SHELL ESPAÑA, N.V.

'CASTELLON B-5' OIL PRODUCTION INSTALLATION

LOCATION

In August 1977 SHELL ESPAÑA brought into production well Castellón B-5 off the Spanish Mediterranean coast, about 50 km South of Tarragona and 60 km Northeast of the Amposta Marino field. The well drains a small oil accumulation situated in the Exploitation Concession TARRACO which covers a total area of 20,044 hectares. The interests of the partners are: CAMPSA (Private Company) 25%, SHELL ESPAÑA, N.V. 75% and operatorship.

DRILLING

The first well in the area, drilled by the semisubmersible unit SEDNETH in 1968, was a dry hole.

In 1973, the drilling rig TRANSWORLD-61 found some light oil in well Castellón B-2, with further evidence of the presence of non-commercial gas/condensate in well Castellón B-4, drilled with the unit SEDCO 135-D in 1974.

The presently producing well Castellón B-5 was drilled by STAFLO in 1976. The oil, of approximately 35º API, was encountered at 2,700 meters, though the well was drilled to a total depth of some 3,800 meters in order to verify the true extension of the oil bearing formation.

PRODUCTION

The production system elected for Castellón B-5 is known as SALS (Single Anchor Leg Storage). This is its first installation, though some of its components had already proved their reliability to the oil industry in other parts of the world.

The system has the significant advantage of relative simplicity which considerably reduces installation time; and relatively low capital and operating costs which permit the economic development of offshore fields with small recoverable reserves situated in not too exposed, medium-depth waters. This is the case with the modest Castellón B-5 accumulation in 117 m water depth, the production of which would not have been viable by using a conventional fixed platform installation.

THE SALS SYSTEM

The SALS system is a variation of the single-point mooring concept, hitherto mainly applied in shallower waters for the berthing of loading/discharging crude oil or product tankers off oilfield or refinery terminal installations. It permits the tanker to move around its mooring, always seeking the position of least resistance to wind, waves and currents.

Applied to deeper waters, its engineering adaptation allows a crude oil storage tanker to be permanently moored in an offshore oilfield; and further refined, that same tanker can now also be used for the processing (i.e. oil/gas separation) of the received 'live' crude before it is being stored.

This in combination with the similarly, recently advanced technique of completing production wells at sea bottom, makes it possible - under suitable local conditions - to preclude the installation of a separate wellhead platform and/or fixed or floating production platforms annex to an offshore storage/loading facility as, for instance, are present in the Amposta Marino oil field.

The mooring system consists fundamentally of the following parts:

- above the water, the rigid mooring yoke fixed to the processing/storage tanker;
- in the water, the anchor leg;
- on the seabed, the mooring base.

The mooring base on the seabed is placed at about 150 m from the underwater completed well. It is a steel structure filled with concrete and piled to the ground, designed to resist the lateral and vertical forces the moored tanker may impose through the interconnecting anchor leg, under the most stringent expectation of local weather conditions.

The anchor leg is composed of elongated chain links, forged of solid steel, each seven meters long, articulated and each weighing some three tons. Universal joints at the seabottom base and between the anchor leg and the rigid mooring yoke, permit deflection of the anchor leg in any direction from the vertical.

The rigid mooring yoke consists of a stiff frame, constructed of large diameter tubulars; its general shape is that of an 'A' frame with the apex at the anchor leg. It incorporates a cylindrical buoyancy tank which maintains the anchor leg in tension. This assembly weighs about 600 tons in total.

The yoke is hinged to a 40 ton steel beam which in its turn is welded to a 70 ton box structure attached to the bows of the tanker.

PRODUCTION PROCESS

From the X-mas tree which caps the underwater completed well, the oil is carried through a flexible pipeline (Coflexip) laid on the seabed via a jumper hose and manifolding configuration at the SALS base, to a vertical Coflexip line clamped to the anchor leg; through a high pressure fluid swivel suspended from the rigid mooring yoke and a product line to the tanker deck, it flows into gas/oil separator facilities installed on the processing/storage tanker.

Part of the gas is used as fuel in the steamboilers of the tanker which power the ship's ancillaries and some of the special equipment installed for its new function. The gas in excess of this requirement, is burned in specially constructed incinerators installed at the stern of the tanker.

The separated oil and any formation water are flowed into a settling tank, prior to transferring the dry oil into the ship's storage tanks. Formation water will be segregated in separate tanks for later shipment as and when required, to the Amposta Marino oilfield where it can be injected into that field's water disposal system. This will prevent any formation water from reaching the sea.

The Spanish tanker "ALBUERA" (20,000 DWT) leased from CEPSA, lifts the oil periodically for transport to selected Spanish refineries in the same way as it has been done for the last four years in the Amposta Marino oil field. Special line-throwing equipment installed on board of the processing/storage tanker makes the "ALBUERA" self-mooring, precluding the usage of auxiliary berthing craft.

The processing/storage tanker serves as the field's operations centre and provides support for all field activities besides housing the production and maintenance crews.

The operator made a call for bids among shipowners and the Spanish tanker "DELTA" (ex-"ILDEFONSO FIERRO" - 58,000 DWT) was selected as being the most suitable for this function. The necessary modifications were then made to the tanker in the shipyard "Astilleros Españoles, S.A. Factoría de Cádiz" in accordance with Shell International's design specifications which in turn had to satisfy the requirements of Classification Societies (Lloyd's Register and Bureau Veritas).

SAFETY AND ENVIRONMENTAL ASPECTS

Extensive provisions have been made in the production system to ensure safe operating conditions and to protect the environment against pollution.

Apart from the standard wellhead valve system at seabed (X-mas tree), some of the many controls and safety features are the following:

- Hydraulically operated, surface-controlled well safety valve, located some 30 meters below the seabed.

- A control system at the entrance of the gas/oil separator facilities, and a well 'kill' pump aggregate.

- A pilot valve system at the wellhead through which the well will be closed in if there exists a malfunction anywhere in the well flow or oil/gas processing sequence; either automatically or manually by means of push-button stations in several locations on board the processing/storage tanker.

- Hydrocarbon gas detector alarms, monitoring and protecting every function of the gas disposal system.

- Oil-traps to catch any oil spills on the deck of the processing/storage tanker.

- Extended fire-fighting facilities.

- A heliport on the bow of the tanker and a radio-telephone system for direct and rapid communication with the land base at San Carlos de la Rápita.

- Furthermore, the vessel contains a heave-compensated derrick construction from which well survey and well servicing operations can be performed on the production well, as and when required. For this purpose, the vessel is manoeuvred from its free mooring into a temporary, fixed position exactly above the wellhead.

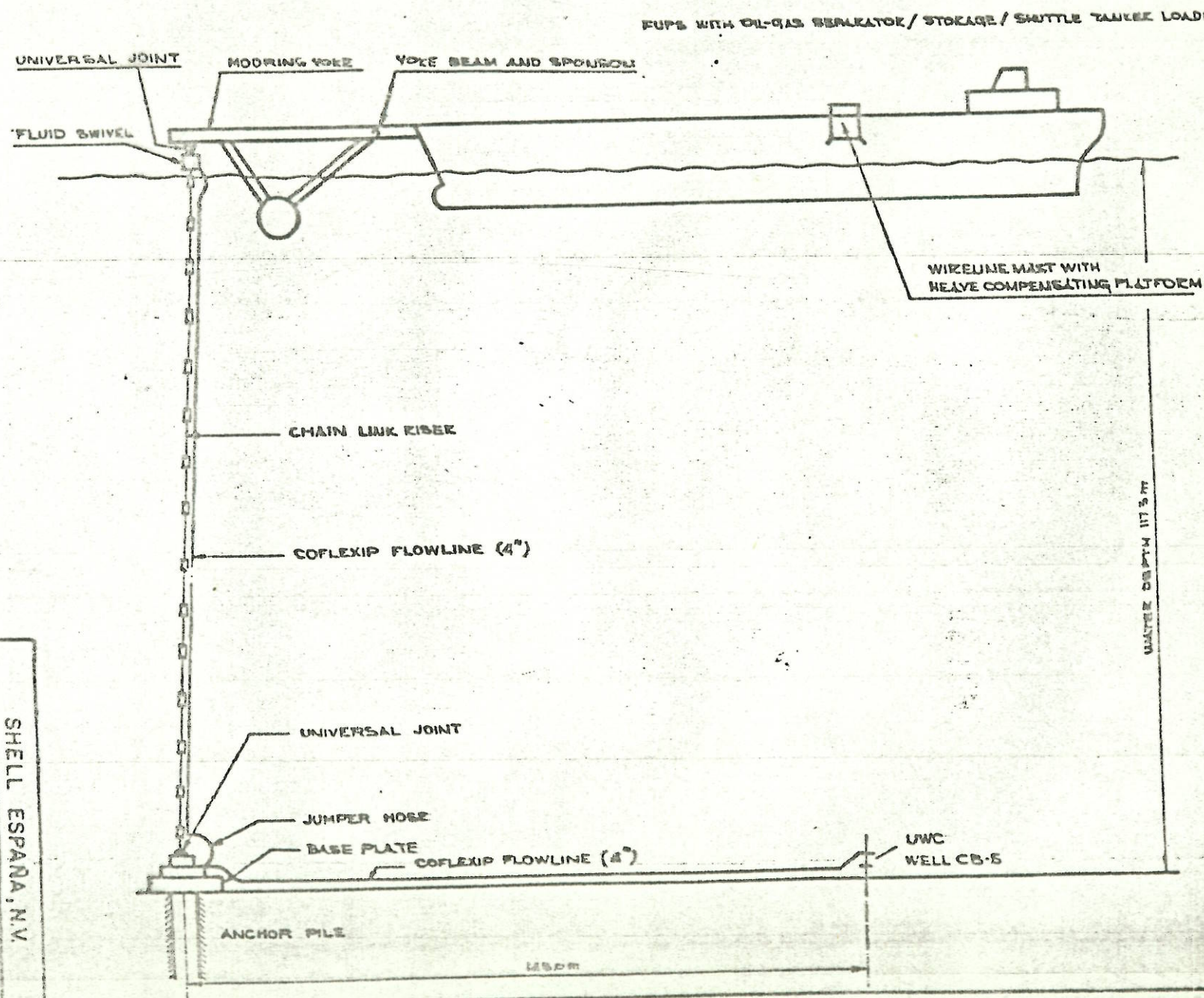
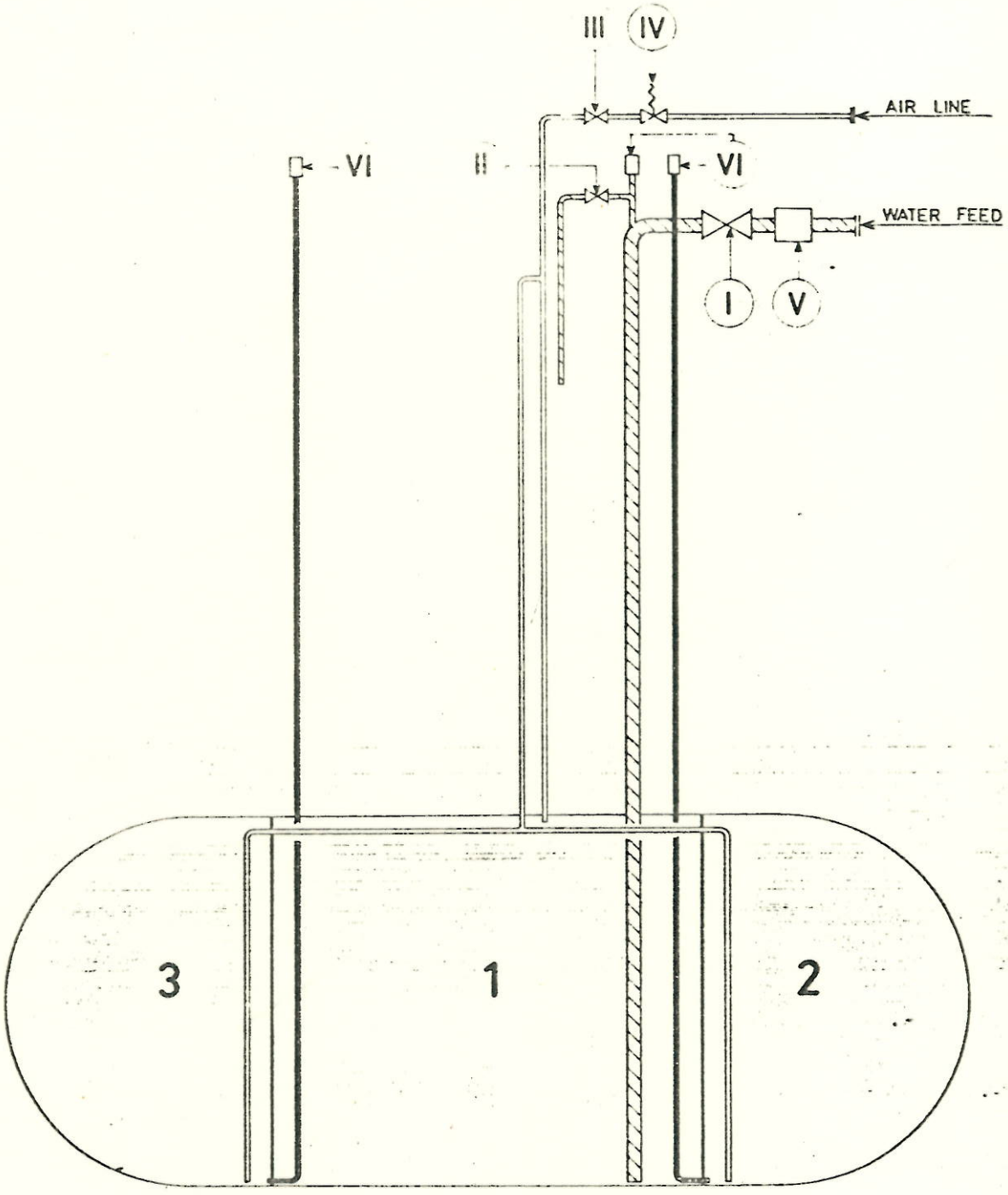

FUPS WITH OIL-GAS SEPARATOR / STORAGE / SHUTTLE TANKER LOADING FAC
UNIVERSAL JOINT
MOORING YOKE
YOKE BEAM AND SPONSON
FLUID SWIVEL
WIRELINE MAST WITH
HEAVE COMPENSATING PLATFORM
CHAIN LINK RISER
COFLEXIP FLOWLINE (4")
UNIVERSAL JOINT
JUMPER HOSE
BASE PLATE
COFLEXIP FLOWLINE (4")
UWC
WELL CB-5
ANCHOR PILE
SHELL ESPAÑA, N.V.
TARRACO (CB-E)
PRODUCTION DEVELOPMENT
CALM SCHEME
(SCHEMATIC LAY-OUT)
AUTHOR - PED
DATE - MARCH 77
PROD DATA BASE
DRAW

Fig. 6



2" SOUNDING PIPE

2" AIR PIPE

2" AIR & WATER PIPE

6" WATER PIPE

I 6" WATER VALVE

II 2" VALVE (AIR & WATER)

III 2" AIR VALVE

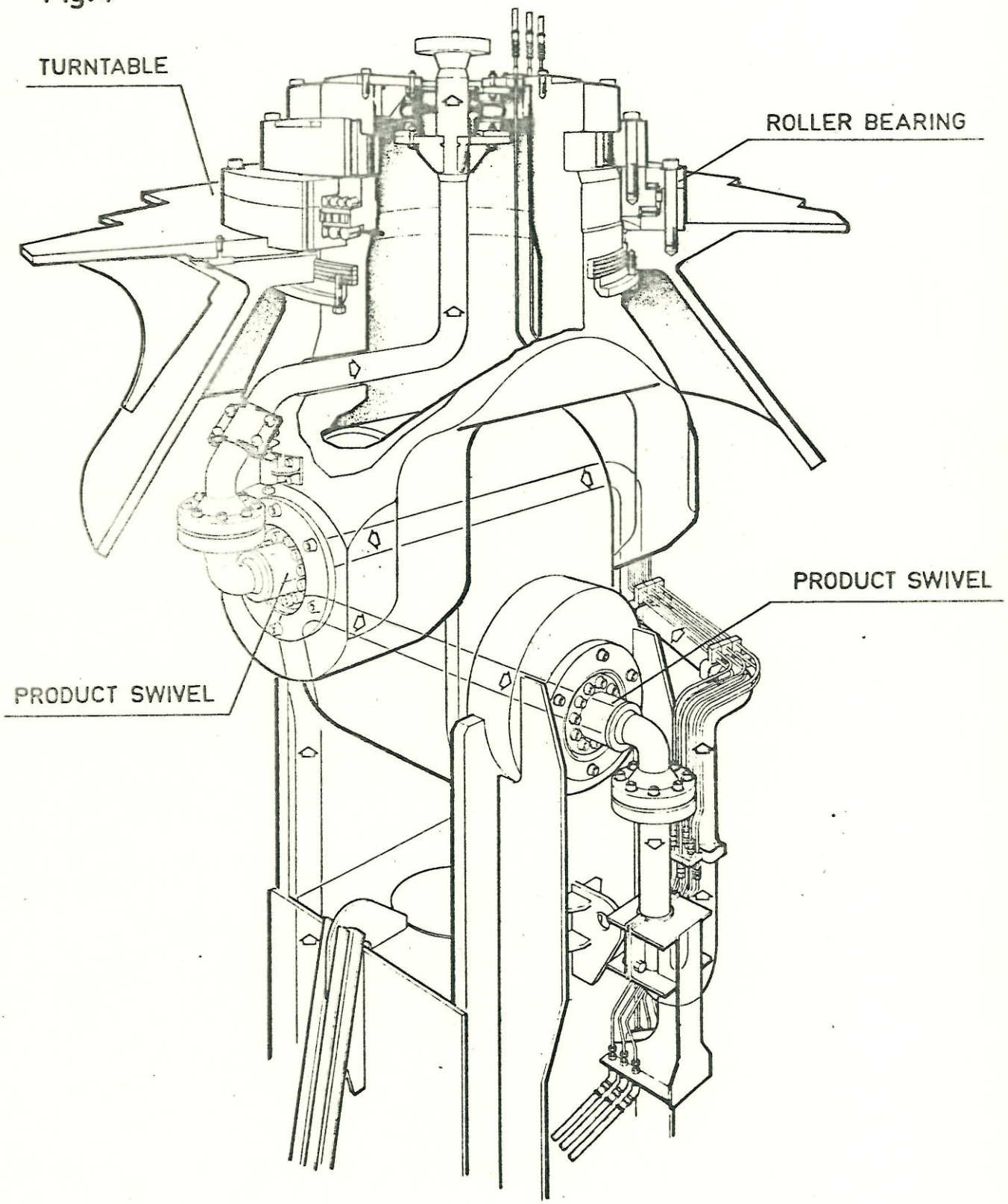
IV 2" RELIEF VALVE

V 6" WATER FLOW METER

VI 2" PLUG

Product Flow Through Top Unijoint & Riser Head Bearing

Fig.4



1.2 GENERAL DESCRIPTION

The Single Anchor Leg Storage system (SALS) is designed, developed and patented by SBM, Inc. The SALS comprises, an anchor point, a riser and a mooring yoke with universal joint interconnections. The mooring yoke is fitted to a permanently moored storage tanker by a hinged connection. A large buoyancy tank, providing the riser tension, is incorporated in the yoke. Weathervaning is made possible by means of a heavy duty roller bearing situated in the riser head.

The storage tanker carries separation equipment for handling the crude oil/gas water mixture which is piped from the subsea oil well to the tanker via the riser and yoke of the SALS.

The crude oil is processed stored and subsequently offloaded into offtaking tankers which will moor alongside the permanently moored storage tanker.

1.2.1 PRINCIPLE

As with all SBM Inc. single point mooring systems, the SALS provides the facility for 360° weather-vaning, that is the yoke together with its permanently attached storage tanker is free to rotate on the vertical axis to take up any position determined by the prevailing wind and sea. In addition the SALS retains the SPM anchor system which provides the restoring force that balances those environmental forces acting upon the moored vessel.

The SALS is provided with a single anchor leg, called a riser. This riser is maintained in a near vertical configuration by the buoyancy force counteracting those external horizontal forces acting upon the moored vessel which tend to deflect riser away from the vertical.

The requisite buoyancy is provided by the buoyancy tank built into the yoke. The riser is slender in design in order to reduce the forces acting upon it during operation.

The total forces in the system are in equilibrium when the tangent of the angle of deviation from the vertical, times the upward buoyancy force, is equal to the horizontal force.

Design studies have shown the installation of a rigid riser in a deep water location to be a complicated and costly operation. In consequence of this SBM Inc. have provided a special riser for the SALS which is flexible for installation purposes but functions as rigid riser in operation when it is held in tension by the buoyancy.

Surge, Sway, Heave, Yaw, Roll and Pitch and the optimum mooring system will permit these motions without setting up resonances in the system.

When a mooring system is provided with more than the requisite articulation necessary to accommodate these six basic motions it is liable to set up motions derived from the system itself. Such system-induced-motions have their own natural frequencies which will interact with some or all of the six motions provided for and set up undesirable resonances within the tanker/mooring system and the component parts of the mooring system. The SALS is constructed to accommodate the six basic motions of the moored vessel without introducing extraneous movements of itself.

The SALS has only one moving component below water. All other articulation points are above water and easily accessible.

The fluid swivel is above water and is not subject to mooring forces. All maintenance including replacement of the swivel can be carried out by the crew working on the platform without disconnecting the mooring system.

1.2.2 TANKER MODIFICATION

The Tanker has a sponson structure built onto the bow by means of a load spreading framework which is specially designed for the tanker which has been used. This structure is attached to the tanker beam which carries the brackets and hinge joints which are connected to the yoke. The tanker is modified internally to compensate for the sponson structure loading.

All designs, fabrication and installation techniques of the structure, the load spreading framework and modification to the tanker have been approved by the relevant classification society.

CASTELLON B-5 PROJECT

OPERATING EXPERIENCE

Par. 1 - Description of Sals System
- a- 'Delta' production unit
- b- Sals yoke
- c- Sals anchor chain and vertical flowline
- d- Sals anchor base and jumper hose
- e- Horizontal Coflexip
- f- Wellhead

Par. 2 - Mooring procedure for well entry

par. 3 - Problems ecountered in the moored position

Par. 4 - Operational experience with yoke and swivel

Par. 5 - Conclusion

Par. 1 - Description of Sals System

The mooring system consists basically of three complementary function, the fixed base at seabed positioned 148 mts. from the underwater completed well, the anchor leg, and the rigid mooring yoke.

a- Delta production unit consists of a 60.000 tons tanker with production, processing units installed on board.

b- Sals Yoke consisting of a steel tubular frame with a cilindrical buoyancy tank (20mts x 8mts) with maintains the anchor leg in tension.

c- Sals anchor chain composed of elongate chain links of solid steel each seven metres long and weighing three tons. Attached by clamps to the chain is the vertical Coflexip flowline and hydraulic control hose bundle.

d- Sals anchor base consists of a steel structure which is fixed to the seabed by piles drilled and filled with concrete and a support frame for the Coflexip jumper hose connecting the vertical and horizontal Coflexip flowlines.

e- The underwater wellhead is connected to the Sals base by a horizontal 4" Coflexip flowline laid on the seabed with a hydraulic control hose for operating the hydraulic master valve and down hole safety valve.

f- The underwater wellhead is a standard Cameron solid block tree with swab valve, manual single wing flowline valve , hydraulic operated master valve and a manual master valve.

Par. 2 - In order to effect a well entry utilizing the motion compensated workover derrick, it is necessary to moor the 'Delta' on the heading of 230º to bring the derrick over the wellhead.

Mooring is executed by connecting port and starboard 63.5 mm Ø stern cables to prelaid anchors by means of connector plates. Tension on stern mooring cables is ajusted by operating two special 100 tons hydraulic operated pulling machines.
Bow mooring utilizes standard ships 82.5 mm anchor chain which are attached to prelaid bow anchors by means of connector plates. This system of mooring allow precise manoeuvring of the vessel to place the workover derrick immediately above wellhead.
To facilitate mooring a supply boat is required for anchor handling and a tug boat to move the 'Delta' onto the correct heading.

Par. 3 - In the moored position two major factors effect the 'Delta'.

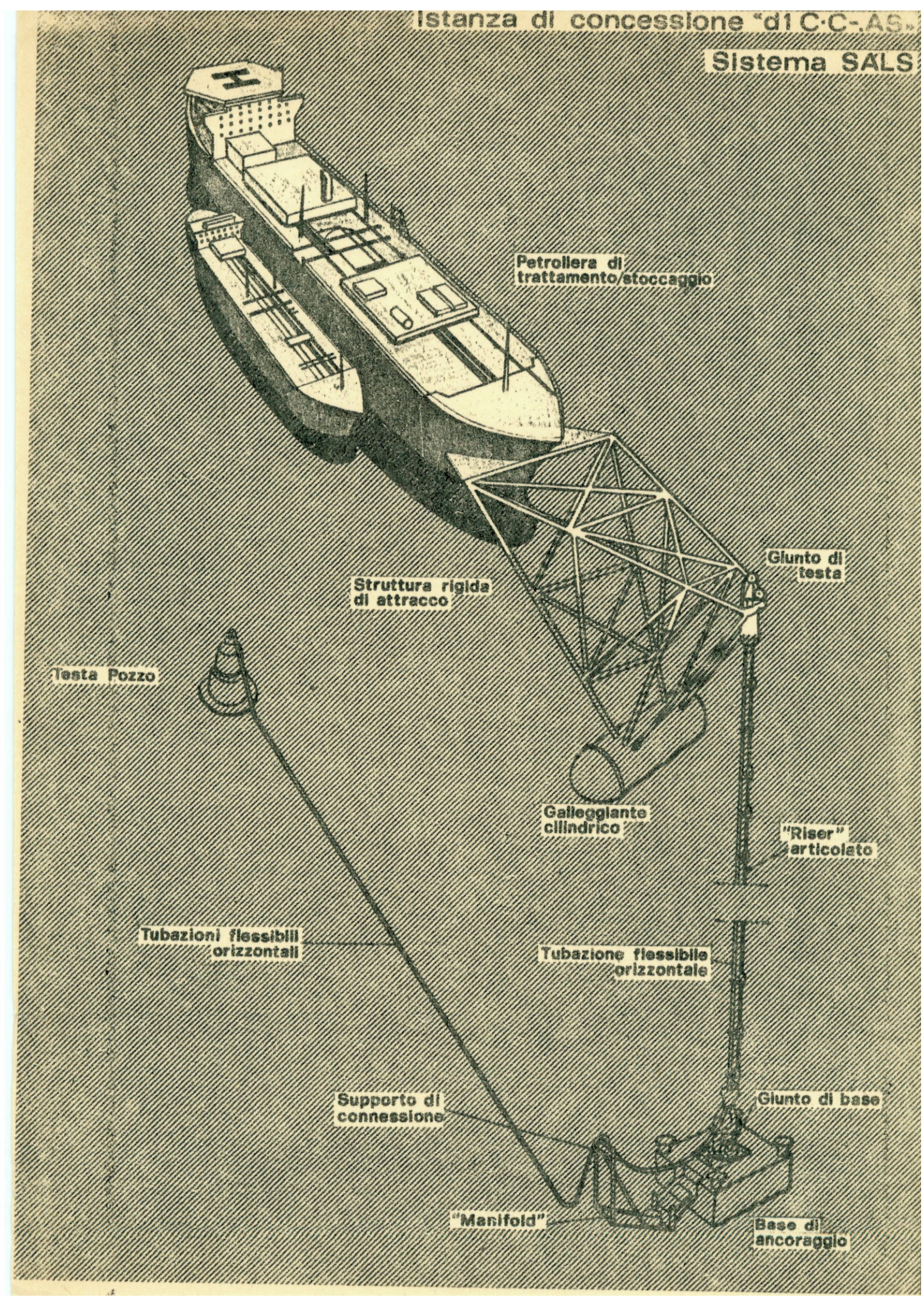
1- The position of the underwater layout with the heading of the Sals base to the wellhead being 230º.
2- Weather conditions in the area of Tarragona where the prevalent winds are coming from the N.W. and build up in strenght to 40-60 knots within 30 minutes. As a consequence of these two factors some difficulty has been experienced in holding the 'Delta' in the moored pattern. It is necessary to maintain a tug boat on stand by whole time , in order to ease the strain on the stern anchor cables should strong winds develop. On January 20 with wind strengtks of 80 knots, two new 10" ropes attached to the 'Delta' broke and within minutes the starboard anchor gragged allowing the vessel to swing from 230º to 303º.

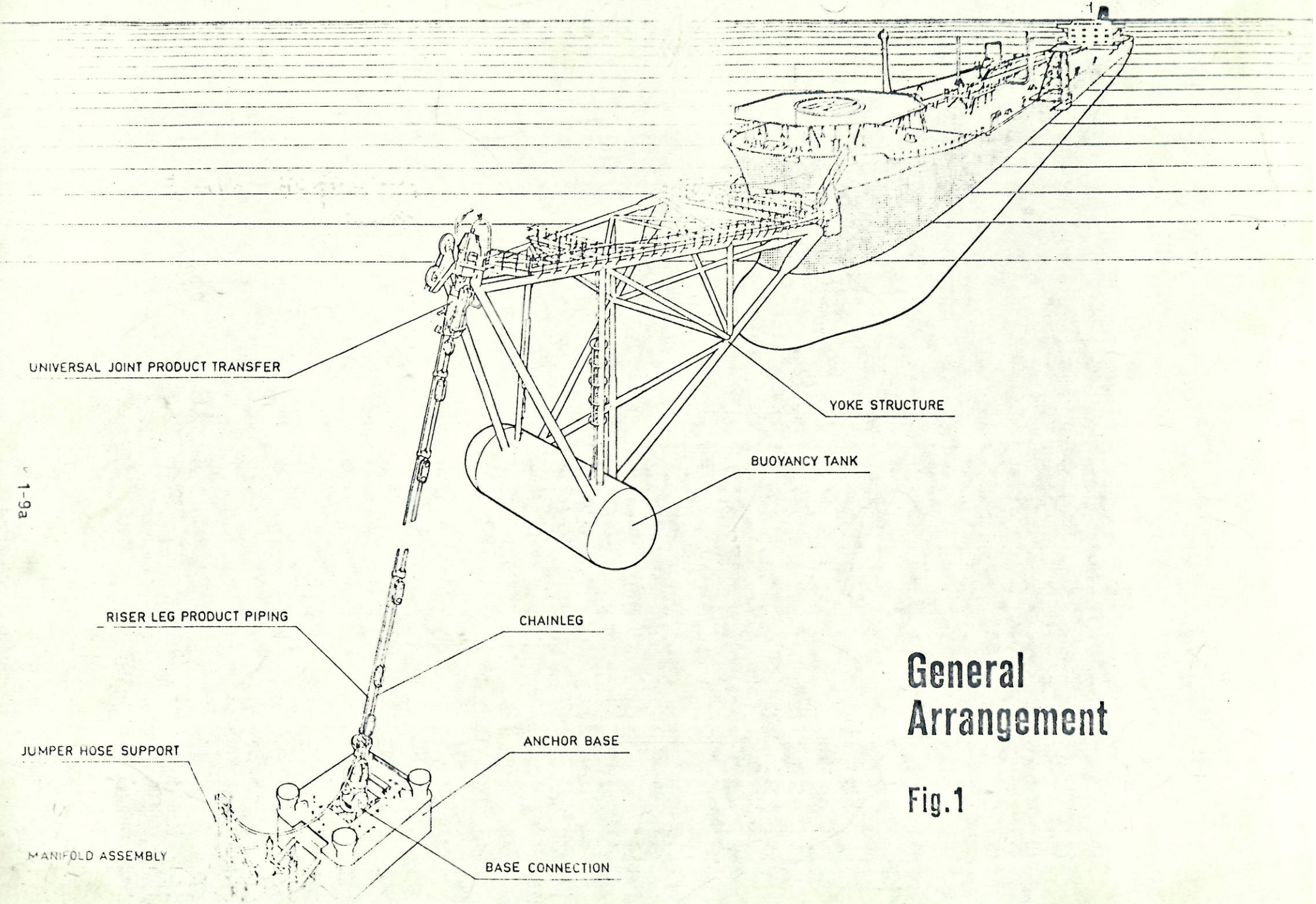
Par. 4 - During the period of service to date no serious defect have occurred with the yoke or anchor leg of the system, the 'Delta' weathervanes around the Sals mooring freely out of the moored position the system operates without problems.
The product and hydraulic control line swivel have given cause for concern, and a certain amount of redressing work on the seals in the swivel will be necessary, as both seals have failed in service.

Par. 5 - Conclusion

Considering the time constraint placed on the project, it must be considered as an outstanding sucess within 12 months of discovering the well a system has been devised whereby a production rate of 10.000 bbls/d has been obtain and store. A conventional tanker with an inert gas system has been converted to a production storage role utilizing the tanker's machinery to support the production module The sals system locates the tanker in the correct position and has given no cause for concern during operation.
There is little doubt that some faults can be found with the project: for instance the position of the Sals base in relation to the wellhead; had more information been available regarding the prevailing weather conditions the position of the Sals base could have been placed so that the heading of the tanker during the moored position for well entry should have been to the N.W.

Sistema SALS





General Arrangement

Fig.1