CARPENTERS-EMPLOYERS

APPRENTICESHIP & TRAINING

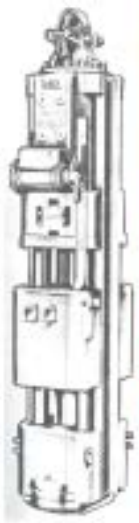
TRUST FUND OF WESTERN WASHINGTON

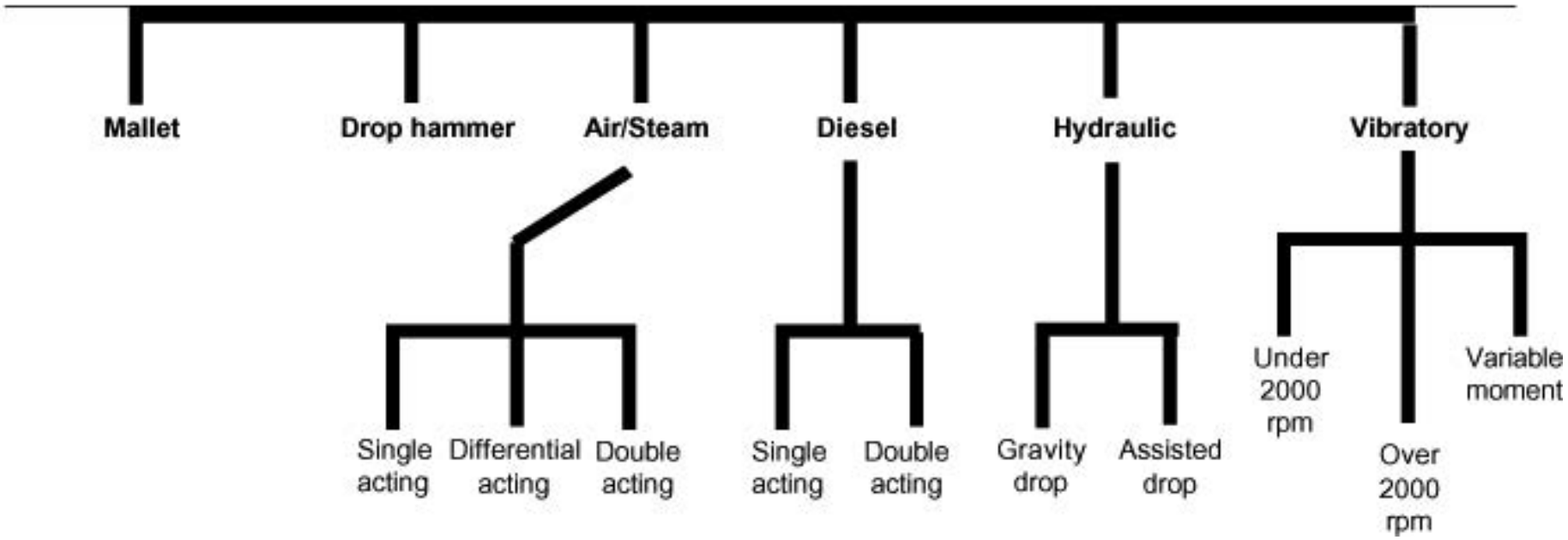
APE Pile Driving School

Topics

- Roman drop hammers
- Pile Types
- Pile Tips & Splices
- Mandrels and Followers
- Leads: Swing, Fixed, Fixed Extended
- Pile Driving Rigs
- Diesel hammers: Single, Double
- Hydraulic impact hammers
- Press Pile Drivers
- Pile Testing
- Pile Inspection
- Pile Cutting
- Vibratory Pile Driver/Extractors
- Noise & Hammers
- Understand Soil Types
- Driven Grout Piles
- Augered Cast-in-Place Piles
- Bored Displacement Piles
- Wick Drains
- Vibroflotation
- Drilled Piles
- Vibro Compaction
- Tie Backs
- Soil Nailing
- Pin Piles
- Anchored Piles
- Jetting
- Air Lifts
- Learning from the Internet
- Crane Signals
- How To Drive & Extract:
  - Wood Piles
  - Concrete Piles
  - Pipe Piles
  - H-Beams
  - Vibrated Beam Slurry Wall
  - Concrete and Wood Sheets
  - Steel Sheets
  - Casings
  - Caissons
  - Power Poles
  - Helicopter
  - Underwater

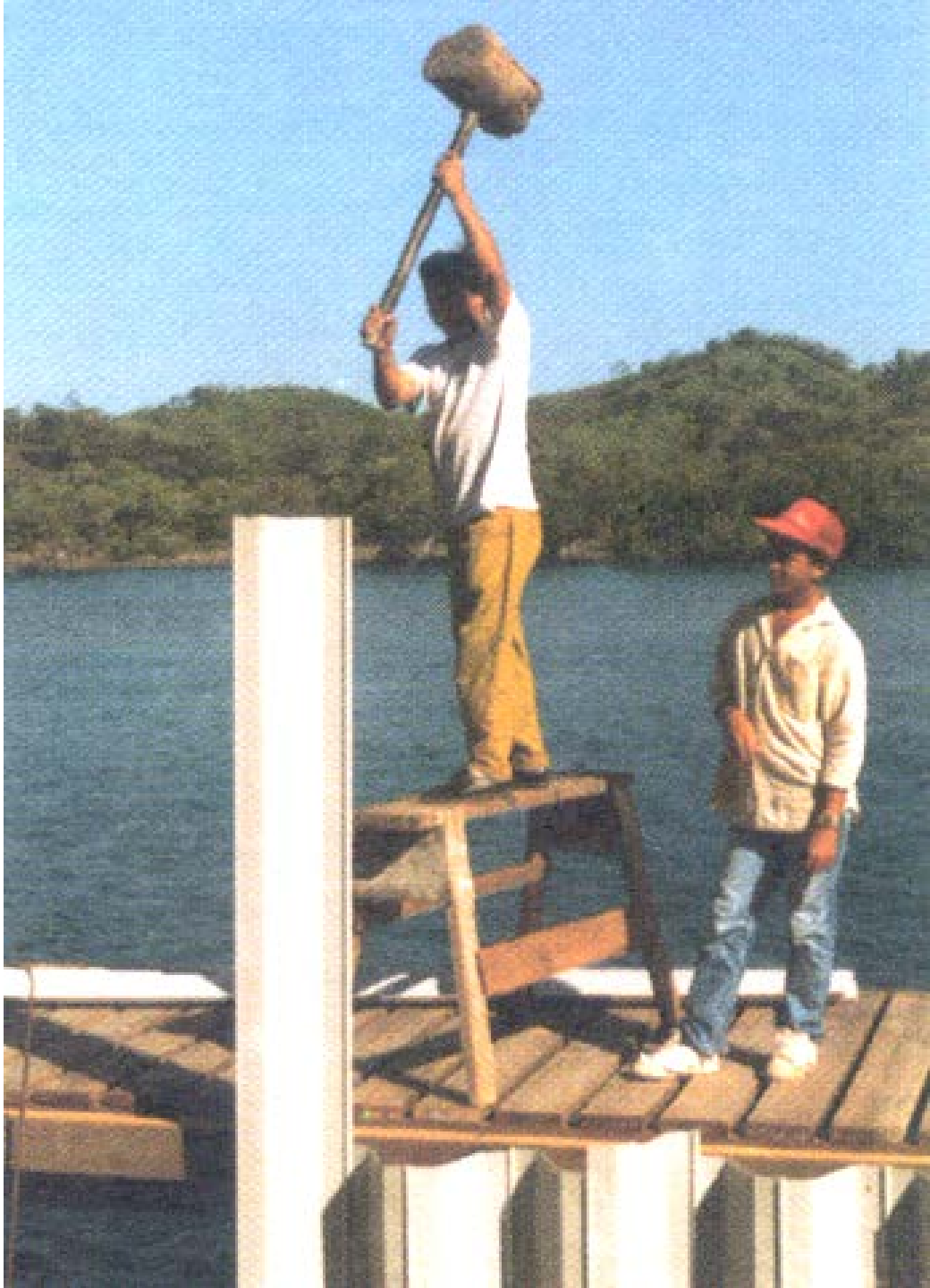




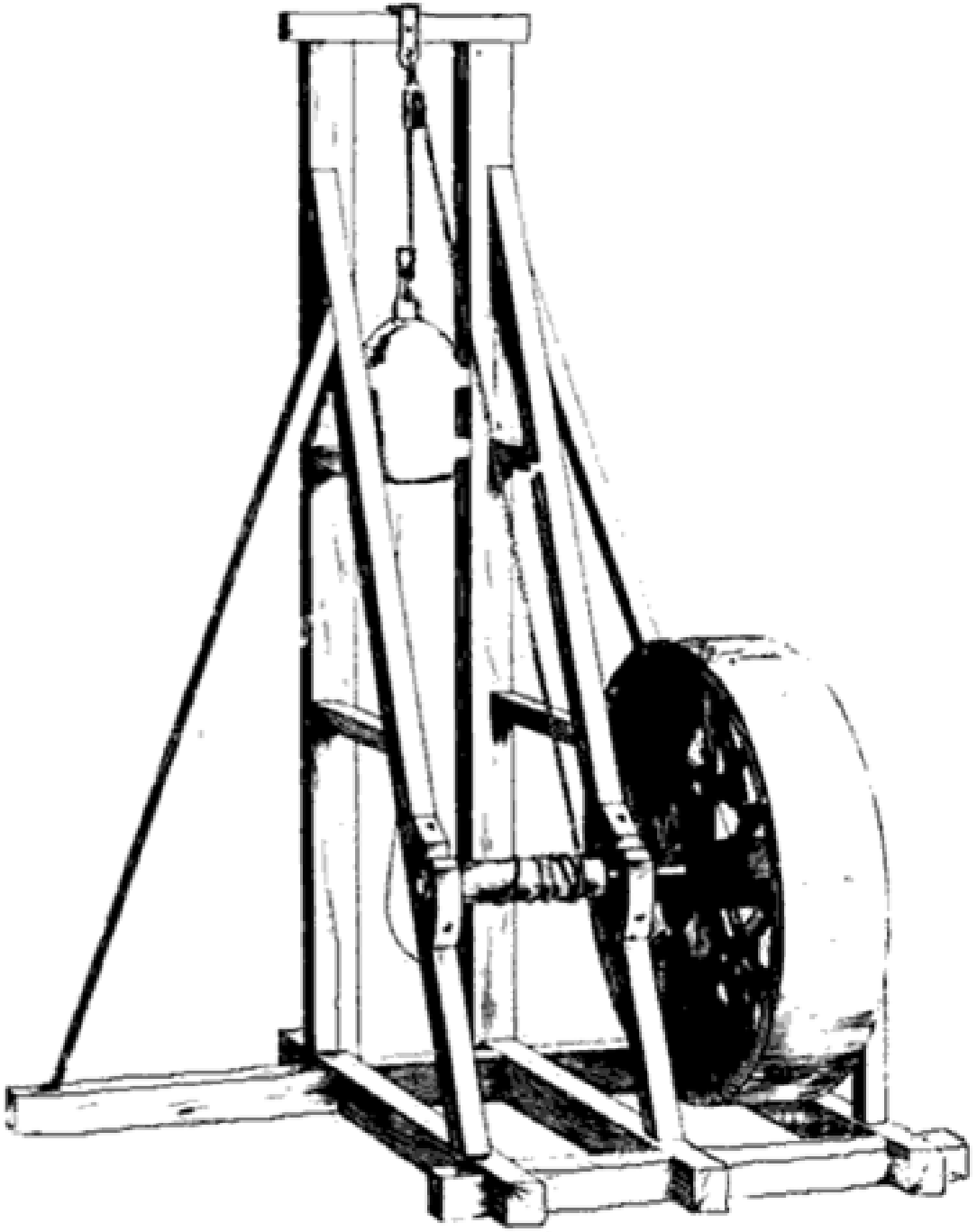



Hammer classification chart

Hand Held Pile Driver



Man Powered Drop Hammers

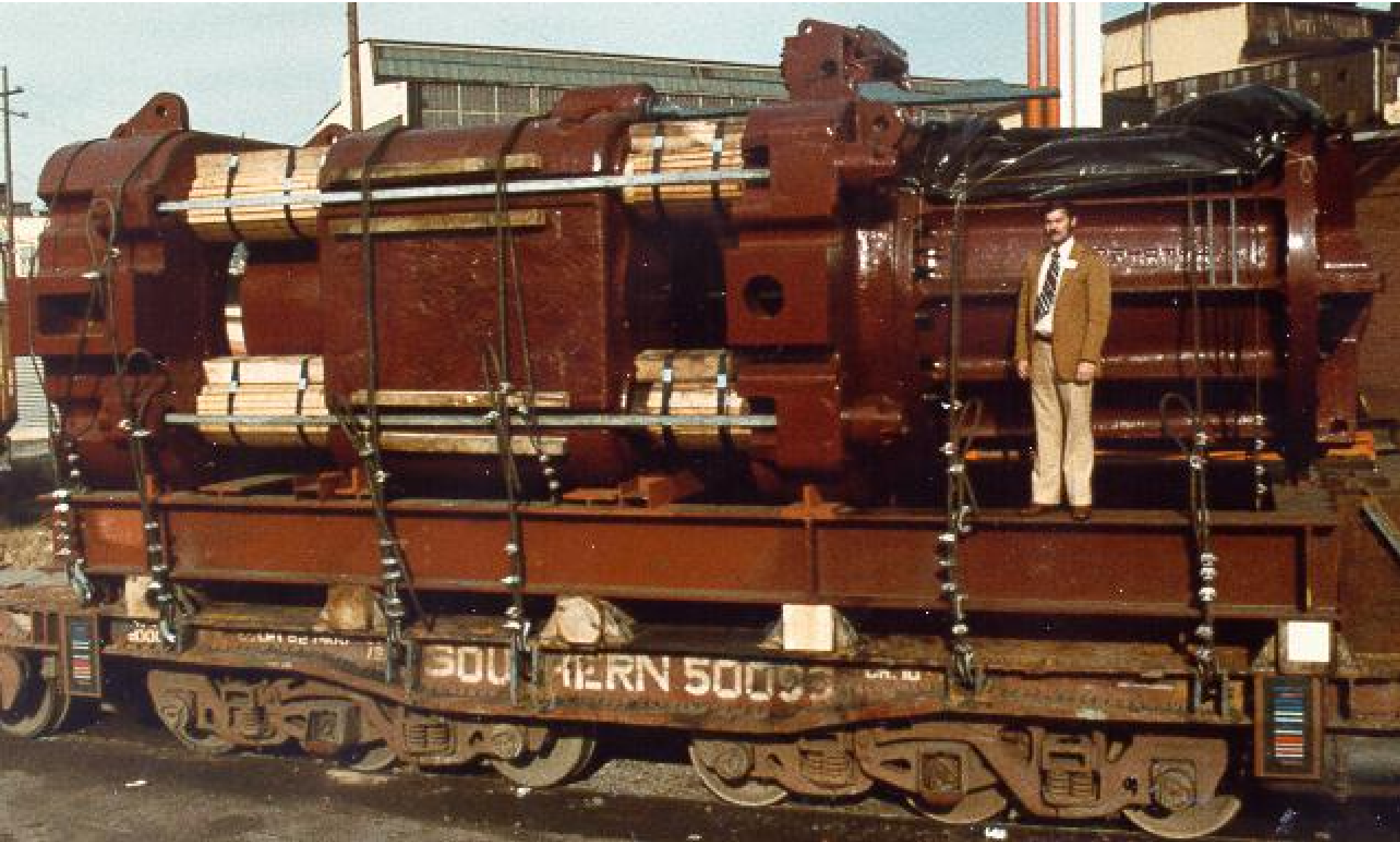


Machine Powered Drop Hammers

On Shore
Air Hammers

Air Steam Hammers

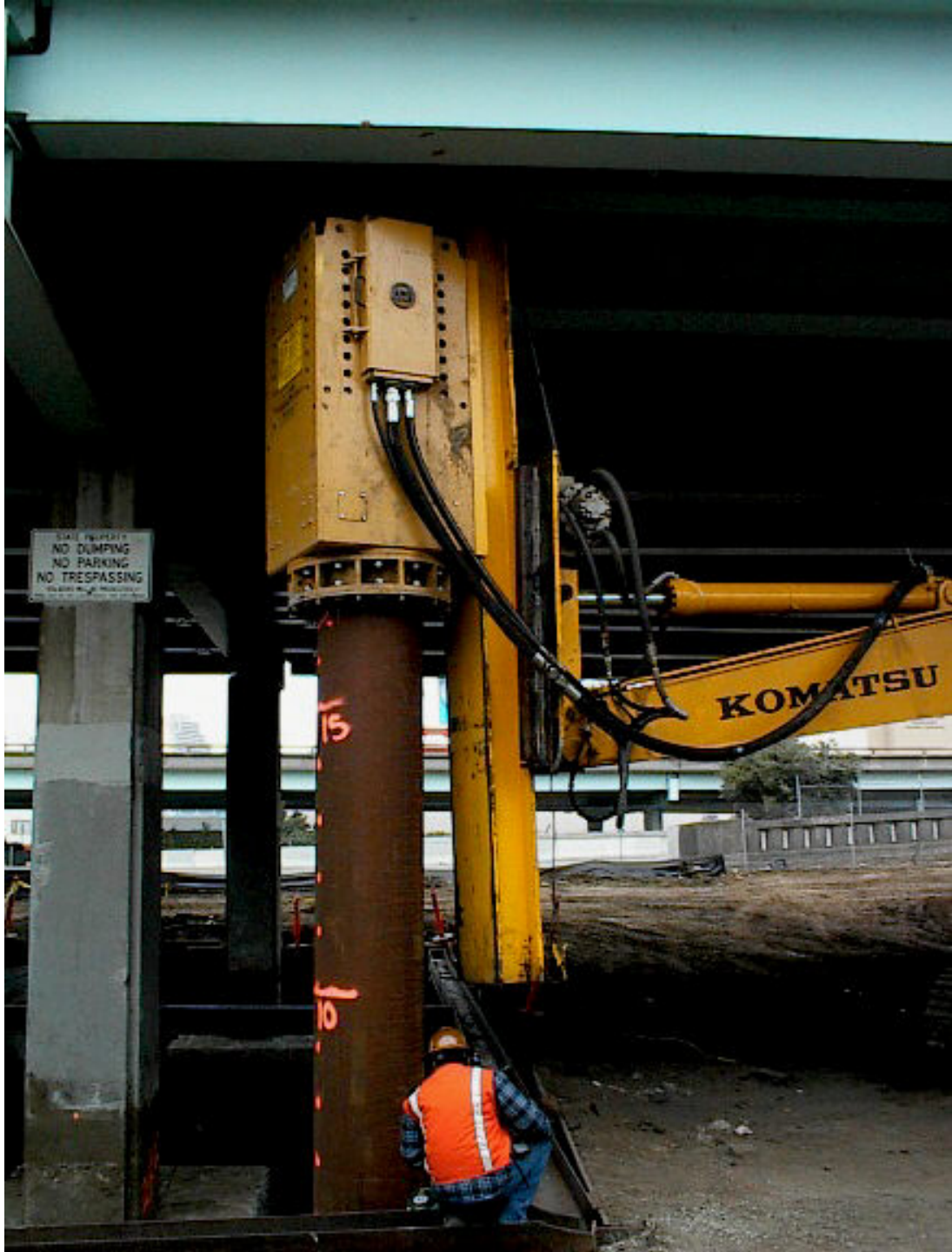
Off Shore Steam or Air Hammer



Diesel Hammers

Delmag's D200

Hydraulic Impact Hammers



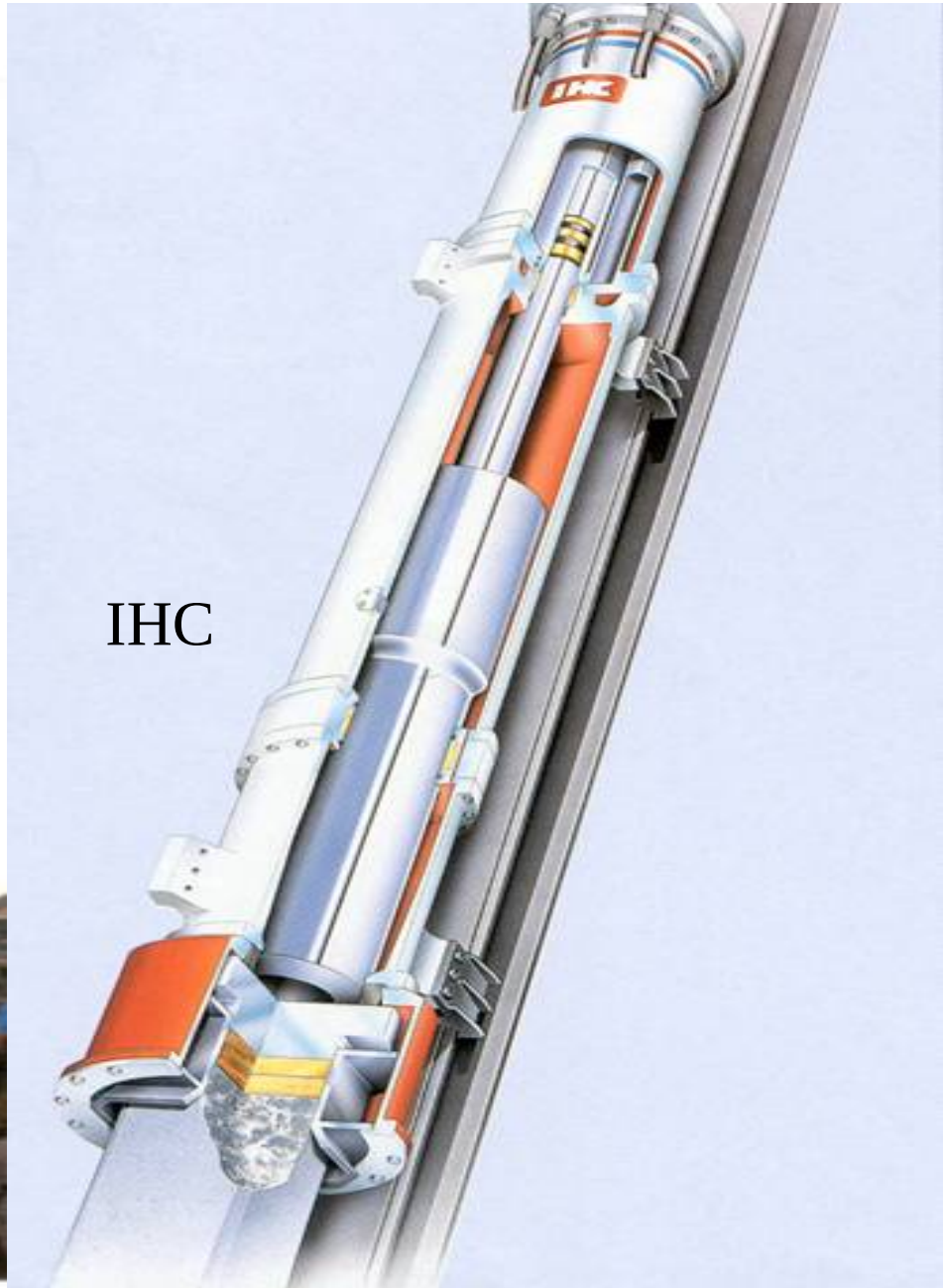
Hydraulic Impact Hammers

Hydraulic Impact Hammers

Hydraulic Impact Hammers

Menck

IHC

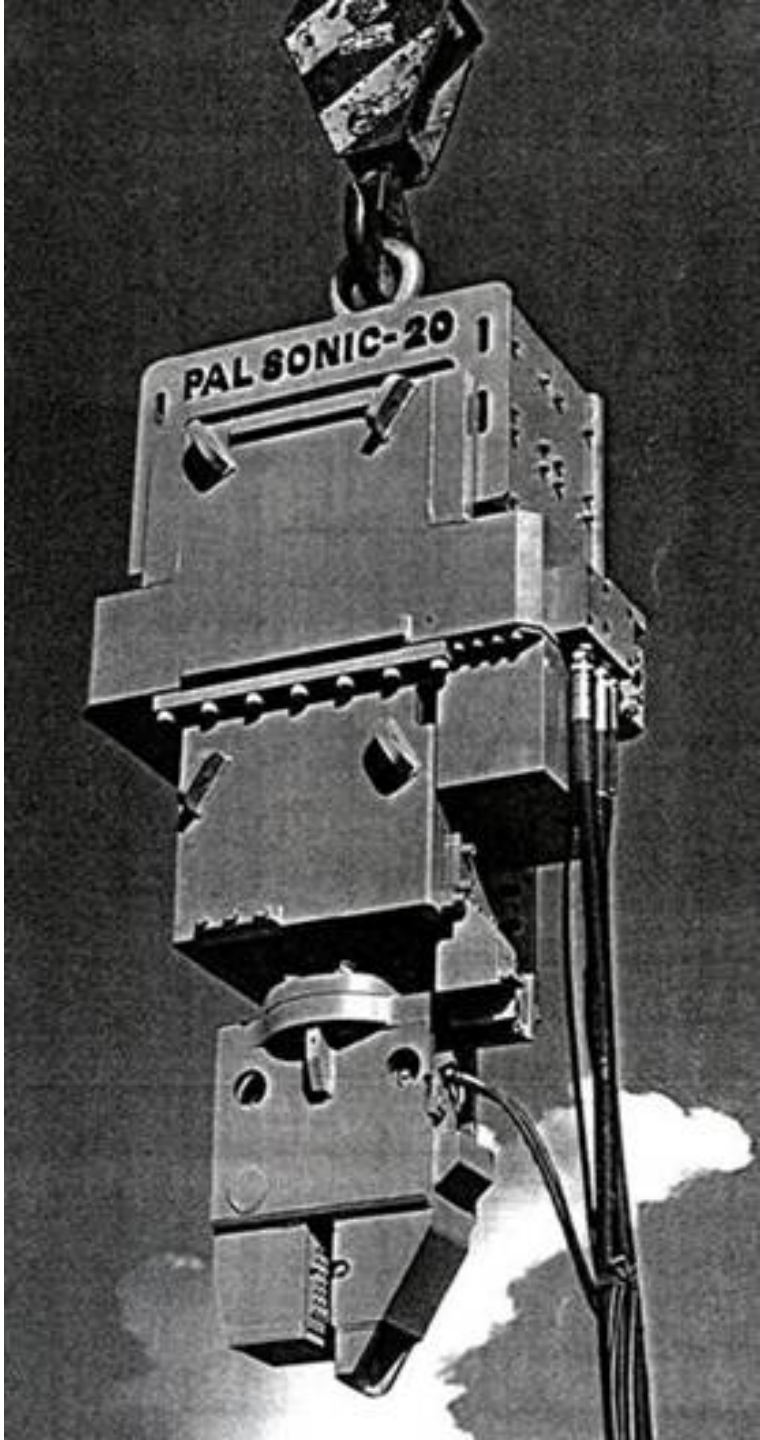


Junttan Hydraulic Impact Hammer

Low
Headroom
Hydraulic

Vibratory Pile Driver/Extractors

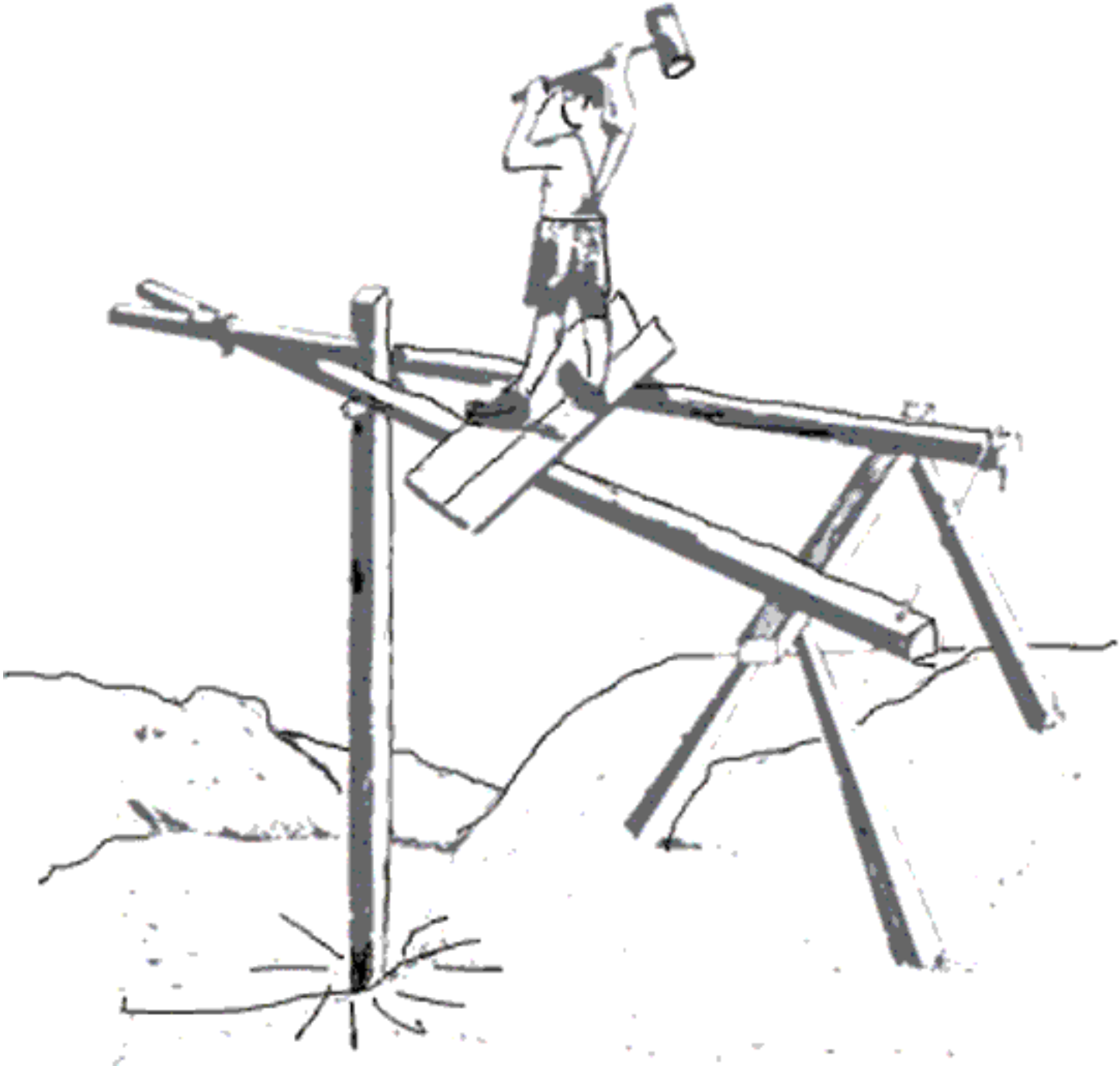
Sonic Impact Hammers

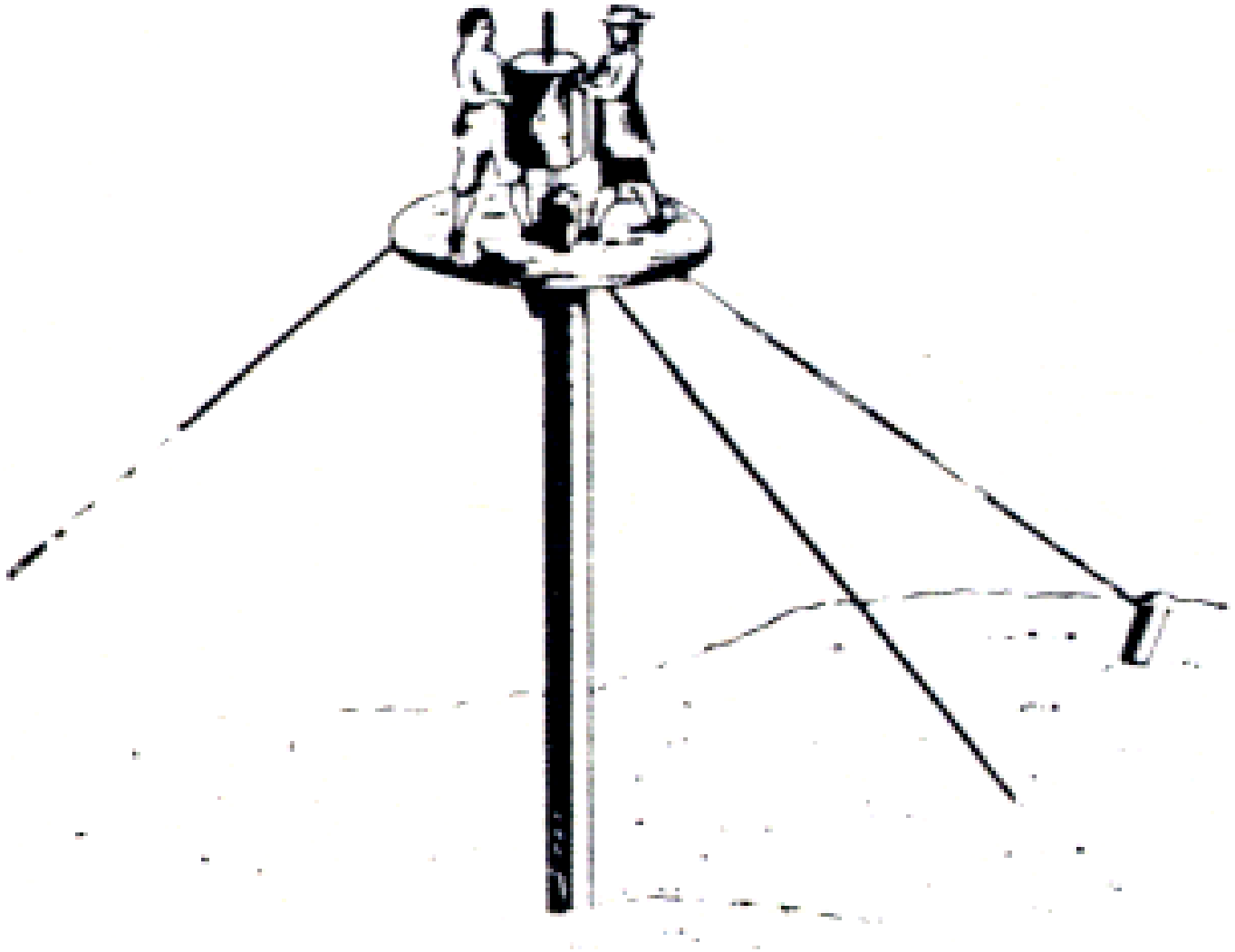


Simple Pile Driver

-

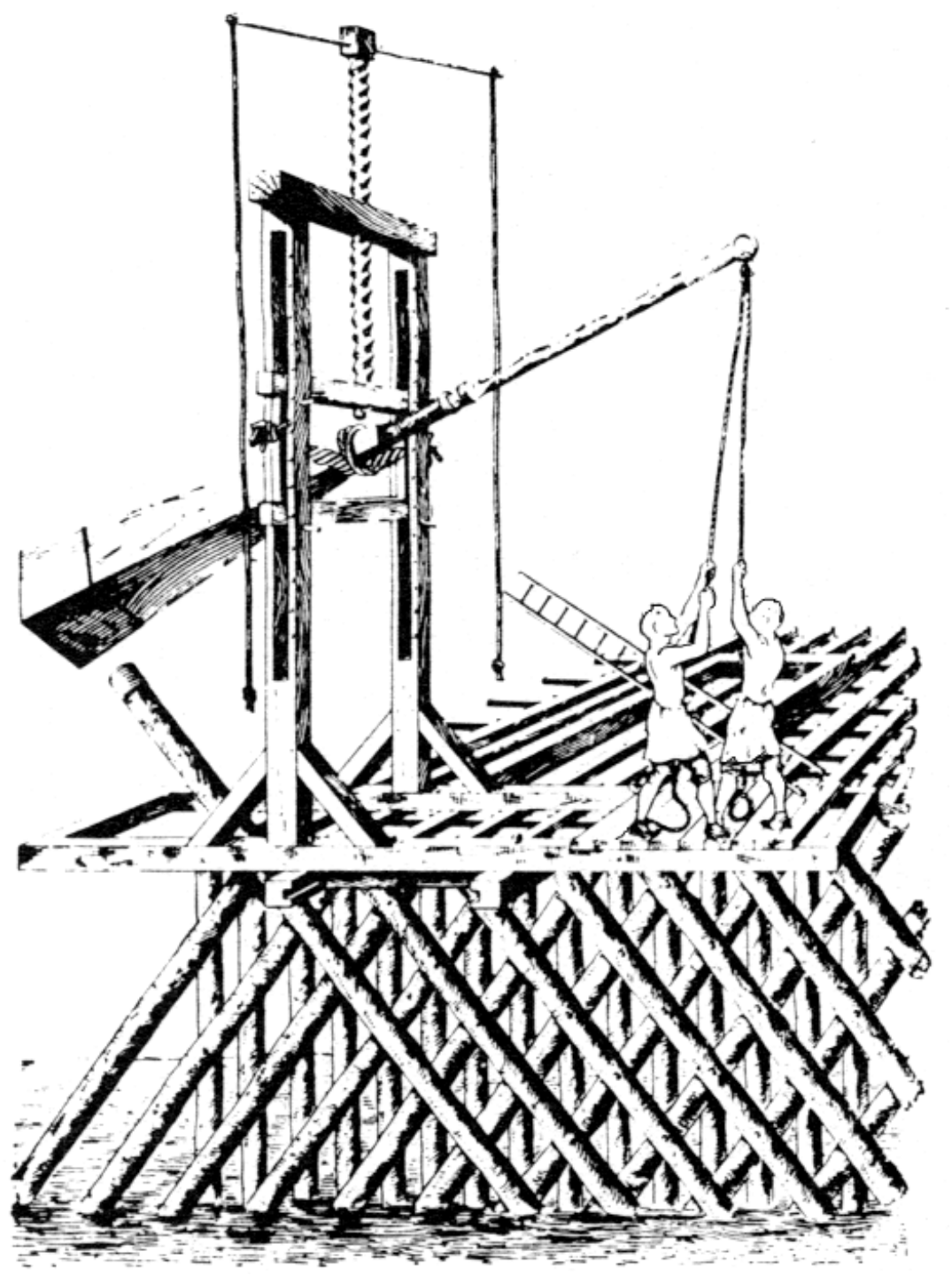
Driving Pile with Maul





The Hand Ram

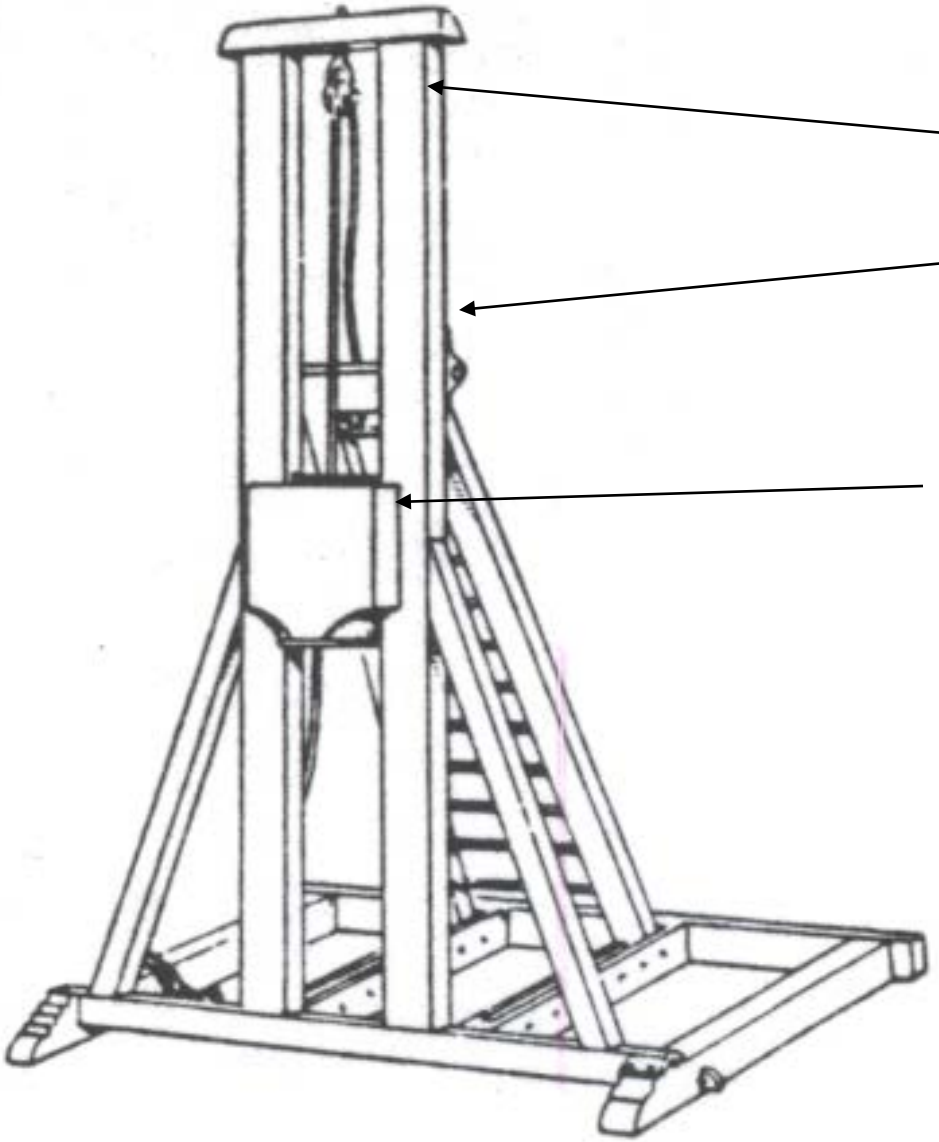
As piles became longer, thicker and thus heavier, the falling weight had to be increased in size.



The hand operated machine maul.

As weight of the ram increased, more man power was required.

Introduction of pile driving leaders systems and other new components.



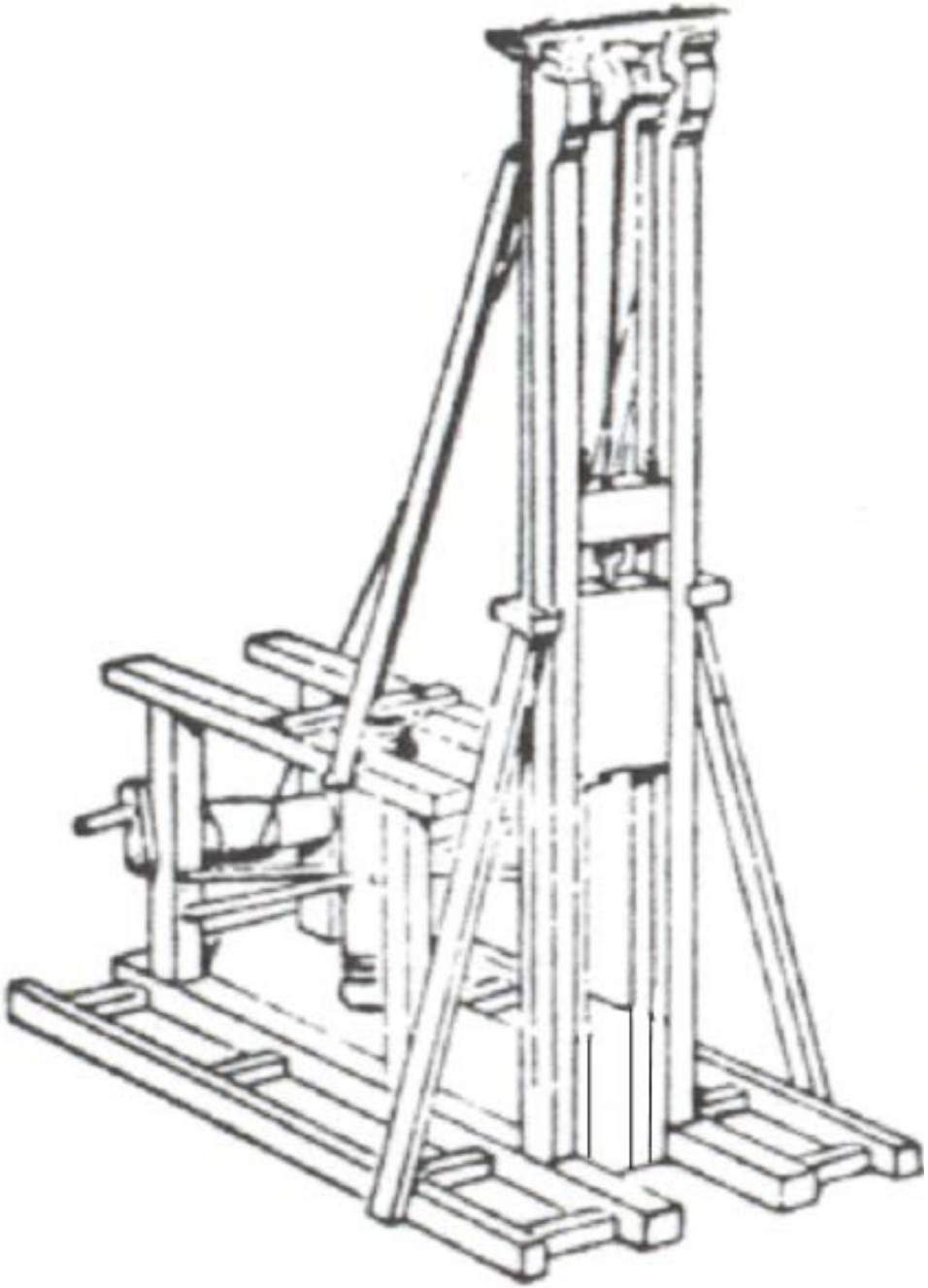
Head sheave

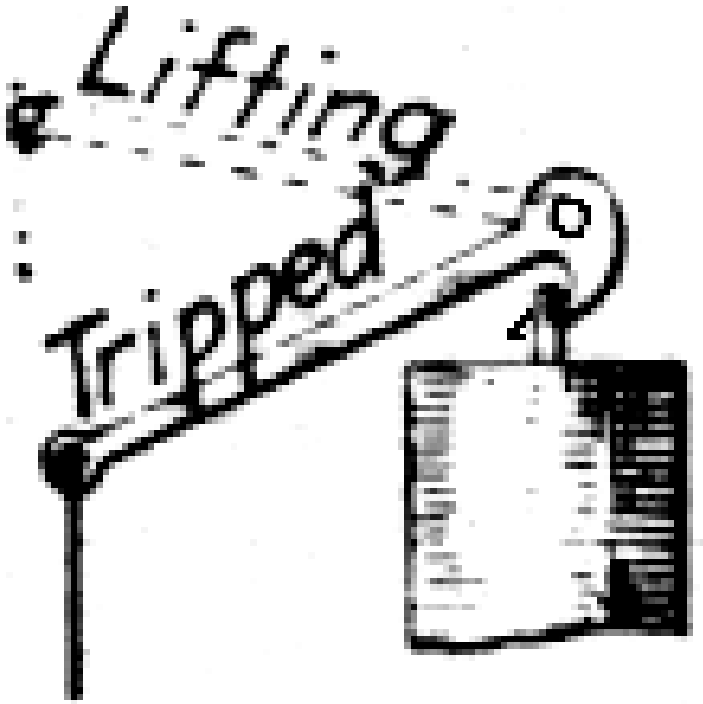
Pile guide or leader system

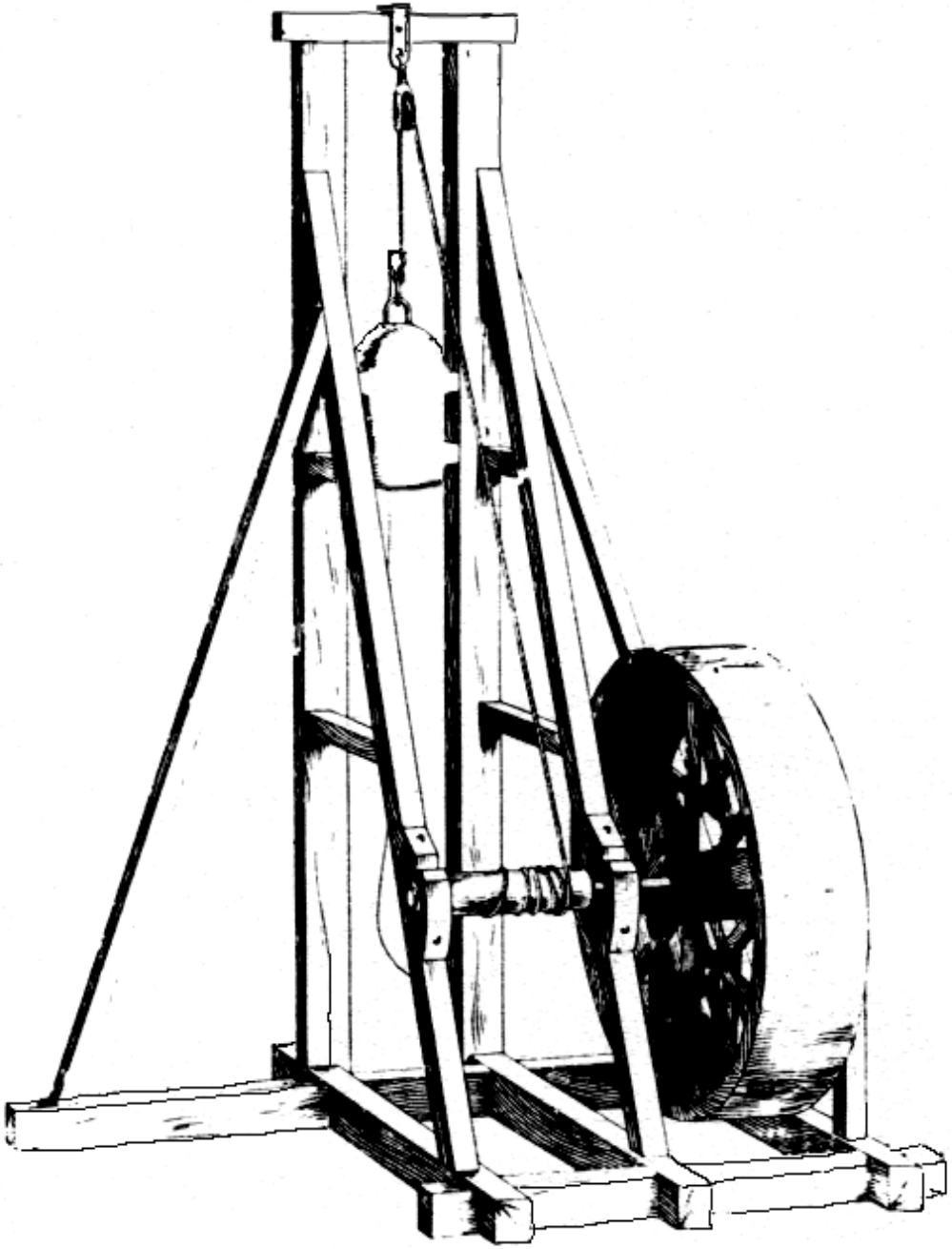
Also called “leads”

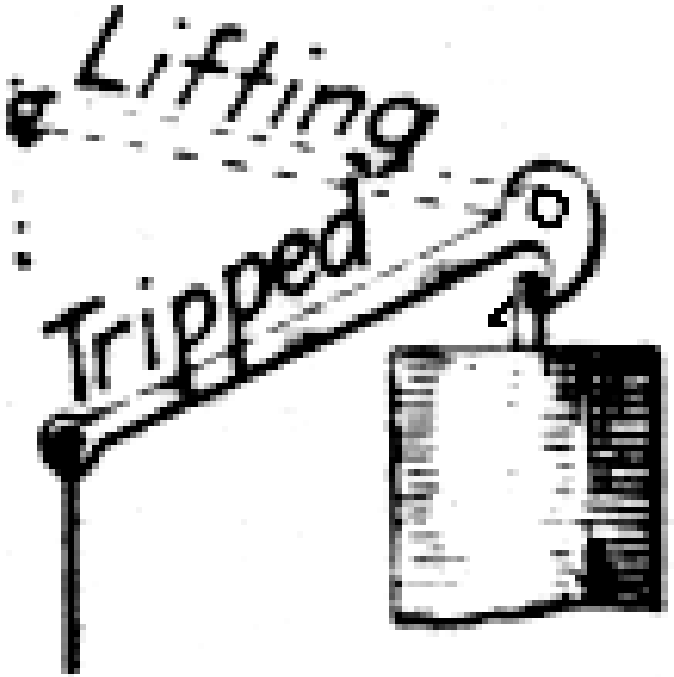
Ram, lump, or piston

Tripping Device





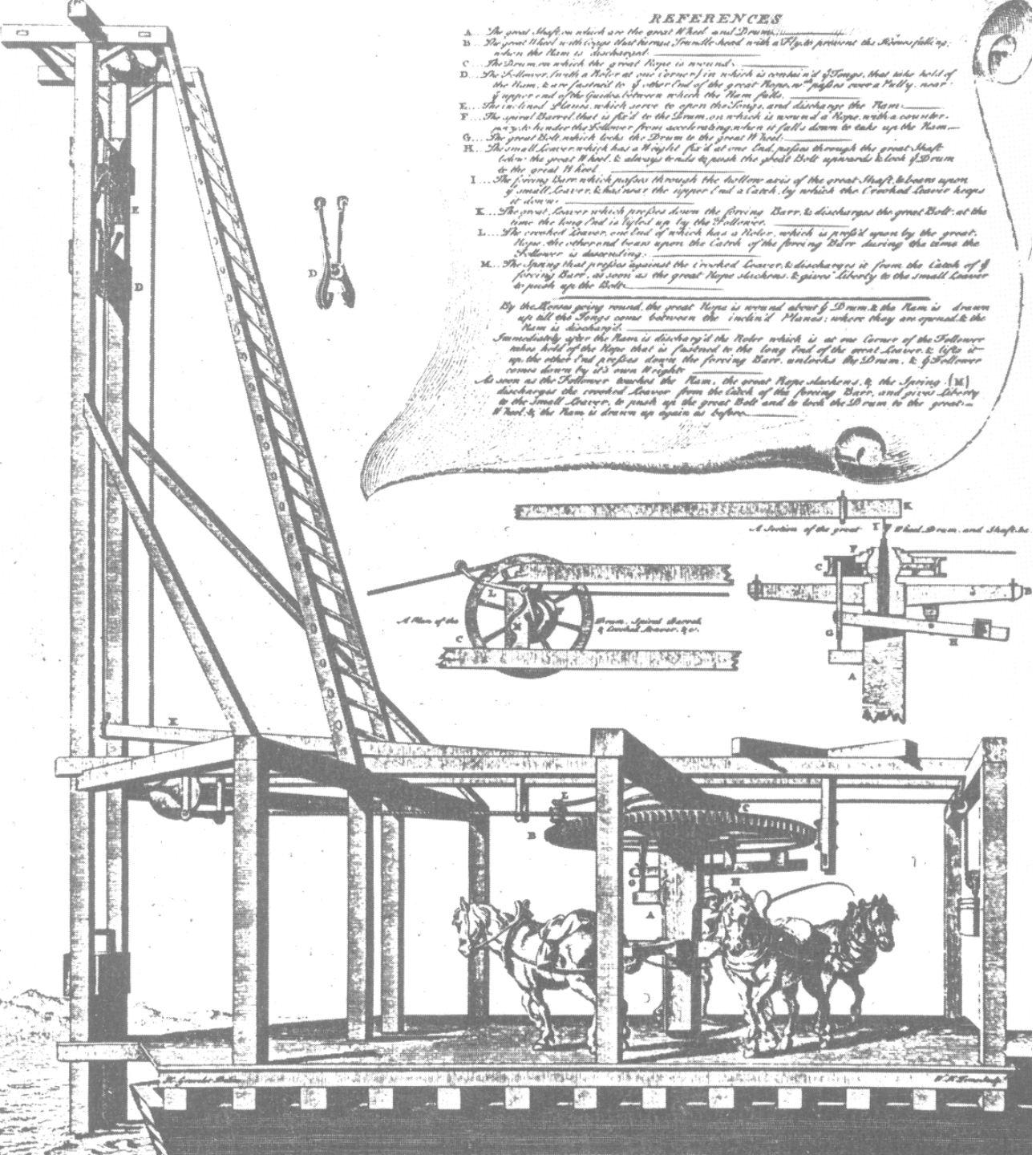




Simple trip system designed by the Romans.

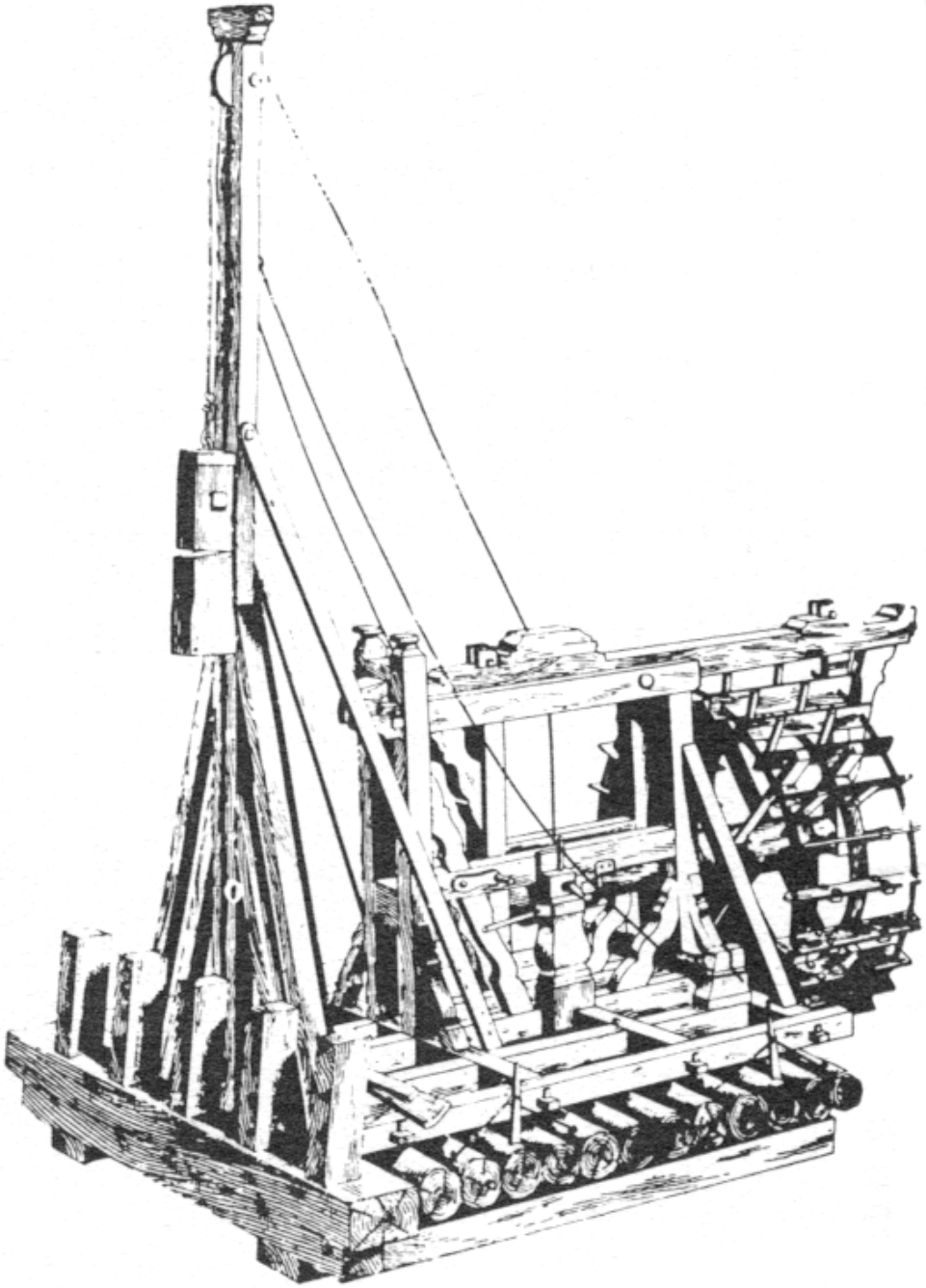
Treadmill Driver with Rope Trip Release

Ancient Drop Hammers



The drop hammer is a heavy weight lifted and dropped on the pile. It operates in guides that position the impact. In the past (and still occasionally) the weight is lifted by man or horse power. Now a line on a crane or a winch raises the weight to a predetermined height where a trip releases it to fall freely on the pile.

The weight of the ram is not less than one third the weight of the pile. A suitable cap with cushion material is used on the pile to distribute driving forces. Drop hammers are still commonly used in some parts of the world.



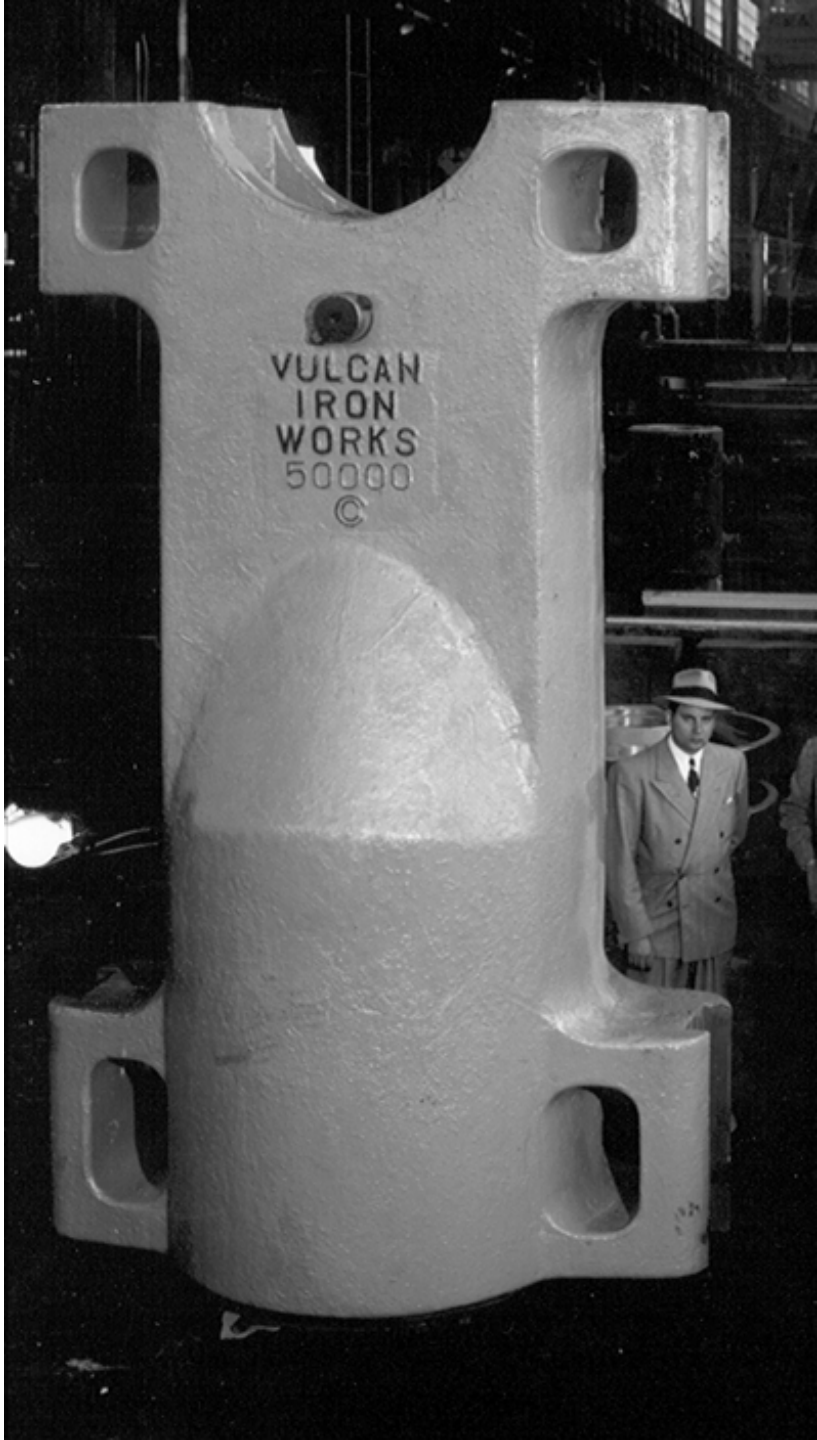
River Current Wheel Pile Driver

With Slotted Single Lead

Paddles drive the mechanism to lift the ram.

Drop Hammer Sizes.

Standard drop hammers weigh from 500 to 3,000 lbs. In round number hundred weights.

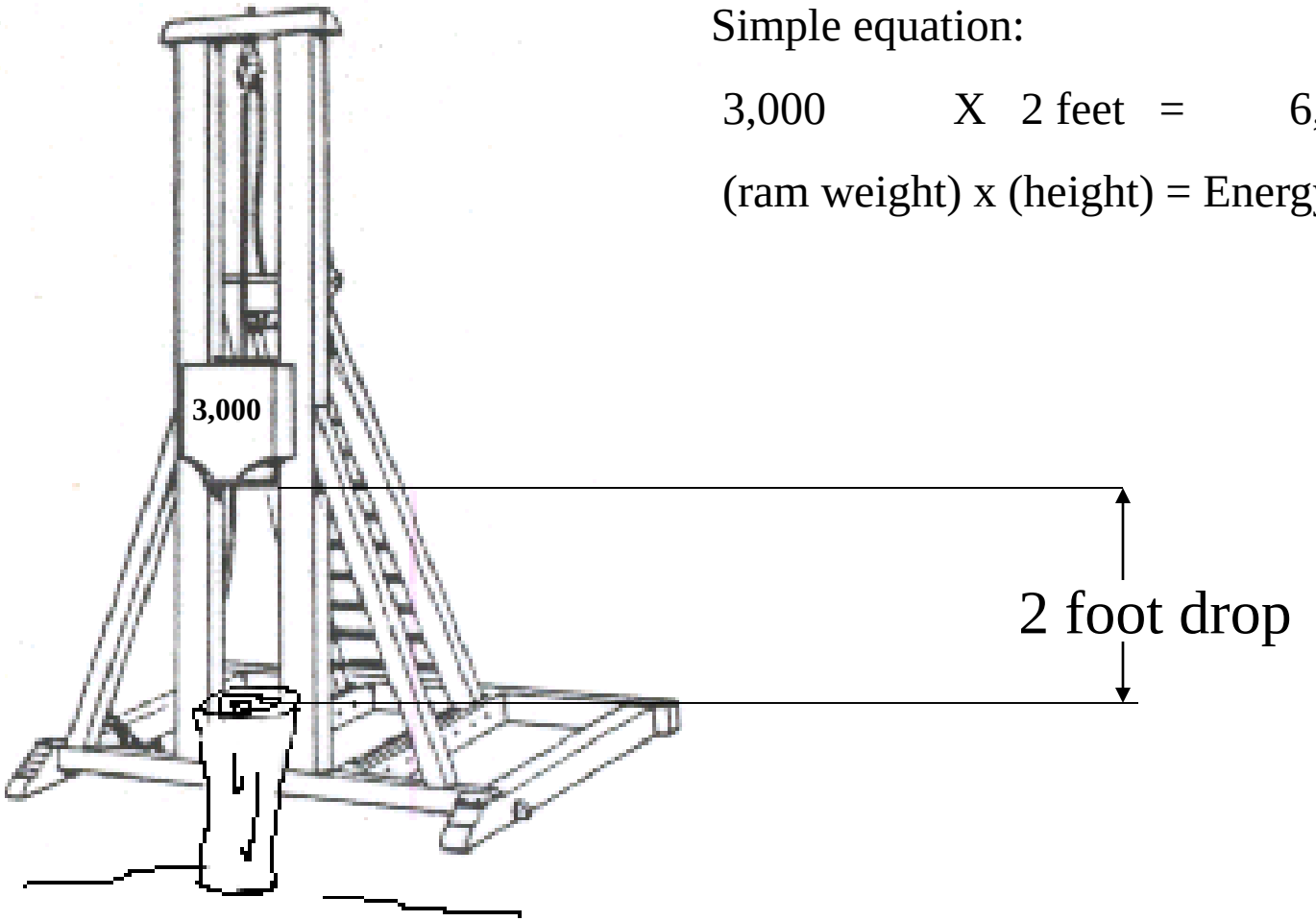


50,000 lb Vulcan drop hammer.

The available impact energy delivered per blow by a drop hammer is calculated simply by multiplying the weight of the hammer times its height of fall.

Weight x Height = Energy

Impact energy delivered per blow by a drop hammer is calculated simply by multiplying the weight of the hammer times its height of fall.



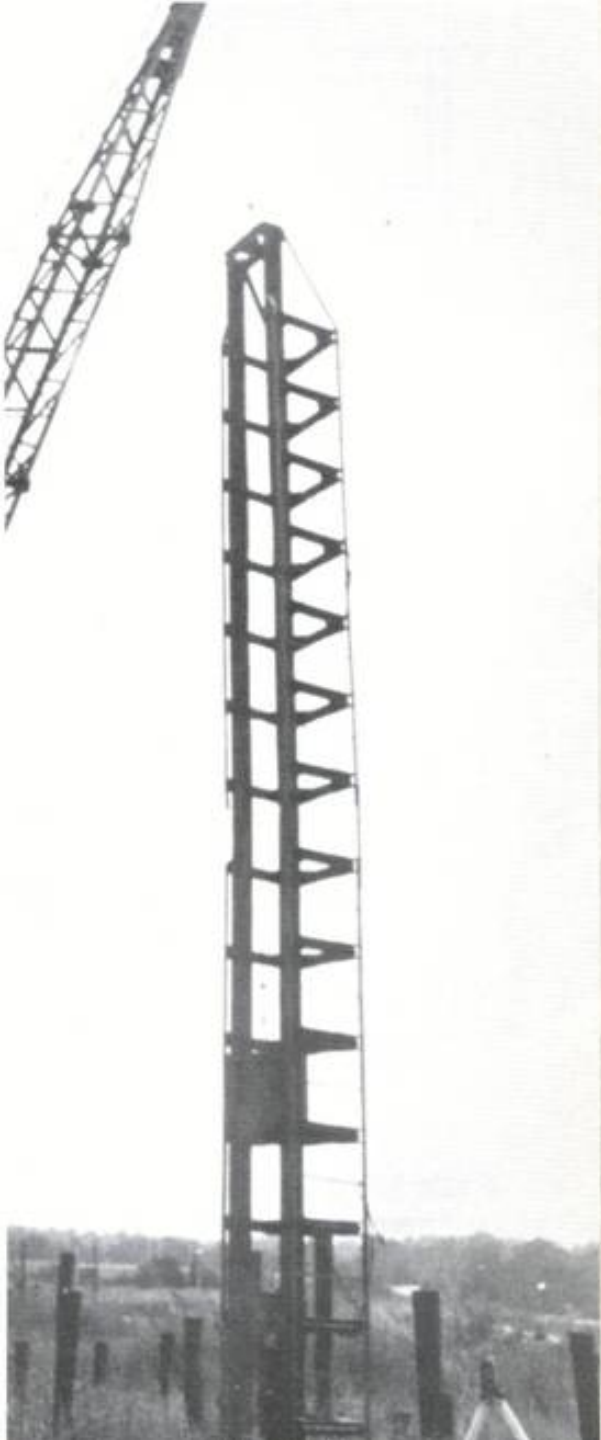
Simple equation:

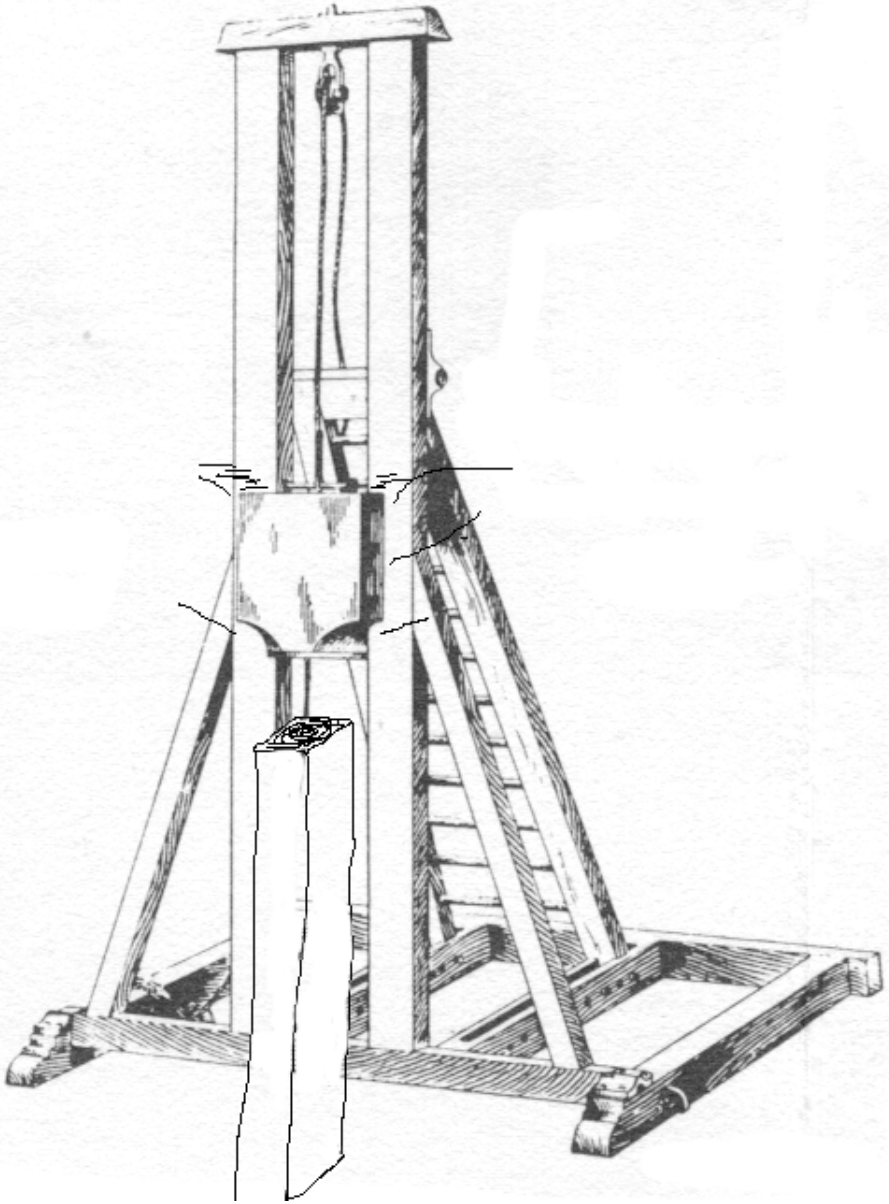
3,000 X 2 feet = 6,000 ft. lbs.

(ram weight) x (height) = Energy in Foot pounds

The higher the drop height, the greater the energy

A drop hammer
weighing 3,000 lb.
falling from
20-feet with
no bounce at
impact would deliver
60,000 ft-lbs of energy.



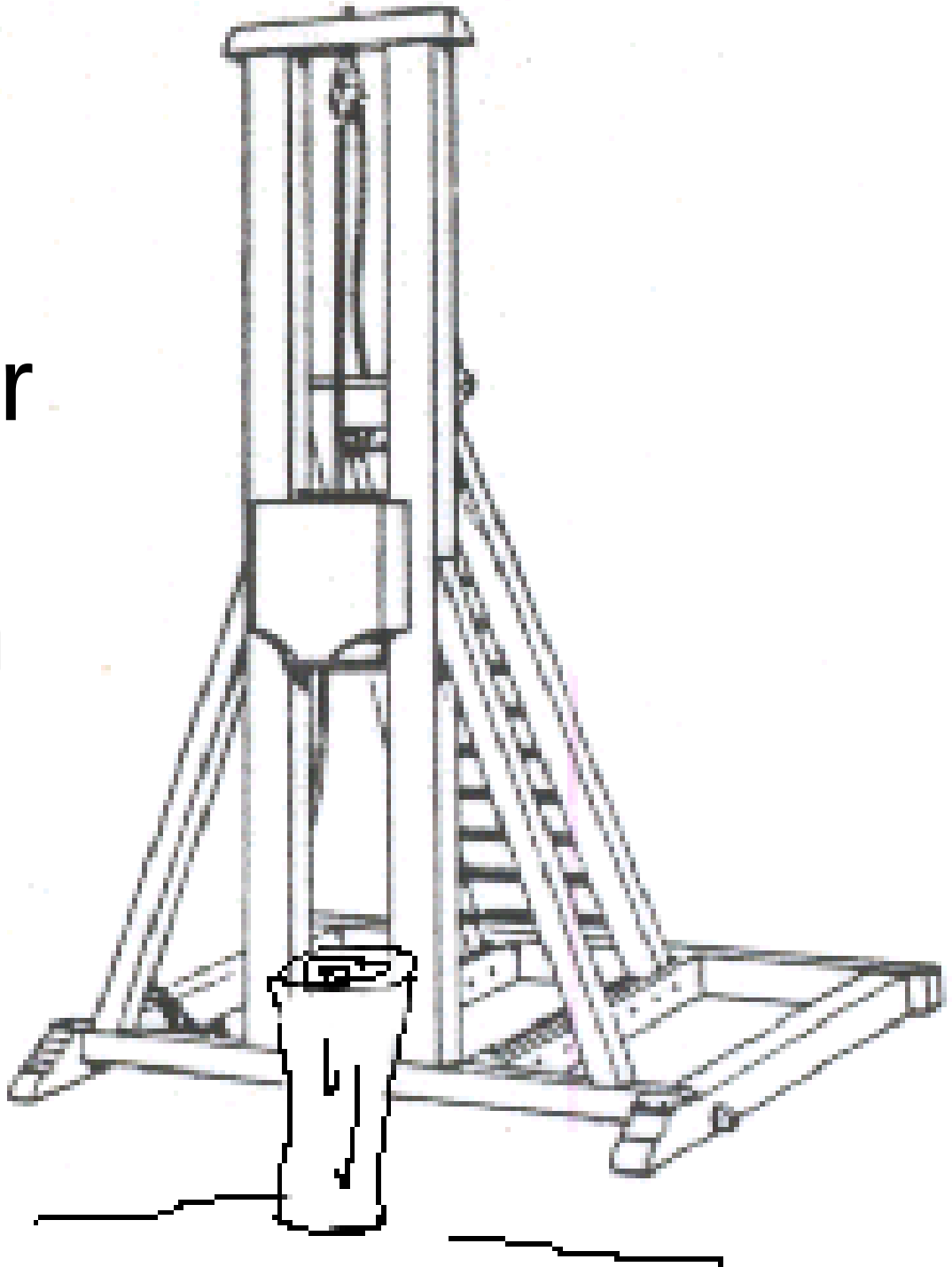


Re-bound Deduction

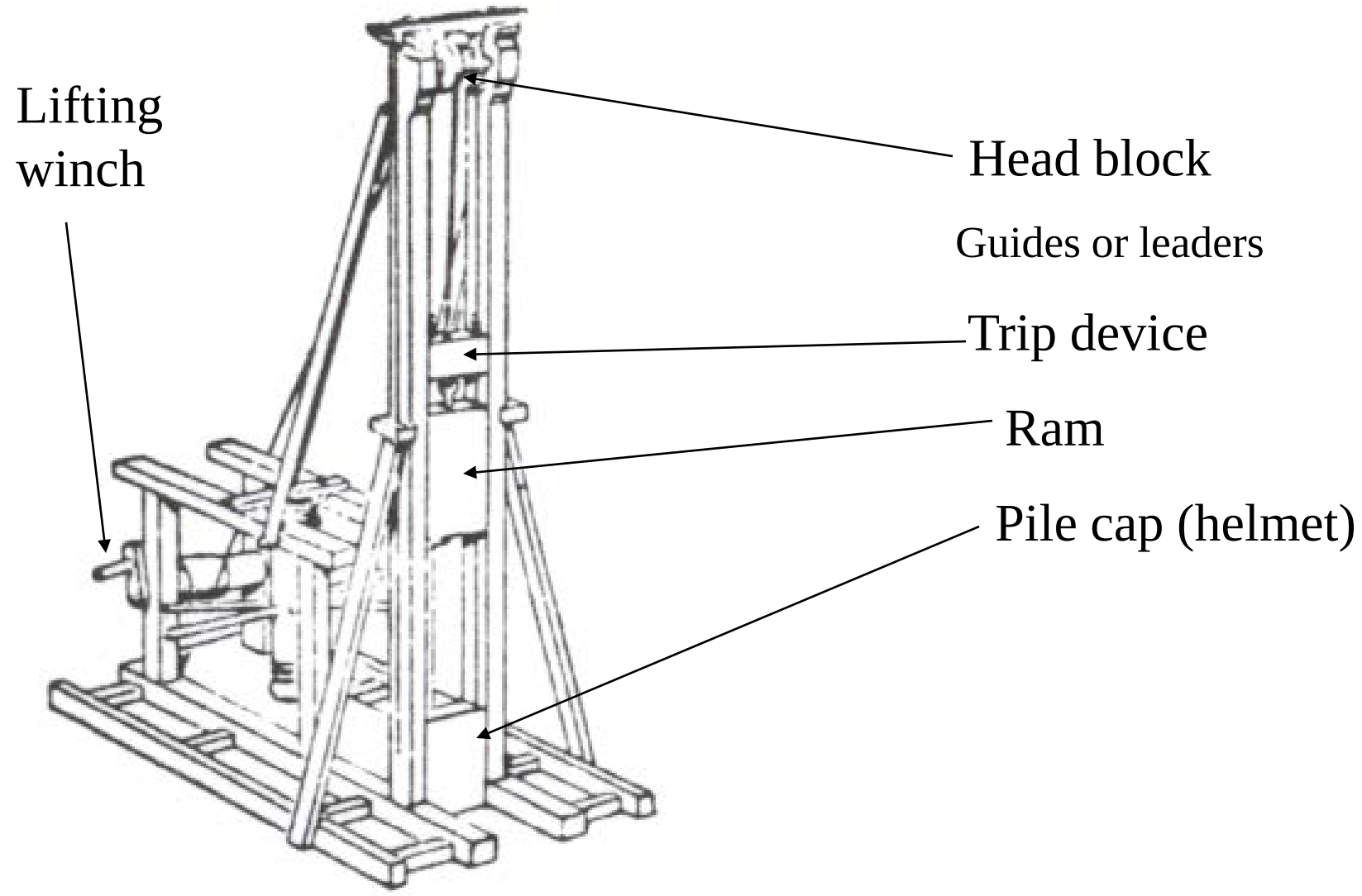
Whenever, upon striking the pile cap, the drop hammer bounces, twice the height of the bounce is deducted from the total height of fall to determine the net fall with which to calculate the delivered energy.

Deduct twice the bounce of the ram from the total drop height to determine net fall.

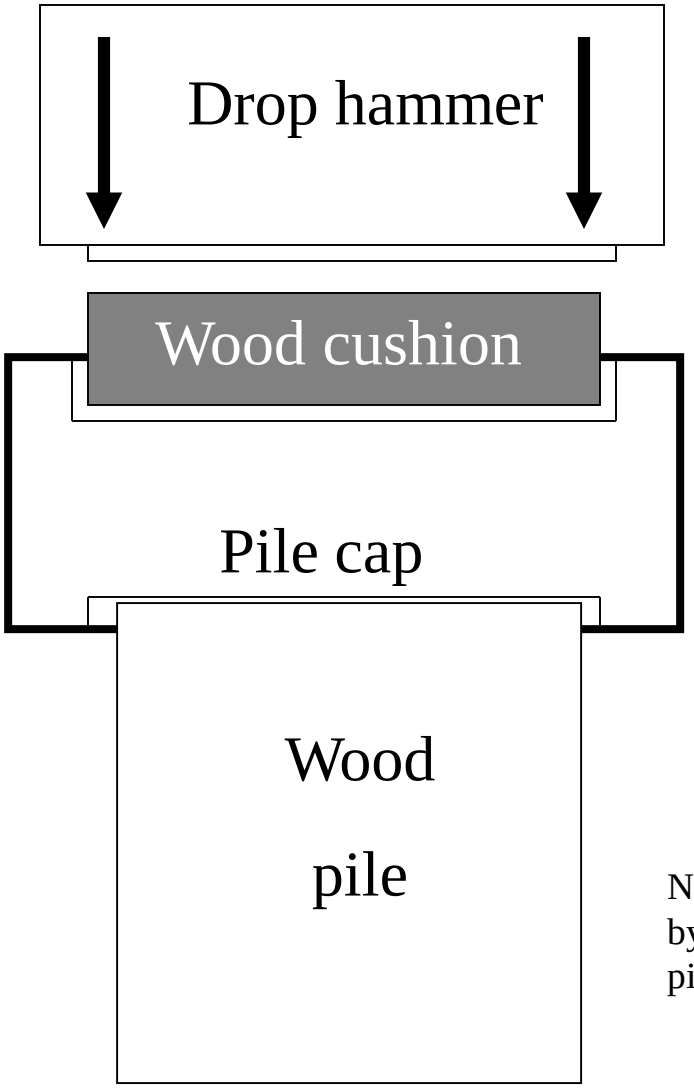
Energy Transfer at impact. Dropping from too high will damage pile.



The introduction of the drive cap.



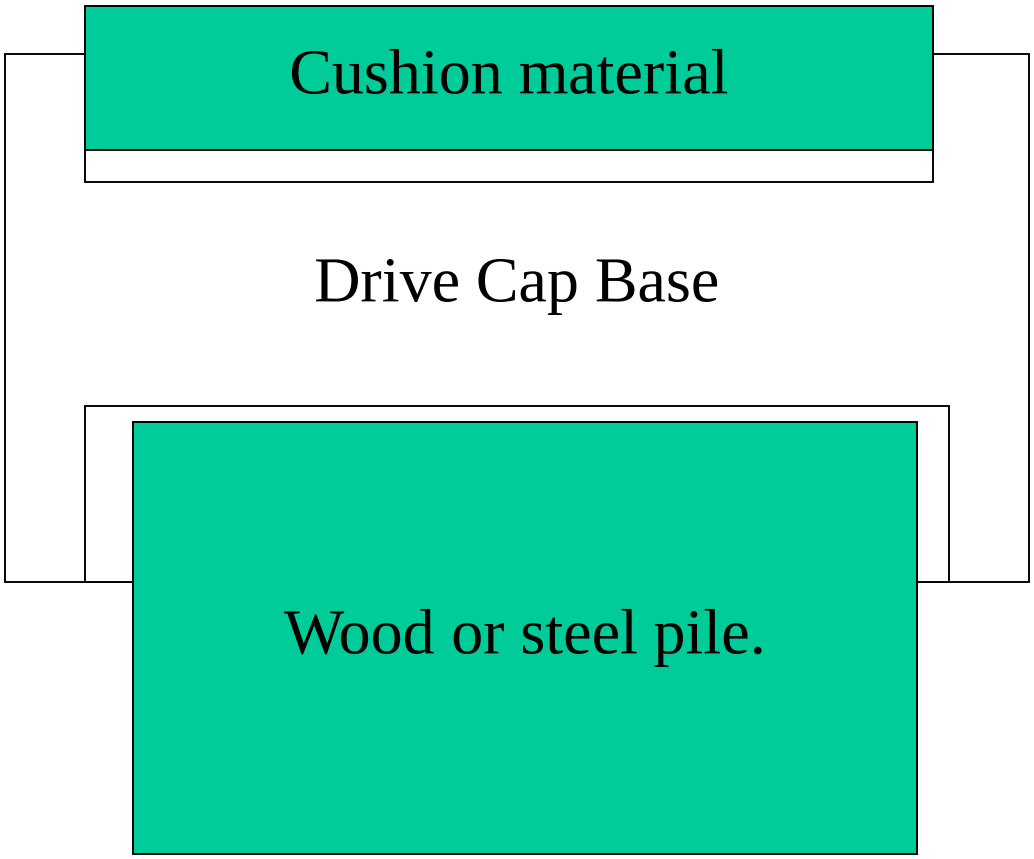
Pile cap or Drive cap



The cushion-pile cap combination serves as a “shock absorber”, blunting the sharp force loading on the pile at impact.

Note: concrete piles, which came much later in time, are protected by an additional wood cushion sandwiched between the top of the pile and the cap.

A closer look at a drop hammer drive cap



Drop hammers are still used today. They are rudimentary pile drivers with elementary maintenance.


WSC
LIMA

Drop hammer riding in front of leads driving concrete spun piles.

Drop Hammers – Pros and Cons

Pro points

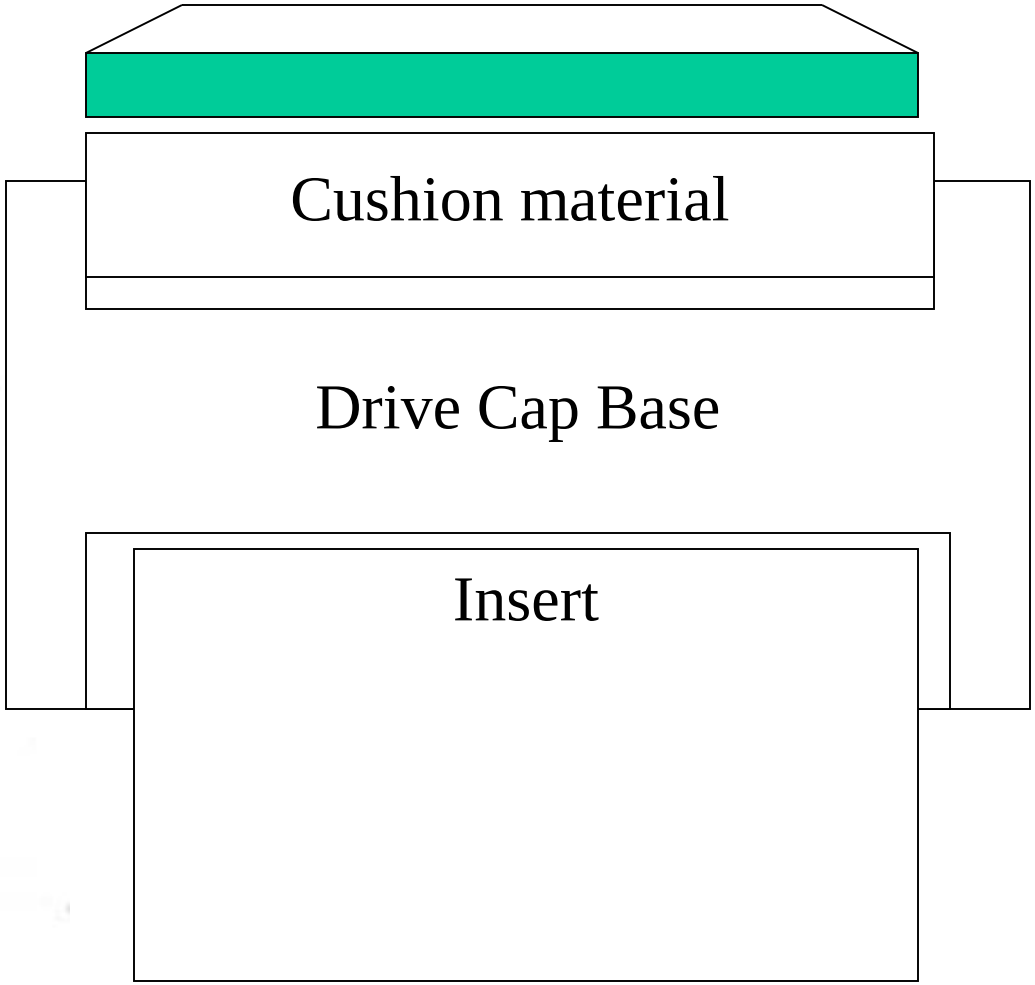
- Low cost investment
- Reliable
- Lightweight

Cons points

- Cannot drop more than 8 feet
- Slow production (4 to 10 blows per min.)
- Not accepted by many engineers due to inconsistent stroke and energy delivery.

Drive Cap Base

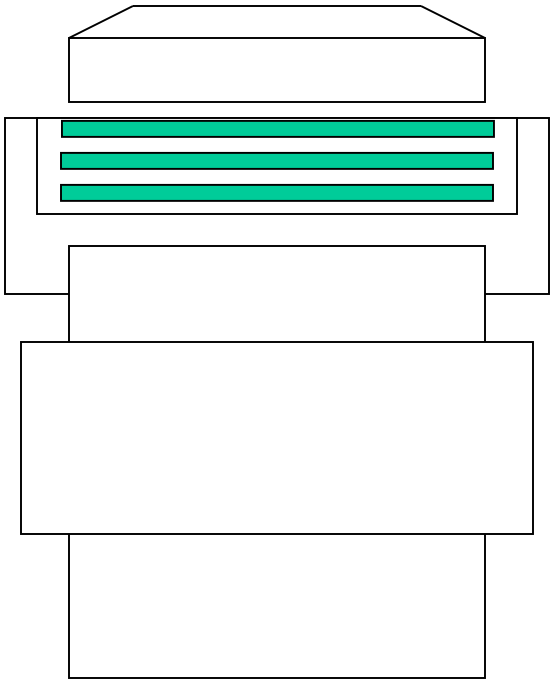
DCB Drive Cap Base 8 by 26 inch
Weight without stricker plate or cushion: 1200 lbs.



Striker plate

Hammer Cushion- Aluminum

Aluminum cushion material
1/2 thick plates in various diameters



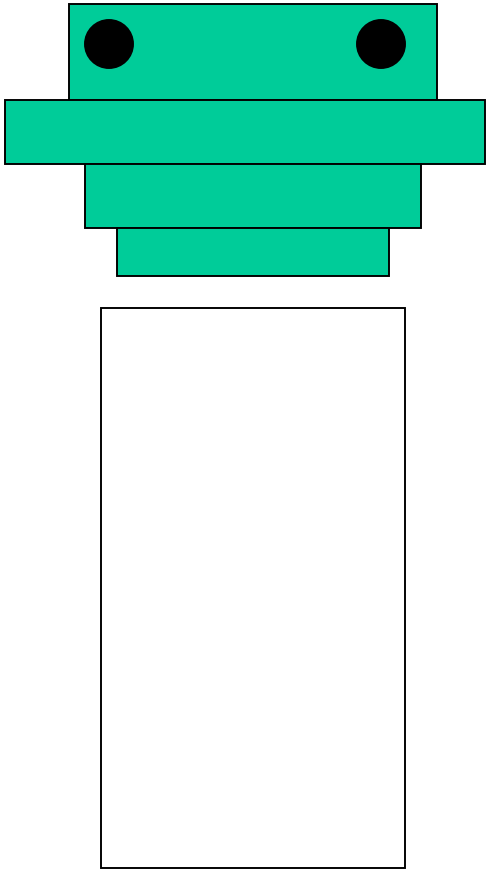
Hammer Cushion

Cushion material, micarta or conbest

Cushion Material - Nylong

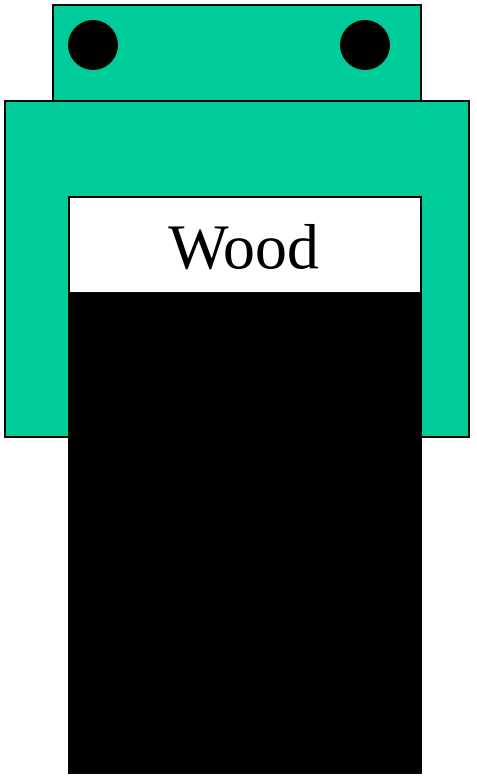
Nylon cushion material
2 inch thick in various diameters
Use on D30 and smaller type hammers
Switch to aluminum and conbest on larger hammers

Inserts



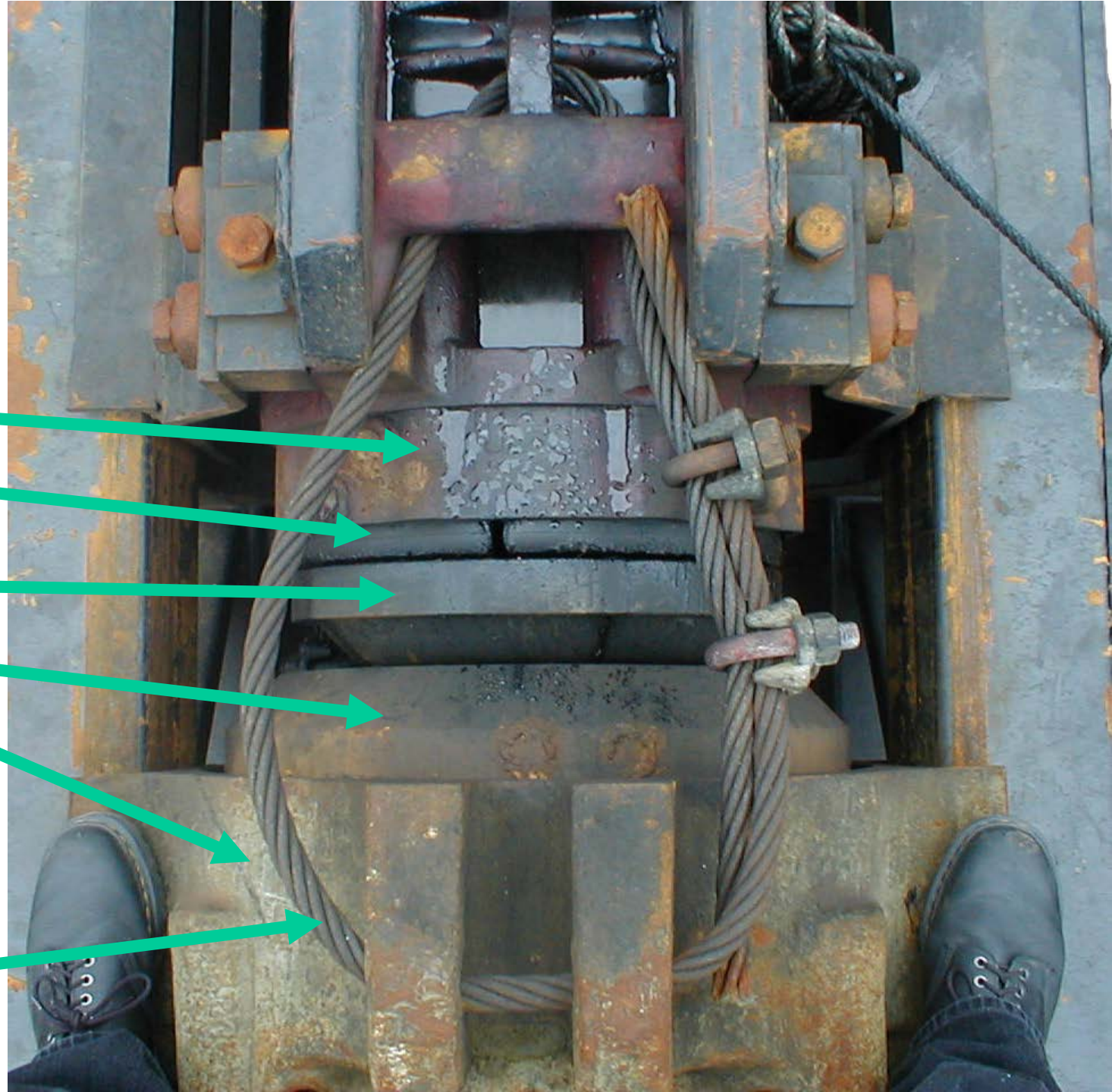
Sheet Pile Insert

Insert: Square box type

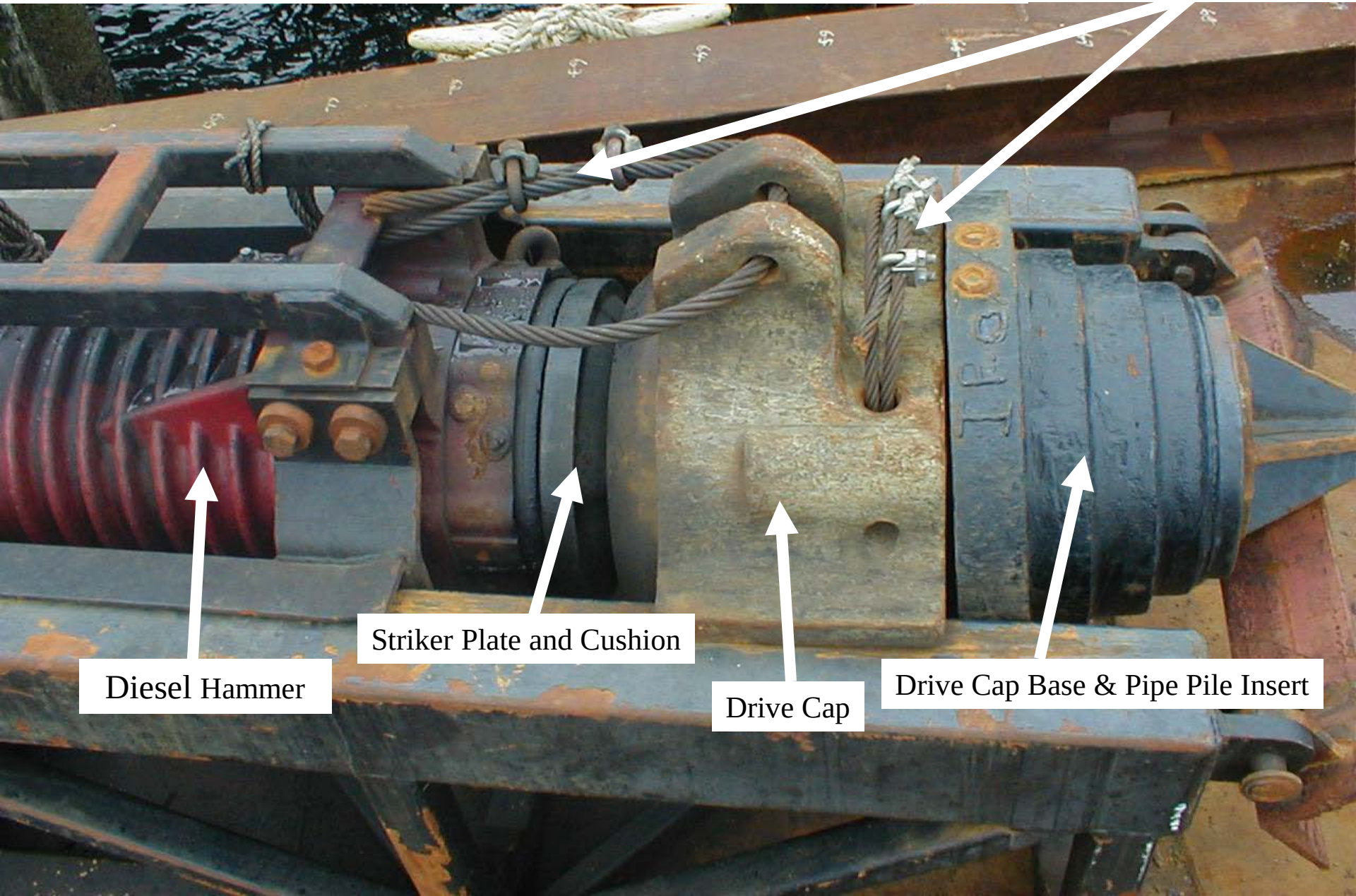


Insert for H-beam and small pipe

Drive Cap Layout (diesel hammer)



Standard drive cap layout



Common Pile Types

Wood piles (Uncoated and coated)

H-Beams

Steel sheet piles

Square Concrete Piles

Octagon Concrete piles

Concrete Pipe Piles

Concrete Sheet Piles

Steel Pipe Piles

King Piles

Power Pole Foundations

Mini Piles

Casings and Caissons

Plastic Sheet Piles

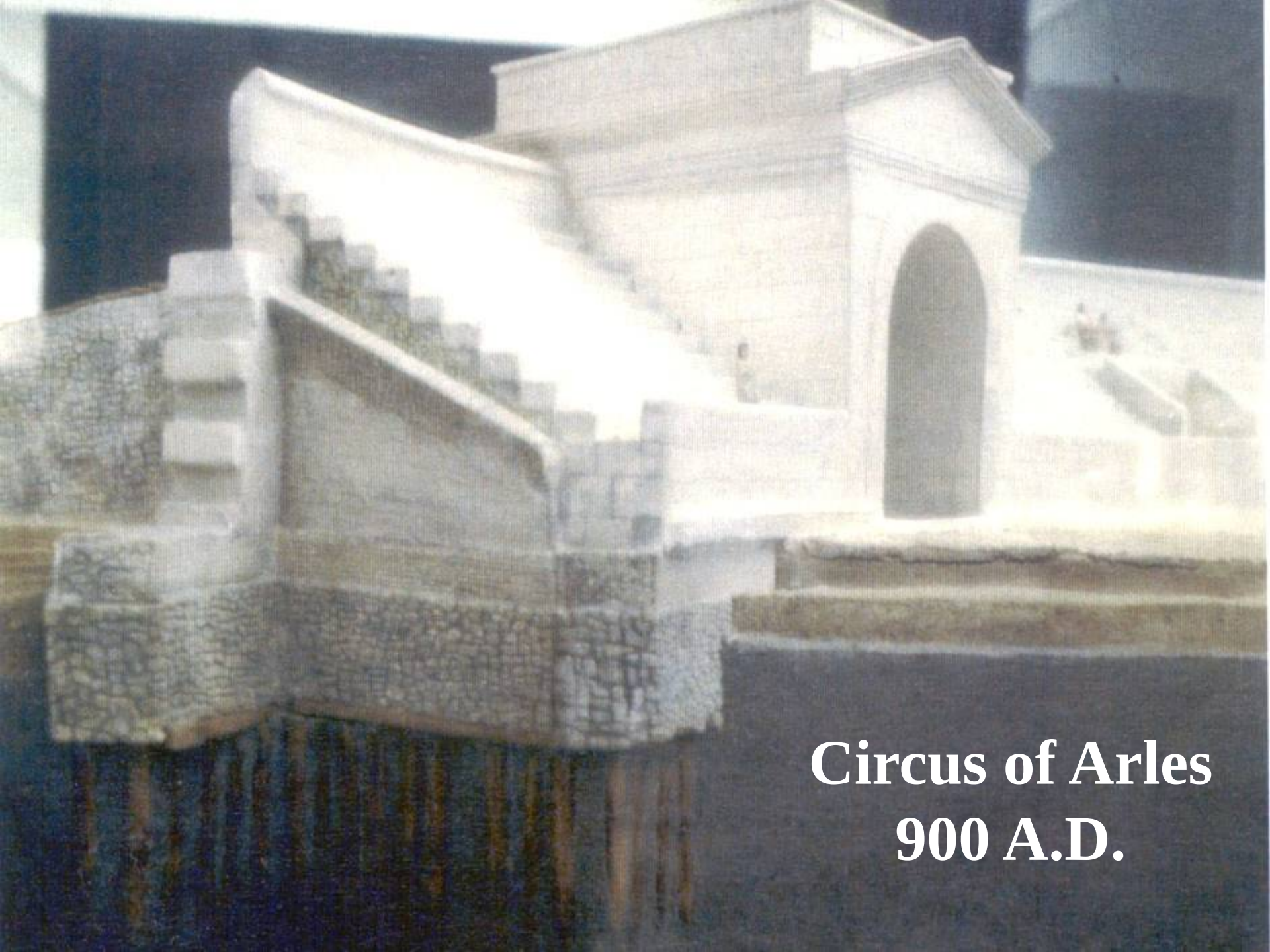
Composite Pipe Piles

Tarpon Piles

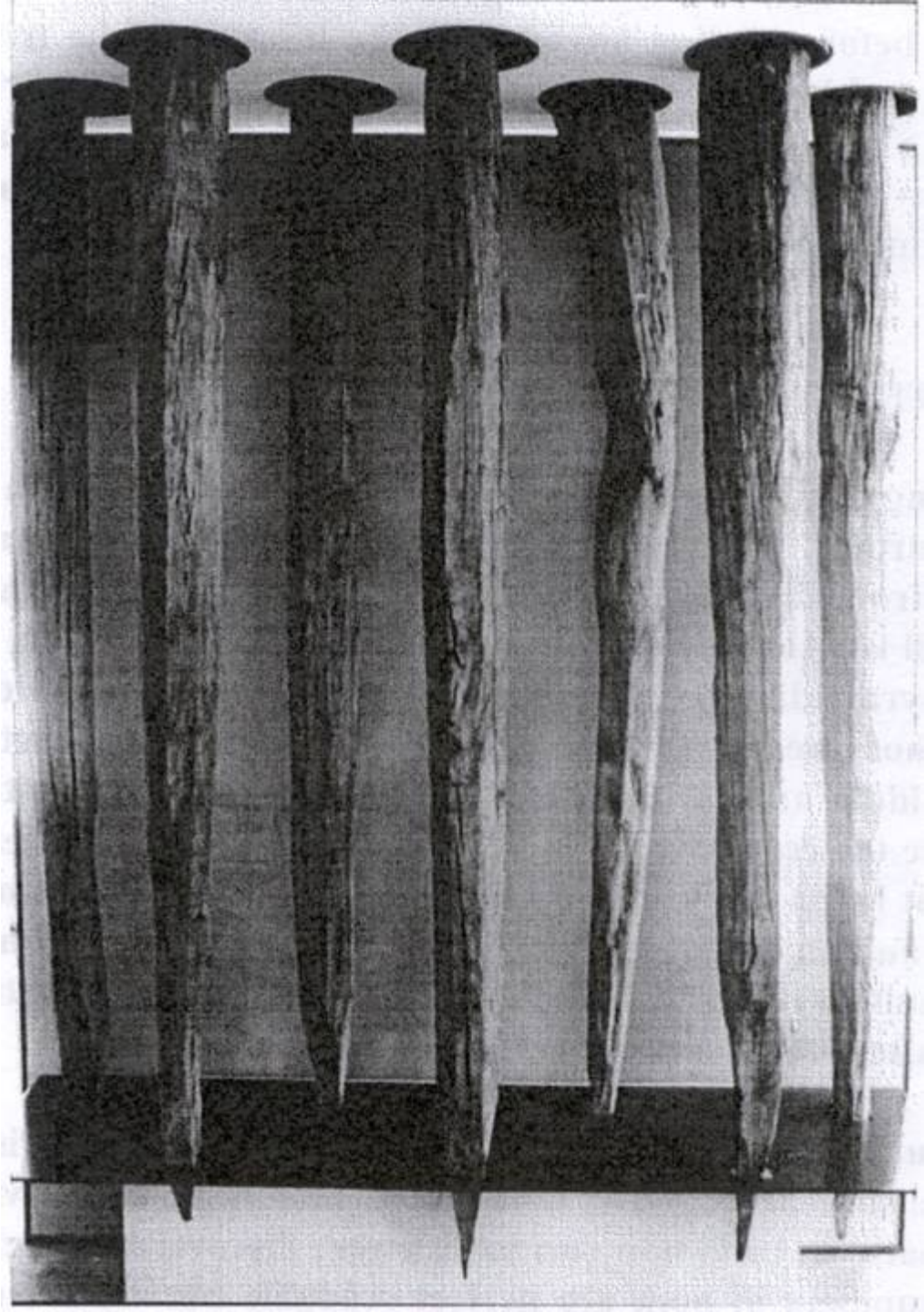
Conductor Piles

Monotubes

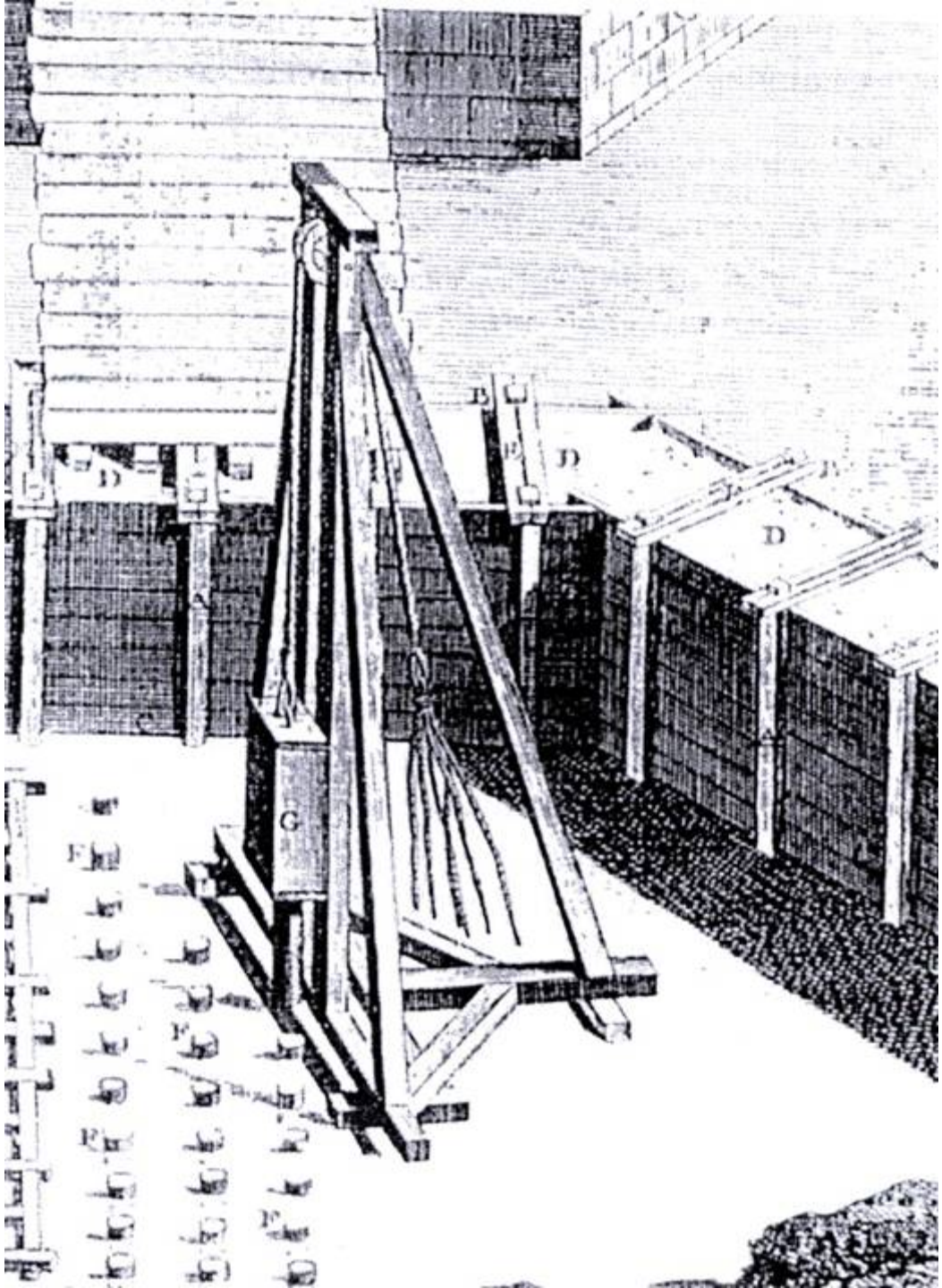
Wood Piles


Circus of Arles
900 A.D.

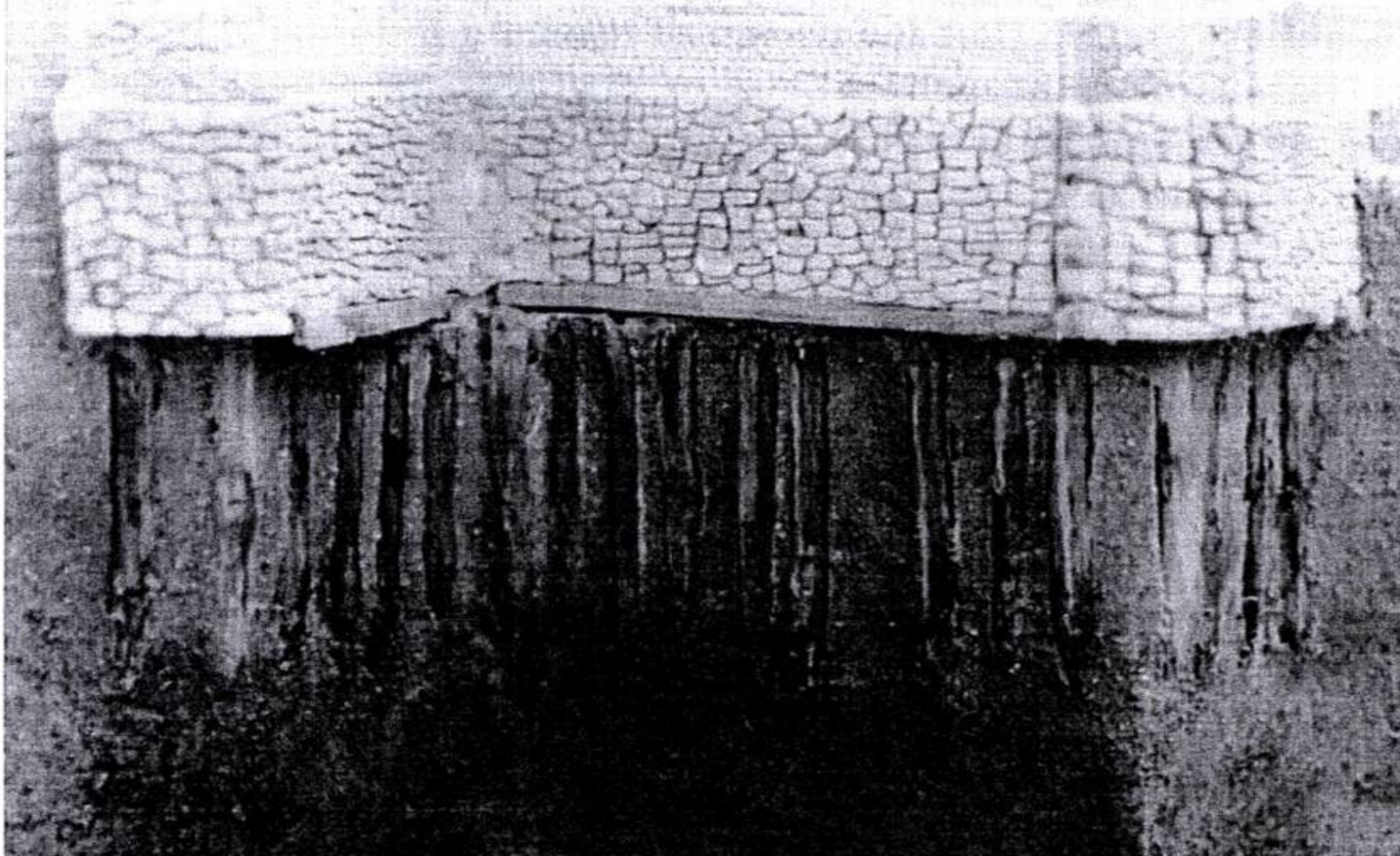
Wood Piles driven in 81 A.D. in Rome for a horse race track like that seen in the Movie Ben Hur



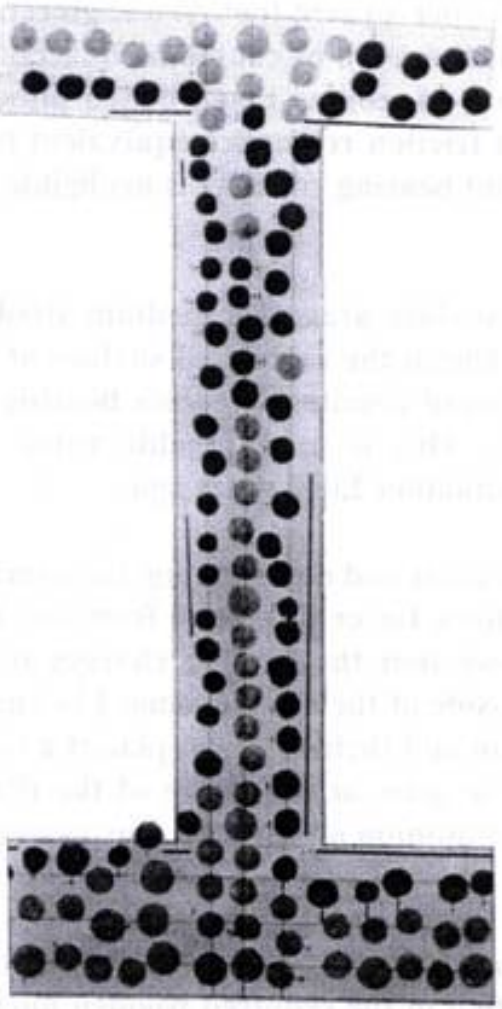
Wood piles driven in 81 A.D.



Cut away view of actual foundation of Roman built structure.



Layout of driven wood piles for Roman Circus of Arles



RECONSTRUCTION OF THE PATTERN OF THE PILING SYSTEM

Modern wood piles, untreated.

Wood Piles
for false piles.
(untreated)
(Falsework)

Wood Pile Seawall

Wood Piles

Wood piles are common on older docks on the waterfronts. They are banned in some areas due to creosote coating which is considered a health hazard.

Extracting wood piles

Things to know about wood piles:

Timbers should be treated if cut-off elevation is above ground water.

Piles should be straight. “Mother Nature” does not grow straight trees for piles, a guide is to stand ant one end, sight the other end, and the line of sight (or a string line) should not depart from the pile. The deviation should be always less than half a diameter.

Timber piles are generally driven toe down.

Become familiar with the ASTM Standard D25 (Standard Specification for Round Timber Piles) as to diameter-circumference-length ratios, cracks, checks, knots, etc.

Ends of timber piles should be cut off perpendicular to the pile axis to minimize local contact stresses.

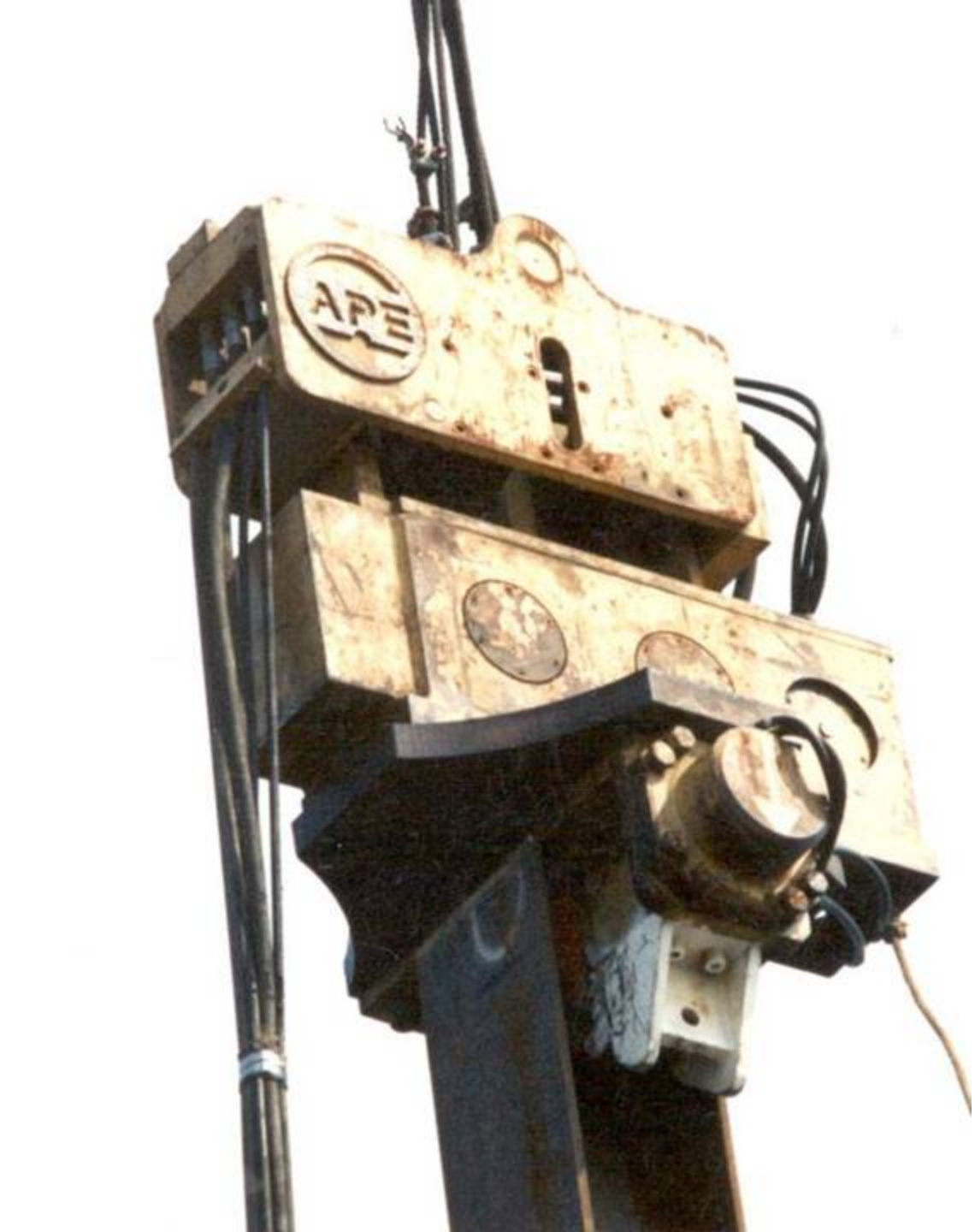
Things to know about wood piles:

- The pile head may require trimming to fit the helmet or insert.
- There are approved splicing techniques for timber piles. However, all are costly and do little toward resisting lateral loads. The general rule is to avoid splices.

H-Beams

H-piles are wide flange structural steel shapes having width and depth of similar dimension, and the same thickness for flange and web.


H-Beams for
bridge piles in
Salt Lake



Driving H-Beams with a vibro fitted with a 90 degree turning plate

Driving H-Beams with a double acting diesel hammer mounted to an H-Beam pogo leader

H-Beams being driven using an APE Model 200 vibro in Saudi Arabia

H-Beams for retro-fit bridge work in California

H-Beams for oil storage tanks

H-Beams driven using a unique hydraulic hammer made in Singapore.

H-Beams for a building in Arizona

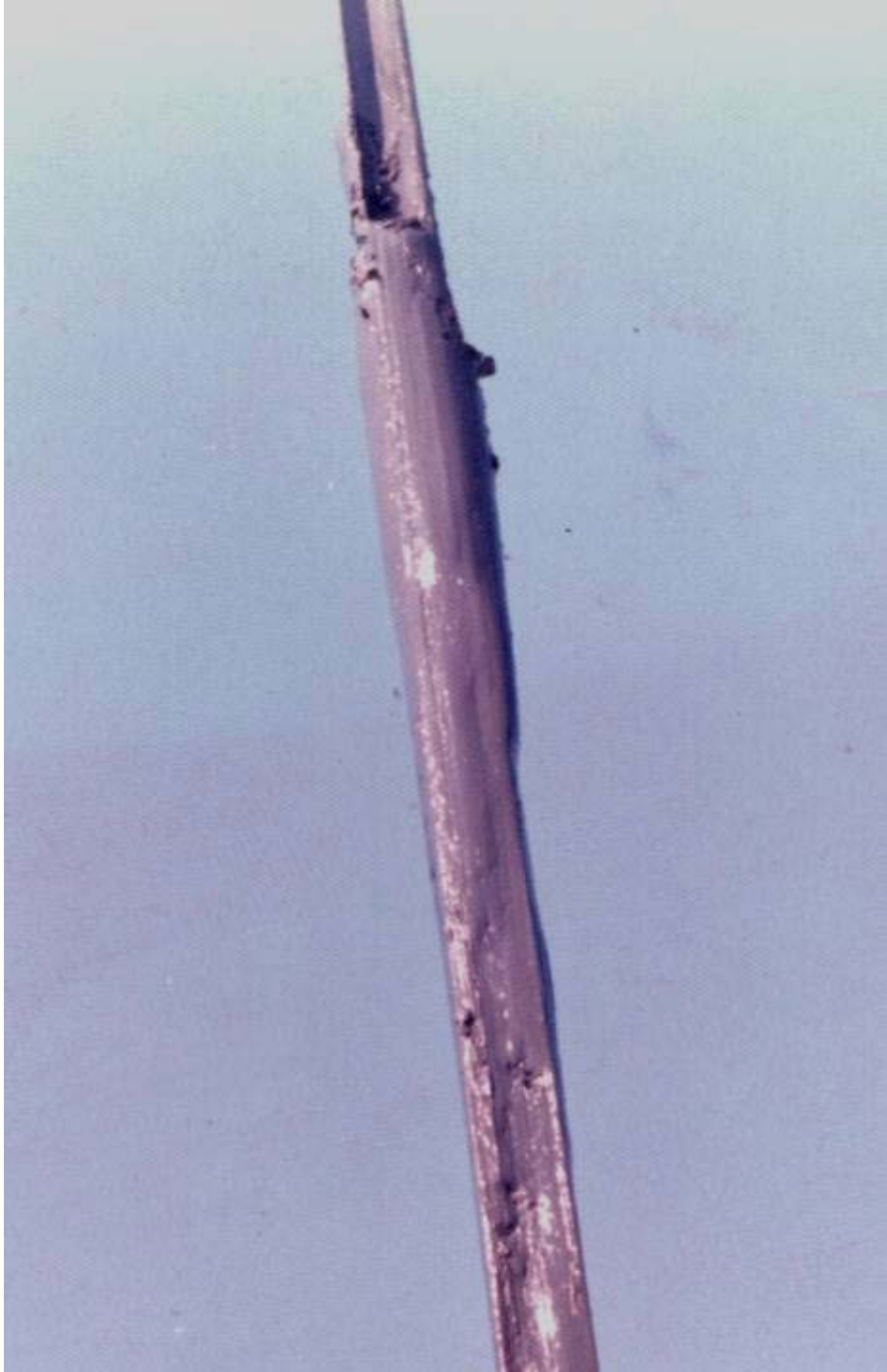
H-Beams being driven inside a pipe pile to add support to the pile structure.

30,000 H-beams for housing in Singapore.

Damaged H-Beams after extraction.

More damaged H-Beams.

H-Beam Filled with Clay



Steel Sheet Piles

Steel Sheet Piles

Interlocks for sheet piles

Ball and Socket (BS)

Double Jaw (DJ)

Single Jaw (SJ)

Double Hook (DH)

Thumb and Finger - three point contact (TF)

Thumb and Finger - one point contact (TFX)

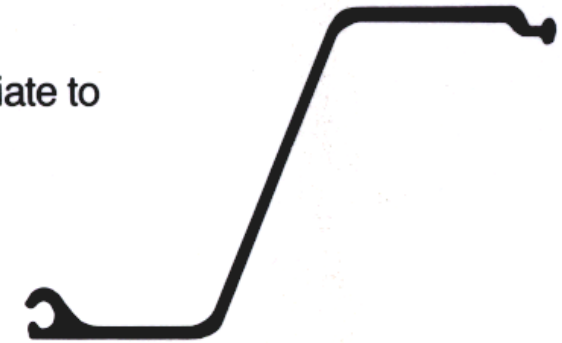
Hook and Grip (HG)

Sheet Pile Shape

SHAPE

This column describes the profile of the cross-sectional area. Sheet piling shapes in the Pile Buck® charts are grouped into four traditional shape classifications. These are:

Z-type (Z) used for intermediate to deep wall construction.

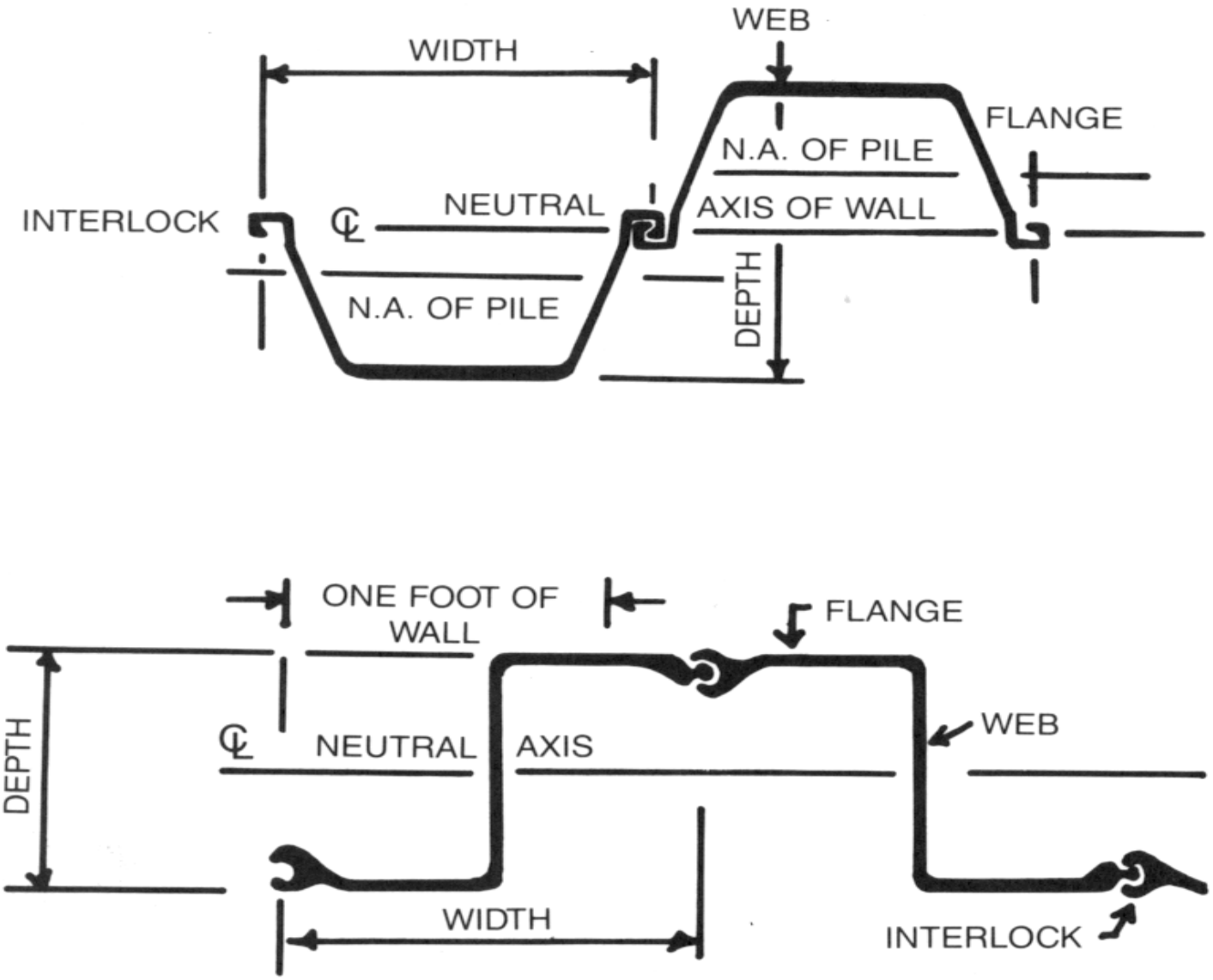


Larssen and other ''U'' types (U) used for applications similar to Z-piles.

Arch shaped and lightweight ''gauge'' sheets (A) used for shallower wall construction.

Flat or straight - web types (SA), (S) with strong interlocks, and little beam strength, for filled cell construction.

Dimension terms you should know




A
B

Sheet Piles Being Pressed in

Driving a sheet pile cell in California.

Flat steel sheets

Z-Sheets

Sheets for a dam project in Kentucky

Long, Flat Sheets

Long sheets being properly handled after extraction

A monster sheet pile cofferdam

Sheet piles for Air Force missile silos

Sheet piles to repair a river lock

Sheets for Shoring Pipe Lines

Sheet Piles

Driving sheets with Press Machine.

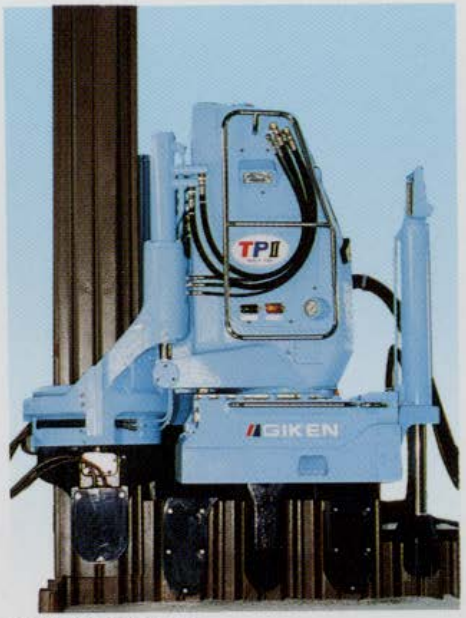
Setting Sheets with Sheet Pile Crane.

Sheet

H-Beam

Pipe

AT-90 Type



TP-II Type

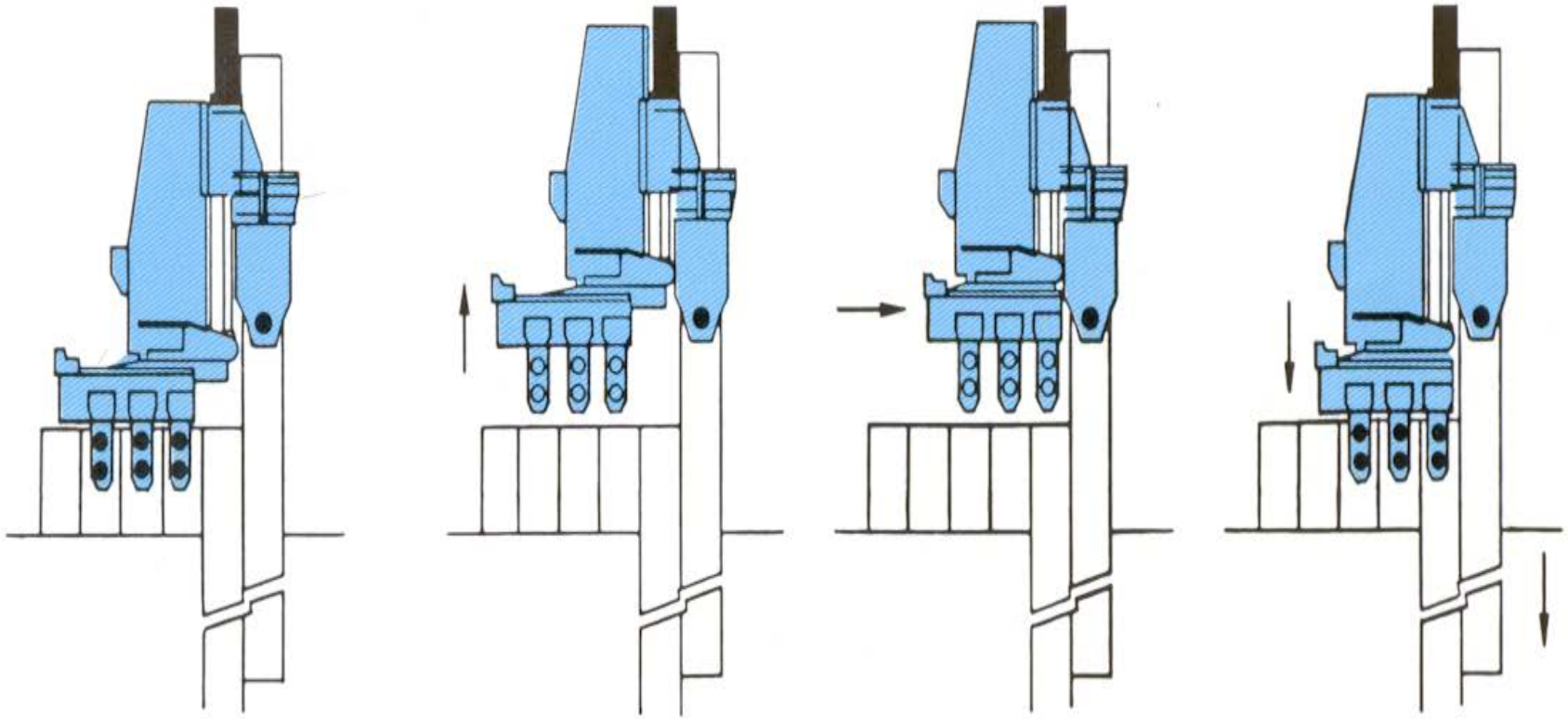
GP-F150 Type

Silent Piler for
H-section Steel Piles Only

Silent Piler for
Steel Tubular Piles Only

Steel Pipe Piler

Sheet driving in steps with silent pile driver



Temporary Sheet Piles

Steel Sheet Piles- Z Sheets

Sheet Pile Wall with Whalers

Sheet Piles PS 31 at Olmstead Lock

Stacked Sheet Piles

Square Concrete Piles

Square Concrete Piles

Square Concrete Piles being Driven by a Twinwood Hydraulic Impact Hammer.

Square piles damaged by ship

Square Concrete Piles

Square Concrete Piles

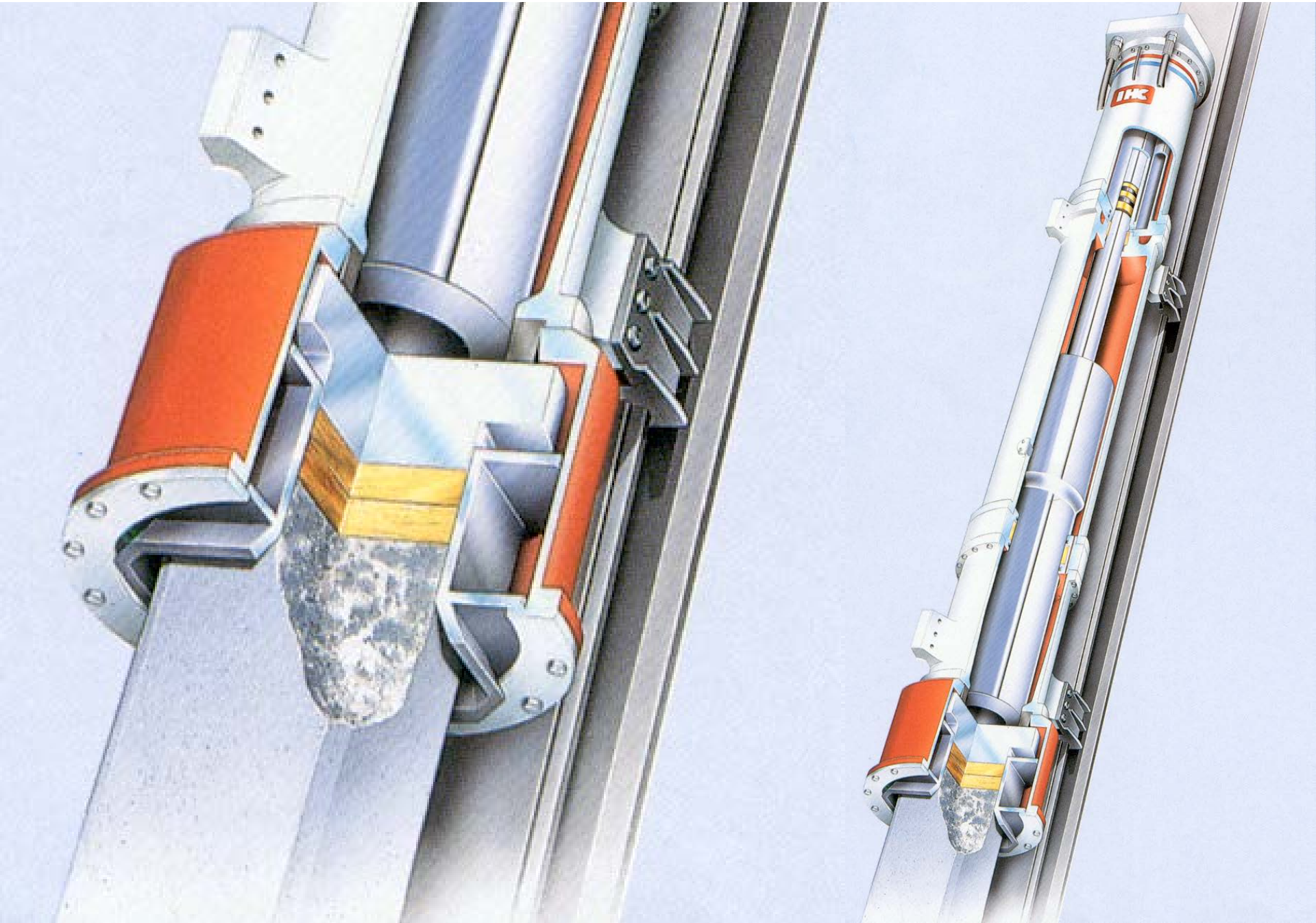
Extracting Square Concrete Piles

Square Concrete Piles

21 inch square pile being pressed into the ground

Square Concrete Piles

Square Concrete Piles



Octagon Concrete Piles

Driving Concrete Piles

Octagon Concrete Piles

Octagon Piles in Hawaii

Concrete Octagon

Extracting Octagon Concrete Piles

Concrete Octagon Piles

Octagon piles ready for final pour

Concrete Pipe Piles

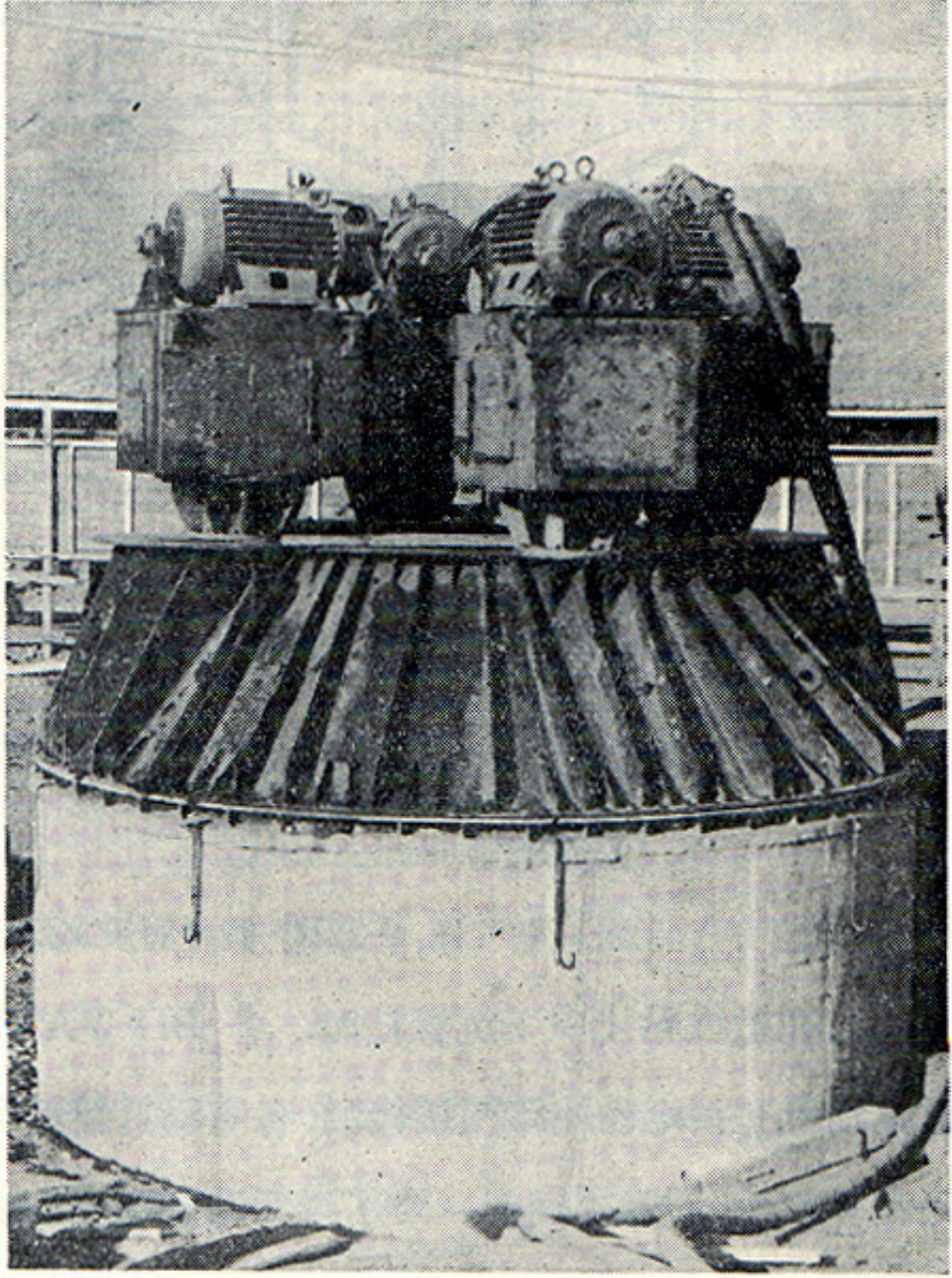
Concrete Pipe Piles

Concrete Pipe (Spun)

Concrete Pile Piles Driven with a Flying Hydraulic Impact Hammer

Concrete pile being cut with a special cutter

World's Largest
Driven
Concrete Pile
1953
15 foot diameter
120 foot long



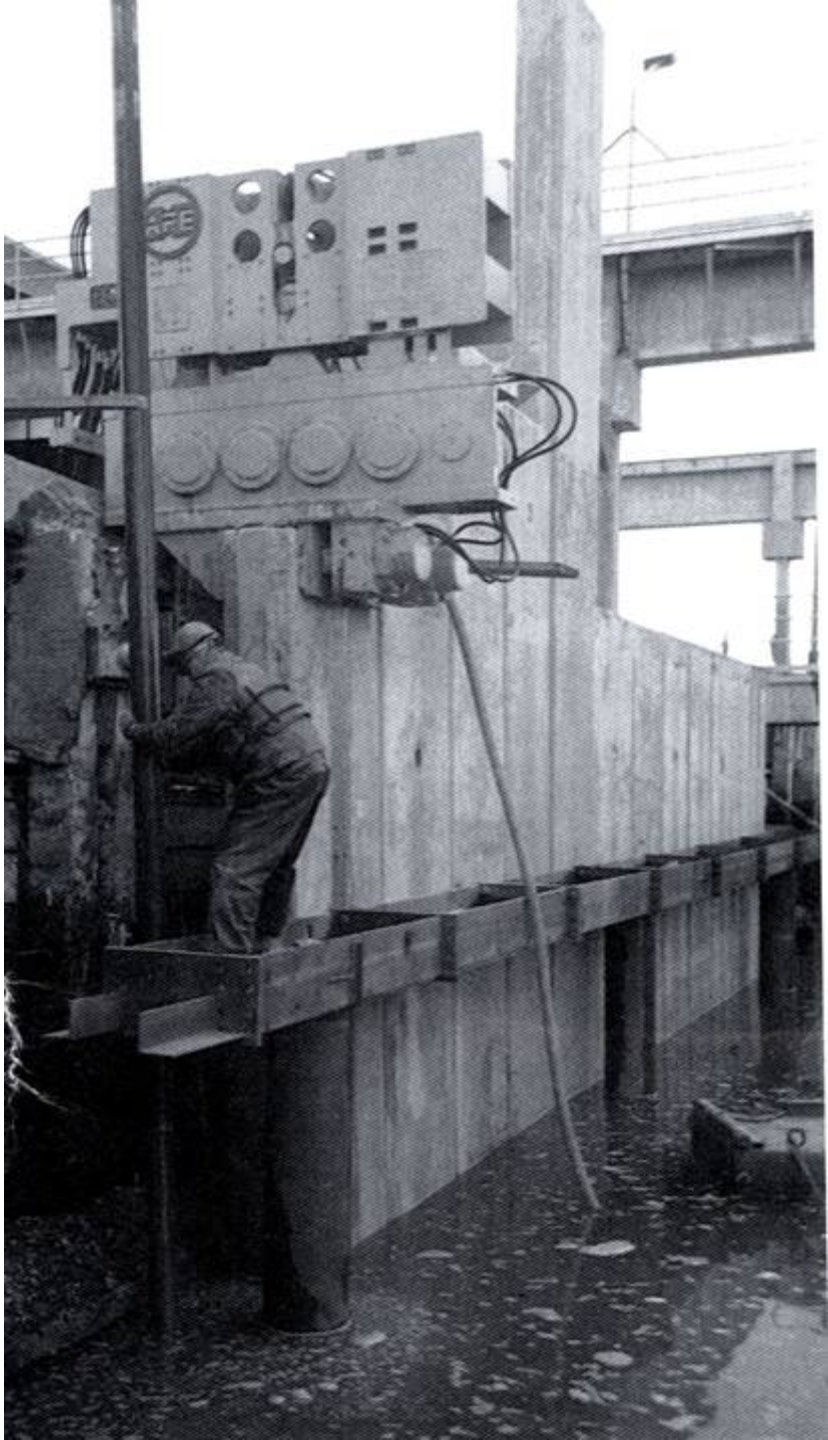
Four Russian Vibros

Concrete Sheet Piles

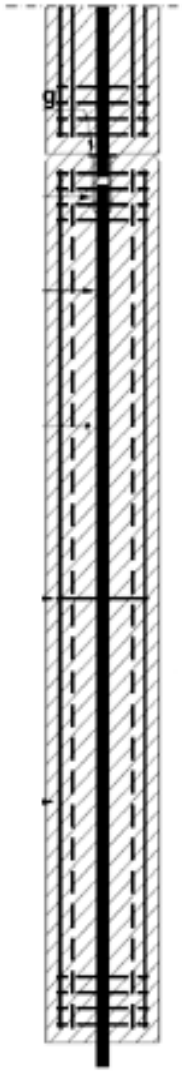
Concrete Sheet Piles

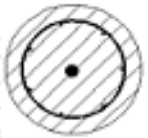
Concrete Sheet Piles

Concrete Sheets



Concrete Screw Pile





Steel Pile Piles

Large diameter pile piles for a bridge in Vancouver, B.C.

Pipe Piles inside a sheet cell

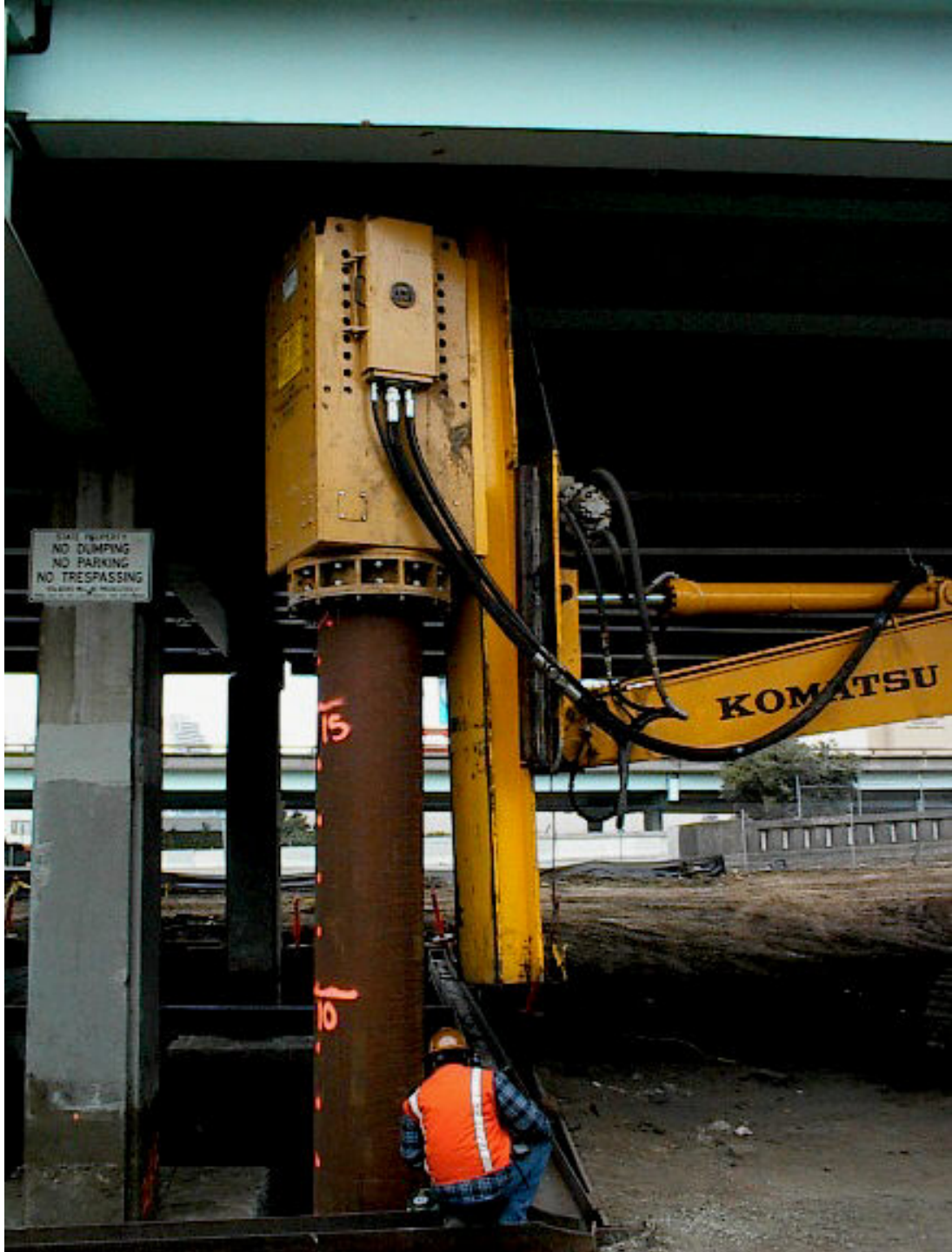
Spliced pipe piles under a bridge using twin vibros

Forklift lead system - Fraser River Pile

Pipe Piles

Junttan HHS9 driving 100 foot long piles in a series of splices under a bridge in California.

Excavator mounted leader system



Steel Pipe Piles

Closed Ended Pile

Menck Driving Pipe Piles

Spiced Pipe Piles being driven under a bridge in California

Pile Piles being driven with a flying hammer

Pipe piles used to protect a river bank from ice flow damage in Bethel, Alaska

Pipe Pile Covered with Clay During Extraction

Junttan Hydraulic Hammer Driving Pipe Piles in Salt Lake City, Utah USA

King Piles

King Pile

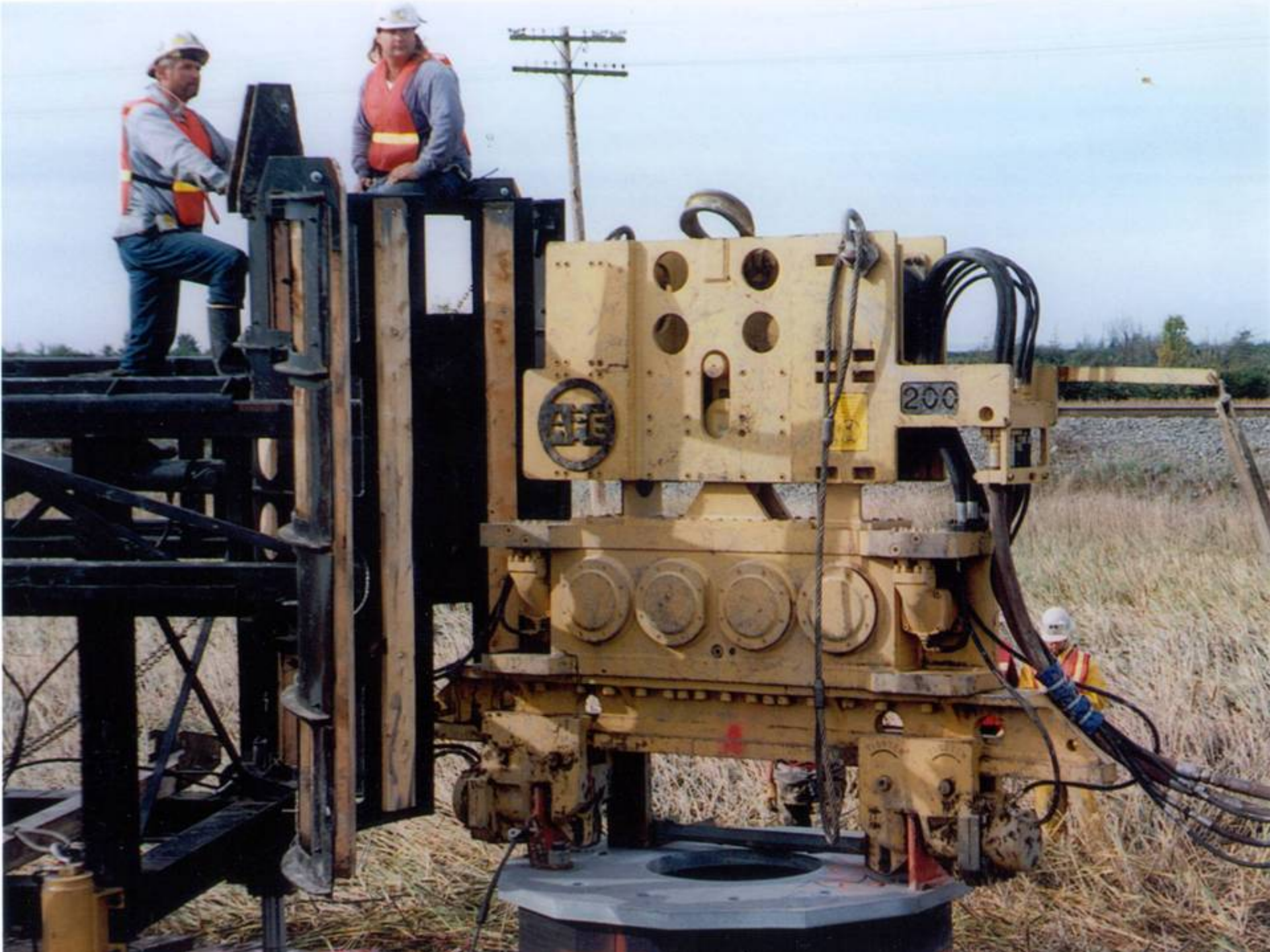
Power Pole Foundations

Power Poles

Power Pole Foundations

Power Pole Foundations

Power Pole Foundations


200

Power Pole Foundations

APE Model 200 drives power poles while suspended from a helicopter.

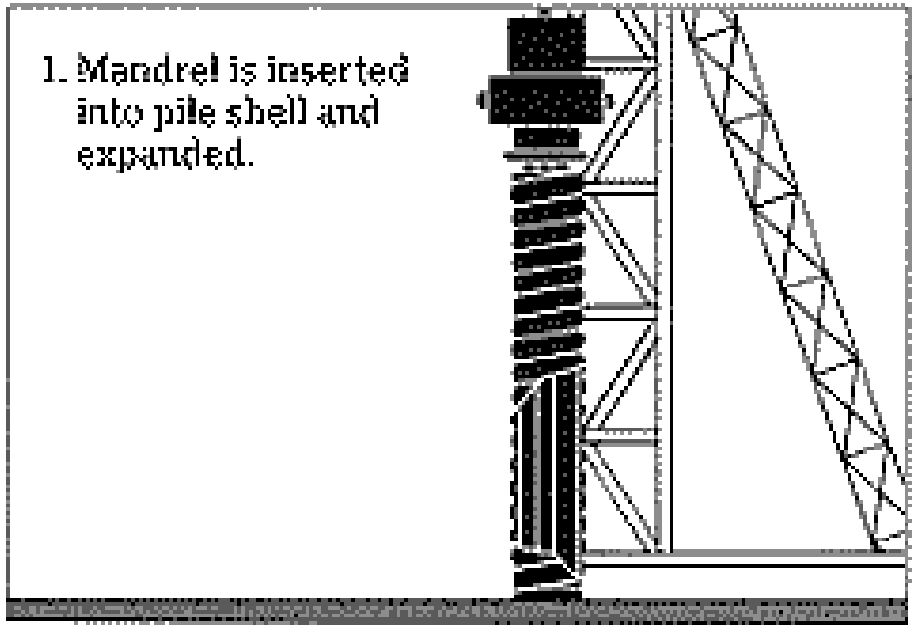
Power Poles are usually twelve sided

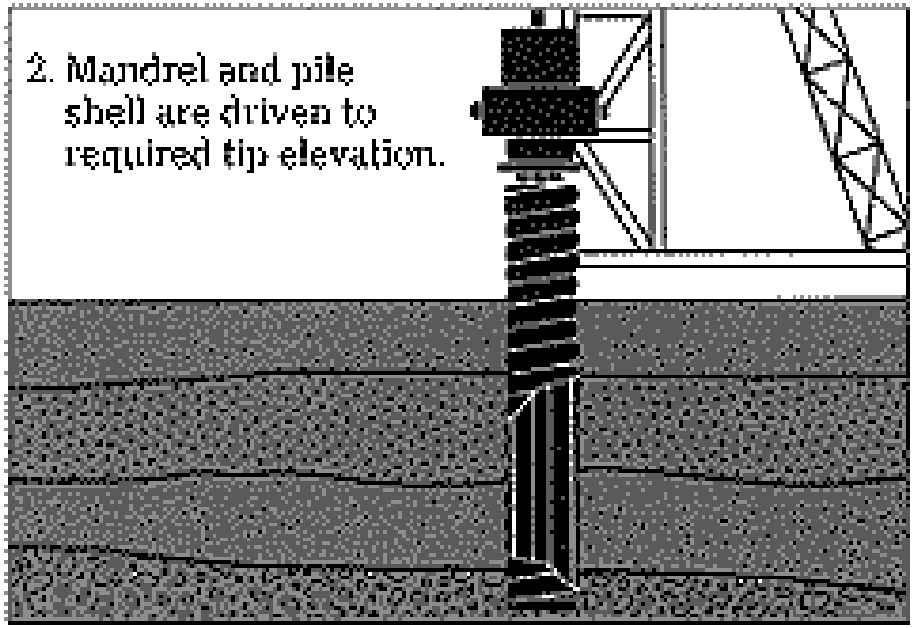
Mini Piles

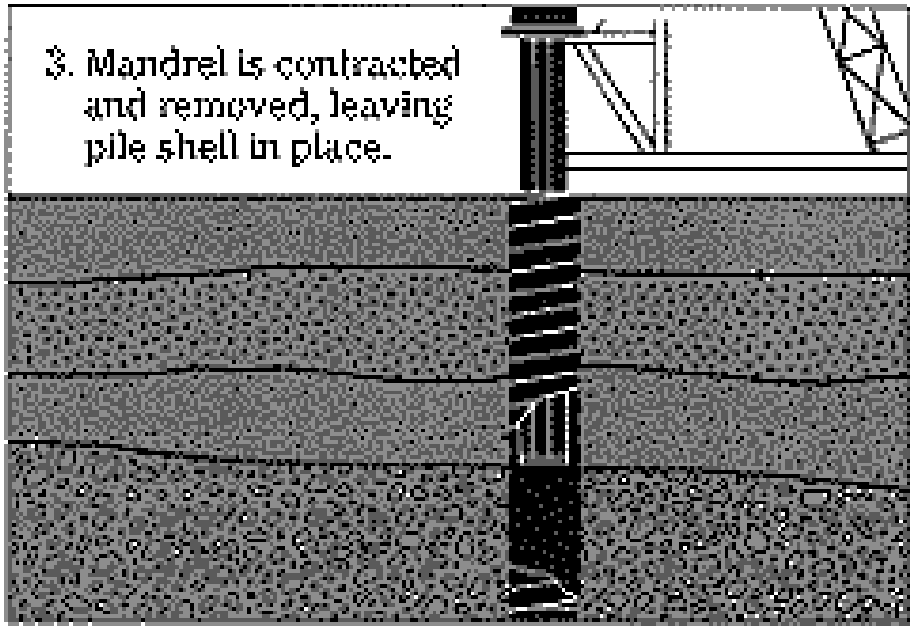
Mini Piles

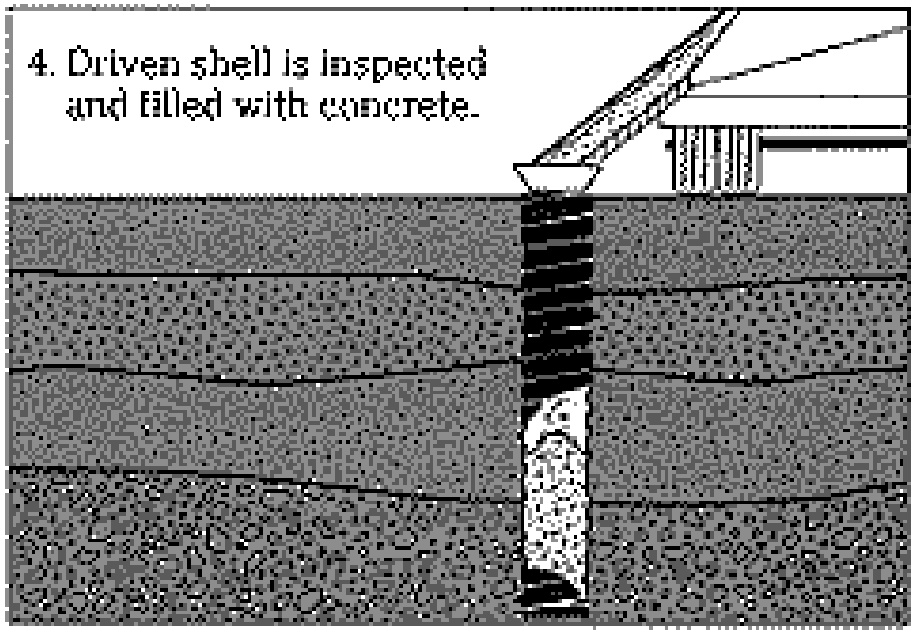
Shell Pile

Mandrel driving steps for shell piles









Expanding Anchor Pile

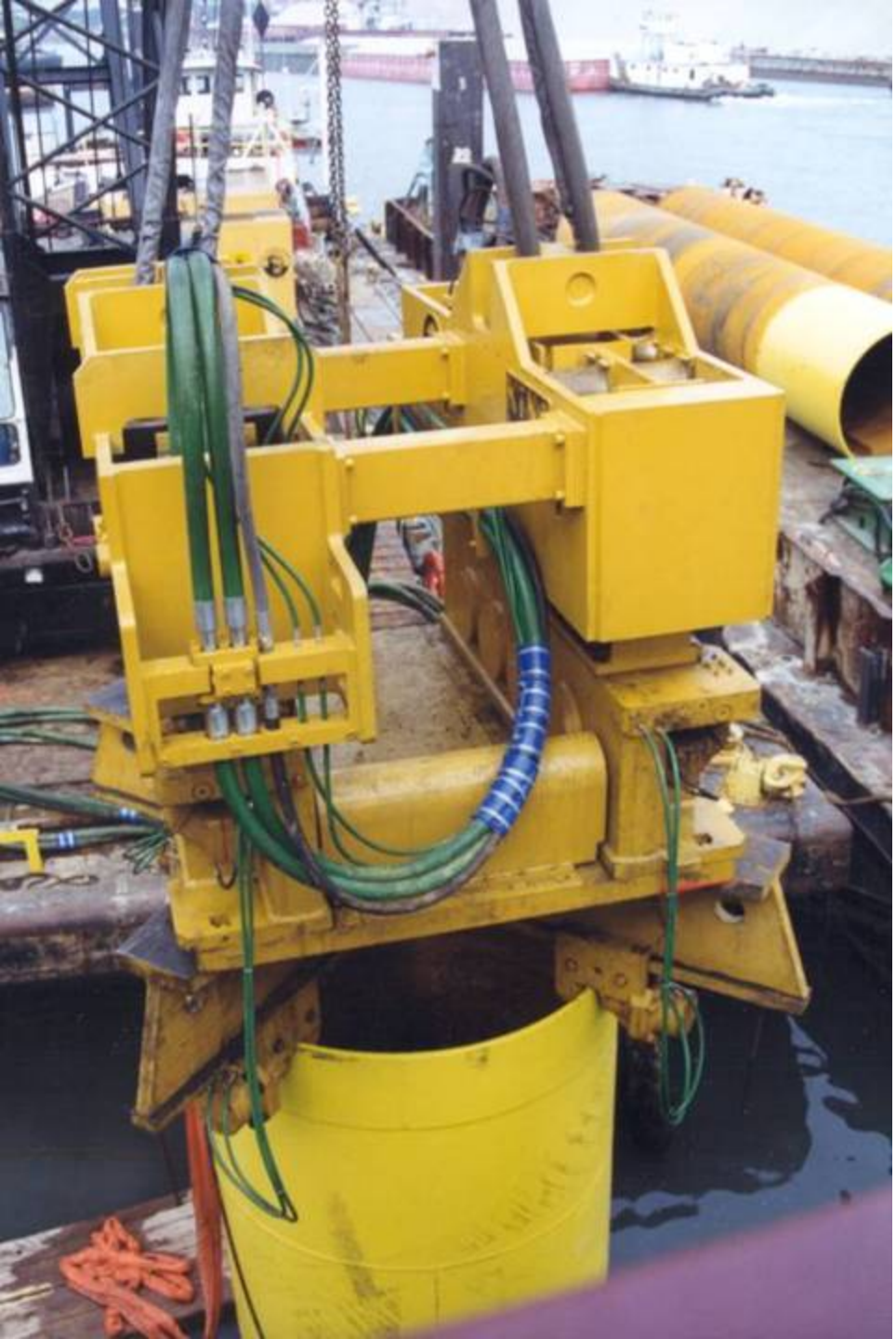
Expanding Anchor Pile

Casings and Caissons

Driving 36 inch cans with a High Frequency APE Model 200 HF


SUPER
KONG
AFE
BD3-3

Large Casings



Large Diameter Piles

Twin APE King Kongs

Driving 8 foot caissons.

Large Diameter Casings with Rebar on Top

Plastic Sheet Piles

Plastic Sheet Piles

Plastic Sheet Piles


APE


DANGER
APE

Heavy duty plastic sheets

Composite Piles

Composite Piles

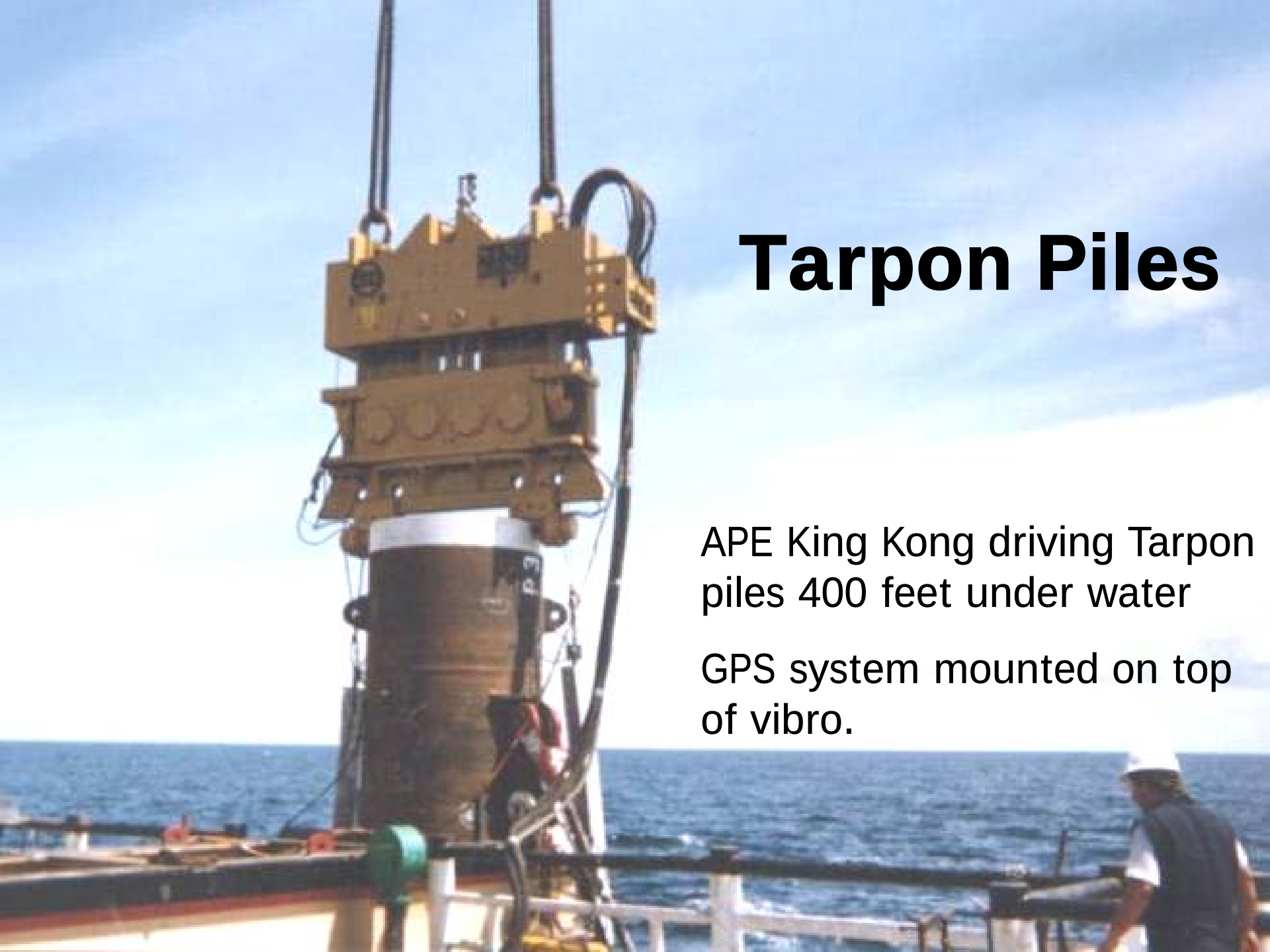
Fiberglass Tubular Piling

- Strong
- Durable
- Warrantied Performance
- Non-polluting

- Fender pile
- Bearing piles
- Dolphins

Tapertube piles

Tarpon Piles



Tarpon Piles

APE King Kong driving Tarpon piles 400 feet under water

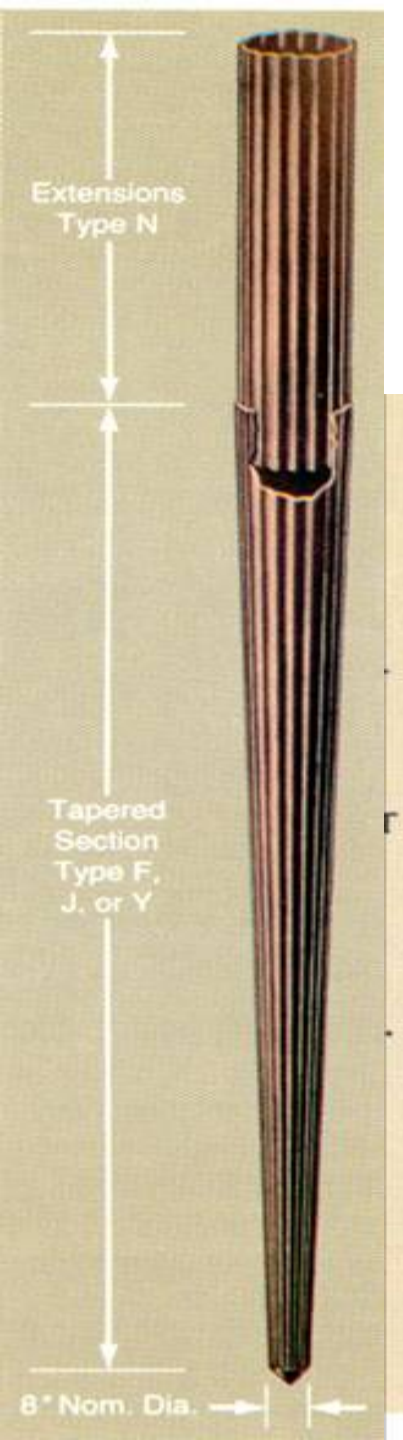
GPS system mounted on top of vibro.

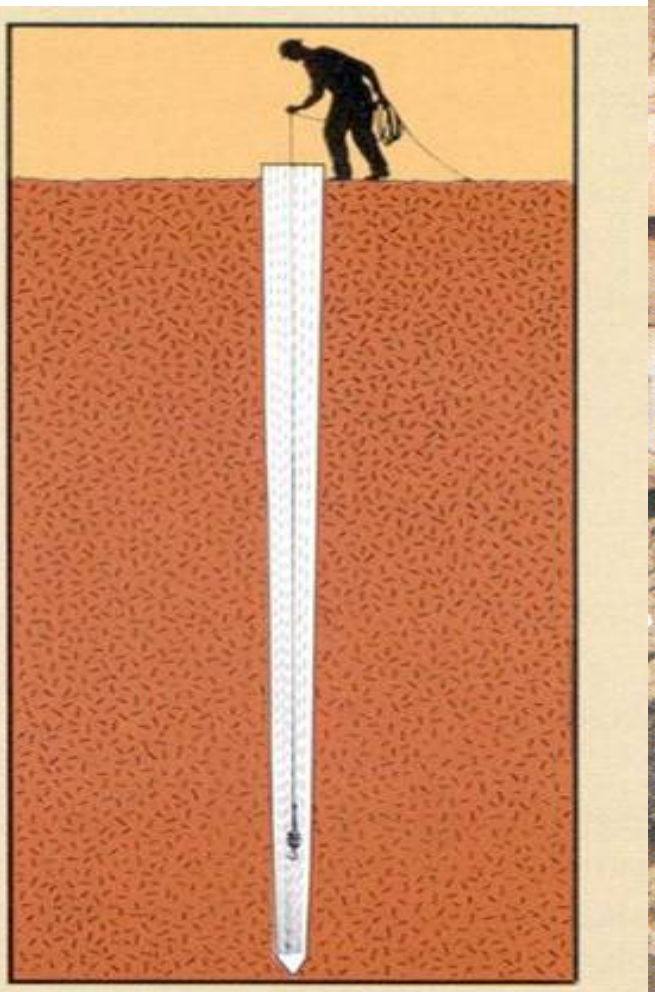
Conductor Piles

APE Model 200 extracts 250 foot long conductor pile on North Slope.

Monotube Piles

Monotube Piles





Monotube piles can simplify design and greatly reduce construction costs when

Followers

Steel follower

Close up view of top of follower

Followers:

For Optimum Energy Transfer the Impedance ("dynamic stiffness") of the follower should match that of the pile.

$$(EA/c)_{pile} \approx (EA/c)_{follower} \qquad \text{(Equation 1.)}$$

where E= Young's Modulus, in kips/square inch,
A= Cross-sectional area, in square inches
C=material wavespeed

Using this approach the area of a steel follower for a concrete pile would be about 20% of the area of the concrete.

Followers:

A Follower must be TOUGH, and it is not uncommon to nearly double the Impedance, or Area, of a follower from that suggested by Equation 1, even though this causes a reduction in driving Efficiency.

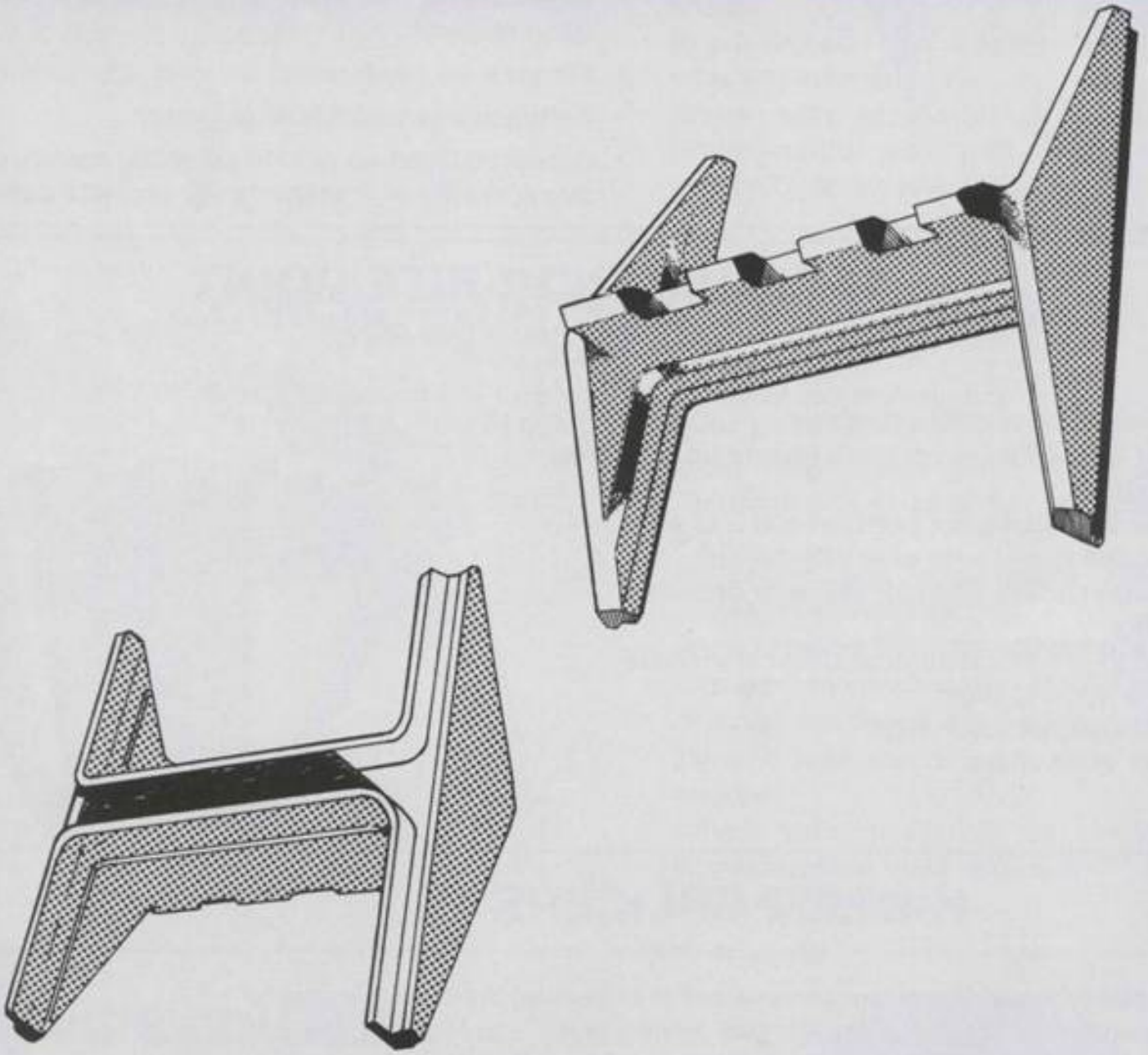
Because a follower is reused, follower design must consider *fatigue strength* of the material and weldments.

Wave Equation Analysis is an effective tool for predicting stresses and driving efficiencies for various proposed configurations

Dynamic measurements with a PDA may provide useful information and may help to calm concerns surrounding follower use.

Pile Points, Splicers, and Boots

Pile points and splices

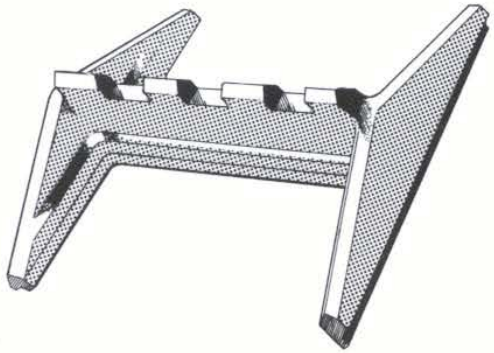


H-Pile Points

ACCESSORIES: H-PILE

THE SUPER-BITE POINT

Model #: PAR-T (Regular Points)



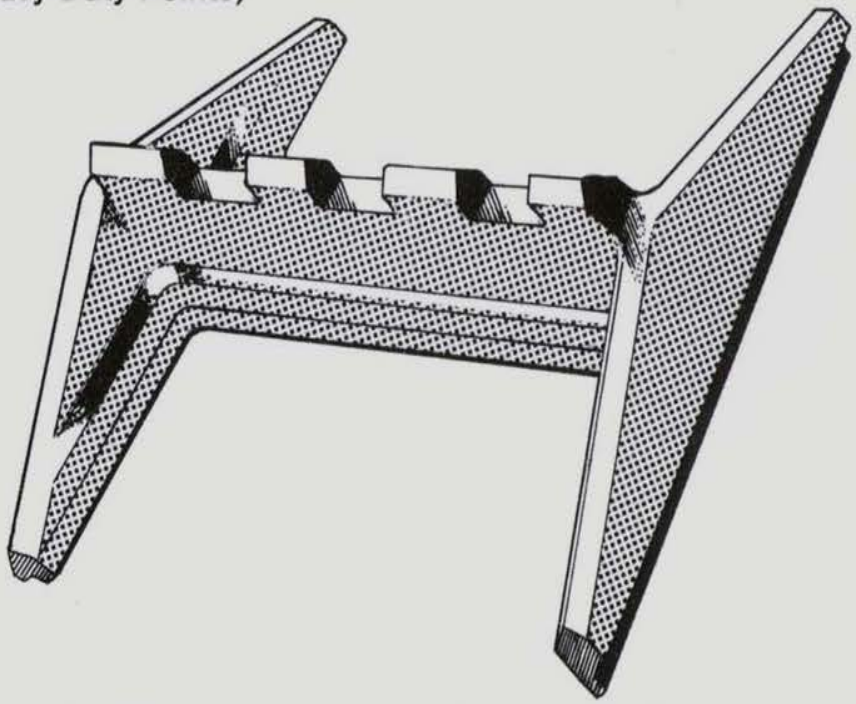
- **Four large cutting teeth on the web section for better gripping in rock formations.**
- **Continuous cutting edges on the flanges.**
- **Continuous backing for both flanges and web.**
- **Thicker flanges and web sections.**
- **Meets ASTM A27 standards. Other standards available upon request.**
- **Flanges are pre-beveled for easy attachment.**
- **Certifications with EACH shipment.**
- **Accepted/Used on private projects, municipalities, and Departments of Transportation projects coast-to-coast.**

H-Pile Points for Rock

THE SUPERIOR-BITE POINT

Model #: PAH (Heavy Duty Points)

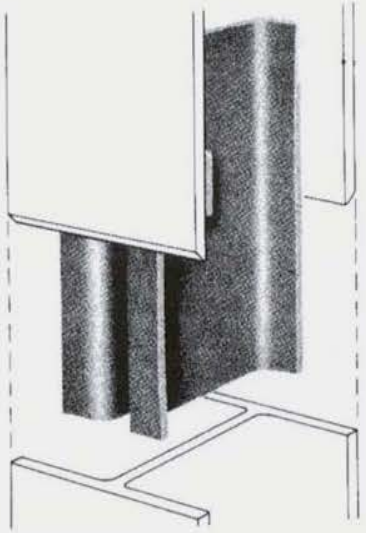
- Extra heavy for special use areas.
- Thicker web & flange sections (minimum 1.5 times beam sizes).
- Continuous backing for both flanges and web.
- Pre-beveled flanges for easy attachment.
- Extra large cutting teeth for superior gripping capability.
- Meets ASTM A27 standards. Other standards available upon request.
- For special application use.



H-Beam Splicers

H-BEAM SPLICERS

Model #: PHS



On many pile jobs where splices are required in H-Beams, the time required to make the splice can equal or exceed pile driving time. PAI H-Beam splicers substantially reduce splicing time in two ways. First, pile alignment is quick and easy as the splicer also serves as the welding template. The splicer slips over the driven pile section and the new section easily slides onto the web of the splicer providing quick and accurate alignment. Second, welding time is greatly reduced - often up to 75% as only a fraction of the weld is required.

WELD PROCEDURE

Chamfer outside edges of flange on ends of both piles to be spliced. Make chamfer equal to about 1/2 material thickness. Cut a rectangular notch in the web of one pile approximately 1" x 3" to accommodate the connecting lug. Insert splicer on first beam making sure lug is completely inside notch so that lug does not interfere with seating of the next pile. Using a 70xx series rod, weld the flanges of the splicer to the flanges of the beam with 5/16" x 2 1/2" fillets. The weld should be on the sides of the splicer near the ends. (Do not weld the web or the end of the splicer.) Install next section of pile and repeat welding. Weld the outside flanges of the pile and your splice is complete.

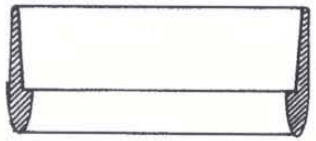
Cutting Shoes- inside or outside

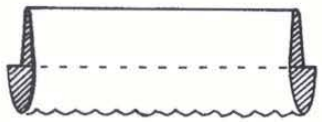
ACCESSORIES: PIPE PILE

CUTTING SHOES FOR PIPE PILES

Model #: PACI (Inside Fit) - PACO (Outside Fit)

Cutting shoes are available for open-end piles, caissons and well pipes.



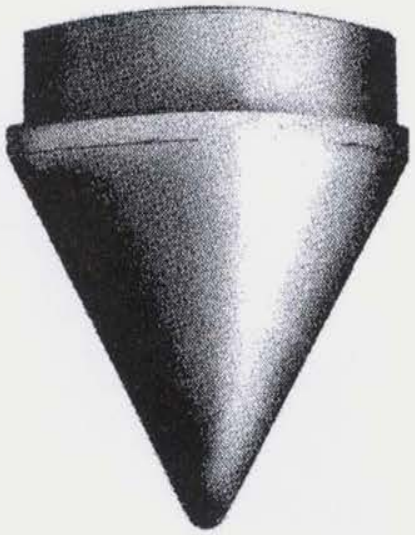


- **Protects pile tip during driving.**
- **Allows seating into rock without pile damage.**
- **Cast from tough alloy steel (ASTM A27).**
- **Open end makes driving easier.**
- **Open end allows drilling below pile tip if required.**
- **Driving force directed to flat ledge of shoe.**
- **Tapered lead allows quick, easy installation on pipe.**
- **Pre-beveled for easier and quicker attachment on the job.**
- **Attach with friction fit or single, simple circumferential weld with a 5/16" fillet weld using a 70 series rod.**

Conical Points for Pile Piles

Model #: PAC 60 Series

Where maximum pile bearing and minimum soil disturbance are required, the PAI conical pipe pile point fills the bill.



- **Most dependable pile point protection.**
- **Distributes load over full circumference of pipe.**
- **Minimizes soil disturbance resulting in maximum friction bearing.**
- **Allows seating into rock without pile damage.**
- **Cast from tough alloy steel (ASTM A27).**
- **Driving force directed to flat ledge of shoe.**
- **Tapered lead allows quick, easy installation on pipe.**
- **Attach with friction fit or single, simple circumferential weld with a 5/16" fillet weld using a 70 series rod.**

Pipe Pile Couplers

PIPE COUPLER

Model #: PAC Series

Made of cast steel for uniform sizing - no risk of improper fit as with fabricated splicers that are individually made. Drive fit requires no welding.

WELD PROCEDURE

Pipe splicers are drive fit and do not require welding. Under proper conditions, the drive fit is water tight. If welding is desired, a simple 5/16" fillet using 70xx series rod at the top and bottom is all that is required.

Timber & Sheet Pile points

ACCESSORIES: TIMBER & SHEETING

TIMBER PILE POINTS and BOOTS

Model #: PAT Series (Points) - PAB Series (Boots)

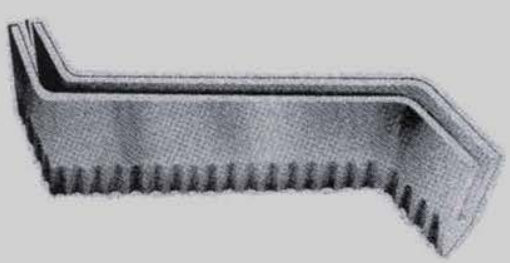
If soil data indicates possible pile damage due to obstructions or a stiff layer which must be penetrated, PAI timber pile points provide the required assurance that the pile will reach required bearing in good condition.

- **Prevents pile splitting and brooming.**
- **Quick and easy to attach.**
- **Available for all timber pile sizes.**
- **Made of ASTM A36 steel plate.**

Sheet Pile Protectors

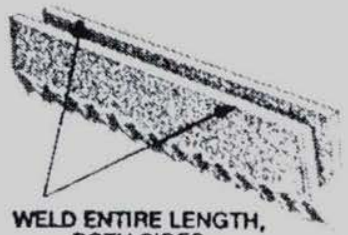
SHEET PILE PROTECTORS

Model #: PASP Series



WELD PROCEDURE

These points should be welded with a 5/16" fillet along the entire length of the top flange on both sides using 70xx series rod.



Your choice of our "universal" sheet pile protector to fit all piles or our wide selection of "Z" protectors are made to fit each of the most popular sheet piles used.

One piece cast steel sheet pile edge protectors help insure pile penetration and at the same time provide significant protection for the leading edge of the pile.

- Edge fluting aids in keeping pile vertical while driving.
- Wedge shape opens slot to ease driving and reduces abrasion of pile coatings.
- Strong cast steel (ASTM A27 minimum) shoe protects pile edge from damage.

Backing Rings and Pipe Caps

ACCESSORIES: PIPE

BACKING RINGS AND PIPE CAPS

BACKING RINGS: Carbon Steel, 1" - 36" O.D. in stock with short nubs (5/32") or long nubs (3/4"). Sizes up to 60" O.D. available.

PIPE CAPS: 1/2" - 42" O.D. in stock with special order sizes up to 72" O.D. Made from 18 to 22 gauge steel depending on size of O.D.