(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 839 321 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
**23.06.2021 Bulletin 2021/25**

(51) Int Cl.:
***F17D 1/04*** *(2006.01)*

(21) Application number: **20209644.2**

(22) Date of filing: **24.11.2020**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
**BA ME**
**KH MA MD TN**

(30) Priority: **17.12.2019 PL 43225419**

(71) Applicant: **NGV Autogas Spólka Z Ograniczona Odpowiedzialnoscia**
**31-127 Kraków (PL)**

(72) Inventors:
- **Rutkowski, Marek**
  **31-127 Kraków (PL)**
- **Michalowski, Jaroslaw**
  **32-085 Modlnica (PL)**
- **Borowiec, Zdzislaw**
  **31-436 Kraków (PL)**
- **Stasko, Dominik**
  **32-085 Modlniczka (PL)**

(74) Representative: **Grzaka, Andrzej**
**Rzecznik Patentowy**
**Ul. Sadowa 7/11**
**31-542 Krakow (PL)**

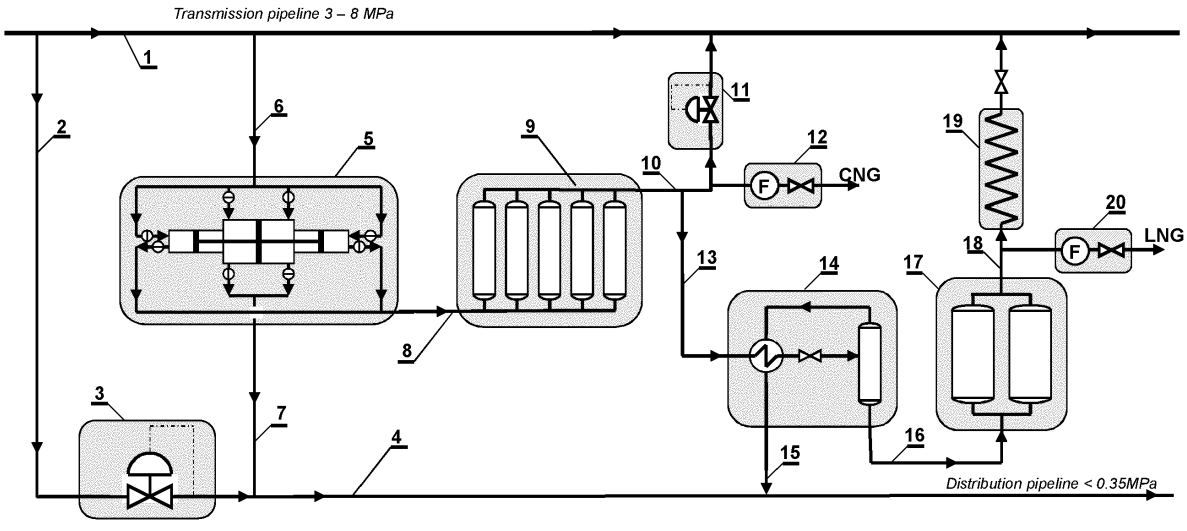
# (54) INSTALLATION FOR COMPENSATING FLUCTUATIONS IN GAS DEMAND IN NATURAL GAS NETWORKS AND THE METHOD OF IMPLEMENTING THIS COMPENSATION

(57) The invention solves the problem of energy-free compensation of fluctuations in gas demand in natural gas networks by means of a compression-storage-expansion installation by using a reciprocating compressor (5) driven by gas taken from a medium or high pressure transmission pipeline.

The compression-storage-expansion installation may additionally have a gas liquefaction module based on gas expansion (14) and at least one low-temperature tank (17) and a liquid gas evaporator (19).

Moreover, it may have measuring-distribution sets for delivering compressed and/or liquefied gas as respectively CNG (12) and/or LNG (20) fuel to the external customers.

Fig. 1




EP 3 839 321 A1

## Description

**[0001]** The subject of the invention is the method of compensating fluctuations in gas demand in natural gas networks and the technological layout of the installation for compensating fluctuations in gas demand in natural gas networks by using energy-free compression-storage-expansion installation.

**[0002]** Natural gas is transported from the sources to places of use via network of medium and high pressure pipelines, usually working under pressure of 3 - 8 MPa. Generally prior to supplying gas to the end users, especially the municipal ones, the gas pressure must be reduced to less than 0.35 MPa. Therefore, network reduction stations are located at the transmission pipelines, where the gas pressure is reduced to the level required in the distribution networks.

**[0003]** Natural gas pipeline networks do not operate under steady-state conditions because gas demand changes both in hourly, daily, weekly and seasonal cycles related to summer - winter seasons. Such fluctuations in demand require compensation, because in extreme cases they can cause periodic gas shortages at customers.

**[0004]** Medium and high pressure pipelines are characterized by possibility of compensating fluctuations in gas demand resulting from operating at a certain level of pressure range, which makes it possible to store gas in an amount depending on the diameter and length of the pipeline and the allowable range of changes in the working pressure. These stored quantities are usually not sufficient to compensate for fluctuations in gas demand, which may result in periodic gas shortages, especially in the end zones of the pipelines, where large pressure drops may occur, preventing proper operation of the gas network.

**[0005]** The system known from the Polish patent description PL 198956 is the pipeline system of the gas distribution station with multidirectional power supply and distribution, which is equipped with shut-off and check valves and filtration units.

**[0006]** The Polish patent description of PL 203759 describes a piping system of the gas distribution station with multidirectional power supply and distribution, which thanks to equipping it with cross-flow pipelines solves the movement problems of the distribution station.

**[0007]** There is a known method of compensating for fluctuations in gas demand in natural gas networks consisting in compressing the intake gas to high pressure in periods of reduced gas demand, storing compressed gas and expanding the stored gas to the gas grid during periods of increased gas demand.

**[0008]** This method is characterized by high energy consumption for gas compression, as the compressors used to compress the gas are powered by electric or combustion engines, mainly gas engines. Therefore, it is mainly used in the nationwide networks to strategically compensate for fluctuating gas demand in seasonal cycles, associated with the summer - winter seasons.

**[0009]** According to the invention the technological layout of the installation for compensating fluctuations in gas demand in natural gas networks including compressor, storage of compressed gas and the pressure reduction module, is characterized by the fact that the used compressor is a reciprocating compressor driven by gas taken from a medium or high pressure transmission pipeline. Gas with reduced pressure from the compressor is directed to the low-pressure distribution pipeline, and compressed gas is stored in pressure tanks and during periods of increased gas demand the stored gas is being expanded and directed to the transmission pipeline.

**[0010]** According to the invention, the compression-storage-expansion installation is located at the network reduction station. The reciprocating compressor used in the method according to the invention is driven by the energy of the gas supplied from the medium or high pressure transmission pipeline, it can be single-sided or preferably double-sided, for example a compressor according to the patent description PL 235574.

**[0011]** Any pressure tanks can be used as storage tanks for compressed gas such as stationary tanks composed of bundles of steel or composite cylinders.

**[0012]** Preferably, the technological layout of the installation according to the invention includes additionally a measuring-distribution set, which is connected to the storage tanks to deliver compressed gas as CNG fuel to automotive vehicles.

**[0013]** Preferably, the technological layout of the installation according to the invention has additionally a gas liquefaction module based on gas expansion using the Joule-Thomson effect and at least one liquid gas vessel and evaporator.

**[0014]** Preferably, the technological layout of the installation according to the invention has additionally a measuring-distribution set, which is connected to the storage tanks, for the delivery of liquefied gas as LNG fuel to the external customers.

**[0015]** According to the invention, a method of compensating fluctuations in gas demand in natural gas networks is the compression of gas, which was taken from a medium or high pressure transmission pipeline during periods of the reduced gas demand, to high pressure whereby the energy used for the gas compression is the energy from medium or high pressure gas expansion. The compressed gas is being stored and during periods of increased gas demand the stored gas is being expanded and directed to the transmission pipeline, and the gas with reduced pressure from compression is being directed to the low-pressure distribution pipeline.

**[0016]** Advantageously, the stored compressed gas can be issued through a measuring-distribution set as an ecological CNG fuel (English for: *Compressed Natural Gas*) for motor vehicles.

**[0017]** According to the invention, in a method for compensating fluctuations in gas demand in natural gas networks, preferably additionally compressed gas is being

liquefied through gas expansion using the Joule-Thomson effect, then the liquefied gas is being stored and during periods of increased gas demand it is being evaporated and introduced to the network.

**[0018]** Preferably, the stored liquefied gas can be issued through the measuring-distribution set as LNG fuel (English for: *Liquefied Natural Gas*) to the external recipients, for example as ecological fuel for automotive vehicles.

**[0019]** The use of the method according to the invention for compensating fluctuations in gas demand in natural gas networks and the technological layout of the installation based on this method enables energy-free compression and storage of the compressed gas, especially in dispersed end zones of the transmission pipelines, where the gas pressure drops caused by the increased gas demand most often occur, preventing the correct operation of the gas network.

**[0020]** Technological layout of the installation for compensating fluctuations in gas demand in natural gas networks and a method for implementing this compensation according to the invention will be explained in an example based on the drawing (Fig. 1) showing the block technological diagram of the installation with all the alternative options including network pressure reduction station.

**[0021]** Example. In commonly used solutions in gas networks the transmission pipeline 1 is connected by pipeline 2 with the entrance of the network reduction station 3, and the output of reduction station 3 is connected to the distribution pipeline 4. The input of a double-acting reciprocating compressor 5 is connected by pipeline 6 to the transmission pipeline 1, and the outlet from compressor 5 is connected by pipeline 7 with distribution pipeline 4. The outlet of compressed gas from compressor 5 is connected by a pipeline 8 with a storage tank 9. Outlet from the storage tank 9 is connected by a pipeline 10 through a pressure reduction module 11 with a transmission pipeline 1. A measuring-distribution set 12 is connected to the pipeline 10 for dispensing compressed gas as CNG fuel. Connected to the pipeline 10 via the pipeline 13 there is also a gas liquefaction module 14, which is based on gas expansion using the Joule-Thomson effect. Gas output with reduced pressure is connected by pipeline 15 with a distribution pipeline 4, and the liquefied gas outlet is connected by pipeline 16 with a set of low temperature storage tanks 17. Outlet from the storage tanks 17 is connected by pipeline 18 through evaporator 19 with the transmission pipeline 1. A measuring-distribution set 20 is connected to the pipeline 18 for delivering liquefied gas as LNG fuel.

**[0022]** The operation method of the technological installation for compensating fluctuations in gas demand in natural gas networks is as follows:

Natural gas is transported via a medium or high pressure transmission pipeline 1 at a pressure of typically 3 - 8 MPa. From this pipeline the gas is being taken to the network reduction station 3, where after reducing the pressure to usually below 0.35 MPa it is directed to the distribution pipeline 4. Also from the transmission pipeline 1, gas is being taken to a double-acting reciprocating compressor 5. A part of the gas taken from the transmission pipeline 1 is a working medium and as a result of the expansion it does the work of compressing the remaining part of the gas taken in. Usually the gas is compressed to a pressure above 20 MPa, most often up to 20 - 25 MPa. The expanded gas is directed to the distribution pipeline 4 and the compressed gas is directed to the storage tank 9 in the form of a parallel connected pressure cylinders. In the periods of increased gas demand compressed gas from the storage tank 9 is directed through the pressure reduction module 11 to the transmission pipeline 1.

**[0023]** The compressed gas from the storage tank 9 can be issued through the measuring-distribution set 12 as CNG fuel.

**[0024]** The compressed gas from the storage tank 9 can also be directed to a gas liquefaction module 14, which is based on gas expansion using the Joule-Thomson effect. Part of the gas is being liquefied in the gas liquefaction module 14 and the rest of the reduced pressure gas is directed to the distribution pipeline 4. The liquefied gas is directed to the low-temperature storage tanks 17. In periods of increased gas demand, liquefied gas from the tank storage 17 is directed through the evaporator 19 to the transmission pipeline 1.

**[0025]** Liquefied gas from the storage tanks 17 can be dispensed by measuring- distribution set 20 as LNG fuel.

## Claims

1. The technological layout of the installation for compensating fluctuations in gas demand in natural gas networks in the form of a compression-storage-expansion installation containing a compressor, a compressed gas storage and a pressure reduction module **characterized in that** the compressor used is a reciprocating compressor (5) powered by gas taken by pipeline (6) from transmission pipeline (1), and the compressor (5) has an outlet of the expanded gas through pipeline (7) to the distribution pipeline (4), and an outlet of the compressed gas through the pipeline (8) to the storage tank (9), connected by a pipeline (10) with a pressure reduction module (11) connected to the transmission pipeline (1), and the compression-storage-expansion installation is located at the network reduction station (3), which has a pipeline (2) for gas collection from the transmission pipeline (1) and a pipeline (7) for directing the expanded gas to the distribution pipeline (4).

2. The technological layout of the installation for compensating fluctuations according to claim 1 **characterized in that** it has an additional measuring-distribution set (12) connected to the pipeline (10) for delivering compressed gas as CNG fuel to motor vehi-

cles.

3. The technological layout of the installation for compensating fluctuations according to claim 1 and 2 **characterized in that** it additionally has a pipeline (13), being a branch from the pipeline (10) leading to the gas liquefaction module (14) based on gas expansion, the liquefaction module (14) having an outlet of the expanded gas through pipeline (15) to the distribution pipeline (4) and an outlet of the liquefied gas to the low temperature storage tanks (17) via pipeline (16) and the storage tanks (17) are connected by pipeline (18) with the evaporator (19) and then with pipeline (1).

4. The technological layout of the installation for compensating fluctuations according to claim 1-3 **characterized in that** it has an additional measuring-distribution set (20) connected to the pipeline (18) for the delivery of liquefied gas as LNG fuel to the external recipients.

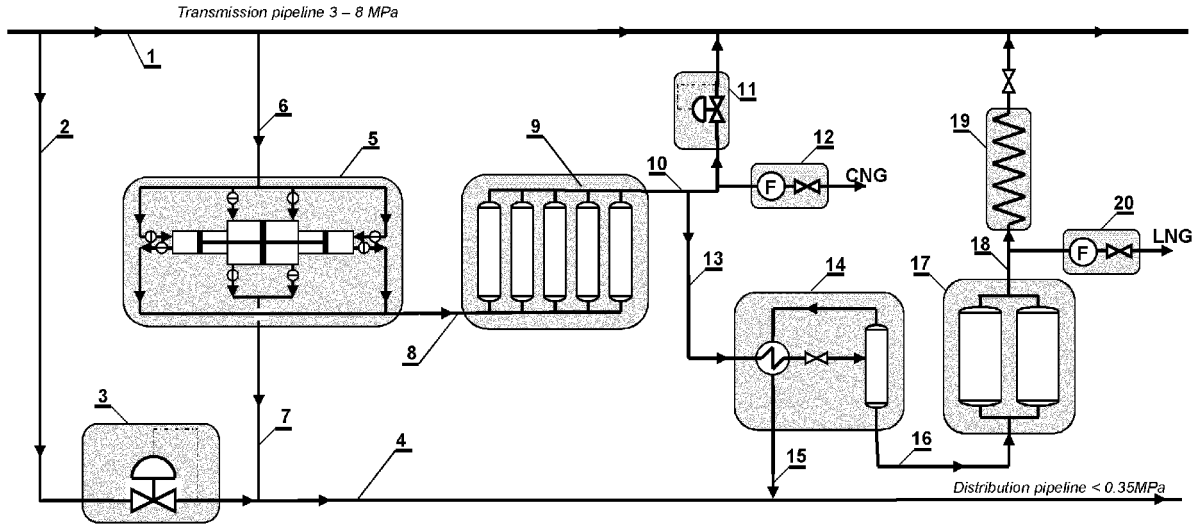
5. Method of compensating fluctuations in gas demand in natural gas networks consisting in compressing of gas, which was taken from a medium pressure or high pressure transmission pipeline in periods of reduced gas demand, to high pressure, storing the compressed gas and expanding the stored gas into the pipeline during periods of increased gas demand **characterized in that** the energy used for the gas compression is the energy from medium or high pressure gas expansion, and the gas with reduced pressure from compression is being directed to the low-pressure distribution pipeline.

6. The method of compensating fluctuations in the natural gas demand according to claim 5 **characterized in that** the stored compressed gas is being issued through the measuring-distribution set (12) as CNG fuel for automotive vehicles.

7. The method of compensating fluctuations in the natural gas demand according to claim 5 **characterized in that** the compressed gas is being liquefied using the Joule-Thomson effect of gas expansion, liquefied gas is being stored and during periods of increased demand it is being evaporated and fed to the network.

8. The method of compensating fluctuations in the natural gas demand according to claim 7 **characterized in that** the stored liquefied gas is being issued through the measuring-distribution set (20) as LNG fuel to the external recipients.

Fig. 1


Transmission pipeline 3 – 8 MPa
1
2
3
4
5
6
7
8
9
10
11
12
CNG
13
14
15
16
17
18
19
20
LNG
Distribution pipeline < 0.35MPa

Europäisches Patentamt
European Patent Office
Office européen des brevets

# EUROPEAN SEARCH REPORT

Application Number
EP 20 20 9644

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
| X | US 3 360 944 A (HELMUT KNAPP ET AL) 2 January 1968 (1968-01-02) | 5-8 | INV. F17D1/04 |
| A | * column 1, line 24 - column 1, line 37; figure 1 * * column 1, line 58 - column 1, line 63 * * column 4, line 3 - column 4, line 15 * * column 1, line 64 - column 4, line 38 * | 1-4 | |
| A | US 4 677 827 A (SHENOY THIRTHAHALLI A [US] ET AL) 7 July 1987 (1987-07-07) * the whole document * | 1-8 | |
| A | US 3 503 220 A (DESAI SUDHIR HARILAL) 31 March 1970 (1970-03-31) * the whole document * | 1-8 | |
| A | US 6 196 021 B1 (WISSOLIK ROBERT [US]) 6 March 2001 (2001-03-06) * the whole document * | 1-8 | |
| A | EP 3 270 033 A1 (BRAUN FRANZ [DE]) 17 January 2018 (2018-01-17) * the whole document * | 1-8 | TECHNICAL FIELDS SEARCHED (IPC) F17D F25J F17C |
| A | US 2008/016879 A1 (WATSON DAVID B [US] ET AL) 24 January 2008 (2008-01-24) * the whole document * | 1-8 | |
| A | DE 44 16 359 A1 (DEHLI MARTIN PROF DR ING [DE]) 16 November 1995 (1995-11-16) * the whole document * | 1-8 | |
| A | US 9 885 239 B2 (BASF SE [DE]) 6 February 2018 (2018-02-06) * the whole document * | 1-8 | |
| A | EP 3 091 176 A1 (RWE DEUTSCHLAND AG [DE]) 9 November 2016 (2016-11-09) * the whole document * | 1-8 | |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| Munich | 12 May 2021 | Forsberg, Peter |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 20 9644

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

12-05-2021

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| US 3360944 A | 02-01-1968 | AT 277179 B | 10-12-1969 |
| | | DD 71567 A1 | 05-03-1970 |
| | | DE 1551597 A1 | 23-04-1970 |
| | | ES 338696 A1 | 01-04-1968 |
| | | FR 1517491 A | 15-03-1968 |
| | | GB 1115689 A | 29-05-1968 |
| | | US 3360944 A | 02-01-1968 |
| US 4677827 A | 07-07-1987 | CA 1264561 A | 23-01-1990 |
| | | US 4677827 A | 07-07-1987 |
| US 3503220 A | 31-03-1970 | DE 1601950 A1 | 04-03-1971 |
| | | FR 1575098 A | 18-07-1969 |
| | | GB 1180496 A | 04-02-1970 |
| | | NL 6805483 A | 29-01-1969 |
| | | US 3503220 A | 31-03-1970 |
| US 6196021 B1 | 06-03-2001 | AU 5136399 A | 09-10-2000 |
| | | US 6196021 B1 | 06-03-2001 |
| | | WO 0057118 A1 | 28-09-2000 |
| EP 3270033 A1 | 17-01-2018 | DE 102016112843 A1 | 18-01-2018 |
| | | EP 3270033 A1 | 17-01-2018 |
| | | ES 2739983 T3 | 05-02-2020 |
| US 2008016879 A1 | 24-01-2008 | AU 2003304148 A1 | 13-12-2004 |
| | | US 2004244388 A1 | 09-12-2004 |
| | | US 2008016879 A1 | 24-01-2008 |
| | | WO 2004104399 A1 | 02-12-2004 |
| DE 4416359 A1 | 16-11-1995 | NONE | |
| US 9885239 B2 | 06-02-2018 | CN 104641083 A | 20-05-2015 |
| | | EP 2898201 A1 | 29-07-2015 |
| | | RU 2015114341 A | 10-11-2016 |
| | | US 2015233247 A1 | 20-08-2015 |
| | | WO 2014044649 A1 | 27-03-2014 |
| EP 3091176 A1 | 09-11-2016 | DE 102015205533 A1 | 29-09-2016 |
| | | EP 3091176 A1 | 09-11-2016 |
| | | HU E046237 T2 | 28-02-2020 |

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

## REFERENCES CITED IN THE DESCRIPTION

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

### Patent documents cited in the description


- PL 198956 **[0005]**
- PL 203759 **[0006]**
- PL 235574 **[0010]**