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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte TENGHUA TOM SHIEH, OANA NITULESCU,
WEI LIU LIU, and KIYOTAKA YAMASHITA

Appeal 2016-001358
Application 13/352,437
Technology Center 3700

Before STEVEN D.A. MCCARTHY, JAMES P. CALVE, and
PATRICK R. SCANLON, *Administrative Patent Judges*.

SCANLON, *Administrative Patent Judge*.

DECISION ON APPEAL

STATEMENT OF THE CASE

Tenghua Tom Shieh et al. ("Appellants")[1] seek our review under 35 U.S.C. § 134 of the Examiner's decision, as set forth in the Final Office Action dated February 12, 2015 ("Final Act."), and rejecting claims 1–7 and 10–20, which are all of the pending claims. An oral hearing was conducted on November 8, 2017. We have jurisdiction under 35 U.S.C. § 6(b).

We AFFIRM.

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[1] Appellants identify Toyota Motor Engineering & Manufacturing North America, Inc. as the real party in interest. Appeal Br. 1.

CLAIMED SUBJECT MATTER

Appellants' claimed invention relates to "a process for reducing abnormal combustion within a combustion chamber of an internal combustion engine." Spec. ¶ 1. Claim 1, reproduced below, is the sole independent claim and is representative of the claimed subject matter.

> 1. A process reducing abnormal combustion within a combustion chamber of an engine, the process comprising:
>
> providing a piston-driven internal combustion engine having a cylinder, a piston with at least one piston ring and a head using the computer, the cylinder, piston and head forming a combustion chamber;
>
> providing a computer with memory and a processing unit, the computer operable to perform simulations and calculations;
>
> simulating at least one of the cylinder, the piston with at least one piston ring and the head of the piston-driven internal combustion engine using the computer;
>
> simulating oil droplets passing past the at least one piston ring and entering into the combustion chamber using the computer;
>
> simulating the location of the oil droplets within the combustion chamber after entering into the combustion chamber using the computer;
>
> determining hot spots in the combustion chamber from the oil droplets simulation and from the location of the oil droplets simulation using the computer;
>
> simulating combustion of fuel and air within the combustion chamber including simulation of fuel properties using the computer;
>
> calculating a probability of pre-ignition for at least a portion of the hot spots in the combustion chamber as a function of the simulated combustion and determined hot spots within the combustion chamber using the computer; and

altering a combustion chamber parameter of the piston-driven internal combustion engine as a function of the determined probability of pre-ignition, the changing of combustion chamber parameter reducing pre-ignition for the piston-driven internal combustion engine.

Appeal Br. 13–14, Claims App.

REFERENCES

The Examiner relies upon the following prior art references:

Yoshino	US 6,058,906	May 9, 2000
Procknow	US 2006/0037577 A1	Feb. 23, 2006
Sullivan	US 2009/0139237 A1	June 4, 2009
Auclair	US 2010/0077992 A1	Apr. 1, 2010

J. H. Chen et al., *Direct numerical simulation of ignition front propagation in a constant volume with temperature inhomogeneities I. Fundamental analysis and diagnostics*, Combustion and Flame, Vol. 145, 128–44 (2006) ("Chen").

K. Jia, A Coupled Model for Ring Dynamics, Gas Flow, and Oil Flow through the Ring Grooves in IC Engines, MSME Thesis, Massachusetts Institute of Technology, January, 2009 ("Jia").

C. Dahnz & U. Spicher, *Irregular combustion in supercharged spark ignition engines - pre-ignition and other phenomena*, International Journal of Engine Research, Vol. 11, 485–98 (2010) ("Dahnz").

REJECTIONS

The following rejections are before us on appeal:

I. Claim 1 stands rejected under 35 U.S.C. § 101 as directed to non-statutory subject matter.

II. Claims 1–7 and 10–20 stand rejected under 35 U.S.C. § 112, second paragraph, as indefinite.

III. Claims 1 and 10 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Auclair, Dahnz, and Chen.

IV. Claims 2–4 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Auclair, Dahnz, Jia, and Chen.

V. Claims 5 and 6 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Auclair, Dahnz, Chen, and Yoshino.

VI. Claim 7 stands rejected under 35 U.S.C. § 103(a) as unpatentable over Auclair, Dahnz, Procknow, and Chen.

VII. Claims 11–20 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Auclair, Dahnz, Chen, and Sullivan.[2]

ANALYSIS

Rejection I

The Supreme Court provides a two-step test for determining whether a claim is directed to patent-eligible subject matter under 35 U.S.C. § 101. *Alice Corp. Pty. Ltd. v. CLS Bank Int'l*, 134 S. Ct. 2347, 2355 (2014). In the first step, we determine whether the claims are directed to one or more judicial exceptions (i.e., law of nature, natural phenomenon, and abstract ideas) to the four statutory categories of invention. *Id.* (citing *Mayo Collaborative Servs.* v. *Prometheus Labs., Inc.*, 132 S. Ct. 1289, 1296–97 (2012). Abstract ideas may include, but are not limited to, fundamental economic practices, methods of organizing human activities, an idea of itself, and mathematical formulas or relationships. *Id.* at 2355–57. Because all inventions, at some level, embody or apply laws of nature, abstract ideas, etc., we must "ensure at step one that we articulate what the claims are

[2] Although the Examiner lists only claims 11–16 as being rejected under 35 U.S.C. § 103(a) over Auclair, Dahnz, Chen and Sullivan on page 16 of the Final Action, the subsequent discussion indicates that the Examiner also rejects claims 17–20 under 35 U.S.C. § 103(a) over the same references.

directed to with enough specificity to ensure the step one inquiry is meaningful." *Thales Visionix Inc.* v. *U.S.*, 850 F.3d 1343, 1347 (Fed. Cir. 2017); *see also Alice*, 134 S. Ct. at 2354 ("[W]e tread carefully in construing this exclusionary principle lest it swallow all of patent law.").

In the second step, we "consider the elements of each claim both individually and 'as an ordered combination' to determine whether the additional elements 'transform the nature of the claim' into a patent-eligible application." *Alice*, 134 S. Ct. at 2354 (citing *Mayo*, 132 S. Ct. at 1297–98). In other words, the second step is to "search for an 'inventive concept'—i.e., an element or combination of elements that is 'sufficient to ensure that the patent in practice amounts to significantly more than a patent upon the [ineligible concept] itself.'" *Id.* (citing *Mayo*, 132 S. Ct. at 1294) (brackets in original).

Regarding the first step of the *Alice* analysis, the Examiner finds the claimed invention is directed to an abstract idea. Final Act. 2–3. More specifically, the Examiner finds "[c]laim 1 is directed to a process for reducing abnormal combustion in an internal combustion engine by simulating said engine on a general-purpose computer." *Id.* at 3. The Examiner further states "the process steps outlined in [claim 1], including 'simulating at least one of the cylinder . . . ,' 'simulating oil droplets,' and 'determining hot spots in the combustion chamber,' are all abstract ideas." Ans. 18.

Appellants, however, argue that claim 1 is not directed to an abstract idea. Reply Br. 2–3. According to Appellants, several steps of claim 1 "are not steps or processes that have long been prevalent in the field of automotive engineering" and, thus, "are not 'abstract ideas' within the meaning of Alice." *Id.* at 2 (citing *Alice,* 134 S. Ct. at 2350).

We disagree that claim 1 is directed merely to an abstract idea. The Examiner does not provide adequate rationale or explanation as to why "a process for reducing abnormal combustion in an internal combustion engine by simulating said engine on a general-purpose computer" is an abstract idea. Merely asserting that the steps of claim 1 "are all abstract ideas," without more, is insufficient as it fails to consider the steps as an ordered combination. *See McRO, Inc. v. Bandai Namco Games Am. Inc.*, 837 F.3d 1299, 1313 (Fed. Cir. 2016) ("Whether at step one or step two of the *Alice* test, in determining the patentability of a method, a court must look to the claims as an ordered combination, without ignoring the requirements of the individual steps."). The Examiner has not established that a process of reducing abnormal combustion in an internal combustion engine, which requires the physical step of altering a combustion chamber parameter, is inherently abstract.

Our reviewing court has held

> The Supreme Court has not established a definitive rule to determine what constitutes an "abstract idea" sufficient to satisfy the first step of the *Mayo/Alice* inquiry. Rather, both this court and the Supreme Court have found it sufficient to compare claims at issue to those claims already found to be directed to an abstract idea in previous cases.

Enfish, LLC v. *Microsoft Corp.*, 822 F.3d 1327, 1337 (Fed. Cir. 2016) (citations omitted). We are not directed, however, to any holding suggesting "a process for reducing abnormal combustion in an internal combustion engine by simulating said engine on a general-purpose computer" is an abstract idea. Indeed, claim 1 is not directed to the types of concepts, such as fundamental economic practices, methods of organizing human activity, or financial data processing, commonly found to be abstract ideas.

Furthermore, even assuming a mathematical relationship is involved in the simulations and calculations of claim 1 (which the Examiner does not find expressly), that alone does not render the claim patent ineligible. *See Thales*, 850 F.3d at 1349 ("That a mathematical equation is required to complete the claimed method and system does not doom the claims to abstraction."); *see also Enfish*, 822 F.3d at 1338 ("[W]e are not persuaded that the invention's ability to run on a general-purpose computer dooms the claims."). Here, we are not provided with any rationale to indicate any such mathematical relationship would be pre-empted by claim 1.

For the reasons above, the answer to the first question of the *Alice* framework is "no" — we are unpersuaded claim 1 is directed to an abstract idea. Because the answer at step one is "no," the inquiry is over and moving to step two is unnecessary. *Thales,* 850 F.3d at 1349 ("Because we find the claims are not directed to an abstract idea, we need not proceed to step two."). Accordingly, we reverse the Examiner's rejections of claim 1 under 35 U.S.C. § 101.

Rejection II

The Examiner finds that independent claim 1, and claims 2–7 and 10–20 depending therefrom, are indefinite because the limitation "the computer" in claim 1 lacks sufficient antecedent basis. Final Act. 3–4. Appellant does not contest this finding and indicates claim 1 will be corrected "assuming the remaining rejections of the claims are reversed." Appeal Br. 5. Accordingly, this ground of rejection is summarily sustained.

Rejection III

In rejecting independent claim 1, the Examiner finds that Auclair, Dahnz, and Chen disclose the claimed limitations and concludes it would have been obvious to one of ordinary skill in the art to combine the references in a manner that renders claim 1 obvious. Final Act. 4–11.

Appellants argue that the following limitations of claim 1 are not taught or suggested by the Examiner's combination of references:

> a) simulating at least one of the cylinder, the piston with at least one piston ring and the head of the piston-driven internal combustion engine using the computer;
>
> b) simulating oil droplets passing past the at least one piston ring and entering into the combustion chamber using the computer;
>
> c) simulating the location of the oil droplets within the combustion chamber after entering into the combustion chamber using the computer;
>
> d) determining hot spots in the combustion chamber from the oil droplets simulation and from the location of the oil droplets simulation using the computer; and
>
> e) calculating a probability of pre-ignition for at least a portion of the hot spots in the combustion chamber as a function of the simulated combustion and determined hot spots within the combustion chamber using the computer.

Appeal Br. 7–8. We address each of these limitations.

The Examiner finds that Auclair's teaching of modeling cylinder pressure discloses limitation a). Final Act. 5 (citing Auclair ¶ 46). The Examiner maintains that modeling cylinder pressure discloses simulating at least a cylinder because "simulating" is interpreted to mean "performing a representation of the behavior or characteristics of one system through the use of another system, which does not require providing a visual display of the simulation process." Ans. 19.

Appellants do not appear to contest this interpretation, so we adopt it for the purposes of this Decision. Appellants argue that "[m]odeling a cylinder pressure using the equation PV^n=cte as taught by Auclair (par. 0051]) is *not* equivalent to computer simulation of a cylinder, a piston with a piston ring, or a head of a piston-driven internal combustion engine." We agree with Appellants. Auclair discloses modeling the pressure in a cylinder using the hypothesis of polytropic compression to estimate the cylinder pressure during conventional combustion without any pre-ignition phenomenon. Auclair ¶¶ 51–56. Auclair thus provides an estimate of a single characteristic—the pressure—of the cylinder. We do not agree that providing an estimate of a single characteristic amounts to making representation of the *behavior or characteristics* of the cylinder. As such, we do not agree that Auclair discloses simulating at least the cylinder.

Next, the Examiner finds Dahnz discloses simulating oil droplets passing past the at least one piston ring and entering into the combustion chamber using the computer (limitation b)). Final Act. 6–7 (citing Dahnz, p. 488, 1:20–38, p. 492, 2:18 through p. 493, 1:11). Appellants argue that Dahnz's disclosure of "*assuming droplets* are released from the top landing does not meet or suggest the limitation of *simulating oil droplets passing past a piston ring*." Appeal Br. 8–9. In response, the Examiner states

> Dahnz assumes that oil droplets pass the top piston ring of the engine. Dahnz then creates a simulation, or model, to demonstrate oil entering the engine cylinder (combustion chamber) based on the aforesaid assumption. Specifically Dahnz teaches that "The main factor influencing droplet release from the oil wiped off from the cylinder liner during the compression

> stroke is its surface tension [6]. Thus, a model has been set up to describe the influence of engine operating conditions on the surface tension of the lubricant" [see section 4.1 Causes of pre-ignition].

Ans. 19. Contrary to the Examiner's reasoning, however, modeling the surface tension of the lubricant does not necessarily mean simulating oil droplets passing a piston ring and entering into the combustion chamber. Section 4.1 of Dahnz identifies the presence of droplets of lubricant oil in the combustion chamber as the most probable mechanism suspected to promote pre-ignition. Dahnz, 492. Dahnz assumes these droplets are released from the top land during the deceleration phase of the piston, as illustrated in Figure 14. *Id.* Figure 14 shows droplets being released upwardly from the top land of a piston ring. *Id.* at 493. As such, Dahnz does not contemplate these released droplets passing the piston ring. And even if Dahnz did address droplets passing the piston ring, simply modeling the *surface tension* of the lubricant on the cylinder liner does not equate to simulating oil droplets passing a piston ring. For these reasons, we do not agree that Dahnz discloses limitation b).

Regarding limitation c), the Examiner finds that Dahnz (in Section 3.2.4) discloses simulating the location of the oil droplets within the combustion chamber after entering into the combustion chamber using an optical approach instead of a computer as claimed. Final Act. 7 (citing Dahnz, p. 491, 1:7–12). In addition, the Examiner finds Chen discloses "simulating the location of temperature inhomogeneities within a combustion chamber using a computer and determining hot spots in the combustion chamber from the location of the oil droplets simulation." *Id.* at

7. The Examiner then concludes it would have been obvious to one of ordinary skill in the art

> to simulate the location of the oil droplets as temperature inhomogeneities as disclosed by Dahnz, using a computer running a direct numerical simulation algorithm, as disclosed by Chen, since spontaneous, or "pre," ignition is directly correlated with the temperature in the combustion chamber. Thus, the resulting simulation would predictably produce an ignition timing of the combustible mixture in the combustion chamber.

Id. at 8. The Examiner took a different position on the Dahnz-Chen combination in the Examiner's Answer, relying on Dahnz's disclosure of numerical simulation in Section 3.1.2 as disclosing simulating a spatial location of oil droplets in the combustion chamber. Ans. 20.

In either case, we disagree that Dahnz discloses simulating the location of the oil droplets in a combustion chamber. First, Section 3.2.4 of Dahnz discloses using an endoscope to optically detect "pre-ignition origins." Dahnz, 491. Even if these "pre-ignition origins" are oil droplets as the Examiner maintains, Dahnz discloses *detecting actual droplets*, not simulating droplets. Second, Section 3.1.2 of Dahnz discloses conducting "simulations of the detailed chemical kinetics which enabled the assessment of auto-ignition properties of the air/fuel mixture" and "[f]or the investigation of spatial inhomogeneities such as droplets, particles, and hot spots, a one-dimensional combustion code was used." *Id.* at 488. Although this description suggests that droplets are simulated, there is no suggestion that the *location* of droplets in a combustion chamber is simulated as claimed.

In addition, the simulation described in Chen is done as part of a study "to understand the influence of temperature inhomogeneities on characteristics of ignition and subsequent combustion in an HCCI-like environment and to provide information relevant to the modeling of HCCI combustion."[3] Chen, 129. As such, Chen does not suggest that simulating hot spots would be useful as part of a process for reducing abnormal combustion. Indeed, Chen is not concerned with advoiding abnormal combustion. Accordingly, we do not agree that one of ordinary skill in the art would have been led to combine the teachings Chen and Dahnz in the manner proposed by the Examiner.

In finding that Dahnz discloses determining hot spots in the combustion chamber from the oil droplets simulation using a computer (limitation d)), the Examiner quotes several passages from Section 4.1 of Dahnz. Final Act. 8. The Examiner does not explain adequately, however, how these passages disclose determining hot spots in a combustion chamber from an oil droplets simulation. Section 4.1 of Dahnz discusses droplets of lubricant oil being the most probable cause of pre-ignition, modeling the influence of engine operating conditions, including oil dilution by liquid fuel, and simulations of the mixture formation showing a large amount of liquid fuel transported to the cylinder liner. Dahnz, 492–93. Section 4.1 does not discuss determining hot spots in a combustion chamber from an oil droplets simulation.

In response to Appellants' argument that Dahnz fails to disclose limitation d) (Appeal Br. 9), the Examiner finds that "the one dimensional code disclosed by Dahnz determines (oil) droplet temperature T_{dr} and thus determines hot spots in the combustion chamber from the oil droplets

[3] HCCI refers to "homogeneous charge compression-ignition." Chen, 128.

simulation." Ans. 20 (citing Dahnz, Section 3.2.5). Section 3.2.5 of Dahnz merely states, however, that "Figure 13 shows the computed ignition limits as a function of droplet temperature T_{dr} and gas phase temperature T_g." Dahnz, 492. This language is not a clear disclosure of determining droplet temperatures, but even if Dahnz does disclose determining droplet temperatures, and such droplet temperatures determined hot spots, such a determination is not based on an oil droplets simulation. Accordingly, we agree with Appellants that Dahnz does not disclose limitation d).

The Examiner finds that Auclair's teaching of detecting the start of abnormal combustion discloses limitation e). Final Act. 5 (citing Auclair ¶ 69). In addition, the Examiner finds that Dahnz discloses this limitation. *Id.* at 9 (citing Dahnz, p. 488, 1:41–49, p. 491, col. 2 through p. 492, col. 2, Figs. 13, 17).

We disagree with both findings. First, paragraph 69 of Auclair discloses that the comparison of the measured and modeled cylinder pressures allows the engine computer to detect the start of abnormal combustion in the combustion chamber. Detecting the *start* of abnormal combustion, which means that the abnormal combustion actually is occurring, is not equivalent to calculating the *probability* of abnormal combustion occurring. Furthermore, because Auclair's detection is based on comparing the measured and modeled cylinder pressures, Auclair discloses calculating the probability *as a function* of the simulated combustion and determined hot spots within the combustion chamber.

Second, the cited passage on page 488 of Dahnz discusses that experimental investigations and numerical simulations were conducted to assess the probability that various mechanisms were the cause of pre-ignition. This assessment is not equivalent to calculating a probability of pre-ignition for at least a portion of the hot spots in a combustion chamber. Similarly, the discussion of ignition delay times in the cited passage on pages 491 and 492 of Dahnz fails to suggest calculating a probability of pre-ignition for at least a portion of the hot spots in a combustion chamber. Moreover, both passages fail to disclose calculating the probability *as a function* of the simulated combustion and determined hot spots within the combustion chamber. We thus determine that both Auclair and Dahnz fail to disclose limitation e).

For the above reasons, we do not sustain the rejection of claim 1, and claim 10 depending therefrom, as unpatentable over Auclair, Dahnz, and Chen.

Rejections IV–VII

The Examiner's rejections of claims 2–4 as obvious over Auclair, Dahnz, Jia, and Chen, claim 5 and 6 as obvious over Auclair, Dahnz, Chen, and Yoshino, claim 7 as obvious over Auclair, Dahnz, Procknow, and Chen, and claims 11–20 as obvious over Auclair, Dahnz, Chen, and Sullivan all rely on the same erroneous findings, noted above, regarding certain limitations of independent claim 1. None of the additionally cited references cures these deficiencies. Accordingly, we do not sustain these rejections for the same reasons stated above with respect to claim 1.

DECISION

We reverse the Examiner's rejection of claim 1 under 35 U.S.C. § 101 and the Examiner's rejections of claims 1–7 and 10–20 under 35 U.S.C. § 103(a). We summarily affirm the Examiner's rejection of claims 1–7 and 10–20 under 35 U.S.C. § 112, second paragraph, as indefinite.

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

AFFIRMED