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"LOW COST ENGINEERING TO IMPROVE WORKING PROCEDURES AND SAFETY ONBOARD DUTCH BEAMTRAWLERS"

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1. INTRODUCTION

The problem of safety in working procedures has always received attention. The origin however is difficult to trace back in history, but that the problem has long been acknowledged is illustrated by phrases in the Holy Bible like Deuteronomium 22:8,

> "When you build a new house, so will you mount on the roof a quord rail in order that you put no blood guilt on your house when someone falls down of it"

For countries since, little has been written on the subject, but we may assume that the human race did pay attention on safety for his own sake.

Law enforcements and regulations however started to appear much later, not until the end of the nineteenth century, where as in modern times legislation is improved and extended on a broader scale.

In 1983 a new law was made in the Netherlands, which is known as the "Arbeidsomstandighedenwet", abbreviated "ARBO"-law.
Several fundamental principles of proper co-operation between employee and employer are given with the aim to create healthier and safer working conditions.

In short these principles are:

- working conditions should be made as safe as possible.
- working conditions should be made as healthy as possible.
- work should be adapted to human physical and mental qualities.
- work of a monotonic nature should be avoided.
- fixed labour cycli, dictated by machines should be avoided.
- work should offer people possibilities for further development and self-fulfillment.

The general trend is toward increased participation of the employee and the government, next to the traditionally strong influence of the employer and to improve the exchange of ideas.

This proces is not expected to halt and improvements in working conditions will eventually result from it, also onboard fishing vessels, although not to be expected before 1990, when this law will become applicable to fishing boats.

In May 1984 the European Commission organised a symposium on safety aspects of fishing vessels in Lorient, which illustrates the international scale of interest.
Apart from a review of accidents and causes in several memberstates of the Community, several environmental conditions and clinical effects were given and aspects concerning the design of vessels and equipment were discussed. Conclusions of the meeting are, that the aspects of safety still deserve great attention, that working

conditions and procedures on board fishing vessels leave room for improvement, and that an integrated approach is needed with all experts involved, ship designers, doctors of medicin, lawyers and of course the fishermen themselves.

Fishermen do tend to react in a negative way initially, especially when being confrontated with additional regulations and additional costs and therefore it is necessary to promote the aspects of safety carefully and to start with improvements in existing working conditions, that require only minor investments.

2. A REVIEW OF ACCIDENTS ON DUTCH FISHING VESSELS.

An inventory of accidents on Dutch fishing boats reported to the Radio Medical Service of Radio Holland has been made by dr. H.B. Lodewijks, who works on the Hospital-Church Vessel "De Hoop", for the years 1978 - 1982. (1)

Not all accidents are indeed reported and registered, due to reluctance of fishermen to report especially minor and seemingly unimportant accidents, so the total number will exceed these figures.
Lodewijks makes a distinction in several causes and also describes the nature of resulting injuries.

The categories are:

1. Hits (67 cases)

with the next subdivision

	causes	effects	nr. of cases
1.1	breaking of steelwire, mooring cable, rope	serious wounds	24 injured
1.2	heavy object falling or swinging to victim	serious or fatal	30 injured 1 fatal
1.3	explosion of warheads fished up	serious or fatal	3 injured 1 fatal
1.4	fights, blows with fists or weapons	light	8 injured

2. Falls (43 cases)

not subdivised

The cause is generally the motion of the vessel due to the seastate, predominently in bad weather conditions. Effects are mostly injured limps.

3. Getting caught (58 cases)

	causes	effects	nr. of cases	
3.1	caught between steel wires or ropes	injuries of fingers, hands legs	40	injured
3.2	shifting of heavy objects	serious wounds	7 1	injured fatal
3.3	caught in winch, block, conveyor belt	hand and finger injuries	11	injured

4. Penetration of sharp object (22 cases)

	causes	effects	nr. of cases	
4.1	working accidents with knives	hand and fingers	16	injured
4.2	fights	several light injuries	3	injured
4.3	step into sharp object	foor injuries	3	injured

5. Unspecified causes (76 cases)

These include burns (15 cases)

Here the overall total accounts to 266 cases.
Systems consisting of men and machines can be very complex with lots of variables involved. It is vital to encorporate in the analysis all the relevant variables. Generally, trying to improve working procedures without also taking environmental conditions like noise, temperature, humidity and light levels into consideration may not lead to optimal results.

There are many cases however, where with relatively small investments and merely using common sense, substantial improvements in safety can be obtained.
The following chapter particularly focusses on such solutions, bearing in mind that in the long run an integral approach will be a necessity.

3. LOW COST IMPROVEMENTS IN SAFETY AND WORKING CONDITIONS.

Mr. Lodewijks' findings and interviews with skippers and crew reveal several major factors leading to unsafe situations and accidents.

These factors are:
A: Fatigue
B: Use of pulling and lifting devices, mostly consisting of winches, ropes or steelwires
C: Procedures to land boxes of fish ashore

A. Fatigue.

Fishing is a continuous operation, going on 24 hours a day, with short periods of rest in between consecutive hauls. A beamtrawler for instance may get 100 hours of fishing a week with an average haul duration of 2 hours, leaving only very short periods of sleep as catches have to be processed as well before the nets are hauled in again. Such a work cyclus must undoubtedly result in fatigue. In addition to that, one has to work on a moving vessel, mostly in noisy surroundings.

The effect of noise has long been underestimated. Not only damage to the hearing may occur at high levels, a fact that is generally acknowledged, but less known are the effects noise has on other organs like the stomach and digestory system.
Without getting into clinical details, it is important to realize, that the common believe that people simply get used to noise and are no longer effected does not match reality.
Effects resulting from noise are present all the time, even when asleep, noise will agitate the central nervous system and cause an increase in pulse rate and blood pressure. (2)

The effect of the work cyclus is difficult to avoid, as this cyclus is very strongly dictated by the fishing operation.
Noise however may be reduced by proper design and engineering of boats and machinery installations, or by insulating machinery spaces and other sources. In order to identify the present situation RIVO has started a programme of measurements of noise levels onboard Dutch fishing vessels.

B. Use of pulling and lifting devices, mostly consisting of winches, ropes or steelwires.

B1 : Warps
The use of the pulling and lifting devices with free running steel wires always encorporates danger.
Usually the wires carry heavy loads up to several tonnes, are constantly deflected by winding up over sheaves of blocks and on winch drums, resulting in material fatigue and breakage of fibres.

Wires are exceptionally hazardous when breaking due to their unpredictable movements resulting from a quick release of a high content of energy.
But even in normal running conditions wires may easily catch parts of the human body such as hands or fingers, especially when their surface is unsmooth, with individual fibres sticking out.
A proper maintenance of steel wires therefore is vital, whereas a regular check is needed and so is frequent replacement of old wires.

The wear of steel wires can be considerably lessened by correct spooling on the winch drums and by regularly greasing. Spooling can be guided by special mechanisms or by using grooved barrels (for instance the LEBUS-system). The latter is a good example of low cost, but effective engineering.

Except from gains in safety, proper handling of wires will increase their lifespan and consequently result in less frequent replacement, which means lower average costs of wires.
This economical gain creates room for investment in such devices, also having a positive bearing on safety.
Different greasing tools were developed, either as to be permanently installed or as a portable device and tested on some Dutch beamtrawlers, among which the UK-95 and GO-41.
A portable prototype was initially developed by RIVO in 1986 and turned out to be successful. Now a Dutch private company has taken over and is commercialising this prototype.
In this machine the wire is guided along a small feeder to be placed around it, and sealed to prevent leakage. Heavy fuel oil, pumped from a small heated tank is led to the feeder. Due to the decline in viscosity the oil penetrates deeply into the fibres of the wire, while it is pulled through the feeding device. The operation can be done quickly and need not interfere with actual fishing. It can be done when steaming to or from the fishing grounds.

Tests on the UK-95 showed an increase in warp lifespan from 8 months untreated up to 18 months with the aid of the greasing device.
An economical appraisal is given in Appendix I, based on calculated average costs per month, assuming on an investment for replacement of the warps of $ 10.000,= and an additional investment for the greasing devices of $ 2.500,=. With an annual interest rate of 10%, the payback period will be approximately 4 months. When using one machine to serve several boats, which should be quite feasible, the prospects are even better.

Conclusively: with a very modest investment some aspects of danger, like the presence of broken fibres in wires can be avoided. However, one should bear in mind, that a regular check and replacement is still a necessity as ever. The method should not be used to overextend the lifespan of the wires to regions of unsafe conduct.

B2 : Cod-end hoists
Modern beamers are equipped with trawl winches, that contain eight separate drums, with special drums for lifting purposes. Older boats are usually fitted out with less advanced winches, with a smallar amount of drums like six.
In these cases winchheads are used for hoisting purposes, a procedure that is potentially dangerous. The procedure involves more crew members, that should co-ordinate their acitivities very precisely, otherwise the hoist may slip and fall or hands are liable to get caught by the rope. A beam trawler may easily reach 40 hauls per week. With 40 weeks of fishing per year, this accounts to 1600 hauls and each haul two men are occupied with cod-end hoisting, so there is ample opportunity for accidents!
The use of cod-end lifting divices has been promoted therefore, resulting in six boats using an additional electrical or hydraulical system at the present day.
Investment costs are rather high however, $ 12.000,= for an electrically driven one and $ 18.000,= for a hydraulically driven system. Economic benefit is not a primary outcome, but it may be expected to improve safety considerably, and result in less men needed on deck while hauling and longer rest periods between hauls, both of which may eventually cause a decrease in accidents.
In some cases skippers changed over to use drums of the main trawl warp winch for hoist purposes, normally utilised to ascertain quick release of the warp attachment to the boom when a gear fastens. The warp release is then solved with a slip hook. Care should be taken however not to improve the safety of one procedure at the cost of creating less safety in others!

C. Procedures to land boxes of fish ahore.

Some older boasts were still using a wooden board for landing boxes of fish ashore. Using the winchhead, with all its potential hazards, two or three boxes of fish and ice are lifted on the woorden board and pulled to the quay by a man on the board, over a distance of some 10-15 meters. This job is not without danger as the board is placed rather high above decklevel and exposed to weather conditions that could result in a slippery surface. In a number of occasions accidents happened, and some of them were fatal.
RIVO developed a prototype of a lifting device, consisting of a boom and a separate hoist winch and cable, to be operated remotely by one man. The winch-motor has two speed values to enable slow or quick displacements. The transmission is self-breaking. The fish-boxes are in a selfighting clamp, that opens automatically when the hoist is picked up put aground. The boom can be swung around easily be hand or by an additional rope.
The prototype was not commercialised, but the idea has been picked up by some fishermen.
Nowadays similar devices are used on a dozen boats, like the KW-221, KW-81, UK-53, GO-44, UK-141. The total investment will be approximately $ 3.000,=, showing the potential for low cost improvements.

4. CONCLUSIONS AND RECOMMENDATIONS

The cases mentioned above do show, that in many occasions minor investments are sufficient and simple engineering can be applied to improve unsafe working procedures onboard of fishing vessels.
Success of these solutions depends largely upon proper introduction and guidance in practice and the fact that, apart from improvement in safety, some economical gain is also to be expected or if such gain is not clearly to be anticipated, the investment is low indeed.
Research institutes like ours can play an important role in the process by developing better procedures or even prototypes of machines and introducing them to the fishermen and potential producers, but can also act as advisers to people concerned with legislation. A common attitude among fishermen, and perhaps among all of us is to be reluctant as it comes to take action.
Calculations and estimates of pay-back-periods may be very helpful in the process of convincing people to change their ways.
Safety is not only a matter of engineering, but certainly also a matter of mentality. In some cases mere lack of knowledge to apply materials properly adjusted to their aims causes unsafety, for instance when using cast iron chains with low tensile strength for hoisting purposes.
Therefore RIVO's Technical Research Department allocates substantial time and effort to promoting safety onboard Dutch fishing vessels.

LITERATURE

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(2) Dr. D. Jegaden.
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(4) M. Andro, P. Borval, G. le Bouar, C. le Pluart.
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APPENDIX I

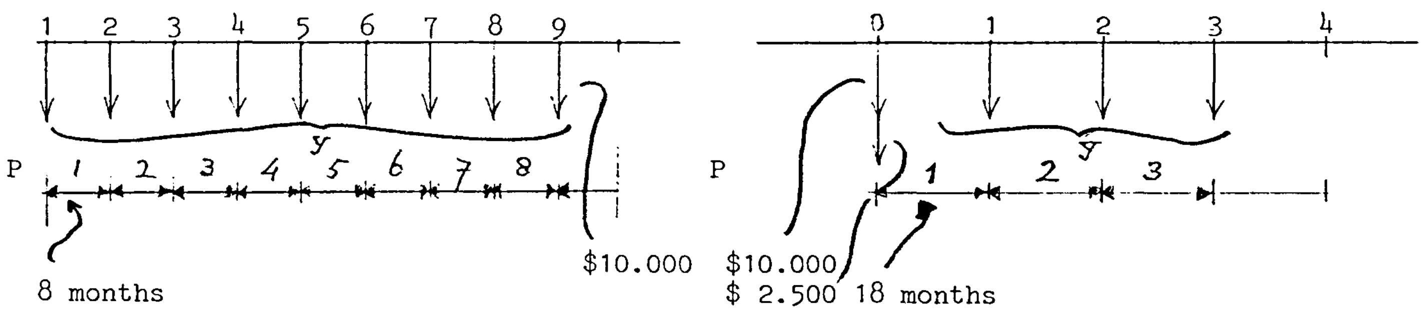
Economical Appraisal of warp greasing device:

An economical comparison between the two alternatives leads to interesting conclusions.
We define case A as the 'defender' , the absence of any greasing activity during the lifespan of warps, and case B as the 'challenger' with additional investment of \$ 2500,= for the greasing machine, leading to a longer lifespan for the warps.

For case A every 8 months an investment in new warps of \$ 10.000,= is needed, whereas in case B the same investment will be necessary every 18 months.
Additional running costs of the greasing device are neglected, such as insurance costs for the device.
The lifespan of the greasing device is taken at 72 months, being the smallest common denominator. No scrap value is assumed for the device. This means that the owner must replace the device after the period of 72 months.
Depreciation and taxes are not taken into account.
An interest rate i = 10% has been taken.

Now we can draw cash-flow diagrams for both cases.

A B



The present worth of all costs in cash-flow A becomes:

$$PW_A = P_A + (UPWF)\left\{ \begin{matrix} (\frac{8}{12} * 10\%) \\ 8 \end{matrix} \right. * Y_B$$

$$= \$\ 10.000 + \$\ 60.492 = \underline{\$\ 70.492}$$

This can be converted to average monthly cost of

$$AMC_A = \left\{ CRF \right\}_{n=72}^{i=10/12} * PW_A \qquad = \underline{\underline{\$\ 1.295}}$$

with PW = present worth of all costs

P = initial cost,

Y = periodical additional costs

i = interest rate (10% on a yearly basis)

n = number of months or other discounting time unit (i.e : A = 8 periods, B = 3 periods)

UPWF = uniform present worth factor = 1/CRF

$$CRF = \text{Capital recovery factor} = \frac{i \cdot (1+i)^n}{(1+i)^n - 1}$$

subscripts one for cases A and B.

Nomenclature is similar to Benford's. (5)

For cashflow B we find:

$$PW_B = P_B + (UPWF)\left\{ \begin{matrix} (\frac{18}{12} * 10\%) \\ 3 \end{matrix} \right. * Y_B$$

$$= (\$\ 10.000 + \$\ 2.500) + \$\ 22.832 = \underline{\$\ 35.332}$$

And this will lead to an average monthly cost of

$$AMC_B = (CRF)\left\{ \begin{matrix} i=10/12 \\ n=72 \end{matrix} \right. * PW_B \qquad = \underline{\underline{\$\ 649}}$$

Thus $AMC_B < AMC_A$, or it pays off to buy the greasing device.

Without interest charges, the time to pay back the investment of \$ 2.500,=. will be:

$$\$\ 2500 / (AMC_A - AMC_B) = \$\ 2500/_{646} \approx \underline{\underline{4 \text{ months.}}}$$

which is a very suitable value.

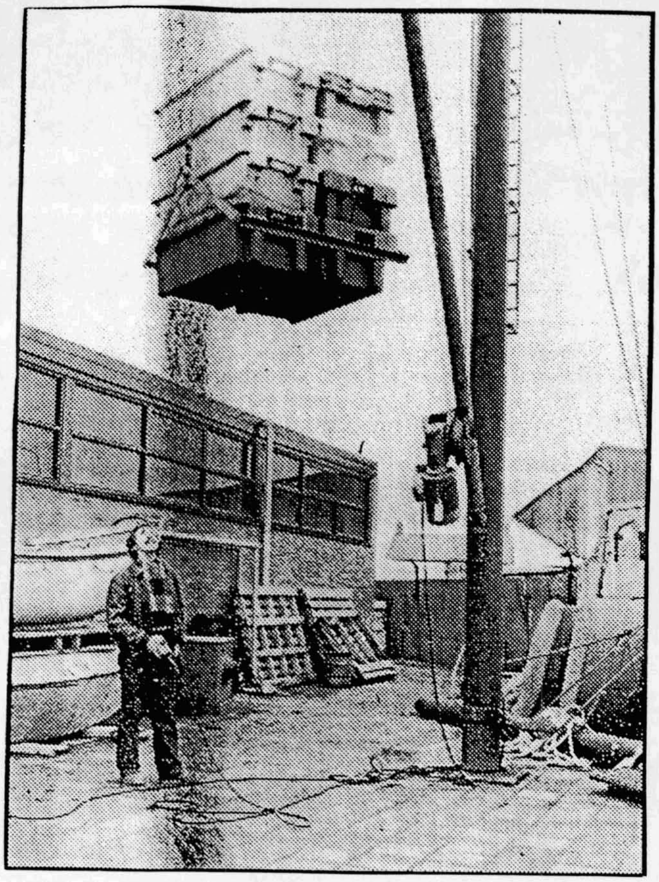


Figure 1 K. Bouwman demonstrates his remotely controlled lifting device.

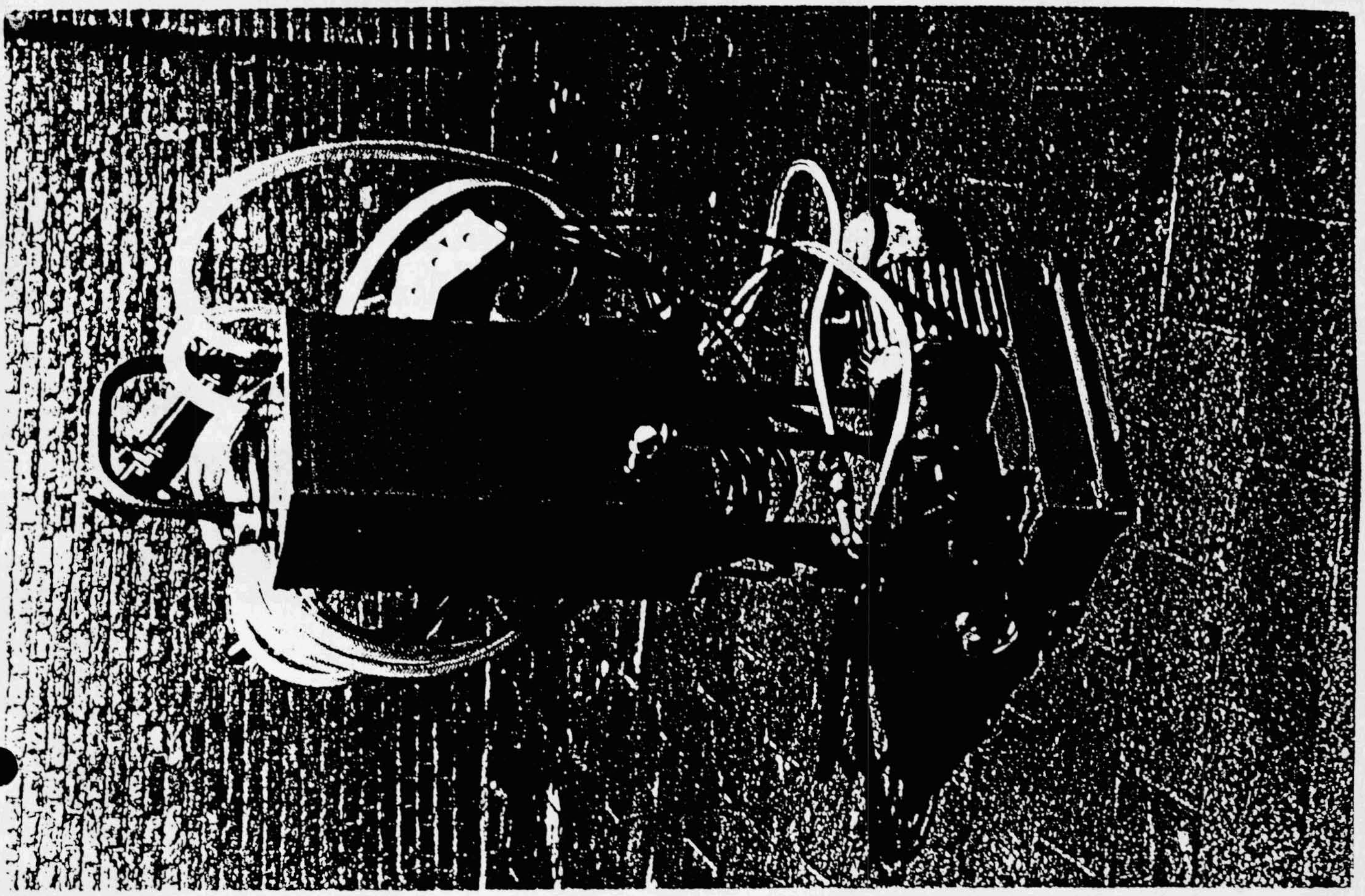


Figure 2 - Warp greasing unit.

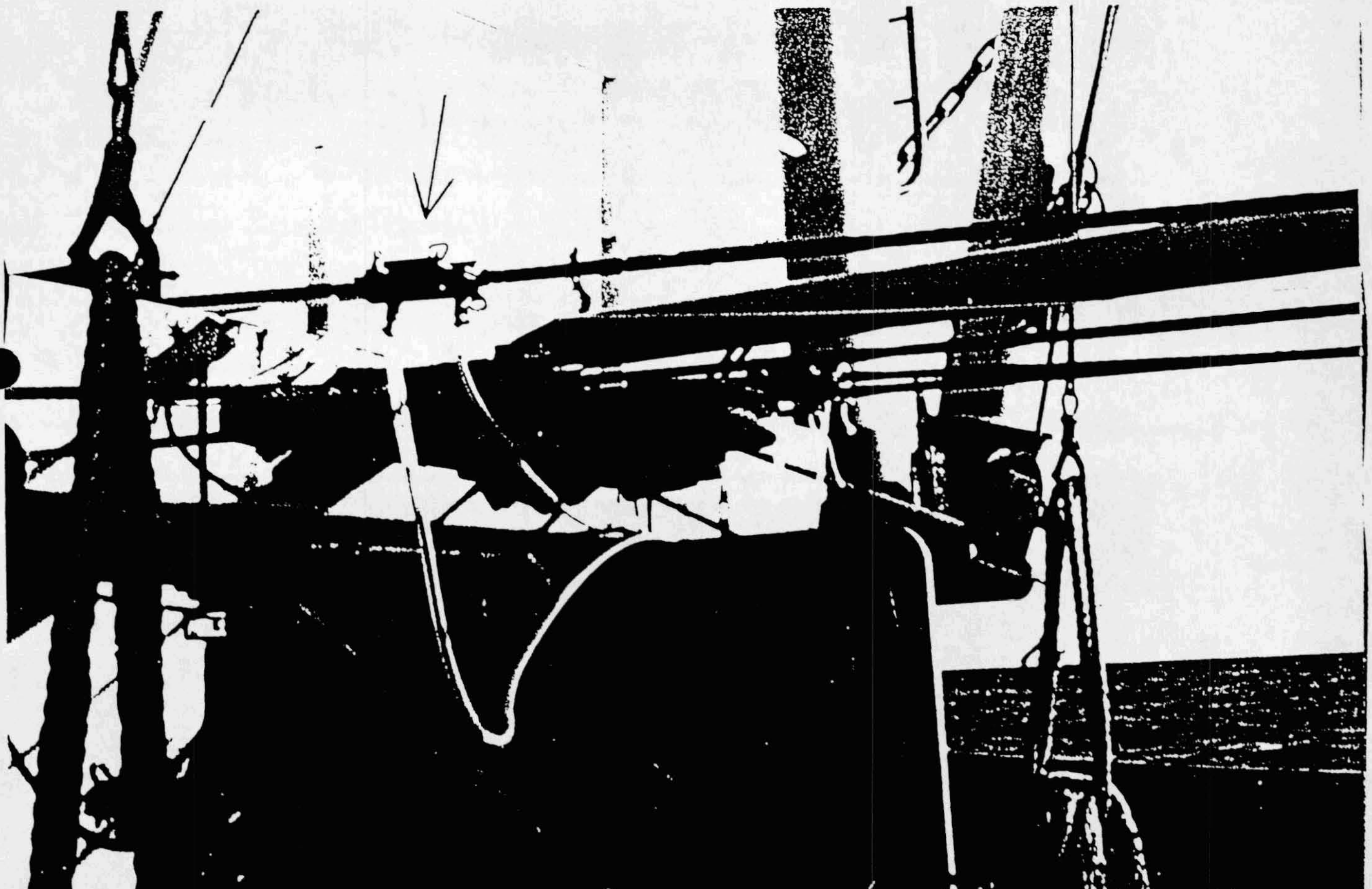


Figure 3 - Greasing device mounted on warp.