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NEW TOWED TRANSDUCER CONCEPT

by

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ABSTRACT

The history of towed transducer applications at the Institute of Marine Research, Bergen, is reviewed. Advantages and disadvantages of several designs are summarized. To improve performance significantly, a new system design is proposed. This entails constant immersion of the towed body, either hydraulically locked in a recess in the hull or in tow. The merits of being able to use the same transducer in both configurations are emphasized.

RéSUMé

Un aperçu sur l'histoire, à l'Institut de Recherches Maritimes, Bergen, des applications du transducteur remorqué est donné. On fait un sommaire des avantages et inconvénients de plusieurs types de construction. Pour améliorer le rendement considérablement, on propose un nouveau système de construction. Ceci implique immersion continuelle du corps remorqué, soit emboîté dans une niche dans la coque, soit de remorque. Les bénéfices de la possibilité d'utilizer le même transducteur dans les deux configurations sont soulignés.

INTRODUCTION

Up to the year 1972, the Institute of Marine Research (IMR), Bergen, mainly used conventional hull-mounted echo sounder transducers on their research vessels. Thus, during surveys with bad weather, the echo recordings and the integrator output were adversly affected by air bubbles in the surface layer. Such bubbles are usually produced by the breaking of waves and maintained by turbulence beneath the surface, causing a profound attenuation of acoustic energy in transmitted sound pulses (Urick 1967).

Increasing demands for collection of more reliable data under such conditions led to extensive field experiments with transducers in towed bodies. The results of these exercises were not convincing, particularly with respect to the question of low noise levels and safe handling operation. The IMR and SIMRAD company therefore initiated in 1974 a project to construct a towed system comprising a body with up- and downward-facing transducers, faired towing cable, hydraulic cable-winch, and handling-crane for easy operation.

The equipment was first tried out during the autumn 1976 on R/V "G.O.Sars". After some minor modifications it was taken into general use. It has since been used whenever demanded by weather conditions.

Later, a pressure element was mounted in the towed body. The towing depth could then be read out directly on a display in the instrument room. The towed transducer was also connected to a separate echo sounder and computerized integrator. This system was self-contained and identical to the system connected to the hull-mounted transducer. Both systems could be used simultaneously without interfering with each other, and conversion factors for the integrator output, as well as factors for the attenuation caused by wind- and wave-induced air bubbles, could be worked out.

New electronic circuitry for continuous automatic transfer of towing depth data to the computerized integrator was constructed in 1986 (Knudsen 1987), and the computer's integrator programme was modified accordingly to present the integrator data from both systems in true - depth intervals referred to the surface (Bangstad 1987). The computers were then linked together, allowing presentation of integrator data from both systems on the same screen display. This gave higher precision to the daily work on analyzing and evaluating integrator data, and thereby, presumably, more accurate abundance estimates.

In 1983 the IMR constructed a smaller towed body with the same streamlined shape as the above-mentioned one. This carries only one transducer, however, but it was mounted in such a way that it was possible, on deck, to turn and lock it to transmit in any chosen transversal angle. In other words, it could be utilized not only as a traditional down- or upward-facing transducer, but, for instance, also as a side-looking device to detect schools in the horizontal plane.

To operate this towed body, a handling-crane including a cable-winch assembly was built. The system was hydraulically operated, either on deck by magnetic valve handles or at a later stage from the bridge by a six-function joystick. The cable-winch was equipped with a simple revolution counter with signal transmission to a display-unit on the bridge. Later, the towed body was also equipped with a pressure element and electronic circuitry for transfer of towing depth data to a display-unit in the instrument room.

This latter type of towed body, including operation and handling arrangement, was first used on the research vessels "Eldjarn" and "Michael Sars". A light-metal version of the same was later installed on the research vessel "Dr.Fridjof Nansen". Further, a Norwegian commercial fishing vessel has successfully begun using the same towed system.

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TECHNICAL DESCRIPTION AND EVALUATION

The illustrations in Figures 1 and 2 show the design of the towed vehicles, as well as their technical specifications.

The largest towed body (Fig.1) has been extensively utilized during recent years when the weather conditions have been too poor for aquisition of high-quality data from the conventional hull-mounted transducers. The depth of the transducers in tow has varied between 50 and 180 metres, depending on the vessel's speed and the length of immersed towing cable. It has been quite feasible to use the system up to a wind force of 40 knots, depending on the course of the vessel relative to the wind direction, provided the vessel's speed can be kept above 5 knots.

<u>In situ</u> calibration and calculation of the instrument factor (C_I) has been based mainly on a comparison of integrator output from the towed transducer at the actual working depth and echo integrator output from the hull-mounted transducer on echo contributions from evenly distributed fish concentrations of varying density in several depths. These intercalibrations been carried out when weather conditions have been extremely fair with calm sea.

When this instrument factor is applied to the integrator output from the towed system, the result is similar to that when the instrument factor derived from the reference-target calibration is applied to the integrator output from the hull-mounted system. In periods of bad weather, however, the integrator values from the towed system are higher due to the previously mentioned loss of acoustic energy caused by air or gas bubbles in the layer just beneath the vessel. The difference, which can be very large, is a direct measure of the attenuation factor, and it can be used for compensation of integrator data from the hull-mounted system for depth intervals not covered by the towed transducer.

The most significant advantages with this type of towed body are:

- The acoustic noise level is acceptably low.

- It carries both upwards- and downwards-looking transducers which can be used at the same time.

- It has a steady course in the sea.

- It can be used when towed at speeds up to 12 knots.

- The time from launching the body until its performance (SL + VR) reaches a steady level is relatively short. (SL is the source level and VR is the system's receiver voltage response.)

The chief disadvantage of the system is that the hydraulic-powered handling-crane arrangement on deck is difficult to operate and keep operational during periods of rough weather, with heavy swell and icing on deck, as often occurs during wintertime in the Barents sea. Under such conditions, the size and the disposition of the towed body in a cradle in the middle of the crane make it and the equipment inside difficult to service and maintain.

The smaller towed body, on the other hand, is easier to handle, and can be brought indoors for service and maintenance. The operation of the crane-arm, as well as the launching and retrieving of the body, are performed by the navigator in the wheel-house, monitored by a TV-camera on deck. This arrangement has worked well under varying weather conditions.

The calibration of this towed system, can be carried out by the fixing of supporting rods to the body (Fig.3). Nylon lines, attached to the calibration sphere, are then threaded through metal rings on the outermost ends of the rods. While the towed body is situated just beneath the sea surface, the sphere is moved onto the acoustic axis of the transducer at a suitable distance from the device, and the nylon lines are secured to a small metal hook premounted on the sea cable. Then the towed body with its attachments is lowered to a suitable depth for performance measurements.

One of the major problems experienced with this type of towed body, has been the relatively long time it takes from launching into the sea until the echo sounding system, using the towed transducer, reaches a steady performance level. It has been speculated that this has been mainly due to a depth-related change of pressure on the transducer.

Recent, extensive experiments (Hansen et al, 1987), however, have clearly indicated that the reason for this phenomenon is attenuation of the energy of the transmitted sound pulse by air bubbles on the surface of the transducer or on the so-called "acoustic window" at the front of the transducer. The same experiments showed that the problems could be avoided by spraying the transducer face and the body internally with a mixture of detergent and water before each launching. When this was done properly, the performance of the system quickly levelled out, and only minimal changes of transducer impedance and performance figures were observed at measuring depths down to 75 metres. This suggested a pressure independent performance valid for both ceramic and magnetostrictive transducers (size 15 x 30/10 cm), over this range.

The towing depth of this body has normally been between 20 and 40 metres, with approximately 100 metres of towing cable in the sea. In the first period of operation, the hydrodynamic performance of the body was rather unstable. This could be inferred from the fish-traces and bottom echoes on the echogram. A solution has been found by fixing a nylon rope of approximately 5 metres length, with a small float of approximately 20 cm in diameter tied to the tail of the body. This simple arrangement gives a satisfactory passage, with a vessel speed up to 11 knots, without hindering the handling operation during launching and retrieving.

Another disadvantage is, of course, that due to its small size, the vehicle carries only one transducer. This may limit its usefulness, especially during multi-species surveys, where both pelagic and demersal species are to be investigated.

A NEW GENERATION TOWED BODY

Experience gained from the described towed bodies has led to the following design of a new towed system.

The concept entails placing one or more transducers in a body which is normally parked in a recess in a large steel blister beneath the vessel. When secured here it can be used as a conventional hull-mounted transducer. However, during bad weather, the body can be lowered and towed at a depth where sound transmissions and receptions are not affected by air bubbles or turbulence. The handling and operation of the body will be completely controlled by navigators on the bridge.

The design also includes construction of a vertical shaft from the hull, above the blister, to the main deck, with machinery mounted in a shaft house to hoist the body into the vessel whenever inspection or maintenance is required.

To prevent the towing cable from destructive contact with propeller or rudder, a nozzle will probably have to be fitted around the propeller, or a curved steel bar will have to be welded to the aft part of the hull.

The size and shape of the towed body preferably should be like the heavy one utilized on the "G.O.Sars" presently, but in order to have enough space to mount a large downward-looking 38 kHz transducer, the mid-section should be quadrangular. This will allow the transducer to be flush-mounted here.

A circular, ceramic 120 kHz transducer should also be included. This should be mounted on the longitudinal shaft of the body in such a way that it can be turned and locked facing any transversal direction. In addition, a preamplifier for the 120 kHz signal is required in the body.

The transducers must be properly covered by a sound-absorbing material to reduce unwanted back radiation.

A small unit comprising a pressure element and two inclinometers, with electronic circuitry for interpretation and transfer of data on depth and orientation, should also be installed in the body.

Figure 4 is a draft of the planned towed system, with its handling arrangement. It has been designed in collaboration with engineers at the SIMRAD Subsea A.S. As it can be seen from the illustration, the towed body , when parked, is locked to a supporting frame. At any time the body can be hoisted up through the vertical access shaft to a deck above sea level, thence brought into a mechanical workshop for inspection and maintenance.

ADVANTAGES AND DISADVANTAGES

Expectations for the new towed system design are great. Some of the most significant advantages are summarized:

- The same transducer can be used in both towed and normal parked modes.

- The transducer will almost always be kept submerged. Thus noise and attenuation problems, created by air bubbles on the surface of the transducer, will be avoided.

- Performance measurements, with a reference target sphere, can easily be carried out in the usual reliable manner with the transducer locked in the parked position.

- The quadrangular mid-section of the body will allow use of a large transducer with a narrow beam.

- The range of application will be extended, as the adjustable 120 kHz transducer can be used for horizontal detection and, perhaps, counting of fish schools.

- Flow-induced vibrations and drag from the towing cable will be minimized by use of noise-reducing streamer fairing.

- Lowering and heaving of the body will be safely handled from the bridge, and crew on deck will not be endangered during poor weather conditions.

- Towing depth data will be continuously transferred to the deck-unit and computerized integrator for automatic surface reference of integrator data.

- Data on the length of towing cable, from slip-rings and electronic circuitry on the cable-winch, can be transferred to a display-unit on the bridge.

- Easy and effective maintenance of the winch system, towed body and electronic circuitry will be faciliated, because it can be carried out indoors. This will lead to reduced maintenance costs.

The most conspicuous drawback of the system is the initial high costs of manufacturing and installation, especially on a research vessel already built. On new, planned vessels, however, the equipment would most probably make the rather expensive gyro-stabilized transducer platforms superfluous, thereby justifying the costs.

CONCLUSIONS

Within acoustic circles the great advantages by applying towed transducers are well known. These apply not only to echo integration surveys, but whenever reliable acoustic data are needed. In addition, towed transducers are often required for detailed studies of fish concentrations at greater depths.

However, up to now, the use has to some extent been restrained, mainly because it has been difficult and expensive to keep such systems operational in areas where extreme weather conditions often prevail.

The new system has been elaborately designed, with the prime objective of easy and safe operation during varying conditions. Presumably, this will lead to the collection of more accurate and reliable acoustic data, unaffected by wind and sea state, and in future add precision to acoustic abundance assessments.

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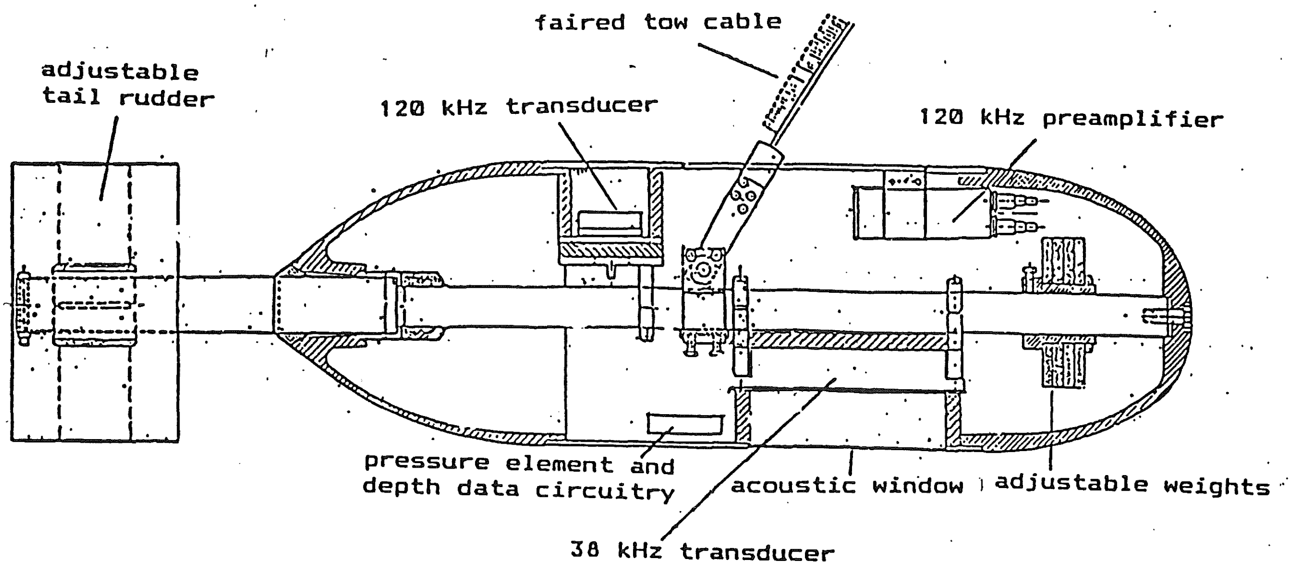
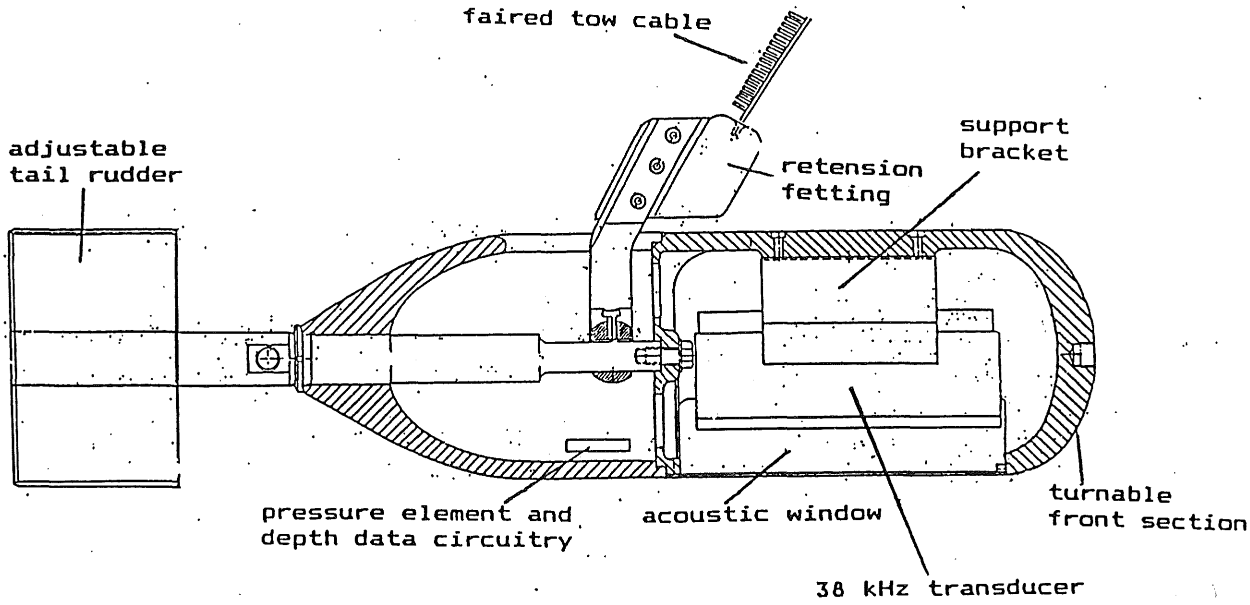


TECHNICAL SPECIFICATIONS

Weight of towed body	500	kg	in air
	450	kg	in water
Dimensions	220	cm	overall length
	50	cm	diameter of mid-section
Transducers	38	kHz	30 x 30 cm magnetostrictive type 69LA H39544, beamwidth 6.5 x 6.5 degr.
	120	kHz	10 cm. circular ceramic H35580, beamwidth 10 degr. with Simrad preampl. 299-051252.5
Pressure element and depth data circuitry			HIV 850501 (H.P.Knudsen)
Acoustic window			46 x 42 cm (polyacrylate)
Tow cable	8.8	mm	4 conductors with two layers of contrahelically wound galv. steel armor
Breaking strength	4400	kg	
Fairing	100	m	streamers (Dupont Tefzel fluor-polymer) Type 200
Winch capasity	1000	m	(approx.)

Figure 1. The large towed body with technical specifications.



TECHNICAL SPECIFICATIONS

Weight of towed body	150	kg	in air
	120	kg	in water
Dimensions	135	cm	overall length
	30	cm	diameter of mid-section
Transducers	38	kHz	15 x 30 cm magnetostrictive type 69M, beamwidth 7 x 13 degr. or 38-26/22, beamwidth 9 x 13 degr.
Pressure element and depth data circuitry			HIV 850501 (H.P.Knudsen)
Acoustic window			35 x 40 cm (polyacrylate)
Tow cable	8.0	mm	8 conductors with two layers of contrahelically wound galv. steel armor
Breaking strength	3400	kg	
Fairing	15	m	(approx.) streamers (Dupont Tefzel fluorpolymer) Type 200
Winch capasity	200	m	(approx.)

Figure 2. The <u>small</u> towed body with technical specifications.

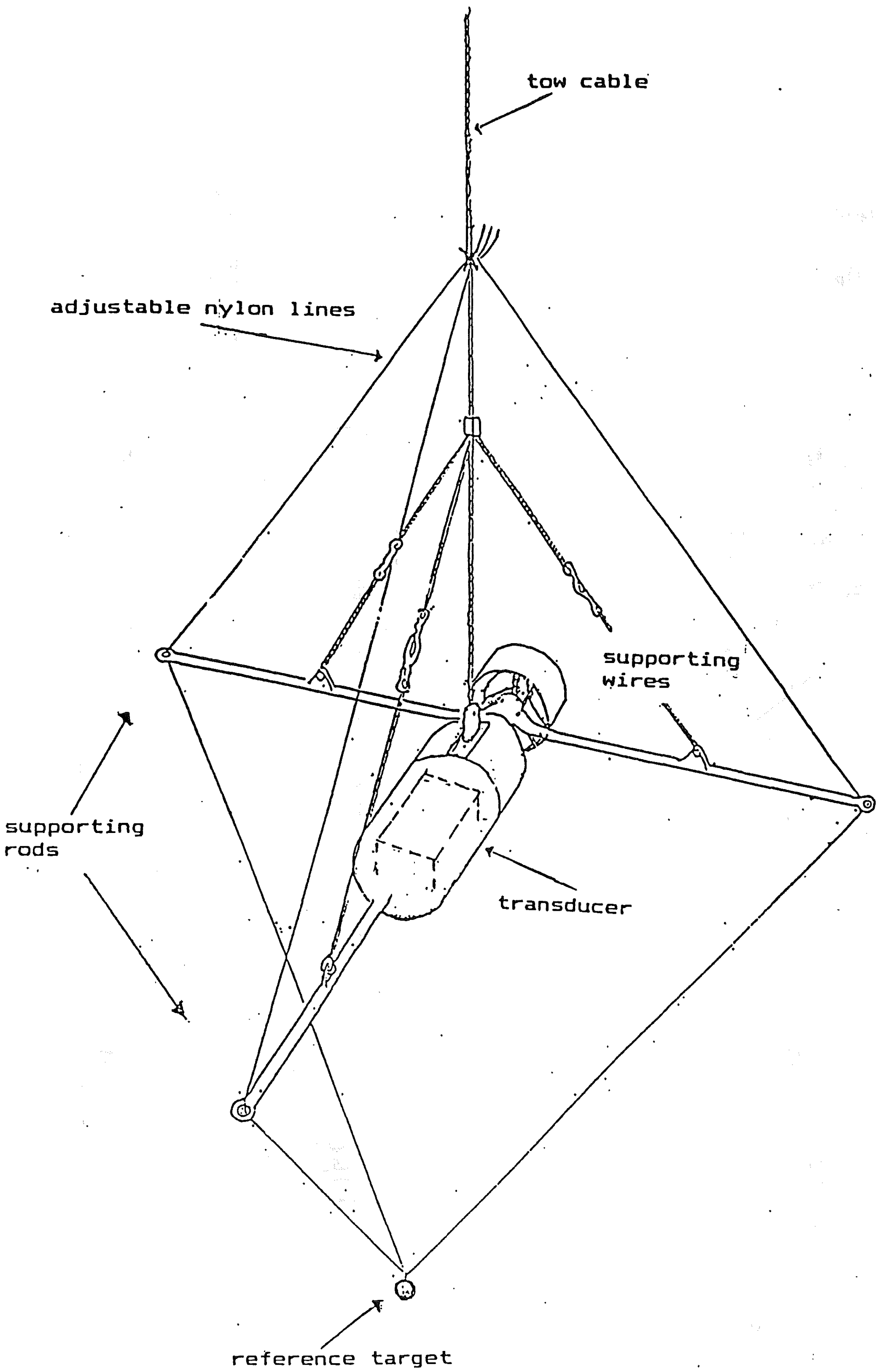


Figure 3. Arrangement for reference target calibration.

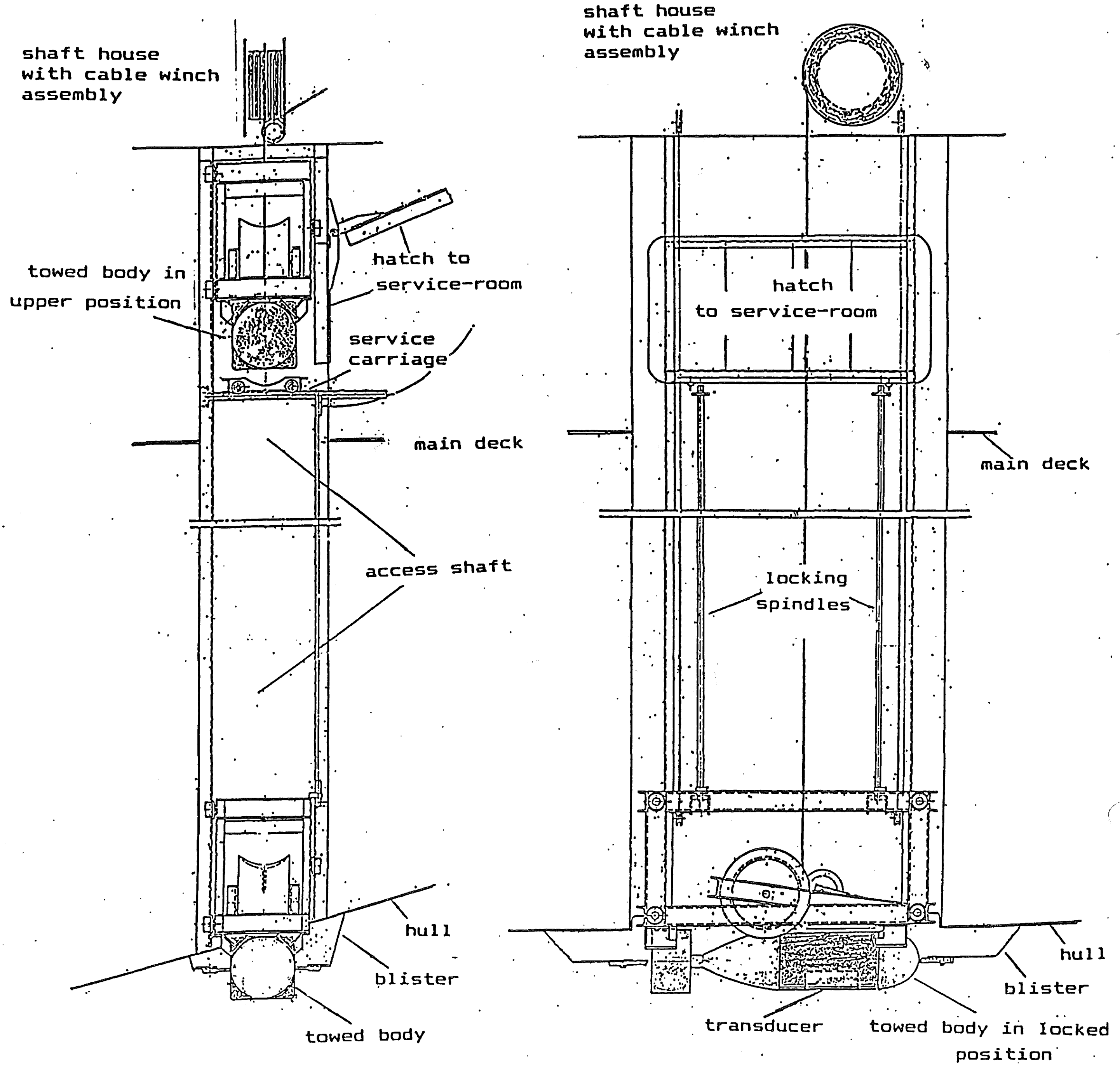


Figure 4. Preliminary draft of the new towed body arrangement.