PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

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PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)*	10 JAN 2019
Applicant's or agent's file reference 1594-P06528WO00	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2018/052895	26 September 2018	26 September 2017

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - C12N 15/113; C12N 15/82 (2018.01)
CPC - C12N 15/8216; C12N 15/8218; C12N 15/8261 (2018.08)

Applicant RUTGERS, THE STATE UNIVERSITY UNIVERSITY OF NEW JERSEY

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☒ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	20 November 2018	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a)).

3. ☒ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed:

      ☐ in the form of an Annex C/ST.25 text file.

      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☒ furnished subsequent to the international filing date for the purposes of international search only:

      ☒ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☒ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

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Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	1, 2, 3a, 3b, 4a, 4b, 5, 7-13	YES
	Claims	None	NO
Inventive step (IS)	Claims	None	YES
	Claims	1, 2, 3a, 3b, 4a, 4b, 5, 7-13	NO
Industrial applicability (IA)	Claims	1, 2, 3a, 3b, 4a, 4b, 5, 7-13	YES
	Claims	None	NO

2. Citations and explanations:

Claims 1, 2, 3b, 4a, 4b, 5, 7, and 9-12 lack an inventive step under PCT Article 33(3) as being obvious over Messing et al. (hereinafter Messing) in view of University of Florida et al. (hereinafter University of Florida).

Regarding Claim 1, Messing discloses a method for obtaining maize with kernels that have altered essential amino acid content (In accordance with one embodiment of the present invention, a method for rapid and accelerated breeding of quality protein maize is provided.... In one aspect, the reduced expression of the zein protein results in an increase in the seed of an amount of at least one amino acid, which is essential to the diet of animals and humans, Para. [0009]) comprising crossing a first maize plant (propagating the seed and crossing the resulting plant with a QPM plant line thereby producing kernels which exhibit increased vitreousness, increased vitreousness providing a dominant phenotype for elevated lysine and rapid selection of QPM. The method can further comprise crossing plants obtained from the resulting QPM lines with a non QPM line, thereby promoting introgression of the QPM trait into the non-QPM line, Para. [0009]) with a second maize plant comprising an RNAi transgene that downmodulates expression at least one of α-zein, β-zein, or γ-zein (An exemplary method entails providing seeds from a plant comprising an RNAi construct which acts in a dominant fashion to down modulate expression of alpha zein, Para. [0009]).
Messing fails to explicitly disclose said first maize plant comprising a transgene for leaf-specific expression of 3'-phosphoadenosine-5'-phosphosulfate reductase (PAPR) enzyme.
University of Florida teaches a maize plant comprising leaf-specific expression of a PAPR enzyme (The present invention overcomes these and other limitations inherent in the prior art by providing compositions and methods for increasing the nutritional value of plants. Methods are also provided particularly for modulating the levels of organic sulfur compounds, such as sulfur- containing amino acids, in plants, plant tissues, and seeds, Pg. 3, Lns. 3-6; This method is particularly useful for increasing the level of cysteine or methionine or other sulfur-containing compounds in the cells, fruits, seeds, and tissues of the transformed plant. The method may also further comprise the step of (e) transforming the plant cell with one or more additional polynucleotides that encode one or more sulfur compound synthesis enzymes, such as one or more enzymes in the pathway for methionine synthesis, to further increase in the cells and tissues of the plant the level of sulfur-containing amino acids, Pg. 8, Lns. 6-11; APS can be phosphorylated by APS kinase, forming 3'- phosphoadenosine-5'-phosphosulfate (PAPS). Either APS or PAPS can be used for sulfate reduction, Pg. 1, Lns. 26-27; Enzymes involved in cysteine and methionine biosynthesis are known in the art. See, e.g.,... PAPS reductase, Pg. 45, Ln. 29; The promoters used in the DNA constructs (i.e. chimeric plant genes) of the present invention may be modified, if desired, to affect their control characteristics. For example, the CaMV35S promoter may be ligated to the portion of the ssRUBISCO gene that represses the expression of ssRUBISCO in the absence of light, to create a promoter which is active in leaves but not in roots, Pg. 80, Lns. 24-28).
It would have been obvious to one of ordinary skill in the art at the time of the invention to modify Messing with the teaching of University of Florida for the purpose of crossing strains of maize each comprise increased essential amino acids to optimize the increased content of essential amino acids in a single corn strain (Likewise, transgenic plants can be grown in the normal manner and crossed with plants that have the same transformed hereditary factors or other hereditary factors. The resulting hybrid individuals have the corresponding phenotypic properties, University of Florida, Pg. 83, Lns. 5-7).

Regarding Claim 2, modified Messing discloses the method of claim 1, but Messing fails to explicitly disclose wherein said first maize plant expressing PAPR is High-Met.
University of Florida teaches a high methionine maize plant expressing PAPR (The present invention overcomes these and other limitations inherent in the prior art by providing compositions and methods for increasing the nutritional value of plants. Methods are also provided particularly for modulating the levels of organic sulfur compounds, such as sulfur- containing amino acids, in plants, plant tissues, and seeds, Pg. 3, Lns. 3-6; This method is particularly useful for increasing the level of cysteine or methionine or other sulfur-containing compounds in the cells, fruits, seeds, and tissues of the transformed plant. The method may also further comprise the step of (e) transforming the plant cell with one or more additional polynucleotides that encode one or more sulfur compound synthesis enzymes, such as one or more enzymes in the pathway for methionine synthesis, to further increase in the cells and tissues of the plant the level of sulfur-containing amino acids, Pg. 8, Lns. 6-11; APS can be phosphorylated by APS kinase, forming 3'- phosphoadenosine-5'-phosphosulfate (PAPS). Either APS or PAPS can be used for sulfate reduction, Pg. 1, Lns. 26-27; Enzymes involved in cysteine and methionine biosynthesis are known in the art. See, e.g.,... PAPS reductase, Pg. 45, Ln. 29).
It would have been obvious to one of ordinary skill in the art at the time of the invention to modify Messing with the teaching of University of Florida for the purpose of crossing strains of maize each comprise increased essential amino acids to optimize the increased content of essential amino acids in a single corn strain (Likewise, transgenic plants can be grown in the normal manner and crossed with plants that have the same transformed hereditary factors or other hereditary factors. The resulting hybrid individuals have the corresponding phenotypic properties, University of Florida, Pg. 83, Lns. 5-7).

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Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

Claims 3 and 4 are objected to under PCT Rule 66.2(a)(v) as lacking clarity under PCT Article 6 because claims 3 and 4 are indefinite for the following reason(s):

Claim 3 lacks clarity as there are two claims numbered 3. For the purpose of this Written Opinion, Claims 3 are being addressed as Claim 3a and Claim 3b.

Claim 4 lacks clarity as there are two claims numbered 4. For the purpose of this Written Opinion, Claims 3 are being addressed as Claim 4a and Claim 4b.

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Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:

Regarding Claim 3b, modified Messing discloses the method of claim 1, and Messing further discloses wherein said second maize plant expresses RNAi transgenes targeting α-zein and γ-zein or α-zein and β-zein (To eliminate pleiotropic effects caused by o2, the 22-kDa α-zein, γ-zein, and β-zein RNAis were stacked, resulting in protein bodies forming as honeycomb-like structures, Para. [0029]).

Regarding Claim 4a, modified Messing discloses the method of claim 1, and Messing further discloses wherein said RNAi transgene comprises at least one selectable marker or reporter gene thereby facilitating identification of progeny comprising said RNAi transgene (In order to facilitate selection of transgenic kernels, the RNAi construct is contained within an expression cassette, which also comprises at least one selectable marker and a visible reporter gene, Para. [0009]).

Regarding Claim 4b, modified Messing discloses the method of claim 1, and Messing further discloses a maize plant obtained by the method of claim 1 (In yet another aspect of the invention, the method may further comprise breeding a transgenic plant from the harvested kernels to yield a progeny plant that has an increase in the amount of at least one amino acid as a dominant trait, Para. [0010]).

Regarding Claim 5, modified Messing discloses a maize plant obtained by the method of claim 1. Messing further discloses a plant that expresses an RNAi transgene targeting γ-zein and has kernels with a vitreous phenotype and increased Lys content (propagating the seed and crossing the resulting plant with a QPM plant line thereby producing kernels which exhibit increased vitreousness, increased vitreousness providing a dominant phenotype for elevated lysine and rapid selection of QPM, Para. [0009]; To eliminate pleiotropic effects caused by o2, the 22-kDa α-zein, γ-zein, and β-zein RNAis were stacked, resulting in protein bodies forming as honeycomb-like structures, Para. [0029]), but Messing fails to explicitly disclose said plant has increased Met content.
University of Florida teaches a plant having increased Met content (The present invention overcomes these and other limitations inherent in the prior art by providing compositions and methods for increasing the nutritional value of plants. Methods are also provided particularly for modulating the levels of organic sulfur compounds, such as sulfur- containing amino acids, in plants, plant tissues, and seeds, Pg. 3, Lns. 3-6; This method is particularly useful for increasing the level of cysteine or methionine or other sulfur-containing compounds in the cells, fruits, seeds, and tissues of the transformed plant. The method may also further comprise the step of (e) transforming the plant cell with one or more additional polynucleotides that encode one or more sulfur compound synthesis enzymes, such as one or more enzymes in the pathway for methionine synthesis, to further increase in the cells and tissues of the plant the level of sulfur-containing amino acids, Pg. 8, Lns. 6-11).
It would have been obvious to one of ordinary skill in the art at the time of the invention to modify Messing with the teaching of University of Florida for the purpose of crossing strains of maize each comprise increased essential amino acids to optimize the increased content of essential amino acids in a single corn strain (Likewise, transgenic plants can be grown in the normal manner and crossed with plants that have the same transformed hereditary factors or other hereditary factors. The resulting hybrid individuals have the corresponding phenotypic properties, University of Florida, Pg. 83, Lns. 5-7).

Regarding Claim 7, modified Messing discloses a maize plant obtained by the method of claim 1, and Messing further discloses a maize plant that expresses RNAi transgenes targeting α-zein and γ-zein and has kernels with an opaque phenotype and increased Lys content (propagating the seed and crossing the resulting plant with a QPM plant line thereby producing kernels which exhibit increased vitreousness, increased vitreousness providing a dominant phenotype for elevated lysine and rapid selection of QPM, Para. [0009]; To eliminate pleiotropic effects caused by o2, the 22-kDa α-zein, γ-zein, and β-zein RNAis were stacked, resulting in protein bodies forming as honeycomb-like structures, Para. [0029]; The opacity was strongly intensified when the γRNAi and βRNAi were combined, Para. [0062]), but Messing fails to explicitly disclose said plant has increased Met content.
University of Florida teaches a plant having increased Met content (The present invention overcomes these and other limitations inherent in the prior art by providing compositions and methods for increasing the nutritional value of plants. Methods are also provided particularly for modulating the levels of organic sulfur compounds, such as sulfur- containing amino acids, in plants, plant tissues, and seeds, Pg. 3, Lns. 3-6; This method is particularly useful for increasing the level of cysteine or methionine or other sulfur-containing compounds in the cells, fruits, seeds, and tissues of the transformed plant. The method may also further comprise the step of (e) transforming the plant cell with one or more additional polynucleotides that encode one or more sulfur compound synthesis enzymes, such as one or more enzymes in the pathway for methionine synthesis, to further increase in the cells and tissues of the plant the level of sulfur-containing amino acids, Pg. 8, Lns. 6-11).
It would have been obvious to one of ordinary skill in the art at the time of the invention to modify Messing with the teaching of University of Florida for the purpose of crossing strains of maize each comprise increased essential amino acids to optimize the increased content of essential amino acids in a single corn strain (Likewise, transgenic plants can be grown in the normal manner and crossed with plants that have the same transformed hereditary factors or other hereditary factors. The resulting hybrid individuals have the corresponding phenotypic properties, University of Florida, Pg. 83, Lns. 5-7).

Regarding Claim 9, modified Messing discloses the plant of claim 4b, and Messing further discloses discloses a composition comprising kernels or ground kernel material obtained from the plant of claim 4b (The elevated level of protein in the seed in the presence of the RNAi construct raises non-zein proteins to a level with sufficient essential amino acids such that no supplementation of corn meal produced therefrom with soybeans will be necessary, Para. [0011]).

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Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:

Regarding Claim 10, modified Messing discloses the method of claim 1, and Messing further discloses further comprising breeding a transgenic plant derived from said kernels to yield a progeny plant that comprises said RNAi transgene, wherein kernels obtained from said progeny plant have increased levels at least one essential amino acid (In order to facilitate selection of transgenic kernels, the RNAi construct is contained within an expression cassette, which also comprises at least one selectable marker and a visible reporter gene, Para. [0009]; In yet another aspect of the invention, the method may further comprise breeding a transgenic plant from the harvested kernels to yield a progeny plant that has an increase in the amount of at least one amino acid as a dominant trait, Para. [0010]).
Messing fails to explicitly disclose said progeny plant comprises a PAPR transgene.
University of Florida teaches a maize plant comprising leaf-specific expression of a PAPR enzyme (The present invention overcomes these and other limitations inherent in the prior art by providing compositions and methods for increasing the nutritional value of plants. Methods are also provided particularly for modulating the levels of organic sulfur compounds, such as sulfur- containing amino acids, in plants, plant tissues, and seeds, Pg. 3, Lns. 3-6; This method is particularly useful for increasing the level of cysteine or methionine or other sulfur-containing compounds in the cells, fruits, seeds, and tissues of the transformed plant. The method may also further comprise the step of (e) transforming the plant cell with one or more additional polynucleotides that encode one or more sulfur compound synthesis enzymes, such as one or more enzymes in the pathway for methionine synthesis, to further increase in the cells and tissues of the plant the level of sulfur-containing amino acids, Pg. 8, Lns. 6-11; APS can be phosphorylated by APS kinase, forming 3'-phosphoadenosine-5'- phosphosulfate (PAPS). Either APS or PAPS can be used for sulfate reduction, Pg. 1, Lns. 26-27; Enzymes involved in cysteine and methionine biosynthesis are known in the art. See, e.g.,... PAPS reductase, Pg. 45, Ln. 29; The promoters used in the DNA constructs (i.e. chimeric plant genes) of the present invention may be modified, if desired, to affect their control characteristics. For example, the CaMV35S promoter may be ligated to the portion of the ssRUBISCO gene that represses the expression of ssRUBISCO in the absence of light, to create a promoter which is active in leaves but not in roots, Pg. 80, Lns. 24-28).
It would have been obvious to one of ordinary skill in the art at the time of the invention to modify Messing with the teaching of University of Florida for the purpose of crossing strains of maize each comprise increased essential amino acids to optimize the increased content of essential amino acids in a single corn strain (Likewise, transgenic plants can be grown in the normal manner and crossed with plants that have the same transformed hereditary factors or other hereditary factors. The resulting hybrid individuals have the corresponding phenotypic properties, University of Florida, Pg. 83, Lns. 5-7).

Regarding Claim 11, modified Messing discloses the method of claim 10, and Messing further discloses seed or progeny of the plant obtained from the method of claim 10 (In yet another aspect of the invention, the method may further comprise breeding a transgenic plant from the harvested kernels to yield a progeny plant that has an increase in the amount of at least one amino acid as a dominant trait, Para. [0010]).

Regarding Claim 12, modified Messing discloses the composition of claim 9, and Messing further discloses an animal feed comprising the composition of claim 9 (In one aspect, the reduced expression of the zein protein results in an increase in the seed of an amount of at least one amino acid, which is essential to the diet of animals and humans, Para. [0009]; The elevated level of protein in the seed in the presence of the RNAi construct raises non-zein proteins to a level with sufficient essential amino acids such that no supplementation of corn meal produced therefrom with soybeans will be necessary, Para. [0011]).

Claim 3a lacks an inventive step under PCT Article 33(3) as being obvious over Messing et al. (hereinafter Messing) in view of University of Florida et al. (hereinafter University of Florida) and Lebel et al. (hereinafter Lebel).

Regarding Claim 3a, modified Messing discloses the method of claim 1, but Messing fails to explicitly disclose wherein said PAPR enzyme is operably linked to a PepC leaf specific promoter.
Lebel teaches using a PepC promoter (The invention provides novel transgenic plants which express trehalose biosynthetic genes, e.g., under control of an inducible promoter, which are developmentally normal, together with methods for improving stress tolerance in said plants, methods of improving food quality, and other methods of making and using the plants of the invention, Abstract; A maize gene encoding phosphoenol carboxylase (PEPC) has been described by Hudspeth & Grula (...). Using standard molecular biological techniques the promoter for this gene can be used to drive the expression of any gene in a leaf-specific manner in transgenic plants, Para. [0175]).
It would have been obvious to one of ordinary skill in the art at the time of the invention to modify Messing with the teaching of Lebel for the purpose of using a leaf-specific promoter effective at expressing exogenous genes in the leaves of maize plants.

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Supplemental Box

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Continuation of:

Claim 8 lacks an inventive step under PCT Article 33(3) as being obvious over Messing et al. (hereinafter Messing) in view of University of Florida et al. (hereinafter University of Florida) and Gepts et al. (hereinafter Gepts).

Regarding Claim 8, modified Messing discloses a maize plant obtained by the method of claim 1, and Messing further discloses said plant elevated kernel Lys content (propagating the seed and crossing the resulting plant with a QPM plant line thereby producing kernels which exhibit increased vitreousness, increased vitreousness providing a dominant phenotype for elevated lysine and rapid selection of QPM, Para. [0009]).
Messing fails to explicitly disclose said plant has elevated levels of GLB1.
Gepts teaches a transgenic maize plant comprising elevated levels of GLB1 (The opaque-2 and floury-2 (maize), Ris0 1508 and Hiproly (barley), P721 opaque and IS 11167 (sorghum) mutants produce a reduction in the prolamine fraction (the most abundant seed protein fraction in these cereals) and concomitantly increase other nitrogen fractions such as glutelins, globulins, albumins or the free amino acid pool. The latter fractions have lysine concentrations which are up to 50 times higher than the lysine content of the prolamine fraction (...). Consequently, a reduction in the major storage protein fraction, prolamine, leads to substantially higher levels of lysine, the major limiting essential amino acid of these cereals, Pg. 52, right column, first full paragraph; In the common bean, the major seed storage protein fraction is the phaseolin fraction (globulin-1 or G1) which accounts for 35 to 50% of total seed nitrogen, Pg. 48, left column, first paragraph).
It would have been obvious to one of ordinary skill in the art at the time of the invention to modify Messing with the teaching of Gepts for the purpose of increasing the levels of GLB1 because GLB1 is a lysine-rich protein.

Claim 13 lacks an inventive step under PCT Article 33(3) as being obvious over Messing et al. (hereinafter Messing) in view of University of Florida et al. (hereinafter University of Florida) and Mbuya et al. (hereinafter Mbuya).

Regarding Claim 13, modified Messing discloses the animal feed of claim 12, but Messing fails to explicitly disclose which is chicken feed.
Mbuya teaches using genetically modified maize with increased lysine content as chicken feed (The concentration of lysine in the maize endosperm has been shown to be highly correlated with the content of a single nonzein protein called the protein synthesis factor EF-Ia (...). Genetic selection of genotypes with a high EF-Ia content can be used to improve the nutritional quality of maize, Pg. 323, first partial paragraph; In the present study, lysine content in QPM proteins was significantly higher than normal maize, Pg. 323, first full paragraph; A number of studies have proved that the more potential impact of QPM can be its use in commercial feeds for pigs and poultry as it results in improved growth (...). There are several evidences that QPM can provide a cheaper way of obtaining a balanced animal feed and that effect can be calculated in monetary terms (...). In the present study, dietary replacement of normal maize with QPM resulted in a significantly higher body weight gain at various growth stages (Table 6) of chicks studied, Pg. 324, first full paragraph).
It would have been obvious to one of ordinary skill in the art at the time of the invention to modify Messing with the teaching of Mbuya for the purpose of creating a high-quality, high-essential amino acid feed for chickens at a lower cost (Interestingly, the weight gain was similar to that observed in poultry feed with a mixture of normal maize, soybean and fish products. Considering the current soybean and fish price, the use of QPM will result in a significant monetary saving, Mbuya, Pg. 324, first full paragraph).

Claims 1, 2, 3a, 3b, 4a, 4b, 5, and 7-13 meet the criteria set out in PCT Article 33(4), and thus have industrial applicability because the subject matter claimed can be made or used in industry.