TOD™ Design Production and Service

"The Age of Tissue Computing has Arrived™"

Brought to you by BCM Industries

Design and Development
Volume Production
Customer Support and Services

Introduction

The dream of building and commercial delivering a live neuron Tissue Computer has been discussed for 50 years or longer. It has not occurred because such an endeavor requires high skills, advanced technologies, and significant creativity.

Given these items, the fulfillment of this dream additionally requires success in three areas of Tissue Computing: (a) Design and Development; (b) Volume Production; and (c) Customer Support and Services.

BCM Industries (BCM) is the first enterprise to acquire the skills, assemble the technologies, and establish a successful process to address all of these- build, mass produce and support volume commercial delivery of a Tissue Computer operating with millions of live neurons.

This Article discusses details on creation, design, development, manufacturing, delivery, and service support of the Tissue Operating Device (TOD™). TOD™ is the world's first mass produced, commercially available, Tissue Computer (TC) that operate using millions of live neurons in a neural network array.

Design and Development

The TOD™ processing structure and neuron array architecture is designed to deliver TC users many orders of magnitude faster processing speeds, massive computational throughput, extreme data storage capacity and lighting fast data transfers.

This TOD™ Tissue Computer is significantly different from the Intel and IBM design and architectural approach to neuron processing. These digital computer manufacturing giants addressed the need for neuron processing by designing artificial neuron processing chips and sticking them on a motherboard. They created an inanimate chip to emulate the processing capacities of a live neuron, with some success.

Their approach was an effective initial entry into neuron processing. Their activities have increased commercial awareness the advantages of neuron processing and driven the development of neuron focus software operating systems, utilities, tools, and many neuron-based application programs. For a discussion of these artificial neuron processors and performance details, see the Article: “History of TOD™ and Tissue Computing.”

In reviewing the successes and actual performance of each of these artificial neuron processor chips, and the research data, one finds the physics of all conventional digital computers with chips and motherboards, no matter how enhanced, will never achieve TOD™ levels of performance.

TOD™ Configuration

As illustrated in Figure 1, TOD™ includes three major components, a Tissue Computer, a Management Computer, and a Laptop computer. TOD™ is commercially offered as a family of general and special purpose neuron processing Tissue Computers. As presented in Table I, the TOD™ family is offered in nine unique Models offering from 16 million to 5 billion neuron powered processing and storage options.

The TOD™ Model 16 is the smallest, delivering up to 16 million neurons from a standard computer desktop or floor tower. The next size is the TOD™ Model 48 delivering up to 48 million neurons in a three-tower wide floor version or a cabinet or rack mounted configuration.

The largest TOD™ Model offered, the 5120 Supercomputer, that can provide up to 5 billion neurons for processing and storge applications. Although it appears feasible, BCM has not addressed the networking of a multiple number of TOD™ Model 5120 units to obtain larger programable pools of available neurons.

Two Digital Computers

Each TOD™ includes two separate and independent digital computers. They function as the controller and manager of the Tissue Computer, and the user interface with all TOD™ activities.

TOD™ Configured Laptop - is a conventional digital laptop computer that has been configured with an operating system, utilities, tools, and application programs which provide users access to and the ability to program and control the services offered by the TOD™. This laptop can be networked to all types of private and public data networks to transfer and process data.

TOD™ Management Computer – is a conventional digital processor, that has been specifically configured to operate the Tissue Computer and to monitor and control all digital data that flows into and out of the Tissue Computer. In addition to user application interfaces, this Management Computer is responsible for the safe and full environmental control and operations of the Tissue Computer. It uses the TOD™

Configured Laptop and other digital ports as the I/O devise to communicate with the TOD™ system administrator, and the many users.

The Tissue Computer

Each TOD™ includes one Tissue Computer. This computer is the neuron processor of the TOD™ system configuration. It contains living tissue highly populated with approximately 16 million to 5 billion neurons, depending upon the Model. To assure continuous and robust processing this Tissue Computer must hold, continue to support, and provide a living tissue environment for all the resident neurons.

To be and remain effective in addressing processing application, these many millions of neurons must be structured and configured in an ordered and programmable computer architecture. Also, they must be able to be accessed and controlled by the system administrator, operating systems, and users with access to the Management Computer and/or the TOD™ Configured Laptop computer.

To avoid neuron caused operational processing chaos, the Tissue Computer includes two specialized tissue structures. One is the TC Disk, and the other is the TC Cord.

TC Disk – is a disk-shaped cluster of live tissue. It is not rigid but a soft shaped disk. Each TC Disk is populated with up to one million active neurons that are addressable and programmable as an item or element of the Tissue Computer.

Figure 2 is an actual picture of a fully populated TC Disk in a Petrie Dish. This TC Disk is embedded with approximately one million neurons and is ready for insertion into a Tissue Computer Array.

TC Cord – is a cord-shaped flexible tissue structure. When filled with tissue and fully populated with neurons a TC Cord functions similar to a nerve or spinal cord structure. The diameter varies per application and can be less than 20 micrometers. The cord length varies depending upon the application. The function of the TC Cord, within the Tissue Computer, is to utilize neurons, within the TC Cord, to move data at high speeds and great bandwidths between TC Disks.

Figure 3 illustrates a TC Cord section with the interior of the Cord filled with Tissue and that embedded Tissue within the TC Cord is heavily populated with neurons. The Figure also illustrates a different type of TC Cord. It is a branching section that can support the building of TC Cord networks needed to link together many TC Disks within an Array. This illustration does not portray the Cord filled with Tissue or neurons. However, that is within the process of constructing this TC Cord.

Tissue Computer Architecture

To obtain the desired neuron processing from all these many millions of neurons, all the TC Disks and TC Cords must be structured and organized to function as a reliable and effective processing unit. To accomplish this mission, the Tissue Computer has been organized into an Array structure.

Figure 4 illustrates a basic 4 set TC Disk and TC Cord linkage network. This form of networking is the bases of all Tissue Computer architectural Arrays. Each TC Disk is connected to at least two TC Cords. These TC Cords are prevalent throughout the Array. One end of each TC Cord is tissue embedded into a TC Disk. These TC Disk embedded data ports are identifiable and programmable by the Management Computer software and the TOD™ Configured Laptop operating system and application programs.

The Tissue Computer processing architecture uses two unique array structures. One is a Planar Array and the other a Cubic Array.

Planar Array – is an arrangement of TC Disks in a flat 2-dimensional pattern. It includes 4 TC Disks across and is 4 TC Disks high. Illustrated in Figure 5, this Array is a 16 TC Disk Planner Array. Currently this Array is only used in the TOD™ Model 16. It delivers approximately 16 million neurons for processing and is small enough to allow the Tissue Computer to reside inside of a standard desktop or floor tower. (See Figure 9.)

Cubic Array - is an arrangement of TC Disks in a cubic 3-dimetional pattern. It includes three, 3D stacked, 16 TC Disk Planner Arrays. Linked by TC Cords in all three directions, this Array delivers 48 TC Disks across a 3D cube. Illustrated in Figure 6, this Array is a 48 TC Disk Cubic Array. Currently this Array is the used in the TOD™ Model 48. It delivers approximately 48 million neurons for processing and fits comfortably into the Tissue Computer that resides in a four standard tower volume sized floor version of Model 48 (See Figure 9.) This Model is also available in a rack version.

Larger Tissue Computer Configurations

The 48 TC Disk Cubic Array is the baseline design architecture for all Tissue Computers that support the larger numbered TOD™ models, beginning with Model 96 and extending through Model 5120. Figure 7 illustrates how the 48 TC Disk Cubic Array is configured to build a Model 96 and a Model 192.

Figure 8 illustrates how a Model 96 can be reconfigured by the Management Computer and/or the TOD™ Configured Laptop to operate as two separate Model 48 units. They can be setup to independently parallel process the same identical tasks, where one acts as a full real-time back processor.

They can each be assigned separate independent processing tasks. They can be programed to run the same tasks and check to see that both the intermediate and final results match when the tasks are processed by two different neuron professors.

Figure 9 presents the current view of a single desktop or floor tower version of the TOD™ Model 16. Also shown, is the floor version of the TOD™ Model 48. This Model is approximately the volume of four standard tower units and is also available in a rack system version.

Networking and Direct Sensor Sourced Data

Low to moderate bandwidth networking of a multiple number of the same TOD™ Models and/or a mixture of TOD™ Models is possible using currently available commercial digital network services.

All Tissue Computer internal data networking is neuron-to-neuron, using the TC Cord network. BCM is also developing a special flexible pipeline protected TC Cord, which may support direct neuron-to-neuron data transfers between multiple Tissue Computers.

In addition to neuron and digital data transfers, BCM is developing TC Cords and interface ports on the Tissue Computer to support raw, direct sourced data in these formats: optical, audio, video, RF, Inferred, thermal, and seismic.

Mobile-Ruggedized Models

Initially all available TOD™ Models are for fixed operations. BCM is developing mobile-ruggedized versions of some models. To address the delay in their availability, BCM suggests users requiring mobile-ruggedized versions initially purchase or lease a fixed operations model, and later upgrade.

Users can thereby benefit from initial use of the fixed model to perform system analysis, development, and testing of their TOD™ application. Upon availability of the new mobile-ruggedized Model, BCM will accept the fixed model as a trade-in for the new ruggedized model.

Programming and Controlling a Tissue Computer

For more than a decade a growing community of scientists, engineers, and application developers have been building and using software that is focused on neural networks and neuron processing. The result is that many of the software utilities, tools, and application programs required to manage and control TOD™ are currently available, and many are open-source.

These existing programs are either directly TOD™ compatible, or with modification can become a part of the TOD™ software users' library to operate, manage, and leverage the massive performance capabilities available from TOD™.

Volume Production

One can design an amazing Tissue Computer but if that computer cannot be mass produced and delivered to customers at an affordable price, the Tissue Computing era would never materialize. BCM has specifically designed the first commercially available Tissue Operating Device (TOD™) to be mass producible, extremely dependable, and service supportable.

This discussion is directed at presenting the manufacturing, packaging, and delivery process and systems used by BCM to make and deliver TOD™ and all the associated components, including the Tissue Computer.

The packaging and transport of the TOD™ components, excluding the Tissue Computer, uses standard computer equipment packaging and shipping. Packaging and transporting of the Tissue Computer which includes millions of neurons, live nerve cells, requires special procedures.

Tissue Manufacturing

The Tissue Computer is filled with neuron populated tissue structures. Because this computer contains many millions of living neurons, the manufacturing processes must be totally performed within a medically sterile Lab Environment.

The process includes first manufacturing of the TC Disk tissue scaffolding. Next the growth and propagation of the Disk structure with approximately one million new living neurons. This newly created and fully populated TC Disk is then processed through a battery of tests and validation procedures. These tests assess the levels of TC Disk functionality and performance.

In parallel, to this TC Disk production activity, is a process to produce TC Cords. Manufacturing a TC Cord is a three-step serial process. First, the exterior of the tube structure is manufactured. Next, is the manufacturing of the Cord's interior tissue scaffolding. Last is the process which grows and populates the Cord's interior scaffolding structure with many newly grown neurons. Each newly created TC Cord is then repeatedly evaluated to assess effectiveness of data transfer functionality and performance.

Each approved TC Disk and TC Cord is them packaged and placed into a medically sterile Lab Environmental warehouse to await an allocation to a specific TOD™ customer order. Figure 10 is an image of the sterile temporary storage and warehousing container used to assure each newly manufactured TC Disk and TC Cord produced remains fully compliant with medical grade sterile manufacturing procedures.

Manufacturing Quality

In the tissue manufacturing process, BCM utilized only animal source material that meets or exceeds all U.S. FDA recommended "Guidelines as to Pedigree and Handling" procedures for materials to be used in medical devices. BCM's controlled sourcing process assures a pure material that contains no growth stimulating hormones or GMO products are used in the birthing and raising of the animals or herds.

All BCM processing and manufacturing is performed under strict Standard Operating Procedures and are cGMP ("current good manufacturing practice") compliant, and compliant with the USDA and FDA regulations. These operating controls, procedures

and qualified processes enable BCM to provide the highest quality and purity of materials used in the manufacture of each Tissue Computer.

Order Processing

Upon acceptance of a TOD™ purchase order, and authorization to proceed with manufacturing, the required number of TC Disks and TC Cords are withdrawn from the manufacturing warehouse. Within a medically sterile Lab Environmental these components are arranged into the processing array configuration required for the TOD™ Model ordered.

Upon completion of the construction phase of the array manufacturing, all the TC Disk and TC Cord in the architectural array structure, including the internal TC Cord network and the special TC Cord external data ports, are cell growth bonded into the final deliverable Tissue Computer.

The packaging and shipping of the tested and approved Tissue Computer to the TOD™ Support Team for delivery and install at the customer site, uses the BCM proprietary live tissue transporter, named Steff.

As reference, Figure 11 is a picture of Steff after successfully delivering BCM created ARTR™ organ repair tissue to the Hayatabad Medical Complex, Peshawar, Pakistan. Steff has successfully demonstrated the ability to sustain cell populated living tissue for over 20 days, without the need for any internal or external power.

Steff has also successfully survived many unplanned air courier drop tests, being lost in an airfreight warehouse for over a week and being left on a hot airport runway for an extended lunch break. In simple terms, Steff is amazing.

Volume Tissue Production

Manufacturing a TOD™ computer is complex and challenging. However, BCM has previously, and repeatedly performed all these manufacturing steps and maliciously validated all the processes, equipment, and procedures. The latest tissue production system validation was in the manufacturing, and delivery of multiple sets of Autologous Regenerative Tissue Replacement (ARTR™) organ repair tissue units in support of human kidney repair clinical trials. To learn more, review the ARTR™ data at the BCM website.

A key element in an ability to deliver high-volume manufacturing of tissue products is a BCM designed tissue production machine known as Cliff. Illustrated in Figure 12, with extremely limited manual supervision, a single Cliff unit produces up to 120 TC Disk units per week, or 6,000 per year. All BCM tissue manufacturing machines, including Cliff, are modular and can be quickly expanded to increase production based upon market demand.

For example, by installing 2,000 Cliff units into a TOD™ manufacturing facility, annual production will exceed 12 million TC Disks. A modified version of Cliff can manufacture TC Cords at the same annual production rates. The use of 2,000 Cliff units is an example only, there are no physical limits to the number of Cliff units that can be added to the BCM manufacturing facility production lines.

Customer Support and Services

All TOD™ Model purchases include a one-year full replacement warranty. That warranty includes the delivery, and complete professional installation by a highly trained and certified TOD™ Team. The team assembles, connects, tests, and performs full system tests to assure each delivered TOD™ Model fully meets or exceeds all performance standards.

The Team does not leave the customer's site until all interfaces are functioning as required and the TOD™ system configuration, including the TOD™ installed software, meets performance specifications. This delivery and support services is provided to purchasers located in all accessible locations around the Globe.

The Tissue Computer includes millions of active neurons. To survive and successfully perform requested processing tasks, these neurons require a conducive sterile environment, specific temperature, humidity, energy needs, and other life supporting services. The Tissue Computer is constructed to provide this operating environment and required services.

A Tissue Computer is somewhat more demanding of technical service support than an inanimate digital device. However, the required purchaser's support tasks will be simple and infrequent. Moreover, the TOD™ Support Team is always available to help, by phone or online chat, and if a serious issue exists, the BCM Support Team will provide on-site service, and if necessary, fully replace the Tissue Computer under terms of the warranty.

As shown in Figure 1, the digital data interface with the Tissue Computer, is through the TOD™ Management Computer. If TOD™ is to receive or send digital data to any external devices those data transfers must flow through the Management Computer.

These digital connections can be by standard digital cabling, a USB connection, Wi-Fi device, or other wireless connection. As illustrated, this data interface procedure also applies to the TOD™ laptop computer.

Delivery of every TOD™ Model includes a single conventional digital laptop computer, with either a USB or wireless connections to the TOD™ Management Computer. This laptop is preloaded with TOD™ user operating software, utilities, application developer tools, and Tissue Computer appropriate application programs.

All TOD™ Model sales include 24/7 complete customer support services. The TOC™ warranty and extend service agreement includes, if required, total TOD™ Model replacement.

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Figures and Tables

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Figure 1

TOD™ System Configuration

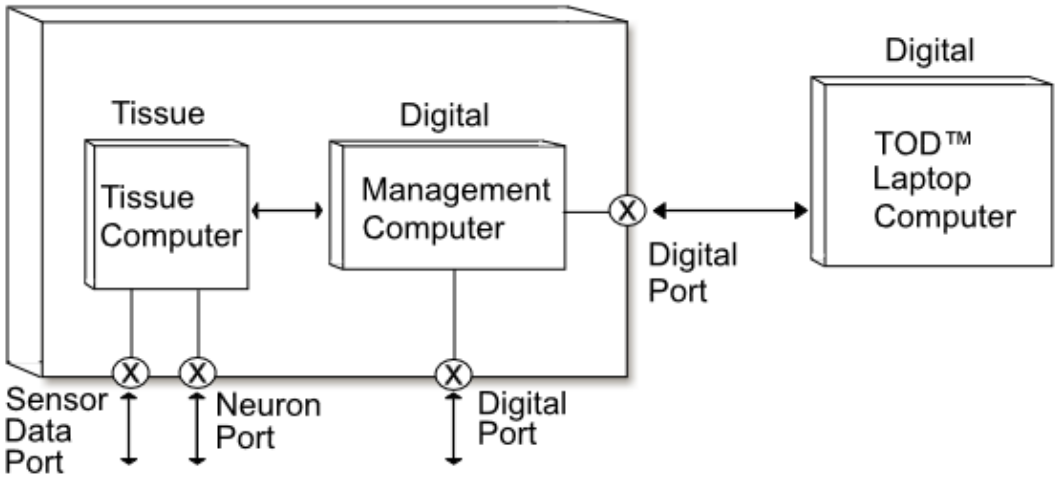


Table I

Commercially Available TOD™ Models

TOD™ Model Number	Max Neuron Capacity (1) (2)	Number of TC Disks	Number of TC Arrays (3)
TOD™ 16	16 million	16	1
TOD™ 48	48 million	48	3
TOD™ 64	64 million	64	4
TOD™ 96	96 million	96	6
TOD™ 192	192 million	192	12
TOD™ 480	480 million	480	30
TOD™ 1024	1 billion	1024	64
TOD™ 2048	2 billion	2048	128
TOD™ 5120 Supercomputer	5 billion	5120	320

Notes: (1) The actual number of neurons present at any given time will vary due to many factors that affect neuron birth, death, and growth rates. BCM cannot therefore guarantee the number of neurons in any specific TC Disk. However, every BCM manufactured TC Disk has the potential to hold and deliver up to one million neurons.
(2) TC Disk neuron population density is established by tissue and other factors. The human brain has 100 billion neurons in a volume of 1500 cc, or 91.5 cubic inches. Each TC Disk is approximately 2x2x0.5 inches or 2 cubic inches, establishing a maximum capacity of one million neurons per TC Disk.
(3) The Model 16 Tissue Computer planar array has 16 TC Disks in a 4x4 array. The Model 48 cubic array has 48 TC Disks in a 3D structure of a 3 deep 4x4 array. The 3D structure of the cubic array is the bases for all Tissue Computer architectures in the larger TOD™ Models.

Figure 2

Picture of a Single TC Disk

Single TC Disk in a Petrie Dish

TC Disk embedded with up to one million neurons

Ready for insertion into Tissue Computer Array

Figure 3

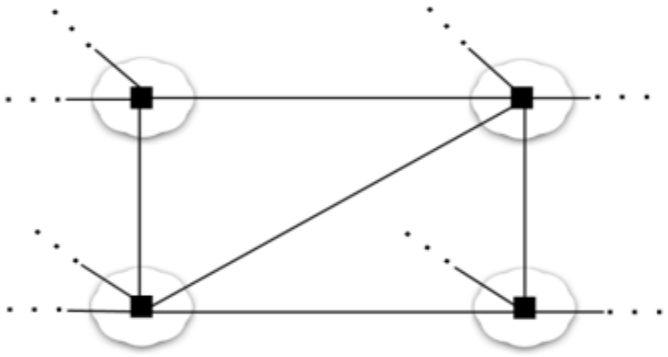
Standard TC Cord

Standard TC Cord
TC Cord Section filled with Tissue
Embedded with Neurons

Network Branching TC Cord
Network Branching TC Cord Section
Internal Tissue Structure with
Embedded Neurons Absent

Figure 4

4 TC Disk – TC Cord Linked Tissue Array



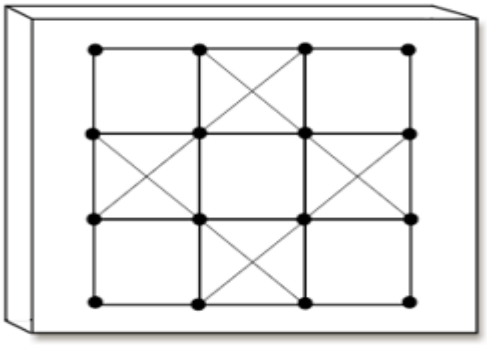
Segment of a neuron processing array

Code:
○ TC Disk
■ A TC Cord
— A TC Disk Embedded Data Port
Note: All TC disks are identifiable and programable tissue computer components addressable by the management computer operation system

Figure 5

16 TC Disk Programable Planar Array

Tissue Computer



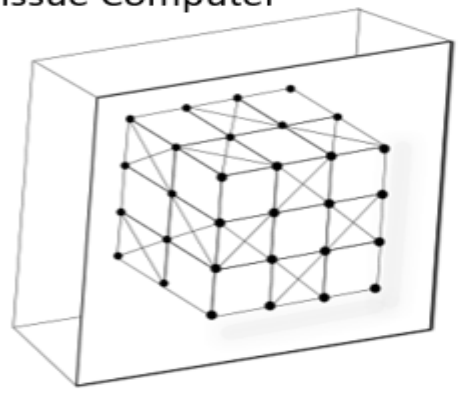
2D Planar Tissue Processing Array

Code:
● A single TC Disc
— A single TC Cord
Note: All TC disks are connected to at least 2 or more TC Cords

Figure 6

48 TC Disk Programable Cubic Array

Tissue Computer

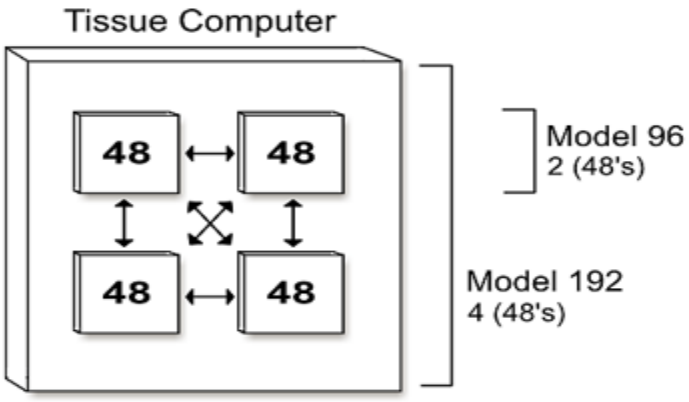


3D Cubic Tissue Processing Array

Code:
● A single TC Disc
— A single TC Cord
Note: Exterior view only all TC disks are connected to at least 2 or more TC cords.

Figure 7

48 TC Disk Cubic Array Architecture
TOD™ Model 96 and 192 Configurations



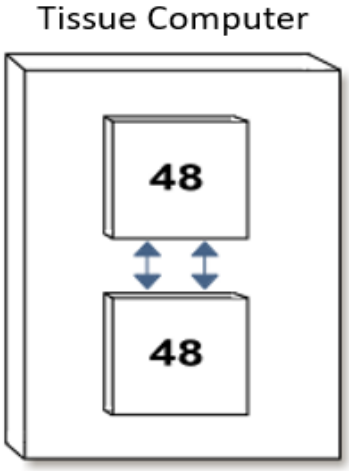
Code:

48 A standard 48 TC disk cubic array

Note: Illustration shows difference between Model 96 and Model 192

Figure 8

Model 96 in Full Real-Time Backup



TOD™ Model 96 program partitioned into a model 48 with full-time duplicate processing.

Code:

48 A standard 48 TC disk cubic array

Figure 9

View of TOD™ Models 16 and 48

TOD™ Models 16
Standard Desktop or Floor Tower

TOD™ Models 48

Standard Three-Wide Floor Tower

Figure 10

Medically Sterile Storage and Transport Packaging

TC Disk and TC Cord Sterile Storage Unit

Figure 11

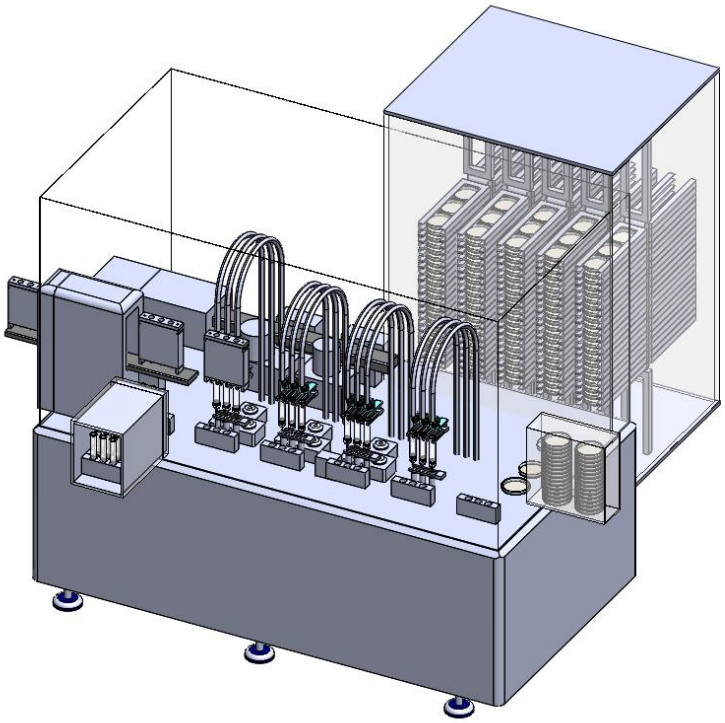
Steff - Tissue Computer Transporter

Environmentally Sterile Extended Duration Tissue Shipper

Figure 12

Cliff - Fully Automated Tissue Manufacturing Unit

High-Volume Manufacturing of TC Disk and TC Cord Units



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