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Description

[0001] This invention relates to a method for generating a time-dependent profile of a parameter, the parameter being associated with the operation of a device at an underwater well facility, a method of determining the health of a device at an underwater well facility and an underwater well facility comprising means for generating a time-dependent profile of a parameter.

Background

[0002] Underwater hydrocarbon extraction facilities, for example subsea well facilities, make use of subsea well "trees" (also known as "Xmas trees") located on the seabed. Such trees are highly complex constructions, which incorporate many different components and systems. Typically, different components and systems will deteriorate or fail at different rates, i.e. they have differing operational lifespans. Once such subsea well trees are deployed, there is currently no information available as to how devices or components in systems, such as those operating in a subsea control module (SCM) of the tree for example, change their characteristics over time and under different operational conditions. Thus it is not possible to predict the operational lifespan of the devices and in particular when a device is likely to fail.

[0003] An example of a conventional subsea well system is shown in Fig. 1. The well is controlled from a surface mounted master control station (MCS) 1, which may be located on a vessel, platform or at the surface. This feeds, via an umbilical cable 2, hydraulic power (i.e. hydraulic fluid) via a hydraulic line 3, electric power via current carrying line 4, and communications via a data carrying line 5, such as an optical fibre for example, to a subsea control module 6 which is mounted on a Xmas tree 7 located above a well head. The hydraulic line 3 feeds a manifold 9 at the SCM 6. Because the umbilical cable 2 can be several kilometres long, a hydraulic accumulator 8 is also provided at the SCM 6, proximate the termination of hydraulic line 3, to enable supply of hydraulic fluid at peak demands to the manifold 9. The manifold 9 provides a mechanical mounting for, and feeds hydraulic fluid to, the many DCVs required for operation of the well control system. For clarity, only one such DCV 10 is shown, though it should be noted that a typical well has a substantial number of DCVs controlling devices. Each DCV 10, when electrically energised, operates a subsea hydraulic device, here a hydraulic valve 11 for shutting off the production fluid flow through a production pipeline 12. Electric power via line 4 is fed to a subsea electronics module (SEM) 13, housed in the SCM 6. SEM 13 performs electronic control functions for the tree within its internal electronic processing 14, and bi-directionally communicates with the MCS 1, via a communications system 15 linked to line 5. In this way, operating commands from a well operator at the MCS 1 may be actioned by the SEM processing 14. The processing 14 is operable to output electric power via line 16, to the DCV 10, and thus to operate the valve 11.

[0004] Typically, electrical and hydraulic functions are monitored by sensors which conventionally connect to the SEM 13, and the parameter data is transmitted via the communication system 15, and the line 5 of umbilical cable 2 to the MCS 1. Typical functions monitored may include: input hydraulic pressure via sensor 17, DCV input hydraulic pressure via sensor 18, DCV solenoid current via sensor 19 and DCV solenoid voltage via sensor 20. Other or additional sensors may also be employed. All of these sensors 17-20 are within the SCM 6, and each of the sensor outputs is connected to the SEM processing 14. Further sensors for measuring well operation parameters are also installed outside of the SCM 6, such as sensor 21 for monitoring the production fluid pressure and sensor 22 for monitoring the production fluid flow rate. The outputs from such sensors are also connected to the SEM processing 14. Note that for clarity none of the connections from the various sensors to the SEM processing 14 are shown on Fig. 1, but simply indicated by the input arrow 23.

[0005] As in the example described above, operating parameters are typically monitored with appropriate sensors or circuitry within a subsea well system mainly within the SCM, since this is the hub that houses most of the well operating devices such as directional control valves (DCVs), which control the majority of the well production flow control valves and chokes used by the facility. The operating parameters that are monitored in existing well systems typically include voltages, currents and hydraulic pressures. The method of monitoring employed normally provides for monitoring of the profile, with time, of these parameters. Thus, for example, the current and voltage profiles of the electrical supply applied to the coil of a DCV can often be monitored simultaneously. Such data are typically transmitted to the well surface platform via a well communication system, and there selected and viewed by a well operator. The operator can therefore observe "live" parameters. In addition, the operator could try to establish trends by looking back through previously observed or recorded parameters. In practice this is difficult and is not implemented.

[0006] A condition monitoring system has been proposed in GB 0916421.1 which assesses the data received from the wellhead and their variation over time, by comparison with a model of their expected behaviour. However, a weakness of this system is that it is only as good as the model used. If the models are based on laboratory measurements of operational parameters for a device, there is scope for errors to emerge when used in respect of the device when deployed. Furthermore, an initial model used is static, and may not adequately model operation of the device over time.

[0007] It is an aim of the present invention to overcome this problem. This aim is achieved by directly acquiring diagnostic information of a selected set of parameters that can be used to capture how the characteristics / parameters of devices change with respect to time. This data is then used to identify patterns and failure models thus permitting prediction of failures and calculation of the useful life of devices. More particularly, the profiles generated in accordance with the present invention may be used to dynamically update the models used in a condition monitoring system.

[0008] In accordance with a first aspect of the present invention there is provided a method of determining the health of a device at an underwater well facility, comprising the steps of:

a) generating a time-dependent profile of a parameter, the parameter being associated with the operation of a device at an underwater well facility, by

i) obtaining data relating to measured values of said parameter,
ii) passing said data to a storage means,
iii) storing said data to produce a set of data related to the parameter at a plurality of times, and
iv) generating a profile of the parameter from the data set, characterised in that the method further comprises the step of

b) comparing the profile with parameter data obtained at a different period of time during operation of the device at the underwater well facility,

wherein steps a) and b) are carried out within a subsea electronics module.

[0009] In accordance with a second aspect of the present invention there is provided an underwater well facility comprising means for generating a time-dependent profile of a parameter, the parameter being associated with the operation of a device at the facility, the generating means comprising:

means for obtaining data relating to measured values of said parameter;
a data storage means;
means for producing a set of data related to the parameter at a plurality of times; and means for generating a profile of the parameter from the data set;
characterised in that the generating means further comprises
means for comparing the profile with parameter data obtained at a different period of time during operation of the device at the underwater well facility, wherein the data storage means and data set producing means are located within a subsea electronics module, and
the profile generating means and the means for comparing the profile with parameter data obtained at a different period of time during operation of the device at the underwater well facility is located within a subsea electronics module.

[0010] With the present invention, data may be stored over time so as to build up a library of operating parameters, thus permitting any change over time to be observed. When such parameters are related to the eventual failure of a device it is possible to model the failure mode such that the potential for failure can be forecast, thus enabling preventive maintenance to be implemented.

[0011] In the case of AC power supplies, parameters monitored may include the power factor and load voltages and currents in conjunction with the operation of DCVs over time, to identify potential power supply failure. Monitoring of hydraulic pressure profiles around DCVs in conjunction with the electrical voltage and current profiles of DCV coil supplies can also reveal, from previously recorded data of a failure mode, the likelihood of a DCV failure.

[0012] The data recorded over time may also provide valuable information to designers to optimise designs for longer equipment life.

[0013] It can therefore be seen that the present invention provides various advantages over existing systems, including primarily that the well operator may be provided with information regarding the life of the well operating devices and the potential to predict failure.

[0014] The invention will now be described with reference to the accompanying figures, in which:

Fig. 1 schematically shows a known well system; and
Fig. 2 schematically shows an embodiment of a well system incorporating the present invention.

[0015] Fig. 2 shows a similar well system to Fig. 1, and wherever possible like reference numerals have been retained. Here, in accordance with the present invention, the data output by the sensors received by the SEM processing 14, are also passed on to a storage / processing module 24, a new module not present in conventional systems such as that shown in Fig. 1. High speed sampling of the data is used, such the data is passed to module 24 virtually continuously and there associated with a time component. The required sampling rate must be fast enough to detect a trend so that possible failure might be detected to give useful warning of a problem. Taking the failure of the SEM power supply for example, failure may take around a second, so to detect the trend it would be necessary to check about every one tenth of a second - thus a sample rate of 10Hz. In other words, the module 24 produces time-dependent parameter data, i.e. a profile of the parameter data. Processing module 24 stores these data profiles and compares them with previously-recorded, i.e. already stored, data to reveal operating changes and trends. If a previously recorded data profile is indicative of a correctly operating device, then a trend away from that profile may indicate faults or failures of the device. In this way, the module 24 is able to provide "failure forecasting" for devices. The storage / processing module 24 communicates with the MCS 1, and thus the well operator, via communication system 15 and line 5 of umbilical cable 2. The time dependent data output by module 24 can then be used to construct reference parameters or models for use in a condition monitoring system such as described in GB0916421.1.

[0016] Initial operating parameters for devices, for example a DCV, can be obtained from initial measurements made in manufacture at production testing, with failure parameters obtained from original measurements made in the laboratory at the design stage. This initial information may be used to initialise the models used in a condition monitoring system, and which would then be updated or replaced by the profiles generated in accordance with the present invention.

[0017] In an alternative embodiment, failure forecasting is programmed into the storage / processing module 24, operable to output an alarm to the operator if required, i.e. if a failure or imminent failure is detected. In this embodiment, the module 24 is operable to compare a recently generated profile against a historically obtained profile stored within module 24.

[0018] Preferably, the data received by module 24 is measured against the temperature at the device location, i.e. it is time-correlated with the output from a temperature sensor (not shown) proximate the device. In this way, the operational parameters sent to MCS 1 can be adjusted to allow for the different operating conditions subsea to that of the laboratory, e.g. a low operating environmental temperature, or obtained in the laboratory in an environmental chamber set to the subsea conditions.

[0019] The above-described embodiments are exemplary only, and other possibilities and alternatives within the scope of the invention will be apparent to those skilled in the art.

[0020] A modification of the above-described methodology would combine a plurality of parameters associated with a particular device, such that a composite profile may be produced. For example, the output from sensors 21 and 22, i.e. which measure the pressure and flow of production fluid, may be combined, with time information, to produce a composite profile of these production fluid parameters.

Claims

1. A method of determining the health of a device at an underwater well facility, comprising the steps of:

a) generating a time-dependent profile of a parameter, the parameter being associated with the operation of a device at an underwater well facility, by

i) obtaining data relating to measured values of said parameter,
ii) passing said data to a storage means,
iii) storing said data to produce a set of data related to the parameter at a plurality of times, and
iv) generating a profile of the parameter from the data set,

characterised in that the method further comprises the step of
b) comparing the profile with parameter data obtained at a different period of time during operation of the device at the underwater well facility,

wherein steps a) and b) are carried out within a subsea electronics module (13).

2. A method according to claim 1, wherein step ii) includes sampling said data at a required rate.

3. A method according to either of claims 1 and 2, comprising the step of time-correlating the obtained data to temperature measurements taken in respect of the device.

4. A method according to any preceding claim, comprising the initial step of measuring the parameter values.

5. A method according to any preceding claim, wherein the profile is used to construct a model of parameter behaviour, and the model is compared to currently generated parameter data.

6. A method according to claim 5, wherein the profile is used to dynamically update the model.

7. A method according to any of claims 1 to 4, wherein the profile is compared to a previously obtained parameter profile.

8. A method according to any preceding claim, comprising the steps of:

obtaining second data relating to measured values of a second parameter associated with the operation of the device,
passing said second data to the storage means,
storing said second data to produce a second data set, and
generating a composite time-dependent profile of the first and second parameters from the first and second data sets.

9. An underwater well facility comprising means for generating a time-dependent profile of a parameter, the parameter being associated with the operation of a device at the facility, the generating means comprising:

means for obtaining data relating to measured

values of said parameter;
a data storage means (24);
means (24) for producing a set of data related to the parameter at a plurality of times; and
means (24) for generating a profile of the parameter from the data set;
characterised in that the generating means further comprises
means for comparing the profile with parameter data obtained at a different period of time during operation of the device at the underwater well facility, wherein
the data storage means (24) and data set producing means (24) are located within a subsea electronics module (13), and
the profile generating means (24) and the means for comparing the profile with parameter data obtained at a different period of time during operation of the device at the underwater well facility is located within a subsea electronics module (13).

Patentansprüche

1. Verfahren zum Bestimmen des Zustands einer Vorrichtung an einer Unterwasserbohrlochanlage, umfassend die Schritte:

   a) Erzeugen eines zeitabhängigen Profils eines Parameters, wobei der Parameter dem Betrieb einer Vorrichtung an der Unterwasserbohrlochanlage zugeordnet ist, durch

   i) Erhalten von Daten im Zusammenhang mit gemessenen Werten des Parameters,
   ii) Übergeben der Daten an eine Speichereinrichtung,
   iii) Speichern der Daten, um einen Datensatz im Zusammenhang mit dem Parameter mehrere Male zu erzeugen, und
   iv) Erzeugen eines Profils des Parameters aus dem Datensatz, **dadurch gekennzeichnet, dass** das Verfahren ferner folgende Schritte umfasst

   b) Vergleichen des Profils mit Parameterdaten, die zu verschiedenen Zeiträumen während des Betriebs der Vorrichtung an der Unterwasserbohrlochanlage erhalten werden,

   wobei die Schritte a) und b) im Inneren eines Untersee-Elektronikmoduls (13) durchgeführt werden.

2. Verfahren nach Anspruch 1, wobei der Schritt ii) das Abtasten von Daten mit einer erforderlichen Geschwindigkeit umfasst.

3. Verfahren nach einem der Ansprüche 1 und 2, umfassend den Schritt des Zeitkorrelierens der erhaltenen Daten zu Temperaturmessungen, die in Bezug auf die Vorrichtung vorgenommen werden.

4. Verfahren nach einem der vorhergehenden Ansprüche, umfassend den Anfangsschritt des Messens der Parameterwerte.

5. Verfahren nach einem der vorhergehenden Ansprüche, wobei das Profil verwendet wird, um ein Parameterverhalten-Modell zu erstellen, und wobei das Modell mit aktuell erzeugten Parameterdaten verglichen wird.

6. Verfahren nach Anspruch 5, wobei das Profil verwendet wird, um das Modell dynamisch zu aktualisieren.

7. Verfahren nach einem der Ansprüche 1 bis 4, wobei das Profil mit einem zuvor erhaltenen Parameterprofil verglichen wird.

8. Verfahren nach einem der vorhergehenden Ansprüche, umfassend die Schritte: Erhalten von zweiten Daten im Zusammenhang mit gemessenen Werten eines zweiten Parameters, der dem Betrieb der Vorrichtung zugeordnet ist,
   Übergeben der zweiten Daten an eine Speichereinrichtung,
   Speichern der zweiten Daten, um einen zweiten Datensatz zu erzeugen, und
   Erzeugen eines zusammengesetzten zeitabhängigen Profils des ersten und zweiten Parameters aus dem ersten und zweiten Datensatz.

9. Unterwasserbohrlochanlage umfassend eine Einrichtung zum Erzeugen eines zeitabhängigen Profils eines Parameters, wobei der Parameter dem Betrieb einer Vorrichtung an der Anlage zugeordnet ist, wobei die Erzeugungseinrichtung Folgendes umfasst:

   Einrichtung zum Erhalten von Daten im Zusammenhang mit gemessen Werten des Parameters; eine Datenspeichereinrichtung (24);
   Einrichtung (24) zum mehrmaligen Erzeugen eines Datensatzes im Zusammenhang mit dem Parameter; und
   Einrichtung (24) zum Erzeugen eines Profils des Parameters aus dem Datensatz;
   dadurch gekennzeichnet, dass die Erzeugungseinrichtung ferner eine Einrichtung zum Vergleichen des Profils mit Parameterdaten, die zu verschiedenen Zeiträumen während des Betriebs der Vorrichtung an der Unterwasserbohrlochanlage erhalten werden, wobei die Datenspeichereinrichtung (24) und die Datensatzerzeugungseinrichtung (24) sich im Inneren eines

Untersee-Elektronikmoduls (13) befinden, und die Profilerzeugungseinrichtung (24) und die Einrichtung zum Vergleichen des Profils mit Parameterdaten, die zu verschiedenen Zeiträumen während des Betriebs der Vorrichtung an der Unterwasserbohrlochanlage erhalten werden, sich in Inneren eines Untersee-Elektronikmoduls (13) befinden.

Revendications

1. Procédé de détermination du bon état de fonctionnement d'un dispositif au niveau d'une installation de forage sous-marine, comprenant les étapes de :

a) génération d'un profil dépendant du temps d'un paramètre, le paramètre étant associé au fonctionnement d'un dispositif au niveau d'une installation de forage sous-marine, en

i) obtenant des données relatives aux valeurs mesurées dudit paramètre,
ii) en passant lesdites données à un moyen de mémorisation,
iii) en mémorisant lesdites données pour produire un ensemble de données liés au paramètre à une pluralité de temps, et
iv) en générant un profil du paramètre à partir de l'ensemble de données, **caractérisé en ce que** ledit procédé comprend en outre l'étape de

b) comparaison du profile avec des données de paramètre obtenues à une période de temps différente durant le fonctionnement du dispositif au niveau de l'installation de forage sous-marine,

lesdites étapes a) et b) étant effectuées dans un module électronique sous-marin (13).

2. Procédé selon la revendication 1, ladite étape ii) comprenant l'échantillonnage desdites données à une cadence requise.

3. Procédé selon l'une quelconque des revendications 1 et 2, comprenant l'étape de corrélation dans le temps des données obtenues avec des mesures de températures prises par rapport au dispositif.

4. Procédé selon l'une quelconque des revendications précédentes, comprenant l'étape initiale de mesure des valeurs de paramètre.

5. Procédé selon l'une quelconque des revendications précédentes, ledit profil étant utilisé pour construire un modèle de comportement de paramètre, et ledit modèle étant comparé aux données de paramètre présentement générées.

6. Procédé selon la revendication 5, ledit profil étant utilisé pour mettre à jour dynamiquement le modèle.

7. Procédé selon l'une quelconque des revendications 1 à 4, ledit profil étant comparé à un profil de paramètre obtenu précédemment.

8. Procédé selon l'une quelconque des revendications précédentes, comprenant les étapes de : obtention de secondes données relatives aux valeurs mesurées d'un second paramètre associé au fonctionnement du dispositif,
passage desdites secondes données au moyen de mémorisation, mémorisation desdites secondes données afin de produire un second ensemble de données et génération d'un profil composite dépendant du temps des premier et second paramètres à partir des premier et second ensembles de données.

9. Installation de forage sous-marine comprenant un moyen de génération d'un profil dépendant du temps d'un paramètre, le paramètre étant associé au fonctionnement d'un dispositif au niveau de l'installation, ledit moyen de génération comprenant :

un moyen d'obtention des données relatives aux valeurs mesurées dudit paramètre ; un moyen de mémorisation de données (24) ;
un moyen (24) de production d'un ensemble de données lié au paramètre à une pluralité de temps ; et
un moyen (24) de génération d'un profil du paramètre à partir de l'ensemble de données ;
caractérisé en ce que le moyen de génération comprend en outre un moyen de comparaison du profil avec des données de paramètre obtenues à une période de temps différente durant le fonctionnement du dispositif au niveau de l'installation de forage sous-marine, ledit moyen (24) de mémorisation de données et ledit moyen (24) de production de données étant situés dans un module électronique sous-marin (13), et ledit moyen (24) de génération de profil et ledit moyen de comparaison de profil avec des données de paramètre obtenues à une période de temps différente durant le fonctionnement du dispositif au niveau de l'installation de forage sous-marine étant situés dans un module électronique sous-marin (13).

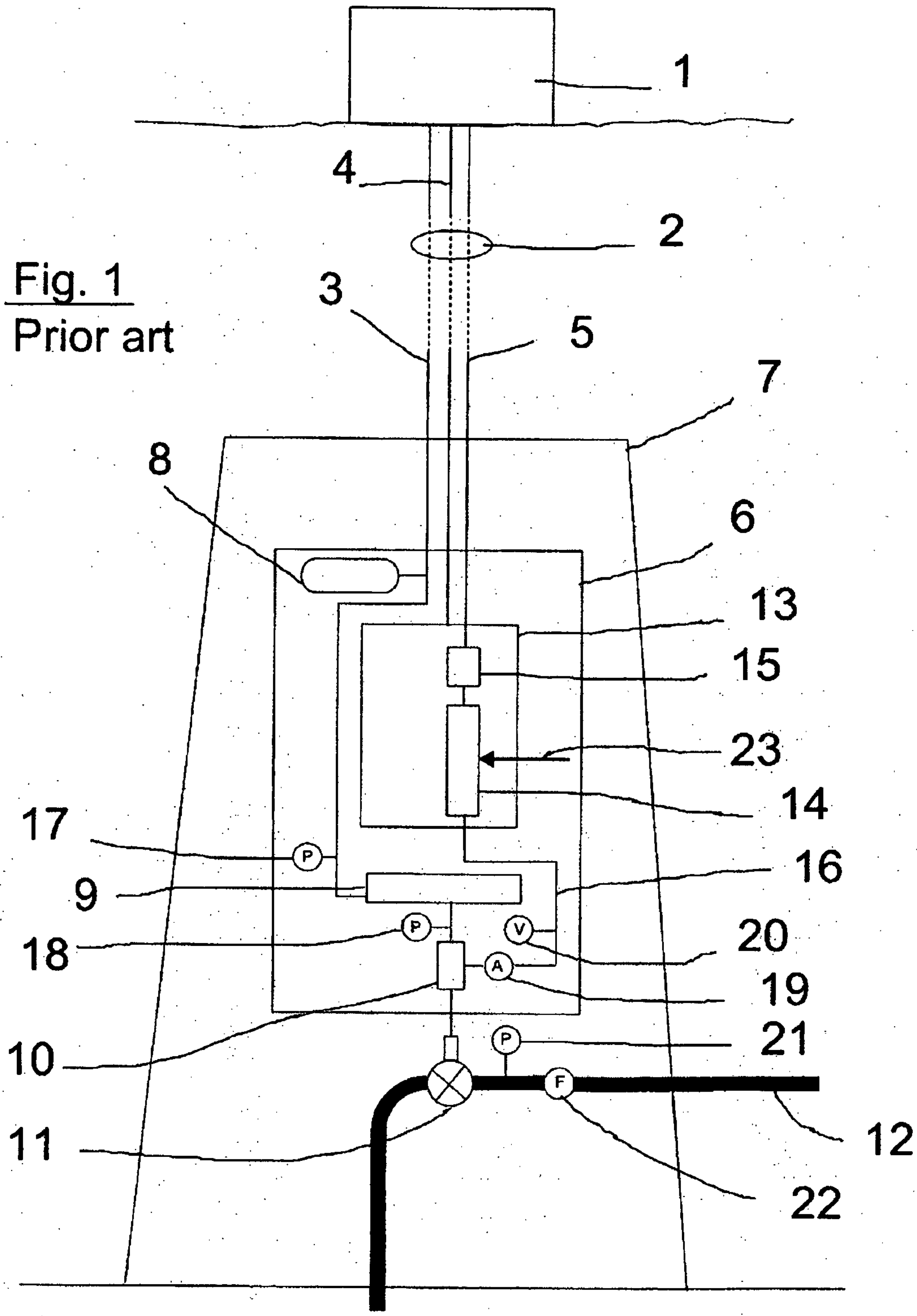
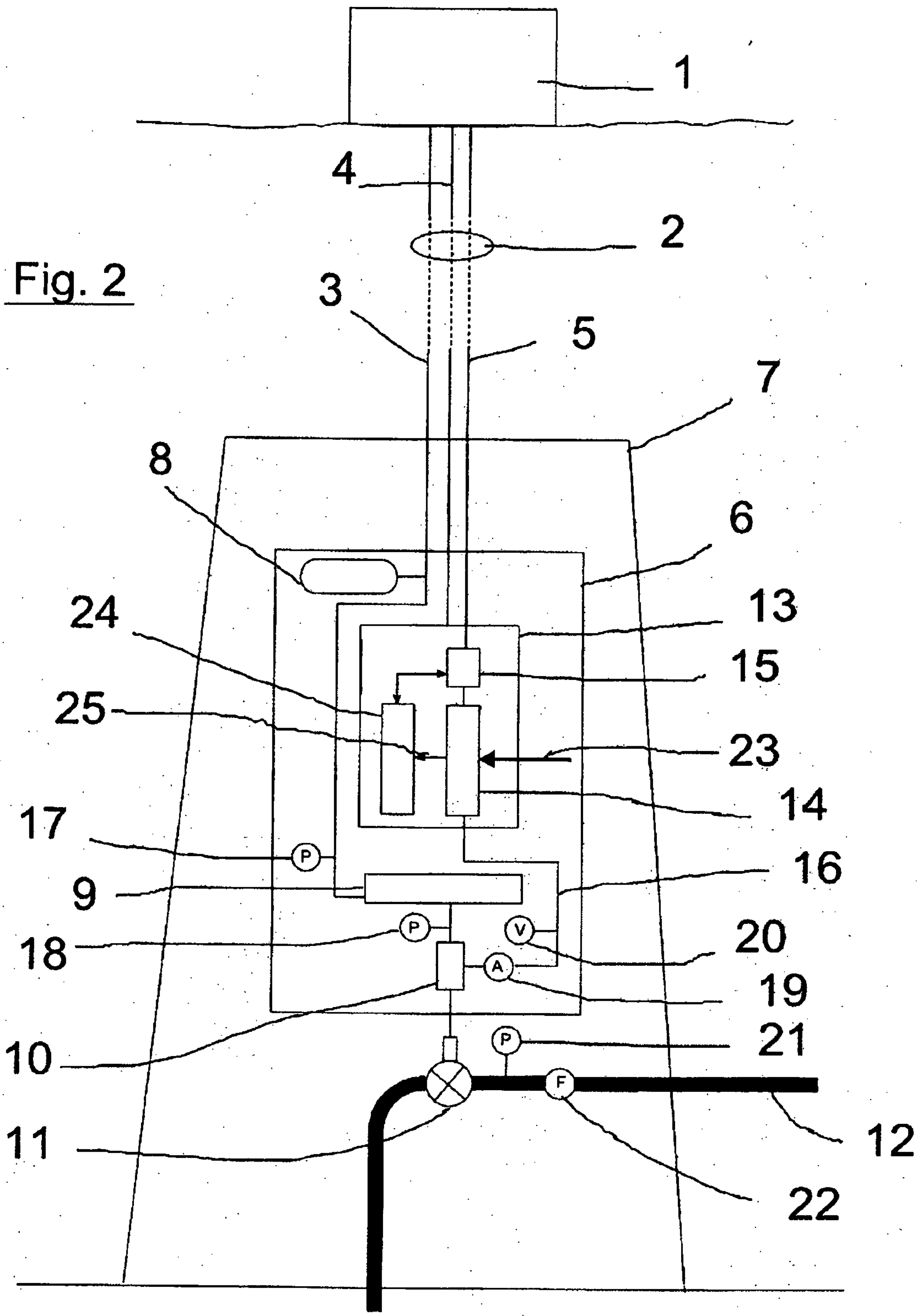


Fig. 1
Prior art

Fig. 2



REFERENCES CITED IN THE DESCRIPTION

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