

**JACK-UP KITS FOR OFFSHORE
PLANTS TO BE BUILT ANYWHERE IN THE WORLD**

presentation by

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About the Author

P. M. Lovie is a director of Lovie & Co., a Houston based firm active in the offshore business.

About \$220 million worth of jack-ups have now been built that use designs and patents created by Peter Lovie: these include the largest ever built which also are for design conditions two or three times as severe as any jack-up built hitherto.

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Jack-up Kits for Offshore Plants to be Built Anywhere in the World

The discussion here covers:

1. Aspects of jack-ups that are pertinent to offshore plants,
2. Reasons for jack-up kits,
3. Description of a jack-up kit,
4. A case history, giving costs, weights, and dimensions.

Jack-up Offshore Plants. What are jack-ups? As the name implies, they jack up: they're barges that float along and when they reach their intended location offshore, they lower their legs until they touch the bottom of the sea, and then the hull jacks itself up out of the water. There has been an excellent model of a jack-up arrangement at this Symposium. If you look on the back page of the Coastal & Offshore Plant Systems Inc. folder, there's a picture of this. You can see the hull and the legs which go through the hull. In this case, there are two barges that make up the plant and each barge has four legs, and each leg is square in section.

One of the design considerations is that, when the jack-up barge is being towed, it has to be stable enough that it won't turn over in a storm during the trip to its final location. On this type of application, floating stability is usually not too much of a problem.

With offshore plants, this reserve of stability means that one can usually stack up process equipment on the deck pretty high without bothering too much about floating stability: the jack-up concept therefore suits the limitation of relatively small space being available for equipment, in comparison with land installations.

The legs are quite long in such an installation: maybe up to 400 or 500 feet. They may be 30 or 40 feet on a side. They may be, as shown in the models, square in section, but they could also be triangular. In shallower water, where shorter legs would be used, they could also be cylindrical.

Much of this technology has evolved from offshore drilling: the model which we have seen at this Symposium is based on that technology. It's based on designs that have been developed and used successfully on many rigs over the last ten to fifteen years. The particular situation in the model uses square legs. It uses a jacking system that is a rack-and-pinion mechanism: this is not the only type that is commonly used, but is a type that has been used more than any other type.

A critical factor is the load that the jacking system has to carry. On process plants, one may be looking at ten to twenty thousand tons to be lifted, maybe more than that. So one needs a lot of pinions meshing with the rack on the legs to raise such a weight out of the water. The design shown by the model here used pinion loads of about 170 short tons per pinion. Later, a jacking system with drive pinions carrying 2.0 to 2.5 times as much will be discussed.

Although the model shows two barges, each with four legs, with the plant mounted on the decks of these two barges, one could use a single, very large barge, perhaps, with six legs or with four or even three legs: the number of legs is one of the factors that can be varied. An important factor is that these legs have to pass through the hull with close tolerances. So one has perhaps a 400-foot long leg that has to be manipulated through a well in the hull - which means very accurate fabrication. They are very heavy loads, so high strength steels have to be used, and

that then may mean welding problems. Thus the jacking mechanism, the hull/leg arrangement, the steel quality and the fabrication of the legs are all important. One may have tolerances, for example, in the leg well in the hull that are plus or minus an eighth of an inch, or plus or minus a quarter of an inch, and similar tolerances must be maintained throughout the leg so that it will pass through the hull properly. Steel sections that are five or six inches thick, involving yield strengths of 100,000 psi (sometimes higher) add emphasis on the need for careful fabrication. It is some of these factors that have led to the development of jack-up "kits".

Reasons for jack-up "kits". For maximum economy to the plant owner, it is important to achieve the benefits of worldwide competition: this was touched on earlier in this Symposium. It may be necessary to be able to build the plant anywhere in the world, perhaps at one of a number of places where the constructor may know all about process work, and can do some shipyard work, but doesn't know anything about jack-ups. The "kit" supplies this missing component. Such a kit consists of jacks, their power source, controls and the legs and know-how to make it all work.

Building jack-ups is something that has caused problems in many shipyards in the past. There are a few places in the world that have a track record of successfully building jack-ups. However, these successful builders of jack-ups may not necessarily be at places where one wants to build one's process plant and they may not have process plant construction capabilities. However, using a kit, one can take the parts and go almost anywhere, e.g., one could take a "kit" of parts supplied from this country to be used in building a plant to go into Malaysia or Indonesia or the Middle East, where the entire construction could be done in Singapore.

Financing may dictate where one has to build, without regard to the jack-up technology being available locally.

The installation and the commissioning of these jack-up systems is a somewhat specialized thing. Since large and very valuable equipment is being lifted, it is therefore unwise to unnecessarily risk problems with this operation by using untried technology.

A typical jack-up kit. The components in such a kit would be as follows:

- a) The leg chords (these are the corners of the triangular or square legs). These have heavy welding in them, perhaps involve 100,000 psi yield strength material, and have five or six inch thick sections which include the rack which meshes with the pinions in the jacking units. In shallower water, say less than 150 ft., entire leg and cylindrical leg sections, may be supplied.
- b) The jacks. These are electronically controlled and hydraulically driven with hydraulic motors acting through a gear train to drive the final drive pinions that mesh with the rack on the legs.
- c) The controls. These are important because the barge must be raised evenly and level. If something goes wrong, it has to be able to be stopped safely. Thus fail safe controls and brakes are critical.
- d) Power source. This is the group of hydraulic pumps which feed fluid to the motors at the jacks located at each leg.
- e) Expertise. The jacks, legs, controls and power source must all be correctly installed and must operate correctly and reliably together.

f) These kits have been offered by Baker Marine Corporation of Corpus Christi, Texas. They have been used in several jack-ups now in operation. The leg components are precision built in a factory, use specialized jigs, and are manufactured under controlled conditions, using automatic welding procedures. Thus the heat distortion that occurs with the asymmetric sections is minimized. They must be built straight, to tight tolerances, with materials, in some cases with yield strengths up to 140,000 psi. Despite such stringent design parameters these can readily be fabricated in the plant. The manufacturing system has been worked out over the last four years, and jack-ups using such kits are in operation in the North Sea, the Gulf of Mexico, and South America.

A feature of such kits is also that they're economical to ship: all the parts are compact, although they're sometimes fairly heavy, up to 100/110 tons.

Unlike many jacking systems that have been used on drilling rigs, the system here is a very, very high capacity and is uniquely suited to this type of application. The elevating load capacity is two to two and a half times as great as these used in other existing rack-and-pinion jacking systems. For example, the Baker Marine jacking system operates with elevating loads of four to five hundred tons per pinion, for this type of application. And, because such high loads can be used, the number of jacking units is reduced and there are further economies in manufacture and in controls.

The electro-hydraulic rack-and-pinion drive has four important features. First, it is continually engaged throughout the jacking operation giving maximum safety

when going on location. There's no jacking stroke to worry about. When the barge is on location, and sea conditions cause it to move around as the legs are about to touch bottom, the sea motion has a heaving effect, causing the legs to slam into the bottom and wave action on the barge. It's important during this time to have a steady, fast movement while getting out of the water - which this system provides.

The system uses a variable speed and gives a very precise control, allowing the barge to be easily lined up to within a quarter of an inch. This means that one can be lifting ten or twenty thousand tons and align it very accurately.

The Baker Marine Corporation jacking system can be made to be removable so that if it is necessary to set a platform, for example, with one of these process plants on it, and then remove the jacks, this can readily be done. Thus the jacks can be removed and taken somewhere else and used again.

Four years ago the system was checked out in a full scale load test, operating over a typical 20-year life. It has since been installed on a number of rigs, including the Transworld 64, which has the highest jacking capacity ever installed: so the components discussed here have been widely used under a range of working conditions.

A typical application. Referring to the illustration (Figure 4), a single platform holding a 1000 STPD ammonia and its associated urea plant is considered here. The design is laid out for operation in 250 feet of water in a fairly mild environment, such as in the U.S. Gulf of Mexico or similar.

A single rectangular barge, with four legs is considered. In contrast to the model mentioned earlier, triangular legs are used. The reason for choosing this

particular arrangement is that from a marine viewpoint, a single barge is a more economical solution. It is also more economical to have a fewer number of legs and to use triangular legs.

Earlier in this Symposium there was some discussion about having parallel process trains: it may well be appropriate to put parallel process trains on this single barge. However, duplicate jack-ups will be more costly than a single unit. A total elevated load of about 21,000 tons is needed. This is broken down as follows: 5,732 tons of hull, marine services, outfitting, i.e., basically all of the marine side and the hull; 9,760 tons for the ammonia plant; 3,975 tons for the urea plant; about 1,500 tons for the jacks and miscellaneous equipment such as the heliport, cranes and generators. Adding up these weights, one gets 20,967, or about 21,000 tons to be lifted with the jacking system.

The size of the barge in this example is 300 by 250 feet. This design shows a cantilevered portion around all of the barge: the reason for that is that a large deck area is needed, but from an on location stability point of view and from a floating stability point of view, it doesn't have to be a barge all the way underneath the cantilever portion. Also, it's somewhat cheaper to build using this technique.

The hull itself is 240 x 190 x 26 feet. Taking a water depth of 250 feet, a leg length of about 350 feet will be appropriate. A loaded draft of about 15.8 feet will be needed, not counting spud cans.

Considering just the marine side, let us evaluate next the costs of such a plant. This offshore plant site could be used for many other applications aside from ammonia and urea. Looking at lifting the weight for that application and the size

here, the cost of the jacks and controls would be six to seven and a half million dollars. A range of costs is given since it is assumed that for the lower number (i.e., six million dollars) that the load is almost equally distributed amongst the four legs. It won't necessarily happen that way, and it may be that there should be extra jacking capacity at one end, and the higher number of seven and a half million dollars for the jacks and controls will be appropriate.

The cost of the legs and spud cans (i.e., the footings) is estimated at seven and a half to eight and a half million dollars. Again, there's a range quoted because it depends on the environmental criteria and it also depends on how soft the bottom conditions are, (if big footings are needed, then more steel is needed and thus more cost). Nine and a half to ten and a half million dollars is estimated for the hull. All of this comes out to be a total for the platform on which to put all this ammonia and urea plant (or paper pulp plant or whatever) of 22.5 to 26.0 million dollars. These numbers are based on fairly current shipyard rates. Shipyard rates are down from last year and oftentimes they may be about the same as three years ago. It's therefore a very good time to be buying equipment like this.

So buying the "grass roots" for your plant out in 250 ft. of water, will cost you about 22.5 to 26.0 million dollars to build a plant like this 1000 STPD ammonia/urea installation. Or, it costs about 30 to 35 dollars per square foot. So the real estate cost is about the same as building a plant downtown in many medium size cities in the United States!

Out of all this, it can be seen that even though a plant constructor may not be familiar with jack-ups and the technology that goes with them, it's possible to obtain and define that technology and then use it just about anywhere in the world.

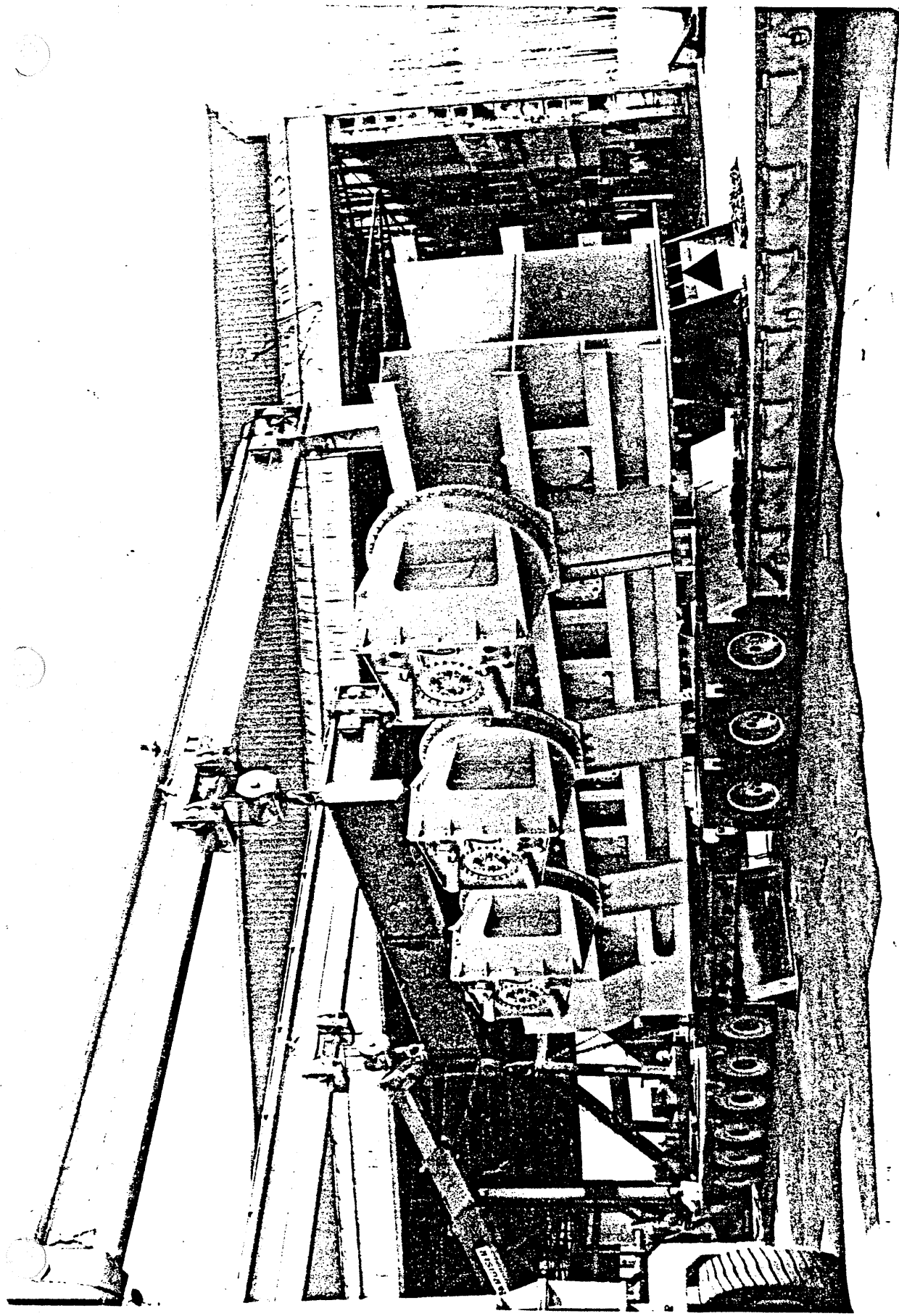


Figure 1.

Electro-hydraulic jacking unit leaves factory for installation in large jack-up:
this is identical to that needed for the jack-up ammonia/urea plant, proposed in Figure 5.

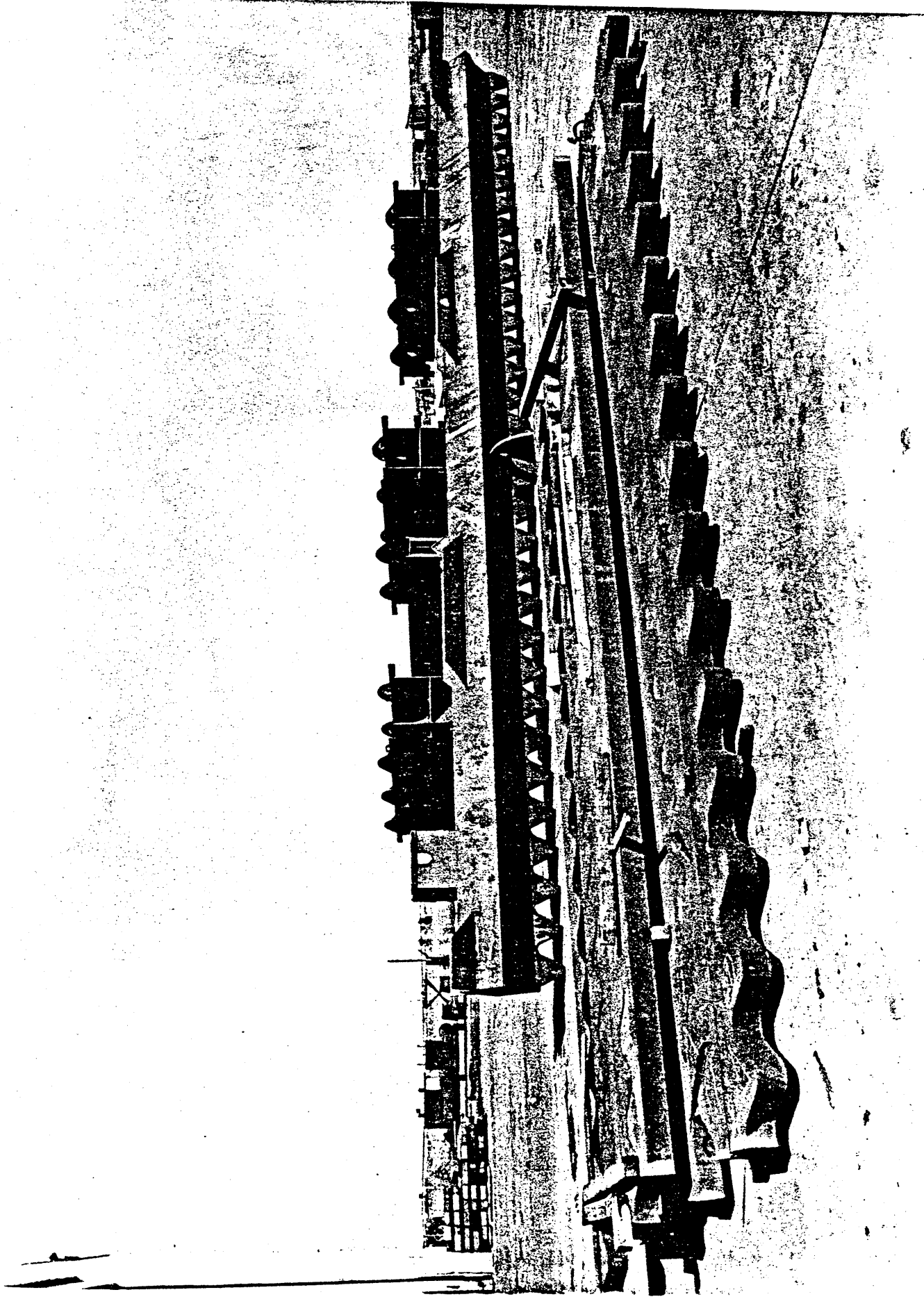


Figure 2
Leg chord components, with jacking unit frames in the background.

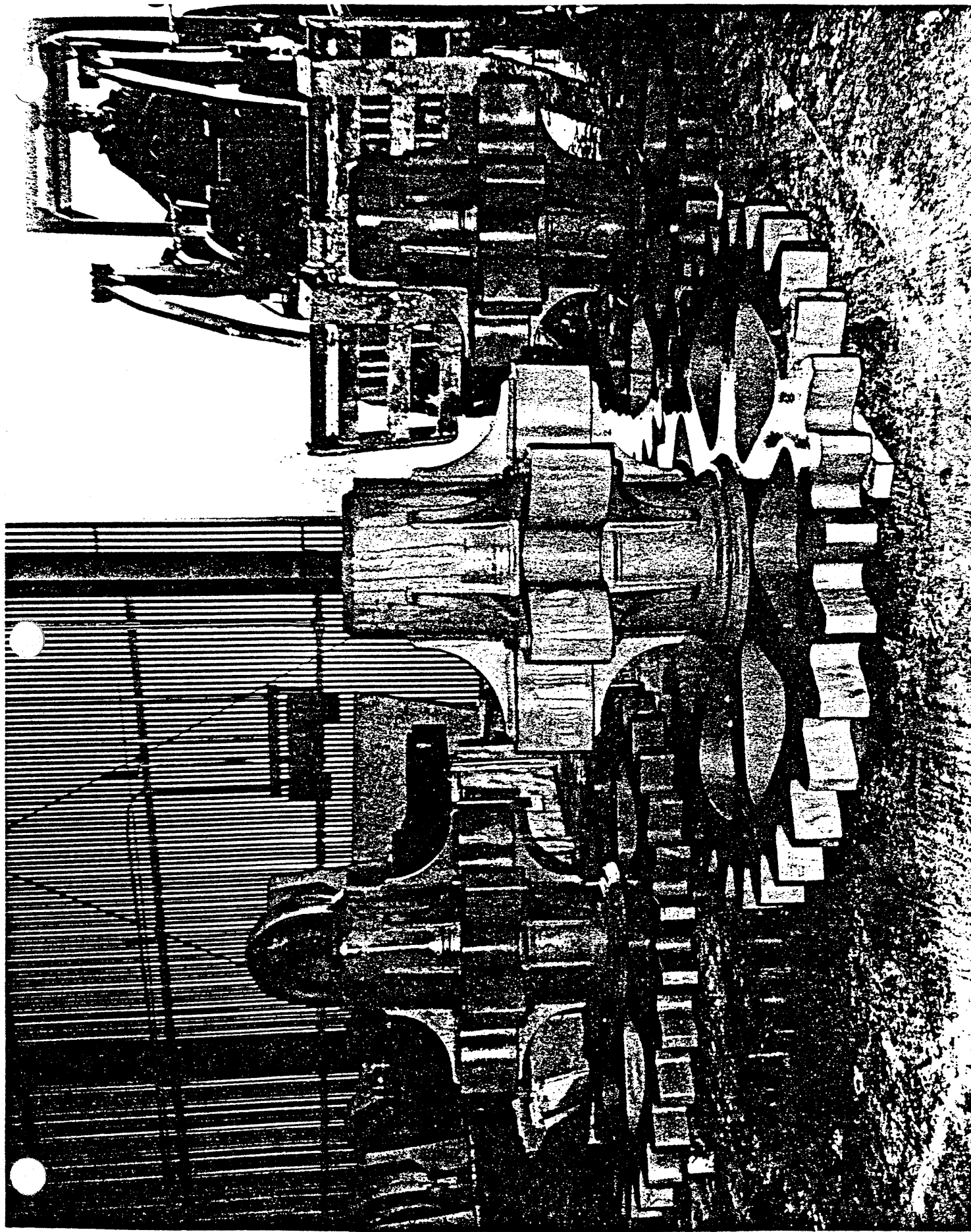


Figure 3
Final drive pinions: these are used in the jacking units as in Figure 1.

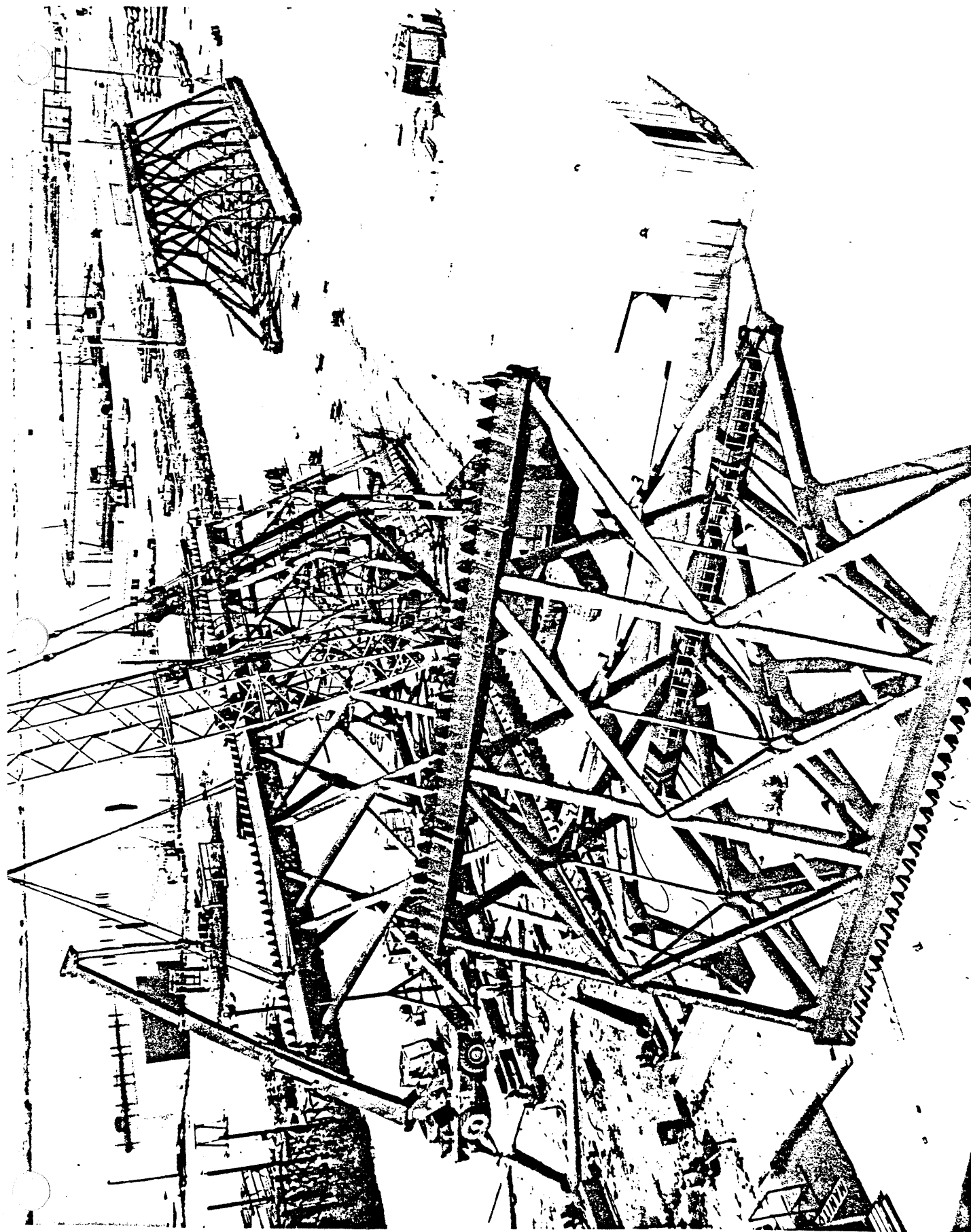
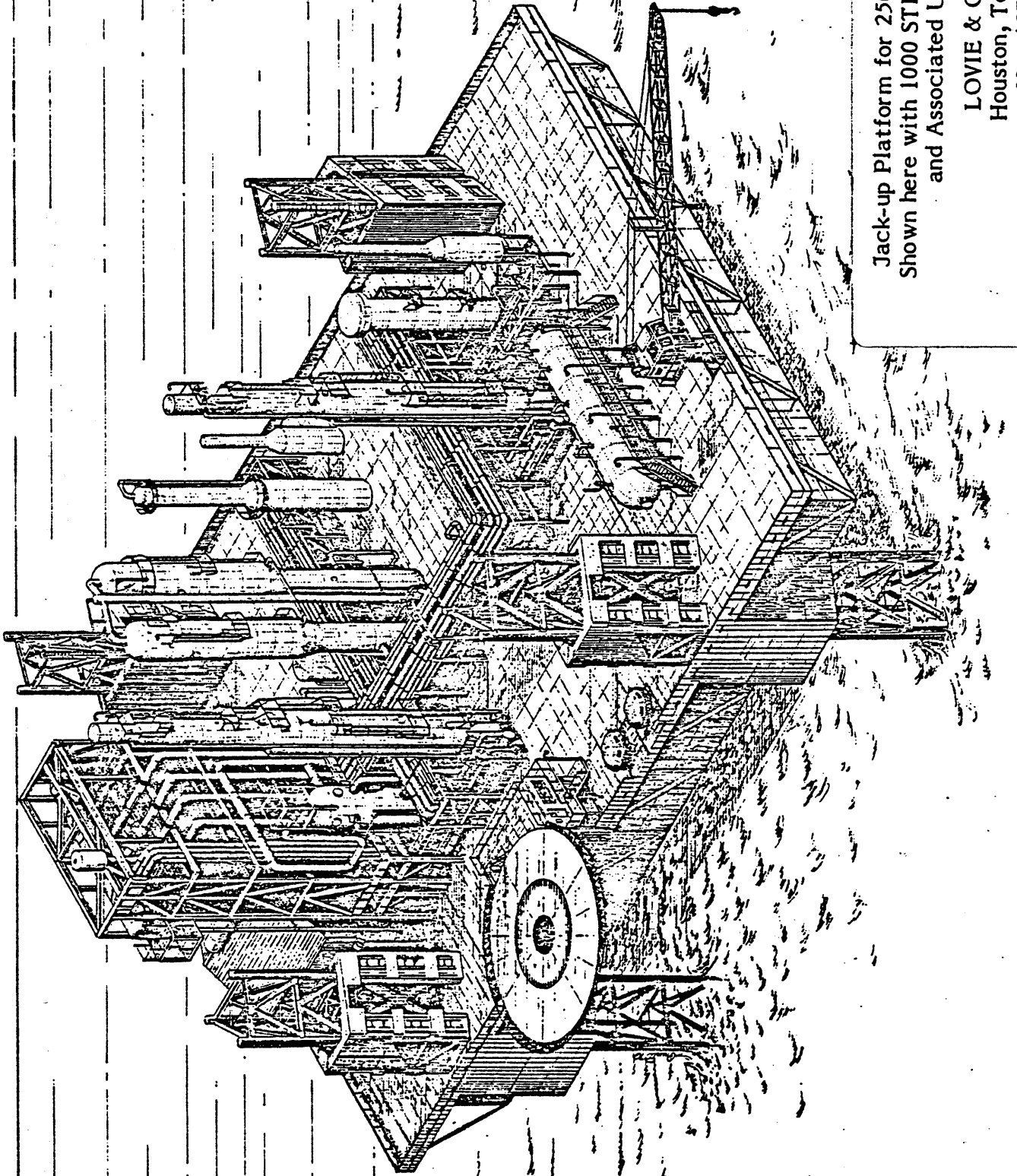


Figure 4

Leg sections being assembled: these are similar to the construction needed in the jack-up ammonia/urea plant in Figure 5.



Jack-up Platform for 250 ft. water depth:
Shown here with 1000 STPD Ammonia Plant
and Associated Urea Plant

LOVIE & CO.

Houston, Texas

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Design Proprietary to LOVIE & CO.

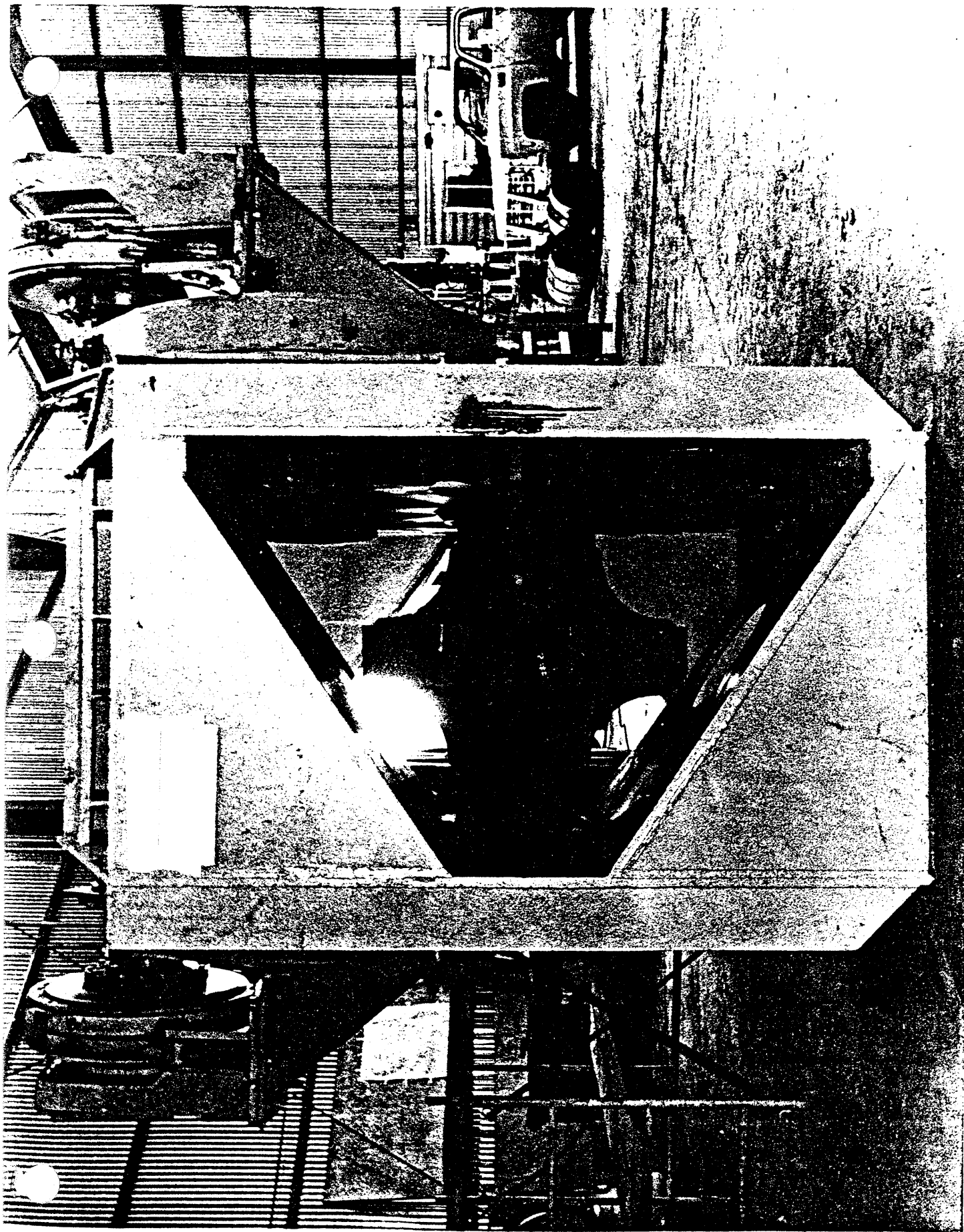


Figure 6. Medium size rack and pinion jacking system: to lift 500 tons in offshore drilling operations.