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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte JAYDEV P. DESAI, MINGYEN HO, J. MARC SIMARD, and RAO GULLAPALLI[1]

Appeal 2017-011048
Application 13/763,284
Technology Center 3700

Before RICHARD M. LEBOVITZ, JOHN E. SCHNEIDER, and RYAN H. FLAX, *Administrative Patent Judges*.

SCHNEIDER, *Administrative Patent Judge*.

DECISION ON APPEAL

This is an appeal[2] under 35 U.S.C. § 134 of the Examiner's rejection of claims to minimally invasive neurosurgical intracranial robot system as obvious. We have jurisdiction under 35 U.S.C. § 6(b).

We AFFIRM.

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[1] Appellants identify the Real Parties in Interest as University of Maryland and the National Institutes of Health. Br. 1.

[2] We have considered and herein refer to the Specification of Aug. 5, 2013 ("Spec."); Non-Final Office Action of Sept. 26, 2016 ("Non-Final Act."); Appeal Brief of Feb. 23, 2017 ("Br."); and Examiner's Answer of June 15, 2017 ("Ans.").

STATEMENT OF THE CASE

The Specification states that "[b]rain tumors are among the most deadly adult tumors which accounts for about 2% of all cancer deaths in the United States." Spec. 4. "Surgical resection of the tumor is considered the optimal treatment for most brain tumors." *Id.* Minimally invasive surgery is often used to reduce tissue disruption during tumor removal. *Id.* "However, due to the lack of satisfactory continuous imaging modality, it is extremely challenging to remove brain tumors precisely and completely without damaging the surrounding brain tissue using traditional surgical tools." *Id.* To address this problem, the Specification describes "a robotic system for minimally invasive surgical procedures which can be teleoperatively controlled by a neurosurgeon in a highly efficient and precise manner." *Id.* at 10.

Claims 1–24 are on appeal.[3] Claim 1 is the sole independent claim; it is representative and reads as follows:

> 1. Minimally Invasive Neurosurgical Intracranial Robot (MINIR) system, comprising:
>
> a robot sub-system compatible with an imaging system and introduced in an intracranial area containing a target of interest;
>
> a tracking sub-system operatively coupled to said robot sub-system and generating tracking information corresponding to said robot sub-system position;
>
> an interface operatively coupled to said imaging system and said tracking sub-system to display, substantially in real-

[3] Claims 25–39 are also pending in the application, but have been withdrawn from consideration. Non-Final Act. 2.

time, images of the intracranial area generated by said imaging system aligned with said tracking information, wherein said interface is further operatively interconnected between a user and said robot sub-system, and wherein the user applies commands to said interface to manipulate said robot sub-system based on said substantially in real-time images and said tracking information to reach said target of interest for an intended interaction therewith;

wherein said robot sub-system includes:

a robot body composed of a plurality of links and N revolute joints interconnecting respective of said plurality of links each to the other, wherein each of said N revolute joints is formed between respective adjacent links for rotational motion of each link with respect to the other about a corresponding rotational axis extending through said each revolute joint in substantially orthogonal relationship to a rotational axis of an adjacent revolute joint, and wherein each of said plurality of links is configured with cylindrically shaped walls extending substantially along the periphery of said each link and defining a central channel surrounded by said walls, wherein said each link has opposite edges spaced apart along a length of said each link, and wherein a plurality of wall channels extend internally within and between said opposite edges of said cylindrically shaped walls;

a tendon sub-system integrated with said robot body, said tendon sub-system containing N independent tendons, each independent tendon being routed internally within said cylindrically shaped walls through said wall channels extending internally through said cylindrically shaped walls of said each link in a non-interfering relationship with said central channel of said each link, wherein each of said N independent tendons is operatively coupled to a respective one of said N revolute joints;

an actuator sub-system operatively coupled to said tendon sub-system, said actuator sub-system containing N independently operated temperature sensitive actuating mechanisms, wherein each actuating mechanism is operatively coupled to a respective one of said N revolute joints through a respective one of said N tendons to independently control said respective revolute joint through controlling the motion of said respective tendon of said tendon sub-system;

a control sub-system operatively coupled between said interface and said actuator sub-system; and

a feedback control sub-system including at least a temperature based feedback sub-system coupled between said temperature sensitive actuating mechanisms and said control sub-system, wherein said temperature based feedback sub-system is configured to acquire data on a temperature regime applied to said temperature sensitive actuating mechanisms;

wherein said control sub-system is configured to generate control signals responsive to the user's commands input via said interface and responsive to at least said temperature regime data received from said at least temperature based feedback subsystem of said feedback control sub-system, and transmits said control signals to said actuator sub-system; and

wherein said actuator sub-system is configured, responsive to said control signals received thereat, to control, through controlling the motion of at least one said respective tendon, the rotational motion of adjacent links of at least one said revolute joint, thereby steering said robot sub-system relative to said target of interest.

The claims stand rejected as follows:

Claims 1, 2, 5–8, 11, 14, 15, and 17 have been rejected under 35 U.S.C. § 103(a) as unpatentable over Ishiguro[4] and Donhowe[5], Rogers[6], Browne[7], and Sizer.[8]

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[4] Ishiguro et al., US 2010/0022837 A1, published Jan. 28, 2010 ("Ishiguro").
[5] Donhowe et al., US 2011/096199 A1, published Aug. 11, 2011 ("Donhowe").
[6] Rogers et al., US 2008/0287963 A1, published Nov. 20, 2008 ("Rogers").
[7] Browne et al., US 2007/0243810 A1, published Oct. 18, 2007 ("Browne").
[8] Sizer et al. US 7,637,105 B2, issued Dec. 29, 2009 ("Sizer").

Claims 9, 10, and 16 have been rejected under 35 U.S.C. § 103(a) as unpatentable over Ishiguro, Donhowe, Rogers, Browne, Sizer, and Birkenbach.[9]

Claims 12 and 13 have been rejected under 35 U.S.C. § 103(a) as unpatentable over Ishiguro, Donhowe, Rogers, Browne, Sizer, and Okihisa.[10]

Claim 18 has been rejected under 35 U.S.C. § 103(a) as unpatentable over Ishiguro, Donhowe, Rogers, Browne, Sizer, and Moll.[11]

Claims 19 and 20 have been rejected under 35 U.S.C. § 103(a) as unpatentable over Ishiguro, Donhowe, Rogers, Browne, Sizer, and Kudoh.[12]

Claim 21 has been rejected under 35 U.S.C. § 103(a) as unpatentable over Ishiguro, Donhowe, Rogers, Browne, Sizer, Kudoh, and Omori.[13]

Claims 22 and 23 have been rejected under 35 U.S.C. § 103(a) as unpatentable over Ishiguro, Donhowe, Rogers, Browne, Sizer, Kudoh, Omori, and Choi.[14]

Claim 24 has been rejected under 35 U.S.C. § 103(a) as unpatentable over Ishiguro, Donhowe, Rogers, Browne, Sizer, and Webster.[15]

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[9] Birkenbach et al., US 2014/0235999 A1, published Aug. 21, 2014 ("Birkenbach").
[10] Okihisa et al., US 2009/0182282 A1, published July 16, 2009 ("Okihisa").
[11] Moll et al., US 2007/0197896 A1, published Aug. 23, 2007 ("Moll").
[12] Kudoh et al., US 2011/0065994 A1, published Mar. 17, 2011 ("Kudoh").
[13] Omori, US 2009/03690 A1, published Feb. 5, 2009 ("Omori").
[14] Choi et al., US 2012/0004648 A1, published Jan. 5, 2012 ("Choi").
[15] Webster et al., US 2009/0171271 A1, published July 2, 2009 ("Webster").

DISCUSSION

Rejection of Claims 1, 2, 5–8, 11, 14, 15, and 17

Issue

The issue with respect to this rejection is whether a preponderance of the evidence supports the Examiner's determination that the subject matter of claims 1, 2, 5–8, 11, 14, 15, and 17 would have been obvious over Ishiguro combined with Donhowe, Rogers, Browne, and Sizer.

The Examiner finds that Ishiguro teaches an MINIR comprising a robot sub-system and an interface. Non-Final Act. 3. The Examiner finds that the robot subsystem comprises a robot body, a tendon subsystem, an actuator subsystem, a control subsystem. Non-Final Act. 3–4. The Examiner finds that Ishiguro does not teach a tracking system nor does it teach temperature sensitive actuating mechanisms or a temperature base feedback subsystem.

The Examiner finds that Donhowe teaches an MINIR comprising a robot subsystem, a tracking subsystem, an interface, and an actuator subsystem. Non-Final Act. 5. The Examiner finds that Donhowe teaches that the actuator subsystem contains independently operated temperature sensitive actuating mechanisms. *Id.*

The Examiner finds that Rogers teaches a minimally invasive surgical apparatus having a plurality of links, wherein each link has opposite edges, spaced apart along a length of each link, with a plurality of wall channels extending internally within cylindrically shaped walls. *Id.* The Examiner also finds that Rogers teaches a tendon subsystem integrated with the robot body such that the tendons are routed internal to the walls. *Id.*

The Examiner finds that Browne teaches the use of a temperature sensitive actuating mechanism with a control subgroup and a feedback control subsystem. Non-Final Act. 6.

The Examiner finds that Sizer teaches a feedback control subsystem comprising a temperature based feedback subsystem coupled between a temperature sensitive actuating mechanism and a control subsystem. *Id.*

Further to these findings, the Examiner concludes:

> it would have been *prima facie* obvious to one of ordinary skill in the art at the time of invention to utilize the tracking sub-system of Donhowe et al. in order to allow a user to automatically maintain a desired roll orientation at a distal tip while moving the tip towards a target site (paragraph [0009] of Donhowe et al.).
>
> It would have been prima facie obvious to one of ordinary skill in the art at the time of invention to modify the links of Ishiguro to utilize in-wall channels as taught by Rogers in order to reduce the cross-sectional area of the device while increasing the size of the lumen provided within (para [0032] of Rogers).
>
> Further, it would have been *prima facie* obvious to one of ordinary skill in the art at the time of invention to utilize the SMA actuator of Browne et al. in order to reduce actuator size, weight, volume, cost, noise, and an increase simplicity, robustness, and/or reliability of the overall system in comparison with traditional electromechanical and hydraulic means of actuation (para [0048] of Browne). Finally, it would have been *prima facie* obvious to one of ordinary skill in the art at the time of invention to utilize the temperature based feedback of Sizer et al. with the system of Ishiguro in view of Donhowe and Browne in order to minimize the stress and strain on the SMA spring and thereby increase its working life (column 1, lines 37-48 of Sizer et al.).

Non-Final Act. 6–7.

Findings of Fact

We adopt the Examiner's findings as our own, including with regard to the scope and content of, and motivation to modify or combine, the prior art. Non-Final Act. 4–7. The following findings highlight certain evidence.

FF1. Ishiguro teaches "a surgical instrument having a surgical unit which operates on an operating portion in a body cavity." Ishiguro Abstract.FF2. As shown in Figure 10, reproduced below, Ishiguro's instrument comprises a robotic arm having a plurality of links (51, 52, and 53) and joints (61, 62, and 63) connecting the links.

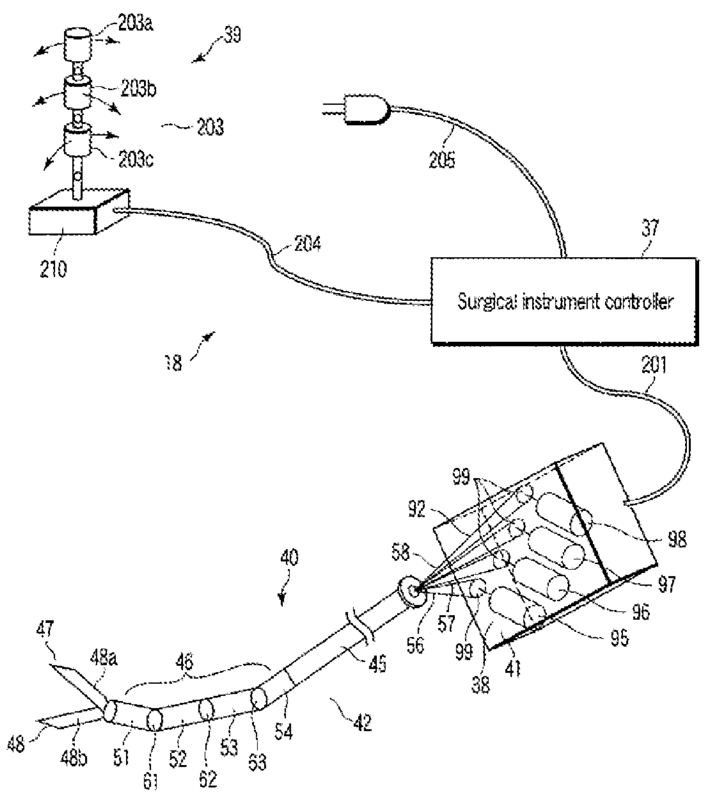

FIG. 10

Figure 10 of Ishiguro shows a perspective view of a surgical instrument having a bending manipulation unit in an endoscope apparatus system. *See also* Ishiguro ¶¶ 129–134.

FF3. In Figure 1, Ishiguro discloses that its robotic arm 40 is connected to an imaging system 5. Figure 1 is reproduced below:

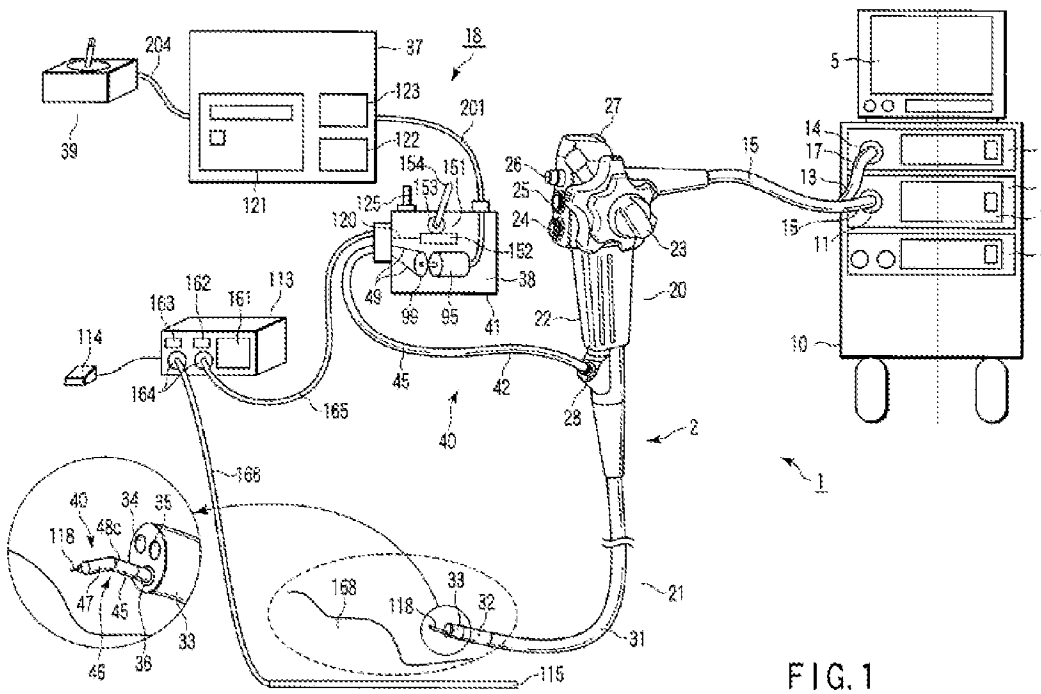

FIG. 1

Figure 1 of Ishiguro shows an endoscope system. *See also* Ishiguro ¶¶ 51 and 67.

FF4. Ishiguro teaches:

> As shown in FIG. 10, the manipulation unit 41 is provided with a bending portion manipulation mechanism and an end effector manipulation mechanism. The bending portion manipulation mechanism is provided with drive motors 95, 96, 97 for pushing and pulling the manipulation wires 56, 57, 58,

> respectively. Further, the end effector manipulation mechanism is provided with a drive motor 98 for pushing and pulling the manipulation wire 92. The manipulation wires 56, 57, 58 correspond to the bending pieces (targets to be rotated) 51, 52, 53 and execute rotating manipulations.

Ishiguro ¶ 180; *see also supra* FF2.

FF5. Ishiguro teaches that the manipulation wires run internally in the robotic arm. Ishiguro ¶¶ 143, 160, Figures 12A and 12B.

FF6. The MINIR of Ishiguro includes a control subsystem operatively coupled between the interface and the actuator subsystem. Ishiguro Fig. 10.

FF7. Ishiguro teaches:

> Although the bending portion manipulation mechanism and the end effector manipulation mechanism use transmission mechanisms making use of the pulleys 99, they may use, for example, a gear mechanism and the like making use of a pinion gear and a rack. *Further, the bending portion manipulation mechanism and the end effector manipulation mechanism may use other types of drive actuators in place of the drive motors 95, 96, 97, 98.*

Ishiguro ¶ 184 (emphasis added).

FF8. Ishiguro teaches:

> The surgical instrument controller 37 transmits a control signal for driving the drive motors 95, 96, 97 in response to the manipulation of the joystick 203 executed by the operator to the motor driver 122 and rotates the drive motors 95, 96, 97. Encoders (not shown) are mounted on the drive motors 95, 96, 97 to measure the numbers of revolutions thereof. The encoders feedback-control the drive motors 95, 96, 97 by generating signals according to the number of revolutions and transmitting the signals to the motor driver 122.

Ishiguro ¶ 190.

FF9. Donhowe relates to "robotic endoscopes and in particular, to a method and system for automatically maintaining an operator selected roll orientation at a distal tip of a robotic endoscope while controlling operator commanded movement of the robotic endoscope tip." Donhowe ¶ 2.

FF10. In one embodiment, the system of Donhowe comprises "a robotic endoscope, a plurality of fiber optic cables inserted in the endoscope, a control processor with memory, an actuating system, an image processor, a display screen, and input control devices." Donhowe ¶ 25 (reference number omitted).

FF11. Donhowe teaches a tracking system for an endoscope. Donhowe ¶ 28.

FF12. Donhowe incorporates the teachings of Belson[16] by reference. Donhowe ¶ 28.

FF13. Belson teaches a steerable endoscope. Belson Abstract.

FF14. Belson teaches the use of temperature sensitive actuators to control the movement of the endoscope. Belson col. 5, ll. 41–67.

FF15. Rogers relates to an apparatus for performing a surgical procedure comprising an entry guide tube and a steering device. Rogers Abstract.

FF16. Figure 3C of Rogers, reproduced below, is a perspective view of the flexible shaft of the device showing that the control cables 380 and 382, lie within the walls of the device.

[16] Belson, US 6,869,396 B2, issued Mar. 22, 2005 ("Belson").

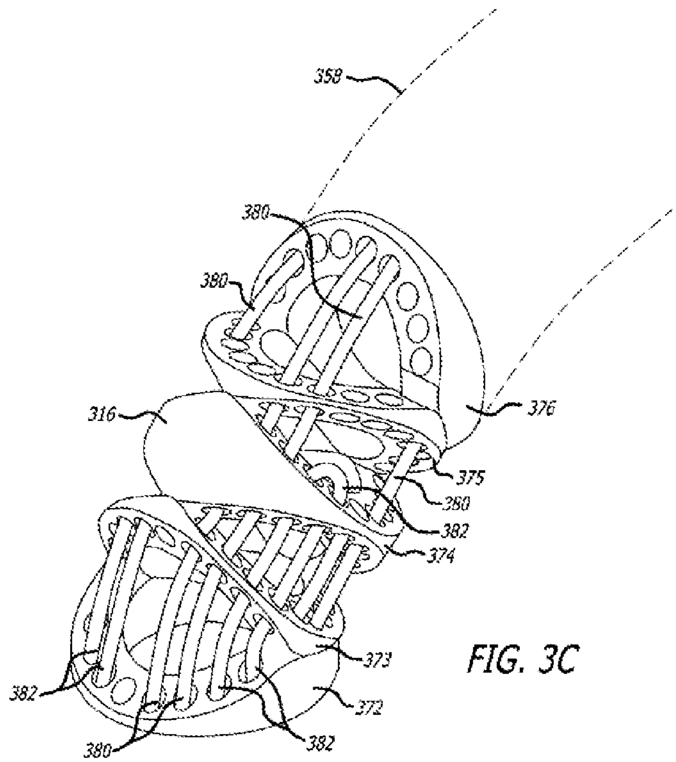

FIG. 3C

Figure 3C of Rogers which is a perspective view of a portion of the flexible shaft of a robotic surgical tool.

FF17. Browne teaches the use of a temperature sensitive actuating mechanism with a control subsystem and a feedback control subsystem. Browne ¶¶ 34–35 and Figure 1.

FF18. Sizer discloses "a method for improving performance and life of a material adapted to contract when heated to a critical temperature such as shape memory alloy wire (SMA)." Sizer Abstract.

FF19. The system of Sizer is shown in Figure 2 below:

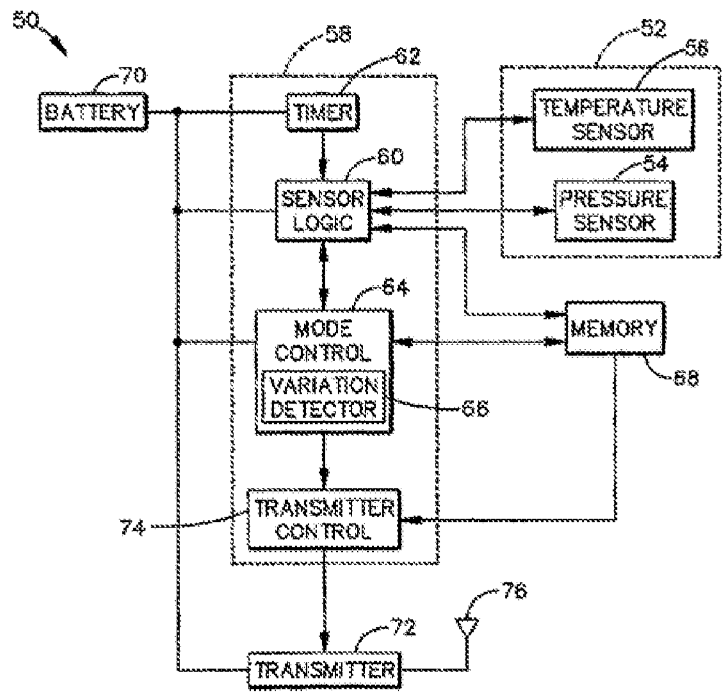

Fig.2

Figure 2 of Sizer shows a schematic illustration of the components of a controller.

FF20. Sizer teaches:

> When the method of the invention is used in connection with a mechanism, which includes a microprocessor, the microprocessor may control energy delivery to the SMA wire, preferably by a temperature-dependent algorithm. The microprocessor can also sense the state of the mechanism and whether it is engaged or not. The microprocessor may report this, along with secondary sensed information, to a network of which the mechanism forms a part. The mechanism may be, for example, a fastener.

Sizer col. 3, ll. 23–31.

FF21. Sizer also teaches:

> If necessary, power and energy delivery may be adjusted at the start of each cycle in order to achieve the desired target for subsequent cycles. In this way, operation may adaptively track any changes in the SMA element or mechanism characteristics, in order to maintain consistent operation over time. Each time drive parameters are modified, they may be stored in, for example, a non-volatile FLASH memory so as to be preserved through power cycles.

Sizer col. 3, ll. 54–61.

Principles of Law

> [T]he examiner bears the initial burden, on review of the prior art or on any other ground, of presenting a *prima facie* case of unpatentability. If that burden is met, the burden of coming forward with evidence or argument shifts to the applicant.
>
> After evidence or argument is submitted by the applicant in response, patentability is determined on the totality of the record, by a preponderance of evidence with due consideration to persuasiveness of argument.

In re Oetiker, 977 F.2d 1443, 1445 (Fed. Cir. 1992). "Non-obviousness cannot be established by attacking references individually where the rejection is based upon the teachings of a combination of references. . . . [The reference] must be read, not in isolation, but for what it fairly teaches in combination with the prior art as a whole." *In re Merck & Co.*, 800 F.2d 1091, 1097 (Fed. Cir. 1986).

Analysis

We conclude the Examiner has established that claims would have been obvious to one of ordinary skill in the art at the time the invention was made over the combination of Ishiguro, Donhowe, Rogers, Browne, and

Sizer. Appellants have not produced evidence showing, or persuasively argued, that the Examiner's determinations on obviousness are incorrect. The arguments made by Appellants in the Brief have been considered in this Decision; arguments not presented in the Brief are waived. *See* 37 C.F.R. § 41.37(c)(1)(iv) (2015). We address Appellants' arguments below.

Appellants contend that each of the individual references fails to teach one or more of the elements of the claims. Br. 24–33. Appellants also contend that Browne and Sizer are not related subject matter and are not relevant to MINIRs. Br. 31. As discussed below, Appellants do not adequately address the combined teachings of the references and the motivation to combine the references. Appellants' attack on the individual references fails to overcome the Examiner's prima facie case of obviousness base on the combination of prior art.

Appellants contend that Ishiguro does not teach or suggest that the walls of the bending portions of its device have internal channels for the manipulating wires to pass. Br. 24–25. Appellants argue that the wires in Ishiguro pass on the outside of the bending portions of its device. *Id.* Appellants also argue that the Ishiguro wires occupy part of the internal space of the device. *Id.*

We have considered Appellants' arguments and are not persuaded. While Appellants' analysis of Ishiguro may be correct, the rejection is not based on Ishiguro alone, but on the combination of Ishiguro with other references, including Rogers. As shown above, Rogers teaches passing the manipulating wires or tendons through channels in the walls of the device. FF16.

Appellants argue that Ishiguro does not teach or suggest the use of a temperature based actuating system nor a temperature based feedback subsystem. Br. 26. Appellants contend that adding such a system to Ishiguro makes no sense and would be redundant. *Id.*

Appellants' argument is unpersuasive. Ishiguro teaches that alterative actuating systems can be used in place of the system disclosed in Ishiguro. FF7. Belson, which is a part of Donhowe by its incorporation by reference, teaches the use of temperature sensitive actuators in a surgical instrument. FF14. Browne and Sizer teach temperature based actuators and feedback systems. FF17–21. Thus, the combination of references teach the claimed system.

Appellants argue that Ishiguro does not teach or suggest a tracking system integrated into the robot sub-system. Br. 27. Appellants argue that Donhowe does not remedy this deficiency as Donhowe "fails to provide the claimed temperature sensitive actuating mechanism, and thus, the use of the claimed feedback mechanism is not seen as applicable to the Donhowe's actuator sub-system." Br. 28. Appellants also contend that Donhowe does not teach a "robot body having links configured with cylindrically shaped walls formed with a plurality of wall channels extending internally within cylindrically shaped walls for routing the tendons internally within the walls of the robot body." *Id.*

Appellants' arguments are unpersuasive. Donhowe teaches the use of a tracking system. FF11. In addition, as noted above, Donhowe incorporates by reference the teachings of Belson, which teaches the use of a temperature sensitive actuator system. FF12–14. Moreover, temperature sensitive actuators and feedback systems are taught by Browne and Sizer. FF17–21. Incorporating the tendons into the walls of the robot subsystem is taught by Rogers. It is the combination of the references which renders Appellants' invention obvious.

Appellants contend that the vertebrae of Rogers are solid and do not have a central opening. Br. 28–29. This argument is unpersuasive.

As shown in Figure 3C of Rogers, there is a central channel in the vertebrae. FF16. In addition, Rogers incorporates by reference the teachings of Cooper to show the detail of the vertebrae. Rogers ¶ 60. As shown in Figure 12, reproduced below, Cooper discloses cylindrical bodies with a central lumen.

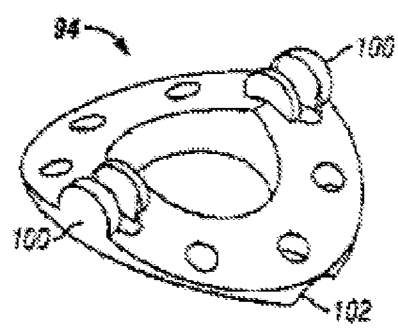

FIG. 12

Figure 12 of Cooper showing a perspective view of a section of the vertebrae.

Appellants argue that Rogers does not teach or suggest a temperature sensitive actuator mechanism. Br. 29. We are not persuaded by this argument. As discussed above, temperature sensitive actuators are taught by Belson, Browne, and Sizer. *See supra* FF14 and FF17–FF21.

Appellants contend that Browne and Sizer are not related to the field of the invention — MINIRs — and do not teach or suggest most of the elements of the claims. Br. 29–32. These arguments are unpersuasive.

While we agree with Appellants that Browne and Sizer are not specifically directed to MINIRS, as the Examiner explained, they do relate to improving the function of temperature sensitive actuators. Ans. 7. Thus, they are reasonably related to a problem faced by the inventor. *Id.* In addition, Belson teaches the use of temperature sensitive actuators in devices that are like those of the instant invention. FF14.

Conclusion of Law

We conclude that a preponderance of the evidence supports the Examiner's determination that the subject matter of claim 1 would have been obvious over the combination of Ishiguro, Donhowe, Rogers, Browne, and Sizer.

While Appellants have presented a separate argument for claims 2, 5–8, 11, 14, 15, and 17, the argument merely refers to the arguments made with respect to claim 1. Br. 33. Having found those arguments unpersuasive, we affirm the rejection of claims 2, 5–8, 11, 14, 15, and 17.

Rejection of Claims 9, 10, and 16

Claim 9 is representative of the group of claims. Claim 9 depends indirectly from claim 1 and adds the limitation calling for a sensor positioned at the distal end of the cannula. Appeal Br. 52

Claims 9, 10, and 16 have been rejected as obvious over the combination of Ishiguro, Donhowe, Rogers, Browne, Sizer, and Birkenbach.

In addition to the findings and rationale discussed above, the Examiner determined that Donhowe teaches a tracking system that includes electromagnetic sensors. Non-Final Act. 9. The Examiner finds that Birkenbach teaches locating a sensor at the distal most end of the articulating body. *Id.*

Appellants argue that Birkenbach does not teach or suggest a robot body comprising a series of links, each having cylindrically shaped walls along the periphery of the linked and formed with the wall for passing tendons. Br. 34, Appellants also argue that Birkenback does not teach revolute joints and does not determine the angels of the joints based on the temperature readings. *Id.* Appellants also contend that claims 9, 10, and 16 are patentable for the same reason claim 1 is patentable. *Id.*

Appellants' arguments are not persuasive. While Birkenbach may not teach the robot body recited in the claims, as the Examiner points out, that teaching is found in Ishiguro and Rogers, with which Birkenbach is combined. Ans. 9; FF2 and FF16. Ishiguro and Rogers also teach revolute joints. FF2 and FF16. It is the combination of the references that renders the subject matter of the claims obvious; therefore, Appellants argument over a single reference's alleged failings, in isolation, is not persuasive.

With respect to determining the angle of the joints, the Examiner correctly determines that such a step is not a limitation of claims 9, 10, and 16.

While the elements of the claims identified by Appellants may not be present in Birkenbach, it is the combination of references that renders the subject matter of claims 9, 10, and 16 obvious. Attacking the individual references does not overcome the Examiner's prima facie case of obviousness.

Appellants contend that claims 9, 10, and 16 are patentable for the same reasons that claim 1 is patentable. Br. 34. For the reasons discussed above, this argument is unpersuasive.

Rejection of Claims 12 and 13

Claims 12 and 13 indirectly depend from claim 1 and add the limitation that the device includes a latching mechanism which includes a plurality of latches arranged circumferentially at the inner wall of the cannula. Appeal Br. 52.

In addition to the findings and rationale discussed above, the Examiner finds that Okihisa teaches a latching mechanism comprising a plurality of latches arranged circumferentially at an internal wall. Non-Final Act. 10.

Appellants argue that Okihisa does not teach or suggest a robot body comprising a series of links, each having cylindrically shaped walls along the periphery of the linked and formed with the wall for passing tendons. Br. 35. Appellants also argue that Okihisa does not teach or suggest a temperature based feedback system to control the shape and advancement of the cannula.

Appellants' arguments are unpersuasive. As discussed above, Ishiguro and Rogers teach the robot subsystems recited in the claims. FF12 and FF16. With respect to the temperature based feedback system, as the Examiner determined, the claims do not call for the feedback system to control the shape and advancement of the cannula. Ans. 11. While the elements of the claims identified by Appellants may not be present in Okihisa, it is the combination of references that renders the subject matter of claims 12 and 13 obvious. Attacking the individual references in isolation does not overcome the Examiner's prima facie case of obviousness.

Appellants contend that claims 12 and 13 are patentable for the same reasons that claim 1 is patentable. Br. 35. For the reasons discussed above, this argument is unpersuasive.

Rejection of Claim 18

Claim 18 indirectly depends from claim 1 and adds the limitation that

> said temperature based feedback sub-system is coupled between said SMA springs and said control sub-system, said temperature based feedback sub-system being configured to acquire data on the temperature regime applied to a respective SMA spring of said antagonistically coupled SMA springs, and wherein said control sub-system computes a corresponding rotational angle of a respective revolute joint affected by said respective SMA spring.

Appeal Br. 53–54.

In addition to the findings and rationale discussed above, the Examiner finds that "Sizer et al. teaches said temperature based feedback system is coupled between SMA wires and a control system, the temperature based feedback system being figured to acquire data on the temperature regime applied to a respective SMA spring and a corresponding rotational angle of a revolute joint affected by said respective SMA wire." Non-Final Act. 11. The Examiner also finds that Moll teaches computing a corresponding rotational angle of a joint affected by an actuator. Non-Final Act. 11.

Findings of Fact.

FF22. Moll discloses "A method for performing an interventional procedure using a robotically controlled guide instrument coupled to an instrument drive assembly." Moll Abstract.

FF23. Moll teaches computing the rotation angles of the joints of a jointed catheter operated by an actuator. Moll ¶¶ 240–241, Figure 125.

FF24. Moll teaches

> Referring to FIG. 125, [reproduced below] the "forward kinematics" expresses the catheter's end-point position as a function of the actuated inputs while the "inverse kinematics" expresses the actuated inputs as a function of the desired end-point position. Accurate mathematical models of the forward and inverse kinematics are essential for the control of a robotically controlled catheter system. For clarity, the kinematics equations are further refined to separate out common elements, as shown in FIG. 125. The basic kinematics describes the relationship between the task coordinates and the joint coordinates. In such case, the task coordinates refer to the position of the catheter end-point while the joint coordinates refer to the bending (pitch and yaw, for example) and length of the active catheter. The actuator kinematics describes the relationship between the actuation coordinates and the joint coordinates. The task, joint, and bending actuation coordinates for the robotic catheter are illustrated in FIG. 126. By describing the kinematics in this way we can separate out the kinematics associated with the catheter structure, namely the basic kinematics, from those associated with the actuation methodology.

Moll ¶ 237.

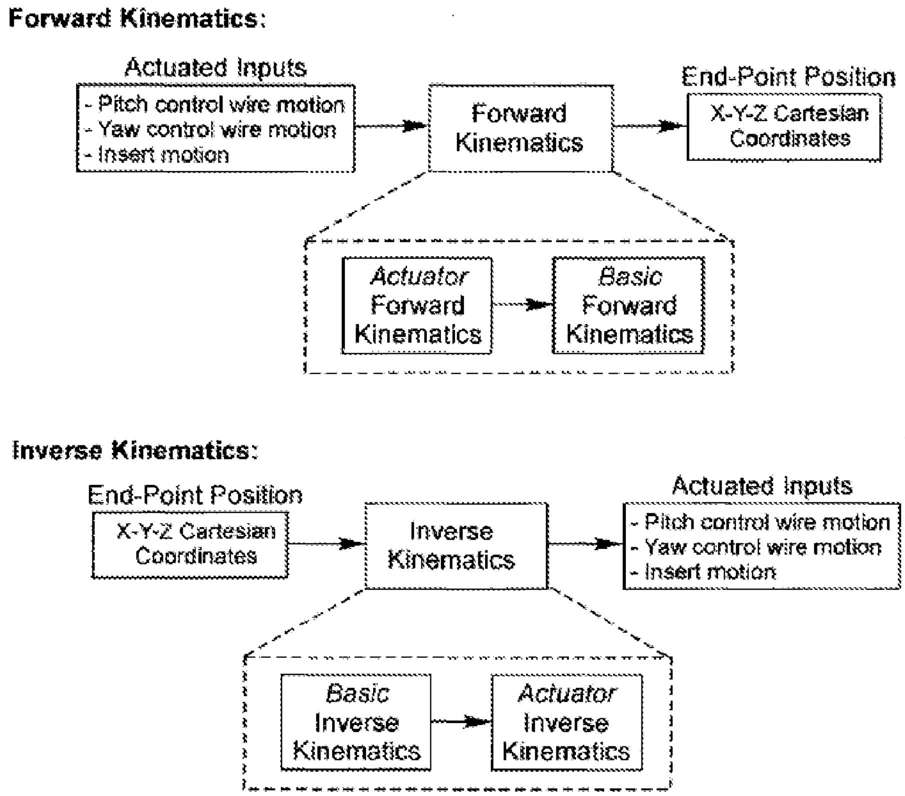

Fig 125

Figure 125 of Moll shows the kinematics of an embodiment of the system of Moll.

Analysis

We agree with the Examiner's conclusion that the subject matter of claim 18 would have been obvious to one of ordinary skill in the art over the combination of Ishiguro, Donhowe, Rogers, Browne, Sizer, and Moll. We address Appellants' arguments below.

Appellants argue that Moll does not teach computing the rotational angle of a resolute joint as Moll does not employ resolute joints. Br. 36. We are not persuaded.

Moll specifically discloses determining the joint coordinates which includes bending of the catheter. FF24. While Moll may not expressly teach measuring the angle of a resolute joint, such joints are taught by Ishiguro and Rogers. FF2 and FF16. We conclude, in agreement with the Examiner, that it would have been obvious to use the joint coordinate determination process of Moll to determine the angle of the revolute joints of Ishiguro and Rogers.

Appellants also argue that Moll does not teach or suggest tension wires routed through the wall of the catheter. Br. 36. Again we are not persuaded. As discussed above, Rogers teaches placing the tension wires within the walls of the device. FF16.

Appellants argue that Moll does not teach or suggest revolute joints, but bends based on the stress relief pattern of the catheter. Br. 36. This argument is not persuasive. Ishiguro and Rogers teach the use of revolute joints. FF2 and FF16.

Appellants argue that Moll used a motor based actuator assembly and not a temperature based actuating mechanism. Br. 37. This argument is unpersuasive. As discussed above Ishiguro teaches that alternate actuating systems can be used in place of mechanical systems. FF7. Belson, Browne, and Sizer teach the use of temperature based actuators. FF14 and FF17–FF21.

Appellants argue that a temperature based feedback subsystem is extraneous to Moll. Br. 37. This argument is unpersuasive. As discussed above, a temperature based feedback system is taught by Browne and Sizer. FF17–FF21.

While the elements of the claims identified by Appellants may not be expressly disclosed in Moll, it is the combination of references that renders the subject matter of claim 18 obvious. Attacking the individual references in isolation does not overcome the Examiner's prima facie case of obviousness based on this combination.

Appellants also contend that claim 18 is patentable for the same reasons that claim 1 is patentable. Br. 37. For the reasons discussed above, this argument is unpersuasive.

Rejection of Claims 19 and 20

Claims 19 and 20 depend from claim 1 and adds the limitation that the gears in claim 1 include a pulley carrying around a respective of the tendons of the tendon subsystem. Appeal Br. 54.

In addition to the findings and rationale discussed above, the Examiner finds that Kudoh teaches a force transfer system comprising a pulley with a respective gear with the pullet and the gear being spaced apart from but coupled to the motor via a wire member. Non-Final Act. 12.

The Examiner finds that

> [c]ombining the force transferring mechanism of Kudoh et al. with the system of Ishiguro et al. in view of Donhowe et al. would allow for the N gears and pulleys to be moved to and secured in the base link, since it has been held that rearranging parts of an invention involves only routine skill in the art.

Id.

With respect to claim 20, the Examiner finds that

> Kudoh et al. teaches a second gear (65A) operatively coupled to said gear in said first set thereof (FIG. 4), and an intermediate tendon sub-system (61A), wherein the actuating mechanism (29) is operatively coupled to a corresponding one of said N tendons of said tendon sub-system through the intermediate tendon (67A) of the intermediate tendon sub-system and said gears in said first and second set thereof (FIG. 4).

Non-Final Act. 12.

Appellants argue that Kudoh does not teach or suggest a robot body "composed of a plurality of links having cylindrically shaped walls along periphery of the link and formed with wan channels for passing tendons through." Br. 38. Appellants also argue that Kudoh fails to teach or suggest an actuating mechanism behaving in correspondence to a temperature regime. *Id.* Again Appellants' argument are unpersuasive.

As the Examiner determined, Kudoh teaches the use of a force transfer mechanism. Ans. 15. Ishiguro and Rogers teach a robot body comprising a plurality of links each having cylindrically shaped walls along a periphery of the link and formed with wall channels for passing tendons through. FF2 and FF16. Ishiguro, Belson, Browne, and Sizer teach using an actuating mechanism behaving in response to a temperature regime. FF7, FF14, and FF17–FF21. While the elements of the claims identified by Appellants may not be present in Kudoh, it is the combination of references that renders the subject matter of claims 19 and 20 obvious. Attacking the individual references in isolation does not overcome the Examiner's prima facie case of obviousness based on this combination.

Appellants also contend that claims 19 and 20 are patentable for the same reasons that claim 1 is patentable. Br. 37. For the reasons discussed above, this argument is unpersuasive.

Rejection of Claim 21

Claim 21 depends from claim 20 and adds the limitation that the gears are positioned at a shaft attached to a based member wherein the based member is removably secured to the base link. Appeal Br. 54.

In addition to the findings discussed above, the Examiner finds that Omori teaches a motion mechanism comprising a second set of gears, which are positioned at a single shaft attached to a base member, and where the base member is irremovably secured to a base link. Non-Final Act. 13. The Examiner concludes "it would have been *prima facie* obvious to one of ordinary skill in the art at the time of invention to utilize removable base member []since it has been held that constructing a formerly integral structure in various elements involves only routine skill in the art." *Id.*

Appellants argue that Omori does not teach or suggest internal channels in the walls of the device where the wires pass through the channels. Br. 39. Appellants contend that the wires of Omori pass outside the wall of the device. *Id.* Appellants also argue that Omori does not teach or suggest an actuating system based on temperature sensitive actuating elements nor does Omori teach or suggest a temperature based feedback subsystem. *Id.*

Appellants' arguments are unpersuasive. As discussed above, Rogers teaches the set of internal channels through with the tendons or manipulating wires pass. FF16. Ishiguro, Belson, Browne, and Sizer teach temperature sensitive actuators and a temperature based feedback system. FF7, FF14, and FF17–FF21. While the elements of the claims identified by Appellants may not be present in Omori, it is the combination of references that renders the subject matter of claim 21 obvious. Attacking the individual references in isolation does not overcome the Examiner's prima facie case of obviousness over the combination.

Appellants also contend that claim 21 is patentable for the same reasons that claim 1 is patentable. Br. 39. For the reasons discussed above, this argument is unpersuasive.

Rejection of Claims 22 and 23.

Claims 22 and 23 depend from claim 21 and adds the limitation call for a quick connect mechanism. Appeal Br. 55.

In addition to the findings and rationale discussed above, the Examiner finds that Choi discloses a quick connect member. Non-Final Act. 13. The Examiner determined:

> Combining this quick connect member with the invention of Ishiguro in view of Donhowe, Kudoh, and Omori would provide for said base member (right side of FIG. 6 of Omori) with said second set of gears (65 of Kudoh) positioned at one thereof and a third set of gears (63 of Kudoh) at another end of said quick-connect mechanism (40 of Choi), and wherein the intermediate tendons (67 of Kudoh) of said intermediate tendon sub-system extends between said second set of gears and said third set of gears in operative coupling to said actuating mechanism.

Id. at 14.

With respect to claim 23, the Examiner finds that Choi teaches "routing pulleys (on either side of 78, FIG. 8) coupled between an actuating mechanism (50) and a proximal gear in the quick connect member (80), wherein said intermediate quick-connect mechanism is irremovably attached by said another end thereof to said routing pulleys via said proximal gear (FIG. 8)." *Id.* The Examiner further determined that:

> Combining Choi et al. with Ishiguro in view of Donhowe, Kudoh, and Omori would provide for the routing pulley on 78 of Choi to be coupled between the actuating mechanism 50 of Choi and the third gear 63 of Kudoh. The intermediate tendons 67 of Kudoh would then be removably attached by said another end thereof to said routing pulley on 78 of Choi via said third gear 63 of Kudoh and by said one end thereof to said base link (FIG. 6 of Omori). To put it another way, the gears 65 of Kudoh would be separable from the gear 59 of Kudoh in the manner as shown by FIG. 6 of Omori. The gears 63 of Kudoh would be separable from 57 and 29 of Kudoh in the manner as shown by FIG. 8 of Choi.
>
> Therefore, it would have been *prima facie* obvious to one of ordinary skill in the art at the time of invention to utilize the quick-connect mechanism of Choi et al. with the system of Ishiguro in view of in view of Donhowe et al., Browne et al., Sizer et al., Kudoh, and Omori in order to allow for disposal of the quick-connect mechanism should it become contaminated (FIG. 8 of Choi et al.).

Id.

Appellants argue that Choi uses a motor based actuating system and does not teach or suggest the temperature sensitive actuating system recited in the claims. Br. 40. Appellants also argue that Choi does not teach or suggest a "robot body composed of a plurality of links having cylindrically shaped walls along periphery of the link and formed with wall channels for passing tendons through." *Id.*

Appellants' arguments are unpersuasive. As discussed above, Ishiguro, Belson, Browne, and Sizer teach using a temperature sensitive actuating mechanism. FF7, FF14, and FF17–FF21. Ishiguro and Rogers teach a robot body composed of a plurality of links having cylindrically shaped walls along periphery of the link and formed with wall channels for passing tendons through. FF2 and FF16. While the elements of the claims identified by Appellants may not be present in Choi, it is the combination of references that renders the subject matter of claims 22 and 23 obvious. Attacking the individual references in isolation does not overcome the Examiner's prima facie case of obviousness based on the combination.

Appellants also contend that claims 22 and 23 are patentable for the same reasons that claim 1 is patentable. Br. 40. For the reasons discussed above, this argument is unpersuasive.

Rejection of Claim 24

Claim 24 depends from claim 1 and adds the limitation calling for

> a data transfonnation having an input for :receiving coordinates of a tracking point on said robot body and the user's commands corresponding to a desired position for said tracking point, wherein said data transformation unit is configured to compute corresponding control signals based on the position and configuration of the robot body, said control signals including coordinates of at least one center of rotation at said robot body and a path for said tracking point corresponding to a displacement of said tracking point from said cordinates thereof to said desired position of said tracking point, said control signals being operatively applied to said actuator sub-system to control motion of at least one corresponding tendon in said tendon sub-system to result in said displacement of said tracking point toward said desired position thereof.

Appeal Br. 55–56.

In addition to the findings and rationale discussed above, the Examiner finds

> Webster teaches an analogous robot system with a control system (FIG. 1) includes a data transformation unit having an input for receiving coordinates of a robot body (para [0078]) and the user's commands corresponding to a desired position for said tracking point (para [0065]-[0066]), wherein said data transformation unit is configured to compute corresponding control signals based on the position and configuration of the robot body (para [0073], [0077]), said control signals including coordinates of at least one center of rotation at said robot body (para [0078]) and a path for said tracking point corresponding to a displacement of said tracking point from said coordinates thereof to said desired position of said tracking point (para [0072]), said control signals being operatively applied to said actuator subsystem to control motion of the robot to result in said displacement of said tracking point toward said desired position thereof (para [0077]).
>
> Therefore, it would have been *prima facie* obvious to one of ordinary skill in the art at the time of invention to utilize the path planning as taught by Webster et al. in order to allow safer guiding of surgical instruments in the presence of sensitive tissue (para [0018] of Webster et al.).

Non-Final Act. 15–16.

Appellants argue that Webster does not teach or suggest a "robot body formed with a plurality of links and revolute joints interconnecting the links and controlled rotational motion of each link respective to the adjacent link, [or] the cylindrically shaped walls extending along periphery of each link and formed with internal channels for passing tendons through." Br. 41. Appellants also argue that Webster does not teach or suggest a "tendon sub-system integrated with the robot body with each tendon routed internally within the walls of the links." *Id.*

Appellants' arguments are unpersuasive. Ishiguro and Rogers teach robot bodies formed with a plurality of links and revolute joints interconnecting the links and controlled rotational motion of each link respective to the adjacent link. FF2 and FF16. Rogers teaches cylindrically shaped walls extending along periphery of each link and formed with internal channels for passing tendons through. FF16. Rogers also teaches a tendon subsystem integrated with the robot body with each tendon routed internally within the walls of the links. *Id.* While the elements of the claims identified by Appellants may not be present in Webster, it is the combination of references that renders the subject matter of claim 24 obvious. Attacking the individual references in isolation does not overcome the Examiner's prima facie case of obviousness over the combination.

Appellants also contend that claim 24 is patentable for the same reasons that claim 1 is patentable. Br. 40. For the reasons discussed above, this argument is unpersuasive.

SUMMARY

We affirm the rejections under 35 U.S.C. § 103(a).

TIME PERIOD FOR RESPONSE

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a).

<u>AFFIRMED</u>