A portable digital electronic communication device includes an analog matrix switch to dynamically route analog signals between user interfaces and communication links. The user interfaces include various microphones, speakers, modems and other user interfaces. The communication links may include multiple telephone modules, such as cellular transceivers and telephone land-line connections, and other connections to communication devices. A processor in the communication device issues commands to the analog matrix switch to establish the desired analog signal routing between user interfaces and communication links.
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SWITCHING OF ANALOG SIGNALS IN MOBILE COMPUTING DEVICES

FIELD OF THE INVENTION

This invention relates to portable intelligent communication devices, whether these devices are for voice communications or data communications (such as smart phone, computers, personal data assistants (PDAs), etc.). The invention specifically relates to an apparatus and method for dynamically connecting a variety of sources and sinks ("source/sinks") of analog signals, such as speaker phones, headsets, modems, wireless cellular telephone links, data links and telephone land lines. The sources/sinks of analog and digital signals may reside entirely within the portable communication device or be connected to other portable device via wireless or wired connections.

SUMMARY OF THE INVENTION

Full-featured smart phones and personal digital assistants may include a variety of sources and sinks of analog and digital signals, such as two or more sets of audio speakers and microphones, cellular and land-line telephone modules, modems, and other devices. Some of the sources and sinks of signals are user interface devices, such as keyboards, LCD displays, analog speakers and microphones, and other types of user interface devices. Other sources and sinks of signals are communication devices such as cellular and land line communications modules, modems, personal computer memory card industry association standard (PCMCIA) devices and other such devices. When a user desires to make a call, the smart phone or personal digital assistant must make a connection between a pair (or more) of the sources and sinks of signals to establish a communication pathway between the user interface
device, e.g., microphone and speaker in a telephone handset, and a
communication device, e.g., a cellular telephone module.

The smart phone or personal digital assistant must dynamically
connect the sources and sinks of signals depending on which user
interfaces and communication devices are active. As each
communication session is initiated, the smart phone or personal digital
assistant must establish a communication path between the selected user
interface and communication modules. For example, if a user desires to
place a cellular telephone call during which a group of individuals will
listen and speak, the smart phone or personal digital assistant must
connect an analog speaker phone device to a cellular telephone
communication module. After a communication session is terminated,
the smart phone or personal digital assistant may disconnect the selected
user interface and communications module in order to be prepared for
the next communication session.

An innovation of the current smart phone or personal digital
assistant system is to route analog signals between sources/sinks (i.e.,
user interfaces and communication links) without converting the analog
signals to digital form. Digital signals may be routed through the
system in a manner similar to that used for analog signals, routed by and
through a processor, or routed by some other technique conventionally
employed for digital signals. In the past, most systems were not adapted
to dynamically interconnect sources and sinks of analog signals, or, if
they did, required manually configured switches and/or ports to inter-
connected analog signals. Systems that did process both analog and
digital signals have typically converted all signals to a digital format and
then processed the digitized signals. For example, an analog signal
would be received by the portable computer device from a telephone
communication module, converted to a digital form, processed by and
routed through the portable device, and then converted back to analog form as the signal is fed to, for example, an analog speaker.

A feature of the present system is that analog signals are maintained as analog signals as they are routed from a source, e.g., a microphone, through a smart phone or personal digital assistant to a sink, e.g., a telephone land line connection. By maintaining analog signals in an analog form, the current system provides a relatively high level of signal integrity between the source and sink of the signal in the system, and reduces complexity over prior art systems that digitize analog signals.

Generally, sources and sinks of analog signals in the present system are communications links or user interfaces. A "communications link" is a wireless phone, a land-line phone, or any other device used to transceive analog electrical signals. The analog electrical signals received and transmitted in an analog communication link typically represent sound waves in the audible range or data. A "user interface" for analog signals is, for example, a set of transducers used to convert sound into electrical signals and vice versa, such as a microphone/speaker pair in a hand set, or in a speaker phone. Smart phones and personal digital assistant may also include as "user interface" devices modems which encode and transmit data through channels optimized to carry transceive data in analog form over communications channels designed for transmission of sound in the audio frequency range, e.g., land-line telephone circuits. Digital user interface devices include displays, keyboards and keypads.

The present system incorporates an analog matrix switch for routing analog signals between sources and sinks in a portable communications device. An analog matrix switch is provided within the portable device to allow an intelligent controller (such as a
microprocessor (μP)) and its software the ability to connect and/or
disconnect the different sources/sink of analog signals in response to
operator commands and/or preset conditions. Previously, such analog
matrix switches were used in non-portable, infra-structure category of
equipment, such as private branch telephone exchanges (PBXs) and
central office switching equipment.

During a communication session, an electronic device embodying
the present system may receive and transmit signals carrying voice
and/or data information over a selected one (or more) of the
communications links, e.g., cellular or land-line, and route the signals to
the appropriate headset, handset, speaker phone, modem or other signal
source/sink. While multiple simultaneous communication links may be
provided within the portable device, generally only one communication
link will be connected to one or two signal user interfaces for a given
communication session. The dynamic connections between the
communication links and analog user interfaces are set up by an analog
matrix switch operating under control of a processor. The analog matrix
switch establishes the connection between the communication links and
analog user interfaces for each communication session. For example, a
user may wish to make a conference call through the speaker phone and
one of the cellular phone modules. At the beginning of the
communications session, the processor controls the analog matrix to
establish a connection between the speaker phone and a cellular phone
module. At the end of the session, the switch may continue the
connection or break the connection.

Other simultaneous communication sessions between other
modules may be carried by the portable communication device
embodying the invention. If the matrix switch is non-blocking, other
sessions with analog signals can be established concurrently with a first
session. For example, if the user has established a call using the speaker
phone and wishes to place another private call at the same time, the idle
handset and a PCMCIA cellular phone module can be enabled and
connected to allow the user to place a second concurrent communication
session independently and separately from the first session.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The present invention and its advantages are further disclosed in
the accompanied drawings and associated description of an embodiment
of the invention.

**FIGURE 1** is an exemplary drawing of a personal digital
assistant;

**FIGURE 2** is a high level schematic diagram showing the user
interfaces and communication links provided by the personal digital
assistant shown in **FIG. 1**; and

**FIGURE 3** is a detailed schematic diagram of an exemplary
circuit for use in the personal digital assistant shown in **FIG. 1**.

**DETAILED DESCRIPTION OF THE DRAWINGS**

**FIG. 1** shows a portable personal digital assistant device 100 (the
invention may also be embodied in a smart phone or other portable
communication device) that includes an interactive touch screen display
102, a cordless telephone handset 104 with a microphone and a speaker,
a built-in cellular phone and antenna 105 for cellular telephone
communications, and a built-in speaker 140 and microphone 142 which
together are used for conference calls. To communicate with external
electronic devices, the personal digital assistant may include accessory
jacks 106, 108 for connecting to, for example, a screen image projector
110, a headset (speaker and microphone) device 112, a printer (not
shown) and other electronic devices. Similarly, the personal digital assistant may include an infrared sensor and transmitter 114 to establish an infrared connection with, for example, a keyboard 116, a mouse or trackball 118, or other digital user interface device. Furthermore, the personal digital assistant 100 may include a PCMCIA (personal computer memory card industry association) standard interface 120 that enables the personal digital assistant to accept modem, LAN and other PCMCIA cards 124. The personal digital assistant may be designed such that all or most of the connections to other devices and communications systems are conducted with wireless connections, such as via radio frequency (RF) and infrared (IR) paths. For example, all of the external connections to peripheral devices and communications systems may be implemented using wireless connections to provide for a truly portable device 100.

The personal digital assistant 100 is also capable of establishing voice communication links via its cellular telephone module and antenna 105 or antennae, and via a land-line to a public switching telephone network (PSTN) 122. In addition to providing analog/digital voice communications, the personal digital assistant provides data links to computer devices, such as to a personal or laptop computer 126 coupled through an accessory port 106 in the device 100 or through a modem 124 installed into the PCMCIA slot 120 of the personal digital assistant 100. Similarly, the personal digital assistant may establish a cellular telephone or land-line telephone connection to a digital storage device 128, which provides e-mail and voice mail digital data storage, or other data access. The digital voice mail data held in digital storage 128 and transferred over a telephone (cellular or land-line) is converted by the personal digital assistant 100 with a codec (coder/decoder) from a digital signal retrieved from the storage device to an analog voice signal by the personal digital assistant.
The personal digital assistant may be operated as an intelligent telephone. For example, the function key icons 130 displayed on the touch screen 102 may be used to dial a telephone number that when entered causes to be established a wireless cellular communication link (or a land-line link) between the personal digital assistant 100 and the telephone system that is being dialed. As the telephone number is dialed, the entered number may be presented on a window 132 of the display so that the personal digital assistant user may confirm that the telephone number actually dialed is the telephone number intended to be dialed. Once the proper telephone number has been entered, the user initiates a call by pressing an appropriate functional button icon, e.g., "send", 134 on the display 120, that causes the personal digital assistant to send the dialed number via a cellular communication module (represented by antenna 105) or a land-line connection 122 to establish a communication link. Once the communication link is established, the user may speak into the handset 104 microphone and listen on the handset speaker of the personal digital assistant, or use the personal digital assistant as a speaker phone using built-in speaker 140 and microphone 142.

The general schematic diagram of the user interfaces and communication links for the personal digital assistant in FIG. 2 shows the operational and functional aspects of the personal digital assistant with respect to the communications links, and user interface components. The personal digital assistant can functionally be divided into user and machine interface components 202 and communication link components 204 as shown in FIG. 2. The user interfaces may be incorporated in the personal digital assistant device, or external to the device and coupled by a wire or wireless connection to the device. The interface functional units provide connections to the user and machine interface devices, and may include analog devices such as a handset.
104, speaker phone 140, 142, analog modem 206 and codec 208 (where
the codec converts analog signals to digital signals). The analog modem
206 may be a conventional four-wire or two-wire interface to a land-line
PSTN connection that provides an analog signal output that comprises a
carrier frequency modulated with digital data signal, such as from a
personal computer 126. Similarly, a codec 208 may convert a digital
signal from an external or internal digital storage device 209, e.g.,
CDROM drive (external) or flash memory (internal), into an analog
signal such as audible sound signals.

The communication links 204 of the personal digital assistant 100
represent the components that provide communications, such as cellular
transceiving modules 210, 211, telephone land-line connections 122,
and other similar communication connections. For example, the
personal digital assistant may have wireless cellular transceivers 210
and 211 to provide multiple cellular telephone communication links
which may be used simultaneously for voice or computer modem
communications. A personal digital assistant user may also simultane-
ously maintain two cellular communication links to both transfer digital
computer data and speak telephonically to a user who is simultaneously
talking and reviewing data on his computer or personal digital assistant
via modem.

In addition, the personal digital assistant may be coupled to a
land-line phone connections 122, such as a PSTN or PBX, when such
land-line phone connections are available. By accessing a land-line
phone, the personal digital assistant may support an alternative
communication link which could offer a higher rate of service than
cellular connections. Moreover, the communication links of the
personal digital assistant may also include connections to other codecs
214 that are connected to, for example, telephones which accept
digitized voice signals or digital storage devices, such as some PCMCIA cards. For example, an external cellular telephone may be coupled to the personal digital assistant via a codec 214 and the IR port 114 to access a cellular phone link or a land-line phone link.

The interfaces and communication links shown in FIG. 2 of the personal digital assistant 100 are conventional interfaces and/or links. For example, the interfaces may be incorporated in the body of the device to provide a compact and convenient digital and analog portable communication and computing device. Alternatively, personal digital assistant may be coupled to peripheral user interfaces and/or communications modules, such as key boards, digital presentation projectors, fax/modems and other devices. The connections between the digital assistant and peripheral devices may be by conventional wire connections or conventional wireless connections. While wireless and wired connections to peripheral devices are well known to persons of ordinary skill in this art, a novel wireless RF or IR connection may be employed to connect the personal digital assistant to a telephone jack wall socket. This wireless connection is described in more detail in connection with FIG. 3.

The personal digital assistant 100 provides connections between the user interfaces and communication links in a flexible manner that allows the various signal sinks and sources to be dynamically coupled to the various available communication links. For example, the personal digital assistant 100 allows either the handset speaker and microphone 104 or an internal microphone 142 and speaker 140, or a headset 112 to be coupled to either cellular phone module 210, 211 or to land-line phone link 122 depending on the particular circumstances of each individual communication. As the communication is established, the user may select whether a cellular telephone link is to be established or
whether a land-line phone connection is to be made. Similarly, the user may select whether to use an internal microphone 142 and speaker 140 in the personal digital assistant, a user headset 112, or a handset 104. In addition, the user may connect a personal computer 126 directly to a bus port in the device 100, and provide a communication path for the computer through the device via one of the available cellular phone links, 210, 211, the land-line phone 122, or to other computers 126 by modems 124a. Moreover, an incoming call may come in via one of the cellular phone links or a land-line phone link to the personal digital assistant 100. The personal digital assistant 100 may connect the communication link to an e-mail or voice mail digital storage device 209 via a codec 208. Accordingly, the present invention provides dynamic interconnection of various signal sources and sinks to the various available communication links or pathways.

As shown in FIG. 3, a device 400 embodying the invention may include an analog matrix switch 402 interconnects a variety of analog signal sources and sinks, such as a wireless speaker/microphone telephone handset 404, a modem 406, a cellular telephone transceiver module 408, a speaker 412 and microphone 414 (e.g., a speaker phone), and a wireless communications module 415 for PSTN land-line connections. Each of these sources and sinks of analog signals is connected by two-lines to respective inlet and outlet ports of the analog matrix switch 402.

By way of example, suitable analog matrix switches 402 may be an MT8809 8 X 8 Analog Switch Array or MSAN-101 8 X 4 Analog Switch Array devices that are sold by Mitel® of Ontario, Canada. The connections to the analog matrix switch in FIG. 3 are shown by way of example. In practice, the arrangement of connections between user interfaces and communication links will depend on the component
layout of the portable digital data device, and the printed circuit board
included in the device on which the switch and other electronic
components are mounted.

A microcontroller (such as a Motorola microprocessor Power PC
821) 416 controls the routing of signals through the analog matrix
switch 402. The processor executes software program instructions that
are stored in a non-volatile memory, e.g., a Flash EPROM 418, for user
programs and data or a ROM 420 for system operating programs. The
programs in conjunction with entries made by the user cause the
processor to send control signals to the analog matrix switch 402. Upon
receipt of these control signals, the switch establishes connections
between selected analog signal sinks and switches.

The microcontroller processor 416 controls the analog matrix
switch 402 using settings that indicate the switch routings to be used for
various types of communications. These settings may be manually
entered by the user in initially setting up the digital data communication
device 400, or may be established at the manufacturing facility or a
service center. These settings for the connection routings through the
switch 402 are stored in memory 418, 420 in a location allocated for
switch settings. For example, during an initial set-up sequence for the
digital data device, the user may be presented with a series of selections
on a touch screen display 422, such as “Select Default Speaker /
Microphone as one of Headset, Speakerphone or Handset", in response
to which the user enters a selection on the display to be stored in a map
of switch connections in memory. If the user selects “speakerphone",
then incoming telephone calls will be automatically routed to the
speakerphone because the processor will send an appropriate command
to establish this routing to the analog matrix switch. Other types of
signal routing that the processor will command may include that audio is
routed to the handset 404 when the handset is removed from its carriage, or that a second cellular telephone module (not shown) is to be used only if the first cellular module 408 is already in use. In addition, the user may override the preselected switch settings stored in memory by entering appropriate commands via the touch screen 462 or a keyboard 424 to, for example, switch on a speaker phone during an ongoing communication session. The dynamic routing ability of the analog matrix switch provides great flexibility to the user and microcontroller to route analog signals between user interfaces and communications links.

A personal digital assistant embodying the present invention makes manual connections (plugging / unplugging) unnecessary to configure the arrangement of analog sources and sinks. The source / sink devices are electrically and possibly permanently attached to the analog matrix switch, where they become available for connection to any other device without the need to physically reconfigure the connection for every session. In addition, the personal digital assistant allows for automation of connections through a suitable user interface, such as keys and a display. The processor which monitors the different sink/source device connected to the matrix switch, may be programmed, for example, to route all PSTN calls to the modem. Or, if an incoming call is detected, the processor may signal ("rings") the operator through a built-in speaker, and automatically route the call through to the handset when it detects that the operator has picked up the handset. Calls may also be routed to the speaker phone, or voice mail (digital storage) by simply pressing a button on the personal digital assistant.

The device 400 shown in FIG. 3 supports full and half-duplex communications. For example, the matrix switch may be bi-directionally connected with full-duplex, twin paths to the cordless
handset 404, the analog modem 406, the PSTN land-line telephone
connection 415, the cellular telephone transceiver module 408, an echo
canceller 426 associated with the speaker 412 and microphone 414, and
to an external system connector 428 that is connectable to peripheral
devices, controlled by serial ports to the processor 416. In addition, the
matrix switch 402 may have half-duplex or full-duplex connections to a
codec 430 associated with a serial I/O port 432 of the processor, and a
speaker signal input 434 from a PCMCIA controller 436 in the
processor.

In addition, to the analog matrix switch 402 and the user input
devices and communications modules interconnected by the switch, the
personal digital assistant 400 may include a liquid crystal display (LCD)
422 connected by a bus 464 to an LCD controller 468 in the processor
416. The LCD may include a touchscreen 462 that has an associated
touchscreen controller / digitizer 470 to detect the location of a user's
fingers or stylus touching the screen.

The microcontroller 416 has three primary buses, which are data
bus 436, address bus 438, and control bus 440. The memory accessible
by the processor may include the ROM 420 and reprogrammable Flash
EPROM 418, and a temporary storage RAM or DRAM 442. Each of
these memories is controlled by the microcontroller 416 and accessible
to the microcontroller via the address and data buses.

In addition, digital control and digital data communications are
provided via the buses and processor between the user interface devices
and the communications devices. The modem 406, PCMCIA interface
448, handset 404, and telephone PSTN land line interface 415 are
connected to one or more of the data, address and control buses.
The keyboard 424 and a power supply module 456 may be also
coupled to the buses. A keyboard and power controller 452 controls and
monitors the power supply 456, turns on and off status LEDs 471 to
indicate the status of, for example, the power supply. In addition, the
keyboard and power controller module, e.g., a slave controller 452,
controls an IR port 472 that provides infrared (IR) communication with
a wireless key board 424. Other wireless IR peripheral devices may
communicate with the personal digital assistant via an IRDA port 454.

A novel wireless PSTN interface module 415 may include a
telephone wire jack attachment 458 that includes a conventional
subscriber line interface connection (SLIC) to the PSTN telephone land
line, a CODEC to digitize the analog line signal, a processor and
memory to control the jack attachment, and a baseband chip and RF
processor to generate an RF signal to carry and receive the digitized
telephone line signals. Similarly, an RF transceiver attachment 457
attached to the personal digital assistant 400 may include an RF
processor and baseband chip to receive and transmit the wireless RF
signals from the jack attachment, a CODEC to convert the digitized RF
signal to an analog signal that is routed to the analog matrix switch, and
a system interface to the buses of the processor. The entire RF system
may, however, be replaced by an IR system not described here.

The invention has been described in connection with what is
presently considered to be its best mode. The invention is not limited to
this disclosed mode, but rather covers the various modifications and
equivalent arrangements included within the spirit and scope of the
appended claims.
WHAT IS CLAIMED IS:

1. A portable communications device comprising:
   a means for entering information into the portable
   communications device and for controlling operation of the
   communications device;
   a display to provide visual information to a user of the
   communications device;
   a plurality of user interface components for transmitting to
   the user and receiving from the user information signals;
   a plurality of communications link components for
   transmitting and receiving the information signals via a communications
   network; and
   a matrix switch to interchangeably, selectively interconnect
   different ones of said plurality of user interface components to different
   ones of said plurality of communications links.

2. The portable communications device of claim 1, further
   comprising a processor to control operation of said matrix switch,
   wherein said different ones of said plurality of user interface
   components are interchangeably selectively interconnected to different
   ones of said plurality of communications links by said matrix switch in
   response to user instructions to said processor or preprogrammed
   instruction stored in a memory associated with said processor.

3. The portable communications device of claim 1, further
   comprising at least one codec connectable to at least one of said
   plurality of communications link components, where one of said
   plurality of communications link components is a microcontroller for
   the portable communications device.
4. The portable communications device of claim 1, wherein the user interface components communications network comprise one or more of a wireless communications network, a wire line communications network, PBX and a satellite communications system.

5. The portable communications device of claim 1, wherein the user interface components comprise one or more of a wireless handset speaker microphone, a speaker phone, a headset, and a modem.

6. The portable communications device of claim 1, wherein different ones of said plurality of user interface components are interconnectable to different ones of said plurality of communications links simultaneously via said matrix switch.

7. A portable digital data device adapted to provide analog voice signal communications comprising:
   a processor coupled to memory storing executable programs for controlling the digital data device, generating digital control commands and processing digital data, and a display, wherein said processor generates digital signal routing commands regarding routing of analog signals between analog communications links and analog user interfaces;
   a plurality of user interfaces, including one or more of a plurality of microphones and audio speakers, and a modem, wherein said user interfaces being integral with said data device or connectable to said data device;
   a plurality of communication links including one or more of a plurality of cellular telephone transceiver modules and at least one telephone land line connection module, wherein said communication links being integral with said data device or connectable to said data device;
an analog switching matrix connectable to each of the user interfaces and communication links, and dynamically routing analog signals between the user interfaces and communication links in accordance with the digital signal routing commands from the processor.

8. A portable digital data device as in claim 7 wherein said user interfaces further comprise a speaker phone.

9. A portable digital data device as in claim 7 wherein said user interfaces further comprise a speaker phone and a wireless handset microphone and speaker.

10. A portable digital data device as in claim 7 wherein the analog matrix switch is a blocking switch for preventing two or more simultaneous communication link connections to a single active user interface.

11. A portable digital data device as in claim 7 wherein the analog matrix switch is a non-blocking switch for establishing two or more simultaneous communication link connections to a single active user interface.

12. A portable digital data device as in claim 7 wherein one of the communications links includes a wireless infrared communications module for connecting to a telephone land line.

13. A portable digital data device as in claim 7 wherein one of the communications links includes a wireless RF module for connecting to a telephone land line.

14. A portable digital data device as in claim 7 wherein an infrared digital device generates digital signals that are sent by the microcontroller to a CODEC converter, and analog signals from the converter are transmitted to the analog matrix switch.
15. A portable digital data device as in claim 7 wherein an RF
digital device generates digital signals that are sent by the
microcontroller to a CODEC converter, and analog signals from the
converter are transmitted to the analog matrix switch.

16. A portable digital data device as in claim 7 wherein one of
the plurality of analog user interfaces is a codec device converting
digital signals to analog signals.

17. A portable digital data device adapted to provide analog
voice signal communications comprising:
   a digital processor coupled to digital memory for generating
digital control commands and processing digital data;
   a data entry unit for entering commands and data from a
user to generate digital commands regarding connections and
disconnections to be made between one or more selected signal sources
and a selected signal sinks,
   a display to provide the user with information regarding
connections between the selected signal sources and selected signal
sink;
   a plurality of user interfaces wherein one or more of said
interfaces are housed in the digital data device;
   a plurality of communications modules for establishing
communications with other persons or computers, and wherein one or
more of said communications modules are housed in the digital data
device;
   an analog switching matrix connected to the user interfaces
and communications modules and adapted to dynamically connect
selected user interfaces to selected communications modules at the
beginning of a communications session, and switching the connections
between the user interfaces and communications modules after the
sessions, wherein the switching matrix is controlled by the processor.

18. A portable digital data device as in claim 17 wherein said
user interfaces further comprise a speaker phone.

19. A portable digital data device as in claim 17 wherein said
user interfaces further comprise a speaker phone and a headset
microphone and ear phones.

20. A portable digital data device as in claim 17 wherein the
analog matrix switch is a blocking switch for preventing two or more
simultaneous communication link connections to a single active user
interface.

21. A portable digital data device as in claim 17 wherein the
analog matrix switch is a non-blocking switch for establishing two or
more simultaneous communication link connections to a single active
user interface.

22. A portable digital data device as in claim 17 wherein one of
the communications modules is a wireless connection to a PSTN
telephone land line wall jacket.

23. A portable digital data device as in claim 17 wherein the data
entry unit includes a keypad icon on a display and wherein the display is
a touch screen.
FIG. 2
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04M1/72

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Relevant to claim No.</th>
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Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

* Special categories of cited documents:
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Date of the actual completion of the international search: 1 April 1999

Date of mailing of the international search report: 13/04/1999

Name and mailing address of the ISA
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 Hl Rijswijk Tel.: (+31-70) 340-2000, Tx.: 31 651 apo nl, Fax: (+31-70) 340-3016

Authorized officer: Delangue, P
### INTERNATIONAL SEARCH REPORT

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