UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte JEFFREY A. NEILSON, STEVEN T. CASTLE,
DAVID C. COLLINS and SHAWN D. HUNTER

Appeal 2008-3608
Application 10/354,538
Technology Center 1700

Decided: September 12, 2008

Before TERRY J. OWENS, CATHERINE Q. TIMM, and
JEFFREY T. SMITH, *Administrative Patent Judges*.

TIMM, *Administrative Patent Judge*.

DECISION ON APPEAL

Appellants appeal under 35 U.S.C. § 134(a) from the Examiner's decision rejecting claims 1-25 and 43-54. We have jurisdiction under 35 U.S.C. § 6(b).

We AFFIRM-IN-PART.

I. BACKGROUND

The invention relates to a solid freeform fabrication process. Solid freeform fabrication is a process for manufacturing three-dimensional objects, for example, prototype parts, models, and working tools which involves building the part one layer at a time (Spec. ¶ 1). One of the on-going deficiencies of the process is that, by building the object with discrete layers, the layers may still be apparent in the finished product (Spec. ¶ 8). With objects that have vertical contours across multiple layers, the result is a "terracing" effect which leaves noticeable "stair steps" along the contour of the object (Spec. ¶ 8). Appellants' process reduces terracing by varying the quantity of the material applied at the edges of the layers. Claim 1 is illustrative:

> 1. A method of producing an object through solid freeform fabrication, said method comprising ejecting material to form a particular planar layer of said object, said planar layer having a height (h), and while forming said planar layer and at an edge of said planar layer, varying a quantity of said ejected material applied per unit volume to form a series of steps in said planar layer with heights different than (h).

On review is the Examiner's rejection of claims 1-3, 5-10, 13-25, 43-45, 47-51, and 54 under 35 U.S.C. § 103(a) as unpatentable over Jang (US 6,405,095 B1 issued Jun. 11, 2002 to Jang et al.), and the rejection of claims

4, 11, 12, 46, 52, and 53 as unpatentable over Jang in view of Fink (US 5,510,066 issued Apr. 23, 1996 to Fink et al.).[1]

Appellants present separate arguments under separate headings. We select one claim from each group to decide the issues on appeal. Unargued dependent claims stand or fall with the claim from which they depend.

II. DISCUSSION

A. Obviousness over Jang

1. Claims 1, 13, and 43

We select claim 1 to represent the issues on appeal with respect to Appellants' arguments made under the heading "Claims 1, 13, and 43."

The Examiner finds that Jang describes various known solid freeform fabrication processes (fused deposition modeling, ballistic particle manufacturing, shape deposition manufacturing) in the "Background of the Invention" section of the reference, and that these processes eject material to form planar layers within the meaning of claim 1 (Ans. 5). The Examiner also finds that the process of Figure 5 of Jang is within the scope of claim 1 (Ans. 5). The Examiner further finds that Jang teaches varying the amount of ejected or dispensed material to form layers of different heights to reduce a "staircase" or "terracing" effect in the object (Ans. 5). Based on these findings, the Examiner concludes that "forming a step (or more than one step) in the object would have been obvious to one of ordinary skill in the art at the time the invention was made in the process of Jang et al" (Ans. 5-6).

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[1] The Examiner has withdrawn a rejection under 35 U.S.C. § 112, ¶ 1 and has removed Saches from the prior art rejections (Ans. 5).

Appellants contend that "Jang teaches two entirely different and separate processes for forming the bulk of each individual layers [sic] and the 'step zones' between those layers. Consequently, Jang does not and cannot teach or suggest the claimed method in which material is deposited to form a planar layer and, *while that planar layer is being formed*, varying a quantity of the ejected material applied per unit volume to form a series of steps at an edge of that planar layer." (App. Br. 18; Reply Br. 3.)

The Examiner contends that "Jang et al does teach or suggest all of the features of claim 1 because Jang et al teaches ejecting material to form layers of an object (by solid freeform fabrication techniques) and varying the amount of ejected or dispensed material to form layer(s) having different height(s)," noting particularly Figure 6(E) (Ans. 7).

The main issue on appeal arising from the contentions of Appellants and the Examiner is: have Appellants established that the Examiner reversibly erred in concluding that Jang would have suggested to one of ordinary skill in the art of solid freeform fabrication a process in which, "while forming said planar layer and at an edge of said planar layer, varying a quantity of said ejected material applied per unit volume to form a series of steps in said planar layer" as required by claim 1?

To answer this question, we must first consider the scope of the claim language. In considering the meaning of the terms, we apply "the broadest reasonable meaning of the words in their ordinary usage as they would be understood by one of ordinary skill in the art, taking into account whatever enlightenment by way of definitions or otherwise that may be afforded by the written description contained in the applicant's specification." *In re Morris*, 127 F.3d 1048, 1054 (Fed. Cir. 1997).

The following Findings of Fact are relevant in determining the meaning of the claim language:

1. According to the Specification several forms of solid freeform fabrication involve a liquid ejection process, and two main types are binder-jetting systems and bulk-jetting systems (Spec. ¶ 2).
2. Binder-jetting systems eject a binder onto a flat bed of powdered build material to create a layer of the object (Spec. ¶¶ 3 and 5).
3. Bulk-jetting systems eject a solidifiable build material and a solidifiable support material onto a platform, the support material supporting overhanging portions of the object created by the solidifiable build material (Spec. ¶¶ 4 and 5).
4. Appellants describe techniques for reducing terracing created by the layer-by-layer building of the objects (Spec. ¶ 9 and 23).
5. Appellants' process is one in which "the amount of binder or build material added across an object layer may be varied to reduce the effects of terracing." (Spec. ¶ 33, ll. 6-7.) This variation takes place "over a transition region between succeeding layers." (Spec. ¶ 34.)
6. The variation in binder application in the transition region is shown in Figure 3b reproduced below:

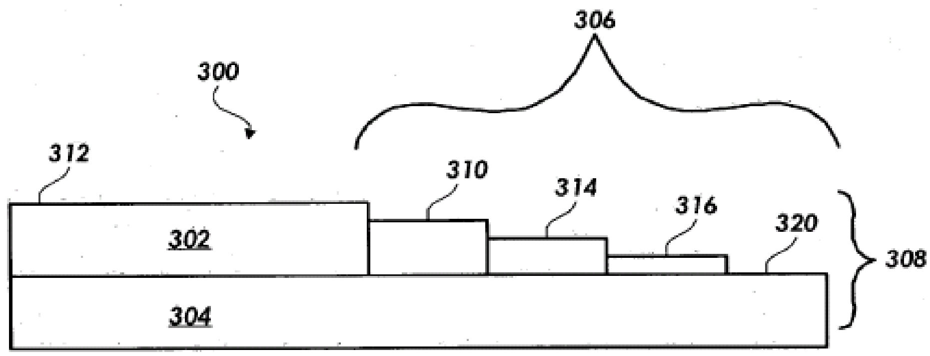

FIG. 3b

As stated in the Specification, "[t]he variation in binder application shown in FIG. 3b is a binder concentration reduction that occurs in forming the upper layer (302) over a transition region (306) between the successive terraced layers (308)." (Spec. ¶ 37.)

7. The Specification does not describe any specific embodiments of varying the quantity of material outside of the transition region (Spec. in its entirety).

Based on the above findings, we interpret the language "while forming said planar layer and at an edge of said planar layer, varying a quantity of said ejected material" as encompassing processes in which the variation takes place in the transition regions between layers, i.e., the regions where there would otherwise be a terracing effect. The Specification focuses on varying the binder (in the binder-jetting process) or build material (in the bulk-jetting process) in the transition region and does not disclose any specific process of varying the quantity of binder or build material in other regions (FF 1-7).

With the above claim interpretation in mind, we consider what Jang would have taught to one of ordinary skill in the art relative to what is claimed. The following enumerated findings of fact (FF) are of particular relevance:

8. One of Jang's objects is to provide a solid freeform fabrication process of both high speed and high part accuracy (Jang, col. 5, ll. 31-33).
9. Jang's inventive process uses two procedures to build the layers of the object, a weld pool procedure (form a pool of molten material by melting a powdered material with a heat source) and a fine liquid droplet procedure.
10. "Preferably, the weld pool is used to build the bulk of the object while the fine ejected droplets are used to build the peripheries to reduce the "staircase" effect" or other regions containing fine features." (Jang, col. 6, ll. 27-30).
11. As shown in Figures 6(C) and (D), reproduced below,

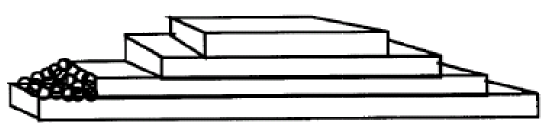

FIG.6C

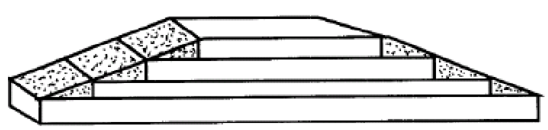

FIG.6D

the fine droplets may be deposited in a gradient-thickness manner, i.e., stacked one upon the other with the thickness varying from being very thin (e.g., one droplet size) at one end of each "step" to being as thick as the next layer at another end of this step (Jang, col. 17, l. 67 to col. 18, l. 7). This can be accomplished, for instance, by, in addition to the data packages corresponding to the logical layers, further dividing each staircase step zone into several thinner logical sub-layers, as schematically shown in Figure 6(E) reproduced below:

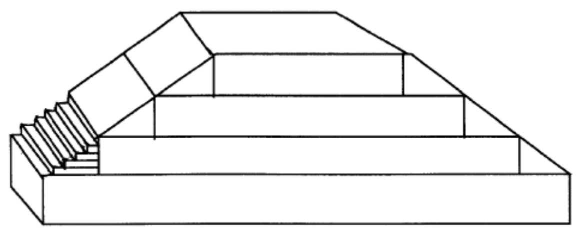

FIG.6E

Figure 6(E) shows the logical sub-layers of the data package within the step zones. The data from these logical sub-layers drives the liquid deposition device to form the gradient-thickness step zone (Jang, col. 14, ll. 31-40; col. 18, ll. 12-19).

12. The process makes it possible to slice the object into much thicker logical layers and fill the interior space with large amounts of weld pool materials at a higher rate, yet avoid the "staircase" effect of the thicker layers by building the gradient-thickness zones using the fine droplets. Both speed and precision are increased. (Jang, col. 18, ll. 20-31).
13. A wide range of solid freeform fabrication processes which build objects layer by layer were known in the art at the time of the invention (Jang, col. 1, l. 12 to col. 5, l. 11) including processes of building the layers by ejecting liquid or solidifiable droplets (Jang, e.g., col. 2, ll. 1-27).

14. "All the layer-additive techniques produce parts with a "staircase" appearance (see FIG.6a), which compromises the part accuracy." (Jang, col. 5, ll. 28-30.)

"The combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results." *KSR Int'l Co. v. Teleflex Inc*., 127 S. Ct. 1727, 1739 (2007). Moreover, one of the ways in which a claim's subject matter can be proved obvious is by establishing that there existed at the time of invention a known problem for which there was an obvious solution encompassed by the claims. *KSR*, 127 S. Ct. at 1742.

On the essential facts, arrived at through proper application of the relevant law, we agree with the Examiner's conclusion of obviousness.

We agree with Appellants that the inventive process of Jang is mainly directed to building the bulk of the layers with the weld pool procedure and using the fine droplets mainly to build the peripheries (Appellants' transition regions; Jang's staircase zones) (FF 9, 10). Implied in Appellants' argument is that claim 1 excludes such a two-procedure process. Indeed, we note that claim 1 requires that what is varied is "a quantity of *said* ejected material" (emphasis added) and this ejected material is the material used "to form a particular planar layer." The claim, therefore, requires that the ejected material be the same material throughout the building of the layer. However, as we determined above, the claim allows for the building of a bulk planar layer using the ejected material and then only varying the quantity of the material in the transition region, i.e., the region where the staircase effect occurs.

The Examiner has established, and the Appellants have not contested, that it was known in the art to build the bulk layers of an object by ejecting liquid or solidifiable droplets (FF 13). It was also known that such a process, as do all layer-additive processes, produce a staircase appearance which compromises part accuracy (FF 14). The purpose of Jang's fine droplet thickness-gradient procedure is to increase the speed of the process by allowing thicker layer building but at the same time mitigating the larger staircase effect thicker layer building causes (FF 8, 12). One of ordinary skill in the art would have recognized that this building of thickness-gradient zones would have application to other layer-additive processes including the well known droplet ejection systems. The result of using the fine droplets to build the thickness-gradient zone would have had the predictable result of lessening the staircase effect. Moreover, using the fine droplets to establish a thickness-gradient was a known solution to a known problem of staircasing. Under the law of obviousness, as it now stands, the evidence provided by the Examiner supports a conclusion of obviousness.

Appellants have not established that the Examiner reversibly erred in concluding that Jang would have suggested to one of ordinary skill in the art of solid freeform fabrication a process in which, "while forming said planar layer and at an edge of said planar layer, varying a quantity of said ejected material applied per unit volume to form a series of steps in said planar layer" as required by claim 1. We, therefore, sustain the Examiner's rejection of claims 1, 13, and 43, along with the dependent claims that were not separately argued, as unpatentable over Jang.

2. Claim 19

Turning to claim 19, Appellants additionally contend that Jang does not teach or suggest "'applying *less* ejected material at a transition between adjacent layers than is applied at a bulk material region' as claimed." (App. Br. 20.)

The Examiner responds that Jang "teaches varying the amount of ejected or dispensed material to form layer(s) having different height(s), and this would include applying a desired amount of material (e.g., less material) at a desired location (e.g., a transition region; see also Figure 6(E) of Jang . . .)" (Ans. 8).

The issue is: have Appellants established that the Examiner reversibly erred in finding that Jang suggests applying less ejected material in the transition region?

We answer this question in the negative.

Jang describes driving the fine droplet deposition with sub-layer data packages (FF 11). The sub-layers of the data package shown in Figure 6(e) shows that less material is applied when moving from the layer to the edge and apply more material when moving from the edge to the layer. Whether less or more is deposited depends on the direction of travel. An obviousness analysis "need not seek out precise teachings directed to the specific subject matter of the challenged claim, for a court [or this Board] can take account of the inferences and creative steps that a person of ordinary skill in the art would employ." *KSR*, 127 S. Ct. at 1741.

Appellants have not established that the Examiner reversibly erred in finding that Jang suggests applying less ejected material in the transition region.

3. Claim 22

With respect to claim 22, Appellants contend that Jang does not teach or suggest "applying *more* ejected material" (App. Br.20-21). But as we point out above, such is suggested by Jang to one of ordinary skill in the art. Therefore, we cannot say that Appellants have established that the Examiner reversibly erred in finding such a suggestion in Jang.

4. Claims 3 and 45

Appellants contend that Jang does not teach or suggest "dithering a fluid ejection apparatus that is ejecting said binder or build material" to reduce the quantity of binder or build material applied over a transition region between terraced layers as required by claim 3 and as similarly required by claim 45 (App. Br. 21).

The Examiner responds that "dithering" refers to vacillating the print-head of the printer, which is a conventional and well-known technique in the printing art, and as such it would have been obvious to "dither" in the process of Jang (Ans. 9).

Appellant responds that they are not merely "dithering" within the context of the printing art, but are dithering to reduce the quantity of material applied over a transition region (Reply Br. 8).

On the current record, the Examiner has not provided a sufficient amount of evidence to support the rejection. The fact that "dithering" is known in the printing art does not establish that it would have been obvious to use dithering as a technique to progressively reduce the quantity of the material applied over the transition region of Jang. We can only take the Examiner's well known statement at face value and it alone does not establish that dithering was known to accomplish a function sufficiently analogous to the reduction required by the claims to provide a suggestion to one of ordinary skill in the art of solid freeform fabrication for using it as claimed.

We do not sustain the rejection of claims 3 and 45 over Jang.

5. Claims 7 and 23

Appellants contend that Jang does not teach or suggest "oversaturating a build material with binder over said transition region" as required by claim 7 and as similarly recited in claim 23 (App. Br.22; Reply Br. 8-9).[2]

The Examiner contends that Jang, in column 2, lines 28-53, teaches a binder application process, "and the amount of binder used depends on the particular powder material used and the type of product desired, and the amount of binder used would have been obvious to one of ordinary skill in the art at the time the invention was made in the process of Jang" (Ans. 9).

The evidence does not support the Examiner's conclusion of obviousness. Jang discloses at column 2, lines 28-53 a conventional process of applying liquid binder onto a layer of powder. There is no evidence that, in this conventional process, binder levels are progressively increased over a transition region by oversaturating the build material. In fact, the Examiner provides no evidence that, in this conventional process, there is any variation in the quantity of applied binder within a transition region.

We do not sustain the rejection of claims 7 and 23 over Jang.

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[2] Claim 7 is dependent on claim 6. Claim 6 is presently dependent on claim 1, but it appears that claim 6 is intended to depend from claim 2, not claim 1. It is claim 2 that provides antecedent basis for "said transition region" recited in both claims 6 and 7.

6. Claims 9 and 51

Appellants contend that Jang does not teach or suggest "wherein varying further comprises a combination of reducing a quantity of ejected material applied to certain portions of one or more layers and increasing a quantity of ejected material applied to other portions of one or more layers" as recited in claim 9 and similarly required by claim 51 (App. Br. 9-10; Reply Br. 9). We select claim 9 as representative.

As we pointed out above in our discussion of claim 19, in order to carry out Jang's process of depositing in a gradient-thickness manner, one would apply less material when moving from the layer to the edge and apply more material when moving from the edge to the layer. The deposition is driven by the data package (FF 11). Appellants have not established that the Examiner reversibly erred in finding that Jang suggests reducing and increasing the quantity as claimed.

7. Claim 54

Appellants contend that Jang does not teach or suggest the two-binder method of claim 54 and, particularly, not the method "wherein one of said binders binds said build material more strongly than another of said binders and said binders are selectively ejected into a layer to reduce terracing with one or more adjacent layers in said object." (App. Br. 23; Reply Br. 10.)

The Examiner contends that the conventional freeform technique described in column 2, lines 28-53 of Jang includes the use of binder materials and "using more than one binder material would have been obvious to one of ordinary skill in the art at the time the invention was made in the process of Jang et al principally in order to manufacture a desired object from a particular powder materials." (Ans. 10-11.)

The Examiner has not provided the level of evidence necessary to meet the specific limitation of selectively ejecting the two different binders claimed to reduce terracing. In fact, the Examiner provides no evidence the binder method of the prior art addresses the terracing problem at all.

We do not sustain the rejection of claim 54 over Jang.

B. Obviousness over Jang and Fink

The Examiner adds Fink to reject claims 4, 11, 12, 46, 52, and 53. Appellants present arguments under two headings one directed to claims 4 and 46 and one directed to claims 11 and 52. We select one claim from each group to decide the issues on appeal with respect to those groups.

1. Claims 4 and 46

For the group of claims 4 and 46, we select 4 as representative. Appellants note that claim 4 requires "reducing the size of binder or build material and 'applying smaller drops of binder or build material over said transition region than are applied at bulk regions of the object.'" (App. Br. 24.) Appellants argue that Fink teaches that "for each separate build project, the size of the drops may be adjusted." (App. Br. 24; Reply Br. 11.) Appellants contend that Fink does not teach or suggest applying smaller drops in a transition region as compared to the bulk region (App. Br. 24).

The Examiner contends that Fink teaches using smaller drops and larger drops to manufacture an object, and Jang teaches smaller drops to reduce or eliminate a staircase effect and, thus, the subject matter of claims 4 and 46 would have been obvious to one of ordinary skill in the art in view of the combined disclosures (Ans. 11).

The issue is: have Appellants established that the Examiner reversibly erred in finding that the combined teachings of Jang and Fink suggest applying smaller drops of binder or build material over a transition region as compared to the bulk region?

We answer in the negative.

The following Findings of Fact (FF) are relevant to the disposition of the issue:

15. Fink relates to a solid freeform fabrication process which builds layers with liquid drops of a first reactant and liquid drops of a second reactant which upon reaction provide a planar cross-sectional layer (Fink, col. 1, ll. 21-39).
16. Fink discloses that computer aided manufacturing (CAM) is used to, among other things, "control parameters of various liquid drop size and their placements and the like during the creation of the free-standing, three-dimensional structural body." (Fink, col. 3, l. 61 to col. 4, l. 3; col. 16, ll. 29-41.)
17. Fink discloses applying the drops with one or more modified "bubble jet" ink jet printers (Fink, e.g., col. 16, ll. 34-35).
18. For forming the gradient-thickness zones, Jang discloses using as the liquid droplet deposition device a thermal ink jet print-head also known as a "bubble jet" ink jet printer to form the required fine droplets (Jang, col. 10, ll. 6-15).
19. Jang also indicates that it was known in the art to use inkjet print-head technology including thermally activated, i.e., "bubble jet" inkjet print-heads for forming sold freeform bodies (i.e., the bulk planar layers), the inkjet heads capable of creating 30-50 µm drops, but could form drops down to 13 µm (Jang, col. 2, ll. 11-24)

As pointed out by the Examiner, Jang teaches using fine droplets in what Appellants call the transition region to reduce the "staircase" effect (Ans. 11; FF 10). Building the bulk of the layers using a conventional drop ejecting device such as a bubble jet print head was known in the art (FF 19). Jang and Fink also establish that in such print heads the size of the drops can be controlled as can the placement of the drops (FF 16, 19). Moreover, those of ordinary skill in the art desired to use larger amounts of material to form larger thickness layers and then fill-in the resulting "staircase" with a thickness-gradient of fine droplets (FF 12). The evidence supports the Examiner's conclusion that the prior art combination suggests applying bigger drops in the bulk area and only applying the fine drops in the transition area. The prior art provides evidence that such was within the capabilities of those of ordinary skill in the art. *See KSR Int'l. Co. v. Teleflex Inc.*, 127 S. Ct. 1727, 1740 (2007) (stating that "if a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill").

2. Claims 11 and 52

For the group of claims 11 and 52, we select claim 11 as representative.

Appellants contend that Fink does not teach or suggest "ejecting large drops of binder or build material with a first fluid ejection apparatus; and ejecting small drops of binder or build material with a second fluid ejection apparatus" as required by claim 11 and as similarly required by claim 52.

The Examiner responds that Fink teaches drop-on-demand technology as recited in claims 11 and 52 citing to column 8, line 44 to column 9, line 19 of Fink (Ans. 11).

Turning to column 8, line 44 to column 9, line 19 of Fink, we note that this portion of Fink does indeed teach drop-on-demand of an ink composition. Fink indicates that "[w]ith an apparatus element arrangement of a plurality of tiny tubes and their directed nozzles, and with the resistance heaters operated as dictated and controlled by the computer, one can rapidly deposit to print characters in numerous fonts, graphics, and the like." (Fink, col. 8, ll. 56-61). Modification of such print heads for the solid freeform process of Fink are said to be within the skill of the art (Fink, col. 1-18). For instance, "[t]he number and size of the ink jet printer's nozzles, as well as their size . . . is believed to be readily accomplished without undue experimentation by one of skill in the art to accommodate and to apply the respective discrete drops **27** and **30**, respectively, at their desired and requisite pattern locations for creation of successive cross-sectional layers." (Fink, col. 9, ll. 8-18). The prior art supports the position of the Examiner that it was within the skill in the art to adapt the ink jet head to eject drops of desired size. Again, Jang uses similar ink jet print-head technology (FF 18), indicates that different sized drops can be formed with such print-heads (FF 19), and that it was desirable to build thick layers and then fill-in the resulting "staircase" zones with fine droplets (FF 12). Appellants have not shown that the Examiner committed a reversible error in finding a suggestion in the combination of the prior art of ejecting large drops from one ink jet nozzle and fine drops from a different ink jet nozzle using the type of drop-on-demand print head taught by Fink.

3. Claims 12 and 53

Appellants present no arguments directed to claims 12 and 53. We, therefore, summarily sustain the rejection of these claims over Jang and Fink.

III. CONCLUSION

In summary, as to the rejections under 35 U.S.C. § 103(a), we

sustain the rejection of claims 1, 2, 5, 6, 8, 10, 13-18, 43, 44, and 47-50 as obvious over Jang;

do not sustain the rejection of claims 3, 7, 23, 45, and 54 as obvious over Jang; and

sustain the rejection of claims 4, 11, 12, 46, 52, and 53 over Jang and Fink.

IV. DECISION

The decision of the Examiner is affirmed-in-part.

V. TIME PERIOD FOR RESPONSE

No time period for taking any subsequent action in connection with this appeal maybe extended under 37 C.F.R. § 1.136(a)(1)(iv).

AFFIRMED-IN-PART

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