because some of these operations require more time to complete than others, the arrangement of independent processes allows various operations to execute in parallel or to execute on other machines. The processes functionally interconnect through logical path sockets, i.e., virtual circuit connections, which, for the illustrative embodiment described herein, are TCP/IP sockets.

FIG. **6** illustrates the processes constituting the REMOTE **50** software subsystem. The USER INTERFACE **52** process facilitates configuration of the subscriber device **20** and entry of the limit parameters by providing speech recognition and voice response interface capabilities to an authorized user; however, for the exemplary embodiment set forth herein, the USER INTERFACE **52** provides a series of menus on the display **28** (FIG. **2**). Initially, a configuration screen **53** enables selection of a communications port, e.g., a serial port, and inquires about the type of modem connected to that port. A user screen **54** then prompts the authorized user to enter a user identification (ID) and a password. Typically, the user ID comprises a 20-character alpha-numeric string, while the password is an 8-character string. The password provides a measure of security by enabling validation of the user.

A table screen **55** provides a template for entering the selection and limit parameters. The selection parameter is typically a symbol (SYM) specifying, for example, a particular blood chemistry parameter. A dictionary of symbols feature of the interface process allows a user to identify appropriate symbol acronyms and abbreviations. The limit parameters, which are typically numeric characters, include a low (L) or "initial" limit value, a high (H) limit value and an incremental (I) limit value. The USER INTERFACE **52** process validates the format of these parameters but does not interpret them. In the exemplary embodiment of the invention, the incremental limit is used to increment both the initial and high limits by the specified value when either of those latter limits are met, thereby maintaining a limit "window"; accordingly, the limit parameters function as "adaptive" limits. In an alternate embodiment, the incremental limit may specify the relation in degree or number between two similar things, e.g., the rate of change of the blood chemistry parameter from a previous (initial limit) close. Here, the high limit is not needed. Use of the incremental limit as a ratio of change is particularly advantageous in such medical information applications, as described further below.

A MESSAGE-FORMING **56** process assembles the parameters into a data packet **60** for transfer to the host computer **12**. The format **60** of a typical data packet is depicted in FIG. **7**. An eight-bit "start-of-header" SOH field **61** identifies the beginning of the packet and a 16-bit LENGTH field **62** identifies the amount of data in the packet. The field SEQ_NUM **63** is an eight-bit packet identification value and the PACKET_TYPE field **64** identifies whether the packet includes command and data parameters or control-type information.

The PACKET_DATA field **65** may be as large as two hundred and fifty-five bytes and consists of subfields that include a user identification USER_ID subfield **66**, a selection parameter SELECTION field **67** and limit parameter LIMIT fields **68***a–c*. Preferably, the SELECTION field **67**

contains symbol data and the LIMIT fields **68***a–c* contain numerical data. Lastly, an eight-bit checksum CHKSUM field **69** consisting of an algebraic sum of transmitted characters is included within the packet for reliability purposes.

Referring again to FIG. **6**, the packet **60** is uploaded to the host computer **12** over the communications network **45** in accordance with a conventional asynchronous transfer protocol implemented by the TRANSPORT **58** process. This process initiates a connection to the host, preferably using a conventional wireline modem circuit, thereby obviating the need for a continuous, interactive exchange with the host during the selection and limit entry process.

FIG. **8** depicts the processes constituting the DBASE **70** subsystem. The main DATABASE **72** process is responsible for initializing the MRFILT **74** process of this subsystem and ensuring that it remains active. Because the DBASE **70** software is embodied within the host computer **12** for the exemplary embodiment described herein, DATABASE **52** also initializes the ALERT and BROADCAST processes of the LIMIT **90** subsystem. DATABASE **72** also administers an information record database **720** of information received from the telemetry sources **15**. Examples of the administration functions performed by DATABASE **72** include modification of the contents of the information records and transfer of the record contents to other processes upon request. Requests for selected records are effectuated by exchanging messages through direct socket connections **75** with the DATABASE **72** process.

To facilitate the exchange of messages, the processes perform read and write operations to storage locations in memory that are organized to provide data structures, e.g., linked lists. It is to be understood that the CPU **14** performs the actual read, write and booleon operations on behalf of the processes resident in the host memory **16**, whereas the communications system **30** incorporates the necessary "intelligence" to perform similar operations on behalf of the processes resident in its memory **36**.

FIG. **9** illustrates a typical linked list **80** that includes entries **82** for storing database records. A header **88** contains an address that points to first entry in the list **80**. Each entry **82** contains a forward link pointer **84** referencing the memory location of the next entry in the list; therefore, the entries **82** do not have to occupy consecutive locations in memory and additional entries can be dynamically allocated by the operating system **25**. Rather than allocating a separate block of memory locations for each entry, the operating system **25** apportions a block into one hundred (100) entries. The blocks may then be swapped in and out of memory at the appropriate time; in the illustrative embodiment, swapping is performed in accordance with standard UNIX System **5** (page) swapping techniques.

Each record entry **82** also contains, inter alia, a record name (symbol) field **820**, a current value field **822** and an IN_ALERT flag **86**. The IN_ALERT flag **86** is preferably a 1-bit flag that is constantly checked by the DATABASE **72** process to initiate selective filtering of the database information. When asserted, the flag **86** directs the DATABASE **72** process to write the contents of the record entry **82** as an ALERT_LIMIT message to an ALERT process of the LIMIT **90** subsystem.

FIG. **10** depicts the processes constituting the LIMIT **90** subsystem. The ALERT **92** process is the entity that manages the selection and limit parameters received by the PCALERT **94** processes. The ALERT **92** process maintains its own database **96** of "alert records" **980** which include the parameters provided by the subscribers **20**. Specifically, each alert record **980** contains the user ID **982** of the subscriber, the name (symbol) **984** of the selected record, and the high limit **986**, initial limit **988** and incremental limit **990** desired for that record. In addition, each record **980** may include a pre-programmed message of instructions for a patient when a limit is met.

When an ALERT_LIMIT message is received from the DATABASE **72** process, ALERT **92** parses the contents of the message and compares the record name field **820** of the message to the name field **984** of the alert record **980**. If a match ensues, the parsed current value field **822** of the message is compared to the limits of the matching alert record. If a limit is met, ALERT **92** then sends a page, including the message as described below, to the PAGE **110** subsystem for transmission to the subscriber **20**.

The PCALERT **94** process provides an interface between the data packets received from the subscribers **20** and transferred to the ALERT **92** process. PCALERT **94** is preferably distinct from the ALERT process so that the former process can assume responsibility for handling operations required to establish simultaneous connections with subscribers. PCALERT **94** hibernates in a suspended state until prompted by receipt of a packet that either inquires about certain information or requests changes to selection and limit parameters. PCALERT **94** then transitions to a running state and validates the user ID **36** of the packet. Upon validation, the process forwards the packet to the ALERT **92** process.

If the packet involves an inquiry of current limits, the ALERT **92** process obtains the appropriate record from its database **96** and forwards the information back to the PCALERT **94** process. There, the information is transmitted to the subscriber. If the packet includes selection and limit parameters, the ALERT **92** process converts the packet to a message format for transfer to the DATABASE **72** process.

As noted, the processes communicate by exchanging messages through socket connections. In accordance with the invention, there are basically two types of messages used in the system: a DB_MSG and a DB_REQUEST. DB_MSG is a 1-way message in the sense that it only directs the receiving process to perform some function. FIG. **11**A depicts the format **700** of a typical DB_MSG. The identifier field **720** indicates the symbol (name) of the record. The message type field **730** identifies the action to be taken, such as asserting a flag, and the value field **740** specifies the particular flag, e.g., the IN_ALERT flag **66**.

On the other hand, a DB_REQUEST is a request by a process for information; therefore, the process receiving the request is expected to reply. FIG. **11**B shows the format **750** of a typical DB_REQUEST, including the identifier field **760** for identifying the name of the record and the message type field **780** for identifying the request, such as the current value of that record entry.

Referring again to FIG. **10**, the BROADCAST **95** process manages the type and frequency of announcements that are transmitted for general reception by the subscribers. A broadcast.1st file **950** is created at system initialization and contains a list of group/individual ID records together with broadcast information associated with each record. Specifically, the broadcast information includes the starting time **952** and ending time **954** for broadcasting, the type **956** of announcement to be broadcast, the intervals **958** at which the announcements are broadcast and the group/individuals **960** receiving the broadcast. In some cases, the group ID specifies a class of subscribers for receiving a broadcast.

When a broadcast is scheduled to take place, the BROADCAST **95** process sends a DB_REQUEST **750** to the DATABASE **72** process requesting the contents of a particular record. The information is then forwarded to BROADCAST **95** in a BRDCAST_DATA message. It should be noted that the BRDCAST_DATA and ALERT_LIMIT messages are facsimiles of the record entries **82**. Upon receipt of the BRDCAST_DATA message, BROADCAST **95** formats an announcement, establishes a socket connection to the PAGE **110** subsystem and forwards the announcement for broadcast transmission to the subscribers. The BROADCAST **95** process then enters a suspended state and, at the appropriate time, resumes execution.

The MRFILT **74** process, shown in FIG. **8**, provides an interface between the sources' information, which is received via data packets having a format similar to that of FIG. **7**, and the database subsystem. Specifically, the interface process decodes and converts the received information to DB_MSGs **700** for transfer to the DATABASE **72** process. The MRFILT **74** process also examines the contents of the information feed and, if the examination indicates an appropriate "newsworthy" topic, extracts that information for transfer to the MRNEWS **76** process. This latter process identifies which subscribers, if any, should receive the information, establishes a socket connection to the PAGE **110** subsystem and forwards the information as a page or announcement to that subsystem.

FIG. **12** depicts the processes constituting the PAGE **110** subsystem. The PAGECTL **112** process manages the interface between the LIMIT **90** and DBASE **70** software, and various known paging services used for distributing messages to the subscribers **20**. Specifically, PAGECTL **112** receives pages **116** and announcements **118** from the software processes of the system, and forwards them to available PAGESERV **114** processes. A page **116** includes the ID **982** of a user and a text string message **995**, and an annoucement **118** includes a group/individual ID **960** and a text string message **975**. The PAGESERV **114** processes operate with the remote paging services by establishing connections with the services. Each PAGESERV **114** process collects the pages **116** and announcements **118** in a queue (not shown) and then transfers them to the paging service for transmission.

Operation of the medical alert system **10** will now be described in connection with the flowchart **1200** of FIGS. **13A–13C**. The system includes at least one subscriber coupled to a host computer that is configured to collect information from telemetry sources attached to ambulatory patients.

At initialization, the DATABASE **72** process spawns the other processes in the DBASE **70** and LIMIT **90** subsystems, fetches groups of the database information files from the storage devices **18** and loads these files into host memory **16**. Concurrently, the PAGECTL **112** process spawns PAGESERV **114** processes to communicate with the paging services. (Step **1210**.) The DATABASE **72** and PAGECTL **112** processes then scan their respective sockets, waiting for messages.

The MRFILT **74** process decodes streams of incoming information from the telemetry sources, converts them to message formats and transfers the messages to the DATABASE **72** process as DB_MSGs. (Step **1220**.)

Upon receiving the DB_MSG, the DATABASE **72** process parses the fields of the DB_MSG and updates the appropriate record entry as follows. The first two characters of the identifier field **720** contained in the DB_MSG are used to identify the correct data structure list **80** in the database **720**. (Step **1230**.) The DATABASE **72** process then compares the entire identifier field **720** of the DB_MSG with the name field **820** of the record entries **82**. (Step **1240**.) Preferably, the record entries **82** are stored alphabetically by symbol name. When a match (Step **1250**) occurs, the contents of the value field **740** of the DB_MSG **700** are written to the current value field **822** of the record entry **82**. (Step **1260**.)

At a remote location in relation to the host computer, an authorized user, such as a doctor, may be interested in status of particular body function data, e.g., blood pressure, blood chemistry, heart beats (arrhythmia), of the patient or the location of an ambulatory patient. Additionally, the doctor may be interested in a particular level of the selected data and the rate of change of from that level, or the proximity of travel of the ambulatory patient. Accordingly, the doctor enters a user identification (ID) and a symbol of body function data, i.e., the selection parameter, together with a numerical level value and an adjustment value, i.e., initial and incremental limit parameters, into the subscriber device **20** in response to a menu display; these parameters are assembled into a data packet in accordance with the MESSAGE-FORMING **56** process of the REMOTE **50** software subsystem. (Step **1270**.) The data packet is then transmitted to the host computer **12** at the initiative of the subscriber. Arrangement of the parameters to a data packet format is performed at the remote site; therefore, there is no need for a continuous, interactive communication exchange between the subscriber **20** and host **12**. (Step **1275**.) Upon reception, the host computer responds with an acknowledgement; failure to receive the acknowledgement within a predetermined time interval is an indication that the packet was not correctly received and that retransmission is required.

At the host computer **12**, the data packet is received by a PCALERT **94** process associated with a receiver; at this time, the PCALERT **94** process validates the user ID. (Step **1280**.) If the user ID is not validated (Step **1290**), the packet is discarded. (Step **1300**.) If the ID is validated, the packet is forwarded to the ALERT **92** process, where it is converted to an alert record **980** and stored in the alert record database **96**. (Step **1305**.) The record **980** is then converted to a DB_MSG **700** and transferred to the DATABASE **72** process. (Step **1310**.) DATABASE **72** asserts the IN_ALERT flag **86** after indexing into the proper database list **80** as described above. (See Steps **1230–1250**.)

Meanwhile, the DATABASE **72** process is constantly checking the IN_ALERT flag **86** of entries **82** while updating their records with incoming DB_MSGs. (Step **1320**.) If a flag **86** is not asserted, DATABASE **72** resumes scanning the sockets for incoming messages and updating the appropriate records. (Step **1330**.) However, if an IN_ALERT flag is asserted, DATABASE **72** sends a copy of the entire record as an ALERT_LIMIT message to the ALERT **92** process. (Step **1340**.) There, the contents of the message are parsed and compared with the limits of the alert records **980**. (Step **1350**.) If a match (Step **1360**) occurs, ALERT **92** creates a page **116** that includes a message specifying that the limit condition was met. The page **116** is transferred to the PAGE **110** subsystem and through to a paging service, where it is transmitted to the subscriber **20** and/or the source **15**. (Step **1370**.) Upon reception, the subscriber/patient responds with an acknowledgement; again, failure to receive the acknowledgement within a predetermined time interval is an indication that the page was not correctly received and that corrective action, such as retransmission, is required.

The ALERT **92** process then updates the initial parameter **988** of its record **980** with the incremental limit **990** and this

latter limit is compared to the contents of subsequently-received ALERT_LIMIT messages. (Step **1380**.) When the incremented limit matches the updated value of the stock (Step **1390**), the subscriber **20** is again notified in the manner described above. (Step **1400**.)

While there has been shown and described an illustrative embodiment for selectively manipulating a medical database "filter" from a remote location in a non-interactive manner, it is to be understood that various other adaptations and modifications may be made within the spirit and scope of the invention. For example, the invention is applicable to financial and news information databases or information stream applications. Similarly, the invention is applicable to medical laboratory applications, as described below.

In one embodiment of the latter application, a hospital database may be the repository for supplying medical laboratory information about patients. The information may include lab test results or patient data that is periodically monitored, e.g., blood chemistry parameters. This information may be collected at the database and forwarded to the host computer for filtering in accordance with controlling parameters entered at the subscriber device by an authorized user, such as a doctor.

For the above applications, the LIMIT (and DBASE) software of the host computer (and database) and the REMOTE software of the subscriber device operate in the manner described above. For patient data information, the doctor may be concerned about, e.g., the rate of change in the blood chemistry parameters. By entering, at the subscriber device, a selection parameter (specifying a blood chemistry value), an initial limit parameter (specifying a previous value of the blood chemistry) and an incremental limit value (specifying a percent change of the previous value), the information distribution system, operating as set forth herein, will notify the doctor when and if the desired change occurs.

The foregoing description has been directed to specific embodiments of this invention. It will be apparent, however, that other variations and modifications may be made to the described embodiments, with the attainment of some or all of their advantages. Therefore, it is the object of the appended claims to cover all such variations and modifications as come within the true spirit and scope of the invention.

What is claimed is:

1. A medical alert distribution system for distributing information messages to an authorized user, said system comprising:

a source of inbound information records, each information record containing a name and a current value;

a host computer coupled to said source, said host computer including

(A) a first memory for storing selection and limit parameters, provided by the authorized user from a remote location, as a first database, said limit parameters including an initial limit and an incremental limit;

(B) means for selectively filtering the inbound information records in response to said selection and limit parameters, said means for selectively filtering including

first means, for comparing said selection parameter against said information records to determine if a said information record name matches said selection parameter, and for asserting a flag associated with said information record having said name which matches said selection parameter;

second means, coupled to said first means for comparing, for comparing said current value of said information record with said initial limit parameter when said flag associated with said information record is asserted;

means, coupled to said comparing means, for creating a selectively filtered message in response to said matched condition, said selectively filtered message including said current value of the information record; and

(C) means for distributing said selectively filtered message to the authorized user.

2. The apparatus of claim **1** wherein said source of inbound information records comprises an inbound stream of information records.

3. The apparatus of claim **1** wherein said source of inbound information records comprises an external database subsystem.

4. The apparatus of claim **1** wherein said source of inbound information records comprises a second memory for storing said inbound information records as a second database.

5. The system of claim **4** further comprising means for managing the information records of said second database, said managing means including means for updating said current value of the information record.

6. The system of claim **5** wherein said managing means comprises a first DATABASE software process executed by a central processing unit of the host computer.

7. The system of claim **6** wherein said comparing means comprises a second ALERT software process executed by said central processing unit.

8. The system of claim **7** wherein said selectively filtered message is a paging message.

9. The system of claim **8** wherein said distributing means is a communications system comprising a memory means for storing a third software process and a processor means for executing said third software process to control the transfer of said paging message to the authorized user.

10. The system of claim **9** further comprising:

means, coupled to said comparing means, for incrementing said initial limit with said incremental limit parameter.

11. The system of claim **10** wherein said incrementing means comprises said ALERT process executed by said central processing unit.

12. A method for distributing medical information messages to authorized users in response to selection and limit parameters provided by the authorized users, said method comprising the steps of:

storing medical information records received from an incoming source of records as database entries, each database entry having as contents a name, a current value and a flag;

receiving said selection and limit parameters as alert records, said selection parameter comprising the name of a selected database entry and said limit parameters comprising an initial limit value and a high limit value;

asserting said flag of said selected database entry in response to said selection parameter matching the name of said selected database entry;

updating the contents of said selected database entry in accordance with the received medical information records;

comparing the updated contents of said selected database entry with said limit parameters; and

creating a medical information message in response to the updated contents of said selected database entry exceeding one of said limit parameters, and transmitting said medical information message to the authorized users.

13. A medical alert distribution system for distributing medical information messages to authorized users in response to selection and limit parameters provided by the authorized users, said system comprising:

a database for storing medical information records received from an incoming source of medical information records as database entries, each database entry having as contents a name, a current value and a flag;

means for receiving said selection and limit parameters as alert records, said selection parameter comprising the name of a selected database entry and said limit parameters comprising an initial limit value and a high limit value;

means, coupled to said receiving means, for asserting said flag of said selected database entry in response to said selection parameter matching the name of said selected database entry;

means, coupled to said database, for updating the contents of said selected database entry in accordance with the received medical information records;

means for comparing said curent value of said selected database entry with said limit parameters; and

means for creating a medical information message in response to current value of said selected database entry exceeding one of said initial limit value and said high limit value to enable distribution of said medical information message to the authorized users.

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