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THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Reduction/Elimination of Welded Temporary Attachments

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

in cooperation with
National Steel and Shipbuilding Company
San Diego, California

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**NSRP 0528
PROJECT 8-97-1**

**REDUCTION / ELIMINATION OF
WELDED TEMPORARY
ATTACHMENTS**

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March 1999

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1.0 INTRODUCTION

Modern shipbuilding is characterized by tight schedules and a high level of competition. In order to succeed, shipyards all over the world need to minimize time and effort spent fitting together the various components of the ships. This necessity requires constant rethinking and updating of the production techniques. Fifty years ago iron workers were pounding and peening hot rivets to fasten the overlapping plates of the hull. Fifty years from now they will control robots capable of laser welding prefitted and outfitted sections of structure. The road to improvement is challenging but we must persist in order to survive. Currently we buy standard structural shapes such as flat plates and straight profiles and through a labor intensive process we form and weld them into ships. We accomplish this metamorphosis using a number of tools. Some of these tools are large, like automated burning machines and hydraulic rollers, others are small, like torches, hammers, dogs and wedges. They all cost money and require time and effort to use them. Some are more effective than others. The optimization of them could substantially reduce the cost of building ships.

1.1 Scope

The purpose of this project is to develop comprehensive guidelines aimed at reducing or eliminating welded temporary attachments used by shipyards to fit and modify the shape of steel structures. Furthermore, the project will explore alternatives to welded padeyes used for lifting and turning steel structures.

1.2 Background

Temporary welded attachments have been used by shipyards for many years as fitting and fairing aids. They are favored by shipbuilders because welding provides a fast and effective means of connecting tools to the workplace. Furthermore, welded attachments are relatively small, light, simple to use and they can be applied, modified, and removed using the tools already at hand, i.e. welding guns, cutting torches and sledge hammers. The main disadvantage in their usage is the surfaces damage suffered upon their

removal. The following clad-welding and grinding job necessary to repair the surface is expensive, time consuming and represents a "non value added" step to the shipbuilding process. Much energy has been spent over the years to find better tools. New devices like electromagnets, vacuum pads and clamps have been designed and built. Some of them proved to be very effective and are now commonly used by shipyards. Others were not effective and shipfitters soon reverted back to using the old and tried welded devices and put up with the repair work.

Good examples of this love / hate relationship between fitters and fitter aids are magnetic and vacuum saddles used to fit stiffeners onto flat panels. Every shipyard we visited has them. They work remarkably well, although in a narrow band of conditions. They are supported by management at all levels even though they are relatively expensive to purchase and maintain. They are there, somewhere in the shops. We must be walking the tables consistently during their well deserved lunch break because we never find them working. Interestingly, when we ask the fitters about them, they all have good words; they like them a lot but not for the job at hand; they use them a lot but not right now. Once again the plate is held against the stiffeners by welded saddles and wedges that happen to be at the right place at the right time.

Ultimately, the success of a fitter aid cannot be measured on the drawing board, it must be accepted, proved and finally adopted by the production workers. New tools cannot be just good enough, they must give the workers clear advantages, allow them to do the job easier, faster and overcome the lore of reversing to "the way it has been done before."

2.0 TECHNICAL APPROACH

The technical approach consisted of a review of public data and an on-site evaluation of fittings aids in the field. The University of Michigan Transportation Institute was asked to conduct a literature search and U.S. yard survey. The results of their work are included in this report as Appendix I. Not much in the way of new fitting tools was found to be available to the shipbuilders, but their discovery includes some very interesting concepts worth further exploration. The use of adhesives as an alternative to welding for attaching, lifting and turning padeyes is one. The development of a turning jig capable of grabbing and rotating entire blocks without using cranes or lifting padeyes, is another.

The NASSCO based research effort was channeled in two directions:

- Audit our internal process and develop a categorization and evaluation work-sheet,
- Benchmark our techniques against overseas shipyards in Europe and Japan.

We collected and evaluated data relative to numerous commonly found fitter aids and we included a selection in the result section of this report. We observed some trends in fitting aid development common to all shipyards visited. A discussion of the observations can be found in the conclusion.

3.0 RESULTS

In order to eliminate welded fitter aids, shipyards must supply workers with alternate viable methods of fitting and fairing steel structures. The search for such alternatives is often very frustrating. The tools we aim to replace have been used for many years. They have been refined, customized and gained acceptance by the workers using them. The same workers are naturally very reluctant to change their work habits, often because the proposed alternative does not offer substantial visible advantages over the old one.

It is our belief that any serious attempt to reduce or eliminate welded fitter aids cannot be limited to tool redesign but needs to extend deep in the shipbuilding processes, changing them and reducing or eliminating the need to use the fitter aids.

3.1 Engineering Instructions and Production information.

The best way to reduce or eliminate the number of fitter aids used to reshape the structures we build, is to produce structures with the correct shape in the first place. This is a very simple concept to stipulate but it implies the error free implementation of perfect processes. Both factors are unattainable in a shipyard environment and will require a certain degree of compromise. Nevertheless the refinement and the control of our upstream processes, beginning in engineering, are the first steps to take toward achieving our goal.

It is the responsibility of the engineering department to produce clear and accurate production drawings. Drawings should include sufficient information for production to proceed without confusion. They should be customized for the production process they control. They also should include intermediate check points for effective accuracy control of the product. Historically, many errors in the engineering product has been generated by the interface between different engineering disciplines. Penetrations, interferences, and equipment foundations are examples of this. Other sources of errors are engineering changes and modifications made subsequent to the issue of drawings. Inaccuracies have come from such areas as the development of compound curved shell plates, molded lines, tolerances, system of measurement, scales, etc. These days, designers and engineers can use computer simulation and modeling to completely define and proof the ship in cyberspace before any drawing is released to production. Highly accurate production information should come as a direct product of this model in the form of documents describing simple, minimal step operation, customized for production needs. Much work still needs to be done to simplify and integrate this technology in order to take full advantage of it.

3.2 Production Facilities and Processes

Production information developed by Engineering is converted into structures by the production departments. The shipyard layout and its facilities define the flow of material through the yard and has a big impact on the kind and number of fitting aids needed to carry

out production. As an example, the number of lifting padeyes needed depends upon the times structures have to be lifted using overhead cranes. This number can be reduced by using transporter trucks loaded by conveyor belts for all movement prior to block erection. Parts should be defined and oriented ready for the following stage of construction at the earliest possible time, thus reducing the turning and manhandling needed. Automatic panel lines can assemble plates and stiffeners with limited human intervention. Small hand tools used for fitting plates and stiffeners are eliminated by using built-in facilities like hydraulic plate clamping at the seam welding station and hydraulic rams at the stiffener fitting station. Material should be stress free at the start of fabrication. Tumblers and rollers located after the shot-blast and primer line will ensure this. Fabrication shops should be enclosed and kept as much as possible in a stable environment; This will reduce inaccuracies caused by thermal expansion. Correlation between layout and burning should be checked and maintained. Fabrication should be automated as much as possible. Successful automation requires the understanding and the control of the process being carried out. This translates into a reduction of the error rate and a higher accuracy of the product. Automation eliminates the possibility of human errors. Many modern shipyards use robots to carry out activities like welding, fitting, lay-out, cleaning, painting etc. Robot performance varies from outstanding to poor. The return cannot be measured only in direct labor savings on the shop floor. Robots perform at their best doing repetitive simple tasks and require structures to be standardized and designed for easy producibility. Automation is slowly changing the way ships are designed and constructed. Accuracy will come as a byproduct of this change. Accurate parts will join together in accurate subassemblies, assemblies and blocks. Blocks will join together in dimensionally accurate ships at a reduced cost. Shipbuilding as a whole will require less effort and fewer fitting aids will be used in the process.

3.3 Fitting Aids

This category includes most of the small tools purchased or fabricated to aid the fitters in their routine work. Historically they have been the subject of scrutiny by many people and studies aimed at simplifying the work and reducing shipbuilding costs by improving on them. Interestingly, many of these small tools have mutated with

time, but have retained the same basic working principles of the original prototype perhaps developed for wooden vessels long ago.

A good set of fitting and fairing tools should be available to shipbuilders. They should be inexpensive to acquire, easy to use and versatile. Shipyards could monitor their usage as a gauge of the internal product quality. Change and improvement in this tool set should come as process development and not as a localized effort. This is not to stifle creativity and ingenuity but rather to retain control of the fitting and fairing process.

Currently, data relative to fitting aids usage is scarce and inconsistent. Most yards keep track of the number and the kind of tools fabricated and issued by the shops but once in the field these tools are reused several times and often modified into different shapes before being discarded or returned to the shops for refurbishing. This variable life cycle reduces the usefulness of the original data to a fabrication shops cost collector for fitting aids as a whole.

For the purpose of this study we collected a set of commonly used welded fitting aids and compared them with non welded alternatives. Our goal is not to provide a comprehensive list of tools available but to show samples and suggest a way to assess their value and relative cost. Shipyards must rely upon their internal knowledge and experience to customize this set to their advantage. A sample set analyzed on work-sheets is included in Appendix II. Included in this set are three tools developed during this study. Two are hinged stands, one for angles and one for bulb plates. These are modified versions of stands used routinely and effectively at KHI to set stiffeners of different shapes and sizes onto flat plates. Our prototypes have been fabricated, field tested and, only after minor modification, they have been accepted. They are currently working daily on the assembly tables and two small sets of fifty units are already in requisition. A picture of them is on page 10 of Appendix III of this report. The third tool is a cam saddle capable of locking onto bulb plates and used to fit web frames on plates previously stiffened with bulb plates. Our sketch was derived from a tool seen in the FINCANTIERI (Monfalcone) yard. A picture of it is on page 8 of Appendix III of this report.

3.4 Rigging devices

Because of the high cost of lifting, turning and moving heavy loads around shipyards, some effort was spent in analyzing different

rigging equipment and techniques. The intent was to discover alternate methods of handling loads that did not require the welding of padeyes and local reinforcement onto the structure to be lifted. Many alternatives are available: Clamps and electromagnets are commonly used in place of welded padeyes to handle plates, profiles and subassemblies in steel yards and fabrication shops. The same devices can support block construction inside assembly shops where conveyor tables can move entire blocks to different work stations. Outside the shops, blocks can be moved efficiently to the outfitting area by transporter trucks.

Turning blocks in ship's coordinate and block erection are done almost exclusively using overhead cranes. Most of the time the connection between the crane hook and the load is obtained using welded padeyes. Even if it is theoretically possible to lift entire blocks using non welded devices, safety, equipment availability and capacity limitation discourage any change in this standard and shipyards must find ways to reduce rigging costs while working within such constraints. At times padeyes can be cut directly into the structure to be lifted. In other circumstances structures can be modified at the design level to include lifting eyes and reinforcements. Sometimes it is possible to leave the lifting eye in the structure after use and save the removal cost. Other times the padeye must be removed, but can be saved and reused at a later date. In any circumstance, construction planning and engineering have the power to modify the padeye requirement and limit its cost by changing the building strategy and physical parameters of the blocks.

Modern adhesives with shear strength to the order of 33 MPa could offer an alternative way of fastening the padeye to the load. Providing the correct physical conditions and an adequate safety factor, a 300 mm x 300 mm glued padeye could be used to lift over 50 tons. After use it could be removed by heating up the glue joint to a temperature around 300°C at which the glue loses its strength but the steel is not affected. In practice primer coat allowable shear stress, reduces considerably the joint load carrying capacity. Furthermore, long glue curing time and difficulty in testing the quality of the joints jeopardizes the validity of use. Another alternative to welded padeyes is the use of synthetic fiber ropes to cradle and lift entire blocks. Travelifts use a similar technique to lift and move small vessels in boat yards around the world and modern

synthetic fibers having tensile strength in the order of 650 MPa are readily available. The use in shipyards is limited by the high initial cost and by the danger of the slings being permanently damaged by sharp edges and hot work. However, the potential applications could be expanded by modifying building strategy and block breakdown.

4.0 CONCLUSION

The project was successful. We were able to define comprehensive guidelines to lower the cost of fitting and fairing aid usage common to all shipyards. The project results show that the solution is not unidirectional in nature but comes from a blend of technological advances, facility improvement, craftsmanship and ingenuity. Shipbuilding is an extremely competitive field, open to countries in very different states of development. Ship demand is higher than ever, but so is the world shipbuilding capacity. Shipyards in more developed countries must offset the higher cost of labor and real estate by improving their efficiency and quality of their product.

The majority of the yards we visited are investing large capital in new equipment, personnel training and state of the art technology. The goal is to design and construct better and less expensive ships. All shipyards recognize accuracy as the key factor in the reduction of costs. The trend common to the most advanced yards is to concentrate the efforts in obtaining flawless products from the upstream stages of construction and harvest the fruits of this effort at assembly and erection.

Fitting aid reduction is never a direct goal, it happens as a consequence of accuracy and producibility improvement. All yards use welded attachments, in some cases the welding is limited to studs and mushroom fittings. In other cases, welded aids are built so they can be used several times and designed so they can do several different jobs. Common to all yards we visited is the presence of one or more maverick craftsmen who create small tools specifically made to accomplish specific tasks. These tools often have attractive names, are brightly colored and work very well. Soon the job is done, foreman and workers move on, and the tool is abandoned at the edge of the table never to be used again. Next time a similar fitting challenge will come about. A different maverick will engineer an equivalent tool and the whole process will start again. Although this

effort is worthy of support, as a whole it has negligible value. Many hours are spent engineering and fabricating tools specific to a job. The same amount of time spent modifying the product design or the production process could eliminate the need altogether for the particular tool.

5. I U.M.T.R.I. REPORT

**Final Report for
Project N8-97-1**

**REDUCTION/ELIMINATION of
WELDED TEMPORARY ATTACHMENTS
SURVEY AND LITERATURE SEARCH**

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Appendix CSP-8 Panel Report

I. INTRODUCTION

The Marine Systems Division of the University of Michigan Transportation Research Institute (UMTRI) has been working with National Steel and Shipbuilding Company (NASSCO) to perform a literature search and survey of U.S. shipyards to support the project "Reduction/Elimination of Welded Temporary Attachments." Basically, UMTRI performed a thorough, but quick, literature search and survey of shipyards relative to welded and nonwelded temporary attachments.

II. LITERATURE AND INTERNET SURVEY

UMTRI has done extensive searches of numerous literature sources but has not found anything in the literature. It appears that rigging, welded and nonwelded temporary attachments are not a popular subject for those that publish technical papers.

The internet was a better source of practical information. Normal items like rigging sources, vacuum lifters, magnetic grabs, etc., were found. Appendix B lists some of these sources. Web sites and addresses are added (and may change) frequently, so more information is available if needed.

III. SHIPYARD VISITS

Al Horsmon conducted a tour of six (6) shipyards from 24-26 February. Appendix A is a photographic record of those visits. At the end of this appendix are more detailed descriptions of the items observed. Shipyards visited were:

- Ingalls Shipbuilding, Pascagoula, MS
- Alabama Shipyard, Mobile, AL
- Bender Shipbuilding, Mobile, AL
- Avondale Shipyard, Gulfport, MS
- Halter Marine, Gulfport, MS
- Avondale Shipyard, New Orleans, LA

Leon Woody, Steel Superintendent at Alabama Shipyard seemed the most proactive about nonwelded attachments. He showed a display of numerous grabs and jigs, and led a tour of the yard looking at others in use. Unfortunately, they did not have a lot of work in the yard at the time.

Mr. L.P. “Trip” Trepagnier at Avondale presented their *Yellow Tools Manual* which contains specifications, use instructions and drawings for nonwelded temporary attachments. A number of those tools were in use around the yard. Unfortunately, he could not secure the release of the manual for use in the project. Perhaps having them review the draft final report could convince them there is something of value coming out of the report and they will let us reference the *Yellow Tools Manual*.

Pat Roberts of Bender showed a number of “buttonhook” attachments for staging. Additional comments on these and other attachments are in the "Analysis" section below.

However, most of the yards, even those with many innovative tools, showed many of the standard welded temporary attachments. A brief report was given to the SP-8 Panel meeting in La Jolla, CA (San Diego area) and is attached as Appendix C.

IV ANALYSIS

The philosophy behind the nonwelded temporary attachments in use in many of the yards could be applied to more uses and other attachments in shipyards. For example, (referring to Appendix A) the welded lugs used in Photo 4 could easily be replaced by an arrangement used to hold the round sections together in Photo 31. A combination of a chain extending from the top of the house section through the opening for the ladder at the lower left side of the photo could exert adequate force to hold the units together.

The alternative methods for holding the edges of two units together are shown in Photo 12. The stud welded attachments are easier to apply and cause less damage to the underlying structure when removed. The buttonhook staging (photos 16 through 20) follows this idea, but Photo 25 shows this concept taken a step further by avoiding welding all together. These are basic concepts that need to become standard work practice on the shop floor through regular training of the workers in that discipline.

The most difficult attachments to replace are the lifting and turning lugs shown as typical in Photos 1, 6, and 10. The safety and potential cost issues involved in dropping a large unit during handling have led to widespread use of these massive lugs. Alternatives discussed with some of the yards visited were:

- slings arranged in multiple layers to transfer the weight of a unit as it is turned
- adhesives to hold units or to act as anchors for wire slings
- dedicated turning stations that use clamps to hold units in a ring frame that then turns the unit over before it is set back on a transporter

A Marine Travelift (contact information is listed in Appendix B) uses multiple slings to lift and carry large yachts and commercial craft. Thus lifting and turning units with similar equipment, without welding lugs, is technically feasible, but a cost benefit analysis would have to be performed to see if it is economically feasible. Slings arranged with grabs and clamps to maintain control of a large steel unit as it is turned could be engineered.

Adhesives can generate up to 4,000 psi in lap shear. A pad arranged to place an adhesive in shear but provide a concentrated attachment for a hook is also technically feasible. A peel and stick picture hanger is a common practical example. A 20 in² pad could provide an attachment point to pull or hold 10 tons along the side of a unit with a safety factor of four. The pad would also have to be designed so that it could be peeled off for removal, as shown in Figure 1, because adhesives have much less strength in peel.

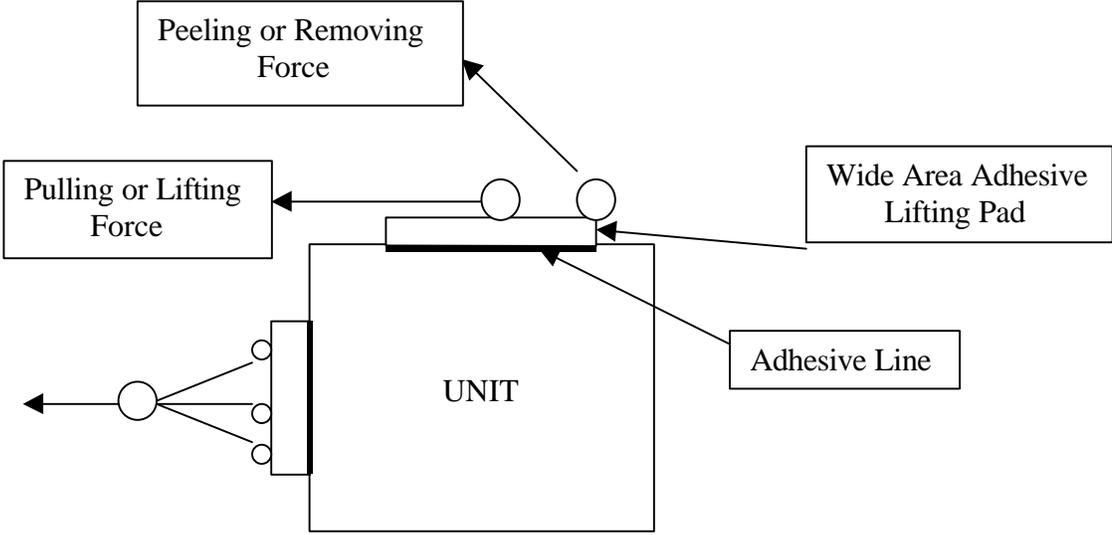


Figure 1

However, a steel surface would have to be blasted or ground clean to support very high strength adhesives. Paint systems have produced as little as 200 psi shear strength, so surface preparation would likely be necessary to support adhesive lifting pads.

Railroad bulk transfer facilities use rail car unloading stations that clamp pairs of 120 ton cars into a ring frame, then turn the cars completely over to dump the cargo out the top. A shipyard with an efficient transporter system could transport units to a dedicated turning station, designed with adjustable clamps to hold various configurations of similar sized units.

The following quote was taken from the mining web site:

“Strachan & Henshaw were responsible for the design, limited supply, installation, supervision and commissioning of this single cage triple car dumper at Qinhuangdao Port in China. The triple car dumper, one of two supplied by Strachan & Henshaw, forms part of a brand new fully integrated system to increase the port’s export capacity by 30 million tons per year. The dumpers are capable of handling cars with a capacity of 73 tonnes, and an unloading rate of 90 cars per hour.”
(<http://www.mining-technology.com/contractors/materials/strachan&henshaw/index.html#TEXT3>)

Mark Miller of Strachan & Henshaw’s Melbourne office stated that the base cost for such a unit is around \$1.5 million, not including the rail interfaces. A shipyard could manufacture such a unit to Strachan & Henshaw’s design. Figure 2 shows their bulk rail car dumper. A shipyard unit would require the capability of handling various size and shape units, but would not need the agility to handle 90 units per hour, and so should cost much less.

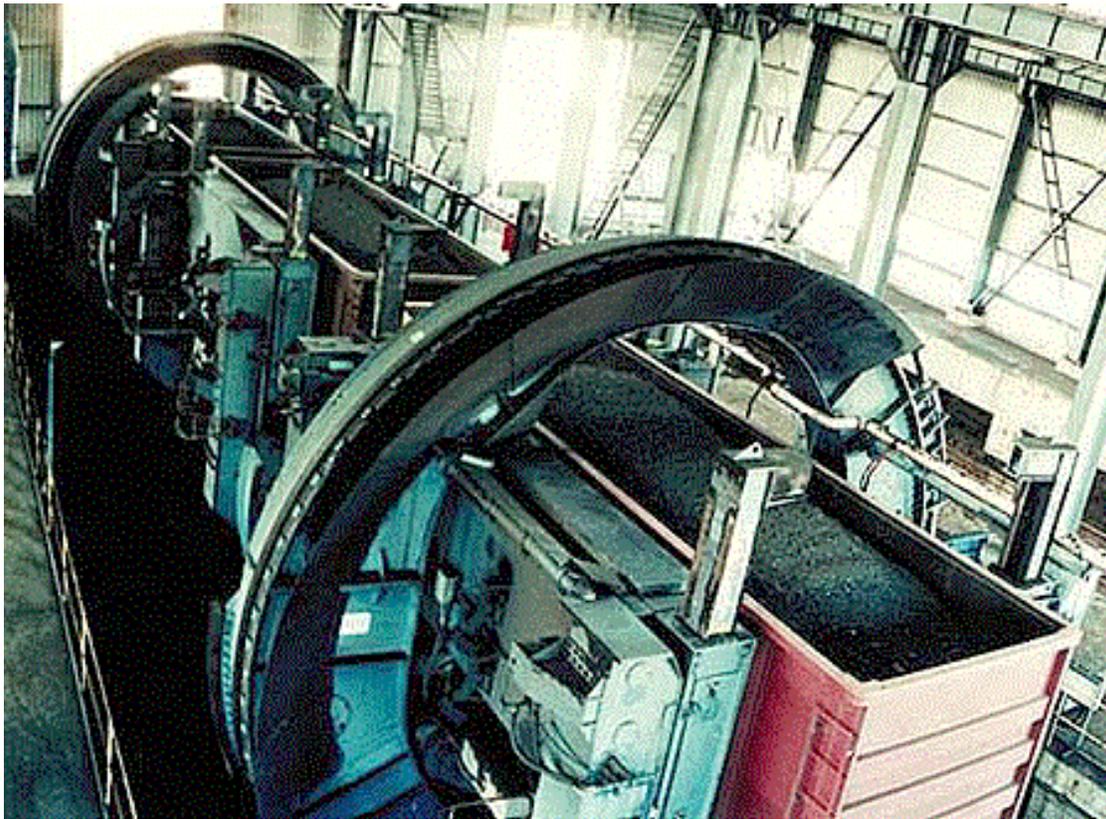


Figure 2. Single Cage Triple Car Dumper at Qinhuangdao Port."

The following information was found at the web site http://www.mining-technology.com/contractors/materials/elecon_materials/index.html#TEXT2. Elecon Engineering designed and built most of the rotary wagon tippler shown in Figure 3. See Appendix B for contact information.



Figure 3. Rotary wagon tippler: Designed for unloading broad-gauge open rail wagons with a gross load up to 110 tons.

V. Recommendations and Future Work

Some of the concepts and items displayed in the photographs and discussed above should be investigated further for feasibility and cost effectiveness. The concepts used for small items, such as buttonhooks, could be applied for heavier requirements, such as ganged, stud-welded pins in place of lifting eyes. Properly engineered, adequate safety factors could be developed. The options identified in the report should be investigated further by NASSCO for feasibility, safety, cost and benefit.

APPENDIX A

PHOTOGRAPHS



Photo 1. Welded pad eye with added angle support and chafing guard around bottom plate.



Photo 2. Welded temporary supports of scrap metal.



Photo 3. Welded butt joint strongbacks.

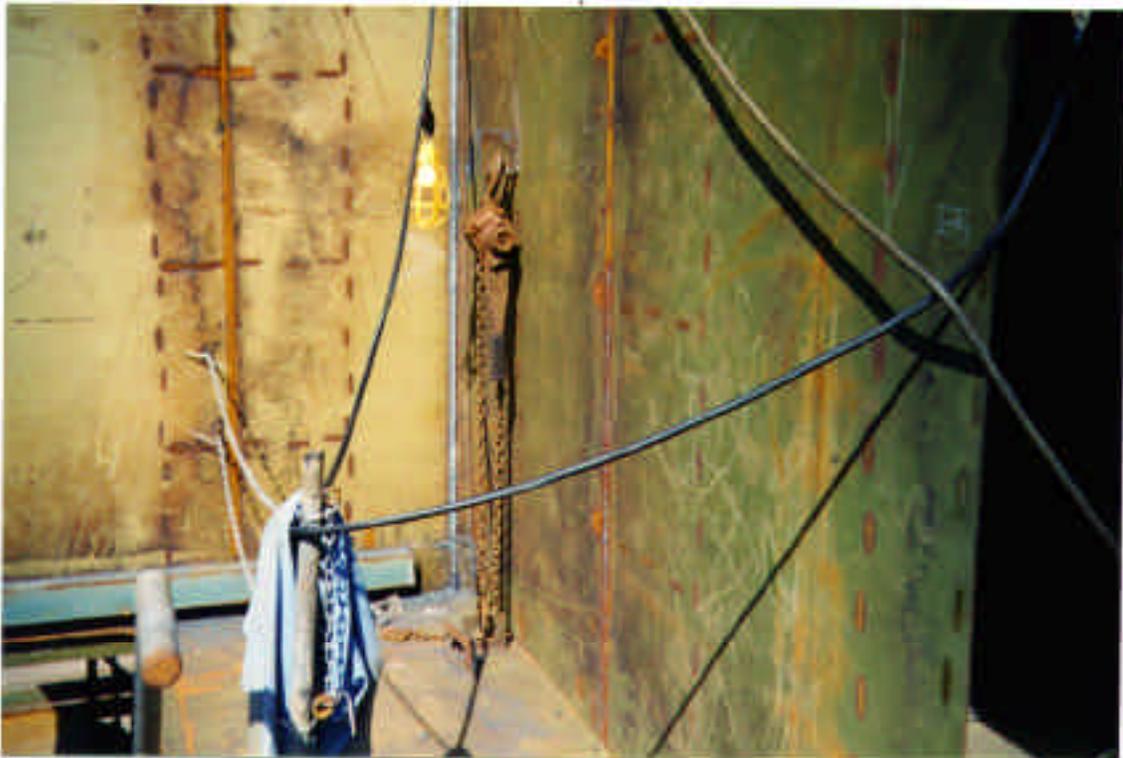


Photo 4. Welded lugs are used for the chain fall.



Photo 5. Welded temporary lifeline stanchion.



Photo 6. Welded pad eyes.



Photo 7. Welded temporary supports, partially cut and awaiting removal.



Photo 8. More welded temporary supports and temporary lifeline stanchions.



Photo 9. Remains of temporary pad eyes, more temporary pad eyes in upper right.



Photo 10. More welded temporary pad eyes.



Photo 11. Temporary support stanchions. Clamped tops, welded or clamped bases. Welded lifeline stanchions in background.



Photo 12. Deckhouse erection butt joint - shows the old method (fillet welded flat bar string backs) and a new method (stud-welded threads with boxed stringbacks) of alignment.



Photo 13. Slotted "T" through the butt with a long wedge. Welded strongback also.



Photo 14. Slotted "T" through the butt with a long wedge - from the inside.



Photo 15. Magnetic hold-down device with manual hydraulic piston to push stiffeners.

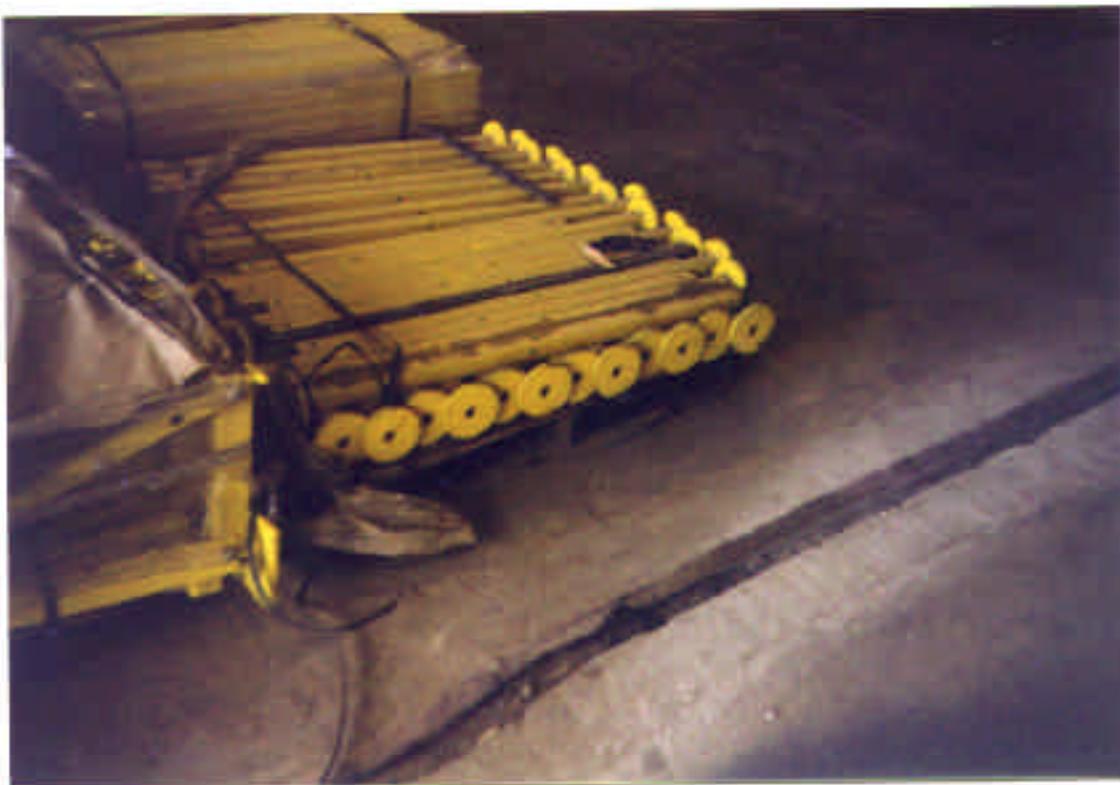


Photo 16. "Buttonhook" staging pieces.



Photo 17. More "Buttonhook" staging pieces with adjustable angle supports.

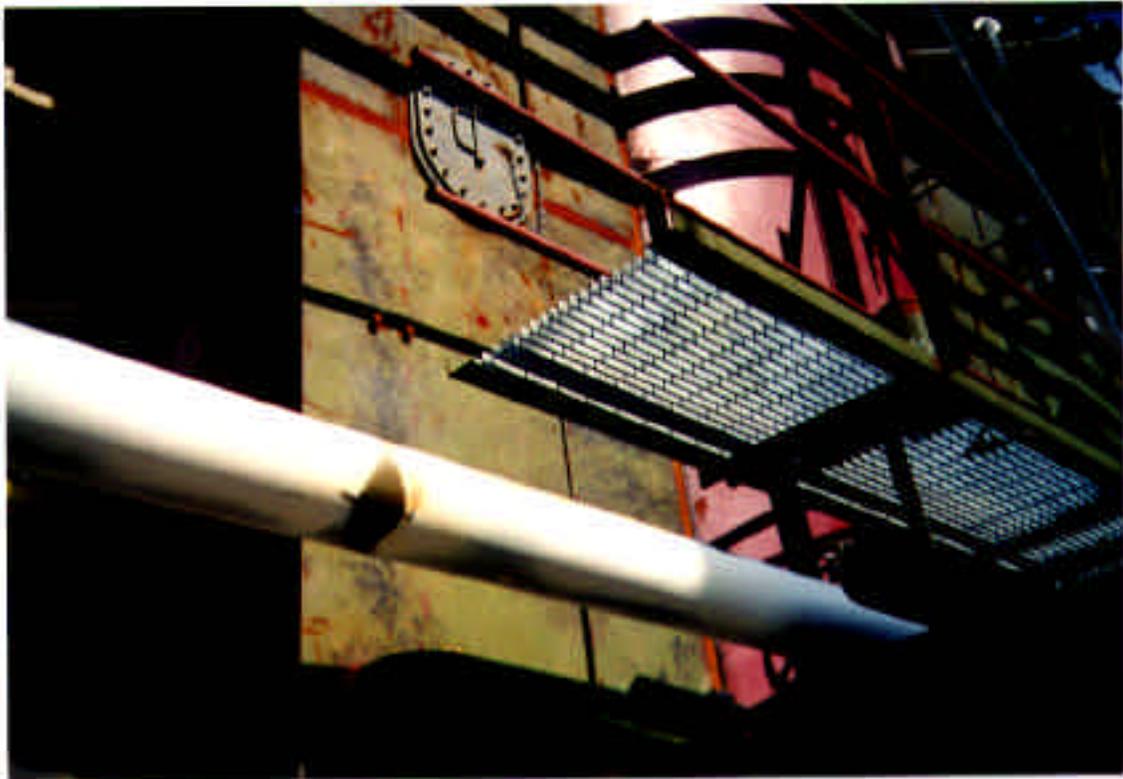


Photo 18. "Buttonhook" studs on a unit.



Photo 19. "Buttonhook" staging brackets in use on a mud tank for an OSV.



Photo 20. "Buttonhook" staging brackets in use.

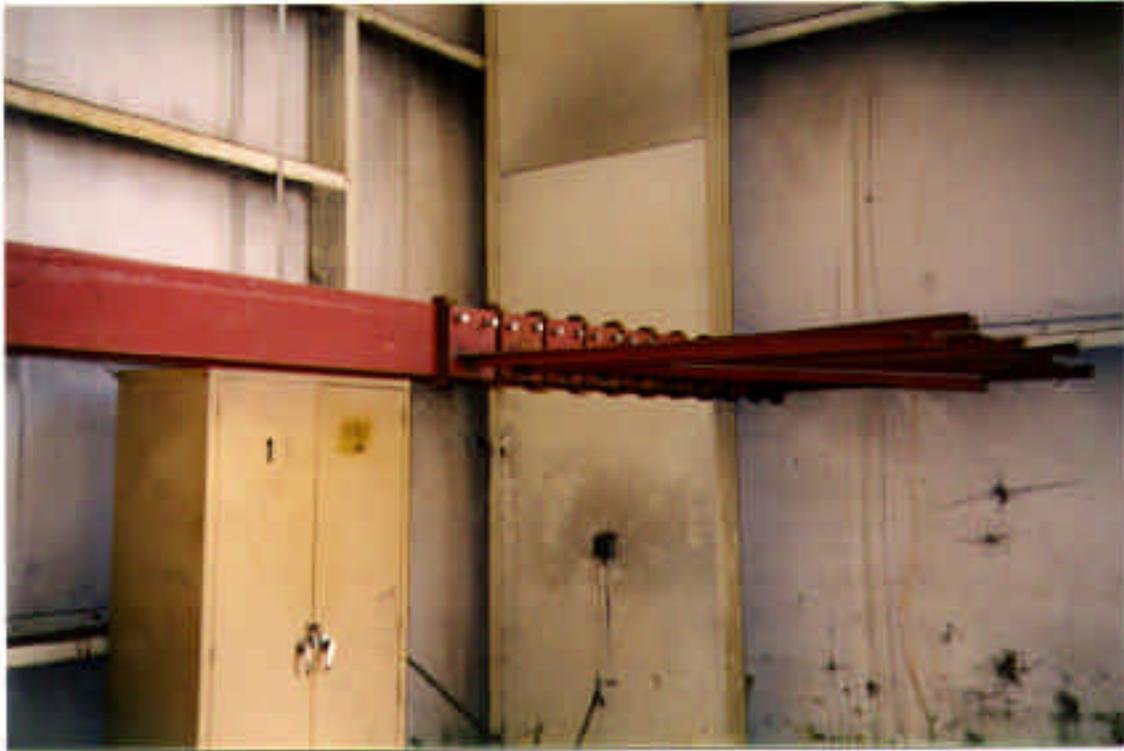


Photo 21. Adjustable alignment tool. Angles welded to the sliding base provide support for framing members. An I-beam is the fixed base. This tool is in storage.



Photo 22. Plate grab support. A series of plate grabs on an I-beam strongback support a stiffened plate blanket until it can be tacked.

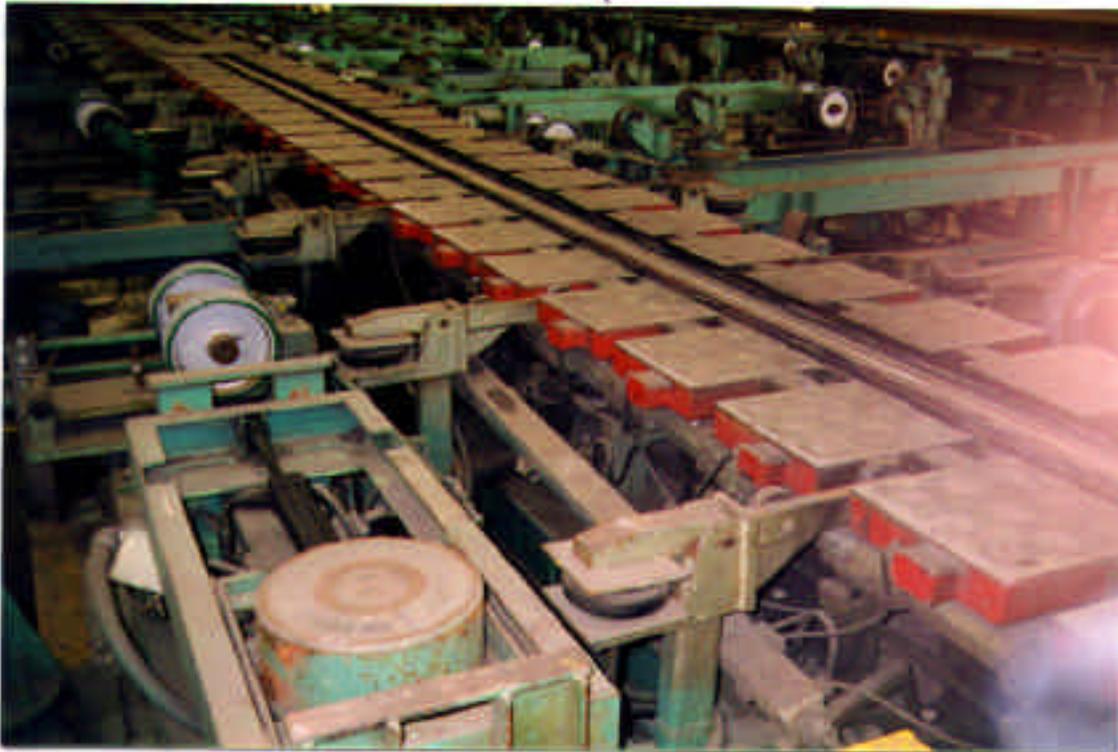


Photo 23. Magnetic pads on a panel line. The series of pads holds two plates in position while the joint is welded.



Photo 24. Non-welded attachment tools arrangement. Includes grabs, scissor grabs, bolted safety stanchions, vacuum/hydraulic hold-down, and C-clamp grabs.



Photo 25. Staging brackets bolted to a series of angles hanging from the side of the unit.



Photo 26. Bolted ladder clamp.



Photo 27. Bolted staging supports and ladder clamp.



Photo 28. Temporary T joint clamps in production..



Photo 29. Brackets for dogging plates in production.



Photo 30. Finish welded dogging plates.



Photo 31. Chain Fall pulling pipe sections together.



Photo 32. Seissors plate clamp.

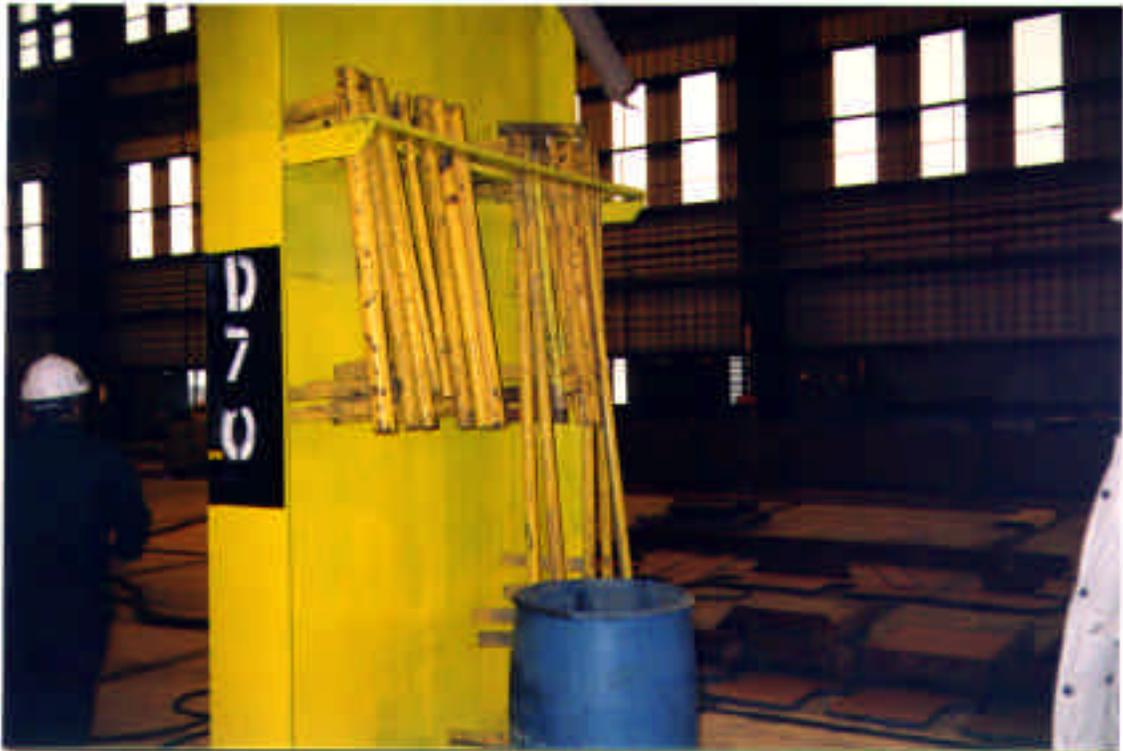


Photo 33. "Yellow Tools," in a dedicated rack - these for a specific stiffener spacing.



Photo 34. More "Yellow Tools."

Appendix A Commentary

Following are additional comments to expand on the photographic record.

Photo 1. Welded pad eye with added angle support and chafing guard around bottom plate.

This is indicative of the many welded pad eyes used in many yards. These are heavy plates with reinforced attachment points and, in many cases, reinforced eyes to take the large concentrated rigging loads. These are specially designed and fabricated for certain categories of loads. However, because of the damage involved in cutting them off, they are usually scrapped after use. Photos 6, 9, and 10 show more of these.

Photo 2. Welded temporary supports of scrap metal.

Application of these types of attachments are of an ad-hoc nature. The material is inexpensive because they are scrap. However, installation and removal still involves a lot of welding, then cutting and grinding, and possibly weld repair, that makes welded attachments expensive. Another potential problem with use of scraps is that the usage can extend to more critical items such as temporary life rails and heavier lifting lugs without proper design and safety. Photos 3, 4, and 25 show some more scrap metal usage.

Photo 3. Welded butt joint strongbacks.

These attachments provide in-plane strength, to hold the plates together, but have little effect on out-of-plane forces.

Photo 5. Welded temporary lifeline stanchion.

This is a good candidate for replacement by a bolted stanchion.

Photo 7. Welded temporary supports, partially cut and awaiting removal.

This continues to show the added labor involved in removing welded attachments after use.

Photo 9. Remains of temporary pad eyes, more temporary pad eyes in upper right.

The pad eyes have been removed, but a fair amount of grinding must be done to repair the surface. Photo 10 is long range shot of the same area.

Photo 11. Temporary support stanchions. Clamped tops, welded or clamped bases. Welded lifeline stanchions in background.

This arrangement preserves the coating on the overhead and uses minimal welding where the stanchions land on the flat deck.

Photo 12. Deckhouse erection butt joint - shows the old method (fillet welded flat bar strong backs) and a new method (stud-welded threads with boxed strongbacks) of alignment.

The boxed strongbacks provide both in-plane and out-of-plane support and are easier to remove. Both allow placement of a backing strip for one-sided welding from inside.

Photo 13. Slotted "T" through the butt with a long wedge. Welded strongback also.

The slotted "T" is thin enough to keep the gap between plates from being too big but strong enough to align the plates in this stiff area at the turn of the bilge and bilge keel.

Photo 14. Slotted "T" through the butt with a long wedge - from the inside.

This is similar to Photo 13 but from the inside.

Photo 18, 19, and 20. "Buttonhook" staging brackets in use.

The owner of this vessel is having the studs for the staging left on the completed vessel so that they can be used later for maintenance.

Photo 25. Staging brackets (yellow colored angled piece in the foreground) bolted to a series of angles hanging (dark nearly black vertical members against the gray vertical surface) from the side of the unit.

Photos 26 - 29. Most of these are examples of simple but effective non-welded attachments.

Photo 30. Finish welded dogging plates.

The holes are for welded studs and bolted application.

Photo 31. Chain Fall pulling pipe sections together.

Where chain long enough is available, units can be pulled together from the ends as opposed to using welded eyes and a short chain across a butt.

APPENDIX B

CONTACTS

APPENDIX B

CONTACTS

Frazier Industrial

Fairview Avenue, Long Valley, NJ 07853

908-876-3001; FAX: 908-876-3615

E-Mail: frazier@frazier.com

<http://www.frazier.com/index.html>

Frazier makes KLAMP/FAST, an infinitely adjustable arm that offers unequaled flexibility for storing flat, long, or hard-to-handle items. KLAMP/FAST has many desirable features:

- Infinite adjustability due to storage arms that can be positioned anywhere you want them.
- Fast assembly and reassembly.
- Capacities to 1/4 million pounds and more
- Single or two-sided storage.
- Storage for extra-long, extra-heavy items.
- All structural steel components

Marine Travelift, Inc.

49-T E. Yew St.

Sturgeon Bay, WI 54235-1976 USA

Tel: 920-743-6202

Fax: 920-743-1622

<http://www.marine-travelift.com/index.shtml>

Marine Travelift produces large, mobile ,boat hoists that are used in marinas, shipyards, fishing ports and naval installations around the world. They are the original and largest manufacturer of this type of boat-handling equipment. The slings they use could be modified for handling interim shipbuilding products.

General specifications of 5 of 11 standard models.

| Model | 15BFM | 50BFM | 70BFM | 100 BFM | 500 BFM |
|---------------------------------|-------|-------|-------|---------|---------|
| Maximum lifting capacity (tons) | 16.5 | 55 | 77 | 110 | 550 |
| Recommended maximum boat length | 45' | 65' | 70' | 95' | 170' |
| Recommended maximum width | 14' | 19' | 20' | 25' | 36' |

Acco Systems

12755-T E. Nine Mile Rd.

Warren, MI 48089 USA

Tel: 810-755-7500

Fax: 810-758-1901

Web site: <http://www.accosystems.com>

Acco manufactures material handling equipment, overhead and inverted, power and free, automated storage and retrieval systems, chain-on-edge and chain on floor systems, low-selectow systems and flattop conveyers. They also have full material handling system implementation and integration capability including engineering, design, manufacturing and installation.

Caldwell Group, Inc.

5049 26th Ave.

Rockford, IL 61109 USA

Tel: 800-624-5216

Fax: 815-229-5686

Manufacturer of all forms of crane and rigging attachments including a full line of shop air and electric vacuum lifters.

Casper, Phillips & Associates

3340 E 11th St

Tacoma, WA 98421-4206

Tel: 253-627-7400

E-mail: casperph@cranedesign.com

Fax: 253-627-4715

Web site: <http://www.cranedesign.com/>

Casper, Phillips & Associates (CP&A) is a multidiscipline engineering firm bringing together structural, mechanical, civil, and electrical engineers. Their background includes engineering of cranes, specialty rigging, port facilities, cargo handling systems, commercial/industrial facilities, and specialty structures/machinery. They also offer services of project/construction management, accident repair, automated design and equipment automation.

Rigging International (RI)

965 Atlantic Avenue

Alameda, CA 94501

Tel: 510-865-2400

E-mail: rigging@worldnet.att.net

Fax: 510-865-9450

Since its beginning in 1969, Rigging International (RI) been working with specialized heavy lift rigging and transport needs of clients in the maritime, fossil and nuclear power, refinery and petrochemical, mining and other industries. With the changing designs of larger and heavier

industrial machinery and equipment, the state of the art in heavy lift rigging and transport is increasing in its complexity. Services provided by RI include:

- Heavy Lift Rigging
- Heavy Lift Transport by Land or Sea
- Container Crane Services
- RIMCO (Rigging International Maintenance Company)
- Nuclear Heavy Lift Services

Anver Corporation

36 Parmenter Road
Hudson, MA, USA 01749-3214

Tel: 978-568-0221 Toll-Free 800-654-3500
Fax: 978-568-1570 Web site: <http://www.anvervacuum.com/>

Anver manufactures a wide range of standard and custom vacuum lifters, offering material handling solutions for many applications. Electric, mechanical, air-powered and battery powered lifters are available. Applications engineers can help select the right lifter, system or components.

Thomas Register

Thomas Publishing Company
Thomas Register Circulation Dept.
5 Penn Plaza,
New York, NY 10001

Web site: <http://www4.thomasregister.com/ss/.512292089/loggedin.cgi>

From this web site one can get access to information on any number of industrial suppliers and manufacturers.

Strachan & Henshaw Inc.

100 Rialto Place Suite 212 Fax.
Melbourne, FL 32901 USA
Tel: 1 407 952 0116
Fax: 1 407 951 4648
E-mail. shmarketing@compuserve.com

They designed the rail car dumper shown in Figure 2 of the report.

Elecon Engineering Company Limited

Material Handling Division:

Anand - Sojitra Road
Vallabh Vidyanagar - 388 120.
Gujarat, INDIA

Tel: +91 2692 47016, 30017
Fax: +91 2692 46457

E-mail: mhe.mkt@gnahd-mhe.globalnet.ems.vsnl.net.in
Web site: <http://www.elecon.co.in>.

They designed and built the rotary car dumper in Figure 3 of the report. Elecon also has their own web site at indicating their other capabilities

APPENDIX C

SP-8 PANEL REPORT

Reduction or Elimination of Welded Temporary Attachments - SP-8 Report

Objective: (from the 1993 abstract) Analyze and identify the potential benefits and savings associated with improving/eliminating temporary structural attachments through design enhancements and technological improvements. Benchmark foreign shipbuilders and other nonrelated steel construction industries. Design and test new attachments and study the feasibility of adapting existing technology to U.S. shipbuilding.

Participants:

NASSCO (prime) - Mauro Brattich
UMTRI - Al Horsmon

Looking at:

Fitting and Fairing Aids
Stiffener, beam clamps
Bulkhead alignment tools
Plate alignment
Unit alignment
Staging, Safety Chain Stanchions
Turning Lugs

To Eliminate or Reduce:

Welding of temporary attachments
Manufacturing non-reusable attachments
Labor involved in removing temporary attachments
Labor and materials in:
Grinding the excess weld
Weld repairs of gouges
Coatings

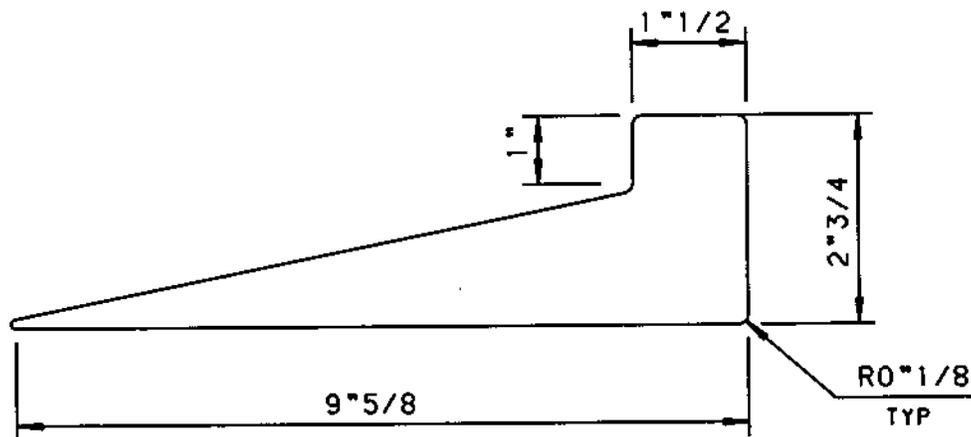
Alternatives Considered

| | |
|--------------------|----------------------|
| Vacuum handlers | Adhesives |
| Bolted attachments | Magnetic attachments |
| Straps | |

5. II FITTING AIDS SAMPLE SET.

DEVICE I.D.: NASSCO 08-42
 DEVICE NAME: WEDGE
 USE: DEVELOPE COMPRESSION FORCE FOR ALIGNING
 STRUCTURE

S.O.C. : SUB-ASSEMBLY. ASSEMBLY. GROUND OUTFITTING. ERECTION.
 SKETCH :



MATERIAL = PLT 30.6# TO 61.2#

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 0.5 | 2 | N/A | 2.5 |

EVALUATION AND COMPARISON:

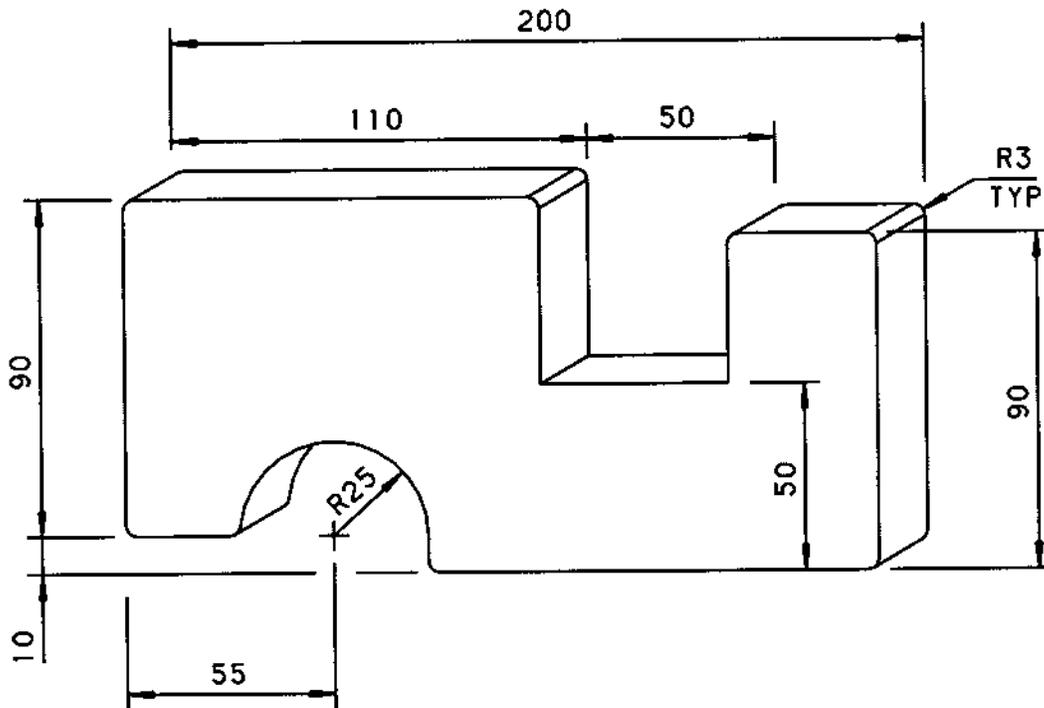
VERY EFFECTIVE SIMPLE MACHINE TOOL USED WIDELY SINCE
 WOODEN BOAT CONSTRUCTION IN COMBINATION WITH DOG SADDLES
 ETC. IT CAN COME LOOSE UNLESS SECURED IN PLACE.

POSSIBLE IMPROVEMENTS:

PROVIDE FLAT SECTION IN THE END OF THE SLOPING PART TO ACT
 AS A LOCK & PROVIDE A SMALL HOLE IN THE HEAD FOR A TIE ROPE.

DEVICE I.D.: KHI 2
 DEVICE NAME: UNIVERSAL AID
 USE: TO FIT PLATES & SHAPES.

S.O.C. : ASSEMBLY. ERECTION.
 SKETCH :



MATERIAL 15 mm GRADE 'A' PLT

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 2 | 2 | 10 | 14 |

EVALUATION AND COMPARISON:

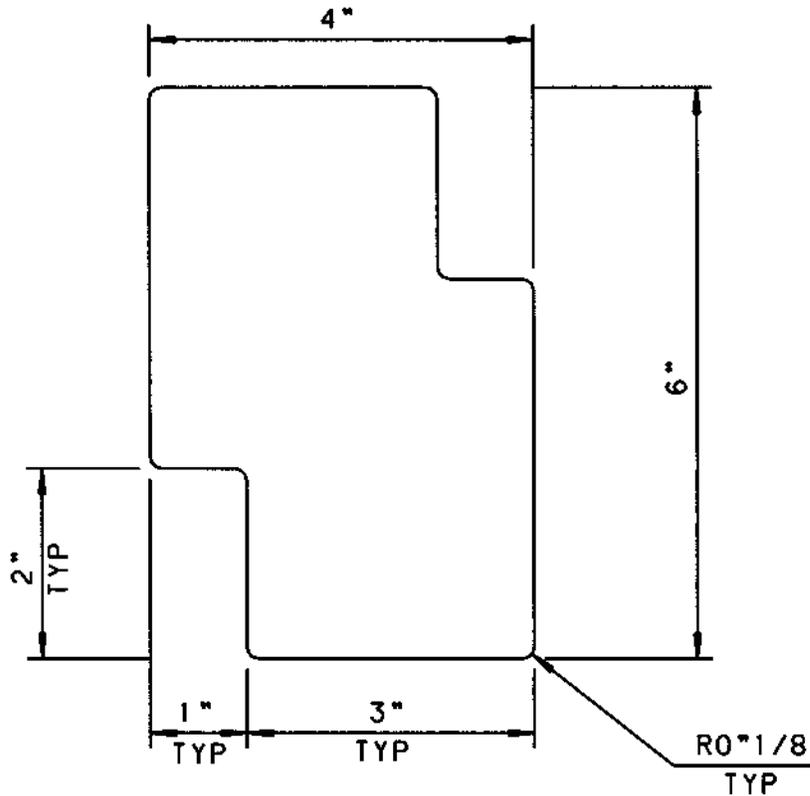
GOOD MULTI-PURPOSE TOOL. IT IS USED TOGETHER WITH A WEDGE TO ALIGN PLATES & SHAPES AND TO SUPPORT WELDING BACK-UP.

POSSIBLE IMPROVEMENTS:

NASSCO CHICKEN FOOT. NELSON STRONGBACK.

DEVICE I.D.: NASSCO 08-40
 DEVICE NAME: DOG
 USE: TO ALIGN STRUCTURE.

S.O.C. : SUB-ASSEMBLY, ASSEMBLY, GROUND OUTFITTING, ERECTION.
 SKETCH :



MATERIAL = PLT 30.6# X ABS GRADE 'A' STEEL

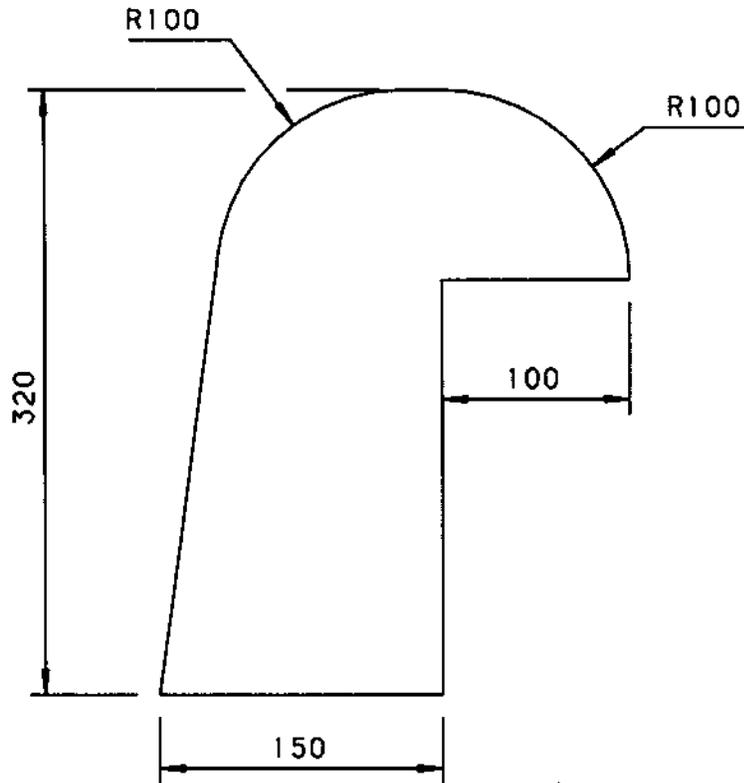
| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 1.50 | 1 | 10 | 12.50 |

EVALUATION AND COMPARISON:
 SIMPLE AND EFFECTIVE TOOL USED WORLDWIDE IN EQUIVALENT CONFIGURATIONS. SURFACE DAMAGE IS THE ONLY DISADVANTAGE.

POSSIBLE IMPROVEMENTS:
 IN MOST CASES CAN BE REPLACED BY A "CHICKEN FOOT"
 (NASSCO 07-231)

DEVICE I.D.: KHI 3
 DEVICE NAME: LONG NECK DOG
 USE: TO ALIGN STRUCTURES.

S.O.C. : ERECTION.
 SKETCH :



MATERIAL 19 MM GRADE 'A' PLT

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 5 | 2 | 10 | 17 |

EVALUATION AND COMPARISON:

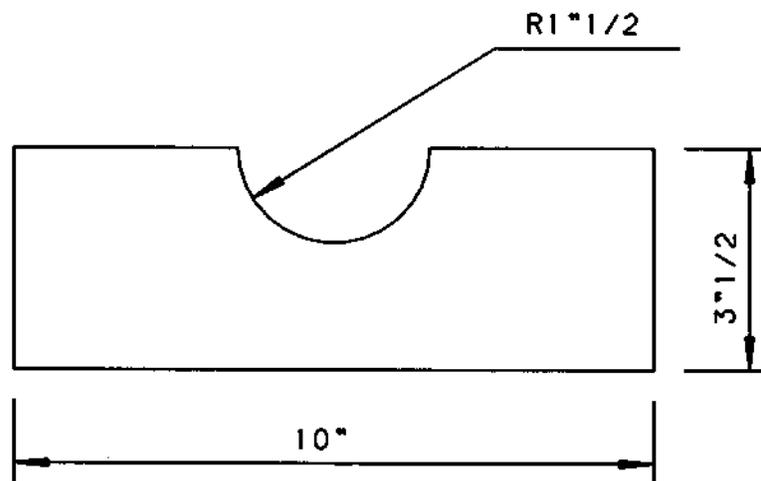
USED IN COMBINATION WITH HYDRAULIC RAM TO ALIGN SHELL & DECKS ACROSS ERECTION BREAKS. IT IS VERY STRONG AND EFFECTIVE.

POSSIBLE IMPROVEMENTS:

NASSCO CHICKEN FOOT & NELSON STRONGBACK. CAN OFTEN REPLACE IT EFFECTIVELY.

DEVICE I.D.: NASSCO 08-185
 DEVICE NAME: STRONGBACK
 USE: TO ALIGN STRUCTURES.

S.D.C. : ASSEMBLY, GROUND OUTFITTING, ERECTION.
 SKETCH :



MATERIAL = PLT 20.4# X 3"1/2 X 10" ABS GRADE 'A' STEEL

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 1 | 2 | 10 | 13 |

EVALUATION AND COMPARISON:

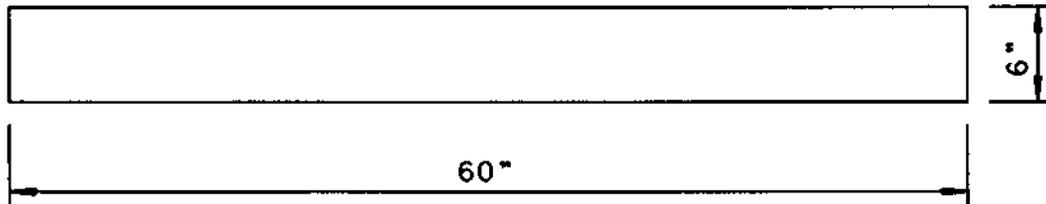
THIS IS AN OLD FASHION TOOL STILL USED IN MANY YARDS. IT DOES NOT OFFER GREAT ADVANTAGES EXCEPT FOR ITS SIMPLICITY.

POSSIBLE IMPROVEMENTS:

THE MOST CONVENIENT SUBSTITUTE IS THE "CHICKEN FEET" (NASSCO 07-231)

DEVICE I.D.: NASSCO 08-58
 DEVICE NAME: STRONGBACK
 USE: TO FAIR PLATES.

S.O.C. :SUB-ASSEMBLY. ASSEMBLY. GROUND OUTFITTING. ERECTION.
 SKETCH :



MATERIAL = PLT 30.6# X ABS GRADE 'A' STEEL
 OR FB 3/4" X ABS GRADE 'A' STEEL

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 20 | 2 | 20 | 42 |

EVALUATION AND COMPARISON:

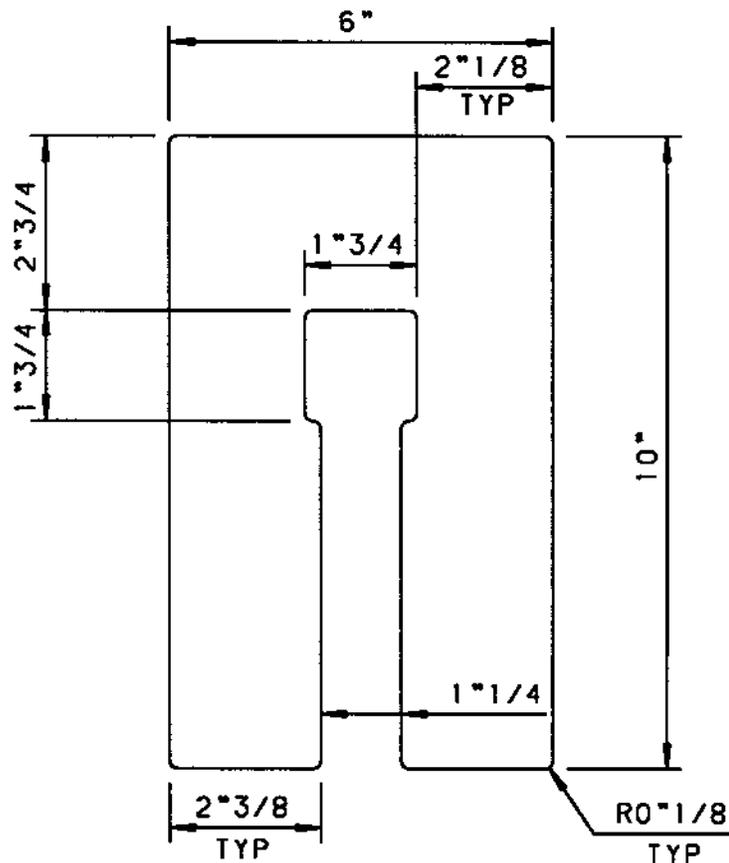
THIS STRONGBACK IS USED IN COMBINATION WITH SADDLES & WEDGES TO FAIR PLATES & STRUCTURES. IT IS EFFECTIVE BUT EXPENSIVE TO USE.

POSSIBLE IMPROVEMENTS:

LIMIT THE USE AS MUCH AS POSSIBLE BY INCREASING ACCURACY AND AVOID DISTORTION.

DEVICE I.D.: NASSCO 08-25
 DEVICE NAME: SADDLE PLATE
 USE: TO FAIR PLATES BY PULLING THEM AGAINST STRONGBACKS.

S.O.C. : SUB-ASSEMBLY. ASSEMBLY. GROUND OUTFITTING. ERECTION.
 SKETCH :



MATERIAL = PLT 20.4# X ABS GRADE 'A' STEEL

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| CDST (\$) | 2.50 | 1.50 | 10 | 14 |

EVALUATION AND COMPARISON:

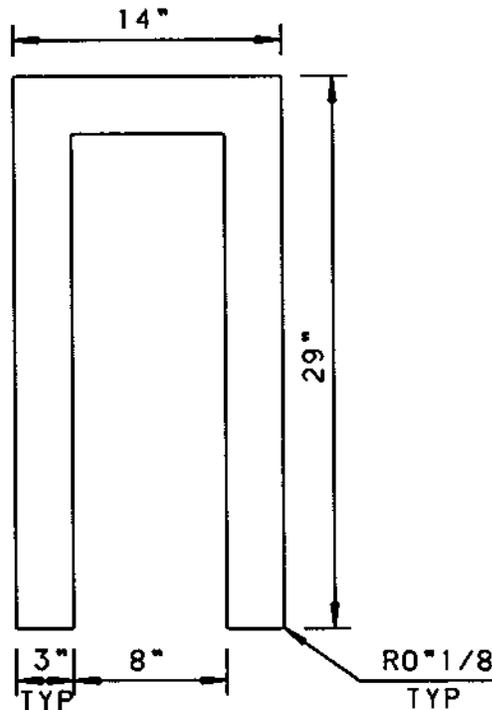
IT IS USED TOGETHER WITH WEDGES AND FLAT BAR STRONGBACKS.
 IT IS VERY EASY TO APPLY, VERY STRONG AND EFFECTIVE.
 ITS REMOVAL OFTEN DAMAGES THE STRUCTURE SURFACE.

POSSIBLE IMPROVEMENTS:

PROVIDE HINGED FEET TO REDUCE THE WELD SIZE AND THE
 CONSEQUENT SURFACE DAMAGE.

DEVICE I.D.: NASSCO 08-26
 DEVICE NAME: SADDLE PLATE
 USE: PULLING STRUCTURE INTO ALIGNMENT

S.O.C. : SUB-ASSEMBLY. ASSEMBLY. GROUND OUTFITTING. ERECTION.
 SKETCH :



MATERIAL = PLT 35.7# X ABS GRADE 'A' STEEL

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 15 | 2 | 10 | 27 |

EVALUATION AND COMPARISON:

IT WORKS TOGETHER WITH A HYDRAULIC RAM. IT IS VERY STRONG AND EFFECTIVE BUT VERY HEAVY AND DAMAGING TO THE SURFACE.

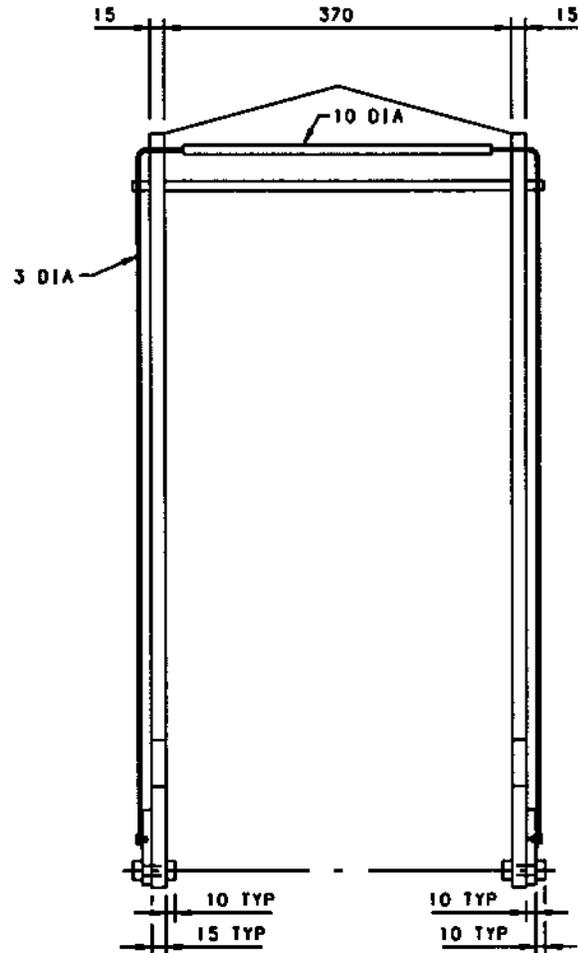
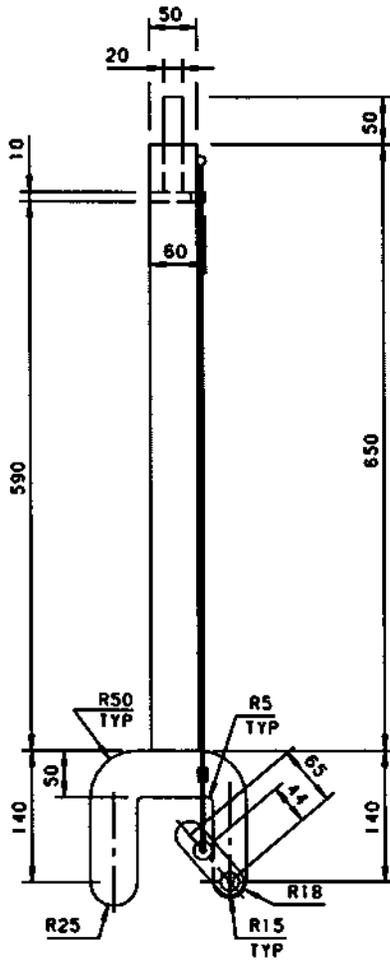
POSSIBLE IMPROVEMENTS:

MAGNETIC OR VACCUM SADDLES CAN SOMETIMES REPLACE IT EFFECTIVELY.

DEVICE I.D. :
 DEVICE NAME :
 USE :

FINCANTIERI 1
 CAM SADDLE
 TO PUSH "T" BEAMS AGAINST PLATE BY
 PULLING ON PREVIOUSLY WELDED BULB FLATS.
 ASSEMBLY.

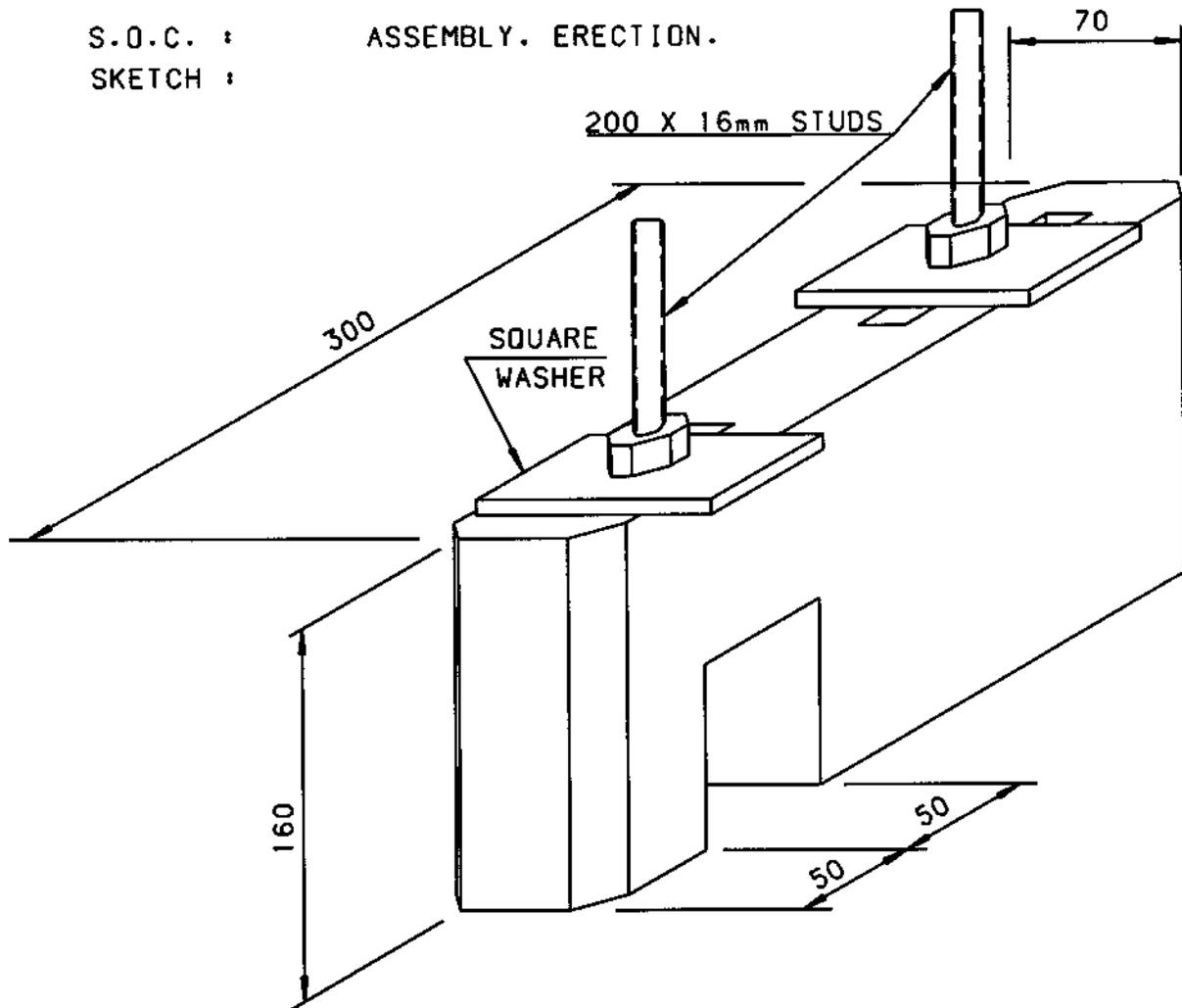
S.O.C. :
 SKETCH :



| | MATERIAL | MANUFACTURE | USE | TOTAL |
|----------|----------|-------------|-----|-------|
| COST (€) | 25 | 60 | 5 | 90 |

DEVICE I.D.: FINCANTIERI 2
 DEVICE NAME: "NELSON" STRONGBACK
 USE: STRUCTURE ALIGNMENT

S.O.C. : ASSEMBLY. ERECTION.
 SKETCH :



MATERIAL = ALUMINIUM, STEEL

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 20 | 20 | 5 | 45 |

EVALUATION AND COMPARISON:

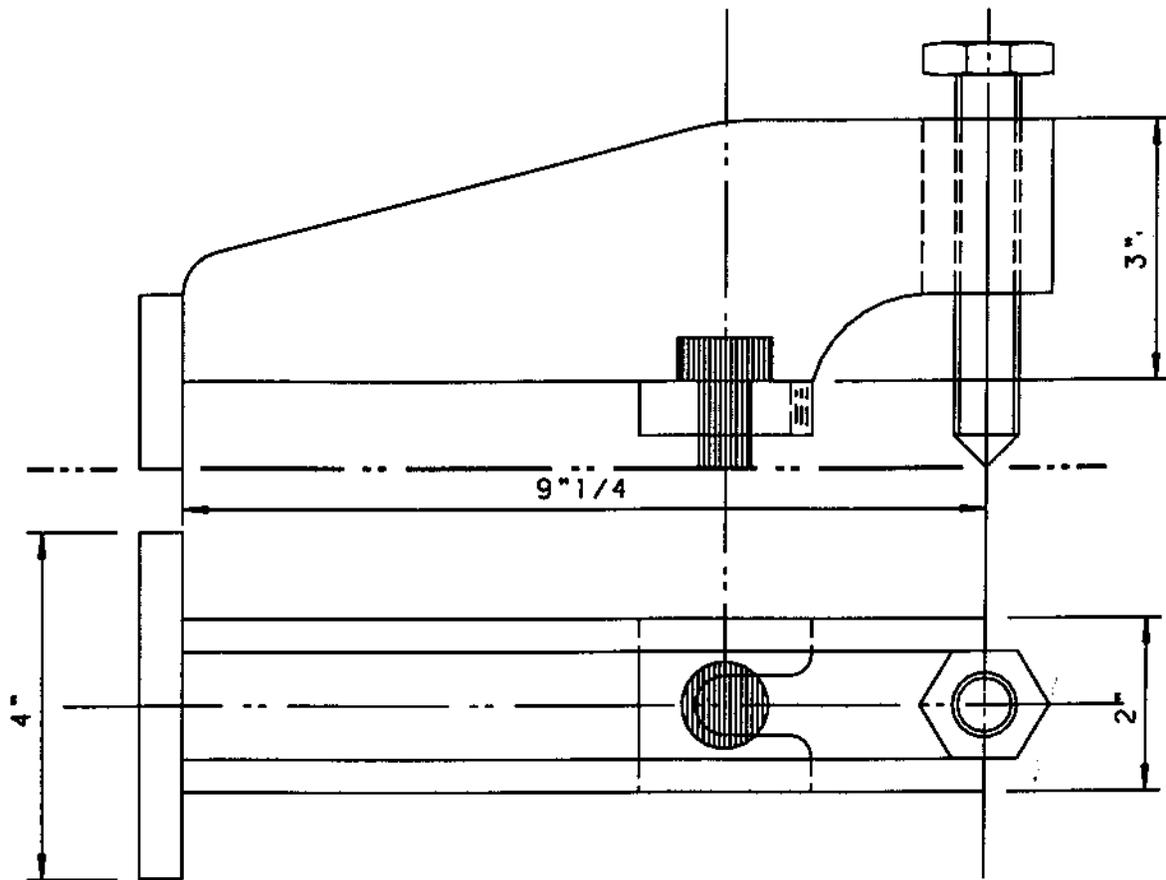
GOOD TOOL USED SINGLE OR IN SERIES WELDED TOGETHER.
 VERY POPULAR IN EUROPEAN YARDS. CONSUMABLE STUDS ARE SOMEWHAT EXPENSIVE .

POSSIBLE IMPROVEMENTS:

NASSCO 07-231 (CHICKEN FOOT) CAN REPLACE IT EFFECTIVELY.

DEVICE I.D.: NASSCO 07-231
 DEVICE NAME: CHICKEN FOOT
 USE: STRUCTURE ALIGNMENT

S.O.C. : ASSEMBLY. GROUND OUTFITTING. ERECTION.
 SKETCH :



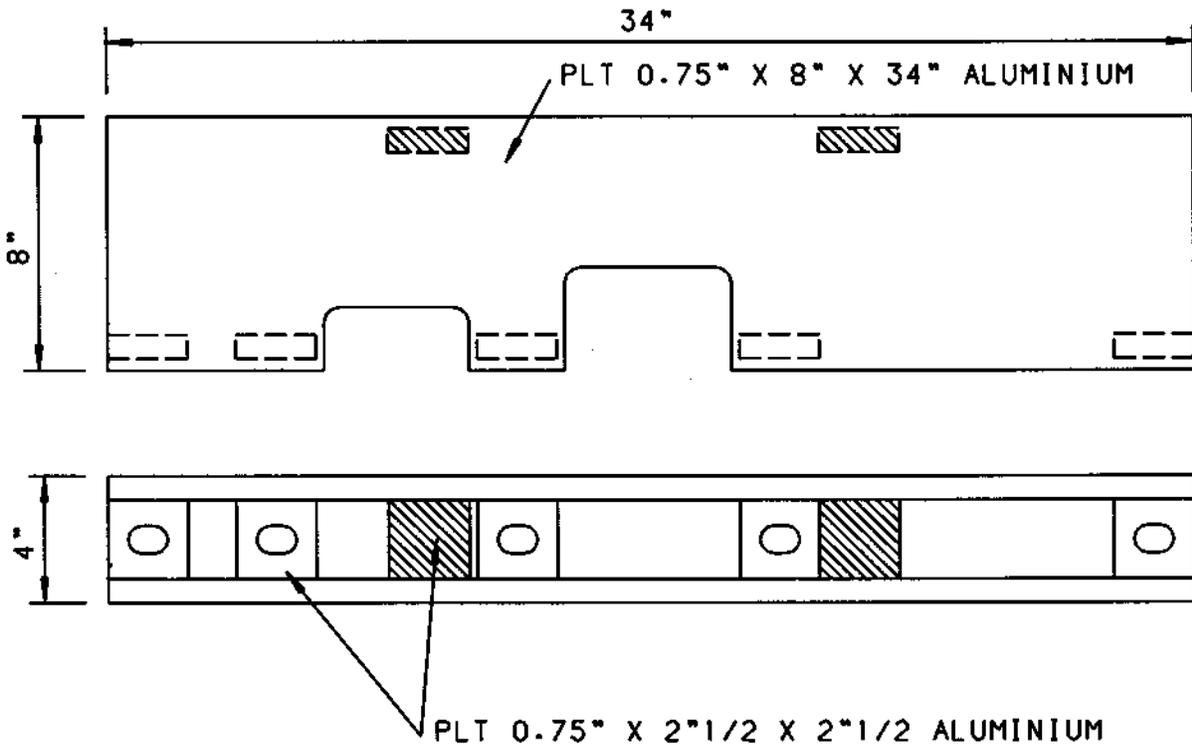
| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 10 | 15 | 2 | 27 |

EVALUATION AND COMPARISON:
 STRONG AND VERSATILE TOOL. REUSABLE MANY TIMES REQUIRING ONLY THE REPLACEMENT OF THE MUSHROOM STUD.

POSSIBLE IMPROVEMENTS:
 A BUSHING FIT ON THE SCREW TIP WOULD MAKE THE TOOL MORE DURABLE.

DEVICE I.D.: NASSCO 07-15
 DEVICE NAME: STRONGBACK
 USE: SHELL ALIGNMENTS.

S.O.C. : ASSEMBLY. GROUND OUTFITTING. ERECTION.
 SKETCH :

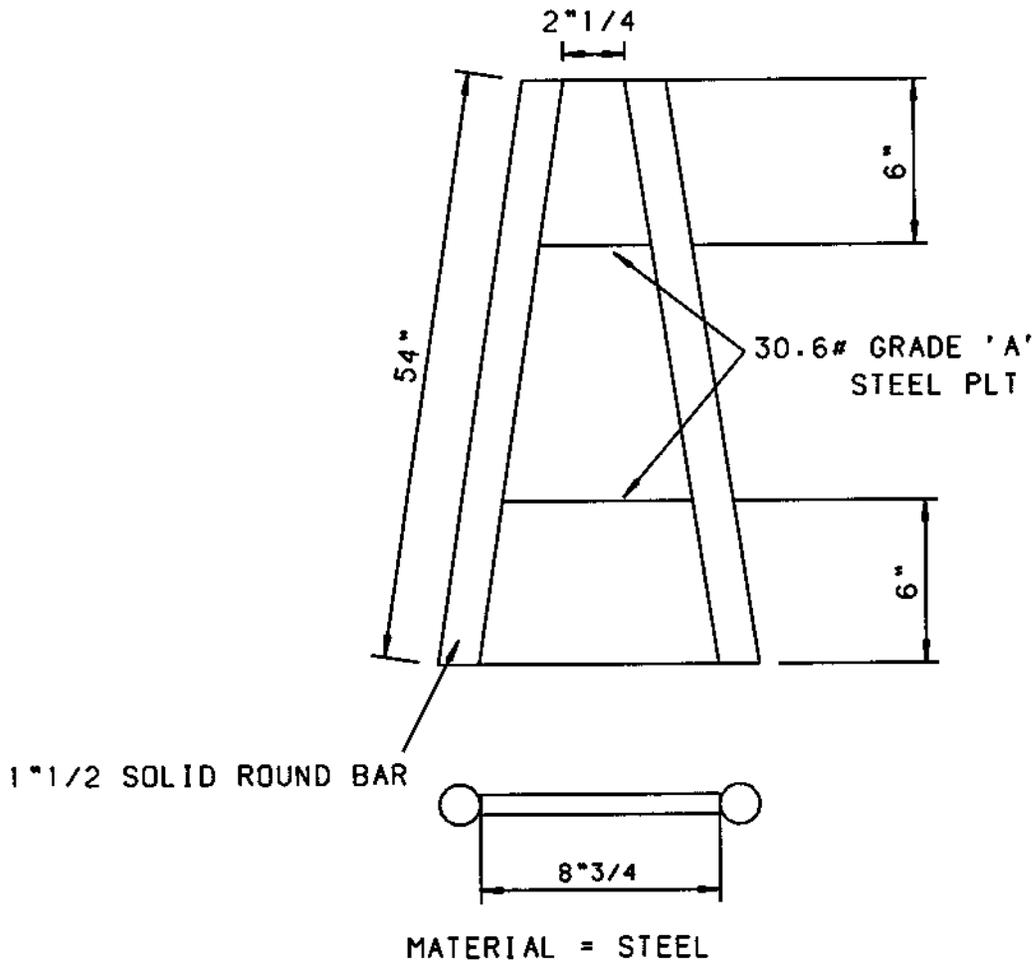


| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 50 | 40 | 5 | 95 |

EVALUATION AND COMPARISON:
 VERY EFFECTIVE TOOL BUT BULKY AND EXPENSIVE.

POSSIBLE IMPROVEMENTS:
 FABRICATE A SMALLER ONE AND ELONGATE THE STUD SLOTS.

DEVICE I.D.: NASSCO 07-14
 DEVICE NAME: BANJO
 USE: TOGETHER WITH HYDRAULIC RAMS & STRONGBACKS TO MOVE & ALIGN HEAVY STRUCTURES.
 S.O.C. : ERECTION.
 SKETCH :



| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 20 | 10 | 10 | 40 |

EVALUATION AND COMPARISON:

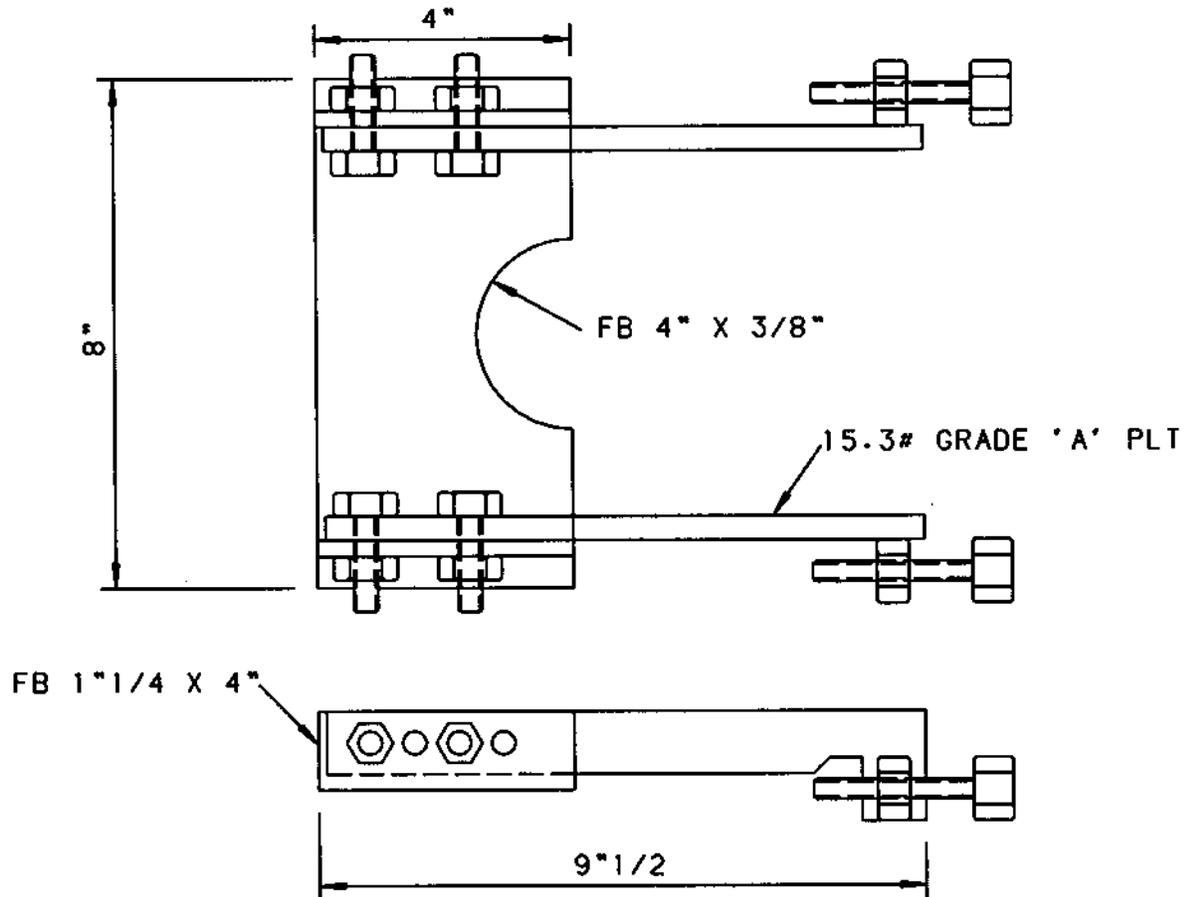
VERY USEFUL TOOL. IT IS ABLE TO HARNESS THE FORCE OF HYDRAULIC RAMS (PORTAPOWER) AND MOVE HEAVY STRUCTURES.

POSSIBLE IMPROVEMENTS:

PROVIDE A MORE STABLE SUPPORT FOR THE HYDRAULIC RAM. BY FLANGING THE INNER EDGE OF THE PLATES.

DEVICE I.D.: NASSCO 07-229
 DEVICE NAME: FAIRING AID
 USE: ALIGN SMALL ANGLES AND "T" BEAMS ACROSS WELDS.

S.O.C. : SUB-ASSEMBLY. ASSEMBLY.
 SKETCH :



| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 10 | 10 | 2 | 22 |

EVALUATION AND COMPARISON:

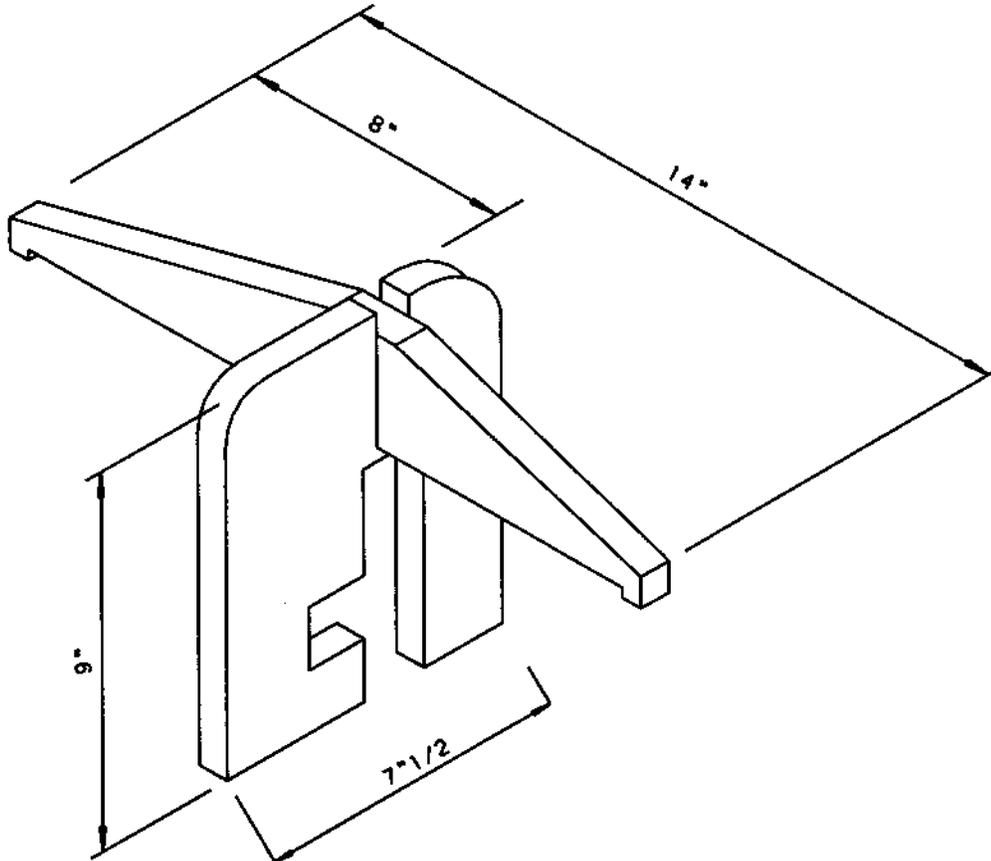
EFFECTIVE TOOL ON VERY LIGHT STIFFENERS.
 DIFFICULT TO SET AND EASILY DAMAGED.

POSSIBLE IMPROVEMENTS:

MINIMIZE THE NUMBERS OF PARTS. INCREASE THE LEVER ARM.
 INCREASE THE SETTING STABILITY.

DEVICE I.D.: NASSCO 07-224
 DEVICE NAME: PLATEN TIE DOWN DOG
 USE: SECURE PLATES ON TABLE FLAT BARS

S.O.C. : SUB-ASSEMBLY, ASSEMBLY.
 SKETCH :



MATERIAL = 30.6# GR A STEEL PLATE

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 5 | 10 | — | 15 |

EVALUATION AND COMPARISON:

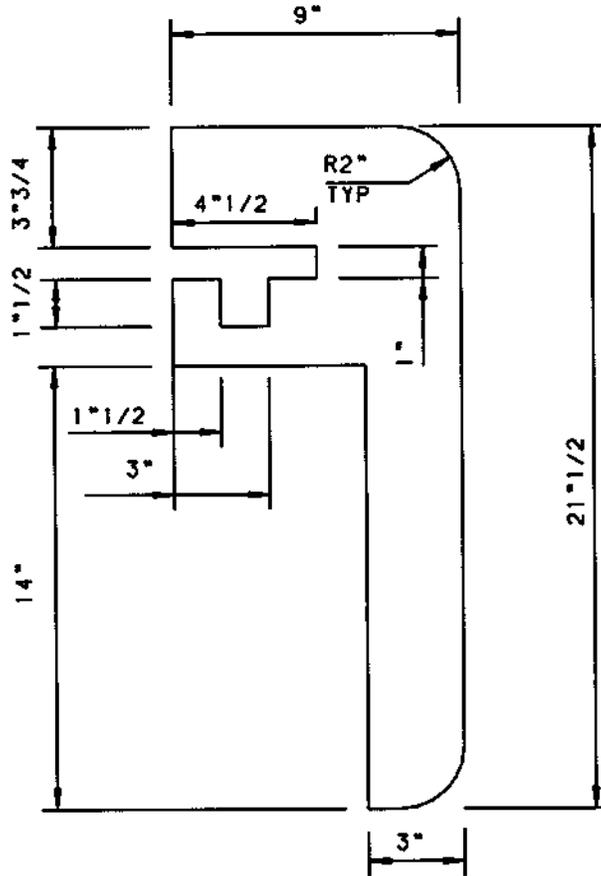
USED IN COMBINATION WITH WEDGE IT UTILIZES FRICTION TO LOCK ONTO FB OF ASSEMBLY TABLES.

POSSIBLE IMPROVEMENTS:

TABLES FITTED WITH ANGLES OR T-BEAM INSTEAD OF FB WILL PROVIDE A MORE POSITIVE HOLD ON PLATES.

DEVICE I.D.: NASSCO 08-73
 DEVICE NAME: PLATE DOG
 USE: TO SECURE PLATES ONTO WORK TABLES

S.O.C. : SUB-ASSEMBLY. ASSEMBLY.
 SKETCH :



MATERIAL = PLT 30.6# X ABS GRADE 'A' STEEL

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 10 | 5 | 2 | 17 |

EVALUATION AND COMPARISON:

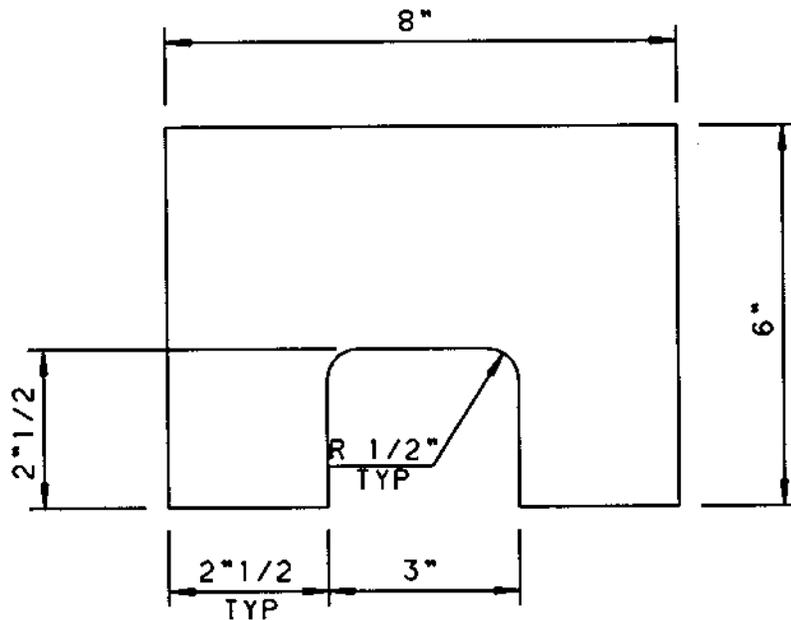
TOGETHER WITH A WEDGE UTILIZES FRICTION TO RETAIN ITS POSITION & HOLD DOWN PLATES. IMPACTS & VIBRATION WILL RELEASE ITS GRIP.

POSSIBLE IMPROVEMENTS:

PROVIDE A MORE EFFECTIVE MEAN TO LOCK THE DOG ON THE TABLE. SUBSTITUTING T-BAR FOR FLAT BAR OR PROVIDING HOLES & PINS.

DEVICE I.D.: NASSCO 08-90
 DEVICE NAME: SADDLE
 USE: SECURE STRUCTURAL ALIGNMENT
 AND SUPPORT WELDING BACK-UP

 S.O.C. : ASSEMBLY, ERECTION
 SKETCH :



MATERIAL = PLT 40.8# ABS GRADE 'A' STEEL

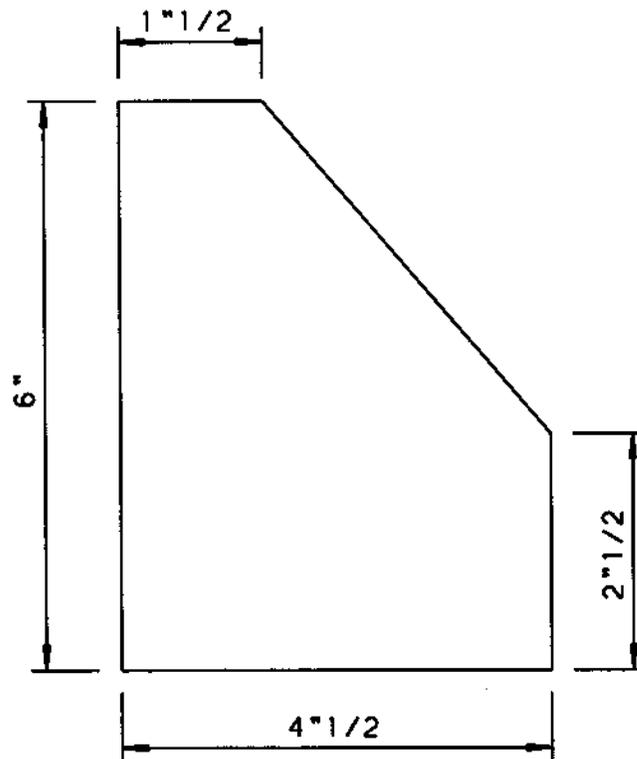
| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 2 | 2 | 10 | 14 |

EVALUATION AND COMPARISON:
 SIMPLE DEVICE USED WIDELY TO SUPPORT COPPER BACKING.

POSSIBLE IMPROVEMENTS:
 "CHICKEN FEET" AND "NELSON" STRONGBACKS CAN REPLACE THIS WELDED DEVICE. SELF ADHESIVE CERAMIC TAPE IS OFTEN USED AS WELDING BACK-UP INSTEAD OF THE COPPER SHOE.

DEVICE I.D.: NASSCO 08-41
 DEVICE NAME: LANDING CLIP
 USE: TO MOUNT ASSEMBLIES AND BLOCKS ONTO OTHERS.

S.O.C. : ASSEMBLY, GROUND OUTFITTING, ERECTION.
 SKETCH :



MATERIAL = PLT 20.4# X ABS GRADE 'A' STEEL

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 3 | 1 | 10 | 14 |

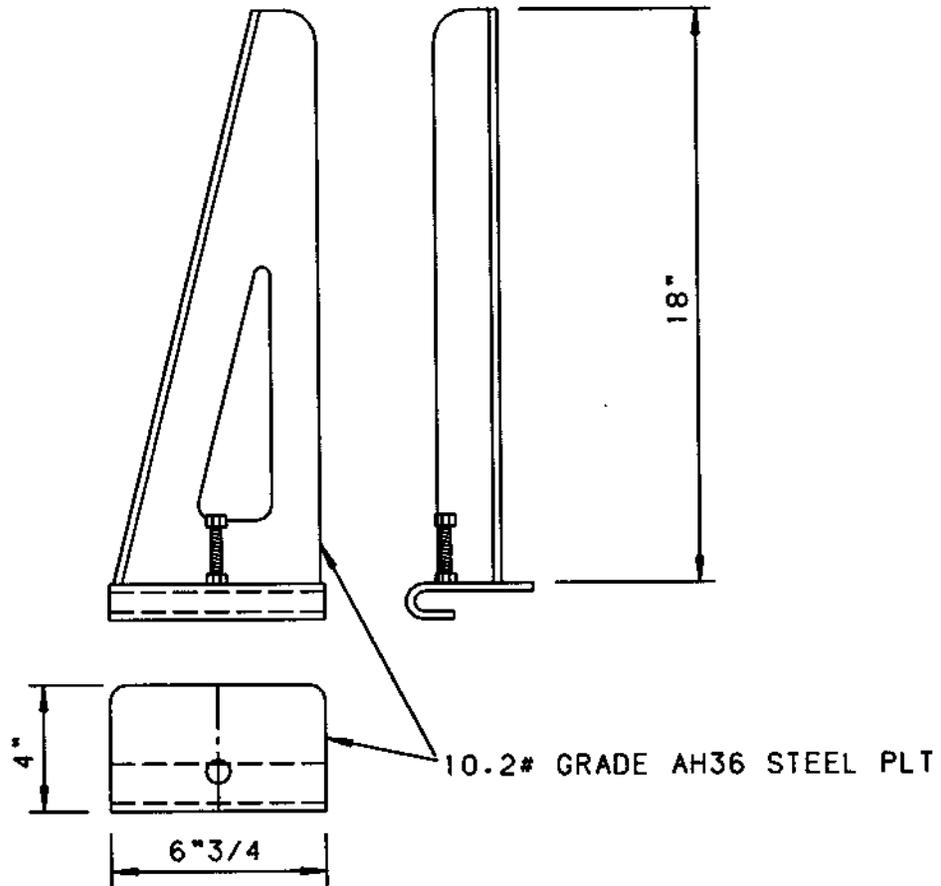
EVALUATION AND COMPARISON:

SIMPLE, EFFECTIVE & VERSATILE TOOL USED TO HELP IN THE ALIGNMENT OF BLOCKS DURING ERECTION.

POSSIBLE IMPROVEMENTS:

DESIGN STRUCTURES INTERFACE SO THAT LANDING GEAR IS BUILT INTO IT.

DEVICE I.D.: NASSCO 07-007
 DEVICE NAME: WEB STAND
 USE: TO STAND UP WEB FRAMES AND SMALL BHDS. BY ATTACHING
 TO PLATE EDGES AND STIFFENER FLANGES.
 S.O.C. : SUB-ASSEMBLY. ASSEMBLY.
 SKETCH :



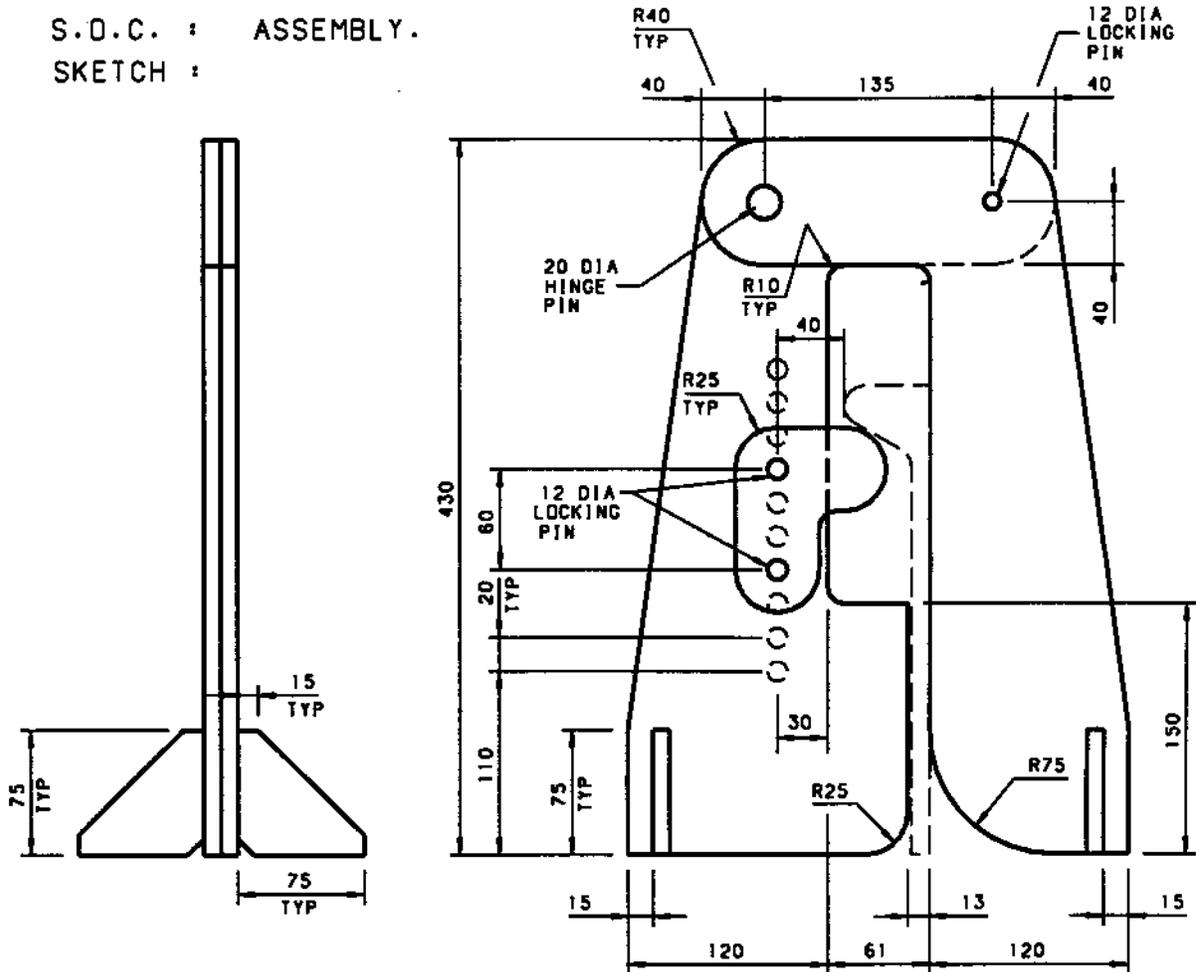
| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 5X2 | 20X2 | — | 50 |

EVALUATION AND COMPARISON:
 SIMPLE AND EFFECTIVE TOOL USED IN PAIRS. EQUIVALENT SHAPES
 ARE COMMON THROUGHOUT THE INDUSTRY.

POSSIBLE IMPROVEMENTS:
 ALUMINIUM CONSTRUCTION WOULD LOWER THE WEIGHT.

DEVICE I.D.: NSRP 1
 DEVICE NAME: BULB FLATS STAND
 USE: POSITION BULB FLATS ON PLATES

S.D.C. : ASSEMBLY.
 SKETCH :



MATERIAL 10mm GRADE 'A' PLT

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 10 | 10 | 2 | 22 |

EVALUATION AND COMPARISON:

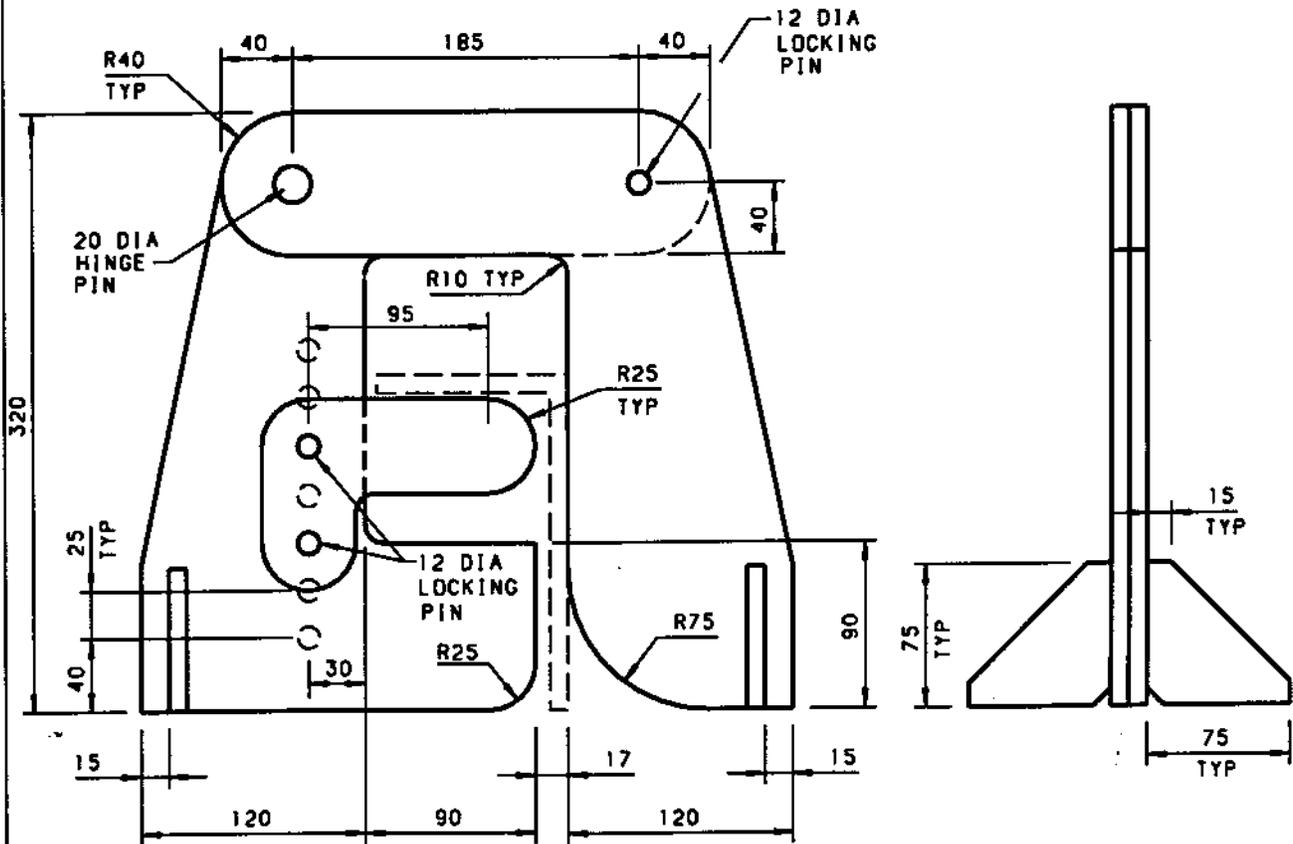
VERY GOOD TOOL MEMBER OF A LARGE FAMILY OF STANDS.
 IT CAN BE SET & REMOVED WITHOUT ACCESSING THE STIFFENER END.

POSSIBLE IMPROVEMENTS:

ALUMINUM CONSTRUCTION WILL LOWER THE WEIGHT.

DEVICE I.D.: NSRP 2
 DEVICE NAME: ANGLE STAND
 USE: POSITION ANGLE BAR ON PLATE

S.D.C. : ASSEMBLY.
 SKETCH :



MATERIAL 10mm GRADE 'A' PLT

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 10 | 10 | 2 | 22 |

EVALUATION AND COMPARISON:

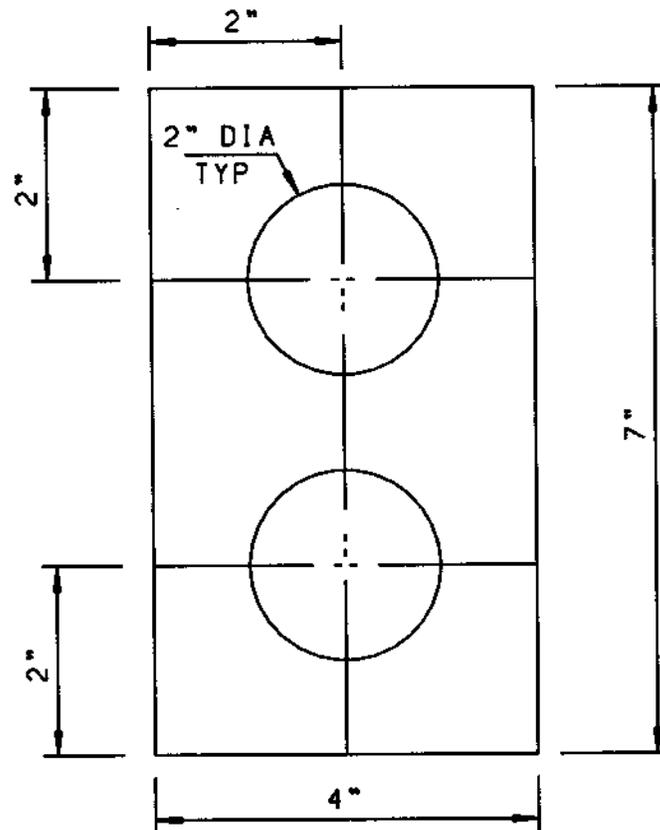
VERY GOOD TOOL MEMBER OF A LARGE FAMILY OF STANDS.
 IT CAN BE SET & REMOVED WITHOUT ACCESSING THE STIFFENER END.

POSSIBLE IMPROVEMENTS:

ALUMINUM CONSTRUCTION WILL LOWER THE WEIGHT.

DEVICE I.D.: NASSCO 08-186
 DEVICE NAME: PADEYE
 USE: TO CONNECT TOOLS TO STRUCTURE

S.O.C. : SUB-ASSEMBLY. ASSEMBLY.
 SKETCH :



MATERIAL = PLT 25.5# ABS GRADE 'A' STEEL

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| CDST (\$) | 1 | 3 | 20 | 24 |

EVALUATION AND COMPARISON:

USED BY FITTERS TO ATTACH FITTING AIDS eg TURNBUCKLES, CHAIN FAILS, BRACES. IT PROVIDES A QUICK AND EFFECTIVE ATTACHMENT POINT.

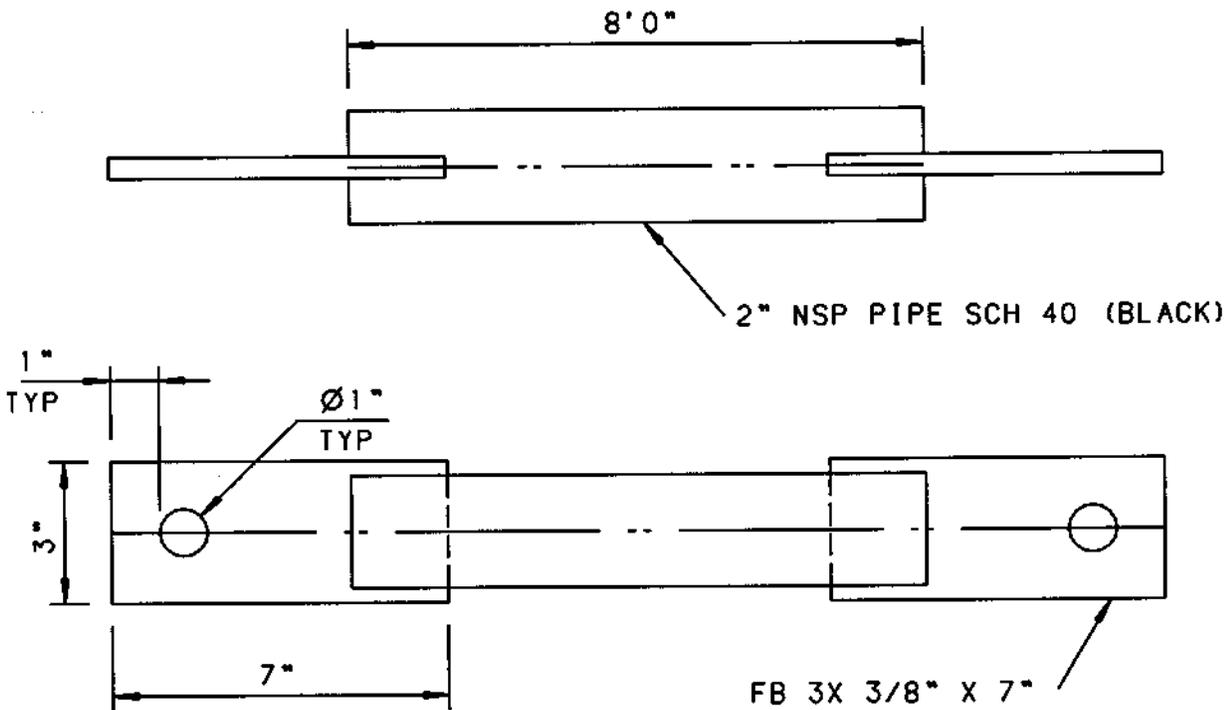
POSSIBLE IMPROVEMENTS:

SOMETIMES IT CAN BE REPLACED BY A CLAMPING DEVICE.

DEVICE I.D.: NASSCO Q7-18
 DEVICE NAME: BULKHEAD BRACE
 USE: TO STAND UP OR RETAIN STRUCTURE DURING FITTING.

S.O.C. : SUB-ASSEMBLY. ASSEMBLY.

SKETCH :



| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 25 | 20 | N/A | 45 |

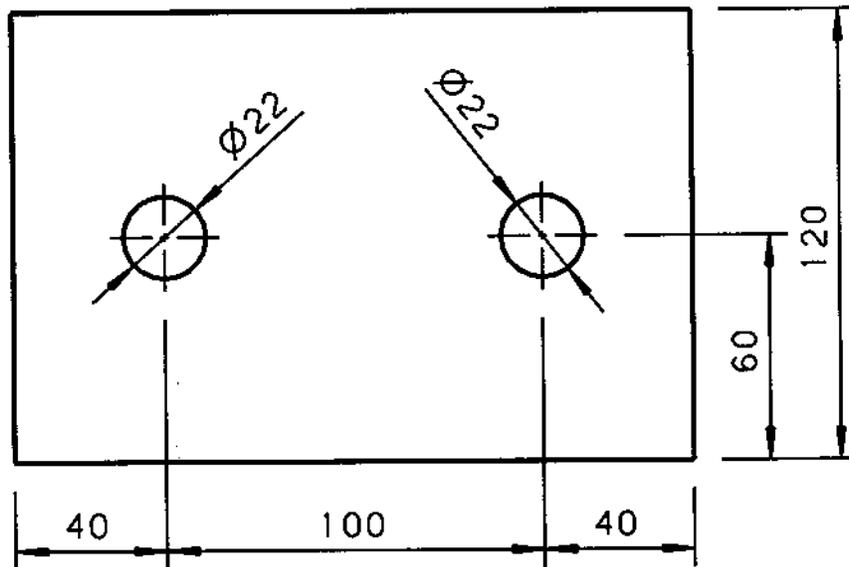
EVALUATION AND COMPARISON:

SIMPLE WAY TO ERECT SMALL BULKHEADS. ENDS OF BRACE ARE BOLTED TO SMALL PADEYES OR SLIDING CLAMPS.

POSSIBLE IMPROVEMENTS:

PROVIDE TELESCOPIC LENGTH ADJUSTMENT. AND LOWER THE WEIGHT BY BUILDING IT IN ALUMINUM.

DEVICE I.D.: ODENSE 1
 DEVICE NAME: STAGING CLIP
 USE: TO ATTACH TEMPORARY PLATFORMS
 & SCAFFOLDING
 S.O.C. : 5.6
 SKETCH :



MATERIAL 12mm GRADE 'A' PLT

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| CDST (\$) | 2 | 5 | 5 | 12 |

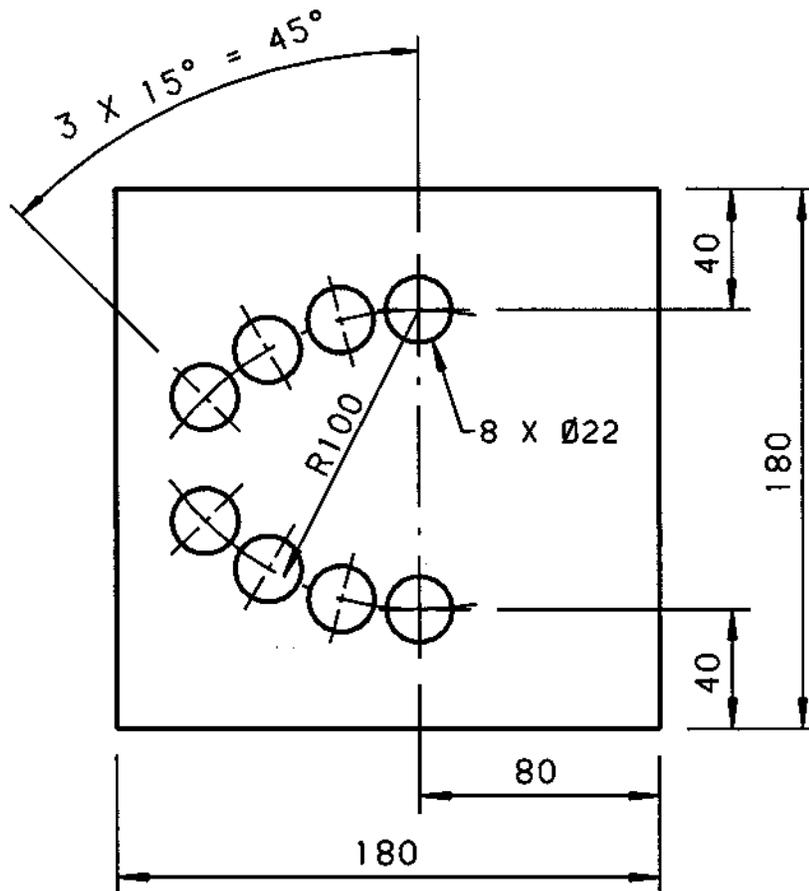
EVALUATION AND COMPARISON:

MEMBER OF A LARGE FAMILY OF SIMILAR DEVICES. IS NORMALLY LEFT BEHIND FOR FUTURE USE.

POSSIBLE IMPROVEMENTS:

FOR TEMPORARY USE. CLAMP-ON CLIPS CAN OFTEN REPLACE IT ADVANTAGEOUSLY.

DEVICE I.D.: ODENSE 2
 DEVICE NAME: STAGING CLIP
 USE: TO ATTACH TEMPORARY PLATFORMS
 & SCAFFOLDING
 S.O.C. : 5.6
 SKETCH :



MATERIAL 12mm GRADE 'A' PLT

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 2 | 10 | 5 | 17 |

EVALUATION AND COMPARISON:

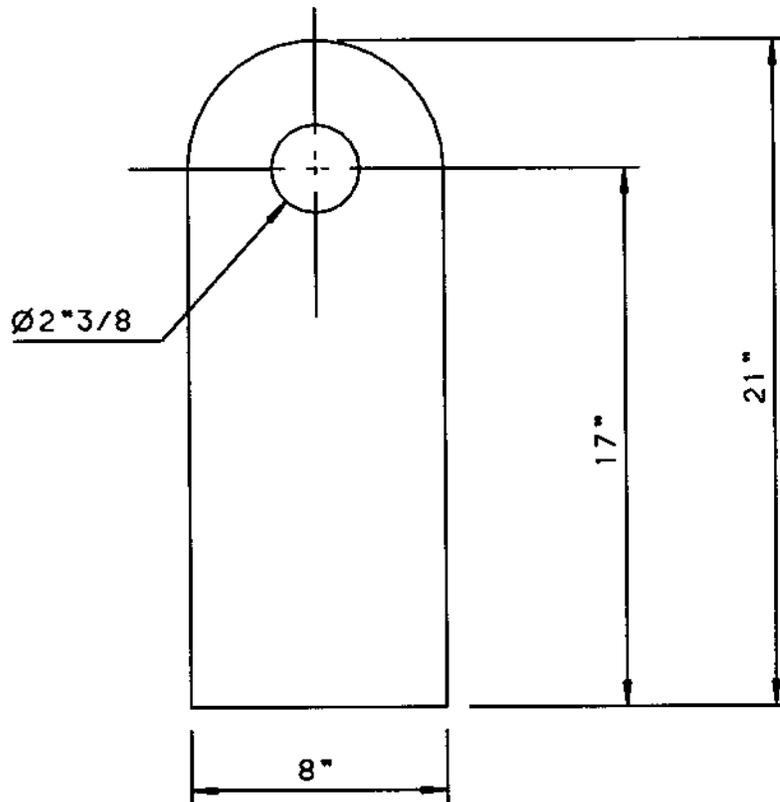
CLEVER DEVICE CAPABLE OF ACCOMMODATING SLOPING BHDS, PLATFORMS & STAGING.

POSSIBLE IMPROVEMENTS:

CLAMP-ON CLIPS CAN REPLACE IT EFFECTIVELY FOR TEMPORARY USE.

DEVICE I.D.: NASSCO D8-150
 DEVICE NAME: PADEYE
 USE: LIFTING

S.O.C. : SUB ASSEMBLY. ASSEMBLY. GROUND OUTFITTING. ERECTION.
 SKETCH :



MATERIAL 40.8# GRADE 'A' PLT

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|------|-------|
| COST (\$) | \$30 | \$5 | \$40 | \$75 |

EVALUATION AND COMPARISON:

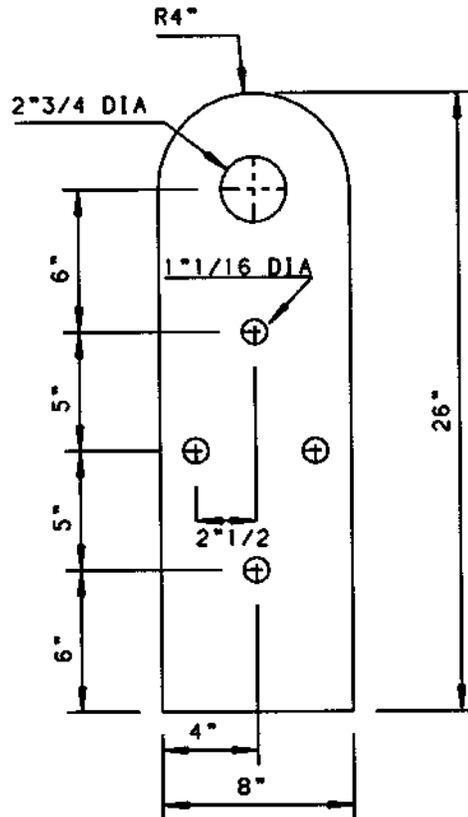
USED TO LIFT SMALL LOADS. CAN BE LAPPED TO THE STRUCTURE AND PARTIALLY LEFT BEHIND AFTER USE.

POSSIBLE IMPROVEMENTS:

DESIGN PADEYE INTO STRUCTURE.

DEVICE I.D.: NASSCO 08-816
 DEVICE NAME: BOLTED PADEYE
 USE: TO LIFT STRUCTURES

S.O.C. : SUB-ASSEMBLY, ASSEMBLY, ERECTION.
 SKETCH :



MATERIAL = PLT 40.8# X ABS GRADE 'A' STEEL

| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 35 | 5 | 20 | 60 |

EVALUATION AND COMPARISON:

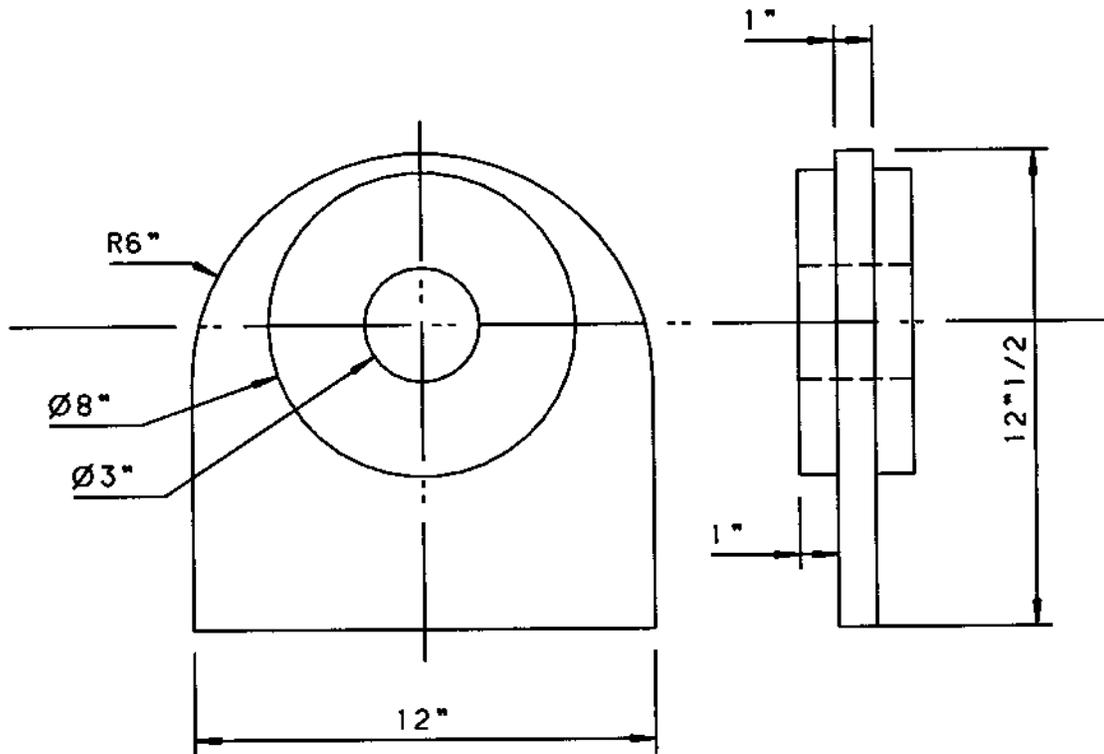
INTERESTING ALTERNATIVE TO WELDED PADEYES. REQUIRES THE ACCURATE POSITIONING OF THE STUDS.

POSSIBLE IMPROVEMENTS:

MANUFACTURE A STUD PAD TO WELD IN POSITION & LEAVE BEHIND AFTER THE LIFT.

DEVICE I.D.: NASSCO 07-04
 DEVICE NAME: PADEYE
 USE: LIFTING STEEL STRUCTURE.

S.O.C. : ASSEMBLY. GROUND OUTFITTING. ERECTION.
 SKETCH :



MATERIAL 40.8# GRADE 'A' PLT

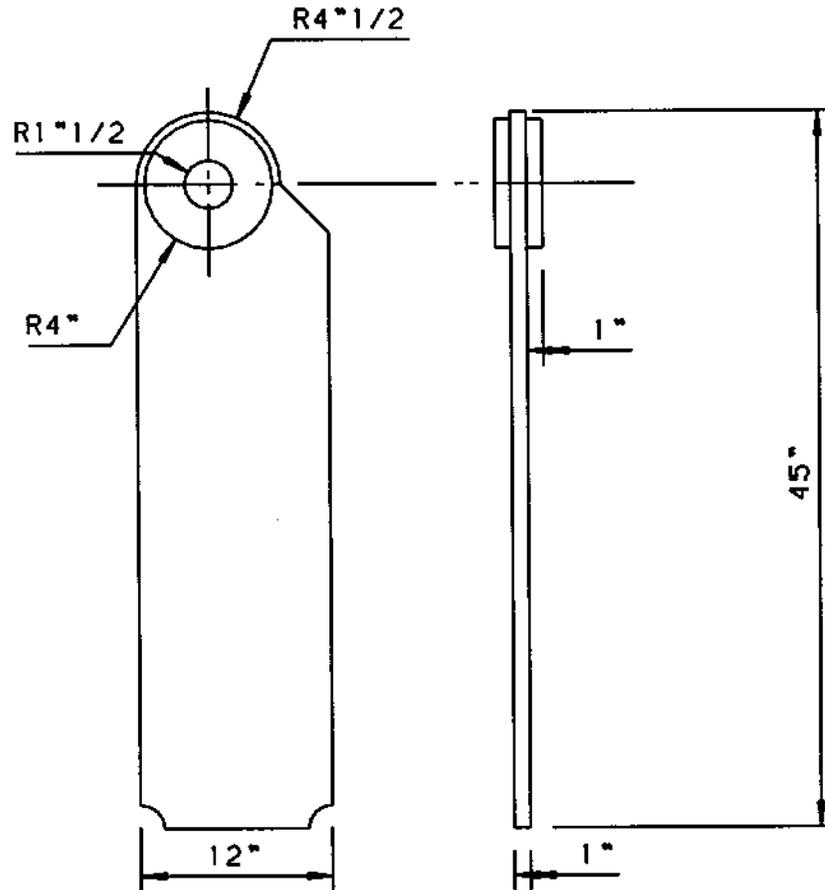
| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 25 | 20 | 40 | 85 |

EVALUATION AND COMPARISON:
 USED TO LIFT LOADS UP TO 35 TONS.

POSSIBLE IMPROVEMENTS:
 BUILD PADEYE INTO STRUCTURE TO BE LIFTED.

DEVICE I.D.: NASSCO Q7-06
 DEVICE NAME: PADEYE
 USE: LIFTING STEEL STRUCTURES.

S.O.C. : SUB-ASSEMBLY. ASSEMBLY. GROUND OUTFITTING. ERECTION.
 SKETCH :



MATERIAL = 40.8# GRADE 'A' PLT

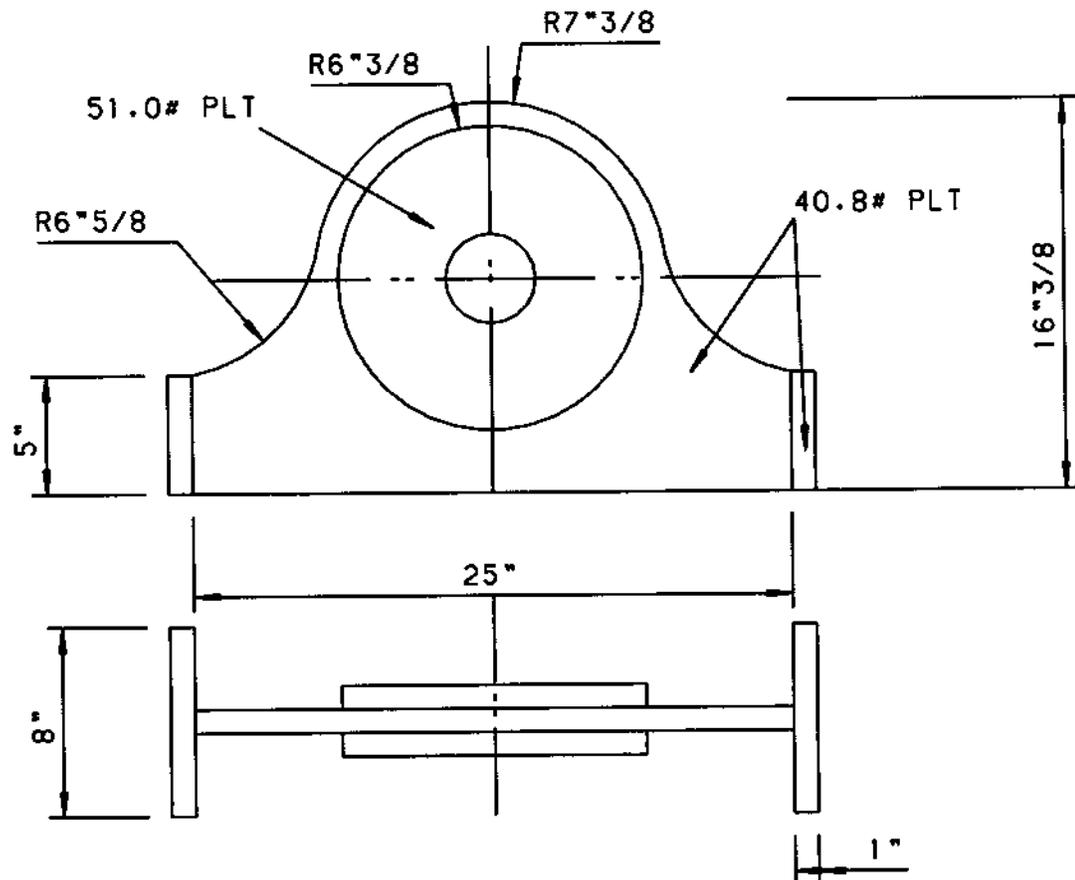
| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 40 | 20 | 40 | 100 |

EVALUATION AND COMPARISON:
 CAN BE LAP WELDED ONTO THE STRUCTURE AND PARTIALLY LEFT
 BEHIND AFTER THE LIFT.

POSSIBLE IMPROVEMENTS:
 BUILD PADEYE INTO STRUCTURE TO BE LIFTED.

DEVICE I.D.: NASSCO 07-184
 DEVICE NAME: PADEYE
 USE: LIFTING STEEL STRUCTURES.

S.O.C. : ASSEMBLY. GROUND OUTFITTING. ERECTION.
 SKETCH :



| | MATERIAL | MANUFACTURE | USE | TOTAL |
|-----------|----------|-------------|-----|-------|
| COST (\$) | 80 | 20 | 120 | 220 |

EVALUATION AND COMPARISON:

CAPABLE OF LIFTING WEIGHTS UP TO 80 TONS.
 SIMILAR TO MANY OTHER SURFACE WELDED PADEYES. VERY EFFECTIVE
 AND VERY EXPENSIVE.

POSSIBLE IMPROVEMENTS:

LIMIT THE USAGE BY MODIFYING ERECTION SCHEDULE AND PLANNING.

5.III

PICTURES

KIII

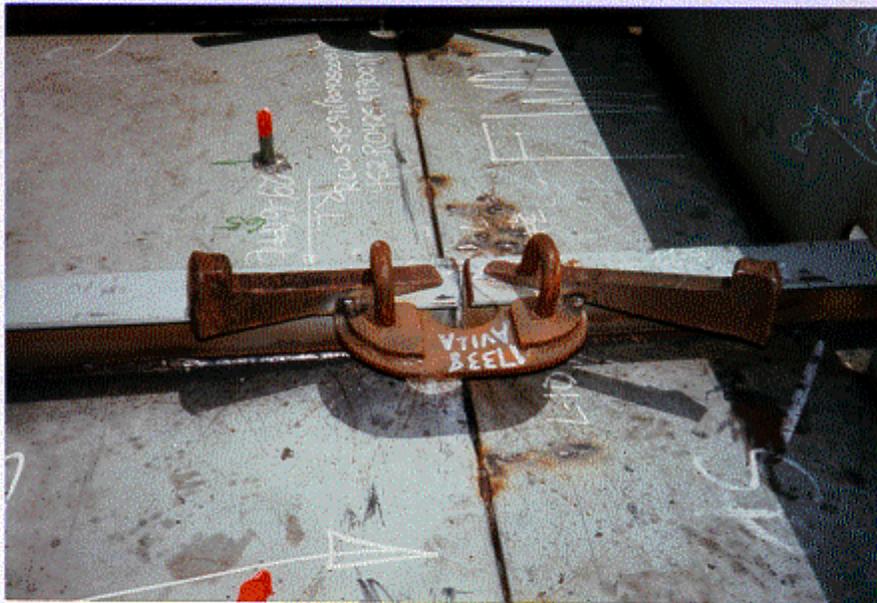


SMALL WEDGES UNDER REFURBISHING



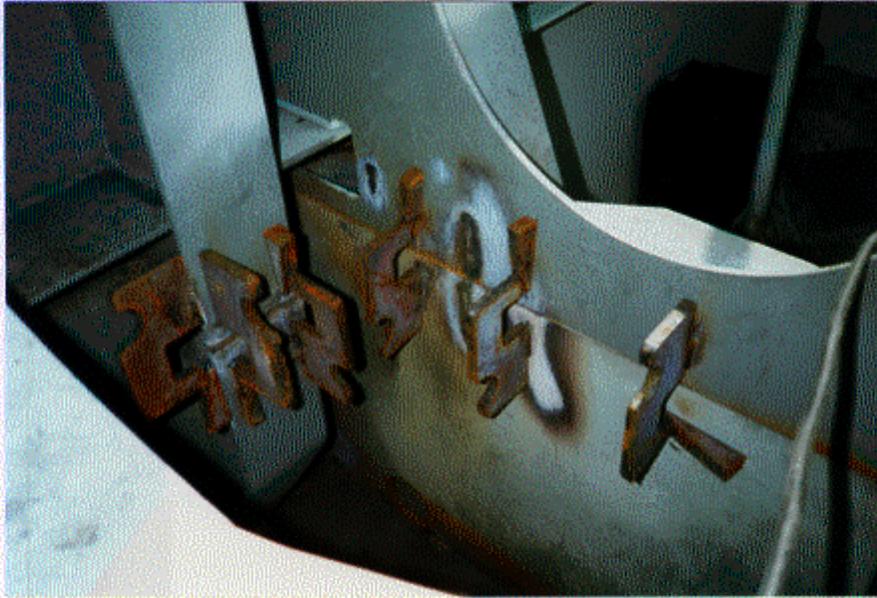
FITTER AIDS DEDICATED SHOP

NASSCO



"NO WELD" TOOLS USED TO ALIGN STIFFENERS.

KHI



UNIVERSAL FITTING AIDS AT WORK.



PADEYES IN SERIES

FINCANTIERI (GENOVA)



BULB PLATES STANDS.



BULB PLATES LIFTING CLAMPS.

SHINKURUSHIMA



RECEIVING CLIPS

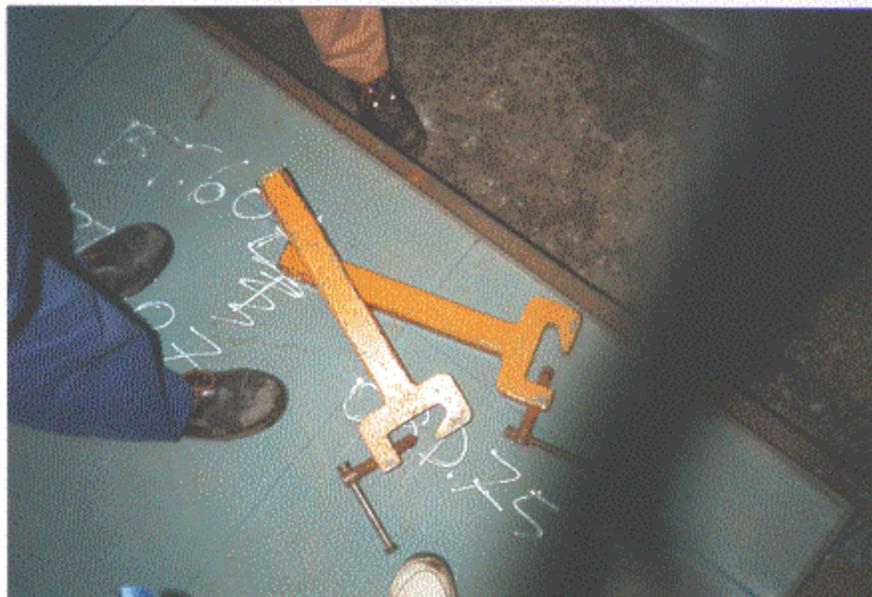


WELDED STANDS.

FINCANTIERI (GENOVA)



IMPROVISED WELDED STAND.



"CLAMP ON" STANDS FOR BULB PLATES.



WEB FRAME STAND



VACUUM SADDLE

FINCANTIERI (MONFALCONE)



WEB FRAME STAND



CAM CLEAT SADDLE FOR BULB PLATES

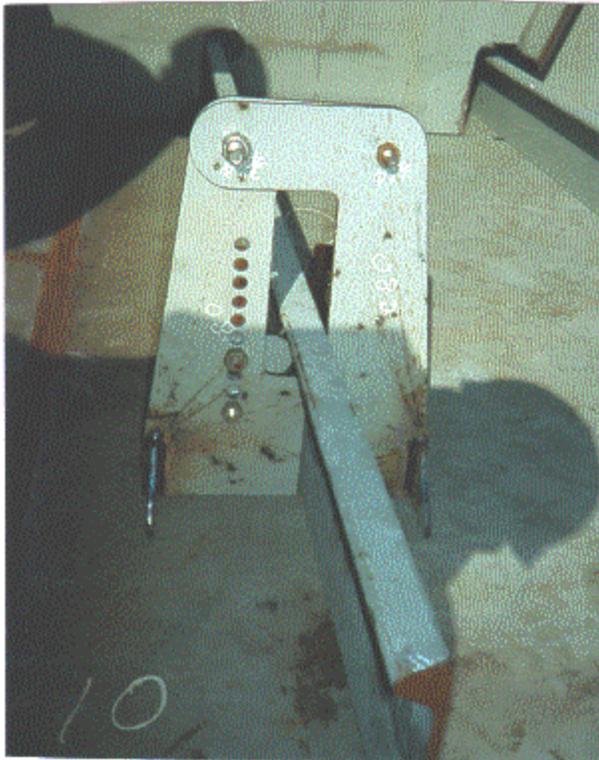
KHI



"TEE" BEAM STANDS



NASSCO



**N.S.R.P.
PROTOTYPES OF
HINGED STANDS**

SHINKURUSHIMA



CHAIN FALL + WELDED
STAND ON BULKHEAD



SCREW JACK

FINCANTIERI (GENOVA)



NELSON STRONGBACKS USED AS FITTING AND WELDING AIDS

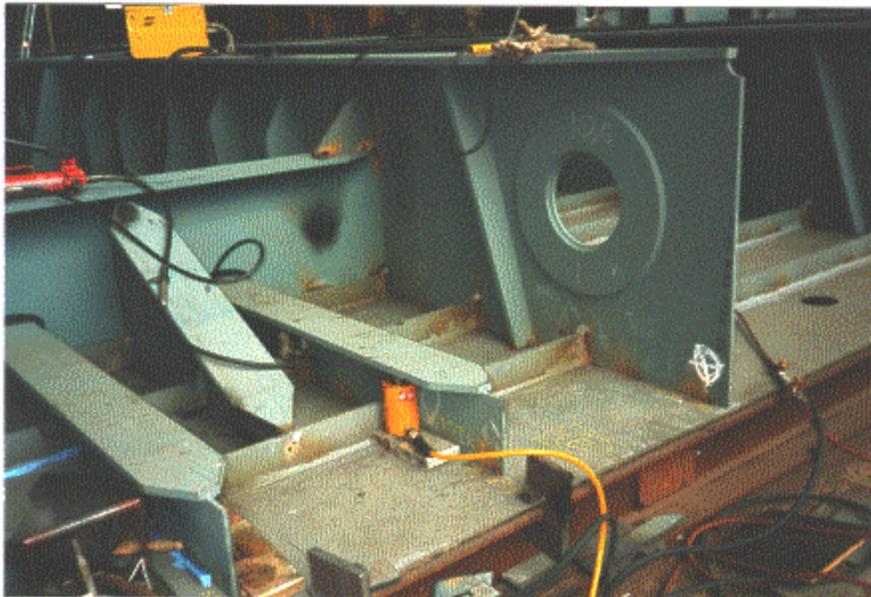


PLATE DOGS, HYDRAULIC RAM AND NELSON STRONGBACK

SHINKURUSHIMA

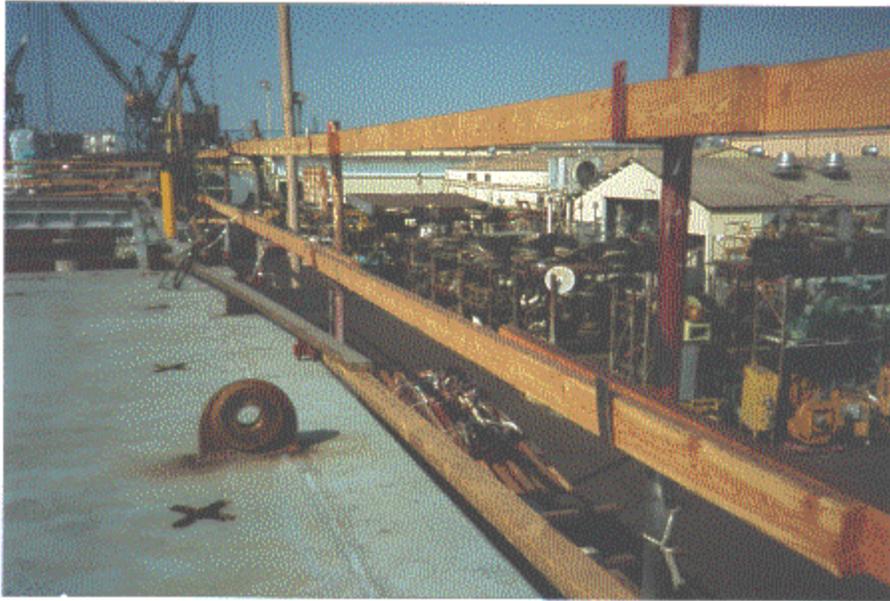


PROFILE STANDS



PLATE DOG

NASSCO



TEMPORARY PLATFORMS AND HANDRAILS

NASSCO



MODULAR HANDRAIL SECTION



NASSCO



MOBILE PLATFORM AND ACCESS LADDER





**DECK ERECTION BREAK:
THREADED STUDS ARE PREFITTED AND READY TO RECEIVE
NELSON STRONGBACKS.**

FINCANTIERI (MONFALCONE)



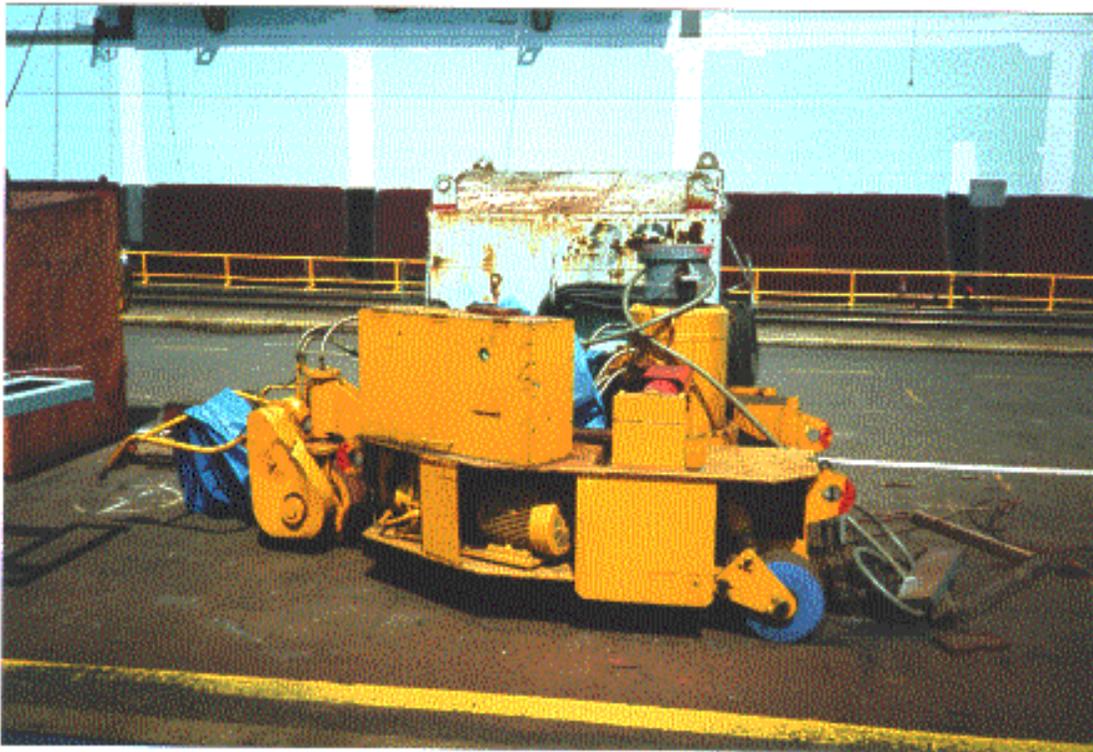
TURNING JIG FOR DECK BLOCKS

KHI



CLAMP ON ROLLER USED ON THE PANEL LINE TO SUPPORT THE EDGES OF OVERSIZED PLATES

KHI



MOTORIZED KEELBLOCK USED TO FINE ADJUST THE RELATIVE POSITION OF BLOCKS DURING GRAND ASSEMBLY

FINCANTIERI (MONFALCONE)



FAIRING AND ALIGNMENT TOOLS

KHI



LONG NECK DOG



"UNIVERSAL" FITTER AID

FINCANTIERI (MONFALCONE)



BUILT-IN LIFTING PADEYES ON DECK BEAMS



DECK REPAIR IN WAY OF PADEYE

NASSCO



"CHICKEN FEET" FAIRING SHELL PLATES ACROSS ERECTION BREAKS

SHINKURUSHIMA

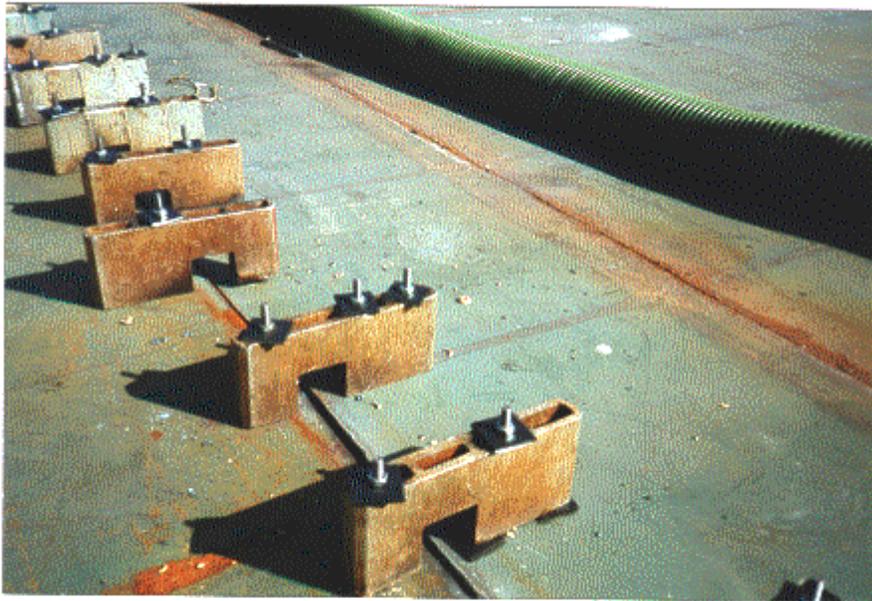


**STRONGBACKS FAIRING
DECK PLATES ACROSS
ERECTION BREAK**



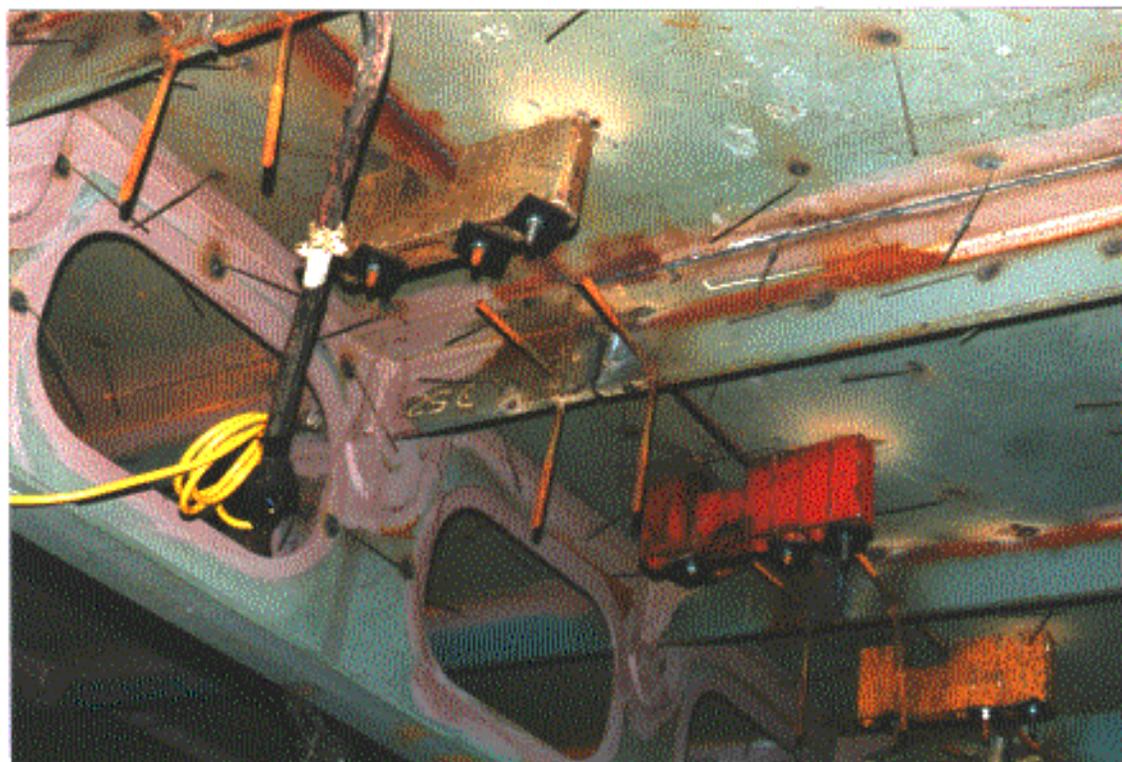
**RECYCLED PADEYE
CONVERSION**

FINCANTIERI (MONFALCONE)



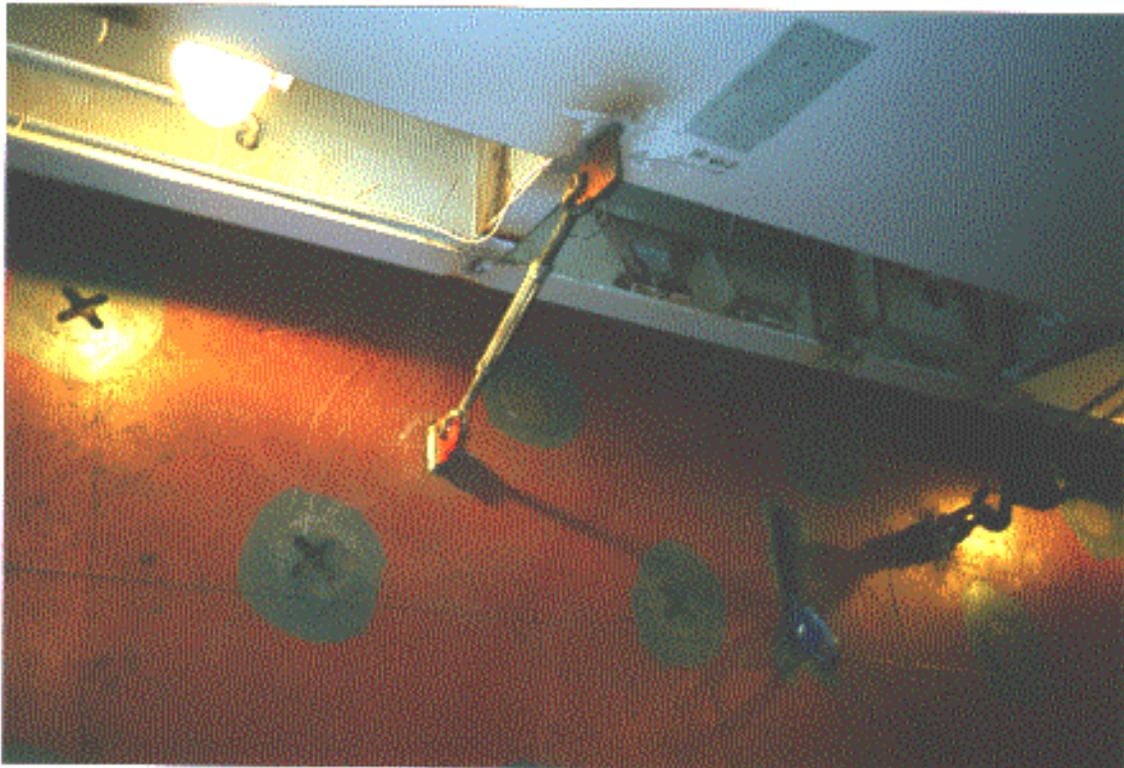
WELDED AND NELSON STRONGBACK ACROSS DECK SEAMS

FINCANTIERI (MONFALCONE)



DECK ERECTION BREAK. ABOVE AND BELOW.

NASSCO



WELDED PADEYES AND TURNBUCKLES USED TO RETAIN STRUCTURES

5. IV ACKNOWLEDGMENT of CONTRIBUTORS.

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