

Declaration of Andrew Wolfe, Ph.D.
U.S. Patent No. 8,562,324

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Shenzhen Tuozhu Technology Co., Ltd.

Petitioner,

v.

Stratasys, Inc.

Patent Owner.

U.S. Patent No. 8,562,324

**DECLARATION OF ANDREW WOLFE, PH.D.
ON BEHALF OF PETITIONER**

I, Andrew Wolfe, Ph.D., declare as follows:

1. I have been retained on behalf of Shenzhen Tuozhu Technology Co., Ltd. (“Petitioner” or “Tuozhu Tech”) to provide my independent opinions regarding U.S. Patent No. 8,562,324 (“the ’324 Patent”).
2. To the best of my knowledge, I have no financial interest in Shenzhen Tuozhu Technology Co., Ltd. or any related entity.
3. I am being compensated at my standard consulting rate of \$750 for my time. My compensation is in no way contingent on the results of this or any other proceedings relating to the ’324 Patent.
4. For ease of understanding, I have annotated figures and added emphasis in my discussions unless otherwise noted.

1. Background and Qualifications

5. My qualifications and professional experience are described in my curriculum vitae, a copy of which is provided as Appendix A to this declaration. The following briefly summarizes my relevant qualifications and professional experience.

6. I have more than 40 years of experience in consumer electronics and interactive graphics and interactive video computer systems, including as a computer architect, computer system designer, PC graphics designer, educator, and as an executive in the consumer electronics business.

7. In 1985, I earned the B.S.E.E. degree in Electrical Engineering and Computer Science from the Johns Hopkins University. In 1987, I received the M.S. degree in Electrical and Computer Engineering from Carnegie Mellon University and then in 1992, I received a Ph.D. in Computer Engineering from Carnegie Mellon University. My doctoral dissertation proposed a new approach for the architecture of a computer processor.

8. In 1983, I began designing Touch Sensing systems as a senior design engineer for Touch Technology, Inc. In some of these design projects, I designed interrupt-based I/O cards for PC-compatible computer systems including the IBM PC-AT to interface interactive touch-based computer terminals that I designed for use in public information systems. I later worked for the Carroll Touch division of AMP where I designed additional touchscreen technologies, developed system firmware, and designed the company's first custom integrated circuit. I designed the touch/pen input system for the Linus WriteTop, which many believe to be the

first commercial tablet computer. Between 1983 and 2003 I designed many different devices which detected touch and/or measured forces.

9. From 1986 through 1987, I designed and built a high-performance computer system at Carnegie Mellon University. From 1986 through 1988, I also developed the curriculum and supervised the teaching lab for the processor design courses.

10. In 1987-88, I worked as a senior design engineer for ESL-TRW Advanced Technology Division. I designed and built a bus interface and memory controller for a workstation-based computer system and worked on the design of a multiprocessor system.

11. At the end of 1989, along with some partners, I reacquired the technology I had developed at Touch Technology and at AMP and founded The Graphics Technology Company. As an officer and a consultant, I managed engineering development activities at that company and personally developed dozens of touch sensing devices over the next seven years. Many of these could distinguish between different levels of touch force.

12. I have consulted, formally and informally, for a number of consumer electronics design companies. In particular, I have served on the technical advisory

boards for two media processor design companies, BOPS, Inc., where I chaired the board, and Siroyan Ltd. I served in a similar role for three networking chip companies, Intellon, Inc., Comsilica, Inc., and Entridia, Inc. and one 3D game accelerator company, Ageia, Inc. I have also served as a technology advisor to Motorola and to several venture capital funds in the U.S. and Europe. Currently, I am a director of Turtle Beach Corporation, providing guidance in its development of premium audio peripheral devices for a variety of commercial electronic products. My consulting has included electromechanical and robotic systems for measuring touch pressure and stylus force including X-Y-Z positioning systems that move in the same way as common 3D printers.

13. From 1991 through 1997, I served on the Faculty of Princeton University as an Assistant Professor of Electrical Engineering. At Princeton, I taught undergraduate and graduate-level courses in Computer Architecture, Advanced Computer Architecture, Display Technology, and Microprocessor Systems courses as well as conducting sponsored research in the area of computer systems and related topics. My research included some of the first systems that displayed real-time video over a computer network in a web-based interface. My courses included teaching about electromechanical sensors and actuators. From 1999 through 2002, I also taught the Computer Architecture course to both

undergraduates and graduate students at Stanford University several times as a Consulting Professor. At Princeton, I received several teaching awards, both from students and from the School of Engineering. I have also taught advanced microprocessor architecture to industry professionals in IEEE and ACM sponsored seminars. I currently teach at Santa Clara University including courses on Embedded Systems, Real-Time Computing, Mechatronics, and Engineering Practice. Since 2014, these classes have included comprehensive instruction and experimentation with sensors and actuators for measuring distance, force, and other physical phenomena. I have also worked with two undergraduate teams to design and construct material extruders for 3D printing. Additionally, I teach all of these students to use 3D FDM printers and have used them myself for more than a decade.

14. From 1997 through 2002, I held a variety of executive positions at a publicly-held PC graphics company originally called S3, Inc. and later called Sonicblue Inc. These included Chief Technology Officer, Vice President of Systems Integration Products, Senior Vice President of Business Development, and Director of Technology. At the time I joined S3, it supplied graphics accelerators for more than 50% of the PCs sold in the United States.

15. In these roles, I managed teams of engineers developing complex graphics chips for use in personal computers. This included visualization of 3D objects and generating 2D representations of 3D objects. I also managed the video research lab. I was involved in every aspect of the relationship with PC manufacturers ranging from discussions of product requirements, testing and qualification procedures, and competitive analysis, to market segmentation and pricing discussions. I met with senior executives in major PC manufacturers on numerous occasions to discuss business opportunities and general market trends. I also developed numerous consumer audio and video products including the Rio MP3 players, the ReplayTV digital video recorders, certain Löewe televisions, and the GoVideo DVD and VCR products. I also developed user interfaces and remote control protocols. I further assisted in the launch of streaming services. During my time at SonicBlue we launched more than 30 new consumer electronics products.

16. I have published more than 50 peer-reviewed papers in computer architecture and computer systems design including papers related to video streaming. I have also chaired IEEE and ACM conferences in microarchitecture and integrated circuit design. I am a named inventor on at least fifty-seven U.S. patents and thirty-seven foreign patents, more than ten related to touch and/or force

sensing. I am an IEEE Fellow and an IEEE Computer Society Distinguished Contributor.

17. I have been the invited keynote speaker at the ACM/IEEE International Symposium on Microarchitecture and at the International Conference on Multimedia. I have also been an invited speaker on various aspects of technology or the PC industry at numerous industry events including the Intel Developer's Forum, Microsoft Windows Hardware Engineering Conference, Microprocessor Forum, Embedded Systems Conference, Comdex, and Consumer Electronics Show as well as at Harvard Business School and the University of Illinois Law School. I have been interviewed on subjects related to computer graphics and video technology and the electronics industry by publications such as the Wall Street Journal, New York Times, LA Times, Time, Newsweek, Forbes, and Fortune as well as CNN, NPR, and the BBC. I have also spoken at dozens of universities including MIT, Stanford, University of Texas, Carnegie Mellon, UCLA, University of Michigan, Rice, and Duke.

18. In summary, I have extensive familiarity with fields involving electromechanical devices, sensors, and material deposition. I am familiar with the state of this field at the time of the '324 Patent, which I have been informed by

Petitioner's counsel to assume as being August 18, 2010, for the purposes of this proceeding.

2. Relevant Legal Standards

19. I am not an attorney and offer no legal opinions, but in the course of my work, I have had experience studying and analyzing patents and patent claims from the perspective of a person skilled in the art.

20. In expressing my opinions and considering the subject matter of the claims of the '324 Patent, I am relying upon certain basic legal principles that have been explained to me.

21. I understand that "the time the claimed invention was made" is often referred to as the priority or critical date. I have been informed by Petitioner's counsel to assume that August 18, 2010 is the critical date, for the purposes of this proceeding.

22. I understand that, before considering the prior art, the claims are first construed to determine their scope. I understand that the claims are read from the perspective of POSITA at the time of the alleged invention. I understand that the words of a claim are generally given their ordinary and customary meaning as

understood by a POSITA in light of the entire patent specification in which they appear, as well as the prosecution history of the patent.

23. I understand, however, that the words of a claim may be given a meaning other than their plain and ordinary meaning if: (1) a patentee expressly and unambiguously defined a term in a way that is different from its plain meaning; or (2) a patentee “disclaims” the full scope of a claim term’s plain meaning, for instance, by making clear and unambiguous statements during prosecution that a claim term does or does not encompass certain features.

24. I understand that, after construing the claims, the teachings of the prior art are considered. I also understand that a POSITA is assumed to be aware of all relevant prior art in the field of endeavor covered by the patent-at-issue and all analogous prior art.

25. I understand that although the ultimate question of the obviousness of a claimed invention is a legal determination, obviousness is based on several factual inquiries, including: the scope and content of the prior art, the differences between the claimed subject matter and the prior art, the level of ordinary skill in the art at the time of the invention, and any “objective indicia” or “secondary considerations” of non-obviousness, which must all be considered.

26. I understand that, in determining the scope and content of the prior art, a reference is considered relevant prior art if it falls within the field of the inventor's endeavor, or if it is reasonably pertinent to the particular problem that the inventor was trying to solve. A reference is reasonably pertinent if it logically would have commended itself to an inventor's attention in considering his problem.

27. I understand that, to assess the differences between prior art and the claimed subject matter, the claimed invention must be considered as a whole.

28. I understand that there are several rationales for combining prior-art references. For instance, I understand that it is considered obvious to: combine prior-art elements according to known methods to yield predictable results; substitute one known element for another to obtain predictable results; use the prior-art elements in a predictable way according to their established functions; apply a known technique to a known device (method or product) ready for improvement to yield predictable results; choose from a finite number of identified, predictable solutions, with a reasonable expectation of success; or if there is some teaching, suggestion, or motivation in the prior art that would have led a POSITA to modify a prior-art reference or combine prior-art teachings to arrive at the claimed invention. I understand, however, that a POSITA does not

need to have the same motivations or reasons to combine the prior art as the inventors, and can arrive at the claimed invention for completely different reasons than the inventors.

29. I also understand that the prior art cannot be modified or combined using “hindsight.” I understand that hindsight refers to situations in which the patent-at-issue is used as a framework to pick and choose pieces from the prior art to arrive at the claims, or adopting rationales identified by the patent-at-issue that those in the art would not have recognized. Instead, I understand that the obviousness inquiry is evaluated from the perspective of a POSITA as of the critical date of the patent-at-issue, with all the prior art before them, to determine whether the POSITA would have independently arrived at the claimed invention without the benefit of the patent-at-issue for guidance.

30. I understand that “objective indicia” or “secondary considerations” of non-obviousness include whether: (1) there was a long-felt need for the claimed invention; (2) the claimed invention has achieved commercial success; (3) there was copying of the claimed invention by others; (4) there were failed attempts by others to make the alleged invention; (5) there was praise of the invention in the field; and (6) there was skepticism the claimed invention could be achieved, among a few others.

31. As of the time that I prepared this declaration, the Patent Owner had not identified any secondary considerations of non-obviousness. Therefore, I might address any secondary considerations if the Patent Owner later identifies any.

32. Finally, I understand that, in an inter partes review proceeding, the Petitioner bears the burden of proving obviousness of a challenged patent claim by “a preponderance of the evidence.” I understand that the preponderance of the evidence standard requires that a reasonable factfinder could find a material fact is more probable than the nonexistence of that fact. I have applied the “preponderance of the evidence” standard throughout my declaration.

3. Materials Considered

33. The opinions contained in this declaration are based on the documents I reviewed, my professional judgment, as well as my education, experience, and knowledge regarding electro-mechanical engineering.

34. In forming my opinions expressed in this declaration, I reviewed all the materials cited within this declaration, including:

- U.S. Patent No. 8,562,324 to Pettis et al. (“the ’324 Patent”; EX1001)

- Excerpts from the Prosecution History of the '324 Patent (“the Prosecution History”; EX1002)
- U.S. Patent No. 6,580,959 to Mazumder (“Mazumder”; EX1004)
- U.S. Patent Pub. No. 2010/0063615 to Mori et al. (“Mori”; EX1005)
- U.S. Patent Pub. No. 2009/0015668 to Tian et al. (“Tian”; EX1006)
- Japanese Patent Publication Number JP2000218708 (EX1007)
- Certified English Translation of Japanese Patent Publication Number JP2000218708 (“Hull”; EX1008)
- U.S. 5,278,479 to Seki et al. (“Seki”; EX1009)
- U.S. Patent Pub. No. 2006/0171452 to Waehner (“Waehner”; EX1010)
- Lan, *Web-based Rapid Prototyping and Manufacturing Systems: A Review*, Computers in Industry (December 2009) (“Lan”; EX1011)
- U.S. Patent Pub. No. 2004/0207662 to Anderson et al. (“Anderson”; EX1012)

- Tay et al., *Distributed Rapid Prototyping – A Framework for Internet Prototyping and Manufacturing*, Integrated Manufacturing Systems (November 2001) (“Tay”)
- Henke et al., *Rapid Prototyping Modules for Remote Engineering Applications*, International Journal of Online Engineering, Vol. 4, Issue 1 (July 2008), available at <https://online-journals.org/index.php/i-joe/article/view/532/513> (“Henke”; EX1014) (also available at <https://core.ac.uk/download/pdf/224750644.pdf>).
- U.S. Patent Pub. No. 2006/0054039 to Kritchman et al. (“Kritchman” EX1015)
- Exhibit J of Infringement Contentions from Stratasys, Inc., v. Shenzhen Touzhu Technology Co., Ltd., et al., Case Nos. 2:24-cv-00644-JRG and 2:24-cv-00645-JRG (E.D. Tex. Nov. 14, 2024) (EX1016).

35. All of the opinions contained in this declaration are based on the documents I reviewed and my knowledge and professional judgment. My opinions have also been guided by my appreciation of how a person of ordinary skill in the art would have understood the claims and the specification of the ’324 patent at the

time of the alleged invention, which I have been asked to initially assume is August 18, 2010.

36. Based on my experience and expertise, it is my opinion that certain references disclose and/or suggest, alone or in combination, all the features recited in the Challenged Claims of the '324 patent, as I explain in detail below.

37. My opinions are based on my years of education, research, and experience, as well as my investigation and study of relevant materials. In forming my opinions, I have considered the materials I identify in this declaration and those listed in the Exhibit List above.

38. I may rely upon these materials and/or additional materials to respond to arguments raised by the Patent Owner. I may also consider additional documents and information in forming any necessary opinions — including documents that may not yet have been provided to me.

39. My analysis of the materials produced in this matter is ongoing and I will continue to review any new material as it is provided. This declaration represents only those opinions I have formed to date.

4. Level of Ordinary Skill in the Art

40. I understand that patents and prior art references are analyzed from the point of view of a person of ordinary skill in the art (“POSITA”) at the time of the invention of, in this case, the ’324 Patent, which, as I explained above, is assumed to be August 18, 2010. I have been informed that the level of ordinary skill of a POSITA at the time of the invention is based on consideration of factors such as the educational level of the inventor and persons working in the field, the types of problems encountered in the field, prior art solutions to those problems, rapidity with which innovations are made, and the sophistication of technology.

41. Based on my knowledge and experience in the field and my review of the ’324 patent and its file history, I believe the range of qualifications for a POSITA would have included a bachelor’s degree in Mechanical Engineering, Electrical Engineering, Computer Engineering, Materials Science, or a comparable field and two years of experience (e.g., research or industry experience) related to 3D printing including remote control of rapid fabrication systems. For example, pertinent to the ’324 patent, the design and development of remote control and communication for a 3D printing system, including video camera monitoring, would have been well within the capabilities of a junior engineer. Such a person would have understood the purpose of such control and monitoring systems would

have been able to apply basic product design principles. A POSITA could potentially have higher extent of education and a lower level of work experience or vice versa.

42. My analysis and conclusions expressed in this Declaration are based on the perspective of a POSITA having this level of knowledge and skill. My education, technical expertise and personal knowledge discussed above shows that I meet the qualifications of a POSITA. For example, I am a Ph.D. computer engineer, an expert on user interfaces and 3D visualization with many years of work and management experience in the field, an expert on user interfaces, and an experienced teacher and user of 3D modeling software and 3D FDM printers.

5. Overview of the '324 Patent

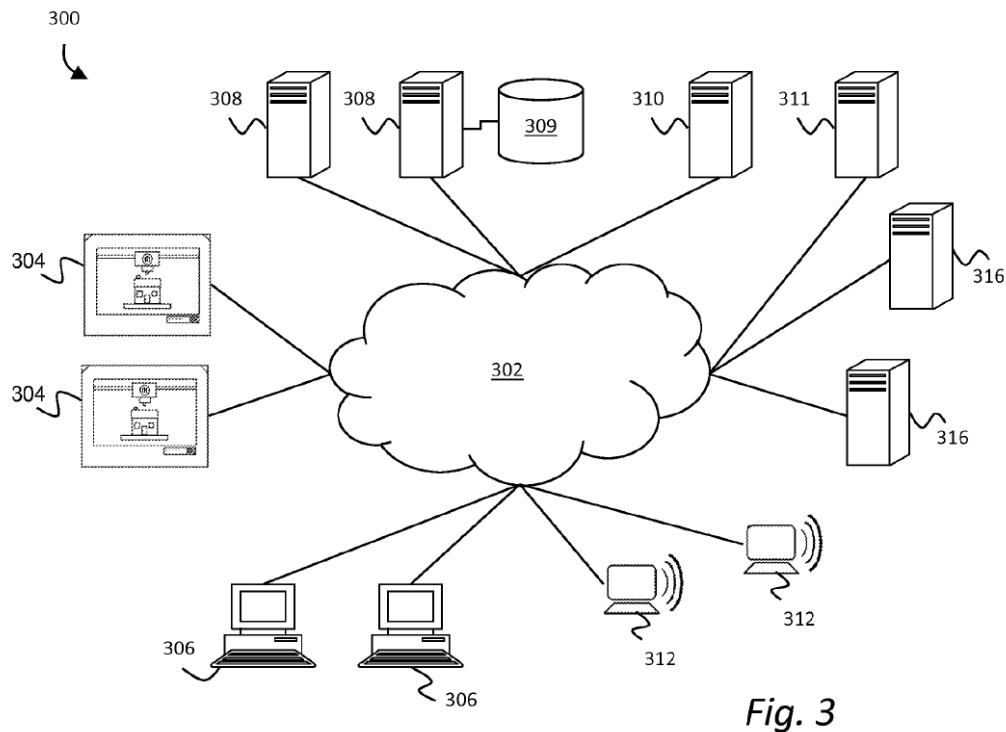
43. The '324 Patent describes that “[w]eb-based servers or the like can provide a single point of access for remote users to manage access to distributed content on one hand, and to manage use of distributed fabrication resources on the other EX1001, 1:32-38. Such fabrication resources include “networked three-dimensional printers.” *Id.*, 1:65-66. Such “three-dimensional printers 304 may be any computer-controlled devices for three-dimensional fabrication.” *Id.*, 8:28-31. For example, in a primary embodiment, the '324 patent describes that the printer

extrudes build material “at a controlled volumetric rate” to fabricate a three-dimensional object. *Id.*, 4:14-32. The system further includes a “controller 110” having “any combination of software and/or processing circuitry suitable for controlling the various components of the printer 100.” *Id.*, 5:13-37.

44. The '324 patent further describes that the 3D printing system includes various imaging devices for monitoring progress of the fabrication process. For example, the printer can include “an imaging device and image processing circuitry to capture an image of the working volume 114 and analyze the image to evaluate a position of the object 112.” EX1004, 5:57-65. The printer can further include a “video camera” to “provide a remote video feed through the network interface 136, which feed may be available to remote users through a user interface maintained by, e.g., remote hardware.” *Id.*, 6:21-33, 6:61-7:17 (network interface “to retrieve printable content, or respond[] to a remote request for status or availability”). The printer can also include “a three-dimensional scanner” to “extract three-dimensional information from the working volume.” *Id.*, 6:34-50.

45. Figure 3 shows an example configuration for the system, demonstrating communication between various remote client computers and rapid fabrication devices. For example, the networked system includes “client devices 306, print servers 308, content sources 310, mobile devices 314, and other

resources 316” for interacting with the three-dimensional printers 304 within the system. EX1004, 8:7-15.



EX1001, FIG. 3.

46. In this networked system, each remote client device 306 “generally provides a user interface, which may include a graphical user interface and/or text or command line interface to control operation of remote three-dimensional printers 304.” EX1001, 8:54-58, 16:40-42. Upon completion, the system can “notify[] the requester of a successful print job.” *Id.*, 20:15-31. “[T]he status

information may include at least one photograph captured, e.g., from a video camera.” *Id.*

47. The three-dimensional printers can serve a user interface that is displayed as a user interface at the remote client device and includes “information for a currently active print job.” EX1001, 21:18-25, 22:30-31. The user interface can also include “a visual representation of the print job.” *Id.*, 22:41-60.

6. Overview of the Prior Art

6.1. Mazumder (EX1004)

48. Mazumder describes a system for remotely controlling and monitoring a 3D printer via the Internet. Mazumder’s system “utilizes advances in telecommunication and fast data transfer to control the fabrication of precisely dimensioned and intricately-detailed products through an automated feedback-controlled, laser-aided direct material deposition (DMD) process.” EX1004, 1:62-66. Mazumder describes that users can design models for objects to be fabricated by a 3D printer using standard computer-aided design (CAD) software. *Id.*, 2:3-13. Computer-aided manufacturing (CAM) software is used to generate a deposition tool path for fabricating the object defined by the CAD model. *Id.* Mazumder describes that such CAD software can be used to generate tool paths for both

material deposition based rapid fabrication and material removal based rapid fabrication. *Id.*

49. Mazumder describes that “[f]or remote control of the DMD process, a design team or an individual designer is located at the ‘remote’ site and operates, through a user interface, their ‘remote’ host computer. The remote computer stores the description of a product to be fabricated.” EX1004, 2:14-23. The 3D printer at the local fabrication site includes a local computer 70 that coordinates and controls all functions of the local fabrication site and communicates with the remote users computer 95. *Id.*, 3:26-39, 4:18-38. The local computer 70 at the location of the 3D printer “receives instructions from the remote computer 95 to control the deposition process and, if necessary, to alter the entire laser source path or parts of it.” *Id.*, 4:30-37. Mazumder also describes remotely controlling the deposition process via the remote computer 95 by providing the designer with the ability to “pause or abort the fabrication process by sending a command to the controller” of the system. *Id.*, 2:34-42, 6:44-67.

50. The local fabrication device includes a number of sensors for tracking the progress of a fabrication process being executed by the device, including “strain gages 40, acoustic sensors 50, optical sensors 60 and video or television camera 65.” *Id.*, 3:26-31. The “video or TV camera 65 records the laser-aided

DMD process and transmits the images to the local computer 70, which then sends the images together with the associated temperature, strain and stress data to the remote computer 95 to be displayed preferably on a TV screen or shown on the remote computer monitor as streaming video.” *Id.*, 6:36-43. Specifically, Mazumder describes “using a video or television camera to record the fabrication of the product and sending the images to a display connected to the remote computer.” *Id.*, 8:51-54. Mazumder teaches that the remote computer 95 includes a user interface “for image and video observation of the laser-aided direct material deposition process.” EX1004, 2:27-30, 6:36-55. The remote user can use the sensor data, including the video data, to identify defects or design flaws “for remote control of the process, or for modification of the product design, in its entirety or in part, and for replacement of the original CAM file with a new edited CAM file or CAM-file block to be transmitted back to the local computer 70” to improve the resulting design. *Id.*, 6:24-35.

51. Figure 1 shows the various components of Mazumder’s local site fabrication assembly and the network connection between the local computer 70 and the remote computer 95:

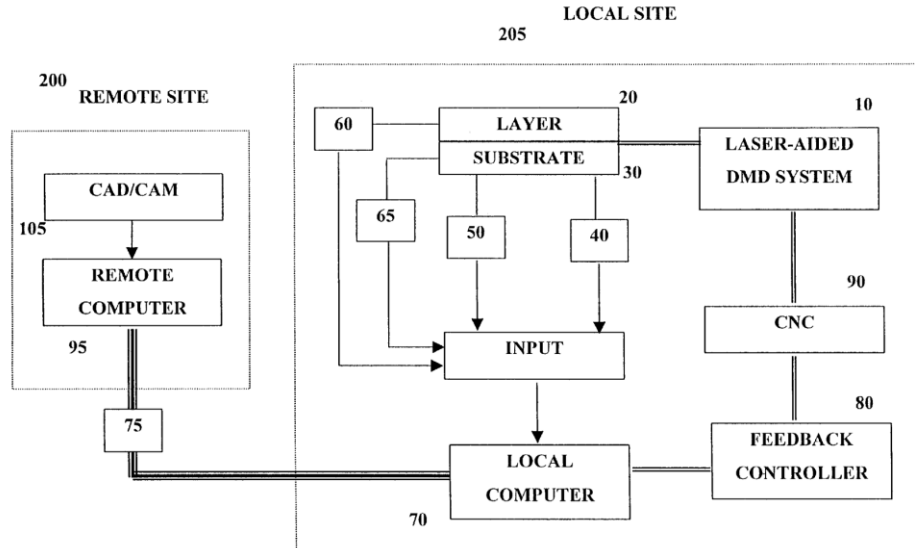


FIG - 1

EX1004, FIG. 1, 3:26-63 (describing communication between the local computer 70 and the remote computer 95 “via the communications system 75”).

6.2. Mori (EX1005)

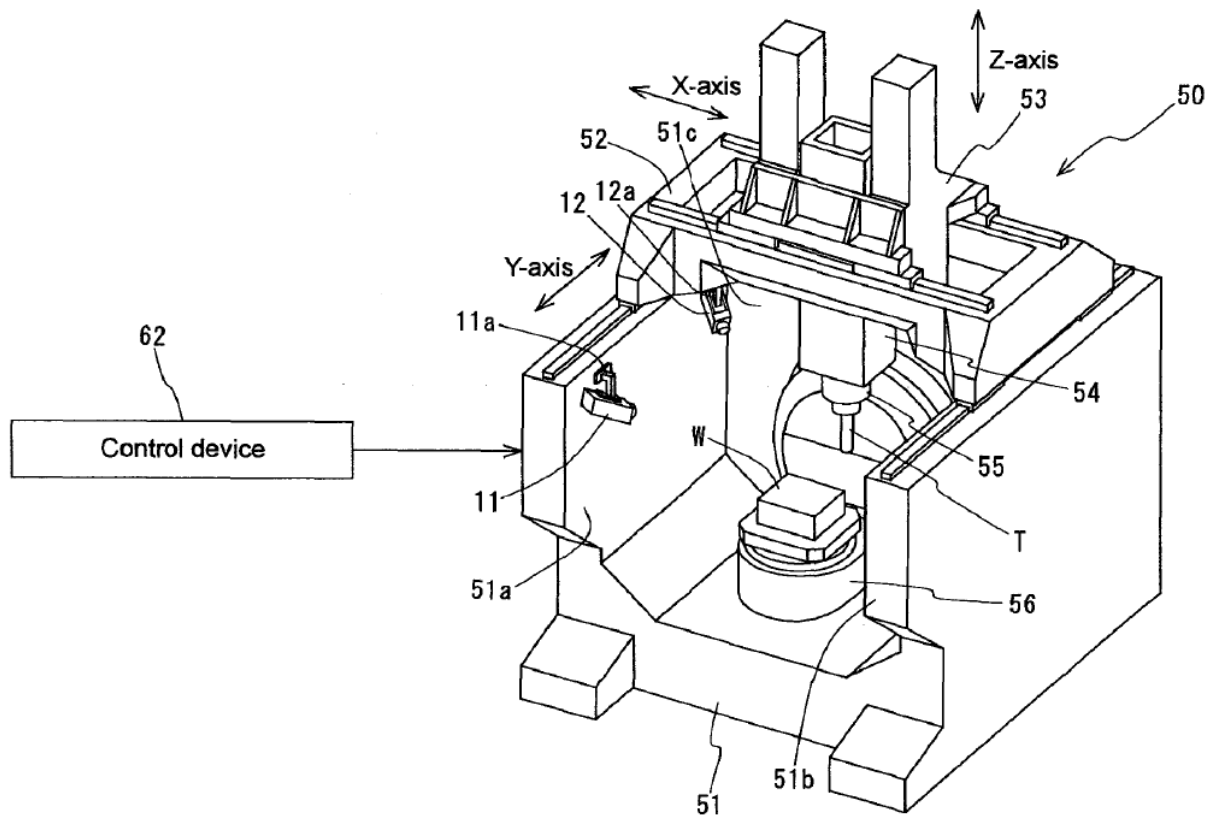
52. Mori describes a “machining status monitoring apparatus is provided on a machine tool, and has a plurality of actual CCD cameras for imaging the tool and workpiece from different view points and generating actual two-dimensional image data thereof, a virtual image generating section having a plurality of virtual CCD cameras corresponding to the actual CCD cameras, in which the tool and workpiece of three-dimensional model are imaged by the virtual CCD cameras from each point and virtual two-dimensional image data thereof are generated, and a display control section for selecting one virtual CCD camera corresponding to

the virtual two-dimensional image data in which the distal end of the tool is not hidden by the workpiece among the generated two-dimensional image data, and displaying the actual two-dimensional image data generated by the actual CCD camera corresponding to the selected virtual CCD camera on a display device.”

EX1005, Abstract.

53. Mori describes that “tool holding means for holding a tool and workpiece holding means for holding a workpiece are operated based on operation commands.” EX1005, [0006]. Figure 2 shows an example of Mori’s automated fabrication device:

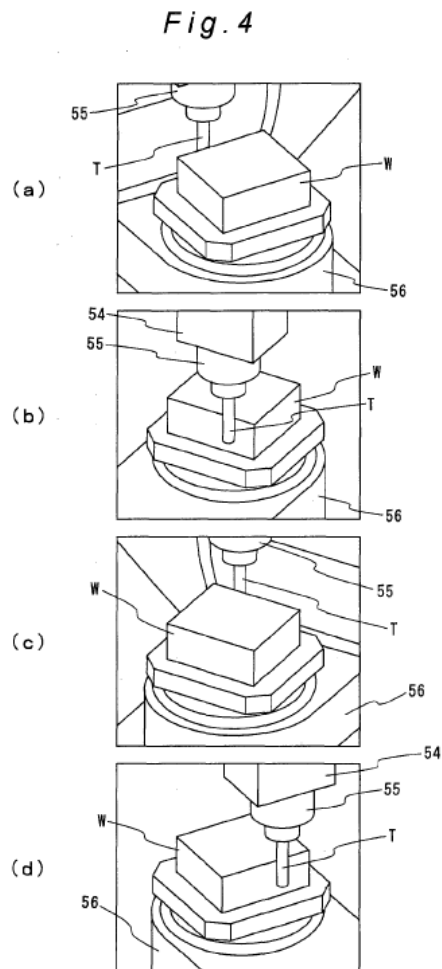
Fig. 2



EX1005, FIG. 2.

54. Similar to Mazumder, Mori describes that its fabrication device fabricates a “workpiece of [a] three-dimensional model.” EX1005, Abstract, [0001]. As shown above, Mori’s machine tool 50 includes a bed 51 for holding a “workpiece W” and “a control device 62 for controlling the operations of the feed mechanisms 57, 58 and 59, spindle motor 60 and coolant supply device 61.” Id., [0044].

55. Also similar to Mazumder's device, Mori's rapid fabrication system includes "a machining status monitoring apparatus 1" having "a plurality of actual CCD cameras." EX1005, [0043]. Mori describes that "the actual CCD cameras 11, 12, 13 and 14 are arranged to surround the workpiece W on the table 56, and are configured so as to be able to image the workpiece W from four directions" to "generate two-dimensional image data (actual image data) thereof" as shown in FIG. 4. Id., [0049]-[0050]. Figure 4 shows images of the workpiece within Mori's rapid fabrication device as captured by each of Mori's four CCD cameras:



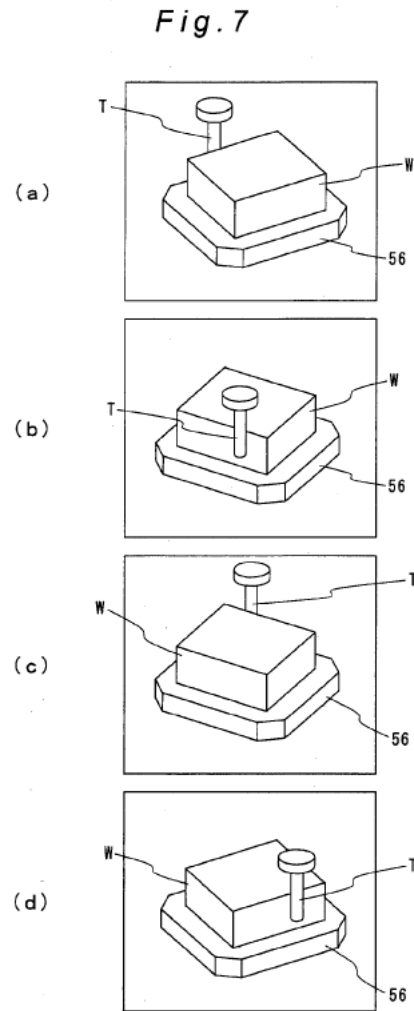
EX100, FIG. 4.

56. In addition to these actual CCD cameras positioned within Mori's device to capture images of the workpiece from a variety of angles, Mori's system also includes a "virtual image generating section 18" that provides views of the workpiece and work environment based on the stored model of the workpiece.

EX1005, [0059]-[0065]. Mori explains that it's "virtual image generating section 18 generates two-dimensional image data (virtual image data) of, for example, the

tool T, workpiece W and a part of the table 56 by a computer process based on the parameters stored in the camera parameter storage section 15 and the model data updated by the model data updating section 17.” *Id.*, [0059]. This allows Mori’s system to display virtual images of the model in the user interface as if captured from “virtual CCD cameras” that “are respectively arranged at the same positions and in the same orientations as the actual CCD cameras.” *Id.*, [0061]-[0062].

Figure 7 shows examples of such virtual CCD camera images depicting the workpiece from the same four perspectives as the actual camera images depicted in the example in Figure 4:



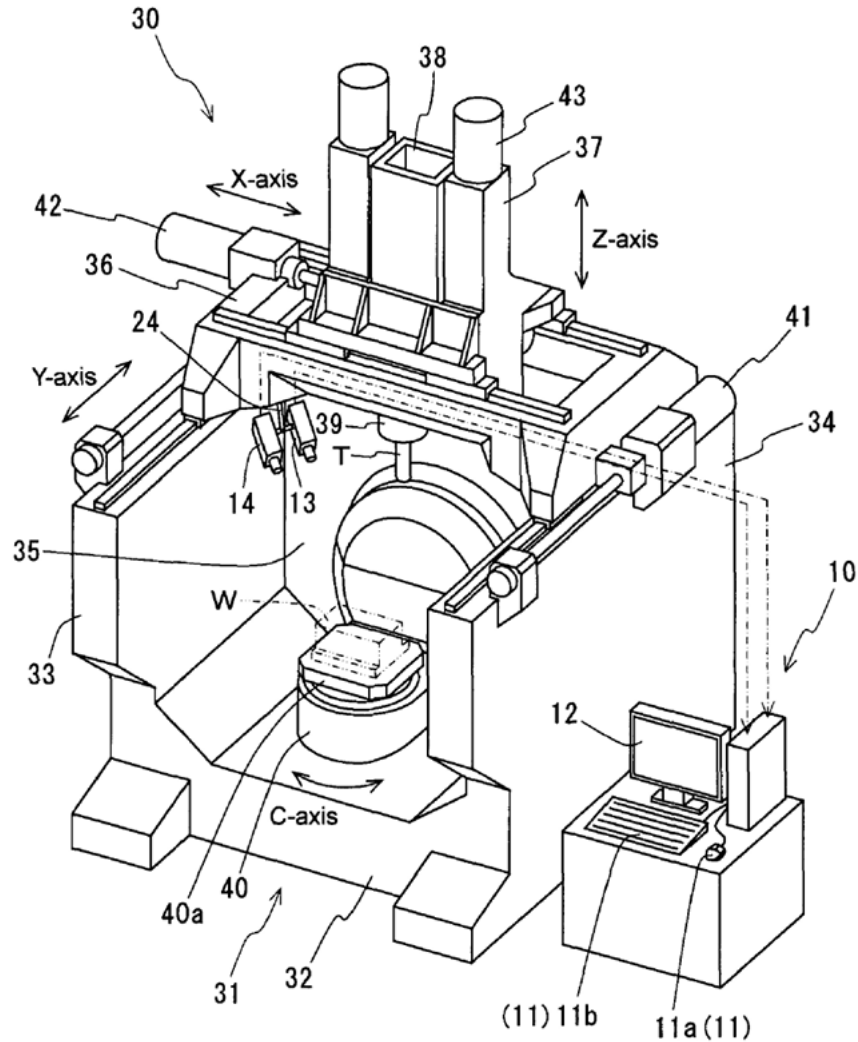
EX1005, FIG. 7.

57. “Thereafter, the virtual image generating section 18 in turn generates two-dimensional image data which is assumed to be obtained when the tool T, workpiece W and a part of the table 56 which are represented by three-dimensional model are imaged at a certain time interval by the virtual CCD cameras 19, 20, 21 and 22, and transmits the generated two-dimensional image data to the display

control section 23.” EX1005., [0063]. For example, Mori’s system displays on the display device 65 the actual image data output from any one of the actual CCD cameras 11, 12, 13 and 14, the virtual image data transmitted from the camera selection section 24, or the sectional image data transmitted from the sectional image generating section 26.” *Id.*, [0070]. Mori describes that the “sectional image data” is virtual two-dimensional image data depicting “sectional shape appearing when at least the workpiece W is cut along a predetermined cutting plane, and the shape of the workpiece W which is located behind the predetermined cutting plane.” *Id.*, [0074].

6.3. Tian (EX1006)

58. Tian describes “an apparatus for confirming three-dimensional model data or the like, capable of confirming easily, efficiently, and precisely whether three-dimensional model data including an attached object attached to a machine tool and at least a part of the machine tool good are accurate.” EX1006, Abstract. Similar to both Mazumder and Mori, Tian describes an automated manufacturing system for making a “workpiece” that includes a plurality of CCD cameras for monitoring the fabrication process. EX1006, [0005]-[0007], [0077]-[0079]. As shown in Figure 2, Tian’s automated fabrication device is highly similar in design to that of Mori:



EX1006, FIG. 2.

59. Also similar to Mori, Tian discloses generating “virtual image data” that “correspond[s] to the CCD cameras 13 and 14[] of the workpiece W.”

EX1006, [0098]. Tian describes comparing the images of the workpiece as captured by the CCD cameras and a two-dimensional projection of the object being fabricated generated based on a model to “confirm[] easily, efficiently, and

precisely whether three-dimensional model data including an attached object attached to a machine tool and at least a part of the machine tool good are accurate.” EX1006, Abstract. For example, Tian describes comparing “the two-dimensional image data related to the actual attached object generated in the actual-image-data generating process and the two-dimensional image data of the attached object related to the three-dimensional model” to determine if the actual object and the model “match.” *Id.*, [0013], [0022], [0025], [0100], [0111]. In another example, Tian describes that “the actual image data obtained by the first CCD camera 13 and the virtual image data generated to correspond to the first CCD camera 13; and the actual image data obtained by the second CCD camera 14 and the virtual image data generated to correspond to the second CCD camera 14 are compared, respectively, to determine whether these image data match.” *Id.*, [0100].

60. Upon performing this comparison function, if the virtual image data generated from the model and image data of the actual object do not match “the computer may be configured to further function as model-data updating means for updating the model data related to at least a part of the machine tool to match an actual operation of the machine tool.” EX1006., [0026]-[0029]. In some examples “when the actual image data and the virtual image data do not match, it is

determined that the three-dimensional model data of the whole of the machine tool 30 are wrong, that is, the shape of the workpiece W, the mounting position thereof, and the mounting attitude thereof do not match those of the actual workpiece W (step S18), a message to this effect is displayed on the screen display device (not shown) of the operation panel 47 or on the screen display device 12 of the computer 10.” *Id.*, [0101]-[0102].

6.4. Hull (EX1007, EX1008)

61. Hull is a translation of a Japanese patent application describing a stereolithography 3D printer that “automatically build[s] complex plastic parts by successively printing cross-sections of photopolymer (such as liquid plastic) on top of each other until all of the thin layers are joined together to form a whole part.” EX1008, [0004]. Hull describes that “[s]tereolithography represents an unprecedented way to quickly make complex or simple parts” based on computer designed CAD models. *Id.*, [0007], [0036]-[0037], [0042]. Hull’s system “forms the object one horizontal layer at a time by moving the ultraviolet beam of a helium-cadmium laser or the like across the surface of a photocurable resin and solidifying the liquid where it strikes.” *Id.*, [0042].

62. Similar to Mazumder, Hull also describes remote control functionality for its 3D printing system. Specifically, the fabrication site of Hull’s system

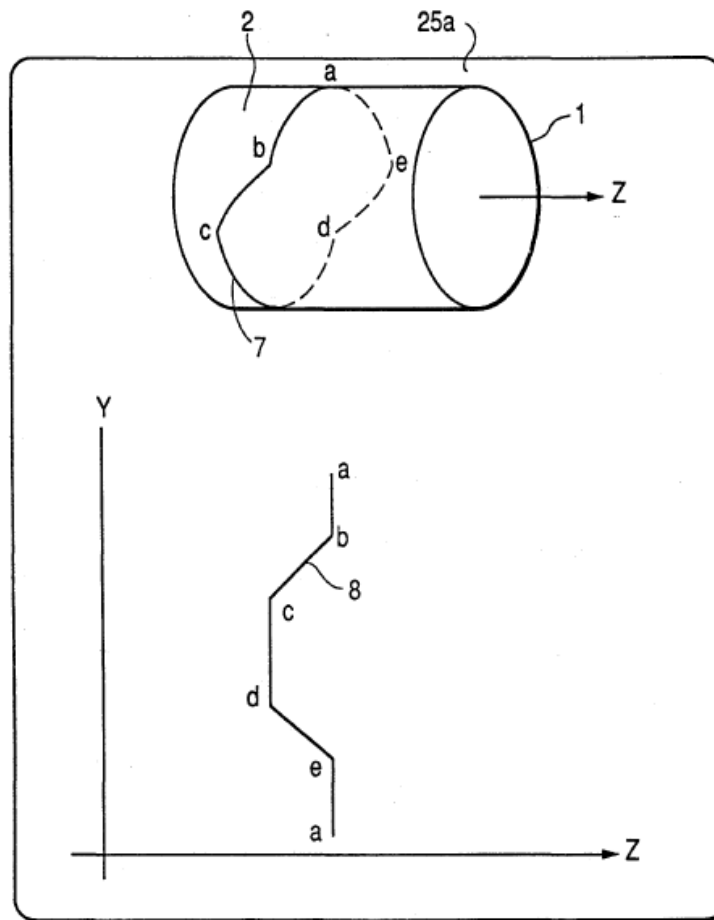
includes a “process computer” that controls the 3D printer based on instructions received from other remote devices. EX1008, [0140]. In Hull’s preferred embodiment, “three computers [are] needed to control the stereolithographic apparatus, a CAD system, a slice computer, and a process computer.” *Id.*, [0143]. The CAD system is used to design the object model and generate the CAD file defining the object model. *Id.* The CAD system is connected to the slice computer via an “Ethernet” connection and provides the CAD files to the slice computer which “breaks down the CAD part into individual horizontal slices.” *Id.* Hull further describes that the slice computer is “connected to the SLA-1 process computer by an Ethernet data bus.” *Id.* The slice computer transfers the sliced files “to the process computer through Ethernet.” *Id.* Hull provides details on how to transfer files from the slice computer to the process computer via the network connection. EX1008, [0157]. In particular, the user is required to enter a password to access the process computer and transfer files. *Id.*

6.5. Seki (EX1009)

63. Seki describes “[a] tool path drawing method which facilitates confirmation of the movement of a tool associated with three-dimensional machining.” EX1009, Abstract. Seki describes that “[b]ased on NC data associated with a figure definition statement, moreover, a workpiece FIG. 1 indicative of the

cylindrical workpiece is three-dimensionally drawn in a perspective view on the upper portion of a display screen 25a.” *Id.*, 2:24-28. In addition to the three-dimensional representation of the workpiece, the user interface also displays a corresponding “two-dimensional” display of the workpiece is displayed in a lower portion of the display. *Id.*, 2:28-32. Seki goes on to describe that, “[e]very time NC data associated with a motion definition statement is executed, thereafter, one of first to fifth sections of a tool path 7 which corresponds to this NC data, along with its preceding tool path section, is drawn on a peripheral surface 2 of the workpiece FIG. 1 which is drawn on the display screen 25a.” *Id.*, 2:32-37. This includes drawing the section of the tool path “along with its preceding tool path sections...on the YZ coordinate system” on the display screen. *Id.*, 2:38-43. Figure 1 of Seki shows the user interface that shows the three-dimensional tool path and two-dimensional display of the tool path representing the current motion of the machine tool:

FIG. 1



EX1009, FIG. 1.

6.6. Waehner (EX1010)

64. Waehner discloses a system for recording video data at different rates, with its primary application being focused on video surveillance systems.

EX1010, [0006]. For example, Waehner describes “recording the received video data at a first rate, and recording the received video data at a second rate with the

second rate being slower than the first rate.” *Id.* This second mode “provides time lapse recording where the various cameras are recorded at a slower rate and, if desired, at a lower resolution but for a much longer period of time” which allows for easier “longer term archival storage” of such video. *Id.*, [0010]. The user of the system can provide various parameters for the two recording modes, including “the record rate in frames per second, recording resolution for each camera, how long that digital video recorder can record at maximum speed and how many channels of data will be sampled, compressed and stored as explained hereinafter in detail.” *Id.*, [0018]. The user provides such parameters via a user interface that can take the form of “control buttons” using “a workstation,” “personal computer,” or “laptop computer” to “provid[e] setup information over a network to digital video recorder 18.” *Id.*

65. Regarding creation of the time lapse video, Waehner describes receiving video feeds from multiple digital cameras or digitizing video feeds from multiple analog cameras. EX1010, [0019]. Waehner’s system compresses and stores the video data. *Id.* The system then creates time-lapse versions of the video for long-term storage by sampling “only one out of every predetermined number of sequential images or frames.” *Id.* This sampling “reduces the number of images per camera per second” to facilitate efficient storage “for a long period of time.” *Id.*

6.7. Lan (EX1011)

66. Lan is a journal article reviewing a number of studies regarding web-based rapid prototyping and manufacturing systems, allowing for “remote service and manufacturing for rapid prototyping, enhance the availability of RP&M facilities and improve the capability of rapid product development for a large number of small and medium sized enterprises. EX1011, 1. Lan teaches that rapid prototyping and manufacturing (RP&M) techniques “using the Internet can further enhance the design and manufacturing productivity, speed, and economy, as well as share the RP machines.” *Id.* Lan reviews various aspects of web-based rapid prototyping, including “job planning and scheduling” and “remote control and monitoring for RP machines.” *Id.*

67. The job planning and scheduling functionality can be facilitated through the user of print servers that match remote users to appropriate rapid prototyping devices “to maximize the system utilization and minimize the average response time for scheduling non-preemptive aperiodic tasks so that it is suitable for the distributed Web-based RP systems.” EX1011, 10. Lan shows example systems from several papers that use a remote print server to facilitate scheduling and remote control of various rapid fabrication devices:

H. Lan/Computers in Industry 60 (2009) 643–656

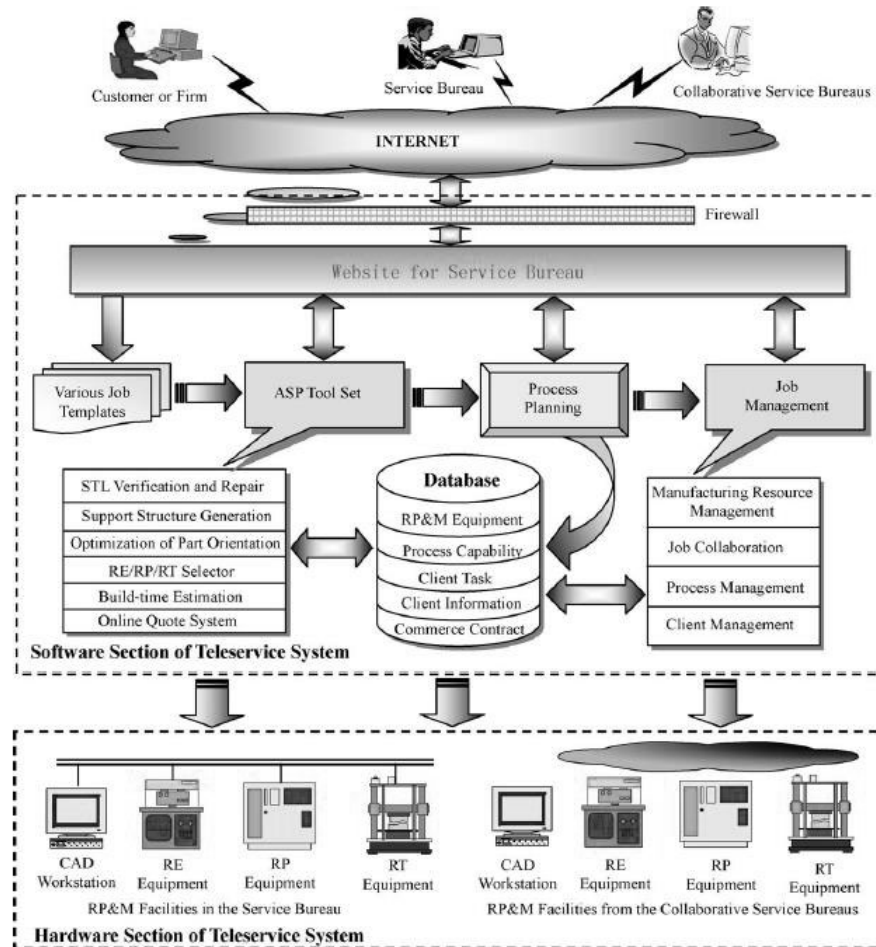


Fig. 4. Architecture of the Web-based RP&M system.

EX1011, 5.

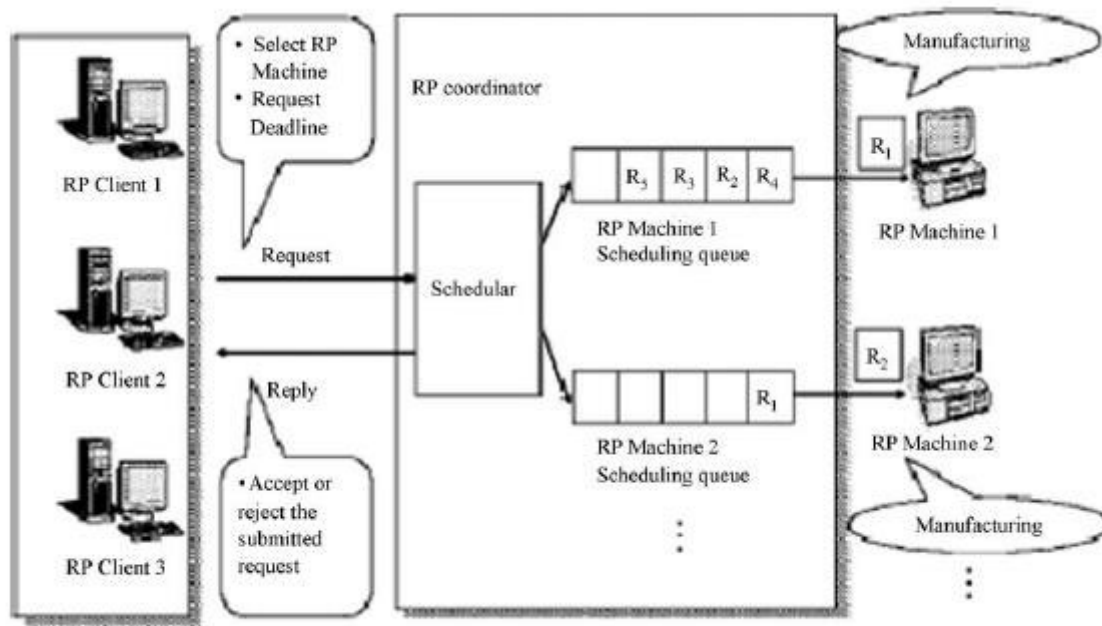


Fig. 10. Distributed RP platform scheduler [65].

EX1011, 10.

68. Similar to Mazumder, Lan describes various communications between the user's computer and the rapid fabrication devices (facilitated by the print servers). For example, Lan describes that the user at the remote computer can transmit their CAD model (such as an STL file) "via the Internet to the RP Web server." EX1011, 3, 10. The Web server then schedules the fabrication/print job with an available device and "the Web server can transmit the STL file to the RP machine that [is] chosen by the customers." *Id.* Similar to Mazumder and Mori, "[d]uring manufacturing process, customers also can watch a live image of RP part via Internet, and monitor the RP machine which fabricates physical part through

CCD camera.” *Id.* With respect to another system described in one of the surveyed studies, Lan describes “a teleservice system for RP service bureaus to support the implementation of the Web-based RP manufacturing” in which remote users connect through the internet to an “information center” which connects users to rapid fabrication devices and transmits STL files to those devices after verification and repair of the files. EX1011, 3-4, FIG. 4.

6.8. Anderson (EX1012)

69. Anderson describes a user interface for providing status information for rapid fabrication processes executing on multiple, geometrically dispersed rapid fabrication systems. Such [t]hree-dimensional (3D) objects fabrication techniques” include “solid freeform fabrication (SFF) and layer manufacturing (LM)” to “allow a 3D object to be built layer-by-layer or point-by-point without using a pre-shaped tool (die or mold).” EX1012, [0001]. Such 3D printing is based on a model “representing the geometry or shape of an object to be fabricated.” *Id.*

70. In the primary example in Anderson, the system presents a user interface that visually depicts “three-dimensional object fabrication status in the form of a progressively filled-in wireframe model representation of the three-dimensional object.” EX1012, [0015]. An example of such a progressively filled-in wireframe model is shown in Figure 2A of Anderson:

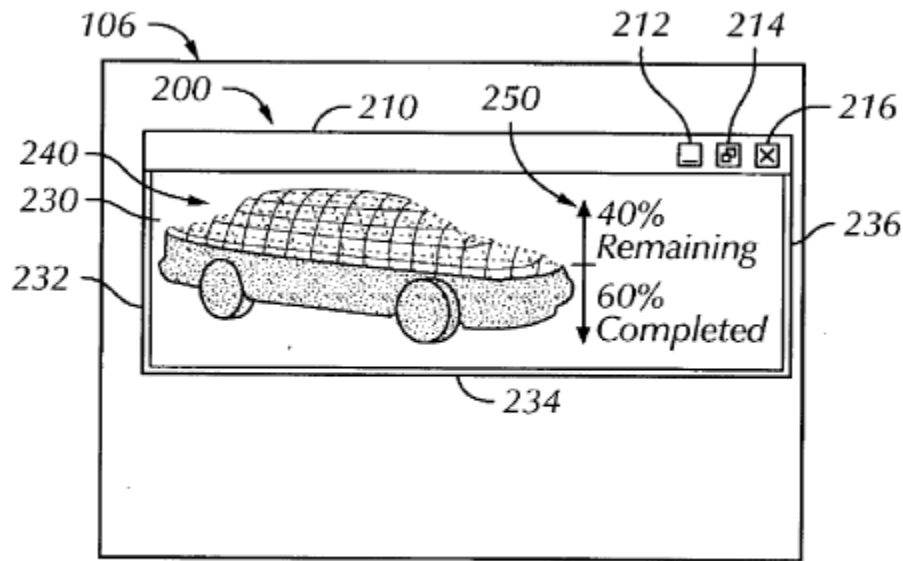


FIG. 2A

EX1012, FIG. 2A.

71. As shown in Figure 2A, in addition to the visual representation of the portion of the object completed, the user interface also provides a numerical value for the percentage of the object that is completed and the percentage of the object that remains to be fabricated. EX1012, [0021], [0025]. As shown in Figure 1, the user interface can provide status information for 3D objects being fabricated at various different 3D printers. “The graphical user interface 108 also has a main section 130 with ‘Job#’, ‘Owner’, ‘Status’ and ‘Progress’ (or similar) column headings under which information in the form of human-readable indicia and/or visual representations are provided for each 3D object fabrication.” *Id.* [0019].

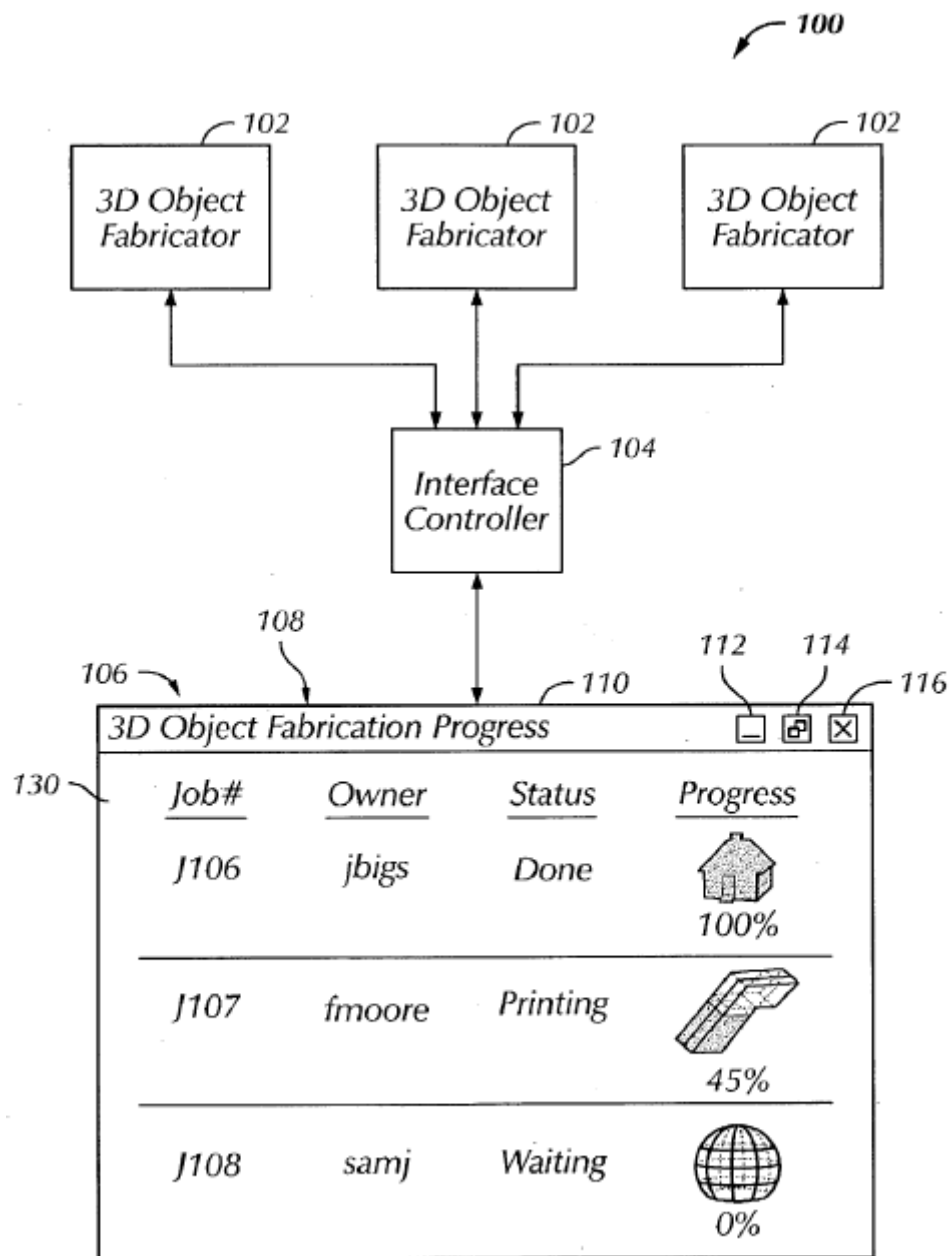


FIG. 1

EX1012, FIG. 1.

72. Anderson contemplates numerous other visualizations that can help the user to quickly assess the progress of a 3D print job:

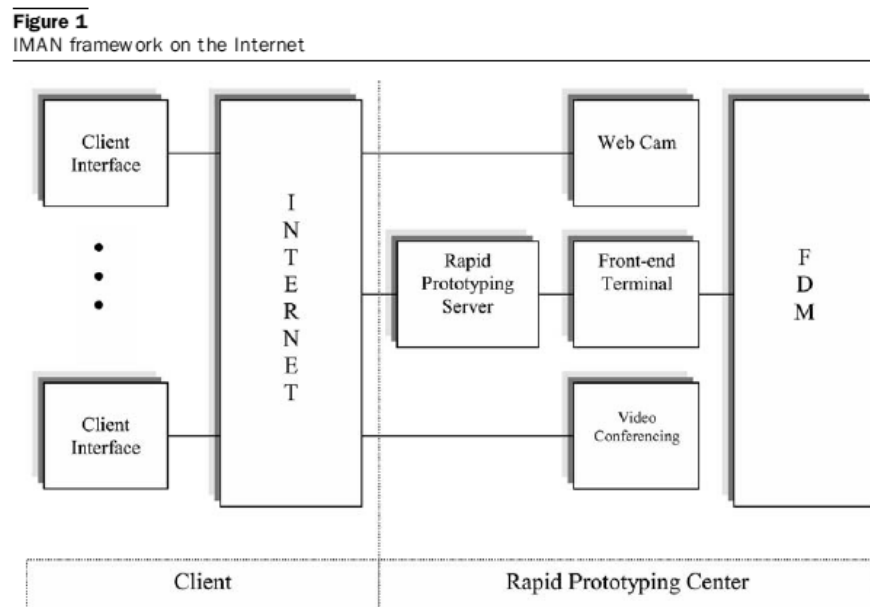
In one embodiment, the interface controller 104 is configured to control the graphical user interface 108 such that the filled-in portion(s) transition(s) from one color to another, for example, while the 3D object fabrications are in progress. In another embodiment, the interface controller 104 is configured to control the graphical user interface 108 such that the filled-in portion(s) pulsate(s). In another embodiment, the interface controller 104 is configured to control the graphical user interface 108 such that the filled-in portion(s) pulsate(s) at rates depending upon the progress of the 3D object(s) fabrication.

EX1012, [0021].

6.9. Tay (EX1013)

73. Tay describes that “[m]anufacturing and design technologies are gradually gravitating towards Internet integrated technology to cope with emerging challenges such as the need for shorter time to market, reduced lead time in the supply chain of new products, reduced cost and higher quality.” EX1013, 1. The system described by Tay allows “a wide audience using a disparate range of computer systems to access remotely located rapid prototyping facilities via the Internet for prototype fabrication.” *Id.* Tay leverages “client server

communications for the remote control of rapid prototyping hardware (called fused deposition modeling) via the Internet.” *Id.* Tay describes that “the server applications...have a direct link with the front-end terminals controlling the rapid prototyping hardware.” *Id.* Figure 1 of Tay shows the direct interface between the client device and the rapid prototyping center via the Internet:



EX1013, 3.

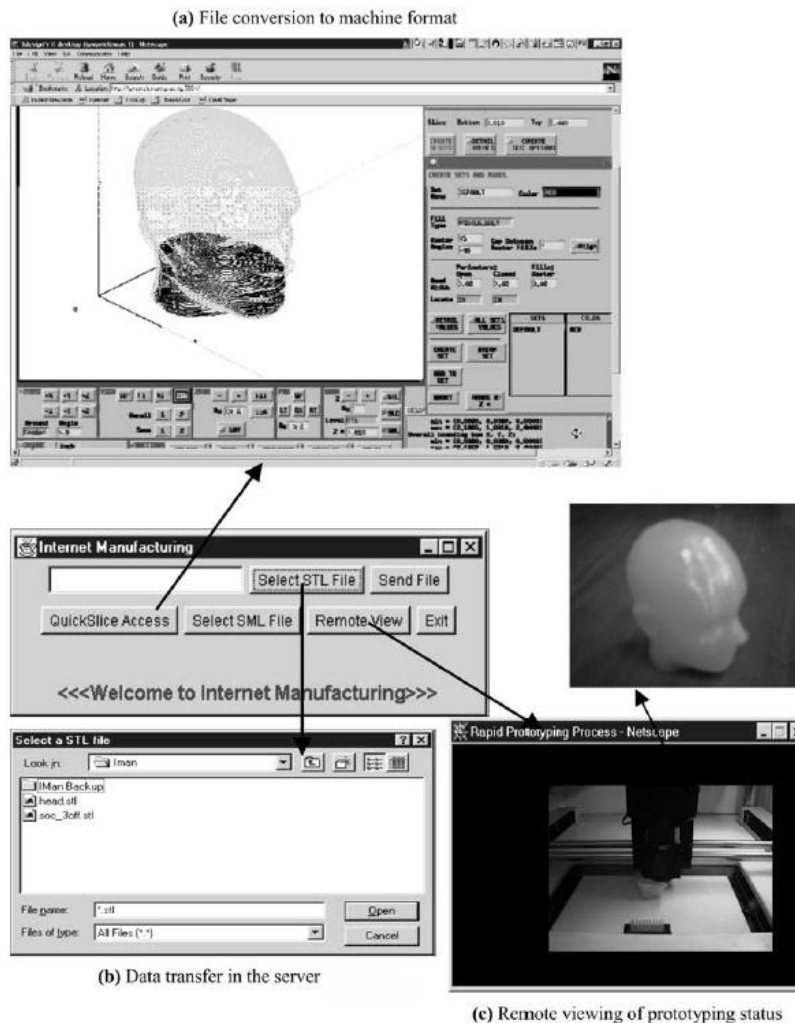
74. Tay’s remote control techniques are applicable to fused deposition modeling (FDM), selective laser sintering (SLS), stereo-lithography apparatus (SLA) and laminated object manufacturing (LOM) 3D printing technologies,

among others. EX1013, 2-3. To facilitate remote control of the 3D printer at the rapid prototyping center, Tay's client devices use "common Web tools such as Netscape Communicator browser" to present a "transparent and user friendly" interface that does not require "extra plug-ins to run the application." *Id.*, 3-4.

75. Tay utilizes "a platform neutral framework for the construction of the human computer interface (HCI)." EX1013., 2. "The client and server applications are linked to one another via the Internet." *Id.*, 3. The rapid prototyping center further includes a web cam and video conferencing software to provide images of the fabrication process in progress to the user at the client device. *Id.* Tay describes that the user interface at the client device includes functionality "for configuring and monitoring the remote prototyping system." *Id.* Figure 3 shows the user interface of Tay which includes displays of the model of the object to be fabricated and actual images of the build process captured by cameras located at the rapid prototyping center:

Figure 3

(a) File conversion to machine format (b) Data transfer in the server (c) Remote viewing of prototyping status



EX1013, 5.

76. As shown above, Tay's system provides "audio and visual feedback" from the fabrication system to the client device using a "Web cam and video conferencing." EX1013, 4. These web cams can allow "multiple clients...to watch the same fabrication process for discussion and analysis." *Id.* The user interface at

the client device displays status information for the object being fabricated, including showing a virtual rendering of the progress of the object in comparison to a wireframe of the entire object and actual images of the object being fabricated as captured by the Web cam. *Id.*, 5.

77. Tay describes that the described “platform independency was a critical factor to ensure that end users using different computer systems can interact with the rapid prototyping center effectively. EX1013, 5. Furthermore, “[t]he modular software architecture for the IMAN system is also highly scalable for further research and development.” *Id.*, 5-6. Utilization of the Internet as the means of communication also allows for cheap and reliable data communication. *Id.*, 6. As such Tay’s system can “considerably reduce the product development lead time.” *Id.*

6.10. Henke (EX1014)

78. Henke presents yet another example of a rapid prototyping system that allows for remote control and monitoring of a rapid prototyping process by a user at a geographically remote computer. Henke describes use of “Rapid Prototyping modules” in “a Remote Lab system” that “enables a Web-based access to control electro-mechanical models.” EX1014, 2. Henke describes that “Remote Labs can open opportunities, allowing an experimental approach for a wider audience and an

independence of opening times of the laboratory as well.” *Id.*, 5. Henke’s “Web-interface” allows a remote user test control algorithms in remote, real-world devices. *Id.* Various controls that the remote user can execute include “handl[ing] the laboratory procedure (start, stop, reset),” and “chang[ing] environmental variables if necessary.” *Id.* Henke also describes that the user at the remote client device can “watch the laboratory procedure by supervising the model and environmental variables inside an I/O monitor or by observing the hardware model directly via a Web-Cam.” *Id.* Henke shows the user interface for facilitating remote control and observation of the process via the Internet, including displaying camera images of the actual hardware, a model of a virtual version of the hardware, and other status and control information:

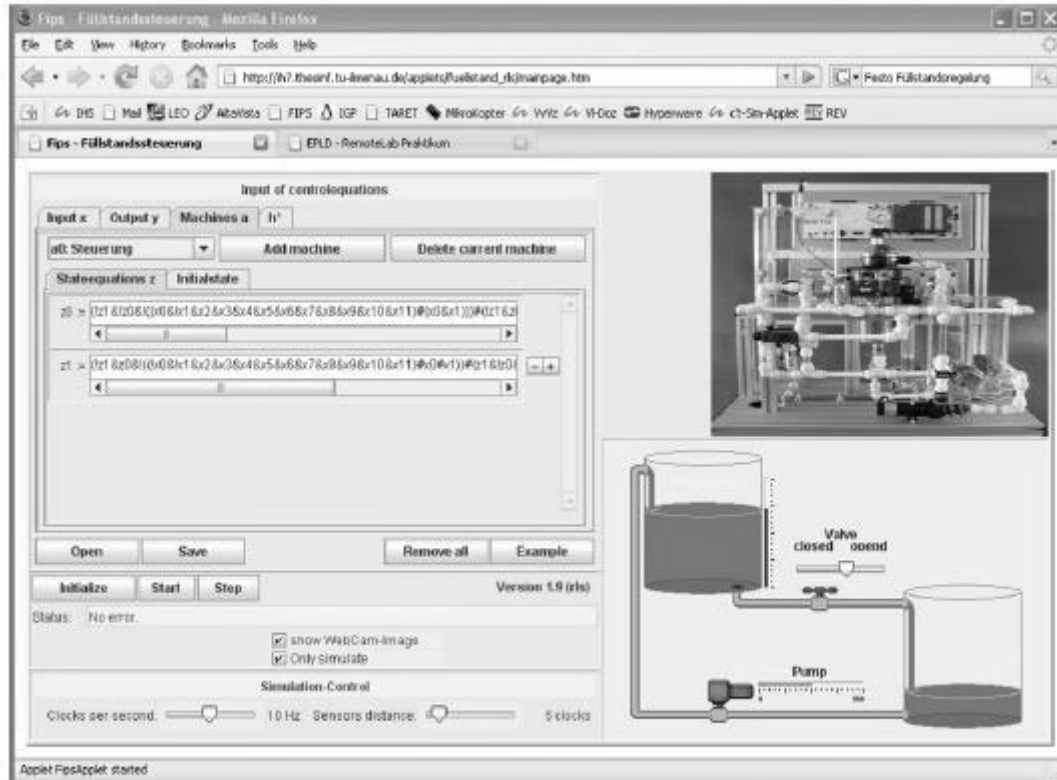


Figure 8. Online control of the Water level control - with Internet connectivity to the Remote Lab

EX1014, 5.

6.11. Kritchman (EX1015)

79. Kritchman describes a 3D printing system having “a printing apparatus to print three-dimensional objects; a controller that may prepare the digital data that characterizes the 3-D object for printing, and control the operation of the printing apparatus; and a printing tray with a selected adhesion characteristic.” EX1015, [0005]. Kritchman describes that its 3D printer includes one or more printing heads and that “the printing head may move in the X-Y

direction, depositing the materials in the course of its passage over the printing tray or printing area, in a predetermined configuration. This forward passage of the printing head may be followed by curing of the deposited material by a source of electromagnetic radiation. In the reverse passage of the printing head, back to its starting point for the layer just deposited (point 0 on the X-Y axes), an additional deposition of materials may be carried out, according to predetermined configuration.” *Id.*, [0069]. Kritchman discloses that its techniques are compatible with other forms of rapid fabrication in addition to “alyer-by-layer deposition.” *Id.*, [0059]. “The location of depositing, and the amount and/or type of material to be deposited may be controlled by the apparatus' controller as preprogrammed from a 3-D data file. The depth of each deposited layer may be controlled by selectively adjusting the output from each of the plurality of nozzles.” *Id.*, [0064].

80. Kritchman’s controller utilizes “Computer Object Data (COD) representing an object or a model, for example, CAD data in STL format” and “convert[s] such data to instructions for the various units within 3D printer system 100 to print a 3D object.” EX1015, [0075]. Kritchman describes that the “[c]ontroller 105 may be located inside printing apparatus 140” as shown in Figure 1. *Id.*

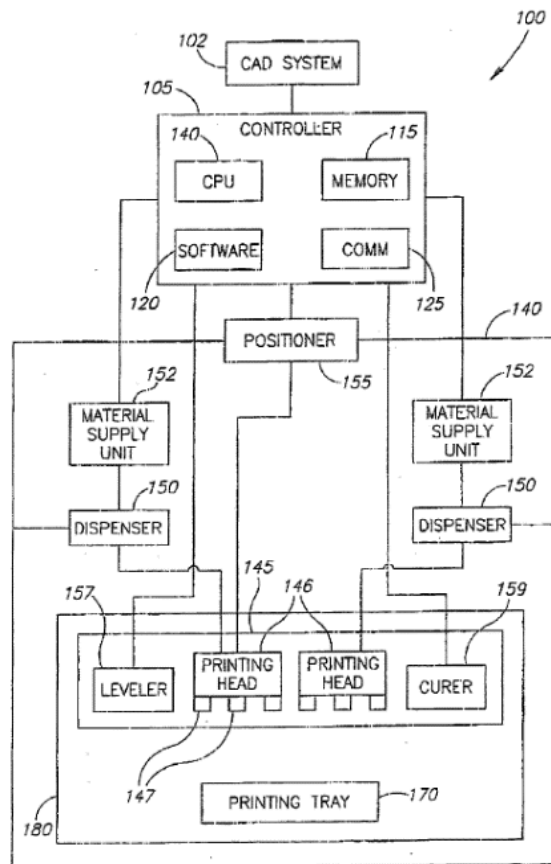


FIG.1

EX1015, FIG. 1.

81. Kritchman describes that:

Controller 105 may be implemented using any suitable combination of hardware and/or software. In some embodiments, controller 105 may include, for example, a processor 110, a memory 115, and software or operating instructions 120. Processor 110 may include conventional devices, such as a Central Processing Unit (CPU), a microprocessor, a “computer on a chip”, a micro controller, etc.

Memory 115 may include conventional devices such as Random Access Memory (RAM), Read-Only Memory (ROM), or other storage devices, and may include mass storage, such as a CD-ROM or a hard disk. Controller 105 may be included within, or may include, a computing device such as a personal computer, a desktop computer, a mobile computer, a laptop computer, a server computer, or workstation (and thus part or all of the functionality of controller 105 may be external to 3D printer system 100). Controller 105 may be of other configurations, and may include other suitable components.

EX1015, [0077].

82. In describing the communications unit included in the controller 105, Kritchman describes that “[c]ommunications unit 125 may, for example, *enable transfer of data and instructions* between controller 105 and CAD module 102, between controller 105 and printing apparatus 140, and/or *between controller 105 and other system elements*. Controller 105 may be suitably coupled and/or connected to various components of printing apparatus 140.” EX1015, [0073].

83. The system further includes a temperature control unit 204 for maintaining an optimum fabrication temperature. EX1015., [0091], [0095]-[0096]. Kritchman describes that “the method may include, at block 24, heating printing tray 170, for example using temperature control unit 204, to a selected temperature,

for example, such that the temperature may be substantially at the glass transition point of the modeling and/or support materials.” *Id.*, [0096].

7. Application of the Prior Art to the Challenged Claims

7.1. Ground 1A: The Combination of Mazumder with Mori Renders Obvious Claims 1, 3, 5-7, 9-10, and 19-22

84. A POSITA would have recognized that the teachings of Mori would have been readily applied to the system of Mazumder for multiple reasons to achieve predictable benefits. Specifically, a POSITA would have recognized multiple benefits that would have predictably been provided by modifying Mazumder’s system based on Mori’s teachings to include actual images of the object being fabricated as captured by one or more cameras (as described by both Mazumder and Mori) in the user interface displayed at Mazumder’s remote computer 95 along with virtual images of the object generated from stored model data shown from the perspective of one or more virtual cameras (as suggested by Mori). A POSITA would have further recognized that by 2010 (over a decade after the original priority date of Mazumder), advances in the conventional technologies of three-dimensional rapid fabrication systems, three-dimensional rendering of CAD models, and transfer of video and image information over

networks such as the Internet had become even more sophisticated and therefore routine to implement.

85. As a first reason to apply the suggestions of Mori to Mazumder to include in the user interface at the remote computer, a display of the virtual images of the object being fabricated along with, and from the same perspective as, the images of the real images as captured by one or more video cameras at the rapid fabrication system, a POSITA would have recognized that including both the real images of the fabrication process and the virtual images of the model of how the intended object should look during that particular phase of fabrication, from the same perspective, would have advantageously allowed the user to easily visually compare the “visual images of the product being fabricated” to the virtual images of “three-dimensional models of the...workpiece W” and to easily determine whether the fabrication process is proceeding as planned. EX1004, 7:27-28; EX1005, [0061]-[0062]. For example, such a side-by-side comparison of the actual fabrication process to the intended structure of the object being fabricated (as represented in the virtual images taught by Mori) would have allowed the user to easily visually detect defects or other deviations in the fabrication process. Mazumder expressly states that part of the goal of providing visual feedback in the user interface at the remote computer in the form of the video from the camera at

the fabrication device is to allow the remote user to identify “a defect” or “abnormality” and providing the virtual images along with the actual images, as suggested by Mori, would have provided additional visual information to aid in such defect/abnormality detection. As such, providing such an onscreen comparison of the actual object and the model would have enabled the user to more quickly adjust the manufacturing process to correct for or avoid additional defects. For example, a POSITA would have recognized that such observation of the process and visual comparison to the intended outcome would have allowed the user to “adjust” aspects of the model or the fabrication process (e.g., temperature of the build environment) “in case of fault...to achieve a fault free solution.”

EX1014, 5.

86. As a second reason to apply the suggestions of Mori to Mazumder to display virtual images generated from the three-dimensional model along with actual images of the fabrication process captured by the camera(s), such inclusion of both actual and virtual images of the fabrication process in the user interface would have allowed the user to of the remote computer to monitor the progress of the object even when the actual view of the object is partially or totally obscured. EX1005, [0073], [0082]. For example, a POSITA would have recognized that in some cases, based on the angle of the camera, the material deposition

head/extruder or another part of the rapid fabrication device may temporarily partially or completely obscure the camera's view of the object being fabricated in the build volume. As another example, a support structure or other material involved in the manufacturing process that is not part of the intended finished object being manufactured may obscure the view of some or all of the object. As such, a POSITA would have recognized that it would have been beneficial to display a virtual view of the object from the same angle (based on Mori's suggestion) such that the user can "always visually recognize the machining status of the workpiece W" even when the actual view is partially or completely obscured. EX1005, [0083].

87. As a third reason, a POSITA would have recognized that including additional virtual views of the object being fabricated in the user interface (as suggested by Mori), including the virtual sectional images showing cross sectional representations of the object "when at least the workpiece W is cut along a predetermined cutting plane, and the shape of the workpiece W which is located behind the predetermined cutting plane," would have provided more additional, helpful information to the remote user in the Mazumder-Mori combination because such cross section views cannot be obtained from a video camera alone. EX1005, [0074]-[0076]. As such, including a display of a virtual image of the object (from

the same perspective as the actual camera) along with the actual images of the object being fabricated as captured by the camera(s) at the fabrication device would have allowed the user to observe progress of inner or rear portions of the object being fabricated that may not be visible from the angle of the actual camera due to the specific geometries of the object being fabricated and the placement/angle of the camera(s).

88. *As a fourth reason*, a POSITA would have been prompted to modify Mazumder's rapid fabrication system to include in the user interface at the remote computer, a display of the virtual images of the object being fabricated along with, and from the same perspective as, the images of the real images as captured by one or more video cameras at the rapid fabrication system (as suggested by Mori) because doing so would be merely the application of a known technique (as suggested by Mori) to a known system (e.g., Mazumder's remotely controlled rapid fabrication system) ready for improvement to yield predictable results. Here, Mori provides straightforward evidence of a known technique for providing virtual images of a rapid fabrication process based on a three-dimensional model of the object being fabricated depicting the object from the same perspective as real images capturing the rapid fabrication process, and Mazumder's teaching provides a known system that would have been improved by application of Mori's

suggested technique for at least the reasons described above. Based upon my knowledge and experience in this field and my review of Mazumder and Mori, I am confident a POSITA would have recognized that this modification would have yielded predictable results and required only routine adjustments to the user interface and software to provide the virtual images disclosed by Mori and as such a POSITA would have had a reasonable expectation of success in making such modifications. This modification would not have significantly altered or hindered the functions performed by Mazumder's system, and these modifications would have been within the predictable and ordinary level of skill of a POSITA (certainly by a time frame as late as 2010).

89. As demonstrated below, the predictable combination of Mazumder with Mori renders obvious all elements of claims 1, 3, 5-7, 9-10, and 19-22 of the '324 patent.

Element [1.pre]: A device comprising:

90. To the extent the preamble is considered limiting, Mazumder discloses a device that provides a manufacturing system at a local site 205 for fabrication of a product that, when predictably combined with Mori, includes all of the features recited by claim 1. For example, Mazumder describes that "[t]he local site includes a laser-aided, computer-controlled direct material deposition system

10” and that “[t]he manufacturing system at the local site includes a local computer 70 interfacing with the feedback controller 80 and receiving input data from one or more sensors outputting information representative to fabrication progress. Such sensors may include strain gages 40, acoustic sensors 50, optical sensors 60 and video or television camera 65.” EX1004, FIG. 1, 3:3-39. The local site 205 further includes “[o]ne or more cameras” that enable “dimensions to be remotely determined from the remote location. Contact and non-contact metrological instruments may also be used to perform accurate measurements to monitor the fabrication process.” *Id.* Mazumder describes this system as a “computer-aided manufacturing system” having a number of “important sub-systems.’ *Id.* 2:3-13, 2:61-62. In another example, Mazumder refers to the local site as “a local manufacturing system for fabricating the product in accordance with the design description using a laser-aided direct material deposition (DMD) process.” 7:5-12, 7:39-51 (“A remote control manufacturing system...”). Mazumder discloses that all functions of the computer-aided manufacturing system at the local site 205 system are “coordinated by the local computer 70” and as such a POSITA would have recognized that the local computer 70 controls the other “sub-systems” to coordinate the 3D manufacturing process. EX1004, 4:32-38. A POSITA would have recognized that the various sub-systems that make up the local site system

collectively constitute a device under the control of the local computer 70. *Id.*

However, to the extent that this claim element is read narrowly and/or that Mazumder does not expressly describe its “local manufacturing system” as a “device,” a POSITA would have recognized that it would have been obvious and beneficial to integrate the various components (sub-systems) of the manufacturing system at the local site 205 into a device and that such a configuration would have been straight forward and routine. The fact that the various sub-systems of the local site are all collectively dedicated to the three-dimensional fabrication of a “product” using direct material deposition (rather than conducting disparate, unrelated tasks) would have suggested to a POSITA that the various sub-systems would have beneficially implemented together as a device. EX1004, FIG. 1, 3:25-39, 4:7-10, 7:5-12, 7:39-51. This is especially true given developments in 3D printing and computing technology that occurred in the decade between the priority date of Mazumder and the relatively late time frame leading up to 2010. As such, a POSITA would have readily recognized that such a predictable configuration of Mazumder’s local sub-systems depicted in FIG. 1 would have allowed for easier transportation and installation of the local site portion of Mazumder’s system thereby increasing the ease of use of such a device.

Element [1.a]: a three-dimensional printer including a build volume;

91. The Mazumder-Mori system provides a three-dimensional printer including a build volume. Mazumder describes that “[t]he local site includes a laser-aided, computer-controlled direct material deposition system 10, which is used to fabricate, repair or modify three-dimensional products by applying sequentially layers of material 20 on a substrate 30.” EX1004, 3:11-25. In another example, Mazumder describes remote control of “an automated, feedback-controlled, laser-aided direct material deposition (DMD) process, as described in co-owned and co-pending U.S. patent application Ser. No. 09/107,912, filed Apr. 10, 1997, and in U.S. patent application Ser. No. 09/522,671, filed Mar. 10, 2000.” EX1004, 1:62-2:2, 7:39-51.

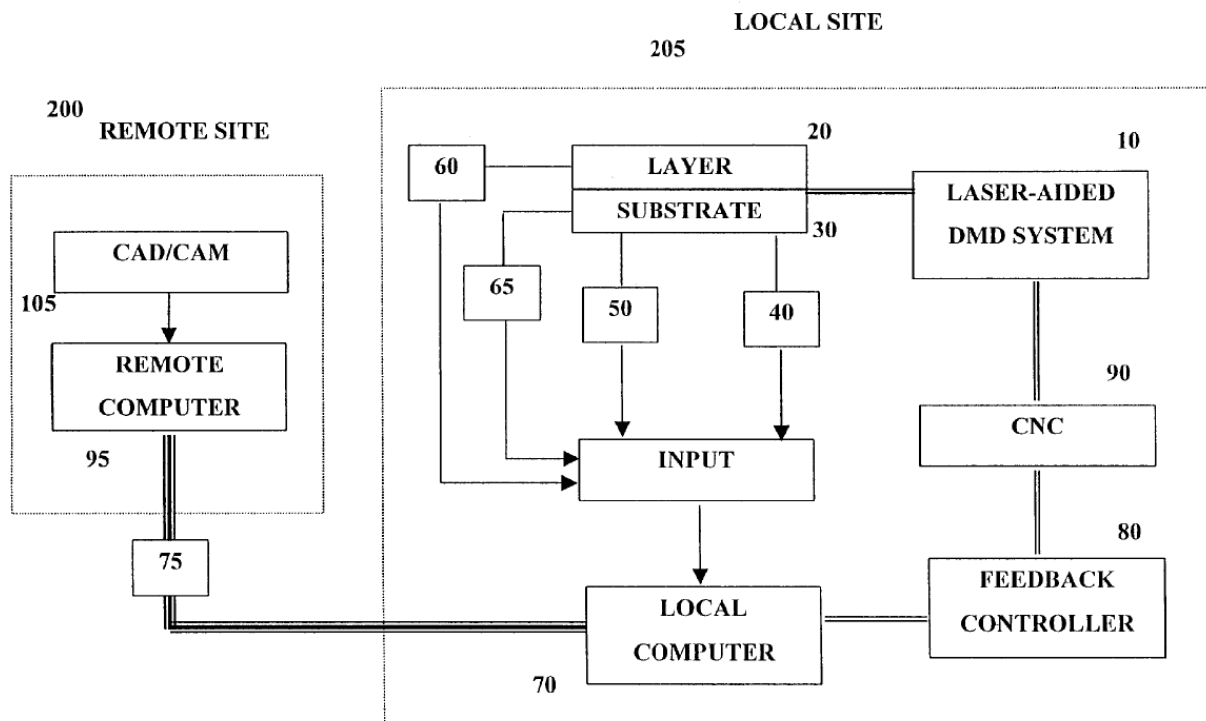


FIG - 1

EX1004, FIG. 1.

92. As shown in Figure 1, a POSITA would have recognized that the substrate and the work space defined by and immediately above the substrate is a build volume. EX1004, 4:7-10.

Element [1.b]: a network interface coupled to a data network;

93. As I discussed above, Mazumder discloses that all functions of the computer-aided manufacturing system at the local site 205 system are “coordinated by the local computer 70” and as such a POSITA would have recognized that the

local computer 70 controls the other “sub-systems” to coordinate the 3D manufacturing process. EX1004, 4:32-38. Figure 1 shows that the local computer 70 communicates with the remote computer 95 “via a communications system 75, preferably including the Internet.” EX1004, 3:4-10.

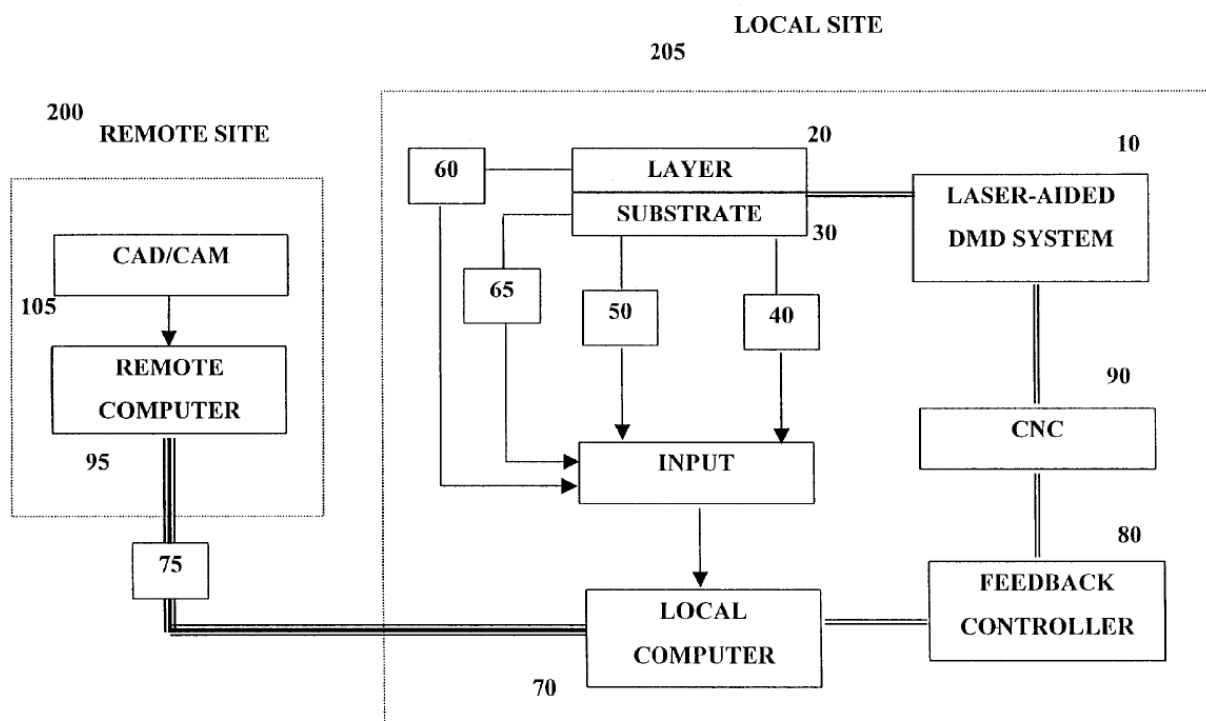


FIG - 1

EX1004, FIG. 1. For example, Mazumder describes that “[t]he local computer 70 communicates with a remote computer 95 via the communication system 75 and receives the necessary computer files defining the deposition tool path for the numerical controller (CNC) 90.” EX1004, 3:26-56. Mazumder describes

transmitting data over the communication system 75, including control files for controlling the fabrication process. *Id.* (“For remote-control DMD manufacturing, the deposition tool-path files generated by the CAM software reside in the remote computer 95 and are sent via the communications system 75 to the local computer 75 which interfaces with the feedback controller 80.”).

94. Mazumder’s system “utilizes advances in telecommunications” (col. 1:62-2:2), which Mazumder earlier described as “including the Internet, as well as advances in data acquisition and manipulation, allow the transfer of large volumes of data between distant sites” using “high-speed links in asynchronous transfer mode (ATM) or using Ethernet and Fast-Ethernet in a Local Access Network (LAN) or Wide Access Network (WAN) environment.” EX1004, 1:24-35. A POSITA would have known that the Internet is a data network and the point at which the local computer 70 interfaces with the communication system 75 (the Internet) is a network interface. Thus, based on Mazumder’s teaching for the bi-directional network communication between the local manufacturing system and the remote computer (over a communications system 75 such as “the Internet”), Mazumder discloses or plainly suggests that the local computer 70 of the manufacturing system included a conventional network interface to achieve such connectivity via the Internet. EX1004, 3:5-7, 3:36-39.

95. Alternatively, even though a POSITA would have recognized that the connection between Mazumder's local computer 70 is a network interface, to the extent that Mazumder does not expressly use the term "network interface," it would have been obvious to a POSITA to implement Mazumder's local computer 70 to include an ordinary and conventional network interface at the time so as to advantageously achieve Mazumder's suggestions for "fast data transfer," "fast transmission, e.g., over the Internet," and "fast communication connections." EX1004. 1:62-2:2, 2:23-26, 4:38-48, 6:36-55, 7:59-61. For example, Mazumder describes that "temperature, strain and stress data, visual images or metrological information collected at the local manufacturing site 205 are ***all processed through the local computer 70, which communicates with the remote computer 95.***" *Id.*, 6:36-55. A POSITA would have been readily aware that such a conventional network interface for a computing device such as Mazumder's local computer 70 was widely available as an off-the-shelf component by the relatively late timeframe leading up to 2010 and would have been straightforward to integrate into Mazumder's local computer to facilitate such communications with the remote computer 95.

Element [1.c]: a video camera positioned to capture video of the build volume from a point of view; and

96. Mazumder discloses that the “manufacturing system at the local site” includes multiple sensors and that “[s]uch sensors may include strain gages 40, acoustic sensors 50, optical sensors 60 and **video or television camera 65**.” EX1004. 3:26-36. For example, [o]ne or more cameras may be spatially calibrated enabling dimensions to be remotely determined from the remote location.” *Id.* Mazumder is also express that the video captured by the video camera is video of the build volume during the fabrication process from a point of view, describing that “a video or TV camera 65 records the laser-aided DMD process and transmits the images to the local computer 70, which then sends the images together with the associated temperature, strain and stress data to the remote computer 95 to be displayed preferably on a TV screen or shown on the remote computer monitor as streaming video (display screens not shown in FIG. 1).” *Id.*, 6:34-48 (“visual images or metrological information collected at the local manufacturing site 205 are all processed through the local computer 70.”). In another example, Mazumder describes that the “manufacturing system” includes “a video or television camera recording the fabrication process and transmitting the images to be viewed on a screen display situated at the remote computer system.” *Id.*, 8:13-17, Abstract.

97. Mori includes additional disclosures regarding the traditional use of cameras positioned at a rapid fabrication device for monitoring a rapid fabrication

process. For example, Mori describes the use of multiple video cameras, for example, four “actual CCD cameras” arranged to surround the workpiece so as to advantageously “image the workpiece W from four directions” and “output the generated two-dimensional image data to the display control section.” EX1005, [0049]-[0050]. Thus, in one predictable option based on Mori’s suggestion and its predictable benefits, the Mazumder-Mori combination would have included multiple cameras to view the product during fabrication.

Element [1.d]: a processor configured to receive a three-dimensional model through the network interface, and to control operation of the three-dimensional printer to fabricate the three-dimensional model as an object within the build volume of the three-dimensional printer, the processor further configured to provide a user interface to a remote user accessing the device through the network interface, and to present in the user interface an image of the build volume from the video camera and a two-dimensional projection of the three-dimensional model from the point of view of the video camera.

98. As I discussed above, Mazumder discloses that all functions of the computer-aided manufacturing system at the local site 205 system are “coordinated by the local computer 70” and as such a POSITA would have recognized that the local computer 70 controls the other “sub-systems” to coordinate the various functions of the 3D manufacturing process. EX1004, 4:32-38. A POSITA would have recognized that such a local computer 70 would have included a conventional computer processor for carrying out the described computer functionality, including coordination of the various sub-systems of the local site 205. EX1004,

4:32-38; 6:18-23, 6:36-53, 7:44-50, 7:58-61. Mazumder further describes that local computer “sends appropriate commands to a feedback controller 80, which interfaces with the numerical controller 90” to control the fabrication process. Id., 6:18-23. Additionally all recorded sensor information (including video images) “are all processed through the local computer 70.” Id., 6:36-53. As such, Mazumder demonstrates that the processor of the local computer controls the sub-systems of the local site 205 to perform the functions of the 3D fabrication process.

99. As previously discussed, the functionality of the local computer 70 includes that “[t]he local computer 70 communicates with a remote computer 95 via the communication system 75 and receives the necessary computer files defining the deposition tool path for the numerical controller (CNC) 90.” EX1004, 3:26-56. In this example, the CAM software at the remote computer “generates the deposition tool path” based on the CAD file defining “[t]he geometry of the product to be manufactured.” Id., 3:40-56. In another example, describes that “[a]ll these functions are coordinated by the local computer 70, which sends feedback data to the remote computer 42 and receives instructions from the remote computer 95 to control the deposition process.” EX1004, 4:32-38. A POSITA would have recognized that such data representing “instructions from the remote computer 95 *to control the deposition process*” including the “necessary computer

files defining the deposition tool path for the numerical controller (CNC) 90” represent a three-dimensional model of the object to be fabricated by Mazumder’s local site 205. EX1004, 4:32-38, 3:26-56.

100. In another example, Mazumder describes that the designer that controls the fabrication process from the remote computer 95 uses “computer-aided design/computer-aided manufacturing (CAD/CAM) software” to generate a model “of the product to be manufactured at the local site 205.” EX1004, 3:40-56; 4:44-49, 2:14-23. Mazumder describes that the “CAD/CAM data and sensor updates are preferably delivered to a data sorter and from there, to a compression/encryption platform” and that this data is then received by the local computer 70 and the local site 205 where the data is “decompressed and applied to the DMD system.” *Id.*, 3:57-63. Specifically, as I mentioned above, “the *CAM file of the product description*” is “transmit[ted], e.g. over the Internet, to the manufacturing site.” *Id.*, 2:24-43. For example, when modifying a design of an object to be fabricated (e.g., to correct for an identified defect), “[t]he designer then edits the CAD file and transmits over the Internet the modified and post-processed CAM file, either in its entirety, or only a block of it containing the modification.” *Id.* In this example, a POSITA would have recognized that “the CAM file of the product description” that is received at the local computer is a three-dimensional

model (or at least renders obvious transmission of a three-dimensional model) and that it is received at the local computer through the above described network interface. *Id.*

101. In another example, Mazumder discloses that rather than generating the CAM files defining the tool path for the object to be fabricated at the remote computer 95 and transmitting these CAM files to the local computer 70 “the CAD files are simply transmitted to the local computer 70.” EX1004, 6:60-67. As such, in at least this example, Mazumder expressly discloses that the local computer 70 receives a three-dimensional model through the network interface. *Id.*, 6:60-67, 2:14-18 (“The remote computer stores the description of a product to be fabricated.”) A POSITA would have further recognized that this transmission occurs via the network interface of the computer 70 in the predictable combination, as I discussed above with respect to Element [1.b].

102. In addition to these disclosures of receiving the CAM files defining the tool path for the object at the local computer 70 or additionally/alternatively receiving the CAD file defining the model itself at the local computer 70 (e.g., EX1004, 2:24-43, 6:60-67), it would have been obvious to a POSITA to modify Mazumder’s primary configuration to generate the deposition tool path at the local computer rather than the remote computer while still maintaining other control

functionality at the remote computer (e.g., such as the ability to modify the CAD file, stop the deposition process upon detection of a defect, etc.). A POSITA would have recognized that, by the relatively late timeframe leading up to 2010, such a predictable modification would have advantageously allowed for a wider variety of devices to serve as the remote computer because the processing capacity necessary to generate the tool path would not be necessary in the remote device. For example, a POSITA would have been aware that by 2010, many consumer devices, including traditional desktop and laptop computers but also smart phones and internet connected tablets, would have had the computing, network connectivity, and user interface capabilities required to allow users to create/edit CAD files, communicate with the local computer 70 over the Internet, and present the user interface elements described by Mazumder but that avoiding the complex computing requirements for generating the tool paths would have beneficially allowed such devices to perform other parallel tasks without hinderance of performance of the device. Furthermore, configuring Mazumder's system to send the CAD file to the local computer 70 such that the tool path is generated at the local computer 70 (EX1004, 6:60-67) would eliminate the complexity or requirements for the remote user to install special tool path generation software on their device. As such, it would have been obvious to transmit the CAD file of

“[t]he geometry of the product to be manufactured” to the local computer 70 (via the network interface) to allow the local computer to generate the tool path from the CAD file. EX1004, 3:40-56.

103. Also, regarding the second functional recitation of Element [1.d], Mazumder discloses that the processor (of the local computer 70) is configured to control operation of the three-dimensional printer to fabricate the three-dimensional model as an object. Mazumder describes that “[t]he local site includes a laser-aided, computer-controlled direct material deposition system 10, which is used to fabricate, repair or modify three-dimensional products by applying sequentially layers of material 20 on a substrate 30.” EX1004, 3:11-25. In the preferred embodiment of Mazumder, this computer-control of the direct material deposition system 10 is “coordinated by the local computer 70” and as such a POSITA would have recognized that the local computer 70 controls the other “sub-systems” to coordinate the 3D manufacturing process. EX1004, 4:32-38.

104. For example, Mazumder teach that that local computer “interface[es] with the feedback controller 80” (col. 3:25-28) and can “send appropriate commands to [the] feedback controller 80, which interfaces with the numerical controller 90” (col. 6:21-23). As such, the aforementioned “CAD/CAM data” received at the local computer 70 (as I discussed above) is then “applied to the

DMD system” via this interface to the feedback controller 80 and numerical controller 90” to fabricate the product using the direct material deposition system. EX1004, 3:57-4:7. Such control of the directed material deposition system by the local computer based on the received CAD/CAM files satisfies this portion of Element [1.d]. EX1004, 4:29-38; 6:18-23, 6:36-53. Mazumder’s system deposits the material to generate the product on the substrate and therefore the object is fabricated within the build volume. EX1004, 3:11-25 (“computer-controlled direct material deposition system 10, which is used to fabricate, repair or modify three-dimensional products by applying sequentially layers of material 20 on a substrate 30.”) 4:8-37.

105. Regarding the third functional recitation of Element [1.d], Mazumder’s local computer provides a user interface to a remote user accessing the device through the network interface and the user interface includes an image of the build volume from the video camera. Mazumder describes that “a video or TV camera 65 records the laser-aided DMD process and transmits the images to the local computer 70, which then sends the images together with the associated temperature, strain and stress data to the remote computer 95 to be displayed preferably on a TV screen or shown on the remote computer monitor as streaming video.” EX1004, 6:36-43. As Mazumder describes, “visual images or metrological

information collected at the local manufacturing site 205 are all processed through the local computer 70” and as such, it is the processor of the local computer 70 that provides the user interface containing the video images. *Id.*, 6:44-48. In another example, Mazumder describes that the “manufacturing system” includes “a video or television camera recording the fabrication process and transmitting the images to be viewed on a screen display situated at the remote computer system.” *Id.*, 8:13-17, 8:51-54, Abstract.

106. As I mentioned above, in one configuration, the combined video and sensor data is displayed on a “TV screen.” EX1004, 6:36-45. As such, a POSITA would have recognized that, because the combined video and sensor data can be displayed on a “TV screen,” which is a display device that does not include its own computing capability, it is the local computer 70 that transmits this data for display that generates the user interface showing this video information. This is especially true given that Mazumder discloses that, as mentioned above, “temperature, strain and stress data, visual images or metrological information collected at the local manufacturing site 205 are all processed through the local computer 70.” EX1004, 6:44-48.

107. Alternatively, it would have been obvious for the Mazumder-Mori system to generate the interface at the local computer. As mentioned above,

Mazumder discloses “[a]ll the data processing is done locally at the manufacturing site 205.” EX1004, 6:44-55. Mazumder also indicates in its background section that its system is facilitated using “web browsers” for viewing text, “video, graphics and audio files.” EX1004, 1:24-29. Mazumder later makes this more express, stating that “a user interfaces to the communications link through an Internet browser.” *Id.*, 7:36-38. In another example, Mazumder similarly describes that “the communications system connecting the local and remote computers includes an Internet browser.” *Id.*, 8:18-20. Mazumder describes the communications link as the link between the remote computer system and the local manufacturing system, and therefore, a POSITA would have recognized that it is the local computer’s processor that produces the user interface for display in the “Internet browser” of the remote computer. EX1004, 7:12-17. That is, a POSITA would have known that when a generic web browser executing on a user’s device (such as the remote computer of Mazumder) displays a user interface, it is the computing device that the user’s device is in communication with that generates the user interface for presentation via the web browser. Therefore, in the case of Mazumder’s specific system, a POSITA would have recognized that when the designer at the remote computer views the user interface using a web browser executing on the remote computer (EX1004, 1:24-29, 7:36-38, 8:18-20), that based

on Mazumder's disclosure that the "temperature, strain and stress data, visual images or metrological information collected at the local manufacturing site 205 are all processed through the local computer 70, which communicates with the remote computer 95" that this indicates that it is the local computer that generates the user interface for presentation in the web browser at the remote computer. *Id.*, 6:36-55. I have reviewed portions of the Patent Owner's infringement contentions and with respect to this feature claim 1, the Patent Owner asserts that this claim feature encompasses "software or firmware to collect image content" and therefore Mazumder's disclosure of transmitting image content alone would satisfy this claim. However, as I have discussed here, a POSITA would have recognized that Mazumder's local computer 70 generates the user interface for presentation at the remote computer 95.

108. Alternatively, it would have been obvious to a POSITA to implement the Mazumder-Mori system to generate the user interface at the local computer 70 (using the processor of the local computer 70). Generation of the user interface at the local computer 70 (as described above) would have allowed the sensor information and video image data to be viewed using a generic web browser. This is especially obvious in light of Mazumder's express disclosure that all sensor and video data processing are *all processed through the local computer*

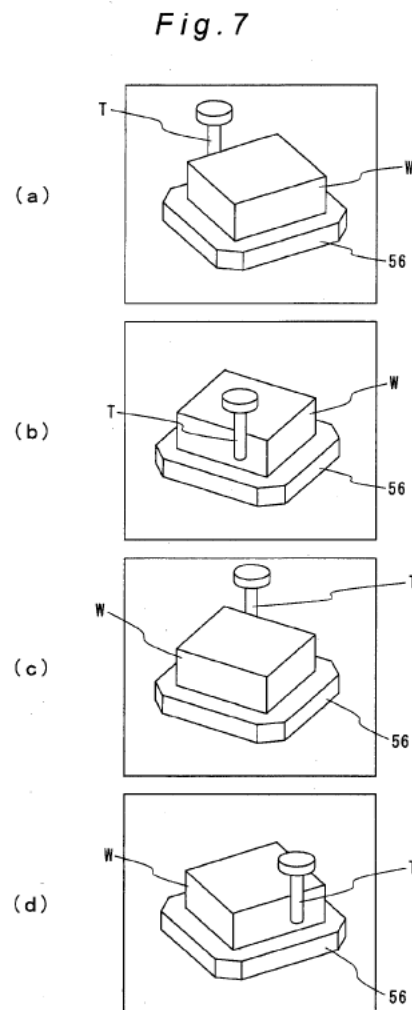
70, which communicates with the remote computer 95.” Id., 6:36-55. In such an implementation, the remote user would have beneficially viewed the user interface through a generic web browser rather than requiring installation of specialized software on the remote computer to generate the user interface at the remote computer.

109. Turning now to the claim recitation of including a two-dimensional projection of the three-dimensional model from the point of view of the video camera in the user interface, as I described above when discussing the predictable combination of Mazumder with Mori, Mori demonstrates that the resulting combination includes such features. As I discussed above, Mori describes a “machining status monitoring apparatus is provided on a machine tool, and has *a plurality of actual CCD cameras for imaging the tool and workpiece from different view points* and generating actual two-dimensional image data thereof, *a virtual image generating section having a plurality of virtual CCD cameras corresponding to the actual CCD cameras, in which the tool and workpiece of three-dimensional model are imaged by the virtual CCD cameras from each point and virtual two-dimensional image data thereof are generated*, and a display control section for selecting one virtual CCD camera corresponding to the virtual two-dimensional image data in which the distal end of the tool is not hidden

by the workpiece among the generated two-dimensional image data, and displaying the actual two-dimensional image data generated by the actual CCD camera corresponding to the selected virtual CCD camera on a display device.” EX1005, Abstract.

110. In further examples, Mori describes that, similar to Mazumder, its system includes multiple CCD cameras configured so as to be able to image the workpiece W from four directions” to “generate two-dimensional image data (actual image data) thereof” as shown in FIG. 4. EX1005, [0049]-[0050]. Mori would have been applied to Mazumder such that the resulting system also includes a “virtual image generating section 18” that provides views of the object being fabricated based on the stored model of the object. EX1005, [0059]-[0065]. Mori explains that in the resulting system, “virtual image generating section 18 generates two-dimensional image data (virtual image data) of, for example, the tool T, workpiece W and a part of the table 56 by a computer process based on the parameters stored in the camera parameter storage section 15 and the model data updated by the model data updating section 17.” *Id.*, [0059]. Thus, in the resulting Mazumder-Mori system, based on the teachings of Mori, the system displays virtual images of the model in the user interface as if captured from “virtual CCD cameras” that “are respectively arranged at the *same positions and in the same*

orientations as the actual CCD cameras.” Id., [0061]-[0062]. Figure 7 shows examples of such virtual CCD camera images depicting the workpiece from the same four perspectives as the actual camera images depicted in the example in Figure 4:



EX1005, FIG. 7.

111. Mori goes on to elaborate that “[t]hereafter, the virtual image generating section 18 in turn generates two-dimensional image data which is assumed to be obtained when the tool T, workpiece W and a part of the table 56 which are represented by three-dimensional model are imaged at a certain time interval by the virtual CCD cameras 19, 20, 21 and 22, and transmits the generated two-dimensional image data to the display control section 23.” *Id.*, [0063]. In the resulting combination, this virtual image would be a virtual image of the object being fabricated by Mazumder’s 3D printer. Mori describes that the user interface displays the actual image data from the actual CCD cameras, the virtual image data, and the sectional image data showing a virtual cross section of the workpiece. EX1005, [0070], [0074]-[0076], FIGs. 4, 7, 10. As such, in the predictable combination of Mazumder with Mori, the user interface generated by the local computer and provided to the remote computer for display includes both actual images of the volume and a two-dimensional projection of the three-dimensional model “arranged at the same positions and in the same orientations.” EX1005, [0061]-[0062];.

112. A POSTIA would have recognized that in at least some applications of Mori’s teachings to Mazumder’s system, the resulting system would have

provided only a single virtual camera image of the object being fabricated to correspond to the single camera embodiments of Mazumder.

113. A POSITA would have additionally recognized that, in the predictable combination of Mazumder with Mori, it would have been obvious to display the actual image and the virtual image of the product simultaneously, which would have helped further achieve the advantages that I discussed above. For example, the presentation of the actual images captured by the camera and the virtual images simultaneously within the user interface would have beneficially aided the remote user to more easily visually compare the actual image and virtual image to quickly identify any defects or problems with the fabrication process. Indeed, this is consistent with both Mazumder's goals and Mori's suggested benefits.

114. Alternatively, I have reviewed portions of the Patent Owner's infringement contentions and it appears that Patent Owner contends in the district court litigation that both the required "image of the build volume from the video camera" and the required "two-dimensional projection of the three-dimensional model" recited by this claim element are fulfilled by merely displaying images captured by a video camera alone. EX1016, 42-105. Under such an interpretation, Mazumder's disclosure of video images that are "displayed preferably on a TV

screen or shown on the remote computer monitor as streaming video” at the remote computer 95 satisfies both of these requirements, demonstrating another way that the Mazumder-Mori combination provides this claim element. EX1004, 6:36-43, 8:14-17. While I disagree with this characterization of the claims, Mazumdar also discloses this limitation as Patent Owners have applied it in the District Court.

115. To the extent that it is argued that the processor of Mazumder’s local computer is not expressly described as performing each of the functions discussed above, a POSITA would have recognized, due to improvements in computing capacity of processors during the decade between the 1999 priority date of Mazumder and the August 2010 priority date of the ’324 patent, it would have been obvious and beneficial to implement the processing and control functions of the local computer 70, the feedback controller, 80 and the CNC 90 using a single processor. Such an implementation would have reduced the number of components required for the device thereby reducing the overall footprint and improved efficiency by eliminating the need for communication between disparate processors within the resulting device. Additionally, utilization of a single processor would have allowed for changes and improvements to be made to the system through software updates to software installed on a single processor rather than requiring different software updates for different components of the system.

Claim [3]: The device of claim 1 wherein the two-dimensional projection is simulated based upon operation of the three-dimensional printer.

116. Mori demonstrates that in the Mazumder-Mori combination, the two-dimensional projection is simulated based upon operation of the three-dimensional printer. For example, Mori explains that it's "virtual image generating section 18 ***generates two-dimensional image data (virtual image data)*** of, for example, the tool T, workpiece W and a part of the table 56 by a computer process ***based on*** the parameters stored in the camera parameter storage section 15 and ***the model data updated by the model data updating section 17.***" *Id.*, [0059]. Mori provides details on the model data updating section 17, explaining that "the ***model data*** storage section 16 is ***updated by the model data updating section 17 synchronically with the actual operations***" of the fabrication system. *Id.*, [0078]. As another example, Mori describes that the model data is continually updated as the object is fabricated, stating that "the model data in the model data storage section 16 are updated." *Id.*, [0053]-[0059]. Based on these descriptions of the model being updated based on operation of the machine during the fabrication process, it is clear that in the predictable combination of Mazumder with Mori, the virtual image is simulated based upon operation of the three-dimensional printer of Mazumder. Furthermore, a POSITA would have recognized that these teachings of Mori regarding updating the virtual image data based on updated model data

would have been applied to the CAD model for the object being fabricated received at the local computer 70 in the predictable combination of Mazumder with Mori.

117. Alternatively, I have reviewed portions of the Patent Owner's infringement contentions and it appears that Patent Owner contends in the district court litigation that merely displaying video camera images of the product at a remote computer satisfies this claim. EX1016, 57-66. Under such an interpretation, Mazumder's descriptions of displaying the image data captured by the camera of the object being fabricated in the user interface presented at the remote computer also demonstrate that the Mazumder-Mori combination meets this claim. EX1004, 6:36-43, 8:14-17.

Claim [5]: The device of claim 1 wherein the two-dimensional projection is dynamically updated to correspond to a state of physical completion of the object.

118. Mori demonstrates that in the Mazumder-Mori combination, the two-dimensional projection is dynamically updated to correspond to a state of physical completion of the object. As I discussed above with respect to claim 3, Mori explains that it's "virtual image generating section 18 ***generates two-dimensional image data (virtual image data)*** of, for example, the tool T, workpiece W and a part of the table 56 by a computer process ***based on*** the parameters stored in the

camera parameter storage section 15 and *the model data updated by the model data updating section 17.*” *Id.*, [0059]. Mori provides details on the model data updating section 17, explaining that “the *model data* storage section 16 is *updated by the model data updating section 17 synchronically with the actual operations*” of the fabrication system. *Id.*, [0078]. As another example, Mori describes that the model data is continually updated as the object is fabricated, stating that “the model data in the model data storage section 16 are updated.” *Id.*, [0053]-[0059]. Based on these descriptions of the model being updated as the object is fabricated to reflect the current state of the object being fabricated, it is clear that in the predictable combination of Mazumder with Mori, the virtual image is dynamically updated to correspond to a state of physical completion of the object.

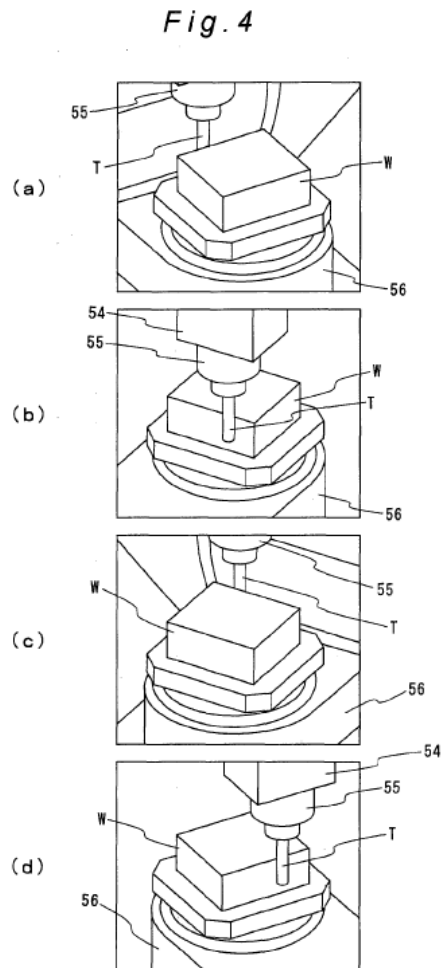
119. Alternatively, I have reviewed portions of the Patent Owner’s infringement contentions and it appears that Patent Owner contends in the district court litigation that merely displaying video camera images of the product at a remote computer satisfies this claim. EX1016, 67-90. Under such an interpretation, Mazumder’s descriptions of displaying the image data captured by the camera of the object being fabricated in the user interface presented at the remote computer also demonstrate that the Mazumder-Mori combination meets this claim. EX1004, 6:36-43, 8:14-17.

Claim [6]: The device of claim 1 wherein the two-dimensional projection is a video image from the video camera.

120. As I discussed with respect to claim 1, Mazumder describes that “a video or TV camera 65 records the laser-aided DMD process and transmits the images to the local computer 70, which then sends the images together with the associated temperature, strain and stress data to the remote computer 95 to be ***displayed preferably on a TV screen or shown on the remote computer monitor as streaming video.***” EX1004, 6:36-43. As Mazumder describes, “visual images or metrological information collected at the local manufacturing site 205 are all processed through the local computer 70” and as such, it is the processor of the local computer 70 that provides the user interface containing the video images. *Id.*, 6:44-48. In another example, Mazumder describes that the “manufacturing system” includes “a video or television camera recording the fabrication process and ***transmitting the images to be viewed on a screen display situated at the remote computer system.***” *Id.*, 8:13-17, 8:51-54, Abstract.

121. Mori provides similar disclosure, describing that “the actual CCD cameras 11, 12, 13 and 14 are arranged to surround the workpiece W on the table 56, and are configured so as to be able to image the workpiece W from four directions” to “generate two-dimensional image data (actual image data) thereof” as shown in FIG. 4. *Id.*, [0049]-[0050]. Figure 4 shows images of the workpiece

within Mori's rapid fabrication device as captured by each of Mori's four CCD cameras:



EX100, FIG. 4.

122. I have reviewed portions of the Patent Owner's infringement contentions and it appears that Patent Owner contends in the district court litigation that merely displaying video camera images of the product at a remote computer

satisfies this claim. EX1016, 91-105. As such, Mazumder's descriptions of displaying the image data captured by the camera of the object being fabricated in the user interface presented at the remote computer demonstrates that the Mazumder-Mori combination meets this claim. EX1004, 6:36-43, 8:14-17.

Claim [7]: The device of claim 1 wherein the user interface provides at least one control for manual operation of the three-dimensional printer by the remote user.

123. Mazumder describes that “[f]or ***remote control of the DMD process***, a design team or an individual designer is located at the ‘remote’ site and ***operates, through a user interface***, their ‘remote’ host computer. The remote computer stores the description of a product to be fabricated.” EX1004, 2:14-23. Mazumder also describes remotely controlling the deposition process via the remote computer 95 by providing the designer with the ability to “pause or abort the fabrication process by sending a command to the controller” of the system. *Id.*, 2:34-42, 6:44-67. In another example, Mazumder describes that its system allows for “real-time, on-line control of the deposition process from the remote site.” *Id.*, 4:30-41. In another example, Mazumder describes “sending control commands from the remote computer to the local computer to control the material deposition process.” EX1004, 8:36-38.

124. As I discussed above with respect to Element [1.d], Mazumder provides, or at least renders obvious, that the user interface is provided by the local site through the network to the remote computer where it is presented in a browser. EX1004, 6:36-55, 1:24-29, 7:36-38, 8:18-20. A POSITA would have recognized that Mazumder's descriptions of the remote computer controlling the fabrication process by "sending control commands" including to perform operations such as "pause or abort the fabrication" based on input from the user of the remote computer indicates that the user interface includes a control for issuing such commands. Alternatively, it would have been obvious to include one or more controls in the user interface provided by the local site for display at the remote computer for facilitating the remote control so that the user can "control and modify the fabrication of the product in real time on line" while continuing to monitor the fabrication process by viewing the video images and virtual images. EX1004, Abstract.

Claim [9]: The device of claim 1 wherein the user interface provides status information for the three-dimensional printer.

125. Mazumder discloses that it captures status information for the three-dimensional printer using various sensors and includes information captured by those sensors in the user interface provided by the local computer 70 for display at the remote computer 95. Mazumder describes that the various sensors located at

the rapid fabrication device include “strain gages 40, acoustic sensors 50, optical sensors 60 and video or television camera 65.” EX1004, 3:26-31. The “video or TV camera 65 records the laser-aided DMD process and transmits the images to the local computer 70, which then sends the images together with the associated temperature, strain and stress data to the remote computer 95 to be displayed preferably on a TV screen or shown on the remote computer monitor as streaming video.” *Id.*, 6:36-43. A POSITA would have recognized that these video images of the build volume of the three-dimensional printer and the associated temperature, strain and stress data are all examples of status information for the three-dimensional printer. For example, the strain gauges measure strain/stress data via contact with “the back of the substrate” while the temperature readings indicate the temperature of the build volume. *Id.*, 5:30-36, 6:24-35.

Claim [10]: The device of claim 1 wherein the user interface provides status information for a build process executing on the three-dimensional printer.

126. Mazumder discloses that it captures status information for a build process executing on the three-dimensional printer using various sensors and includes information captured by those sensors in the user interface provided by the local computer 70 for display at the remote computer 95. Mazumder describes that the various sensors located at the rapid fabrication device include “strain gages 40, acoustic sensors 50, optical sensors 60 and video or television camera 65.”

EX1004, 3:26-31. Mazumder describes that “data from the sensor systems 40, 50, 60 are processed by the local computer to produce real-time temperature, strain and stress data during the fabrication process.” *Id.*, 6:24-35, 5:25-63. The “video or TV camera 65 records the laser-aided DMD process and transmits the images to the local computer 70, which then sends the images together with the associated temperature, strain and stress data to the remote computer 95 to be displayed preferably on a TV screen or shown on the remote computer monitor as streaming video.” *Id.*, 6:36-43. A POSITA would have recognized that these video images of the object being fabricated along with the associated temperature, strain and stress data are all examples of status information for the build process 3 executing on the three-dimensional printer.

Element [19.pre]: A method comprising:

127. Mazumder describes “[a] system and method for remotely controlling the fabrication of a product at a local manufacturing site.” EX1004, Abstract, 1:17-21. A POSITA would have recognized that the functions described throughout Mazumder, and the additional functions described in Mori, are a method.

Element [19.a]: providing a three-dimensional printer including a build volume, a network interface coupled to a data network, and a video camera positioned to capture video of the build volume from a point of view;

128. As I discussed with respect to Elements [1.a]-[1.c], above, Mazumder discloses a three-dimensional printer including a build volume, a network interface coupled to a data network, and a video camera positioned to capture video of the build volume from a point of view. Mazumder discloses Element [19.a] for the reasons discussed with respect to Elements [1.a]-[1.c].

129. For example, Mazumder describes that “[t]he local site includes a laser-aided, computer-controlled direct material deposition system 10, which is used to fabricate, repair or modify three-dimensional products by applying sequentially layers of material 20 on a substrate 30.” EX1004, 3:11-25, 1:62-2:2, 7:39-51. As such, Mazumder discloses a three-dimensional printer having a build volume in the form of the substrate and the work space defined by and immediately above the substrate. *Id.*, 4:7-10.

130. As I discussed above with respect to Element [1.b], Mazumder’s local computer 70 communicates with the remote computer 95 “via a communications system 75, preferably including the Internet.” EX1004, 3:4-10, 3:26-56, FIG. 1. A POSITA would have known that the Internet is a data network and the point at which the local computer 70 interfaces with the communication system 75 (the Internet) is a network interface. Alternatively, such a network

interface would have been obvious to include in Mazumder's local computer 70 for the reasons that I discussed with respect to Element [1.b], above.

131. Lastly, as I discussed above with respect to Element [1.c], Mazumder discloses that "a video or TV camera 65 records the laser-aided DMD process and transmits the images to the local computer 70, which then sends the images together with the associated temperature, strain and stress data to the remote computer 95 to be displayed preferably on a TV screen or shown on the remote computer monitor as streaming video (display screens not shown in FIG. 1)." EX1004, 6:34-48, 3:26-36, 8:13-17, Abstract; EX1005, [0049]-[0050].

Element [19.b]: receiving a three-dimensional model through the network interface;

132. The Mazumder-Mori combination provides, or at least renders obvious, this claim element for the reasons that I discussed above with respect to Element [1.d]. For example, Mazumder describes that "the CAM file of the product description" is "transmit[t]ed, e.g. over the Internet, to the manufacturing site." EX1004, 2:24-43. 102. In another example, Mazumder discloses that rather than generating the CAM files defining the tool path for the object to be fabricated at the remote computer 95 and transmitting these CAM files to the local

computer 70 “the CAD files are simply transmitted to the local computer 70.”

EX1004, 6:60-67, *see also*, 2:14-23, 4:32-38, 3:26-56, 4:44-49, 3:57-63.

Element [19.c]: fabricating the three-dimensional model as an object within the build volume of the three-dimensional printer; and

133. The Mazumder-Mori combination provides, or at least renders obvious, this claim element for the reasons that I discussed above with respect to Element [1.d]. For example, Mazumder describes that “[t]he local site includes a laser-aided, computer-controlled direct material deposition system 10, which is used to fabricate, repair or modify three-dimensional products by applying sequentially layers of material 20 on a substrate 30.” EX1004, 3:11-25. Mazumder describes that the received “CAD/CAM data” is “applied to the DMD system” via this interface to the feedback controller 80 and numerical controller 90 to fabricate the product using the direct material deposition system. EX1004, 3:57-4:7, 4:29-38; 6:18-23, 6:36-53, 4:8-37.

Element [19.d]: providing a user interface to a remote user accessing the device through the network interface, wherein the user interface presents an image of the build volume from the video camera and a two-dimensional projection of the three-dimensional model from the point of view of the video camera.

134. The Mazumder-Mori combination provides, or at least renders obvious, this claim element for the reasons that I discussed above with respect to Element [1.d]. For example, Mazumder describes “a video or television camera

recording the fabrication process and transmitting the images to be viewed on a screen display situated at the remote computer system.” EX1004, 8:13-17, 8:51-54, 6:36-48, Abstract. Mazumder also discloses, or at least renders obvious, generating the user interface at the local computer 70 and transmitting the user interface including the image data and other sensor data to the remote computer 95 for display in a web browser of the remote computer 95, for the reasons I discussed with respect to Element [1.d], above. EX1004, 1:24-29, 7:36-38, 8:18-20, 7:12-17, 6:36-55.

135. Additionally, as I discussed above, Mori would have been applied to Mazumder such that the resulting system also includes a “virtual image generating section 18” that provides views of the object being fabricated based on the stored model of the object. EX1005, [0059]-[0065]. Mori explains that in the resulting system, “virtual image generating section 18 generates two-dimensional image data (virtual image data) of, for example, the tool T, workpiece W and a part of the table 56 by a computer process based on the parameters stored in the camera parameter storage section 15 and the model data updated by the model data updating section 17.” *Id.*, [0059]. Thus, in the resulting Mazumder-Mori system, based on the teachings of Mori, the system displays virtual images of the model in the user interface as if captured from “virtual CCD cameras” that “are respectively

arranged at the same positions and in the same orientations as the actual CCD cameras.” *Id.*, [0061]-[0062].

Claim [20]: The method of claim 19 further comprising transmitting status information over the data network upon completion of the object.

136. As I discussed above with respect to claims 9 and 10, Mazumder’s system has various sensors and includes information captured by those sensors in the user interface provided by the local computer 70 for display at the remote computer 95. Mazumder describes that the various sensors located at the rapid fabrication device include “strain gages 40, acoustic sensors 50, optical sensors 60 and video or television camera 65.” EX1004, 3:26-31. The “video or TV camera 65 records the laser-aided DMD process and transmits the images to the local computer 70, which then sends the images together with the associated temperature, strain and stress data to the remote computer 95 to be displayed preferably on a TV screen or shown on the remote computer monitor as streaming video.” *Id.*, 6:36-43.

137. Mazumder also discloses that interactions between the remote computer 95 and local computer 70 occur “in real time on line.” EX1004, Abstract, 4:39-41, 6:27-55, 7:56-61, 8:31-38. Mazumder is also express that its system “fabricate[s] completed parts and products.” EX1004, 4:1-3. Based on these

disclosures of Mazumder of sending status information regarding the fabrication process to the remote computer 95 from the local computer 70 “in real time” over the data network (e.g., the Internet) for display in the user interface, a POSITA would have recognized that this information is transmitted both during the fabrication process and upon completion of the product, thus providing this claim recitation.

Claim [21]: The method of claim 20 wherein the status information includes data presented through the user interface.

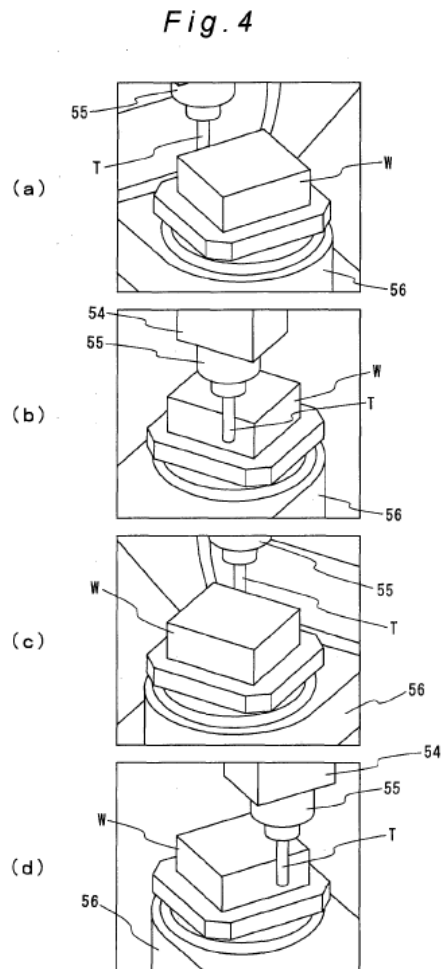
138. As I discussed above, Mazumder discloses that the local computer “sends the images together with the associated temperature, strain and stress data to the remote computer 95 to be displayed.” EX1004, 6:24-55, Abstract. As I discussed with respect to Element [1.d], above, this status information would have been displayed as part of the user interface generated by the local computer 70 and transmitted to the remote computer 95 for display in the web browser executing at the remote computer. Additionally, as I discussed with respect to claim 20, above, this status information would have been displayed in the user interface both during the fabrication process and upon completion of the product, thus providing this claim recitation.

Claim [22]: The method of claim 20 wherein the status information includes a digital image from the video camera.

139. The combination of Mazumder with Mori provides this claim for the reasons that I discussed above with respect to Element [1.d] and claims 6 and 20-21. For example, Mazumder describes that “a video or TV camera 65 records the laser-aided DMD process and transmits the images to the local computer 70, which then sends the images together with the associated temperature, strain and stress data to the remote computer 95 to be *displayed preferably on a TV screen or shown on the remote computer monitor as streaming video.*” EX1004, 6:36-43. As Mazumder describes, “visual images or metrological information collected at the local manufacturing site 205 are all processed through the local computer 70” and as such, it is the processor of the local computer 70 that provides the user interface containing the video images. *Id.*, 6:44-48. In another example, Mazumder describes that the “manufacturing system” includes “a video or television camera recording the fabrication process and *transmitting the images to be viewed on a screen display situated at the remote computer system.*” *Id.*, 8:13-17, 8:51-54, Abstract.

140. Mori provides similar disclosure, describing that “the actual CCD cameras 11, 12, 13 and 14 are arranged to surround the workpiece W on the table 56, and are configured so as to be able to image the workpiece W from four directions” to “generate two-dimensional image data (actual image data) thereof”

as shown in FIG. 4. Id., [0049]-[0050]. Figure 4 shows images of the workpiece within Mori's rapid fabrication device as captured by each of Mori's four CCD cameras:



EX100, FIG. 4.

141. I have reviewed portions of the Patent Owner's infringement contentions and it appears that Patent Owner contends in the district court litigation

that merely displaying video camera images of the product at a remote computer satisfies this claim. EX1016, 187-189. As such, Mazumder's descriptions of displaying the image data captured by the camera of the object being fabricated in the user interface presented at the remote computer demonstrate that the Mazumder-Mori combination meets this claim. EX1004, 6:36-43, 8:14-17.

7.2. Ground 1B: The Combination of Mazumder with Mori and Tian Renders Obvious Claim 4

142. Multiple reasons would have motivated a POSITA to modify the system of Mazumder-Mori to further include functionality to compare the model data (which serves as the basis of the two-dimensional projection in the proposed combination) with the actual image of the object and adjust the model as a result for multiple reasons based on the suggestions of Tian. As a first reason for such a modification, one of the aims described by Mazumder is to enable the designer at the remote computer to identify “a defect, an abnormality or some other undesirable characteristic affecting the final quality of the product.” EX1004, 2:34-42. Mazumder describes that such identification of defects or abnormalities allows the remote designer to take corrective measures such as by pausing or aborting the fabrication process and editing the CAD file to improve the design and correct for the defect. *Id.* For example, multiple portions of Mazumder describe giving the remote designer the ability to “monitor, control and modify the fabrication of the

product.” EX1004, Abstract, 3:11-25, 6:24-35. Such modifications include “[m]odification of the CAD and CAM files.” *Id.*, 6:44-55. Application of Tian’s suggestion to compare the images of the object being manufactured as captured by one or more cameras and a two-dimensional projection of the object being fabricated generated based on a model to “confirm[] easily, efficiently, and precisely whether three-dimensional model data including an attached object attached to a machine tool and at least a part of the machine tool good are accurate” would have aided the remote designer of Mazumder’s system in identifying defects/abnormalities/errors in the object being fabricated and therefore would have furthered Mazumder’s express goal of allowing the designer to modify the CAD design to avoid such defects in future fabrication runs. EX1006, Abstract. For example, Tian describes comparing “the two-dimensional image data related to the actual attached object generated in the actual-image-data generating process and the two-dimensional image data of the attached object related to the three-dimensional model” to determine if the actual object and the model “match.” *Id.*, [0013], [0022], [0025], [0100], [0111]. A POSITA would have recognized that such automated comparing of the model image data (the virtual images) to the actual images of the object being fabricated, as captured by the cameras at the fabrication device, would have aided in defect/abnormality detection, thereby

improving the ability of the resulting system to detect and correct for defects/abnormalities while reducing the cognitive load on the human designer .

143. As a second reason, a POSITA would have recognized that comparing the virtual images of the object being fabricated (as derived from the model) to the actual images of the object during the fabrication process (as suggested by Tian) would have beneficially allowed the resulting system to detect and correct for defects/abnormalities/errors in instances in which such defects/abnormalities/errors would be difficult or impossible for a human to detect through manual, visual comparison. Improving such error correction would have ultimately led to further modifications to the CAD design that would beneficially improve the resulting product.

144. As a third reason, Mazumder expressly discloses comparing information collected by its various sensors to “pre-determined failure criteria” to identify defective products/designs. EX1004, 6:10-23. Tian provides additional details that compliment this functionality in Mazumder by providing additional details on comparing specific sensor data (image data) to the virtual images of the object being fabricated (as derived from the object model) to identify specific failure scenarios. EX1006 [0013], [0022], [0025], [0100]-[0002], [0111].

Identification of such specific failure scenarios would then allow the user to

beneficially modify the CAD design to avoid such failure scenarios, thus improving the overall design. EX1004, 2:34-42, Abstract, 3:11-25, 6:24-35, 6:44-55. As such, Tian furthers the goal of Mazumder by providing additional teachings on specific comparisons between sensor data and pre-determined criteria.

145. As a fourth reason, a POSITA would have been prompted to modify Mazumder's rapid fabrication system (as already modified by Mori) to monitor operation of the three-dimensional printer by comparing the two-dimensional virtual images derived from the object model to the actual images of the object during fabrication (as suggested by Tian) because doing so would be merely the application of a known technique to a known system (e.g., Mazumder's remotely controlled rapid fabrication system) ready for improvement to yield predictable results. Here, Tian provides straightforward evidence of a known technique for comparing virtual images of a rapid fabrication process to actual images of the rapid fabrication process and Mazumder's teaching (as modified by Mori) provides a known system that would have been improved by application of Tian's suggested technique for at least the reasons described above. Based upon my knowledge and experience in this field and my review of Mazumder, Mori, and Tian, I am confident a POSITA would have recognized that this modification would have yielded predictable results and required only routine adjustments to the system and

as such a POSITA would have had a reasonable expectation of success in making such modifications. This modification would not have significantly altered or hindered the functions performed by Mazumder's system, and these modifications would have been within the predictable and ordinary level of skill of a POSITA (certainly by a time frame as late as 2010).

146. As demonstrated below, the predictable combination of Mazumder with Mori and Tian renders obvious claim 4.

Claim [4]: The device of claim 3 wherein the processor is configured to monitor operation of the three-dimensional printer based upon a comparison of the two-dimensional projection with the image of the build volume.

147. Tian demonstrates that in the Mazumder-Mori-Tian combination, the processor of the resulting system (e.g., the processor of Mazumder's local computer located at the fabrication site) is configured to monitor operation of the three-dimensional printer based upon a comparison of the two-dimensional projection with the image of the build volume. For example, similar to Mori, Tian discloses generating "virtual image data" that "correspond[s] to the CCD cameras 13 and 14[] of the workpiece W." EX1006, [0098]. The virtual images are derived from a model of the object to be fabricated. EX1006, Abstract, [0012]. Tian describes comparing the images of the workpiece as captured by the CCD cameras and a two-dimensional projection of the object being fabricated generated based on

a model to “confirm[] easily, efficiently, and precisely whether three-dimensional model data including an attached object attached to a machine tool and at least a part of the machine tool good are accurate.” EX1006, Abstract. For example, Tian describes comparing “the two-dimensional image data related to the actual attached object generated in the actual-image-data generating process and the two-dimensional image data of the attached object related to the three-dimensional model” to determine if the actual object and the model “match.” *Id.*, [0013], [0022], [0025], [0100], [0111]. In another example, Tian describes that “the actual image data obtained by the first CCD camera 13 and the virtual image data generated to correspond to the first CCD camera 13; and the actual image data obtained by the second CCD camera 14 and the virtual image data generated to correspond to the second CCD camera 14 are compared, respectively, to determine whether these image data match.” *Id.*, [0100].

148. Upon performing this comparison function, if the virtual image data generated from the model and image data of the actual object do not match “the computer may be configured to further function as model-data updating means for updating the model data related to at least a part of the machine tool to match an actual operation of the machine tool.” EX1006., [0026]-[0029]. In some examples “when the actual image data and the virtual image data do not match, it is

determined that the three-dimensional model data of the whole of the machine tool 30 are wrong, that is, the shape of the workpiece W, the mounting position thereof, and the mounting attitude thereof do not match those of the actual workpiece W (step S18), a message to this effect is displayed on the screen display device (not shown) of the operation panel 47 or on the screen display device 12 of the computer 10.” *Id.*, [0101]-[0102].

7.3. Ground 1C: The Combination of Mazumder with Mori and Hull Renders Obvious Claim 8

149. Multiple reasons would have motivated a POSITA to modify the system of Mazumder-Mori to further include functionality to require a user to provide credentials to access the user interface for multiple reasons based on the suggestions of Hull. As a first reason, similar to Mazumder, Hull describes allowing a user to transfer design files from a remote computer to a “process computer” that controls the cabinet assembly of a 3D printer deposition machine to allow a user to remotely initiate and control a 3D printing process without being physically present at the location of the 3D printer. EX1008, [0140], [0143]. A POSITA would have beneficially applied Hull’s teachings to the Mazumder-Mori system to require login credentials, including a password, to remotely access the computing system in control of the 3D printer to prevent unauthorized users from accessing the fabrication system. EX1008, [0157]. As such, users who are not

authorized to use the 3D printing system (e.g., because they have not scheduled use of the device or have not paid for use of the device) can thus be prevented from accessing the system at Mazumder's local site.

150. As a second reason, implementing Mazumder's system to require credential based access for the local site fabrication system would have prevented unauthorized waste of fabrication time, power usage, and deposition material, thereby freeing up these resources for authenticated/authorized users. A POSITA would have recognized that fabricating objects at Mazumder's 3D printer utilizes a number of resources. Credential based access would have prevented unauthorized users from wasting such resources.

151. As a third reason, implementing Mazumder's system to require credential based access for the local site fabrication system would have allowed the operators of the local fabrication system described by Mazumder to more easily track the remote users that have accessed the system by recording the remote users' access credentials when they are entered.

152. As a fourth reason, implementing Mazumder's system to require credential based access for the local site fabrication system would have helped to

prevent bad actors from accessing the local fabrication system to send operating commands that could potentially damage or disable the system.

153. As a fifth reason, a POSITA would have been prompted to modify Mazumder's rapid fabrication system (as already modified by Mori) to require login credentials, including a password, to access Mazumder's local fabrication site (as suggested by Hull) because doing so would be merely the application of a known technique to a known system (e.g., Mazumder's remotely controlled rapid fabrication system) ready for improvement to yield predictable results. Here, Hull provides straightforward evidence of a known technique for requiring login credentials to access a remote 3D printing facility and Mazumder's teaching (as modified by Mori) provides a known system that would have been improved by application of Hull's suggested technique for at least the reasons described above. Based upon my knowledge and experience in this field and my review of Mazumder, Mori, and Hull, I am confident a POSITA would have recognized that this modification would have yielded predictable results and required only routine adjustments to the system and as such a POSITA would have had a reasonable expectation of success in making such modifications. This modification would not have significantly altered or hindered the functions performed by Mazumder's

system, and these modifications would have been within the predictable and ordinary level of skill of a POSITA (certainly by a time frame as late as 2010).

154. As demonstrated below, the predictable combination of Mazumder with Mori and Hull renders obvious claim 8.

Claim [8]: The device of claim 1 wherein the processor is configured to provide credential-based access to the user interface.

155. Hull demonstrates that in the Mazumder-Mori-Hull combination, the processor of the local computer is configured to provide credential-based access to the user interface. In particular, Hull discloses that to remotely access the “process computer” that controls its rapid fabrication system, a user is required to a password. EX1008, [0157]. As discussed with respect to Element [1.d], *supra*, Mazumder discloses, or at least renders obvious, that the user interface is generated and provided by the local site in the Mazumder-Mori-Hull combination and therefore requiring credential-based access to the local site encompasses requiring the credential-based access to access the user interface provided by the local site. EX1004, 6:36-55, 8:14-17; 7:36-38, 8:18-20.

7.4. Ground 1D: The Combination of Mazumder with Mori and Seki Renders Obvious Claim 11

156. Multiple reasons would have motivated a POSITA to modify the system of Mazumder-Mori to further include functionality to display a two-dimensional tool path for the three-dimensional printer corresponding to a current layer of the object during a fabrication of the object by the three-dimensional printer within the user interface for multiple reasons based on the suggestions of Seki. *As a first reason*, multiple portions of Mazumder describe giving the remote designer the ability to “**monitor**, control and modify the fabrication of the product.” EX1004, Abstract, 3:11-25, 6:24-35. Providing a display of the tool path of the 3D printer for the current portion of the fabrication procedure being conducted, as taught by Seki, would have given the remote designer additional visual information with which to better monitor the fabrication process, including providing the designer with an improved ability to identify defects/abnormalities in the design process (e.g., by observing unexpected movements of the deposition tool as represented by the displayed tool path). As such, the designer would have had a better overall understanding of the fabrication process as it proceeds.

157. *As a second reason*, display of the tool path in the user interface would have allowed the designer to easily identify unexpected motions of the fabrication system to more easily identify defects or abnormalities in the

design/model or possible malfunction of the deposition system. Comparison of the expected movements of the device (as represented by the displayed tool path) to actual movements of the device (as shown in the live camera feed) would have allowed the remote designer to identify problems or unexpected motions in the fabrication process that could indicate defects with the fabrication machine itself.

158. As a third reason, Seki describes that displaying both the three-dimensional tool path and two-dimensional tool path as the fabrication device operates makes it easier for the remote user observing the fabrication process to confirm correct movement of the tool. EX1009, 1:36-40. Such confirmation by the operator can allow for correction of the model. *Id.*, 4:42-50. This can lead to “no or less errors” in the resulting object being fabricated. *Id.*, 1:58-2:2.

159. As a fourth reason, a POSITA would have been prompted to modify Mazumder’s rapid fabrication system (as already modified by Mori) to display a two-dimensional representation of the tool path of the fabrication tool (as suggested by Seki) because doing so would be merely the application of a known technique to a known system (e.g., Mazumder’s remotely controlled rapid fabrication system) ready for improvement to yield predictable results. Here, Seki provides straightforward evidence of a known technique for displaying a tool path for a rapid fabrication device in a user interface and updating the displayed tool

path to represent the current movements of the rapid fabrication device tool and Mazumder's teaching (as modified by Mori) provides a known system that would have been improved by application of Seki's suggested technique for at least the reasons described above.

160. Mazumder, Mori, and Seki are each directed to automated manufacturing systems. Although Mazumder's system is an additive manufacturing process while Seki's is directed toward machining tools for removing material from a starting workpiece, a POSITA would have recognized that Seki's teachings regarding displaying the tool-path of the device would have been equally applicable to Mazumder to achieve the above described benefits because Mazumder's system similarly fabricates an object based on a programmed tool path. EX1004, 2:3-13, 3:36-39, 4:8-29. Indeed, Mazumder discloses that similar Computer Aided Manufacturing software is used for additive "deposition" manufacturing and "conventional CNC machining" involving material removal. EX1004, 2:3-13, 3:47-50. In this context, a POSITA would have possessed ample skill to successfully implement the combination as described above. Based upon my knowledge and experience in this field and my review of Mazumder, Mori, and Seki, I am confident a POSITA would have recognized that this modification would have yielded predictable results and required only routine adjustments to the

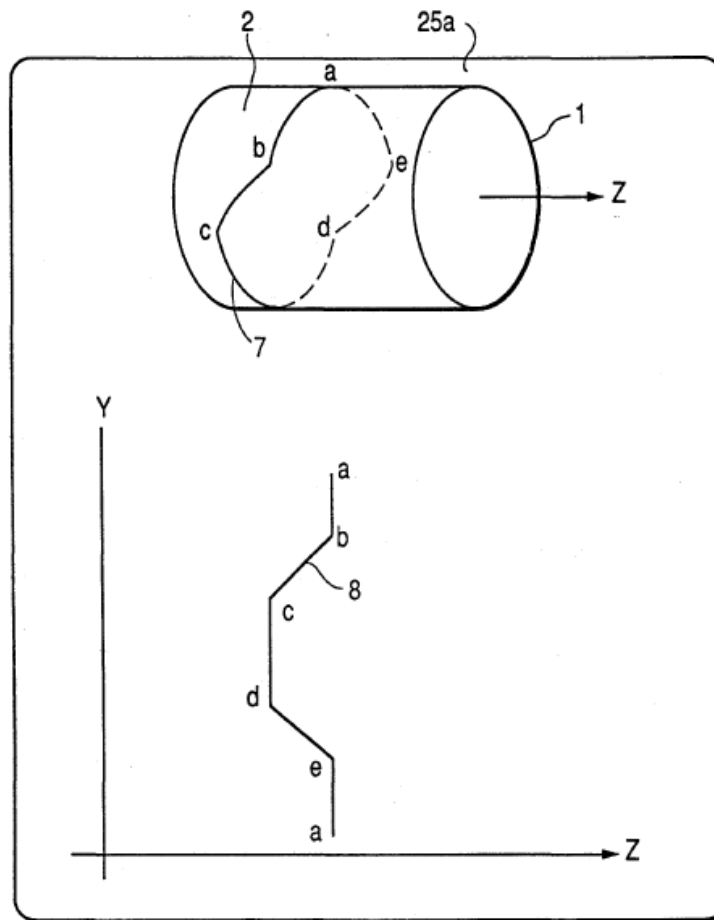
system and as such a POSITA would have had a reasonable expectation of success in making such modifications. This modification would not have significantly altered or hindered the functions performed by Mazumder's system, and these modifications would have been within the predictable and ordinary level of skill of a POSITA (certainly by a time frame as late as 2010).

161. As demonstrated below, the predictable combination of Mazumder with Mori and Seki renders obvious claim 11.

Claim [11]: The device of claim 1 wherein the user interface displays a two-dimensional tool path for the three-dimensional printer, the two-dimensional tool path corresponding to a current layer of the object during a fabrication of the object by the three-dimensional printer.

162. Seki demonstrates that the Mazumder-Mori-Seki combination displays a two-dimensional tool path for the three-dimensional printer in the user interface, the two-dimensional tool path corresponding to a current layer of the object during a fabrication of the object by the three-dimensional printer. Seki describes "[a] tool path drawing method which facilitates confirmation of the movement of a tool associated with three-dimensional machining." EX1009, Abstract. Specifically, Seki displays displaying both three-dimensional and two-dimensional representations of the tool path in the user interface. EX1009, 2:24-32. Examples of such displayed tool paths are shown in Figure 1.

FIG. 1



EX1009, FIG. 1.

163. For example, Seki describes that when an instruction for machining the workpiece occurs, “the CPU 21 calculates a tool path section” for both the three-dimensional and two-dimensional display and provides the information to the display device such that “the tool path section b'-c' is drawn on the YZ coordinate system.” EX1009, 4:19-41.

164. Seki goes on to describe that, “[e]very time NC data associated with a motion definition statement is executed, thereafter, one of first to fifth sections of a tool path 7 which corresponds to this NC data, along with its preceding tool path section, is drawn on a peripheral surface 2 of the workpiece FIG. 1 which is drawn on the display screen 25a.” *Id.*, 2:32-37. This includes drawing the section of the tool path “along with its preceding tool path sections...on the YZ coordinate system” on the display screen. *Id.*, 2:38-43. As such, Seki not only discloses displaying the two-dimensional tool path in the user interface but also discloses that, when predictably applied to Mazumder, the two-dimensional tool path corresponds to a current layer of the object during a fabrication of the object by the three-dimensional printer because the displayed tool path is updated based on the current operation of the 3D printer.

7.5. Ground 1E: The Combination of Mazumder with Mori and Waehner Renders Obvious Claim 17

165. Multiple reasons would have motivated a POSITA to modify the system of Mazumder-Mori to further include functionality to include at least one control to capture a stop-motion animation of a fabrication of the object using the video camera within the user interface for multiple reasons based on the

suggestions of Waehner. As a first reason, Waehner's techniques for sampling video image data captured by a camera "so that for each camera only one out of every predetermined number of sequential images or frames is provided" results in video image data in which "each of the data streams received by digital video recorder 18 is performed at a predetermined rate selected by a user at setup of digital video recorder" which "reduces the number of images per camera per second." EX1010, [0019]. As such, Waehner's time lapse video recording technique "reduce[s] the amount of storage required to record the video captured by cameras." *Id.* As such, applying Waehner's teachings for allowing a user to select, and provide parameters for, a time lapse video recording mode would have reduced the amount of storage required for the video images captured by the camera(s) of the resulting Mazumder-Mori-Waehner system. EX1010, [0004], [0019].

166. As a second reason, Waehner's time lapse recording mode "provides time lapse recording where the various cameras are recorded at a slower rate and, if desired, at a lower resolution but for a much longer period of time" which allows for easier "longer term archival storage" of such video. *Id.*, [0010]. As such, application of Waehner's teachings for allowing a user to select, and provide parameters for, a time lapse video recording mode would have facilitated long term

storage of large amounts of video data without the need to add additional storage capacity in the resulting system. EX1010, [0004], [0010], [0019]-[0020].

167. As a third reason, the increased ability to store video data based on employing Waehner's time lapse recording mode can allow for later review of fabrication procedures to identify "events that have not been detected and would otherwise be lost" such as when a defect in an object/design is detected a period of time after the fabrication process has completed. EX1010, [0010].

168. As a fourth reason, application of Waehner's teachings for allowing a user to select between regular, high-definition recording and time-lapsed recording would allow for "review[ing] of recent events" with "the maximum amount of information" in the video while providing the storage benefits that I mentioned above. EX1010, [0009].

169. As a fifth reason, a POSITA would have been prompted to modify Mazumder's rapid fabrication system (as already modified by Mori) to provide a control to capture a stop-motion (time lapse) animation of a fabrication of the object using the video camera in the user interface (as suggested by Waehner) because doing so would be merely the application of a known technique to a known system (e.g., Mazumder's remotely controlled rapid fabrication system)

ready for improvement to yield predictable results. Here, Waehner provides straightforward evidence of a known technique for selecting and setting parameters for a time lapse video recording mode and Mazumder's teaching (as modified by Mori) provides a known system that would have been improved by application of Waehner's suggested technique for at least the reasons described above. Based upon my knowledge and experience in this field and my review of Mazumder, Mori, and Waehner, I am confident a POSITA would have recognized that this modification would have yielded predictable results and required only routine adjustments to the system and as such a POSITA would have had a reasonable expectation of success in making such modifications. This modification would not have significantly altered or hindered the functions performed by Mazumder's system, and these modifications would have been within the predictable and ordinary level of skill of a POSITA (certainly by a time frame as late as 2010).

170. As demonstrated below, the predictable combination of Mazumder with Mori and Waehner renders obvious claim 17.

Claim [17]: The device of claim 1 wherein the user interface includes at least one control to capture a stop-motion animation of a fabrication of the object using the video camera.

171. Waehner demonstrates that the resulting Mazumder-Mori-Waehner system implements the user interface generated by Mazumder's local computer 70

for display at the remote computer 95 includes at least one control to capture a stop-motion animation of a fabrication of the object using the video camera. For example, Waehner describes “recording the received video data at a first rate, and recording the received video data at a second rate with the second rate being slower than the first rate.” EX1010, [0006]. This second mode “provides time lapse recording where the various cameras are recorded at a slower rate and, if desired, at a lower resolution but for a much longer period of time” which allows for easier “longer term archival storage” of such video. *Id.*, [0010].

172. The user of the system can provide various parameters for the two recording modes, including “the record rate in frames per second, recording resolution for each camera, how long that digital video recorder can record at maximum speed and how many channels of data will be sampled, compressed and stored as explained hereinafter in detail.” *Id.*, [0018]. The user provides such parameters via a user interface that can take the form of “control buttons” using “a workstation,” “personal computer,” or “laptop computer” to “provid[e] setup information over a network to digital video recorder 18.” *Id.* As such, a POSITA would have recognized that in the Mazumder-Mori-Waehner combination, the user interface provided by the local site for display at the remote computer would have included at least one control for capture of the time lapse video (stop-motion

animation) of the fabrication process. The end result is a time-lapse version of the video created by sampling “only one out of every predetermined number of sequential images or frames.” *Id.*, [0019]. This sampling “reduces the number of images per camera per second” to facilitate efficient storage “for a long period of time.” *Id.* A POSITA would have recognized that Waehner’s descriptions of a “time lapse” video provides, or at least renders obvious, the stop-motion animation recited by claim 17.

7.6. Ground 1F: The Combination of Mazumder with Mori and Lan Renders Obvious Claim 18

173. Multiple reasons would have motivated a POSITA to modify the system of Mazumder-Mori to further configure the processor of Mazumder’s local computer 70 to couple the three-dimensional printer in a communicating relationship with a remote print server through the data network (the Internet) for multiple reasons based on the suggestions of Lan. As a first reason, including a print server in the Mazumder-Mori system that is in communication with the local computer 70 (and remote computer 95) would have allowed for multiple remote users, each utilizing their own remote computing device, to easily identify and communicate with multiple rapid fabrication devices located at various geographic locations, to control and monitor various different types of rapid fabrication processes efficiently and effectively. Lan describes various different of web-based

rapid prototyping systems, including discussing functionality for “job planning and scheduling” and “remote control and monitoring for RP machines.” EX1011, 1.

As such, implementing Lan’s 3D printer scheduling using a remote print server facilitates multiple users interfacing with multiple different geographically disperse 3D fabrication devices in a straight forward manner using a common interface.

174. As a second reason, Lan describes that the job planning and scheduling functionality described therein can be facilitated through the user of print servers that match remote users to appropriate rapid prototyping devices “to maximize the system utilization and minimize the average response time for scheduling non-preemptive aperiodic tasks so that it is suitable for the distributed Web-based RP systems.” EX1011, 10. Lan shows example systems from several papers that use a remote print server to facilitate scheduling and remote control of various rapid fabrication devices:

H. Lan/Computers in Industry 60 (2009) 643–656

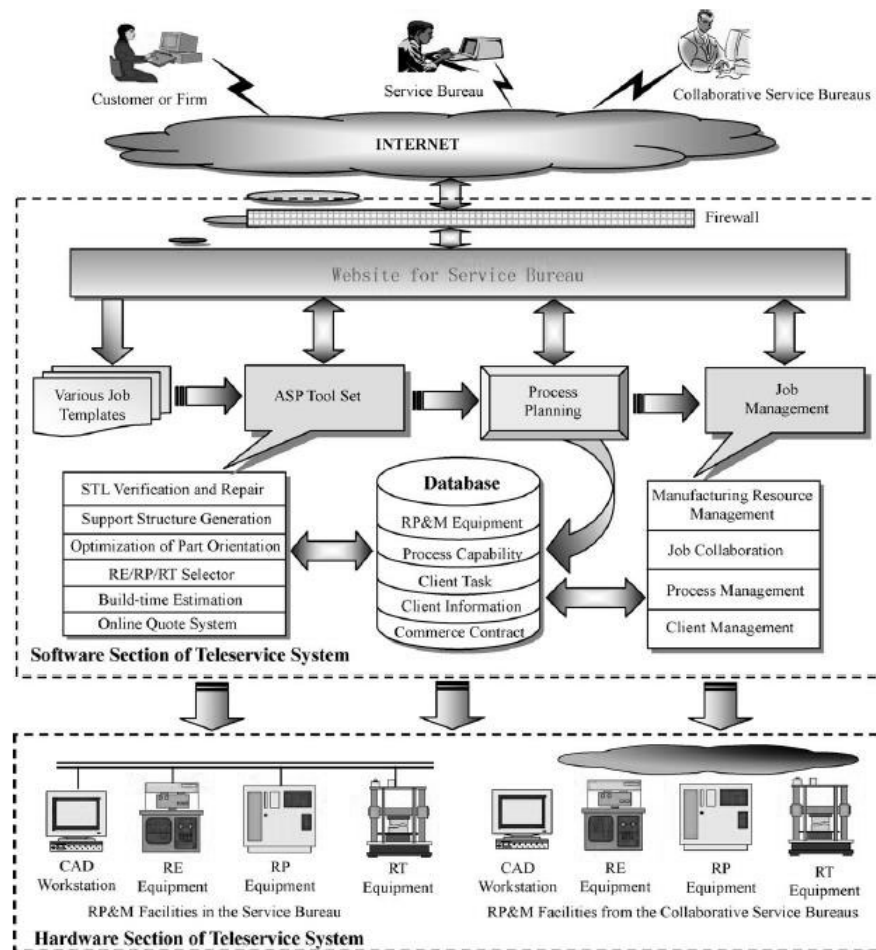


Fig. 4. Architecture of the Web-based RP&M system.

EX1011, 5.

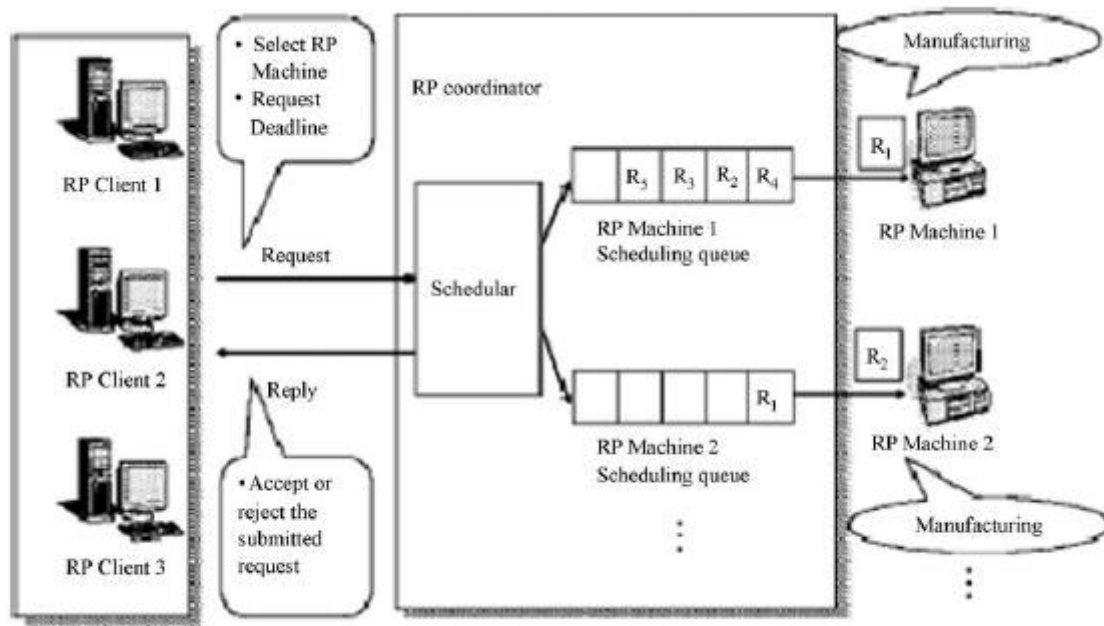


Fig. 10. Distributed RP platform scheduler [65].

EX1011, 10.

175. As a third reason, Lan describes that the Web server schedules the fabrication/print job with an available device based on capabilities of the available devices and requirements of the print job and “the Web server can transmit the STL file to the RP machine that [is] chosen by the customers.” EX1011, 3, 10. This use of an intermediary web-based print server allows for automated scheduling of rapid fabrication processes “to minimiz[e] idle time” and lower “the effective cost rate.” EX1011, 9-10, 3.

176. As a fourth reason, application of Lan's print server enabled techniques for matching users to remote 3D fabrication devices and automatically facilitating scheduling and transfer of design files to the fabrication devices achieves an "optimal" scheduling solution in which "new requests can be accepted dynamically and all accepted requests can be finished before deadlines" such that "the quality of service is significant[ly] improved." EX1011, 10, 5.

177. As a fifth reason, Applying Lan's print server enabled techniques to the Mazumder-Mori system would have allowed for automated selection of "a valid and feasible RP manufacturing site" for a given design so that the remote facility having the correct "site manufacturing capability" is selected while meeting "delivery time constraints." EX1011, 10. This includes automated RP&M process selection. *Id.*, 6-8.

178. As a sixth reason, Lan describes allowing "remote users [to] select a suitable RP through calculating possible delivery time" including providing "help [to] users to select an appropriate RP machine. EX1011, 10, 3, 5. As such, application of Lan's teachings to the Mazumder-Mori system would have allowed users to select a preferred remote rapid fabrication device, in at least some scenarios.

179. As a seventh reason, a POSITA would have been prompted to modify Mazumder's rapid fabrication system (as already modified by Mori) to include a remote print server in communication with Mazumder's local computer over the data network (as suggested by Lan) because doing so would be merely the application of a known technique to a known system (e.g., Mazumder's remotely controlled rapid fabrication system) ready for improvement to yield predictable results. Here, Lan provides straightforward evidence of a known technique for implementing a 3D printer in a networked 3D printer environment and Mazumder's teaching (as modified by Mori) provides a known system that would have been improved by application of Lan's suggested technique for at least the reasons described above. Based upon my knowledge and experience in this field and my review of Mazumder, Mori, and Lan, I am confident a POSITA would have recognized that this modification would have yielded predictable results and required only routine adjustments to the system and as such a POSITA would have had a reasonable expectation of success in making such modifications. This modification would not have significantly altered or hindered the functions performed by Mazumder's system, and these modifications would have been within the predictable and ordinary level of skill of a POSITA (certainly by a time frame as late as 2010).

180. As demonstrated below, the predictable combination of Mazumder with Mori and Lan renders obvious claim 18.

Claim [18]: The device of claim 1 wherein the processor is configured to couple the three-dimensional printer in a communicating relationship with a remote print server through the data network.

181. Lan demonstrates that in the Mazumder-Mori-Lan combination, the processor of Mazumder's local computer is configured to couple the three-dimensional printer in a communicating relationship with a remote print server through the data network. Lan teaches that rapid prototyping and manufacturing (RP&M) techniques "using the Internet can further enhance the design and manufacturing productivity, speed, and economy, as well as share the RP machines." EX1011, 1. Lan reviews various aspects of web-based rapid prototyping, including "job planning and scheduling" and "remote control and monitoring for RP machines." *Id.*

182. The job planning and scheduling functionality can be facilitated through the user of print servers that match remote users to appropriate rapid prototyping devices "to maximize the system utilization and minimize the average response time for scheduling non-preemptive aperiodic tasks so that it is suitable for the distributed Web-based RP systems." EX1011, 10. Lan shows example

systems from several papers that use a remote print server to facilitate scheduling and remote control of various rapid fabrication devices:

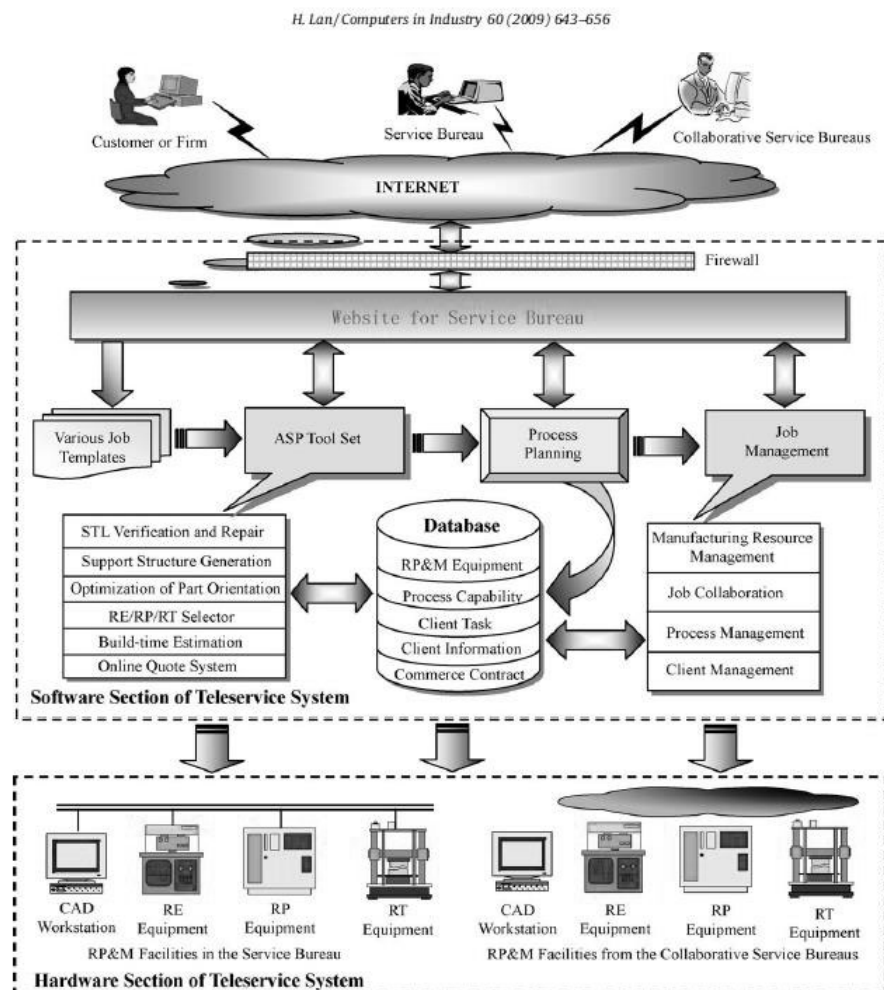


Fig. 4. Architecture of the Web-based RP&M system.

EX1011, 5.

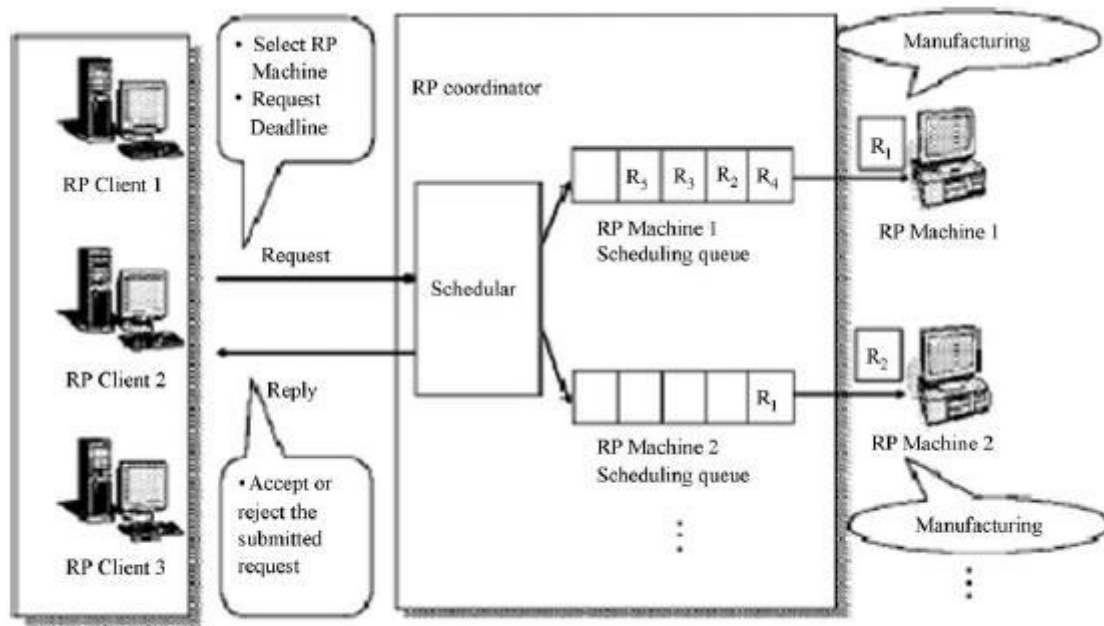


Fig. 10. Distributed RP platform scheduler [65].

EX1011, 10.

183. In one specific example, Lan describes that the user transmits the CAD model (an STL file) “via the Internet to the RP Web server” which then schedules the print job and “transmit[s] the STL file to the RP machine that [is] chosen by the customers.” EX1011, 3. In another example, the web server selects “a valid and feasible RP manufacturing site” for a given design so that the remote facility having the correct “site manufacturing capability” and schedules the print job “to minimiz[e] idle time.” *Id.*, 10. The user provides the STL file to the web server, which queues the print job for the appropriate fabrication machine. *Id.* A POSITA would have recognized that the web servers described in Lan, which

coordinate and schedule rapid fabrication jobs between multiple users and multiple rapid fabrication devices, and provide model data to those devices, meet the description of a print server in the '324 patent. EX1001, 9:4-37.

7.7. Ground 1G: The Combination of Mazumder with Mori and Anderson Renders Obvious Claims 20-22

184. Multiple reasons would have motivated a POSITA to modify the system of Mazumder-Mori to include additional status information in the user interface generated by Mazumder's local computer for presentation at the remote computer, including status information indicating if a design is waiting, printing, or done, the percentage of the object completed, and a comparison of the portion fabricated against a wire frame in the user interface for multiple reasons based on the suggestions of Anderson.

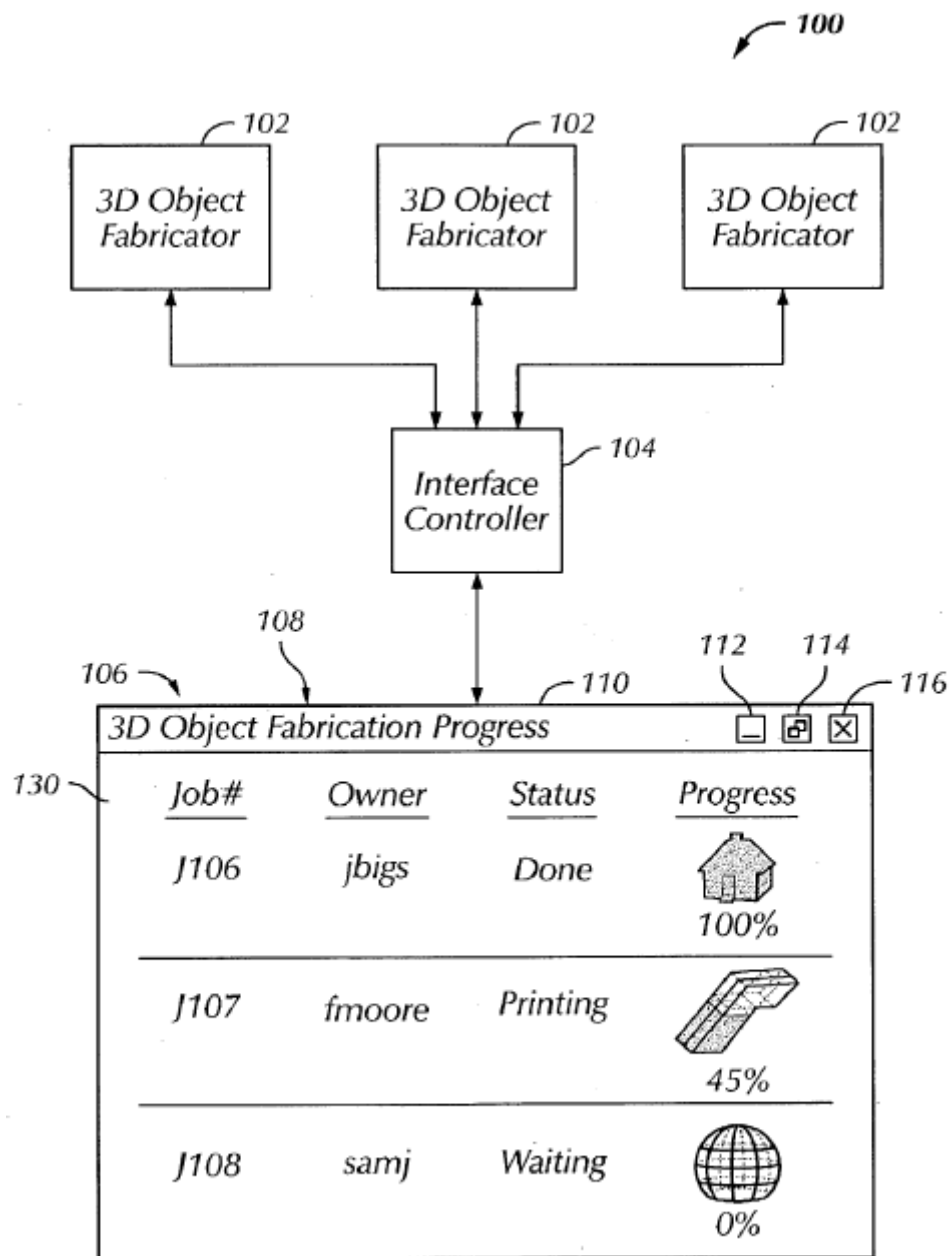


FIG. 1

EX1012, FIG. 1.

185. *As a first reason*, displaying such additional status information in the user interface of the resulting Mazumder-Mori-Anderson system would have helpfully provided extra context for the displayed virtual images of the object model. As discussed in Ground 1A, above, Mori discloses that in the Mazumder-Mori combination, the user interface includes displays of virtual images of the object being fabricated that are based on the model for the object. EX1005, [0059]-[0065], [0079]-[0083]. Anderson complements this teaching by providing additional context for the virtual view of the object by showing which layers have been completed with respect to a wireframe of the entire object and identifying a percentage that has been completed:

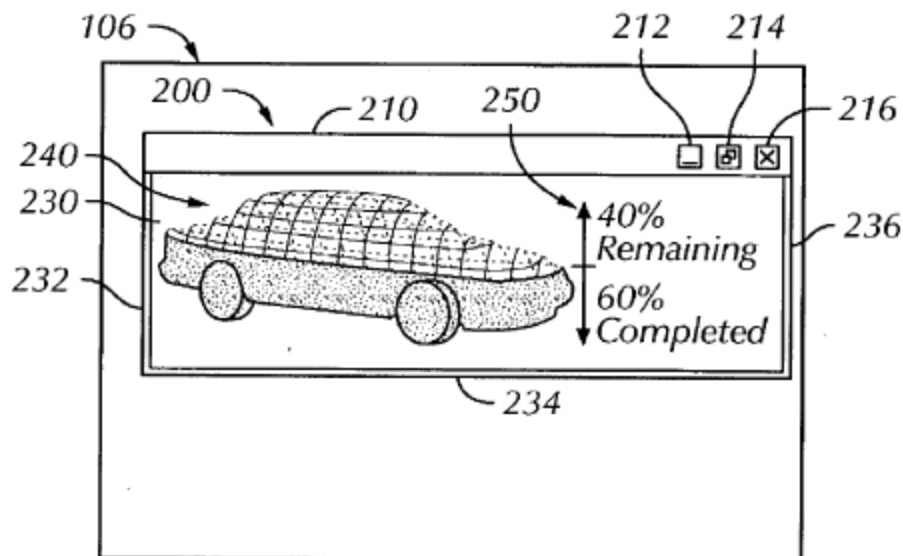


FIG. 2A

EX1012, FIG. 2A, [0018]-[0020].

186. Providing this additional information, including the virtual image of the object in comparison to the wireframe representing the completed object, and the percentage of the object that has been fabricated, would have increased the user's knowledge and understanding of the overall fabrication process and help the user to visualize the completed portion of the object with respect to the full design.

187. As a second reason, displaying this the additional information regarding progress of the fabrication process, including the virtual image of the object in comparison to the wireframe and numerical indications of the percentage of completion of the fabrication process, would help the user to readily assess the progress of the fabrication process and estimate the amount of time remaining

188. As a third reason, displaying this additional status information described by Anderson would have allowed users to easily identify where in a print queue the user's particular design is to help the user to better schedule other tasks with respect to the rapid fabrication process. For example, the user interface elements shown in Figure 1 of Anderson not only display progress of jobs in progress but also indicate the status of whether a print job is completed, in progress, or queued for future execution:

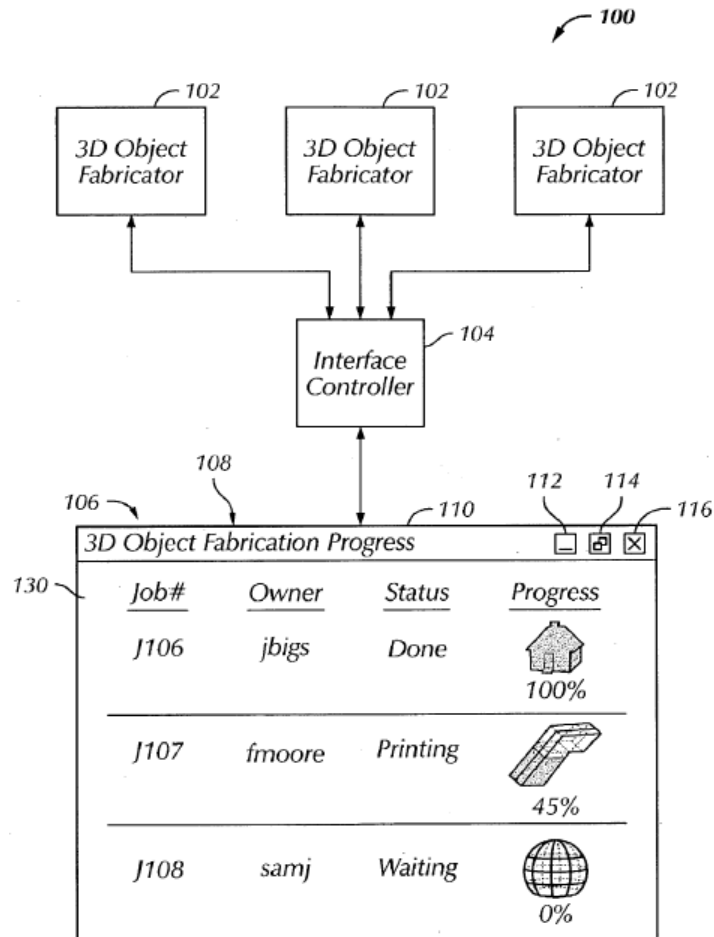


FIG. 1

EX1012, FIG. 1, [0019].

189. As a fourth reason, providing visual indicators of completion of the fabrication process for a given fabrication project in the user interface displayed to the remote user would have allowed users to conduct post fabrication actions (such as communicating with persons at the local fabrication site) in a timely manner.

190. As a fifth reason, a POSITA would have been prompted to modify Mazumder's rapid fabrication system (as already modified by Mori) to include the additional visual status information described by Anderson in the user interface displayed at the remote computer because doing so would be merely the application of a known technique to a known system (e.g., Mazumder's remotely controlled rapid fabrication system) ready for improvement to yield predictable results. Here, Anderson provides straightforward evidence of a known technique for providing status information for a 3D printing process to a remote user and Mazumder's teaching (as modified by Mori) provides a known system that would have been improved by application of Anderson's suggested technique for at least the reasons described above. Based upon my knowledge and experience in this field and my review of Mazumder, Mori, and Anderson, I am confident a POSITA would have recognized that this modification would have yielded predictable results and required only routine adjustments to the system and as such a POSITA would have had a reasonable expectation of success in making such modifications. This modification would not have significantly altered or hindered the functions performed by Mazumder's system, and these modifications would have been within the predictable and ordinary level of skill of a POSITA (certainly by a time frame as late as 2010).

191. As demonstrated below, the predictable combination of Mazumder with Mori and Anderson renders obvious claims 20-22.

Claim [20]: The method of claim 19 further comprising transmitting status information over the data network upon completion of the object.

192. Anderson demonstrates that in the resulting Mazumder-Mori-Anderson combination, the 3D printing system at Mazumder's local sight transmits status information over the data network upon completion of the object. This is demonstrated, for example, by Figure 1 of Anderson, which shows that the status information in the user interface includes changing the "status" of the object fabrication process to "Done" upon completion of the object and updating the "progress" indicator to show that the wireframe of the model of the object as 100% filled in. EX1012, [0019], [0021].

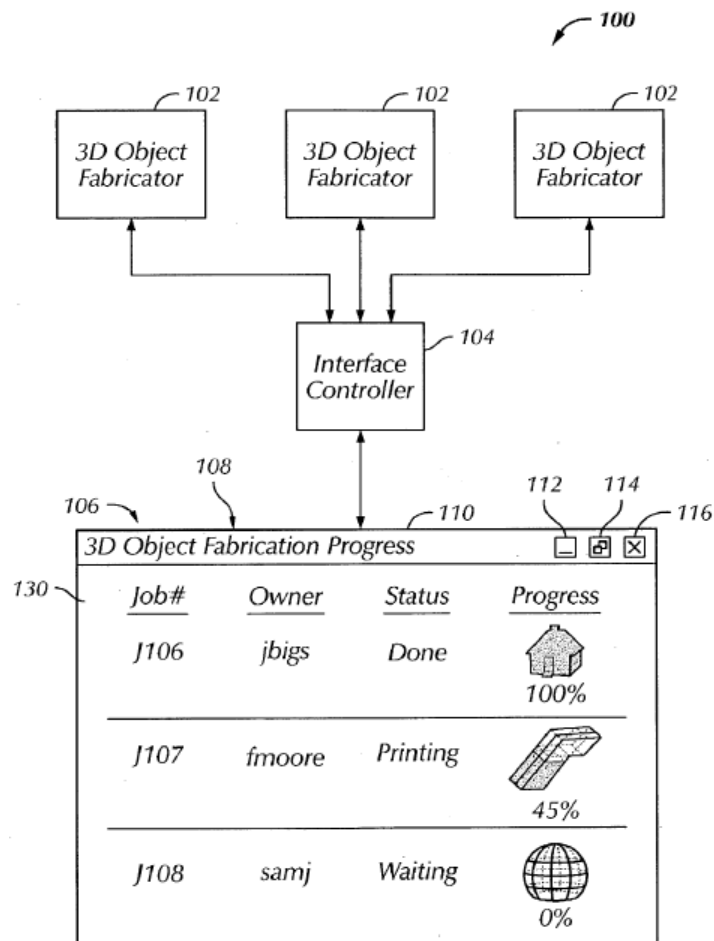


FIG. 1

EX1012, FIG. 1. A POSITA would have recognized that this change of the status to “Done” upon completion of the object satisfies claim 20.

Claim [21]: *The method of claim 20 wherein the status information includes data presented through the user interface.*

193. As I discussed with respect to Ground 1A, above, Mazumder discloses that the local computer “sends the images together with the associated temperature, strain and stress data to the remote computer 95 to be displayed.” EX1004, 6:24-

55, Abstract. Specifically, when addressing Element [1.d] in Ground 1A, above, I explained that this status information would have been displayed as part of the user interface generated by the local computer 70 and transmitted to the remote computer 95 for display in the web browser executing at the remote computer. Anderson discloses that in the Mazumder-Mori-Anderson combination, the additional status information disclosed by Anderson is also displayed as part of the user interface displayed at the remote device which can be “implemented via the printer driver” of the computing device at the fabrication site. EX1012, [0017]-[0021].

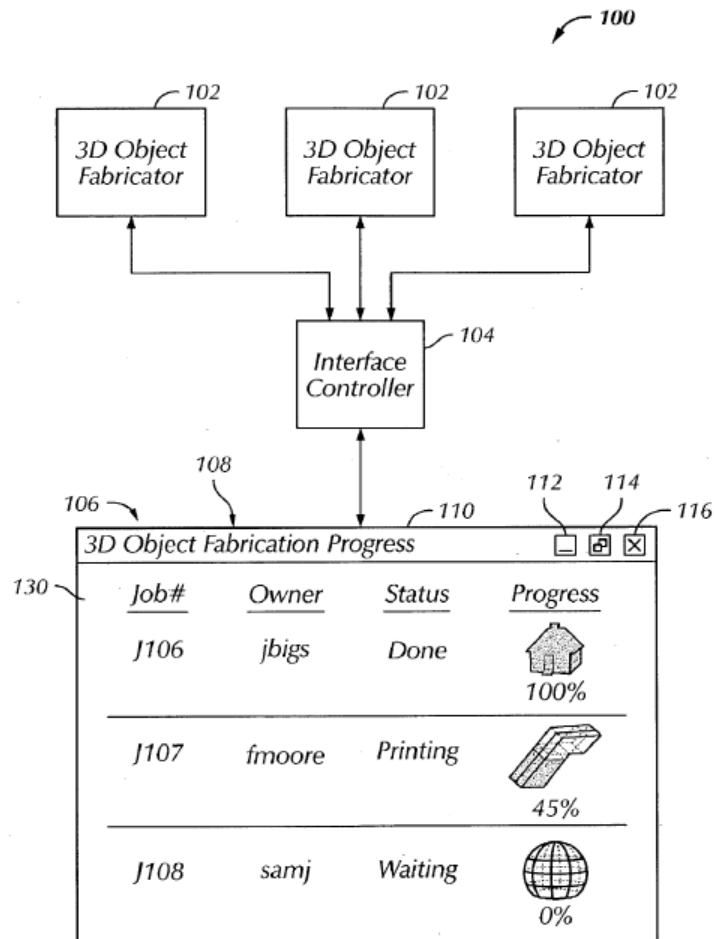


FIG. 1

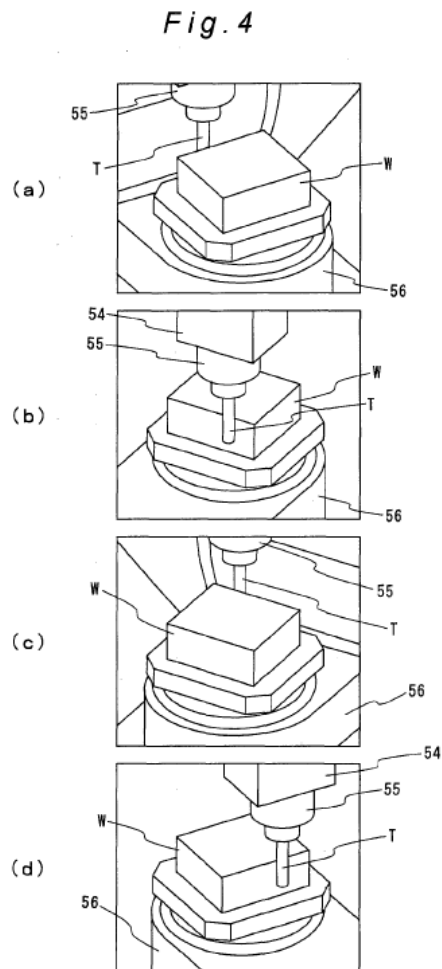
EX1012, FIG. 1.

Claim [22]: *The method of claim 20 wherein the status information includes a digital image from the video camera.*

194. The combination of Mazumder with Mori and Anderson provides this claim for the reasons that I discussed above with respect to Element [1.d] and claims 6 and 20-22 in Ground 1A. For example, Mazumder describes that “a video or TV camera 65 records the laser-aided DMD process and transmits the images to

the local computer 70, which then sends the images together with the associated temperature, strain and stress data to the remote computer 95 to be *displayed preferably on a TV screen or shown on the remote computer monitor as streaming video.*” EX1004, 6:36-43. As Mazumder describes, “visual images or metrological information collected at the local manufacturing site 205 are all processed through the local computer 70” and as such, it is the processor of the local computer 70 that provides the user interface containing the video images. *Id.*, 6:44-48. In another example, Mazumder describes that the “manufacturing system” includes “a video or television camera recording the fabrication process and *transmitting the images to be viewed on a screen display situated at the remote computer system.*” *Id.*, 8:13-17, 8:51-54, Abstract.

195. Mori provides similar disclosure, describing that “the actual CCD cameras 11, 12, 13 and 14 are arranged to surround the workpiece W on the table 56, and are configured so as to be able to image the workpiece W from four directions” to “generate two-dimensional image data (actual image data) thereof” as shown in FIG. 4. *Id.*, [0049]-[0050]. Figure 4 shows images of the workpiece within Mori’s rapid fabrication device as captured by each of Mori’s four CCD cameras:



EX100, FIG. 4.

196. I have reviewed portions of the Patent Owner's infringement contentions and it appears that Patent Owner contends in the district court litigation that merely displaying video camera images of the product at a remote computer satisfies this claim. EX1016, 187-189. As such, Mazumder's descriptions of displaying the image data captured by the camera of the object being fabricated in

the user interface presented at the remote computer demonstrate that the Mazumder-Mori combination meets this claim. EX1004, 6:36-43, 8:14-17.

7.8. Ground 2A: The Combination of Krtichman with Tay and Henke Renders Obvious Claims 1, 3, 5-7, 9-10, and 19-22

197. A POSITA would have recognized that the teachings of Tay and Hanke would have been readily applied to the 3D printer system of Kritchman for multiple reasons to achieve predictable benefits. As I discussed above, Kritchman describes a 3D printing system having “a printing apparatus to print three-dimensional objects; a controller that may prepare the digital data that characterizes the 3-D object for printing, and control the operation of the printing apparatus; and a printing tray with a selected adhesion characteristic.” EX1015, [0005].

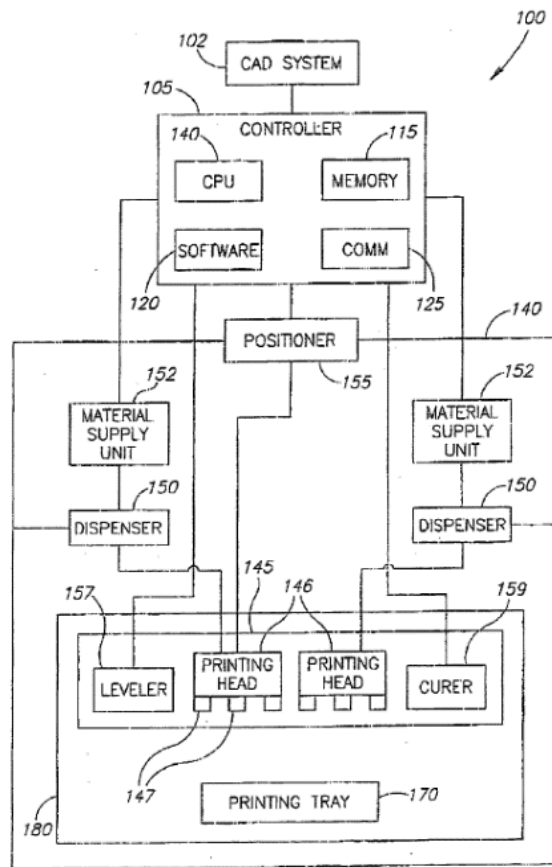


FIG.1

EX1015, FIG. 1.

198. A POSITA would have predictably applied the teachings of Tay to Kritchman to allow for communication, including file transfer, between Kritchman's 3D printer and a remote computer over the internet to allow the user of the remote computer to control Kritchman's 3D printer and monitor the 3D printing process (as taught by Tay). *As a first reason*, Kritchman already describes utilizing an external computer to perform at least some of the control functionality

for Kritchman's 3D printer. For example, Kritchman describes that "an external control or processing unit (e.g., a personal computer, workstation, computing platform, or other processing device) may provide some or all of the printing system control capability." EX1015, [0075]. Kritchman's unaltered system also includes a communications unit 125 for communicating with such an external computer, describing that "[c]ommunications unit 125 may, for example, enable transfer of data and instructions between controller 105 and CAD module 102, between controller 105 and printing apparatus 140, and/or between controller 105 and other system elements." *Id.*, [0073].

199. Tay provides additional, helpful teachings that compliment these disclosures of Kritchman by providing additional details on how to implement a system in which a remote computing device controls part of the 3D printing process via communication with the 3D printer over the internet. For example, applying Tay's teachings to Kritchman would beneficially facilitate "a wide audience using a disparate range of computer systems to access remotely located rapid prototyping facilities" via already existing Internet infrastructure. EX1013, 1, 6. Tay describes that use of rapid prototyping in product development can "considerably reduce the product development lead time." EX1013, 2, 6. Applying Tay's teachings to Kritchman to allow a remote computer to access Kritchman's

3D printer over the internet would have predictably “enhance[d] the accessibility of available rapid prototyping services to a broader community of users” and thus allowed a greater number of users to achieve the reduced cost and product development lead time afforded by use of rapid prototyping machines, such as Kritchman’s 3D printer. *Id.*, 2. As such, in the resulting system “[m]ore effective utilization of geographically distributed resources is realized.” EX1013, 6.

200. As a second reason, application of Tay’s suggestion to allow for remote control and observation of 3D printing jobs performed by Kritchman’s 3D printer would have “provid[ed] manufacturing facilities to geographically separated partners.” EX1013, 2. Therefore, such a modification would have allowed geographically distributed teams to advantageously work together when developing prototypes through utilization of Krtichman’s rapid prototyping system “without the need for their own investment for setting up costly prototyping facilities.” *Id.* As such, applying Tay’s teachings to Kritchman would have lowered barriers of entry for product development teams designing and fabricating prototypes that could be used for testing and further refinement.

201. As a third reason, a POSITA would have recognized that Tay’s “platform neutral framework” that “is kept simple” by implementing a remote user interface through a generic web browser and is “very transparent and user friendly”

without requiring “extra plug-ins to run the application” would make application of Tay’s teachings to a variety of rapid fabrication devices, including the 3D printer of Kritchman, relatively straight forward. EX1013, 2-4. Such a platform neutral framework also would have made accessing Kritchman’s 3D printer remotely rather straightforward and easy as remote users would only need to have access to a computing device with a generic web browser and an Internet connection.

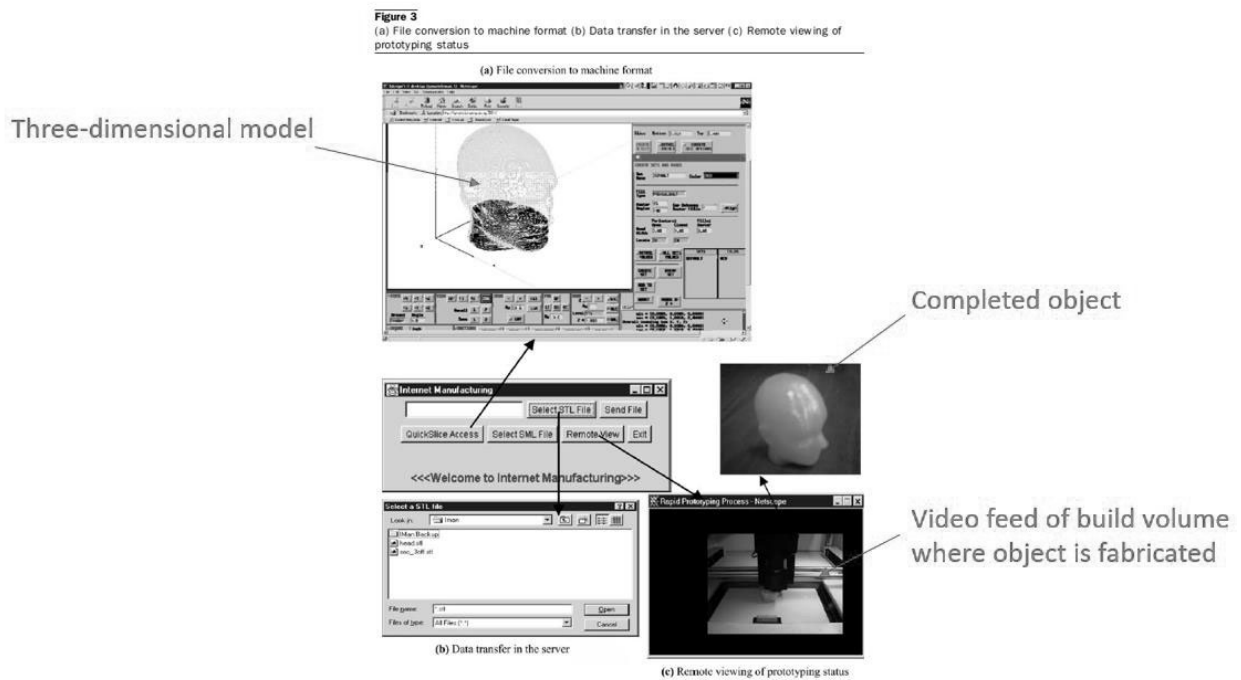
202. *As a fourth reason*, Tay also provides convenient remote monitoring of the fabrication process through one or more WebCams to allow improved remote control and provide observation for “multiple clients” in different locations. EX1013, 4. Application of Tay’s teachings regarding remote viewing of the fabrication process to Kritchman’s 3D printer would have advantageously allowed remote users to visually identify defects or problems in the fabrication process, including defects in the object being fabricated or malfunctioning of the 3D printer itself. As such, remote users would be able to stop defective fabrication processes and improve the design of the object or adjust fabrication process parameters to improve the fabrication process.

203. A POSITA also would have recognized multiple reasons to beneficially apply the teachings of Henke to Kritchman’s system (modified to include Tay’s remote control and monitoring functionality) to further include

functionality to display both the actual video images of the fabrication process (as captured by a camera at the fabrication system, as taught by Tay) and the virtual model of the process simultaneously and from the same viewing perspective.

EX1014, 5. A POSITA would have further applied Henke's teachings to the Kritchman-Tay system to provide additional control functionality in the user interface at the remote computer to allow the remote user to control the fabrication process, such as by including start, stop, or reset commands in the user interface, as suggested by Henke. EX1014, 5.

204. As a first reason, as I discussed above, Tay describes displaying an image of the model of the object to be fabricated and actual images of the object as it is being fabricated using a camera located at the 3D printer, as shown in Figure 3 of Tay:



EX1013, 5.

205. Henke provides additional teachings that would have been directly applicable to Tay's user interface, describing a user interface for facilitating remote control and observation of an automated process process via the Internet, including displaying camera images of the actual hardware, a model of a virtual version of the hardware, and other status and control information, as shown in Figure 8:

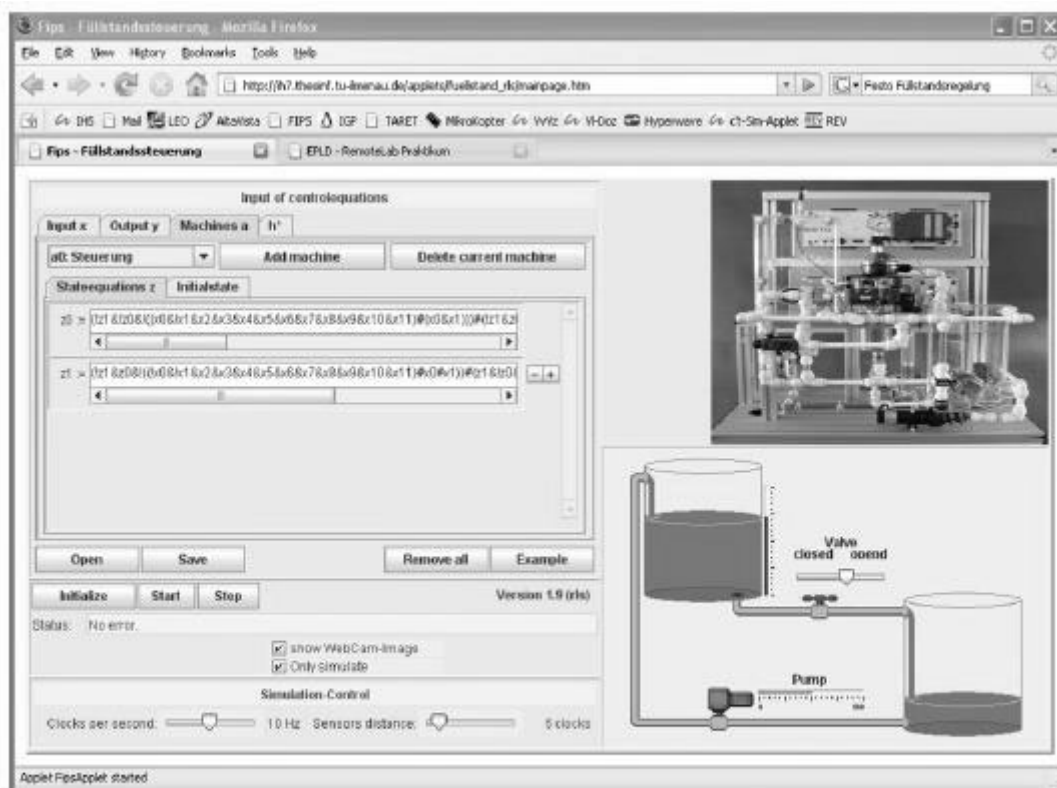


Figure 8. Online control of the Water level control - with Internet connectivity to the Remote Lab

EX1014, 5.

206. A POSITA would have predictably applied this teaching to the Kritchman-Tay system to simultaneously display actual images of the fabrication process and the visual representation of the model (from the same perspective as the actual images) on the remote client device. Such an implementation would have beneficially allowed the user to visually compare the actual images to the simulated images (based on the model) to quickly identify whether the fabrication

process is proceeding correctly and that the object matches the model. Kritchman expressly teaches that one of its goals is to prevent “defects in the finished product.” EX1015, [0071], [0080]. Application of Henke’s teachings to the Kritchman-Tay system would have furthered this goal by facilitating onscreen visual comparison of the model and the actual object being fabricated to detect defects. Based on these detected defects, the remote user could then “adjust” the fabrication process or model to eliminate faults and “achieve a fault free solution.” EX1014, 5.

207. As a second reason, a POSITA would have recognized that displaying the virtual model of the process simultaneously with the actual images of the process (as suggested by Henke) would have allowed the user to of the remote computer to monitor the progress of the object even when the actual view of the object is partially or totally obscured. For example, a POSITA would have recognized that in some cases, based on the angle of the camera, the material deposition head/extruder or another part of the rapid fabrication device may temporarily partially or completely obscure the camera’s view of the object being fabricated in the build volume. As another example, a support structure or other material involved in the manufacturing process that is not part of the intended finished object being manufactured may obscure the view of some or all of the

object. As such, a POSITA would have recognized that it would have been beneficial to display a virtual view of the object from the same angle (based on Henke's suggestion) such that the user can visually recognize the machining status of the object being fabricated.

208. As a third reason, applying the suggestions of Henke to the Kritchman-Tay system to display virtual images generated from the three-dimensional model at the same time and from the same perspective as the actual images of the fabrication process captured by the camera at the 3D printer would have provided more full information to the remote user to allow the user to better monitor all aspects of the fabrication process.

Finally, a POSITA would have been prompted to modify Kritchman's 3D printer to include in the user interface and remote control and monitoring functionality of Tay, and the additional user interface display elements and control remote control functionality disclosed by Henke, because doing so would be merely the application of known techniques (as suggested by Tay and Henke) to a known system (e.g., Kritchman's 3D printer having the controller and communications unit) ready for improvement to yield predictable results. Here, Tay and Henke provide straightforward evidence of known techniques for remotely controlling and monitoring an automated process, and Kritchman's

teaching provides a known system that would have been improved by application of the suggested techniques of Tay and Henke for at least the reasons described above. Based upon my knowledge and experience in this field and my review of Kritchman, Tay, and Henke, I am confident a POSITA would have recognized that such modifications would have yielded predictable results and required only routine adjustments to the system to provide the additional functionality disclosed by Tay and Henke and as such a POSITA would have had a reasonable expectation of success in making such modifications. This modification would not have significantly altered or hindered the functions performed by Kritchman's system, and these modifications would have been within the predictable and ordinary level of skill of a POSITA (certainly by a time frame as late as 2010). Indeed, Kritchman states that "[i]t should be appreciated by persons skilled in the art that many modifications, variations, substitutions, changes, and equivalents are possible in light of the above teaching" and both Tay and Henke propose just such modifications that would have been beneficially applied to Kritchman for the reasons stated above. EX1015, [0157]. Similarly, Tay states that "[f]uture research works" will include designing "[a] highly interactive GUI...to communicate with the Programmable Logic Controller...to achieve more intelligent functions of the system remotely" and Henke describes desirable features to include in these future

GUI developments. EX1013, 6. Additionally, although Tay contemplates separating its “server applications and front-end terminal applications,” a POSITA would have recognized that improvements in computing capacity between Tay’s 1999 submission date and the 2010 priority date of the ’324 patent would have rendered such a separation unnecessary and thus Kritchman’s single, integrated controller implementation would have readily handled the additional functionality described in Tay (and Henke). EX1013, 3.

209. As demonstrated below, the predictable combination of Kritchman with Tay and Henke renders obvious all elements of claims 1, 3, 5-7, 9-10, and 19-22 of the ’324 patent.

Element [1.pre]: A device comprising:

210. To the extent the preamble is considered limiting, Kritchman (as predictably modified based on Tay and Henke) discloses the claimed device in the form of “a printing apparatus to print three-dimensional objects; a controller that may prepare the digital data that characterizes the 3-D object for printing, and control the operation of the printing apparatus; and a printing tray with a selected adhesion characteristic.” EX1015, [0005].

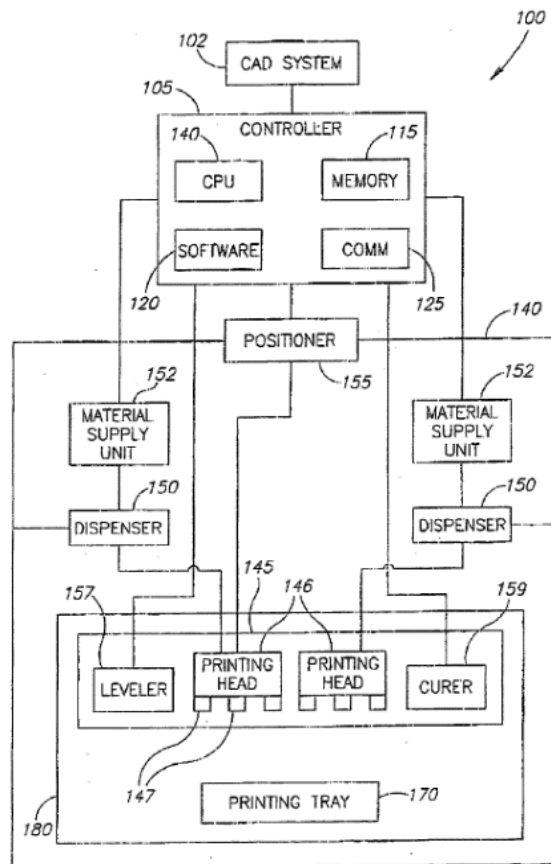


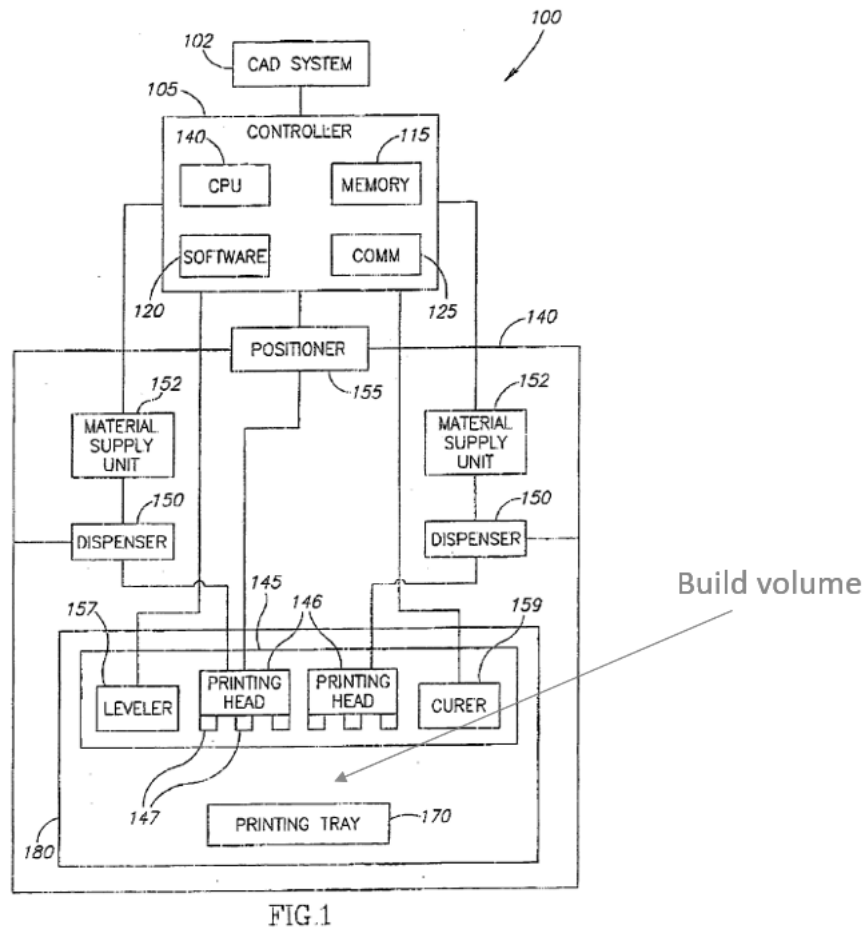
FIG.1

EX1015, FIG. 1.

211. Kritchman discloses that “[c]ontroller 150 may be located inside printing apparatus 140” and as such, a POSITA would have recognized that Kritchman’s printing apparatus, including the controller 105 having a CPU and communications unit, is a device. EX1015, [0075], [0073] (“Controller 105 may be suitably coupled and/or connected to various components of printing apparatus 140.”).

Element [1.a]: a three-dimensional printer including a build volume;

212. Kritchman discloses a three-dimensional printer including a build volume. For example, Kritchman discloses that its “3D printer system 100” includes “printing apparatus 140.” EX1015, [0072]-[0075]. Kritchman describes the knowledge of a POSITA that “[v]arious systems have been developed for three-dimensional printing, wherein material for object printing is deposited in consecutive layers according to a pre-determined configuration or in selected arrays as defined by, for example, a Computer Aided Design (CAD) system connected to the printing systems.” *Id.*, [0003]. In describing various embodiments depicted in the figures, Kritchman describes that “a printing apparatus for three-dimensional printing may be provided that may include a printing head (e.g., an ink jet head or another suitable material deposit system or dispenser) to deposit material for a three-dimensional object; a printing tray to support the objects being printed by the apparatus; and a temperature control unit to control the temperature in the apparatus.” EX1015, [0007]. A POSITA would have recognized that, as shown in Figure 1, the printing tray 170 (and the work space immediately above) is a build volume. EX1015, [0074], [0085]-[0088].

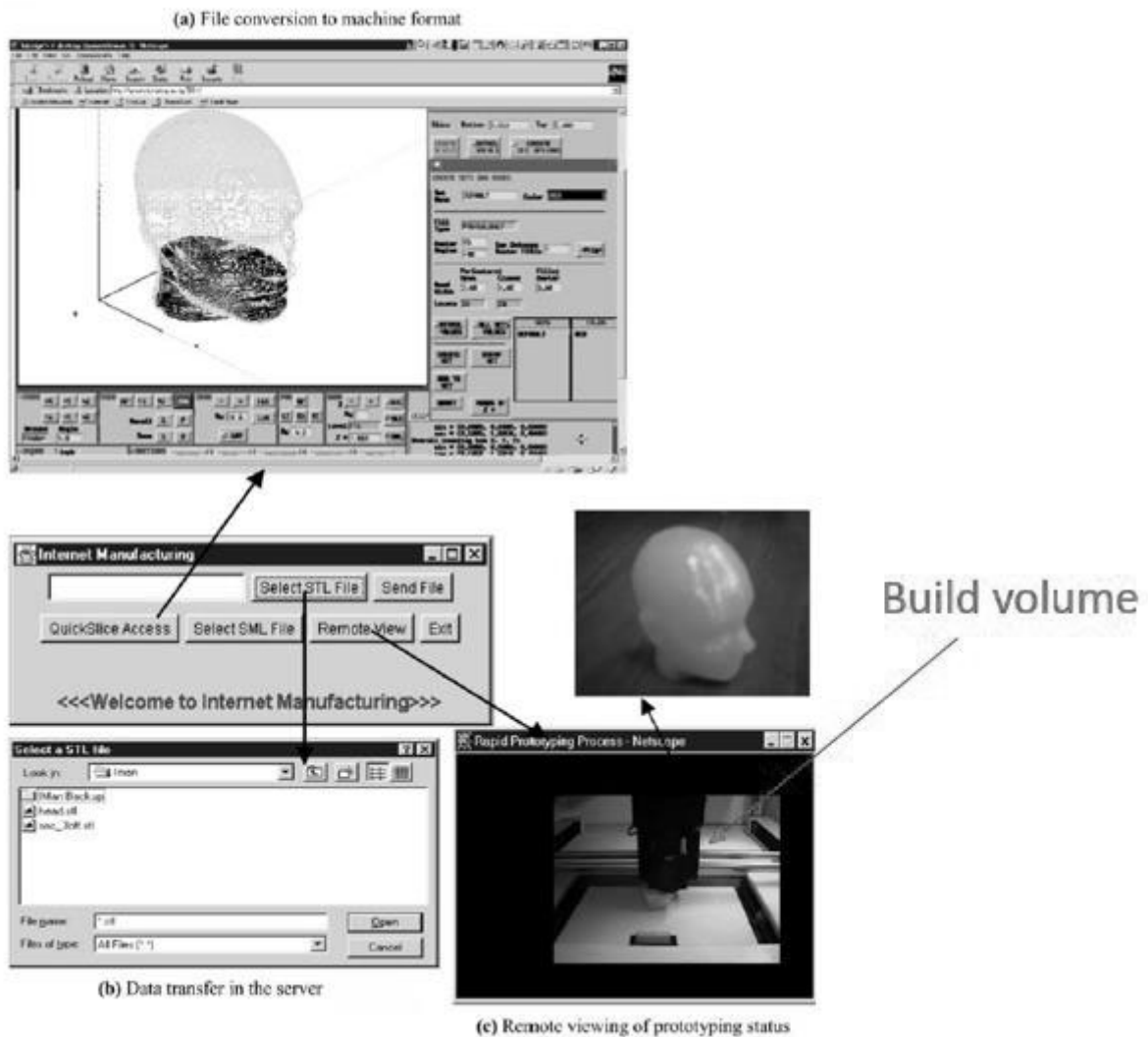


EX1015, FIG. 1.

213. Consistent with Kritchman's disclosure, Tay similarly depicts a build volume in the 3D printer:

Figure 3

(a) File conversion to machine format (b) Data transfer in the server (c) Remote viewing of prototyping status



EX1013, 5.

Element [1.b]: a network interface coupled to a data network;

214. The Kritchman-Tay-Henke system demonstrates that the resulting device includes a network interface coupled to a data network. For example, a

POSITA would have recognized that Kritchman's communications unit 125 is a network interface because "[c]ommunications unit 125 may, for example, *enable transfer of data and instructions between controller 105* and CAD module 102, between controller 105 and printing apparatus 140, and/or between controller 105 and *other system elements*." EX1015, [0073]. Kritchman goes on to describe that these "other system elements" can include "an external control or processing unit (e.g., a personal computer, workstation, computing platform, or other processing device) [that] provide some or all of the printing system control capability." *Id.*, [0075]. As I discussed above, the communications unit 125 is part of the controller 105 and "[c]ontroller 150 may be located inside printing apparatus 140." *Id.*, [0075], [0073].

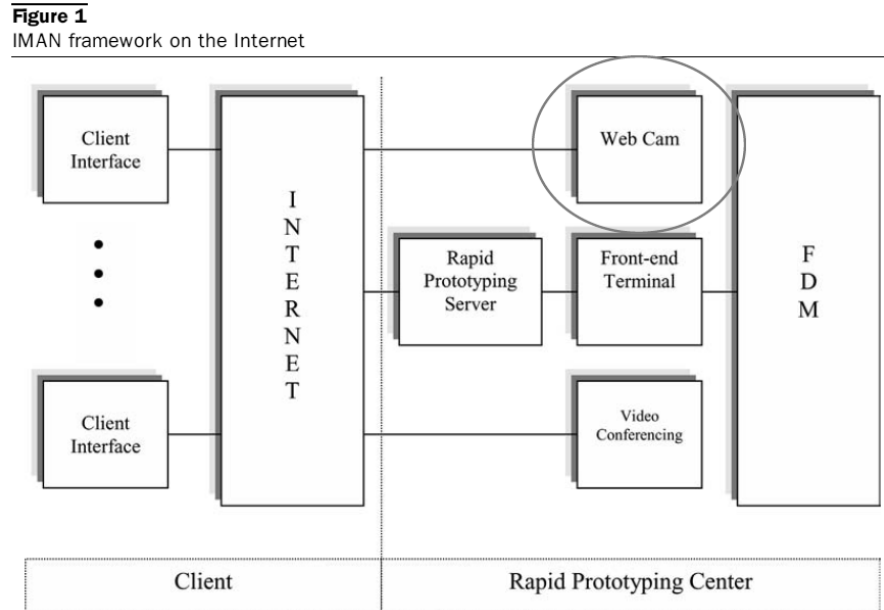
215. As I described above, Tay's teachings would have been predictably applied to Kritchman's system such that Kritchman's "communications unit 125" of the controller 105 would have predictably functioned as a "network interface" to the Internet to allow for remote control of the fabrication process by a remote user over the Internet. EX1013, 1. Such an implementation would have allowed "a wide audience using a disparate range of computer systems to access remotely located rapid prototyping facilities" via already existing Internet infrastructure. EX1013, 1. For example, Tay describes that "[m]ore effective utilization of

geographically distributed resources is realized using one [of] the cheapest sources of data carrier – the Internet as the means of communications.” *Id.*, 6. As such, “prototyping can be further enhanced by use of the distributed rapid prototyping system via the Internet for remote prototyping to considerably reduce the product development lead time.” *Id.* As such, a POSITA would have applied Tay’s teachings to Kritchman such that Kritchman’s communications unit 125 would have been implemented to remotely communicate with the remote computer over the internet to achieve the benefits that I previously discussed. EX1013, 1, 2 (“Internet: as the standard communications infrastructure”), 3-4 (“The client and server applications are linked to one another via the Internet.”), 6.

Element [1.c]: a video camera positioned to capture video of the build volume from a point of view; and

216. Kritchman includes a brief disclosure that its 3D “printer system” can include an “imager.” EX1015, [0059]. Tay provides additional details demonstrating that in the predictable combination “audio and visual feedback” are provided from the rapid prototyping center (Kritchman’s 3D printer) “by the use of Web cam and video conferencing.” EX1013, 4. For example, Tay describes that “multiple clients could be allowed to watch the same fabrication process for discussion and analysis.” *Id.* In another example, Tay describes “video conferencing and concurrently viewing of the rapid prototyping status. *Id.* Figure

1 of Tay shows the Web Cam positioned at the rapid prototyping center, which in the predictable combination would be Kritchman's 3D printing apparatus.

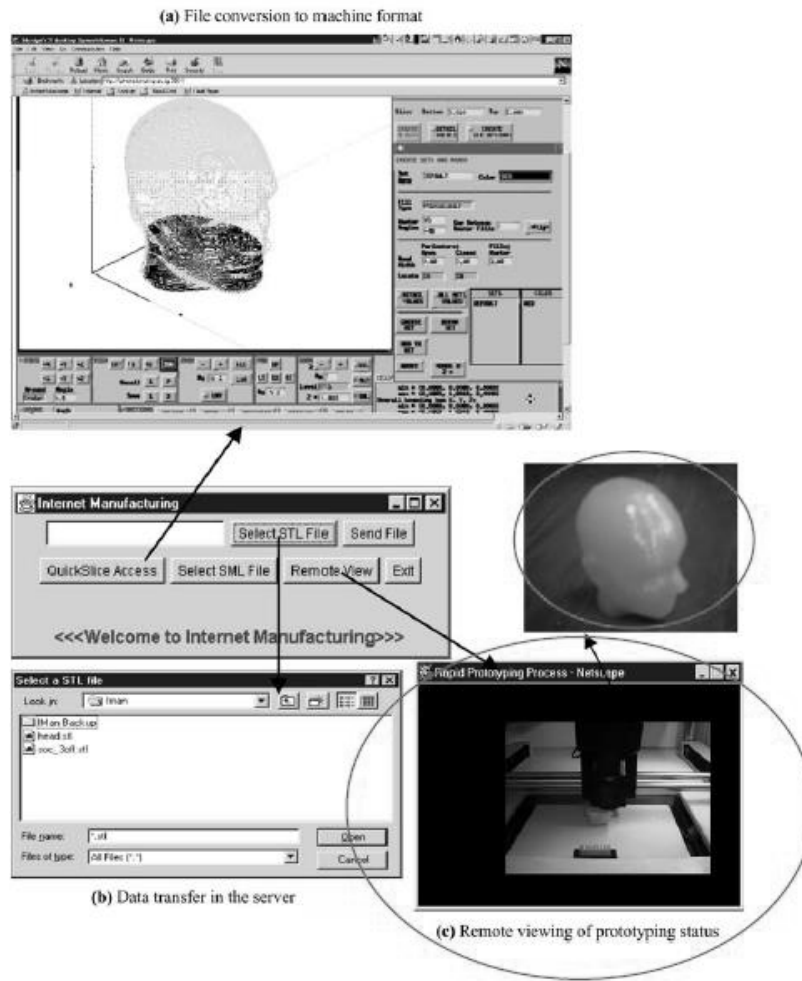


EX1013, 3.

217. Figure 3 of Tay shows images displayed in the user interface at the remote client computer as captured by the camera located at the 3D printer:

Figure 3

(a) File conversion to machine format (b) Data transfer in the server (c) Remote viewing of prototyping status



EX1013, 5. A POSITA would have recognized that, in the predictable combination of Kritchman with Tay and Henke, the Web Cam disclosed by Tay would have been integrated into Kritchman's 3D printer apparatus (e.g., as the "imager" of Kritchman's 3D printer). As I discussed above, Kritchman discloses that the various controller and feedback components described by Kritchman are integrated as part of the 3D printer apparatus. EX1015, [0073]-[0075]. A POSITA

would have similarly implemented Tay's Web Cam to be integrated as part of the 3D printer apparatus to allow for control and positioning of the Web Cam and communication with the Web Cam to be controlled by Kritchman's controller 105 (based on communication with Tay's remote client device).

218. Not only is this predictable option consistent with Kritchman's FIG. 1 and other teachings, it is likewise corroborated by Henke, which similarly describes allowing the remote user to "watch the laboratory procedure by supervising the model and environmental variables inside an I/O monitor or by observing the hardware model directly via a Web-Cam." EX1014, 5, 6 ("...supervising the hardware equipment via Web-Cam (a video camera with internet connectivity)"), Figure 8.

Element [1.d]: a processor configured to receive a three-dimensional model through the network interface, and to control operation of the three-dimensional printer to fabricate the three-dimensional model as an object within the build volume of the three-dimensional printer, the processor further configured to provide a user interface to a remote user accessing the device through the network interface, and to present in the user interface an image of the build volume from the video camera and a two-dimensional projection of the three-dimensional model from the point of view of the video camera.

219. Kritchman discloses a processor that, when predictable combined with the teachings of Tay and Henke, provides all of the functionality recited by this claim element. For example, Kritchman describes that its 3D printer includes a

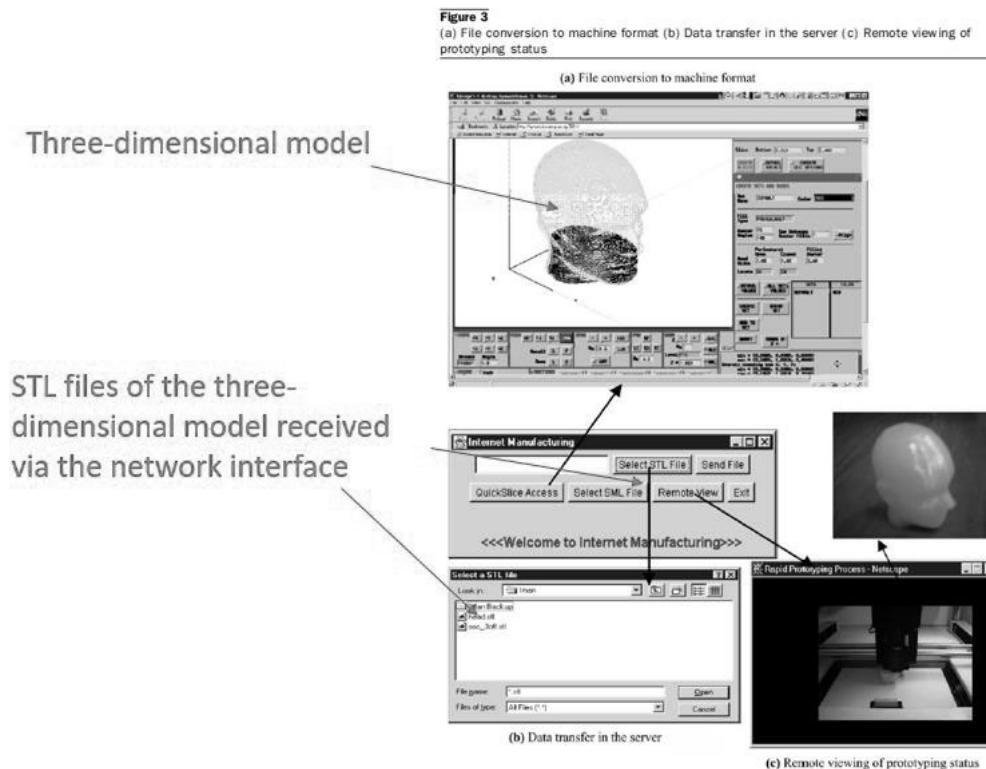
“**[c]ontroller 105**, which may prepare the digital data that characterizes a 3-D object for printing, and **control the operation of the printing apparatus**, may include, for example, **a processor 110**, a memory unit 115, software code 120, and a communications unit 125.” EX1015, [0073], FIG. 1. Kritchman goes on to describe that “[c]ontroller 105 may be implemented using **any suitable combination of hardware and/or software**. In some embodiments, controller 105 may include, for example, a processor 110, a memory 115, and software or operating instructions 120. **Processor 110 may include conventional devices, such as a Central Processing Unit (CPU), a microprocessor, a “computer on a chip”, a micro controller, etc.**” *Id.*, [0077].

220. Kritchman also discloses receiving a three-dimensional model through the network interface (the communications unit 125). Specifically, Kritchman’s “[c]ommunications unit 125” (i.e., the network interface) “enable[s] transfer of data and instructions between controller 105 and CAD module 102” such that the controller 105 receives “Computer Object Data (COD) representing an object or **a model**, for example, **CAD data in STL format**” from an external CAD system/module 102. EX1015, [0072]-[0075], FIG. 1. The controller 105 converts this CAD model data “to instructions for the various units within 3D printer system 100 to print a 3D object.” *Id.*, [0075]. This and other disclosures of Kritchman

reveal that the processor of the controller 105 controls operation of the three-dimensional printer to fabricate the 3D object and that this fabrication occurs within the build volume defined by/above printing tray 170. EX1015, [0074], [0085]-[0088].

221. In applying Tay's teachings to Kritchman's 3D printing system, a POSITA would have implemented Kritchman's CAD module 102 is part of the remote client device, which allows the remote user to provide the CAD model through the Internet via the network interface. Such an implementation would have allowed the user at the remote client device to generate and modify the CAD model for use in fabricating the object at Kritchman's 3D printer. For example, Tay describes that its remotely controlled rapid fabrication system provides "reliable data transfer...and successful access to the remotely located server applications for data conversion to machine format." EX1013, 4. Tay goes on to describe that "converted CAD data" is transmitted over "long distance transmission" and conver[t]ed to the machine format by the QuickSlice translator" located at the rapid fabrication site. *Id.* In the combination of Kritchman with Tay and Henke, this transfer of the CAD data representing the model of the three-dimensional object to be fabricated would have been received at Kritchman's 3D printer via the communications unit 125 (network interface). As I mentioned

above, Kritchman's CAD model data takes the form of STL files. EX1015, [0075], [0141]. Tay provides similar disclosure that the "CAD data" received at the rapid fabrication system takes the form of STL files representing a three-dimensional model of the object:



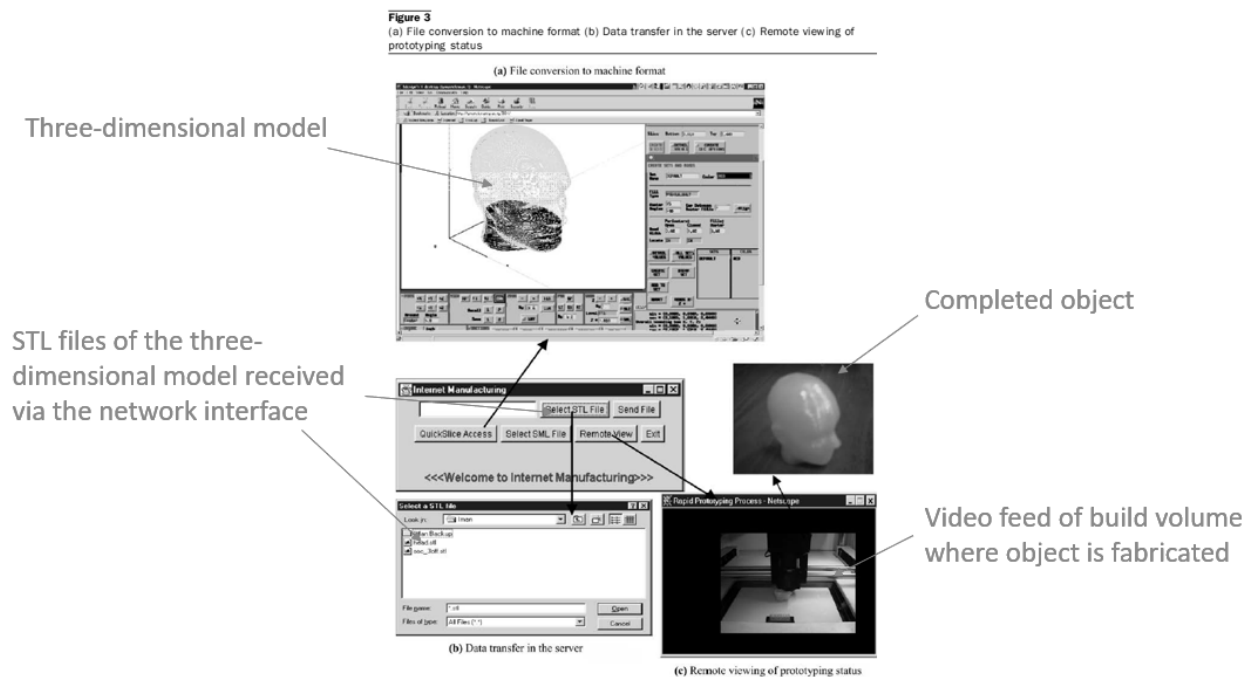
EX1013, 5.

222. Henke similarly discloses "uploading a source file to the Remote Lab server." EX1014, 2, 4, 8 (describing uploading "[t]he generated hardware module"). Henke also discloses that in the predictable combination of Kritchman

Declaration of Andrew Wolfe, Ph.D.
U.S. Patent No. 8,562,324

with Tay and Henke, the user interface at the remote client computer includes various controls that the remote user can execute to “handle the laboratory procedure (start, stop, reset),” and “change environmental variables if necessary.” EX1014, 5.

223. Turning back to Tay, Figure 3 of Tay shows that the user interface at the remote client computer in the predictable combination of Kritchman with Tay and Henke includes both an image of the build volume from the video camera and a two-dimensional projection of the three-dimensional model:



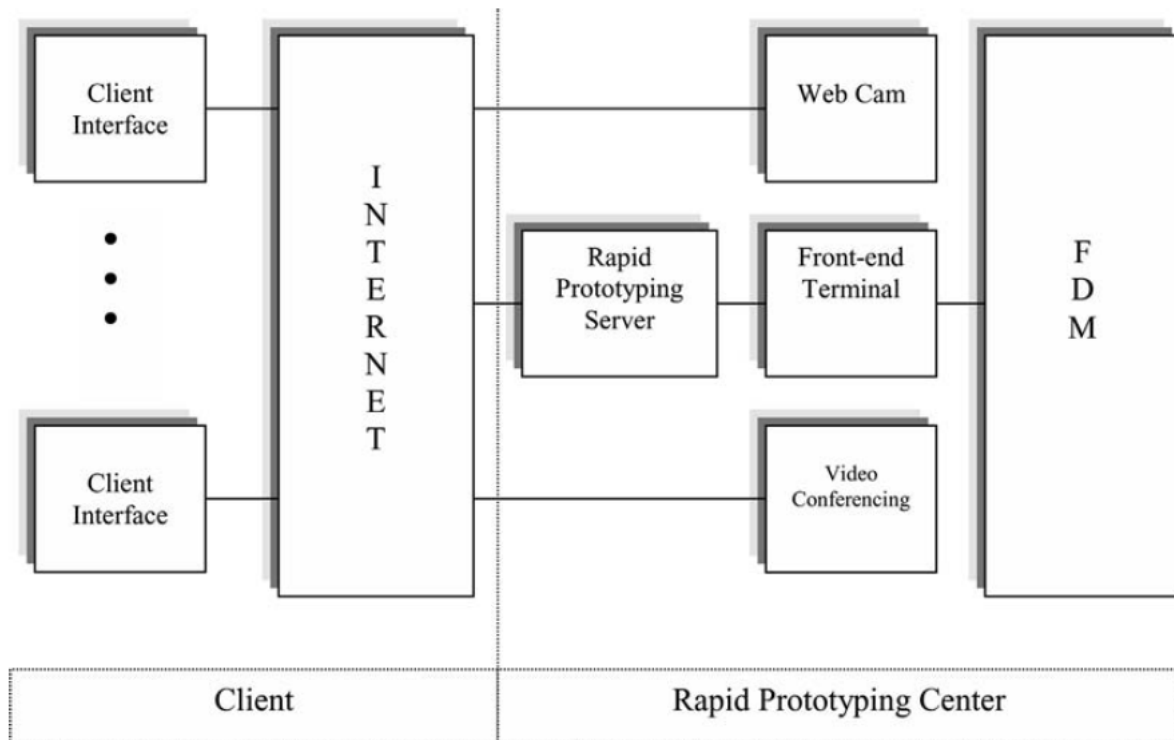
EX1013, 4-5.

224. Tay describes that the user interface at the client device includes functionality “for configuring and monitoring the remote prototyping system.” EX1013, 3. As shown in Figure 3, above, Tay’s system provides “audio and visual feedback” from the fabrication system to the client device using a “Web cam and video conferencing.” EX1013, 4. These web cams can allow “multiple clients...to watch the same fabrication process for discussion and analysis.” *Id.* The user interface at the client device displays status information for the object being fabricated, including showing a virtual rendering of the progress of the object in comparison to a wireframe of the entire object and actual images of the object being fabricated as captured by the Web cam. *Id.*, 5.

225. In the example in Figure 1, Tay shows the Web Cam and Video Conferencing system of its rapid prototyping center as having separate communications links from the server:

Figure 1

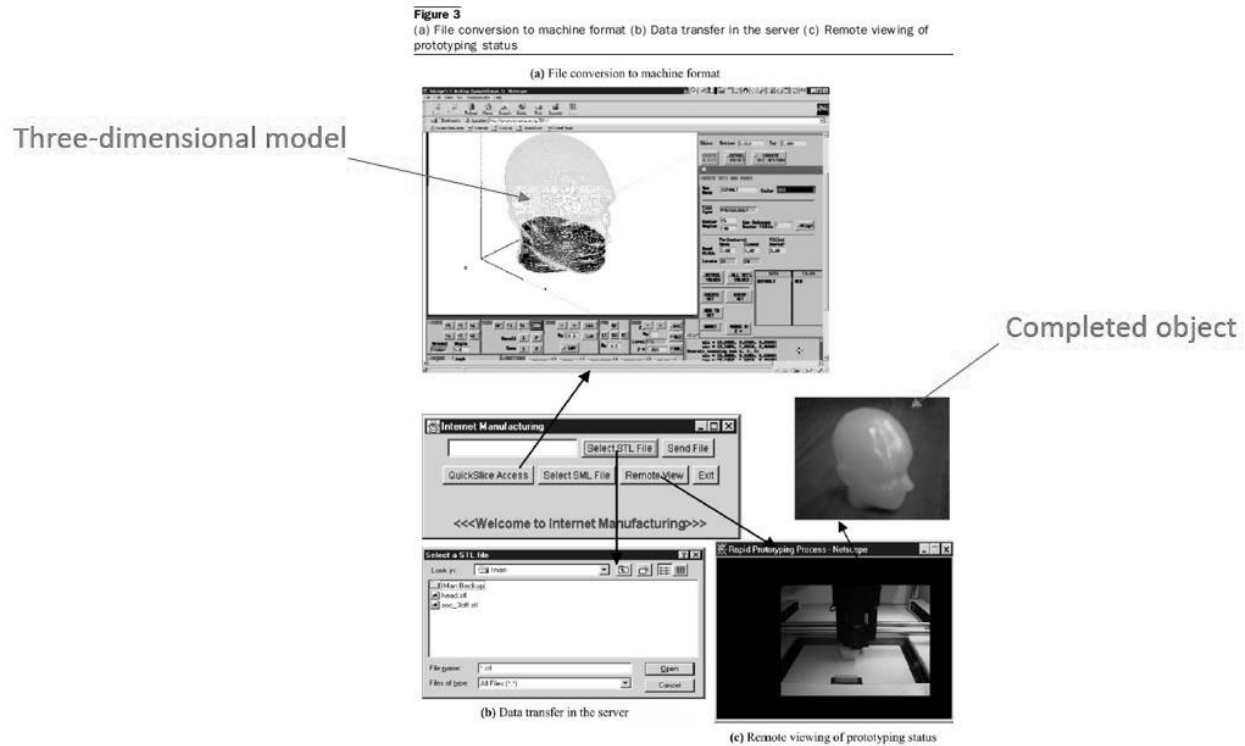
IMAN framework on the Internet



EX1013, 3. However, a POISTA would have recognized that in applying Tay's teachings to Kritchman, it would have been obvious and beneficial to implement all communications to and from the 3D printer (that includes controller 105) via Kritchman's communications unit 125. Such an implementation would have beneficially eliminated the need for additional hardware, such as an additional communications unit and related controlling hardware. Such an implementation would have been consistent with Kritchman's express disclosure of conducting all communications "between controller 105 and other system elements" (such as

Tay's WebCam) via the communications unit 125. EX1015, [0073]. Furthermore, such an implementation using a single network interface (as taught by Kritchman) would have reduced the number of components required for the device, thereby reducing the overall footprint and improved efficiency by eliminating the need for communication between disparate components within the resulting system. As such, in the resulting Kritchman-Tay-Henke system, the user interface that includes the images of the build volume from the video camera are transmitted via the network interface (Kritchman's communications unit 125 as modified based on the teachings of Tay).

226. Returning to Figure 3 of Tay, the displayed image of the completed object and the displayed two-dimensional projection of the three-dimensional model appear to be from the same point of view included in Tay's user interface:



EX1013, 5.

227. As I discussed above, a POSITA also would have found it obvious to apply the teachings of Henke to the Kritchman-Tay system to display both the actual video images of the fabrication process (as captured by a camera at the fabrication system, as taught by Tay) and the virtual model of the process simultaneously and from the same viewing perspective. EX1014, 5. As shown in Figure 8 of Henke, Henke includes a suggestion to implement a user interface for remotely observing an automated process in which the video image of the actual automated process and the model of the process are shown concurrently and from

the same point of view to allow the user of the resulting combination to easily compare the actual process to the model:

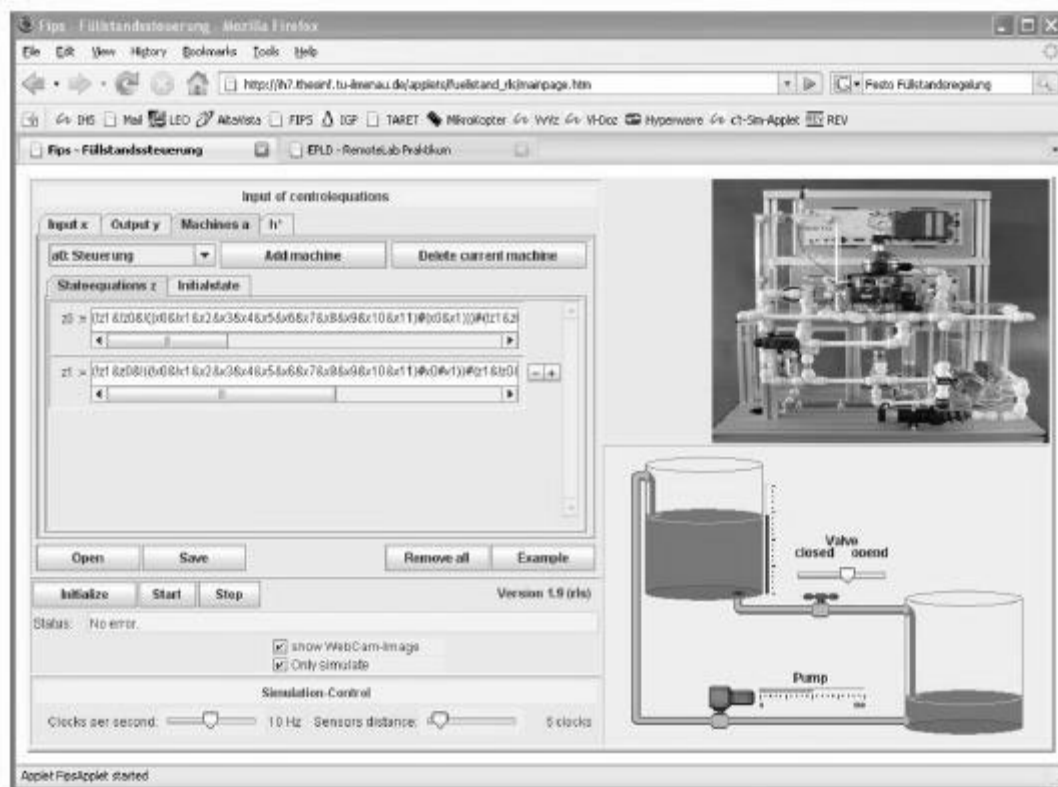


Figure 8. Online control of the Water level control - with Internet connectivity to the Remote Lab

EX1014, 5. In applying these teachings to the Kritchman-Tay-Henke combination, a POSITA would have implemented the resulting user interface to display the image of the object being fabricated and the two-dimensional projection of the three-dimensional model of the object to be fabricated from the same point of view and at the same time in the user interface.

228. The Kritchman, Tay, and Henke references also demonstrate that the processor at the rapid fabrication apparatus (Kritchman's controller 105 as modified based on the suggestions of Tay and Henke) generates the user interface and provides the user interface for display at the remote client computer through the internet, via the network interface (Kritchman's communications unit 125). For example, Kritchman describes that the communications unit 125 communicates with "an external control or processing unit" such as a "personal computer," which in the predictable combination includes the remote client interface computers described by Tay. EX1015, [0073]-[0075]; EX1013, 2-3. Tay discloses that the remote client computer in the predictable combination displays the user interface using a generic web browser such as "Netscape Communicator browser. EX1013, 3-5. For example, Figure 3 of Tay, reproduced above, shows that the user interface is displayed in a Netscape browser. EX1013, 5. Similarly, Figure 8 of Henke, also reproduced above, shows that the user interface is displayed in a FireFox web browser. EX1014, 5. Tay describes "a platform neutral framework for the construction of the human computer interface (HCI)." EX1013, 2. Specifically, "the user does not need to download and install extra plug-ins to run the application" but only needs "common Web tools" such as "Netscape Communicator browser," as discussed above. *Id.*, 3. Because the user interface is

presented in a generic web browser with no “extra-plug-ins” or specialized software via direct communication with Kritchman’s controller 105 (modified to include functionality of Tay’s rapid prototyping center), a POSITA would have understood that the user interface is generated and provided by the controller 105 in the predictable combination. EX1015, [0073]-[0075], FIG. 1; EX1013, Figure 1, Figure 3; EX1014, 5.

Claim [3]: The device of claim 1 wherein the two-dimensional projection is simulated based upon operation of the three-dimensional printer.

229. Henke demonstrates that in the Kritchman-Tay-Henke combination, the two-dimensional projection is simulated based upon operation of the three-dimensional printer. As I discussed above, based on Henke’s teaching, the user interface in the resulting combination displays the actual images of the device performing the automated process (as captured by the on-site camera) and virtual images of the simulation of the process based on the model:

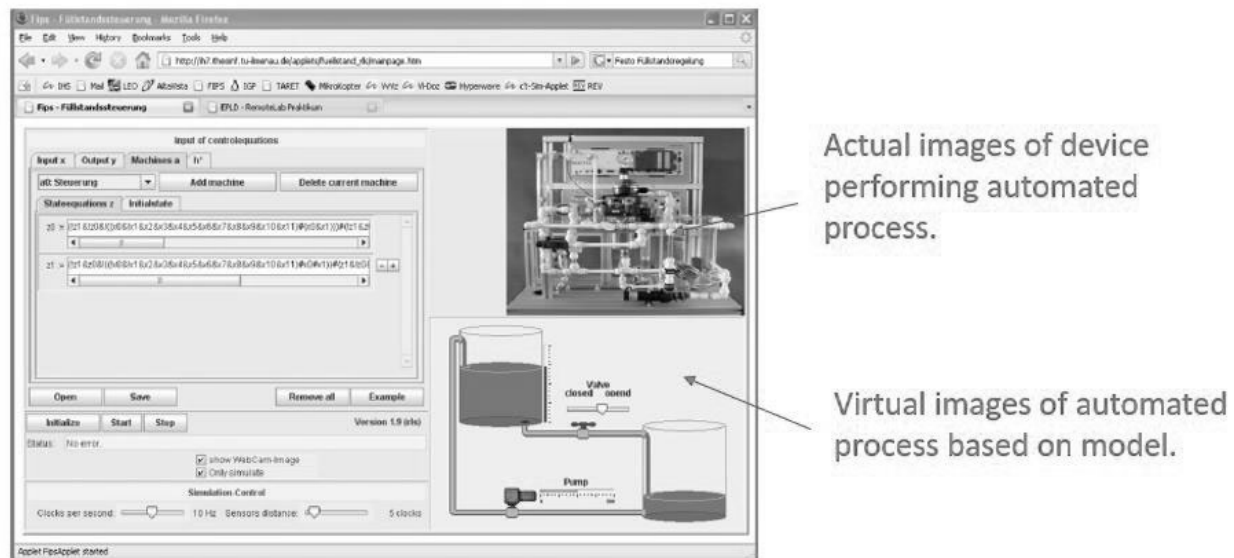
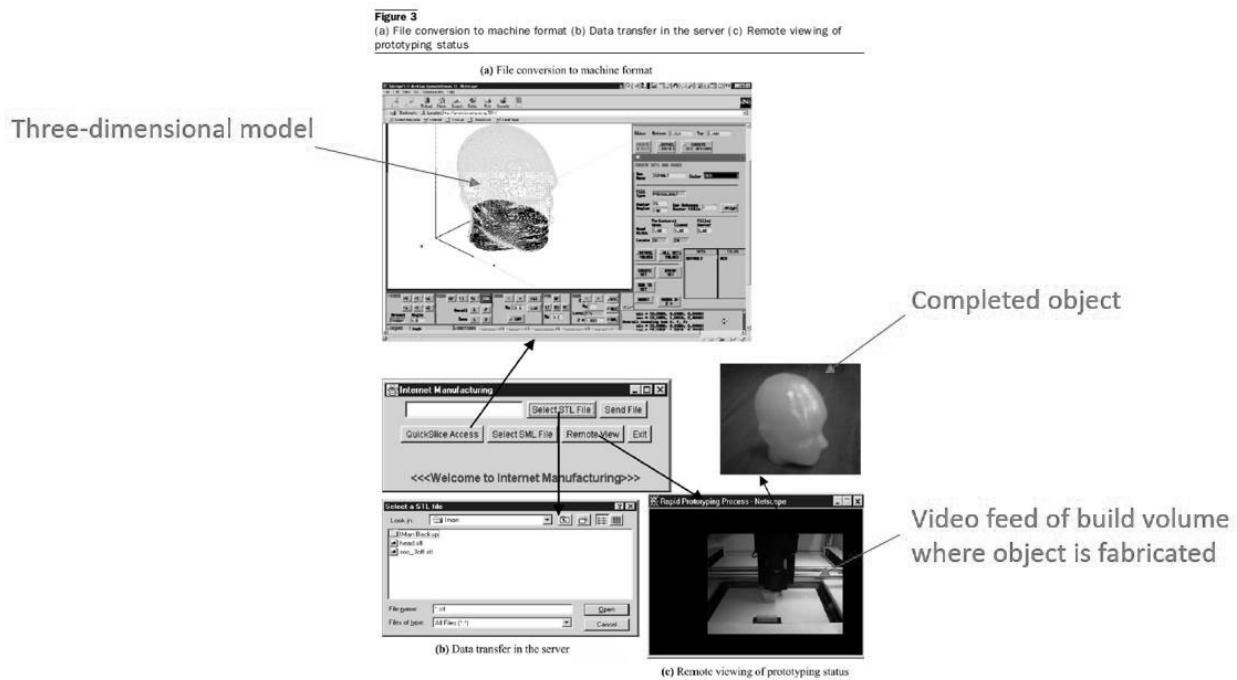


Figure 8. Online control of the Water level control - with Internet connectivity to the Remote Lab

230. As I discussed above, when this teaching is applied to the Kritchman-Tay-Henke combination, the resulting user interface would display both actual images of the 3D printing process as captured by a camera at the 3D printer and a virtual image of the object being fabricated based on the model, as discussed by Tay:



EX1013, 5.

231. Returning to the disclosures of Henke, in describing the displayed simulation of the automated process, Henke states that “[t]he physical behaviour of the actual model, and its environment as well, will be emulated (e. g. as simulation model)” and the “[d]ynamic activities will be animated.” EX1014, 3. Henke goes on to describe that its system “offers a Web-based environment including verification and simulation features to generate and execute a design within visual prototypes.” *Id.*, 5. As shown in Figure 8 (reproduced above) the user interface allows the remote user to monitor the progress of the automated process by “watch[ing] the laboratory procedure by *supervising the model* and environmental

variables inside an I/O monitor or by *observing the hardware model directly via a Web-Cam.*” As such, when these teachings for displaying the simulation based on the model to correspond to the actions of the actual real-world apparatus are applied to Kritchman (as modified by Tay), in the resulting combination, the two-dimensional projection displayed in the user interface at the remote client computer is simulated based upon operation of the three-dimensional printer.

232. Alternatively, I have reviewed portions of the Patent Owner’s infringement contentions and it appears that Patent Owner contends in the district court litigation that merely displaying video camera images of the product at a remote computer satisfies this claim. EX1016, 57-66. Under such an interpretation, Tay’s descriptions of displaying the image data captured by the camera of the object being fabricated in the user interface presented at the remote computer also demonstrates that the Kritchamn-Tay-Henke combination meets this claim. EX1013, 4-5.

Claim [5]: The device of claim 1 wherein the two-dimensional projection is dynamically updated to correspond to a state of physical completion of the object.

233. Henke demonstrates that in the Kritchman-Tay-Henke combination, the two-dimensional projection is dynamically updated to correspond to a state of physical completion of the object. As I discussed above with respect to claim 3,

Henke teaches that the user interface in the resulting combination displays the actual images of the device performing the automated process (as captured by the on-site camera) and virtual images of the simulation of the process based on the model and when applied to Tay's user interface, this would have resulted in the user interface displaying the actual images of the object being fabricated along with virtual images of the object based on the model. EX1014, 5; EX1013, 4-5.

234. For example, Henke states that “[t]he physical behaviour of the actual model, and its environment as well, will be emulated (e. g. as simulation model)” and the “[d]ynamic activities will be animated.” EX1014, 3. Henke goes on to describe that its system “offers a Web-based environment including verification and simulation features to generate and execute a design within visual prototypes.” *Id.*, 5. As shown in Figure 8 (reproduced above) the user interface allows the remote user to monitor the progress of the automated process by “watch[ing] the laboratory procedure by *supervising the model* and environmental variables inside an I/O monitor or by *observing the hardware model directly via a Web-Cam.*” As such, when these teachings for displaying the simulation based on the model to correspond to the actions of the actual real-world apparatus are applied to Kritchman (as modified by Tay), in the resulting combination, the two-dimensional

projection displayed in the user interface at the remote client computer is dynamically updated to correspond to a state of physical completion of the object.

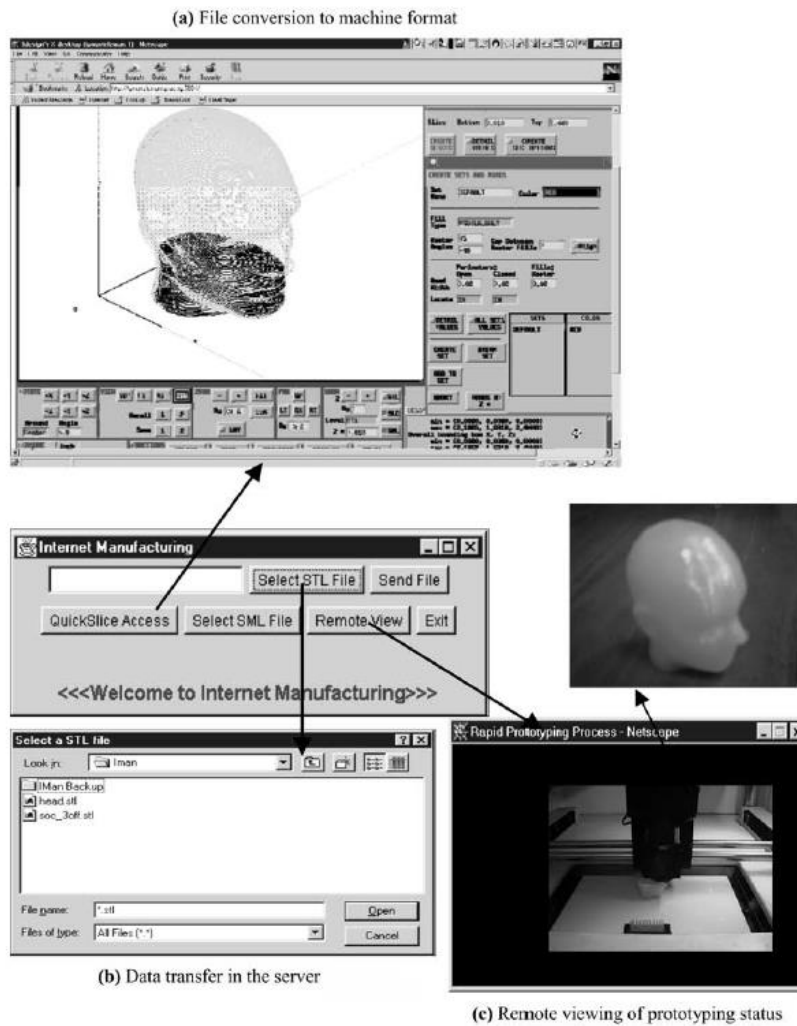
235. Alternatively, I have reviewed portions of the Patent Owner's infringement contentions and it appears that Patent Owner contends in the district court litigation that merely displaying video camera images of the product at a remote computer satisfies this claim. EX1016, 67-90. Under such an interpretation, Tay's descriptions of displaying the image data captured by the camera of the object being fabricated in the user interface presented at the remote computer also demonstrates that the Kritchman-Tay-Henke combination meets this claim. EX1013, 4-5.

Claim [6]: The device of claim 1 wherein the two-dimensional projection is a video image from the video camera.

236. As I discussed with respect to claim 1, Tay describes that the user interface at the client device includes functionality "for configuring and monitoring the remote prototyping system." EX1013, 3. As shown in Figure 3, Tay's system provides "audio and visual feedback" from the fabrication system to the client device using a "Web cam and video conferencing." EX1013, 4. These web cams can allow "multiple clients...to watch the same fabrication process for discussion and analysis." *Id.*

Figure 3

(a) File conversion to machine format (b) Data transfer in the server (c) Remote viewing of prototyping status



EX1013, 5.

237. I have reviewed portions of the Patent Owner's infringement contentions and it appears that Patent Owner contends in the district court litigation that merely displaying video camera images of the product at a remote computer satisfies this claim. EX1016, 91-105. As such, Tay's descriptions of displaying the

image data captured by the camera of the object being fabricated in the user interface presented at the remote computer demonstrate that the Kritchman-Tay-Henke combination meets this claim. EX1013, 4-5.

Claim [7]: The device of claim 1 wherein the user interface provides at least one control for manual operation of the three-dimensional printer by the remote user.

238. Henke demonstrates that in the Kritchman-Tay-Henke combination, the user interface provides at least one control for manual operation of the three-dimensional printer by the remote user. As I explained above, a POSITA would have predictably applied Henke's teachings to the Kritchman-Tay system to provide additional control functionality in the user interface at the remote computer to allow the remote user to control the fabrication process, such as by including start, stop, or reset commands in the user interface, as suggested by Henke. EX1014, 5. Specifically, Henke's "Web-interface" allows a remote user test control algorithms in remote, real-world devices including "handl[ing] the laboratory procedure (start, stop, reset)," and "change environmental variables if necessary." EX1014, 5.

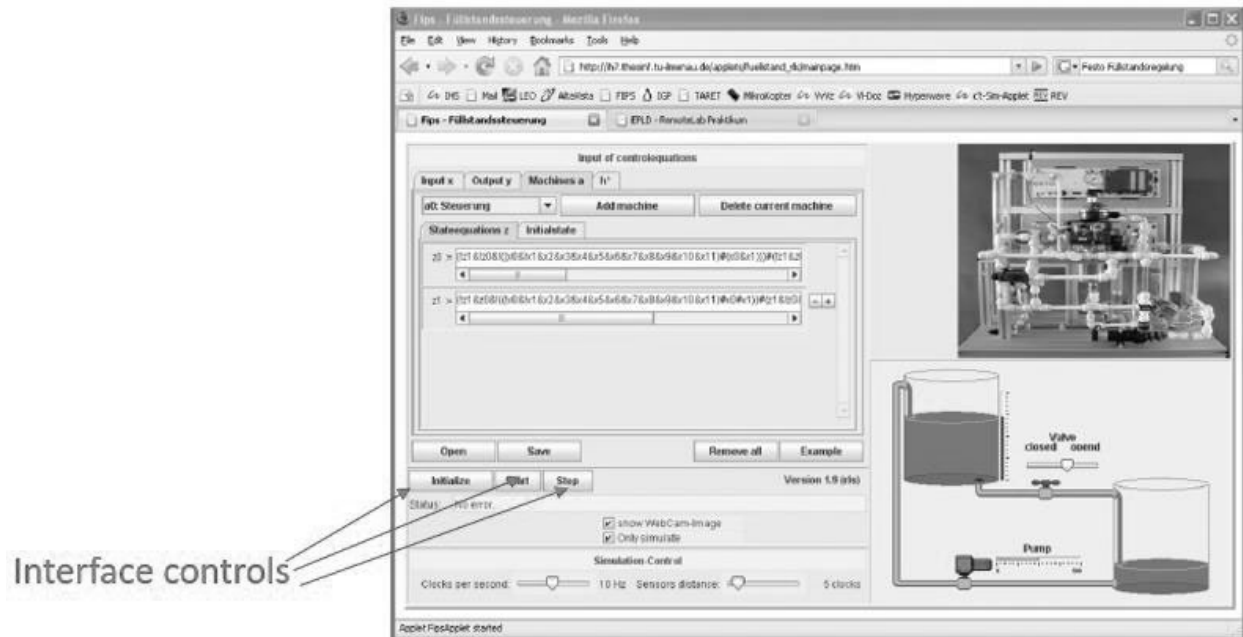


Figure 8. Online control of the Water level control - with Internet connectivity to the Remote Lab

EX1014, 5.

Claim [9]: The device of claim 1 wherein the user interface provides status information for the three-dimensional printer.

239. Both Tay and Henke provide teachings demonstrating that in the Kritchman-Tay-Henke combination, the user interface provides status information for the three-dimensional printer. For example, Tay discloses that Web Cam and video conferencing functionality allow the remote “viewing of the rapid prototyping status.” EX1013, 4-5. Henke provides a similar disclosure that in the resulting combination, the remote user can observe various “environmental

variables” through the user interface such that the user is better informed of the automated process. EX1014, 5

Claim [10]: The device of claim 1 wherein the user interface provides status information for a build process executing on the three-dimensional printer.

240. Both Tay and Henke provide teachings demonstrating that in the Kritchman-Tay-Henke combination, the user interface provides status information for the three-dimensional printer. For example, Tay discloses that Web Cam and video conferencing functionality allow the remote “viewing of the rapid prototyping status.” EX1013, 4-5. Henke provides a similar disclosure that in the resulting combination, the remote user can observe various “environmental variables” through the user interface such that the user is better informed of the automated process. EX1014, 5.

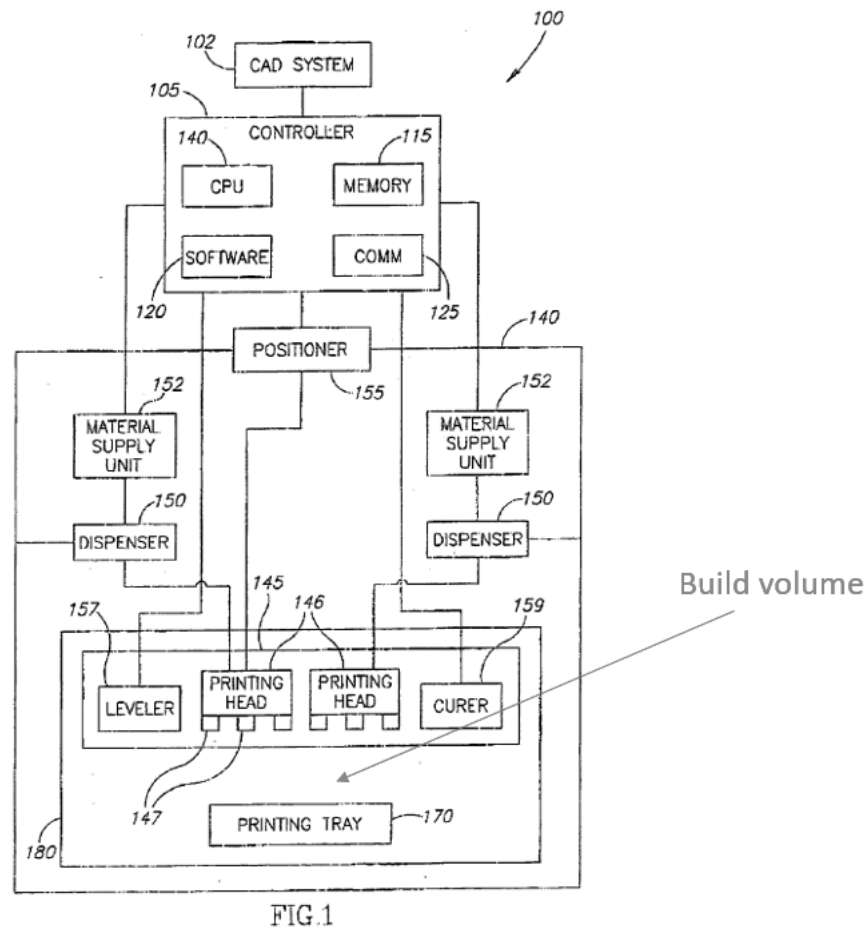
Element [19.pre]: A method comprising:

241. The Kritchman-Tay-Henke combination is directed to “methods for controlling the quality of printing in three-dimensional object-printing systems” including “remote control” and observation “of rapid prototyping hardware...via the Internet.” EX1015, [0005], [0064], [0071]; EX1013, 1-6. A POSITA would have recognized that the functions described throughout Kritchman, and the additional functions described in Tay and Henke, are a method.

Element [19.a]: providing a three-dimensional printer including a build volume, a network interface coupled to a data network, and a video camera positioned to capture video of the build volume from a point of view;

242. As I discussed with respect to Elements [1.a]-[1.c], above, Kritchman, when predictably modified based on the teachings of Tay and Henke, discloses a three-dimensional printer including a build volume, a network interface coupled to a data network, and a video camera positioned to capture video of the build volume from a point of view. The Kritchman-Tay-Henke combination discloses Element [19.a] for the reasons discussed with respect to Elements [1.a]-[1.c].

243. For example, Kritchman discloses a three-dimensional printer including a build volume. For example, Kritchman discloses that its “3D printer system 100” includes “printing apparatus 140.” EX1015, [0072]-[0075]. Kritchman further describes that “a printing apparatus for three-dimensional printing may be provided that may include a printing head (e.g., an ink jet head or another suitable material deposit system or dispenser) to deposit material for a three-dimensional object; a printing tray to support the objects being printed by the apparatus; and a temperature control unit to control the temperature in the apparatus.” *Id.*, [0007], [0074], [0085]-[0088].



EX1015, FIG. 1. As such, Kritchman discloses a three-dimensional printer having a build volume in the form of the printing tray 170 and the work space defined by and immediately above the printing tray 170. *Id.*, , [0074], [0085]-[0088].

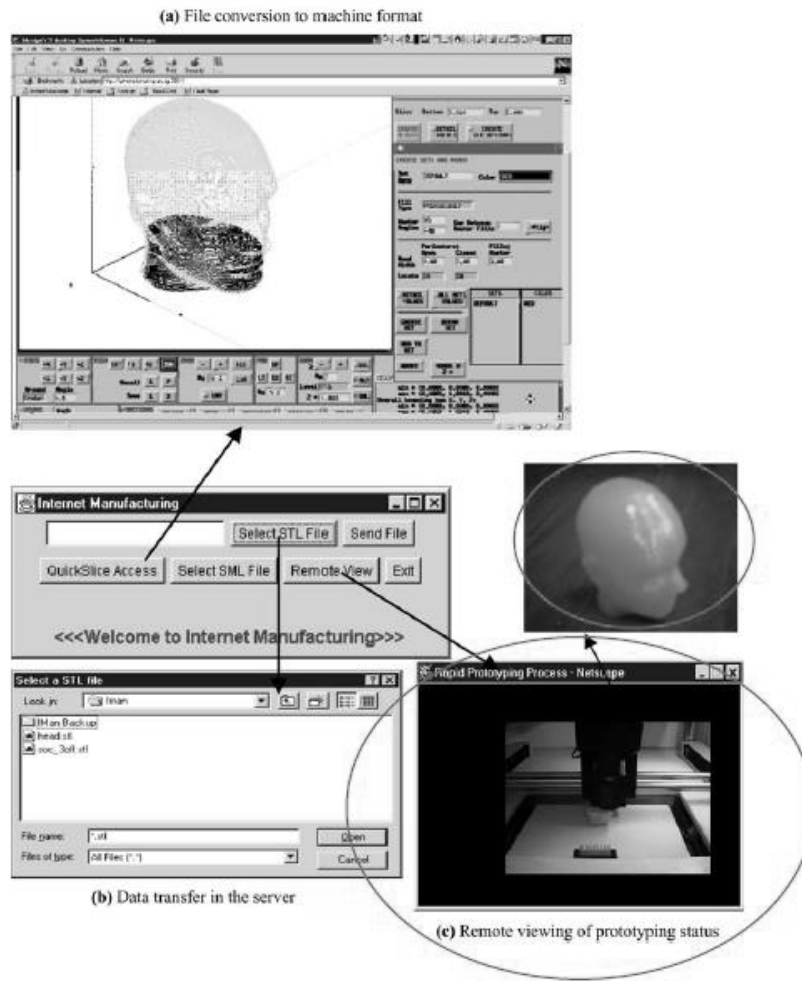
244. As I discussed above with respect to Element [1.b], a POSITA would have recognized that Kritchman's communications unit 125 is a network

interface because “[c]ommunications unit 125 may, for example, *enable transfer of data and instructions between controller 105* and CAD module 102, between controller 105 and printing apparatus 140, and/or between controller 105 and *other system elements*.” EX1015, [0073]. Kritchman’s communications unit 125 would have been predictably modified based on Tay to connect to the internet. EX1013, 1-2, 6

245. Lastly, as I discussed above with respect to Element [1.c], Tay describes that in the predictable combination “audio and visual feedback” are provided from the rapid prototyping center (Kritchman’s 3D printer) “by the use of Web cam and video conferencing.” EX1013, 4. For example, Tay describes that “multiple clients could be allowed to watch the same fabrication process for discussion and analysis” in the resulting user interface. *Id.*

Figure 3

(a) File conversion to machine format (b) Data transfer in the server (c) Remote viewing of prototyping status



EX1013, 5.

Element [19.b]: receiving a three-dimensional model through the network interface;

246. The Kritchman-Tay-Henke combination provides, or at least renders obvious, this claim element for the reasons that I discussed above with respect to Element [1.d]. For example, Kritchman discloses receiving a three-dimensional

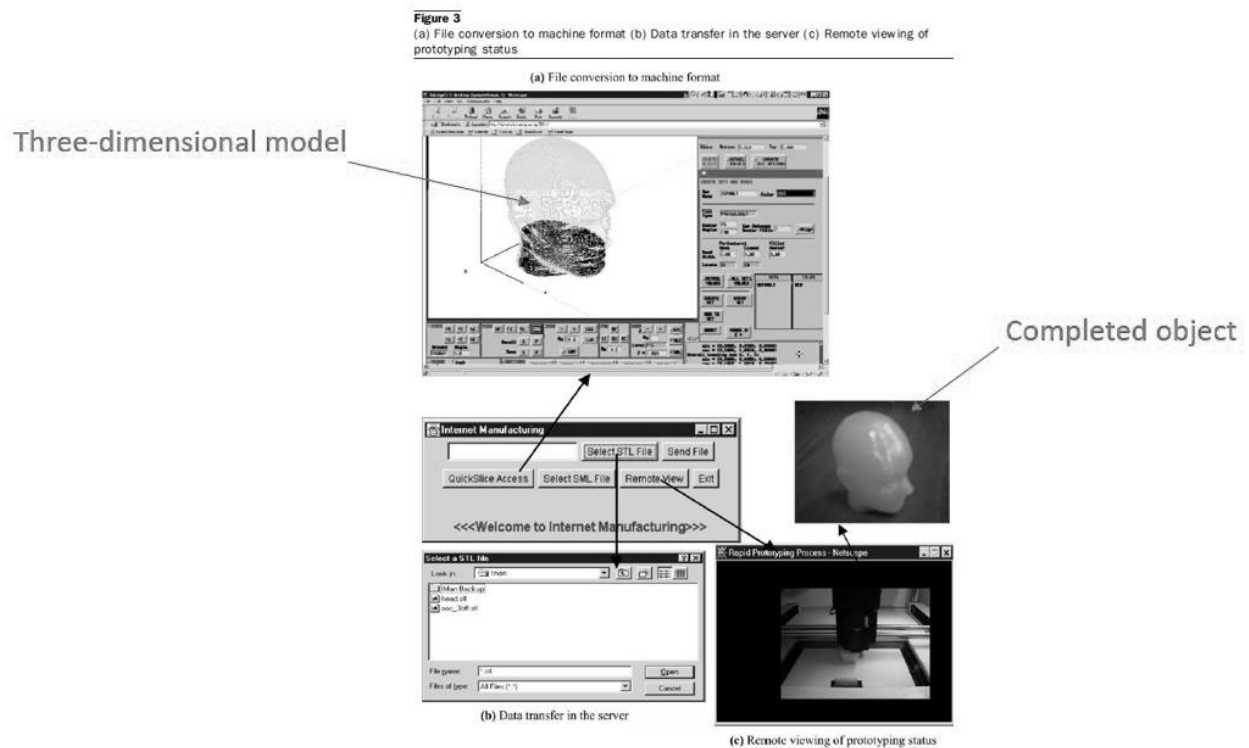
model through the network interface (the communications unit 125). Specifically, Kritchman's "[c]ommunications unit 125" (i.e., the network interface) "enable[s] transfer of data and instructions between controller 105 and CAD module 102" such that the controller 105 receives "Computer Object Data (COD) representing an object or a model, for example, CAD data in STL format" from an external CAD system/module 102. EX1015, [0072]-[0075], FIG. 1. Tay similarly discloses that "converted CAD data" is transmitted over "long distance transmission" and conver[ted] to the machine format by the QuickSlice translator" located at the rapid fabrication site. EX1013, 4.

Element [19.c]: fabricating the three-dimensional model as an object within the build volume of the three-dimensional printer; and

247. The Kritchman-Tay-Henke combination provides, or at least renders obvious, this claim element for the reasons that I discussed above with respect to Element [1.d]. For example, Kritchman's controller 105 converts this CAD model data "to instructions for the various units within 3D printer system 100 to print a 3D object." *Id.*, [0075]. This and other disclosures of Kritchman reveal that the processor of the controller 105 controls operation of the three-dimensional printer to fabricate the 3D object and that this fabrication occurs within the build volume defined by/above printing tray 170. EX1015, [0074], [0085]-[0088].

Element [19.d]: providing a user interface to a remote user accessing the device through the network interface, wherein the user interface presents an image of the build volume from the video camera and a two-dimensional projection of the three-dimensional model from the point of view of the video camera.

248. The Krtichman-Tay-Henke combination provides, or at least renders obvious, this claim element for the reasons that I discussed above with respect to Element [1.d]. For example, Figure 3 of Tay shows that the user interface at the remote client computer includes both an image of the build volume from the video camera and a two-dimensional projection of the three-dimensional model from the same point of view as the video camera:



EX1013, 5.

249. Furthermore, a POSITA also would have found it obvious to apply the teachings of Henke to the Kritchman-Tay system to display both the actual video images of the fabrication process (as captured by a camera at the fabrication system, as taught by Tay) and the virtual model of the process simultaneously and from the same viewing perspective. EX1014, 5.

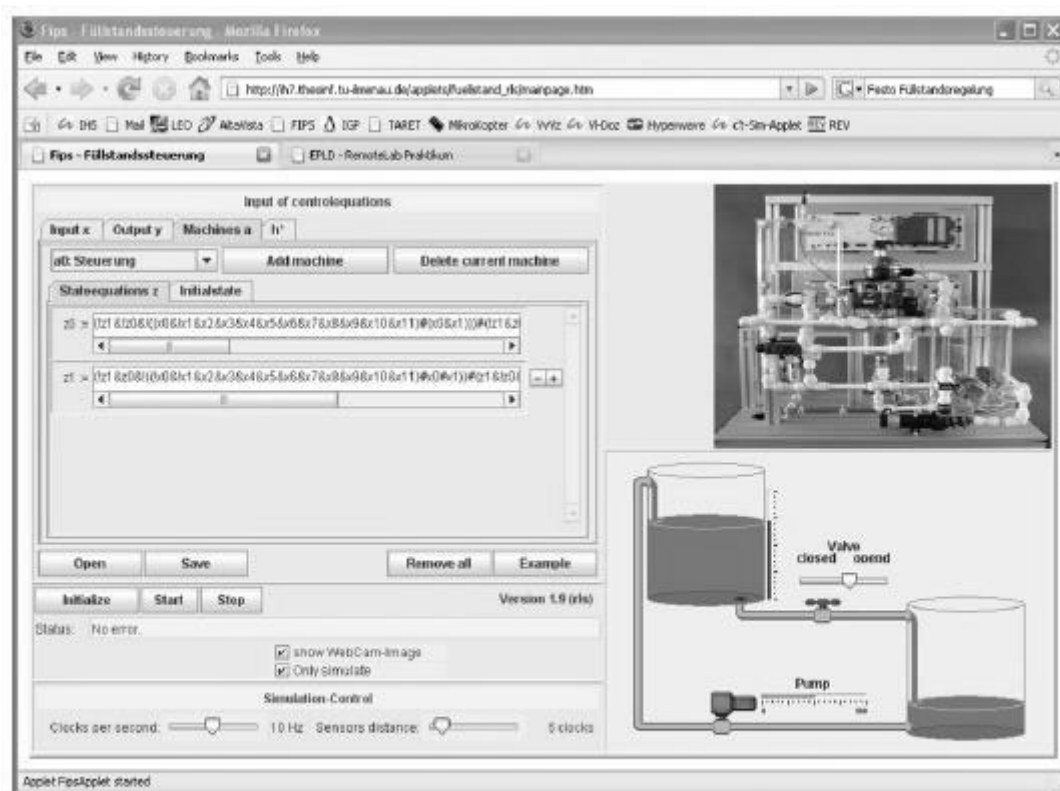


Figure 8. Online control of the Water level control - with Internet connectivity to the Remote Lab

EX1014, 5.

Claim [20]: The method of claim 19 further comprising transmitting status information over the data network upon completion of the object.

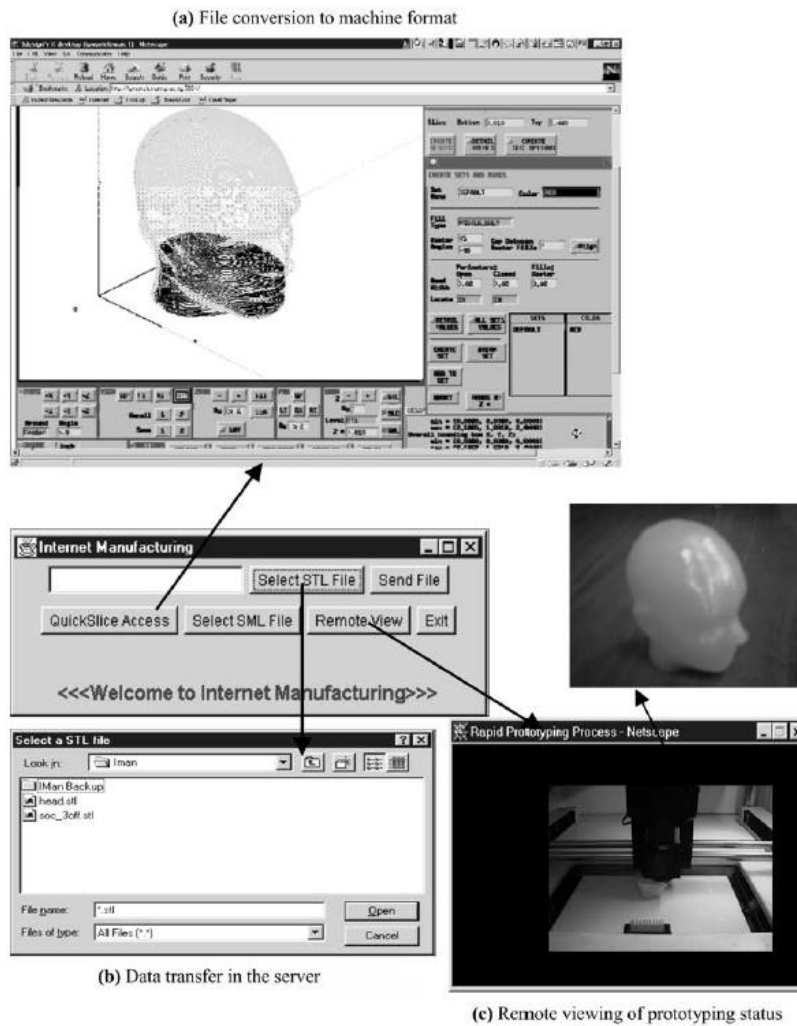
250. As I discussed above with respect to claims 9 and 10, Tay discloses that Web Cam and video conferencing functionality allow the remote “viewing of the rapid prototyping status.” EX1013, 4-5. Henke provides a similar disclosure that in the resulting combination, the remote user can observe various “environmental variables” through the user interface such that the user is better informed of the automated process. EX1014, 5. A POSITA would have recognized that this information is transmitted both during the fabrication process and upon completion of the product, thus providing recitation this claim.

Claim [21]: The method of claim 20 wherein the status information includes data presented through the user interface.

251. As I discussed above, both Tay and Henke disclose that the status information (including the images captured by the camera) are displayed as part of the user interface. EX1013, 5; EX1014, 5.

Figure 3

(a) File conversion to machine format (b) Data transfer in the server (c) Remote viewing of prototyping status



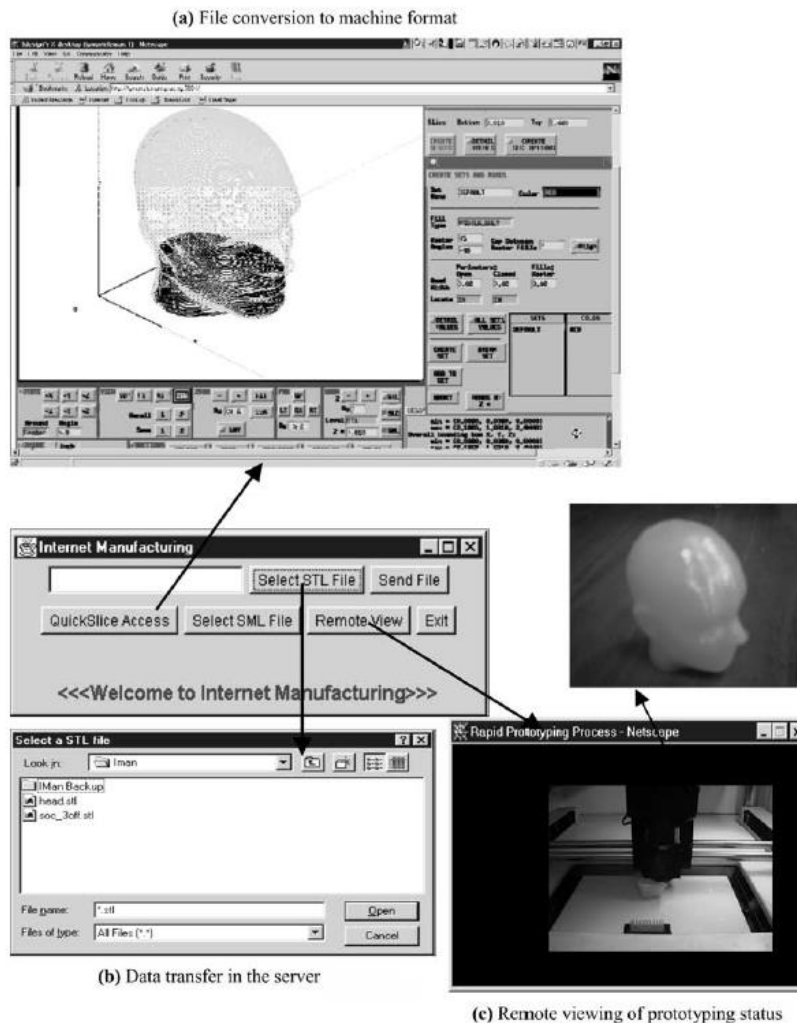
EX1013, 5. Additionally, as I discussed with respect to claim 20, above, this status information would have been displayed in the user interface both during the fabrication process and upon completion of the product, thus providing this claim recitation.

Claim [22]: The method of claim 20 wherein the status information includes a digital image from the video camera.

252. The combination of Kritchman with Tay and Henke provides this claim for the reasons that I discussed above with respect to Element [1.d] and claims 6 and 20-21. For example, Tay describes that the user interface at the client device includes functionality “for configuring and monitoring the remote prototyping system.” EX1013, 3. As shown in Figure 3, Tay’s system provides “audio and visual feedback” from the fabrication system to the client device using a “Web cam and video conferencing.” EX1013, 4. These web cams can allow “multiple clients...to watch the same fabrication process for discussion and analysis.” *Id.*

Figure 3

(a) File conversion to machine format (b) Data transfer in the server (c) Remote viewing of prototyping status



EX1013, 5.

253. I have reviewed portions of the Patent Owner's infringement contentions and it appears that Patent Owner contends in the district court litigation that merely displaying video camera images of the product at a remote computer satisfies this claim. EX1016, 187-189. As such, Tay's descriptions of displaying

the image data captured by the camera of the object being fabricated in the user interface presented at the remote computer demonstrate that the Kritchman-Tay-Henke combination meets this claim. EX1013, 4-5.

7.9. Ground 2B: The Combination of Kritchman with Tay, Henke, and Tian Renders Obvious Claim 4

254. Multiple reasons would have motivated a POSITA to modify the system of Kritchman-Tay-Henke to further include functionality to compare the model data (which serves as the basis of the two-dimensional projection in the proposed combination) with the actual image of the object and adjust the model as a result for multiple reasons based on the suggestions of Tian. *As a first reason* for such a modification, Kritchman expressly teaches that one of its goals is to prevent “defects in the finished product.” EX1015, [0071], [0080]. Application of Tian’s suggestion to compare the images of the object being manufactured as captured by one or more cameras and a two-dimensional projection of the object being fabricated generated based on a model to “confirm[] easily, efficiently, and precisely whether three-dimensional model data including an attached object attached to a machine tool and at least a part of the machine tool good are accurate” would have aided the user of the Kritchman-Tay-Henke-Tian system to identify such defects in the object being fabricated and therefore would have furthered Kritchman’s express goal of identifying defects such that they can be

prevented in future redesigns of the object to be fabricated. EX1006, Abstract. For example, Tian describes comparing “the two-dimensional image data related to the actual attached object generated in the actual-image-data generating process and the two-dimensional image data of the attached object related to the three-dimensional model” to determine if the actual object and the model “match.” *Id.*, [0013], [0022], [0025], [0100], [0111]. A POSITA would have recognized that such automated comparing of the model image data to the actual images of the object being fabricated, as captured by the camera at the fabrication device, would have aided in defect/abnormality detection, thereby improving the ability of the resulting system to detect and correct for defects/abnormalities while reducing the cognitive load on the human user at the remote computer, especially with respect to defects that would be difficult or impossible to identify with the human eye.

255. As a second reason, a POSITA would have recognized that comparing the images of the model of the object being fabricated to the actual images of the object during the fabrication process (as suggested by Tian) would have beneficially allowed the resulting system to detect and correct for defects/abnormalities/errors in instances in which such defects/abnormalities/errors would be difficult or impossible for a human to detect through manual, visual comparison. Improving such error correction would have ultimately led to further

modifications to the CAD design that would beneficially improve the resulting product.

256. As a third reason, a POSITA would have been prompted to modify Kritchman's rapid fabrication system (as already modified by Tay and Henke) to monitor operation of the three-dimensional printer by comparing the two-dimensional virtual images derived from the object model to the actual images of the object during fabrication (as suggested by Tian) because doing so would be merely the application of a known technique to a known system ready for improvement to yield predictable results. Here, Tian provides straightforward evidence of a known technique for comparing virtual images of a rapid fabrication process to actual images of the rapid fabrication process and Kritchman's teaching (as modified by Tay and Henke) provides a known system that would have been improved by application of Tian's suggested technique for at least the reasons described above. Based upon my knowledge and experience in this field and my review of Kritchman, Tay, Henke, and Tian, I am confident a POSITA would have recognized that this modification would have yielded predictable results and required only routine adjustments to the system and as such a POSITA would have had a reasonable expectation of success in making such modifications. This modification would not have significantly altered or hindered the functions

performed by Krtichman's system, and these modifications would have been within the predictable and ordinary level of skill of a POSITA (certainly by a time frame as late as 2010). Krtichman states that "[i]t should be appreciated by persons skilled in the art that many modifications, variations, substitutions, changes, and equivalents are possible in light of the above teaching" and Tian proposes just such a modification that would have been beneficially applied to Krtichman for the reasons stated above. EX1015, [0157].

257. As demonstrated below, the predictable combination of Krtichman with Tay, Henke, and Tian renders obvious claim 4.

Claim [4]: The device of claim 3 wherein the processor is configured to monitor operation of the three-dimensional printer based upon a comparison of the two-dimensional projection with the image of the build volume.

258. Tian demonstrates that in the Krtichman-Tay-Henke-Tian combination, the processor of the resulting system (e.g., the Krtichman's controller) is configured to monitor operation of the three-dimensional printer based upon a comparison of the two-dimensional projection with the image of the build volume. For example Tian discloses generating "virtual image data" that "correspond[s] to the CCD cameras 13 and 14[] of the workpiece W." EX1006, [0098]. The virtual images are derived from a model of the object to be fabricated. EX1006, Abstract, [0012]. Tian describes comparing the images of the workpiece

as captured by the CCD cameras and a two-dimensional projection of the object being fabricated generated based on a model to “confirm[] easily, efficiently, and precisely whether three-dimensional model data including an attached object attached to a machine tool and at least a part of the machine tool good are accurate.” EX1006, Abstract. For example, Tian describes comparing “the two-dimensional image data related to the actual attached object generated in the actual-image-data generating process and the two-dimensional image data of the attached object related to the three-dimensional model” to determine if the actual object and the model “match.” *Id.*, [0013], [0022], [0025], [0100], [0111]. In another example, Tian describes that “the actual image data obtained by the first CCD camera 13 and the virtual image data generated to correspond to the first CCD camera 13; and the actual image data obtained by the second CCD camera 14 and the virtual image data generated to correspond to the second CCD camera 14 are compared, respectively, to determine whether these image data match.” *Id.*, [0100].

259. Upon performing this comparison function, if the virtual image data generated from the model and image data of the actual object do not match “the computer may be configured to further function as model-data updating means for updating the model data related to at least a part of the machine tool to match an

actual operation of the machine tool.” EX1006., [0026]-[0029]. In some examples “when the actual image data and the virtual image data do not match, it is determined that the three-dimensional model data of the whole of the machine tool 30 are wrong, that is, the shape of the workpiece W, the mounting position thereof, and the mounting attitude thereof do not match those of the actual workpiece W (step S18), a message to this effect is displayed on the screen display device (not shown) of the operation panel 47 or on the screen display device 12 of the computer 10.” *Id.*, [0101]-[0102].

7.10. Ground 2C: The Combination of Kritchman with Tay, Henke, and Hull Renders Obvious Claim 8

260. Multiple reasons would have motivated a POSITA to modify the system of Kritchman-Tay-Henke to further include functionality to require a user to provide credentials to access the user interface for multiple reasons based on the suggestions of Hull. *As a first reason*, similar to Tay and Henke, Hull describes allowing a user to transfer design files from a remote computer to a “process computer” that controls the cabinet assembly of a 3D printer deposition machine to allow a user to remotely initiate and control a 3D printing process without being physically present at the location of the 3D printer. EX1008, [0140], [0143]. A POSITA would have beneficially applied Hull’s teachings to the Kritchman-Tay-Henke system to require login credentials, including a password, to remotely

access the computing system in control of the 3D printer to prevent unauthorized users from accessing the fabrication system. EX1008, [0157]. As such, users who are not authorized to use the 3D printing system (e.g., because they have not scheduled use of the device or have not paid for use of the device) can thus be prevented from accessing Kritchman's 3D printer system and the fabrication site.

261. As a second reason, implementing the Kritchman-Tay-Henke system to require credential based access for the 3D printer fabrication system would have prevented unauthorized waste of fabrication time, power usage, and deposition material, thereby freeing up these resources for authenticated/authorized users. A POSITA would have recognized that fabricating objects at Kritchman's 3D printer utilizes a number of resources. Credential based access would have prevented unauthorized users from wasting such resources.

262. As a third reason, implementing the Kritchman-Tay-Henke system to require credential based access for the local site fabrication system would have allowed the operators of Kritchman's 3D printer system (as predicably modified based on Tay and Henke) to more easily track the remote users that have accessed the system by recording the remote users' access credentials when they are entered.

263. As a fourth reason, implementing the Kritchman-Tay-Henke system to require credential based access to access the 3D printer system would have helped to prevent bad actors from accessing the local fabrication system to send operating commands that could potentially damage or disable the system.

264. As a fifth reason, a POSITA would have been prompted to modify Kritchman's 3D printer system (as already modified by Tay and Henke) to require login credentials, including a password, to access Kritchman's 3D printer in the predictable combination (as suggested by Hull) because doing so would be merely the application of a known technique to a known system ready for improvement to yield predictable results. Here, Hull provides straightforward evidence of a known technique for requiring login credentials to access a remote 3D printing facility and Kritchman's teaching (as modified by Tay and Henke) provides a known system that would have been improved by application of Hull's suggested technique for at least the reasons described above. Based upon my knowledge and experience in this field and my review of Kritchman, Tay, Henke, and Hull, I am confident a POSITA would have recognized that this modification would have yielded predictable results and required only routine adjustments to the system and as such a POSITA would have had a reasonable expectation of success in making such modifications. This modification would not have significantly altered or hindered

the functions performed by Kritchman's system, and these modifications would have been within the predictable and ordinary level of skill of a POSITA (certainly by a time frame as late as 2010). Kritchman states that "[i]t should be appreciated by persons skilled in the art that many modifications, variations, substitutions, changes, and equivalents are possible in light of the above teaching" and Hull proposes just such a modification that would have been beneficially applied to Kritchman for the reasons stated above. EX1015, [0157].

265. As demonstrated below, the predictable combination of Kritchman with Tay, Henke, and Hull renders obvious claim 8.

Claim [8]: The device of claim 1 wherein the processor is configured to provide credential-based access to the user interface.

266. Hull demonstrates that in the Kritchman-Tay-Henke-Hull combination, the processor of Kritchman's controller 105 is configured to provide credential-based access to the user interface. In particular, Hull discloses that to remotely access the "process computer" that controls its rapid fabrication system, a user is required to a password. EX1008, [0157]. As discussed with respect to Element [1.d], *supra*, the Kritchman-Tay-Henke provides, or at least renders obvious, that the user interface is generated and provided by the controller of Kritchman's 3D printer (as modified by Tay and Henke) and therefore requiring

credential-based access to the 3D printer encompasses requiring the credential-based access to access the user interface provided by the controller of the 3D printer. EX1015, [0072]-[0075]; EX1013, 2-3.

7.11. Ground 2D: The Combination of Krtichman with Tay, Henke, and Seki Renders Obvious Claim 11

267. Multiple reasons would have motivated a POSITA to modify the system of Krtichman-Tay-Henke to further include functionality to display a two-dimensional tool path for the three-dimensional printer corresponding to a current layer of the object during a fabrication of the object by the three-dimensional printer within the user interface for multiple reasons based on the suggestions of Seki. *As a first reason*, Tay and Henke expressly describe giving the remote user the ability to monitor the automated process (performed at Krtichman's 3D printer in the predictable combination). EX1013, 4-5; EX1014, 5. Providing a display of the tool path of the 3D printer for the current portion of the fabrication procedure being conducted, as taught by Seki, would have given the remote user additional visual information with which to better monitor the fabrication process, including providing the user at the remote client computer with an improved ability to identify defects/abnormalities in the design process (e.g., by observing unexpected movements of the deposition tool as represented by the displayed tool path). As

such, the remote user would have had a better overall understanding of the fabrication process as it proceeds.

268. As a second reason, display of the tool path in the user interface would have allowed the remote user to easily identify unexpected motions of the fabrication system to more easily identify defects or abnormalities in the design/model or possible malfunction of the deposition system. Comparison of the expected movements of the device (as represented by the displayed tool path) to actual movements of the device (as shown in the live camera feed) would have allowed the remote user to identify problems or unexpected motions in the fabrication process that could indicate defects with the fabrication machine itself.

269. As a third reason, Seki describes that displaying both the three-dimensional tool path and two-dimensional tool path as the fabrication device operates makes it easier for the remote user observing the fabrication process to confirm correct movement of the tool. EX1009, 1:36-40. Such confirmation by the operator can allow for correction of the model. *Id.*, 4:42-50. This can lead to “no or less errors” in the resulting object being fabricated. *Id.*, 1:58-2:2.

270. As a fourth reason, a POSITA would have been prompted to modify Kritchman’s 3D printer (as already modified by Tay and Henke) to display a two-

dimensional representation of the tool path of the fabrication tool (as suggested by Seki) because doing so would be merely the application of a known technique to a known system ready for improvement to yield predictable results. Here, Seki provides straightforward evidence of a known technique for displaying a tool path for a rapid fabrication device in a user interface and updating the displayed tool path to represent the current movements of the rapid fabrication device tool and Kritchman's teaching (as modified by Tay and Henke) provides a known system that would have been improved by application of Seki's suggested technique for at least the reasons described above. Based upon my knowledge and experience in this field and my review of Kritchman, Tay, Henke, and Seki, I am confident a POSITA would have recognized that this modification would have yielded predictable results and required only routine adjustments to the system and as such a POSITA would have had a reasonable expectation of success in making such modifications. This modification would not have significantly altered or hindered the functions performed by Kritchman's system, and these modifications would have been within the predictable and ordinary level of skill of a POSITA (certainly by a time frame as late as 2010). Kritchman states that "[i]t should be appreciated by persons skilled in the art that many modifications, variations, substitutions, changes, and equivalents are possible in light of the above teaching" and Seki

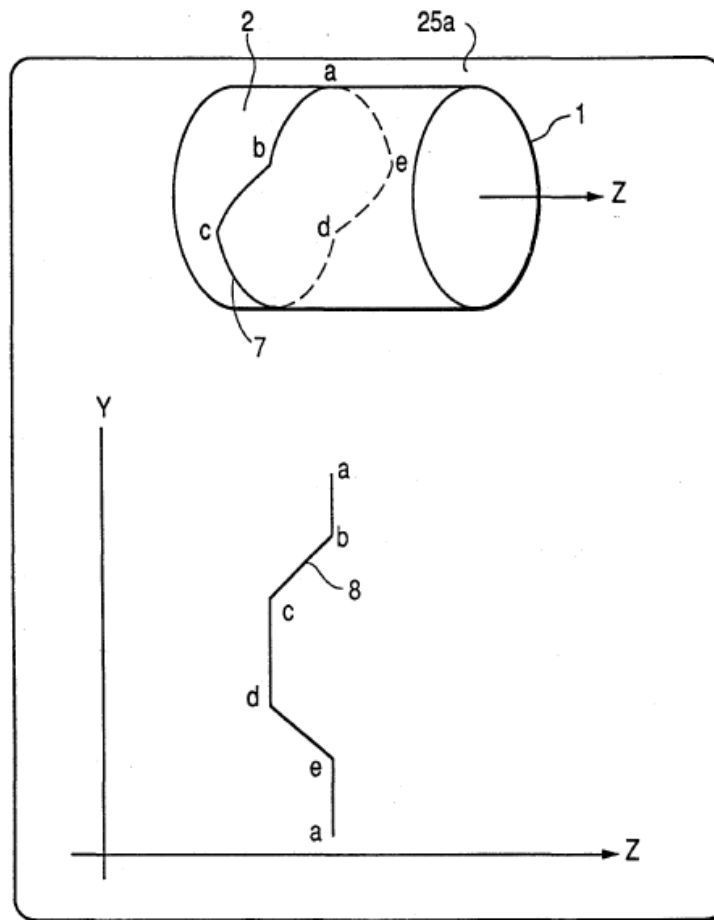
proposes just such a modification that would have been beneficially applied to Kritchman for the reasons stated above. EX1015, [0157].

271. As demonstrated below, the predictable combination of Kritchman, Tay, Henke, and Seki renders obvious claim 11.

Claim [11]: The device of claim 1 wherein the user interface displays a two-dimensional tool path for the three-dimensional printer, the two-dimensional tool path corresponding to a current layer of the object during a fabrication of the object by the three-dimensional printer.

272. Seki demonstrates that the Kritchman-Tay-Henke-Seki combination displays a two-dimensional tool path for the three-dimensional printer in the user interface, the two-dimensional tool path corresponding to a current layer of the object during a fabrication of the object by the three-dimensional printer. Seki describes “[a] tool path drawing method which facilitates confirmation of the movement of a tool associated with three-dimensional machining.” EX1009, Abstract. Specifically, Seki displays displaying both three-dimensional and two-dimensional representations of the tool path in the user interface. EX1009, 2:24-32. Examples of such displayed tool paths are shown in Figure 1.

FIG. 1



EX1009, FIG. 1.

273. For example, Seki describes that when an instruction for machining the workpiece occurs, “the CPU 21 calculates a tool path section” for both the three-dimensional and two-dimensional display and provides the information to the display device such that “the tool path section b'-c' is drawn on the YZ coordinate system.” EX1009, 4:19-41.

274. Seki goes on to describe that, “[e]very time NC data associated with a motion definition statement is executed, thereafter, one of first to fifth sections of a tool path 7 which corresponds to this NC data, along with its preceding tool path section, is drawn on a peripheral surface 2 of the workpiece FIG. 1 which is drawn on the display screen 25a.” *Id.*, 2:32-37. This includes drawing the section of the tool path “along with its preceding tool path sections...on the YZ coordinate system” on the display screen. *Id.*, 2:38-43. As such, Seki not only discloses displaying the two-dimensional tool path in the user interface but also discloses that, when predictably applied to the Kritchman-Tay-Henke system, the two-dimensional tool path corresponds to a current layer of the object during a fabrication of the object by the three-dimensional printer because the displayed tool path is updated based on the current operation of the 3D printer.

7.12. Ground 2E: The Combination of Kritchman with Tay, Henke, and Waehner Renders Obvious Claim 17

275. Multiple reasons would have motivated a POSITA to modify the system of Kritchman-Tay-Henke to further include functionality to include at least one control to capture a stop-motion animation of a fabrication of the object using the video camera within the user interface for multiple reasons based on the suggestions of Waehner. *As a first reason*, Waehner’s techniques for sampling video image data captured by a camera “so that for each camera only one out of

every predetermined number of sequential images or frames is provided” results in video image data in which “each of the data streams received by digital video recorder 18 is performed at a predetermined rate selected by a user at setup of digital video recorder” which “reduces the number of images per camera per second.” EX1010, [0019]. As such, Waehner’s time lapse video recording technique “reduce[s] the amount of storage required to record the video captured by cameras.” *Id.* As such, applying Waehner’s teachings for allowing a user to select, and provide parameters for, a time lapse video recording mode would have reduced the amount of storage required for the video images captured by the camera(s) of the resulting Kritchman-Tay-Henke-Waehner system. EX1010, [0004], [0019].

276. As a second reason, Waehner’s time lapse recording mode “provides time lapse recording where the various cameras are recorded at a slower rate and, if desired, at a lower resolution but for a much longer period of time” which allows for easier “longer term archival storage” of such video. *Id.*, [0010]. As such, application of Waehner’s teachings for allowing a user to select, and provide parameters for, a time lapse video recording mode would have facilitated long term storage of large amounts of video data without the need to add additional storage capacity in the resulting system. EX1010, [0004], [0010], [0019]-[0020].

277. As a third reason, the increased ability to store video data based on employing Waehner's time lapse recording mode can allow for later review of fabrication procedures to identify "events that have not been detected and would otherwise be lost" such as when a defect in an object/design is detected a period of time after the fabrication process has completed. EX1010, [0010].

278. As a fourth reason, application of Waehner's teachings for allowing a user to select between regular, high-definition recording and time-lapsed recording would allow for "review[ing] of recent events" with "the maximum amount of information" in the video while providing the storage benefits that I mentioned above. EX1010, [0009].

279. As a fifth reason, a POSITA would have been prompted to modify Kritchman's 3D printer system (as already modified by Tay and Henke) to provide a control to capture a stop-motion (time lapse) animation of a fabrication of the object using the video camera in the user interface (as suggested by Waehner) because doing so would be merely the application of a known technique to a known system ready for improvement to yield predictable results. Here, Waehner provides straightforward evidence of a known technique for selecting and setting parameters for a time lapse video recording mode and Kritchman's teaching (as modified by Tay and Henke) provides a known system that would have been

improved by application of Waehner's suggested technique for at least the reasons described above. Based upon my knowledge and experience in this field and my review of Kritchman, Tay, Henke, and Waehner, I am confident a POSITA would have recognized that this modification would have yielded predictable results and required only routine adjustments to the system and as such a POSITA would have had a reasonable expectation of success in making such modifications. This modification would not have significantly altered or hindered the functions performed by Kritchman's system, and these modifications would have been within the predictable and ordinary level of skill of a POSITA (certainly by a time frame as late as 2010). Kritchman states that "[i]t should be appreciated by persons skilled in the art that many modifications, variations, substitutions, changes, and equivalents are possible in light of the above teaching" and Waehner proposes just such a modification that would have been beneficially applied to Kritchman for the reasons stated above. EX1015, [0157].

280. As demonstrated below, the predictable combination of Kritchman with Tay, Henke, and Waehner renders obvious claim 17.

Claim [17]: The device of claim 1 wherein the user interface includes at least one control to capture a stop-motion animation of a fabrication of the object using the video camera.

281. Waehner demonstrates that the resulting Kritchman-Tay-Henke-Waehner system implements the user interface includes at least one control to capture a stop-motion animation of a fabrication of the object using the video camera. For example, Waehner describes “recording the received video data at a first rate, and recording the received video data at a second rate with the second rate being slower than the first rate.” EX1010, [0006]. This second mode “provides time lapse recording where the various cameras are recorded at a slower rate and, if desired, at a lower resolution but for a much longer period of time” which allows for easier “longer term archival storage” of such video. *Id.*, [0010].

282. The user of the system can provide various parameters for the two recording modes, including “the record rate in frames per second, recording resolution for each camera, how long that digital video recorder can record at maximum speed and how many channels of data will be sampled, compressed and stored as explained hereinafter in detail.” *Id.*, [0018]. The user provides such parameters via a user interface that can take the form of “control buttons” using “a workstation,” “personal computer,” or “laptop computer” to “provid[e] setup information over a network to digital video recorder 18.” *Id.* As such, a POSITA would have recognized that in the Kritchman-Tay-Henke-Waehner combination, the user interface provided by the local site for display at the remote computer

would have included at least one control for capture of the time lapse video (stop-motion animation) of the fabrication process. The end result is a time-lapse version of the video created by sampling “only one out of every predetermined number of sequential images or frames.” *Id.*, [0019]. This sampling “reduces the number of images per camera per second” to facilitate efficient storage “for a long period of time.” *Id.* A POSITA would have recognized that Waehner’s descriptions of a “time lapse” video provides, or at least renders obvious, the stop-motion animation recited by claim 17.

7.13. Ground 2F: The Combination of Kritchman, Tay, Henke, and Lan Renders Obvious Claim 18

283. Multiple reasons would have motivated a POSITA to modify the system of Kritchman-Tay-Henke to further configure the processor of Kritchman’s controller 105 to couple the three-dimensional printer in a communicating relationship with a remote print server through the data network (the Internet) for multiple reasons based on the suggestions of Lan. As a first reason, including a print server in the Kritchman-Tay-Henke system that is in communication with the Kritchman’s controller (as modified based on the teachings of Tay and Henke) would have allowed for multiple remote users, each utilizing their own remote computing device, to easily identify and communicate with multiple rapid fabrication devices located at various geographic locations, to control and monitor

various different types of rapid fabrication processes efficiently and effectively.

Lan describes various different of web-based rapid prototyping systems, including discussing functionality for “job planning and scheduling” and “remote control and monitoring for RP machines.” EX1011, 1. As such, implementing Lan’s 3D printer scheduling using a remote print server facilitates multiple users interfacing with multiple different geographically disperse 3D fabrication devices in a straight forward manner using a common interface.

284. As a second reason, Lan describes that the job planning and scheduling functionality described therein can be facilitated through the user of print servers that match remote users to appropriate rapid prototyping devices “to maximize the system utilization and minimize the average response time for scheduling non-preemptive aperiodic tasks so that it is suitable for the distributed Web-based RP systems.” EX1011, 10. Lan shows example systems from several papers that use a remote print server to facilitate scheduling and remote control of various rapid fabrication devices:

H. Lan/Computers in Industry 60 (2009) 643–656

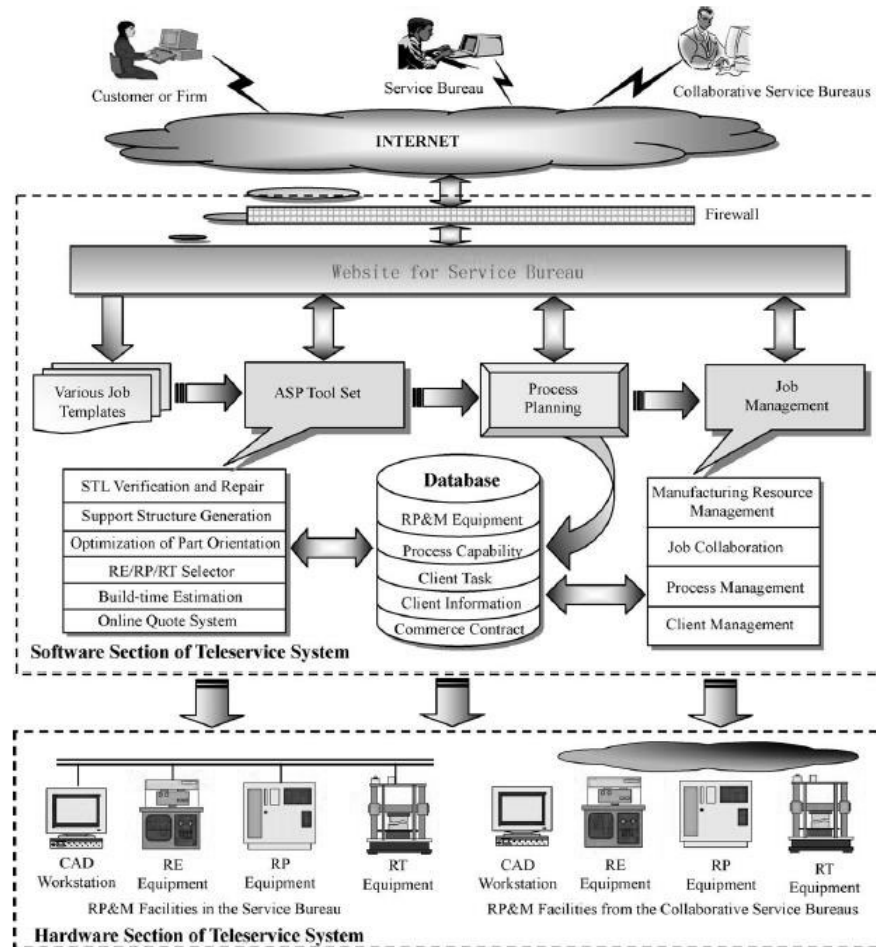


Fig. 4. Architecture of the Web-based RP&M system.

EX1011, 5.

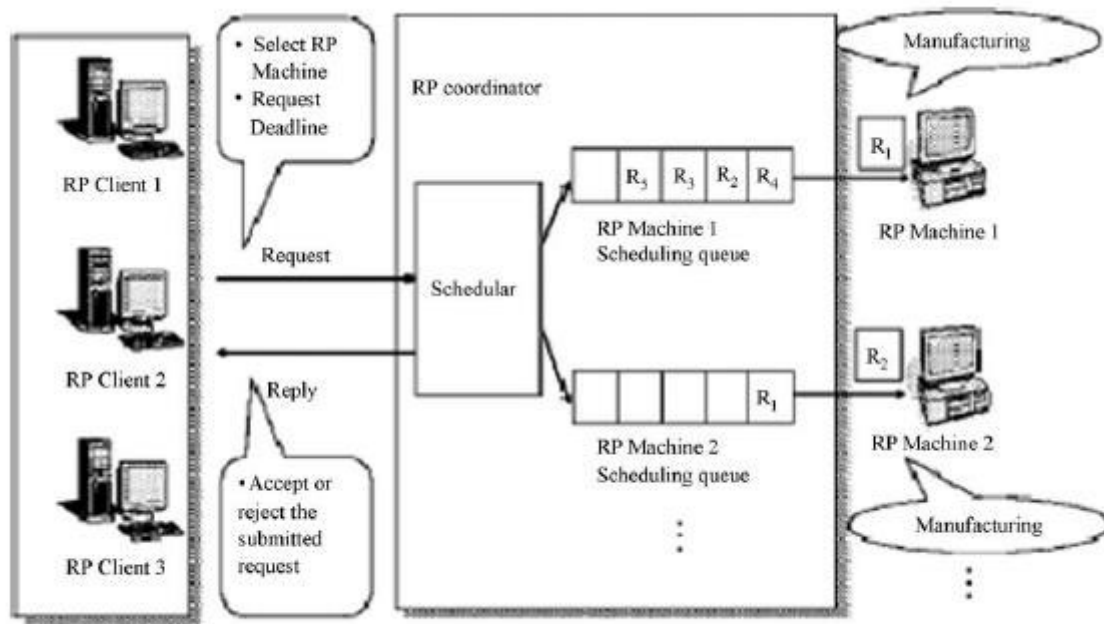


Fig. 10. Distributed RP platform scheduler [65].

EX1011, 10.

285. *As a third reason*, Lan describes that the Web server schedules the fabrication/print job with an available device based on capabilities of the available devices and requirements of the print job and “the Web server can transmit the STL file to the RP machine that [is] chosen by the customers.” EX1011, 3, 10. This use of an intermediary web-based print server allows for automated scheduling of rapid fabrication processes “to minimiz[e] idle time” and lower “the effective cost rate.” EX1011, 9-10, 3.

286. As a fourth reason, application of Lan's print server enabled techniques for matching users to remote 3D fabrication devices and automatically facilitating scheduling and transfer of design files to the fabrication devices achieves an "optimal" scheduling solution in which "new requests can be accepted dynamically and all accepted requests can be finished before deadlines" such that "the quality of service is significant[ly] improved." EX1011, 10, 5.

287. As a fifth reason, Applying Lan's print server enabled techniques to the Kritchman-Tay-Henke system would have allowed for automated selection of "a valid and feasible RP manufacturing site" for a given design so that the remote facility having the correct "site manufacturing capability" is selected while meeting "delivery time constraints." EX1011, 10. This includes automated RP&M process selection. *Id.*, 6-8.

288. As a sixth reason, Lan describes allowing "remote users [to] select a suitable RP through calculating possible delivery time" including providing "help [to] users to select an appropriate RP machine. EX1011, 10, 3, 5. As such, application of Lan's teachings to the Kritchman-Tay-Henke system would have allowed users to select a preferred remote rapid fabrication device, in at least some scenarios.

289. As a seventh reason, a POSITA would have been prompted to modify Kritchman's 3D printer system (as already modified by Tay and Henke) to include a remote print server in communication with Kritchman's controller over the data network (as suggested by Lan) because doing so would be merely the application of a known technique to a known system ready for improvement to yield predictable results. Here, Lan provides straightforward evidence of a known technique for implementing a 3D printer in a networked 3D printer environment and Kritchman's teaching (as modified by Tay and Henke) provides a known system that would have been improved by application of Lan's suggested technique for at least the reasons described above. Based upon my knowledge and experience in this field and my review of Kritchman, Tay, Henke, and Lan, I am confident a POSITA would have recognized that this modification would have yielded predictable results and required only routine adjustments to the system and as such a POSITA would have had a reasonable expectation of success in making such modifications. This modification would not have significantly altered or hindered the functions performed by Kritchman's system, and these modifications would have been within the predictable and ordinary level of skill of a POSITA (certainly by a time frame as late as 2010). Kritchman states that "[i]t should be appreciated by persons skilled in the art that many modifications, variations,

substitutions, changes, and equivalents are possible in light of the above teaching” and Lan proposes just such a modification that would have been beneficially applied to Kritchman for the reasons stated above. EX1015, [0157].

290. As demonstrated below, the predictable combination of Kritchman with Tay, Henke, and Lan renders obvious claim 18.

Claim [18]: The device of claim 1 wherein the processor is configured to couple the three-dimensional printer in a communicating relationship with a remote print server through the data network.

291. Lan demonstrates that in the Kritchman-Tay-Henke-Lan combination, the processor of Kritchman’s controller is configured to couple the three-dimensional printer in a communicating relationship with a remote print server through the data network. Lan teaches that rapid prototyping and manufacturing (RP&M) techniques “using the Internet can further enhance the design and manufacturing productivity, speed, and economy, as well as share the RP machines.” EX1011, 1 Lan reviews various aspects of web-based rapid prototyping, including “job planning and scheduling” and “remote control and monitoring for RP machines.” *Id.*

292. The job planning and scheduling functionality can be facilitated through the user of print servers that match remote users to appropriate rapid

prototyping devices “to maximize the system utilization and minimize the average response time for scheduling non-preemptive aperiodic tasks so that it is suitable for the distributed Web-based RP systems.” EX1011, 10. Lan shows example systems from several papers that use a remote print server to facilitate scheduling and remote control of various rapid fabrication devices:

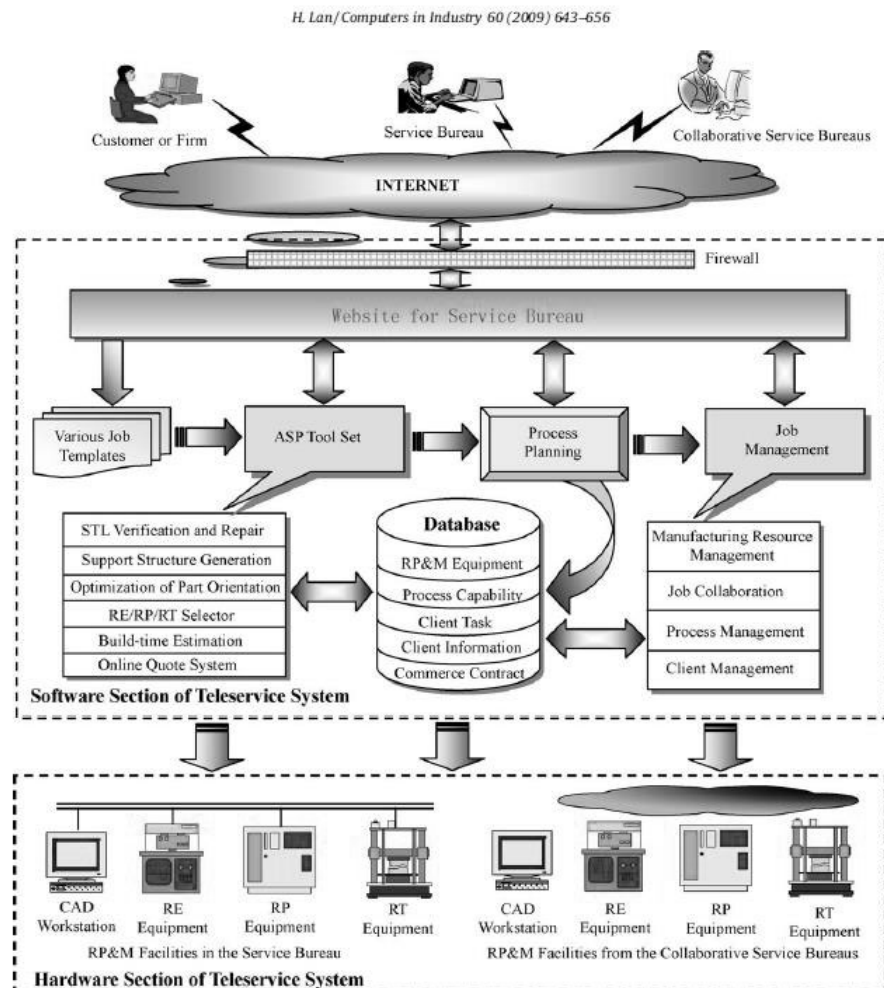


Fig. 4. Architecture of the Web-based RP&M system.

EX1011, 5.

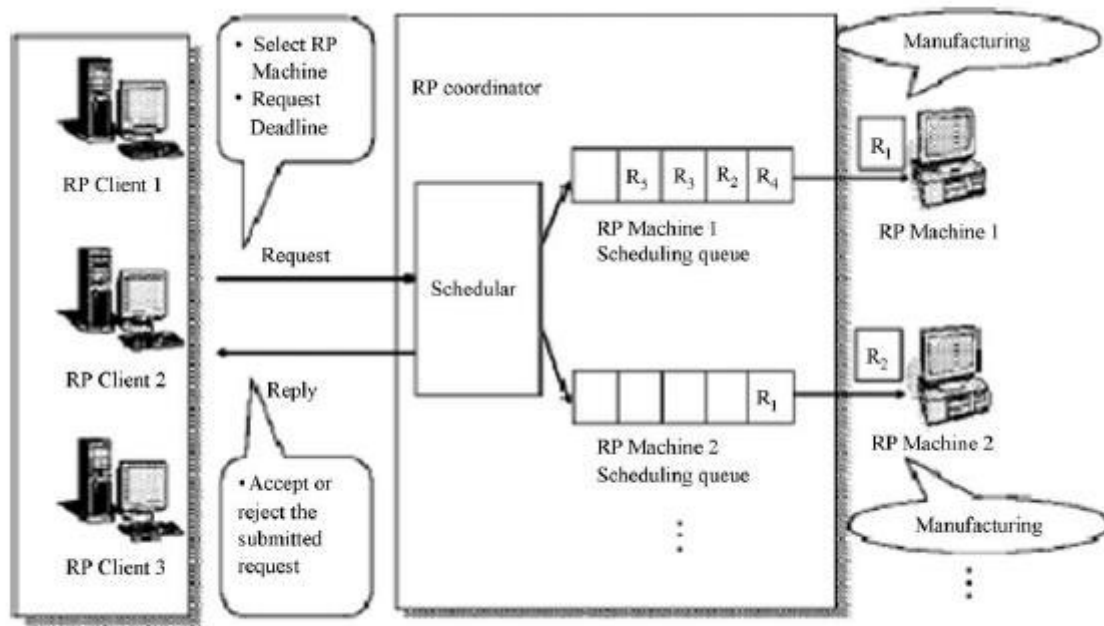


Fig. 10. Distributed RP platform scheduler [65].

EX1011, 10.

293. In one specific example, Lan describes that the user transmits the CAD model (an STL file) “via the Internet to the RP Web server” which then schedules the print job and “transmit[s] the STL file to the RP machine that [is] chosen by the customers.” EX1011, 3. In another example, the web server selects “a valid and feasible RP manufacturing site” for a given design so that the remote facility having the correct “site manufacturing capability” and schedules the print job “to minimiz[e] idle time.” *Id.*, 10. The user provides the STL file to the web server, which queues the print job for the appropriate fabrication machine. *Id.* A POSITA would have recognized that the web servers described in Lan, which

coordinate and schedule rapid fabrication jobs between multiple users and multiple rapid fabrication devices, and provide model data to those devices, meet the description of a print server in the '324 patent. EX1001, 9:4-37.

7.14. Ground 2G: The Combination of Kritchman with Tay, Henke, and Anderson Renders Obvious Claims 3, 5, 9-10, and 20-22

294. Multiple reasons would have motivated a POSITA to modify the system of Kritchman-Tay-Henke to include additional status information in the user interface generated by Kritchman's controller (as modified based on Tay and Henke) for presentation at the remote client computer (as taught by Tay), including status information indicating if a design is waiting, printing, or done, the percentage of the object completed, and a comparison of the portion fabricated against a wire frame in the user interface for multiple reasons based on the suggestions of Anderson.

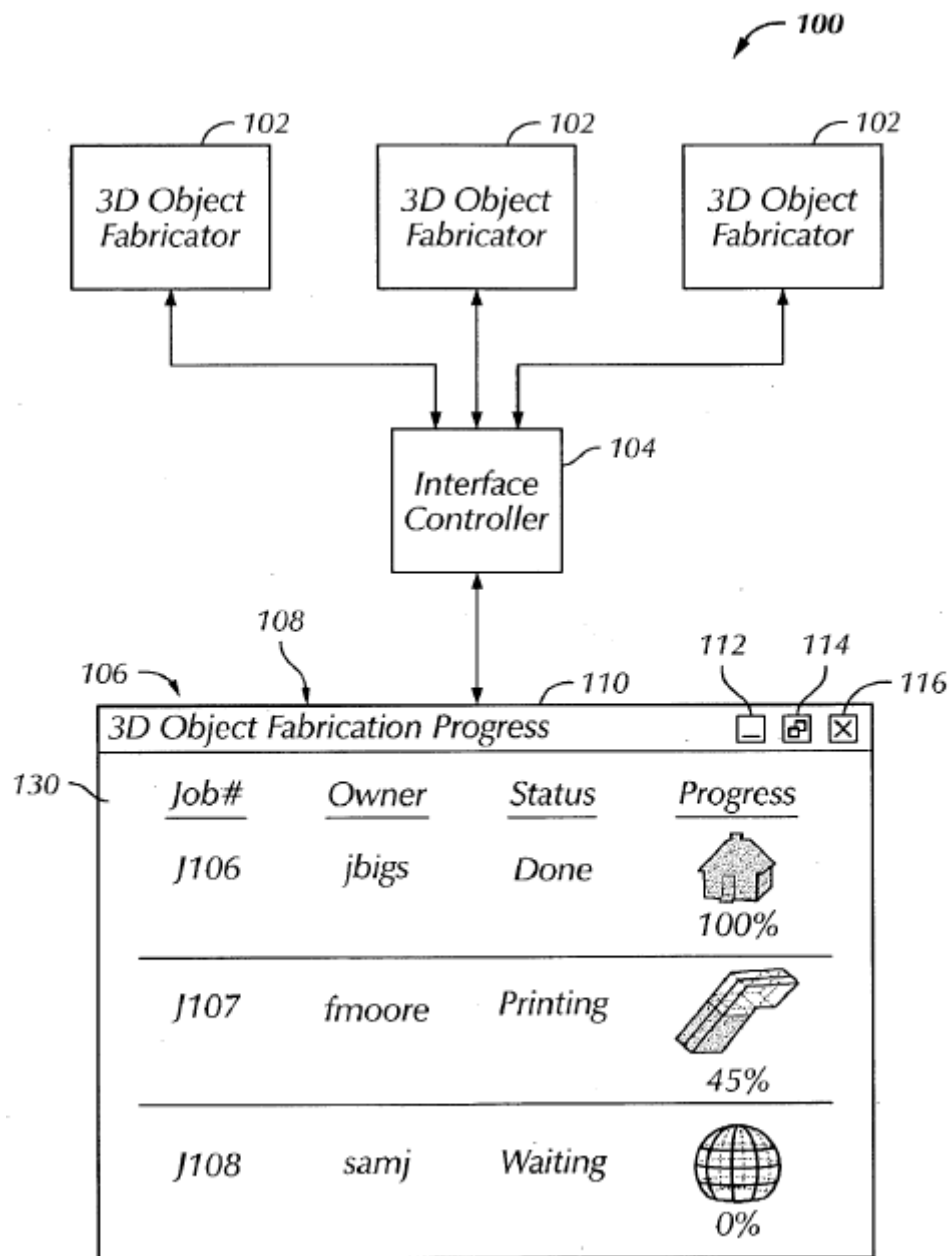


FIG. 1

EX1012, FIG. 1.

295. *As a first reason*, displaying such additional status information in the user interface of the resulting Kritchman-Tay-Henke-Anderson system would have helpfully provided extra context for the displayed virtual images of the object model. As discussed in Ground 2A, above, in the Kritchman-Tay-Henke combination, the user interface images of the model of the object being fabricated. EX1013, 4-5; EX1014, 5. Anderson complements this teaching by providing additional context for the virtual view of the object (based on the model) by showing which layers have been completed with respect to a wireframe of the entire object and identifying a percentage that has been completed:

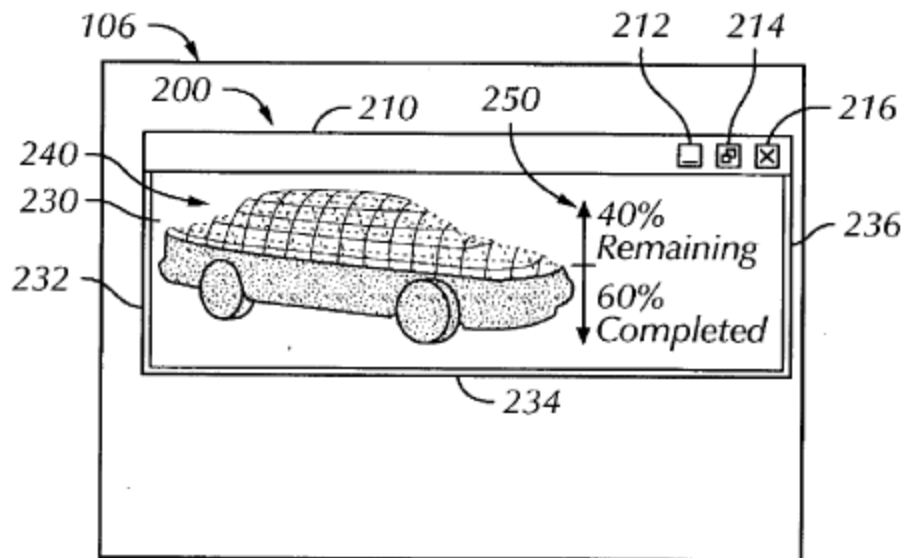


FIG. 2A

EX1012, FIG. 2A, [0018]-[0020].

296. Providing this additional information, including the portions of the virtual image of the object that have been completed in comparison to the wireframe representing the completed object, and the percentage of the object that has been fabricated, would have increased the user's knowledge and understanding of the overall fabrication process and help the user to visualize the completed portion of the object with respect to the full design.

297. *As a second reason*, displaying this the additional information regarding progress of the fabrication process, including the virtual image of the object in comparison to the wireframe and numerical indications of the percentage of completion of the fabrication process, would help the user to readily assess the progress of the fabrication process and estimate the amount of time remaining

298. *As a third reason*, displaying this additional status information described by Anderson would have allowed users to easily identify where in a print queue the user's particular design is to help the user to better schedule other tasks with respect to the rapid fabrication process. For example, the user interface elements shown in Figure 1 of Anderson not only display progress of jobs in progress but also indicate the status of whether a print job is completed, in progress, or queued for future execution:

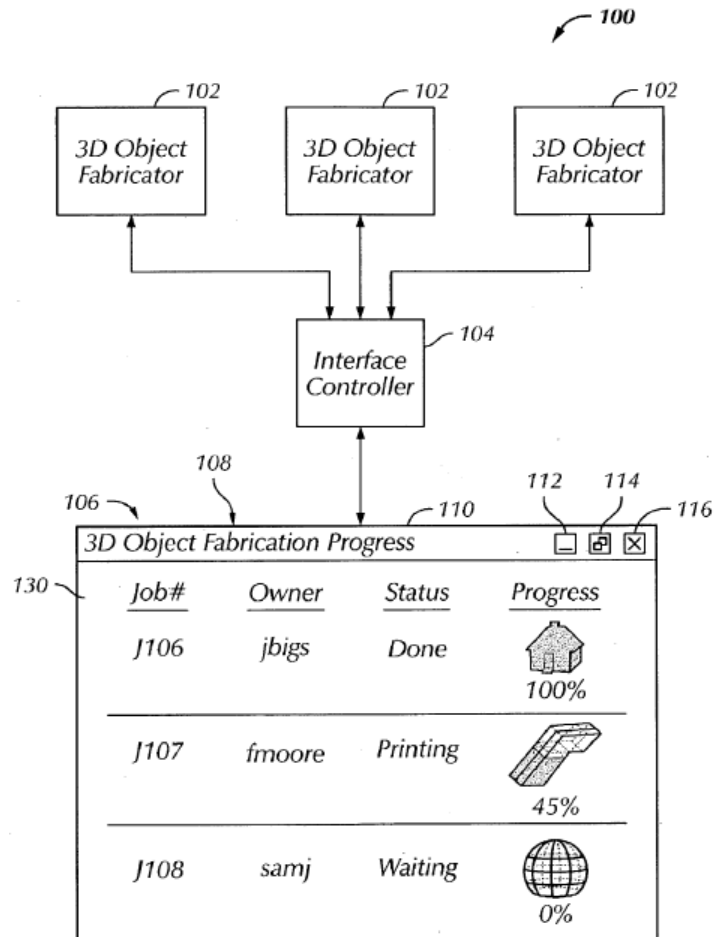


FIG. 1

EX1012, FIG. 1, [0019].

299. As a fourth reason, providing visual indicators of completion of the fabrication process for a given fabrication project in the user interface displayed to the remote user would have allowed users to conduct post fabrication actions (such as communicating with persons at the local fabrication site) in a timely manner.

300. As a fifth reason, a POSITA would have been prompted to modify Kritchman's rapid fabrication system (as already modified by Tay and Henke) to include the additional visual status information described by Anderson in the user interface displayed at the remote computer because doing so would be merely the application of a known technique to a known system ready for improvement to yield predictable results. Here, Anderson provides straightforward evidence of a known technique for providing status information for a 3D printing process to a remote user and Kritchman's teaching (as modified by Tay and Henke) provides a known system that would have been improved by application of Anderson's suggested technique for at least the reasons described above. Based upon my knowledge and experience in this field and my review of Kritchman, Tay, Henke, and Anderson, I am confident a POSITA would have recognized that this modification would have yielded predictable results and required only routine adjustments to the system and as such a POSITA would have had a reasonable expectation of success in making such modifications. This modification would not have significantly altered or hindered the functions performed by Kritchman's system, and these modifications would have been within the predictable and ordinary level of skill of a POSITA (certainly by a time frame as late as 2010). Kritchman states that "[i]t should be appreciated by persons skilled in the art that

many modifications, variations, substitutions, changes, and equivalents are possible in light of the above teaching” and Anderson proposes just such a modification that would have been beneficially applied to Kritchman for the reasons stated above. EX1015, [0157].

301. As demonstrated below, the predictable combination of Kritchman with Tay, Henke, and Anderson renders obvious claims 3, 5, 9-10, and 20-22.

Claim [3]: The device of claim 1 wherein the two-dimensional projection is simulated based upon operation of the three-dimensional printer.

302. Anderson provides additional disclosures demonstrating that in the Kritchman-Tay-Henke-Anderson combination, the two-dimensional projection is simulated based upon operation of the three-dimensional printer. As taught by Anderson, the user interface includes provides “progress information” that is updated as the three-dimensional printer operates such that “[a]fter each pass of the printheads, the printer updates a status register” to accurately track “the number of passes completed by the printhead.” EX1012, [0018]. Anderson teaches that “the server polls the printer for the pass number” and updates the displayed model “to show the completed portion as a filled-in (e.g., solid colored) area.” *Id.*

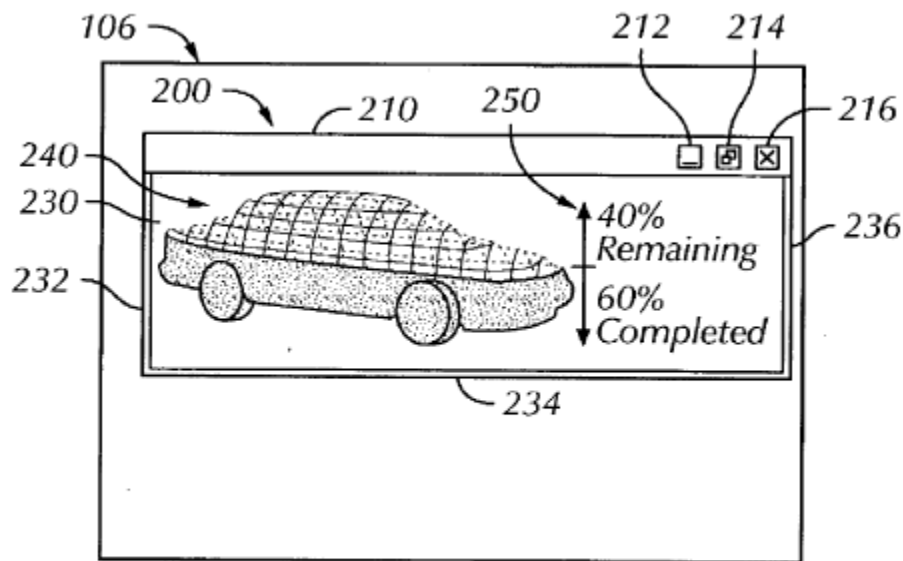


FIG. 2A

EX1012, FIG. 2A, [0018]-[0020]. In another example, Anderson discloses that “status includes...data pertaining to three-dimensional object(s) fabrication progress.” *Id.*, [0026]. As such, the model is simulated based upon operation of the three-dimensional printer to reflect a current state of physical completion of the object by the printer.

Claim [5]: The device of claim 1 wherein the two-dimensional projection is dynamically updated to correspond to a state of physical completion of the object.

303. Anderson provides additional disclosures demonstrating that in the Kritchman-Tay-Henke-Anderson combination, the two-dimensional projection is dynamically updated to correspond to a state of physical completion of the object. As I discussed above with respect to claim 3, Anderson discloses the user interface

includes provides “progress information” that is updated as the three-dimensional printer operates such that “[a]fter each pass of the printheads, the printer updates a status register” to accurately track “the number of passes completed by the printhead.” EX1012, [0018]. Anderson teaches that “the server polls the printer for the pass number” and updates the displayed model “to show the completed portion as a filled-in (e.g., solid colored) area.” *Id.*

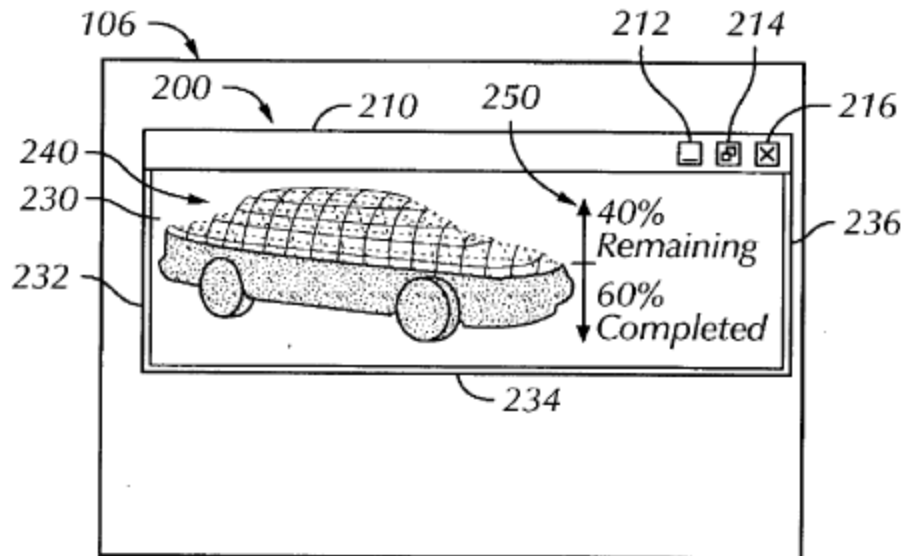


FIG. 2A

EX1012, FIG. 2A, [0018]-[0020]. In another example, Anderson discloses that “status includes...data pertaining to three-dimensional object(s) fabrication progress.” *Id.*, [0026]. As such, the model is simulated based to correspond to a state of physical completion of the object.

Claim [9]: The device of claim 1 wherein the user interface provides status information for the three-dimensional printer.

304. Anderson discloses that the user interface includes status information for the three-dimensional printer, including which object is currently being fabricated by the printer, status of the print job, and progress of an in-process print job as shown, for example, in Figure 1. EX1012, [0018]-[0020].

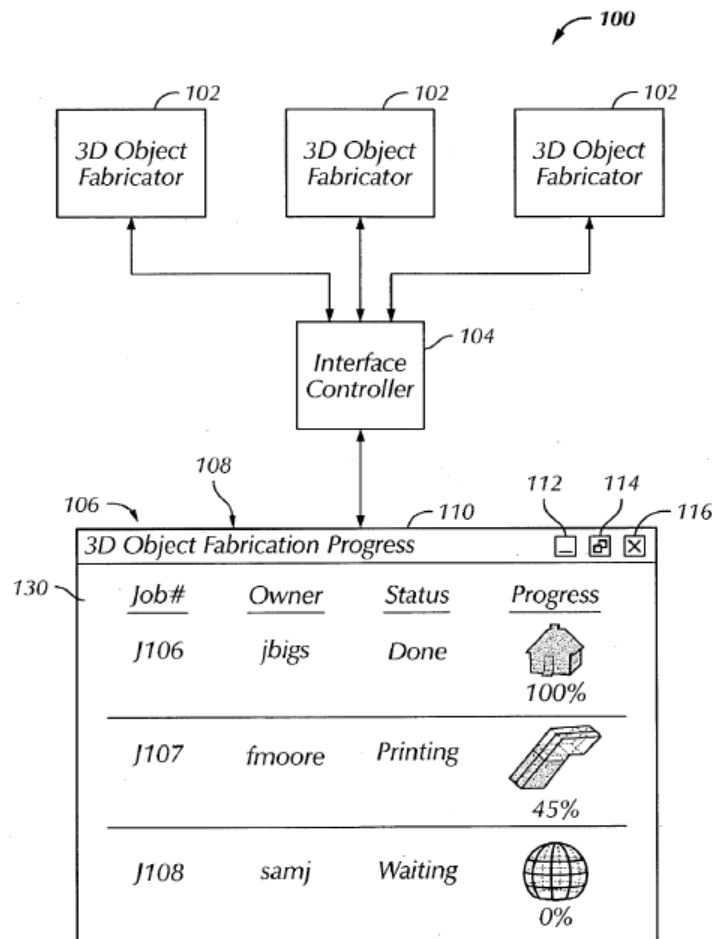


FIG. 1

EX1012, FIG. 1.

Claim [10]: The device of claim 1 wherein the user interface provides status information for a build process executing on the three-dimensional printer.

305. Anderson discloses that the user interface includes status information for the build process, including status of the build process and percent completion of the build process as shown, for example, in Figures 1 and 2A (reproduced above). EX1012, [0018]-[0020], [0026], FIGs. 1, 2A.

Claim [20]: The method of claim 19 further comprising transmitting status information over the data network upon completion of the object.

306. Anderson demonstrates that in the resulting Kritchman-Tay-Henke-Anderson combination, the Kritchman's 3D printing system (as modified by Tay, Henke, and Anderson) transmits status information over the data network upon completion of the object. This is demonstrated, for example, by Figure 1 of Anderson, which shows that the status information in the user interface includes changing the "status" of the object fabrication process to "Done" upon completion of the object and updating the "progress" indicator to show that the wireframe of the model of the object as 100% filled in. EX1012, [0019], [0021].

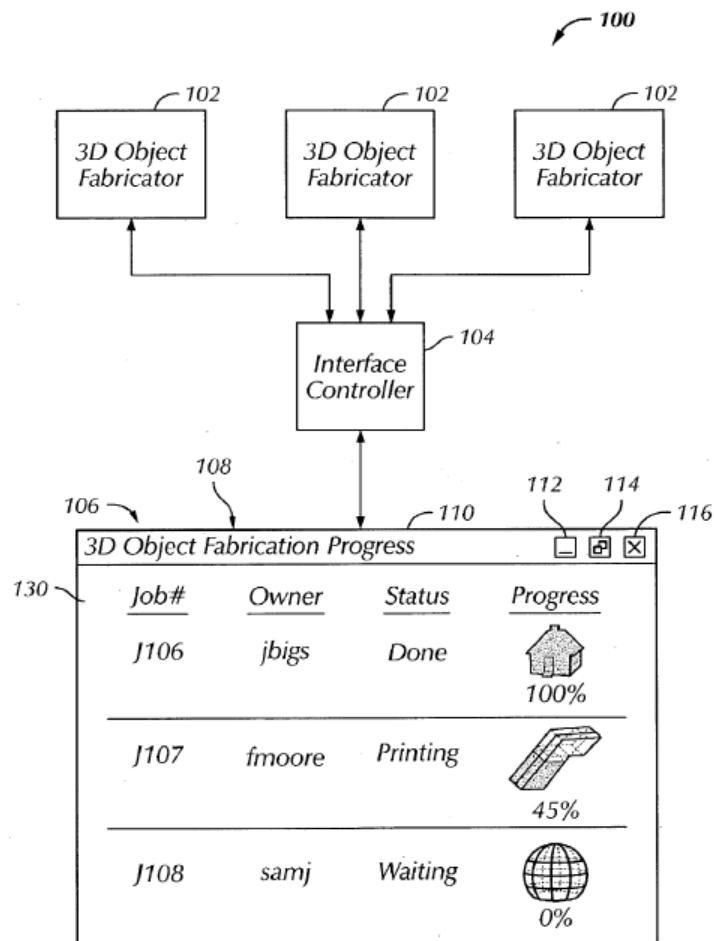


FIG. 1

EX1012, FIG. 1. A POSITA would have recognized that this change of the status to “Done” upon completion of the object satisfies claim 20.

Claim [21]: *The method of claim 20 wherein the status information includes data presented through the user interface.*

307. As I discussed with respect to Ground 2A, above, As I discussed above, both Tay and Henke disclose that the status information (including the

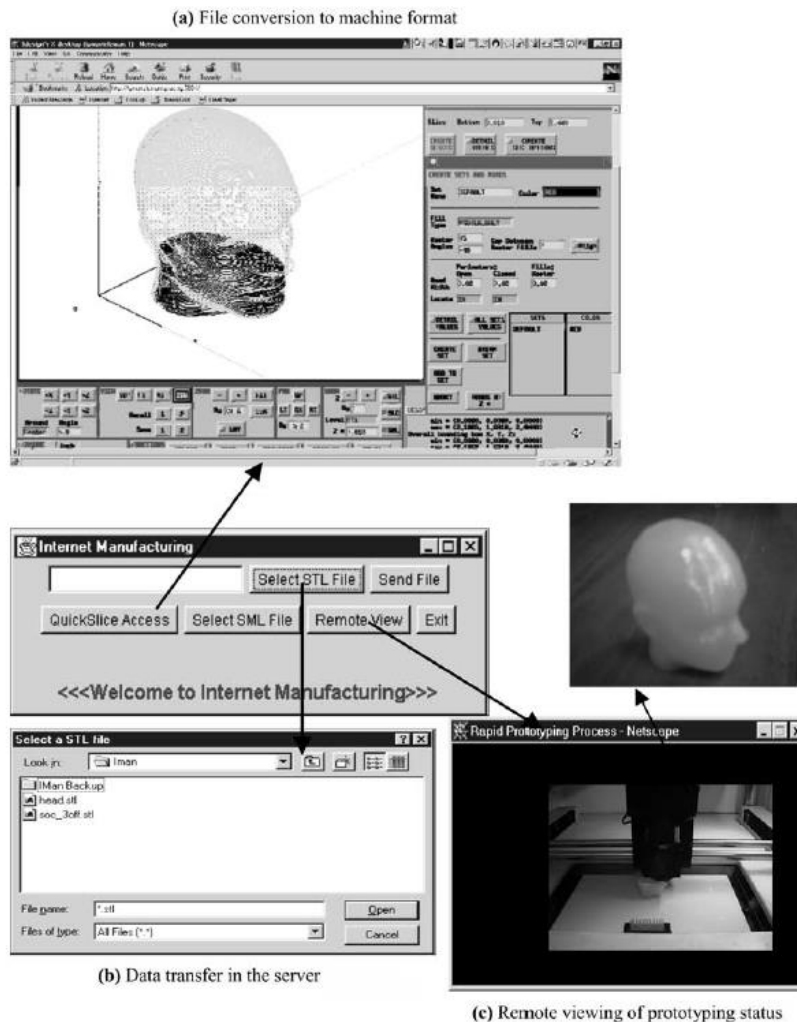
Declaration of Andrew Wolfe, Ph.D.
U.S. Patent No. 8,562,324

images captured by the camera) are displayed as part of the user interface.

EX1013, 5; EX1014, 5.

Figure 3

(a) File conversion to machine format (b) Data transfer in the server (c) Remote viewing of prototyping status



EX1013, 5.

308. Anderson discloses that in the Kritchman-Tay-Henke-Anderson combination, the additional status information disclosed by Anderson is also

displayed as part of the user interface displayed at the remote device which can be “implemented via the printer driver” of the computing device at the fabrication site. EX1012, [0017]-[0021].

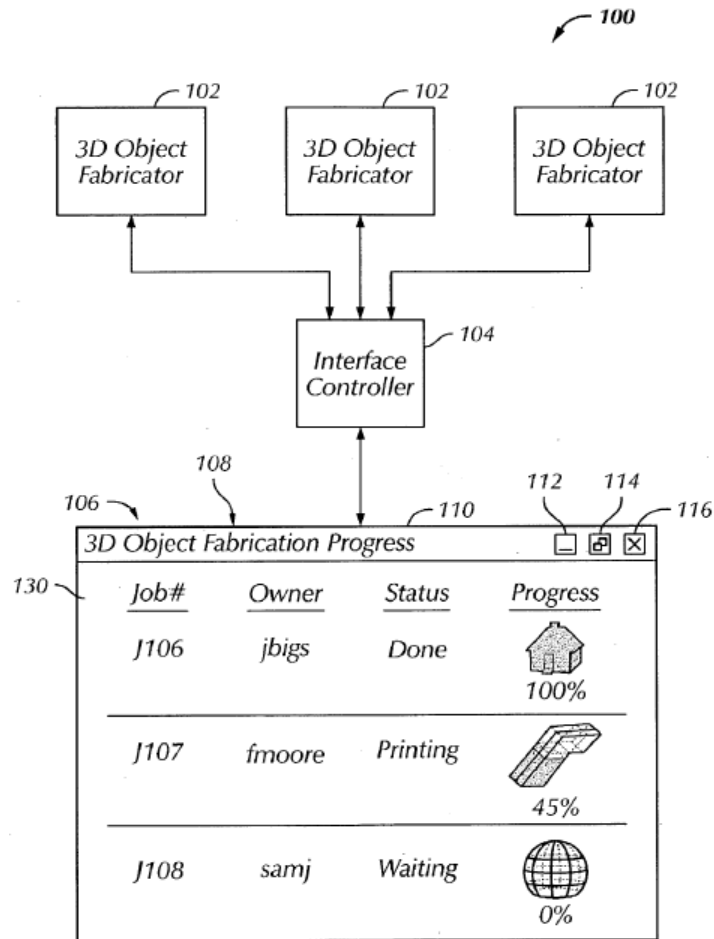


FIG. 1

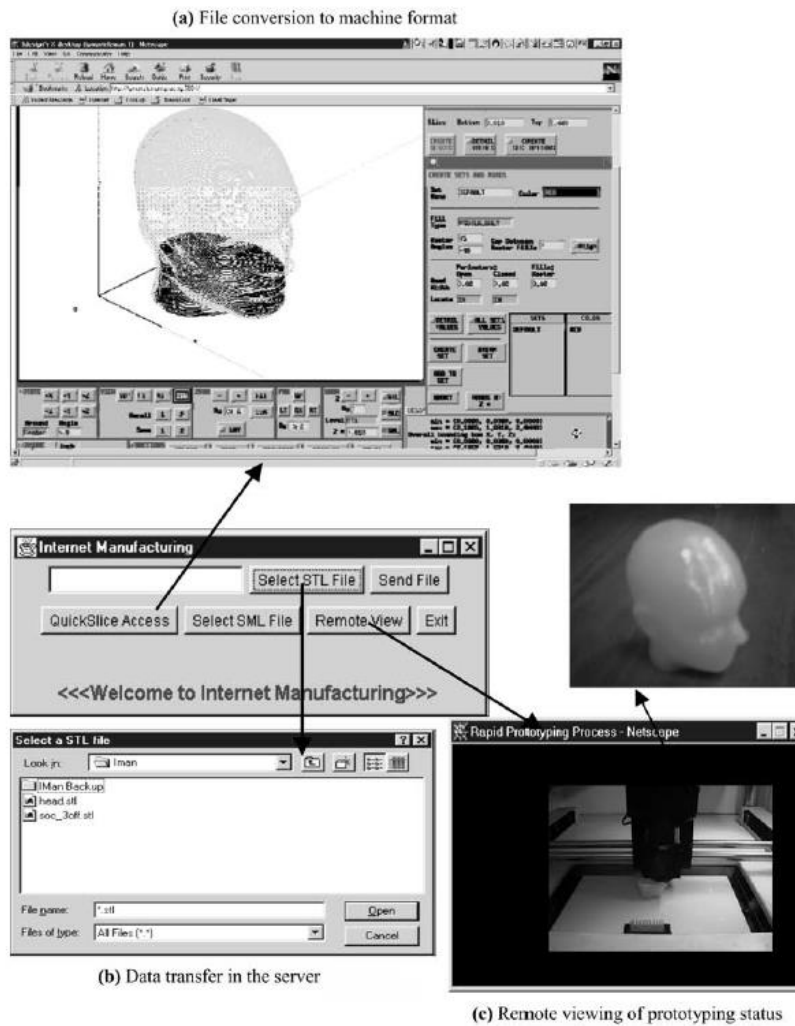
EX1012, FIG. 1.

Claim [22]: The method of claim 20 wherein the status information includes a digital image from the video camera.

309. The combination of Kritchman with Tay, Henke, and Anderson provides this claim for the reasons that I discussed above with respect to Element [1.d] and claims 6 and 20-22 in Ground 2A. For example, as shown in Figure 3, Tay's system provides "audio and visual feedback" from the fabrication system to the client device using a "Web cam and video conferencing." EX1013, 4. These web cams can allow "multiple clients...to watch the same fabrication process for discussion and analysis." *Id.*

Figure 3

(a) File conversion to machine format (b) Data transfer in the server (c) Remote viewing of prototyping status



EX1013, 5.

310. I have reviewed portions of the Patent Owner's infringement contentions and it appears that Patent Owner contends in the district court litigation that merely displaying video camera images of the product at a remote computer satisfies this claim. EX1016, 187-189. As such, Mazumder's descriptions of

displaying the image data captured by the camera of the object being fabricated in the user interface presented at the remote computer demonstrate that the Mazumder-Mori combination meets this claim. EX1004, 6:36-43, 8:14-17. As such, Tay's descriptions of displaying the image data captured by the camera of the object being fabricated in the user interface presented at the remote computer demonstrates that the Mazumder-Mori combination meets this claim. EX1013, 4-5.

8. Secondary Considerations

311. At this stage of these proceedings, it is my understanding that Petitioner has no burden to identify and rebut secondary considerations. Rather, it is my understanding that Patent Owner must first present a prima facie case for such consideration, which Petitioners should then have the chance to rebut. That said, I have considered evidence of secondary considerations that I am aware of at this time, and I am currently unaware of any evidence of secondary considerations that would support a finding of non-obviousness. If additional evidence of secondary considerations becomes available, I would ask to be able to opine on it at that time.

9. Availability for Cross-Examination

312. In signing this declaration, I recognize that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross examination in the case and that cross examination will take place within the United States. If cross examination is required of me, I will appear for cross examination within the United States during the time as mutually agreed between the parties.

10. Right to Supplement

313. I reserve the right to supplement my opinions in the future to respond to any arguments that the Patent Owner may raise. This declaration represents only those opinions that I have formed to date. I reserve the right to revise, supplement, and/or amend my opinions stated herein based on new information that becomes available to me and on my continuing analysis of the materials already provided.

11. Jurat

314. I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

12/18/2024

Date



Andrew Wolfe, Ph.D.

Appendix A

Andrew Wolfe Ph.D.

2005 De La Cruz Blvd STE 142
Santa Clara, CA 95050
(408) 394-1096 (mobile)
Email: awolfe@awolfe.org

Education:

Ph.D. in Electrical and Computer Engineering, Carnegie Mellon University, 1992
Visiting Graduate Student, Center for Reliable Computing, Stanford University, 1988-1989
M.S. in Electrical and Computer Engineering, Carnegie Mellon University, 1987
B.S.E.E. in Electrical Engineering and Computer Science, The Johns Hopkins University, 1985

Recent Employment:

Lecturer, Asst. Teaching Professor [September 2013-present]
Santa Clara University

Teaching graduate and undergraduate courses on embedded computing, mechatronics, real-time systems, computer architecture, design, and community service. Faculty Senate President 2023-24.

Consultant, [October 2002-present]
Wolfe Consulting

Consultant on processor technology, computer systems, consumer electronics, software, design tools, and intellectual property issues. Testifying and consulting expert for IP and other technology-related litigation matters.

Sample clients include:

Google	Apple	Samsung
Sony	Huawei	HTC
AT&T	Verizon Mobile	T-Mobile
IBM	Motorola/Lenovo	Nintendo
Activision	AMD	Western Digital
Sonos	Qualcomm	LG
Netflix	Roku	Tivo
Synaptics	Sawstop	3M
Medigus	TCL	ZTE
Egnyte	Acer	Waymo

Chief Technical Officer, [1999-2002]; Sr. VP of Business Development, [2001-2002]; VP, Systems Integration, S3 Fellow, [1998 – 1999]; Director of Technology, S3 Fellow, [1997 - 1998]
SONIC|blue, Inc., Santa Clara, CA (formerly S3 Inc.)

Strategic Business Development:

Developed and implemented strategy to reposition S3 from PC graphics into the leading networked consumer electronics company.

- Acquired Diamond Multimedia and coordinated integration of communications, Rio digital music, and workstation graphics divisions into S3.
- Identified and negotiated acquisitions to grow digital media businesses including Empeg, ReplayTV, and Sensory Science.
- Identified and negotiated strategic investments including Comsilica, Intellon, KBGear Interactive, Entridia, DataPlay and others.

- Developed strategy for integrated graphics/core-logic products and established a joint venture with Via Technologies to design and market these products.
- Negotiated divestiture of graphics chip business to Via and the workstation graphics division to ATI.

Product Planning and Development:

- Drove roadmap development within SONICblue product divisions.
- Managed Business Development for all product lines.
- Led New Product Development and Corporate Vision processes.
- Acting co-General Manager of Rio digital music business in 2nd half of 2001. Responsible for all areas of product development, business development, and cost management.
- Managed development of the Savage/MX and Savage/IX mobile 3D graphics accelerators and Savage/NB system logic products.

Public Relations, Public Policy and Investor Relations:

- Present company products and strategy at industry events such as CES, Comdex, and Microprocessor Forum.
- Discuss new products and initiatives with the press.
- Promote issues of interest to SONICblue to industry groups and in Washington.
- Brief analysts, and investors on company progress. Participate in quarterly conference calls.

IP Management and Licensing:

- Negotiated and managed partnership agreements including a critical cross-licensing agreement with Intel.
- Renegotiated technology-licensing agreements with IBM for workstation graphics products.
- Evaluated outside technology opportunities, managed video research and development, and managed corporate IP strategy with legal staff including patent filings, cross licensing, and litigation.

Consulting Professor, [1999-2002]

Stanford University, Stanford, CA

Teaching computer architecture and microprocessor design.

Assistant Professor [1991 - 1997]

Princeton University, Princeton, NJ

Teaching and research in the Electrical Engineering department. Research in embedded computing systems, multimedia, video signal processors, compiler optimization, and high performance computer architecture. Principal investigator or project manager for ~\$6M in funded research.

Visiting Assistant Professor, [1992]

Carnegie Mellon University, Pittsburgh, PA

Research and preparation of teaching materials on advanced microprocessor designs including new superscalar and superpipelined processor architectures.

Founder and Vice President and Consultant, [1989 - 1995]

The Graphics Technology Company, Inc., Austin, TX

Founded company to develop touch-sensitive components and systems for the first generation of PDA devices and interactive public systems. Obtained financing from Gunze Corp., Osaka, Japan. Company is now part of 3M.

Senior Electrical Engineer, [1989]

ESL - TRW, Advanced Technology Division, Sunnyvale, CA

Designed the architecture for an Intel i860-based multiple-processor digital signal processing system for advanced military applications. Designed several FPGA interface chips for VME-bus systems.

Design Consultant, [1986 -1987]

Carroll Touch Division, AMP Inc., Round Rock, TX

Developed several new technologies for touch-screen systems. Designed the first ASIC produced for AMP, a mixed-signal interface chip for controlling touch-screen sensors. Developed the system electronics, system firmware, and customer utility software for numerous products including those based on the new ASIC.

Senior Design Engineer, [1983 -1985]

Touch Technology Inc., Annapolis, MD

Advisory Boards:

Director, Turtle Beach Corporation (NASDAQ:HEAR) (formerly Parametric Sound Corporation), KBGear Interactive, Inc., Comsilica, Inc., Rioport.com, various S3 subsidiaries.

Technical Advisory Boards, Ageia, Inc., Intellon, Inc., Comsilica, Inc., Entridia, Inc., Siroyan, Ltd., BOPS, Inc, Quester Venture Funds

Carnegie Mellon University Silicon Valley Advisory Board; Johns Hopkins University Tech Transfer Advisory Board

Awards:

IEEE Fellow - for contributions in hardware code compression of embedded software, power consumption analysis, and optimization, 2022
IEEE Computer Society Distinguished Contributor - 2021
Micro Test-of-Time Award (in recognition of one of the ten most influential papers of the first 25 years of the symposium), 2014
Business 2.0 “20 Young Executives You Need to Know”, 2002
Walter C. Johnson Prize for Teaching Excellence, 1997.
Princeton University Engineering Council Excellence in Teaching Award, Spring 1996
AT&T/Lucent Foundation Research Award, 1996.
Walter C. Johnson Prize for Teaching Excellence, 1995
IEEE Certificate of Appreciation, 1995, 2001.
AT&T Foundation Research Award, 1993.
Semiconductor Research Corporation Fellow, 1986 - 1991.
Burroughs Corporation Fellowship in Engineering, 1985 - 1986.

Professional Activities:

Program Chair: Micro-24, 1991, Hot Chips 13, 2001.
General Chair: Micro-26, 1993, Micro-33, 2000.
Associate Editor: IEEE Computer Architecture Letters; ACM Transactions in Embedded Computing Systems
Speaker at CES, WinHec, Comdex, Intel Dev. Forum, Digital Media Summit, Microprocessor Forum, etc.
Keynote speaker at Micro-34, ICME 2002
IEEE B. Ramakrishna Rau Award committee – 2012-2016
IEEE Computer Society Awards Committee – 2015
Director – IEEE Consultants Network of Silicon Valley – 2022-present
CES Awards Judge – 2016
Entrepreneurship Mentor – Draper University

Over 50 refereed publications.**Publications since January 2006:**

Wolfe, A., “Retrospective on Code Compression and a Fresh Approach to Embedded Systems”, IEEE MICRO, July/Aug. 2016, Invited paper.

Michael Kreienkamp, Olivia McConaghy, Sally L. Wood, Andrew Wolfe, Julia A. Scott, 2024 NYC Neuromodulation Conference, Transcranial Photobiomodulation Control System Compatible with EEG, abstract and poster. June 2024 <https://neuromodec.org/nyc-neuromodulation-2024/poster-list.html#A83D>

Patents:

- U.S. Pat. 5,041,701 – *Edge Linearization Device for a Contact Input System*, Aug. 20, 1991.
- U.S. Pat. 5,438,168 – *Touch Panel*, Aug. 1, 1995.
- U.S. Pat. 5,736,688 – *Curvilinear Linearization Device for Touch Systems*, Apr. 7, 1998.
- U.S. Pat. 6,037,930 – *Multimodal touch sensitive peripheral device*, March 14, 2000.
- U.S. Pat. 6,408,421 – *High-speed asynchronous decoder circuit for variable-length coded data*, June 18, 2002.
- U.S. Pat. 6,865,668 – *Variable-length, high-speed, asynchronous decoder circuit*, March 8, 2005
- U.S. Pat. 7,079,133 – *Superscalar 3D Graphics Engine*, July 18, 2006
- EP 1 661 131 B1 – *PORTABLE ENTERTAINMENT APPARATUS*, Jan. 21, 2009
- U.S. Pat. 7,555,006 – *Method and system for adaptive transcoding and transrating in a video network*, June 30, 2009
- U.S. Pat. 7,996,595 – *Interrupt Arbitration for Multiprocessors*, Aug. 9, 2011
- EP 2 241 979 B1 – *Interrupt Arbitration for Multiprocessors*, Oct. 10, 2011
- U.S. Pat. 8,131,970 – *Compiler Based Cache Allocation*, March 6, 2012
- U.S. Pat. 8,180,963 – *Hierarchical read-combining local memories*, May 15, 2012
- U.S. Pat. 8,193,941 – *Snoring Treatment*, June 5, 2012
- U.S. Pat. 8,203,541 – *OLED display and sensor*, June 19, 2012
- U.S. Pat. 8,243,045 – *Touch-sensitive display device and method*, August 14, 2012
- U.S. Pat. 8,244,982 – *Allocating processor cores with cache memory associativity*, August 14, 2012
- U.S. Pat. 8,260,996 – *Interrupt Optimization for Multiprocessors*, Sept. 4, 2012
- 101185761 (KR) – *Noise Cancellation for Phone Conversation*, Sept. 19, 2012
- 101200740 (KR) – *OLED display and sensor*, November 7, 2012
- 101200741 (KR) – *Touch-sensitive display device and method*, November 7, 2012
- U.S. Pat. 8,321,614 – *Dynamic scheduling interrupt controller for multiprocessors*, Nov. 27, 2012
- U.S. Pat. 8,352,679 – *Selectively securing data and/or erasing secure data caches responsive to security compromising conditions*, Jan. 8, 2013
- U.S. Pat. 8,355,541 – *Texture Sensing*, Jan. 15, 2013
- U.S. Pat. 8,370,307 – *Cloud Data Backup Storage Manager*, Feb. 5, 2013
- U.S. Pat. 8,398,451 – *Tactile Input Interaction*, March. 19, 2013
- JP 5241032 B2 – *Routing Across Multicore Network Using Real World or Modeled Data*, April 13, 2013
- ZL201010124820.3 – *Interrupt Optimization for Multiprocessors*, April 17, 2013
- U.S. Pat. 8,428,438 – *Apparatus for Viewing Television with Pause Capability*, April 23, 2013
- JP 5266197 B2 – *Data Centers Task Mapping*, May 10, 2013
- U.S. Pat. 8,508,498 – *Direction and Force Sensing Input Device*, August 13, 2013
- U.S. Pat. 8,547,457 – *Camera Flash Mitigation*, October 1, 2013
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