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Center-Well Installation of USNS MIZAR (T-AGOR-11)

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CONTENTS

ABSTRACT

A center-well installation on a former NRL assigned ship, USS HUNTING (EAG-398), is described in general terms. Some of the problems encountered with this center-well configuration are pointed out.

The center-well installation of the USNS MIZAR (T-AGOR-11) is described in some detail. Factors which influenced the well design configuration are discussed. Also described are the carriage and cable towpoint system.

PROBLEM STATUS

This is a complete report on one phase of the design relating to the modification of the USNS MIZAR (T-AGOR-11).

AUTHORIZATION

NRL Problem K03-14
Project RR 104-03-41-5904

THE CENTER-WELL INSTALLATION

OF THE

USNS MIZAR (T-AGOR-11)

INTRODUCTION

Research ships which are intended to launch and retrieve moderately heavy equipment on a routine basis must have specialized handling gear aboard. One of the prime considerations for such handling gear is that its operation be as safe as possible from injury to the operating personnel. Secondly, it should inherently be designed to minimize the danger of damage to the equipment being handled. Since there is little control of the type of seas which are encountered, the system should be capable of safe operations in as high a sea state as possible. Ships which are intended for all-weather operations, must consider the degree of physical comfort of the operating personnel since their wellbeing is reflected in the efficiency of the tests being conducted.

Handling equipment exposed to the elements of the sea and weather is much more costly and time consuming to maintain than equipment protected from the elements. For all the above considerations, the Naval Research Laboratory believes that the deep sea equipment handling installation designed for the USNS MIZAR is one of the best installations available for meeting the operating conditions described.

BACKGROUND

In 1953 the Naval Research Laboratory was assigned an LSM class ship (Figure 1) which was to be converted for towing a large acoustic transducer array. The streamlined body which housed the array was 28 feet long, 9 feet wide, 10 feet high and weighed 30,000 pounds (Figure 2). In those days of ocean engineering, a vehicle of this size and weight posed no small problem for its launching and retrieving. "Over-the-side" and "off-the-stern" launching methods for this project were ruled out. The most promising avenue for consideration was the "down-through-the-middle" philosophy. The Bureau of Ships prepared the preliminary plans for the conversion of the LSM; and the work was accomplished at the Norfolk Naval Shipyard. A rectangular hole 12 feet wide and 30 feet long was cut through the centerline of the ship. A bridge-type structure was built over the well and an elevator system installed in the well. The elevator platform, or carriage, travels from the top of the bridge structure down to the keel. The carriage was not powered but was used merely as a steady-rest for holding the towed body nested against its underside and centered in the well (See Figure 3). When the carriage and "fish" were lowered to the "down" position, the carriage was arrested by stops at the keel level - the fish continued downwards as the cable was further paidout. The carriage was then locked in the "down" or towing position and the well doors at the main deck level were closed and dogged. The center-lined tow cable passed through the two-section, closed well door at the line of juxtaposal of the two sections. Upon retrieval, the well doors were opened, the carriage unlocked and the fish and carriage raised to the "up" position. The "up" position was 18 feet above the main deck. At this position the carriage was again locked, the well doors closed and the "fish" lowered to rest on the well doors (See Figure 4). The towed vehicle was streamed from a 2 1/2 inch diameter, double-armored, multiple-conductor electric cable having a breaking strength of 1/4 million pounds.

Soon after putting-to-sea, problems developed with the centerwell installation. The wave action within the well was especially vigorous when heading into a sea. Water which had been reflected off the after bulkhead traveled forward and impacted against the forward bulkhead with such force as to cause extensive damage to this bulkhead. The ship had to be put back into the shipyard for repairs and strengthening of the forward bulkhead.

The other problem concerned the closure for the well opening. The well was covered at the main deck level by a two-section, closely-fitted horizontally sliding door. The bottom of the well was open to the sea. When the water level rose in the well, air between the water surface and the door would be compressed sufficiently to develop the pressure needed to lift the seven-ton doors off their tracks. This design deficiency was corrected by capturing the tracks with roller wheels from below as well as from above; and relieving the degree of air-tightness of closure of the door.

Despite these deficiencies, the primary function of launching and retrieving the large towed body was fully realized. That LSM, which became the USS Hunting (EAG-398), was used by the Laboratory until the end of 1959. Deep ocean towing and acoustic experiments were performed at water depths down to 15,000 feet. Two annoyances with the centerwell installation were: the cumbersome method of mechanically operating the well doors, and the fact that the well deck was often awash when underway. The above discussion concerning the Hunting's centerwell installation was presented for background information as well as historical interest.

In 1963 the Laboratory became involved in the search for the lost Thresher submarine. During that year the Laboratory used the new AGOR-3 class ship, USNS GILLISS. The equipment handling gear on the AGOR-3 class ship was too inadequate and hazardous to both equipment and personnel for the type of deep sea investigation being undertaken. Deep sea work of this nature requires a better surface platform and equipment handling system than is afforded by this class of ship.

DESCRIPTION

A search for a suitable, decommissioned ship having the general hull characteristics desired by the Laboratory had been underway for some time. Late in 1963 such a ship was located. This ship, the USNS MIZAR, is 266 feet long, 52 feet wide and has a full load displacement of 3880 tons (See Figure 5). The ship is basically the Maritime Administration C1-ME2-13 design with an ice strengthened hull. The MIZAR was built in 1957 by the Air Force as a cargo ship for Arctic service. All cargo was carried in two holds at the forward part of the ship between frames 15 and 81. The 34-foot long, centerlined, number 2 hatch straddled the ship's mid-length position (frame 62 1/2). Thus, except for the double-bottoms, there already existed a well through the ship in the precisely desired location. When funds became available for a partial modification of the ship, the No. 1 priority work item was for a centerline well installation. Figure 6 is an artist's drawing of the centerwell arrangement as it now appears. In concept and operation the MIZAR centerwell installation is quite similar to that of the Hunting. The fish handling ideas shown by Figures 3 and 4 are still the same. The differences in design of the MIZAR centerwell from that of the Hunting is attributable largely to the experience gained in operating the Hunting, with some innovations of intuitive origin; plus some design facets which were forced into being because of design-time limitations. It was planned to perform hydrodynamic tests of a ship model having this centerwell configuration, but the design was frozen and construction was underway before a model-study contract could be negotiated.

After reconing with various modifying influences, the resulting dimensions of the centerwell were set at 23 feet long and 10 feet wide. The fore and aft bulkheads of the well were made semicircular instead of flat as was the previous design (Figure 7). It was expected that these curved bulkheads would prevent the pounding action of the wave against them as had occurred in the Hunting. This expectation turned out to be quite valid. A wave shape developed within the well approaching the semi-circular ends is completely modified in form and direction. Instead of being directed forward as a wave having a greater amplitude than that which had impinged against the after bulkhead, the wave is now directed inwards towards the focal point of the semicircle. It is at this focal point in the well that the most water turbulence exists. At 12 knots the maximum rise of the water level in the well is about three feet.

Another variation from the Hunting design is the splash baffles which are installed in the semi-cylindrical ends. These baffles are semicircular angles welded to the end bulkheads. There are nine such baffles at each end, spaced 18 inches apart. It was planned that there should be six baffles below the water line and three above. The installed arrangement has four baffles below and five above the water line. Despite the rearrangement, the baffles appear to perform their intended mission to a surprising degree. These angular baffles are 21 inches wide on the horizontal plane and have a 6" vertical leg facing downwards. The baffles span the semicircular bulkheads for the complete 180 degrees (See Figure 7).

At keel level the opening to the sea was restricted to 8 feet wide and 21 feet long. The semicircular fore and aft ends are concentric with the bulkhead ends of the well. This constriction has a 6-inch radius at the inboard lip and fairs into the hull bottom. The shelf formed by this constriction also supports the carriage in its "down" position. The horizontal cross-sectional area of the well above keel level is 208.5 feet^2. At the keel level the constriction reduces this area to 154.3 feet^2.

The general thoughts behind the reasons for restricting the well opening or the bottom were twofold. The first was to provide a solid support for the carriage when in the towing position. The second concerned a means for reducing the water turbulence within the well. Let us assume that the total energy contained in a volume of water entering the well per unit time is equal to the total energy of an equal volume of water at any level in the well. If an efficient means for converting all the kinetic energy of the entering water to potential or thermal energy were to be provided within the well, then the placidity of the water surface within the well should be similar to that of the water surface external to the ship. The constriction at the keel level, the semicircular ends and the splash baffles were incorporated in the well design to achieve this objective. The constriction was a means of providing a kinetic energy density reduction in proportion to the ratio of areas cited above. The semicircular ends and splash baffles were to provide mechanical dampening of the wave motion and conversion of kinetic to thermal energy.

The degree to which the objective was achieved may be stated in qualitative terms at least. The reduction of water action within the well between the Hunting and MIZAR design is beyond our most optimistic expectations. However, these subjective reactions are quasi-quantitatively substantiated by the following. It can be assumed that the increased drag of the ship when underway as a result of the well installation is proportional to the kinetic energy of the turbulent water within the well. However, the drag of the ship has not been measureably increased as a result of the installation of the well. The top speed of this ship was close to 13 knots prior to modification. Based on four crossings of the Atlantic Ocean since the well installation, the ship has apparently lost none of this capability - it can still do 13 knots. It may then be assumed that the innovations incorporated into the well design serve as effective energy converters.

The well is closed over only at the main deck level. Closure is effected by a flush-mounted, hydraulically operated water tight door. The design static loading for the well doors is 1000 pounds per square foot. As in the Hunting design, half of the door opens forwards, the other half slides aft. Each half-door is made up with three hinged sections. Only the two outboard sections are hydraulically articulated - the inboard sections remain horizontal during the open and close cycle. Compression of air under the closed doors, due to the rise of water within the well, has been practically eliminated by providing large-breather ducts from the well.

The method of providing a towpoint for the cable which had been used on the Hunting was not desirable. The towpoint in that design was formed like an inverted funnel or horn. During inhaul or paying-out, the cable cut grooves into the tow horn resulting in constant replacement of the tow horn liner. The new towpoint design which was adopted utilizes 24-inch diameter sheaves. In order for the cable to remain in the sheave groove during ship maneuvers, it was necessary to use an assemblage of three sheaves. Figure 8 shows the sheaves as installed in the carriage. These sheaves are of the fairlead type. By this is meant, the sheave is capable of assuming a direction in-line with the tension of the cable. In the arrangement shown, the sheave moves athwartships about a fixed, fore and aft axis of rotation. The axis of rotation of the tow sheave being above the lines of action of the loading forces prevents the sheave from ever "over-toggling". In the "down" or towing position, the carriage rests six inches above the keel level. The tow sheave extends nine inches below the carriage and is thus three inches below the hull. Towing from this point eliminates any fear of ever fouling the ship's propellers with negatively buoyant cables - at any speed.

The carriage is a 12-foot long, 3500 pound skeletal structure made of welded aluminum tubing (See Figures 8, 9, 10 and 11). It is held in position by two sets of slippers attached to each of its athwartship sides. These slippers engage four guide rails which extend from the keel to the 02 level. Total vertical travel of the carriage is 44 feet.

In order to "nest" a towed-body under the carriage, and not two-block against the tow sheave, a "standoff" support structure below the tow sheave was needed. Since the athwartship motion of tow sheave is to be measure of the athwartship cable angle, the structure to be provided below the tow sheave must not interfere with the cable and therefore could not be rigidly fixed to the carriage. This support structure, which we call a cradle, is shown in Figure 8. The cradle is free to swing about a fore and aft axis of rotation. This axis is in a vertical plane which contains the axis of rotation of the tow sheave and above the center of gravity of the carriage. As stated previously, the carriage is not separately powered, but is raised and lowered by riding along atop the towed body. For this reason, it becomes necessary that the cradle be attached at points above the gravitational center of the carriage; otherwise the carriage would cant and jam against the guide rails.

The overhead structure which supports all equipment going through the well is designed for a static payload of 100,000 pounds. The vertical members supporting the overhead cross-member trusses are an integral part of the wellhouse. The wellhouse which completely encloses the well area provides the capability and comfort for all-weather operation. Longitudinal and athwartship girders forming the overhead cross-member trusswork are bolted in place - as is also the overhead deck of the wellhouse. The six tow cable sheaves mounted in the carriage and in the wellhouse area are 24 inches in diameter and have a load carrying capacity of 12 tons.

CONCLUSION

These two centerwell installations have amply demonstrated the advantages in terms of personnel and equipment safety, and improvement in operating efficiency due to the ability to operate in weather which would preclude operations over the side or stern. Secondary advantages include protection of personnel and equipment from the weather.

The installation aboard MIZAR represents a significant advancement in the Navy's research platform development program. An effort should be supported to quantize the effect of such an installation on the operation of the ship by a thorough model study followed by measurements on the full scale installation itself. As technology in Ocean Engineering progresses, there may well be many requirements for similarly configured ships.

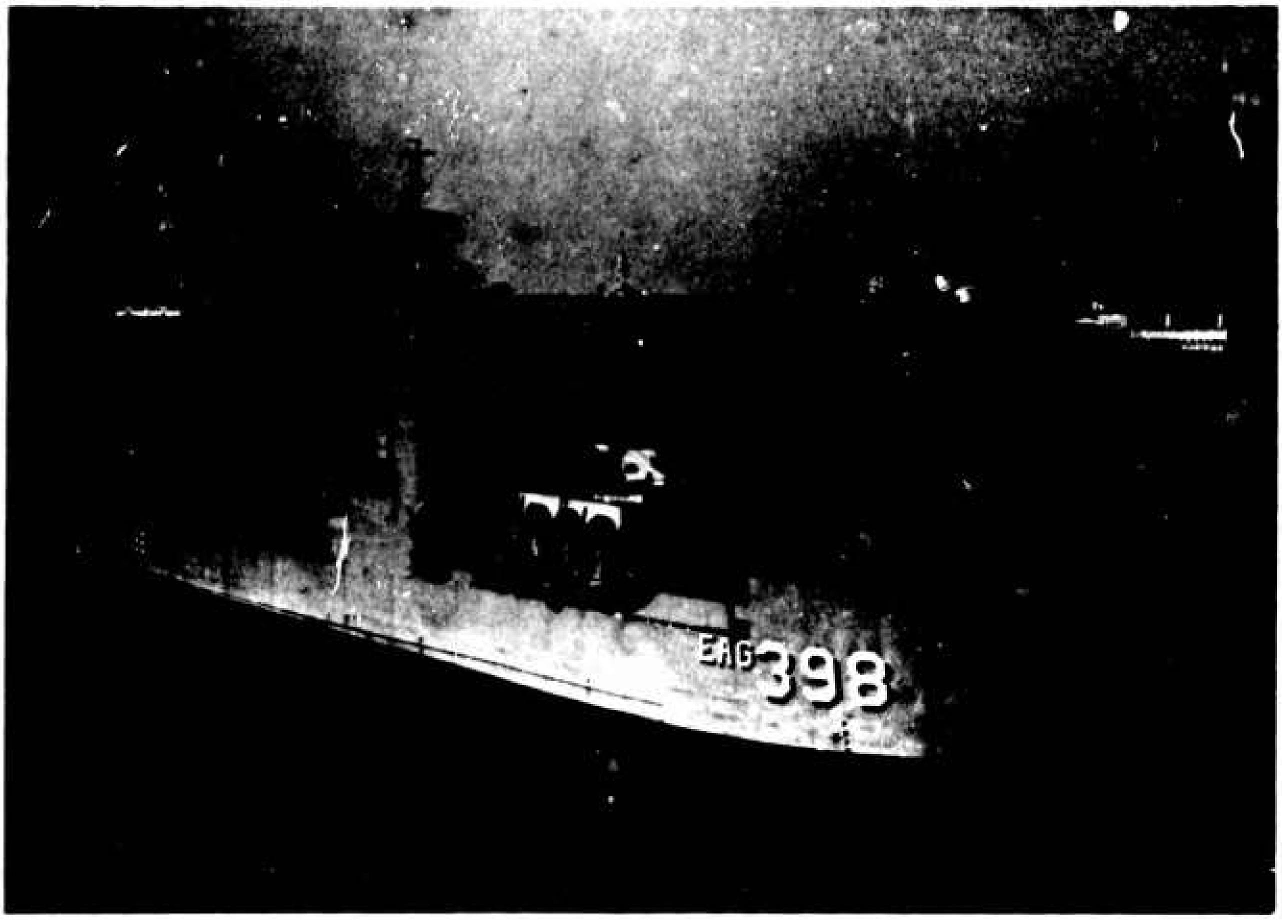


Figure 1 - USS HUNTING (EAG 398)

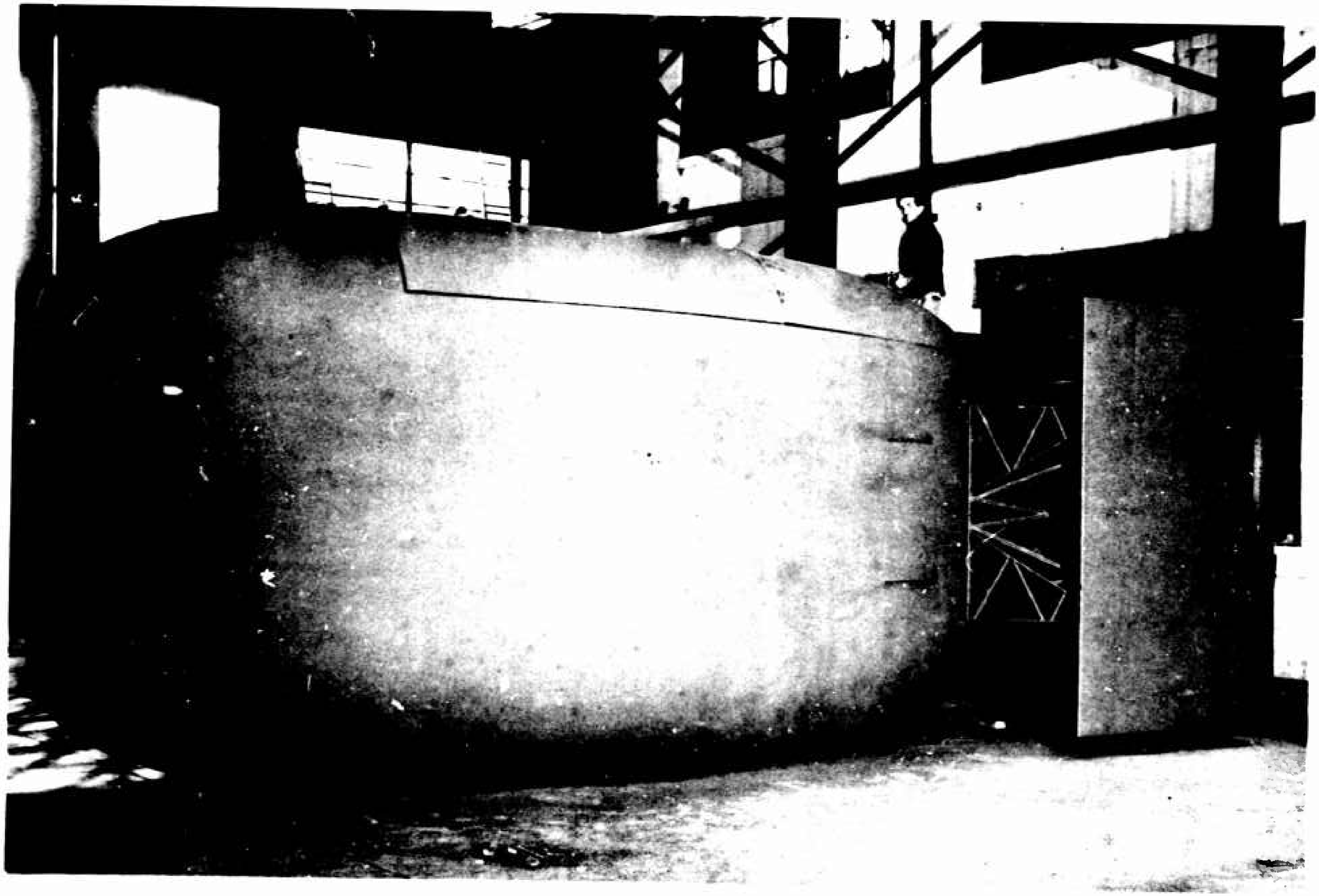


Figure 2 - 30,000 lbs Towed Body

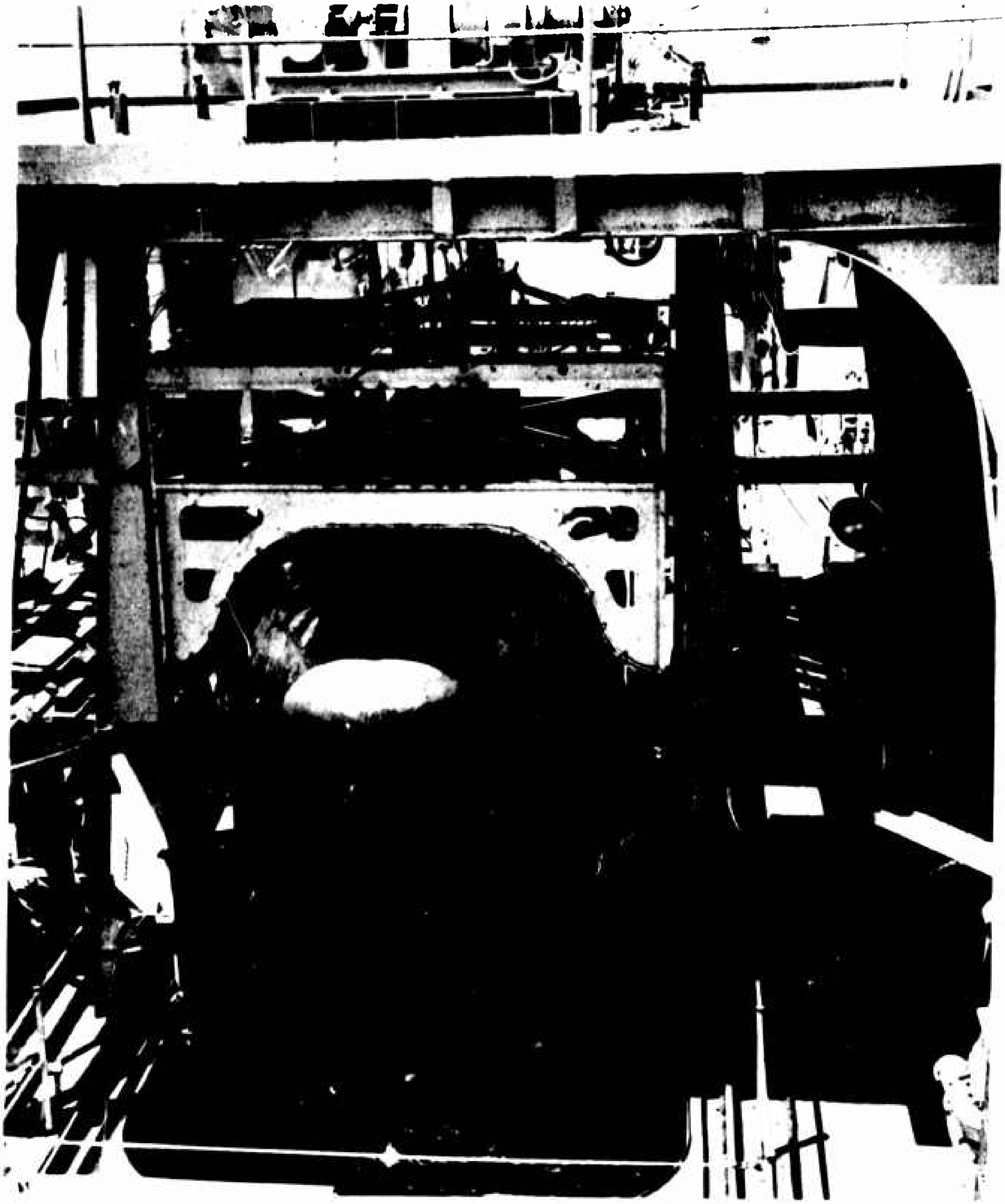


Figure 3 - Towed Body nested under carriage

Figure 4 - Towed Body resting
on well doors

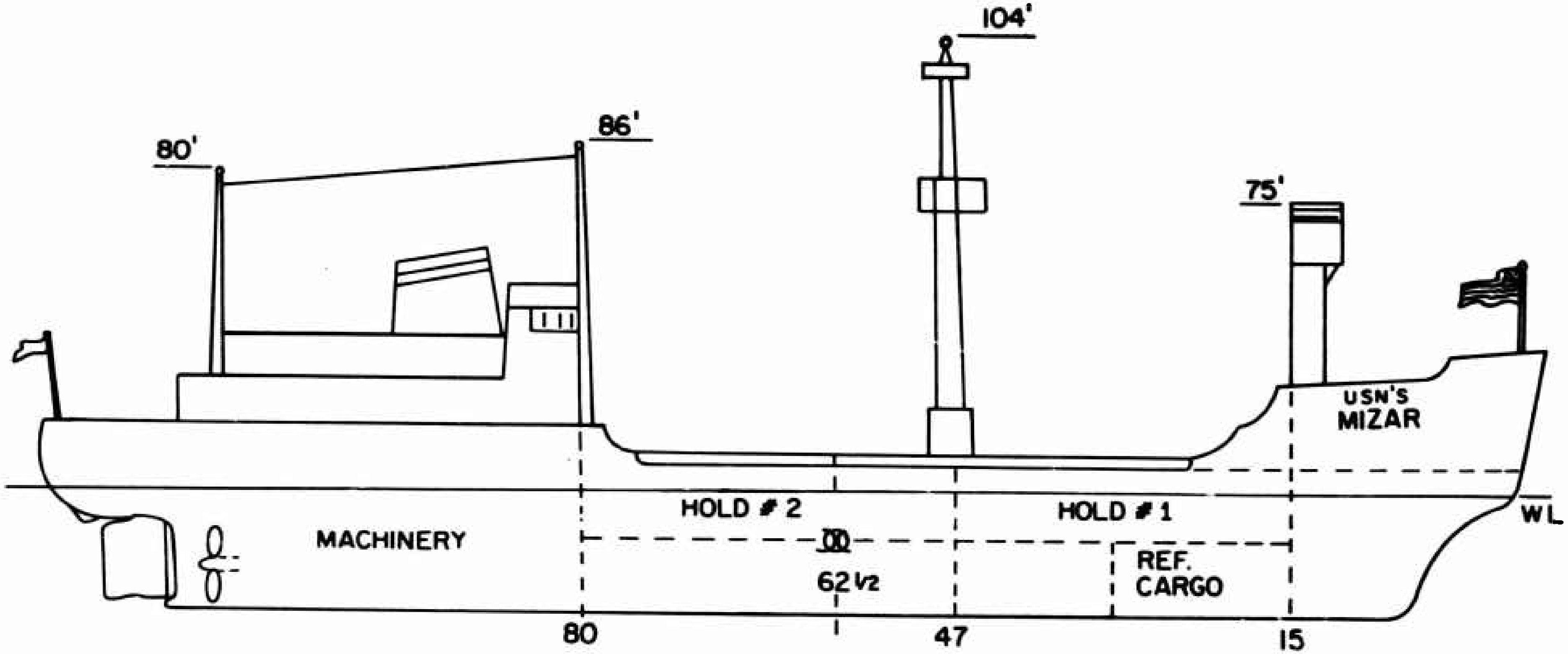


Figure 5 - USNS MIZAR (T-AK 272)

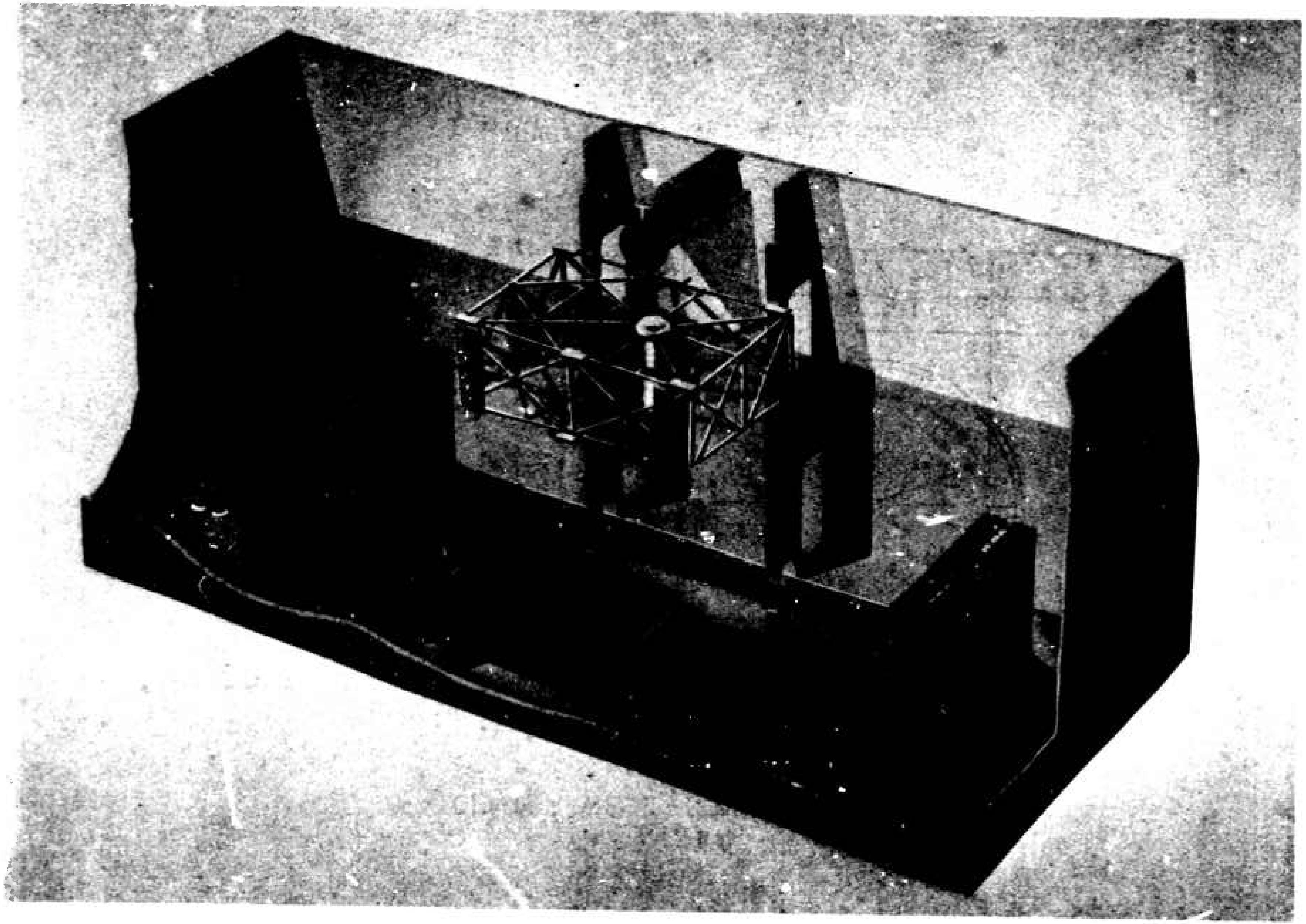
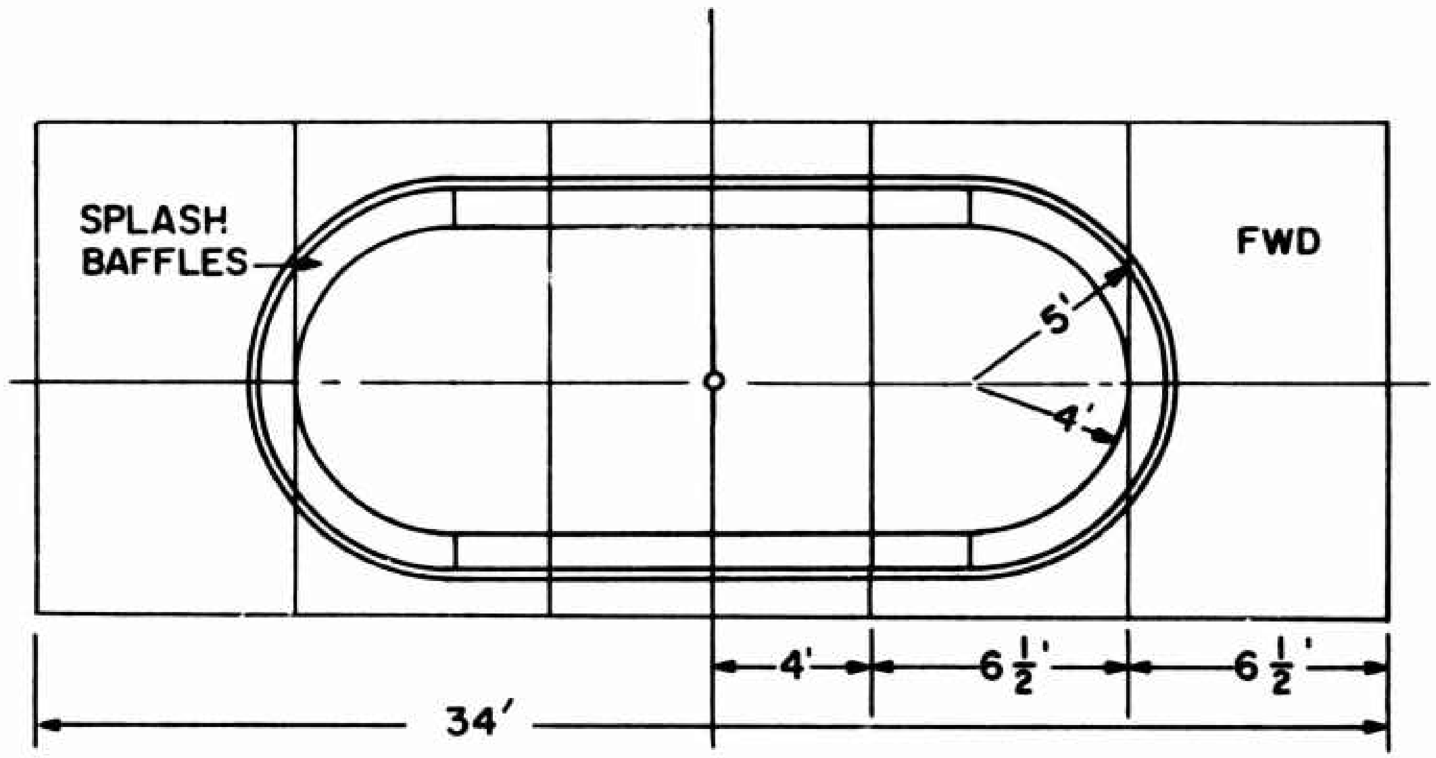


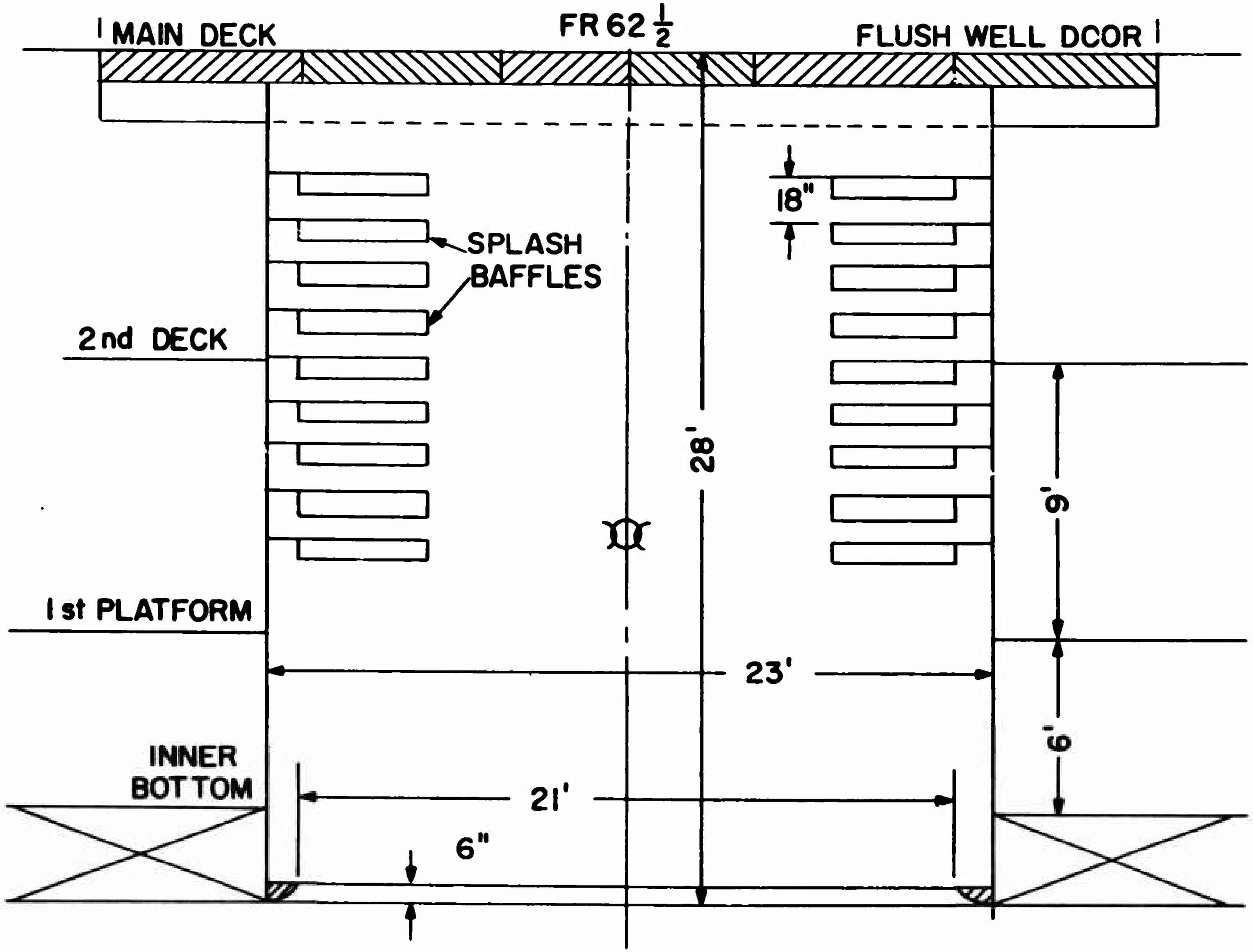
Figure 6 - Artist's Drawing of Mizar center-well installation

MIZAR
CENTER WELL-CONFIGURATION



(a) Plan View

Figure 7 - Center Well-Configuration



(b) Cross-Sectional View

Figure 7 - Center Well-Configuration

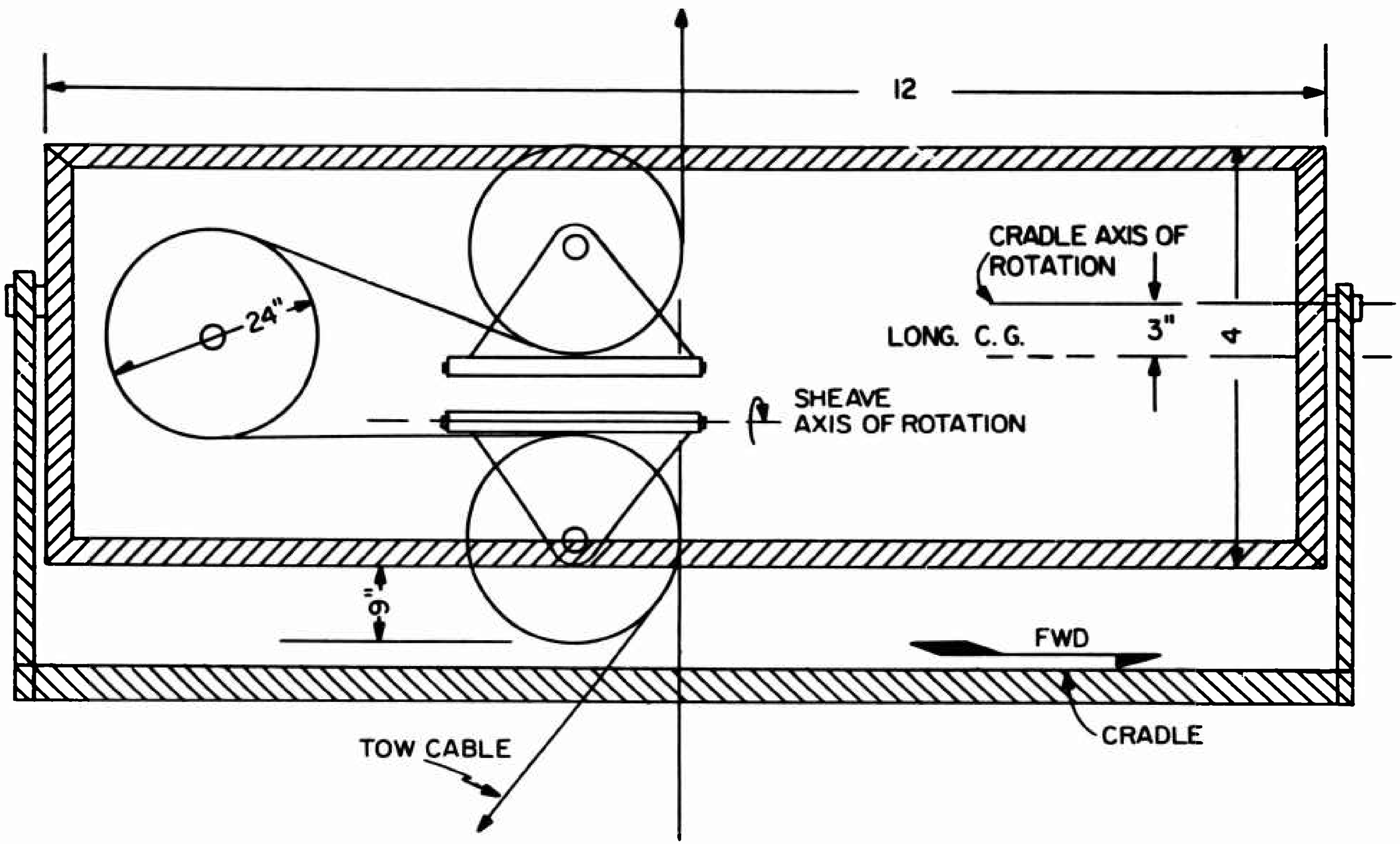


Figure 8 - Tow-Sheaves and Cradle as mounted on Carriage (side view)

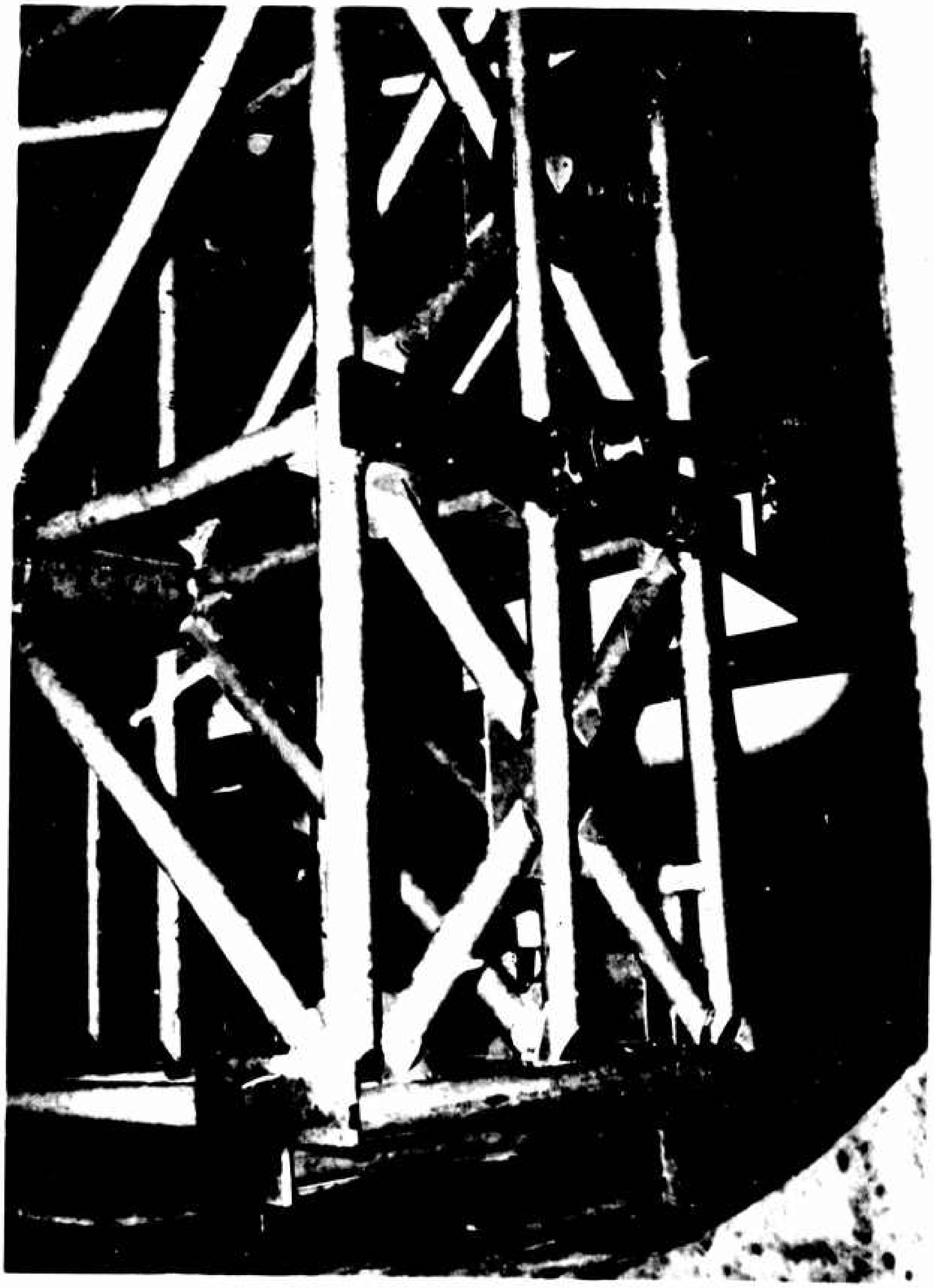


Figure 9 - Carriage and cradle assembly aboard MIZAR

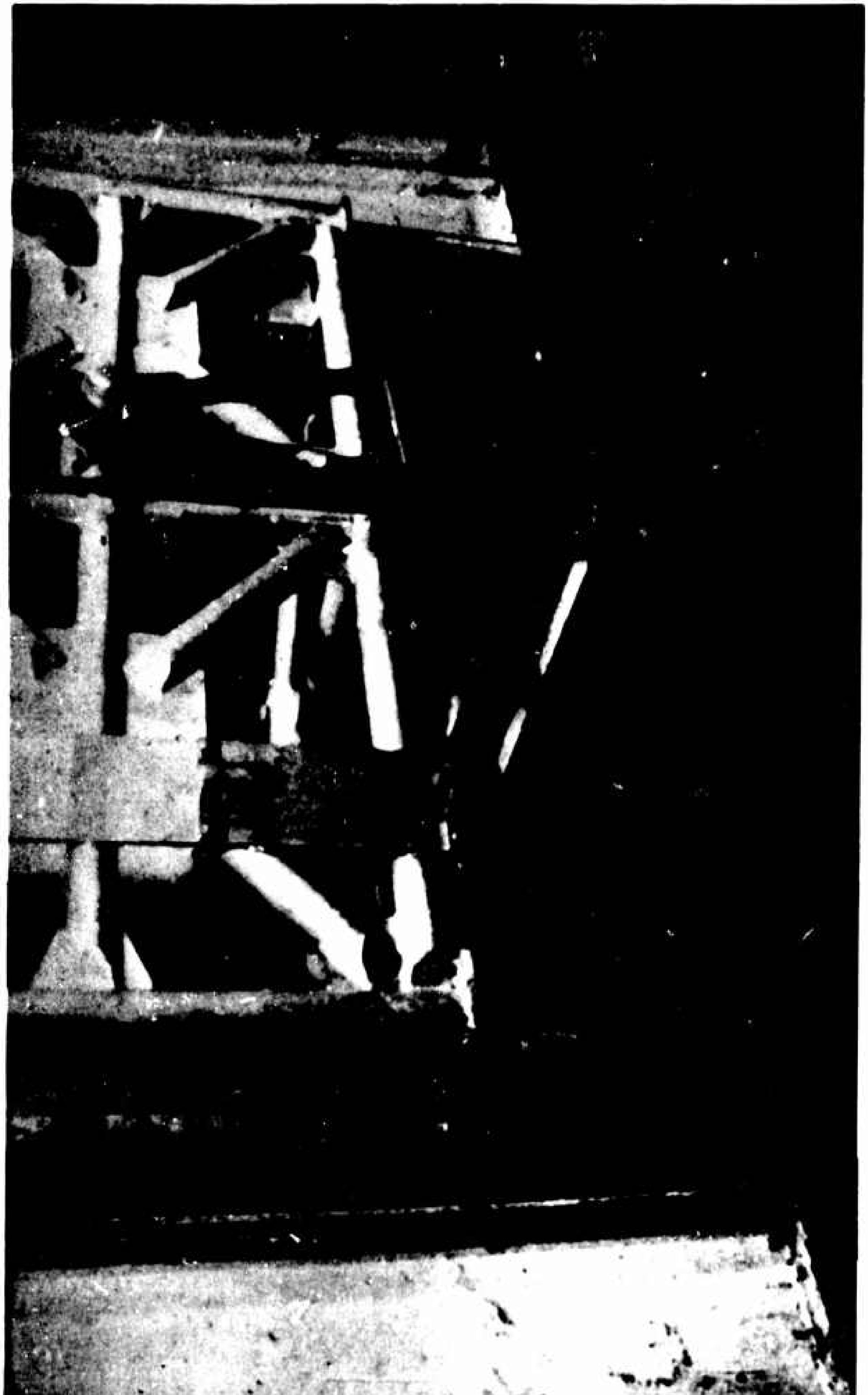


Figure 10 - Carriage and Cradle Assembly - aboard USNS MIZAR

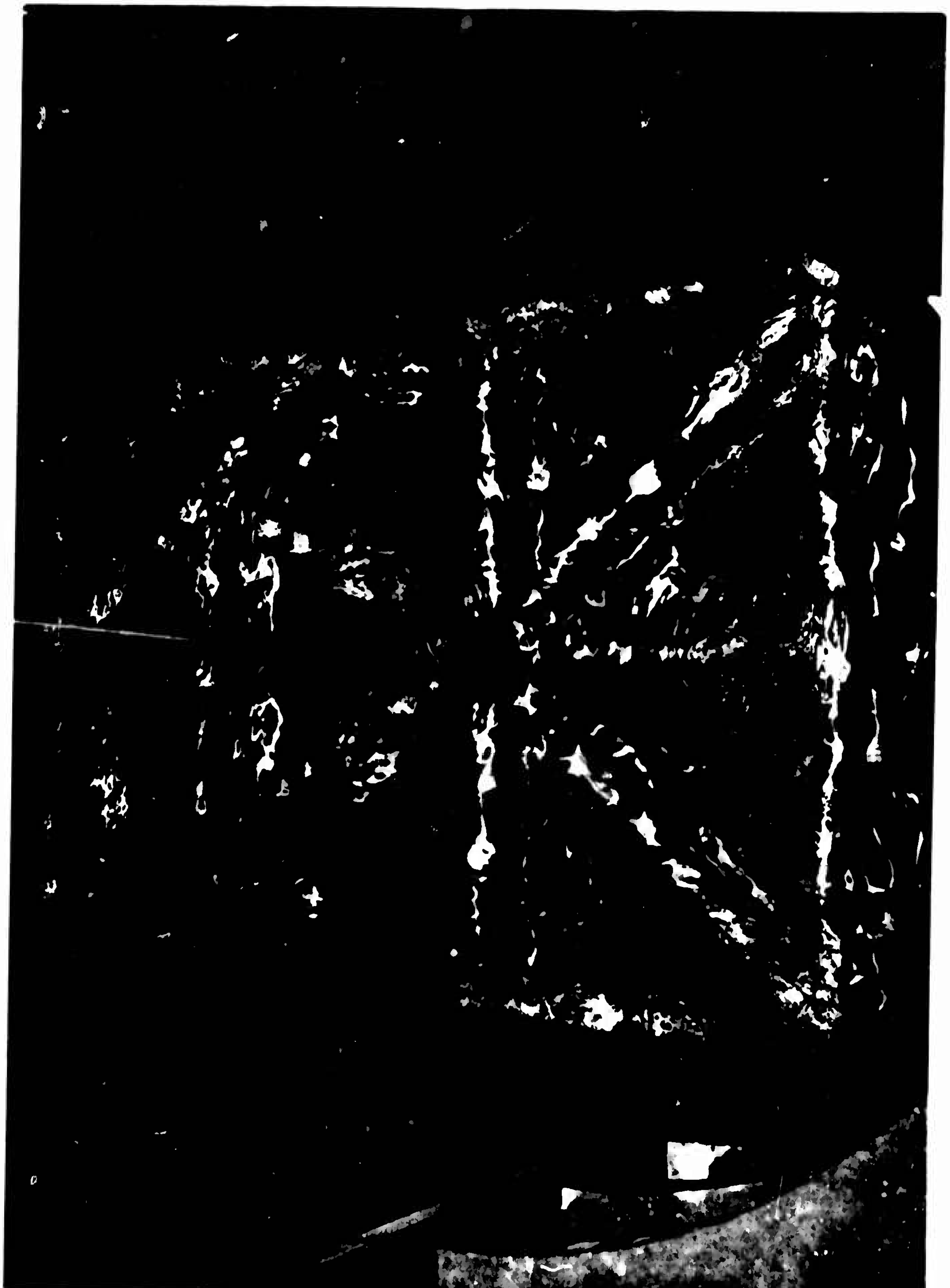


Figure 11 - Carriage being lowered into well

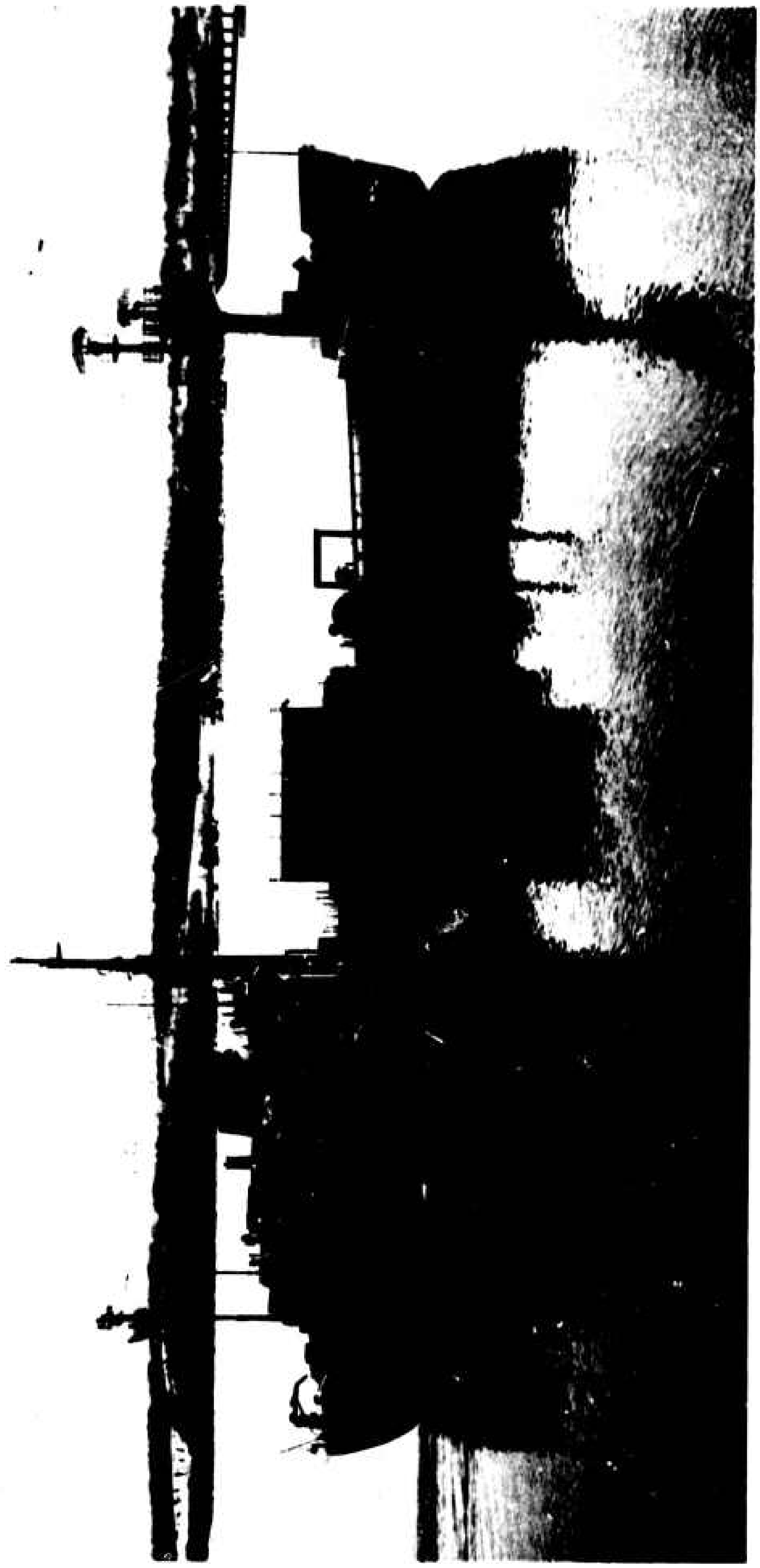


Figure 12 - USNS MIZAR after partial modification

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