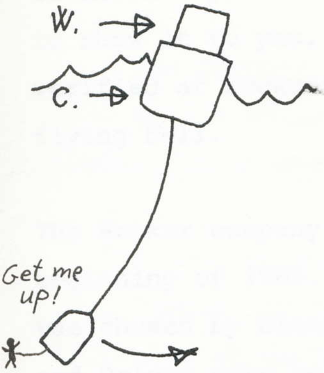
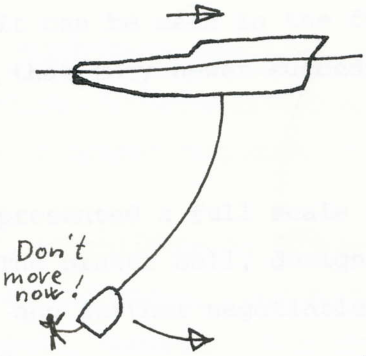
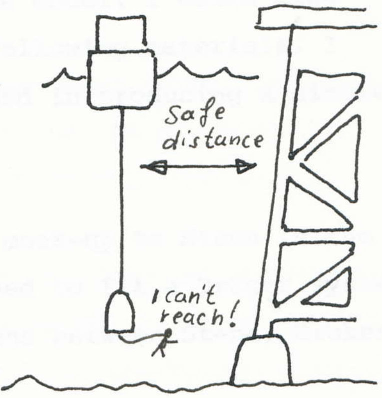
THE FLYING BELL

Already back in 1980 or 1981 or even earlier someone got the idea of a flying bell, i.e. a diving bell able to move both vertically and horizontally. The standard bell is very stable even in strong currents and has unlimited supply of breathing gas, hot water and electrical energy from surface but it is not able to move around.







In bad weather conditions the ship is not able to keep the exact position all the time, therefore, most of the year in the North Sea a SDC bell is not able to stay in a safe working position and if the ship is going to move to a new position or follow a track the bell has to be hoisted during the moves. Also when working on a platform leg job it can be difficult to come close enough with the bell especially in rough weather conditions where a safety distance from ship to the platform is going to be maintained.

The submersible on the other hand is able to move around but its capacity of breathing gas and energy is limited and it is difficult to launch and retrieve in bad weather conditions.

The flying bell, however, can be launched through a moon pool and supplied through the umbillical like an ordinary bell and it is also able to move around almost like a submersible.

Stena put out a request for a flying bell in appr. 1981. Kockums which collaborated with Comex in France started to design a flying bell. Dräger did that too and Dräger contacted Bruker for a subdelivery planning. Both Bruker and Kockums claims to me that they got the idea first. The Kockums' bell was designed to fit a Comex chamber complex and the Bruker bell was designed to fit a Dräger chamber complex.

A fight for the order started. A Norwegian/Swedish collaboration company was established in order to gather enough technical knowledge to design a flying bell among other things. You can see a message which I received in 1983 before the news actually were press released.

Kockums succeded in presenting a small model of the flying bell. I received a picture from Kockums showing the model. I would like to show it to you. It can be seen in the following materials. I verified at Kockums that they newer succeded in producing a single flying bell.

The Bruker company presented a full scale mock-up to Stena in the beginning of 1985. The Bruker bell, designed to fit a Dräger system, was chosen by Stena and further negotiations between Stena, Bruker and Dräger were held.

In the meantime Comex was bought by the huge French company "Ateliers et Chantiers de Bretagne" (ACB). Now something happend. Stena wanted the Bruker bell together with a ACB chamber complex. The Bruker bell was adapted in the design to fit the ACB in stead of the Dräger system.

At my visit at Bruker I asked for the original Dräger oriented specifications of the bell. This imformation is also presented in the following and gives a very good view of the flying bell for the Dräger system.

NS 2525

NEW NORWEGIAN/SWEDISH UNDERWATER TECHNOLOGY COMPANY

Operations down to more than 500 m .... equipment
for use at 650 m has been supplied.

* * *

A new company - SUBTECH Norway A/S - has been formed to develop and narket the skills of Swedish and Norwegian companies in advanced technologies for underwater operations down to more than 500 m.

The new company, established by A/S Møllerodden and A/S Pusnes larine & Offshore Services, of Norway, and Kockums AB, of Sweden, will be pased initially at Haugesund, Norway. According to the Managing Director, Ir. Terje Miljeteig (Fig. 1), they will concentrate at first on "SatMATE" living systems, "RescueMATE" hyperbaric lifeboats, "CheckMATE" underwater vehicles and ROB flying bells. In due course SUBTECH Norway will also levelop cable-repair and welding habitats.

lying Bell

The remotely-operated flying bell ROB (model - Fig. 2) can be used t ranges up to 300 m from the controlling vessel or platform: for diver ock-out, as a transfer chamber to hyperb$\overset{r}{\wedge}$aic or atmospheric habitats, or for escue, observation and manipulator work.

There are two models with displacements of 9000 kg and 11 500 kg, ach able to carry up to 3 divers. The larger bell has 8 x 12 kW thrusters iving it a top speed of 2,5 knots, the smaller 8 x 6 kW thrusters for a peed of 2 knots. A heavy claw enables the ROB to attach itself to nderwater structures.

yperbaric Lifeboat

For recovering divers under pressure in an abandon ship/rig

.../.

ituation, Møllerodden have developed a completely enclosed GRP hyperbaric ifeboat (model - Fig. 3) containing a decompression chamber, rated at 30 nd 45 bar for 6 to 16 divers, which can be directly connected to the diving ystem via an escape trunk. This self-contained unit can support divers uring continued decompression for several days.

The RescueMATE is 8,12 m long x 3,16 m beam x 0,8 m draft. She arries divers' gas for 4 to 7 days, plus 170 litres fuel and a crew of or 3. A 30 hp diesel gives her a speed of 5 knots (maximum range 200 autical miles). Complete with a 700W/24V generator, emergency batteries nd external fire-fighting equipment, she retains positive stability at ngles of heel up to 105°.

atMATE

Standard modules developed by Møllerodden (model - Fig. 4) can be ombined to form either mini-sat systems or complete saturation-diving omplexes for depths of 200 m, 300 m or 460 m. The modules consist of a 160 mm i.d. x 2300 mm o.d. chamber, a decompression chamber from 3360 mm 4 men) to 6000 mm (8 men) long, and a 1670 i.d. x 2500 o.d. bell with an nternal height of 2000 mm (overall 2650 mm). All are insulated with solid oam and a reinforced plastic outer coating.

bservation chamber with manipulators

The CheckMATE (Fig. 5) is a 2-man submersible 1900 mm i.d. acrylic phere with a 700 m umbilical. It has three manipulators, the anoeuvrability of a helicopter and an all-round (360°) view. When attached o its base structure it has a length of 3,25 m, a beam of 2,50 m, a height of ,15 m, and can carry a payload of 300-400 kg. The base can be jettisoned in mergency.

CheckMATE is classified by DnV for operating at depths down to 50 m. Horizontal speed is 3 knots, vertical 2 knots. Life support quipment for 240 man hours includes a CO_2 scrubber, CO_2 monitoring,

.../.

an oxygen monitor and alarm, metabolic oxygen bleed and 3 emergency breathing equipments. The unit is provided with scanning and directional sonar, a VHF tranceiver and colour and black/white TV. The first CheckMATE is at present in service with the Norwegian Underwater Technology Center (NUTEC).

Further information from:

SUBTECH NORWAY A/S
P.O. Box 261
5501 Haugesund
Norway

Tel: + 47 47-22666
Telex: 40960 STN

velopment of sub sea products

AB is specialised in high-technology ships such as ers, Ro-Ro vessels, car carriers and chemical ockums is a member of the Swedyard Group.

Naval Division is specialised in naval ships and designing and building submarines since 1914. The e gained provides the basis for development of nderwater products. A firm cooperation with the dustry, is established.

ower AB, jointly owned with United Stirling AB, ng the Stirling engine for underwater applications.

ft AB, jointly owned with SUTEC AB, marketing ned submersibles.

n Norway A/S, jointly owned with Møllerodden A/S snes A/S i Norway, marketing diving systems.

ucts developed at the Naval Division are focused vater inspection and maintenance.

otely Operated Bell system (ROB) is a tethered divble to 'fly' vertically and horisontally with neutral and with slack umbilical. It is controlled from the ip in a manner identical to that of a remotely operated he ROB enables the support ship to stay away from rm and to use optimal heading due to waves and

oacoustic crack detection system (HYAC) is a based monitoring system for detecting propagating underwater structures. The acoustic emission racks is picked up by hydrophones. Location and of the cracks are then determined by signal analysis. atform operator the HYAC system offers:

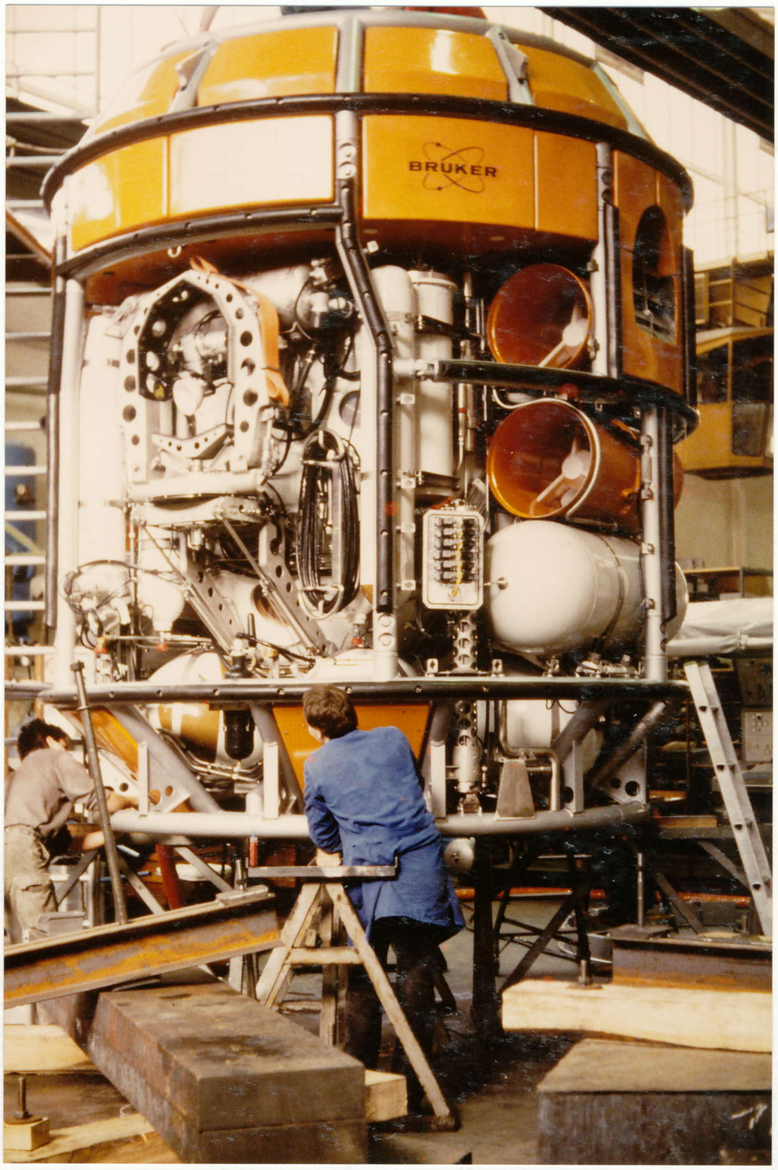
d annual inspection costs by directing the inspection critical parts of the structure.

ed platform safety due to early warnings of dangerous ropagation.

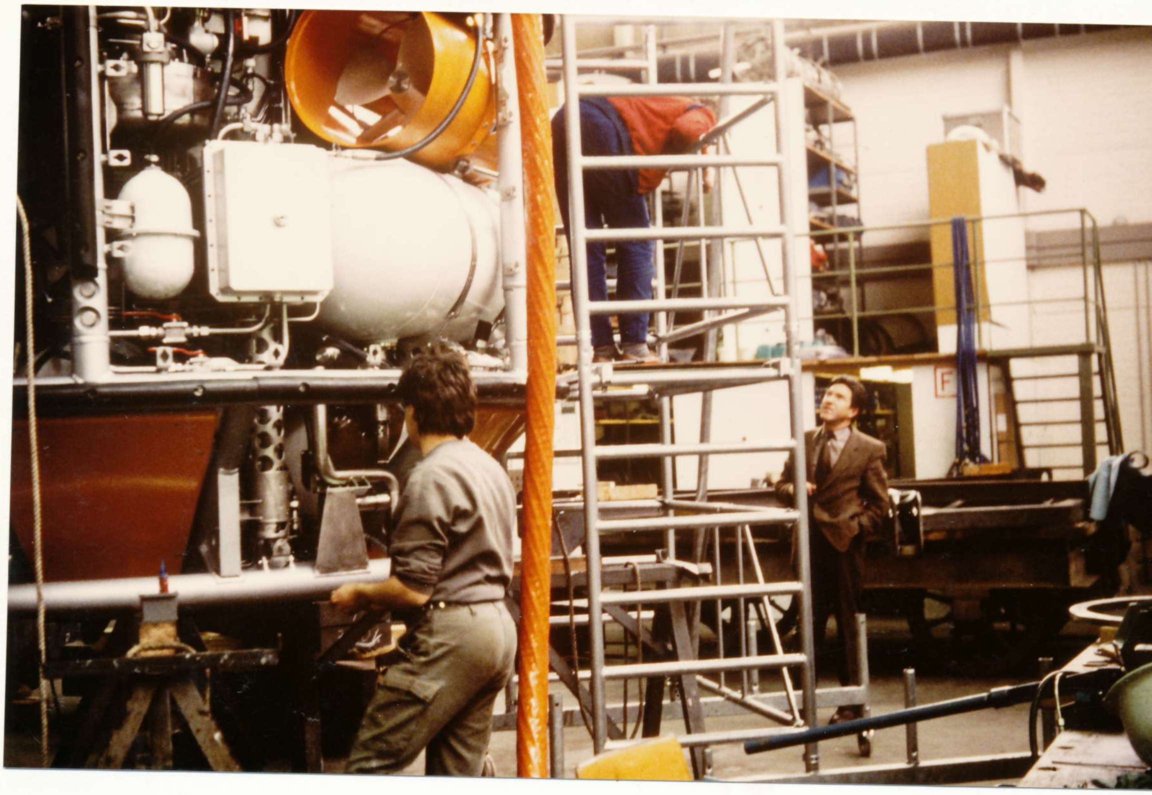
OCKUMS AB

KOCKUMS AB
P.O. Box 832, 201 80 MALMÖ
Tel. +46 40-744 00, telex 33190 kockum s

Jörg Haas, the engineer and managing director of Bruker in Karlsruhe was very busy the day that I and my girlfriend visited the plant. The flying bell was being prepared for shipping to Sweden which was going to take place two days after. The DnV people were there in order to check the final elements of the electrical system.



Here you can see the DnV people checking the flying bell. Note how big it is. You can see the clamp in the midsection of the bell. In the foreground you can see big blocks of steel. That is the clump-weight to be used when the bell is used in the standard SDC mode.

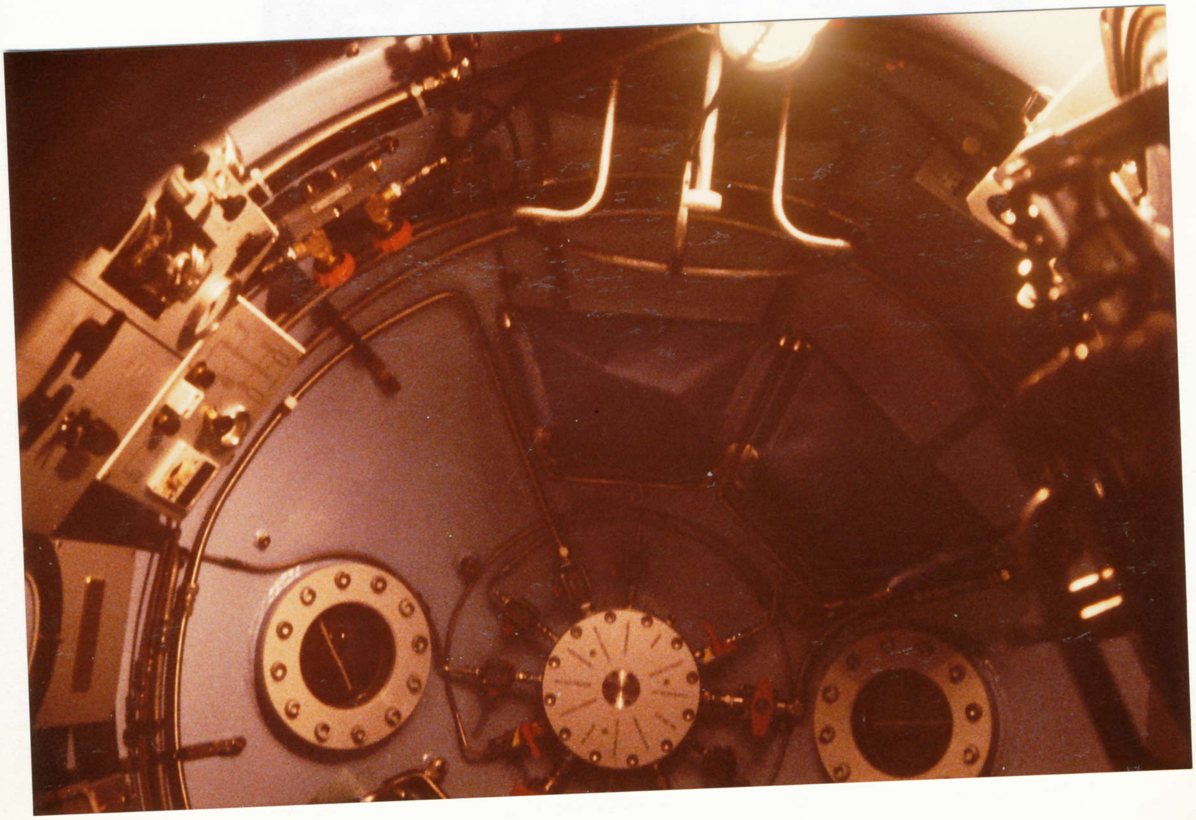


Jörg Haas is a very interesting personality. He is a brilliant engineer always on the move and very innovative. I found him to be a most special version of a managing director. In stead of sitting behind a big desk in a big office he is out in the construction hall all the time checking various details.

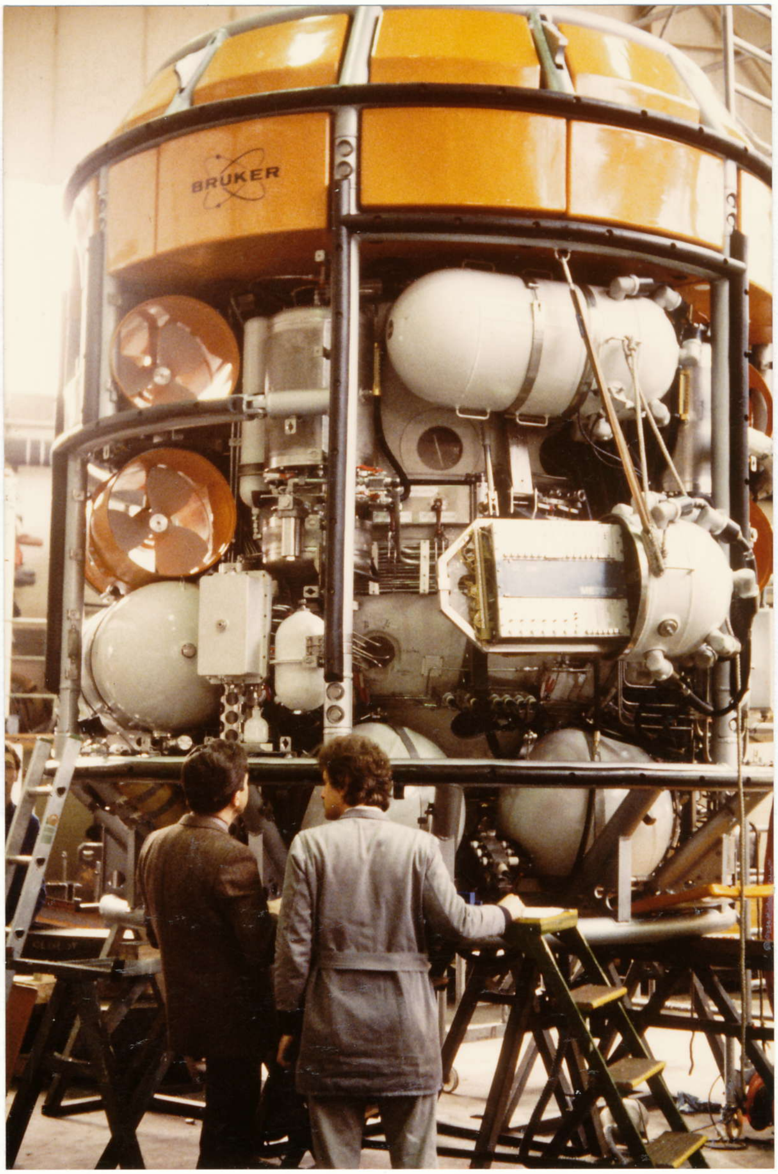
He insists to be the first test pilot on all undervater vehicles which he invents. "Jörg Haas is so proud of his inventions so when he constructs one of these fantastic diving vessels he not only drives them around alone in the nearby waters of the Rhein he can also get the idea of demanding that I shall go with him on such a ride, and it scares me", the secretary said to me. "but of course I belive that the things are working", she added.

When I first came to the plant the secretary tried to keep me away from Jörg Haas because he was so busy. But he saw me and found the project very interesting, so he took me inside the flying bell and closed the hatch so that nobody could disturb us. We talked for about 45 minutes inside the bell. The secretary was furious when we came out.

Here is a picture from the inside of the flying bell taken from the bottom hatch:

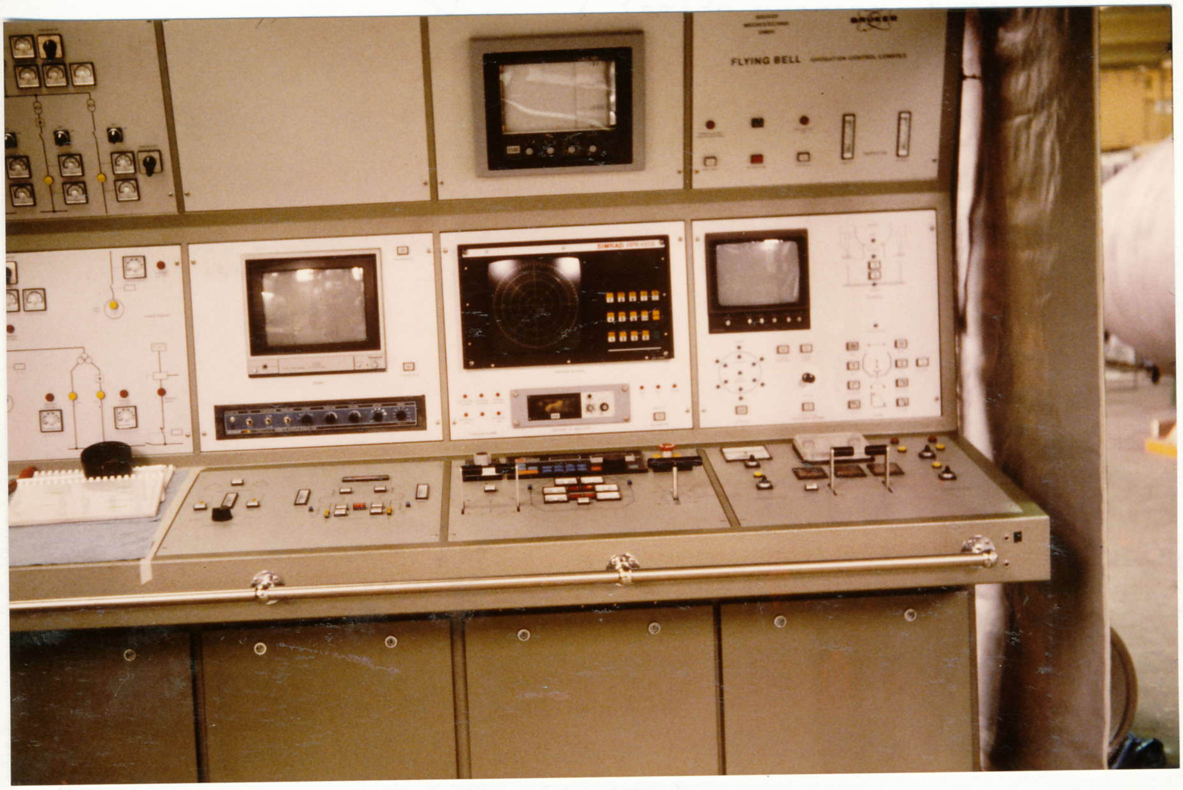


On this picture you can see the bell from the back side. Note the big pressure container in the center. That is the transformer. It is Jörg Haas to the left:

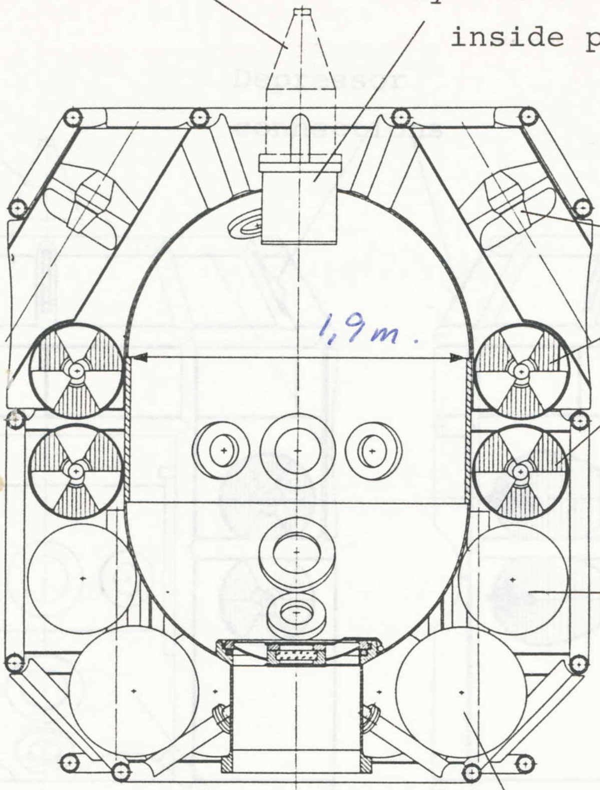


Jörg Haas told me that he would have liked Dräger to be with on this project. I do not like the ACB design as much as the Dräger, he said.

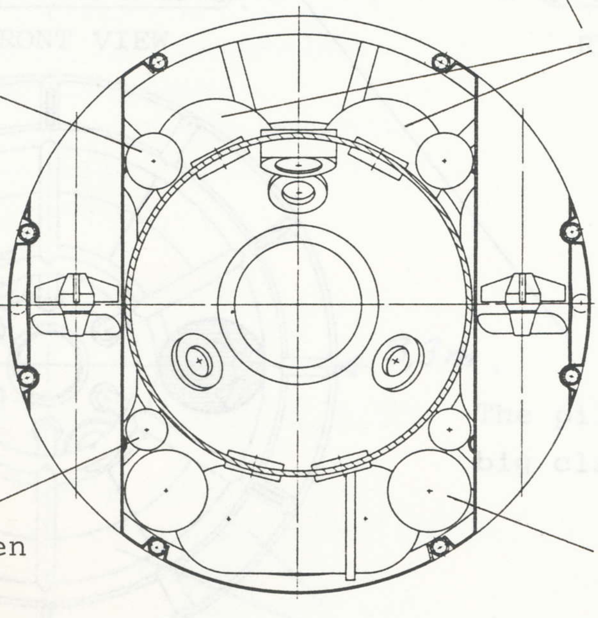
On this picture you can see the control panel of the bell. It has first priority to most of the bell functions. The divers inside the the bell have secundary control over the bell. With the "radar" seen in the center of the panel the bell can be manouvered to the work site from the ship:



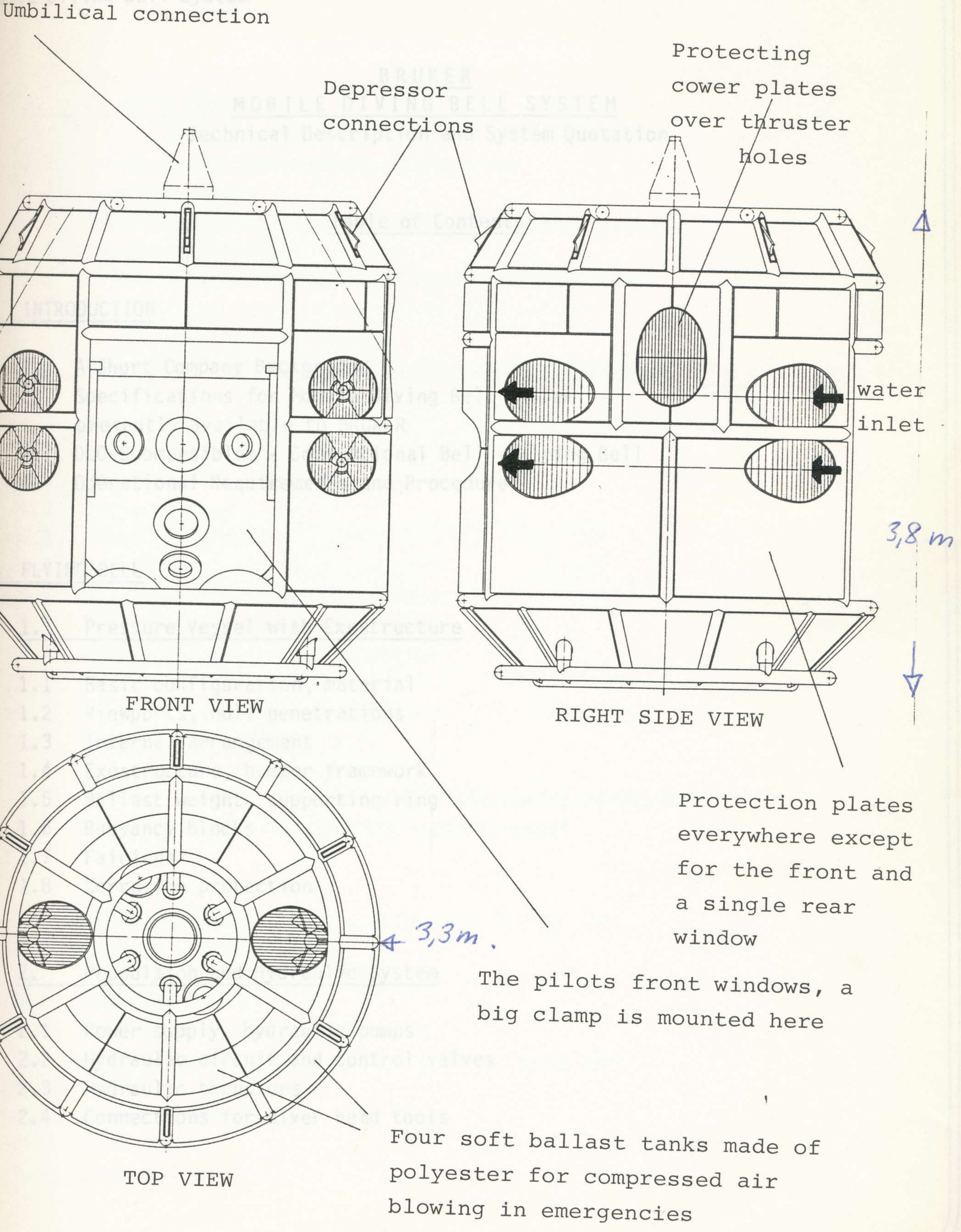
The flying bell incl. control panel and umbilical costs appr. 17.0 mill. D.Kr. A Dräger SDC bell costs appr. 2.5 mill. D.Kr. It seems to be very expensive, but the Stena claims that with a flying bell it will be possible to perform appr. 300 days a year in stead of only appr. 90 days a year in the North Sea region and that the flying bell is only a minor cost of the total ship price.



SECTIONAL VIEW
(seen from behind)



SECTIONAL VIEW
(seen from the top)


Umbilical connection
Depressor connections
Protecting cower plates over thruster holes
water inlet
3,8 m
FRONT VIEW
RIGHT SIDE VIEW
Protection plates everywhere except for the front and a single rear window
3,3m.
The pilots front windows, a big clamp is mounted here
TOP VIEW
Four soft ballast tanks made of polyester for compressed air blowing in emergencies

BRUKER
MOBILE DIVING BELL SYSTEM
Technical Description and System Quotation

Table of Contents

3. Electric System

3.1 Power supply from surface, transformer
3.2 Electric motors
3.3 Transformer/rectifier unit, 120 Volt/24 Volt system
3.4 Emergency battery
3.5 Safety system, monitoring of electrical insulation

4. Operating Devices, Ballast Systems and Life Support

4.1 Soft ballast tanks
4.2 Hard ballast tanks
4.3 Compressed air system
4.4 Oxygen system
4.5 Mixed gas system
4.6 BIB-System
4.7 O_2, CO_2-monitoring, CO_2-scrubber
4.8 Diver heating system, insulation
4.9 Umbilical, umbilical connection

5. Controls, Monitoring

5.1 Control systems installed within the mobile diving bell
5.2 Control console on board the support vessel

6. Special Outfits

6.1 Extendable supporting frame
6.2 Clamping device
6.3 Searchlights, flashlight
6.4 Television systems
6.5 Pinger
6.7 Tracking system
6.8 Gyro Compass
6.9 Sonar System

HANDLING SYSTEM and UMBILICAL WINCH

Not delivered to me

...

not delivered to me.

SYSTEM QUOTATION for
MOBILE DIVING BELL plus HANDLING SYSTEM

BRUKER
MOBILE DIVING BELL SYSTEM

I. INTRODUCTION

1. A Short Company Background

BRUKER MEERESTECHNIK GMBH, a company of the BRUKER group and until 1978 a department of the BRUKER PHYSIK AG in Karlsruhe, Federal Republic of Germany, is now engaged for more than 12 years in the design and construction of manned submersibles, special components and equipment and General Underwater System Technology.

BRUKER Submersibles of the MERMAID class have been built for customers in Italy, the United States and the UK, whereas the latest design of its class, a deep diving submersible with modifications for subsea inspection, diverless intervention, diverlockout, rescue operations and dry/wet transfer techniques, recently has been supplied in two identical units to governmental authorities in the mediterranean area.

Two more rescue submersibles with increased rescue capacity are actually under active negotiation.

The layout and design of advanced handling systems for manned submersibles and system proposals for complete submersible support vessels are also part of the BRUKER activities.

Samples for special components and equipment belonging to the BRUKER pallett of products are: hydraulic rotary actuators, pan and tilt units, remotely operated valves for subsea operations; fixed and steerable hydraulic thrusters from 1,5 to 80 KW power output, heat pump diver heating systems, hydraulic manipulators and tools.

ollowing proposal/quotation is therefore based on these data:

erational depth requirement	450 m
ell capacity	3 divers
ootprint	250 m approx.
equirement to clamp the bell on a structure	
ariable buoyancy	
emote control of bell desirable	
ork capability in currents up to 2 knots	
lassification by DnV	

ne basis of this information, a budget price offer with short description of the ng Bell and later on of the Bell Handling System have been handed over to ERWERK to be incorporated into a complete system quotation.

he following, the proposal for a BRUKER Mobile Diving Bell System is worked out in e detail. It still may be considered as a base for an even more custom tailored em, as soon as more data and information about the customers requirements are lable.

ing closely cooperated with DRÄGERWERK DRUCKKAMMERTECHNIK in other successful jects, BRUKER is convinced to continue it's fruitful contacts also with respect to interfaces between the different systems, in case DRÄGERWERK should win the main BRUKER the Mobile Diving Bell System contract.

ing a discussion in Göteburg covering technical and commerical aspects, Bruker ained important information on the base of which the Technical Description and tation of September 1982 was revised and completed.

DLO-Submersible - Conventional Bell - Flying Bell

free swimming untethered diverlockout submersible ensures the maximum of mobility d flexibility in diver-assisted underwater work. There is no umbilical, which uld entangle on anchor chains and within structures. The support vessel can be kept latively simple with no need for DP systems or other means for station keeping. The ving supervisor working in a shirt sleeve environment in the sub, can directly serve the divers, can assist them and give them a feeling of safety. On the other nd, DLO subs, for a great deal of diving jobs, are presently still submitted to strictions, which are:

...

0/82

e Diving Bell System

andling problems in rough sea
imited gas capacity
imited energy capacity

e problems could be overcome, for example by:

age handling techniques
as reclaim techniques
mproved energy storage techniques

conventional diving bell was, for quite a long period, the only means for
forming deep diving work and thus necessarily is apparently still in the
atively best confidence of divers and diving contractors, despite of its obvious
trictions such as practical immobility, reduced midwater capability, difficult
not impossible work performance close to or within structures and platforms.
plied from the surface, a conventional bell normally suffers from no shortage in
, heat or electrical energy. Being immobile, there is no need to fit out the bell
h highly sophisticated navigational and tracking equipment. From the technical
nt of view, a conventional diving Bell is a relatively simple and inexpensive
ce of equipment with most of the system costs installed on board the vessel.

obile Diving Bell System combines some of the advantages of both, the diverlockout
mersible (mobility) and the conventional bell (no restrictions in gas and
ergy). Handling of a Mobile Bell through a moonpool is safer than the conventional
Frame stern handling of a DLO-Sub and requires no men in the water. On the other
nd, a Mobile Bell is much more than a conventional bell with thrusters clipped on.
requires all technical systems of a free swimming submersible from ballast systems
er maneuvering controls to navigational equipment, except larger battery
pacities. A Mobile Diving Bell therefore comes to costs similar to those for a DLO-
bmersible and even higher, when umbilical and umbilical winch are included.

other advantage of the Mobile Bell versus conventional Bell is the ability to lock
subsea completion systems when suitable adapters are provided.

...

rently, a multi-purpose diving vessel fitted out with a conventional plus mobile
spread will be far ahead compared to a similar system with only one or even two
entional systems.

Operational Requirements and Procedures

he following, the design philosphy of the BRUKER Mobile Diving Bell System shall
xplained through relevant operating criteria. According to our experience with
e swimming submersibles, it is much easier to maneuver the vehicle from within
n in the remote controlled mode. This particularly applies when moving close to a
ucture and in confined areas. It is therefore foreseen, that the Mobile Bell shall
piloted by one of the divers. For safety reasons, all manipulations, such as
euvering and ballasting/deballasting can be carried out by the surface controller
well. Having no one atmospheric command section available as in a DLO-Sub, it is
possible or feasible to install the full spread of electronic monitoring
ipment such as sonar or tracking display units and TV-monitors within the bell.
s type of equipment therefore will be integrated in the surface control console
ether with the usual instrumentation belonging to a conventional bell.

ering a distance of only several hundred meters between the launching point and
working spot requires an accurate course reference, a depth information and a
ative bearing. For this reason, the Mobile Diving Bell will be linked to a short
e tracking system with the display unit installed on surface and the bearing or
rse information transmitted to the bell via underwater telephone.

rrect course information cannot be given but through a north looking gyro compass
stem installed on the bell, with one display within the chamber and another one on
e surface control console. Compass systems based on magnetic effects have proved to
obsolete, latest in the vicinity of structures or pipelines.

...

Being a Flying Bell, the system is neutral buoyant when moving in midwater. Locking out of divers requires negative buoyancy with sufficient safety margin, whereas, also for safety reasons, the bell should be capable to ascend to the surface by it's own, in case the umbilical should be entangled and to be released. While surfacing and when floating on surface the bell should always have a very stable performance, which generally only can be achieved by an adequately designed ballast system with sufficient capacity and the right degree of sensitivity. The ballast system, preferably divided into a soft and a hard ballast tank system, normally will be controlled by the bell's crew. Operating of the control valves from the surface is possible as well.

In many cases, the Mobile Diving Bell will have to be positioned in midwater, i.e. at a certain distance from the bottom. This can be undertaken by clamping the bell to a structure, jacket or the like by means of a hydraulically operated claw with three degrees of motion.

The mobility of the bell is achieved by its propulsion aggregates. Two of them are foreseen on either side of the bell with respect to the main heading direction. This arrangement provides thrust in all directions of a horizontal plane. Motion in vertical direction can be generated by altering the buoyancy conditions. Nevertheless vertical thrusters have proved to be more useful for altering or correcting the level of an underwater vehicle. To avoid obstructions through externally attached thruster units, the two vertical thrusters are slightly inclined and incorporated into the bell's fairings.

Considerable attention has been paid to keep the surface of the Mobile Diving Bell smooth in order to reduce the drag and the danger for entanglement in ropes etc.

As mentioned above, handling in rough seas is one of the most important factors when operating manned underwater vehicles. Handling of the Flying Bell through a moonpool was one of the customers requirements. Besides this, there are several approaches thinkable for the actual launching and recovery of a Mobile Bell. A real cage handling system, as often and successfully practised with remotely operated vehicles (ROV) was abandoned at an earlier discussion due to technical implications such as the requirement for two umbilical winches, one of them to be suitable for operation subsurface.

Also a heave compensation system for the lifting wires was found not to be required in case other means such as sufficient negative buoyancy plus downward directed thrust in connection with a strong enough umbilical and a device absorbing load peaks are provided to prevent impacts between the bell and the cage/depressor hanging below the vessel. While a conventional diving bell is normally sufficiently negative to pass the air/water interface straight downwards, a Flying Bell must be basically neutral with only restricted possibilities to become negative by flooding of the hard ballast tanks. The required force downwards is therefore provided by a depressor weight to which the bell rigidly can lock on. The depressor is hanging on two lifting wires going to the lifting winches. It is foreseen to lower the bell locked on the depressor weight to a depth of 50 m minimum, preferably 100 m or more. During lowering (or lifting) the ships vertical motion is added to the vertical motion of the bell/depressor with no critical aspect so far.

When the bell/depressor unit has been stopped and the bell unlocks from the depressor, it must be made sure, that the vertical acceleration transferred from the ship to the depressor and bell is overcome by downward directed forces acting on the bell. This will be achieved by running the vertical thrusters at full thrust down after having flooded the ballast tanks. Before approaching the bottom, the bell will be trimmed neutrally buoyant and the vertical thrust is reduced. As soon as there is slack in the umbilical, the ships motion is completely uncoupled from the Mobile Bell. The bell maneuvers towards the working area and either clamps on the structure or sits on the bottom with the support structure extended and the hard tanks completely flooded.

For retrieval, the bell moves back into a position underneath the depressor where the slack has to be taken out of the umbilical before the bell takes on water in the hard tanks and thrusts down. The bell is now pulled into the depressor by means of the umbilical winch. Locking of the bell to the depressor is undertaken automatically by spring loaded latches, unlocking by means of hydraulic actuators from within the bell. Lifting of the bell is now performed by means of the lifting winches whereas the umbilical winch runs synchroniously to coil the umbilical.

...

oming to the ship's bottom, the bell/depressor unit is caught by the cursor unning in the moonpool and the whole package consisting of the bell, depressor nd cursor is lifted underneath the trolley. The guide posts of the depressor it into their counterparts in the trolley. For connection of the flying bell to he DDC, the trolley moves horizontally, the bell becomes lowered to the mating lange where a clamp ring ensures the pressure tight connection.

t is foreseen to fit both, the lifting winches and the umbilical winch, on the trolley and also to install the hydraulic aggregates and control valves there, thus providing a very compact unit with only electrical connections and the umbilical connection to be made flexible.

The umbilical winch and winch motors are designed to take full advantage of nearly the breaking strength of the umbilical in order also to be able for recovering the bell when flooded in the worst case.

All functions of the bell handling system including umbilical winch should be remotely controlled either from the control console or a portable control box as well. The hydraulically operated winch motors therefore are controlled via proportional valves or flow controlled hydraulic pumps.

...

iving Bell System

FLYING BELL

essure Vessel with Exostructure

1 Basic configuration, material

e main pressure vessel of the Mobile Bell consists of two hemispheres with a ylindrical section between. The external diameter of the cylinder and the emispheres is 1900 mm. The lockout trunk situated in the bottom of the bell has diameter of 700 mm providing a comfortable passway also for divers with heavy quipment.

he transfer cylinder is topped by a bayonett-type hatch which seals in both irections. The hatch will be opened/closed hydraulically with manual overrides.

The lower edge of the divers passway is formed by a mating flange fitting to the DDC. Exchangeable skirts can be foreseen, if so required, for dry or wet transfer to subsea completion chambers or similar.

For weight- and buoyancy reasons, the main pressure hull is made of high tensile, fine grain steel.

1.2 Viewports, hull penetrations

All together there are fourteen viewports arranged in the chamber walls, providing good visibility in all directions.

Four viewports are situated in the upper hemisphere, four around the exit trunk in the lower hemisphere. Four viewports looking in foreward direction, one of them situated in the lower hemisphere as well, the other ones in the cylindrical section. Another two viewports in the cylindrical part are looking aftwards.

The viewports have internal diameters between 180 and 260 mm, they are made of acrylic plastic.

All through-hull penetrations for electrical cables, hydraulic lines and gas pipework are made of stainless steel.

...

1.3 Internal arrangements

The Mobile Diving Bell is fitted out for three divers. The floor plating is made of seawater resistant, anodized aluminium. Three foldable seats are arranged on the wall of the chamber. Another chair will be adjustable in height and direction to ensure an optimum position for the operator piloting the bell. Most of the control functions will be incorporated into a portable control console following the operator when looking through different portholes.

Further bell instrumentation will be installed in control panels on the chamber wall.

Minor outfits of the chamber, such as hooks for the diver's umbilicals, racks for survival suits, first air kits, spare CO_2-absorbant, personnel equipment etc. are self-evident.

1.4 Exostructure, bumper framework

The Mobile Bell and its externally attached equipment is protected by a strong framework made of steel pipe. The protecting cage will be bolted to the bell by means of studs and consists of an upper and lower section.

Brackets, fasteners etc. for the external equipment, the hydraulic and electric pods are altogether welded to the protecting framework, not to the bell itself.

1.5 Ballast weight, supporting ring

For easier locking of the bell to the flange of the tranfer- or decompression chamber, the lower edge of the passway trunk and the lower ring of the protecting cage are on the same level.

achieve sufficient space between the seafloor and the divers exit, when the l is sitting on the bottom, an extendable supporting structure is provided. e lower part of the supporting structure is formed by a ballast weight ring de of cast iron. Extension/retraction of the ring is performed by means of ree hydraulic cylinders and telescopic guiding tubes. The hydraulic cylinders e fitted out with controllable check valves to prevent inadvertent retraction the structure in case of a leaking main control valve or the like.

6 Buoyancy blocks

espite the intention to design the main pressure vessel as light as possible, ost probably additional buoyancy might be required to compensate the weight of he bell and its appendices. This can be achieved according to the requirements f the weight balance, by fitting buoyancy blocks made of syntactic foam in the pace between the bell and the protecting cage, not required for the soft allast tanks, the vertical thrusters or for the topside viewports.

he buoyancy blocks will be cast into molds adapted to the fairings and rotected by a layer of reinforced fibreglass.

.7 Fairings

All frames between the braces of the protecting cage, which are not filled by buoyancy blocks or soft ballast tanks are covered with fairings to reduce the hydrodynamical drag of the bell, to avoid entanglement and to achieve a smooth design.

The fairings are made of glassfiber reinforced polyester resin and attached to the protecting cage by means of stainless steel screws. They can easily be removed to make the subsystems outside the bell accessible.

...

8 Corrosion protection

pecial care will be taken with respect to corrosion protection.

he main hull will be sandblasted externally and internally and thereafter zink pray galvanized, following two coatings of epoxi-primer and at least one oating of epoxi top coat.

he externally mounted gas containers, hydraulic and electric pods, as far as hey are made of steel, are protected from outside the same way as the main hull.

he protecting cage will be sandblasted and hot zink galvanized. After two coats f a special primer follows an epoxi coating as well.

The inserts for the through hull penetrations are made of stainless steel, as well as all external and internal piping for the gas and the hydraulic system, except the high pressure oxygen piping.

All faces of flanges are made of, or covered, by a stainless steel layer.

As far as aluminium is used for subsystems and components, it will be seawater resistant and anodized. Hydraulic cylinders are made of stainless steel and chrome plated brass. Externally mounted valves will consist of either chrome plated brass or stainless steel. Internal hull stop valves are made of brass or stainless steel as well.

Zink anodes arranged on the protecting cage will complete the precautions for corrosion protection.

...

10/82

pulsion and Hydraulic Systems

for BRUKER submersibles in the past, an electro-hydraulic system has been eseen to drive the hydraulic thrusters and to operate all moving mechanical ipment such as extendable support structure, clamping device, lockout hatch , lock-on latches.

main advantages of a hydraulic energy conversion compared to an electrical are: small weight and size, high energy density, high forces, easy stepless trol and no problems with electrical leaks.

Power supply, hydraulic pumps

achieve smaller units and redundancy, the required hydraulic energy will be plied to two identical units both feeding into a common hydraulic network.

hydraulic pumps are of the variable flow, pressure controlled type. Thus the rgy consumption is continuously adapted to the actual needs and no heat hangers or coolers for the hydraulic system are required.

hydraulic pumps and their three phase high voltage AC motors are installed pods forming pressure compensated oil reservoirs at the same time. The raulic pods are installed opposite the bell's heading side.

2 Hydraulic circuits and control valves

mentioned above, both hydraulic pumps feed into a common hydraulic circuit. hydraulic systems can be operated, when only one of the pumps is working.

hydraulic circuits are pressure compensated, which means, that the back flow pressure is kept slightly above the actual ambient pressure, thus preventing awater from penetrating into the hydraulic system which could cause corrosion thus malfunction of the control valves.

...

e control valves for the thrusters are of the electrically operated oportional type, the valves for the other hydraulic equipment of the 4/3 way pe with throttle plates installed in the hydraulic lines to allow for dividual adjustment of working speeds.

ne hydraulic control valves are easily accessible, installed in a pressure ompensated box with hydraulic and electrical connections.

.3 Hydraulic thrusters

n total six thrusters are foreseen for the propulsion of the Mobile Diving Bell n three degrees of freedom. Two on either side of the bell with horizontal hrust direction and two with slightly inclined vertical thrust direction. The ix thrusters are installed in tunnels in order not to disturb the flow of water et which would reduce the efficiency of propulsion. The tunnels are protected y grids on both ends. The thruster units are incorporated into the fairings and rotecting cage of the bell.

he thrusters consist of radial piston hydraulic motors installed in an luminium housing with the propeller directly coupled to the motor shaft. Built-n rpm sensors allow for correctly adjusting the propeller speed also in onnection with an automatic pilot which is optional. The thrusters have ontinuous speed control in both directions.

2.4 Connections for diver held tools

On DLO-Subs with hydraulic propulsion systems, it proved to be advantageous to have connections available for diver held tools. Therefore two pairs of quick connections with shut off valves will be installed, allowing for feeding of all kinds of commercially available hydraulic unterwater tools such as grinders, drills, impact wrenches, cutters, brushes, saws, etc. with a flow rate and pressure requirement not extending the installed pump capacity of approx. 180 ltr./min. at 200 bar equivalent to 60 KW.

Tools can be carried in externally mounted racks or lockers.

System

wer supply from surface, transformer

power supply for the Mobile Bell is achieved from the surface out of the
lectric circuit, via umbilical. Due to the restricted cross section of
dized, commercially available umbilicals, a relatively high voltage
) has been choosen to supply the electric motors. The transformer unit to
alled on board the ship is part of the delivery volume of the Mobile
Bell System.

lectric motors

ectric motors to run the two hydraulic aggregates will be oil immersed and
1000 Volt three phase AC. The relays for the main electric motors will be
mersed as well.

Transformer/rectifier unit, 120 Volt/24 Volt System

earchlights, most probably the TV-Camera systems and the diver heating
m will be supplied out of a 120 Volt DC net. All the rest of the controls,
rs, instrumentation etc. run on 24 Volt DC.

upply the 120 Volt and the 24 Volt DC-circuit, a transformer unit with
fier will be installed outside the Mobile Bell.

...

control valves for the thrusters are of the electrically operated portional type, the valves for the other hydraulic equipment of the 4/3 way e with throttle plates installed in the hydraulic lines to allow for ividual adjustment of working speeds.

hydraulic control valves are easily accessible, installed in a pressure pensated box with hydraulic and electrical connections.

Hydraulic thrusters

total six thrusters are foreseen for the propulsion of the Mobile Diving Bell three degrees of freedom. Two on either side of the bell with horizontal ust direction and two with slightly inclined vertical thrust direction. The thrusters are installed in tunnels in order not to disturb the flow of water which would reduce the efficiency of propulsion. The tunnels are protected grids on both ends. The thruster units are incorporated into the fairings and otecting cage of the bell.

e thrusters consist of radial piston hydraulic motors installed in an uminium housing with the propeller directly coupled to the motor shaft. Built- rpm sensors allow for correctly adjusting the propeller speed also in nnection with an automatic pilot which is optional. The thrusters have ntinuous speed control in both directions.

.4 Connections for diver held tools

n DLO-Subs with hydraulic propulsion systems, it proved to be advantageous to ave connections available for diver held tools. Therefore two pairs of quick onnections with shut off valves will be installed, allowing for feeding of all inds of commercially available hydraulic unterwater tools such as grinders, rills, impact wrenches, cutters, brushes, saws, etc. with a flow rate and ressure requirement not extending the installed pump capacity of approx. 180 tr./min. at 200 bar equivalent to 60 KW.

ools can be carried in externally mounted racks or lockers.

e Diving Bell System

tric System

Power supply from surface, transformer

main power supply for the Mobile Bell is achieved from the surface out of the
p's electric circuit, via umbilical. Due to the restricted cross section of
ndardized, commerically available umbilicals, a relatively high voltage
00 V) has been choosen to supply the electric motors. The transformer unit to
installed on board the ship is part of the delivery volume of the Mobile
ing Bell System.

2 Electric motors

e electric motors to run the two hydraulic aggregates will be oil immersed and
rk on 1000 Volt three phase AC. The relays for the main electric motors will be
l immersed as well.

.3 Transformer/rectifier unit, 120 Volt/24 Volt System

he searchlights, most probably the TV-Camera systems and the diver heating
ystem will be supplied out of a 120 Volt DC net. All the rest of the controls,
ensors, instrumentation etc. run on 24 Volt DC.

To supply the 120 Volt and the 24 Volt DC-circuit, a transformer unit with
rectifier will be installed outside the Mobile Bell.

...

Emergency battery

4 Volt gel type dry lead acid battery serves for emergency power supply in se the umbilical should be broken, cut or released. It feeds the CO_2-rubbers, the wireless communication system, internal emergency lighting, the ashlight and some more items, which might be of importance.

e emergency battery will be installed within a pressure compensated oil filled sing outside the bell.

.5 Safety system, monitoring of electrical insulation

or safety reasons, the maximum voltage to be dealt with in the bell will be 24 V C. All electrical installations will be unearthed, switched and protected on oth poles.

or checking the electrical insulation values between mass and the ositive/negative pole or the three phases of the AC-system. Ohm-meters will be installed in the surface control console for each system.

In case of an insulation failure in one of the high voltage systems, a safety device cuts off this system automatically.

Operating Devices, Ballast Systems and Life Support

4.1 Soft ballast tanks

The Mobile Diving Bell will be fitted out with four each soft ballast tanks to provide spare buoyancy for emergency surfacing and stability when the bell is floating on the surface. The ballast tanks are situated within the protecting cage on the topside of the bell. They are made of reinforced polyester resin. The soft ballast tanks are fitted out with one solenoid operated vent valve each and a solenoid blowing valve. On the lower edges of the soft tanks there are slots for free entering of the water when being vented or outlet of the water when the tanks are blown.

...

For blowing, the tanks are connected to the compressed air system. In case of a total electrical blackout, blowing can also be done manually.

4.2 Hard ballast tanks

Most important for operating the Mobile Diving Bell is the hard ballast tank system which allows for correctly adjusting the vehicles positive, neutral or negative buoyancy. It's capability range has to be sufficient to compensate the weight of the diver's leaving the bell and additionally to achieve enough negative buoyancy when the bell is standing on the bottom on it's supporting structure. Furthermore negative buoyancy is required during the unlocking/locking procedure to the depressor as mentioned above.

Two pressure resistant hard ballast tanks are installed on each side of the bell underneath the horizontal thruster tunnels.

The hard ballast tanks are of cylindrical shape with hemispherical caps and made of high tensile steel. Each tanks is fitted out with a large sized water inlet-outlet valve on the bottom, a smaller one vent valve, a blowing valve and a pressure relief valve which also serves for water outlet for emergency blowing.

The main controls for the hard ballast tanks are remotely operated electrohydraulical valves. Emergency blowing can be undertaken by manual overrides. Both hard tanks can be flooded/vented separately and independently.

Electrical readouts show the actual content of water in the hard tanks. A semiautomatic switch simplifies the ballast adjustment in the hard tanks.

4.3 Compressed air system

The high pressure air for blowing the soft and the hard ballast tanks is stored in two spherical air containers installed around the exit trunk. Under normal operating conditions, one air container feeds the hard ballast tank system, the other one the soft tanks. Both systems can be interconnected. Furthermore, the air system can be supplied out of the mixed gas system.

...

essure gauges and manifolds for the compressd air systems are installed on a nel in the bell. A manifold for charging the air system and the other gas ystems as well is installed outside on top of the bell.

.4 Oxygen system

he oxygen required for the life support system will be stored in either two 50 tr. cylinders or an equivalent of smaller cylinders depending on the vailability of space on the final design. The oxygen system will be divided nto two cross-connectable subsystems with pressure reduction valves installed utside the bell. Oxygen feeding into the chamber atmosphere will be undertaken by adjustable flow meter with manual override.

.5 Mixed gas system

Under normal operational conditions, the breathing gas will be supplied from the surface via umbilical. For emergency situations, mixed gas is stored in four spherical high pressure gas containers installed around the exit trunk as well.

The four gas containers are connected to form two independent subsystems with cross connection capability. One subsystem serves primarily for pressurization or pressure equalization of the bell, the other one for back up feeding of the divers breathing equipment.

Manifolds and pressure gauges for the mixed gas system are installed in the bell on a control panel. Three connections for the diver's umbilicals are foreseen to be layed out according to the customers requirements.

4.6 BIB system

The BIB System installed in the Mobile Diving Bell consists of three 1) breathing masks with regulators connected to shut off valves. The BIB System is fed out of the mixed gas system via dome loaded pressure regulator.

1) 1984 regulation:
- three BIBS for three men
- one spare BIBS

O_2-, CO_2-Monitors, CO_2-scrubber

rder to continuously survey the O_2 and CO_2-content one ea. O_2-meter and CO_2-
er is installed in the control panel in the bell.

more monitors are part of the surface control console.

emergency gas analysis, a Drager Kit with handpump and reactive tubes will
supplied.

CO_2-Scrubbers driven by hermetically sealed 24 Volt DC electric motors are
stalled in the bell. Spare charges of Soda Sorb can be stored in special racks.

8 Diver heating system, insulation

e bell will be covered by a 30 mm layer of cast syntactic foam protected by a
yer of reinforced fibre glass to achieve a better insulation against heat
osses.

ne heating system itself is layed out to supply up to three divers plus the bell
ith heat energy. The heat is generated electrically and transferred to the
losed loop hot water circuit via heat exchanger and circulating pump. The
rimary temperature is regulated by automatically switching on/off one or more
f the heating coils. The individual heat requirements for the divers can be
adjusted by flow control valves.

The heating system includes the piping, a bell radiator and manifolds with
connections of up to three divers umbilicals for closed loop hot water diving
suits.

Integration of a surface supplied hot water system for open loop suits is
possible on demand.

) changed to open system
) changed to hot water from umbilical system.

4.9 Umbilical, umbilical connection

It is foreseen to use the same standardized umbilical for the Mobile Diving Bell as for the conventional bell. This umbilical will have the following performances:

- internal stress member for for emergency lifting of the bell
- 3 ea. hoses for hot water supply and gas exhaust; 3/4" dia.
- 1 ea. hose for gas supply; 1/2" dia.
- 5 ea. hoses, pneumo lines; 1/4" dia.
- 6 ea. electrical conductors for main power supply, 6 mm^2 36
- 3 ea. electrical conductors for auxiliary power supply, 2,5 mm^2 7,5
- 21 in total screened pairs of electrical conductors for data transmission and control functions 7,5
- 4 ea. coax wires for video transmission

43,5

The umbilical is of electrical plus hose composition type and almost neutral in seawater.

Note: Following discussions in Gothenburg on October 18th, 1982, the standard umbilical shall be strengthened for a load capacity of 12 tons. The hot water supply hose may be dropped to keep the overall diameter of the umbilical constant.

Furthermore, the number of electrical conductors may be adapted to the requirements.

Technical details are being discussed with the subsupplier.

The connection between umbilical and Mobile Bell will be mechanically releasable by means of a hydraulically actuated coupling.

1) A guillotine for emergency cutting of the umbilical is therefore not foreseen but could be installed on demand.

1) the umbilical can be jettizoned from inside the bel

Controls, Monitoring

.1 Control systems installed within the Mobile Diving Bell

As mentioned before, there are some basic restrictions for installation of electric/electronic monitoring equipment and controls within a hyperbaric chamber such as fire hazards by electric sparks, high voltage and implosion of hollow bodies on the equipment (bulbs, tubes, etc.).

The following controls and instrumentation, which are mandatory for the operation of the Mobile Bell, thus are designed fail safe or encapsulated in pressure tight housings:

- thruster control levers
- switches/push buttons for operating the ballast system control valves, the hydraulic equipment, searchlights etc.
- communication systems
- CO_2 / O_2 monitors
- gyro compass repeater
- water level indicators for the hard ballast tanks
- rpm indicators for the hydraulic thrusters

Furthermore, the instrumentation of the Mobile Bell will consist of:

- two ea. pressure gauges for compressed air system
- two ea. pressure gauges for oxygen system
- two ea. pressure gauges for mixed gas system
- one ea. pressure gauge for internal pressure
- one ea. pressure gauge for ambient pressure (depth gauge)
- one ea. thermometer for bell atmosphere and hot water system
- one ea. hygrometer
- one ea. plotting board to mark the position of the ship, the working spot, transponders, eventual obstacles, the bell etc.

5.2 Control console on board the support ship

It is foreseen, either to integrate the manifolds, monitoring devices and instrumentation required for the operation of the flying bell into the main control console system (Dragerwerk) or at least to use a similar design principle.

e control console for the Mobile Diving Bell System will be divided into three ctions including:

Survey of the Diving Bell functions such as:

- internal and ambient pressure
- temperatures
- CO_2/O_2 contents in the breathing gas
- manifolds for gas control
- manifolds for hot water supply eventually
- TV-monitor connected to fixed camera (observation of the bell's crew)
- Communication systems, on line and wireless, between surface and bell including helium unscrambler

Installations for remote maneuvering control of the Mobile Bell:

- slave tracking monitor (from the SIMRAD Tracking System)
- gyro compass repeater
- actuators for hydraulic circuits
- thruster control levers
- rpm indicators for thrusters
- controls for hard ballast tank system
- depth gauge
- echograph (printing echosounder, optional)
- TV-monitor, linked to the pan and tilt camera
- obstacle avoidance sonar monitor. System EDO 4081 or equivalent

) Controls for the Mobile Bell handling system, including:

- main switches
- pressure gauges for hydraulic pressure
- signal lamps for different system-status
- control levers for stepless, continuous control of the winch motor speeds
- indicator for the actual depth of the depressor
- indicator for actually paid out umbilical length

...

Special Outfits

6.1 Extendable supporting frame

The ballast weight in form of a cast iron ring can be extended by means of three hydraulic cylinders guided by telescopic tubes. Due to the high spare buoyancy capacity achieved by the soft ballast tanks, it is actually not foreseen to make the ballast weight droppable. A dropweight design is available on demand.

Controllable check valves protect the frame against inadvertent retraction due to leaking control valves while the divers are locked out.

6.2 Clamping device

The clamp for attaching the bell to a structure will be mounted in the heading direction of the bell above the viewports in the cylindrical section. It is operated by means of hydraulic cylinders and can be moved in three axis: opening/closing, approx. 90 deg. rotation around the horizontal axis to grip braces from horizontal to vertical and 90 deg. inclination around abeam horizontal axis to retract the claw within the protecting cage. To prevent inadvertent opening or motion of the claw due to oil creeping through the control valves, controllable check valves are installed in the hydraulic lines for the cylinders.

6.3 Searchlights, flashlights

The Mobile Bell will be fitted out with three searchlights (more optional) two of them looking foreward, one looking aft. One of the foreward looking lights is attached to a hydraulically operated pan and tilt unit with approx. 90 deg. motion angle in both directions.

A stroboscopic flashlight is installed on top of the bell for easier identification by the divers or for location of the bell floating on surface in case of emergency.

Television systems

identical low light black and white television cameras, make IBAK UF9 or valent, to be installed on the bell. One of them fixed and looking into the ber for observation of the divers crew, the other one on a pan and tilt unit oserve the area ahead of the bell. The pan and tilt unit is based on hydraulic ry actuators again. One of the cameras will be layed out to be removed by a er for close up documentation within the working area.

Underwater telephone, helium unscrambler

Mobile Diving Bell System is fitted out with a helium voice unscrambler unit e Helle model 3342 or equivalent. The surface unit to be installed in the trol panel, one speaker/microphone is installed in the bell and a selecting tch is foreseen to achieve connection to either diver.

r safety reasons, a wireless underwater telephone, type Helle model 3120 or uivalent, consisting of a bell unit and a surface unit, is part of the system uipment. The wireless telephone can be connected to the helium voice scrambler to achieve nearly distortion free communication.

.6 Pinger

ne bell to be fitted out with a battery powered pinger for relocation when arted from the umbilical in emergency situations.

...

7 Tracking system

e ship will be fitted out with a SIMRAD 309 tracking system, which will be stalled on the bridge. A slave monitor will be installed in the remote control nsole for the Flying Bell, a transponder attached to the bell. Both will be pplied by the contractor for the DP system, the console etc. prepared for tegration by the supplier of the flying bell.

8 Gyro compass

mentioned before, a north looking gyro compass seems to be mandatory for aneuvering of underwater vehicles without visual contact to the target or other irection showing means.

herefore, a Subsea Gyrocompass installed in a pressure resistant housing, make obertson, will be fitted outside the main pressure hull of the Mobile Bell. he control box with heading indicator to be installed in the maneuvering ontrol console, another analogue repeater to be mounted on the control box in he bell. The compass works on 24 Volt DC.

.9 Obstacle avoidance sonar

he Flying Bell will be fittd out with an obstacle avoidance sonar system Typ DO-Western Model 4081 OAS-2 for detection of obstacles, structures etc. beyond he range of visibility.

e system will consist of the following components:

display unit
sonar control unit
video processor
multiplexer

l to be installed in the surface control desk, plus

subsea electronic unit
transducer/scanner

o be installed on the Flying Bell.

or reasons mentioned before, the sonar monitor cannot be installed in a yperbaric environment. The system therefore will be used when the bell is perated in the remote control mode or for verbal information to the bell driver bout the position of obstacles.

o avoid an abundant figure of wires in the umbilical, the system is fitted out ith a multiplexer unit reducing the number of wires to one pair.

...

iving Bell System

hnical Data

Overall dimensions and data

erational depth	450 m
ight in air	approx. 10.000 kg 1)
ew	3 divers/operator
ameter over exostructure	3200 mm
ight over protecting frame	approx. 3600 mm (max.)
amber diameter	1900 mm
ight of chamber over hemispheres	approx. 2600 mm (max.)
it trunk diameter	700 mm
ne bayonet type double acting nternal hatch)	
ortholes, 14 ea.	int. dia. 180 and 260 mm

.2 Hydraulic system, propulsion

aximum hydraulic power available	approx. 2 x 30 KW 2)
aximum hydraulic pressure	200 bar
aximum flow rate	2 x 90 ltr/min
hrusters	four ea. horizontal thrusters two ea. vertical thrusters
shaft power	10 KW ea.
thrust	2500 N ea.
rpm - range	0 - 500 rpm
Expected speed of the Mobile Bell	approx. 3 knots

7.3 Electric system

Main power supply	3 phase 1000 Volt AC
Auxiliary voltage	120 Volt DC 24 Volt DC
Output of main electric system	approx. 2 x 35 KW
Emergency battery	dry, gel type, lead acid, 24 Volt, 200 Ah

1) changed 2/85 to 13 tons
2) changed 2/85 to 2 x 35 kW

...

10/82

Operating devices, gas- and ballast system

capacity, compressed air	2 x 100 ltr. at 200 bar
capacity, mixed gas	4 x 110 ltr. at 200 bar 440
capacity, oxygen	2 x 50 ltr. at 200 bar
l ballast tank capacity	approx. 2 x 330 ltr. = 660 ltr.
t ballast tank capacity	approx. 4 x 250 ltr. = 1000 ltr.
al capacity of heating system:	equivalent to approx. 7,5 KW
iable buoyancy :	600 kg

Umbilical

ngth	approx. 400 m 1)
ameter	approx. 90 mm 2)
eaking strength	approx. 12 tons 3)
eable strength	approx. 10 tons 4)
ight in water	approx. almost neutral

r number and size of hoses and electric conductors see 4.9.

are Parts and Tool Package

n on-board spare part and tool package will be supplied and included in the ystem price. The spare parts and tools are the property of the manufacturer ntil the system has been handed over. They must be made available to personnel f the manufacturer on demand when carrying out installation, maintenance or uaranty work. Spare parts, material or tools consumed or used by the seller on he above mentioned occasions are replaced free of charge.

anged 2/85 to 480 meters.

anged 2/85 to 97 mm.

anged 2/85 to 16 tons

anged 2/85 to 13 tons

...

he spare part package will include the following:

1 ea. set of assorted stainless steel bolts and nuts
1 ea. set of assorted lip seals and o-rings for
    portholes and exit hatch
1 ea. set of assorted pipe fittings
1 ea. set of assorted shut off valves
1 of ea. type of remotely operated valves for the ballast system
1 ea. set of assorted seals and o-ring for hydraulic system
1 ea. set of assorted fuses and signal lamps
1 ea. set of assorted small electrical parts

he tool package will consist of:

1 ea. set of spanners
1 ea. set of box wrenches
1 ea. of allan keys
1 ea. set of special pliers
1 ea. set of special tools for hydraulic system
other tools which will prove to be suitable during final
assembly of the system

...

PRESS RELEASE 2/85

BRUKER introduces FLYING BELL

wn as a manufacturer of manned submersibles and autonomous submarines, BRUKER RESTECHNIK GMBH of Karlsruhe, W. Germany is now constructing it's first hered and partly remotely controlled system, a mobile diving bell called ying Bell".

design is based on the requirements and specifications the swedish offshore cialist, STENA, and the experience gained from the MERMAID-Class diverlockout mersibles designed by BRUKER in the past decade.

flying bell units are now under construction at Karlsruhe, to be installed on two highly sophisticated Multi-Purpose Diving Support Vessels of the Stena WELL class presently being built at Sunderland Shipbuilders Ltd. in the U.K. contracts between BRUKER and the yard as general contractor, worth in the order DM 9 million, were signed early in 1984.

pressure vessels recently were submitted to internal and external hydrostatic ssure tests, the latter at the GUSI facilities at Geesthacht, under supervision Det Norske Veritas as classification society.

"Flying Bell" concept was first presented to the public at the Offshore ibition in Göteborg on 25.2. - 1.3.85 in form of a true scale mockup shown on the NA stand.

5

eral attempts have been undertaken in the past to overcome the passive and obile role of conventional diving bells, i.e. installation of a rotatable uster, development of a mobile diving unit (MDU), a large 20 ton system with one osphere control compartment on top of a lockout compartment and various mobile hered one atmospheric bells without facilities to lock out divers.

Flying Bell combines the mobility and manueverability of a diverlockout mersible and the unlimited resources advantages of a conventional diving bell, plied with breathing gas, electrical energy, hot water for heating purposes and ta transfer through an umbilical. Furthermore, handling of the Flying Bell rough a moonpool, assisted by cursor and depressor, will be less weather pendent than handling of a submersible via stern mounted A-frame.

e unconventional features of the Flying Bell SDC are:

full scale submersible-like ballast system, including main ballast tanks for free ascent, double hard ballast tank system for accurate buoyancy control, connected to HP drain pump system and to HP gas system as back up.

six powerful hydraulic thrusters, including two vertical thrusters with abeam-thrust capabilities and four horizontal thrusters.

double hydraulic power packs for supply of the thruster units, other hydraulic equipment and diver held tools.

large hydraulically operated claw to attach the bell to a structure and hydraulically extendable pedestal.

submersible-like navigational aids such as: north seeking gyro compass, autopilot, sonar system, echosounder/echograph and tracking transponder.

hermore there will be installed; two underwater television systems, one fixed an and tilt unit, the other one removeable for use by divers, hard wire unication with helium unscrambler, wireless underwater telephone, emergency sponder, searchlights, flashlight etc.

Flying Bell can be remotely operated from the maneuvering control console on rd the support vessel or by the diving crew from within the bell.

97 mm dia umbilical is fitted out with a unique termination releaseable from hin the bell. It incorporates power and signal cables, hoses for gas supply and trol purposes and hot water hose pipes.

roximately 150 different data and command signals to be transferred between the ing Bell and surface control console are handled by a specially developed lemetry system.

spite the somewhat higher price of a Flying Bell System compared to the nventional SDC, the advantages will, depending on the type of work, obviously y out shortly. Even under good weather conditions, the diving support vessel st often stay away from a platform due to loading activities or external erwater maintenance. On many other occasions, a conventional diving bell cannot t close enough to the worksite and complicated cross hauling techniques have to e applied. The mobility of the Flying Bell thus can cut the diving time and costs rastically.

85

ING BELL

main particulars of the Flying Bell are:

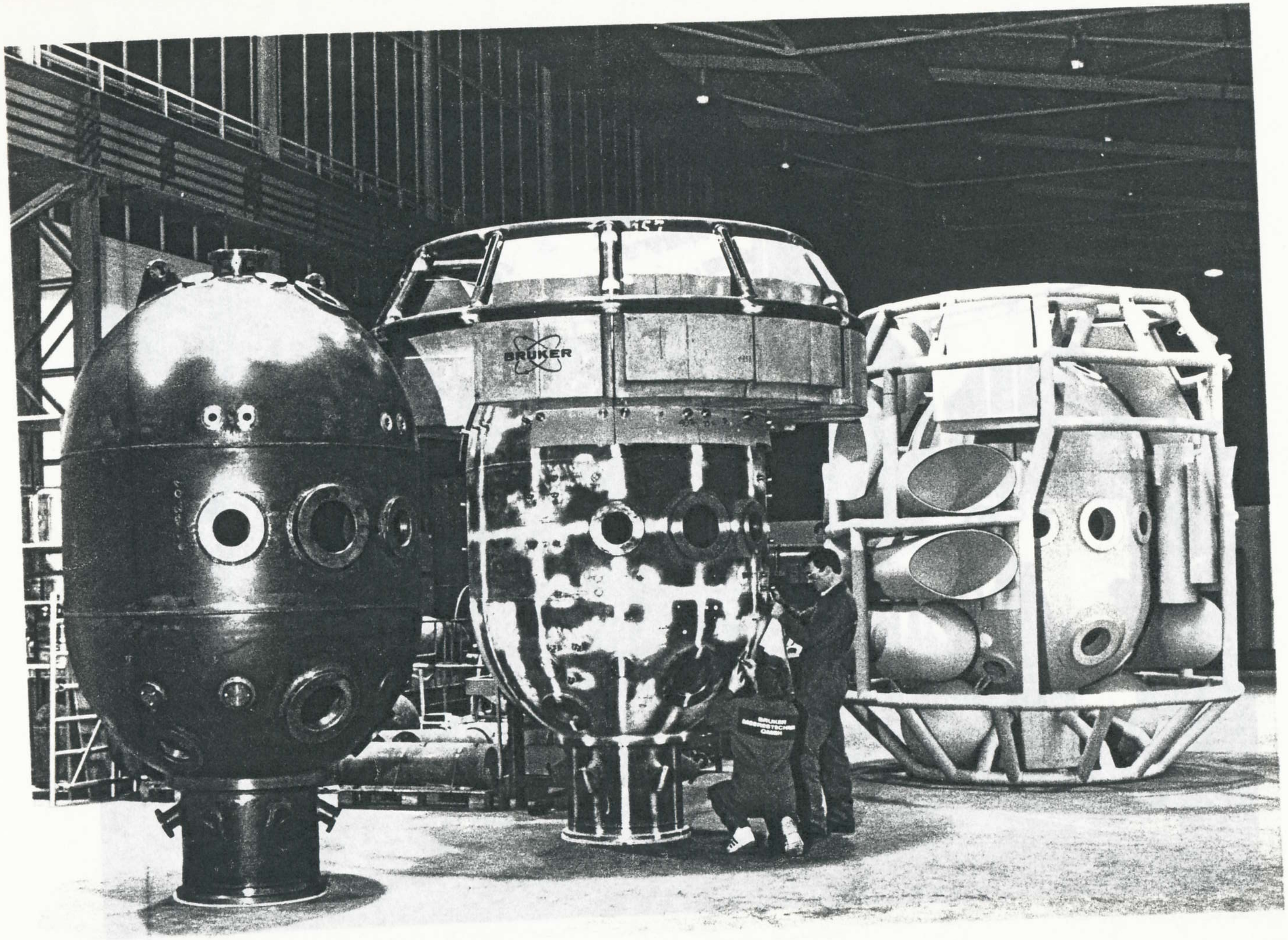
th rating :	450 m
ilical length :	480 m
w :	3 divers (2 + 1 Bellman)
meter overall :	3,3 m
ght overall :	3,8 m
ameter of divers chamber :	1,9 m
ight in air :	approx. 13 to
draulic power packs :	2 x 35 KW
rusters :	6 x 10 KW
riable buoyancy :	approx. 600 kg

e Bruker delivery volume comprises the Flying Bell units and all equipment nstalled, umbilicals with slipring assemblies and rotary unions, surface control anel and installations on board to interconnect the subassemblies.

e shallow water trials at the company owned facilities at Karlsruhe will start in ummer 1985.

/85

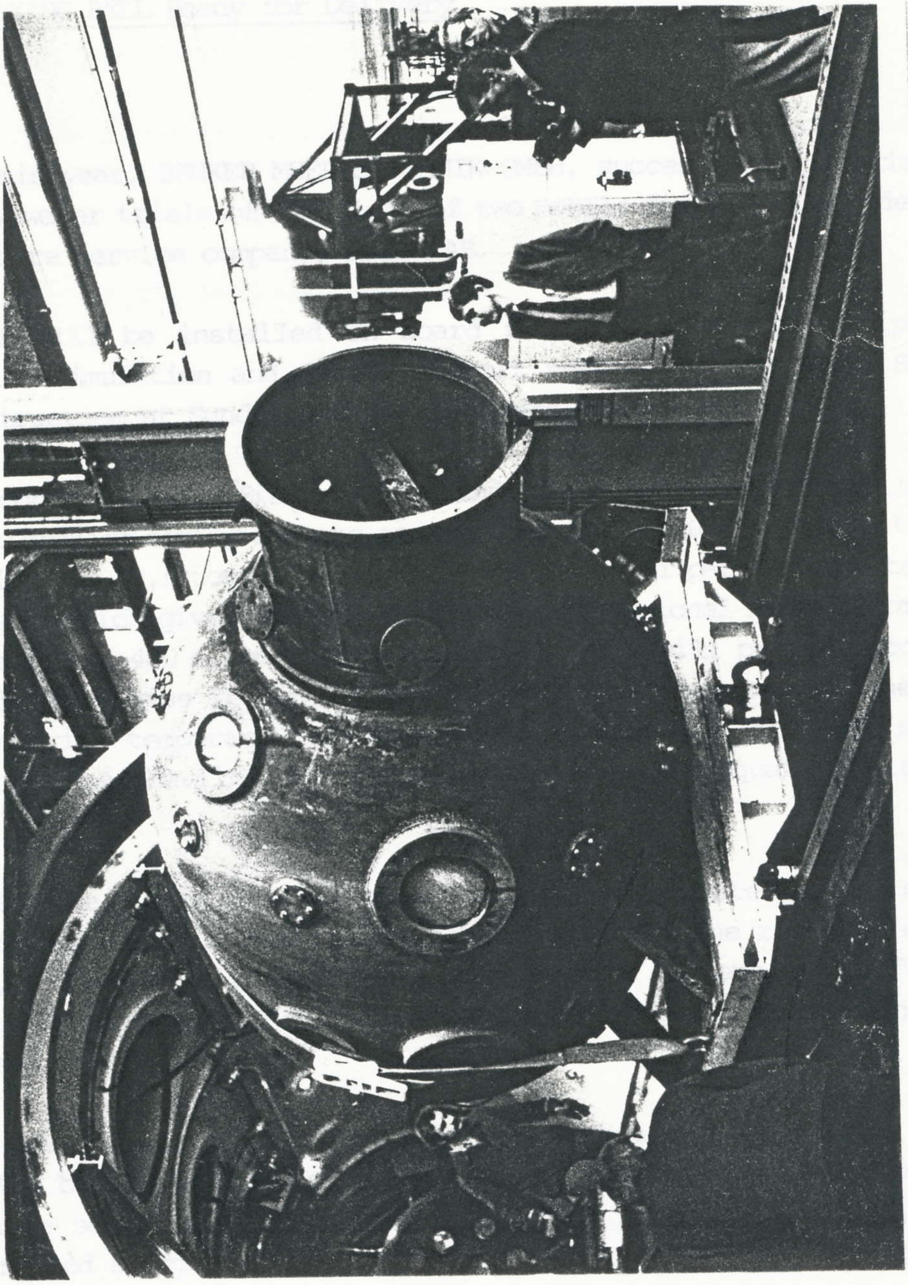
G BELL



Two FLYING BELLS under construction at Bruker Meerestechnik GmbH in Karlsruhe
Mockup version in the background

2/85

FLYING BELL



Pressure vessels during external hydrostatic pressure tests at the GUSI facilities

KER MEERESTECHNIK GMBH BRUKER

EASE 3/86

ater Trials Successfully Completed
first FLYING BELL Ready for Delivery

ary of this year, BRUKER MEERESTECHNIK GMBH, successfully launched and
d shallow water trials of the first of two mobile diving bells ordered by
ish offshore service company, STENA AB.

ING BELLS will be installed on board two ultra modern, multipurpose
nce, well stimulation and diving support vessels of the STENA SEAWELL
der construction at Sunderland Shipbuilders, U.K.

ING BELL concept is the first of its kind. The single compartment unit is
out for saturation diving and one-atmosphere observation at depths to 450 m
a dry weight of 13,5 tons. Two 35 KW hydraulic power packs feed a total of
KW thrusters which give the bell full three dimensional manoeuverability
the range of its 480 m, multicore umbilical. This will provide access to
hich would otherwise be beyond the divers' reach because of the large
ons of the rig, temporary obstacles, strong currents, etc. and make it
e to avoid cross-hauling and other critical or inadequate positioning
vers.

manned sub, the Flying Bell is fitted out with a complete ballast system,
orating soft and hard ballast tanks, drain pump and the related remotely
ed valves, but unlike a free swimming submersible, it does not suffer from
tions in gas, hot water and electrical power coming through the tether from
pport vessel.

YING BELL can be operated as an ROV from the surface control console as well
m within the bell. The unit is fitted out with gyro-compass and autopilot,
cle avoidance sonar, echograph, two underwater TV-cameras, communication
ms, tracking and emergency transponders, flashlight and searchlights.

...

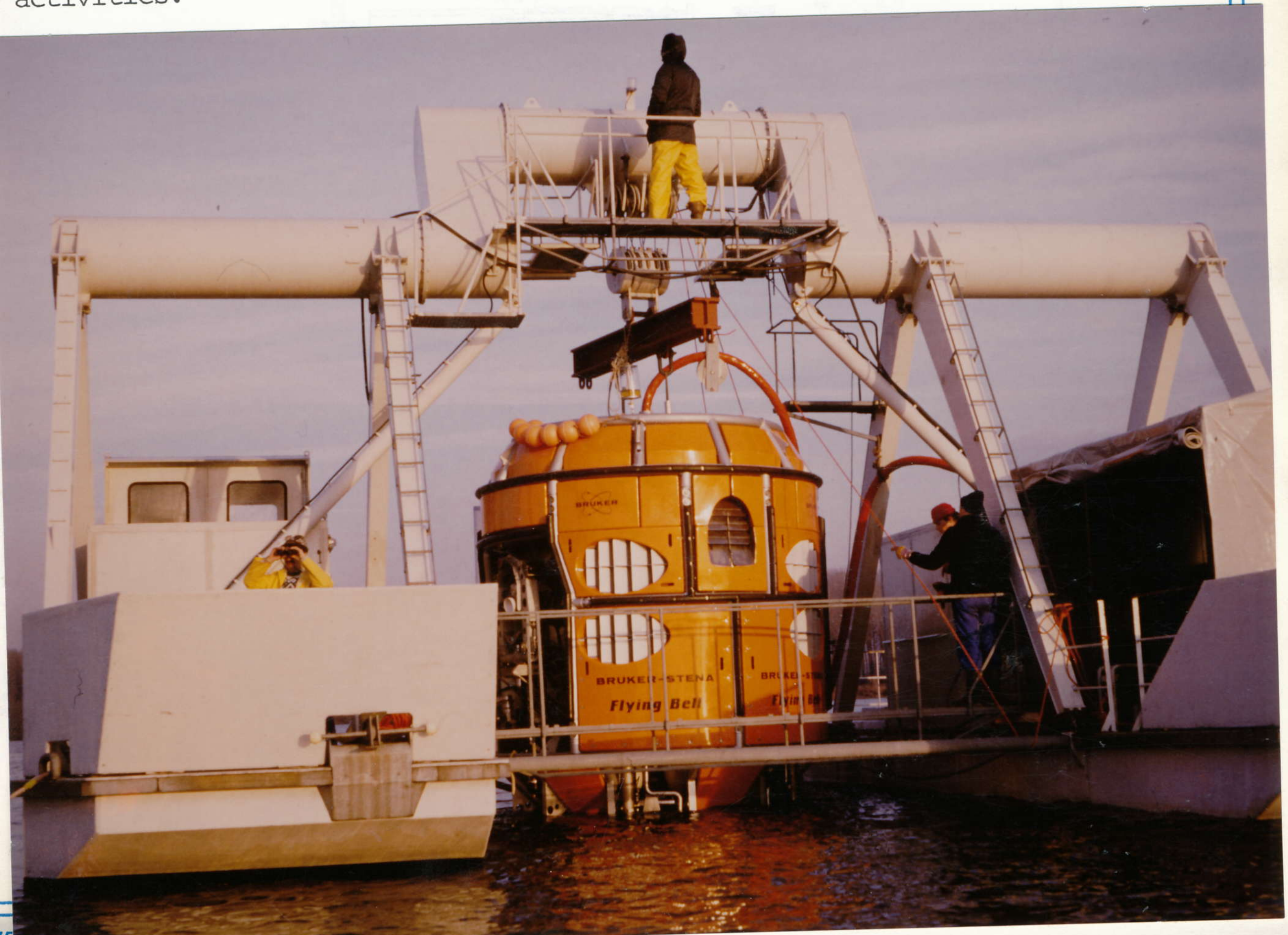
he wet trials, witnessed by a supervising team from the customer, tatives of DnV as the classification society and other interested parties offshore industry, strong gales, heavy rain, snow and ice resulted in c conditions with regard to the foreseen working environment.

er owned catamaran-type test barge was specially converted and fitted out job with 440 Volt 60 Hz Diesel generator, hoisting device and surface console plus original electrical switchboards.

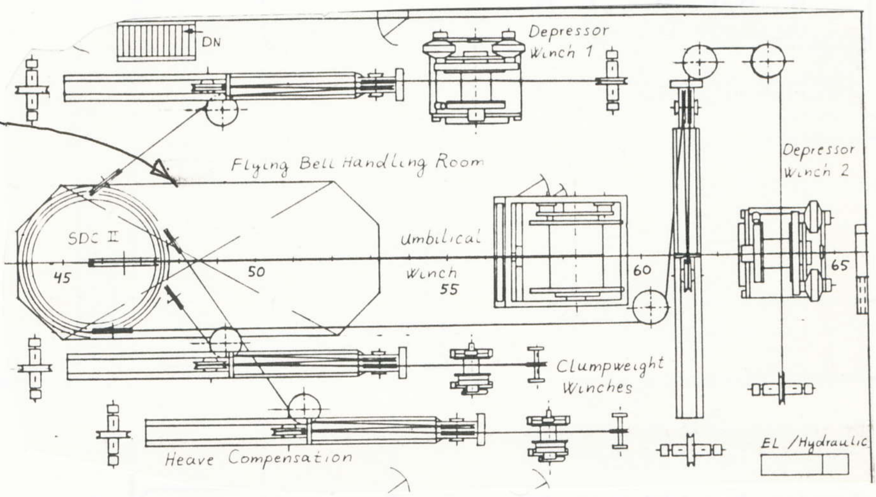
he tests, the Flying Bell was supplied through a 60 m long test umbilical nal diameter.

program included function tests of the special equipment, manoeuvering both modes, manual and autopilot, ballast system, buoyancy and stability, cent capabilities in different operating modes and function tests of diving nt.

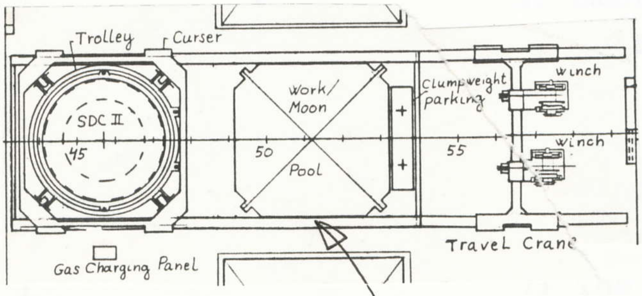
ts were successfully completed just before a thick layer of ice stopped activities.



I was promised to receive information later on about the handling system but I newer received it. Therefore, I have drawn it as I belive it to be. The handling system components are very much the same as for the Dräger bell. Off course the trolley and the curser has to be reinforced to take the extra weight of this big bell according to the guideline provided by DnV, rules for certification of diving systems 1982. The moon pool is bigger than for the SDC bell and a special system for the clumpweight has to be taken into consideration. The total hight demand for the bell and the bell trolley is not known. Therefore, I have an opening in the deck above the bell increasing the total hight between decks from 4 to 8 meters - that should be enough. It looks like this:

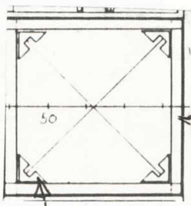


opening in deck above bell



bell on Shelter deck

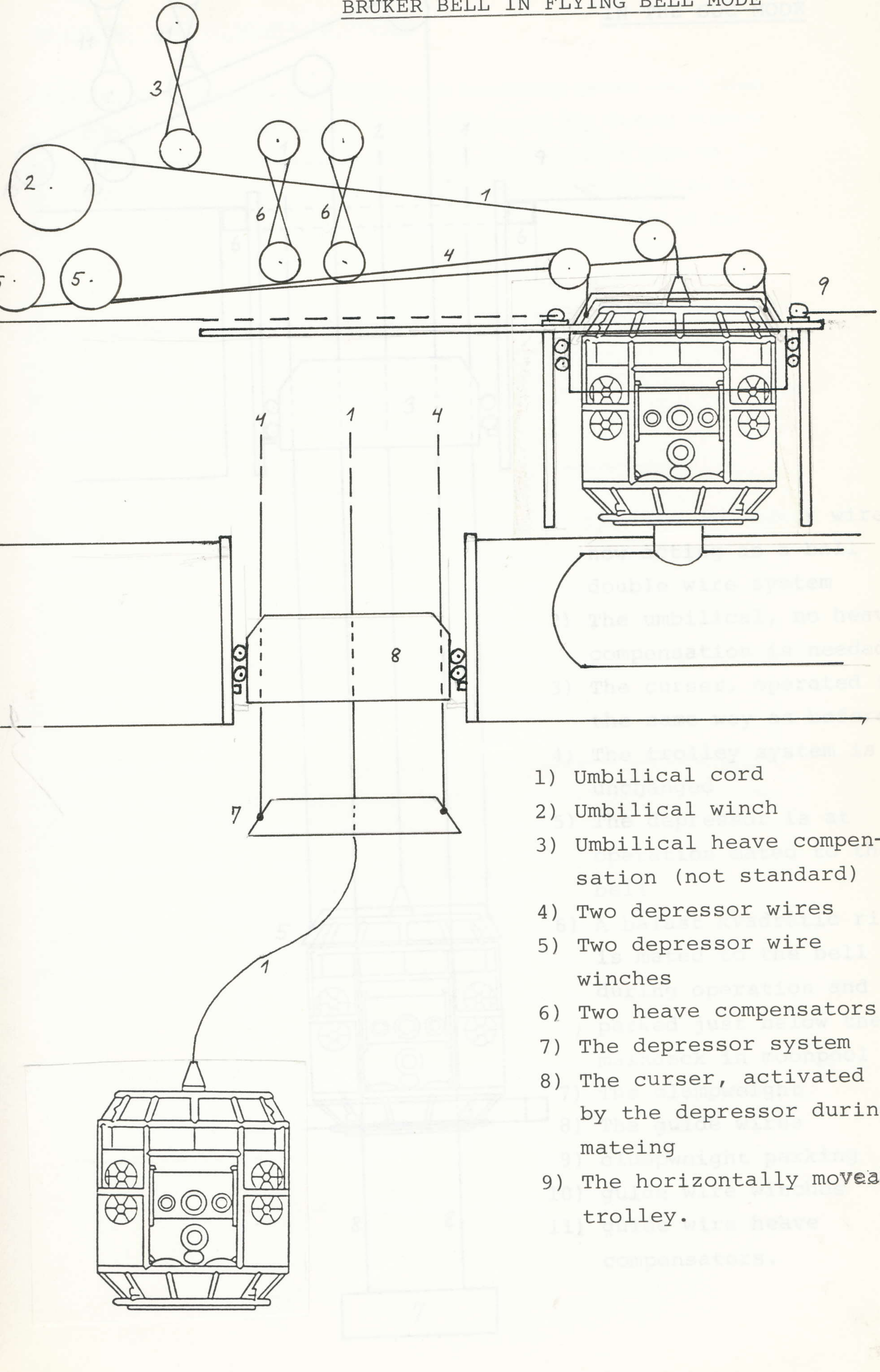
Travel rails for Trolley



Ballast quadratic ring parking just below main deck

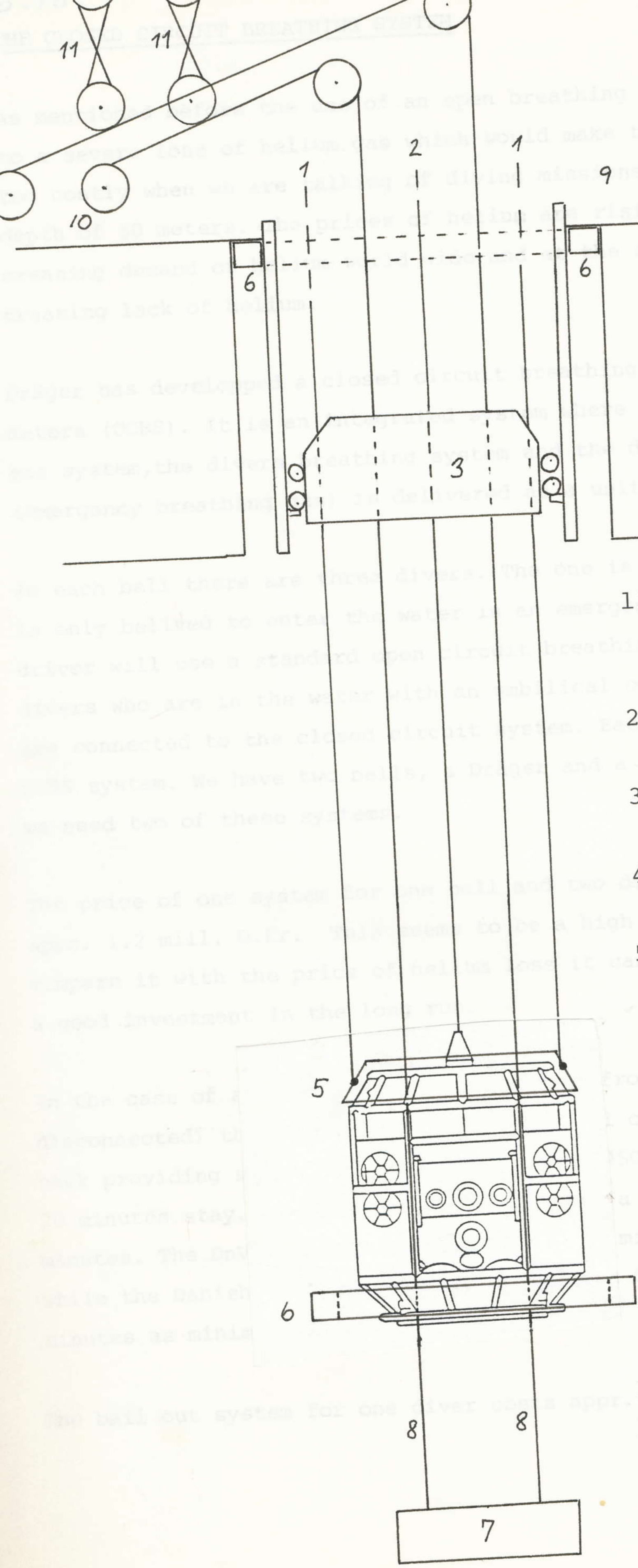
Cursor rails

BRUKER BELL IN FLYING BELL MODE



1) Umbilical cord
2) Umbilical winch
3) Umbilical heave compensation (not standard)
4) Two depressor wires
5) Two depressor wire winches
6) Two heave compensators
7) The depressor system
8) The curser, activated by the depressor during mateing
9) The horizontally moveable trolley.

IN THE SDC MODE



1) The two depressor wires, now acting as a bell double wire system
2) The umbilical, no heave compensation is needed
3) The curser, operated in the same way as before
4) The trolley system is unchanged
5) The depressor is at operation mated to the bell
6) A balast kvadratic ring is mated to the bell during operation and parked just below the maindeck in moonpool
7) The clumpweight
8) The guide wires
9) clumpweight parking
10) guide wire winches
11) guide wire heave compensators.

6.18.

THE CLOSED CIRCUIT BREATHING SYSTEM

As mentioned before the use of an open breathing system would lead to a severe loss of helium gas which would make the diving mission too costly when we are talking of diving missions more than to the depth of 50 meters. The prices of helium are rising due to an increasing demand of helium world wide and at the same time an increasing lack of helium.

Dräger has developped a closed circuit breathing system for 450 meters (CCBS). It is an integrated system where the whole bell gas system,the divers breathing system and the divers bail out system (emergency breathing gas) is delivered as a unit.

In each bell there are three divers. The one is a bell driver and he is only belived to enter the water in an emergency. Therefore, the driver will use a standard open circuit breathing system. The two divers who are in the water with an umbilical connection to the bell are connected to the closed circuit system. Each bell has its own CCBS system. We have two bells, a Dräger and a Bruker bell, therefore we need two of these systems.

The price of one system for one bell and two diver lock outs is appr. 1.2 mill. D.Kr. This seems to be a high price, but when we compare it with the price of helium loss it can be seen that it is a good investment in the long run.

In the case of an emergency (the umbilical from bell to diver becomes disconnected) the diver switches to the bail out system on the divers back providing sufficient breathing gas at 450 meters for a 10 to 20 minutes stay. This gives a mean time for a "standard" diver of 15 minutes. The DnV regulations demands 15 minutes as minimum while the Danish Government Ships Inspection Services demands 5 minutes as minimum only.

The bail out system for one diver costs appr. 90.000 D.Kr.

The Expensive Breathing

A man breathes appr. 20 times per minute. When performing light work each inhalation is appr. 1.5 liters. This means that the flow is appr. 30 liters per minute. If the breathing gas was not regenerated during the diving this would mean that the expensive gas would be lost into the water (exhalation).

How much would it cost to use an open breathing system during a 450 meters dive?

99% x 1.5 liters x 45 bars x 125 kr/m3 x 1/1000 = 8.4 D.kr/inhalatio

or:

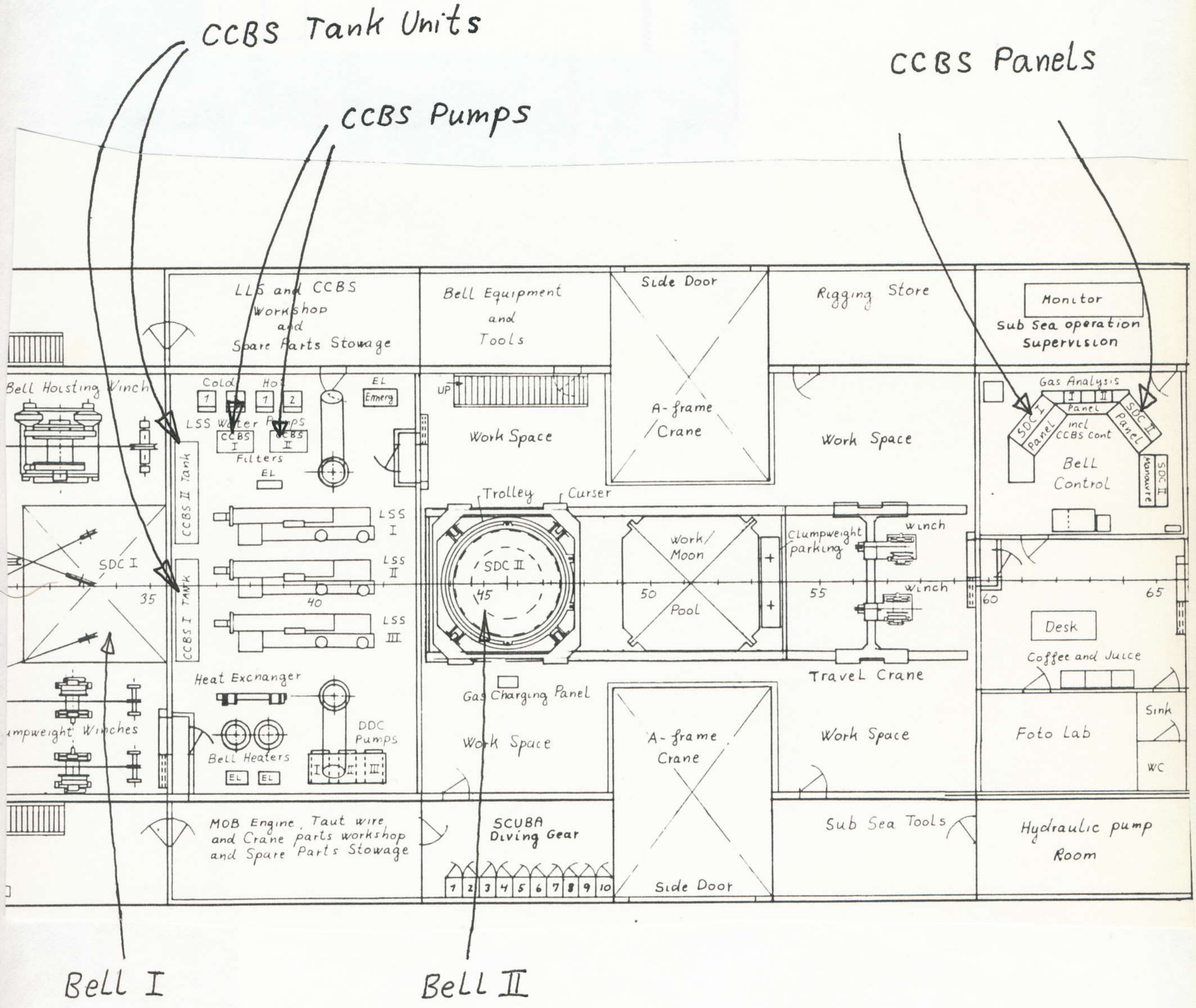
168 D.kr. per minute per diver.

or:

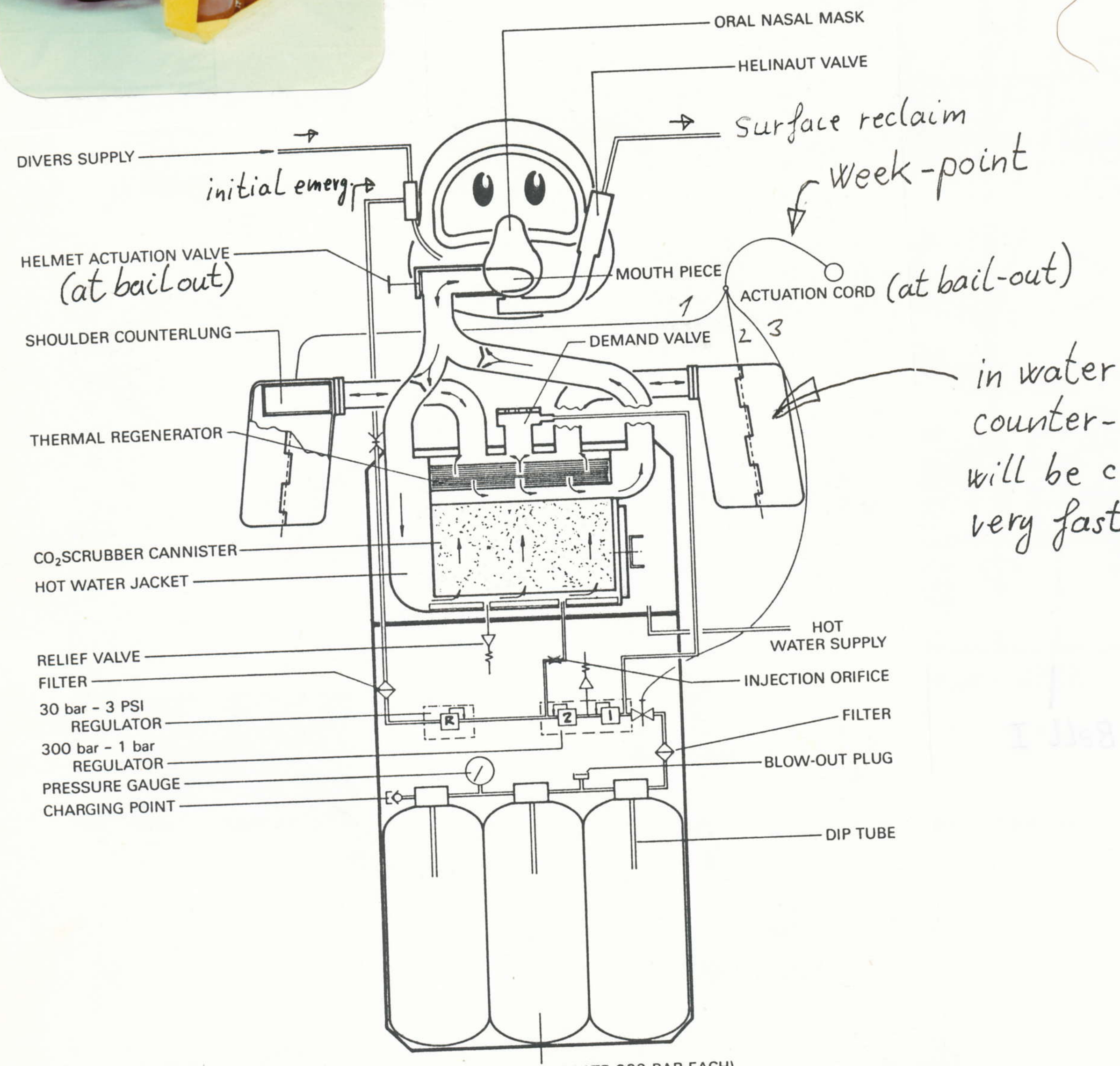
10080 D.kr per hour per diver.

On the following pages you can read more of how the system is functioning and what the technical data are.

The CCBS control panels has been placed in the bell control room. The compressor station has been placed in the compressor room at the tank top deck. The filter station and the tank unit has been placed in the Life Support Room situated just above the saturation chamber room (the distance is therefore equal between the two bells).



GAS SERVICES
OFFSHORE LIMITED
Westhill Industrial Estate,
Aberdeen. AB3 6TQ
Tel (0224) 740145
Fax (0224) 740172
Telex 739762



surface reclaim

initial emerg.

week-point

(at bailout)

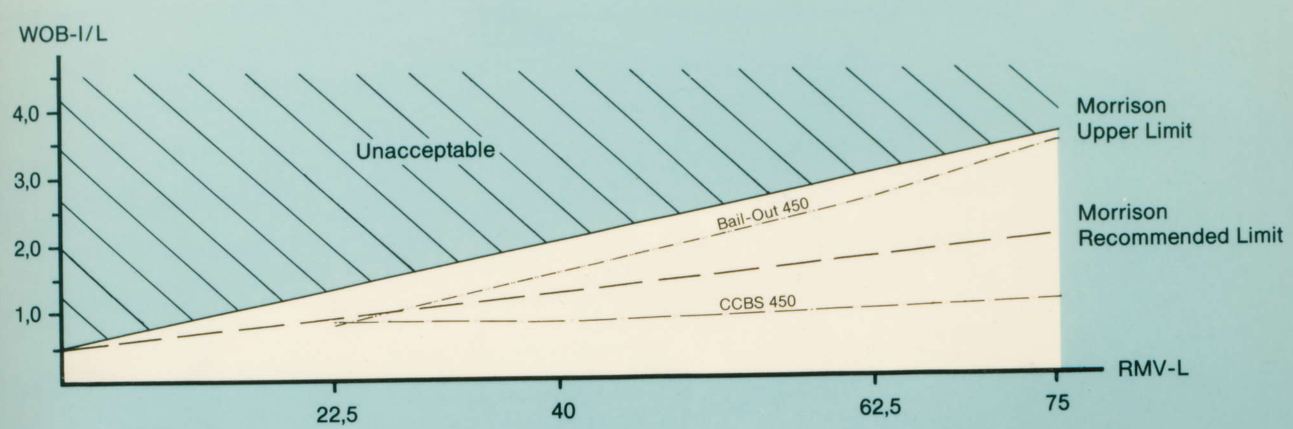
(at bail-out)

1

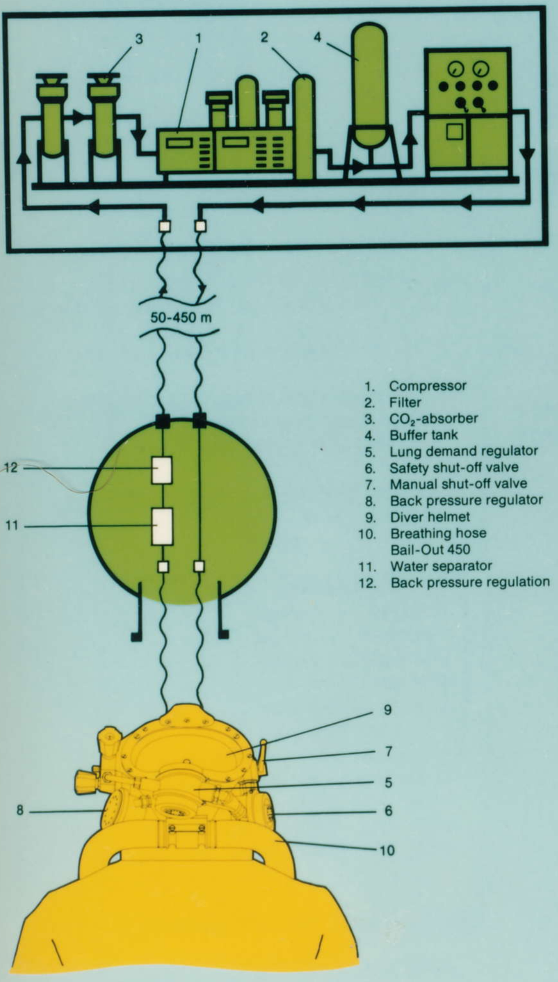
2

3

in water counter- will be c very fast

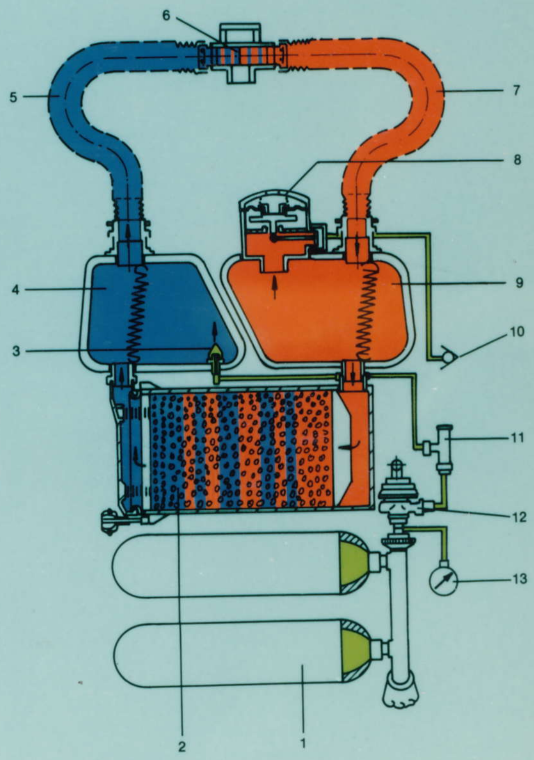


Gasflow CCBS 450



1. Compressor
2. Filter
3. CO_2-absorber
4. Buffer tank
5. Lung demand regulator
6. Safety shut-off valve
7. Manual shut-off valve
8. Back pressure regulator
9. Diver helmet
10. Breathing hose Bail-Out 450
11. Water separator
12. Back pressure regulation

Gasflow Bail-Out 450



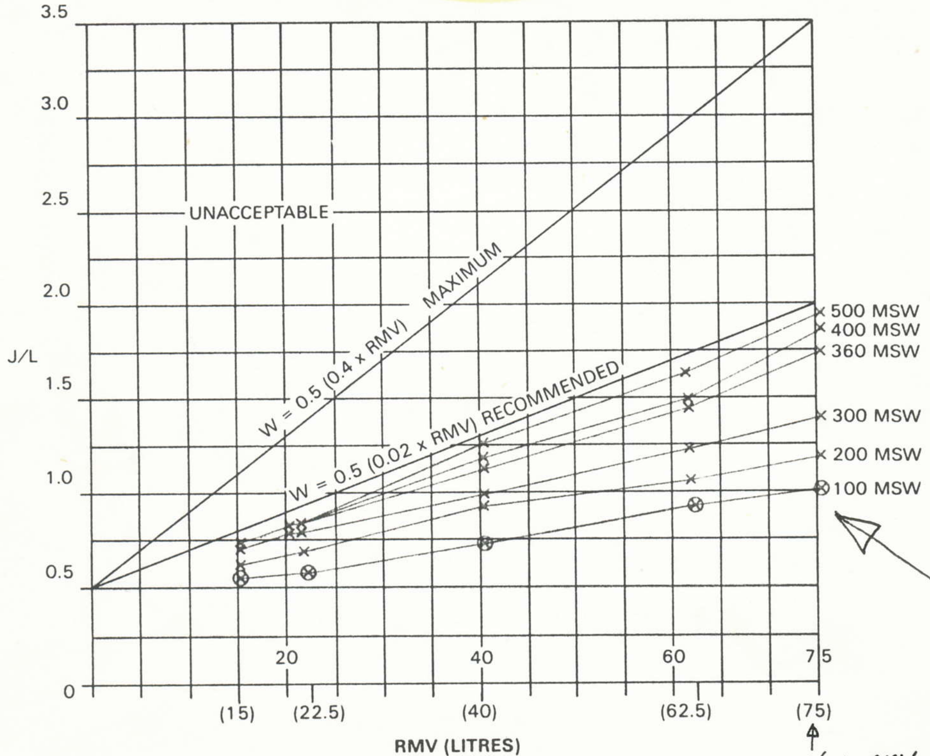
1. Mixedgas cylinders
2. Sodalime container
3. Gas supply
4. Inhalationbag
5. Inhalationhose
6. Connection to diver helmet
7. Exhalationhose
8. Pressure balance device
9. Exhalationbag
10. Gas supply from CCBS 450
11. Gas dosage
12. Pressure reducer
13. Storage gauge

Dräger

Deep Divers Breathing System

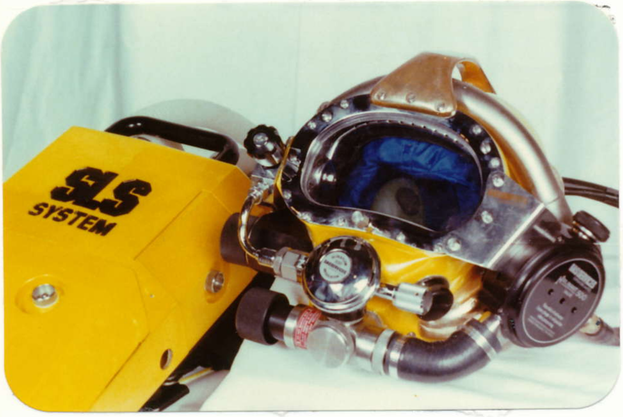
CCBS 450/Bail-Out 450

WORK OF BREATHING RESULTS TO DOE/NPD GUIDELINES



WORK OF BREATHING (J/L AGAINST RMV (L)

75 ℓ/min RMV.



RÄGER
EEP DIVERS BREATHING EQUIPMENT
CBS 450

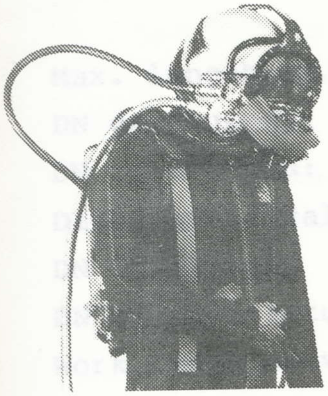


Fig. 1 Complete dressed diver

To meet future demands the Dräger Closed Circuit Breathing System CCBS 450 is desiged to supply 2 divers with sufficient breathing gas down to 450 m water depth.

The system in principle consists of:

- surface unit with two compressors and gasconditioning system
- bell equipment including gaspanel and watertrays
- diver equipment consisting of diver helmet with regulators, breathing gas heating and automatic tracking system

NB

The divers exhaled gas is recovered and returned to the surface for gascleaning. Oxygen is added and the refreshed gas is sent back to the diver.

- System according to DNV level III
- Work of breathing at 75 l/min RMV, less than 1 J/l.

Also at 450 meters?

- Gasflow up to 90 l/min.
- Maximum working depth 450 m
- Excursions below bell max. 30 m
- Excursions above bell max. 10 m
- Easy operation based on ergonomic designed control panel
- Easy to maintain, only 7 working elements in the breathing regulator
- Saves more than 90 % breathing gas
- Homogeneous breathing gas with automatic O_2-adding
- Safe breathing due to Dräger quality
- Reliable also tested during hundreds of hours
- Designed in accordance to recommendations of NPD and DOE.

Instruction and training also from Dräger Druckkammertechnik.

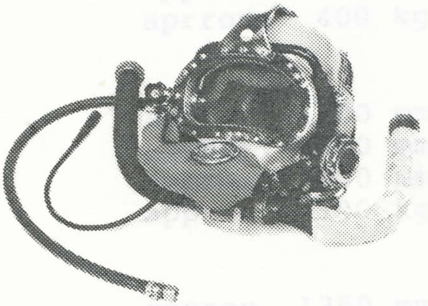


Fig. 2 Dräger CCBS-helmet with breathing gas heating

DRÄGERWERK AG, Werk Druckkammertechnik
P.O. Box 150 149, Auf dem Baggersand 17
D-2400 Lübeck-Travemünde 1

Mr. Jonny Holm

FAX: 0451 / 882 20 80
Telex: 261 455

Telephone: 04502 / 83-21

Technical Data

Principle of function:	automatic lung demand
Diver supply stations:	2
Max. minute breathing volume:	2 x 75L
Operating range:	48 - 450 m depth
Breathing gas:	helium with approx. 0,4 bar O_2
Max. length of umbilical:	500 m
DN gas supply:	3/4"
DN return gas:	3/4"
Diver umbilical length:	30 m
DN supply gas	1/2"
DN exhaust-return gas	5/8"
Work range above bell:	10 m, depending on depth of bell
Work range underneath bell:	30 m, depending on depth of bell
Supply pressure max.:	70 bar
Exhaust return gas pressure:	40 bar
Size of CO_2 filter:	15 litres
Size of drier:	15 litres

Control panel

Height:	approx. 1800 mm
Width:	approx. 1100 mm
Depth:	approx. 450 mm
Weight:	aprrox. 400 kg

Compressor Station

Height:	approx. 1200 mm
Width:	approx. 1800 mm
Depth:	approx. 800 mm
Weight:	approx. 700 kg

15 KW
Leistung
fehlt

Filter station

Height:	approx. 1350 mm
Width:	approx. 1100 mm
Depth:	approx. 600 mm
Weight:	approx. 350 kg

Tank unit

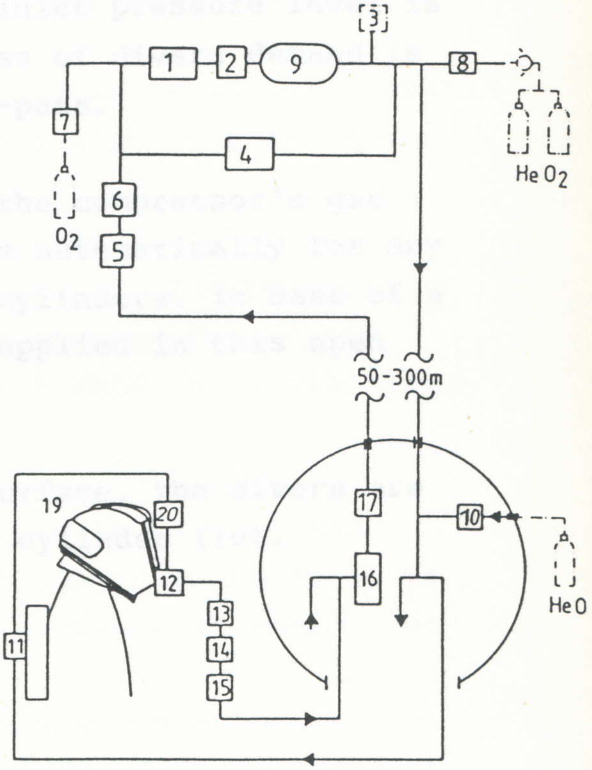
Height:	approx. 700 mm
Width:	approx. 3000 mm
Depth:	approx. 700 mm
Weight:	approx. 800 kg

...

Description of System

Ill. 1 shows diagram with functional elements of system

1. Compressor
2. Separator, filter
3. Gas measurement
4. Return gas pressure regulation
5. CO_2 absorber
6. Gas drier
7. O_2 increase dosage device
8. Supply pressure regulation
9. Pulsation damper
10. Bell gas supply
11. Gas supply pressure regulator
12. Lung demand regulator
13. Safety shut-off valve
14. Manual shut-off valve
15. Delivery pressure regulator
16. Water separator
17. Delivery pressure regulator bell
18.
19. Diver helmet
20. Heater



Ill. 1 Circuit system with functional elements

...

ne circuit compressor (1) re-supplies the breathing gas. On the ontrol panel the compressor's inlet pressure and delivery ressure are set according to diving depth.

y filtering out odorous particles and other contaminants epartor and filter (2) provide for clean breathing gas.

ne pulsation damper (9) compensates for pressure fluctuations aused by the divers inhalation and exhalation cycles.

efore the breathing gas is fed to the dicer its O_2 and CO_2 ontent are measured at the gas analysis station (3). The gas nalysis devices are housed within the gas analysis control panel.

ia the regulator (4) the compressors's inlet pressure level is ept constant and any gas pumped in excess of divers demand is eturned back to the compressor via a by-pass.

e supply pressure regulator (8) keeps the compressor's gas pply pressure constant, and compensates automatically for any eakages by drawing gas off the storage cylinders. In case of a ompressor failure the divers are also supplied in this open rcuit manner.

n case of a broken supply line to the surface, the divers are irectly supplied out of the reserve gas cylinder (10).

...

Irrespective of the diver's depth the supply pressure regulator (11) keeps the supply pressure for the lung demand regulator (12) within optimum range and in this way guarantees a non-varying inhalation resistance at all times.

The delivery pressure regulator (15) functions accordingly at the exhaltation side.

If within helmet a pressure drop is caused by a faulty lung demand regulator (12) the safety shut-off valve (13) shuts off the exhaust return gas line, automatically. It can also be activated manually.

Once activated the safety shut-off valve remains locked. It can only be opened through certain measures after completion of dive.

The manual shut-off valve (14) is a ball valve added as a futhter safety precaution. It can both be opened and shut at any time.

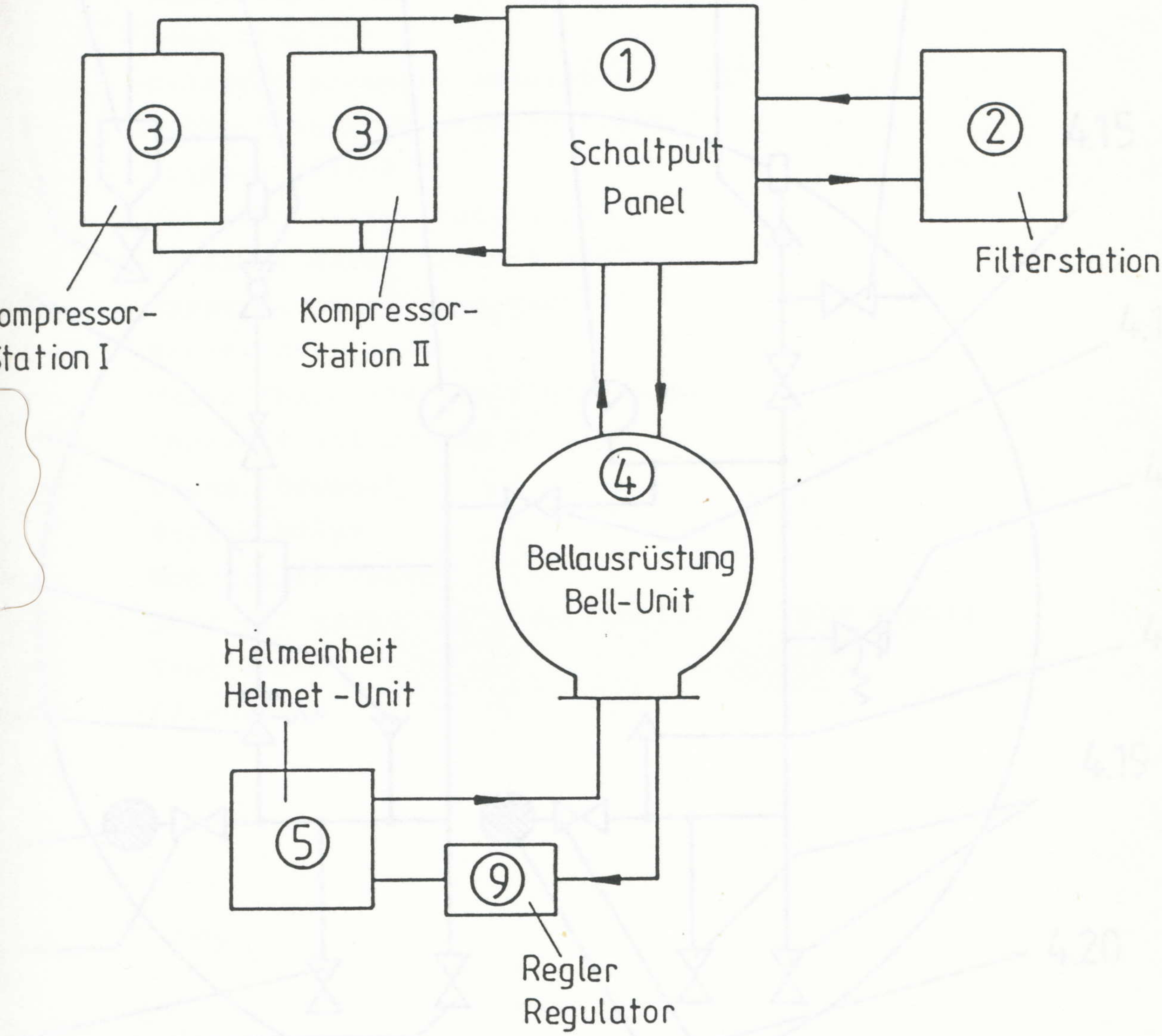
Within the water separator (16) liquid contaminants line seawater, spittle or breathing gas moisture are filtered out of the breathing gas. On the account of its special design the accumulated liquid can even be drained off into the diving bell against a positive pressure difference.

The delivery pressure regulator (17) limits the return gas pressure within diver umbilical and thus protects the diver in case the return gas line breaks between diving bell and surface.

At the filter station (5,6) CO_2 and moisture contents are filtered out of the breathing gas. The consumed oxygen gets re- supplied by means of the dosage device (7) after which the recycled gas gets returned to the compressor once again. Through the heater and the breathing gas the heating for the diver will be put on.

...

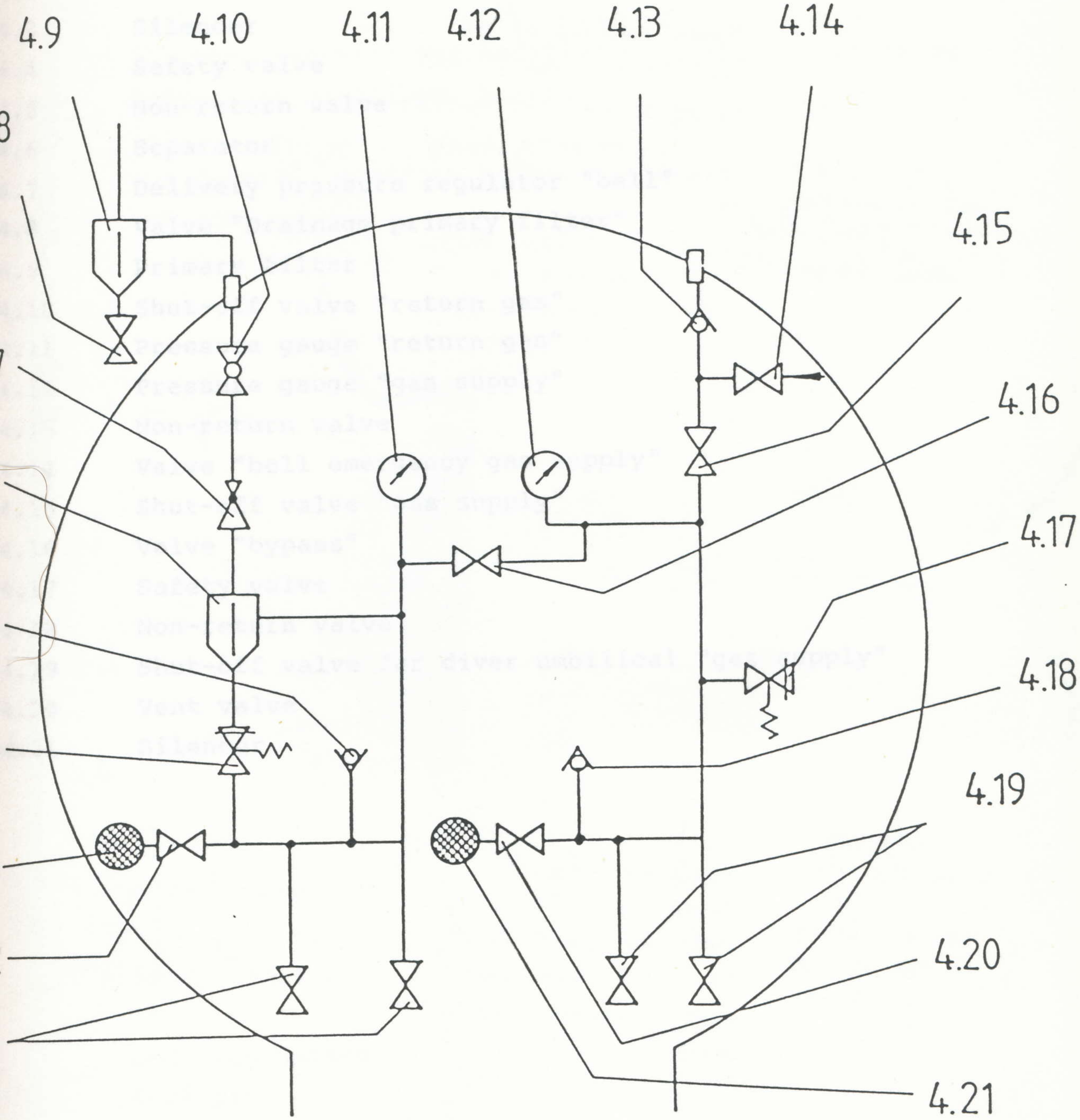
he system consists of several sub-units as shown in III.2. The osition numbers of units are identical with those as shown in rawing no. 6514500



bb. 2 Sub - units of system

...

6.4 Bell eequipment



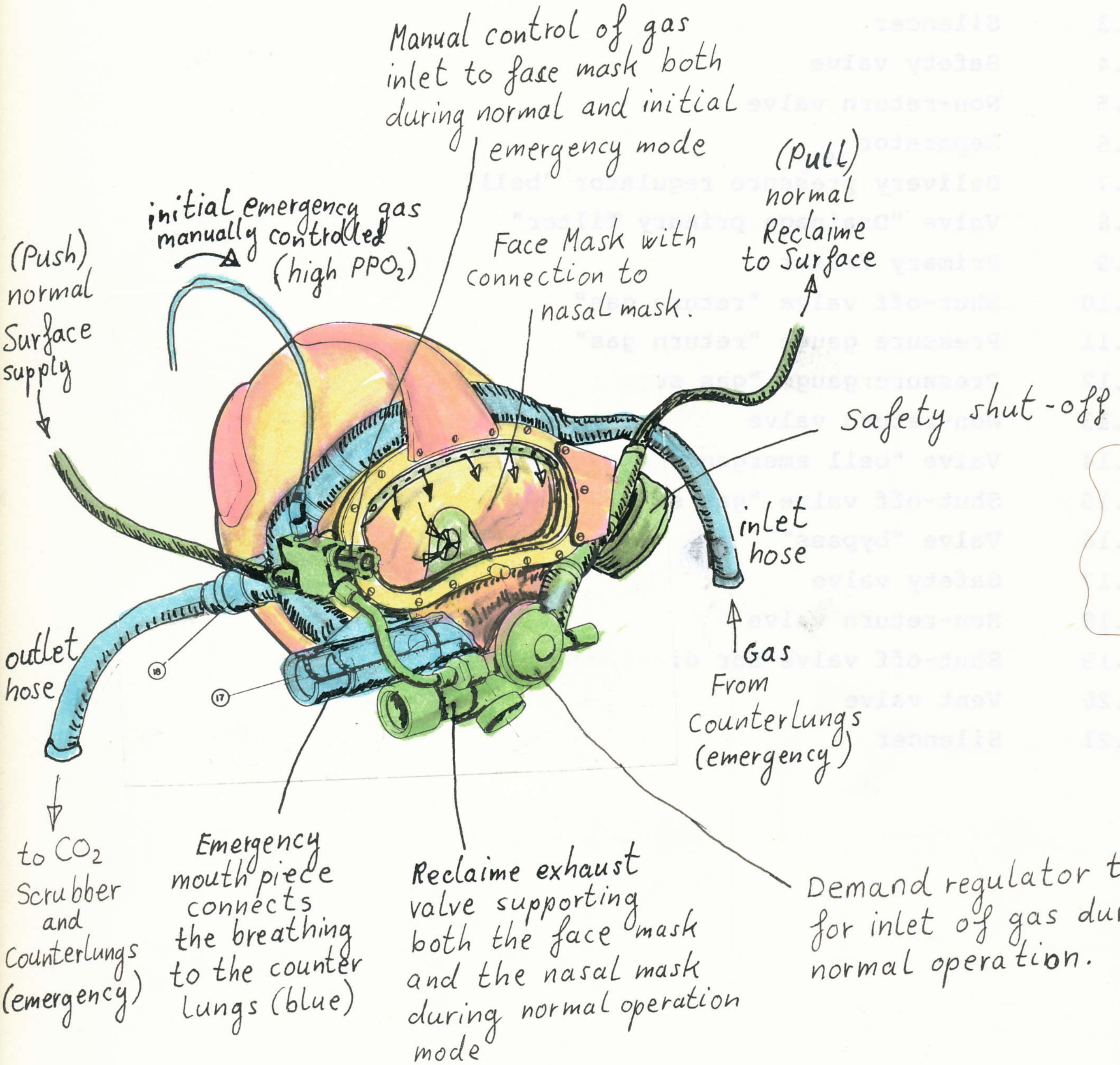
III.7 Bell equipment

...

See III. 7 Bell equipment

4.1 Shut-off valve for diver umbilical "return gas"
4.2 Vent valve
4.3 Silencer
4.4 Safety valve
4.5 Non-return valve
4.6 Separator
4.7 Delivery pressure regulator "bell"
4.8 Valve "Drainage primary filter"
4.9 Primary filter
4.10 Shut-off valve "return gas"
4.11 Pressure gauge "return gas"
4.12 Pressure gauge "gas supply"
4.13 Non-return valve
4.14 Valve "bell emergency gas supply"
4.15 Shut-off valve "gas supply"
4.16 Valve "bypass"
4.17 Safety valve
4.18 Non-return valve
4.19 Shut-off valve for diver umbilical "gas supply"
4.20 Vent valve
4.21 Silencer

...



SIS-SYSTEM

HELMET

Weight	15 kgs (33.0 lbs)
Heliox mix	94.5% He, 5.5% 02 at 500 MSW

↕

$0.055 \times 50 bar = 2.75$ bars partial pressure O_2. Th

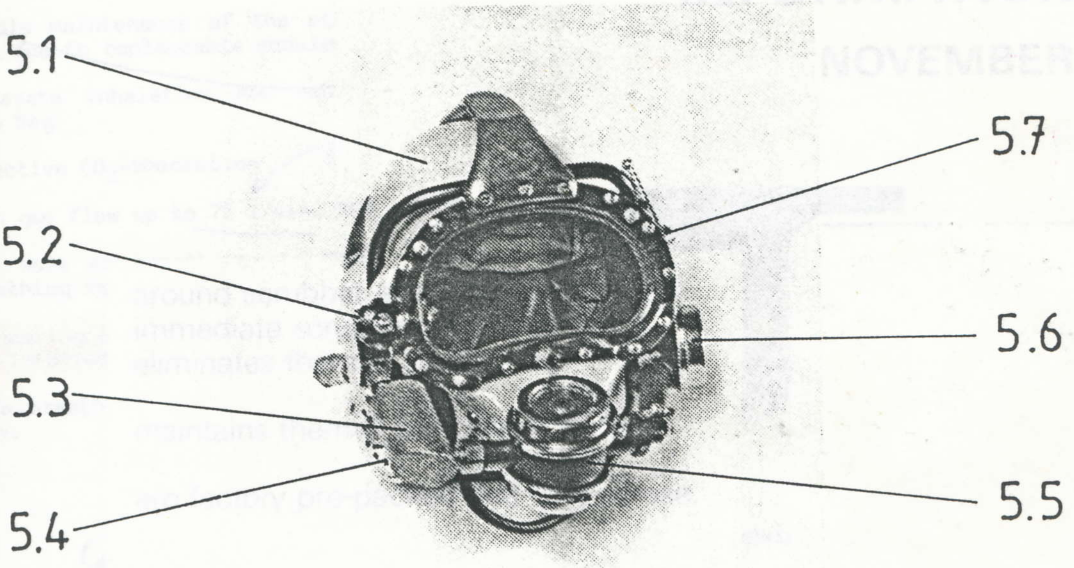
DRÄGER

.5 The helmet unit

Basically the helmet unit consists of a standard Kirby-Morgen helmet type "Superlite - 17 B.

All components either modified or newly developed by Dräger are described, herein.

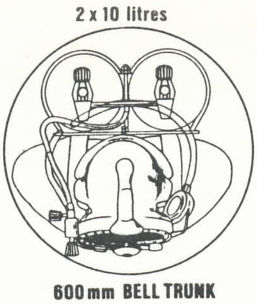
For details regarding helmet "Superlite 17 B", see enclosed manual.

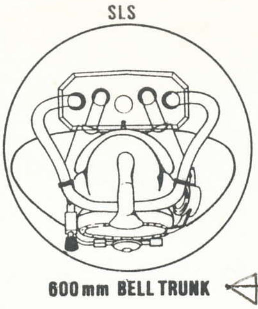


II. 6 Helmet

.1	modified helmet
.2	test pin
.3	heater
.4	delivery pressure regulator
.5	Lung demand regulator
.6	safety shut-off valve
.7	manual shutt-off valve

...





?

DURATION COMPARISON CHART **OPEN CIRCUIT VERSUS SLS SYSTEM**

Volume Litres		8	10	12	14	8	10	12	14	SLS System	
PRESSURE		200 BAR				300 BAR				200 Bar to 250 MSW 300 Bar to 500 MSW	
MSW	FSW	DURATION IN MINUTES BASED ON A 75 Litre RMV									Times Better
50	164	3.4	4.2	5.0	5.9	5.1	6.4	7.7	9.0	>30	> 3.3
100	328	1.8	2.2	2.7	3.1	2.8	3.4	4.1	4.8	>24.5	5.1
150	492	1.2	1.5	1.8	2.0	1.9	2.3	2.8	3.3	18.7	5.7
200	656	0.9	1.1	1.3	1.6	1.4	1.7	2.1	2.4	15.7	6.5
250	820	0.7	0.9	1.0	1.2	1.1	1.4	1.7	1.9	22.6	11.9
300	984	0.6	0.7	0.9	1.0	0.9	1.1	1.4	1.6	19.1	11.9
350	1148	0.5	0.6	0.7	0.8	0.8	1.0	1.2	1.3	16.8	12.9
400	1312	0.4	0.5	0.6	0.7	0.7	0.8	1.0	1.2	15.2	12.7
450	1476	0.4	0.4	0.5	0.6	0.6	0.7	0.9	1.0	13.5	13.5
500	1640	0.3	0.4	0.4	0.5	0.5	0.6	0.8	0.9	12.0	13.3

Open Circuit Bail Out Duration has been Calculated Based On:—

CHARGING PRESSURE—(DEPTH PRESSURE—6 BAR) × FLOODABLE VOLUME
(DEPTH PRESSURE + 1 ATM × 75)

NOTE: It is physiologically impossible for a diver to maintain a 75 litre a minute RMV for more than a few minutes. (normally 3 minutes)

Should the diver's normal gas supply be interrupted for any reason, the diver has only two non-sequential actions to shift the SLS from the STANDBY MODE to the OPERATIONAL MODE. These actions are: 1) rotate the actuation valve which places the mouthpiece in his mouth and opens the valve to the thermally efficient, smoothbore inhalation and exhalation 2) hoses. The other action required is to pull the actuation cord, located on the waist belt, which releases the counterlungs and actuates the onboard gas supply. A high PPO_2 is fed into the SLS via a multiorifice restrictor. Excess gas is vented at the actuation valve. The diver's intitial breath is supplied from the demand regulator, which also compensates for any gas leakage out of the unit. A thermal regenerator prevents the loss of heat through the counterlungs. The diver can now confidently and safely return to the bell knowing he has a minimum of fifteen minutes' Secondary Life Support available.

The Bail-Out mode has no electricity or chemical heating unit, only a exhaust-inlet heat-exchanger is fittet.

RÄGER
EEP DIVERS BREATHING EQUIPMENT
AIL-OUT 450 m

o increase the safety of the diver orking in depth down to 450 m, Dräger developed the emergency breathing ystem BAIL-OUT 450.

he system is connected to the diving helmet of the CCBS 450 and peranent ready for use.

- Compact design ensures fully mobility and lock out through min. diameter of 680 mm
- Semiclosed breathing circuit
- Duration of 10 to 20 minutes at 75 l/min.
- Simple maintenance of the equipment due to replaceable modules
- Separate inhalation and exhalation bag
- Effective CO_2-absorbtion
- High gas flow up to 75 l/min. RMV new 90 l/min.
- Low work of breathing and small breathing resistance
- Gasheating also in case of hot water interruption how ?
- Safe breathing due to Dräger quality.

Fig. 2 CCBS-helmet connected to Bail Out

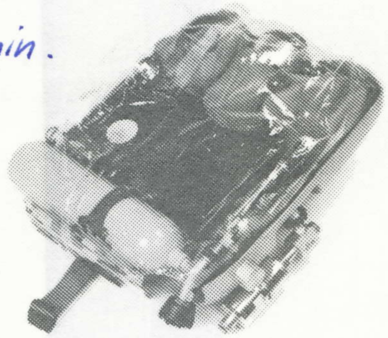


Fig. 3 Bail Out equipment open

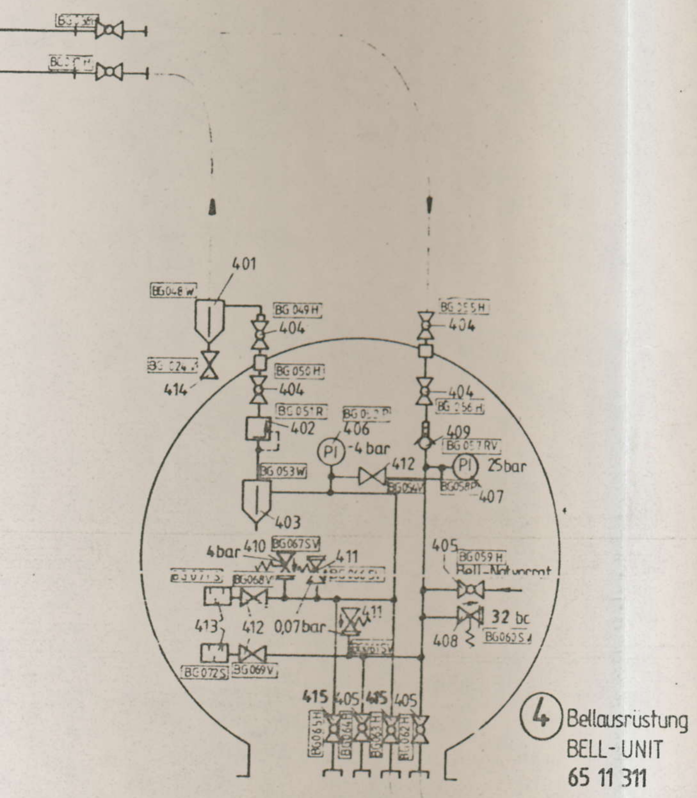
Fig. 1 Side view Diver equipped with CCBS-helmet and Bail Out

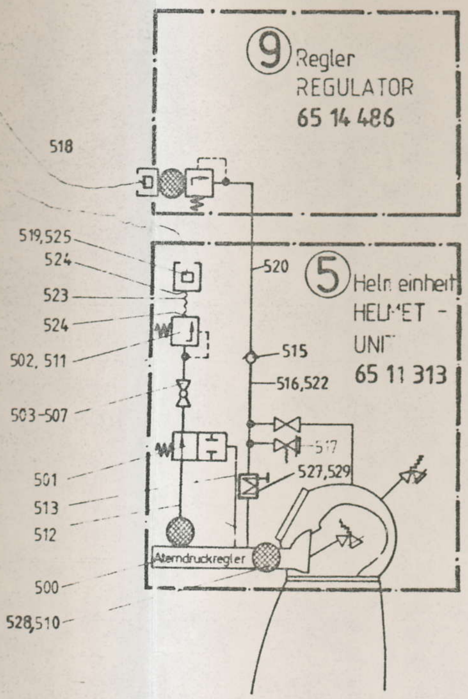
DRÄGERWERK AG, Werk Druckkammertechnik
P.O. Box 150 149, Auf dem Baggersand 17
D-2400 Lübeck-Travemünde 1

Mr. Jonny Holm

FAX: 0451 / 882 20 80
Telex: 261 455

Telephone: 04502 / 83-21





	PIPE-CODE
x1 Cu	PIPE 4x1 CU
x1 Cu	PIPE 6x1 CU
x15 Cu	PIPE 8x15 CU
6x3 Cu	PIPE 16x3 CU
6x2 Niro	PIPE 16x2 SS
0x2 Niro	PIPE 20x2 SS
5x25 Niro	PIPE 25x2,5 SS

REIBUNG	DESCRIPTION
	VALVE
ahn	BALL VALVE
gehar-	3-WAY BALL VALVE
agventil	NONRETURN VALVE
ß, Verbindung	CONNECTION
egrenzungsvent-	RELIEF VALVE
	FILTER
ter	PRESSURE GAUGE
scheider	WATER TRAP
	NOZZL
enti	CONTROL VALVE
uscher	HEAT EXCHANGER
ter	COMPRESSOR
regler	BACK PRESSURE REGULATOR
nderer	PRESSURE REDUCER
gler	PRESSURE REGULATOR
eter	THERMOMETER

10 cm

Hierzu gehört Schilderliste 65 11 371

9	—	Kompressorstation SI-Wasserteil neu	28.2.8		
8	—	Tankeinheit geändert	21.2.86		
7	—	Pos.97 neu div. Änderungen	4.9.85		
6	—	Pos.717 neu hinzu	26.6.85		
5	—	div. Änderungen	8.3.85		
4	—	Schaltpult geändert	14.11.84		
3	—	Kompressorstation II + III neu	7.11.84		
2	—	Schaltpult geändert	10.10.84		
1	—	Tankeinheit geändert	25.9.84	Lub.	

ST 65 14 500

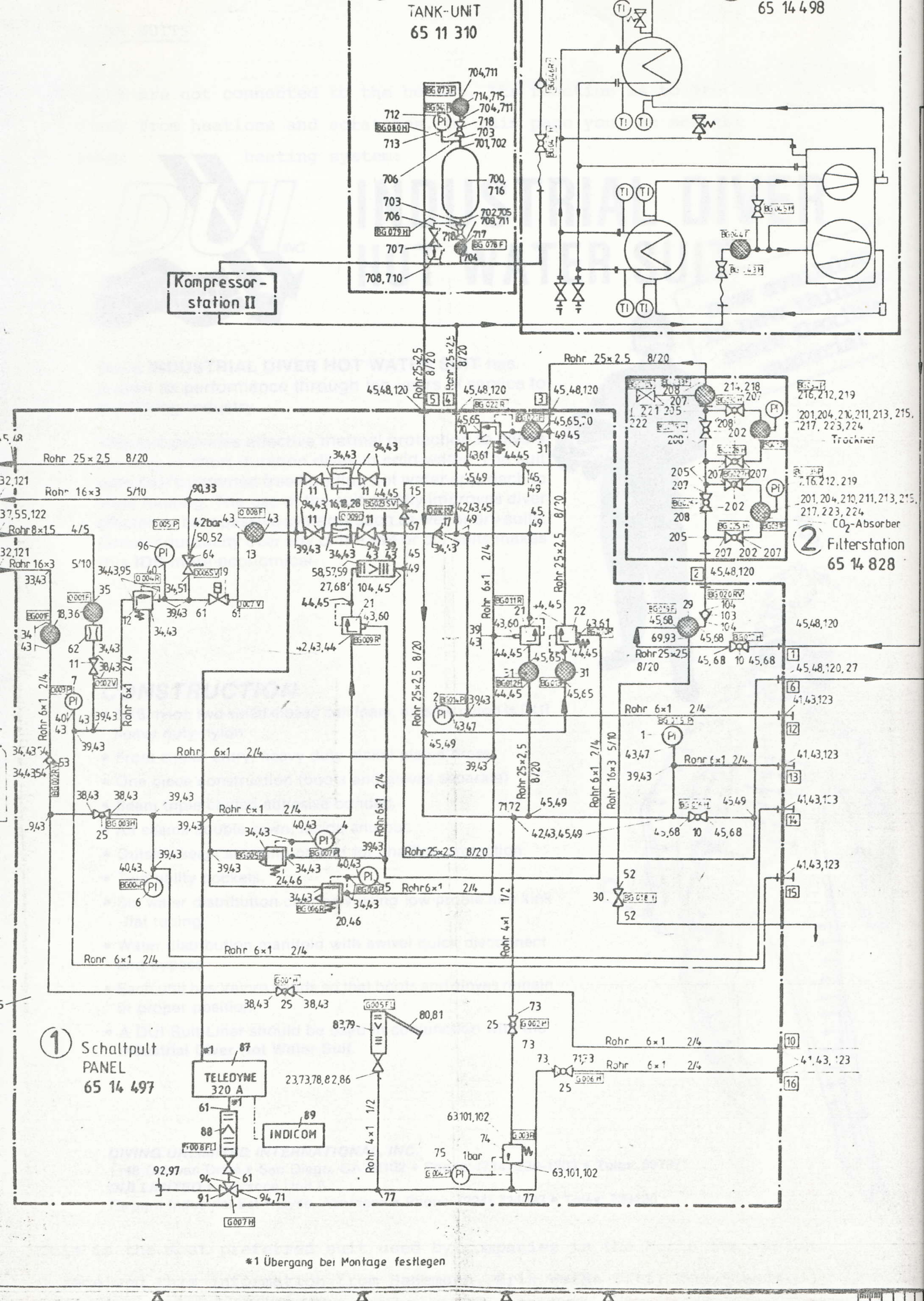
84
6.9
DK

Drägerwerk AG Lübeck

Closed Circuit Breathing
System (GAK 450)

65 14 500

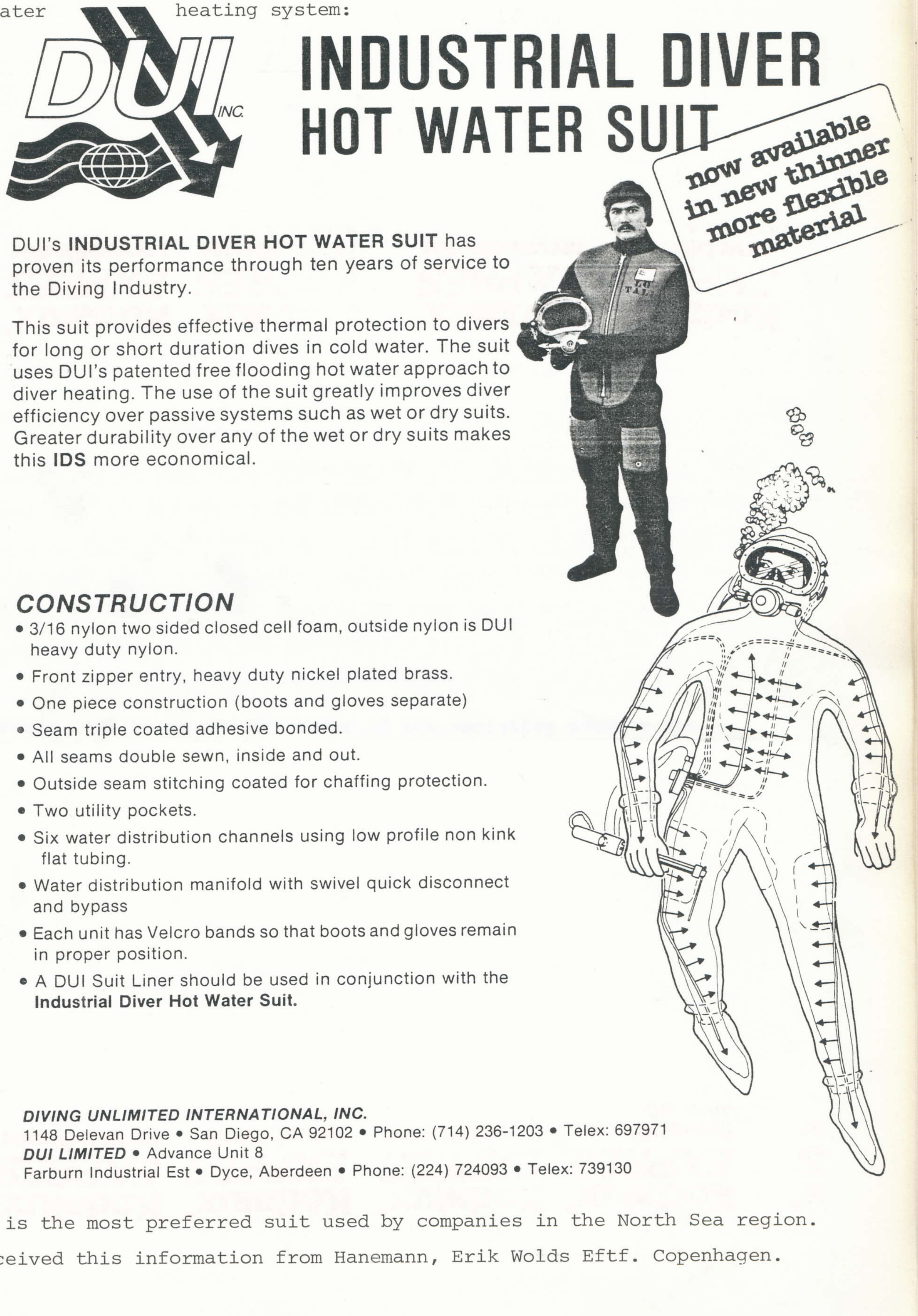
4
3
2



*1 Übergang bei Montage festlegen

THE DIVER SUITS

The suits are not connected to the helmet. Its function is to protect the diver from heatloss and scratches. On this page you can see the hot water heating system:



DUI INC.

INDUSTRIAL DIVER HOT WATER SUIT

now available in new thinner more flexible material

DUI's **INDUSTRIAL DIVER HOT WATER SUIT** has proven its performance through ten years of service to the Diving Industry.

This suit provides effective thermal protection to divers for long or short duration dives in cold water. The suit uses DUI's patented free flooding hot water approach to diver heating. The use of the suit greatly improves diver efficiency over passive systems such as wet or dry suits. Greater durability over any of the wet or dry suits makes this **IDS** more economical.

CONSTRUCTION

- 3/16 nylon two sided closed cell foam, outside nylon is DUI heavy duty nylon.
- Front zipper entry, heavy duty nickel plated brass.
- One piece construction (boots and gloves separate)
- Seam triple coated adhesive bonded.
- All seams double sewn, inside and out.
- Outside seam stitching coated for chaffing protection.
- Two utility pockets.
- Six water distribution channels using low profile non kink flat tubing.
- Water distribution manifold with swivel quick disconnect and bypass
- Each unit has Velcro bands so that boots and gloves remain in proper position.
- A DUI Suit Liner should be used in conjunction with the **Industrial Diver Hot Water Suit.**

DIVING UNLIMITED INTERNATIONAL, INC.
1148 Delevan Drive • San Diego, CA 92102 • Phone: (714) 236-1203 • Telex: 697971
DUI LIMITED • Advance Unit 8
Farburn Industrial Est • Dyce, Aberdeen • Phone: (224) 724093 • Telex: 739130

This is the most preferred suit used by companies in the North Sea region. I received this information from Hanemann, Erik Wolds Eftf. Copenhagen.

Here is two pictures showing the arrangement of the hyperbaric lifeboat onboard the Maersk Defender. The HBL is placed high at the port side of the work deck - againg taking up much space. The connection trunk from the living chambers to the HBL is a quite long trunk passing through rooms. The vessel has been rebuilt to fit this arrangement and it can clearly be seen that it had not been intended from the start.

6.20.

THE HYPERBARIC LIFE BOAT

I think it was the Norwegian Maritime Directorate which started to set rules about resque systems for the divers in the saturation diving chamber complex. It is obvious that the divers cannot leave the chambers directly and entering the standard life boats in the same manner that the rest of the crew is doing it in case of an abandon ship situatiation. As you know it might take many days to decompress the divers before they can be locked out from the chambers. Therefore, the idea of a life boat with an incorporated pressure chamber evolved. Today it has become a must according to the Code of Safety for diving Systems, IMO 1985.

There is going to be at least one hyperbaric life boat with enough space for the maximum divers that can be in the chamber complex. In this case we are talking about an 18 diver system.

A hyperbaric life boat is a quite complicated system and maintenance is necessary. If the HBL is not in perfect condition all the time the mission has to be aborted because if there is something wrong with the HBL there is no HBL. The HBL can also be damaged in a collision and the HBL is the only escape for the 18 divers when the ship is sinking due to a collision. Perhaps that is the reason why some of the latest diving support vessels can be seen with two hyperbaric life boats and that some of the excisting vessels has been designed to allow a future instalment of an extra HBL.

I have decided to design Silver Searambler with two HBL from Dräger. If only one HBL is preferred it is just not installed, but arrangements is there to ensure that a future installment can be done.

If only one HBL is preferred the trunk to the "future" HBL is there and can be used for other purposes. A small submersible can be connected to the trunk. I will return to this later.

The lay-out is free to the engineer except that it must not last longer than 10 minutes from the captains abandon ship order to the HBL hits the surface of the sea. If there are 18 divers and only one HBL and all three chambers are at the same pressure, tests have shown that it takes appr. 4 minutes for the divers to crawl from the chambers and into the HBL and close the pressure hatch.

At the same time three non pressurerized crew members are supposed to enter the HBL from the top into the control room. As soon as they get the lauch signal from the divers (the pressure hatch is closed), one of the crew can from the top of the HBL trigger the remote mechanism that opens the clamp and the HBL can be lowered to the surface in the same manner as with a standard life boat. It must not take longer than 6 minutes to launch the HBL.

Very often during diving operations the three chambers are separated by locked haches due to a need for different pressures (in this way more than one saturation diving depth can be covered at the same time). If this is the case it will take much longer time to get all 18 divers into the HBL where there only can be one pressure. This is also a consideration which points in the direction of a double HBL system.

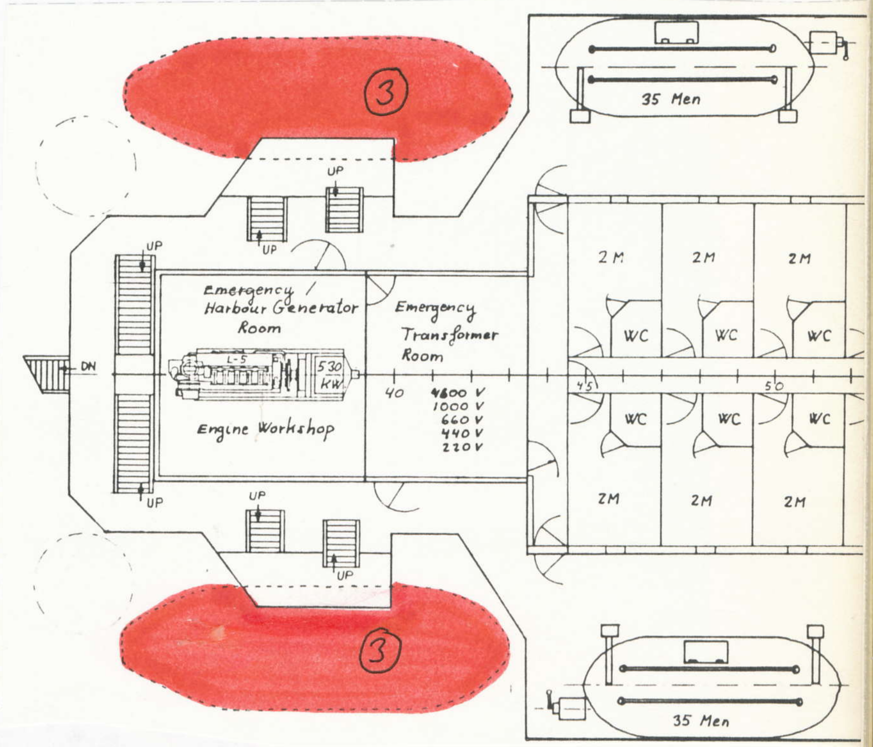
On the next page you can see how I have arranged the two hyperbaric life boats. As you can see the access to the HBL is very good. This is important not only in an emergency situatiation but also in the maintenace situatiation. Note the gas charge panel which is going to be there in order to load the HBL tube system with the correct amount of breathing gas to each each diving mission. No. 1 shows the location of the clamp connection, no. 2 shows the location of the bottom pressure hatch and no. 3 shows the lokation of the top hatch to the control compartment for a crew of three.

One Hyperbaric life boat from Dräger costs appr. 6.3 mill. D.Kr.

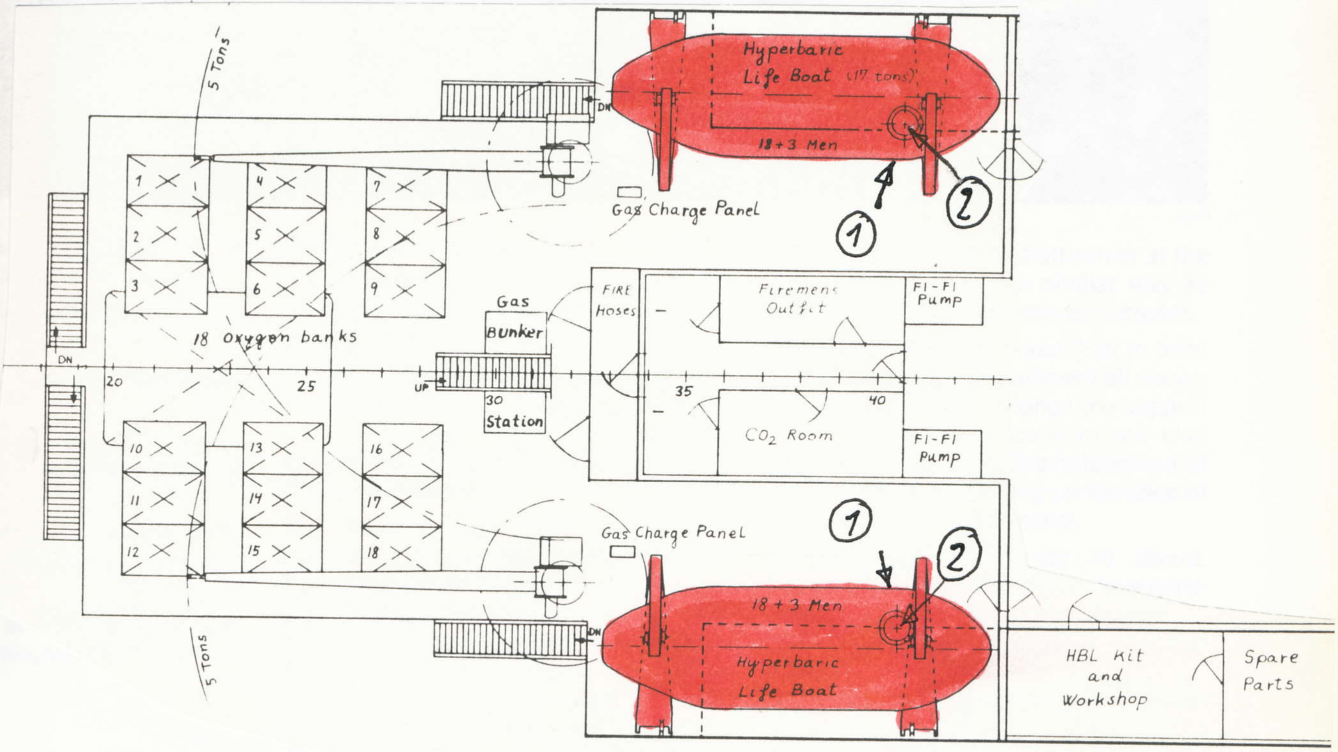
The launch system (david) is not included with the HBL delivery. It will be constructed by the warft or a subcontractor.

The Hyperbaric Life Boat can support the divers under pressure conditions up to 5 days without any support. The HBL is supposed to be found before this time and sailed to the nearest receiving terminal for hyperbaric life boats. These terminals are situated onshore in most of the larger harbours facing the North Sea area. We do have one station situated in Esbjerg. It is owned by Svitzer Diving Services and was completed in 1985. I went there to see the terminal. On one of the next pages you will see the Danish Terminal on a picture.

Heli/ACC.I Deck:



Superstructure Deck



can be operated for up
dependant at sea
about 6 knots
eel boat
mber for 16 divers (stan-
)
inutes complete opera-
power in a totally enclo-
n
and provisions are suffi-
re than 72 hours sulfsus-
tion
dy delivery for operation
ables, provisions, etc.

Hyperbaric Lifeboat

This boat is designed to rescue 16 saturated divers at a maximum pressure of 45 bars and a crew of 3 persons.

The crew consists of one navigator and two diving-system-technicians. Special care will be taken for protection against damage of the boat during launching in heavy sea-conditions.

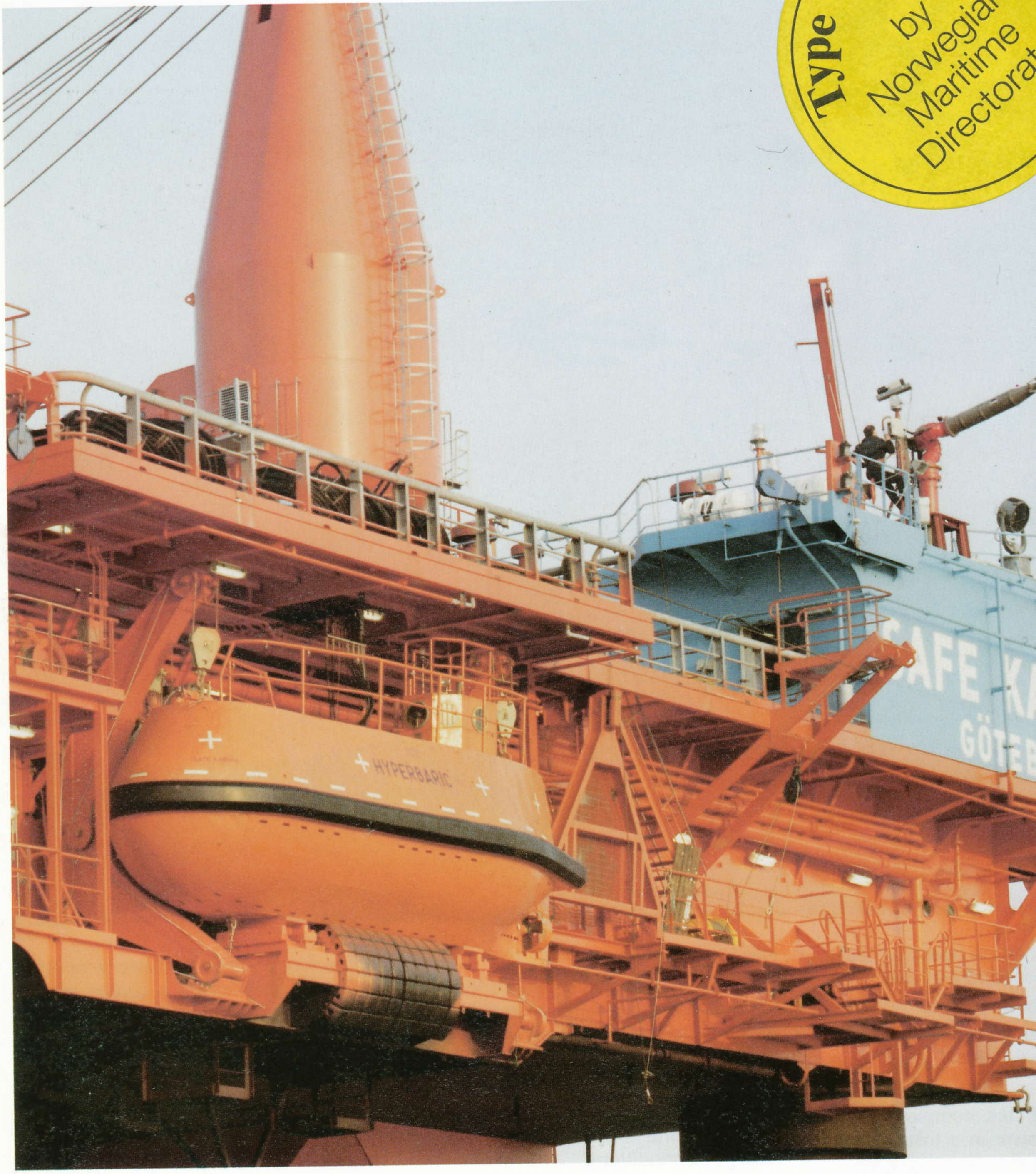
The boat is built from steel. The pressure chamber has comfortable dimensions for 16 divers. The aft watertight compartment with dome and hatch at the top connected to the chamber is the navigation, engine and operating room. Polyurethane-foam is used extensively for insulation and buoyancy. The outer hull of the boat is built from steel too for good fire resistance. The Lifeboat is connected to the chamber-system-arrangements. It can be placed on deck of a vessel or platform or at the side of a platform in a similar way as standard lifeboats or rescue capsules.

Stb.side of the boat's deck just in front of the operating-compartment all necessary connections for long-time-support are installed. These connections also can be used if the boat is hoisted out of the water and is standing on the deck of a stand by or rescue vessel.

Chamber dimensions for 16 divers, (standart version). Maximal 5 days survival time at sea without any support
250 miles cruising range at sea (full power)
500 miles cruising range at sea (econ. speed)
Engineering: Drägerwerk AG
Werk Druckkammertechnik in co-operation with Ingenieur- und Entwicklungsbüro Joachim Rohdjeß, Lübeck.

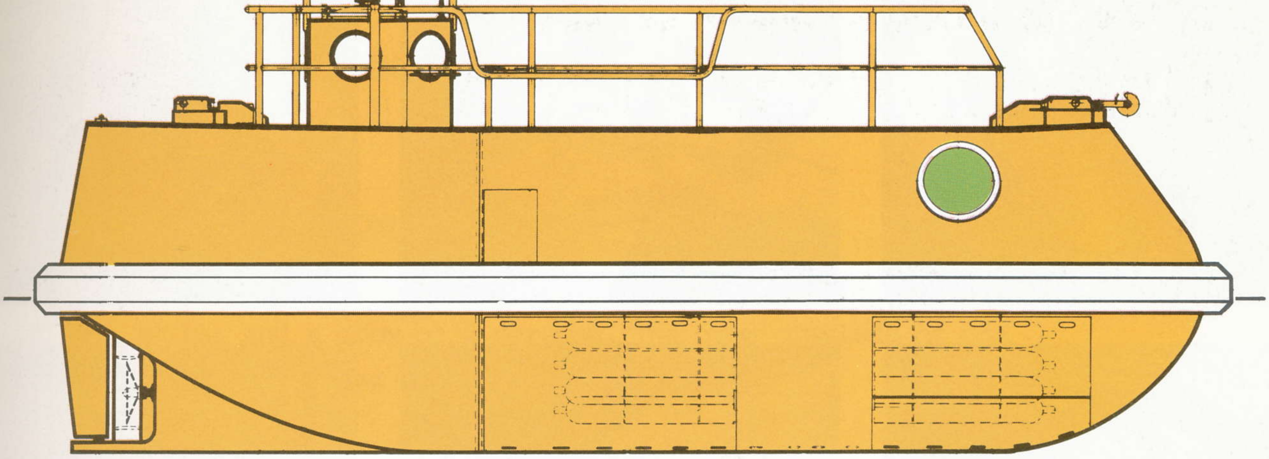
Hyperbaric Lifeboat from Dräger For evacuation of Divers under pressure

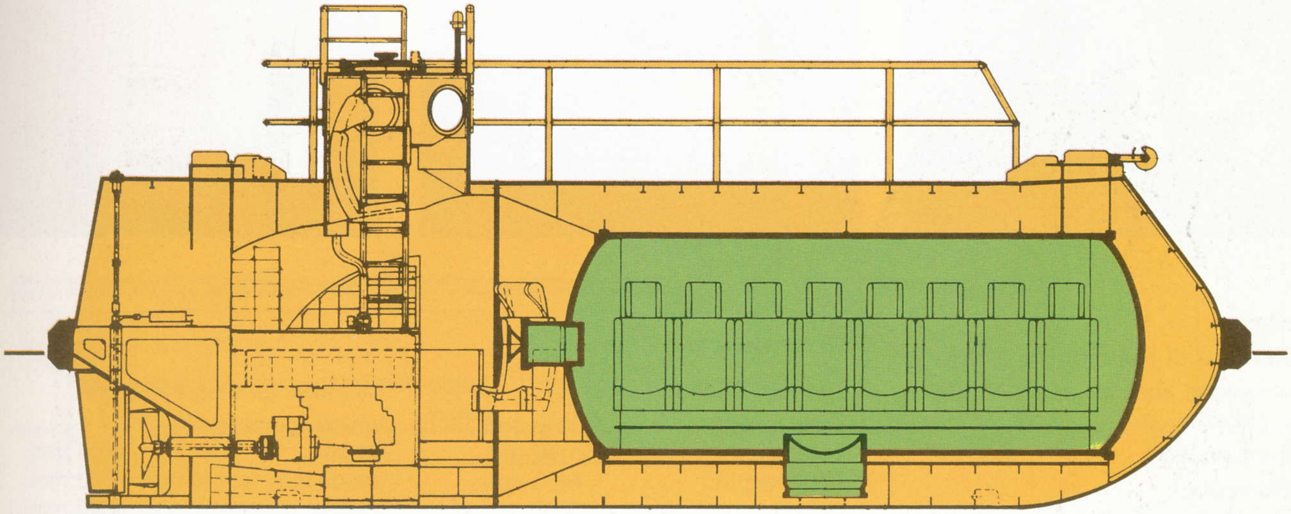
Type approved
by
Norwegian
Maritime
Directorat



Hyperbaric Lifeboat applied for typapproval by NMD (Norwegian Maritime Directorate

Accepted by	DNV (Det Norske Veritas) SSV (Swedish advisory, for shipping and navigation)
Fullfills the requirements of	NPD (Norwegian Petroleum Directoriate) DOE (Department of Energy)
In conformity with	Solas 74 convention





43387

equipment

oat

ear hooks released simultaneously om the operation compartment,

nchor and ropes below a hatch in e deck,

wing hook at the bow,

ome with watertight entrance hatch d six bulleyes,

eling with firefighting Sprinkler- stem around the deck and the me,

dder with emergency tiller,

avy fender all around the boat, pecially protecting the rudder,

opeller with protecting fairwater

Navigation

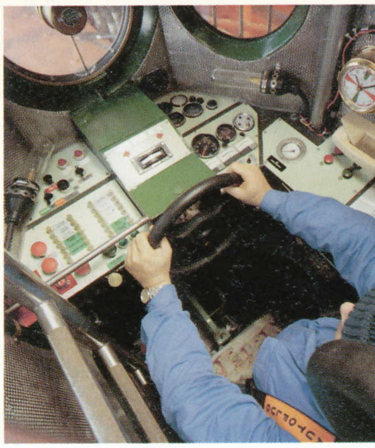
- navigation control panel with wheel and engine control and navigator's seat with belt in the dome,
- flash light,
- magnetic compass,
- search light above the dome,
- VHF-radio and antenna,
- emergency radio beacon.

Operation compartment

- propulsion system with diesel engine and related equipment in a closed and noise insulated engine room,
- engine room ventilation system,
- engine driven generator,
- batteries in closed and watertight compartments,
- electric control system 24 V,
- bilge pump, hand operated,
- drinking water tank,
- small pantry,
- storage for food and soda-lime cartridges,
- two seats with belts for the diving system technicians,
- one berth,
- heating system with integrated engine keel-cooling-system,
- lighting system,
- control systems and panels for all chamber supplies and equipments,
- consumables,
- provisions.
- all controls are within reach of operational personnel


43383


43384




43386


43382

Chamber

- — 16 seats with belts for the divers,
- — one special seat for sanitary purposes (toilet),
- — CO_2-scrubbers,
- — BIBS-system,
- — life support equipment,
- — heating system from the rig and from the motor, cooling system from the rig and from the motor
- — helium unscrambler communication system,
- — pressure gauges,
- — lighting system and emergency lighting system.
- — One mating flange (IUC) ∅ 600 mm for connection to the chamber system at the side ot the chamber,
- — one IUC-flange ∅ 600 mm at the bottom,
- — one medical and food lock,

Dimensions and Data

Lifeboat (Standart version)

Total lenght:		10040	mm	
Total width:		3140	mm	
Total height:		4400	mm	
Height:		3600	mm	
Drought:		1300	mm	
Hook distance:		6900	mm	
Displacement:	abt.	17600	kg	
Speed:	abt.	6	knots	
Capacity of divers:		16		← 18? yes!
Capacity of crew:		3		
Diesel engine:		44,5	kW	
Generator (engine driven)		750	W/24 V DC	
Battery-capacity:		5000	Ah	
Fuel-capacity:	abt.	900	liters	
Drinking water:	abt.	190	liters	
Food:	abt.	50	kg	
Diver's gas, He or premix:		70	Nm³	
Oxygen:		40	Nm³	
Compressed air:		50	Nm³	

Chamber (Standart version)

inside cylindrical length:	4000	mm
inside total free length:	4500	mm
outside diameter:	1800	mm
max. working pressure:	45	bars

Subject to modifications

DRÄGER DRUCKKAMMER-TECHNIK

DRÄGERWERK AG LÜBECK
Werk Druckkammertechnik

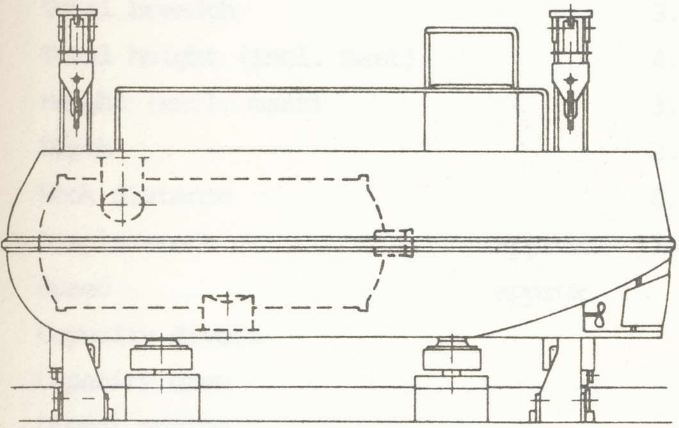
Auf dem Baggersand 17 · D-2400 Lübeck-Travemünde 1
Ruf (0 45 02) 8 30 · Telex 02 61455 · Telefax (04 51) 8 82 20 80

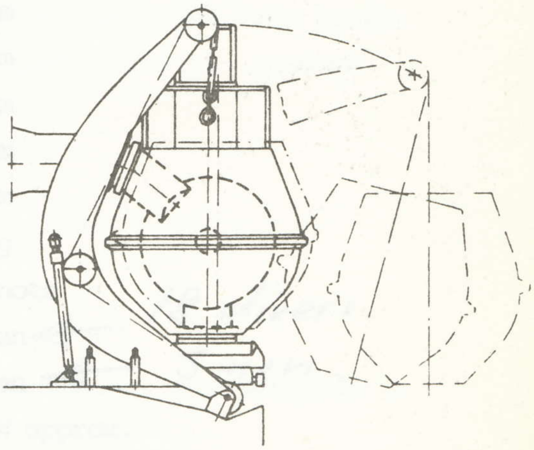
Graphische Werkstätten 2443/84 -

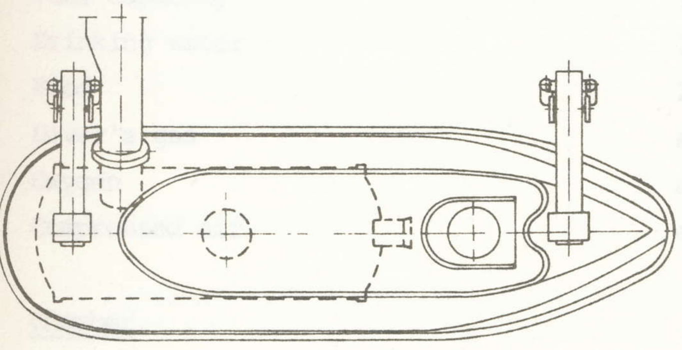
DRÄGER - Hyperbaric Lifeboat

The boat is designed to rescue max. 16 saturated divers at a pressure of max. 50 bar and a crew of 2 persons. The crew consists of one navigator and one diving system technician.

The Hyperbaric Lifeboat is designed to meet the relevant requirements of Norwegian Maritime Directorate, Norwegian Petroleum Directorate, Det Norske Veritas and Swedish Board of Shipping and Navigation.







Special care has been taken for protection against damage during launching in heavy sea-conditions.

The boat is built from steel. The pressure chamber is equipped for 16 divers. The aft watertight compartment with dome and hatch at the top is the navigation, engine and operation room. Polyurethane foam is used extensively for insulation and buoyancy.

The lifeboat is connected to the chamber system via a trunk by a mating flange. This flange is located at the bottom.

Dimensions and data

Lifeboat

Total length		9.500 mm	
Total breadth		3.000 mm	
Total height (incl. mast)		4.600 mm	
Height (excl. mast)		3.200 mm	
Depth		2.100 mm	
Hook distance		6.600 mm	
Displacement	approx.	17.000 kg	
Speed	approx.	4.5 knots	
Capacity divers		16 men	← 18 divers
Capacity crew		2 men	← 3 men.
Diesel engine		35 kW approx.	
Generator (engine-driven)		1.000 W/24 V	
Battery capacity		6.000 Ah	
Fuel capacity		900 liters	
Drinking water		200 liters	
Food		200 kg	
Diver's gas		acc. to authorities requirement	
Oxygen		acc. to authorities requirement	
Compressed air		acc. to authorities requirement	

Chamber

Inside cylindrical length	approx.	4.000 mm
Inside total free length	approx.	4.500 mm
Outside diameter	approx.	1.800 mm
working pressure		50 bar

- One mating flange Ø 600 mm for connection to the chamber system, located at the bottom.
- One window from operation compartment
- One medical and food lock

Main equipment

Lifeboat

- Gear hooks released simultaneously from the operation compartment
- Anchor and ropes below a hatch in the deck
- Towing eye at the bow
- Dome with water-tight entrance hatch and six bulleyes
- Reeling with fire fighting Sprinkler system around the deck and dome
- Two rudders, in case of damage on rudder can be disengaged from inside
- Heavy fender all around the boat, especially protecting the rudders
- Mast with automatic air valve
- Propeller

Navigation

- Navigation control panel with wheel and engine control and navigator's seat with belt in the dome
- Radar reflector and flash light on the mast
- Magnetic compass
- Search light above the dome
- VHF-radio and antenna
- Emergency radio beacon

Operation compartment

- Propulsion system with diesel engine and reduction reverse gear in a closed and noise insulated engine room
- Engine room ventilation system
- Engine driven generator
- Batteries in closed and water-tight compartments
- Electric control system 24 V
- Motor-driven bilge pump
- Emergency bilge pump, hand-operated
- Drinking water tank
- Storage for food and soda-lime cartridges
- One seat with belt for the diving system technician
- One berth

Operation compartment (cont.)

- Heating system
- Lighting system
- Control panels for all chamber supplies and equipment

Chamber

- 16 seats with belts for the divers
- CO_2-scrubbers
- BIBS system
- Life support equipment
- Heating system and emergency heating system
- Communication system with Helium voice unscrambler
- Pressure gauge
- Lighting system

Outside supply connections

On starboard side and on deck:

- Gas supply
- Gas exhaust
- Oxygen supply
- Gas sample
- Pressure control
- BIBS supply
- BIBS exhaust
- Heating water inlet
- Heating water outlet
- Electric power supply for charging
- Emergency electric power supply separately for lighting, CO_2-scrubbers and emergency heater
- Communications

On board the vessel the Hyperbaric Lifeboat is controlled and supplied from the control panel located in the chamber control room.

Trunk, Mating System

The connecting trunk from Deck Chamber to the Hyperbaric Lifeboat has a inside dia of approx. 800 mm and a length according local requirements. The connection to Deck Chamber is made by means of a 2-part clamp coupling of 700 mm Ø. The deck penetration is performed waterproof by a rubber ring gasket.

A mechanically-operated two part quick release clamp coupling with a Ø of 600 mm is situated on deck.

A hand-operated hydraulic operating unit facilitates the opening of the clamp on deck.

When I visited the Hyperbaric Life Boat Station (OHF) in Esberg I found it to unmanned. Off course the operators would be send there in case of an emergency. There is electrical power on the system I could see. The station, however, is situated in the corner of a huge storage room where it could be difficult to create access fast enough in case of an emergency.

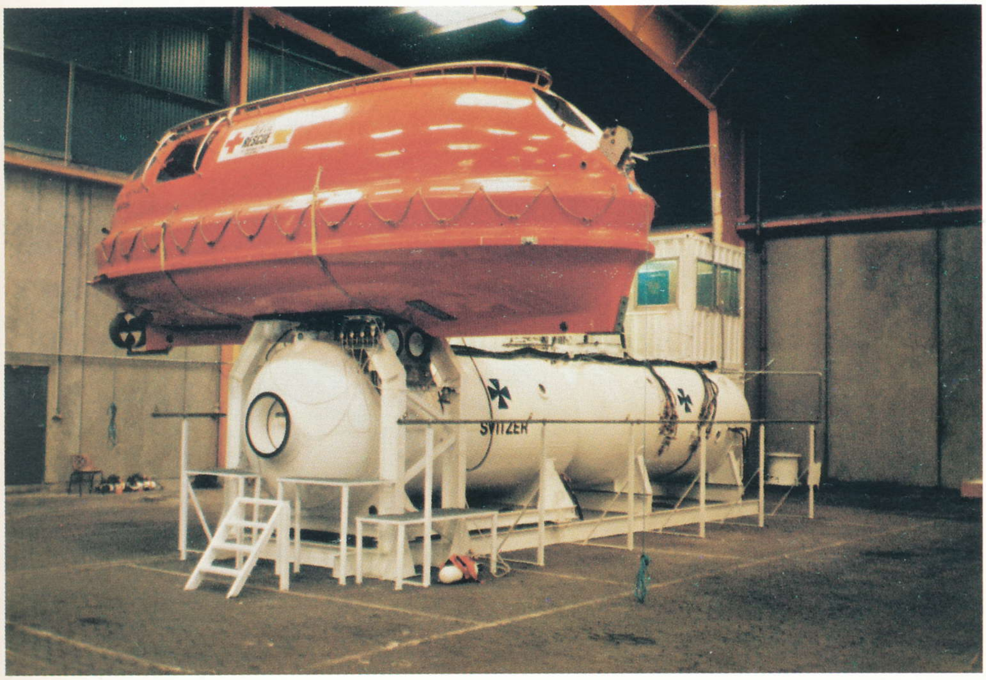
nshore Hyperbaric Facility

cation: Esbjerg, Denmark

erator: Svitzer Diving Services, a branch of Em. Z. Svitzers Salvage-Company, Ltd.

mpletion: 1985

rpose:
- Receiving terminal for hyperbaric lifeboats
- Decompression and medical treatment of injured divers
- Equipment test
- Training of operational personnel and divers



chnical details:

amber	DDC 1	DDC 2
ameter (mm)	1800	1800
erational pressure (bar)	20	20
lumen (m^3)	11,5	11,5
tch diameter (mm)	600	600
pflange	IUC	IUC
de/end flange	IUC	28 bolt holes

th chambers are fully equipped with all equipment necessary for the treatment and accommodation mfort for saturation divers.

ajor parts of the internal equipment are:

nergetics habitat conditioning units, ox-blood fire exstinguishers, medical kits, toilet, sink, shower, nergency heater and schrubbers, beds e.t.c.

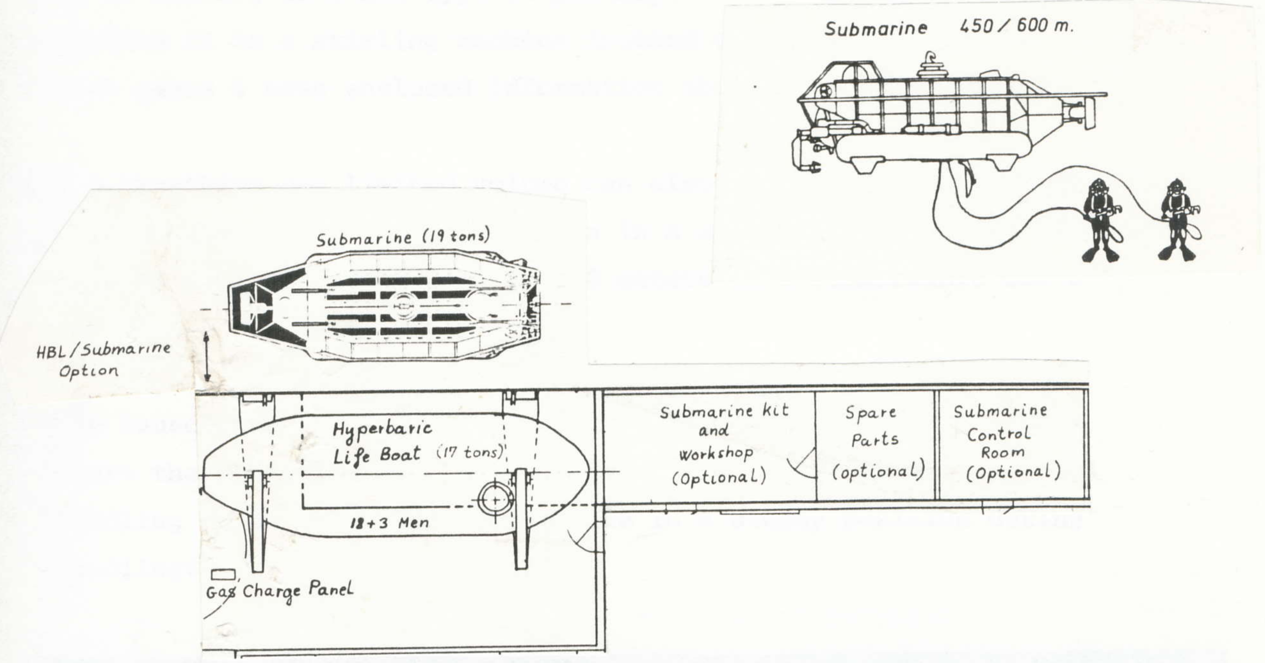
SVITZER DIVING SERVICES

D. LAURITZENSVEJ · DK-6700 ESBJERG · DENMARK · TELEPHONE: INT.+45 5 12 23 55 · TELEX: 54 356 - SVIDIV DK

6.21.

THE SMALL SUBMERSIBLE

As you can see from the main drawing there is a submersible included in the design. It can also be seen here:



The submersible is an option, i.e. if only one hyperbaric life boat is preferred arrangements has been included in the design to install a submersible from Bruker in stead. This can be done because the trunk connection to the saturation chambers is there, the gas charge panel is there and the necessary rooms in connestion with a submersible is there too. The only thing that has to be changed is the handling system. The weight of the two are very much the same (the hyperbaric life boat weighs 17 tons and the submersible weighs 19 tons).

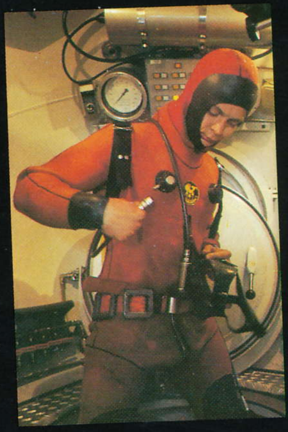
Jörg Haas from Bruker has been producing this kind of submersibles for many years and I asked him if he was going to change this interest now that the flying bell has been developed. He said that the flying bell was developed because the customer wanted it and because he was the only one able to construct such a thing. He thinks that the submersible for diver lock-out is superior even to the flying bell. The submersible is free from the long umbilical to the surface which might be entangled in underwater constructions and that the long umbilical might cause troubles for the bell driver in strong currents. It is correct that there are limited power in the sub and that it is more difficult to launch and retrieve, But this will soon be solved and it is not correct that the submersible is very expensive - the flying bell is as expensive as a submersible, he told me.

He is working on a new type of powersystem to the submersibles, perhabs it is a stirling machine instead of batteries. On the next pages I have enclosed information about a Stirling engine.

The breathing gas limited volume can also be overcomed. If we are able to ship three men to the moon in a small capsule we are also able to send three men down to 450 meters in a submersible for a day or two, he said.

The launch and retrival system of Bruker is not a david or crane where the submarine will swing from side to side, it is a special handling which holds the submersible in a steady position during handling:

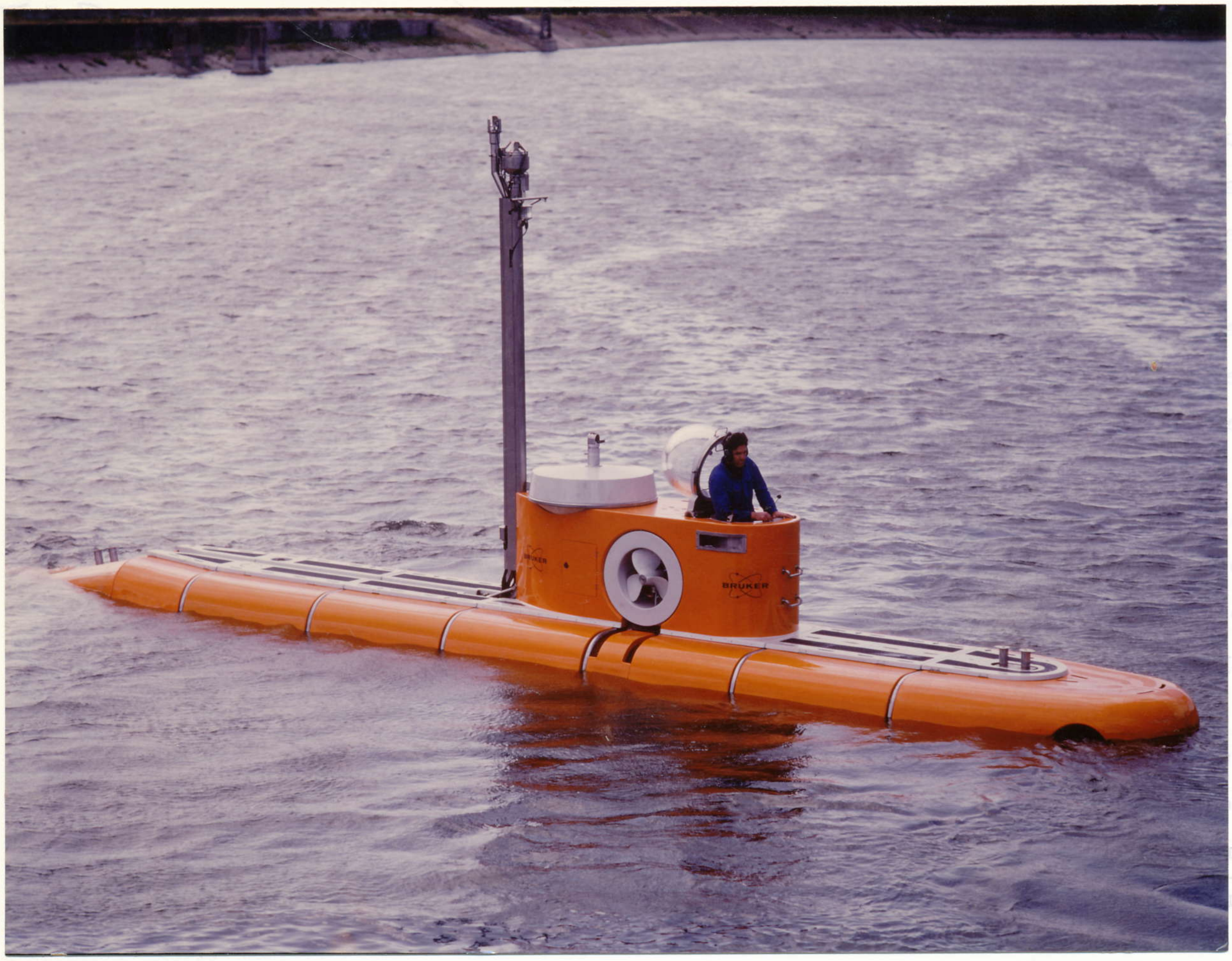
Submarine rescue submersible MERMAID VI SAR with handling system. This versatile vehicle can dive to 600 m and is also suited for dry or wet transfers and diver lock-out.



Interior of 300 m diver lock-out chamber for 3 saturation divers.

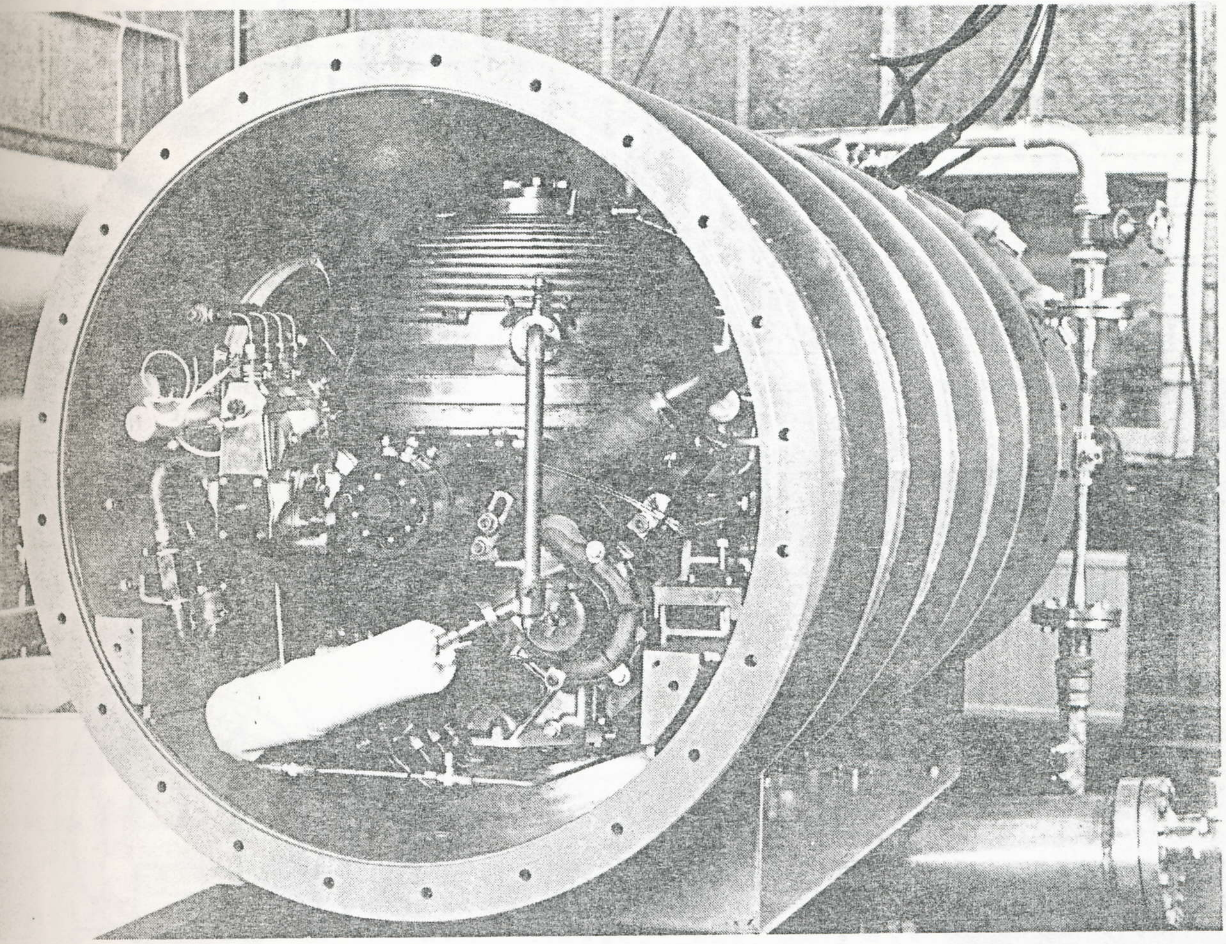
BRUKER also offers heat pump diver heating systems for closed loop hot water suits.

To overcome earlier limitations of manned diver lock-out and inspection submersibles, Bruker initiated the development of releaseable umbilicals and advanced, diverless handling techniques.



The manager Jörg Hass from the Bruker company is dirving one of his military submarines in the waters of the rhein. This submarine type is being transported by railways from Karlsruhe to the customers every where in Europe.

THE STIRLING ENGINES FOR UNDERWATER APPLICATIONS

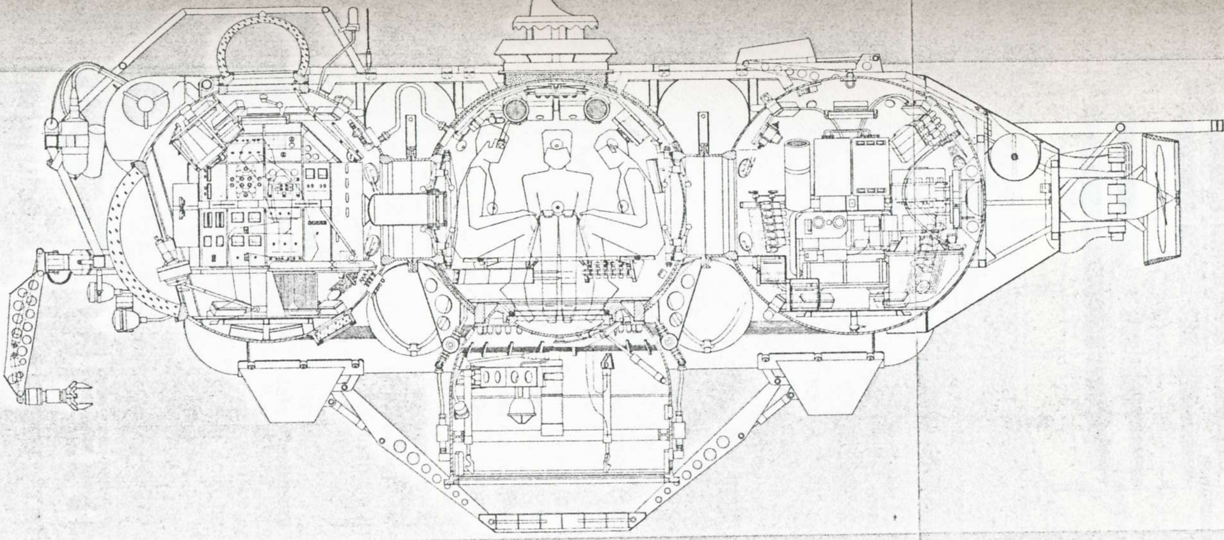


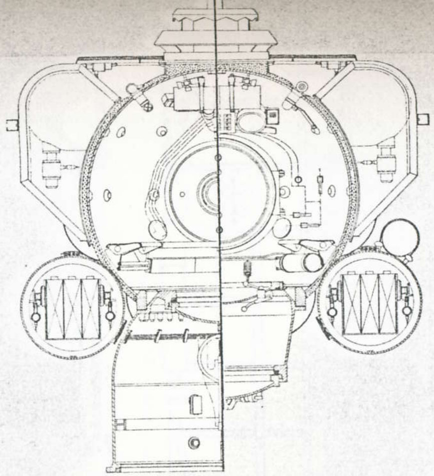
A STIRLING UNDERWATER ENGINE

E UNDERWATER ENGINES

Engine	Continuous operation			Maximum output		
	Speed	Electricity	Heat*	Speed	Electricity	Heat*
4-95	3000 rpm	30 kW	40 kW	4000 rpm	35 kW	65 kW
4-275	2000 rpm	75 kW	110 kW	2600 rpm	100 kW	200 kW

ot water 50° C





Instrumentation and Special Equipment

A wide range of instrumentation and equipment is available.

For instance, MERMAID VI A has been fitted out with:

surface radio, flash light, underwater telephone, pinger locater, scanning sonar, echograph, depth gauges, gyro compass, helium speech unscrambler, fixed and tiltable searchlights; two complete underwater television systems (one fitted out with searchlights and mounted on a pan-and-tilt unit, the other mounted on a removeable arm in the mating skirt), an emergency surface buoy, a buoy release system for four floating marker buoys and a pinger release system which activates the pinger when being launched.

Two hydraulic manipulators of the BRUKER Standard Type BM 76 are installed for many kinds of applications, such as fixing and removing of lift lines, picking up or deposition of equipment, DP-pingers, etc. Cable cutters and rotating tools such as grinders and wire brushes can be exchanged against the standard parallel claw of the manipulator. A set of extendable legs usable in different modes are required for lockout or mating operations.

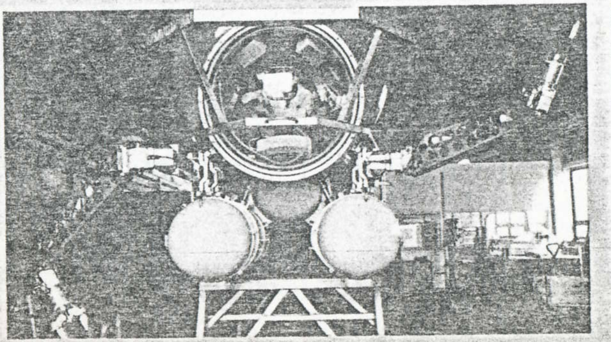
Ballast System

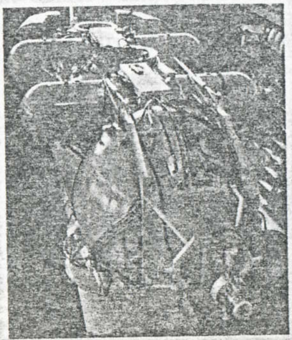
The highly effective ballast system comprises four hard ballast tanks with a total capacity of 1160 ltr and four main ballast tanks of 1300 ltr total volume. Compressed air stored in four high pressure gas spheres of 110 ltr volume each at 300 bar is used for blowing both tank systems. Furthermore the hard tanks can also be emptied by using the drain pump system.

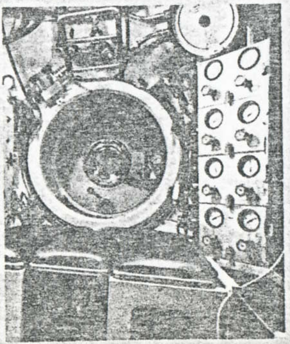
Diving Equipment and Life Support

The DLO-version can be fitted out for air, bounce, and saturation diving. Breathing gas is stored in four high-pressure gas spheres of 110 ltr volume each. Open circuit, semi-closed and closed circuit breathing apparatus can be integrated into the system. A complete control panel including high accuracy pressure gauge for the diving compartment, storage control gauges, control valves, oxygen and carbondioxide monitors, temperature monitors, communication systems etc. is installed in the command sphere to be operated by the diving supervisor.

Heating of the closed-circuit diving suits and the lockout chamber is accomplished by the highly energy-saving heat pump diver heating system developed by BRUKER.







The divers lock out and in through a wide lockout trunk with 700 mm minimum light hatch diameter. The trunk is fitted out with internal hatch and external bayonett type double acting hatch. The latter is fully hydraulically operated. The sub can be locked to any existing deck decompression chamber by using simple specially designed adapters.

For lockout operations, the sub can be made up to 1000 kg negative by using the regular ballast system and partly flooding the lockout trunk. The lockout chamber remains completely dry. Full power of up to 10 kW from the main hydraulic system otherwise used for propulsion is available for divers' tools.

Rescue and Dry/Wet Transfer

In the SAR- or DWT-mode a mating skirt which may vary in size and diameter is bolted to the central sphere instead of the diver lockout trunk. The skirt or dome is fitted out with a fully hydraulically operated bayonett hatch opening into the skirt. The rescue compartment has space for up to 10 passengers or three to four man maintenance personnel in the transfer mode.

Two powerful hydraulically operated high pressure water pumps serve for draining the mating skirt previous to pressure equalization and opening the hatches. Rescue and transfer operations can be performed in up to 600 m water depth. For dry transfer purposes on subsea completion chambers an inert atmosphere can be established within the transfer module while the personnel is using closed circuit breathing apparatus.

The high 1000 kg payload capacity and a hoist installed in the pole of the transfer/rescue sphere allow for transportation and exchange of relatively heavy spare parts and components.

Design History

Development of new components begun in 1977, design and construction of MERMAID VI A and B started in 1978. Shallow water trials of MERMAID VI A in summer 1979, delivery Oct. 1979.

MERMAID VI B scheduled for completion in summer 1980.

MERMAID VI C + D under construction 1980/81.

The subs are or will be certified by Germanischer Lloyd, Hamburg.

THE DIVING COMPLEX PIPING SYSTEM

In the case of the Consafe semisubersible vessels Dräger was the responsible part for all diving systems and produced a piping diagram.

Most of the piping is going to be constructed by the shipyard. From the piping diagrams and specifications from Dräger it is easy to see what pipes there are going to be installed and where the interfaces are. The piping system is very complicated and an analysis is needed for the Searambler.

I have used the pipe diagram from Safe Regalia and modified it to comply with the needs of my diving system.

In the following you will see this modified diagram. Note that Dräger is a company which do not use "short cuts", i.e. they do not like other manufacturers use remote controlled electrical or hydraulic valves in the pipe system. Each and every pipe which function is to be controlled is taken physically to the control panels.

Controlling the gas flows in the system is a very serious matter and a remote controllable system is still not belived to be safe enough to introduce. Therefore, the control panels, the bells, the chambers and the tube system should be placed as close to each other as possible regarding other limitations too in order to save long pipes.

I have taken these considerations in mind when placing the different diving components and diving rooms onboard my ship, although some compromises must be regarded.

Look at the gas pipe diagram. I have changed the original drawing on the following points:

A) The piping to the three Life Support Systems is now shown
B) The piping from each chamber is shown
C) The gas bag piping is now shown
D) The trunk gas release is now taken to the gas bag in stead of overboard dumping
E) The same as with D)

F) Two Hyperbaric Life Boat Chambers with separate is going to be there in stead of only one

G) A flying bell has been introduced

H) The exhaust pipes from the bell is no longer a dump over board system. The pipes are taken to the Closed Circuit Breathing System

I) A helium reclaim system is introduced

J) A Closed Circuit Breathing System is introduced for the Dräger Bell

K) Same as J) for the Bruker bell

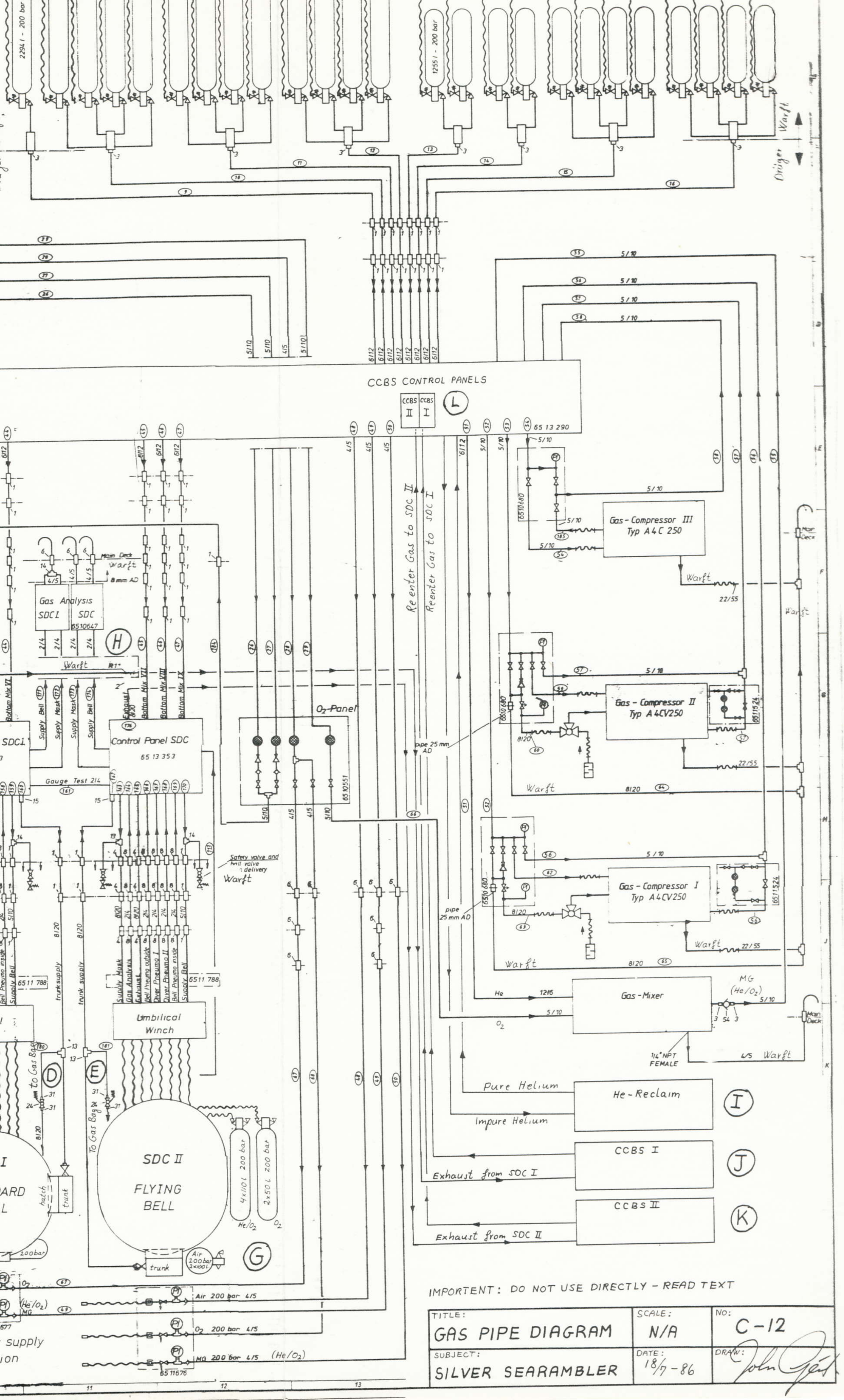
L) Two separate Closed Circuit Breathing System control panels are introduced. They shall be built into the Bell Control Panels

M) Imagine that the DDC II now has two ante chambers in stead of only one and that there, therefore, are two of these pipeconnections and control panels etc. in stead of only one as shown

N) There shall be two gas service station containers for the surface diving system

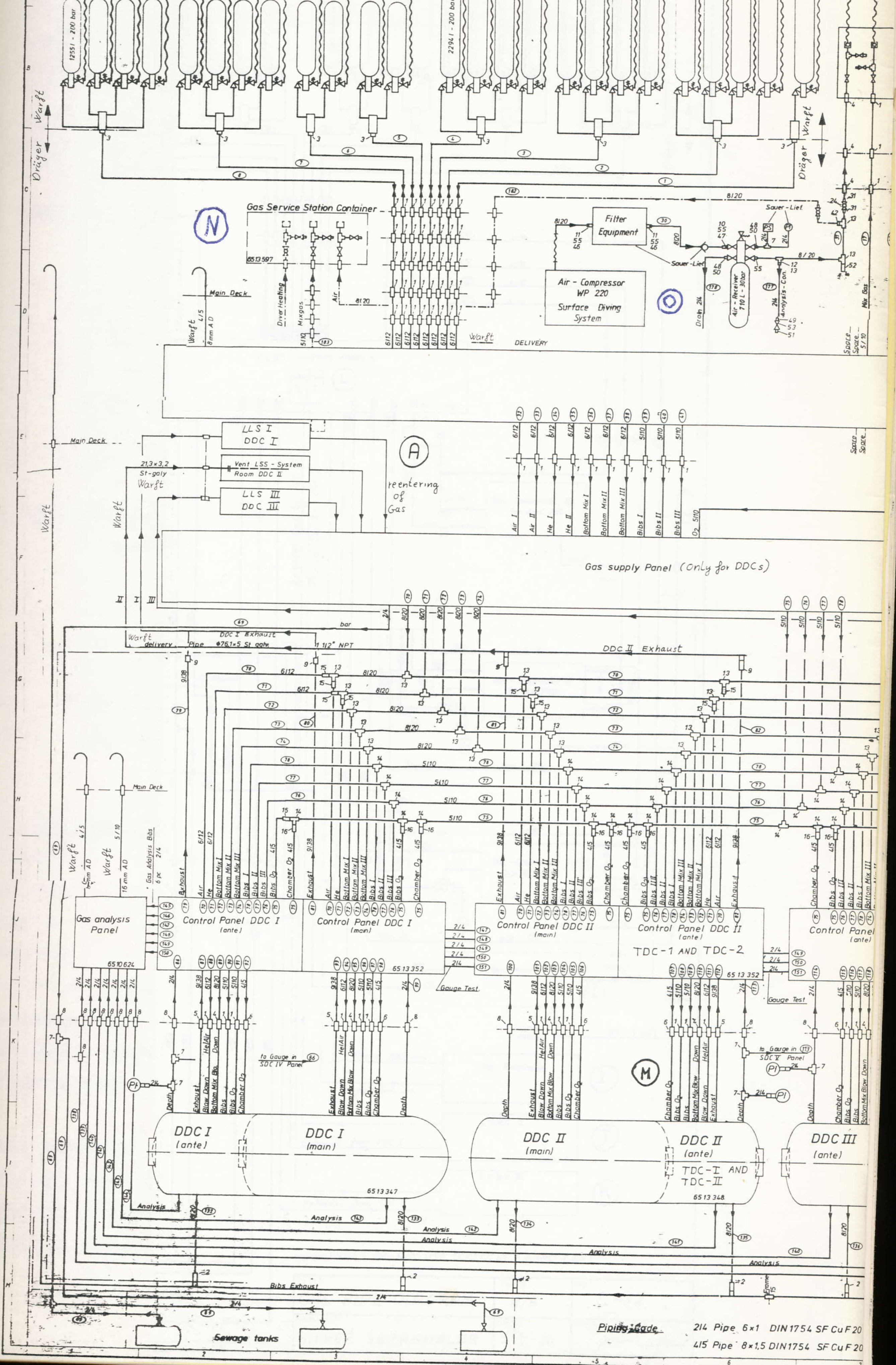
O) There shall be two air compressors in stead of only one and they shall be of the Bauer type. They shall be built into the the service station containers

P) There shall be two surface diving containers and the oxygen banks for the gasmixer function shall be the oxygen stowage systme on open deck.



IMPORTENT: DO NOT USE DIRECTLY - READ TEXT

TITLE:	SCALE:	NO:
GAS PIPE DIAGRAM	N/A	C-12
SUBJECT: SILVER SEARAMBLER	DATE: 18/7-86	DRAW: John

12551 - 200 bar
22941 - 200 bar
Dräger
Warft
Gas Service Station Container
6513597
Diver Heating
Mixgas
Air
8120
N
Filter Equipment
Air - Compressor WP 220
Surface Diving System
Sauer - Lief.
Air - Receiver 710 L - 30bar
Drain 2/4
Analysis - Con.
O
Main Deck
8mm AD
DELIVERY
Mix Gas
Spare
LLS I DDC I
Vent LSS - System Room DDC II
LLS III DDC III
21,3×3,2 St-galv
A
reentering of Gas
Air I
Air II
He I
He II
Bottom Mix I
Bottom Mix II
Bottom Mix III
Bibs I
Bibs II
Bibs III
O2 5/10
Gas supply Panel (Only for DDCs)
DDC I Exhaust
Pipe ⌀76,1×5 St galv
1 1/2" NPT
delivery
bar
DDC II Exhaust
Gas analysis Panel
6510624
Control Panel DDC I (ante)
Control Panel DDC I (main)
6513352
Control Panel DDC II (main)
Control Panel DDC II (ante)
TDC-1 AND TDC-2
Control Panel (ante)
Gauge Test
Gas Analysis Bibs 6 pc 2/4
Exhaust
Chamber O2
to Gauge in SDC IV Panel
to Gauge in SDC V Panel
PI
M
He/Air
Blow Down
Bottom Mix Blow
Bibs O2
Depth
DDC I (ante)
DDC I (main)
6513347
DDC II (main)
DDC II (ante)
TDC-I AND TDC-II
6513348
DDC III (ante)
Analysis
Bibs Exhaust
Sewage tanks
Piping Code
2/4 Pipe 6×1 DIN1754 SF CuF20
4/5 Pipe 8×1,5 DIN1754 SF CuF20

THE HELIUM RECLAIM SYSTEM, (PRICE appr. 1.3 mill. D.Kr.)

Specification

Input impured gas

The respective helium content of the inlet helium gas varies during operation between 80 - 95%, its main inlet impurities being mostly oxygen and nitrogen.

Detailed specification of input impured gas:

1.	Oxygen/O_2	max. 20 Vol. %
2.	Nitrogen/N_2	max. 20 Vol. %
3.	Carbon dioxide/CO_2	max. 1,5 Vol. %
4.	Carbon monoxide/CO	max. 50 ppm
5.	Water/H_2O	saturated
6.	Other gases	
6.1	Hydrocarbons	max. 5 Vol. %
6.2	H_2S, NH_3, SO_2	max. 2 ppm, each

Detailed specification of cleaned gas:

1.	He purity	99 Vol. %
2.	O_2	max. 0,5 Vol. %
3.	N_2	max. 0,4 Vol. %
4.	CO_2	max. 10 vpm
5.	CO	max. 2 vpm
6.	Hydrocarbons	max. 1 vpm
7.	H_2S, NH_3, SO_2	max. 1 vpm, each

Technical data:

Length	2700 mm
Height	2400 mm
Depth	1600 mm
Weight	1800 kg
Services required:	
Working air	
(quality according to DIN 3881)	1 m^3/h, 6 bar
Electrical supply	3 kVA, 440 V, 60 Hz

Gas connection:

Helium impured	16 bar
Helium cleaned	25 m^3/h, 16 bar
Helium exhaust	1 bar (abs.)

ante chambers

BASIC OPERATION

Gas is routed from the CHAMBER EXHAUSTS, MEDICAL LOCKS, EQUIPMENT LOCKS and the BELL MATING TRUNK (1) via pressure piping to a 3-WAY VALVE (2). NOTE: Low pressure tubing such as copper or PVC is quite adequate if a suitable relief valve is connected bypassing the 3-WAY VALVE.

The 3-WAY VALVE routes gas to atmosphere or to the GAS BAG (3).

NOTE: Gas is not normally recovered at depths much less than 66 FSW (20 MSW) due to the relatively high oxygen percentage.

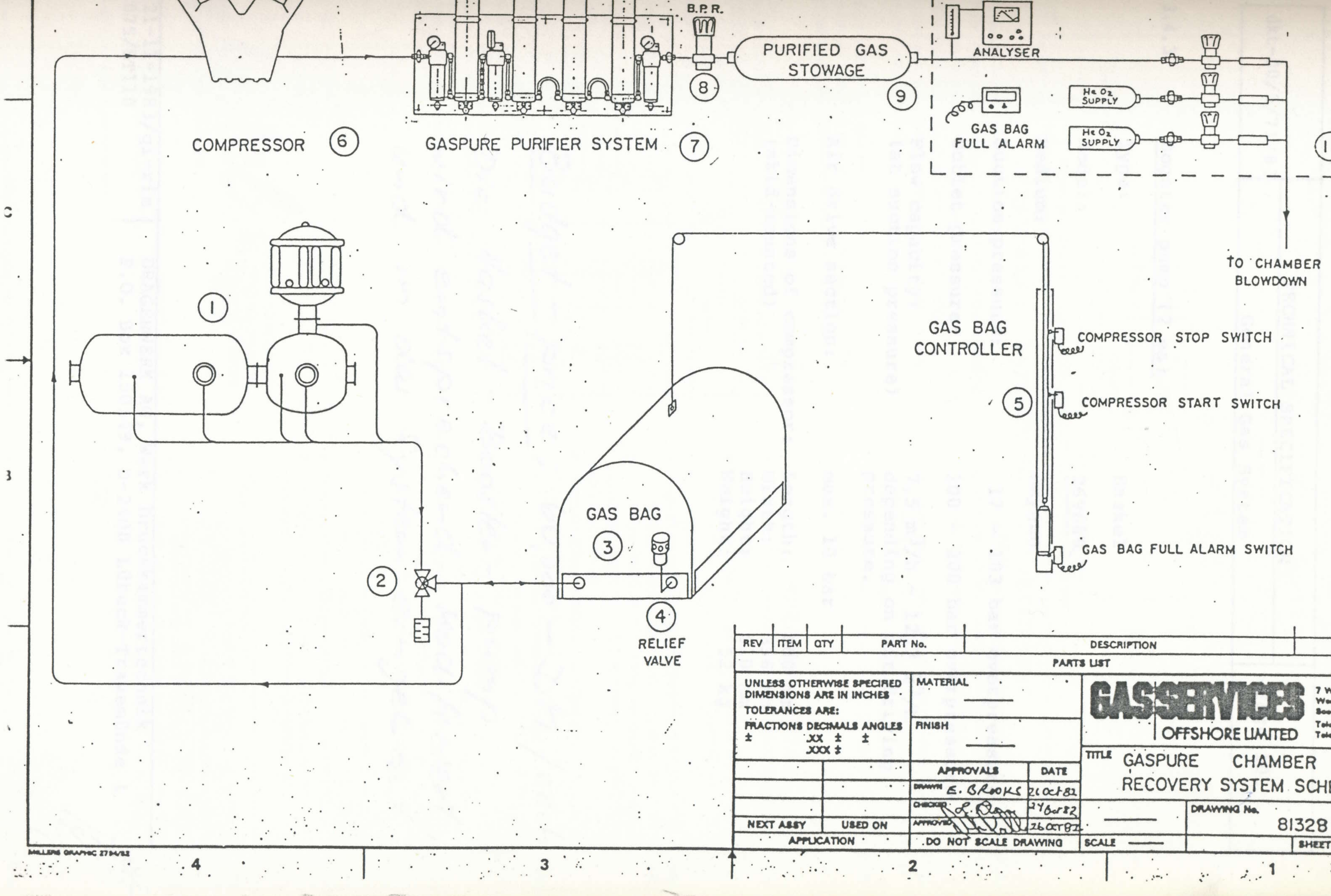
Gas would then enter the GAS BAG inflating it until the GAS BAG LEVEL CONTROLLER (5) turned on the GAS COMPRESSOR (6). The GAS BAG LEVEL CONTROLLER would also turn off the GAS COMPRESSOR after deflating it to a pre-determined level.

NOTE: The GAS BAG is protected from over inflation by a RELIEF VALVE (4) which should be connected to discharge overboard.

The GAS COMPRESSOR would draw from the GAS BAG and discharge into the GASPURE PURIFIER SYSTEM (7) where Water Vapor, Particles, Bacteria, Carbon Dioxide, Carbon Monoxide, Hydrogen Disulphide, Sulphur Dioxide, Ammonia, Mercaptans, Nitrous Oxides, Heavy Hydrocarbons, Methane and other Light Hydrocarbons are removed at a Flow rate up to 80 SCFM (136 SCMH). NOTE: In fact the purified gas is at least 400,000 times cleaner than the air we normally breathe.

A BACK PRESSURE REGULATOR (8) maintains the minimum system pressure at approximately 2,000 psi (138 bar) ensuring efficient operation of each element of the GASPURE PURIFIER SYSTEM.

The purified gas is then routed to suitable HIGH PRESSURE STOWAGE (9) where it is ANALYSED (10) and then ready for re-use as CHAMBER BLOW DOWN GAS (11).

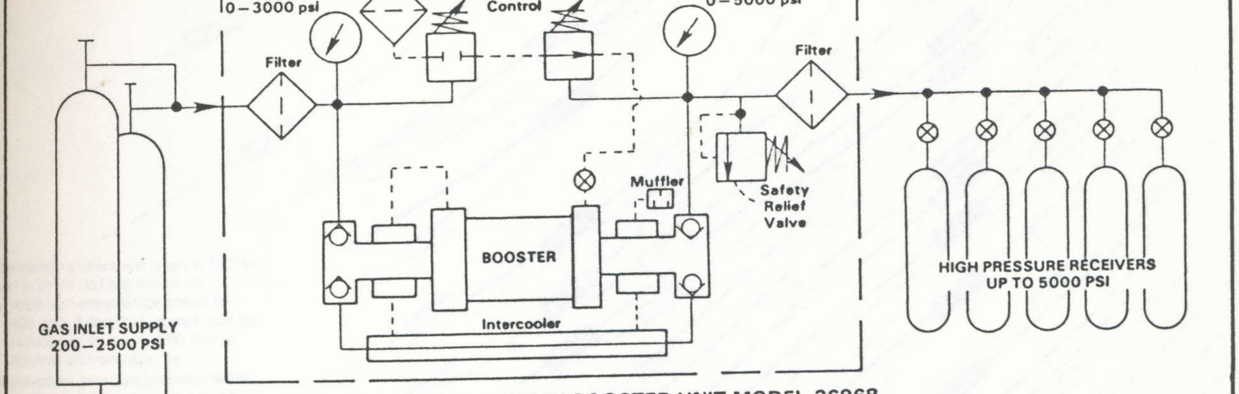

B.P.R.
PURIFIED GAS STOWAGE
ANALYSER
He O2 SUPPLY
He O2 SUPPLY
GAS BAG FULL ALARM
COMPRESSOR
6
GASPURE PURIFIER SYSTEM
7
8
9
1
TO CHAMBER BLOWDOWN
GAS BAG CONTROLLER
COMPRESSOR STOP SWITCH
COMPRESSOR START SWITCH
5
GAS BAG FULL ALARM SWITCH
1
GAS BAG
3
2
4
RELIEF VALVE
REV
ITEM
QTY
PART No.
DESCRIPTION
PARTS LIST
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS DECIMALS ANGLES
± .XX ± ±
.XXX ±
MATERIAL
FINISH
APPROVALS
DATE
DRAWN E. BROOKS 21 Oct 82
CHECKED 24 Oct 82
APPROVED 26 OCT 82
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
GASSERVICES OFFSHORE LIMITED
TITLE GASPURE CHAMBER RECOVERY SYSTEM SCH
DRAWING No.
81328
SCALE
SHEET
MILLERS GRAPHIC 2794/82
4
3
2
1

3.4.3 Booster pump (2 ea)

Type:	Haskel
Model:	269680
Medium:	Oxygen
Suction pressure:	17 - 103 bar overpressure
Outlet pressure:	100 - 200 bar overpressure
Flow capacity: (at suction pressure)	7,5 m^3/h - 12,7 m^3/h depending on air driving pressure.
Air drive section:	max. 10 bar
Dimensions of compressor: (skid-mounted)	Length: 800 mm Width: 356 mm Height: 610 mm Weight: 52 kg

Budget-price: 60.000,- DM/each

Die Haskel-Booster-pump wird entsprechend Modifiziert, und in das System eingebaut.



BASIC SCHEMATIC HASKEL OXYGEN BOOSTER UNIT MODEL 26968

FEATURES OF 26968 OXYGEN BOOSTER UNIT

. Drive is a low friction, slow speed cycling air ylinder, designed for continuous duty without airline brication. Vented distance pieces insure ydrocarbon-free gas section operation. High ressure oxygen seals are wear compensating and nmune to sudden failure.

. Very cold air (as low as −20°F) is a natural y-product from the air powered drive exhaust. This igid exhaust air is channeled through a system of cooling jackets and interstage cooler, resulting in high pressure cylinder temperatures well below limits needed for long life of critical parts.

3. Inlet gas supply pressure acts directly through the opposed piston construction to assist the air drive during the compression stroke, conserving power required by the drive in direct proportion to the gas supply pressure.

PERFORMANCE

EXAMPLES OF PERFORMANCE WITH AIR DRIVE POWER OF 0 SCFM (C) AIR FLOW AT AIR DRIVE PRESSURE INDICATED

OXYGEN GAS PRESSURE — PSI		OXYGEN OUTLET GAS FLOW — SCFM		
		Air Drive PSI		
INLET	OUTLET (B)	60	80	100
250	1500	4.2	4.8	5.3
250	3000	(A)	(A)	2.8
500	2250	6.6	8.5	9.6
500	3000	(A)	4.5	7.6
500	4500	(A)	(A)	(A)
1000	3000	(A)	8.9	15.1
1000	5000	(A)	(A)	1.9
1500	3000 210	(A)	(A)	2.8
1500	5000 350	(A)	(A)	2.8

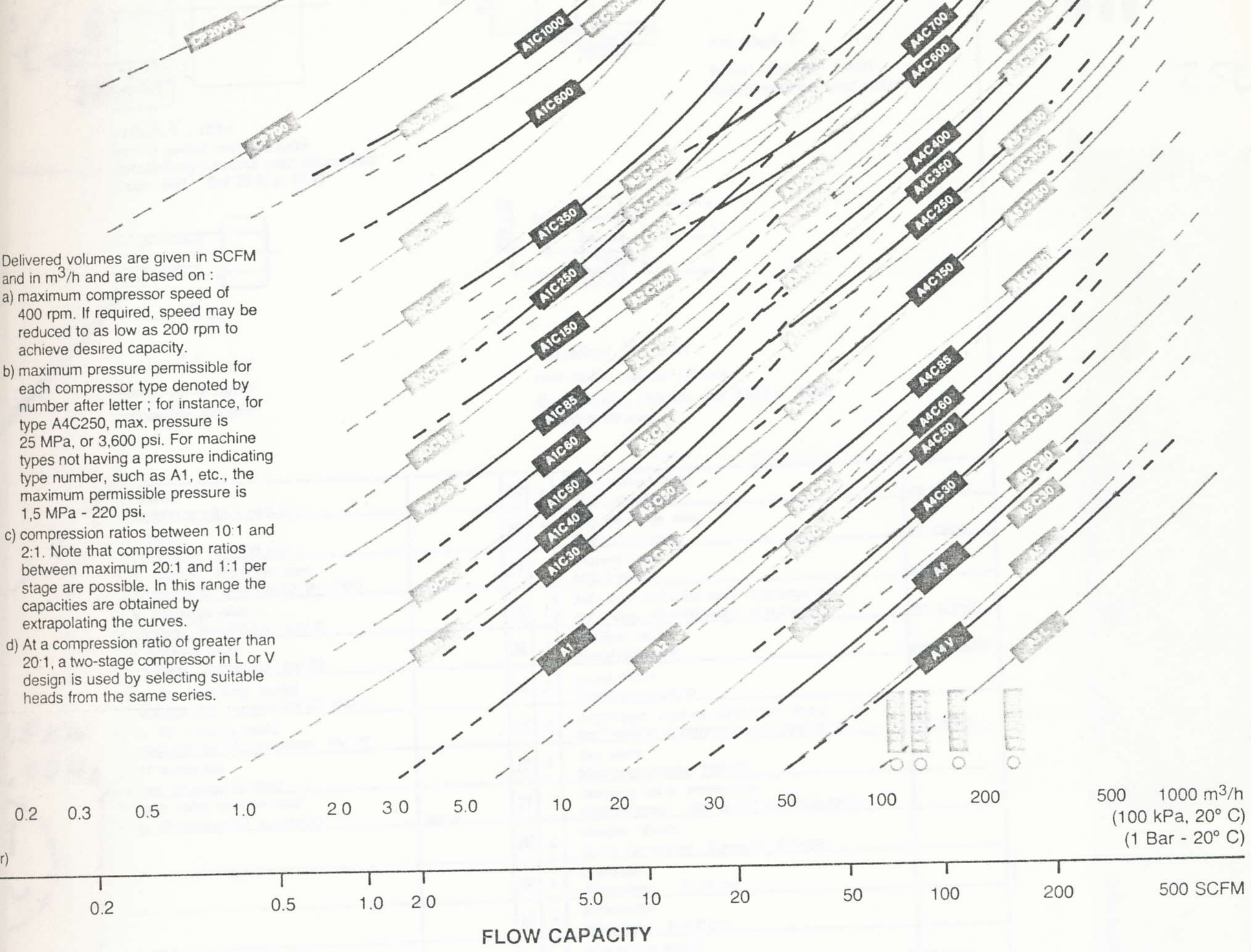
) Stall condition. (Completely safe, no overload or heat occurs.)
) Formula for maximum possible outlet pressure (up to 5,000 psi): Air drive psi x 30, plus 2 x gas inlet psi.
) If less air flow is available, gas flow rates will decrease about in proportion.

SPECIFICATIONS

- **Booster:** Air driven, balanced opposed piston type, two stage.
- **High Pressure Oxygen Chambers:** Non-lube, hydrocarbon free, triple sealed and vented from the drive air chest.
- **High Pressure Sections, Tubing & Fittings:** Stainless steel, 5,000 psi maximum oxygen working pressure.
- **Air Drive Section:** No oiling required, corrosion resistant factory lubed at assembly, 150 psi max. drive pressure.
- **Particle Filters:** Inlet and outlet gas: 5 micron. All stainless steel.
- **Gauges:** Stainless steel tube, solid front 4-½" dial size.
- **Port Sizes:** Inlet and outlet gas: ¼" NPT female; Air Drive: ½" NPT female.
- **Control Range Adjustment:**
  Inlet minimum --- 150—850 psi
  Outlet maximum --- 800—5,000 psi
  Safety relief (outlet) --- 800—5,000 psi
- **Cooling:** With air exhaust to both stages and intercooler.
- **Noise:** 80 db range pulses, depending on working pressure (measured at 30 inches from booster).
- **Maintenance:** Simple seal kit replacement.
- **Installation:** No special foundation, no tie down required, and no electrical connections.

Haskel® INCORPORATED
ENGINEERED PRODUCTS DIVISION
00 E. Graham Place ● Burbank, CA ● 91502 ● U.S.A.
Phone: (213) 843-4000 ● TWX: (910) 498-2734

Your HaskeLine Distributor:
RANDER+CO
HYDRAULIK
2000 HH 50 · Bahrenfelder Kirchenweg 29
☎ 040/89 14 40 / 89 14 49



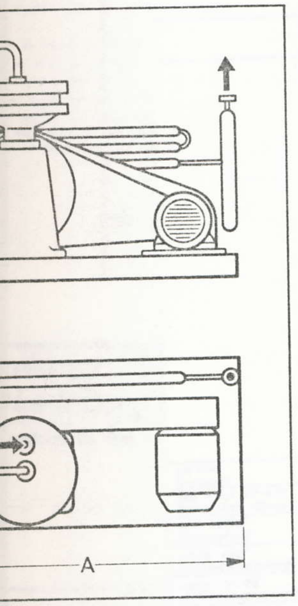
Delivered volumes are given in SCFM and in m^3/h and are based on :

a) maximum compressor speed of 400 rpm. If required, speed may be reduced to as low as 200 rpm to achieve desired capacity.

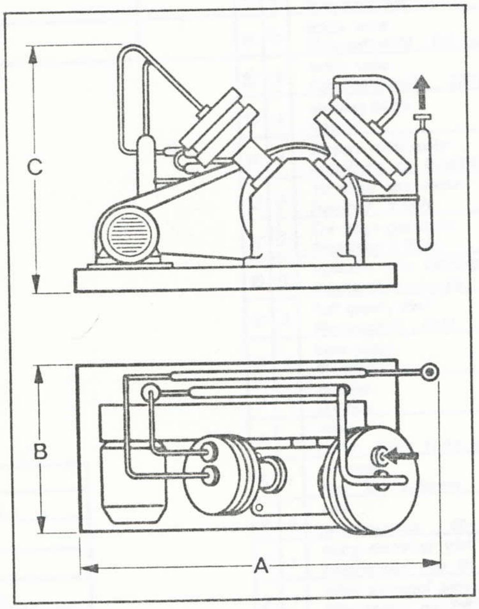
b) maximum pressure permissible for each compressor type denoted by number after letter ; for instance, for type A4C250, max. pressure is 25 MPa, or 3,600 psi. For machine types not having a pressure indicating type number, such as A1, etc., the maximum permissible pressure is 1,5 MPa - 220 psi.

c) compression ratios between 10:1 and 2:1. Note that compression ratios between maximum 20:1 and 1:1 per stage are possible. In this range the capacities are obtained by extrapolating the curves.

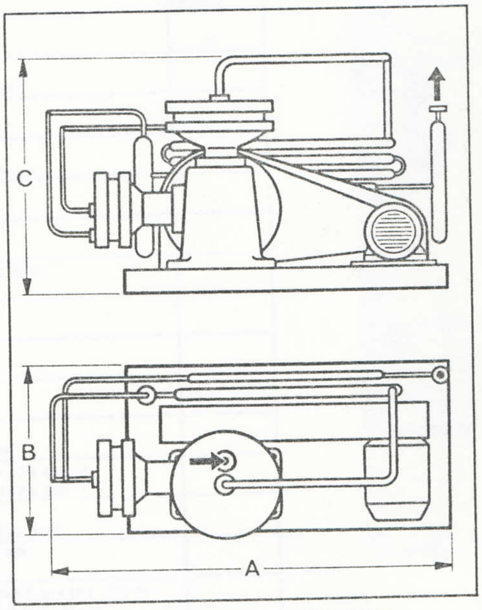
d) At a compression ratio of greater than 20:1, a two-stage compressor in L or V design is used by selecting suitable heads from the same series.



GLE-STAGE, VERTICAL



TWO-STAGE, V-ARRANGEMENT

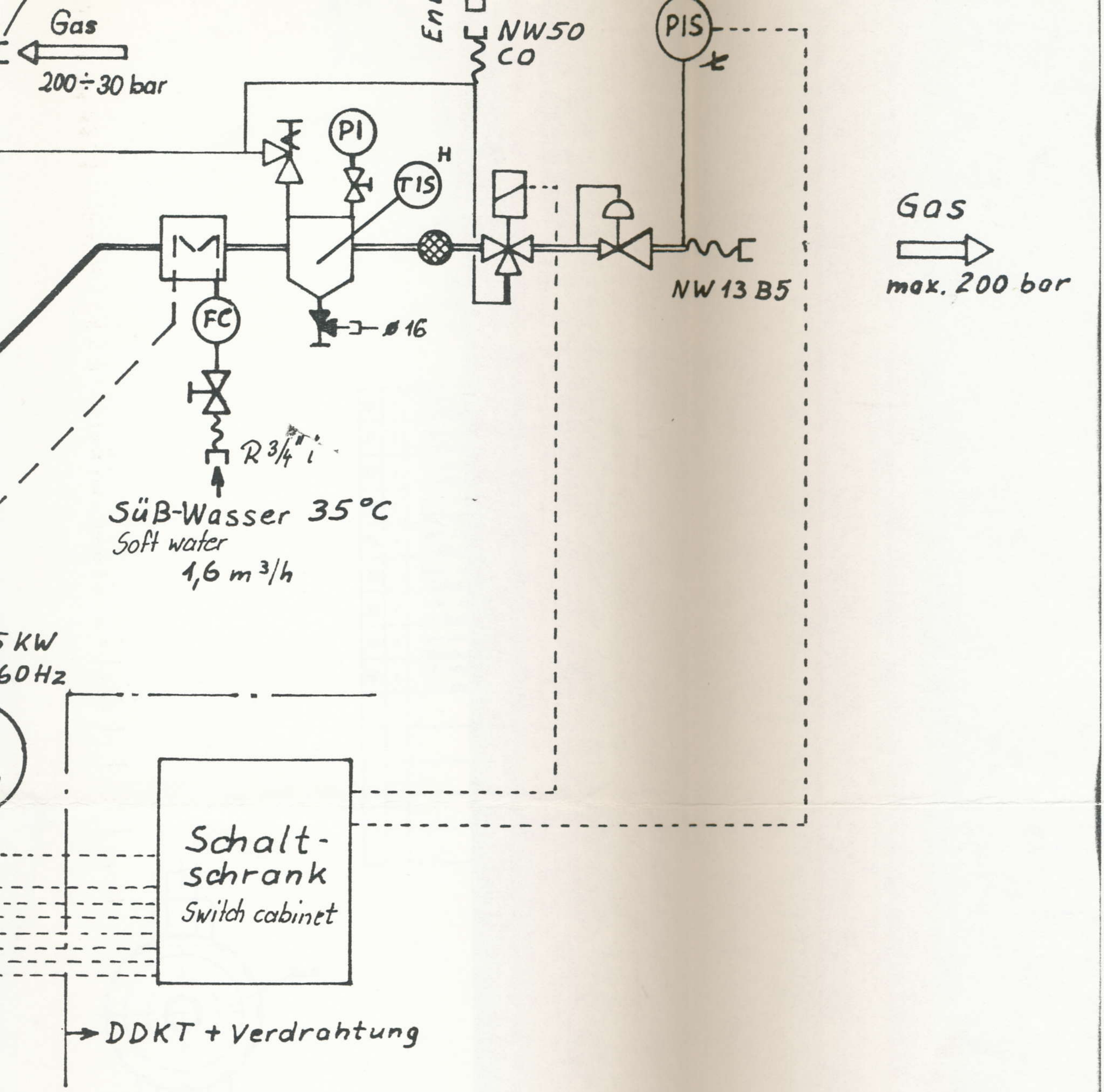


TWO-STAGE, L-ARRANGEMENT

	erall Dimensions (mm)		Weight (Kg)
	B	C	
0	600	900 1100	250
0	660	1000 1200	450
0	750	1100 1300	600
0	850	1400 1700	1000 900
0	1100	1500 1800	1400 1200
0	1150	1800 2100	2900 2500

Type	Overall Dimensions (mm)			Weight (Kg)
	A	B	C	
A1CV A1CCV	1500	850	1050	650
A2CV A2CCV	1500	850	1150	800
A34CV A34CCV	2000	1000	1400	1400
A4V A4CV A4CCV	2000	1200	1500	2100

Type	Overall Dimensions (mm)			Weight (Kg)
	A	B	C	
A0CL A0CCL	1000	700	1000	350
A5L	2700	1500	1900	4300
A5CL A5CCL	2700	1500	1900 2100	3900



lerstr. 17
eonberg
t/Order-No.

kg
ausgefüllt completed

Kunde Customer DRÄGER DKT
Auftrags-Nr Order-No.
Positions-Nr. Item-No.
Bestell-Nr. Reference-No.
Für Anlage For plant CONSAFE
Genehmigung/Revision Approval/Revision

Revisionen/Revisions		geändert	geprüft
Rev.	Änderungstext/Alternation	revised	checked

S-SCHEMA A 4 CV 250

RTON CORBLIN

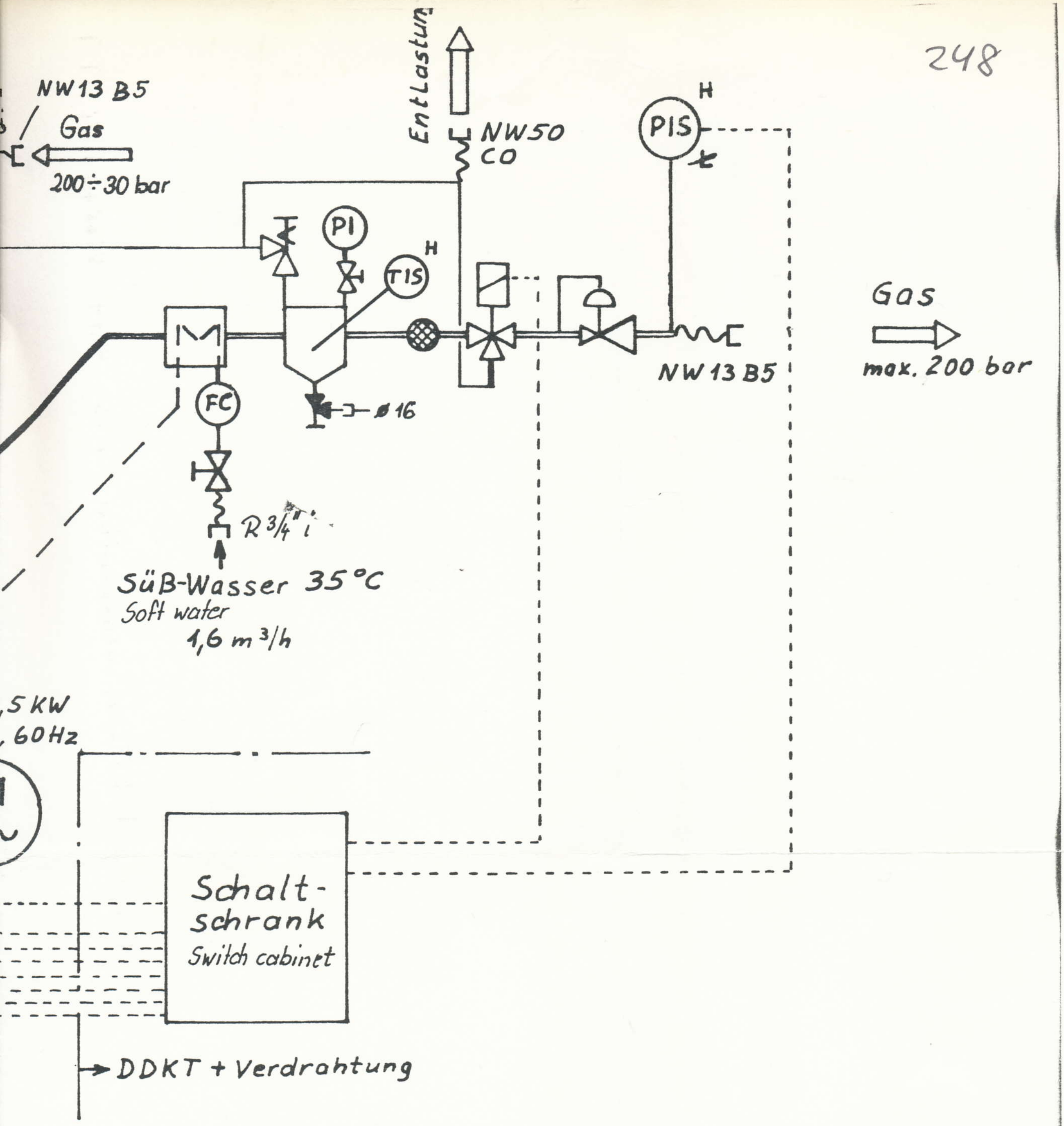
HOV HERBERT OTT VERTRIEBS-GESELLSCHAFT MBH + CO

Vor-Nr./Pre-No. Zeichnungs-Nr./Drawing-No.
BC 44 2980

vir uns alle Rechte vor (DIN 34)
rved

Darstellung nicht streng verbindlich!
Drawing not strictly binding!

Blatt Page 1 von of 1 Blättern pages



mlerstr. 17
Leonberg
ect/Order-No.

kg

ift
ed

ausgefüllt
completed

Kunde
Customer

DRÄGER DKT

Auftrags-Nr
Order-No.

Positions-Nr.
Item-No.

Bestell-Nr.
Reference-No.

Für Anlage
For plant

CONSAFE

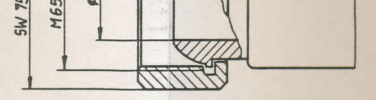
Genehmigung/
Revision
Approval/
Revision

Revisionen/Revisions		geändert	geprüft
Rev.	Änderungstext/Alternation	revised	checked

SS-SCHEMA A 4 CV 250

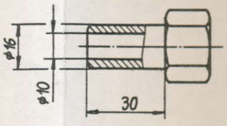
HOV HERBERT OTT VERTRIEBS-GESELLSCHAFT MBH + CO

Vor-Nr./Pre-No. Zeichnungs-Nr./Drawing-No.

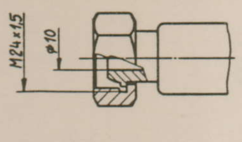


Einzelheit X , M1:1
Collecting outlet and gas inlet
Sammelleitung- Austritt und Gaseintritt
Stutzen 60°, DIN 7631 u. 7647

Einzelheit Y , M1:1
Water inlet and outlet
Kühlwasserein- und austritt

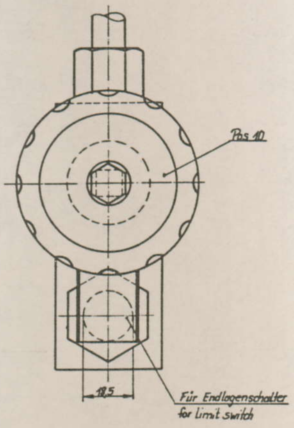


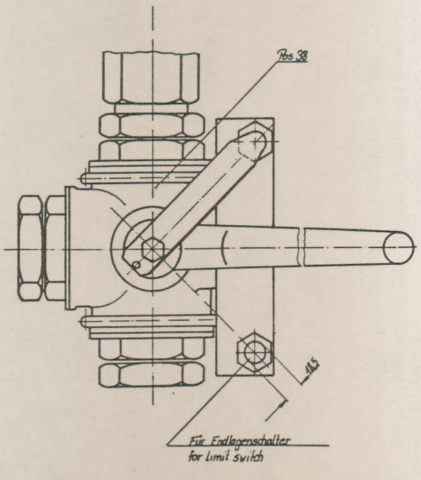
Einzelheit W , M1:1
Draining valve outlet
Ablaßventil- Austritt



Einzelheit Z , M1:1
Gas outlet, Gas inlet HP-side
Gasaustritt , Stutzen DIN 3901 u. 3902
Gaseintritt HD-seitig

30	1	pressure switch Kontaktmanometer -0,3 ÷ +0,3 bar	
31	1	pressure switch Kontaktmanometer 0 ÷ 400 bar	
32	1	automatic detector discharge side Kontaktthermometer druckseitig 0- 100°C	
33	1	hose line discharge side Schlauchleitung druckseitig NW 13	
34	2	hose line suction side Schlauchleitung saugseitig NW 50	
35		hose line for collecting outlet Schlauchleitung für Sammelablaß NW 50	
36	2	hose line for cooling water Schlauchleitung für Kühlwasser NW 21	
37	1	hose line HP suction side Schlauchleitung HD saugseitig NW 13	
38	1	3/2-way gate valve suction side 3/2 - Wege Absperrventil saugseitig	134-2
29	1	filter suction side Filter saugseitig	139.147 50.C
28	1	filter discharge side Filter druckseitig	IMF 1509/L
27	2	draining valve Ablaßventil	30.25
26	1	3/2 - way solenoid valve discharge side 3/2 - Wege Magnetventil druckseitig	IMF EV24/3
26	1	overflow valve Oberströmventil	IMF DV18R2/8
24	2	guard Plate Berührungsschutz	
23	2	diaphragm rupture detection device Druckwächter Membranbruchanzeige BC 18	FF 142-6
22	1	flow warter Strömungswächter PSA-20	
21	1	isolating valve manometer Absperrventil , DIN 16 270 für Manometer	
20	6	damper device Barry Cupmount Element C 4000	
19	1	manometer Manometer 0-40 bar	
18	1	manometer Manometer 0-400 bar	
17	1	oil pressure switch Öldruckwächter	FF 142-8
16	1	safety valve Sicherheitsventil 17,5 bar	
15	1	safety valve Sicherheitsventil 220 bar	
14	1	draining bottle Flasche	
13	2	support after cooler Abstützung für Gaskühler	
12	1	1st stage gas cooler Gaskühler 1. Stufe	
11	1	2nd stage gas cooler Gaskühler 2. Stufe	
10	3	regulation valve discharge side Regelventil druckseitig	
9	1	belt guard, steel Riemenschutz , Stahl	
8	1	base plate Grundplatte	
7	1	oilcooler Ölkühler	
6	1	motor Motor 180 M 1L A4 183	
5	1	rail motor 1x P4 050-1 Paar Spannschienen 1x P4 050-1	
4	5	belt Keilriemensatz 22 x 14 x 3450	
3	1	pulley diametral pitch 180 Motorscheibe dw 180	
2	1	wheel diametral pitch 748,5 grooves 22x 14 Schwungrad dw 748,5 Nuten 22 x 14	
1	1	compressor A 4 CV 250 Kompressor A 4 CV 250	inox





A	gas inlet Gaseintritt
A'	gas inlet HP-side Gaseintritt HD-seitig
B	gas outlet Gasaustritt
C	water inlet Kühlwassereintritt
D	water outlett Kühlwasseraustritt
E	collecting outlet Sammelleitung- Austritt
F	draining valve Kondensatablaß

appr. Weight 2200kg

Lieferant: HOV,Daimlerstr. 17
Supplier: D-7250 Leonberg

Angebots-/Auftrags-Nr., Project/Order-No.
BC 2-2980

Geräte-Nr. / Unit-No.

Gewicht des kompl. Gerätes
Weight of the complet unit kg

	gezeichnet drawn	geprüft checked	ausgefüllt completed
Datum Date	17.5.82	21.5.82	
Name	Bloch.	H	

Kunde
Customer

Auftrags-Nr. Order-No.	
Positions-Nr. Item-No.	
Bestell-Nr. Reference-No.	
Für Anlage For plant	
Genehmigung/ Revision Approval/ Revision	

Revisionen/Revisions		geändert	geprüft
Rev.	Änderungstext/Alternation	revised	checked

Produkt
Product DIM. DRAWING
Aufstellungszeichnung A 4 CV 250

Hersteller
Manufacturer SOCIETE BURTON CORBLIN

HOV HERBERT OTT VERTRIEBS-GESELLSCHAFT MBH + CO

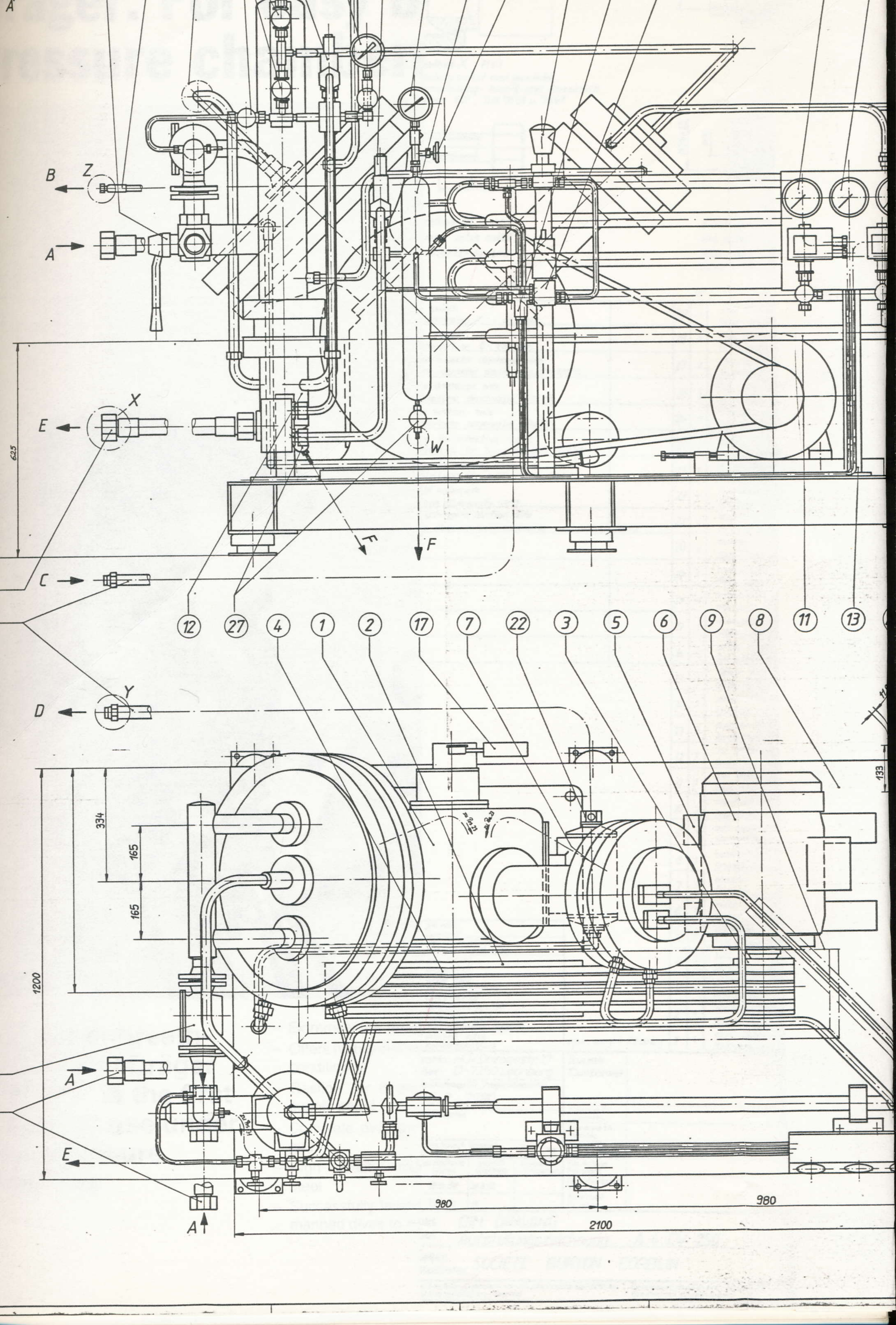
Vor-Nr./Pre-No.

Zeichnungs-Nr./Drawing-No.
11 - 0017/0

Für diese Zeichnung behalten wir uns alle Rechte vor (DIN 34)
Rights for this drawing are reserved

Darstellung nicht streng verbindlich!
Drawing not strictly binding!

Blatt Page 1 von of 1 Blättern pages

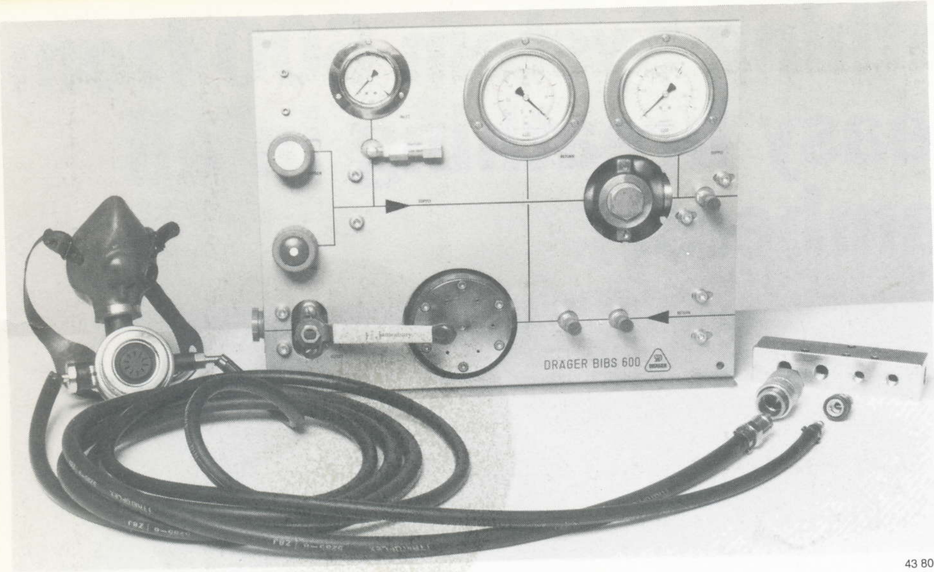

A
B
Z
A
E
X
W
F
F
625
C
D
Y
12
27
4
1
2
17
7
22
3
5
6
9
8
11
13
334
165
165
1200
133
A
E
A
980
980
2100

rager. For easy breathing in all ressure chambers.

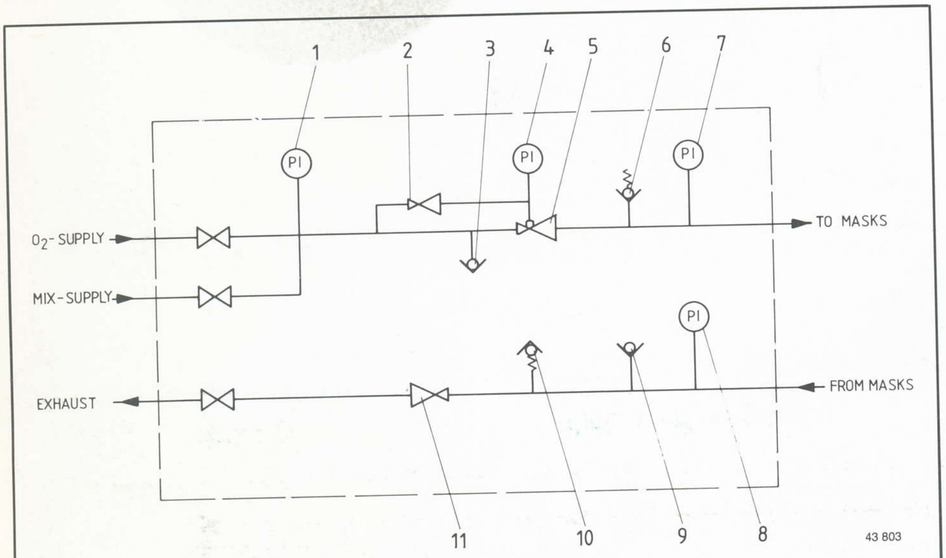
43805

built-in-breath- system "Dräger S 600" is the first tem for use under m pressure ditions

- Extremely low breathing resistance
- Offers high gas-flow also under extreme conditions
- Gasflow for 6 divers from one BIBS supply panel
- Complete overboard dump of exhaled gas
- High quality material/brass-stainless steel
- Successfully tested and proven during manned dives to 450 m
- Certified by DNV
- According to IMO-Standard

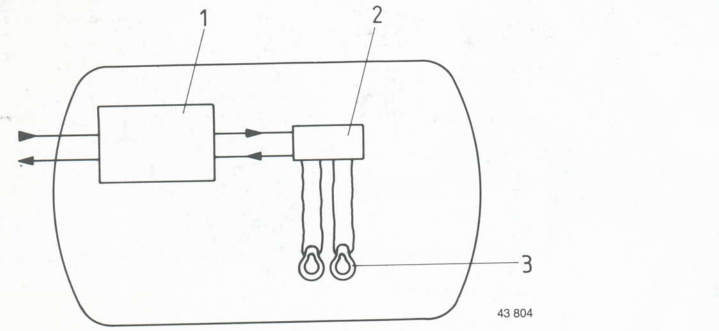


43 806



43 803

1 Supply pressure gauge
2 Pilot regulator
3 Safety value
4 Pilot pressure gauge
5 Dome loaded limiter for masks inlet pressure
6 Relief value
7 Masks inlet pressure gauge
8 Masks outlet pressure gauge
9 Relief value
10 Safety value
11 Back pressure regulator



43 804

BIBS 600 in pressure chamber
1 BIBS supply panel
2 Diver connection manifold
3 Diver's masks with demand regulator and connection hoses supply panel scheme

DRÄGERWERK AG LÜBECK

Werk Druckkammertechnik

Auf dem Baggersand 17 · D-2400 Lübeck-Travemünde 1
Ruf (0 45 02) 83-0 · Telex 02 61455 · Telefax (04 51) 8 82 20 80

The Dräger BIBS 600 is designed acc
ing to all field requirements. Pure O_2 fo
pressure ranges or HeO_2-mixtures ca
breathed. Breathing gas supply of O_2
HeO_2 is directly connected to the pane
relevant gas pressures can be monit
continuously.

Specifications

- Operating range up to 600 msw
- Breathing volume (RMV) using H
  98%/2%:
  300 msw : 62,5 l/min per diver
  450 msw : 40 l/min per diver
  600 msw : 35 l/min per diver
- Supply volume for 6 divers by one
  panel
- Breathing resistance less than 10
  (hPa) at maximum RMV
- Sterilisation of mask and demand
  ulator is possible.

Order list

BIBS panel 600: 65
Distribution block for 2 divers
(order 3 for 6 divers): 65
Breathing mask complete: 65

Subject to modif

Graphische Werkstätten 2234/8
Printed in the Federal Republic

THE SMALL RESQUE CHAMBER

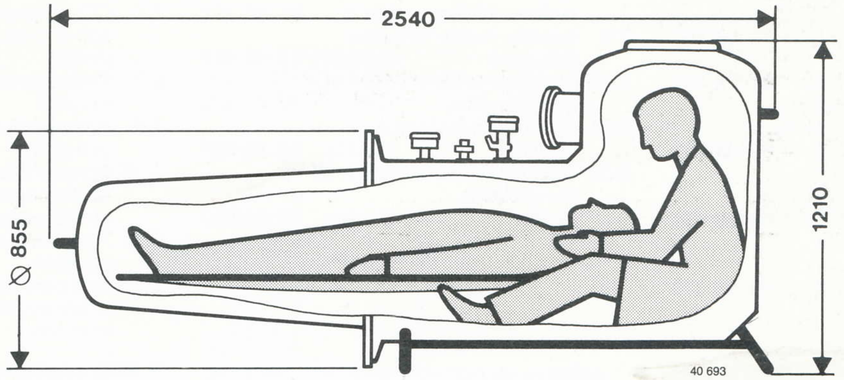
The purpose of the portable resque chamber is to bring injured divers from the pressure chambers via a helicopter to the shore facility where better medical assistance can be arranged.

Dräger has not yet produced a resque chamber to be used with the saturation diving complex - only the surface diving system. It can be expected that Dräger in the future will produce a resque chamber for the saturation diving complex. We have seen such chambers being produced from other manufacturers. It could be expected that Dräger will use the one-man chamber or the two man chamber (Duocom) idea. The changes will manly consists of reinforced pressure hull, insulation and a heliox gas tube system.

Technische Daten

Technical Data

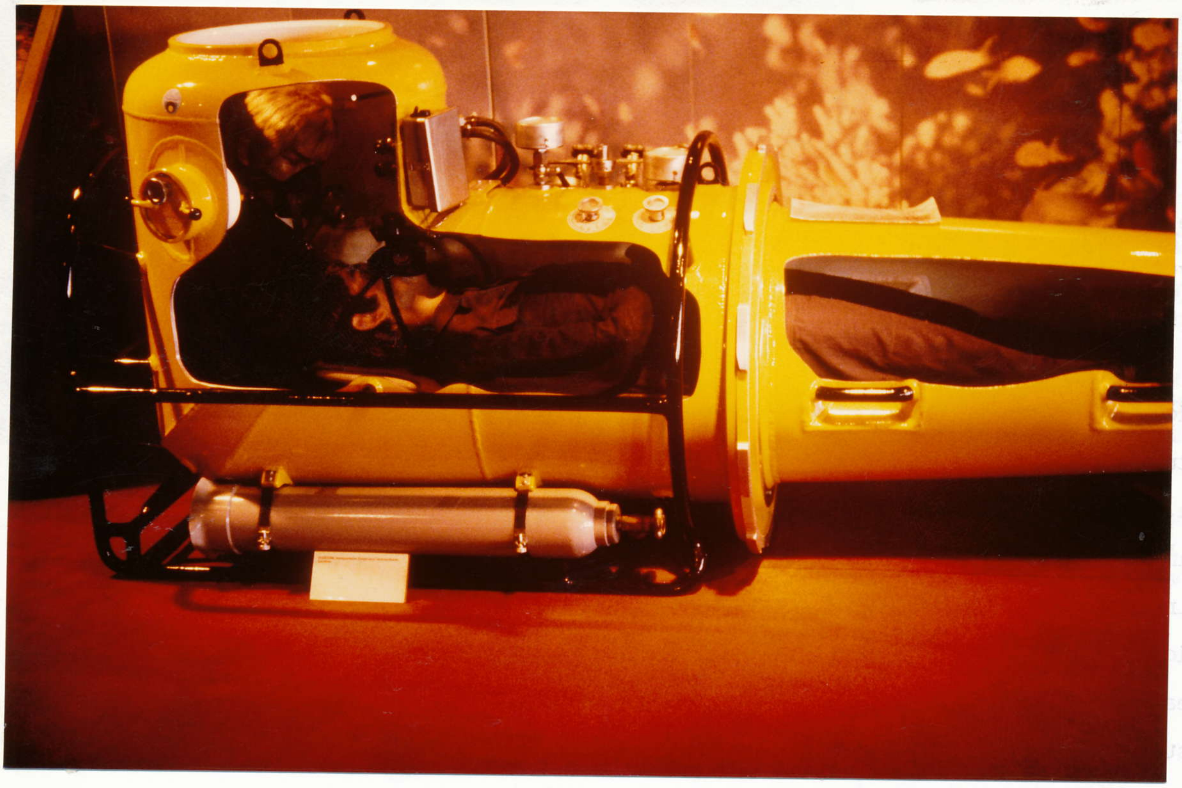
Datos técnicos



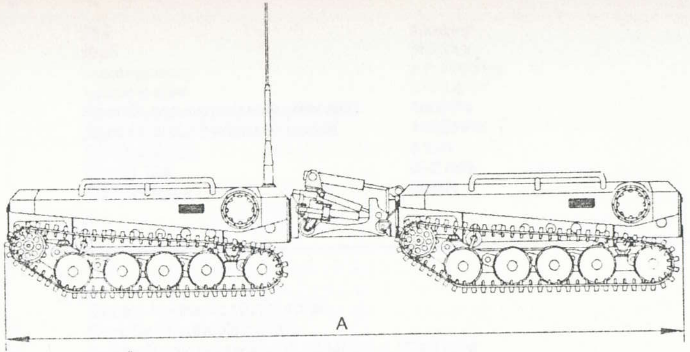
Betriebsüberdruck	5,5 bar
Prüfüberdruck	8,25 bar
Gesamt-Volumen	730 Liter
Länge ü.a.	2540 mm
Breite ü.a.	880 mm
Höhe der Druckkammer	1210 mm
Höhe mit Flaschenwagen	1520 mm
max. Länge innen	2350 mm
max. Durchm. innen	640 mm
Innenmaße der Versorgungsschleuse	∅ 150 × 200 mm
Gewicht der Kammer	225 kg
Gewicht Flaschenwagen	275 kg
Abnahme	TÜV[5]

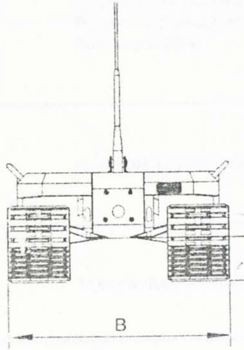
Working pressure	5.5 bar
Test pressure	8.25 bar
Total volume	730 litres
Overall length	2540 mm
Overall width	880 mm
Height of chamber	1210 mm
Height with trolley	1520 mm
Max. inside length	2350 mm
Max. inside diameter	640 mm
Internal dimensions of medical lock	∅ 150 × 200 mm
Weight of chamber	225 kg
Weight of trolley	275 kg
Approval	TÜV[1] or Lloyd's Reg. (on request)

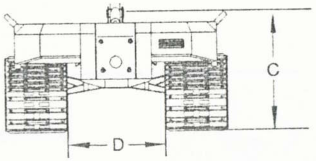
[5] In der Bundesrepublik Deutschland nach UVV 13.5 (VBG 17) § 18 Abs. 4 Abnahmeprüfung am



I took this picture when visiting the Dräger exhibition room. You should visit the Dräger plant one day it is quite interesting. You can see the inside of the double resque chamber. The resque chamber (IUC) connection flange is a Dräger invention and is now NATO standard.







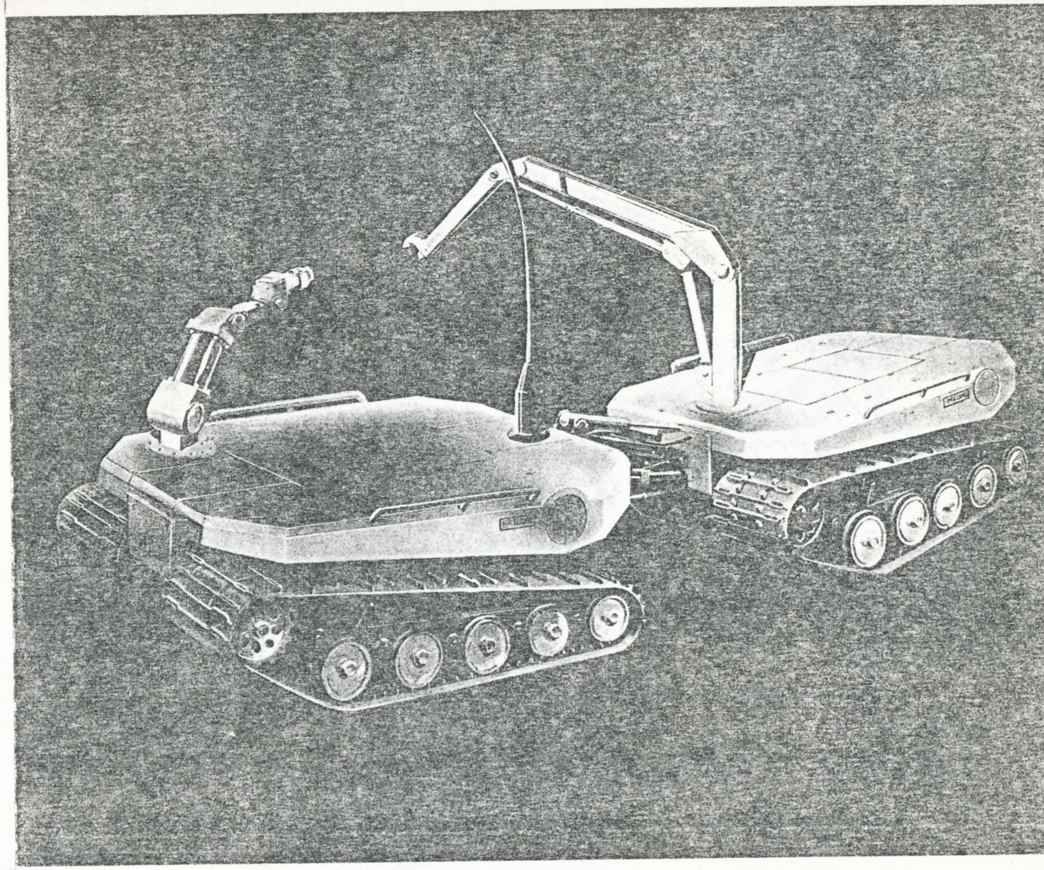
	mm		mm
A	6711	D	960
B	2200	E	435
C	1178		

HÄGGLUNDS

AB HÄGGLUND & SÖNER Vehicle Division

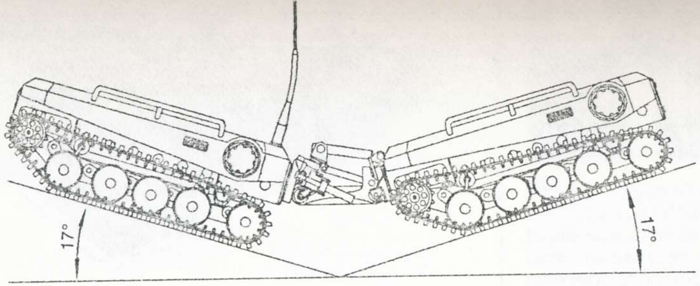
Box 600 · S-89101 ÖRNSKÖLDSVIK · Sweden · Tel +46-66080000 · Telex 6051 HAEGG S

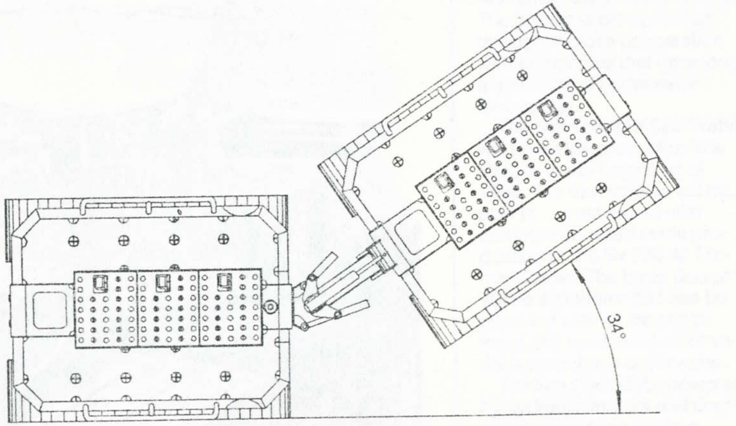
Ågrens Tryckeri AB, Ö-vik 1986

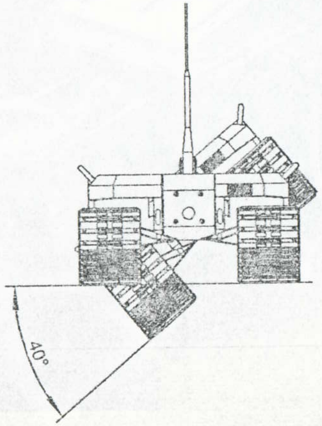


AB HÄGGLUND & SÖNER · Vehicle Division · S-89101 ÖRNSKÖLDSVIK, Sweden

Weight	Dry	4350 kg
	Wet	3500 kg
	Load capacity	2 × 2000 kg
	Loading area	2 × 5.6 m²
	Specific ground pressure unloaded	6000 Pa
	Specific ground pressure loaded	14000 Pa
	Turning radius	8.5 m
	Speed, Uw	0–2 m/s
	Tractive force	30 KN
Power unit	Electro-Hydraulic 40 KW, total	
	Drive by 4 hydraulic motors	
	1–3 hydraulic power outlet, 16 MPa 3 × 30 ml total	
	Power supply subpack	660 V, 50 alt 60 HZ
	Auxiliary supply	24 V, CD
Steering system	Articulated hydrostatic steering unit	
Body	Manufactured of stainless steel Epoxivarnish surfacing	
Navigation equipment	Pingers Sonar Camera + Lights	
Operation	Alt I: Driver operation. Alt II: Remote-controlled from surface 0–500 m depth	
Optional	Sea Crab D500 is prepared for an extra subpack installation which increases the power outlet for optional equipment according to customers requirement.	







OPTIONAL EQUIPMENT

MANIPULATOR

CRANE

WINCH

DOZER BLADE

TRENCHING EQUIPMENT

WATERJET EQUIPMENT

OTHER EQUIPMENT ACCORDING TO CUSTOMERS REQUIREMENT

CONTROL UNIT

CONTROLROOM INSTALLED IN A 20 FEET CONTAINER

VEHICLE DIVISION

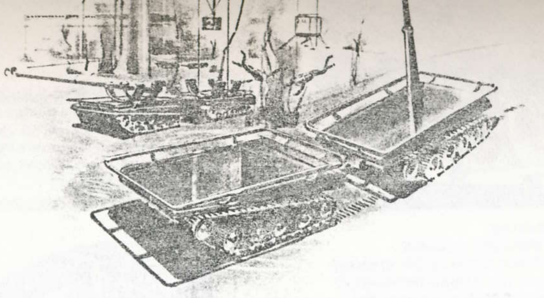
OFFSHOR

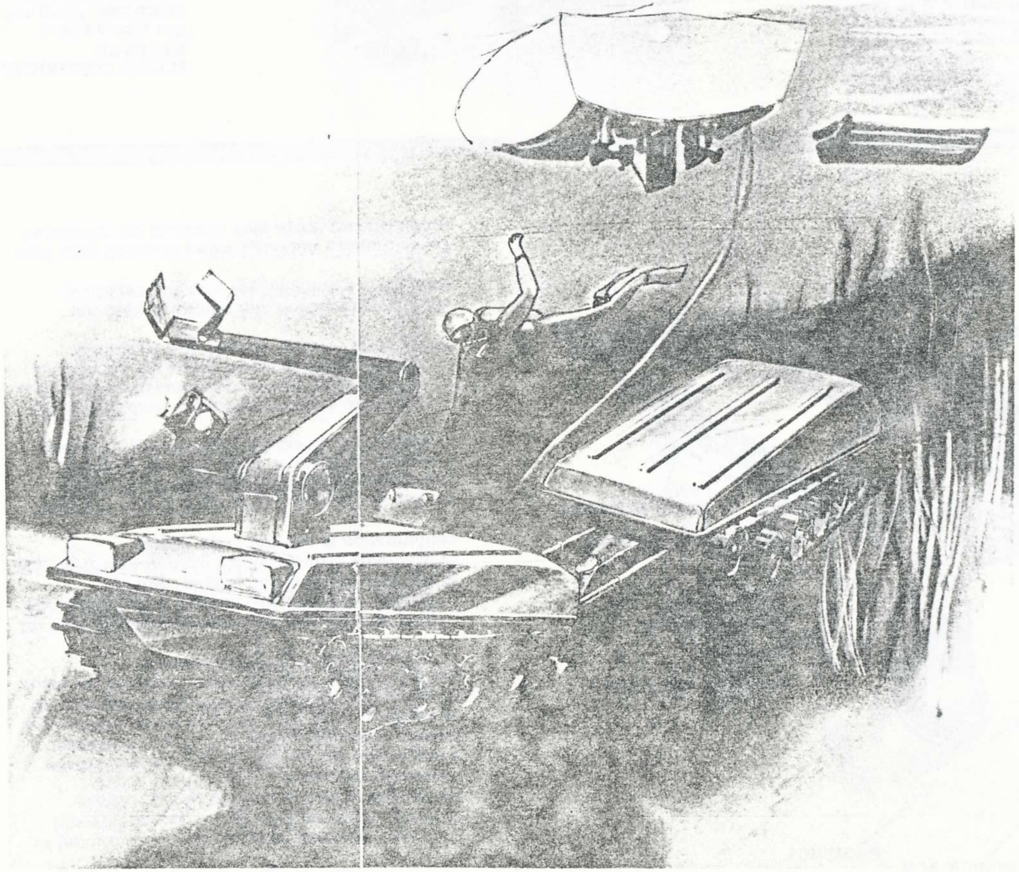
sea-floor operations

Underwater operations have long been dominated by submarines and divers using a variety of aids. Today we face accelerated development in maritime exploitation, and particularly on the sea floor, in a great variety of ways. Drilling platforms, intercontinental cables, pipelines, different sorts of explorations and bottom-based constructions in ever-increasing depths of water have created new requirements.

There is a need for a vehicle providing a firm and stable platform from which a variety of tasks can be performed. Such a platform cannot be floating but must stand steady on the bottom, yet it must also be capable of negotiating a broad range of seabed conditions: in other words, a Multipurpose All-bottom Terrain Vehicle.

HÄGGLUNDS Vehicle Division has long and unique experience in developing and producing cross-country vehicles. All light tracked carriers in the Swedish Armed Forces today have been produced by HÄGGLUNDS. Our Design and Development Department thus has considerable experience in all aspects of All Terrain Vehicles. This is matched by the capabilities of our manufacturing departments, where vehicles and components are produced to match each user's specific requirements.





Artist's impression of Sea Crab in operation.

“ The decision by HÄGGLUNDS Vehicle Division to produce an underwater vehicle, the Sea Crab, is a logical estension of our experience and application of the vast expertise already acquired in All-Terrain Vehicle engineering. The project is being carried through in close cooperation with companies that have long experience of underwater technology.

The first series of Sea Crabs will be on the production line already in the beginning of 1985. The new vehicle will be built to a great extent with components used in the production of the Bv 206 All Terrain Carrier. The basic design will be a platform that can be provided with all the equipment and tools needed for various operations underwater.

The Sea Crab will be powered by hydraulic motors and controlled either from inside a pressure chamber on the vehicle or by outside divers. It will be able to negotiate all seabed obstacles and will be operational at any depth down to 500 metres.

The introduction of the HÄGGLUNDS Sea Crab opens-up completely new possibilities in terms of quailfied support for operators in a broad range of offshore activities. ”

Jarl Hallin

VEHICLE DIVISION
Tel. + 46 660 800 00 Telex 6051 HAEGG S

dragonfly

Dragonfly has been designed and constructed to provide a truly modular facility for quickly and simply changing the payload of the vehicle. Dragonfly comprises a base vehicle which incorporates the hydraulically-powered thruster system, electrical power and control telemetry equipment, basic navigational instrumentation and cameras. Electrical power and signal wiring with easily accessed junction boxes provides for rapid interchanging of payload equipment.

Individual work modules specifically designed for particular tasks may be attached to the underside of the base module, and simple 'bolt-on' connections enable a quick change over from one configuration to another to be made.

Hinged dome ends on the control pod, together with runner mounted equipment racks, allow complete withdrawal of the relevant units for unobstructed access for maintenance purposes.

A composite electro-mechanical umbilical cable incorporating all power and telemetry conductors including optical fibres provides the connection between the control console and Dragonfly.

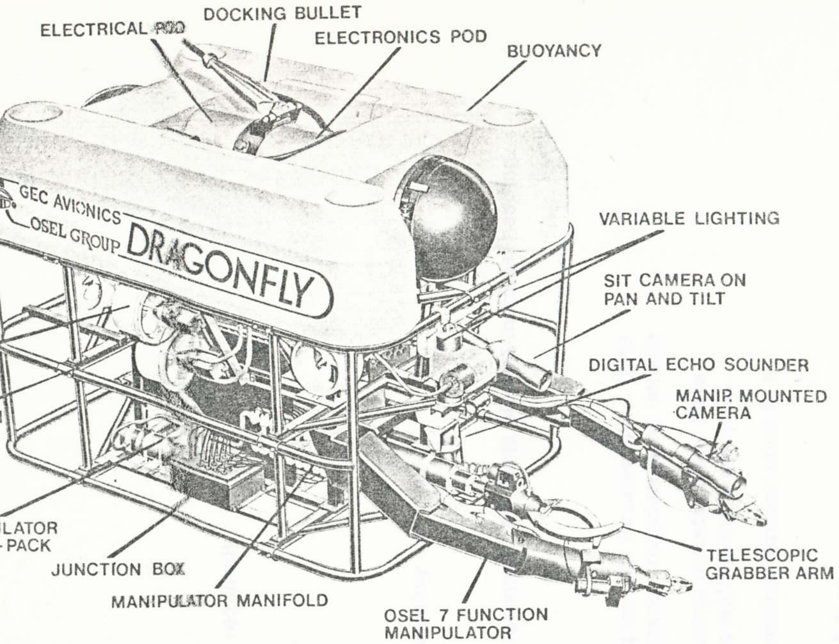
The data acquisition and control system has resulted in a compact yet versatile capability.

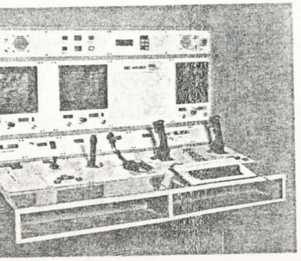
Three digitally encoded video channels plus high speed up and down data channels are combined onto a single optical fibre, using colour multiplexing techniques to provide studio quality, interference-free television and error-free data. The system can be expanded to 6 cameras on the vehicle, and surface-controlled video switching can select any 3 cameras for surface display. A second fibre is incorporated into the umbilical for redundancy, and a co-axial backup video/data system guards against loss of the vehicle in the unlikely event that both optical fibres fail. Reversionary modes are implemented automatically.

All primary video and data are transmitted via optical fibre. There are also two twin-axial and one co-axial cables in the umbilical, to permit sonar or additional payload items to be connected to the system independantly from the main data link.

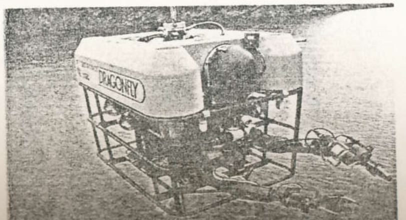
Vehicle control is implemented by micro-computers at each end of the umbilical. These computers, together with the flexible communications protocol enable the system to cope with a wide range of vehicle fittings without redesign. The vehicle computer also carries out a number of functions locally, which helps to cut down the load on the data channel.

In order to lighten the pilot's work load, the console makes extensive use of modern information display techniques, based on technology developed for the aerospace industry.

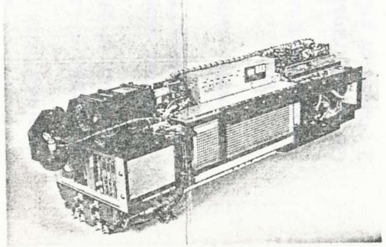




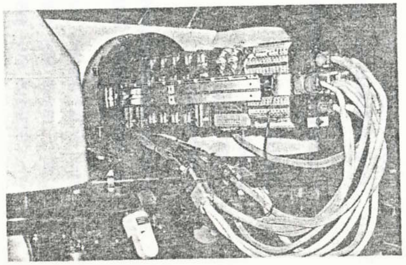
CONTROL CONSOLE
Designed and built by GEC Avionics, is a careful blend of ergonomics and simplicity. The modular panel system enables controls to be easily re-configured to suit varying customer requirements. Selectable, computer-controlled VDU displays and overlays are central to the design philosophy, and replace many of the discrete panel functions normally encountered.



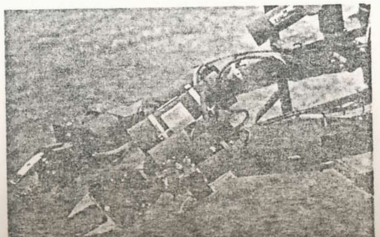
DEPLOYMENT
Dragonfly fitted with manipulator module and optional sonar undergoing



SUBSEA ELECTRONICS PACKAGE
The data acquisition and control system designed and manufactured by GEC Avionics, uses a micro-computer and an optical fibre telemetry system.



SUBSEA ELECTRICAL PACKAGE
The subsea power distribution, fusing and switching equipment provides all low voltage power supplies for the vehicle (such as cameras, lights and solenoid valves).



MANIPULATORS
2×7 function OSEL seawater hydraulically-operated, fitted as standard.
Proprietary manipulators can be substituted.

th Capability : 6,000 ft. (can be increased if required)

ensions : Length 8′ 4″ (2·54 m.)
Beam 6′ 0″ (1·83 m.)
Height 3′ 6″ (1·07 m.)

ght : 3,500 lbs. (1588 kgs.)

oad : 1,000 lbs. (with additional buoyancy material)

vard Speed : In excess of 3 knots

ion Keeping Ability : Vehicle will hold station in a current of 2·5 knots plus on the axial heading, and 1 knot plus on the beam

ing Rate : In excess of 40°/second

th Control : Automatic to +/—1 foot, using vertical thruster units. Data obtained from hydrostatic pressure transducers on vehicle

ding Control : Automatic +/—2°, using transverse thruster units. Data obtained from directional gyro with fluxgate compass.

and Roll Control : Automatic +/—4°, using four vertical thruster units to a maximum of +/—30°.

ht from Seabed rol : 0-200 feet automatic to +/— 1 foot
Data obtained from echo sounder

r Auto Functions : Automatic park mode. Data obtained from above sensors

ary Power Source : 1,000 volts, 3 Phase 50/60 hz. supply at vehicle from surface power supply unit. 15 kVA available for work modules

llary Power Supply : On board transformer in pressure compensated housing. Supplied by 2 phases of primary power source for ancillary system requirements

ulsion System : 2 off 50 HP hydraulic power unit each driving 6 servo controlled thruster units capable of delivering in excess of 200 lbs. of static thrust each

e Construction : Hard anodised aluminium alloy welded and bolted using stainless steel 316 bolts in open frame configuration

ancy Material : Low density syntactic foam

ing : The vehicle has facilities for the operation of up to six cameras simultaneously with any three displays on the surface control at the same time

ing : Total of 3,000 W. output available for variable intensity lighting to suit requirements

ectors and Cables : All cabling will be of the neoprene covered type.
Each cable will be suitably terminated using subsea connectors and positioned for ease of access/maintenance

cle Location : An emergency pinger can be fitted having the following specification unless otherwise requested:

Frequency : 27 Hz
Ping Rate : 1/1·5 sec.
Power : 2 watts
Battery Life : 30 days

Unit will be activated by loss of power during operations

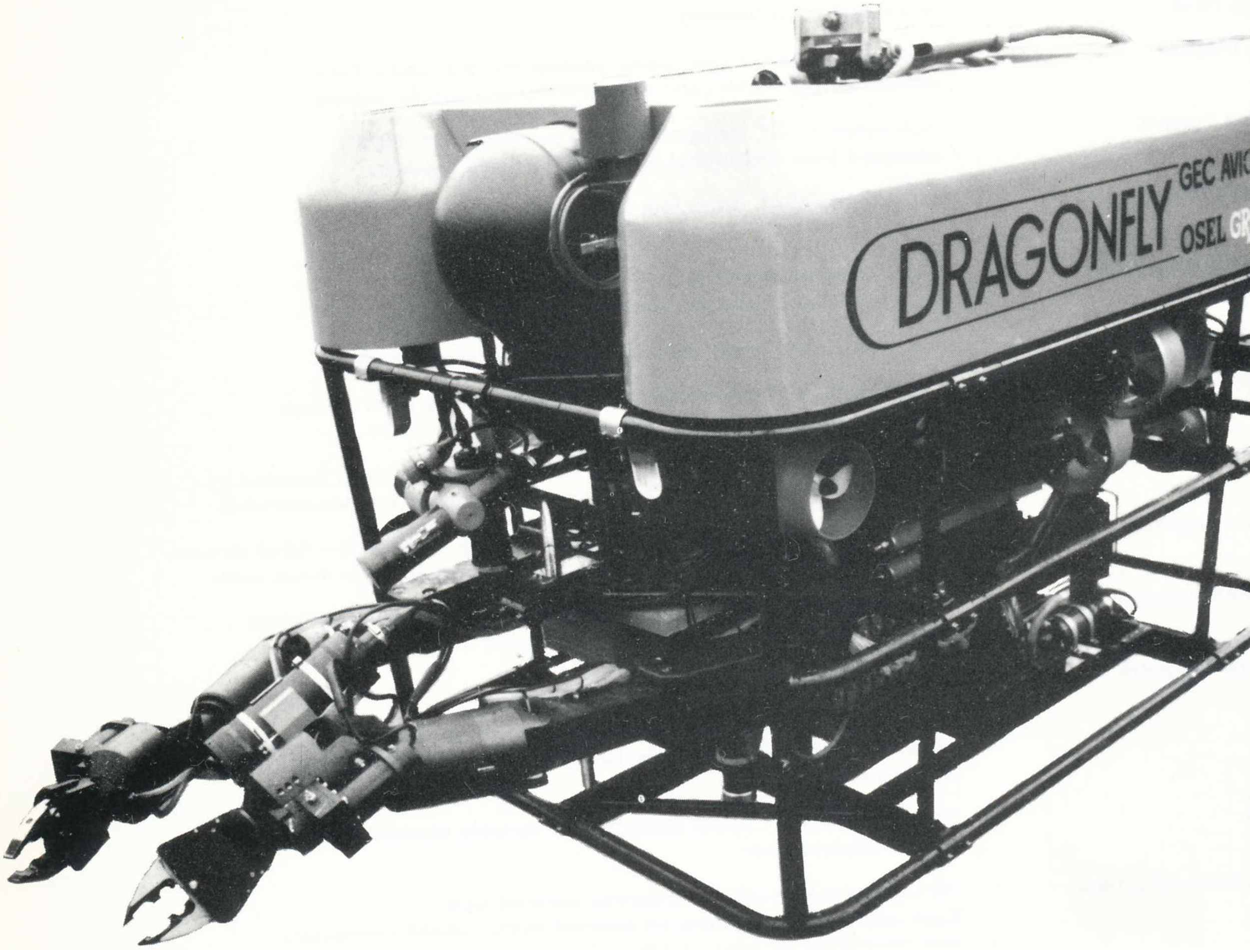
r : The system can be configured to accommodate any proprietary sonar systems

The OSEL Group reserve the right to change these specifications at any time

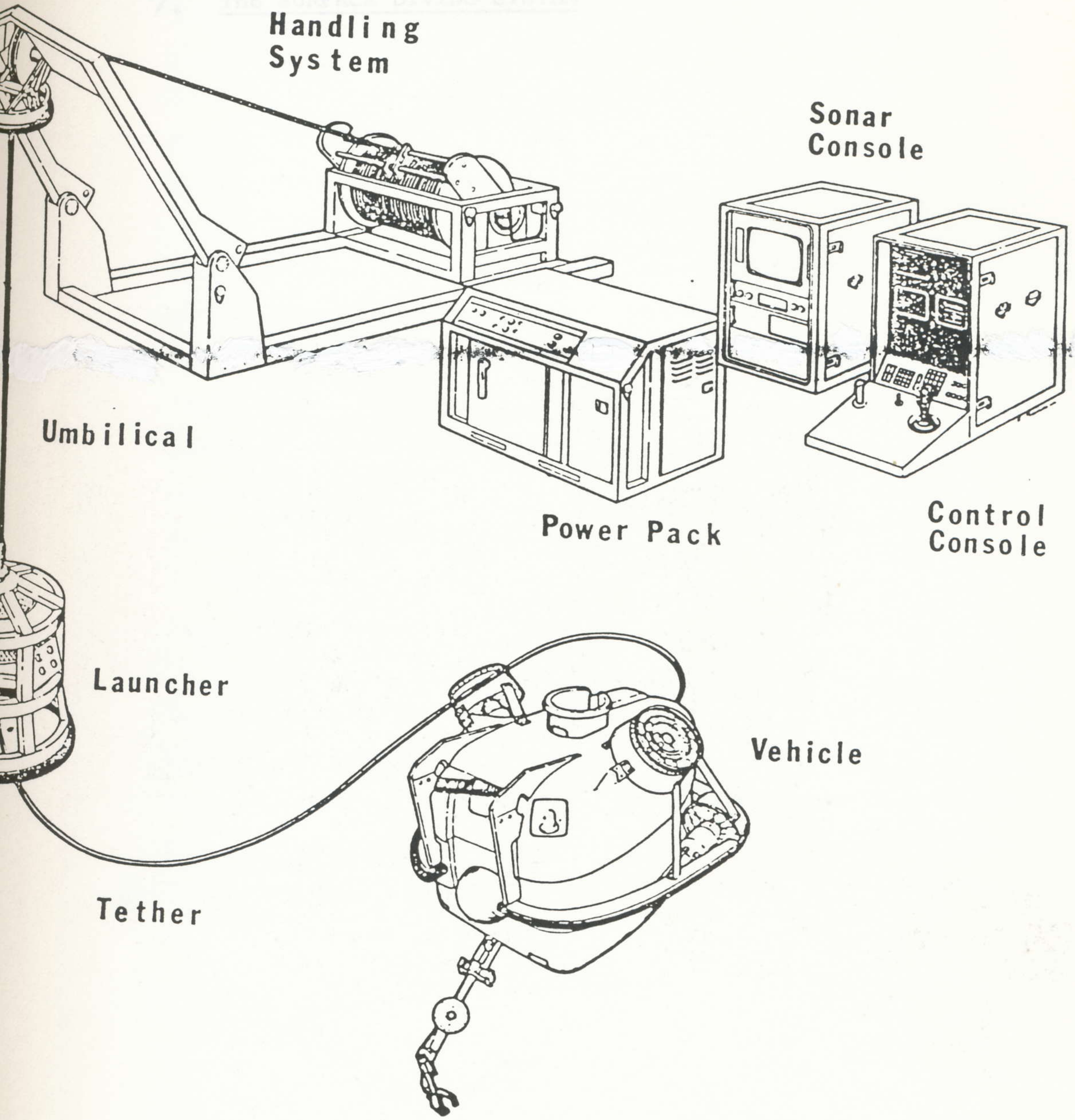
dragonfly

OSEL
GRO

OSEL OFFSHORE SYSTEMS ENG. LTD.
Boundary Road Harfreys Industrial Estate Great Yarmouth Norfolk NR31 0LY U.K. Tel: Gt. Yarmouth (0493) 659916 Tele



7. THE SURFACE DIVING SYSTEM



7. THE SURFACE DIVING SYSTEM

7.1.

Surface Diving Chamber

Installed in a 20 ft. container
Stationary decompression chamber
model DECOM 3 for air diving operations
max. working pressure 10 bar

This chamber can be used immediately after compressed-air connection and electric connection 220 V - 0,2 kVA; it is easily operable and used for decompression and treatment of 3 divers under pressure. A doctor can be locked into the chamber at times.

Technical data:

Total weight	3000 kg	approx.
Total volume of chamber	6700 l	approx.
Total external length	3780 mm	approx.
Total external width	2000 mm	approx.
Total external height	1600 mm	approx.
Total internal length of main chamber	2500 mm	
Total internal length of ante chamber	1000 mm	
external diameter	1500 mm	approx.
Clear diameter of door	650 mm	

As you can see, the external hight is 1600 mm. Therefore, the internal hight of the main chamber must be less than 1600 mm. The Danish Diving Act valid from 1980 states that the internal diameter is going to be at least 1800 mm. Therefore, it is necessary to order a non standard chamber for the 20 feet container. This is possible at Dräger.

The delivery of the decompression chamber system comprises the following:

Basic equipment with

main- and ante chamber, 2 doors, 2 windows, lifting hooks, pipe skids, pressure gauge, inlet- und outlet valves, control panel-protective sheet, silencers, test connection, intercom system, lighting with accessories for main chamber and Teledyne O_2-analyzer which can be used for entrance lock and main chamber.

Accessories:

- 1 pressure reducer (200/20 bar)
  for compressed-air supply

- supply lock
  for locking in of smaller items (e.g.medicaments)
  during operation of the pressure chamber
  consisting of:

  pressure vessel (Ø 200 mm x 300 mm), doors,
  3 valves and screw plugs

- 1 lighting
  for ante chamber
  (in addition to the lighting of the main chamber)

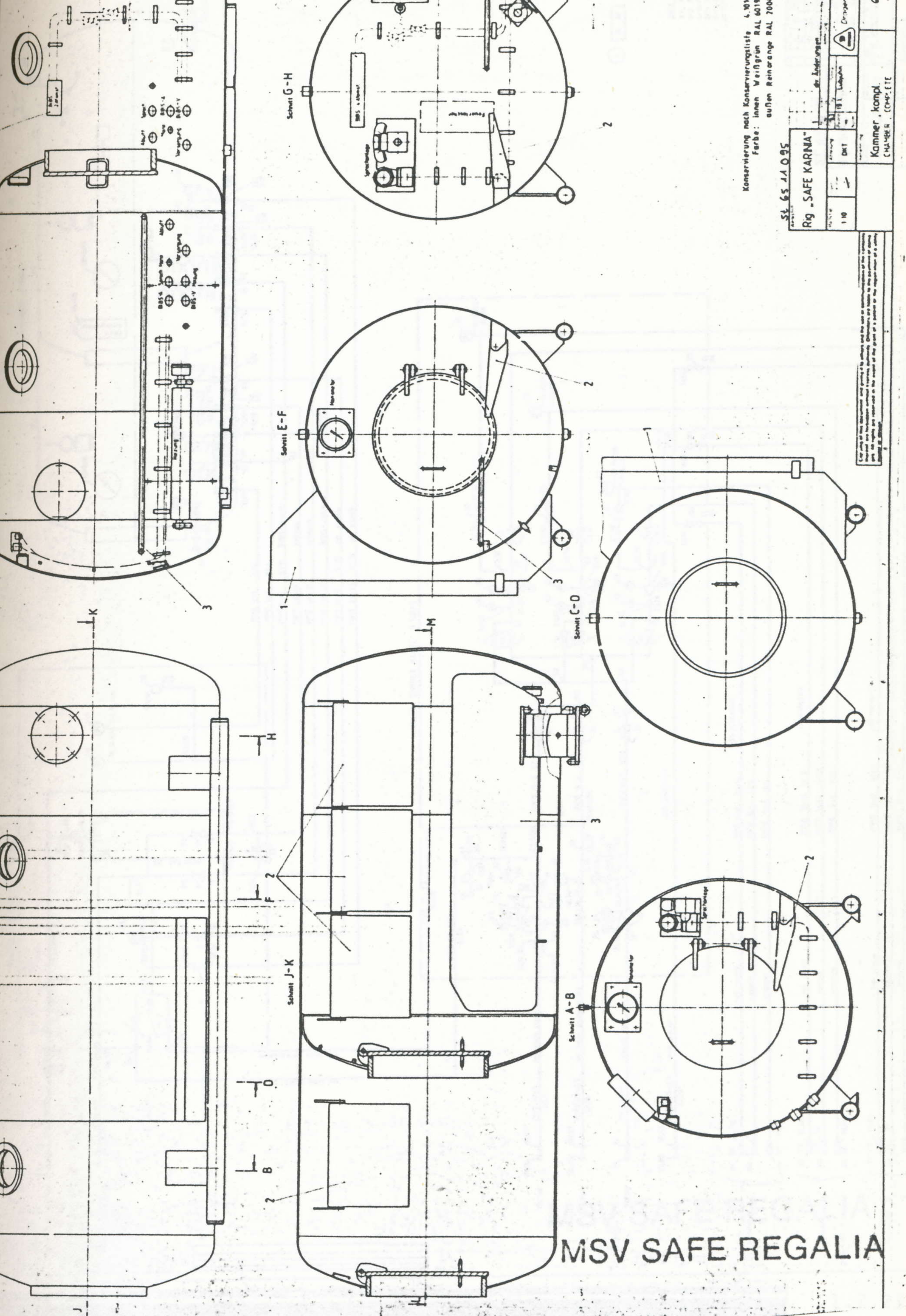
- 1 electric heating
  in the main chamber with 2000 W,
  controllable in 3 stages

- 1 intercom system
  for ante chamber
  (in addition to the intercom system of the main chamber)

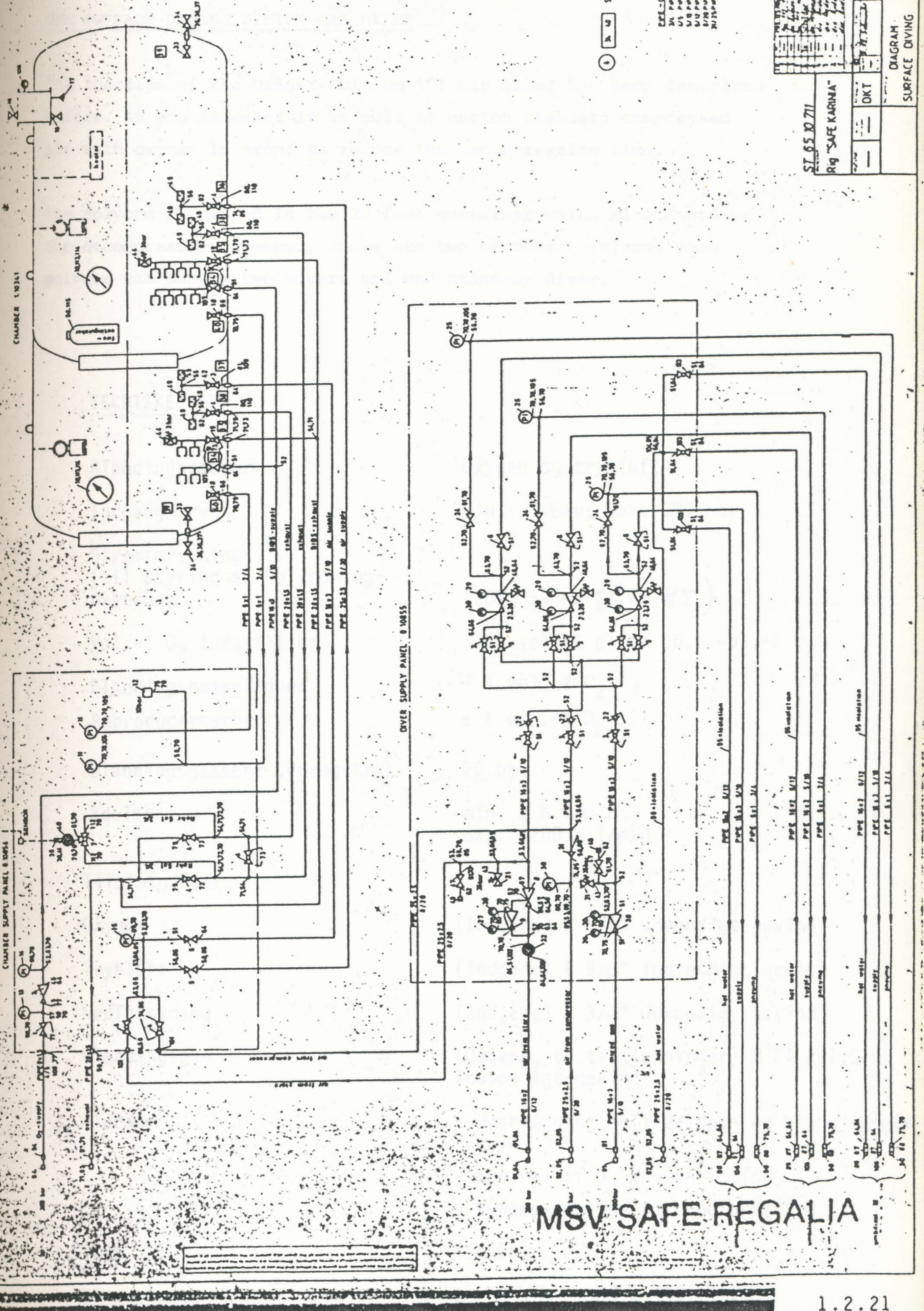
- oxygen-breathing system with O_2-outlet out of the chamber for 4 masks,
  1 pressure reducer for $\overline{O_2}$ (200/10 bar),
  4 breathing masks with overboard O_2dumping

- 1 silencer
  for compressed-air inlet into the ante chamber

- seat bench with
  1 cushion of hardly inflammable material in the main chamber
- internal pressure gauge
- 1 fire extinguisher
- outfitting of entrance lock
  + 1 folding seat
  + 1 internal pressure gauge
  + 1 intercom system
  + 1 O_2-breathing mask with O_2 dump



MSV SAFE REGALIA



MSV SAFE REGALIA

THE SURFACE DIVING SYSTEM GAS MIXER

The function of the Dräger Polycom 101 gas mixer has been described before. As you remember it is able to enrich standard compressed air with oxygen in order to reduce the decompression time.

The polycom is placed in the 20 feet container which also contains the decompression chamber. There are two of these systems. Each polycom can supply two divers and one stand-by diver.

TEKNISKE DATA

Blandingsgasser	Oxygen og trykluft
Indgangstryk	min. 55 bar; max. 200 bar
Strømforsyning (til styring af Polycom og Oxytron)	220V, 50 Hz (60 Hz)
Vol.-% O_2 indstilling	32,5 vol.-% eller 40,0 vol.-% O_2
Blandingsnøjagtighed	± 1 vol.-% O_2
Reproducerbarhed	± 1 vol.-% O_2
Blandingsgassens udgangstryk	20 bar
Ydelse	min. 2 N l/min max. 1200 N l/min
Tilslutninger	
Oxygen	(Indgang) R 3/4" udvendigt gevind
Trykluft	(Indgang) R 5/8" indvendigt gevind
Nødforsyning	(Indgang) R 3/4" udvendigt gevind
Blandingsgas	(Udgang, to tilslutninger) M 24 x 1,5 indvendigt gevind
Alarmer	- Overvågning af indgangs- og blandingsgastryk - Kontrol af O_2 koncentration - Bypass-kobling for nødforsyning
Vægt	192 kg
Dimensioner	B x H x D 1500 x 930 x 315

7.3.

20 ft. Container

The container is equipped with ~~light,~~ LIGHTING electrical heating (ship type approx. 5 kW). The container has one main and one side entrance door each with window.

Inside the container following items are installed:

- air diving decompression chamber
- air/mixed gas dive control manifold

The price for one complete container with a decompression chamber is appr. 1.0 mill. D.Kr.

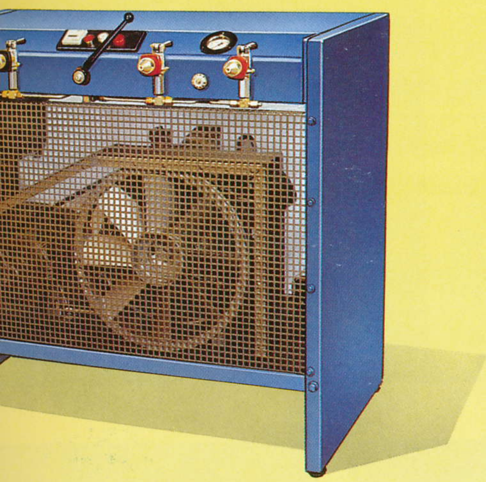
We need two of these containers. We also need two containers with compressor and tubes. In addition to this we also need a container with a divers suit heating generator.

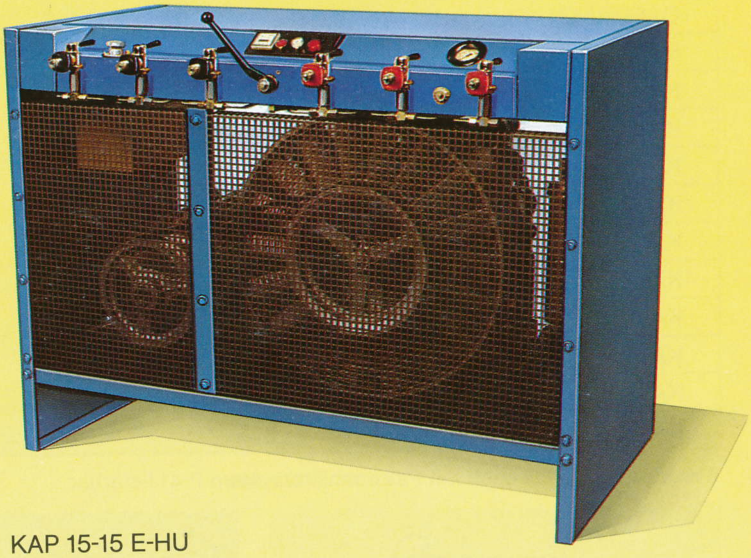
I talked with Claus Frey at Dräger in Germany about the heating system. He told me that the Diesel fired heater from Diving Unlimited International, San Diego (DUI) is very popular (Svitzer uses this in their surface diving container system) and that Dräger used to buy this in order to built it into the Dräger containers but that some customers have complained about the quality of the DUI systems, so that Dräger is looking for a new subdeliver of this.

I would like to use a electrical heated system instead.

THE TWO HIGH PRESSURE COMPRESSORS

The compressors for filling the bottles is a Bauer Kap 21-50 and the working pressure is 200 bars. The bottle station and the compressor is connected to the saturation gas control panel so that the needed air can be piped to the gas charge panels at the bells and the hyperbaric lifeboats. Also the bells can be filled with air when the bells are used for surface diving support down to a depth of maximum 50 meters.





KAP 15-15 E-HU

luftaufbereitung nach internationalen Standards
Jmwandlung auf Anforderung
ronische Patronenüberwachung
altet nach deutschen Sicherheitsvorschriften — TÜV geprüfte Sicherheitsventile

p	Liefermenge		Motor		Filter-system	Maße ca. L		x B		x H		Gewicht ca.	
	l/min.	Scfm	kW	PS		m	in	m	in	m	in	kg	lbs
	190	6,8	4	5,5	P 41	1,15	45	0,73	29	1	39	164	360
-5,5	210	7,4	4	5,5	P 41	1,15	45	0,73	29	1	39	186	410
-7,5	260	9,2	5,5	7,5	P 41	1,15	45	0,73	29	1	39	190	420
-10	320	11,5	7,5	10	P 41	1,15	45	0,73	29	1	39	198	435
-15	440	15,5	11	15	P 41	1,4	55	0,84	33	1,1	43	338	740
0-20 1)	520	18	15	20	P 41	1,3	51	0,8	31	1,1	43	380	840
0-20 2)	600	21	15	20	P 61	1,4	55	0,84	33	1,1	43	363	800
-20 1)	600	21	15	20	P 61	1,3	51	0,8	31	1,1	43	410	900
0-20	650	23	15	20	P 81	1,55	61	0,73	29	1,2	47	685	1510
0-25	800	28	18,5	25	P 81	1,55	61	0,73	29	1,2	47	700	1540
-25	950	34	18,5	25	P 81	2,15	84	0,9	35	1,2	47	870	1910
-30 2)	1050	37	22	30	P 81	2,15	84	0,9	35	1,2	47	870	1910
-40 2)	1250	44	30	40	P 101	2,15	84	0,9	35	1,2	47	880	1940
-50 2)	1400	50	37	50	P 101	2,15	84	0,9	35	1,2	47	900	1980

beziehen sich auf Anlagen mit Drehstrommotor
kuppelt 2) riemengetrieben oder direkt gekuppelt
triebsmotor wird die Typenbezeichnung wie folgt ergänzt. Elektromotor: „E“; Benzinmotor: „B“; Dieselmotor: „D“.

INC.

SIMPLE 520

DIESEL FIRED HEATER

Simple 520 is the most cost
etitive heater on the market
et the needs of saturation diving.
bines the simple operating
cal panel of the Gulf heater and
gh heat output and pumping power
OP1000. The low price, smaller
nd light weight of the Simple 520
his heater an excellent choice for
e supplied or shallow water bell

flame to fresh water, fresh water to
ater type of boiler found on the
e 520 will out perform the tube type
of Gulf heaters from the stand point
ability, maintenance and heat output.

ple" best describes the unit's design
peration. The electrical panel allows
on, burner on, and sets the
rature operation. A maintenance
ule is permanently attached to the
along with burner tip selection and
ional procedures.

l tubing makes up the frame and the
n which the boiler and equipment
ounted. Bolt on stainless steel siding
s environmental protection.

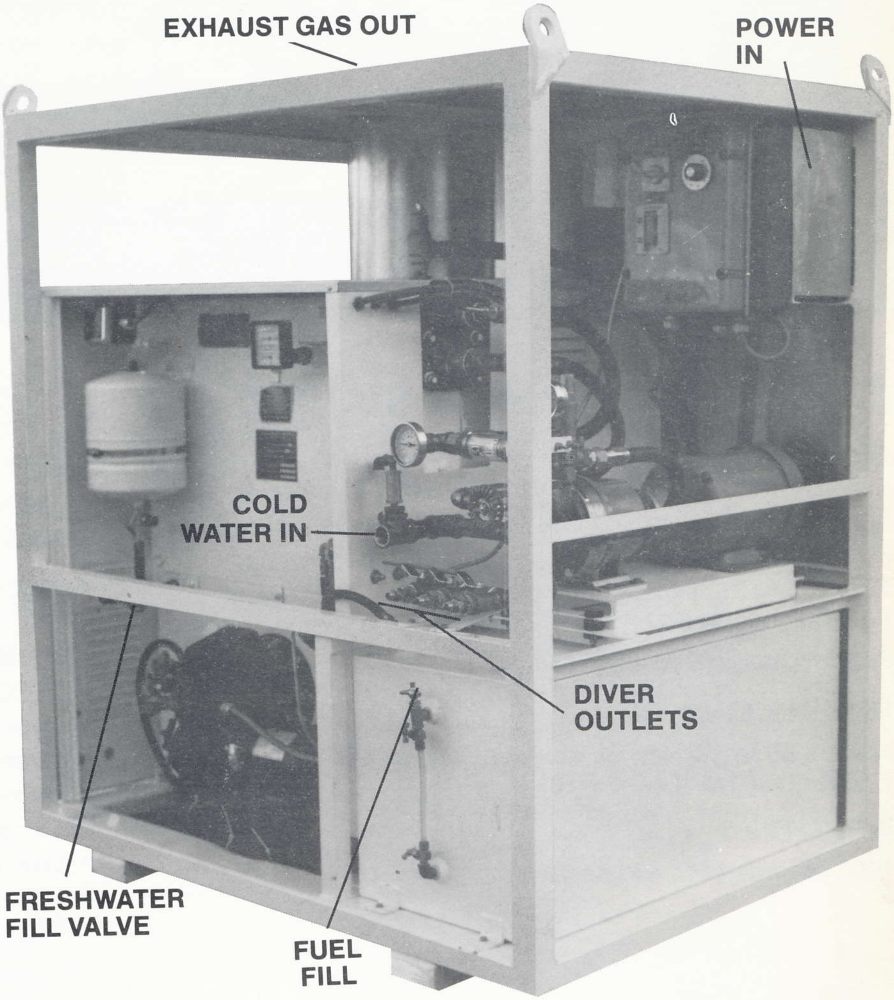


Photo above shows Simple 520 with stainless steel siding removed.

TURES:

- New water-out stack cover
- High output DUI pumping system on cold water side of heat exchanger
- Most parts interchangeable with other DUI heaters
- DUI marine coating, sand blasted, dement coat epoxy primed polyurethane protect all steel parts
- Hairpin ASME boiler with high pressure cupronickel heat exchanger
- High low fired burner, solid state controlled
- Lifting eyes and fork lift provisions

ING UNLIMITED INTERNATIONAL, INC. • SAN DIEGO

7. Surface diving air/mixed gas panel
(mounted in the 20 ft. "DECOM III" container)

A panel on surface for umbilical gas connection for 2 divers and 1 stand by; depth control and surface telephone unit are provided.

8. Divers umbilical, basket and A-frame

Three divers' umbilicals are provided,
each contains:

- 1 air supply hose "gates" type or equivalent (1/2")

- 1 hot water hose of "gates" type or equivalent

- 1 communication line

- 1 pneumoline

7.6.

Basket for two divers (1 each)

The basket for the transport of divers is mainly a pipe construction with open grid.

The opening is on the side.

Space is intended for the installation of 3 x 50 l cylinders which can be used as divers' breathing gas.

		General:	Safe Regalia:	Searambler:
length	approx.	1100 mm	1570	2500
width	"	1100 mm	1100	1100
height	"	2500 mm	2700	2700
weight	"	500 kg (without cylinders)	225 kg	600 kg
Delivery:		Dräger	Götawerket	Dannebrog

Basket handling system will be shipyard delivery but also can be ordered from DRÄGER.

7.7.

Gantry with baseplate

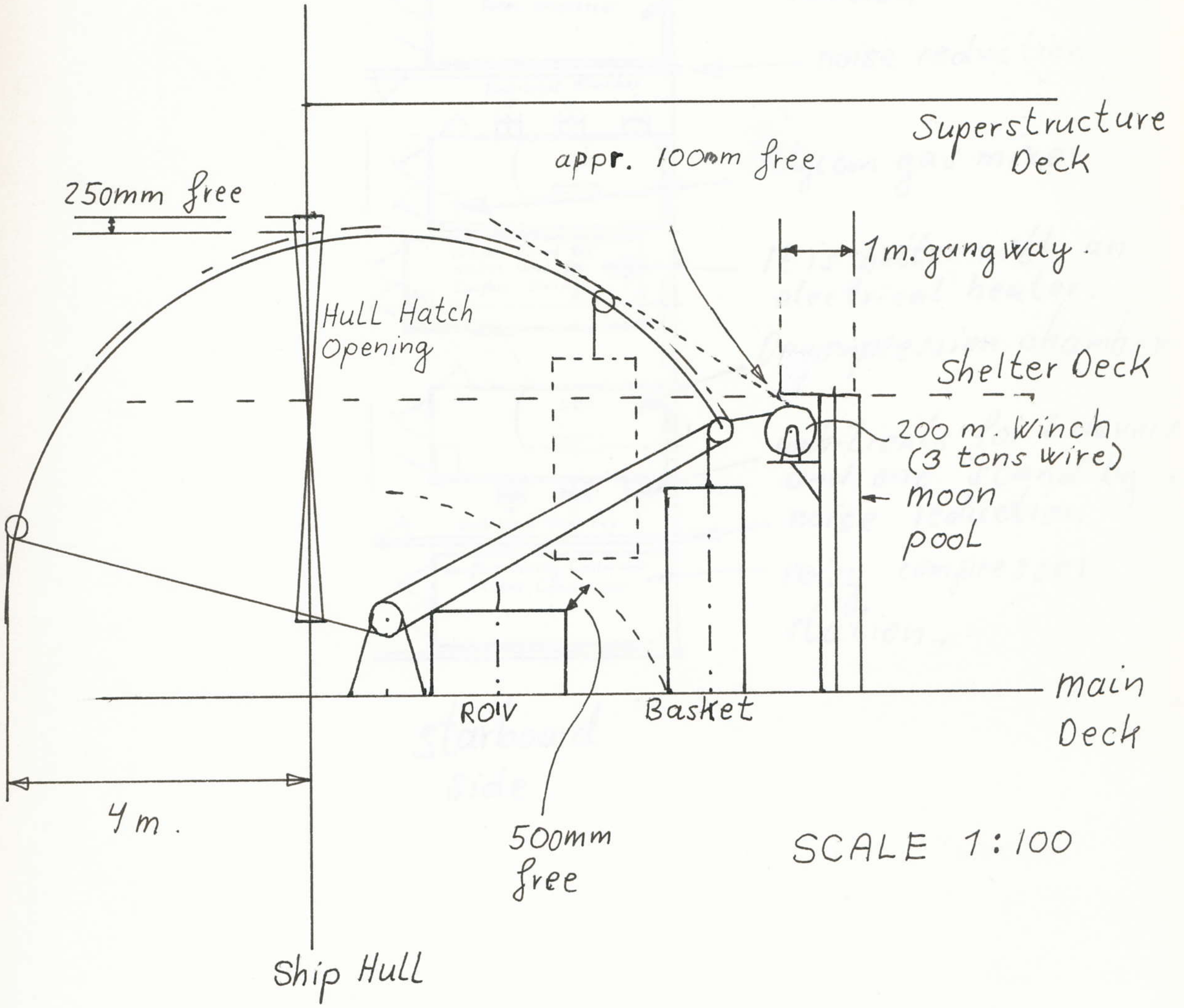
For handling procedures of the wet bell or diving basket a swing Davit or an A-frame with winch is installed on the main deck. The hoisting gear can be also installed at other places on deck.

Outreach over deck side	approx. 2 m
Tensile strength of winch	2 tons
Length of hoisting wires	12o m

THE A-FRAME CRANE

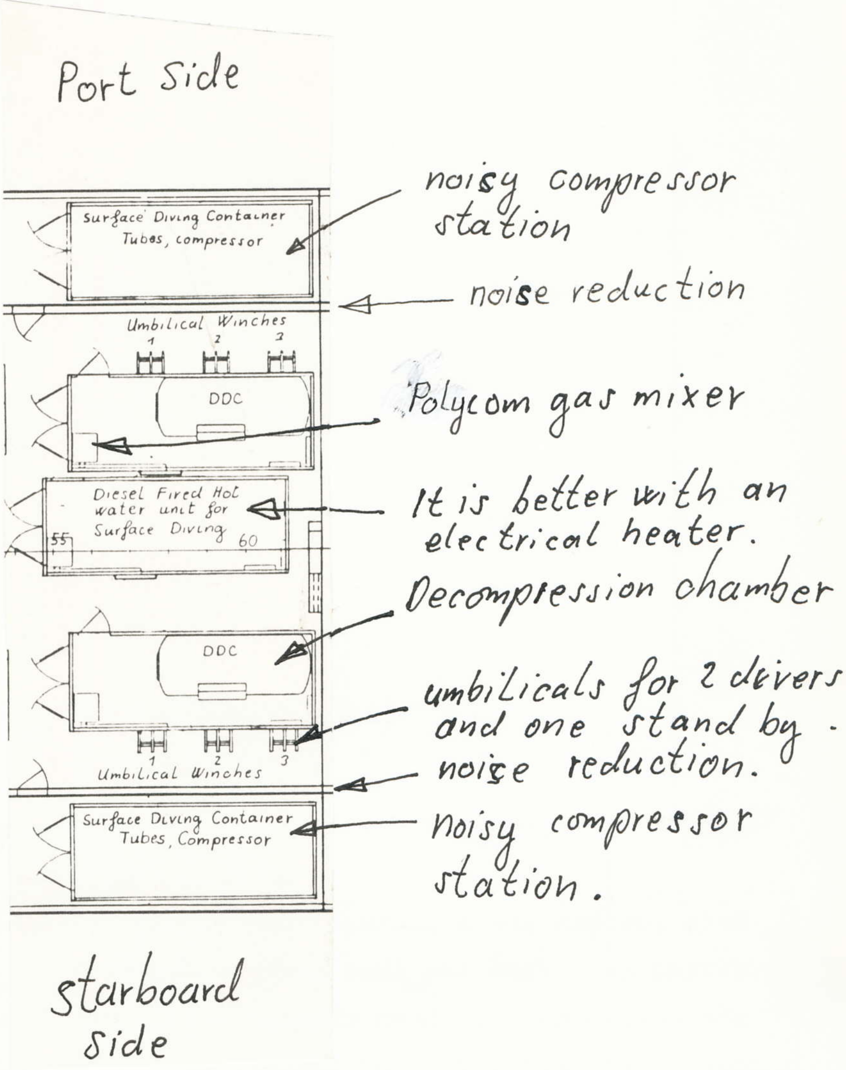
The hoisting of the divers basket is done using an A-frame which is handled out through the opening in the ship's hull when the side hatch is open. There is one A-frame in each side of the ship.

You can see that there are space enough for the handling on this figure:



Note, that the A-frame is constructed for a double function. There are also space for handling the row in stead of the divers basket. Then both ROVs can be lowered at the same time or two baskets can be lowered or one of each can be lowered at the same time.

On this figure you can see the whole surface diving system on board the Silver Searambler:



noisy compressor station

noise reduction

Polycom gas mixer

It is better with an electrical heater.

Decompression chamber

umbilicals for 2 divers and one stand by.

noise reduction.

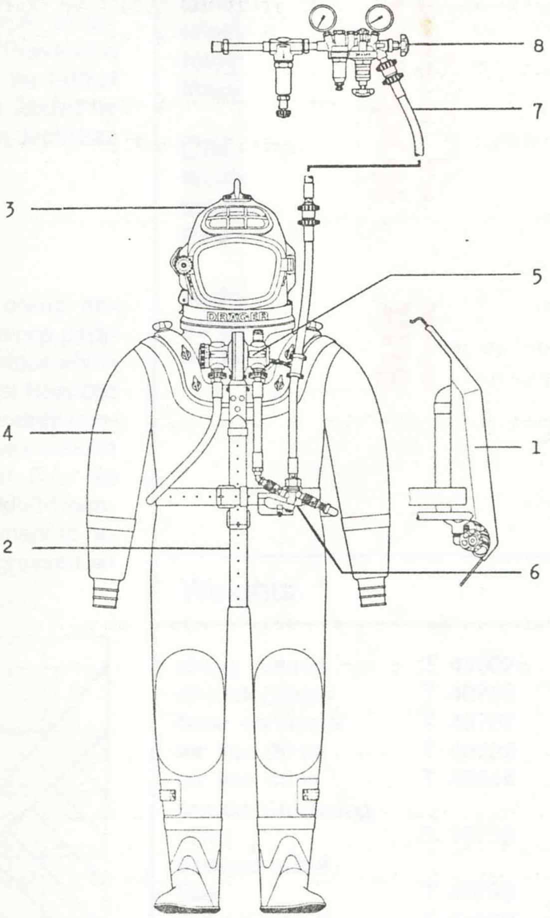
noisy compressor station.

Here you can see a picture showing the original Dräger heavy diving gear from the last century (appr. 1860). As you can see the design has not been changed a lot when comparing to the equipment used today for inshore diving operations.

THE HEAVY DIVING GEAR

This equipment is being called deep diving equipment in the USA. I think it is a wrong thing to call it that. The maximum depth of a heavy diver breathing standard air or oxygen enriched air is according to the rules only 50 meters.

The DM 220 heavy diving gear from Dräger is a dry suit system with an attached helmet. The gear can also be used with swim feets. The suit cannot be warmed by hot water from surface through an umbilical. The heavy gear makes the diver very stable in currents up to appr. 2.5 knots.



1) Emergency air tank (min. 1400 ltr.)

2) Life belt and braces

3) The helmet

4) The suit

5) The breathing regulator

6) The emergency valve

7) The umbilical (min 20m)

8) Pressure reduction valve

+ Telephone

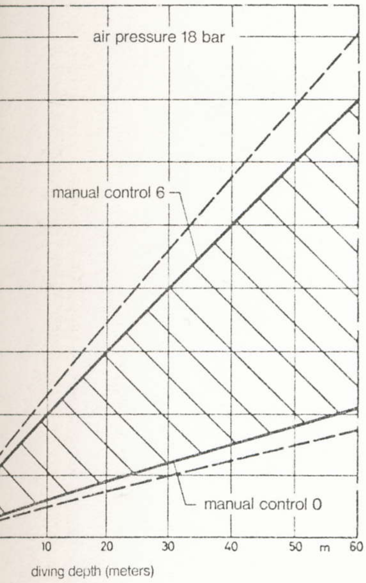
aging, underwater installation, inspec
, repairs and dredging. Compressed air
ording to DIN standard 3188 is supplied
n the surface by a hose.
models are available:
M 220/1 without reserve air equip-
nent and
M 220/2 with reserve air equipment
nd automatic breathing valve

220/1 helmet-type diving apparatus
safety reasons, the diving period is li-
d to the "bottom time without decom-
sion" and the recommended diving
n is 15 m, since this apparatus has no
ve air supply and no automatic brea-
valve. According to a resolution of the
ical committee "civil engineering"
helmet-type diving apparatus will in
e not be approved in the Federal Re-
c of Germany.

20/2 helmet-type diving apparatus
model which has a reserve air equip-
and a automatic breathing valve can
ed to maximum diving depth. In ac-
nce with the Accident Prevention
lations (German: UVV) for the field of
g Procedures" (VBG 39) issued by
ofessional association, this depth has
assessed to 50 m.

proval

DM 220/2 helmet-type diving ap-
is conforms to the regulations perti-
o helmet-type diving apparatus which
esently valid in the Federal Republic
rmany and moreover it already con-
to regulations which will be issued in
ear future e.g.: "Richtlinien über die
derungen an Druckluft-Helm-
geräte" (Regulations pertinent to re-
ments to be met by compressed air
t-type diving apparatus).



Air flow rate

35 015

System:	Helmet-type diving apparatus; open system; constant flow principle
Air supply:	from the surface
Air pressure:	200 bar (minimum 25 bar)
Breathing air quality required:	according to DIN standard 3188
Air hose:	20 m resp. 40 m
Maximum operating pressure:	25 bar
Maximum tensile strength:	2000 N (200 kg)

Diving Suit

System:	dry diving suit, one-piece
Size:	size I for divers of 183 cm and more in height size II for divers of 173–183 cm in height size III for divers of up to 173 cm in height
Boots:	size 46
Cuffs:	slightly conical, one-size, part of suit

DM 220/1

Working pressure (mean pressure):	5 bar
Maximum diving depth recommended:	15 m
Minimum air flow rate at 0 m:	100 l/min
Minimum air flow rate at 15 m:	40 l/min
Maximum air flow rate at 0 m:	250 l/min
Maximum air flow rate at 15 m:	100 l/min

DM 220/2

Working pressure (mean pressure):	18 bar
Maximum diving depth recommended:	50 m
Reserve air equipment:	2 x 2 ltr cylinders, 200 bar = 800 l

Automatic Breating Valve

Air pressure (mean pressure):	18 bar
Air flow rate:	at 18 bar inlet pressure e.g. manual control 0 = 30 ± 5 l/min manual control 6 = 100 ± 15 l/min (see Fig. 1)

Weights		General	DM 220/1	DM 220/2
diving helmet	T 41007	8 kg		
shoulder piece	T 40750	10 kg		
hose connector	T 40707	0.9 kg		
air line 20 m	T 40722	7.8 kg		
air line 40 m	T 40844	14.8 kg		
pressure-reducing valve	D 19735	3.0 kg		
sintered metal filter	T 40799	1.5 kg		
suit e.g. size II	T 41262	4.5 kg	50.5	
chest weight	T 40740		2.85 kg	
chest weight (heavy)	T 41140		5.2 kg	
back weight	T 40790		6.00 kg	
back weight (heavy)	T 41150		10.2 kg	
manual control valve	T 40720		0.85 kg	
connecting hose	T 40710		0.75 kg	76.35
automatic breathing valve	T 12630			5.0 kg
reserve air supply	T 40900			11.5 kg

	93
boots	20
wool suit	15
	128

THE LIGHT WEIGHT DIVER

The light weight diver is equipped with the wet suit hot water system like the one that the saturation divers are using. The hot water comes through the umbilical. The umbilical also delivers the breathing air for the diver. It is very much the same system as with the heavy diver except that the umbilical is connected to a light weight helmet which is the same as the one being used for saturation diving except that it is only built for standard air breathing. Also the light weight diver has an emergency air tank on his back. He is able to move more freely than the heavy diver but he is also more unstable in rough water conditions. the helmet is not attached to the suit, a dry suit can be used also.

Naghilé:

- min. 1400 ltr. emergency air at surface
- telephone
- minimum 800 ltr. emergency air self contained

7.10.

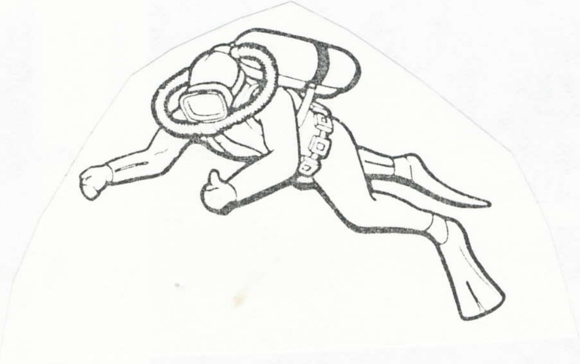
THE SELF CONTAINED UNDERWATER BREATHING DIVER

Any sportsdiver knows what that is. A diver with a wet or dry suit with a simple standard air bottle system with a regulator is able to move freely around in the water. He is however, limited of air and he has no telephone connection to the surface. According to the Danish Diving Act he is also able to go down to 50 meters. The US NAVY Diving manual of June 1985 states, however, that the SCUBA diver should stay within the no-decompression time limit and the recomended maximum diving depth is appr. 20 meters.

The SCUBA diver, however, is very useful in many occations where a quick and easy deployment of the divers is needed.

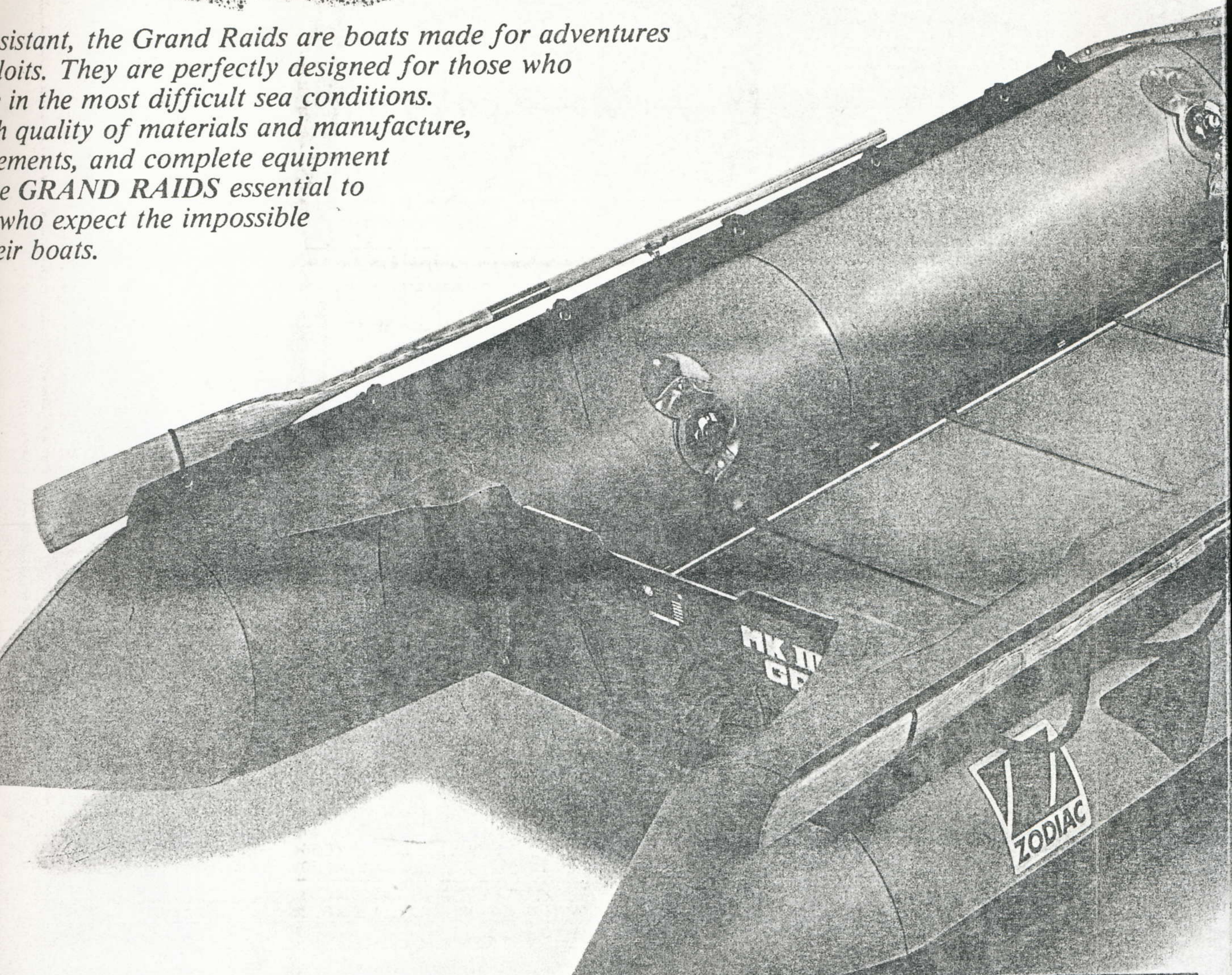
He is very unstable in the water due to the fact that he is neutral in weight-bouyancy and therefore quickly exhausted in waters where the current is stronger than 1 knot.

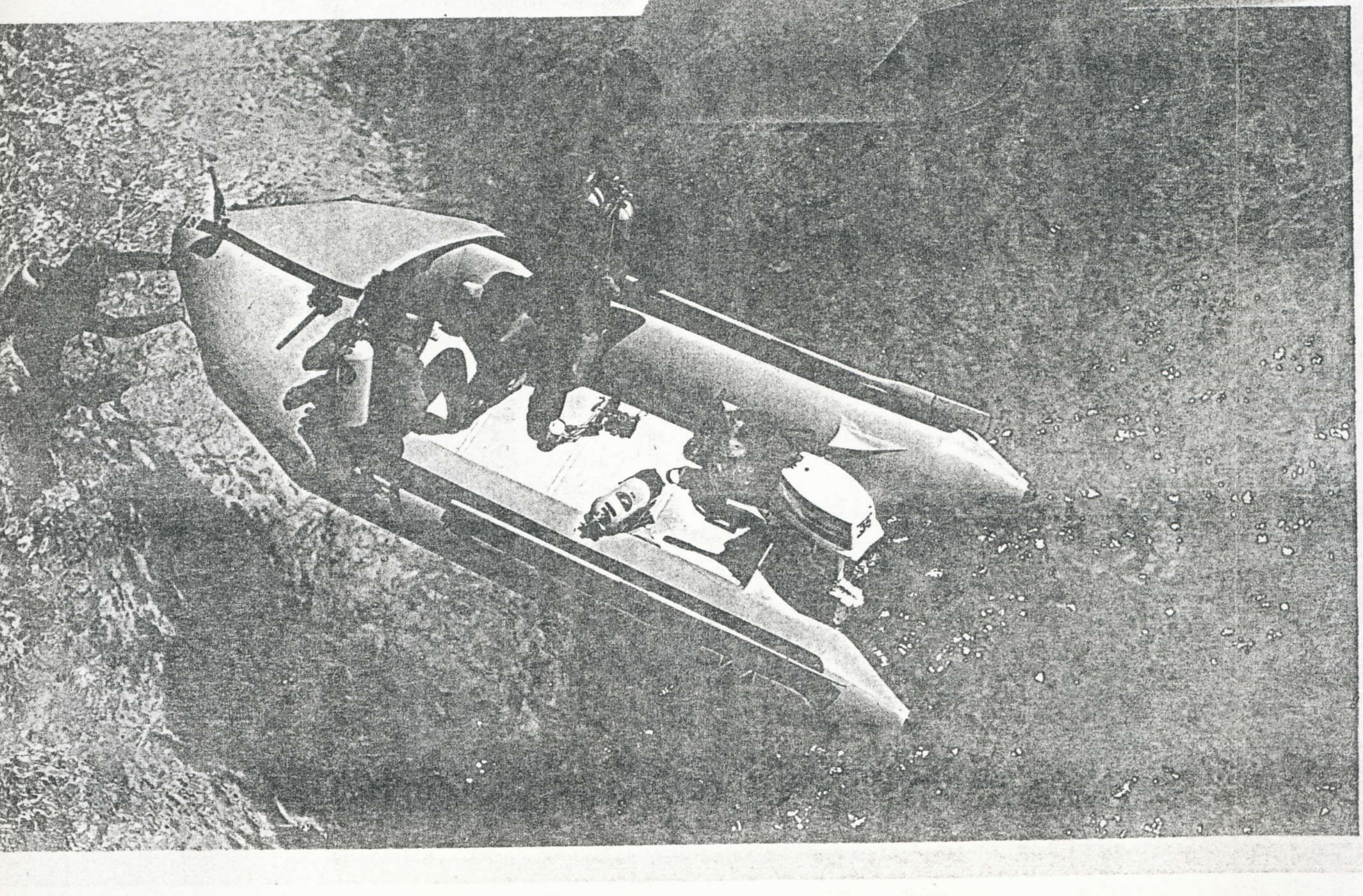
- Min. 1400 ltr.
- Lifeline
- telephone if deeper than 25 meters.

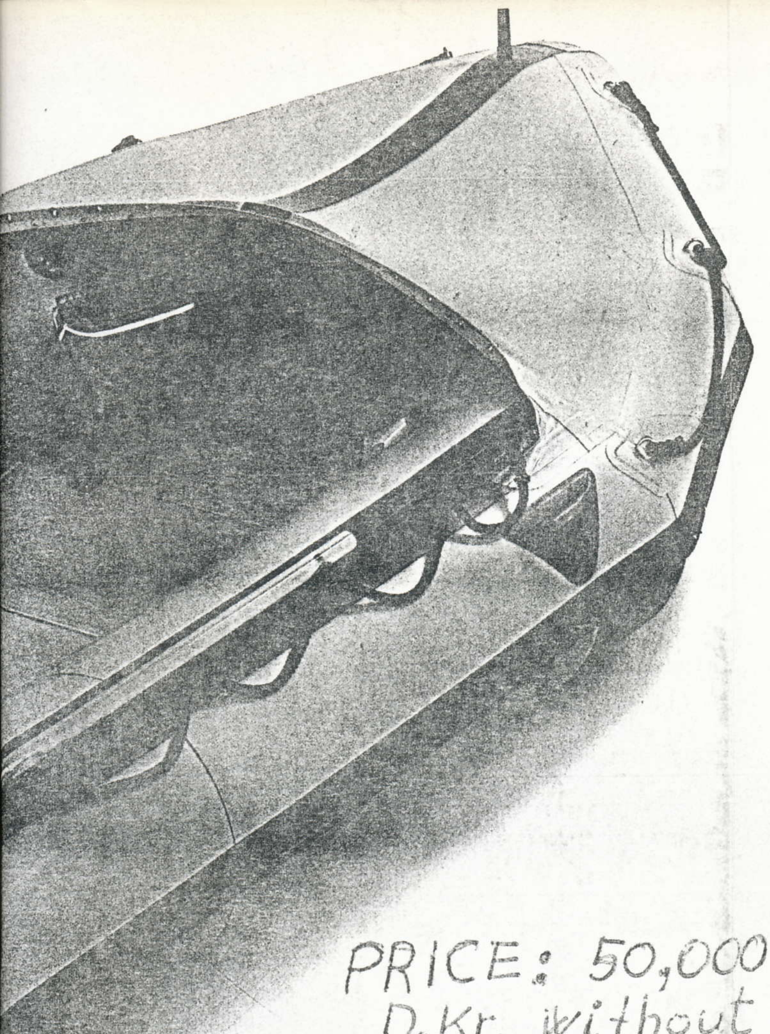


II GR / Mark III GR

sistant, the Grand Raids are boats made for adventures
loits. They are perfectly designed for those who
in the most difficult sea conditions.
h quality of materials and manufacture,
ements, and complete equipment
e GRAND RAIDS essential to
who expect the impossible
eir boats.







MARK III GR

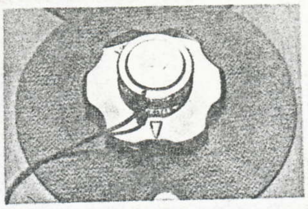
PRICE: 50,000 D.Kr. without Engine

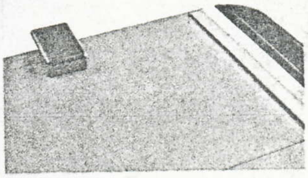
Dimensions of boat folded in bags
(L × W × H)

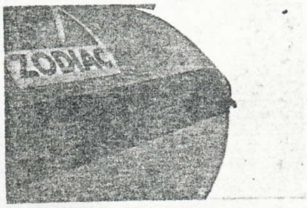
Mark II G.R.	3'10" × 2'2" × 1'2"	1,16 × 0,66 × 0,35 m
	3'7" × 2' × 8"	1,10 × 0,60 × 0.20 m
Mark III G.R.	4'3" × 2'3" × 1'5"	1,30 × 0,68 × 0,43 m
	4'3" × 2'5" × 7"	1,30 × 0,68 × 0.18 m

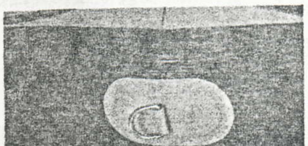
Grand Raid

	MARK II G.R. 6 men
Dimensions	
Overall length	4,20 m 13'9"
Overall width	1,67 m 5'6"
Inside length	2,25 m 7'5"
Inside width	0,76 m 2'6"
Buoyancy tube diameter	0,45m 1'6"
Capacity	
Persons	6
Maximum pay load	700 kg 1.540 lbs
Safety	
Number of airtight compartments	3
Inflatable keel	1
Inflating valves	1
Intercommunicating/overpressure relief valves	2
Carrying handles	4
Outboard motor recommendations	
Water skiing	40 HP 29 kw
Maximum HP capacity	55 HP 40 kw
Total weight in bag	84 kg 185 lbs









Special features

- Nickel-plated bronze intercommunicating and overpressure relief valves (1).
- Reinforced anodized aluminium anti-slip floorboards (2).
- Reinforced transom supports.
- All-round rubbing strake to protect the boat (3).
- Triangular rubbing strake on the hull bottom.
- Reinforcing fabric pads under aft cones.
- Stainless steel plate protecting the bottom of the transom.
- Water-resistant pouch with zip.
- Two D 53 stainless steel towing rings (4).
- Bow grab lines.
- Carrying handles designed to deflect spray.
- Rowlock supports with locking pins
- Accessory fastening rail embedded in the floorboards (MARK II GR only).