# NORTH SEA ALERT !

comex


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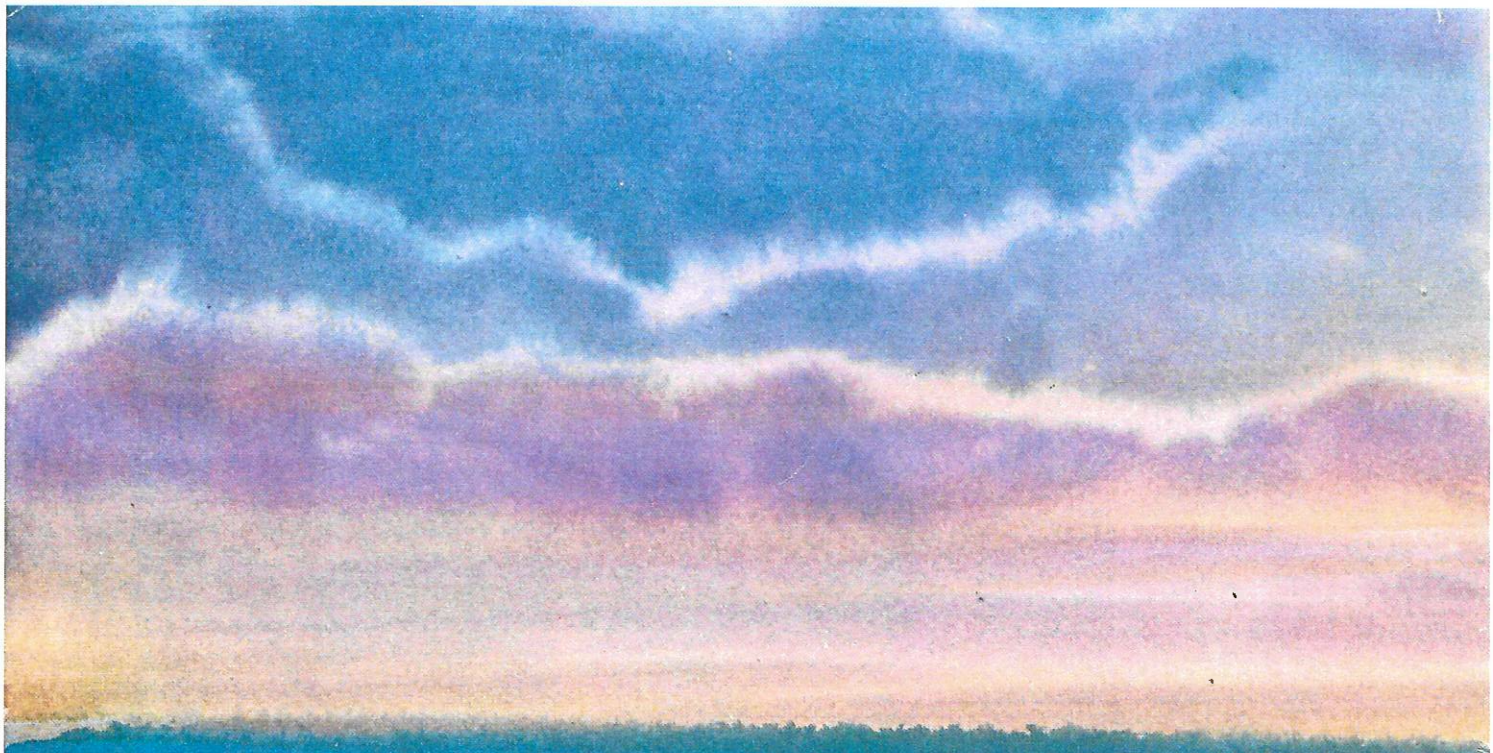
Someone who has never dived himself can scarcely imagine the difficulties which confront man when he leaves the atmosphere of his native habitat to penetrate the hostile environment of the ocean depths.

Despite the spectacular progress which has been made in the fields of underwater physiology and technology over the past decade, the diver still does not have access to great depths and he can still only remain under water for limited periods of time. In diving, depth and duration are in fact related by very strict natural laws. The least infraction of these laws by the diver himself or those responsible for his safety invariably leads to a serious or even fatal accident for the diver.

The systematic exploration of the oceans, however, necessitates the use of divers on increasingly deeper worksites for longer periods of time. These missions have to be carried out following certain inviolable procedures entailing the mobilization of extensive and complex equipment. Comex has thus had to perfect the methods and equipment indispensable to its remaining at the forefront in the conquest of the ocean depths.

For a number of years now, its diving teams have been those able to carry out the greatest variety of missions on the deepest worksites all over the world. It is these methods and this equipment which are presented in this booklet.

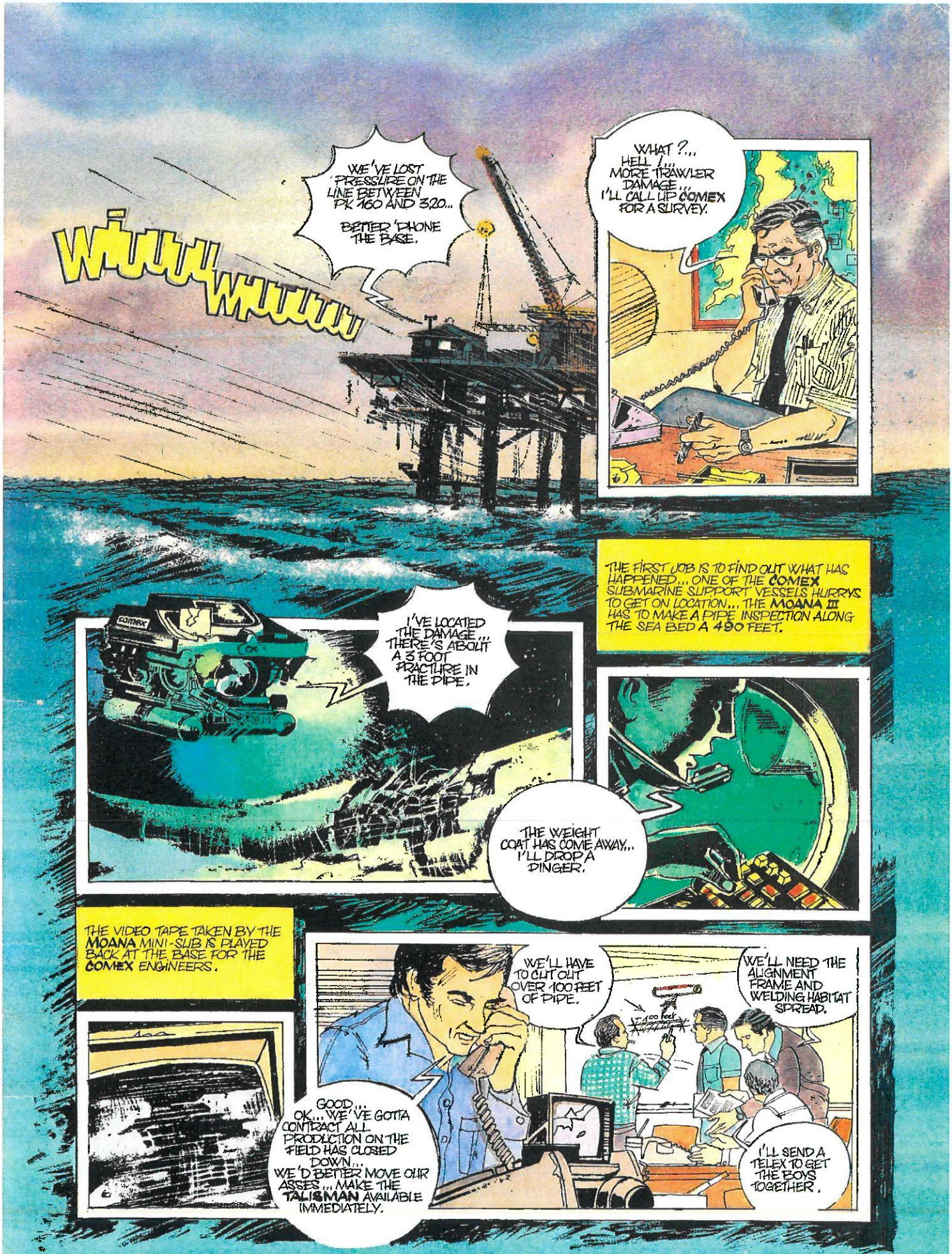
H.-G. Delauze



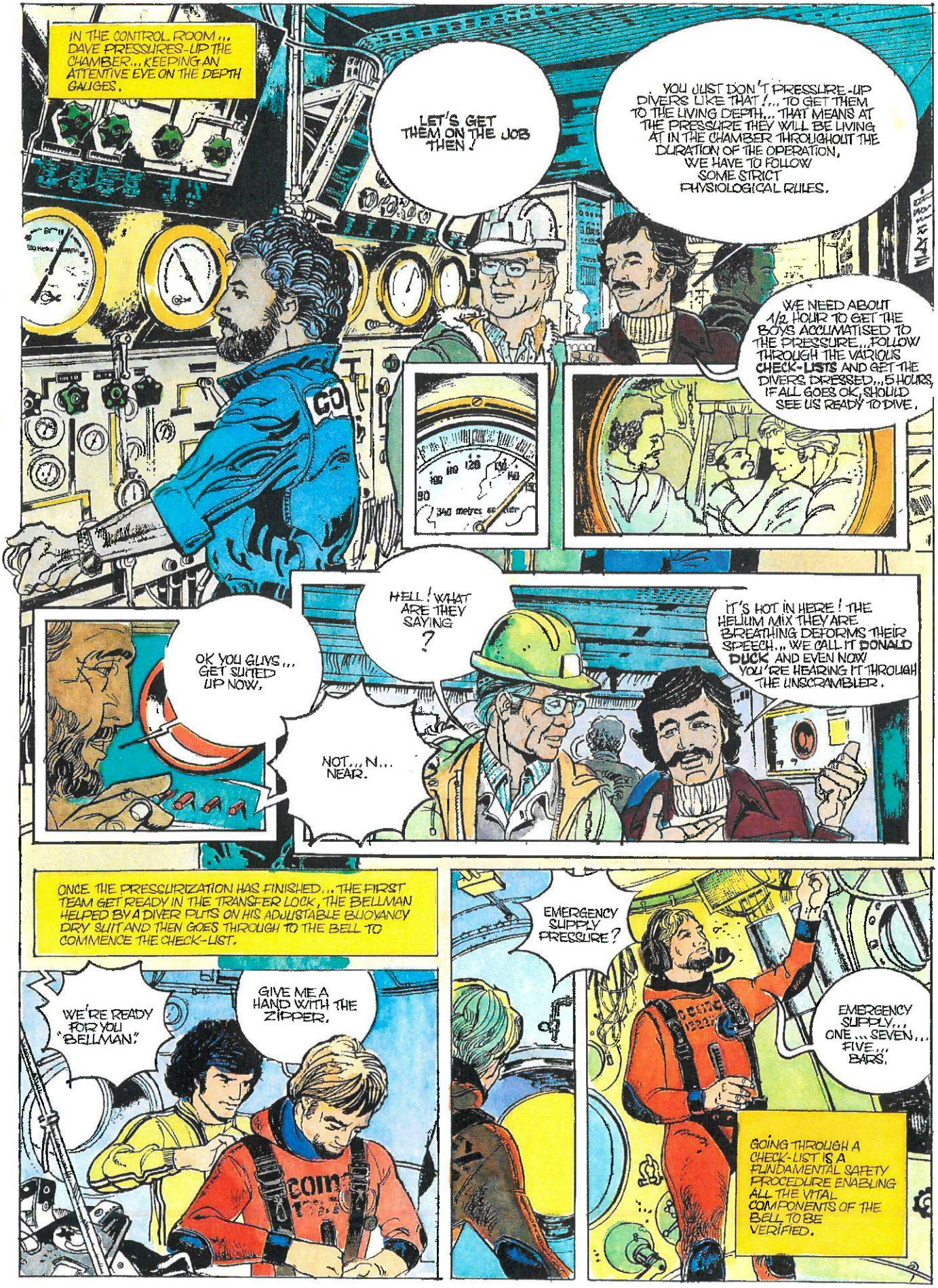
# NORTH SEA ALERT !

The oceans hold innumerable riches in the form of energy, raw materials and foodstuffs that today are of an increasing necessity.
Unfortunately, access to these riches is no easy task, exploitation has hardly started owing to the obstacles encountered when using the most cost effective means.
The oil industry has promoted the most spectacular technological progress. In all of the world's seas, exploration is being undertaken to locate the sources of hydrocarbon energy.

Wells are being put into production and the pipelines that will distribute their produce are being laid on the sea-bed.
There are over eighty drilling and construction sites in the North Sea alone, where the hydrocarbon sources, because of their proximity, have an important economic value to Europe.
Everywhere, at all stages of exploration and production, the offshore oilmen call upon the divers which are their eyes and hands under the sea.
Comex alone, provides over half of the human deep diving interventions carried out worldwide for the offshore oil industry.
It is the story of one such intervention that is told in the following pages.
The story takes place in the North Sea in the vicinity of a production platform. It is almost sundown... an alarm bell rings...


WHUUUU WHUUUUU
WE'VE LOST PRESSURE ON THE LINE BETWEEN PK 160 AND 320... BETTER 'PHONE THE BASE.
WHAT ?... HELL !... MORE TRAWLER DAMAGE... I'LL CALL UP COMEX FOR A SURVEY.
THE FIRST JOB IS TO FIND OUT WHAT HAS HAPPENED... ONE OF THE COMEX SUBMARINE SUPPORT VESSELS HURRYS TO GET ON LOCATION... THE MOANA III HAS TO MAKE A PIPE INSPECTION ALONG THE SEA BED A 490 FEET.
COMEX
I'VE LOCATED THE DAMAGE... THERE'S ABOUT A 3 FOOT FRACTURE IN THE PIPE.
THE WEIGHT COAT HAS COME AWAY... I'LL DROP A DINGER.
THE VIDEO TAPE TAKEN BY THE MOANA MINI-SUB IS PLAYED BACK AT THE BASE FOR THE COMEX ENGINEERS.
WE'LL HAVE TO CUT OUT OVER 100 FEET OF PIPE.
WE'LL NEED THE ALIGNMENT FRAME AND WELDING HABITAT SPREAD.
100 feet
GOOD... OK... WE'VE GOTTA CONTRACT ALL PRODUCTION ON THE FIELD HAS CLOSED DOWN... WE'D BETTER MOVE OUR ASSES... MAKE THE TALISMAN AVAILABLE IMMEDIATELY.
I'LL SEND A TELEX TO GET THE BOYS TOGETHER.


73 HOURS LATER THE COMEX PROJECT MANAGER : ROGER CORTIN AND JOHN CUSTOMER, THE CLIENT REPRESENTATIVE COME ABOARD THE TALISMAN WHICH IS LOCATED ABOVE THE PINGER USING ITS DYNAMIC POSITIONING SYSTEM.
ALREADY ANCHORED AND ON LOCATION !
NO NEED FOR ANCHORS WITH THE TALISMAN, HER ELECTRONICALLY CONTROLLED THRUSTERS KEEP HER RIGHT OVER THE JOB PERMANENTLY.
HERE COME THE WHEELS... BETTER TELL WAYNE.
HI WAYNE !
HI ROGER !
HELLO !
JOHN CUSTOMER THE CLIENT REP WHO'LL BE FOLLOWING THE WHOLE JOB... MEET OUR DIVING SUPERINTENDANT WAYNE CARTER.
WELCOME ABOARD THE "TALISMAN"
I'LL LEAVE YOU... SHOW JOHN TO HIS CABIN.
A COUPLE OF MINUTES TO GET MY COVERALLS ON AND I'LL MEET YOU IN THE CONTROL ROOM.
A FEW MINUTES LATER...
HERE'S THE SAT. SYSTEM.
BUCK-UP LADS NO AEROSOL CANS' AFTER'SHAVE ?
JUST IN TIME THE OTHER DIVERS ARE ALREADY IN THE CHAMBER.
OK DAVE WE KNOW THE SPEECH... KEEP YOUR HAIR ON WE WON'T BLOW-UP YOUR PRECIOUS CHAMBER.
THE SIX DIVERS MAKING UP THE TWO DIVING TEAMS, SLIDE ONE AFTER THE OTHER INTO THE CHAMBER.
CLANG!


IN THE CONTROL ROOM... DAVE PRESSURES-UP THE CHAMBER... KEEPING AN ATTENTIVE EYE ON THE DEPTH GAUGES.
LET'S GET THEM ON THE JOB THEN!
YOU JUST DON'T PRESSURE-UP DIVERS LIKE THAT!... TO GET THEM TO THE LIVING DEPTH... THAT MEANS AT THE PRESSURE THEY WILL BE LIVING AT IN THE CHAMBER THROUGHOUT THE DURATION OF THE OPERATION, WE HAVE TO FOLLOW SOME STRICT PHYSIOLOGICAL RULES.
WE NEED ABOUT 1/2 HOUR TO GET THE BOYS ACCLIMATISED TO THE PRESSURE... FOLLOW THROUGH THE VARIOUS CHECK-LISTS AND GET THE DIVERS DRESSED... 5 HOURS, IF ALL GOES OK, SHOULD SEE US READY TO DIVE.
340 metres
OK YOU GUYS... GET SUITED UP NOW.
HELL! WHAT ARE THEY SAYING?
NOT... N... NEAR.
IT'S HOT IN HERE! THE HELIUM MIX THEY ARE BREATHING DEFORMS THEIR SPEECH... WE CALL IT DONALD DUCK AND EVEN NOW YOU'RE HEARING IT THROUGH THE UNSCRAMBLER.
ONCE THE PRESSURIZATION HAS FINISHED... THE FIRST TEAM GET READY IN THE TRANSFER LOCK, THE BELLMAN HELPED BY A DIVER PUTS ON HIS ADJUSTABLE BUOYANCY DRY SUIT AND THEN GOES THROUGH TO THE BELL TO COMMENCE THE CHECK-LIST.
WE'RE READY FOR YOU "BELLMAN".
GIVE ME A HAND WITH THE ZIPPER.
EMERGENCY SUPPLY PRESSURE?
EMERGENCY SUPPLY... ONE... SEVEN... FIVE... BARS.
GOING THROUGH A CHECK-LIST IS A FUNDAMENTAL SAFETY PROCEDURE ENABLING ALL THE VITAL COMPONENTS OF THE BELL TO BE VERIFIED.

ONCE THE CHECK-LIST HAS BEEN COMPLETED THE TWO DIVERS GO THRO' INTO THE BELL WITH THE BELLMAN.

COME ON... LET'S GO OVER TO THE MOON-POOL.

O.K. WAYNE!

WE LOWER THE BELL WITH A WINCH... IT'LL TAKE ABOUT ¼ OF AN HOUR TO GET THEM TO 490 FEET, THE WORKING DEPTH. WE CAN FOLLOW THE WHOLE DESCENT BY LISTENING TO PHIL, THE BELLMAN, WHO STAYS IN PERMANENT COMMUNICATION WITH THE SURFACE.

WINCHMAN... SLOW ON THE BELL.

O.K... SLOW ON THE BELL.

THE BELL PLUNGES INTO THE ICE COLD WATER AND DISAPPEARS FROM SIGHT.

FOUR... SIX... SIX... FOUR... SIX... SEVEN... SLOW... THE DOOR WILL SOON OPEN.

ONCE THE PRESSURE HAS EQUALISED, THE BELLMAN OPENS THE TOP DOOR. HE LOOKS OUT BY THE VIEW-PORT... EVERYTHING OK. HE HELPS THE TWO DIVERS TO PUT ON THEIR EQUIPMENT; FINS, WEIGHTS, HOT WATER HOSE, FACE-MASK BAIL OUT BOTTLES...

DOOR OPEN.

BLOP

DIVER ONE, LOCKED OUT.


ATTRACTED BY THE LIGHTS ON THE BELL, A GROUP OF COD MOVES SLOWLY OUT OF THE DIVERS WAY.
HOW DOES IT LOOK DIVER?
THE PIPE ISN'T BURIED... GRAVEL BOTTOM... WE'LL BE ABLE TO PASS UNDER THE SLINGS WITHOUT JETTING.
A LONG OPERATION NOW STARTS FOR THE DIVERS... CLEARING THE PIPE FROM THE BOTTOM USING HYDRAULIC JACKS AND LIFTING BAGS ALONG THE LENGTH OF THE FRACTURE.
PIPE SAND-BAGGED ON ONE SIDE... SEND SOME MORE BAGS.
SURFACE... I'M ON THE PIPE
SAY... HOW'S IT GOING?
NOW WE'VE CLEARED THE PIPE FROM THE BOTTOM... WE'LL START REMOVING THE DAMAGED WEIGHT-COAT... THE JOB IS FAR FROM FINISHED YET.
GO BACK TO THE BELL... WE'LL LOWER THE GEAR.
AFFIRMATIVE... GOING BACK TO THE BELL.
USING A HYDRAULIC POWERED CIRCULAR SAW THE DIVERS WILL REMOVE THE CONCRETE WEIGHT-COAT IN ORDER TO ENABLE SUBSEQUENT OXY-ARC CUTTING.
THIRD CUT FINISHED.
OK. LADS... THAT'S ENOUGH WE'RE CHANGING OVER TEAMS... LEAVE THE JOB CLEAR.
OK. WE'RE COMING BACK TO THE BELL.

HAVING FINISHED THE FIRST PHASE OF THE OPERATION... THE DIVERS RETURN TO THE BELL AND SUBSEQUENT ASCENT TO CLAMP BACK ONTO THE CHAMBER

OUF... I'M BUSHED... A SHOWER AND A JUICY 'T' BONE.

FIRST DIVER BACK

THE TWO DIVING TEAMS RELAY EACH OTHER NIGHT AND DAY... PROGRESSING AS RAPIDLY AS POSSIBLE WITH THE WORK AS THE UNPREDICTABLE WEATHER WILL ALLOW.

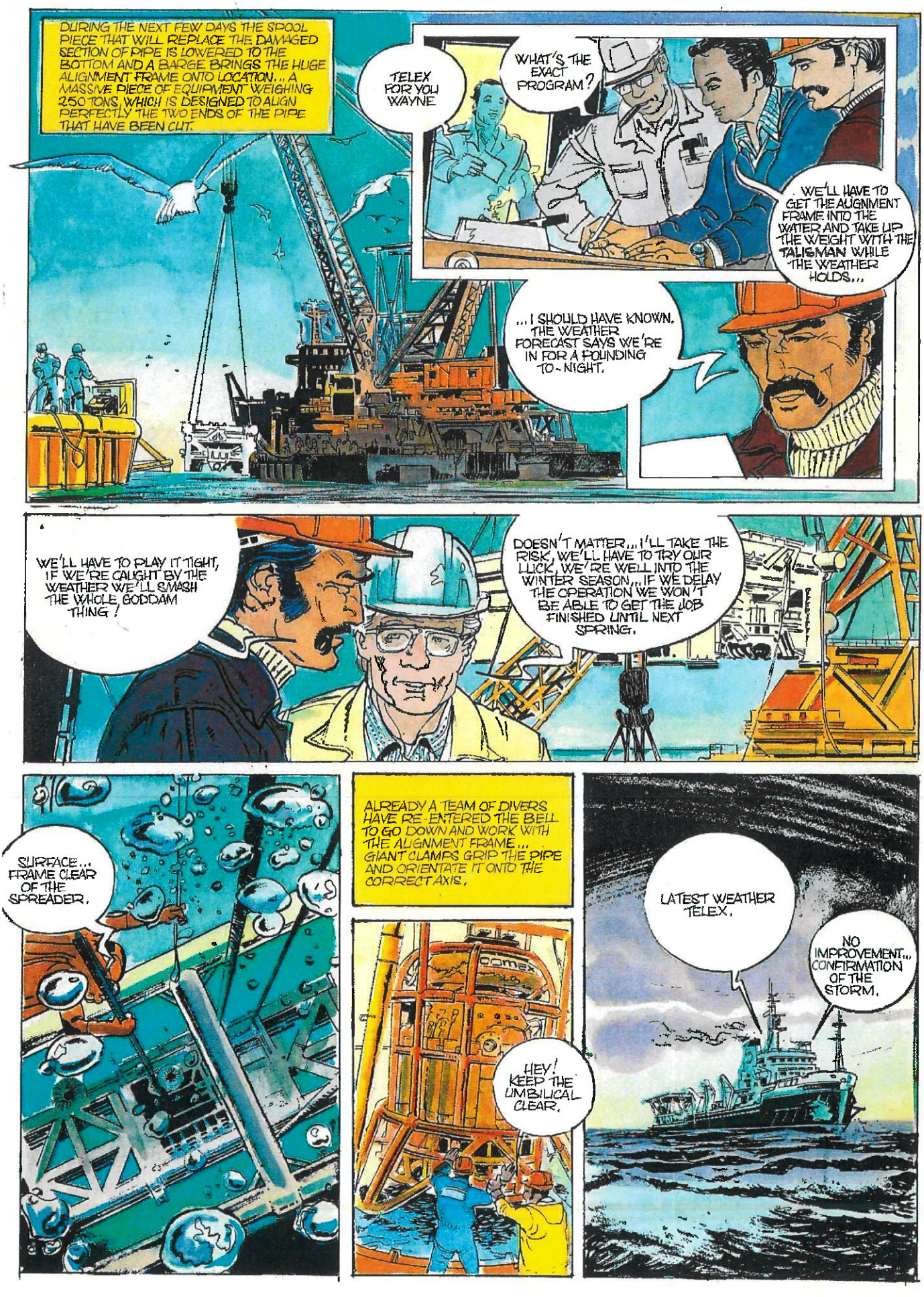
24 HOURS OUT OF 24 THE ACTIVITY CONTINUES ABOARD THE VESSEL.

THE DIVERS HAVING REMOVED THE CONCRETE AND BROKEN AWAY THE BITUMASTIC LAYER... THEY CUT THE PIPE USING OXY-ARC BURNING... FINALLY SEPARATING THE FRACTURED SECTION.

WE'RE COMING BACK TO THE BELL... THE CUT IS FINISHED.

SEAL ON THE DOOR... OK. READY FOR THE ASCENT.

AFFIRMATIVE... UP ON THE BELL.


DURING THE NEXT FEW DAYS THE SPOOL PIECE THAT WILL REPLACE THE DAMAGED SECTION OF PIPE IS LOWERED TO THE BOTTOM AND A BARGE BRINGS THE HUGE ALIGNMENT FRAME ONTO LOCATION... A MASSIVE PIECE OF EQUIPMENT WEIGHING 250 TONS, WHICH IS DESIGNED TO ALIGN PERFECTLY THE TWO ENDS OF THE PIPE THAT HAVE BEEN CUT.
TELEX FOR YOU WAYNE
WHAT'S THE EXACT PROGRAM?
WE'LL HAVE TO GET THE ALIGNMENT FRAME INTO THE WATER AND TAKE UP THE WEIGHT WITH THE TALISMAN WHILE THE WEATHER HOLDS...
...I SHOULD HAVE KNOWN. THE WEATHER FORECAST SAYS WE'RE IN FOR A POUNDING TO-NIGHT.
WE'LL HAVE TO PLAY IT TIGHT, IF WE'RE CAUGHT BY THE WEATHER WE'LL SMASH THE WHOLE GODDAM THING!
DOESN'T MATTER... I'LL TAKE THE RISK, WE'LL HAVE TO TRY OUR LUCK, WE'RE WELL INTO THE WINTER SEASON... IF WE DELAY THE OPERATION WE WON'T BE ABLE TO GET THE JOB FINISHED UNTIL NEXT SPRING.
SURFACE... FRAME CLEAR OF THE SPREADER.
ALREADY A TEAM OF DIVERS HAVE RE-ENTERED THE BELL TO GO DOWN AND WORK WITH THE ALIGNMENT FRAME... GIANT CLAMPS GRIP THE PIPE AND ORIENTATE IT ONTO THE CORRECT AXIS.
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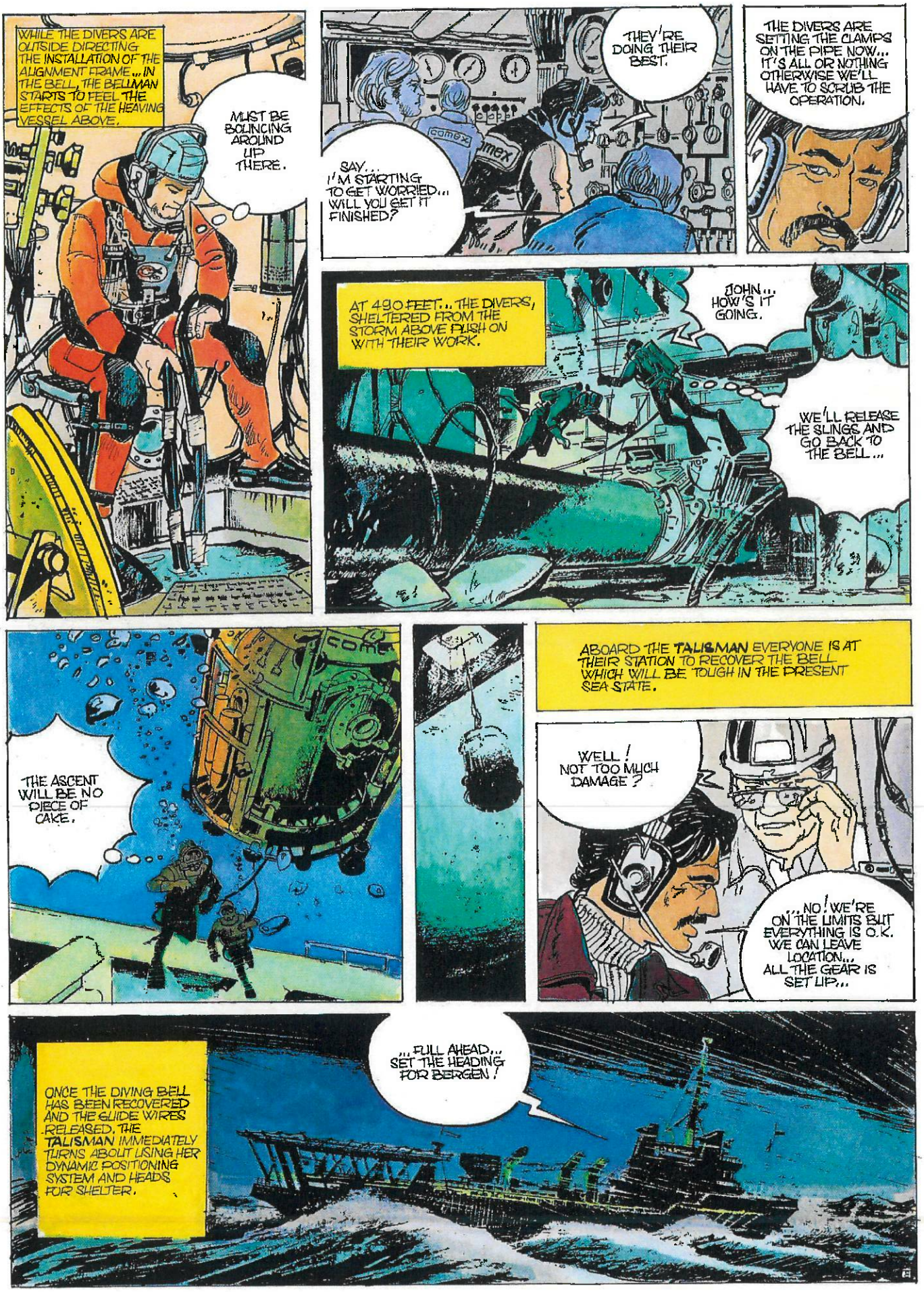
HEY! KEEP THE UMBILICAL CLEAR.
LATEST WEATHER TELEX.
NO IMPROVEMENT... CONFIRMATION OF THE STORM.


WHILE THE DIVERS ARE OUTSIDE DIRECTING THE INSTALLATION OF THE ALIGNMENT FRAME... IN THE BELL, THE BELLMAN STARTS TO FEEL THE EFFECTS OF THE HEAVING VESSEL ABOVE.
MUST BE BOUNCING AROUND UP THERE.
THEY'RE DOING THEIR BEST.
SAY... I'M STARTING TO GET WORRIED... WILL YOU GET IT FINISHED?
THE DIVERS ARE SETTING THE CLAMPS ON THE PIPE NOW... IT'S ALL OR NOTHING OTHERWISE WE'LL HAVE TO SCRUB THE OPERATION.
AT 490 FEET... THE DIVERS, SHELTERED FROM THE STORM ABOVE PUSH ON WITH THEIR WORK.
JOHN... HOW'S IT GOING.
WE'LL RELEASE THE SLINGS AND GO BACK TO THE BELL...
THE ASCENT WILL BE NO PIECE OF CAKE.
ABOARD THE TALISMAN EVERYONE IS AT THEIR STATION TO RECOVER THE BELL WHICH WILL BE TOUGH IN THE PRESENT SEA STATE.
WELL! NOT TOO MUCH DAMAGE?
...NO! WE'RE ON THE LIMITS BUT EVERYTHING IS O.K. WE CAN LEAVE LOCATION... ALL THE GEAR IS SET UP...
ONCE THE DIVING BELL HAS BEEN RECOVERED AND THE GUIDE WIRES RELEASED, THE TALISMAN IMMEDIATELY TURNS ABOUT USING HER DYNAMIC POSITIONING SYSTEM AND HEADS FOR SHELTER.
...FULL AHEAD... SET THE HEADING FOR BERGEN!

AS QUICKLY AS THE STORM BREWED IT DIED DOWN AND THE **TALISMAN** RELOCATED THE SITE BY MEANS OF ITS ACOUSTIC BEACONS. THE DIVERS INSPECT THE ALIGNMENT FRAME AND REPLACE THE GUIDE WIRES WHICH WILL ENABLE THE LOCATION OF THE WELDING HABITAT.

... HABITAT READY...

DIVERS! GO BACK TO THE BELL, WE'RE BRINGING YOU UP AND THEN WE'LL LOWER THE WELDING HABITAT.

THE WELDING HABITAT CONTAINING A PUP PIECE SLIDES DOWN THE GUIDE WIRES TOWARDS ITS RESTING PLACE ON THE ALIGNMENT FRAME

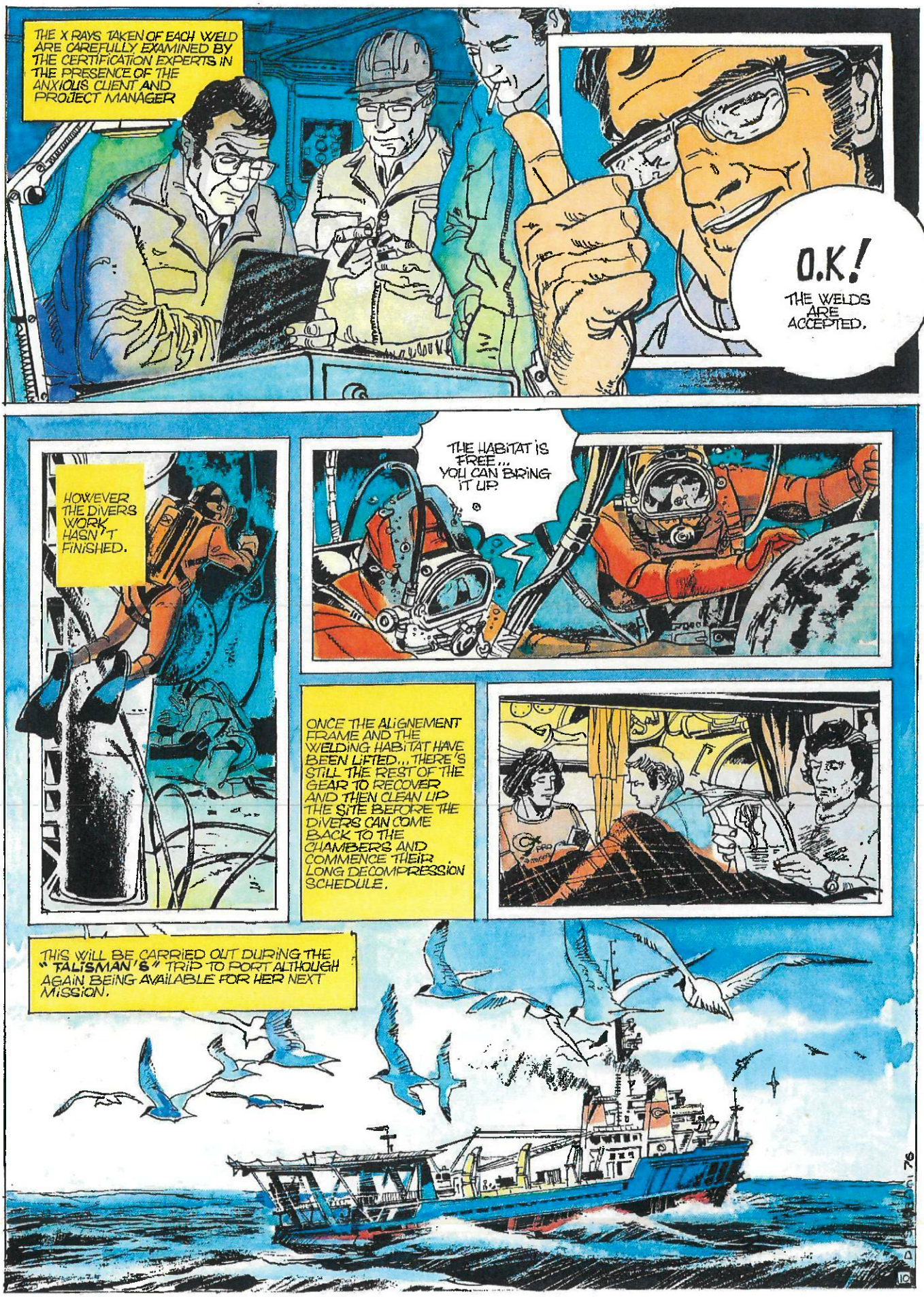
WATER LEVEL ADJUSTED... EVERYTHING IS IN PLACE... NOTHING DAMAGED.

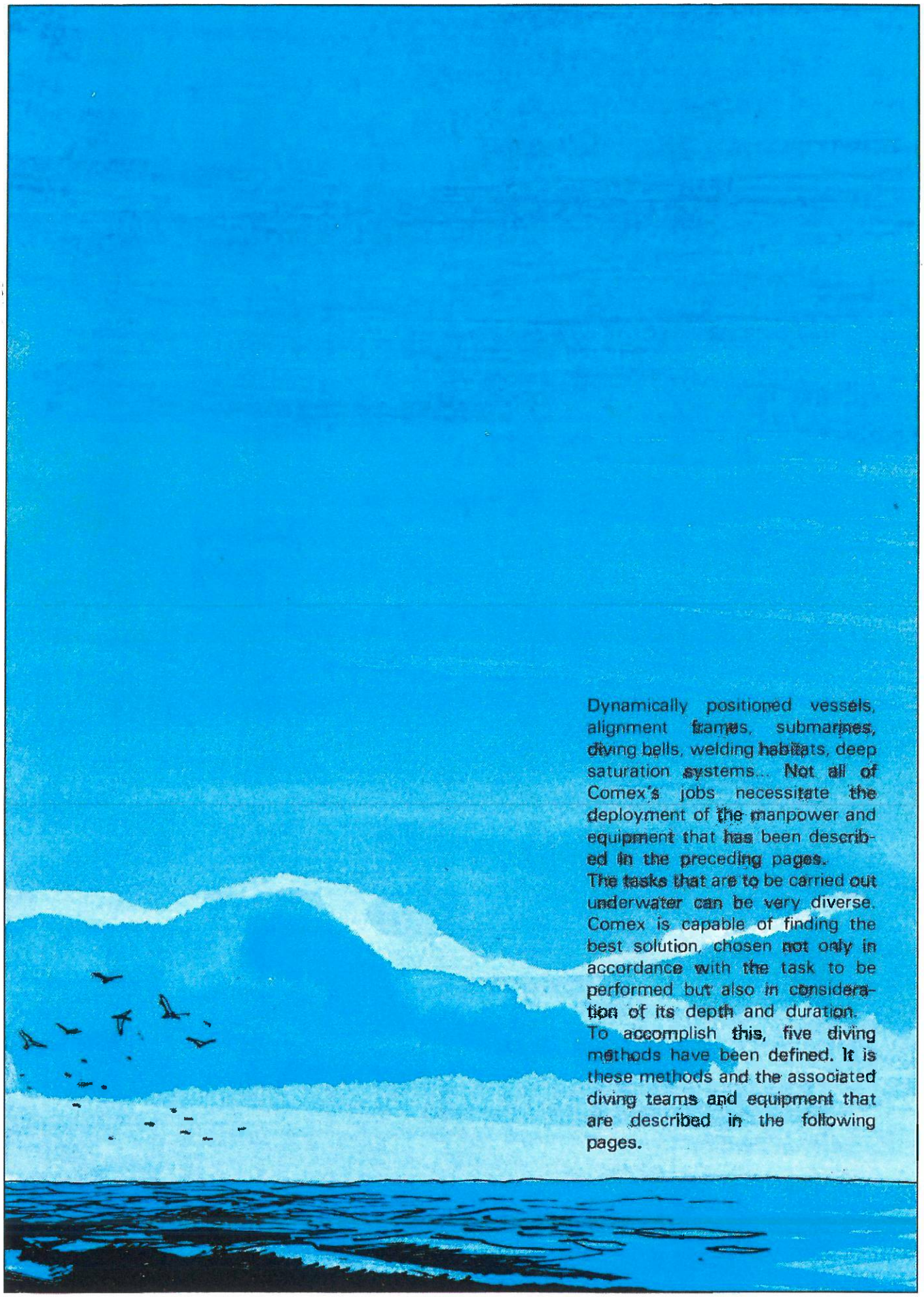
ONCE LOCATED THE DIVERS CHECK FOR SEALING AND THE WATER IS EVACUATED BY BLOWING DOWN FROM THE SURFACE WITH A BREATHABLE GAS FORMING A DRY ENVIRONMENT, THE PIPE-FITTERS AND WELDERS CAN THEN BE TRANSFERRED FROM THE BELL TO THE HABITAT THROUGH THE TOP LOCK.

THEY'RE SETTING THE PUP PIECE.

SURFACE... IT'LL BE GOOD. THE WELDERS CAN GET READY.

THE PUP PIECE ONCE SET... THE BELL ASCENDS WITH THE PIPE-FITTERS WHO WILL CHANGE OVER WITH THE WELDERS WAITING IN THE CHAMBER.


THE X RAYS TAKEN OF EACH WELD ARE CAREFULLY EXAMINED BY THE CERTIFICATION EXPERTS IN THE PRESENCE OF THE ANXIOUS CLIENT AND PROJECT MANAGER
O.K! THE WELDS ARE ACCEPTED.
HOWEVER THE DIVERS WORK HASN'T FINISHED.
THE HABITAT IS FREE... YOU CAN BRING IT UP.
ONCE THE ALIGNEMENT FRAME AND THE WELDING HABITAT HAVE BEEN LIFTED... THERE'S STILL THE REST OF THE GEAR TO RECOVER AND THEN CLEAN UP THE SITE BEFORE THE DIVERS CAN COME BACK TO THE CHAMBERS AND COMMENCE THEIR LONG DECOMPRESSION SCHEDULE.
THIS WILL BE CARRIED OUT DURING THE "TALISMAN'S" TRIP TO PORT ALTHOUGH AGAIN BEING AVAILABLE FOR HER NEXT MISSION.



Dynamically positioned vessels, alignment frames, submarines, diving bells, welding habitats, deep saturation systems... Not all of Comex's jobs necessitate the deployment of the manpower and equipment that has been described in the preceding pages.
The tasks that are to be carried out underwater can be very diverse. Comex is capable of finding the best solution, chosen not only in accordance with the task to be performed but also in consideration of its depth and duration.
To accomplish this, five diving methods have been defined. It is these methods and the associated diving teams and equipment that are described in the following pages.

1 - Project Manager
2 - Barge and Works Supervisor
3 - Diving Superintendant
4 - Diving Supervisor
5 - Life-support Technician
6 - Stand-by Diver
7 - Bellman
8 - Diver


## THE COMEX TECHNICAL TEAM

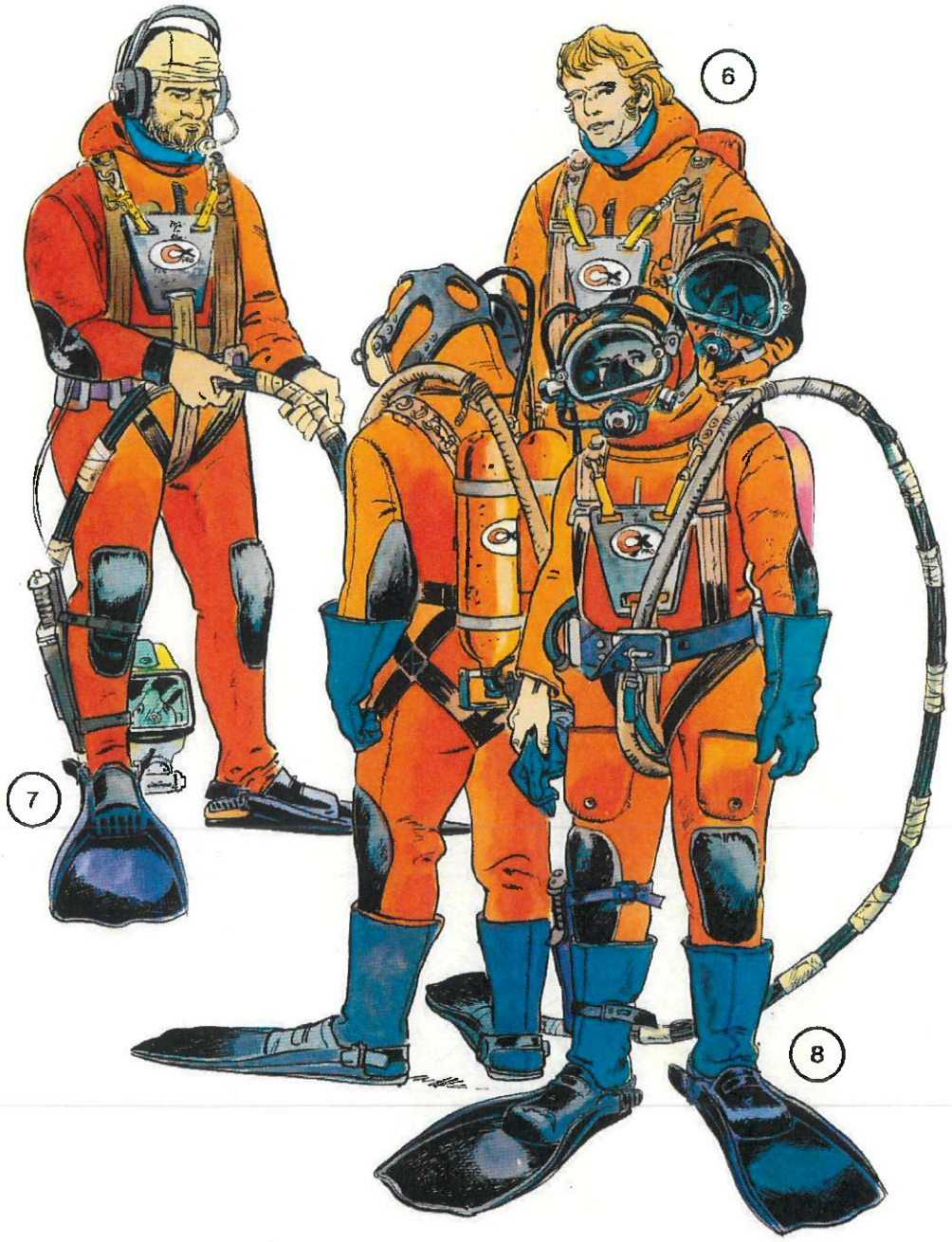
Comex employs on its worksites teams of divers and technicians who share among them eight essential functions, six at the surface and two at the bottom.
Depending on the size of the site, several different jobs are sometimes performed by the same person, or conversely one job is divided up among several people.

**The project manager** is the person responsible to the Comex client for the entire project. It is up to him to see that the terms of the contract (in which he has already played a part by drafting its broad outlines with the client) are properly executed. A project manager may be responsible for several worksites in the same region.

**The barge and works supervisor** is the project manager's permanent representative on the worksite itself, and the customer's on-site liaison man. He decides upon the most suitable procedures to use on the site and sees that the work is done correctly.

**The diving superintendent** is the person in charge of the diving part of the job and for seeing that the underwater tasks defined by the works supervisor are properly executed. It is his responsibility to make sure that the current safety - in - diving regulations are observed.

**The diving supervisor :** every




single dive is performed under the responsibility of a diving supervisor who is designated for that particular dive. He may have other functions in the team, and may equally well be the diving superintendent himself or a highly qualified diver.

**The life-support technician, or chamber-operator** is responsible for controlling the environmental parameters for the divers in saturation. He mixes the breathing gases as required and distributes them to the chambers at the right pressure, as well as monitoring regeneration of these gases. He also selects and applies the appropriate compression and decompression schedules, services the chambers and checks that they are functioning properly.

**The stand-by diver** is equipped with an umbilical, ready to dive immediately if an emergency situation, such as the bell getting stuck, should arise. His job is to ensure from the surface the safety of the divers in the water.

**The bellman** is a diver who never gets into the water, if the dive goes off as it should. He stays at his post inside the bell where he checks that the various necessities such as breathing gas supply regeneration, and communications, etc., are functioning properly and directly oversees the safety of the divers working in the water.

**The diver** may be a welder, a fitter, a mechanic,... in any case he is the technician who performs the actual work on the site, the final link in a chain comprising many specialists and employing, in general, very costly equipment. He is chosen for his intelligence, his physical fitness and his skill in his particular speciality.

## THE DIVING BELL: A DEEP-WATER LIFT

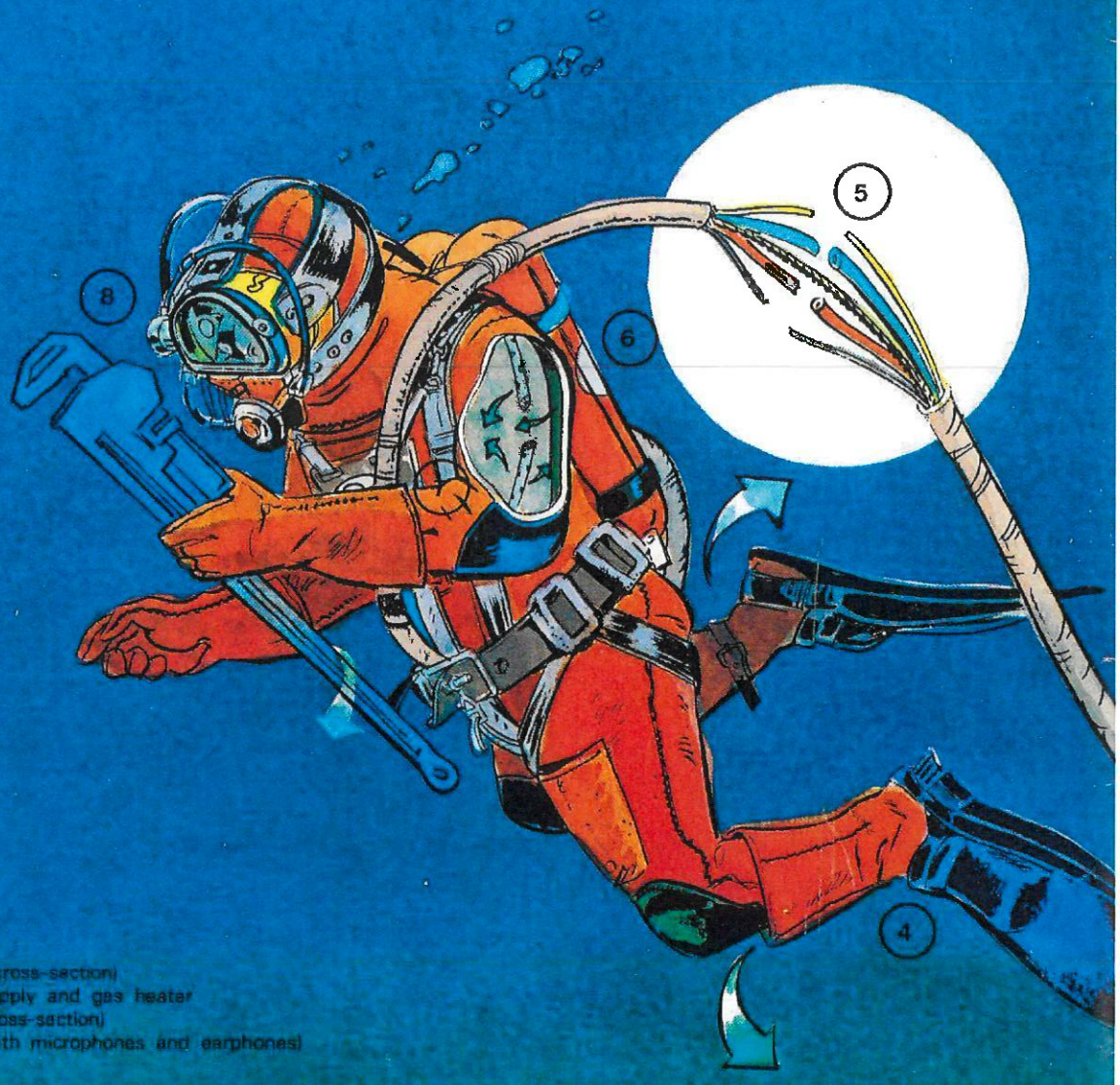
When a dive is limited to ten or twenty minutes and to a depth of less than fifty meters (165 ft.), the diver enters the water at the surface. When the dive lasts longer and the depth is greater, as is usually the case, the divers are taken from the surface to the worksite by a diving bell.

The diving bell is a steel enclosure with a sealed hatch in the bottom, suspended from a carrier cable attached to the top. An umbilical cable supplies it with breathing gases, electricity and hot water from the surface, and transmits intercom messages and some measurements. It has room for three fully equipped men : a bellman and two divers.

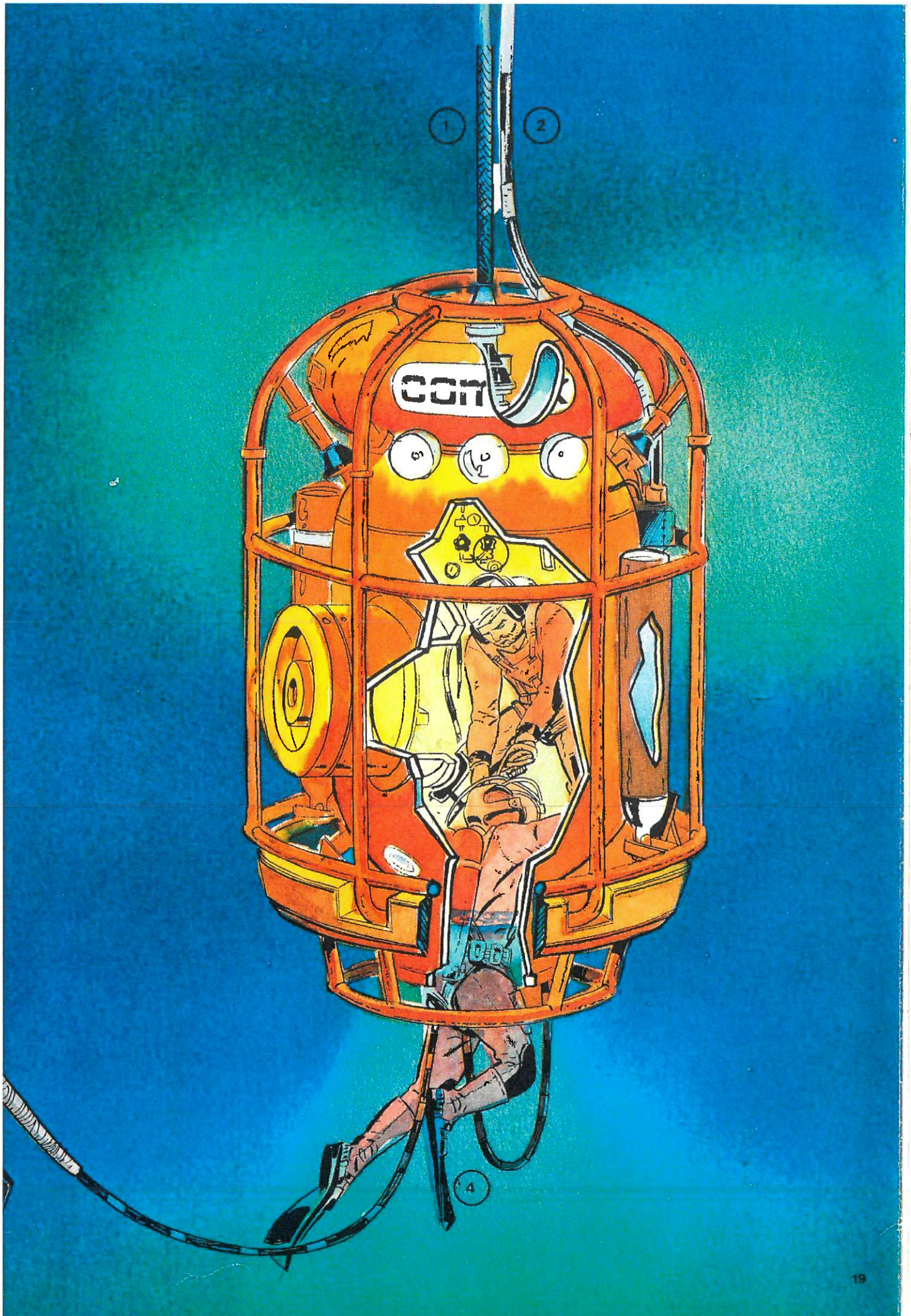
When the bell has reached the working depth, its internal pressure is brought to the same value as that of the ambient pressure. The hatch which was sealed by the effect of the external pressure then opens effortlessly and the divers, with the help of the bellman, can go out into the water. All the time they are in the water, they are connected to the bell by an umbilical which supplies them with breathing gas and hot water. The hot water first passes through a gas heater which warms the diver's breathing gas and then diffuses through his suit, therefore preventing both respiratory and cutaneous heat loss. The umbilical is also the channel by means of which the divers are in continuous contact with the bellman and with the surface, which receives at the same time the constantly changing depth values of each diver.

The bellman stays in the bell and checks the gas supply going to the divers, as well as maintaining their umbilicals at a length that enables them to work easily and without hindrance. He maintains direct contact with the diver at all times, even if hidden in a shadow or has moved outside the bellman's range of vision, by skillfully tending the diver's umbilical.

Under normal circumstances the bellman would not take part in underwater work, he only leaves the bell to help a diver in trouble.




1 - Carrier cable
2 - Bell umbilical
3 - Bellman
4 - Diver
5 - Diver's umbilical (cross-section)
6 - Emergency gas supply and gas heater
7 - Hot water suit (cross-section)
8 - Full face mask (with microphones and earphones)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## THE FIVE METHODS FOR PROFESSIONAL DIVING

Comex does not use the same methods on all worksites. Different size teams and different equipment are employed depending on whether the job consists of a very specific inspection at fifty meters' depth (165 ft.), or making a pipeline tie-in over a long period of time at three hundred and fifty meters (1,200 ft.). Four men and a compressor may suffice for a shallow water surface demand dive, whereas sixty technicians and equipment weighing as much as three hundred tons may be required to accomplish certain complex tasks at great depths.

Comex's interventions can on the whole be classified in two broad categories : bounce dives for short jobs and saturation dives for long ones. Bounce dives can in turn be broken down into four types : surface demand, wet bell, or closed bell for dives less than one hundred and twenty meters (400 ft.) deep, and with closed diving bell for depths over a hundred and twenty meters. With these variations, Comex can satisfy all its customers' requests for diver intervention, selecting on each occasion the alternative best suited to the physiological problems to which the divers will be exposed.

The chief obstacle to man's advance into the ocean depths is not technological in nature, but physiological. Man does not feel like a fish in water, which is a great pity when one thinks of the natural resources waiting to be tapped at the bottom of the ocean. His organism is made to breathe air at atmospheric pressure. Breathing enables his lungs to absorb some of the oxygen in the air, which then passes into his blood through the lung cells and is used for manufacturing energy. Once it has been consumed, the body gives off the used oxygen in the form of carbon dioxide and water vapor, by exhaling.

Nitrogen, which accounts for 79% of the composition of air, does not enter into this process. A certain amount of nitrogen is dissolved in the organism, however, so that a balance is maintained between the nitrogen content of the body and the nitrogen content of the atmosphere it breathes. This balance is what is called a state of saturation. It can be altered by a change in the ambient pressure. Under water both man and the air he breathes are subjected to a pressure which increases every ten meters by about one kilogram per square centimeter. This pressure modification upsets the balance and part of the nitrogen inhaled therefore dissolves in the body.

As the diver returns to the surface he must take the time necessary to get rid of the excess nitrogen in his system, by normal breathing. If he does not do this, but goes too quickly from the bottom pressure to the surface atmospheric pres-

sure, the nitrogen which has not had enough time to be eliminated forms little bubbles which increase in size as the ambient pressure decreases. These bubbles, particularly if they are present in certain vital organs such as the spinal cord or the brain, can create extremely serious lesions which may lead to paralysis or even death. That is why it is imperative to compel divers to only return to the surface by progressive stops conforming to decompression schedules experimentally worked out for each particular working depth and each bottom time.

The length of decompression time increases with the depth and bottom time in certain proportions until a threshold is attained, relatively shallow, where the effective diving time is short compared with the decompression time.

In addition to this phenomenon, which in itself makes air diving below seventy meters (230 ft.) impracticable, there is another which makes it dangerous below fifty meters (165 ft.).

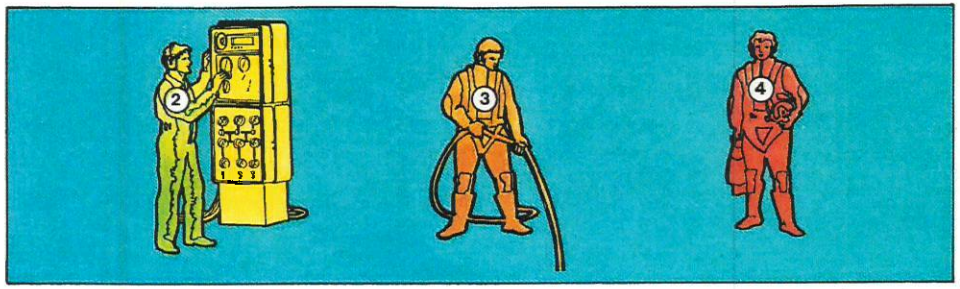
Air becomes denser under pressure and breathing it induces in most divers a narcotic effect which seriously impairs their mental faculties and coordination.

For this reason, when the diving depth is apt to exceed fifty meters, Comex divers are not supplied with air but with a synthetic gas mixture, heliox, in which the nitrogen is replaced by a lighter neutral gas, helium.

This mixture permits the diver to retain all of his comfort and lucidity down to much greater depths, at least six hundred and ten meters (2,000 ft.) according to the experiments conducted by Comex in 1972. Using heliox does not do away with the necessity for decompression. As the depth increases, the length of decompression time becomes such that divers can no longer complete decompression directly in the water. They must enter diving bells in which they can commence the decompression schedule, which is terminated in the deck decompression chamber (D.D.C.).

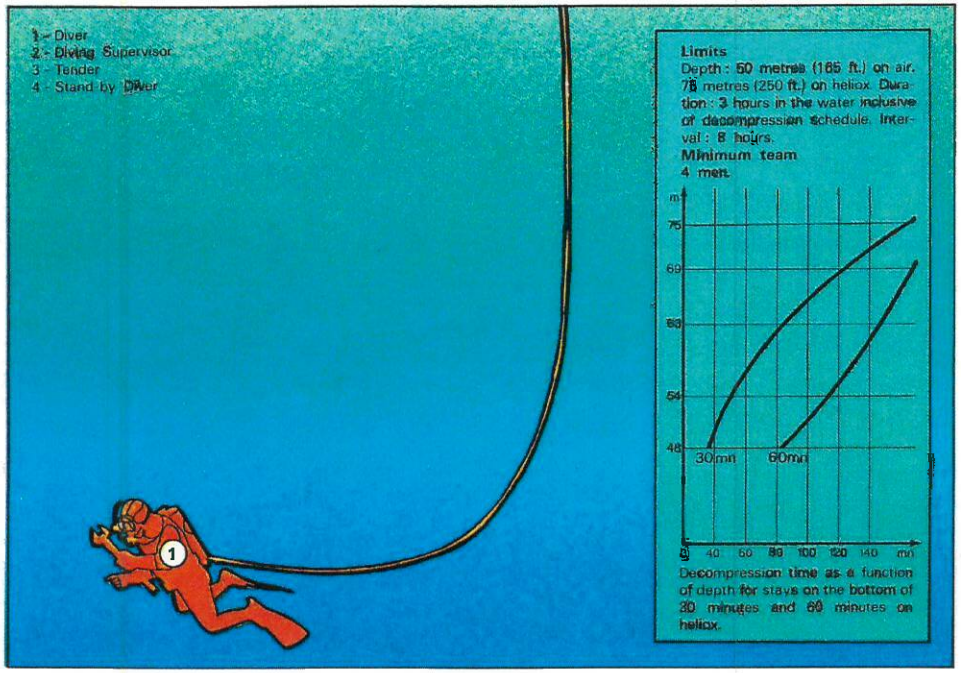
For long term jobs in deep waters, the decompression following each dive is so long that it would cancel out the economical value of human intervention if a method had not been developed of getting around this obstacle : saturation diving.

By this method, instead of the divers living at atmospheric pressure, they are confined in a hyperbaric unit in which the pressure is maintained close to the working level pressure of the site. After a few hours at the living level (storage depth) the equilibrium which prevailed at the surface between the neutral gas content in their bodies and that of the ambient atmosphere establishes itself at a new level due to the pressure increase and change in breathing mixture. The divers can then pass from storage depth to working depth and back at will without following a decompression schedule. They must undergo only one desaturation at the end of their mission when they are about to leave the hyperbaric complex and return to the free air.

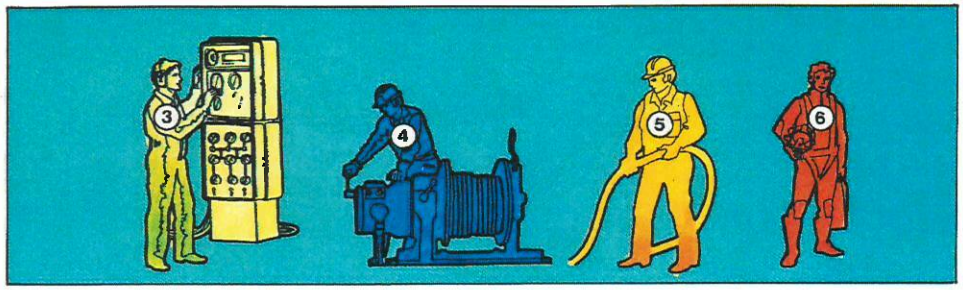


## THE SURFACE DEMAND BOUNCE DIVE

The diver enters the water at the surface. He is supplied with breathing gas by an umbilical which also transmits verbal communications to and from the surface as well as transmitting the diver's depth parameter.
The breathing mixture may simply be air. If so, the dive is limited to fifty meters depth (165 ft.). This can in exceptional cases be extended to seventy-five meters (250 ft.), in an emergency for instance, or to make a rapid inspection. The diver is supplied with heliox in such a case.
A surface demand dive should not exceed three hours, including the decompression time in the water. This means that for an air dive at fifty meters, the bottom time must not exceed sixty minutes and for a heliox dive at seventy-five meters the bottom time must not exceed thirty minutes.
The surface-demand dive requires only a minimum crew of four : on the bottom, the diver ; on the surface, a diving supervisor, a tender who handles the umbilical and a stand-by diver.
In the event of a serious accident, the umbilical tender is also able to dive in order to help the diver at the bottom.

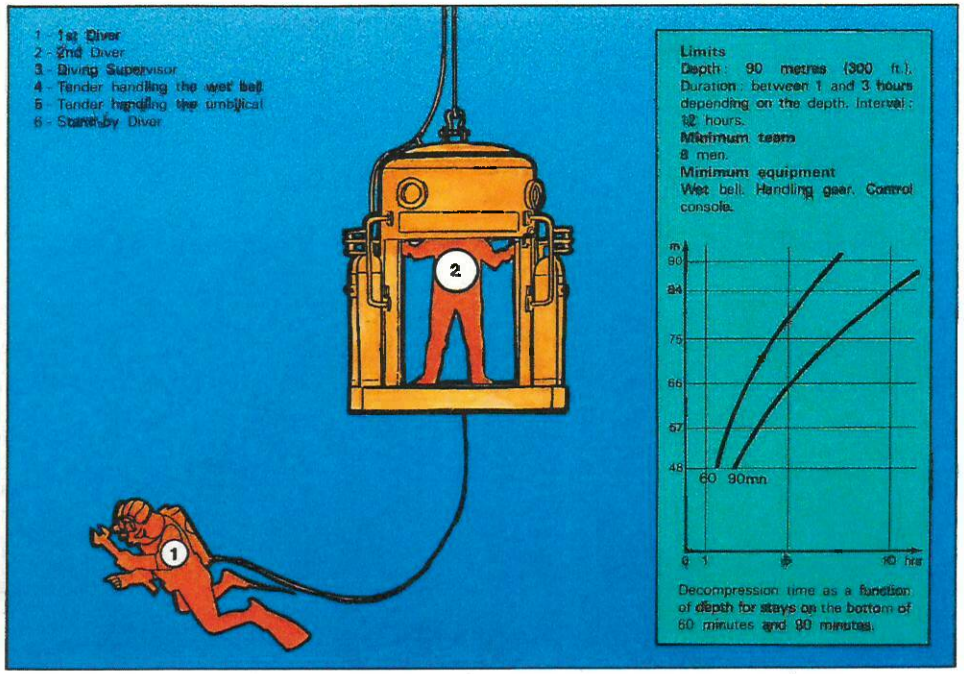


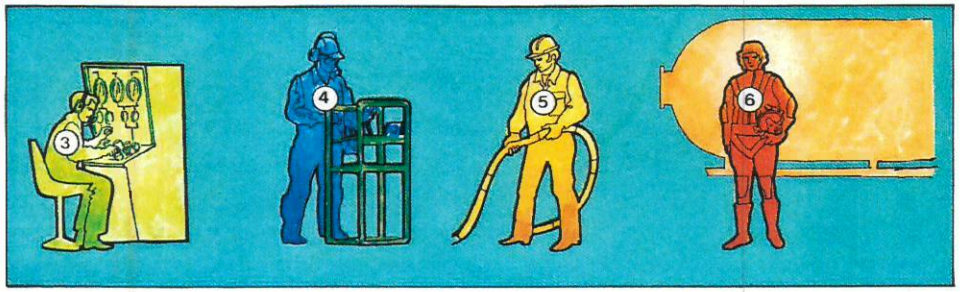


## THE WET BELL BOUNCE DIVE

The wet bell is a small diving bell, open at the bottom, and of very simple design. It is suspended from a carrier cable and connected to the surface by an umbilical which supplies breathing gas, electricity and intercom transmission. It can hold two divers seated in the water but with the upper part of their bodies out of the water, in the gas bubble. The wet bell carries them down to the bottom and brings them back to the surface in some degree of comfort for the successive compression and decompression stages, some of which consist of stops breathing oxygen, thus shortening the decompression process.
The maximum depth to which the wet bell can accede is ninety meters (300 ft.). The bottom working time limit is not more than three hours at shallow depths and one hour at ninety meters.
Use of the wet bell requires a minimum crew of six : on the bottom, a diver for performing the work and a stand-by diver in the bell ; on the surface, the diving supervisor, a tender who handles the wet bell and controls the decompression stops during the ascent, a tender who handles the wet bell umbilical and a stand-by diver in the event of an emergency situation.



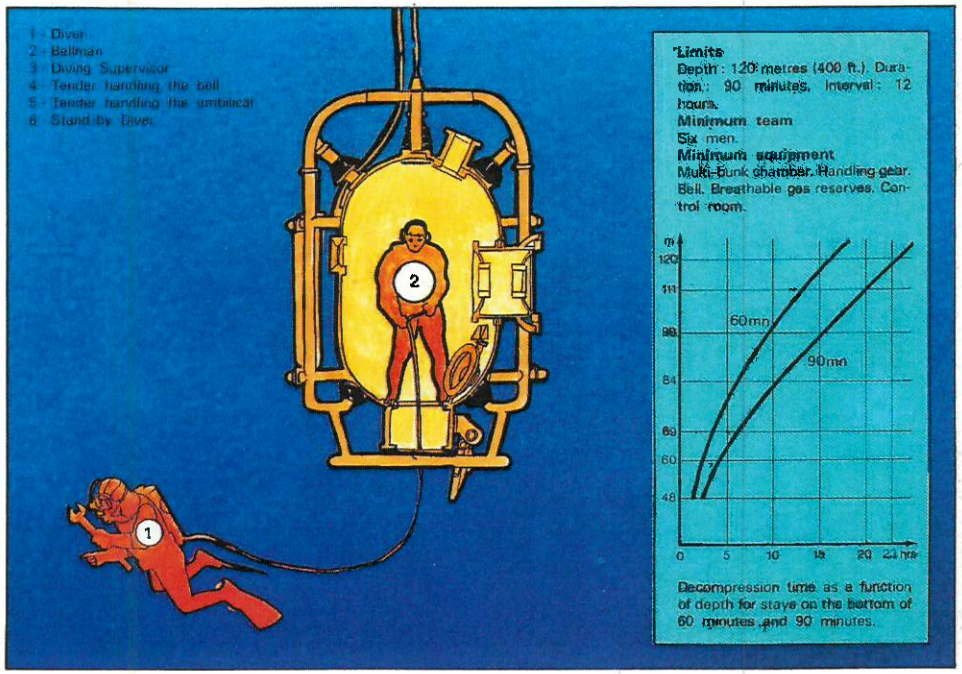



## THE BELL BOUNCE DIVE TO 120 M (400 FT)

In this type of dive, the divers are transferred from the surface to the subsea site in a closed diving bell. They are supplied with breathing gas and if necessary hot water by umbilicals which connect them to the bell on the bottom. At the bottom they breathe a helium mixture, although air is used for the decompression stops, within the D.D.C. on the surface.

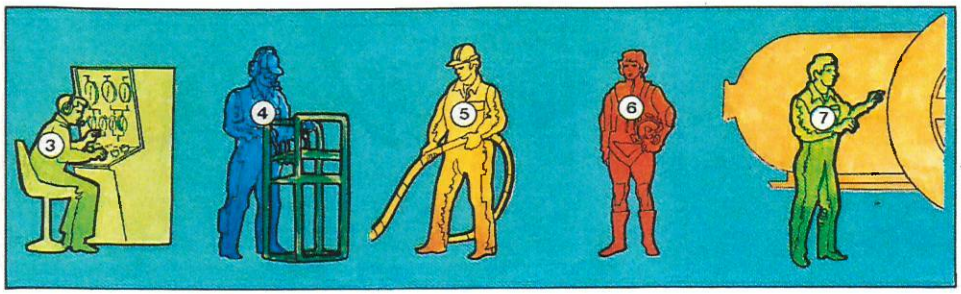
The diving bell is designed to be hermetically coupled to hyperbaric units at the surface in order to transfer the crew between bell and chambers in a compressed air atmospheric without returning to atmospheric pressure.

Air decompression offers the advantage of appreciable economy of synthetic gas, but the dive is limited to a hundred and twenty meters depth (400 ft.) and a bottom time of one and a half hours. It requires a crew of at least six persons : on the bottom, one diver on the site plus a bellman inside the bell who tends the umbilical as needed and ensures the safety of the working diver ; on the surface, a diving supervisor, a tender who handles the bell, an umbilical tender and a stand-by diver in the event of an emergency.




Decompression time as a function of depth for stays on the bottom of 60 minutes and 90 minutes.





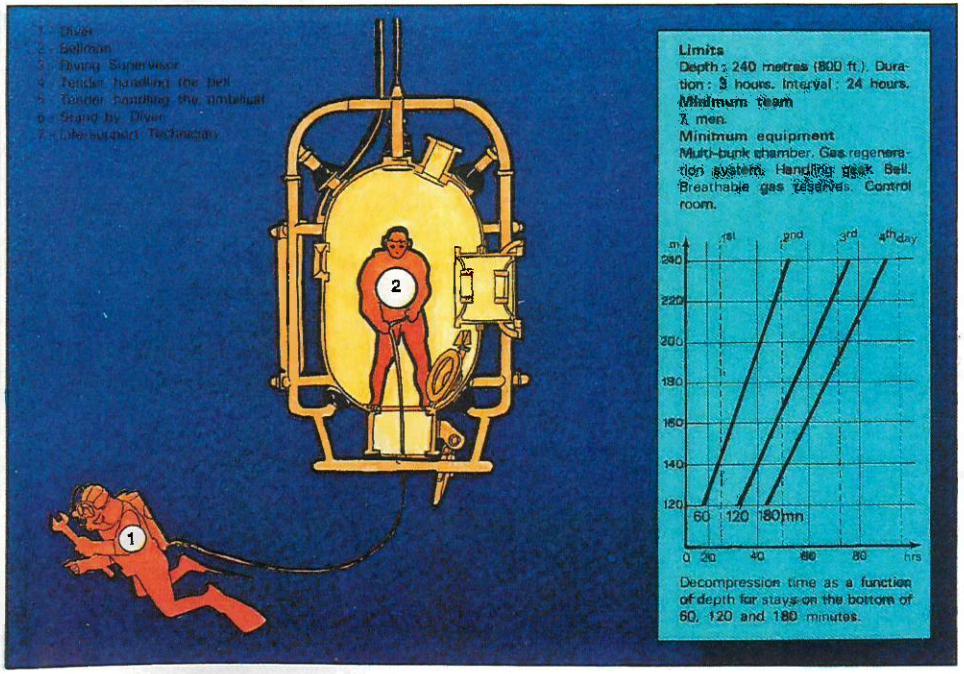

## THE BELL BOUNCE DIVE BELOW 120 M (400 FT)

This method permits access to depths in the two hundred meter range (700 ft.), for which decompression time can be quite long. Conversely, the working periods are relatively short. In addition, this type of dive demands extremely careful preparation.

As far as the dive itself goes the procedure is the same as for depths less than a hundred and twenty meters, but in this case heliox is used for decompression rather than air, and decompression takes place in a hyperbaric chamber with a gas regeneration system.

This type of dive requires a team of at least seven persons: on the bottom, one diver on the site and a bellman inside the bell to tend the umbilical and ensure the diver's safety ; on the surface, a diving supervisor, an umbilical tender, a tender who handles the bell, the hyperbaric chamber life-support technician and a stand-by diver in the event of an emergency.

In view of the length of decompression after each dive it might seem preferable to put the divers into saturation. But because of the limited size of the team, the divers must not remain under pressure for a period exceeding five days, including the final decompression time.




Decompression time as a function of depth for stays on the bottom of 60, 120 and 180 minutes.

## THE SATURATION DIVE

The bounce dives described in the preceding pages employ relatively limited manpower and equipment. They can however only be used for short-term jobs. The saturation dive, on the other hand, theoretically enables the divers to stay on the bottom indefinitely, but requires considerably more surface personnel and extensive equipment that constitutes a diving complex.

The key component in this system is the surface hyperbaric complex with its annexes. Depending on the size of the worksite and the number of divers working on the bottom, the hyperbaric complex has a greater or lesser number of chambers which can be classified in three main categories according to the functions they serve : the living quarters chamber, a sort of bed-living room in which the diving crew spends its time between work shifts ; the wet chamber, a dressing-room where the divers put on and take off their gear (diving suits, helmets, etc.) before and after work shifts ; and a transfer chamber which serves as the intermediate unit between the hyperbaric complex and the outside world, and through which all personnel passing from one to the other must undergo compression or decompression.

Small supply locks in the chamber's wall enable food and other small articles to be passed between the inside and outside environments.

A regeneration system with a booster continuously exhausts the used compressed gas mixture from the chambers, eliminates the carbon dioxide, humidity and any traces of hydrocarbons, reheats it and returns it to the unit.

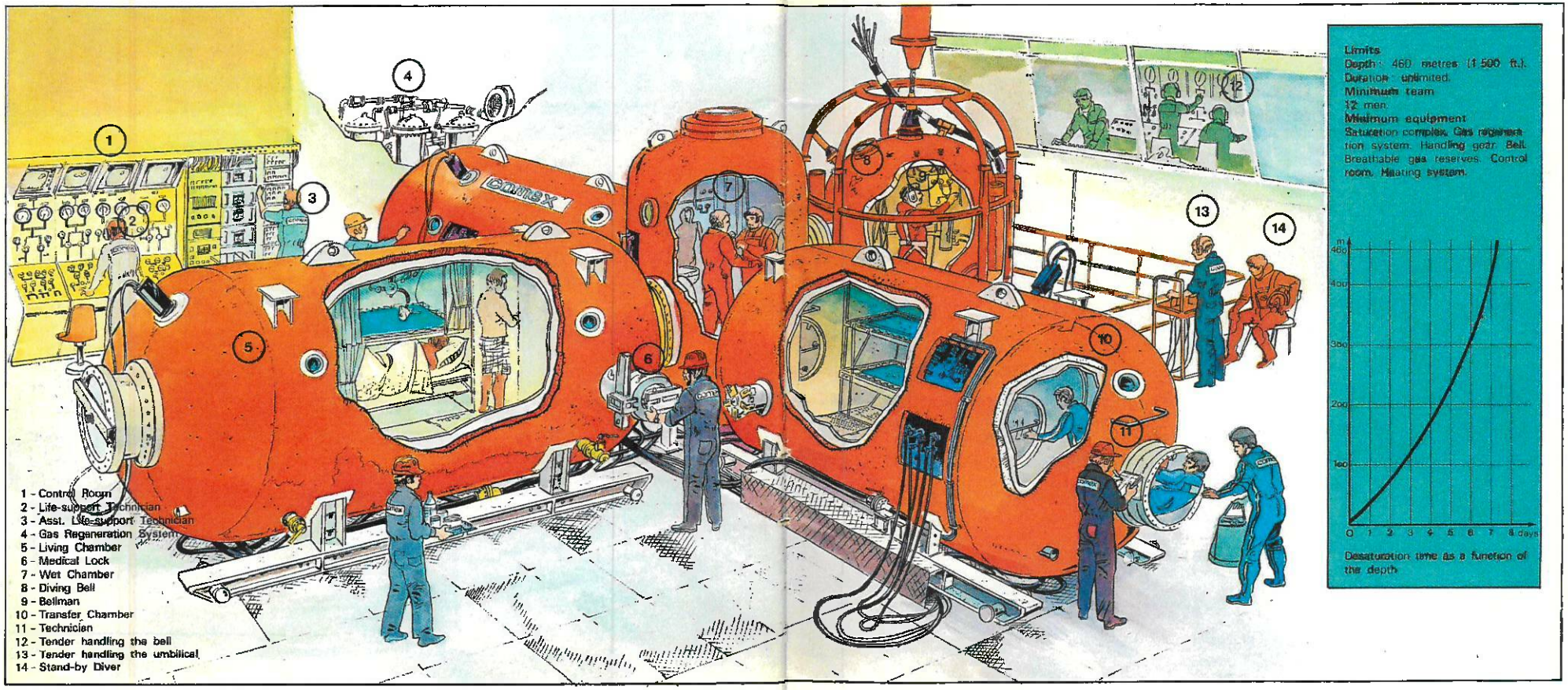
The pressure level and different environmental parameters such as temperature, humidity, oxygen partial pressure, carbon dioxide content, etc., are continuously monitored and regulated from a control room adjacent to the chambers. The life-support technicians can monitor the movements inside the chambers on television screens without moving from their control consoles. They also broadcast music (and television programs) to the hyperbaric unit and try to ensure that a good psychological ambiance prevails among the divers in saturation.

Divers are transferred in saturation between the hyperbaric complex and the bottom by means of a diving bell, a mobile compression chamber which can be hermetically clamped to the wet chamber. The bell is controlled entirely from the diving control station.

The actual dive takes place exactly like a bounce dive with bell at more than a hundred and twenty meters, with the difference that as this is a saturation system, the depth attained can be as much as four hundred and fifty meters (1,500 ft.) at the present time, and the length of time the divers remain in the water is not limited by considerations other than physical fatigue.

The saturation dive makes it possible to have divers working at the bottom eighteen hours out of twenty-four by using two or three crews in shifts, and allowing for the unavoidable time lapses for changing shifts.

The saturation system ordinarily functions with two twelve-hour shifts. Excluding the divers in saturation who perform the actual work, at least eight people are needed for each shift. Namely : a diving supervisor and his assistant, a life-support technician and his assistant, a tender who handles the bell, a tender who handles the umbilical, a stand-by diver and a worksite technician.



1 - Diving superintendant
2 - Handling supervisor
3 - Crane operator
4 - Derrick barge
5 - Electronic unscrambler
6 - Diver's voice in heliox

## THE COMMUNICATIONS PROBLEM

The obstacles preventing man's penetration of the ocean depths are of a purely physiological nature as the great pressures encountered make it necessary to set up cumbersome and complex equipment whenever human beings are needed to work at the bottom of the sea. Smooth operation of the worksites can also run into another problem of quite a different order, that of communication between the bottom and the surface.

In spite of the sometimes considerable depth of water which separates them it is essential to maintain close and continuous collaboration between the divers on the bottom and the technicians on the surface. Let us take as an example a case where divers are supposed to put a spool-piece in place, i.e. a piece of pipeline which may weigh as much as two hundred tons. The spool-piece is launched from a barge by a giant crane capable of handling, perhaps, up to two thousand tons. It must be lowered to the bottom several hundred meters below and deposited in the chosen spot with an accuracy of twenty centimeters (eight inches !).

Transmission of the instructions necessary to perform this tricky maneuver, given by the diver to the crane operator, in itself poses a problem not easy to solve. The situation is somewhat as though a giant crane atop the Eiffel Tower had to be operated at night by a blind crane driver getting orders from a foreigner, whose language he doesn't understand, standing at the foot of the Tower with a flashlight.

As a matter of fact, the diver's voice which comes through the umbilical is completely distorted due to the heliox he breathes. It would be totally incomprehensible to the diving supervisor if it weren't first unscrambled electronically. As the diving supervisor must stay in direct contact with the bottom at all times, it is his assistant who transmits the divers' instructions by walkie-talkie to the handling supervisor on the bridge of the barge, who in turn conveys them to the crane operator under his command.

You can see that getting this spool-piece down in precisely the right spot is no less a feat for the diver than that of the control tower operator who has to bring a Boeing 747 down onto a handkerchief in a blizzard.

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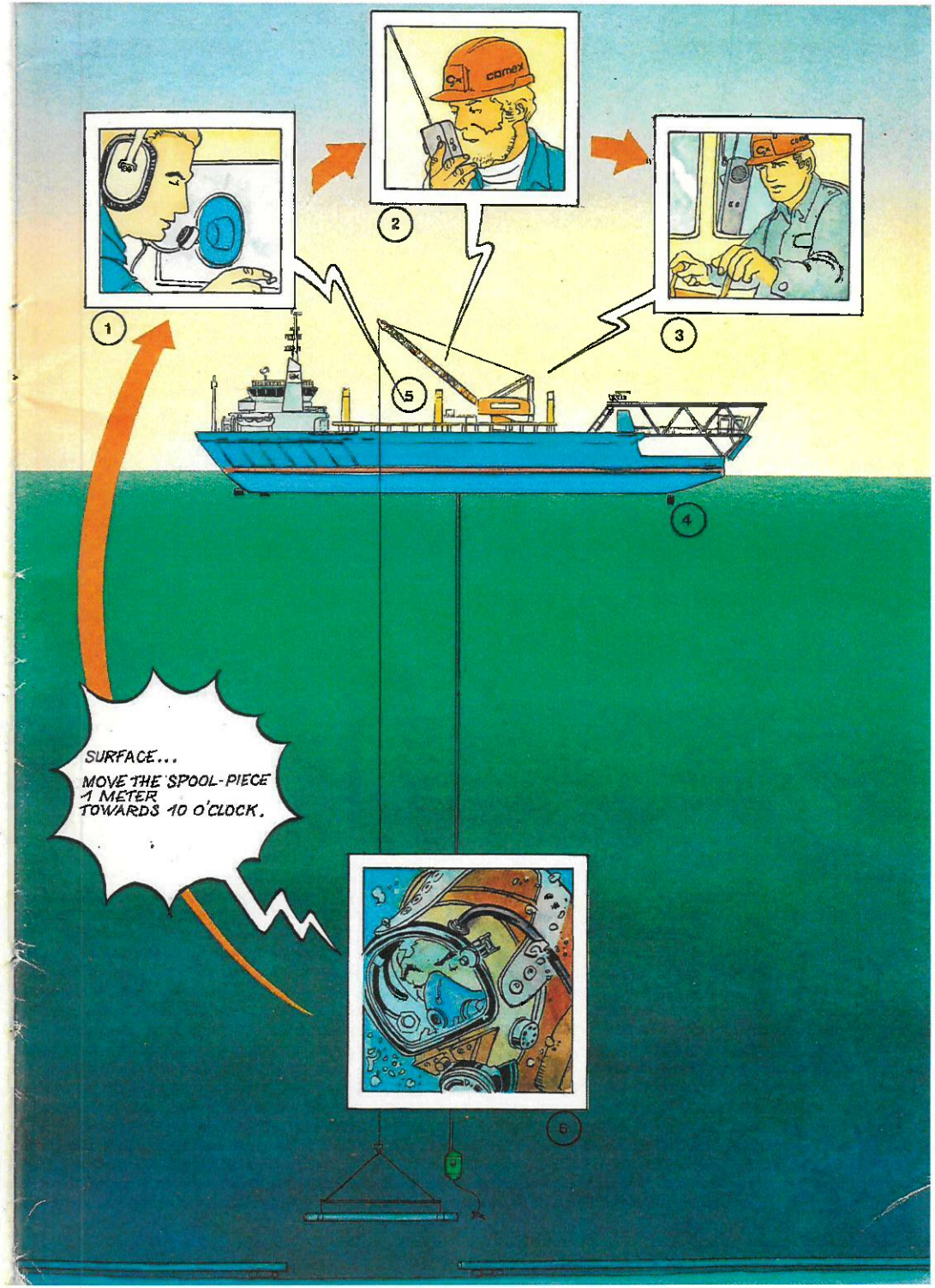


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