A system for the production of methanol from an offshore natural gas field comprises a floating production unit (10) in the form of a floating platform. The production unit (10) includes a methane-to-methanol production plant (18). A floating storage unit (12) is spaced apart from the production unit (10) but is coupled to the production unit (10) by a pipeline (26) which conveys produced methanol from the production unit (10) to the storage unit (12).
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"Floating Methanol Production Complex"

This invention relates to the offshore production of methanol from natural gas extracted from a subsea well. The invention makes possible engineering developments to enable substantial quantities of chemical grade AA methanol and other refined products to be produced on a floating production facility moored over a reservoir of feed stock.

Offshore natural gas is currently exploited in two ways. When the gas field is reasonably close to centres of use, the gas is transported ashore via a pipeline, and transmitted to the users via a distribution network after minimal treatment. If there is no centre of use in the vicinity of the field, the gas is piped ashore and liquefied to form liquefied natural gas (LNG) which is held in cryogenic storage tanks until it is exported by LNG tanker to the area of consumption. LNG storage and gasification facilities are also required at the point of reception.

It will be appreciated that exploiting natural gas by the LNG route requires extremely high capital
expenditure, including the use of specialised tankers which are not suitable for any other uses. These constraints have inhibited the development of offshore gas fields which are below a rather large size, or which are in particularly remote locations.

The conversion of methane to methanol is a well known process in widespread commercial use. Offshore natural gas may be exploited by conversion to methanol, which is very much easier to store and transport than LNG. Currently, this is done by piping the gas to an onshore conversion plant, but this has disadvantages in the cost of transmission and the fixed location of the plant.

It has been proposed to convert natural gas to methanol in a floating plant located at the gas field. However, no such installation has been made hitherto. It is believed that the reasons why floating conversion has not hitherto been practicable are both economic and technical. The various proposals which have been made have been centred on the use of a single-hull vessel, such as a tanker or barge, to accommodate the entire installation including conversion, storage and crew accommodation. It would be difficult to build or convert a vessel of this nature at a cost which would make the overall system economic. It would also be difficult to achieve an acceptable degree of safety for the operating personnel or the environment, given that the vessel would combine storage of a flammable product with a chemical conversion plant and accommodation for personnel. Further, the usual processes for converting methane to methanol are gravity-dependent and their functioning is severely affected by changes in inclination, to an extent that it is believed that
these processes could not be made to work on a vessel undergoing pitch or roll.

According to the present invention, a system for the production of methanol from an offshore natural gas field comprises a floating production unit in the form of a floating platform carrying a methane-to-methanol production plant, a floating storage unit spaced apart from the floating production unit, and pipeline means interconnecting the production and storage units.

Preferably the floating platform is semisubmersible and may be moored to the seabed.

Preferably the floating storage unit is a tanker vessel which may be secured to a single point mooring.

Preferably personnel accommodation and plant control are located on the floating storage unit.

The plant control suitably comprises a master control unit on the floating storage unit, a slave control unit on the floating production unit, and double or triple telecommunications links between the storage and production units. The telecommunications links are suitably microwave, radio or troposcatter.

The floating platform is preferably moored at each corner to a seabed anchor. Preferably each anchor is drilled and permanently set in place; suitably each anchor is formed by drill collar and a rock bit, most preferably also with an under reamer, to form an annulus which is cemented.

Preferably also, each anchor includes a pulley fairlead
set at seabed level, a mooring line being looped around
the fairlead and led to a pair of deck winches.

The floating production unit preferably includes a vent
boom mounted on the floating platform. Typically, the
vent boom is mounted at a corner of the floating
platform and is preferably rotatable through ninety
degrees. Preferably, a vent boom control arrangement is
provided which acts to position the boom rotationally
in accordance with the prevailing wind.

An embodiment of the present invention will now be
described, by way of example only, with reference to
the drawings, in which:-

Fig. 1 is a schematic perspective view of an
offshore installation embodying the invention;
Fig. 2 is a block diagram illustrating the control
system of the installation of Fig. 1;
Fig. 3a is a schematic side view of part of a
mooring system used in the installation;
Fig. 3b is a cross-section of a mooring anchor
used in the mooring system, as installed;
Fig. 3c is a side view of a tool used in the
mooring anchor;
Fig. 4 is a plan view of the production platform
in the system of Fig. 1, illustrating the mounting
and use of a vent boom;
Fig. 5 is a control schematic of the drive and
control arrangement for the vent boom; and
Fig. 6 is a process flow schematic for the
floating storage unit in the system of Fig. 1.

Referring to Fig. 1, the system of the present
invention includes a floating production unit 10 and a
floating storage unit 12.
The floating production unit 10 is in the form of a conventional semisubmersible platform vessel 10, having a deck 14 mounted on six columns 16 which are in turn carried on two submersible hulls 58 (see Fig. 3A). A suitable form of vessel 10 is a modified "Sedco 600" semisubmersible.

The vessel 10 is positioned geographically above or adjacent to a gas field and is connected to receive gas from the field. Preferably, a number of wells are connected to a christmas tree assembly located on the seabed under the vessel 10, which is connected thereto by a flexible riser. These arrangements are well known and do not in themselves form part of the present invention, and are therefore not shown or described in detail.

The floating production unit 10 includes a methanol conversion plant generally indicated at 18 carried on the deck 14, and a vent boom 20 which will be described in detail below.

The methanol conversion plant 18 may be any suitable known system. Preferably, the plant 18 uses the "Katalco" methanol synthesis system by Imperial Chemical Industries in conjunction with partial oxygenation (gasifier) equipment by Texaco.

The floating storage unit 12 is in the form of a converted tanker 22 pivotally secured at the stern to a single point mooring 24 of known type. Methanol is transferred from the floating production unit 10 to the floating storage unit 12 by a pipeline 26. The two units are preferably spaced apart by about 1.5km for safety reasons.
Methanol is pumped to the storage unit 12 as it is produced and is stored there as will be described in more detail below. It is then exported in conventional product or parcel tankers periodically, transhipment being accomplished with the tanker moored bow-to-bow with the storage unit 12.

A typical system would suitably produce 2,500-3,000 tonnes of methanol per day, with the floating storage unit being of approximately 110,000 tonnes useful deadweight. Export would typically require two shuttle tankers of 35,000 deadweight tonnes each.

The control arrangements are shown in Fig. 2. These are based on the use of a main control centre 30 on the floating storage unit 12, connected to a slave or backup control centre 32 on the floating production unit 10. These may be interconnected as shown via duplicated or triplicated microwave, radio or troposcatter data links 34, or in any other suitable manner such as cable or fibre optic links on the seabed.

This arrangement allows all control functions normally to be carried out from the main control centre located on the floating storage unit 12, thus allowing only a minimum number of personnel to be required aboard the floating production unit 10 at any time.

The integrity of the data links is constantly monitored by heartbeat. In the event of failure, both the main and slave control centres act to safely shut down the process plant and utilities.

The fabrication of the main and slave control centres
can be carried out on land, thus allowing the system
pre-commissioning to be carried out and the data links
proved prior to fitting out on the marine facilities.

The preferred mooring arrangement is illustrated in
Fig. 3. The vessel 10 is moored by a four point
permanent mooring system, each corner column being
connected to a permanently set anchor arrangement.

Each anchor arrangement is drilled with a drill string
consisting of a 12-1/4" rock bit 40, a 12-1/4" x 17-
1/2" under reamer 42, a 20’ x 7-3/4" spiral ground
drill collar 44, a 6’6" x 12-1/4" stabiliser 46, and a
30’ x 7-3/4" spiral ground drill collar 48. This string
is run to give a 12-1/4" hole with an enlarged 17-1/2"
intermediate section created by operating the under
reamer 42, the entire annulus then being filled with
oil well cement 50.

A pad eye 51 is welded to the top of the collar 48, to
which a pulley fairlead 52 is connected. A mooring line
54 is looped around the fairlead 52 and is connected to
double deck winches (not shown) via a double fairlead
56 secured to the hull 58 and a double fairlead (not
shown) at deck level.

The catenary of the four mooring lines is adjusted by
their respective winches in accordance with weather-
induced heave of the vessel 10 to achieve optimum
motion characteristics. The use of mooring lines looped
around fairleads at anchor level reduces mooring line
tension to approximately half of that in conventional
single line systems.

Referring to Figs. 4 and 5, the vent boom system is
directed to ensuring that carbon emissions can be
vented away from the vessel 10 without coming into
contact with the oxygen plant, and this can be achieved
for any wind direction without repositioning the vessel
10.

As shown in Fig. 4, the vent boom 20 is mounted on a
gimbal mechanism with drive ring, generally indicated
at 60, which incorporates a slipring seal through which
waste gases can be passed while allowing the boom to be
rotated through 90 degrees. The main drive is by an
electric motor 62, with backup drive by a hydraulic
motor 64 (or a hydraulic ram) actuated by solenoid
operated valves 66, 68 (see Fig. 5).

The control system, Fig. 5, is fully duplicated with
wind direction inputs from a main position transducer
70 driven by a weathervane 72 on the vessel aerial
mast, and a standby position transducer 70a driven by a
weathervane 72a at an alternative elevated position.
Integrity of the system is monitored by a comparator 74
which compares weathervane position with boom position.
When out of limits, the comparator 74 disables the main
system and enables the backup system. The backup system
remains enabled until the comparator 74 is reset via
reset input 76; the comparator reset will latch only if
the main system is functioning normally. Once reset has
been achieved, the main system will be enabled and the
secondary system disabled.

An important aspect of the overall system is the
downloading of product from the floating production
unit 10 to the floating storage unit 12, since this
allows the loads acting on the vessel 10 to be
controlled within suitable parameters. As seen in
Fig. 6, product arriving on the floating storage unit 12 is metered by a flow meter 80 and passed to one of two day tanks 82a, 82b which suitably are sized to accept the entire methanol production from one 12 hour shift period, that is 1,250-1,500 tonnes. The product is held in the day tank until it has undergone laboratory analysis before being downloaded into the main cargo tanks 84. Any product found to be out of specification is pumped to a holding tank 86. As seen in Fig. 1, the tanks 82, 86 may suitably be deck mounted. A fourth deck mounted tank may be provided to allow for redundancy.

Product is offloaded to the shuttle tankers by the floating storage unit's normal cargo handling pumps 88 and cargo shipping pumps 90 via a fiscal metering system 92 of known type.

Out of specification product is returned periodically from the holding tank 86 to the floating production unit 10 by a transfer pump 94 via a flow meter 96, for re-processing or for use as fuel. The data generated from the various metering stations can be used to monitor the integrity of the pipeline.

It will thus be seen that the present invention provides a system which enables relatively small and remote offshore gas fields to be exploited in an efficient and safe manner. The separation of storage from the high temperature production process provides safety, and allows weight control at the production unit such that a semisubmersible may be used, which in turn provides a stable platform for the production process.
As an alternative or addition to shipping methanol, the whole or part of the methanol synthesis gas could be used as a feedstock for the production of high grade diesel fuel. There are well known methods of converting synthesis gas to hydrocarbons, such as the Fischer-Tropsch process and more recent processes using cobalt or precious metal catalysts.

In one modification, a proportion of the methanol syngas is mixed with nitrogen before being passed through a cooled slurry reactor. The product, a mixture of light material, diesel and wax, needs to be hydrocracked slightly and isomerised to produce more diesel; this would be performed ashore. The end product is free of aromatics and sulphur and can therefore be sold at a premium. The additional plant required is the slurry-type reactor and a nitrogen/CO₂ circulator and cooler. The light ends column of the methanol plant is used to stabilise the hydrocarbon product prior to transfer to the floating storage unit and shipping to the onshore facility.

Alternatively, the system could be dedicated to diesel production, and in this case the hydrocracker could be accommodated on the floating production unit, with diesel product being loaded for export directly from the floating storage unit.

Other modifications may be made within the scope of the invention.
CLAIMS

1. A system for the production of methanol from an offshore natural gas field comprises a floating production unit in the form of a floating platform carrying a methane-to-methanol production plant, a floating storage unit spaced apart from the floating production unit, and pipeline means interconnecting the production and storage units.

2. A system according to claim 1, wherein personnel accommodation is located on the floating storage unit.

3. A system according to claim 1 or claim 2, wherein plant control for the methane-to-methanol production plant is located on the floating storage unit.

4. A system according to claim 3, wherein the plant control comprises a master control unit on the floating storage unit, a slave control unit on the floating production unit and a communications link between the master and slave control units.

5. A system according to claim 4, wherein the communications link is a double or a triple communications link.

6. A system according to any of the preceding claims, the system further comprising anchoring means to moor the platform to the seabed.

7. A system according to claim 6, wherein the anchoring system comprises an anchor which is drilled into the seabed.
8. A system according to claim 7, wherein the anchor is cemented to the seabed after being drilled into the seabed.

9. A system according to any of claims 6 to 8, wherein the anchoring system comprises a fairlead which co-operates with a mooring line to moor the platform to the seabed.

10. A system according to claim 9 when dependent on claim 7 or claim 8, wherein a fairlead is mounted on the anchor and another fairlead is mounted on the floating platform.

11. A system according to any of claims 6 to 10, wherein a number of anchors are provided to moor the floating platform to the seabed.
Four point permanent mooring system.  Drilled in 3 permanently cemented bottom hole assembly. 40 off. Mooring line catenary adjusted with tension winches in accordance with weather induced heave of semi-submersible. Mooring line tensions approx. 40% that of conventional single line anchor system.
### INTERNATIONAL SEARCH REPORT

#### A. CLASSIFICATION OF SUBJECT MATTER

| IPC 5  | B63B35/44 |

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

#### B. FIELDS SEARCHED

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

Electronic data have been consulted during the international search (name of database and, where practical, search terms used).

#### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>Y 9TH ANNUAL OFFSHORE TECHNOLOGY CONFERENCE, vol.4, 2 May 1977, HOUSTON, TEXAS, USA pages 255 - 264 R.S. HOLLEY ET AL. 'Offshore chemical processing of associated natural gas: a case study of methanol production at the offshore well' see page 255 ***</td>
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<td>Y 4TH INT. SYMPOSIUM ON ALCOHOL FUELS TECHNOLOGY, vol.2, 5 October 1980, GUARUJA, SP, BRASIL pages 855 - 859 S.HIRAKAWA ET AL. 'Utilisation of methanol from natural gas as a fuel' see page 858, fig. 2 *** /&gt;</td>
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Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

**Special categories of cited documents:**

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- "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

8 August 1994

Date of mailing of the international search report

16. Oct. 94

Name and mailing address of the ISA
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HU Rijswijk
Tel. (+31-70) 430-2300, TeX 31651 epo nl,
FAX (+31-70) 434-3016

Authorized officer
Rampelmann, K
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<td>H.BACKHAUS 'Flüssiggas, Methanol, Ammoniak und elektrischer Strom aus marginalen</td>
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<td>Erdgasfeldern im Meer' see page 102, paragraph 3</td>
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<td>SCHIFF &amp; HAFEN / KOMMANDOBRÜCKE, vol.29, no.8, August 1977, HAMBURG pages 710 - 714</td>
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<td>E.BERGER 'Erdgasverflüssigungsanlagen auf schwimmenden Plattformen' see page 711, right column and page 712, fig.3</td>
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<td>H.GOLDBACH ET AL. 'Barge-mounted methanol production plant developed by Blohm + Voss and LURGI' see the whole document</td>
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<td>OFFSHORE, vol.32, no.10, September 1972, HOUSTON page 39 'Mitsui develops new anchor piling system for offshore' see the whole document</td>
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<td>GB,A,1 495 174 (INTERCONTINENTAL MARINE DEVELOPMENT LTD.) 14 December 1977 see page 2, line 54 - line 58; figure 1</td>
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<td>FR,A,2 408 511 (R.DZIEWOLSKI) 8 June 1979 see page 2, line 5 - line 9 see page 2, line 20 - line 25; figures 1,2</td>
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Form PCT/ISA 218 (patent family annex) (July 1992)