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Session 1 : Off-Shore - Inspection - Maintenance - Repair

- GULLFAKS "C" Offshore Operation : **USE OF AN HYBRID TEAM WOROV /DIVER**

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GULLFAKS "C" PROJECT

1 - PROJECT DESCRIPTION

Installation and tie-in using tig automatic hyperbaric welding of 3 expansion loops to the Gullfaks "C" gravity base platform at 220 meters in the Norwegain sector of the North Sea. Operation performed from a dynamically positioned diving support vessel using divers and construction ROV during the summer 1989.

2 - PROJECT INNOVATIONS

Facing the technological challenge created by the deep diving aspects, the technical difficulties of doing welding operation at this depth, and the tight commercial constraints, a review of the tasks was conducted to optimize and reduce the offshore time, leading to innovations in the procedures selected to perform the work :

- Use of a working ROV, assisted by an observation vehicle, to carry out subsea tasks traditionally reserved for construction divers :
  - preconstruction survey,
  - cutting of submerged pipelines,
  - positioning and installation of expansion loops,
  - deployment and inflation of air bags,
  - removal and recovery of lifting clamps,
  - and other ROV conventional tasks like : cuting and release of slings, recovery of mattresses, dredging, etc...
- Use of an hybrid team consisting of a diver assisted by a working ROV for :
  - alignement of pipelines using hydraulic H-frames,
  - transport by the ROV of heavy tools, then operation by the diver,
  - work inside the welding habitat supported by the ROV in the water.
- Use of mechanized hyperbaric tig welding for all 6 tie-ins :
  - 2 types of orbital welding systems developped for small pipes and 36" pipes,
  - no manual back-up qualified for use as a contingency.

3 - CONCLUSION

This project was a typical example of the joint work ROV / ROBOTIC / DIVER, which proved very efficient at this depth and which opens new perspective for deeper welded tie-ins.

USE OF AN HYBRID TEAM IN SUBSEA CONSTRUCTION WORK : THE GULLFAKS 'C' AND OSEBERG NORTH PROJECTS

The scope of work of the Gullfaks 'C' project was the tie-in of the Gullfaks 'C' gravity base platform at 220 meters in the Norwegian sector of the North sea to the 3 export pipelines using a TIG automatic hyperbaric welding process. The operation was performed in the late summer 1989, from a dynamically positioned diving support vessel : the NORSKALD (ex SEACOM). The vessel had been specially upgraded to carry out deep diving work in this part of the North sea, and 15 divers in saturation were used on a continuous round the clock basis diving from the 2 bells. 2 ROVs were also in the water at any one time to support the operation : an observation vehicle SPRINT and a large working ROV, CHALLENGER or TRITON.

But facing the technological challenge created by the deep diving aspect, the technical problems of doing robotised welding operations at this depth, and the tight commercial constraints, a review of the tasks was conducted to optimize and reduce the offshore time. Despite a rather conventional scope of work for an offshore diving contractor, this evaluation led to a major innovation in the procedures selected to perform the work which is the use of an hybrid team : Diver/WOROV.

The offshore industry has seen the significant growth of the ROV usage over the past last years, but the presence of a WOROV into the subsea construction market traditionally reserved to divers is rather recent. They are some example of diverless field developments, but these have been made possible through an extensive and comprehensive engineering and testing phase. Where the tooling and the design of the permanent subsea installation have been specially engineered to suit the ROV capability. The economical interest to use an hybrid team is the immediate access to an efficient operation within the range of the ROV capability without new or major investment.

We will further analyze in detail the split of activities between the man and the machine, but one can say that with the level of the present standard ROV technology available, the diver was only called to take over at a point where :
either the ROV was not able to it, or it would have cost more to do it with the ROV.

Although this distinction seams quite theoretical, it did however in practice work quite well. This required a surface support vessel large enough to carry in parallel a diving operation and a WOROV operation without any major interferences between them. The size of the vessel also allows to reduce the exposure to weather conditions and contributes to optimize the usage of the whole spread.

The example of the Gullfaks 'C' project enhances the advantages of this hybrid association, due to the very constraining rules and regulations applicable for deep diving in Norway. The offshore work was split into phases, with 14 days diving work alternating with 10 days decompression period for the complete diving team. These decompression periods were used by the WOROV to proceed alone and prepare the work for the next diving phase. The new diving team was only brought in when the WOROV had achieved sufficient progress on its own to justify the saturation of 12 divers.

We have today the opportunity to compare the Gullfaks 'C' operation with the Oseberg North field extension operation, which is the latest offshore operation done by Comex.

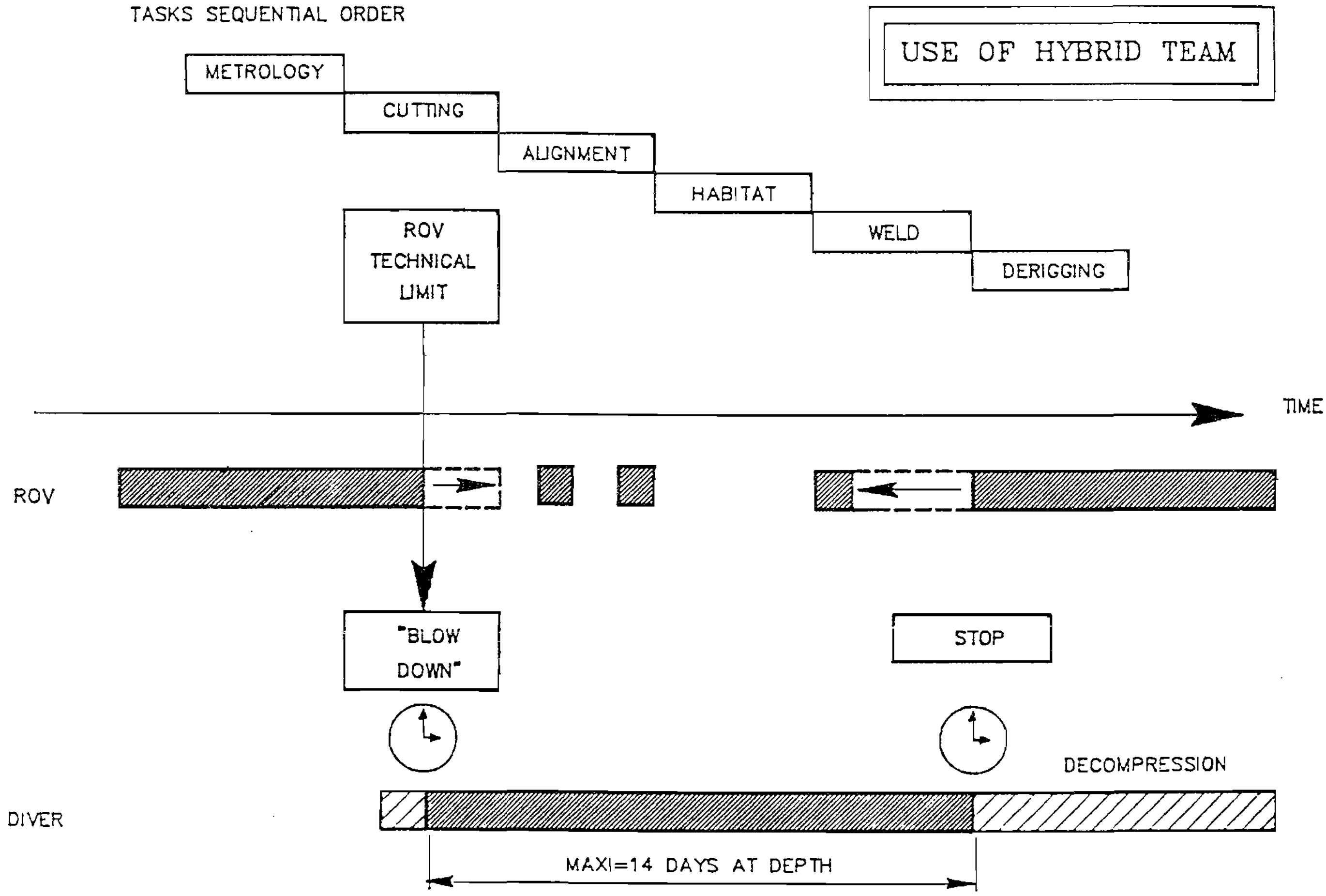
The type of work is almost identical in the 2 cases : platform to pipeline tie-ins, TIG automatic welding, same sector of the North sea, but the water depth of 110 meters of the Oseberg field brings this latest operation into a more classical frame and permits to confirm the interest of the use of an hybrid team even at a shallower depth. It also demonstrates that the efficiency previously reached was not only caused by the unusual water depth.

Looking now into the future, we can confidently plan to perform deep welded tie-in, below 300 meters using similar procedures with the use of a diving team and a working ROV. This association being extended to a point where all wet tasks will be performed by the ROV, the diver being reserved the dry tasks inside the welding habitat where its skill could not easily be replaced by manipulators unless a major investment was done in this direction using the latest development done in robotics. This is the current company policy for the deep field development in Norway : Snorre and Troll fields.

THE EXPANDING ROLE OF ROVS
ON CONSTRUCTION PROJECTS

The table below shows the tasks performed with a working ROV on the Gullfaks 'C' project together with the tasks that could be carried out on future projects after further engineering work.

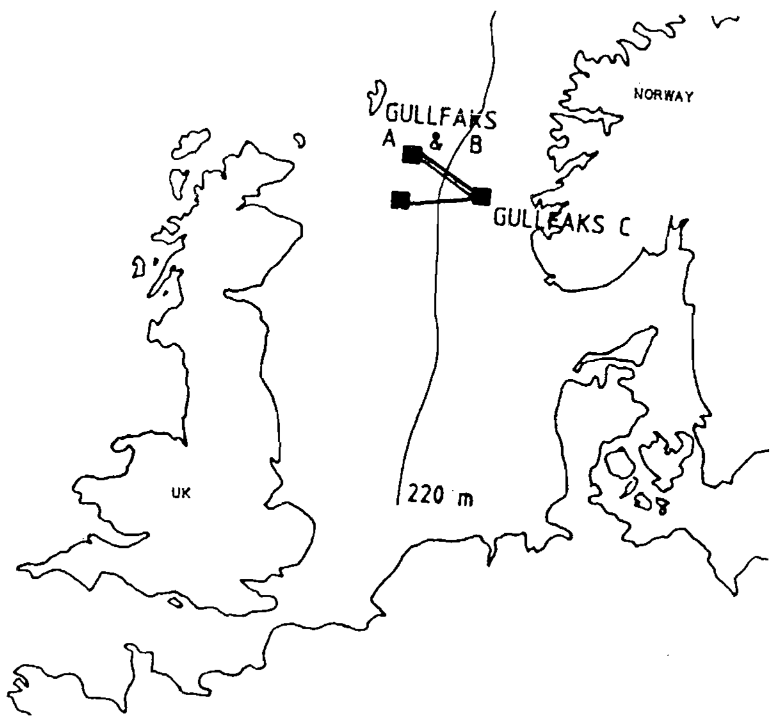
CONSTRUCTION ACTIVITY *DURING A TYPICAL* WELDED TIE-IN OPERATION	GULLFAKS 'C' PROJECT			FUTURE PROJECTS			COMMENTS
	ROV	ROV/ DIVER	DIVER	ROV	ROV/ DIVER	DIVER	
WORKSITE METROLOGY Measurement for spool fabrication, debris removal, etc	■			■			Sufficient accuracy can now be achieved with ROV carried/operated survey equipment
CUTTING RISERS & PIPES		■		■			10"/12" risers and pipelines cut with guillotine saw on GFC project. A new tool is required to cater for all pipe
H-FRAMES INSTALLATION PIPE SHIFTING	■			■			ROV control panel and pipeclaws fitted to two H-frames for GFC project
SPOOL POSITIONING AND RELEASE OF SLINGS	■			■			A wire cutter is the only special ROV tool required for this operation
HABITAT POSITIONING AND RELEASE OF SLINGS including set-up of guide wires and inflation of air-bags	■			■			A special push/pull pin arrangement was engineered for connection/disconnection of habitat slings
LEVELLING OF HABITAT			■	■			Habitat hydraulic system to be modified and control panel provided for ROV
LIFTING OF SPOOL/PIPES AND CLOSING HABITAT CLAWS		■		■			As above for habitat, also securing bolts to be modified for ROV operation
CLOSING OF HABITAT DOORS DEWATERING OF HABITAT			■	■			ROV control panel needed for door hydraulic and pneumatic system
POCO & TRACO INSTALLATION			■	■			Screw jack system to be modified for ROV operation and QDs fitting needed for hot water supply
SET-UP EMERGENCY GAS BANK			■	■			ROV control panel needed for valve operation QD fitting needed for gas connection
SET-UP DRY DIVER TRANSFER	■			■			ROV used to position the guide wires weights into the habitat receptacles
DRY WORK INSIDE HABITAT			■			■	ROV can be used to provide light during set-up activities and to transfer equipment
FLOODING OF HABITAT AND OPENING DOORS			■	■			see above
HABITAT RECOVERY			■	■			see above
SITE CLEARANCE AND SURVEY including removal of spool clamps	■			■			New standard lifting clamp design required to ease removal of bolts by ROV



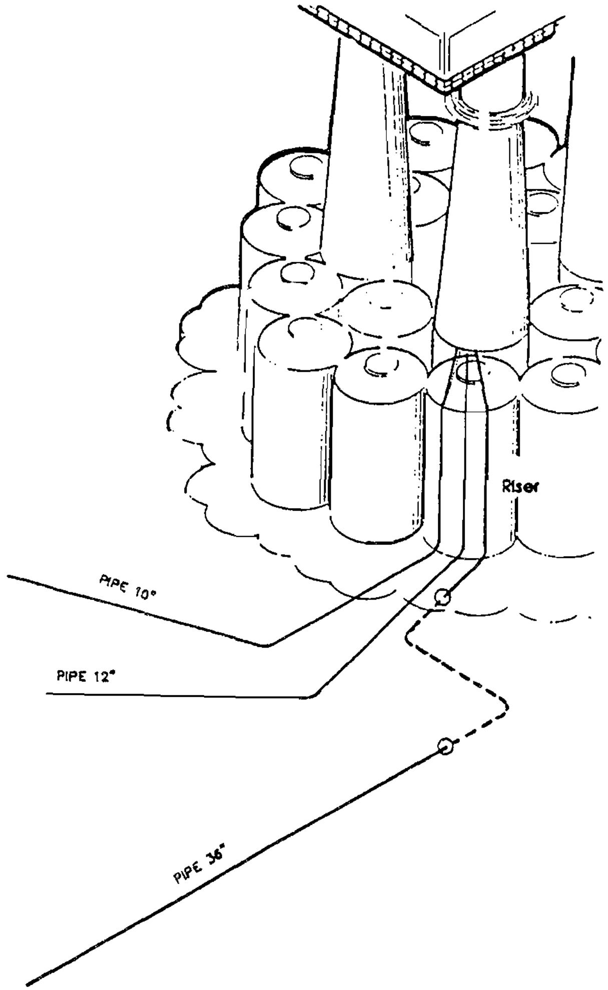
HYBRID OPERATION:

PLATFORM TIE-IN IN THE NORTH SEA AT 220 METERS

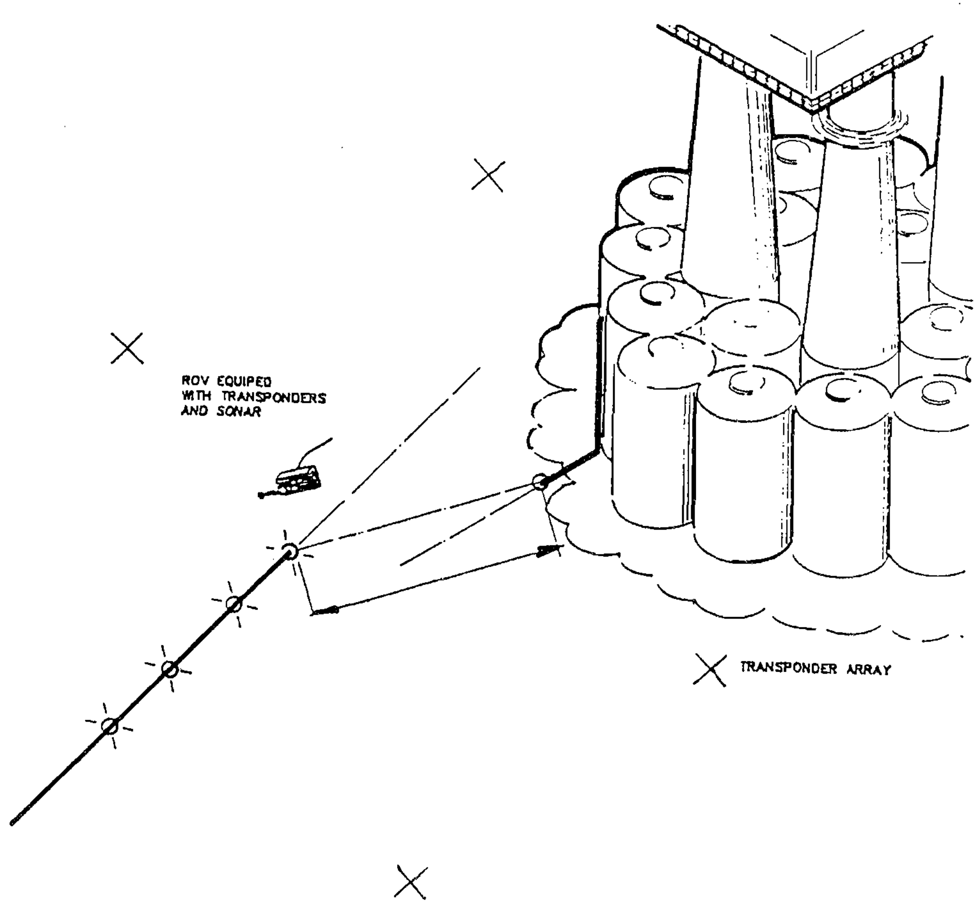
JULY TO OCTOBER 1989



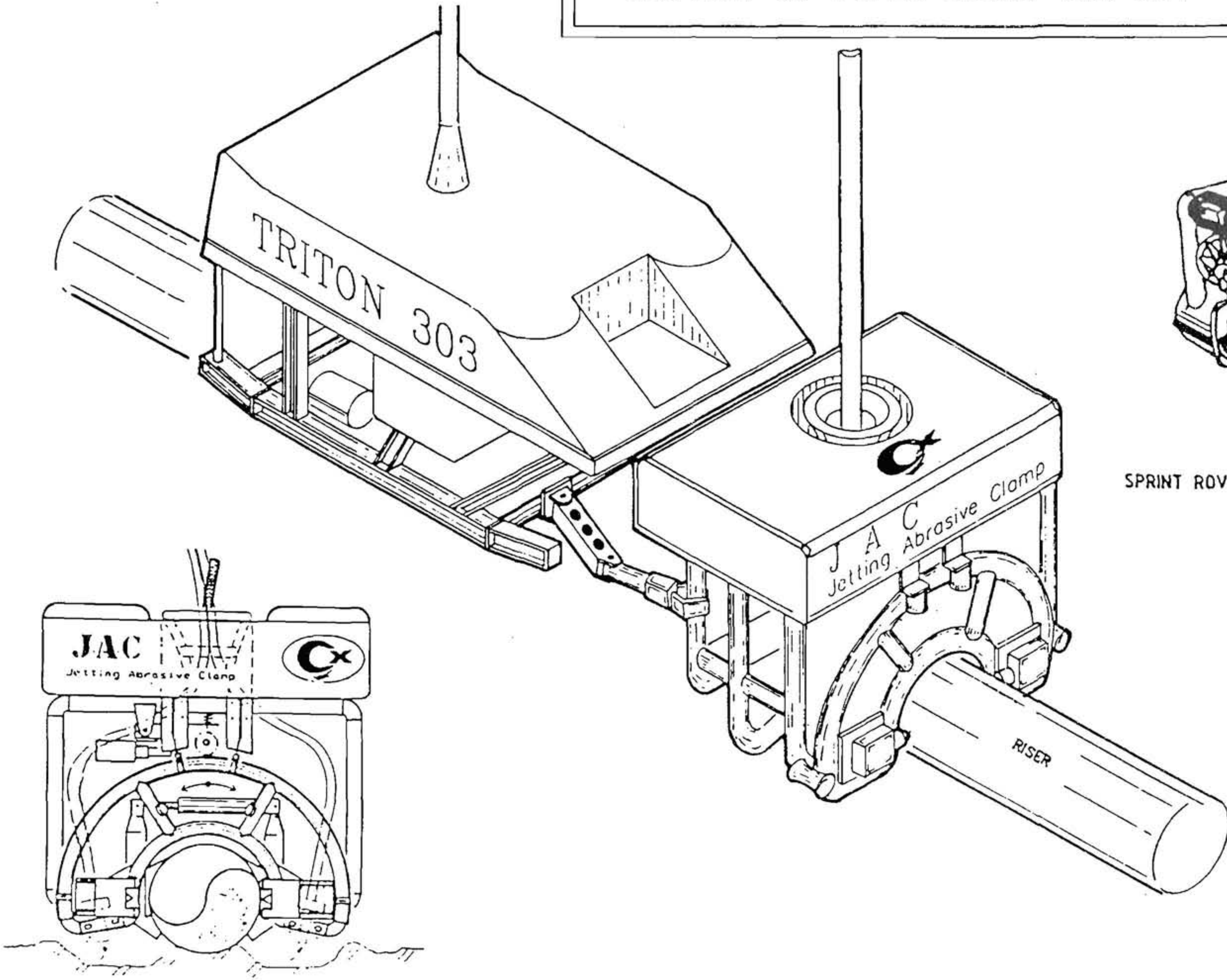
SITE LAY OUT



PIPE METROLOGY WITH THE ROV

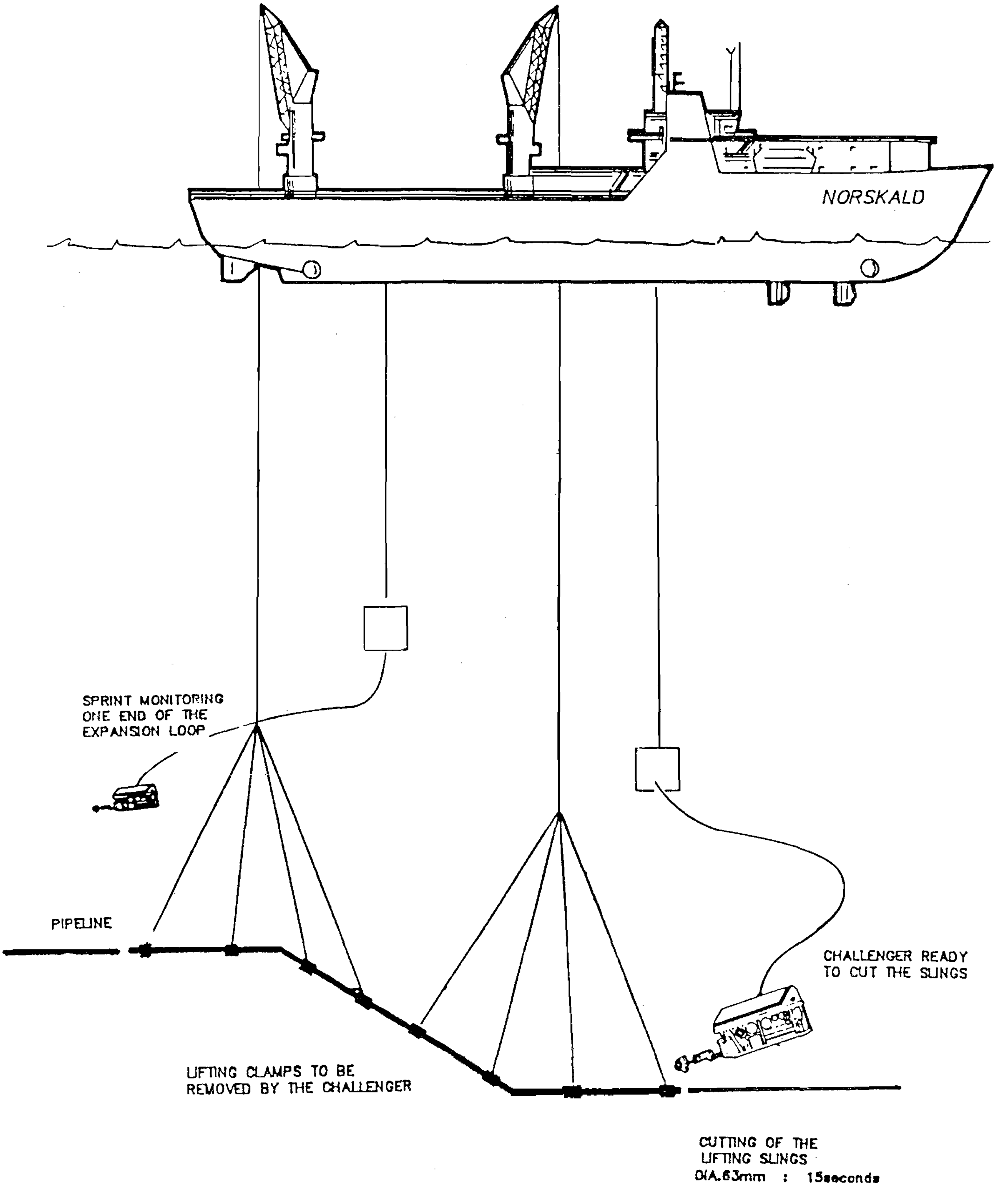


CUTTING OF PIPES USING THE ROV

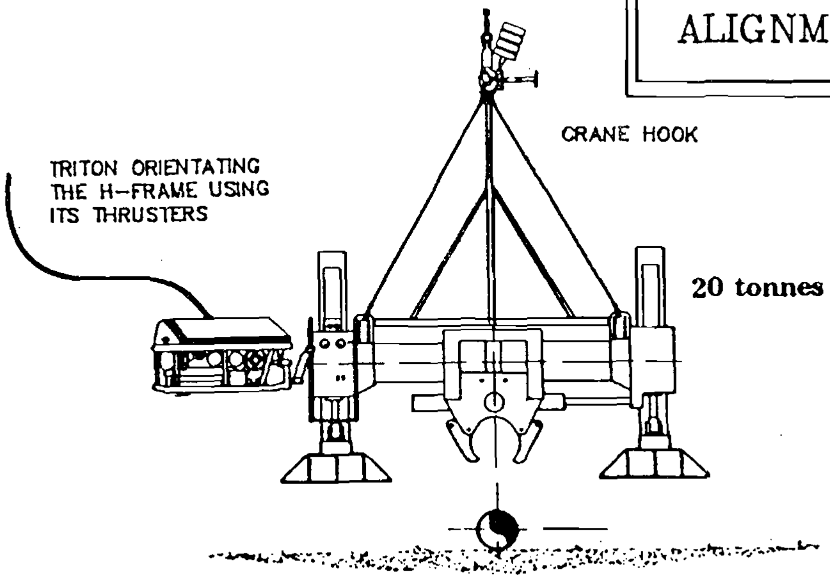


110 m

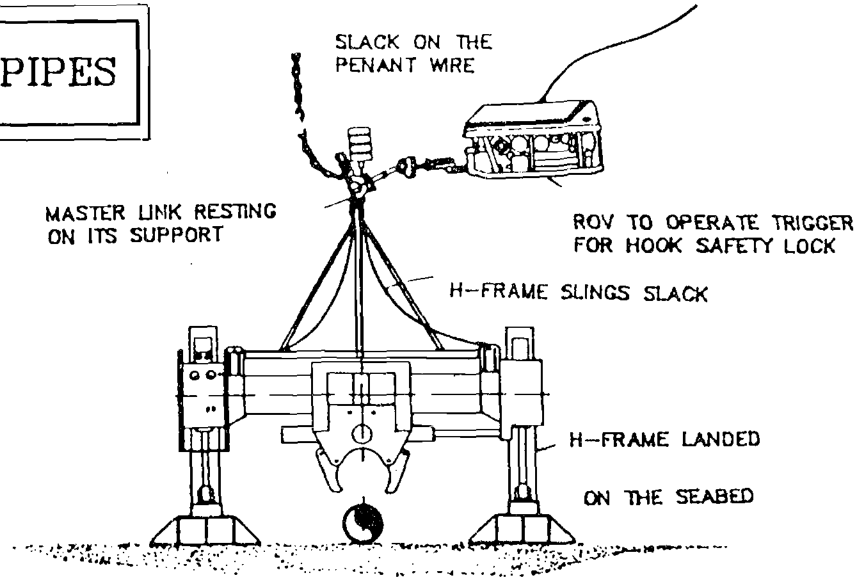
EXPANSION LOOP INSTALLATION



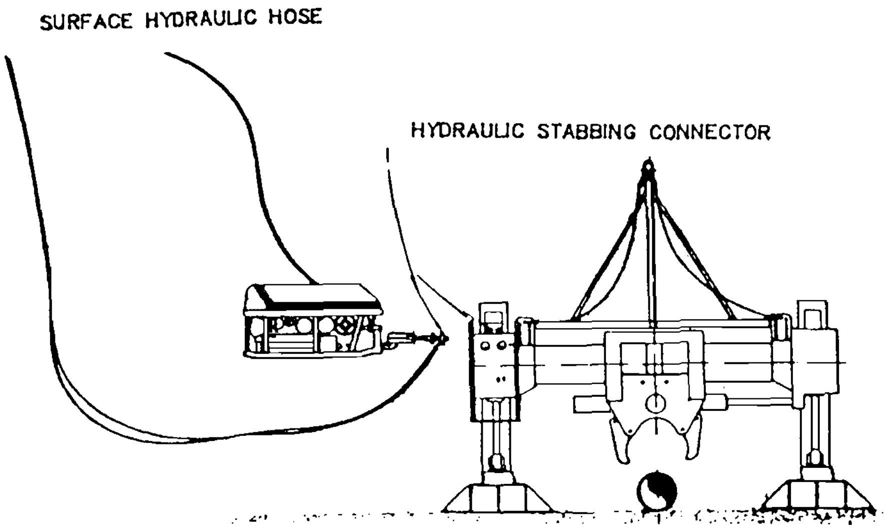
ALIGNMENT OF THE PIPES



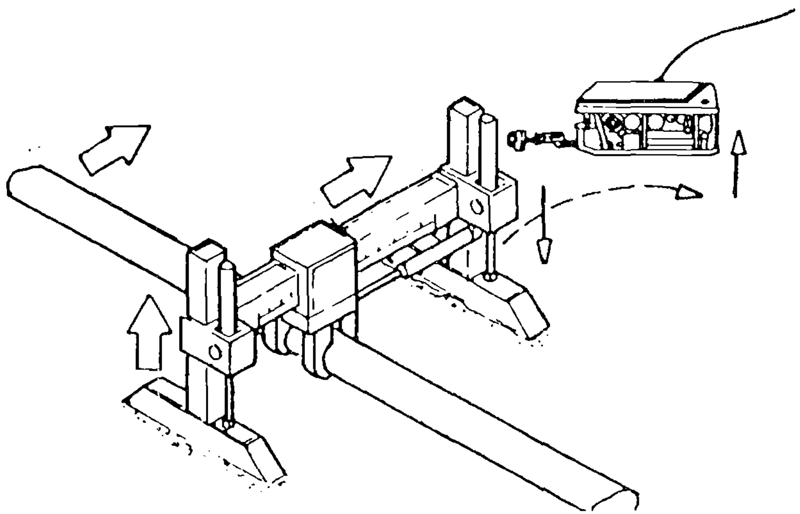
(A) POSITIONING OF THE H-FRAME OVER THE PIPE



(B) DISCONNECTING THE CRANE HOOK

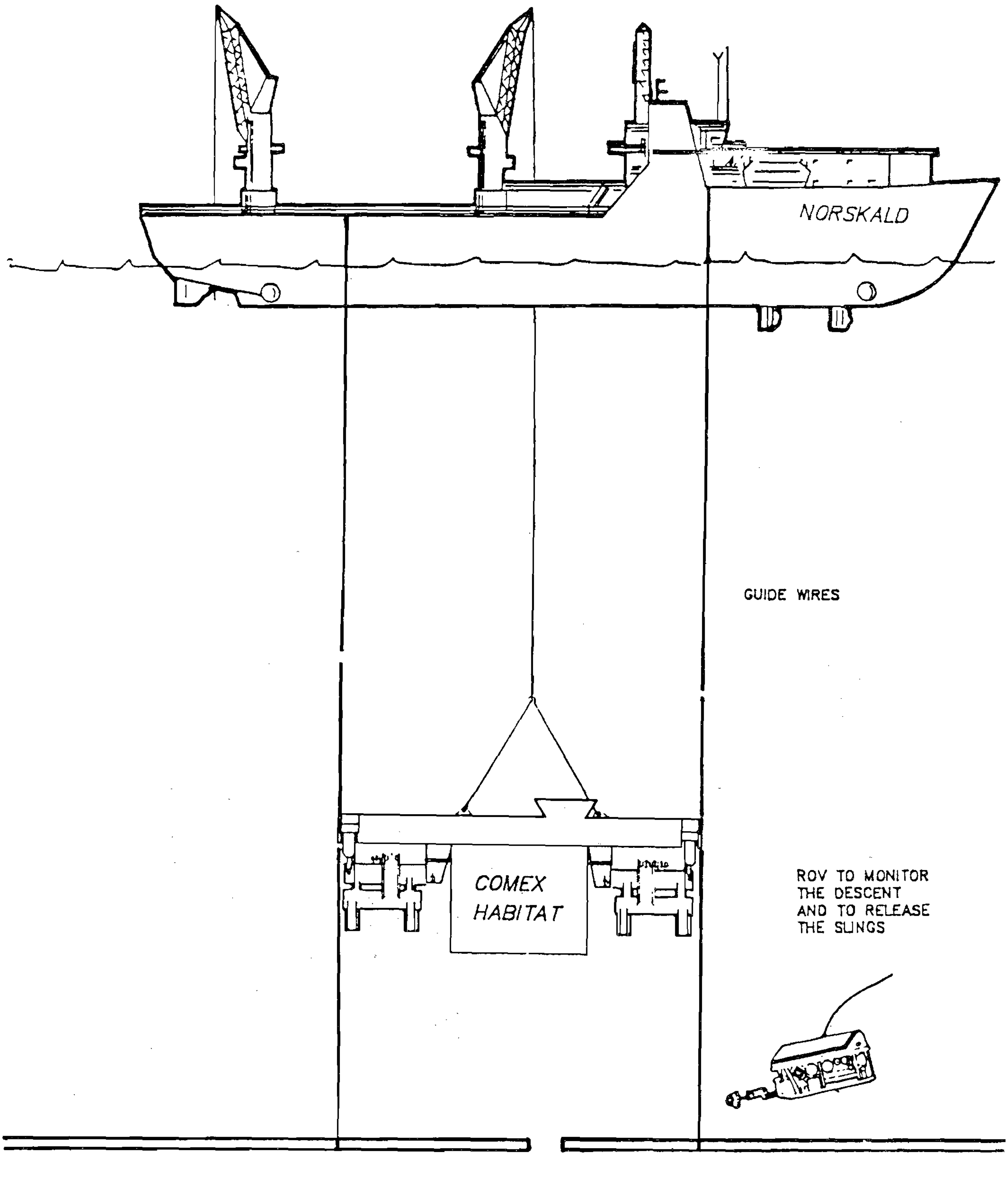


(C) HYDRAULIC POWER CONNECTION USING QUICK PUSH-PULL CONNECTOR

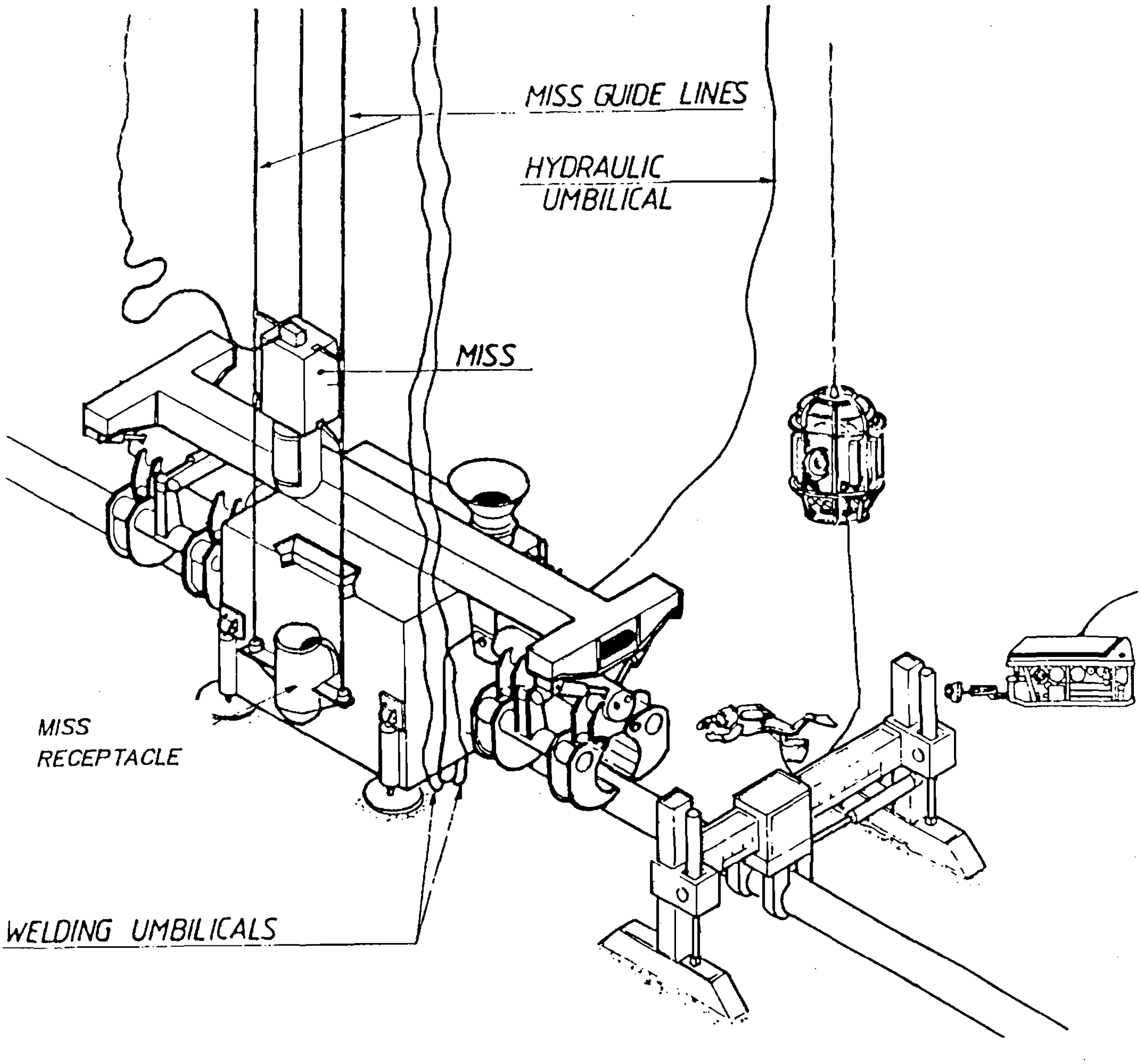


(D) ROV TO OPERATE THE H-FRAME VALVES TO LIFT OR SHIFT THE PIPE

WELDING HABITAT LOWERING AND INSTALLATION



WELDING SPREAD SUBSEA DEPLOYMENT
ROV + DIVER SIMULTANEOUSLY



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VIDEOGRAMMETRIE

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Le principe de la vidéogrammétrie est celui de la photogrammétrie où l'on a remplacé les appareils photo par des caméras vidéo CCD ou CID. Ce principe permet d'obtenir les coordonnées X, Y et Z de tout point de l'espace filmé, sans contact, en temps réel et avec une grande précision.

L'application qui nous intéresse ici concerne l'inspection de structures immergées : par exemple un noeud de jacket. Le champ couvert nécessaire est de 3 m x 3 m avec une profondeur de champ de 3 m. Le capteur employé sera un CHROMO 200 embarqué sur R.O.V. L'ombilical du R.O.V. servira au transfert d'informations. L'unité de traitement et de métrologie sera embarquée sur un support naval.

On projette un plan de surbrillance sur le noeud, on en fait l'acquisition, ce qui donne une coupe du noeud en 200 millisecondes, soit les coordonnées X, Y et Z de 512 points. Si l'on fait une coupe tous les 30 mm on a la cartographie du noeud en 20 sec avec une précision de ± 3 mm. Notons que c'est la cartographie réelle du noeud. Pour avoir le volume du noeud nous aurons besoin de faire 3 prises de vue de ce noeud.

A partir de cette inspection d'ensemble du noeud on peut avoir besoin de plus de précision dans une zone déterminée ; on utilisera pour ce faire un second capteur (l'unité de traitement et de métrologie reste la même) : CHROMO 10. Avec lui on pourra inspecter par exemple un cordon de soudure ou autre chancre ou fissure. Le champ couvert de CHROMO 10 est de 24 mm x 36 mm ; sa profondeur de champ est 50 mm et sa précision de 7×10^{-2} à 1×10^{-1}.

The basic principle of videogrammetry is the one used in photogrammetry systems, except that videogrammetry systems use video or digital cameras instead of photo cameras and that all the processing which is needed to obtain object coordinates from the images is performed in real time, whithout contact and with a high level of accuracy.

One exemple of what kind of job could be achieved with videogrammetry systems, concerning the offshore field, is the inspection of a jacket node. The purpose of such an operation is to acquire the 3D characteristics of a complete jacket node. This means that the object covered field is 3 m x 3 m and that the depth of field is also 3 m. CHROMO 200 system used for such an operation is fitted on a R.O.V. for the picture taking device, the processing unit being on the supply boat, the links between these two subsets are those of the R.O.V. umbilical from the picture taking device.

An overbrightness light is projected on the node. This overbrightness line is acquired and the coordinates X, Y et Z of 512 points are calculated, which give a shape of the node. If we scan a shape every 30 mm which give a real cartography in 20 seconds with an accuracy of ± 3 mm. To get the complete information about the node we need at least 3 points of view.

From the global inspection performed with the previous CHROMO 200 system we may have the need to process a more accurate 3D metrology on a determined part of the node welding, pittings, holes, concretes and so on ... : This can be achived by using a CHROMO 10 system whose the processing unit is the same as for the CHROMO 200. The object covered field of CHROMO 10 is 24 mm x 36 mm, the depht of field is about 40 mm to 50 mm and the accuracy system is from 7×10^{-2} to 1×10^{-1}.

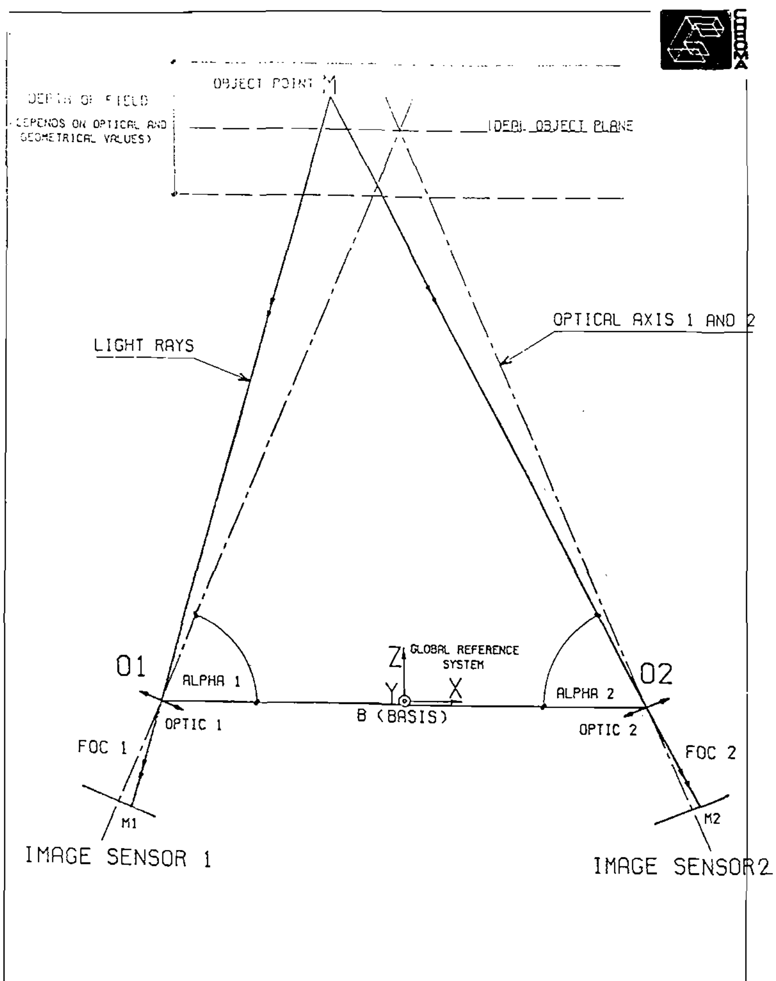

FIGURE 1