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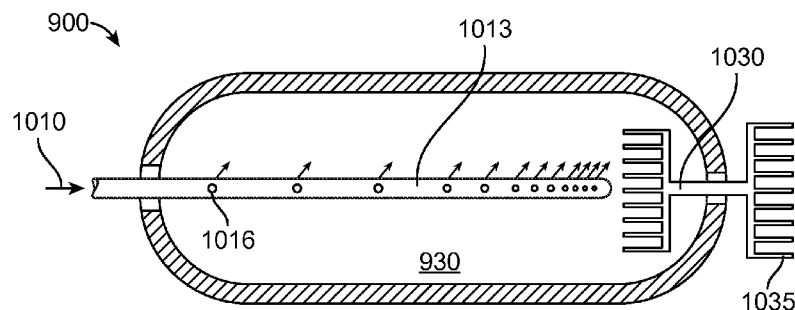


FIG. 10A

(57) Abstract: Improved methods, systems, and devices for filling fuel tanks, particularly compressed natural gas (CNG) fuel tanks, are provided. Such methods, systems, and devices enhance heat rejection when the fuel tank is being filled to a temperature lower than that if such methods, systems, and devices were not used. Pressure sensor logic on a fuel station will be less prone to error in gauging the mass of the fuel in the tank, enabling the tank to be filled more accurately and fully. To enhance heat rejection, the fuel tank may be provided with a heat sink to passively facilitate heat transfer from the fuel tank interior to the exterior. Alternatively or in combination, the fuel tank can be provided with a fuel flow channel through which fuel from the fuel tank interior is circulated. The fuel flow channel can be actively cooled with a fan or water cooling system.



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US15/38546

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B60K 15/03, 15/07; F17C 13/00 (2015.01)

CPC - B60K 15/03006, 15/07; F17C 13/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) Classification(s): B60K 15/03, 15/04, 15/07; F17C 1/00, 13/00 (2015.01)

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); Google; Google/Scholar; ProQuest; Keywords: sink*, fin, cooler, exchanger, fuel*, tank, vortex, vort*, swirl*, whirl*, helic*, chamber, storage

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/0246122 A1 (HANDA K) October 25, 2007; figures 3, 4A, 4B; paragraphs [0002], [0018], [0021]	1-6, 8-11
X	US 2007/0000561 A1 (HANDA K) January 4, 2007; figure 2B; paragraphs [0019], [0027]	1, 7, 12-16
A	US 3,886,733 A (CONNELL JA) June 3, 1975; figure 3; column 10, lines 60-64	6, 14
A	US 6,230,692 B1 (THOMPSON RH) May 15, 2001; entire document	1-16



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US15/38546

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

-Please See Supplemental Page-

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
Group I: claims 1-16

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

-Continued from Box No. III Observations where unity of invention is lacking-

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: claims 1-16 are directed toward a method of filling a fuel tank with fuel comprising: providing a heatsink.

Group II: claims 17-20 are directed toward a method of filling a fuel tank with fuel wherein the fuel is directed through a plurality of outlet perforations of the fuel insert.

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons.

The special technical features of Group I include a heatsink coupled to the wall, the heatsink being disposed within the interior volume and exposed to an exterior of the wall; introducing fuel into the interior volume through the fuel inlet, wherein introducing the fuel generates a heat of compression; and directing, with the heatsink, at least a portion of the generated heat of compression from the interior volume to the exterior of the wall of the fuel storage chamber, wherein introducing fuel into the interior volume comprises channeling the fuel through a flow modification element, wherein the heatsink and the flow modification element combine to reduce heat generated by filling of the fuel tank (which is not present in Group II).

The special technical features of Group II include wherein the fuel is directed through a plurality of outlet perforations of the fuel insert into the interior volume, the plurality of outlet perforations reducing noise generated by the introduction of the fuel into the interior volume (which is not present in Group I).

The common technical features of Groups I-II include a method of filling a fuel tank with fuel, the method comprising: providing a fuel tank comprising a fuel inlet, a fuel storage chamber having a wall defining an interior volume to reduce heat generated by filling of the fuel tank.

These common technical features are disclosed by US 2007/0000561 A1 (HANDA): a method of filling a fuel tank with fuel, the method comprising: providing a fuel tank (1; figure 2B) comprising a fuel inlet (V1), a fuel storage chamber having a wall defining an interior volume (fuel storage chamber defined by the wall of tank 1; figure 2B) to reduce heat generated by filling of the fuel tank (via the conduit disposed within tank 1, fuel is introduced in tank such that the heat from the introduced fuel can be absorbed in coolant circulating conduit 40 via coil 45; figure 2B).

Because the common technical features are disclosed by HANDA, the inventions are not so linked as to form a single general inventive concept. Therefore, Groups I-II lack unity.