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SHIP LANDING TRIALS WITH THE BO 105

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Contents

It was desired to define the limiting deck motions for shipboard landing with a rigid skid undercarriage equipped BO 105.

Initial trials on the Rolling Platform at Bedford are described, where approximately 120 landings with roll- and pitch amplitudes of $\pm$ 2^{o} to $\pm$ 10^{o} were performed with a standard BO 105. The helicopter was fitted with a comprehensive test instrumentation, so that many important parameters could be recorded.

It transpired that, provided the qualities of the hingeless rotor are exploited, the stress limits of the main rotor shaft are not attained even during landings with large angular motions, and that the peak undercarriage stresses are almost equal to those attained during hard landings on concrete, i.e. well inside the stress limits.

Based on these results, reals ship landings were begun with trials on a pilot ship. Due to fine weather, the limiting conditions could not be established.

Only during further trials onboard the rescue vessel "John T. Essberger" were more difficult conditions encountered.

This paper describes the results of more than 90 landings at various ship speeds and weather conditions (sea state, wind force and -direction).

A short film shows some landings on the Rolling Platform and on the rescue vessel J.T.E.

1. General

Since several years there has been an increasing need for helicopter landings on ships in the civil sector as well, e.g. in sea rescue service, in harbour pilot service or for work on drilling ships.

Although the helicopter has a vertical flight capability, such maneuvers may be extremely difficult when landing on very small landing areas. This is particularly the case when the relative motions between the landing area and the helicopter become very large due to strong and usually gusty winds. Solely wheel-type landing gear with very high energy absorption were previously able to withstand the often unavoidable heavy landing shocks.

The second problem concerns arresting the helicopter immediately after landing so that it will not slide from the landing area due to heavy seas.

The BO 105 features rigid, relatively stiff landing skids and a "hingeless rotor". The former require higher precision during touchdown while this increased precision is provided by the hingeless rotor due to its good control response, but on the other side the rotor is subjected to higher stresses than an articulated rotor during unsymmetric touchdown.

Therefore, thorough testing of the BO 105 for its employment on ships was absolutely necessary. The objective of these tests was to establish a landing procedure suitable for this type of helicopter as well to define the limiting conditions for touchdown and the time after landing.

2. Preliminary Trials on Rolling Platform in UK

Extensive preleminary trials were performed on the Rolling Platform in Bedford in cooperation with the Royal Aircraft Establishment.

This Rolling Platform (with a landing area of approximately 7 x 7 m) permits stepwise adjustment of the angle of roll from $\pm 1^\circ$ to $\pm 15^\circ$, the rolling frequency remaining constant at approximately 8 seconds for one cycle. In addition, the type of drive used causes a transverse motion depending on the angle of roll and a slight vertical motion. The transverse motion is approximately $\pm$ 2.5 m at $\pm 10^\circ$.

The angle of pitch usual on ships or the combination of angle of pitch and angle of roll may be simulated by changing the landing direction with respect to the roll axis.

The helicopter was equipped with comprehensive test instrumentation for the trials. In particular, the loads on the airframe, on the rotor mast, on the blades and on the skids, as well as the motions and accelerations about all 3 axes and all the control angles were measured.

Since it was quite clear from the beginning that both the bending moment in the rotor mast and the skid stress would be critical factors, all flight trials were performed twice under the respective most critical loading conditions: a first flight was performed with the maximum take-off weight (2300 kp) for the skids and a second one with a low take-off weight and maximum forward C.G. position, critical for the mast moment.

For the individual angles of roll, the test program included relevant measurements when starting and stopping the rotor, a check as to whether the helicopter was sliding and 3 landings each parallel to the roll axis, at 45° and 90° with respect to the roll axis.

At the beginning the landing procedure corresponded to the navy standard procedure, i.e. after approaching a position lateral to the landing area, the marshaller guides the helicopter above the touchdown point through adequate signals (Fig. 5) and gives the sign for landing at the appropriate moment. Appropriate moment means: the skids are more or less parallel to the landing area. The helicopter must then land within approximately one second.

Using this standard landing procedure, the limit of the acceptable rotor mast loading was reached at an angle of roll of $6 - 7^\circ$. However, it was possible, by utilizing the advantages inherent in the rigid rotor, to compensate for part of the landing area motion. Thus it was still possible to land at angles of $\pm 10^\circ$ without again reaching the high mast bending moments (Fig. 1). At an angle of $\pm 10^\circ$ the bending moments are only approximately 20% higher compared with the hard landings on concrete, but even at that high angle only about 65% of the permissible range is used (Fig. 6).

When employing the special landing technique the pilot observed the attitude and motion of the platform and at the same time the marshaller signals. The actual touchdown then was initiated at a moment where the motion of the platform was advantageous for the specific characteristics of the helicopter.

The bending moments at the cross tubes of the undercarriage were uncritical througout the trials (Fig. 2). Here too, due to the changed landing procedure, a notable kink in the curve is evident. However, the peak value is almost equal to the value measured during the landings on concrete, and again only 60% of the permissible stress limit is attained.

The tail boom loading increased only slightly compared with landings on concrete, with the exception of the peak value at an angle of pitch of $\pm$ 6° when employing the standard landing procedure. That peak value reached 90% of the permissible stress range (Fig. 3).

The vertical acceleration measured under the pilot's seat remained inferior during all the platform landings to the values registered during landing on concrete (Fig. 4). Solely the acceleration values in longitudinal and transverse direction rose by approximately 30% as a result of the lateral motions of the platform.

Extensive measurements by the DFVLR on a harbour pilot ship [1] have shown that the majority of the angles of roll measured ranged between $\pm$ 1° and $\pm$ 6° (93%) and that the angles of pitch which occurred were even lower.

Thus, the trials on the Rolling Platform approached the practical application quite closely, but they could not be considered a substitute for real landings on ship.

3. Landings on Ships

The trials in Bedford were followed by landings on the harbour pilot ship " Kommodore Ruser " (Fig. 7). The ship is 55 m in lenght, has 725 gross registered tons and has a maximal speed of 13 kts. To perform landings with gradually increasing swell, the ship was accompanied when leaving Cuxhafen for its operational area near the lightship " ELBE 1 ".

Unfortunately, the weather conditions were too favorable. For 35 landings the maximum angle of roll was only 1.2^{o} and the maximum vertical motion of the landing area solely about 0,5 m (Fig. 8).

These conditions of course presented no problems for the BO 105, and the stresses measured were entirely uncritical.

The tests were therefore continued on the new sea rescue ship " John T. Essberger " owned by the German Society for the Rescue of Shipwrecked Persons (DGzRS).

The ship is of highly advanced technical design with high installed power which results in a maximum maintainable speed of 32 kts. Furthermore, it incorporates a helicopter working platform. The ship is 43 m in lenght and has a gross weight of 175 tons (Fig. 9).

The operations to be investigated were as follows:

- landings with differing swell (achieved through variation of the weather conditions or the ship's location), and
- landings at differing ship speeds.

The measuring equipment installed in the helicopter again recorded rotor system stresses, 3 accelerations below the pilot's seat and, using 2 attitude gyros, the angular motions of the helicopter, and consequently those of the ship after touchdown.

The grid of the working platform was covered with a widemeshed hemp net in order to prevent the helicopter from sliding (Fig.10). To tie down the helicopter, provision was made for 4 arrestor hooks which were introduced from below through the grid to engage the skids and then tied down.

Almost all landings were again performed without use of a marshaller. Instead, pilot judgement was relied upon for landing. Since the ship was not very large, the pilot could simultaneously observe the landing deck, the superstructure and the horizon in the decisive landing phase, so that here too, he could compensate for part of the deck's motions after some familiarisation -- as in the case of the rolling platform. This technique also entails the advantage that in the case of inhomogeneous seas, the pilot himself can determine the moment of touchdown, depending on the size of the arriving wave.

A jump take-off was performed to reach a safe hover altitude before leaving the vicinity of the ship.

On all test days an extremly strong wind was blowing, frequently gusting up to more than 40 kts (wind force 8), so that the desired high swell was obtained.

At a ship's speed of 10 kts landings were performed up to a swell of 2.5 m. The pitching motion of the ship amounted to $1.5^{\circ} \pm 3^{\circ}$, the rolling motion to $3^{\circ} \pm 1.5^{\circ}$, and the wind speed exceeded 40 kts.

These values constituted a limit since the helicopter was no longer able to stand stable without being tied down after touchdown.

The more than 90 landings on the JTE showed the following results:

- the 2.5 m limit achieved for the swell was not a question of the permissible stresses but purely a tie-down problem. For wave heights of 1.5 m or more the helicopter must be tied down immediately after touchdown. Even when travelling in smooth water, strong rolling motions may occur during turning maneuvers, so that the helicopter must be tied down in this case as well.

- during none of the landings was a strength limit reached. The mast bending moment reached about 70% of its permissible range, and the accelerations during the landing shock only slightly exceeded the values achieved during normal landings.

- if the local conditions permit, the ship should travel during the landing operation in such a way that the wind is blowing from the forward starboard quarter. The static angle of roll of the ship achieved in this way is advantageous for the specific characteristics of the BO 105.

- the ships speed at the moment of touchdown was no real limit - at least for the JTE. However, a speed of 6 - 10 kts. proved to be most favorable. For a 1 m swell it was still possible to perform landings at a ship speed of 20 and 30 kts without difficulty.

- some night landings were also completely unproblematic due to the good deck lighting of the ship and the low swell.

Reports from customers show that full use is made of this type of application of the BO 105. An English pilot, for example, landed on a cable ship under weather condition which caused another crew to abort landings.

References

1. E. Skubinna, H. Keil und P. Schenzle, Kriterien für Hubschrauberlandungen auf Schiffen. Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt e.V., Institut für Schiffbau der Universität Hamburg. Hamburg Januar 1971.

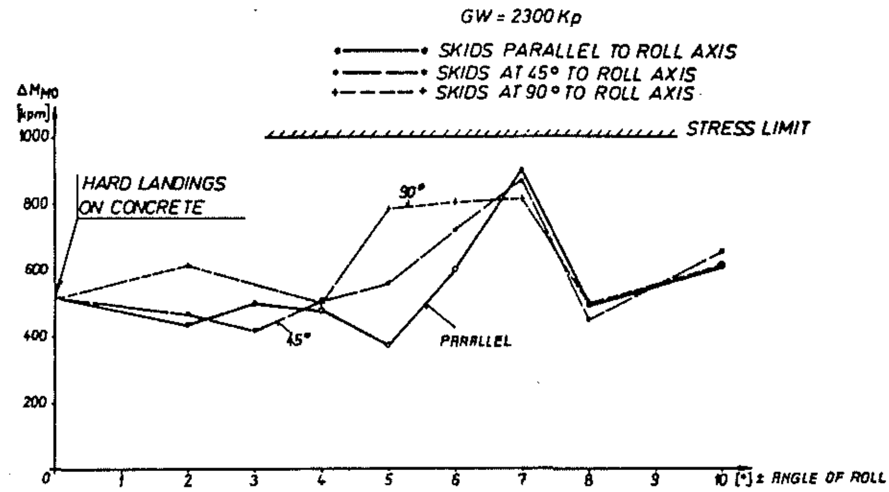

FIG. 1: ALTERNATING MAIN ROTOR SHAFT BENDING MOMENT DURING TOUCHDOWN

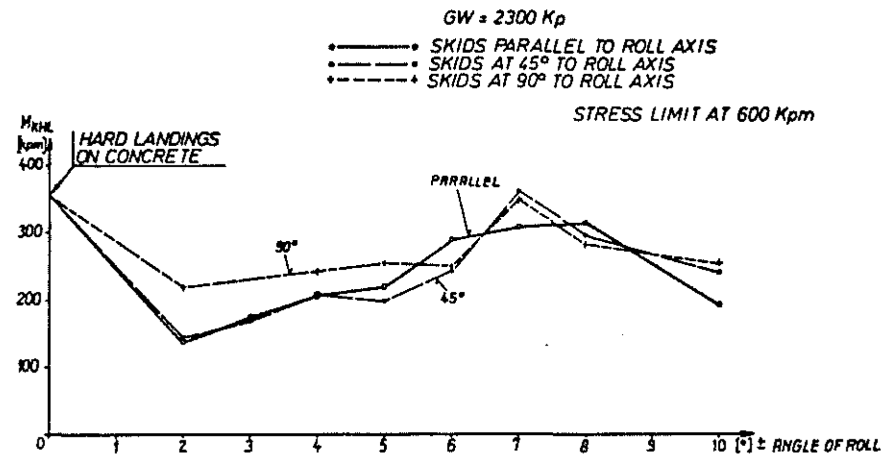

FIG. 2: BENDING MOMENT ON REAR PORT UNDERCARRIAGE CROSS-TUBE DURING TOUCHDOWN

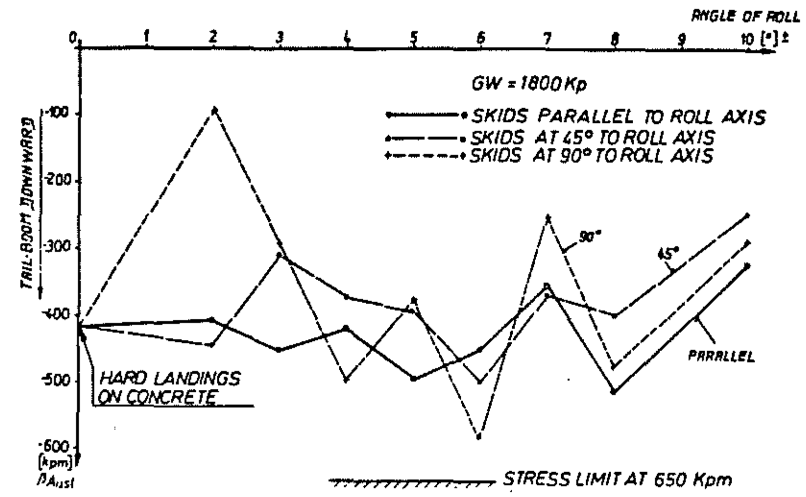

FIG. 3: TAILBOOM VERTICAL BENDING MOMENT DURING TOUCHDOWN

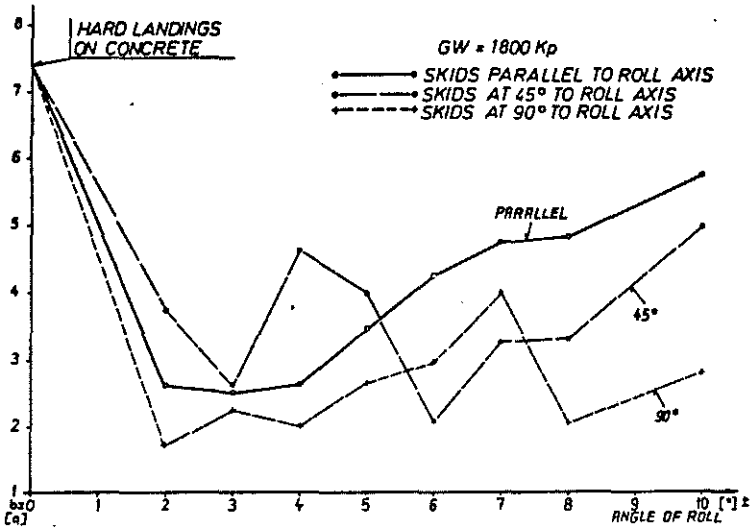

FIG. 4: VERTICAL ACCELERATION UNDER PILOTS SEAT DURING TOUCHDOWN

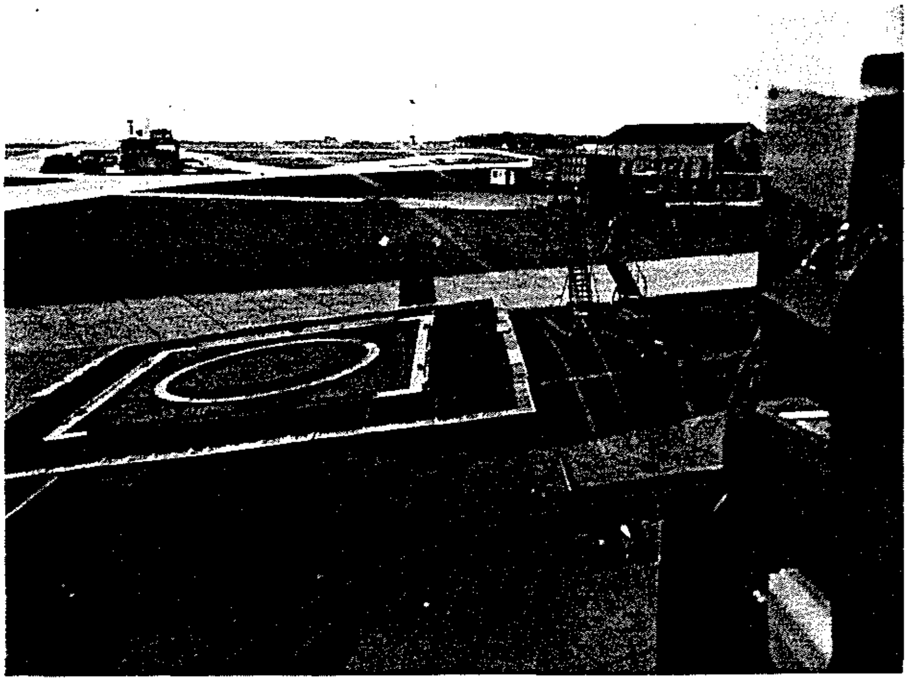

FIG. 5: Pilot's view of the Rolling Platform

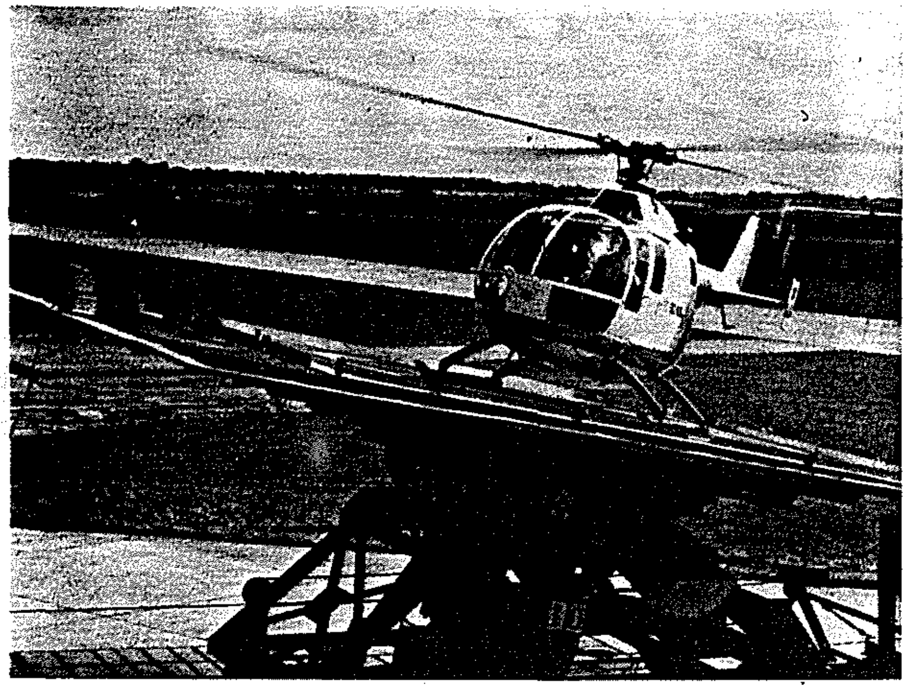

FIG. 6: BO - 105 on Rolling Platform.
Landing direction 45° to roll axis

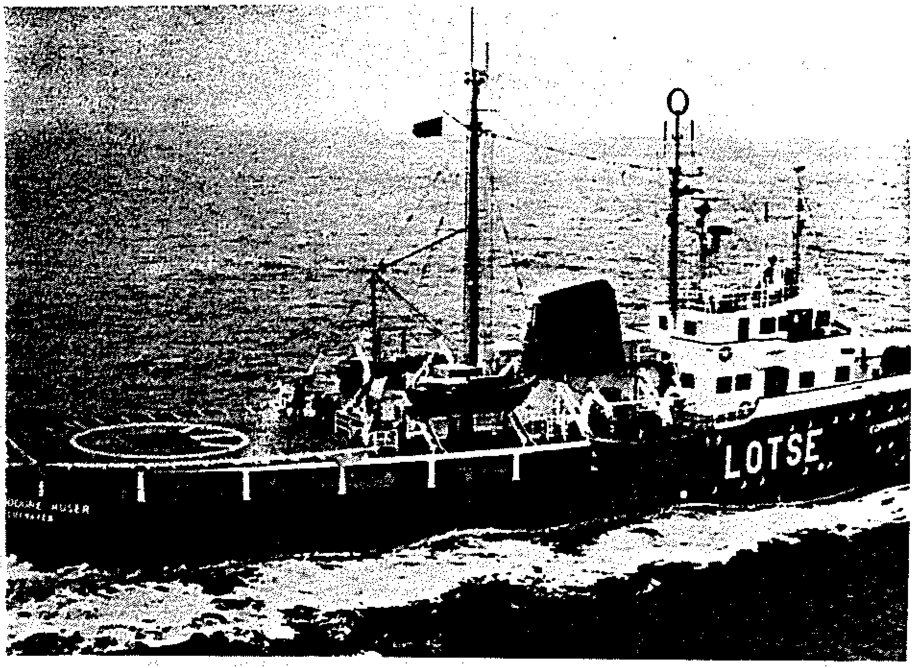

FIG. 7: Pilot transportation ship
"Kommodore Ruser"

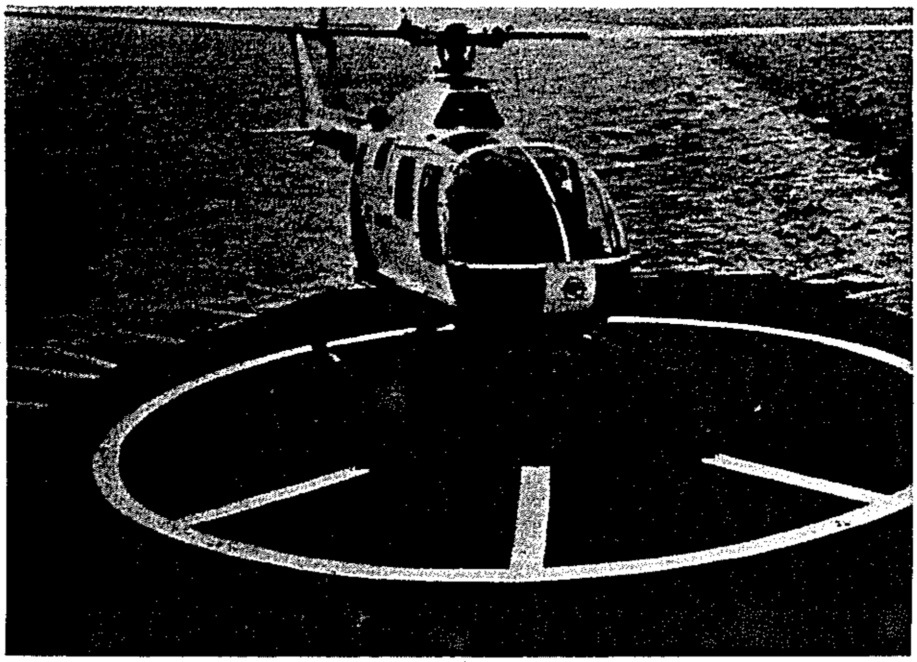

FIG. 8: BO - 105 during touchdown on
"Kommodore Ruser"

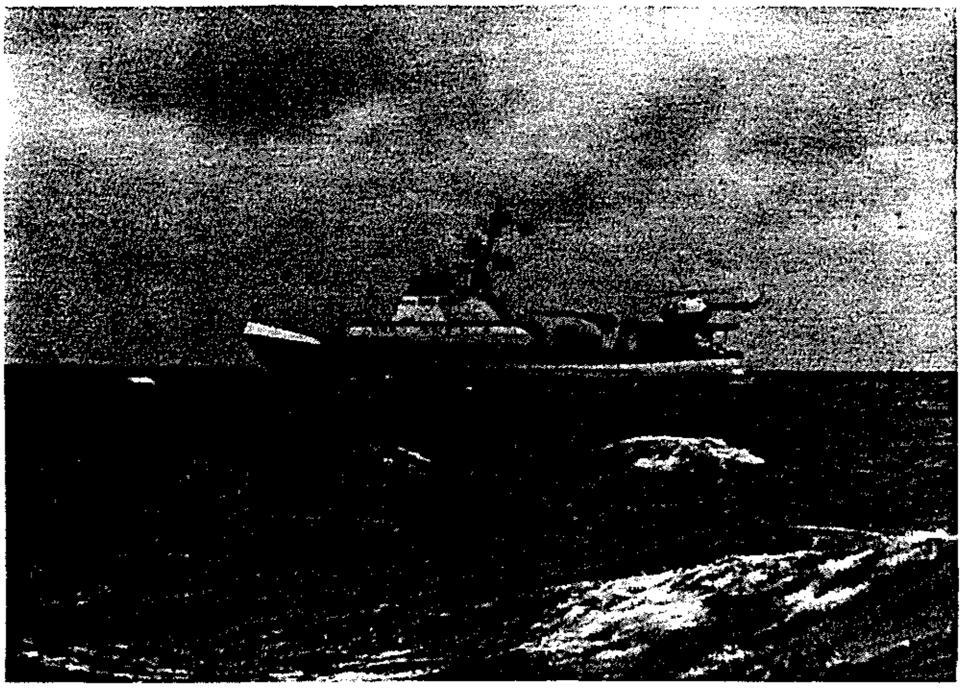

FIG. 9: BO - 105 on deck of the rescue ship " John T. Essberger"

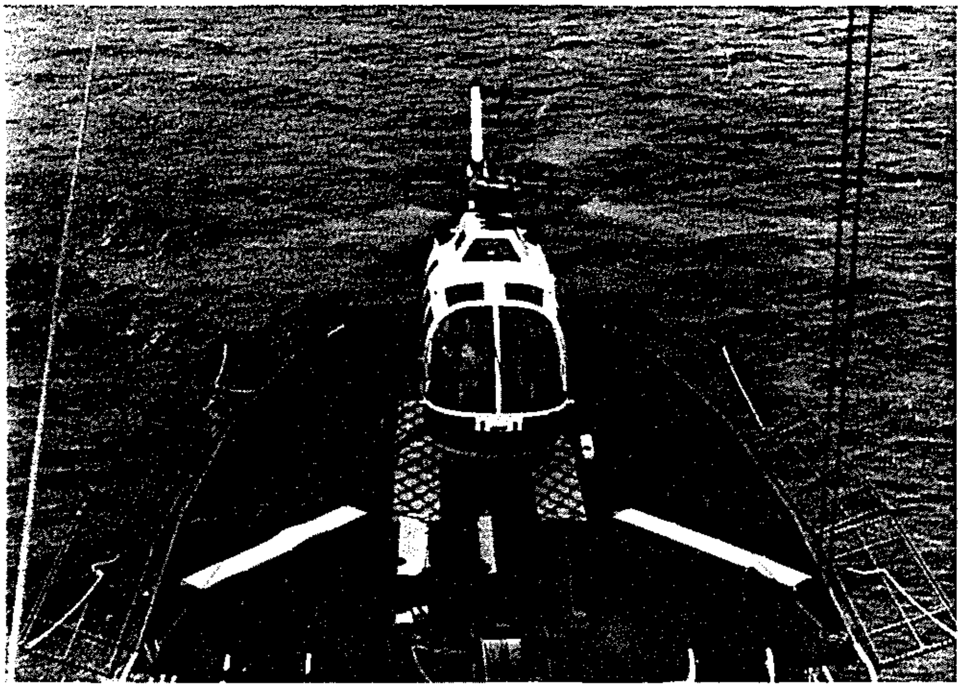

FIG. 10: Helicopter working platform on the "John T. Essberger"