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(54) **CONFIGURATION MANAGEMENT AND RETRIEVAL SYSTEM FOR PROTON BEAM THERAPY SYSTEM**

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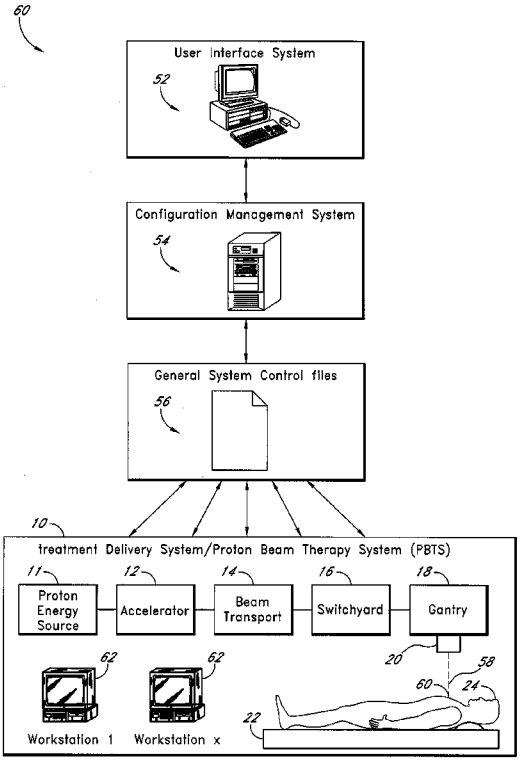
USPC **600/1**

(57) **ABSTRACT**

In a complex, multi-processor software controlled system, such as proton beam therapy system (PBTS), it may be important to provide treatment configurable parameters that are easily modified by an authorized user to prepare the software controlled systems for various modes of operation. This particular invention relates to a configuration management system for the PBTS that utilizes a database to maintain data and configuration parameters and also to generate and distribute system control files that can be used by the PBTS for treatment delivery. The use of system control files reduces the adverse effects of single point failures in the database by allowing the PBTS to function independently from the database. The PBTS accesses the data, parameters, and control settings from the database through the system control files, which insures that the data and configuration parameters are accessible when and if single point failures occur with respect to the database.



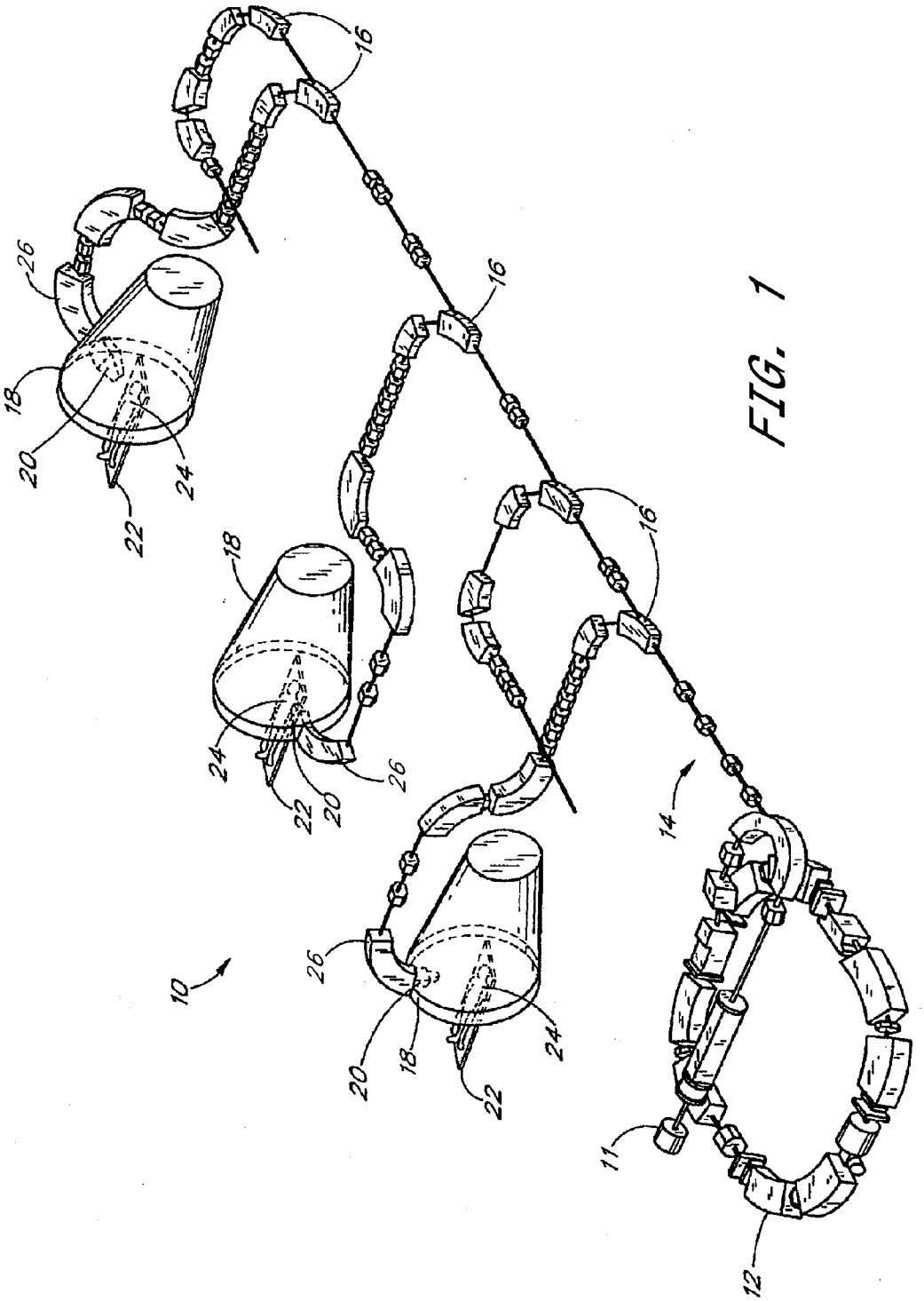


FIG. 1

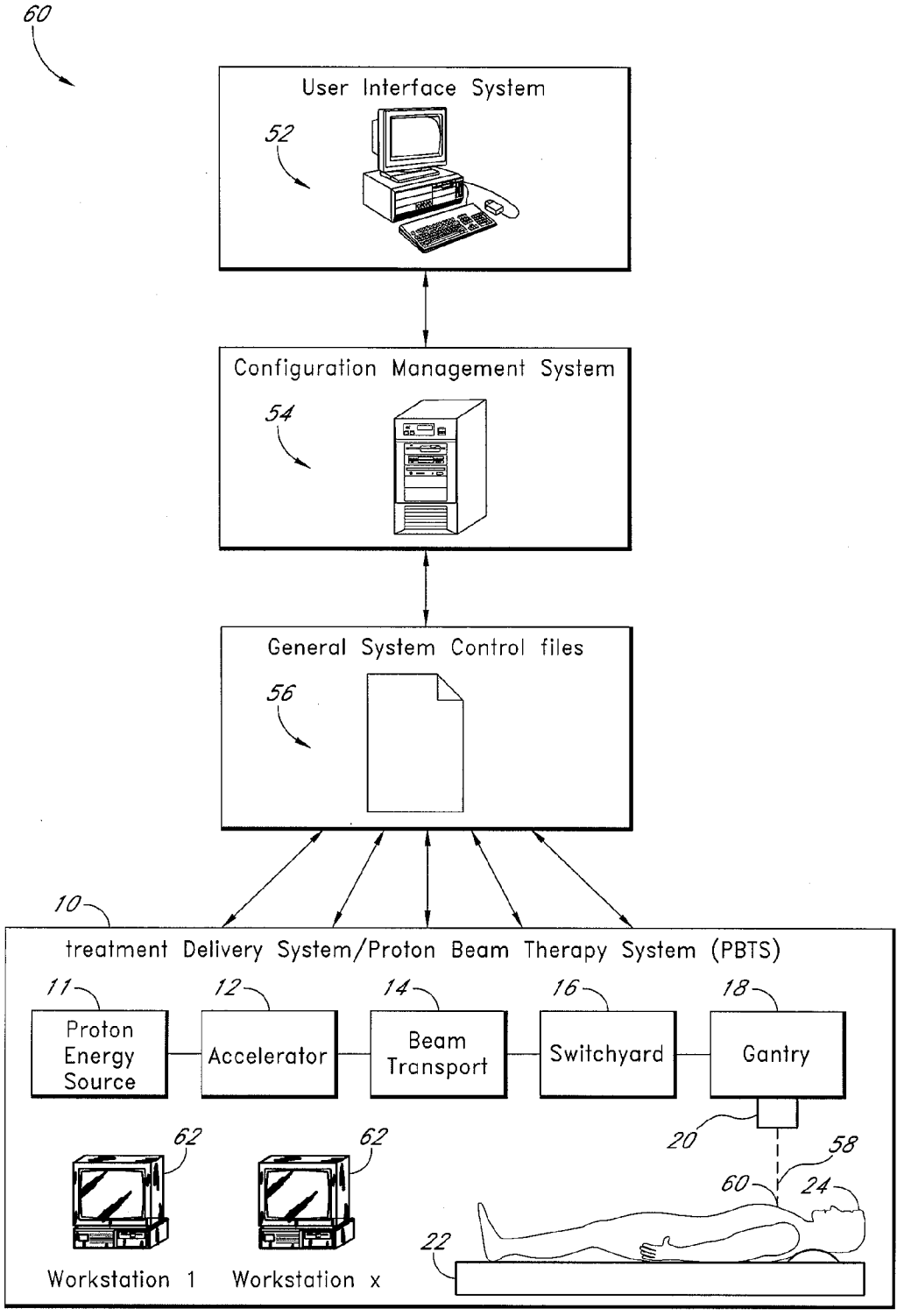

60
User Interface System
52
Configuration Management System
54
General System Control files
56
10
treatment Delivery System/Proton Beam Therapy System (PBTS)
11
Proton Energy Source
12
Accelerator
14
Beam Transport
16
Switchyard
18
Gantry
20
58
60
24
22
62
62
Workstation 1
Workstation x

FIG. 2

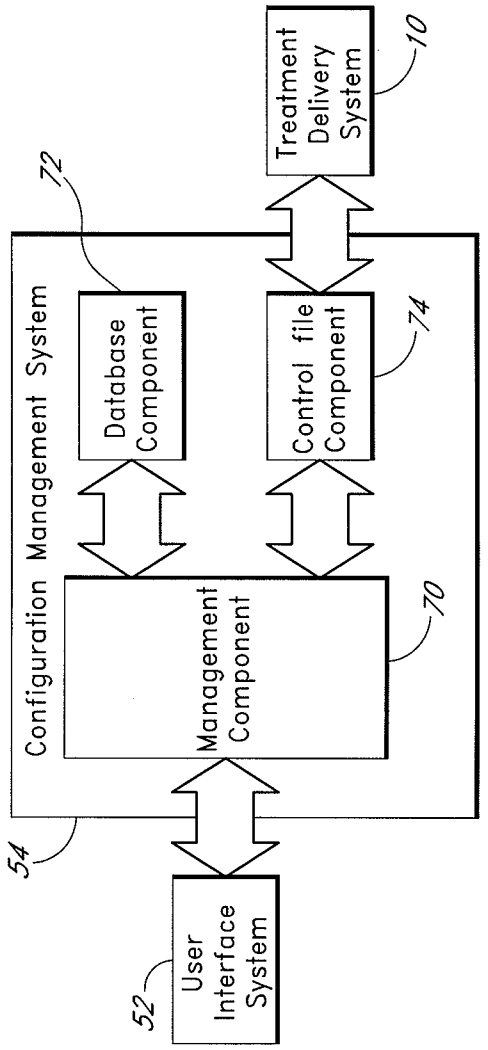

Treatment Delivery System
10
72
Configuration Management System
Database Component
Control file Component
74
Management Component
70
54
User Interface System
52

FIG. 3A

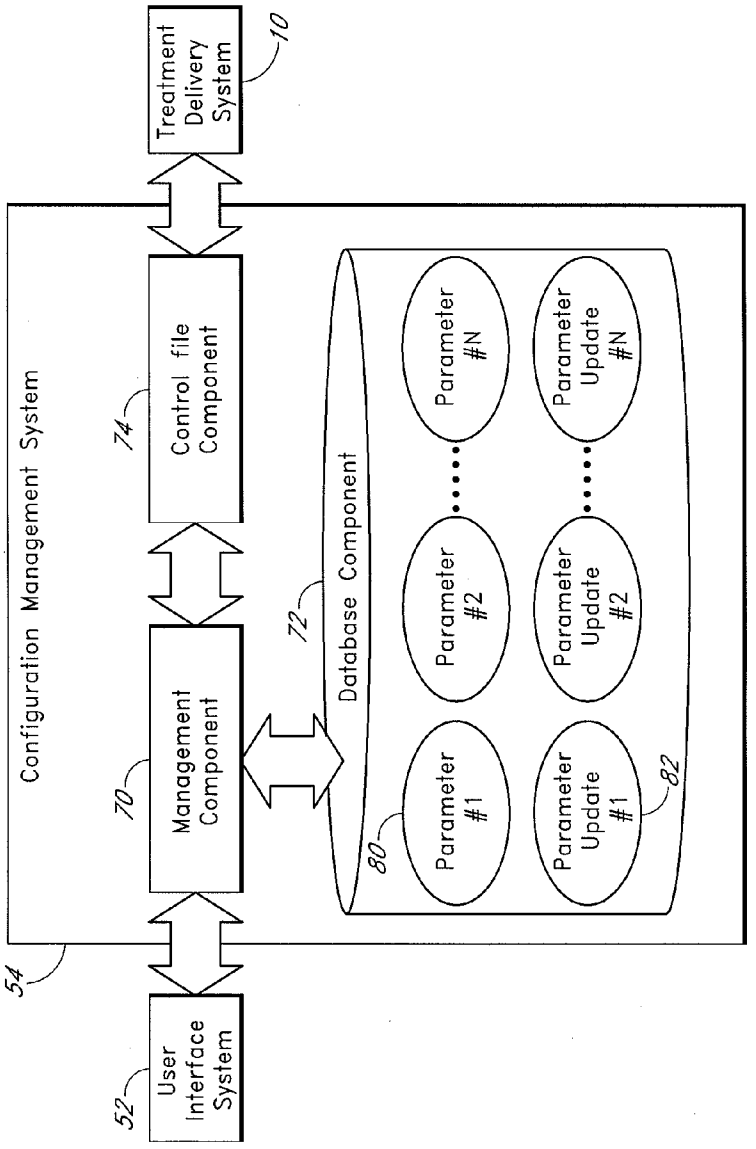

Treatment Delivery System
10
Configuration Management System
Control file Component
74
Management Component
70
Database Component
72
Parameter #1
Parameter #2
Parameter #N
Parameter Update #1
Parameter Update #2
Parameter Update #N
80
82
User Interface System
52
54

FIG. 3B

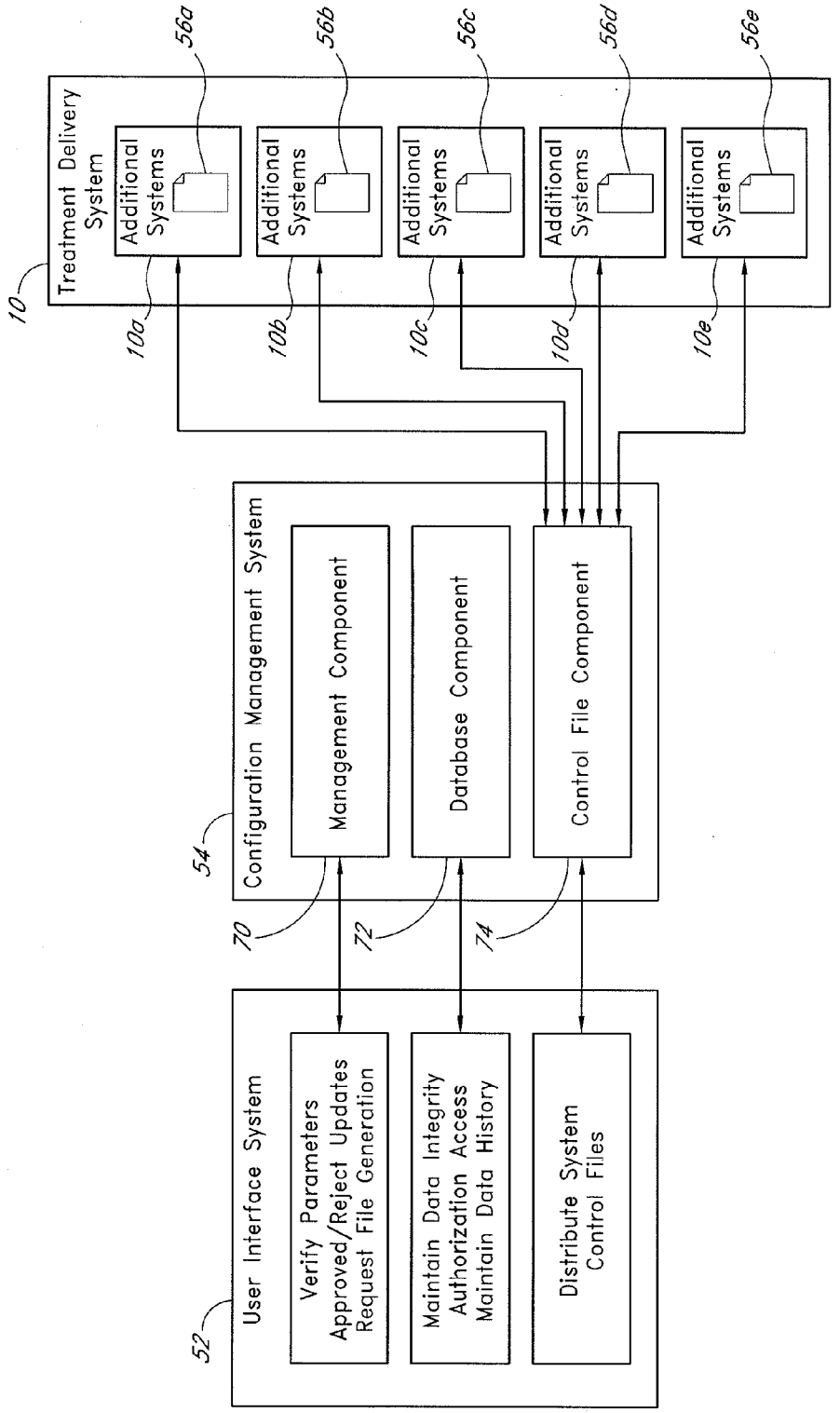

Treatment Delivery System
10
Additional Systems
56a
56b
56c
56d
56e
10a
10b
10c
10d
10e
Configuration Management System
54
Management Component
Database Component
Control File Component
70
72
74
User Interface System
52
Verify Parameters
Approved/Reject Updates
Request File Generation
Maintain Data Integrity
Authorization Access
Maintain Data History
Distribute System
Control Files

FIG. 3C

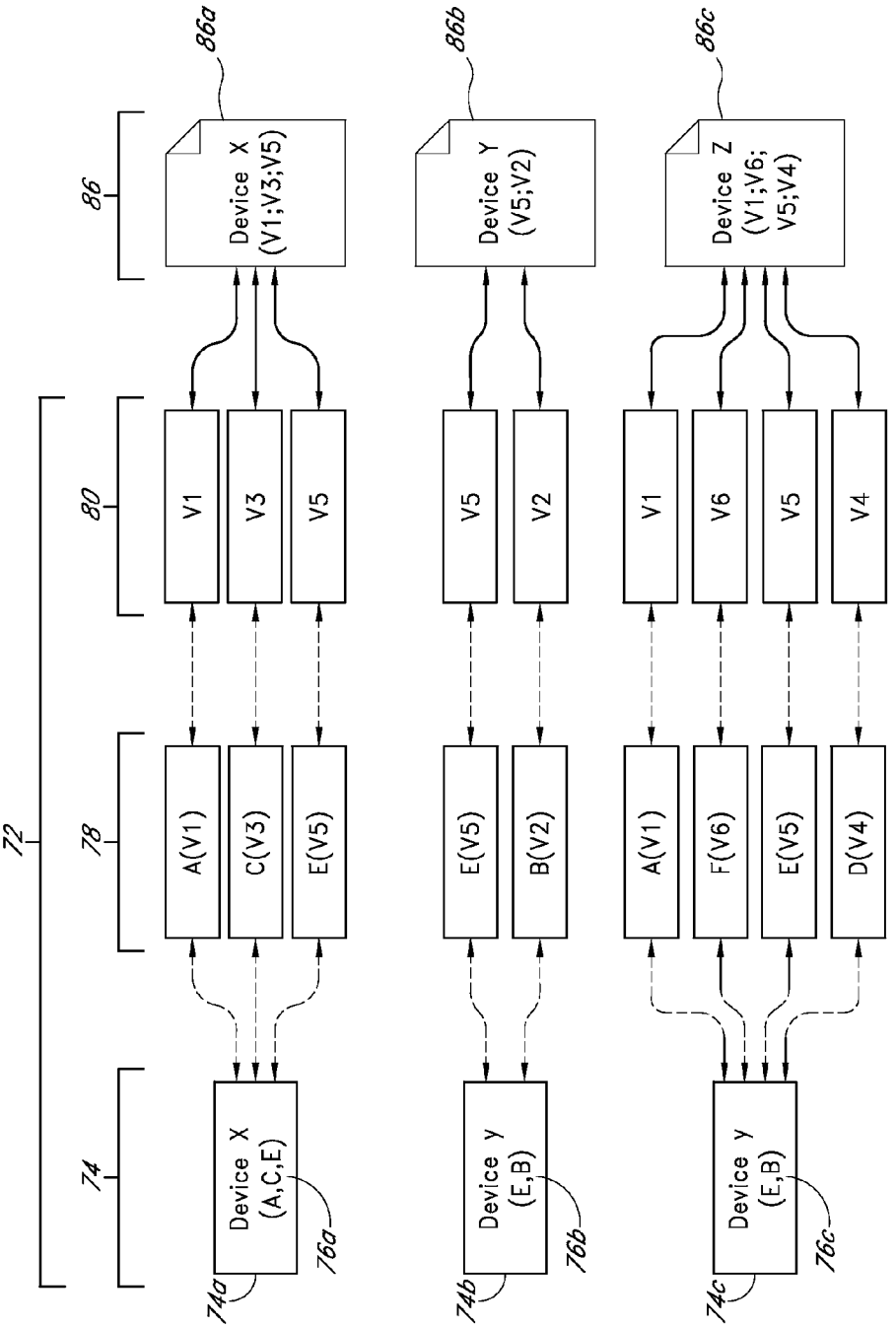

72
74
78
80
86
Device X (A,C,E)
Device y (E,B)
Device y (E,B)
A(V1)
C(V3)
E(V5)
E(V5)
B(V2)
A(V1)
F(V6)
E(V5)
D(V4)
V1
V3
V5
V5
V2
V1
V6
V5
V4
Device X (V1;V3;V5)
Device Y (V5;V2)
Device Z (V1;V6; V5;V4)
74a
74b
74c
76a
76b
76c
86a
86b
86c

FIG. 4A

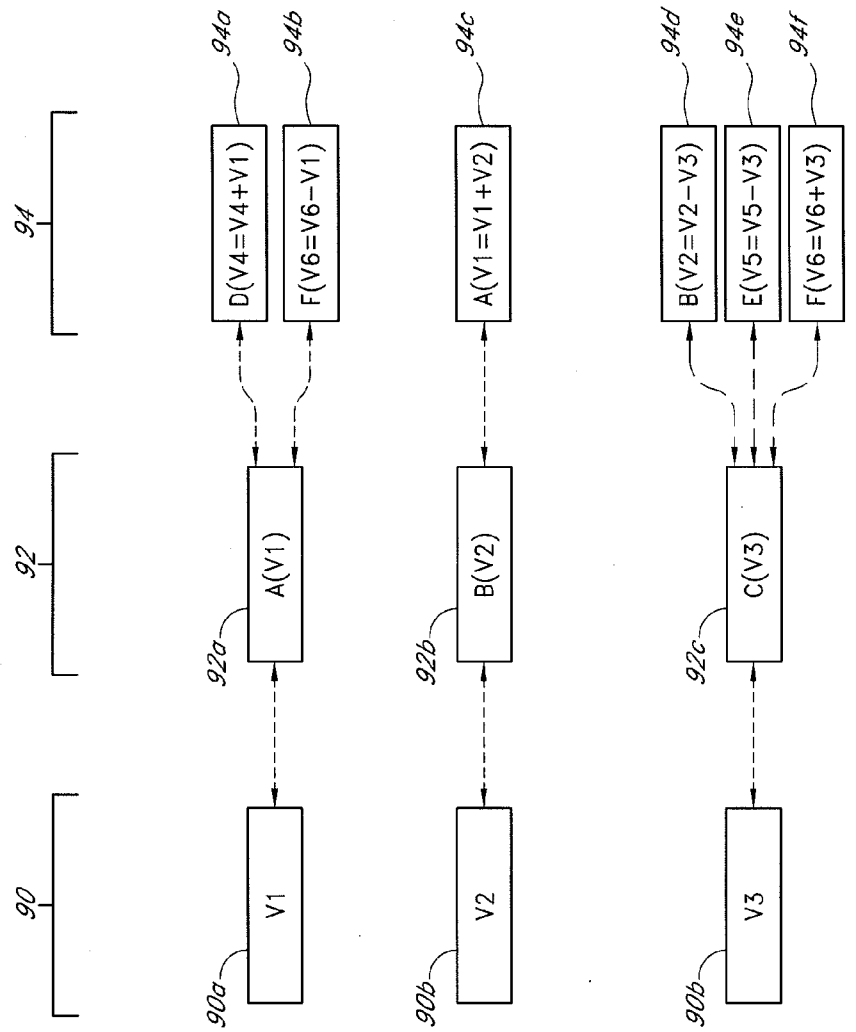

94
92
90
94a
94b
94c
94d
94e
94f
D(V4=V4+V1)
F(V6=V6-V1)
A(V1=V1+V2)
B(V2=V2-V3)
E(V5=V5-V3)
F(V6=V6+V3)
A(V1)
B(V2)
C(V3)
92a
92b
92c
V1
V2
V3
90a
90b
90b

FIG. 4B

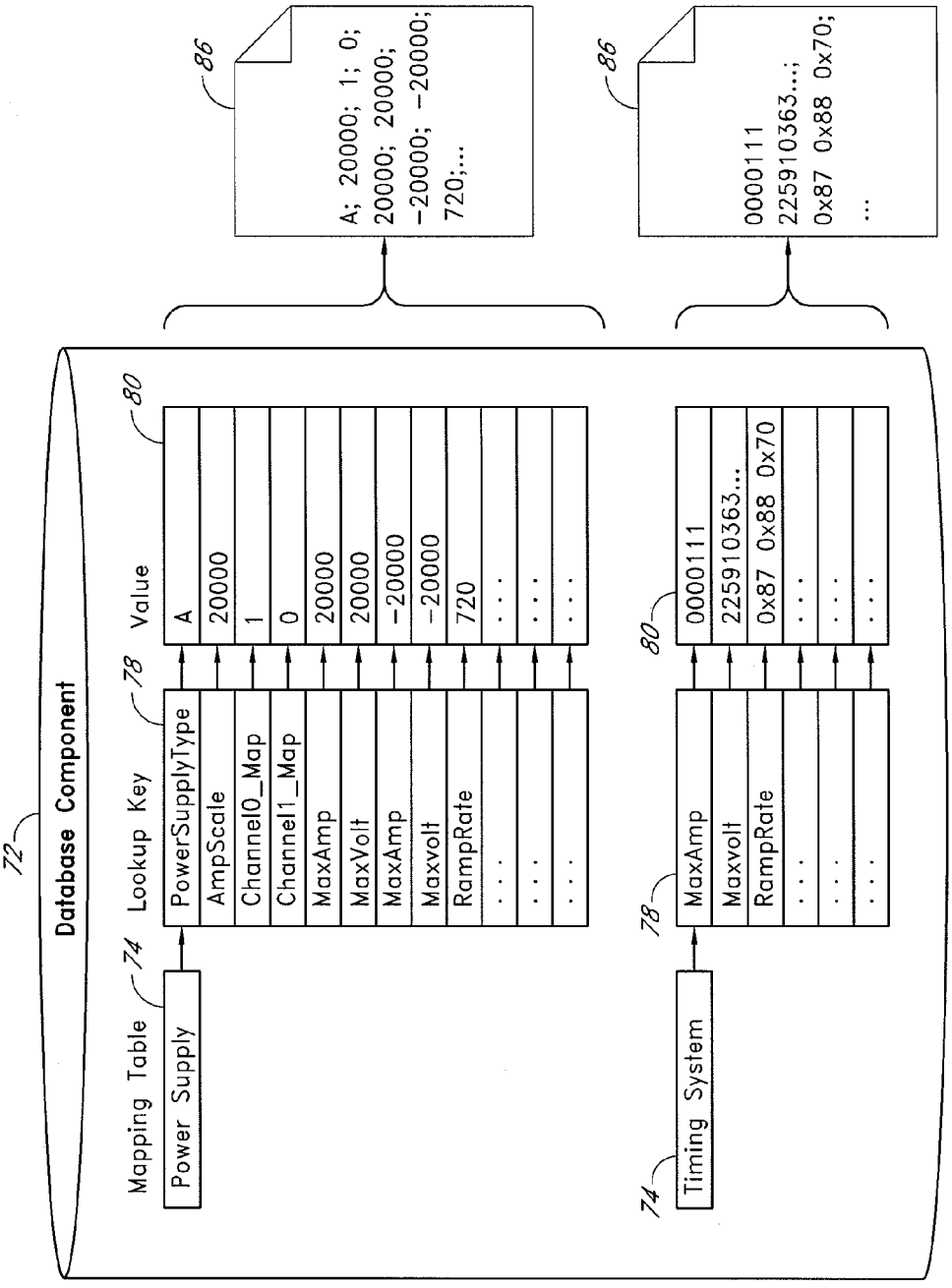

72
Database Component
Mapping Table
74
Power Supply
Timing System
Lookup Key
78
PowerSupplyType
AmpScale
Channel0_Map
Channel1_Map
MaxAmp
MaxVolt
MaxAmp
Maxvolt
RampRate
Value
80
A
20000
1
0
20000
20000
-20000
-20000
720
0000111
225910363...
0x87 0x88 0x70
86
A; 20000; 1; 0;
20000; 20000;
-20000; -20000;
720;...
0000111
225910363...;
0x87 0x88 0x70;
...

FIG. 4C

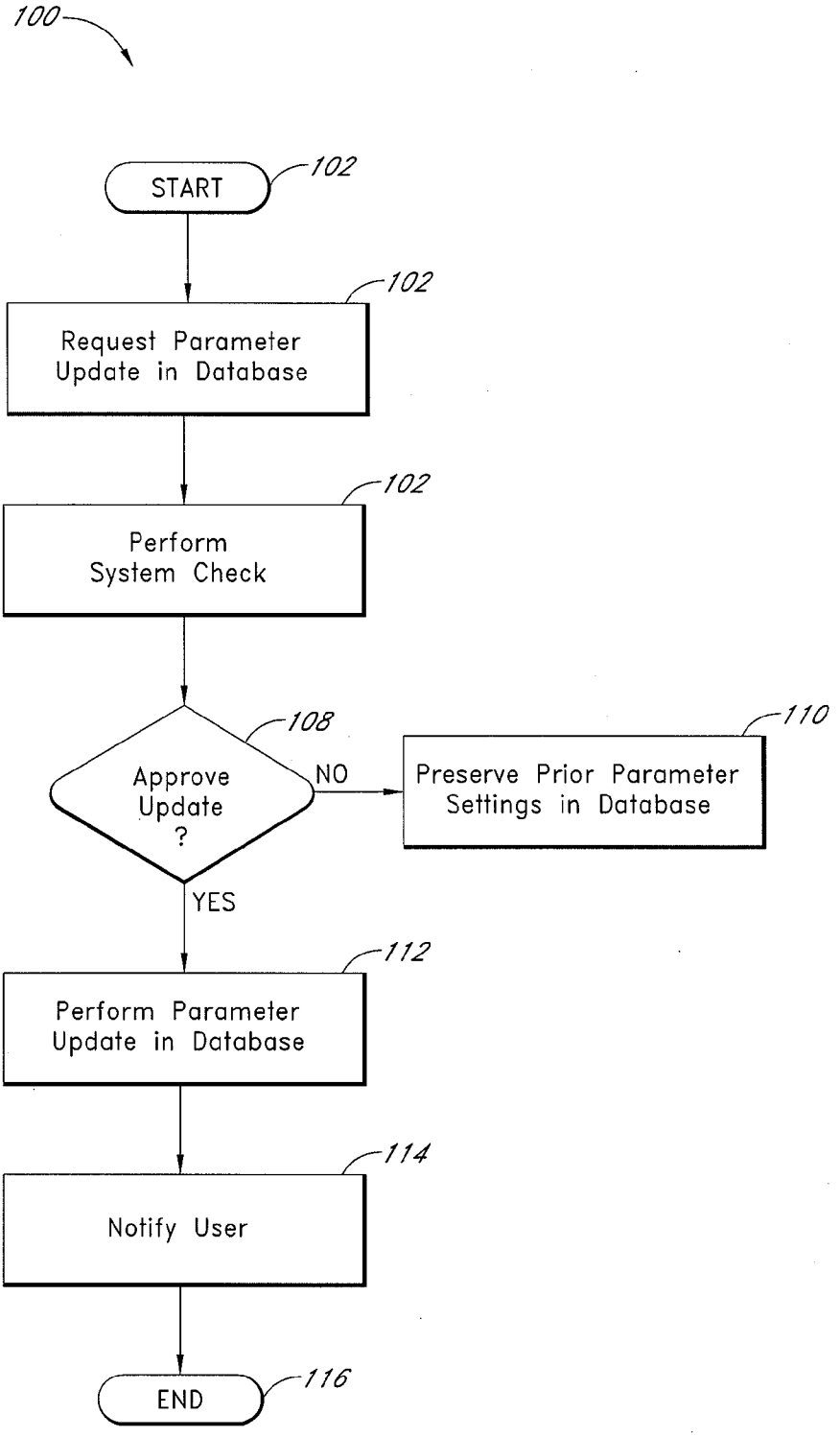

100
START
102
Request Parameter Update in Database
102
Perform System Check
102
Approve Update ?
108
NO
Preserve Prior Parameter Settings in Database
110
YES
Perform Parameter Update in Database
112
Notify User
114
END
116

FIG. 5

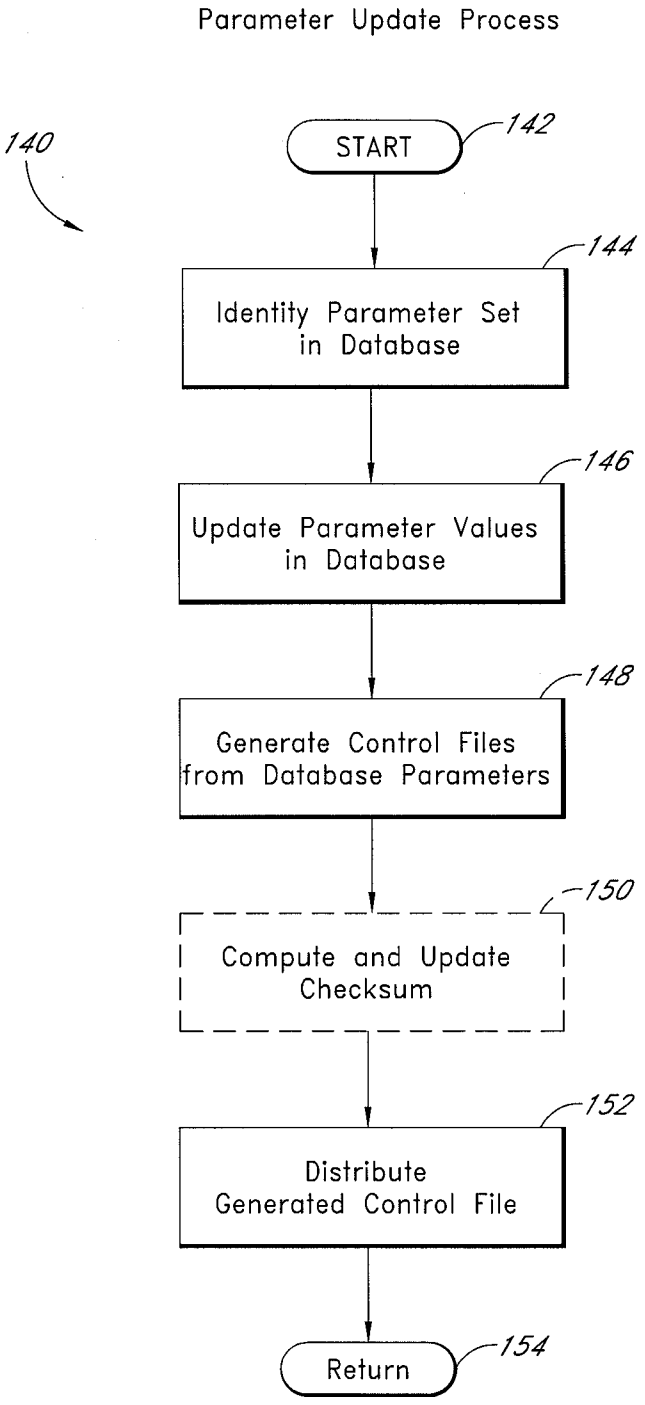

Parameter Update Process
140
START
142
Identity Parameter Set in Database
144
Update Parameter Values in Database
146
Generate Control Files from Database Parameters
148
Compute and Update Checksum
150
Distribute Generated Control File
152
Return
154

FIG. 6

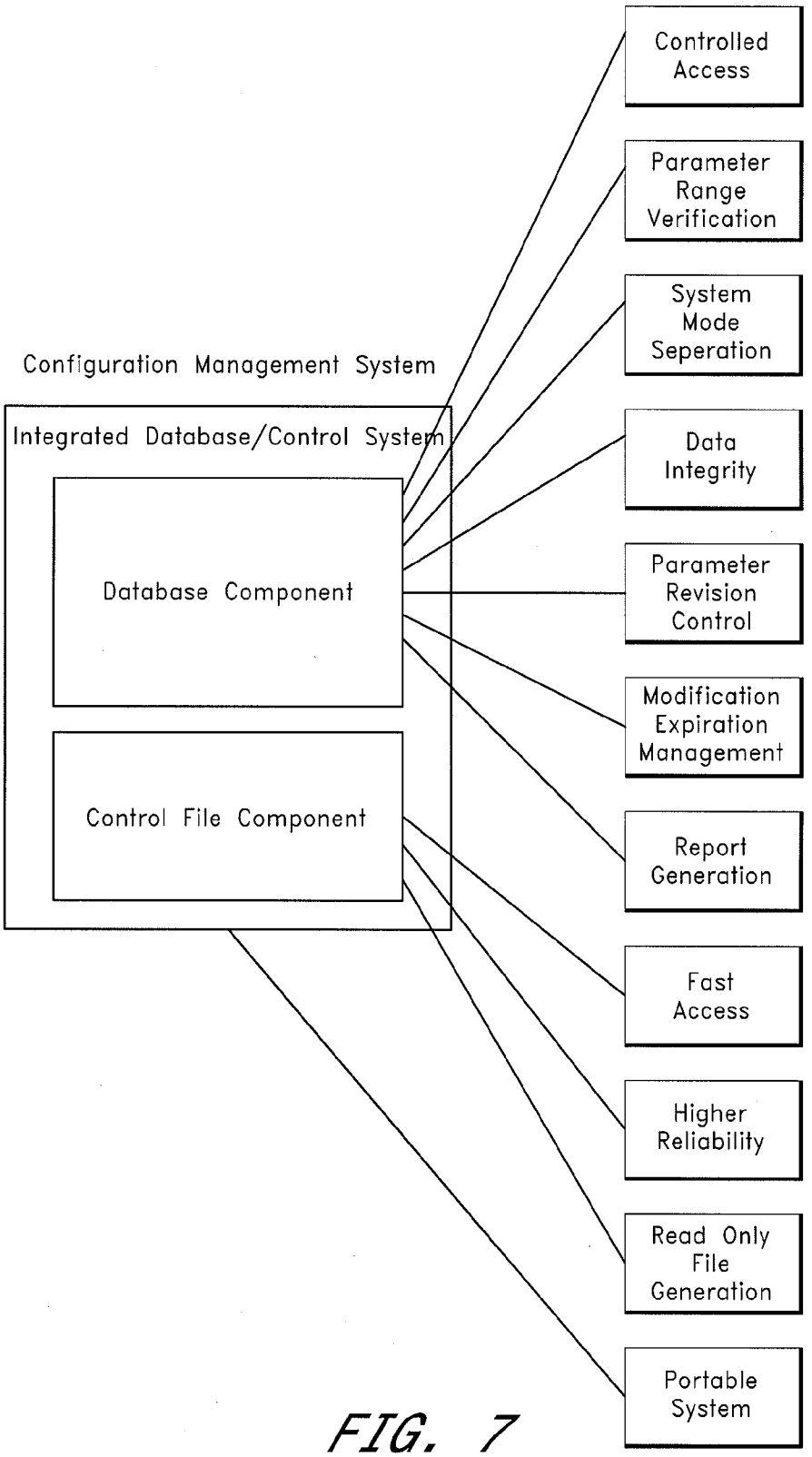

Configuration Management System
Integrated Database/Control System
Database Component
Control File Component
Controlled Access
Parameter Range Verification
System Mode Seperation
Data Integrity
Parameter Revision Control
Modification Expiration Management
Report Generation
Fast Access
Higher Reliability
Read Only File Generation
Portable System

FIG. 7

CONFIGURATION MANAGEMENT AND RETRIEVAL SYSTEM FOR PROTON BEAM THERAPY SYSTEM

RELATED APPLICATIONS AND CLAIM OF PRIORITY

[0001] This application is a continuation of: U.S. patent application Ser. No. 12/876,902 filed on Sep. 7, 2010, titled "CONFIGURATION MANAGEMENT AND RETRIEVAL SYSTEM FOR PROTON BEAM THERAPY SYSTEM" (shortly to issue as U.S. Pat. No. 8,354,656); which is a continuation of U.S. patent application Ser. No. 12/056,623, filed Mar. 27, 2008, titled "CONFIGURATION MANAGEMENT AND RETRIEVAL SYSTEM FOR PROTON BEAM THERAPY SYSTEM" (now U.S. Pat. No. 7,791,051); which is a continuation of U.S. patent application Ser. No. 11/460,880, filed Jul. 28, 2006, titled "CONFIGURATION MANAGEMENT AND RETRIEVAL SYSTEM FOR PROTON BEAM THERAPY SYSTEM" (now U.S. Pat. No. 7,368,740); which is a continuation of U.S. patent application Ser. No. 10/994,911 filed Nov. 22, 2004, titled "CONFIGURATION MANAGEMENT AND RETRIEVAL SYSTEM FOR PROTON BEAM THERAPY SYSTEM" (now U.S. Pat. No. 7,084,410); which is a continuation of U.S. patent application Ser. No. 10/744,697 filed Dec. 22, 2003, titled "CONFIGURATION MANAGEMENT AND RETRIEVAL SYSTEM FOR PROTON BEAM THERAPY SYSTEM" (now U.S. Pat. No. 6,822,244); which claims the benefit of U.S. Provisional Application No. 60/438,281 filed Jan. 2, 2003. The entire disclosure of each of the above-listed applications is hereby incorporated herein by reference, for all the each contains.

BACKGROUND

[0002] 1. Field

[0003] The present invention relates to particle radiation therapy systems and, in particular, concerns an improved data storage system that reduces the effects of single point failures for radiation beam therapy systems.

[0004] 2. Description of the Related Art

[0005] Particle radiation therapy involves coordinating complex systems and devices to enable targeting of specific cancerous regions of a patient. In particular, proton beam therapy utilizes one or more precisely aligned particle streams to irradiate cancer or tumor cells. The energized protons disrupt targeted cells or tissue so as to effectively halt the progression of the disease. In proton beam therapy, the patient should be accurately positioned with respect to the one or more beams so that the stream irradiates only the desired target region. Otherwise, the stream may damage other healthy cells within the patient's body. Specific alignment in this manner requires numerous control systems to maintain accurate and precise dosage delivery to a plurality of patients during prescribed treatments.

[0006] As described in U.S. Pat. No. 4,870,287, a proton treatment facility may comprise a proton energy source, an injector, an accelerator, a beam transport system, a switchyard, and a plurality of treatment stations so as to accommodate multiple patients. Each treatment station may comprise a plurality of treatment components such as treatment platforms, gantry structures, and patient monitoring components. Additionally, control and monitoring of the proton treatment facility may be directed by computer and hardware subsystems, which coordinate the activities of each treatment station using software configurable components.

[0007] Moreover, control system activities may include beam intensity management, beam position orientation and modification, digital imaging performance, safety condition monitoring, and various other treatment functions. Together these systems form a highly complex collection of hardware and software components. The complexity of the proton treatment facility may be further magnified by managing multiple treatment stations where additional requirements for system redundancy and selective control of each treatment station is required.

[0008] The complex architecture of proton therapy systems present numerous obstacles for coordinating control of a high volume patient throughput. On a typical treatment day, prescribed treatment dosages may be configured for many patients using a plurality of treatment stations, whereby delivery of simultaneous treatments may effect concurrent treatment dosages between patients. For example, each treatment station may require a different proton beam energy delivery, wherein the overall energy is calculated and produced at the source, the switchyard diverts the proper amount of proton beam energy to each treatment station, and the multiple gantries are positioned to deliver the diverted energy to the target regions of the patients on the treatment platforms.

[0009] To elicit the coordination control of multiple treatment stations, conventional proton beam therapy control systems use either a centralized computer system, such as a database server, or separate computer subsystems to localize control. The problem with a centralized computer system is that, if one or more treatment components fails to function or goes offline, the system as a whole may shut down. Also, if the centralized computer fails, the treatment components may stop functioning because they rely on the centralized computer for operational instructions. Unfortunately, with the high volume of treatments to be delivered, a system shut down would be inconvenient, costly, and reduce treatment efficiency.

[0010] Some treatments may be delayed or postponed for another day, which inconveniences everyone including the patient and the system operators. In other circumstances, a delayed or postponed treatment may degrade the therapy provided, wherein the treatment time may need to be reduced or the dosage modified to accommodate a larger number of treatments in a reduced period of time. Additionally, delayed treatments may also incur additional treatment costs due to extended periods of operation, where system operators are paid overtime wages and the treatment delivery systems remain operable for longer periods of time. Therefore, a centralized computer alone is not the answer due to unavoidable failures that may occur during treatment delivery, which may endanger some patients.

[0011] Since patient safety is a great concern, some conventional proton beam therapy control systems use separate computer subsystems to localize control to particular treatment components. The problem with localized control is that each component requires a system operator to manually enter prescribed treatment and operational parameters for each patient at each treatment station. Unfortunately, the length of each treatment would be extended due to the additional time needed to enter prescribed parameters for each patient treatment and system operation. Also, the high volume of treatments to be delivered would need to be reduced to accommo-

date the additional time or additional system operators would need to be hired to extend the treatment day, which results in additional operational costs.

[0012] Hence, there is a need for an improved proton beam therapy control system that manages multiple treatment delivery components and coordinates delivery of simultaneous treatments without compromising patient safety. There is also a need for an improved proton beam therapy control system that reduces the adverse effects of centralized computer failures if one or more treatment components fails to function. Additionally, this system architecture should be able to accommodate the complexity associated with proton beam therapy control systems while maintaining an acceptable level of user interactive simplicity so as to facilitate configuration, maintenance, and development in an efficient manner.

SUMMARY

[0013] The aforementioned needs are satisfied by a radiation beam therapy system having a plurality of treatment devices including a radiation beam source and a beam transport device. In one embodiment, the radiation beam therapy system comprises a database component that stores subsets of parameters associated with selected treatment devices, wherein the parameters comprise instructional information that can be used to configure the selected treatment devices for operation. In addition, the radiation beam therapy system comprises an interface component that allows a user to modify the subsets of parameters associated with selected treatment devices stored in the database. Moreover, the radiation beam therapy system comprises a management component that extracts subsets of parameters from the database and generates data storage elements comprising the extracted subsets of parameters in a format recognizable by the selected treatment devices, wherein the data storage elements permit configuration of the selected treatment devices based, at least in part, on the instructional information comprised therein, the management component further distributes the data storage elements to the selected treatment devices to thereby permit the selected treatment devices to operate independently of the database component.

[0014] In one aspect, operation of the selected treatment devices includes a treatment mode of operation. The plurality of treatment devices includes at least one of a charged particle source, an accelerator, and a beam transport system. The source or accelerator includes a proton synchrotron and the beam transport system includes a plurality of steering and focussing magnets with beam sensors distributed along an evacuated beam transport tube. The beam transport system connects to a series of switchyards that include an array of dipole bending magnets which deflect the beam to any one of a plurality of beam focussing and deflection optics leading to respective treatment locations having rotatable gantries. Also, a beam delivery system may be located within each rotatable gantry, which may be adapted to deliver therapeutic radiation doses to a patient lying on a treatment platform according to a specific patient treatment plan.

[0015] In another aspect, the subsets of parameters include treatment data, configuration parameters, operational parameters, and control settings for the selected treatment devices. The selected treatment devices are software controlled instruments that require at least one of the subsets of parameters for operation and treatment. The database component comprises a centralized database server, which stores configuration and operational information, such as data, parameters, and control settings, for the selected treatment devices in a manner so as to provide easy access to the stored configuration and operational information, wherein parameter retrieval and modification are easily performed by the centralized database server via requests from the interface component. The centralized database server provides configuration management activities, which may include record keeping and version/revision control. The management component reduces the occurrence of single point failures by generating appropriate data storage elements and distributing the data storage elements to the selected treatment devices. The distribution of data storage elements by the management component affords the selected treatment devices operational independence from the database component due to the associated reliance on the data storage elements for parameter retrieval and operational configuration.

[0016] In still another aspect, the radiation beam therapy system comprises at least one communication link between the management component and the selected treatment devices so as to distribute the generated data storage elements to the selected treatment devices. The subsets of parameters are stored in the database component in at least one of database table structures, records, and values. The data storage elements are arranged in a consolidated information set that is recognizable by the selected treatment devices. The consolidated information set exploits the native functionality of the selected treatment devices in a manner such that an additional numerical or supplemental program or application may be unnecessary for the selected treatment devices to recognize the configuration parameter values from the data storage elements. The data storage elements comprise a data type that is stored and accessed in a file-oriented manner as is suitable for each selected treatment devices. The data storage elements comprise a data type that is stored and accessed in an address-oriented manner as is suitable for each selected treatment devices. The data storage elements comprise one or more volatile or non-volatile system control files. The data storage elements comprise one or more system control files including flat files. The one or more system control files include one or more flat files.

[0017] In still another aspect, the management component sends configurable parameters to each treatment device, and wherein a selected treatment device retrieves usable parameters from the configurable parameters. Additionally, the management component selectively sends configurable parameters to each treatment device representing usable parameters by each treatment device.

[0018] The aforementioned needs are also satisfied by a radiation beam therapy system comprising a plurality of distributed functional components whose operation is coordinated to elicit a selected operational mode. In one embodiment, the system comprises a database component that stores a plurality of parameters associated with the distributed functional components. In addition, the system comprises an interface component that allows a user to select an operational mode for which the database component identifies appropriate subsets of parameters that are associated with the distributed functional components and generates at least one system control file containing an appropriate subset of parameters used to configure a selected distributed functional component to operate in such a manner to elicit the selected operational mode. Moreover, the system comprises a control file distribution component that provides each of the distributed func-

tional components with the appropriate system control file such that the functional components are able to operate substantially independently of the database component while eliciting the selected operational mode.

[0019] The aforementioned needs are also satisfied by a radiation beam therapy system comprising, in one embodiment, a plurality of treatment devices including a radiation beam source and a beam transport device and a database that stores subsets of specific parameters associated with selected treatment devices, wherein the specific parameters comprise a logical collection of instructional information that can be used to configure the selected treatment devices for operation. In addition, the system comprises an interface that allows a user to modify the subsets of specific parameters associated with selected treatment devices stored in the database. Moreover, the system comprises a management component that extracts selected subsets of specific parameters from the database and generates system control files comprising the extracted subsets of specific parameters in a format recognizable by the selected treatment devices, wherein the system control files permit configuration of the selected treatment devices based, at least in part, on the instructional information comprised therein, the management component further distributes the system control files to the selected treatment devices to thereby permit the selected treatment devices to operate independently of the database. Furthermore, the subsets of specific parameters comprise, for example, subsets of instrument specific parameters.

[0020] The aforementioned needs are also satisfied by a radiation beam therapy system having a plurality of functional components including a radiation beam source and a beam transport device. In one embodiment, the system comprises a database that stores subsets of configurable parameters associated with the operation of the functional components, the database further comprising an interface component that allows a user to modify the stored subsets of configurable parameters. In addition, the system comprises a management component that retrieves subsets of configurable parameters associated with selected functional components from the database, the management component further generating control files from the stored configurable parameters, and subsequently distributing the generated control files to the identified functional components such that the identified functional components can operate independently.

[0021] The aforementioned needs are also satisfied by a radiation beam therapy system comprising, in one embodiment, at least one functional component that can be configured for treatment delivery via a subset of configurable parameters and a database component that stores the subset of configurable parameters as a logical collection of information, the database component having a user interface that allows a user to modify the logical collection of information. In addition, the system comprises a management component that communicates with the database component and the at least one functional component, wherein the management component identifies the subset of configurable parameters associated with the at least one functional component, generates a first file from the identified subset of configurable parameters, and distributes the first file to the at least one functional component so that, upon reception of the first file, the at least one functional component can extract the subset of configurable parameters from the first file and configure itself for treatment delivery.

[0022] The aforementioned needs are also satisfied by a method for managing a plurality of distributed instruments used in treatment delivery for a radiation beam therapy system. In one embodiment, the method comprises storing operational instructions for each instrument within a centralized configuration management system having a database component in which the operational instructions are maintained and selecting an operational mode for the radiation beam therapy system and identifying a subset of operational instructions stored in the database component for each of the distributed instruments to be used in configuring the radiation beam therapy system to function in the selected operational mode. In addition, the method comprises generating a data storage element for each of the distributed instruments containing the required operational instructions necessary to configure each distributed instrument to function in such a manner so as to result in the radiation beam therapy system functioning in the selected operational mode. Moreover, the method comprises transferring the data storage element to the distributed instruments thereby providing the necessary operational instructions for a selected distributed instrument to operate without requiring further access to the centralized configuration management system to elicit functioning of the radiation beam therapy system in the desired operational mode.

[0023] In one aspect, generating a data storage element includes generating a plurality of data storage elements. Also, generating a data storage element includes generating at least one flash memory element. Additionally, generating a data storage element includes generating at least one system control file. Moreover, transferring the data storage element to the distributed instruments includes transmitting the data storage element to the distributed instruments.

[0024] The aforementioned needs are also satisfied by a method of configuring a radiation beam therapy system having a plurality of functional components for directing a beam to at least one of a plurality of treatment locations. In one embodiment, the method comprises maintaining a plurality of configurable parameters in a database, the configurable parameters used to coordinate the function of the plurality of functional components thereby eliciting operational control of the radiation beam therapy system and selecting an operational mode in which the beam is to be directed to a particular treatment location with a desired set of operational parameters. In addition, the method comprises identifying subsets of parameters from the plurality of configurable parameters maintained in the database that are used to configure and control the functional components in such a manner so as to direct the beam to the selected treatment location with the desired set of operational parameters. Moreover, the method comprises generating at least one system control file which reflects the subsets of parameters used to configure and control the functional components and distributing the at least one system control file to at least one of the plurality of functional components thereby directing the operation of the functional components.

[0025] These and other objects and advantages of the present invention will become more apparent from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] FIG. **1** illustrates one embodiment of a clinically-based radiation beam therapy system, such as, for example, a

proton beam therapy system (PBTS), that may used in a particle radiation treatment facility.

[0027] FIG. **2** illustrates one embodiment of a PBTS configuration management system that may be used for accessing and maintaining PBTS configuration data and parameters.

[0028] FIG. **3**A illustrates a simplified block diagram of the PBTS treatment delivery system, the PBTS user interface system, and the PBTS configuration management system having a management component, a database component, and a control file component.

[0029] FIG. **3**B further illustrates the PBTS configuration management system with functional features associated with the database component.

[0030] FIG. **3**C further illustrates the management component, which may be used by the PBTS configuration management system to identify, retrieve, and update configuration parameters from the database component and to generate system control files using the control file component.

[0031] FIG. **4**A illustrates one embodiment of a logical organization of the configuration parameters in the database component.

[0032] FIG. **4**B illustrates one embodiment of configuration parameter associations, wherein modifications to one parameter may effect other parameters.

[0033] FIG. **4**C illustrates one example of using mapping tables to generate system control files associated with specific treatment delivery devices in the PBTS.

[0034] FIG. **5** illustrates one embodiment of a system configuration process that may be used by the PBTS configuration management system to modify parameters for the PBTS treatment delivery system.

[0035] FIG. **6** illustrates one embodiment of a parameter update process that may be used by the management component of the PBTS configuration management system to update system configuration parameters used by the PBTS treatment delivery system.

[0036] FIG. **7** illustrates the advantages of using the PBTS configuration management system of the present invention to manage, update, and distribute configuration parameters for the PBTS treatment delivery system.

DETAILED DESCRIPTION

[0037] In complex, multi-processor software controlled systems, it may be important to provide treatment configurable parameters that are easily modified by an authorized user to prepare the software controlled system for various modes of operation. In one embodiment, a configuration management system of the present invention provides a centralized database server, which stores configuration and operational information, such as data, parameters, and control settings, for the software controlled systems. Advantageously, the database approach provides easy access to the stored configuration and operational information, wherein parameter retrieval and modification are easily performed by the configuration management system via requests from a user interface system. Additionally, the configuration management system provides configuration management activities, which may include record keeping and version/revision control as will be described in greater detail herein below.

[0038] In conventional treatment delivery systems, the treatment delivery components access operational and configuration parameters directly from the database component using a single point acquisition approach. Single point acquisition requires a direct dependence on the database component for operation and parameter retrieval via a direct communication link between the treatment delivery devices and the database component. As a result of operational dependence, if a network problem occurs and the database component is offline or unavailable, then the conventional treatment delivery systems are forced to shut down and patient treatments may be terminated until the database component is functionally online or available. Single point failures are disadvantageous to patient health, treatment stability, and operational efficiency.

[0039] Conversely, the present invention reduces the occurrence of single point failures by generating a static document, such as a flat text file, read-only file, or flash memory element, comprising operational and configuration parameters and distributing the static document to the treatment delivery components. The distribution of static documents affords the treatment delivery components operational independence from the database component due to the associated reliance on the static documents for parameter retrieval and operational configuration. Although a communication link may be used to distribute the generated static document or system control file to the treatment delivery components, operational reliance is advantageously shifted to the static document. The scope and functionality of the static documents or system control files will be described in greater detail herein below.

[0040] Moreover, for ease of updating and retrieval, configuration parameters, for example, may be stored in the database table structures as records or values. When generating the static document or system control file, the retrieved configuration parameter values may be arranged in a consolidated information set that is recognizable by the treatment delivery components. Advantageously, the consolidated information set exploits the native functionality of the treatment delivery devices in a manner such that an additional numerical or supplemental program or application may be unnecessary for the treatment delivery devices to parse the configuration parameter values from the static document. Moreover, the static documents or system control files provide fast, localized parameter retrieval capability and independent operational capabilities for the software controlled systems as will be further described in greater detail herein below.

[0041] Reference will now be made to the drawings wherein like numerals refer to like parts throughout. FIG. **1** illustrates one embodiment of a clinically-based radiation beam therapy system, such as, for example, a proton beam therapy system (PBTS) **10**, that may used in a particle radiation treatment facility. In one embodiment, the proton beam therapy system **10** may comprise a plurality of treatment delivery components including a charged particle source **11**, an accelerator **12**, and a beam transport system **14**. Additionally, the source/accelerator **11**, **12** may comprise, for example, a proton synchrotron and the beam transport system **14** may comprise, for example, a plurality of steering and focussing magnets with beam sensors distributed along an evacuated beam transport tube.

[0042] In one aspect, the beam transport system **14** connects to a series of switchyards **16** that may comprise an array of dipole bending magnets which deflect the beam to any one of a plurality of beam focussing and deflection optics **26** leading to respective treatment locations having rotatable gantries **18**. Moreover, a beam delivery system **20** may be located within each rotatable gantry **18**, which may be adapted to deliver therapeutic radiation doses to a patient **24**

lying on a treatment platform **22**, according to a specific patient treatment plan. An exemplary proton beam treatment system is more fully disclosed in U.S. Pat. No. 4,870,287, which is hereby incorporated by reference in its entirety.

[0043] In operation, charged particle beams of a predefined energy may be generated by the proton synchrotron **12** and transported by the beam transport system **14** to the switchyards **16**. The switchyards **16** may be configured to select a one or more gantries **18** for transport of radiation thereto. Each rotatable gantry **18** is capable of orienting the beam delivery system **20** relative to the target location of the patient **24**. Beam orientation allows directed deposition of radiation to a predefined location along the rotation axis or a so-called isocenter. Additionally, to facilitate accurate and precise dosage delivery to one or more of the patients **24**, the beam delivery system **20** may be positioned, configured, and calibrated for radiation delivery according to prescribed specifications of the patient treatment plan.

[0044] One of the central components of the proton beam therapy system **110** is the radiation delivery system **20**, designed to deliver precise dose distributions to a target volume within a patient. In general, such delivery systems are comprised of components which may either modify or monitor specific properties of a radiation beam relevant to the treatment plan. The beam delivery system **20** may, for example, comprise a device to spread or otherwise modify the beam position and profile, a dispersive element to modify the beam energy and a plurality of beam sensors to monitor such properties. Additional disclosure relating to the radiation delivery system **20** is provided in U.S. Pat. No. 4,870,287.

[0045] FIG. **2** illustrates one embodiment of a central configuration of a particle radiation treatment facility **50** that may be used to provide proton beam therapy treatments to patients in a manner as previously described with reference to FIG. **1**. The particle radiation treatment facility **50** may comprise the proton beam therapy system (PBTS) **10** of FIG. **1**, a user interface system **52**, and a configuration management system **54** that may be used to generate one or more static documents or system control files **56** for the PBTS treatment delivery components **11**, **12**, **14**, **16**, **18**, **20** of the PBTS **10**. In addition, the one or more generated system control files **56** may be distributed to the PBTS **10** by the configuration management system **54** in a manner so as to provide configuration data and parameters in a recognizable format to the PBTS treatment delivery components **11**, **12**, **14**, **16**, **18**, **20**.

[0046] In one embodiment, the user interface system **52** may comprise a generally known computer workstation, such as a personal computer, that may be used to retrieve and modify the configuration parameters for the PBTS **10**. One or more users, such as system operators, field service engineers, medical physics personnel, facility administrators, etc., may update PBTS configuration data, parameters, and/or control settings in the configuration management system **54** via the user interface system **52**. The user interface system **52** provides access to data, parameters, and control settings that may be used to configure the previously mentioned PBTS treatment delivery components in the PBTS **10**. The PBTS **10** may be given access to the configuration data through the system control files **56** that may be generated and provided by the configuration management system **54**.

[0047] It should be appreciated that there may be more than one user interface system **52** to the configuration management system **54** without departing from the scope of the present teachings. However, for safety reasons, a preferred embodiment may comprise one designated user interface system **52** to the configuration management system **54** to update configuration data, parameters, and control settings for the PBTS treatment delivery components **11**, **12**, **14**, **16**, **18**, **20** in the PBTS **10**. It should be appreciated that there are configurable parameters and control settings that may apply to software related components as well as the hardware related components. Some software and hardware components that may be configured through the configuration management system **54** may include, but are not limited to, power supplies, tesla meters, sensors, detectors, timing control systems, user interfaces, network configurations, and safety systems.

[0048] In one embodiment, the configuration management system **54** may comprise a generally known centralized computer system, such as a database server, that may be used to store the PBTS configuration data and parameters in database components, such as files, in a manner so as to be easily retrievable by the user interface system **52** when prompted by a user. Advantageously, the manipulation of the configuration data and parameters through the configuration management system **54** allows for maintaining configuration data and parameter integrity as well as providing an interactive interface to the user. In a manner as will be described in greater detail herein below, the configuration management system **54** may comprise processing and management components that may be used to verify updated parameter settings to an acceptable operational range. For example, if the operational range of a power supply is between 0 and 500 amps, then the management component verifies that supply output is not set less than 0 amps and greater than 500 amps.

[0049] In one embodiment, the configuration management system **54** uses a PBTS software application that allows authorized users to easily access and modify the PBTS configurable parameters while maintaining data integrity. The PBTS software application may be used in conjunction with common desktop environments on various platforms, such as those used with Solaris™ and X Windows™ on UNIX based platforms. In one aspect, a configurable parameter may comprise a piece of data or information needed by the PBTS **10** to configure, for example, control settings, wherein the value of the configurable parameter may vary depending on the treatment dosage and/or environment. Some of the devices in the PBTS **10** need configuration data for proper initialization. For example, magnets are configured with default output specific to their target energy. Moreover, other functional components of the PBTS **10**, such as ion source, power supplies, timing, etc., may require configurable initialization data, scale factors, conversion factors, mapping, etc.

[0050] As will be described in greater detail herein below, the data is accessible to the user through a graphical user interface (GUI) via the user interface system **52**, and the data is stored and maintained in a database component of the configuration management system **54**. When an authorized user requests a configuration update, a connection to the database component is established and any modifications to the data are applied to the database component. In addition, authorized user accounts may be created via the user interface system **52**, wherein authorized users comprises varying degrees of permission or access levels, which may be determined by administrators. For example, different types of users may be granted access to data related only to a specific job function. Accelerator staff may be allowed to modify accelerator related parameters, such as magnet settings. Medical physicians may be allowed to modify treatment

room related parameters, such as detectors and scattering foils. Various other users, such as field service personnel and system administrators may have access to data needed to maintain the system.

[0051] Moreover, the database component of the PBTS configuration management component **54** may be initialized with two sets of data: treatment data and non-treatment data. The treatment set may comprise configuration data that has been approved for treatment operations. In most cases, there is one treatment set or one set of approved treatment data that is available. The non-treatment set may comprise configuration data that may be used for other functional operations, such as research, maintenance, and/or tuning. For the most part, authorized users are able to retrieve and view most configurable parameters. If a user has write access to a parameter, then the user is able to modify its value within an acceptable range, which will be described in greater detail herein below. However, proposed modifications related to treatment data is subject to approval by a designated administrator, wherein the designated administrator is responsible for patient treatment and approving proposed modifications to the treatment data.

[0052] In one embodiment, the PBTS **10** of FIG. **1** may further comprise one or more PBTS workstations **62** that may house the hardware and software used to operate and control the PBTS treatment delivery components **11**, **12**, **14**, **16**, **18**, **20** of the PBTS **10**. The PBTS workstations **62** function independently from the configuration management system **54** so as to provide localized control to the PBTS **10**. As previously mentioned, the user interface system **52** is used to interact with the configuration management system **54**. Conversely, the PBTS workstations **62** are used to interact with the PBTS treatment delivery components **11**, **12**, **14**, **16**, **18**, **20**. In one embodiment, there is no direct link between the configuration management system **54** and the PBTS **10**. Instead, the PBTS workstations **62** and/or the PBTS **10** access the PBTS configuration data, parameters, and control settings from the configuration management system **54** via the system control files **56**.

[0053] In one aspect, it should be appreciated by those skilled in the art that the configuration management system **54** provides one or more system control files **56** to the treatment delivery components **11**, **12**, **14**, **16**, **18**, **20** of the treatment delivery system **10**. Additionally, it should also be appreciated that the treatment delivery components **11**, **12**, **14**, **16**, **18**, **20** may retrieve one or more operational parameters from the system control files **56**. In another aspect, it should be appreciated by those skilled in the art that the management component is adapted to send configurable parameters to each treatment device, wherein a selected treatment device retrieves usable parameters from the configurable parameters. Moreover, the management component is further adapted to selectively send configurable parameters to each treatment device representing usable parameters by each treatment device.

[0054] Advantageously, this particular embodiment provides a separation of control between the configuration management system **54** and the PBTS workstations **62**. Configuration data, parameters, and control settings are more easily updated using the configuration management system **54**, which offers more reliable database management and controlled parameter revision. The generation of system control files **56** allows the PBTS workstations **62** to access the PBTS configuration data, parameters, and control settings when and if the configuration management system **54** is offline or unavailable. Therefore, the PBTS **10** is able to operate independently of the configuration management system **54**.

[0055] During treatment delivery, the operation of the PBTS treatment delivery components **11**, **12**, **14**, **16**, **18**, **20** are desirably coordinated to direct a precisely calibrated and aligned proton beam **58** towards a specific target region or isocenter **60** of the patient **24**. As previously described, the patient **24** is supported by the treatment platform **22** and the gantry **18** is rotatable about an axis of rotation and is used to properly align the proton beam **58** with respect to the patient **24** and the isocenter **60**. The PBTS control system **62** monitors and coordinates the operational activities of the hardware and software subsystems used to configure and direct the proton beam **58** as well as insure patient safety. Patient safety is a primary concern in radiation treatment and strict control over the PBTS **10** must be maintained at all times to insure that the proton beam **58** is accurately and precisely directed with an appropriate intensity or energy level. It should be appreciated that a more in depth discussion relating to the PBTS control system **62** is more fully disclosed in U.S. Pat. No. 5,260,581, which is hereby incorporated by reference in its entirety.

[0056] In addition, the PBTS **10** including the PBTS workstations **62** may utilize the system control files **56** to access configuration data, parameters, and control settings from the configuration management system **54**. In one embodiment, the system control files **56** may comprise a series of strings or characters in one or more recognizable files or formats that may be parsed by the PBTS **10**, PBTS workstations **62**, or the functional components **11**, **12**, **14**, **18**, **20** of the PBTS **10** to retrieve configuration data, parameters, etc. stored in a control file format, such as, for example, a flat file, binary file, flash memory file, etc. One advantage to using flat files is that flat files are human readable, but various other file structures, such as binary files, may be used by those skilled in the art without departing from the scope or functionality of the present teachings. Moreover, in one aspect, the system control files **56** may be delineated using a reference identifier, such as a comma, hyphen, semi-colon, etc. Alternatively, strings may be delineated using codes that signify tabs or new lines. Additionally, a sequentially oriented group of characters that are not likely to be found in the record itself may serve as the reference identifier for string parsing.

[0057] In various embodiments, system control files **56** may be file and/or address oriented and stored in a variety of different formats. For example, a file-oriented schema may comprise a "textual document" (e.g. based on the ASCII character set) which is stored and accessed as a discrete file using a non-volatile data storage device (e.g. a hard disk drive, optical drive, tape drive, flash memory device, etc.). Likewise, an address-oriented schema may comprise system control file information stored in a manner that may be accessible at selected locations within a volatile or non-volatile memory or storage device (e.g. bits/bytes of information stored at a particular memory address). It will further be appreciated that the information contained in the system control file may be represented in numerous different manners, such as for example, using binary, octal, hexadecimal, html or other data types/representations. These data types may be stored and accessed in file-oriented, address-oriented, or other organizational manners as is suitable for each instrument or device which is desirably configured to use the system control file information.

[0058] In certain embodiments, the system control files **56** may comprise, for example, data files or formats stored in various types of data storage elements, such as flash memory, read-only memory, etc. As is generally known, programmable read-only memory (PROM) is read-only memory (ROM) that can be modified once by a user. Since PROM processes are relatively inflexible, many PROM chips designed to be modified by users may be implemented with erasable programmable read-only memory (EPROM) or electrically erasable programmable read-only memory (EEPROM), which can be programmed, erased and reprogrammed multiple times. In addition, flash memory represents a type of non-volatile memory that can be erased and reprogrammed in units of memory blocks. Other types of devices that may be used in accordance with the present teachings may include magnetic and optical data storage formats, such as compact disks, floppy disks, tape drives, etc. Therefore, in general, it should be appreciated that system control files may comprise various types of data storage or memory elements having various compositions without departing from the scope of the present invention. Moreover, the access configuration data, parameters, and control settings from the configuration management system **54** may be stored on the various types of data storage or memory elements so as to provide system control files **56** to the operational and treatment devices **11**, **12**, **14**, **18**, **20** of the PBTS **10**.

[0059] Once the configuration data, parameters, etc. are identified and retrieved from the system control file **56**, the PBTS control system **62** or the functional components **11**, **12**, **14**, **18**, **20** of the PBTS **10** may use the retrieved data, parameters, etc. to configure its functional and operational components for delivery of treatment. It should be appreciated that the PBTS **10** may receive and interpret the PBTS system control files **56** as read-only formatted files that may comprise spreadsheets, tables, etc.

[0060] Additionally, the retrieved information may also comprise a set of instructions that may be used by the PBTS **10** to configure its operational components. Advantageously, configuration may occur without depending on the processing and management components of the configuration management system **54** during delivery of treatment. Therefore, the operational components of the PBTS **10** may function in an independent manner, which reduces the adverse effects of single point failures in the configuration management system **54**. The management of data, parameters, and control settings by the configuration management system **54** allows for preserving data integrity as well as insuring no duplication of data. For example, data integrity may be preserved with automatic backup, wherein the configuration management system **54** archives backup files comprising copied configuration data, parameters, etc. in a separate storage component without consent from a user. In addition, controlled access to configuration data, parameters, etc. allows the configuration management system **54** to prioritize multiple updates according pre-determined criteria so as to substantially avoid the duplication of configuration data, parameters, etc. Moreover, the PBTS **10** accesses the data, parameters, and control settings from the system control files **56**, which insures that the configuration data, parameters, etc. are accessible when and if a single point failures occurs with respect to the configuration management system **54**.

[0061] For example, configuration of the PBTS **10** may include setting proton energy source **11**, the accelerator **12**, and the beam transport **14** to deliver a prescribed proton beam **58** to the switchyard **16**. In addition, configuration of the PBTS **10** may also include setting the switchyard **16** to direct the prescribed proton beam **60** to a specific treatment station and the corresponding gantry **18** to orient the proton beam **60** towards a specific isocenter **60** on the patient **24**. Moreover, configuration data, parameters, etc. may further include length of treatment delivery, energy strength of the proton beam, duration of radiation dosage, and radiating multiple treatment areas on the patient. It is critical to patient safety that the configuration data, parameters, etc. stored in the system control files **56** is locally accessible so that, if the configuration management system **54** goes off line for some reason, the PBTS **10** and its components may remain functional. Advantageously, generation and distribution of system control files **56** to the PBTS treatments delivery system **10** and its components by the configuration management system **54** offers control separation so that the PBTS **10** and its components rely less on the configuration management system **54** to deliver treatments to patients.

[0062] In general, it should be appreciated that the PBTS control system **62** and the processing components of the configuration management system **54** may comprise, by way of example, computers, program logic, or other substrate configurations representing data and instructions, which operate as described herein. In various other embodiments, the PBTS control system **58** and the processing and management components of the configuration management system **54** may comprise controller circuitry, processor circuitry, processors, general purpose single-chip or multi-chip microprocessors, digital signal processors, embedded microprocessors, microcontrollers and the like. Additionally, it will be appreciated that in one embodiment, the program logic may be implemented as one or more components, wherein the components may be configured to execute on one or more processors. The components may include, but are not limited to, software or hardware components, modules such as software modules, object-oriented software components, class components and task components, processes methods, functions, attributes, procedures, subroutines, segments of program code, drivers, firmware, micro-code, circuitry, data, databases, data structures, tables, arrays, and variables.

[0063] In one aspect, the configuration management system **54** may be implemented using applications designed for relational database development and implementation. It is further recognized that the configuration management system **54** may be implemented as spreadsheet or a single database with separate tables or as other data structures that are well known in the art such as linked lists, binary trees, and so forth. Also, the configuration management system **54** may be implemented as a plurality of databases which are collectively administered. It should also be appreciated that the structure and schema of the configuration management system **54** may be altered, as needed, to implement the relations or associations utilized to organize and categorize the information in the configuration management system **54**.

[0064] FIGS. **3**A-**3**C illustrate various functional embodiments of the PBTS **10** of FIGS. **1**, **2** and the configuration management system **54** of FIG. **2**. For ease of discussion, FIG. **3**A illustrates a simplified block diagram of the user interface system **52**, the configuration management system **54**, and the treatment delivery system **10**. In this particular embodiment, the configuration management system **54** may comprise a management component **70**, a database component **72**, and a control file component **74** that are functionally

interconnected so as to manage, update, and distribute PBTS configuration data, parameters, and control settings for the PBTS **10**. The PBTS database system components **70**, **72**, **74** may comprise hardware and/or software subsystems that may be adapted for specific functionality with respect to the PBTS **10**.

[0065] Advantageously, the use of system control files as described herein reduces the occurrence of single point failures by generating a static document, such as, for example, a flat file, binary file, flash memory file, etc., comprising operational and configuration parameters and then distributing the static document to the treatment delivery components. In addition, the distribution of system control files allows the treatment delivery components operational independence from the database component due to the associated reliance on the system control files for operation and parameter retrieval. In one aspect, although a communication link may be used to distribute the generated system control file or static document to one or more of the treatment delivery components, operational reliance may be shifted to the distributed system control file or static document.

[0066] For ease of updating and retrieval, configuration parameters, for example, may be stored in the database table structures as records or values. When generating the static document or control file, the retrieved configuration parameter values may be arranged in a consolidated information set that is recognizable by the treatment delivery components. Advantageously, the consolidated information set exploits the native functionality of the treatment delivery devices in a manner such that an additional numerical or supplemental program or application is unnecessary for the treatment delivery devices to parse the configuration parameter values from the static document. The scope and functionality of these processes will be more fully described in greater detail herein below.

[0067] In one embodiment, when parameter modifications have been requested, the treatment delivery system **10** receives periodic parameter updates in the form of electronic control files from the configuration management system **54** via, for example, a communication network, such as an Ethernet, intranet, or internet communication system. In some circumstances, the treatment delivery components may send request to the configuration management system inquiring whether parameter updates are available. As will be in greater detail below, the parameter updates are sent to the treatment delivery system in a recognizable format that is easily identified by the treatment delivery components of the system.

[0068] FIG. **3**B further illustrates the configuration management system **54** of FIGS. **2**, **3**A with additional functional features associated with the database component **72**. Configuration and operational parameters **80**, such as data, information, and control settings, may be stored in the database component **72** of the configuration management system **54** as database files in a generally known manner. For example, each PBTS treatment delivery component **11**, **12**, **14**, **16**, **18**, **20** of the PBTS **10** may have its own set of parameters **80** related to configuration and operation. A relational association may be established in the database component **72** between the particular PBTS treatment delivery component **11**, **12**, **14**, **16**, **18**, **20** and its own set of parameters **80** from 1 to N. These parameters **80** may be searched for, retrieved, sorted, and edited by the management component **70** in a generally known manner so as to produce parameter update files **82** whenever an authorized user requests a parameter update via the user interface system **52**. The process of updating parameters will be described in greater detail herein below.

[0069] In one embodiment, the configuration data and parameters are maintained in sets. The database component **72** is responsible for maintaining approved, current, and proposed sets of configuration data and parameters. An approved set may comprise the set of parameter configurations that are acceptable for allowing treatments to proceed. Preferably, for safety reasons, there is only one approved set of configuration parameters at any one time. A current set may comprise the set of parameter configurations that the PBTS **10** is currently being configured with, which may or may not be permissible for treatments. The current set may be one of a plurality of configuration sets stored in the database component **72**. A proposed set may comprise a set of parameter configurations waiting approval from a system administrator before it can be used for treatments.

[0070] As illustrated in FIG. **3**C, the management component **70** may be used by the configuration management system **54** to identify, retrieve, and update configuration parameters from the database component **72** and to generate system control files **56** using the control file component **74**. After generating the system control files **56**, the management component **70** subsequently distributes the system control files **56***a*, **56***b*, **56***c*, **56***d*, **56***e* to the corresponding PBTS treatment delivery systems **10***a*, **10***b*, **10***c*, **10***d*, **10***e* of the PBTS **10**, which may include beam control systems **10***a*, safety systems **10***b*, power systems **10***c*, logging systems **10***d*, and various additional systems **10***e*. Beam control systems **10***a* may include the beam transport **14**, the switchyard, the gantry **18** and the beam delivery system **20**. Power systems **10***c* may include the proton energy source **11** and the accelerator **12**.

[0071] The database component **72** may function in the capacity of generally known memory devices, such as hard drives, compact discs, removable storage media, tape drives, flash memory, optical devices, integrated circuitry, etc., wherein the parameter information may easily stored, altered, and retrieved by the user interface system **52**. The control file component **74** may function as relational translator that interprets database language formats into control file language formats so that configuration parameters stored in the database may translated into recognizable operational parameters for the functional components of the PBTS **10**.

[0072] In a complex, multi-processor software controlled system, such as the PBTS **10**, it may be important to provide treatment configurable parameters that are easily modified by an authorized user to prepare the software controlled system for various modes of operation, such as modifying parameter tolerance, user access, access levels, debug output, etc. In most cases, configuration parameters are loaded by execution software of the PBTS **10** in a safe and timely manner. Moreover, the PBTS **10** often involves multiple modes of operation (treatment, research, commissioning), multiple configuration setups (passive beam delivery, active beam delivery), and multiple patient setups. In addition, there may be more than one person who has authorized access to modify data and parameter sets.

[0073] In one embodiment, the configuration management system **54** provides a centralized database server, which stores configuration and operational information, such as data, parameters, and control settings, for the software controlled PBTS **10**. In one embodiment, parameter modification and parameter retrieval are performed by the configuration

management system **54** via requests from the user interface system **52**. Moreover, the configuration management system **54** provides configuration management activities, which may include record keeping (i.e., who, when, and why modified certain parameter, has a parameter been approved for a certain mode), providing backup of the data, and version/revision control. Additionally, configuration data and parameters may be temporarily changed in a manner such that, after a designated time period, newly modified values of configuration data and parameters may revert back to previously stored values. Reversion to previous data, parameters, etc. may also occur after the system control files **56** are generated.

[0074] In one aspect, modifying data and parameters may be subject to approval by an administrator, which helps to maintain data integrity and insure proper treatment dosages and delivery. The system administrator may either approve, reject, or institute a time limit for the modification availability. In some cases, if duplicate modification requests are requested by one or more authorized users and the system administrator approves all pending modification requests, then the latest modification request may override all other requests. In other cases, a time out period indicates that the system administrator is approving a proposed modification but only for a limited amount of time. In this particular situation, once the specified date and/or time have elapsed, the previous value of the data or parameter prior to the modification request will be reinstated.

[0075] Advantageously, the configuration management system **54** comprises the capability to generate system control files **56** to substantially avoid problematic situations that may occur during operation of the PBTS **10**. Network problems and single-point failures may occur as the result of an unexpected shutdown and/or an emergence of a corrupted file. The system control files **56** may comprise various types of control files, such as, for example, flat files, binary files, flash memory files, etc., that provide fast, localized parameter retrieval capability and independent operational capabilities for the PBTS **10**. In one aspect, modifying configuration data and parameters during treatments may adversely affect the treatment delivery. Therefore, for safety reasons, system control files **56** are preferably generated between treatments.

[0076] Additionally, the configuration management system **54** comprises an information management and retrieval system with adequate configuration management capabilities and fast, safe, and localized parameter retrieval. For example, the configuration management system **54** utilizes the management component **70** in conjunction with the database component **72** to provide restricted access to parameter modification, wherein authorized users are allowed to revise configuration data, parameters, etc. and unauthorized users are not granted access to the configuration data, parameters, etc. In addition, the configuration management system **54** uses the management component **70** in conjunction with the control file component **74** to generate the system control files **56** from parameter files **80**, **82** for distribution of configuration parameters to the PBTS **10**.

[0077] In one aspect, on a periodic basis or when a parameter has been modified either temporarily or permanently, the configuration management system **54** may generate system control files **56** from the parameter files **80**, **82**, substantially insuring that proper syntax has been followed during generation. For example, the management component **70** has access to the programming language used by each of the treatment delivery components in the PBTS **10**. In one aspect, proper syntax may comprise using a specific set of rules prescribed by the programming language to combine instructional elements into permitted constructions that will be recognizable to the designated treatment delivery component. Proper syntax may also refer to a systematic arrangement of data and instructions that may be easily parsed from the system control files **56** by the designated treatment delivery component. Moreover, the generated system control files **56** are then placed in the appropriate directories associated with the functional components of the PBTS **10**. In addition, execution software used by the functional components of the PBTS **10** retrieves the appropriate system control file **56** and loads the requested configuration parameters for treatment delivery.

[0078] FIG. **4**A illustrates one embodiment of a logical organization of a plurality of configuration parameter values **80** in the database component **72**. As previously described, there are a significant number of configuration parameter values **80** that may be applied to each PBTS treatment delivery component in the PBTS **10**. Tracking the configuration parameter values for PBTS treatment delivery components can be highly complex and cumbersome. Therefore, the management component **70** may be used to map parameters to specific treatment delivery components in the PBTS **10** using a plurality of mapping tables **74**. In the database component **72**, the mapping tables **74** comprising deployment labels **76***a*, **76***b*, **76***c* to lookup keys **78** may be created to identify and retrieve configuration parameter values **80** to thereby generate a plurality of system control files **86**. In one aspect, the lookup keys **78** identify where the data and parameter values **80** can be located within the database component **72**, wherein each deployment label **76** points to a specific lookup key **78** where the data or parameter values **80** can be found in the database component **72**.

[0079] For example, a first treatment delivery component of the PBTS **10** may be mapped to a first mapping table **74***a* comprising a first set of deployment labels **76***a*. A second treatment delivery component of the PBTS **10** may be mapped to a second mapping table **74***b* comprising a second set of deployment labels **76***b*. A third treatment delivery component of the PBTS **10** may be mapped to a third mapping table **74***c* comprising a third set of deployment labels **76***c*. As illustrated in FIG. **4**A, the first set of deployment labels **76***a* may point to lookup keys A, C, and E, (**78**) which may further point to configuration parameter values V1, V2, and V5 (**80**). The second set of deployment labels **76***b* may point to lookup keys B and E (**78**), which may further point to configuration parameter values V2 and V5 (**80**). The third set of deployment labels **76***c* may point to lookup keys A, D, E, and F (**78**), which may further point to configuration parameter values V1, V4, V5, and V6 (**80**).

[0080] For the most part, parameter referencing, as indicated in FIG. **4**A with a dashed line, takes place in the database component **72** in a generally known manner. In one aspect, once the configuration parameter values **80** have been identified and retrieved, the configuration parameter values **80** may be subsequently imported, as illustrated in FIG. **4**A with a solid line, into the system control files **86** for distribution to the corresponding PBTS treatment delivery component in the PBTS **10**. For example, the first mapping table **74***a* may be used to generate and distribute a first system control file **86***a* to the first treatment delivery component of the PBTS **10**. The second mapping table **74***b* may be used to generate and distribute a second system control file **86***b* to the second treatment delivery component of the PBTS **10**. The third

mapping table **74***c* may be used to generate and distribute a third system control file **86***c* to the third treatment delivery component of the PBTS **10**.

[0081] It should be appreciated that the order in which the parameter values are retrieved may vary and may depend on the specific order in which the designated treatment delivery component parses the information from the control file. It should also be appreciated that any number of control file generation techniques may be used by one skilled in the art without departing from the scope of the present invention.

[0082] As previously described, treatment parameter values may need to be updated to reflect new treatment dosages, etc. Therefore, once the configuration parameter values **80** have been identified and located in the database component **72**, the configuration parameters values **80** may be replaced or revised with updated configuration parameters values **82**. It should be appreciated that storing data and information is generally known in the art and any of a number of generally known storage methods may be used to store the updated configuration parameters values **80** in the database component **72**.

[0083] FIG. **4**B illustrates one embodiment of a logical organization of configuration parameter associations **94**. User input modifications **90** to specific configuration parameters may effect other dependent configuration parameters in a manner such that the dependent configuration parameter values may need to be re-calculated. In one aspect, a plurality referential locations **92** may be used to identify a plurality of parameter associations **94** corresponding to the user inputted modifications **90**. For example, as illustrated in FIG. **4**B, a first input modification **90***a* to a first configuration parameter value V1 referenced by lookup key A may point to a first referential location **92***a*, which may further point to a first and second parameter association **94***a*, **94***b*. Since V1 has been modified by the user, the database component **72** locates the configuration parameter values V4 and V6 associated with the lookup keys D and F. Subsequently, the configuration parameter values V4 and V6 may then be re-calculated according to a specified function, such as V4=V4+V1 and V6=V6+V1. It should be appreciated that the re-calculation function may vary depending on a particular application without departing from the scope of the present invention.

[0084] Similarly, in another example, a second input modification **90***a* to a second configuration parameter value V2 referenced by lookup key B may point to a second referential location **92***b*, which may further point to a third parameter association **94***c*. Since V2 has been modified by the user, the database component **72** locates the configuration parameter value V1 associated with the lookup key A. Subsequently, the configuration parameter value V1 may then be re-calculated according to a specified function, such as V1=V1+V2. In addition, a third input modification **90***c* to a third configuration parameter value V3 referenced by lookup key C may point to a third referential location **92***c*, which may further point to a fourth, fifth, and sixth parameter association **94***d*, **94***e*, **94***f*. Since V3 has been modified by the user, the database component **72** locates the configuration parameter values V2, V5, and V6 associated with the lookup keys B, E, and F. Subsequently, the configuration parameter values V2, V5, and V6 may then be re-calculated according to a specified function, such as V2=V2+V3, V5=V5+V3, and V6=V6+V3.

[0085] It should be appreciated that the order in which the configuration parameter values are re-calculated may vary depending on specific application priorities established by the user. As previously mentioned, the most recent modification may be given priority over past modifications or priority may be established by a configuration administrator. It should also be appreciated that any number of parameter association techniques may be used by one skilled in the art without departing from the scope of the present invention.

[0086] FIG. **4**C illustrates one example of using mapping tables **74** to generate system control files **86** associated with specific treatment delivery devices in the PBTS **10**. In one embodiment, the mapping tables **74** comprise records and keys for maintaining the data as well as the actual parameters and their associated attributes. As previously described, the configuration management system **54** uses input data from authorized users via the user interface device **52** to manipulate or modify the configuration data, parameters, etc. in the database component **72**. This data is made available to the treatment delivery components and devices in the PBTS **10** as a mapping from the tables to text based control files **86**. For example, the power supply in the PBTS **10** may be used to energize one or more magnets in order to reach the desired energy and control the beam in a generally known manner. There are different types of power supplies and each type of power supply may be configured differently. As a result, the configuration parameters associated with the power supplies may be stored in the database component **72**.

[0087] As illustrated in FIG. **4**C, the configuration parameters may be stored, for example, in the database component **72** using tables. In one aspect, the tables hold information that is used to look up and maintain the parameters and their values in a manner as previously described with reference to FIGS. **4**A, **4**B and as illustrated herein below.

...	...	...	... ...	...	...	... ...	...	
...	...	...	... ...	...	...	... ...	...	
attr1	attr2	...	... ...	AmpScale	20000	... ...	...	attrn
attr1	attr2	...	... ...	MaxAmp	20000	... ...	...	attrn
attr1	attr2	...	... ...	MaxVolt	20000	... ...	...	attrn
attr1	attr2	...	... ...	MinAmp	−20000	... ...	...	attrn
attr1	attr2	...	... ...	MinVolt	−20000	... ...	...	attrn
attr1	attr2	...	... ...	RampRate	720	... ...	...	attrn
...	...	...	... ...	...	...	... ...	...	
...	...	...	... ...	...	...	... ...	...	
...	...	...	... ...	...	...	... ...	...	
...	...	...	... ...	...	...	... ...	...	
...	...	...	... ...	...	...	... ...	...	
...	...	...	... ...	...	...	... ...	...	

[0088] In one embodiment, the management component **70** of the configuration management system **54** uses the database component **72** to select necessary parameter values **80** and further uses the control file component **74** to write the parameter values **80** to control files **86**. As a result, the configuration parameter values in control file form **86** are available for retrieval by the designated treatment delivery components of the PBTS **10**.

[0089] For example, as illustrated in FIG. **4**C, the database component **72** may comprise a mapping table **74** for the power supply. The power supply mapping table **74** comprises deployment labels that point to one or more lookup keys **78** which further point to configuration parameter values **80** associated with the power supply. These configuration parameter values **80** for the power supply may be imported into a control file **86** for distribution to the power supply component of the PBTS **10**. In another example, as illustrated in FIG. **4**C, the database component **72** may further comprise

a mapping table **74** for a timing system. The timing system mapping table **74** comprises deployment labels that point to one or more lookup keys **78** which further point to configuration parameter values **80** associated with the timing system. These configuration parameter values **80** for the timing system may be imported into a control file **86** for distribution to the timing system component of the PBTS **10**.

[0090] FIG. **5** illustrates one embodiment of a system configuration process **100** that may be used by the configuration management system **54** to modify parameters for the PBTS **10**. The database component **72** of the PBTS configuration management component **54** is used to maintain and preserve the integrity of configuration data, parameters, etc. in a manner so as to avoid duplicating configuration settings. In addition, the stored configuration data, parameters, etc. may be easily retrieved, modified, and archived so that configuration parameters may be updated in a more efficient manner.

[0091] The system configuration process **100** initiates in a start state **102** and then advances to a state **104** where a user may request a parameter update via the user interface system **52**. In one embodiment, the user enters new system configuration parameters into the user interface system **52** via a computer workstation, and the requested parameter update having the new system configuration parameters is electronically sent to the configuration management system **54** for evaluation. Subsequently, upon receiving the requested parameter update, the management component **70** of the configuration management system **54** runs through a PBTS system check that compares the new system configuration parameters to a tolerance range of values. For example, if the operational range of a power supply is between 0 and 500 amps, then the management component **70** verifies that the new system configuration parameter for the power supply is not set less than 0 amps and greater than 500 amps.

[0092] In a decision state **108**, if one or more of the new system configuration parameters in the requested parameter update are out of tolerance range, then the prior database settings for the prior system configuration parameters are preserved and the user is notified in a state **114** and the process **100** subsequently terminates in an end state **116**. Otherwise, in the decision state **108**, if the new configuration parameters in the requested parameter update fall with the pre-determined tolerance ranges then the process **100** proceeds to a state **112** where the management component **70** of the configuration management system **54** performs a parameter update as described in greater detail herein below with reference to FIG. **6**. Once the system configuration parameters in the database component **72** of the configuration management system **54** have been updated to the new system configuration parameters in the requested parameter update, the user is notified in the state **114**, and the process **100** terminates in the end state **116**.

[0093] As previously described, in a complex, multi-processor software controlled system, such as the PBTS **10**, it may be important to provide treatment configurable parameters that are easily modified by an authorized user to prepare the software controlled system for various modes of operation. Advantageously, the configuration management system **54** provides a centralized database, which efficiently stores configuration data, parameters, etc., for the software controlled PBTS **10**. Also, parameter modification and parameter retrieval may be efficiently performed by the configuration management system **54** via requests from the user interface system **52**.

[0094] FIG. **6** illustrates one embodiment of a parameter update process **140** that may be used by the management component **70** of the configuration management system **54** to update system configuration parameters used by the PBTS **10**. The updated parameters are easily identified and retrieved from the database files and then converted to control files for distribution to the PBTS **10**. Generation and distribution of system control files **56** to the PBTS treatments delivery system **10** and its components by the configuration management system **54** offers control separation so that the PBTS **10** and its components rely less on the configuration management system **54** to deliver treatments to patients. For ease of discussion, FIG. **3**B will be referenced in conjunction with FIG. **6**.

[0095] The parameter update process **140** initiates in a start state **142** and proceeds to a state **144** where the management component **70** of the configuration management system **54** identifies the parameters **80** associated with the requested parameter update **82** in the database component **72**. In a state **146**, the new system configuration parameters in the requested parameter update **82** are temporarily stored in the database component of the configuration management system **54** while waiting approval from a system administrator.

[0096] After modification approval is granted, either the requested parameter update **82** is stored in a permanent manner so as to replace the previous parameters **80** with the parameter update **82**, or the requested parameter update **82** is used to generate system control files **56** for a specific treatment and the previous parameters **80** are maintained in the database component **72**. By temporarily storing the parameter update **82**, duplication of data does not occur, and the previous parameters **80** are not lost. A temporary parameter update **82** will have a specified time period for expiration in a manner as previously described. This allows for increased treatment flexibility in that treatment dosages can vary for each treatment delivery without losing prior configuration parameters.

[0097] Next, in a state **148**, the management component **70** uses the control file component **74** to generate the system control file **56** with the new system configuration parameters from the requested parameter update **82**. In one embodiment, the management component **70** retrieves configuration parameters from the database component **72** and queues the parameter values in a string by separating each value with a delimiter. In one aspect, the control file component **74** has prior knowledge of the order in which the parameter values will be parsed by the designated functional component of the PBTS **10**. Hence, the management component **70** uses the control file component **74** to track the placement of each parameter value in the queue so that the system control file **56** will be appropriately generated with the correct parsing order.

[0098] Optionally, the management component **70** may then calculate and update the checksum, which checks the generated system control file **56** for errors. In one aspect, generated system control files **56** provide checksum mechanisms to verify that generated data is current and up-to-date. When the system control files **56** are generated, the management component **70** uses a checksum algorithm to allow the detection of file corruption. The checksum method is a common form of detecting corruption in network transfer of data packets. The sending process appends a checksum to the end of the packet that the receiver uses to confirm the packet is not corrupted. There are many checksum algorithms out there. They basically take the information in the packet/file and

perform mathematical operations and/or logical operations (bit shifting, bit twiddling, etc.) to "sum" the packet/file. The receiving process uses the same algorithm on the data and compares it to the checksum. If they match, there is no data corruption. Following, the configuration management system **54** establishes communication with PBTS **10** and distributes the generated system control file **56** to the appropriate functional component of the PBTS **10**. Subsequently, the parameter update process **140** terminates in an end state **154**.

[0099] Advantageously, the PBTS **10** or its operational components accesses the data, parameters, etc. through the system control files **56**. This substantially insures that the data, parameter, etc. may be accessible even when and if a single point failures occurs with respect to the configuration management system **54**. In addition, configuration of the PBTS **10** or its operational components may be achieved without depending on the configuration management system **54** during treatment delivery. Therefore, the PBTS **10** and its operational components may function in an independent manner, which reduces the adverse effects of single point failures in the configuration management system **54**.

[0100] FIG. **7** illustrates the advantages of using the configuration management system **54** of the present invention to manage, update, and distribute configuration parameters for the PBTS **10**. Advantageously, the configuration management system **54**, as described herein, utilizes the positive characteristics of both database oriented file management systems and control files configuration systems.

[0101] As illustrated in FIG. **7**, with reference to the database management systems, the configuration management system **54** provides controlled access to configuration information, such as authentication and logging, parameter range verification before parameter is read by the PBTS **10**, operational mode separation in configuration parameters, automated backup, and data integrity. In addition, the database management system may further provide revision control for a single parameter, parameter modification expiration date management, and report generation capabilities to insure the proper syntax, data integrity of the system control files.

[0102] As further illustrated in FIG. **7**, with reference to the control file configuration systems, the configuration management system **54** provides fast access to configuration parameters in system control files, which may take less time to access a file than accessing a field in the database, and provides localized access to configuration parameters with higher reliability, which substantially insures that parameter information is accessible in case of database server or network interruptions and/or failures. Additionally, the control file configuration system may further provide configuration information in an archived or read-only format to the user, administrator, and/or system operator. It should be appreciated that the configuration management system **54** may be added on or to existing control files configuration systems in various currently used medical devices by one skilled in the art without departing from the scope of the present invention.

[0103] Although the preferred embodiment of the present invention has shown, described, and pointed out the fundamental novel features of the invention as applied to this particular embodiment, it will be understood that various omissions, substitutions and changes in the form of the detail of the device illustrated may be made by those skilled in the art without departing from the spirit of the present invention. Consequently, the scope of the invention should not be limited to the foregoing description, but should be defined by the appending claims.

What is claimed is:

1. A radiation beam therapy system comprising:

a plurality of treatment devices, including:

a charged-particle accelerator that provides a beam of energetic charged particles;

a treatment station that allows positioning of a patient to receive at least a portion of the beam of charged particles; and

a beam delivery system that delivers the beam of charged particles to the patient positioned at the treatment location;

a database component that stores parameters associated with respective treatment devices, wherein the parameters comprise instructional information that can be used to configure the respective treatment devices for operation;

an interface component that allows an authorized user to modify at least one of the parameters associated with a respective treatment device; and

a management component that,

retrieves a subset of parameters from the database, the subset of parameters including at least one of the stored parameters and modified parameters,

generates a data storage element comprising the subset of parameters in a format recognizable by the selected treatment device, wherein the data storage element permits configuration of the selected treatment device based, at least in part, on the subset of parameters, and

distributes the data storage element to the selected treatment device to thereby permit the selected treatment device to operate independently of the database component.

2. The system of claim **1**, wherein the management component has no direct link to the plurality of treatment devices.

3. The system of claim **1**, wherein the management component retrieves parameters upon receiving a request from the treatment devices inquiring whether parameter updates are available.

4. The system of claim **1**, wherein the management component retrieves parameters, generates a data storage element, and distributes a control file to the treatment devices on a periodic basis.

5. The system of claim **4**, wherein the management component distributes updated parameters to the treatment devices, after a parameter modification is requested by a user, on a periodic basis via the control file.

6. The system of claim **1**, wherein the management component waits for administrator approval before retrieving the subset of parameters, generating the data storage elements, and distributing the data storage elements.

7. The system of claim **1**, wherein administrator approval temporarily allows the at least one parameter modification.

8. The system of claim **1**, wherein the parameters include one or more of treatment data, configuration parameters, operations parameters, and control settings.

9. The system of claim **1**, wherein the interface component allows the user to temporarily modify the one or more parameters.

10. The system of claim **9**, wherein temporarily modified parameters expire after a predetermined period of time.

11. The system of claim **9**, wherein temporarily modified parameters revert to previously stored values after the system control files are generated.

12. The system of claim **1**, wherein the selected treatment device is software controlled and requires at least one of the parameters in the subset of parameters for operation.

13. A radiation beam management system configured to control a plurality of proton beam therapy systems that comprise treatment devices including a radiation beam source and a beam transport device, the radiation beam management system comprising:

a database that stores a plurality of parameters associated with respective treatment devices, wherein a parameter comprises instructional information that can be used to control a treatment device;

an interface that allows an authorized user to modify at least one parameter of the plurality of parameters, wherein the at least one parameter is associated with a respective treatment device; and

a management component configured to

retrieve a subset of parameters from the database, wherein the subset of parameters includes at least one of the stored parameters and modified parameters,

generate a system control file comprising the retrieved subset of parameters, wherein the system control file is usable to control the respective treatment device based, at least in part, on the instructional information comprised therein, and

transmit the system control file to a proton beam therapy system associated with the respective treatment device, thereby permitting the respective treatment device to operate independently of the database.

14. The system of claim **13**, wherein the management component has no direct link to the plurality of treatment devices.

15. The system of claim **13**, wherein the management component retrieves parameters upon receiving a request from the treatment devices inquiring whether parameter updates are available.

16. The system of claim **13**, wherein the management component retrieves parameters, generates a data storage element, and distributes a control file to the treatment devices on a periodic basis.

17. The system of claim **16**, wherein the management component distributes updated parameters to the treatment devices, after a parameter modification is requested by a user, on a periodic basis via the control file.

18. The system of claim **13**, wherein the proton beam therapy system comprises a control station, and wherein the management component transmits the system control file to the control station.

19. The system of claim **18**, wherein the control station transmits the system control file to the respective treatment device.

20. The system of claim **19**, wherein the respective treatment device is a proton energy source, an accelerator, a beam transport system, a switchyard, a gantry, or a treatment platform.

21. The system of claim **13**, wherein the subset of parameters in the control file is arranged so as to enable the respective treatment device to recognize each of the parameters.

22. The system of claim **13**, wherein parameters include one or more of treatment data, configuration parameters, operations parameters, and control settings.

23. The system of claim **13**, wherein the interface does not allow the user to modify parameters while a patient is being treated by the proton beam therapy system.

24. The system of claim **13**, wherein the system control file is a flat file or a binary file

25. The system of claim **13**, wherein the management component transmits the system control file to a plurality of proton beam therapy systems.

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