3. Mooring

3.1. Introduction

The purpose of this chapter is two-fold: first, it is intended to acquaint the prospective Salvage Officer with the essentials of the theory of mooring so that he may better understand the forces and phenomena involved. Secondly, it is to equip the Salvage Officer with rudimentary tools that may help him evaluate the effect of changing any element of a predesigned moor.

The design of a moor is a complex problem and should be handled by those well versed in the art of mooring design. In the NAVY, this function is fulfilled by the Naval Ship Systems Command. In most salvage cases which require moors of greater capability than those provided by the standard ASR moor, sufficient time will be available for a detailed moor design by that group.

The Salvage Officer may very well find that he has inherited a moor from the rescue phase. In that case, it undoubtedly will be a standard ASR moor. It is hoped that this chapter will provide a sufficient understanding of moors in general, and the ASR moor in particular, so that the Salvage Officer may make temporary adjustments to the moor to meet the salvage requirements, if the situation so dictates.

In dealing with the problems of mooring, the following subjects will be treated:

- Forces acting upon a moored ship.
- Dynamic moors.
- Static moors.
- Anchor and bottom phenomena.
- Catenaries and mooring rigs,

  Simple catenaries
  Compound catenaries.
- The standard ASR moor.
- Available mooring equipment.

3.2. Forces Acting Upon a Moored Ship

The forces acting upon a moored ship are attributes of three phenomena:

- Wind
- Wave
- Current

3.2.1. Wind Forces

Wind forces actually have a three-fold effect in that they not only apply a force to that portion of the ship which rises above the waterline, but they also create waves and can create surface current. To estimate the force that the wind imparts on a moored ship, due strictly to the wind velocity alone, model tests are run at the Naval Ship Research and Development Center for each ship type. In extrapolating the wind forces from the scale model to full size, the following formulation is used:

$$D_W = (k_B)(A_A)(W_R^2) \qquad \text{(Equation 3-1)}$$

where:

D_W = drag due to wind velocity

k_B = dimensional coefficient for drag of a given ship with a beam aspect

A_A = the projected profile area of the ship above the waterline (ft^2)

W_R = the maximum wind velocity encountered in the moor (kts)

The values of k_B generally vary between 0.003 and 0.0042. A value of k_B of 0.004 is recommended for estimating the force on any given ship type if a more refined coefficient is not available.(1)

NOTE: Superscript numbers in parentheses refer to entries in the list of References.

Surface water currents due to natural wind may be estimated, recognizing that data exists which indicates the surface current may be 1.5 to 3.0 percent of the sustained wind velocity and is more or less uniform for the draft of a conventional ship.

3.2.2. Wave Forces

Wave forces acting upon a moored ship are fluctuating in nature and stem from three characteristics of the wave; these characteristics are:

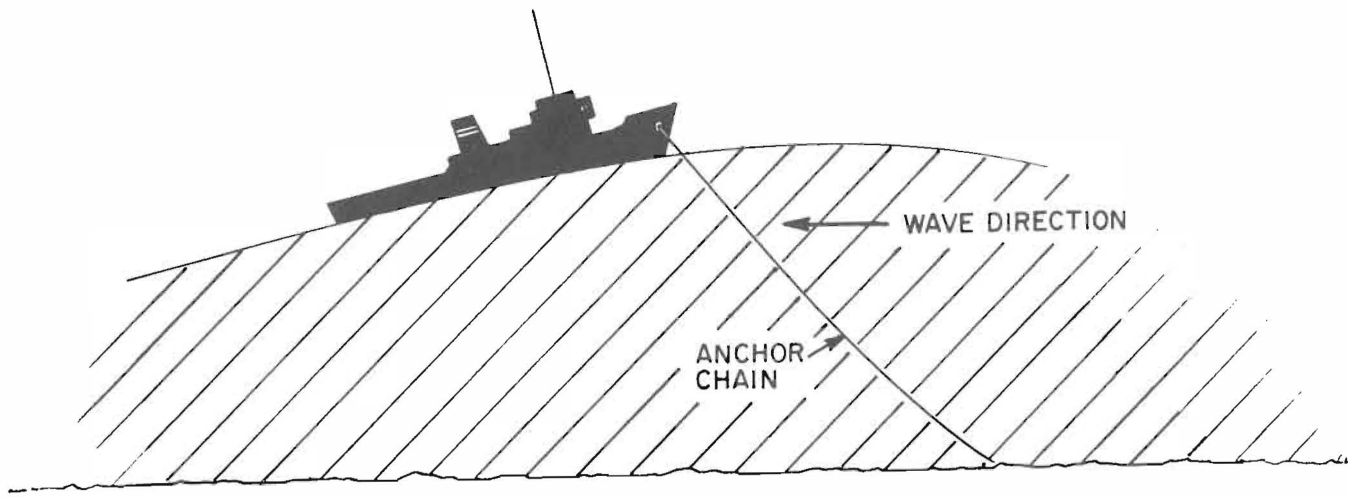
1. Heave of the ship as it is buoyed up by an on-coming wave.
2. The sloped surface of the wave which, as the wave approaches, causes the ship to attempt to slide down the sloped face of the wave (Figure 3-1).
3. Increased velocity of the water due to orbital motion as the wave crest passes.

The wave forces are periodic in nature and the "ship-mooring leg - anchor" system reacts very much as a weight on a spring. In this analogy the ship corresponds to the weight, and the spring is represented by the catenary in the mooring leg. The problem of analyzing the transitory force on the mooring leg when it is disturbed by the wave force is complex, and any solution is peculiar to a given situation only. Obviously, the possible situations that may exist are infinite. For this reason, moors are usually designed neglecting the wave forces, and a sufficient safety factor is utilized to make the moor adequate under most situations. The important thing for the Salvage Officer to note is that a moor which is adequate for a steady state wind or current condition, may drag or part under specific wave conditions that may accompany the wind and/or current.

3.2.3. Current

The current acting upon the ship produces forces due to skin friction. The basic formulas for wind and for current are similar, but since the specific gravity of water is many times that of air, the forces induced by even slow ocean currents may exceed those produced by extremely high winds.

An additional complicating factor is that currents do not normally coincide with wind direction. Mooring equations, normally utilized, assume that the moor lies in one vertical plane. If the wind drag on the ship does not coincide with the current, the drag caused by the ocean current on the mooring leg will probably cause it to move out of a single plane; the problem will become a three-dimensional analysis of the catenary. Few analysts are equipped to cope with this problem, and any mooring problem involving a significant current should be referred to the Naval Ship Systems Command.



SLOPE DRAG DUE TO WAVES.
FIGURE 3-1

As has previously been noted, current forces may exceed wind forces, and any choice that must be made between heading into the wind or heading into the current should be decided in favor of the current.

A very crude formula for estimating the drag imposed by a current upon a given ship is:

$$D_c = 0.3\ AV_c^2 = \text{beam aspect} \qquad \text{(Equation 3-2)}$$

$$D_c = 0.016\ AV_c^2 = \text{bow aspect}$$

where:

D_c = drag of current (lbs)

A = wetted surface of ship bottom (ft^2)

V_c = velocity of current (kts) (see Reference 2.)

3.3. Dynamic Moors

Dynamic moors are being utilized for deep water problems in increasing numbers. Two examples are CUSS I, used in a prototype drilling operation which was to be the prelude to MOHOLE, and a support ship for the CURV vehicle which is under the operational control of NOTS, Pasadena.

The dynamic moor consists of propulsion devices that will permit propulsive forces to be applied to the ship in any direction so as to hold the ship stationary against the forces of wind and sea. In addition, a dynamic moor requires some kind of sensing device which will accurately locate the ship with respect to the desired position on the bottom. The dynamic moor is a relatively expensive solution to the mooring problem, and, therefore, from a cost effectiveness viewpoint, is not attractive for mooring problems of 1,000 feet or less. Should salvage mooring requirements exceed 1,000 feet, the dynamic moor may become more attractive and at some future date replace the static moor. One problem which must be avoided, should salvage operations utilize a dynamic moor, is the entanglement of salvage lines in the propulsive devices of the dynamic mooring system. (3)

3.4. Static Moor

Since the static moor is the only moor currently of interest to the Salvage Officer, it will be treated in greater detail than was the dynamic moor.

The static moor consists of some attachment to the ocean bottom, usually an anchor; a mooring leg consisting of one or more chains or wires; and, finally, a buoy or the ship itself. Multi-leg moors usually terminate in surface buoys and the ship makes fast these buoys.

3.4.1. Anchors

In temporary moors, such as those encountered in salvage, anchors are usually used. These anchors are available in several sizes and shapes. Those most commonly encountered in salvage work are described in Table 3-1.

The ability of an anchor to hold to the ocean bottom depends on a number of factors:

1. Fluke shape.
2. Fluke angle with respect to the shank.
3. Type of ocean bottom.
4. Angle of pull exerted on the shank measured in the vertical plane.
5. Distance anchor is dragged over the bottom to permit it to dig in.

The important parameter in the shape of the fluke is the moment of the fluke area about the trunion. The greater the fluke moment, the greater is the anchor's holding power. Since a family of anchors, such as the LWT or the Eells, all have basically the same shape and proportion, the holding power of a given anchor in each of these types is approximately proportional to the anchor weight for any given bottom or direction of pull.

The holding power of an anchor may be estimated using the formula:

$$H = k \text{ (anchor wt)} \qquad \text{(Equation 3-3)}$$

where:

H = anchor holding power (lbs.)

k = a constant peculiar to an anchor family and the ocean bottom involved (see Table 3-2)

The maximum angle which the fluke makes with the shank affects the holding power of an anchor on any given bottom.

TABLE 3-1

TABLE OF ANCHORS

Type	Weight	Maximum Holding Power (Sand)	Remarks
LWT	4,000 lb	75,000 lb	Used in standard ASR Moor
LWT "Wedge Block"	6,000 lb	106,000 lb	4 each on ATS and ARS ship types
LWT "Wedge Block"	10,000 lb	175,000 lb	In Emergency Ship Salvage Pools
LWT "Wedge Block"	25,000 lb	430,000 lb	In Emergency Ship Salvage Pools
Eells	8,000 lb	80,000 lb	4 each in ATS and ARS ship type

TABLE 3-2

ANCHOR TYPES AND HOLDING POWER

	Ocean Bottom		
Anchor Type	k for mud	k for sand	k for coral
Navy Standard	3.50 lb/lb	7 lb/lb	3.0 lb/lb
LWT (Model A.1, Full Fluke)	2.5 lb/lb	18.5 lb/lb	7.0 lb/lb
Eells	1.5 lb/lb	10 lb/lb	5.0 lb/lb

NOTE: This Table is based on NAVY data obtained in tests at Little Creek and Yorktown, Virginia, and at Key West, Florida, in October and November 1956.

The optimum fluke angle is not the same for all bottoms, and experiments have indicated that for a mud bottom the maximum holding power is attained when the fluke angle is approximately 50°, whereas on a sand bottom the optimum angle appears to be about 30°. (Figure 3-2 illustrates the effect of fluke angle on the two bottoms.) It is this variance in the fluke angle that has led to the development of the LWT "Wedge Block" anchor which may be adjusted to a maximum angle of either 30° or 50°, depending upon whether the holding ground is to be sand or mud.

The maximum holding power of an anchor is developed when the pull exerted is parallel to the ocean bottom. If the anchor end of the mooring leg rises so that the angle of pull begins to assume finite values, the flukes of the anchor tend to break out of the bottom. Another way of visualizing the same problem is to realize that pull at positive angles raises the shank and is effectively reducing the angle that the flukes make with respect to the ocean bottom, thus the holding power decreases. (Figure 3-3 illustrates the effect of the angle of pull on the holding power of an anchor.)

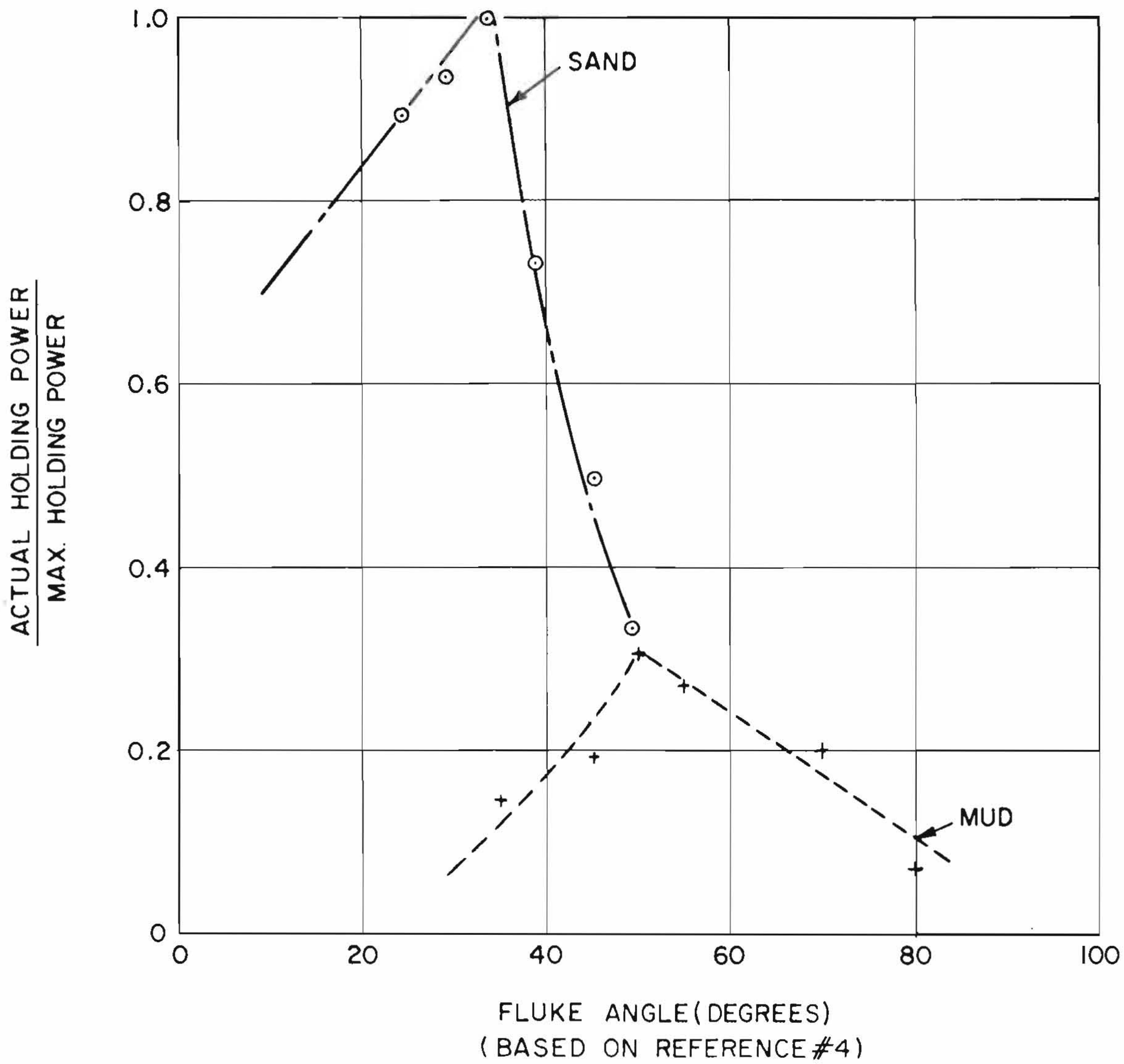
An anchor does not immediately develop its full holding capability; it must be pulled over the bottom for a distance before it develops. The distance involved varies from approximately 40 to 100 feet, depending upon the ocean bottom, anchor size, and other factors. (Figure 3-4 illustrates the effect of anchor drag upon holding power.) The essential point for the Salvage Officer is that in laying a moor, the mooring leg should be subjected to a strain so that the anchor can begin to dig itself in and develop holding power.

Anchors are usually sized to accommodate the drag forces imposed by the ship on the moor. The anchor should develop a minimum holding power that is at least equal to the maximum drag force which the ship will place upon the moor, and which occurs under the most adverse condition in which the ship will be required to stay on station. If these forces are greater than the holding power of the anchor, two or more mooring legs may be required in the general direction from which the most adverse wind or current conditions are anticipated.

3.4.2. Catenaries

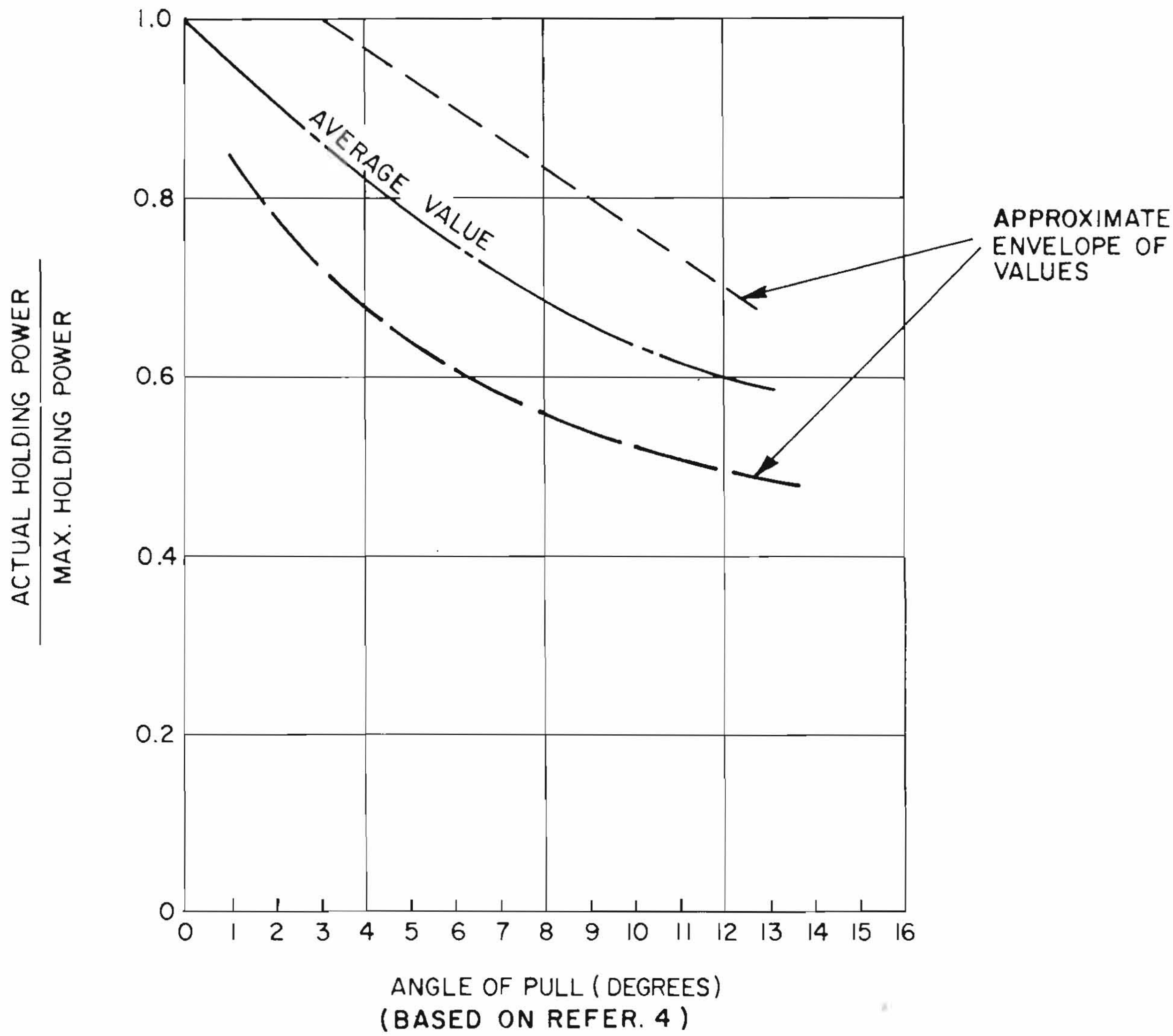
Simple Catenaries

The curve described by any line having finite weight and subjected to tension is known as a catenary.



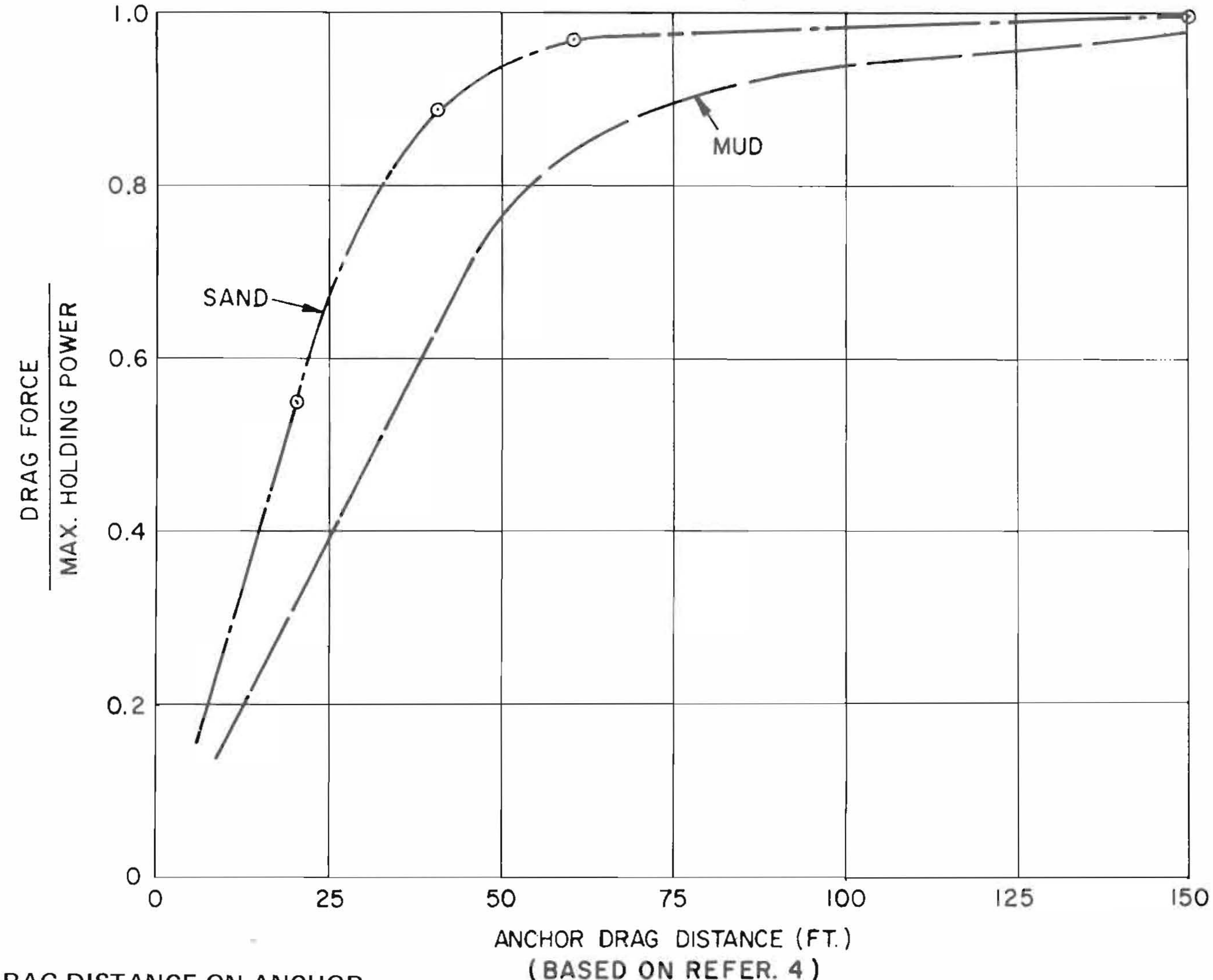
ANCHOR HOLDING POWER AS A FUNCTION OF FLUKE ANGLE WITH BOTTOM.

FIGURE 3-2



HOLDING POWER AS A FUNCTION OF ANGLE OF PULL.

FIGURE 3-3



EFFECT OF DRAG DISTANCE ON ANCHOR HOLDING POWER.
FIGURE 3-4

The mathematical equation of a catenary is well defined and is encountered in engineering problems in many fields. A simple moor involving an anchor, a single mooring line, and either a ship or a buoy at the surface may be described using the following equations: (5)

$$Y = {}^{H}/_{W}\ (\sec \theta_b - \sec \theta_o) \qquad \text{(Equation 3-4)}$$

$$S = {}^{H}/_{W}\ (\tan \theta_b - \tan \theta_o) \qquad \text{(Equation 3-5)}$$

$$X = {}^{H}/_{W}\ \ln \frac{\tan (^{\pi}/_{4} + \frac{\theta_b}{2})}{\tan (^{\pi}/_{4} + \frac{\theta_o}{2})} \qquad \text{(Equation 3-6)}$$

(see Figure 3-5)

where:

- S = scope of mooring leg (ft)
- Y = vertical projection of mooring leg (ft)
- X = horizontal projection of mooring leg (ft)
- H = holding power (lbs)
- W = WT/FT in sea water of mooring leg ($^{lbs}/_{ft}$)
- θ_b = angle of tangent to mooring leg with respect to horizontal (at the buoy)
- θ_o = angle of tangent to mooring leg (at the anchor) with respect to horizontal. (5)
- ln = the natural logarithm (i.e., to the base e).

Figure 3-5 illustrates a simple catenary and the nomenclature involved in the equations. As indicated in the previous discussion, in order for the anchor to develop its maximum holding power, the angle which the catenary makes with the bottom at the anchor (θ_o) should be 0 degrees. In shallow waters this can be obtained using reasonable scopes of chain or line.

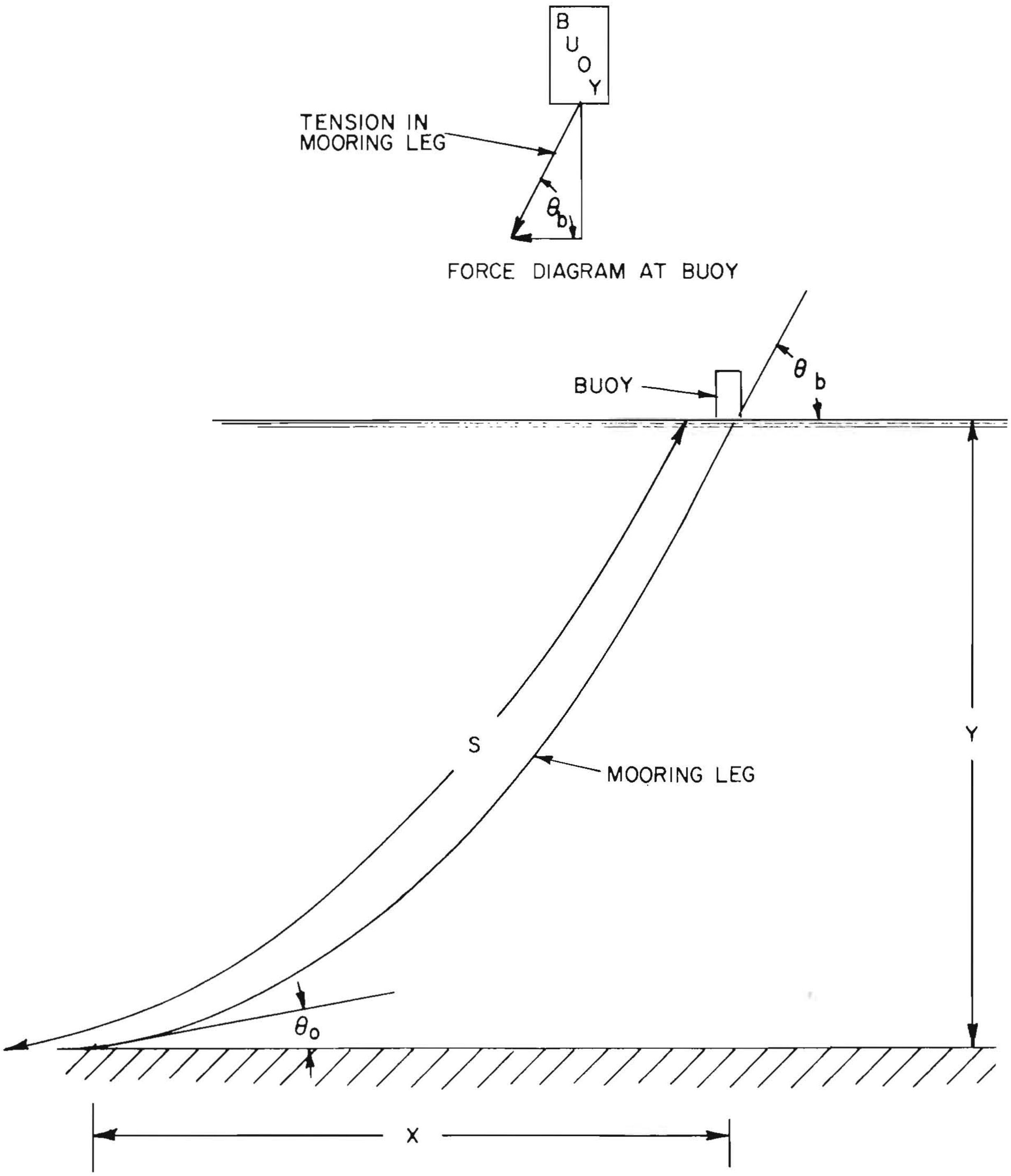
An example of a solution for a simple catenary problem involving the terms listed above is:

given:

water depth = 650 ft

scope = 27 shots, 3/4-inch chain

bottom slope and angle of pull (θ_o) = 0^o



GEOMETRY OF A MOORING LEG.

FIGURE 3-5

Example 3-1. Find Holding Power

$$\frac{Y}{S} = \frac{(\sec \theta_b - \sec \theta_o)}{(\tan \theta_b - \tan \theta_o)} \qquad \text{(Equation 3-7)}$$

$$H = {}^{WT}/_{\tan \theta_b} \qquad \text{(Equation 3-8)}$$

solution:

$$\frac{Y}{S} = \frac{\text{depth}}{\text{scope}} = \frac{650 \text{ ft}}{27 \text{ shots} \times 90 \ {}^{\text{ft}}/_{\text{shot}}}$$

$$\frac{Y}{S} = \frac{650}{2430} = 0.268$$

enter Figure 3-6 with 0.268 and find that

$$\theta_b = 30^o \text{ on } \theta_o = 0 \text{ line}$$

$$W_T = 27 \text{ shots} \times 478 \ {}^{\text{lbs}}/_{\text{shot}} \text{ (sea water)} = 12{,}900 \text{ lbs}$$

enter Figure 3-7 using

$$W_T = 12{,}900 \text{ and } \theta_b = 30^o$$

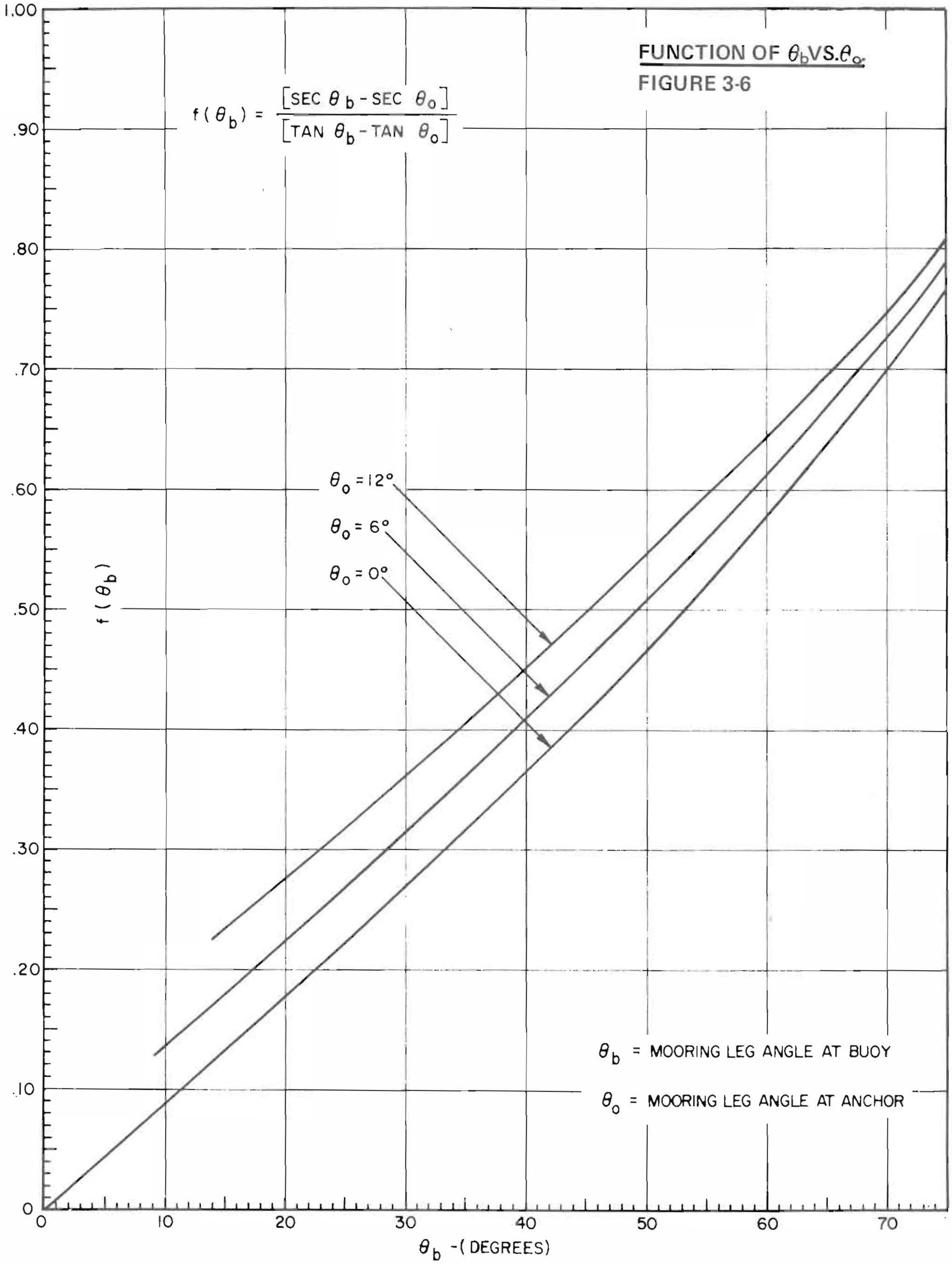
Connect these points with a straight line and extend the line to the holding power scale.

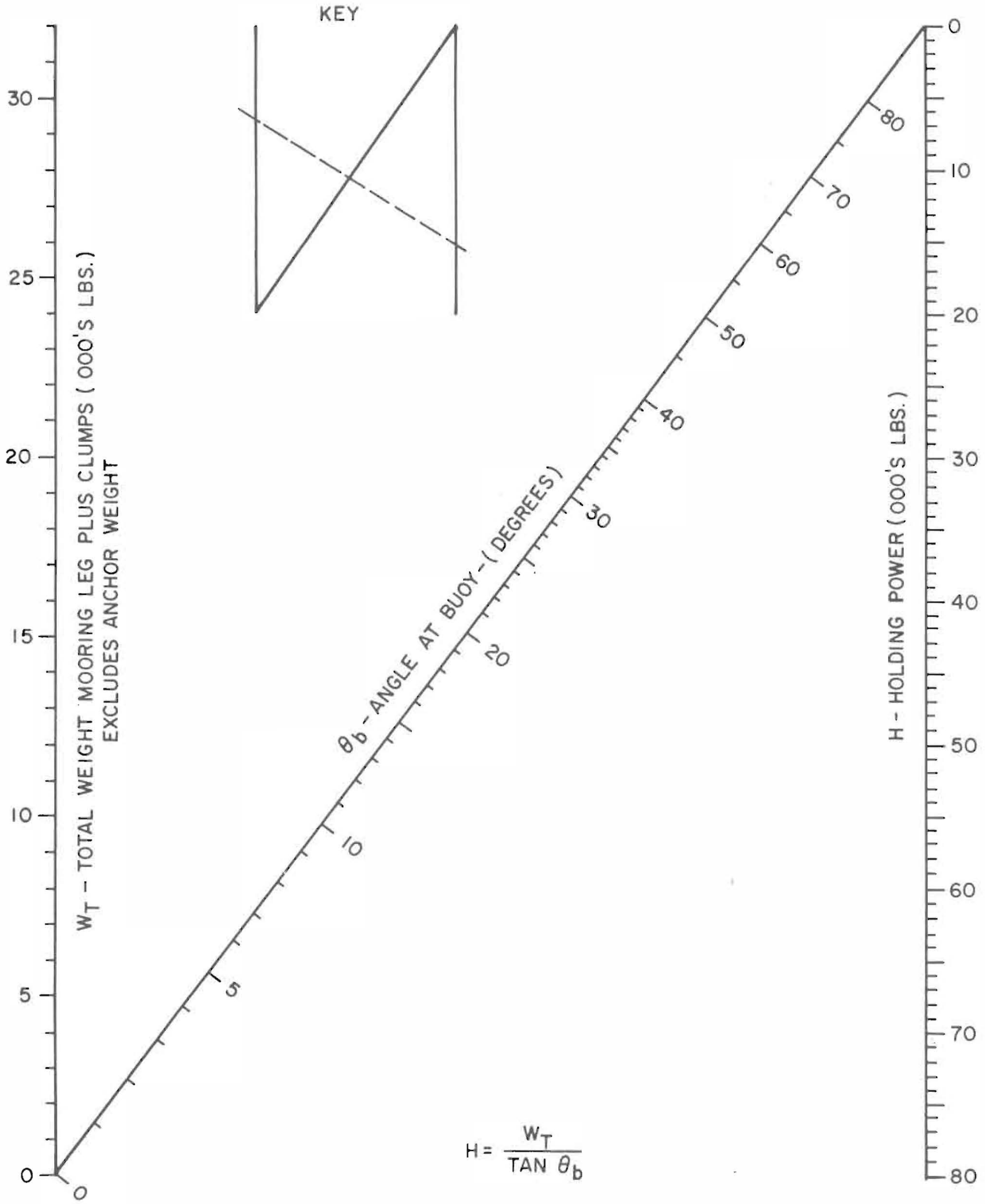
read

$$H = 22{,}300 \text{ lbs}$$

Compound Catenaries

As water depth increases, the length of the scope of chain required to let the anchor develop its full holding power becomes great. This condition tends to make the mooring designer think in terms of adding weights at the lower end of the mooring line in order to modify the catenary and make it tangent to the ocean bottom at the anchor, permitting shorter mooring legs to be used. Using clumps or chains of different weights for various segments of the mooring leg transforms the simple catenary problem into one involving a compound catenary. The basic equations which describe a compound catenary are the same as equations 3-4 through 3-8.


FUNCTION OF θ_b VS. θ_o
FIGURE 3-6
$f(\theta_b) = \frac{[\sec\theta_b - \sec\theta_o]}{[\tan\theta_b - \tan\theta_o]}$
$\theta_o = 12°$
$\theta_o = 6°$
$\theta_o = 0°$
$f(\theta_b)$
θ_b = MOORING LEG ANGLE AT BUOY
θ_o = MOORING LEG ANGLE AT ANCHOR
θ_b -(DEGREES)
0
10
20
30
40
50
60
70
.10
.20
.30
.40
.50
.60
.70
.80
.90
1.00



MOORING LEG HOLDING POWER NOMOGRAPH.
FIGURE 3-7

These equations, however, must be applied to each segment of the mooring leg. For example, if a mooring leg is assembled using 27 shots (2430 feet) of 3/4-inch chain and one shot (90 feet) of 2-1/4-inch chain, then each of these two segments must be treated as a simple catenary. The two catenaries may be related to each other by imposing two conditions:

Condition I:

If equation 3-4 is solved for both segments, then the sum of the results is equal to the depth of the water in which the moor is placed (see Figure 3-8).

$$Y_a = \frac{H}{W_a} (\sec \theta_1 - \sec \theta_o) \qquad \text{(Equation 3-9)}$$

$$Y_b = \frac{H}{W_b} (\sec \theta_2 - \sec \theta_1) \qquad \text{(Equation 3-10)}$$

$$\text{depth} = Y_a + Y_b \qquad \text{(Equation 3-11)}$$

Condition II:

The angles at the ends of the catenary segments may be related by the following equation:

$\tan \theta_o$ - must be assumed. It is usually assumed to be zero. Therefore, $\theta_o = 0$, and the catenary is tangent to a horizontal ocean bottom.

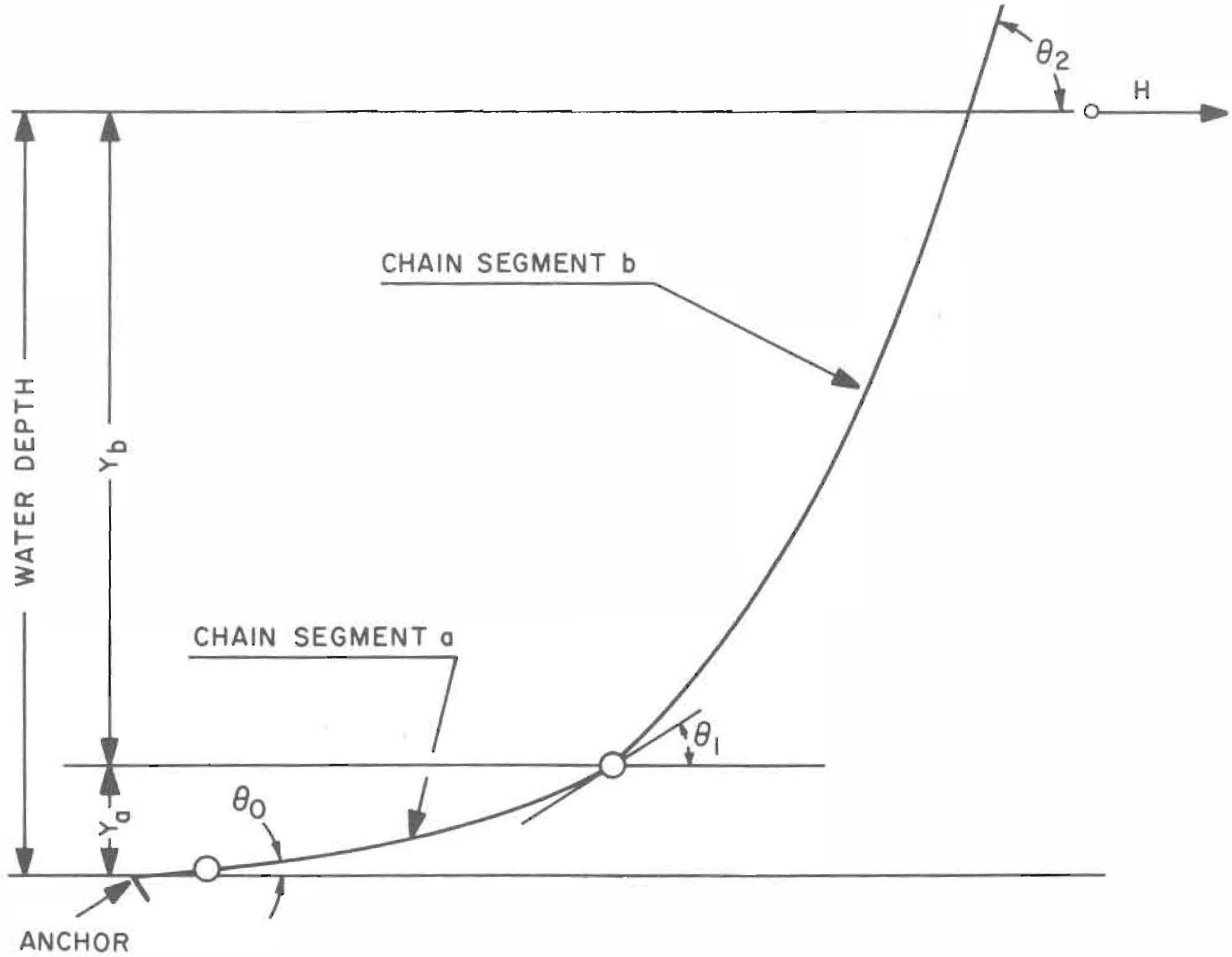
$$\tan \theta_1 = \frac{S_a W_a}{H} + \tan \theta_o \qquad \text{(Equation 3-12)}$$

$$\tan \theta_2 = \frac{S_b W_b}{H} + \tan \theta_1$$

therefore,

$$\tan \theta_2 = \frac{S_b W_b}{H} + \frac{S_a W_a}{H} + \tan \theta_o \qquad \text{(Equation 3-13)}$$

Because of the nature of the equations, they cannot be simplified into a direct solution of holding power. It becomes a matter of assuming various values of holding power and solving for the depth of water associated with this holding power.



S_a = SCOPE OF SEGMENT a (FT)

S_b = SCOPE OF SEGMENT b (FT)

W_a = WEIGHT PER FOOT IN WATER OF CHAIN a (LB/FT)

W_b = WEIGHT PER FOOT IN WATER OF CHAIN b (LB/FT)

H = HOLDING POWER (LBS)

Y_a = VERTICAL PROJECTION OF CHAIN a (FT)

Y_b = VERTICAL PROJECTION OF CHAIN b (FT)

SEC θ_0 = SECANT OF ANGLE θ_0

TAN θ_0 = TARGET OF ANGLE θ_0

θ_0 = ANGLE OF ANCHOR CHAIN AT THE ANCHOR

θ_1 = ANGLE OF CHAIN a AND CHAIN b AT THEIR JUNCTURE

θ_2 = ANGLE OF CHAIN b AT THE WATER SURFACE

CATENARY NOMENCLATURE.

FIGURE 3-8

A plot of holding power versus depth may then be made and the desired solution of holding power for the given depth may be located on that curve. Figure 3-9 is a plot of depth versus holding power for a standard ASR moor using 27 shots of 3/4-inch chain (curve B). A second plot is given of holding power versus depth for a moor consisting of 27 shots of 3/4-inch chain with a 90-foot section of 2-1/4-inch chain added (curve B).

To illustrate the manner in which the points are calculated in order to determine the curve of holding power versus depth, the following example is a calculation of one point in curve A of Figure 3-9.

Example 3-2

given:

$S_a = 90$ ft

$W_a = 43.1$ lbs/ft in water (49.6 lbs in air)

$S_b = 2430$ ft

$W_a = 5.31$ lbs/ft in water (6.11 lbs in air)

assume:

$\theta_o = 0^o$

therefore:

$\sec \theta_o = 1.0000, \; \tan \theta_o = 0.0000$

$H = 30{,}000$ lbs

$$\tan \theta_1 = \frac{S_a W_a}{H} + \tan \theta_o = \frac{3879}{30{,}000} + 0 = 0.1293$$ (from eq. 3-12)

$\theta_1 = 7^o\ 22'$

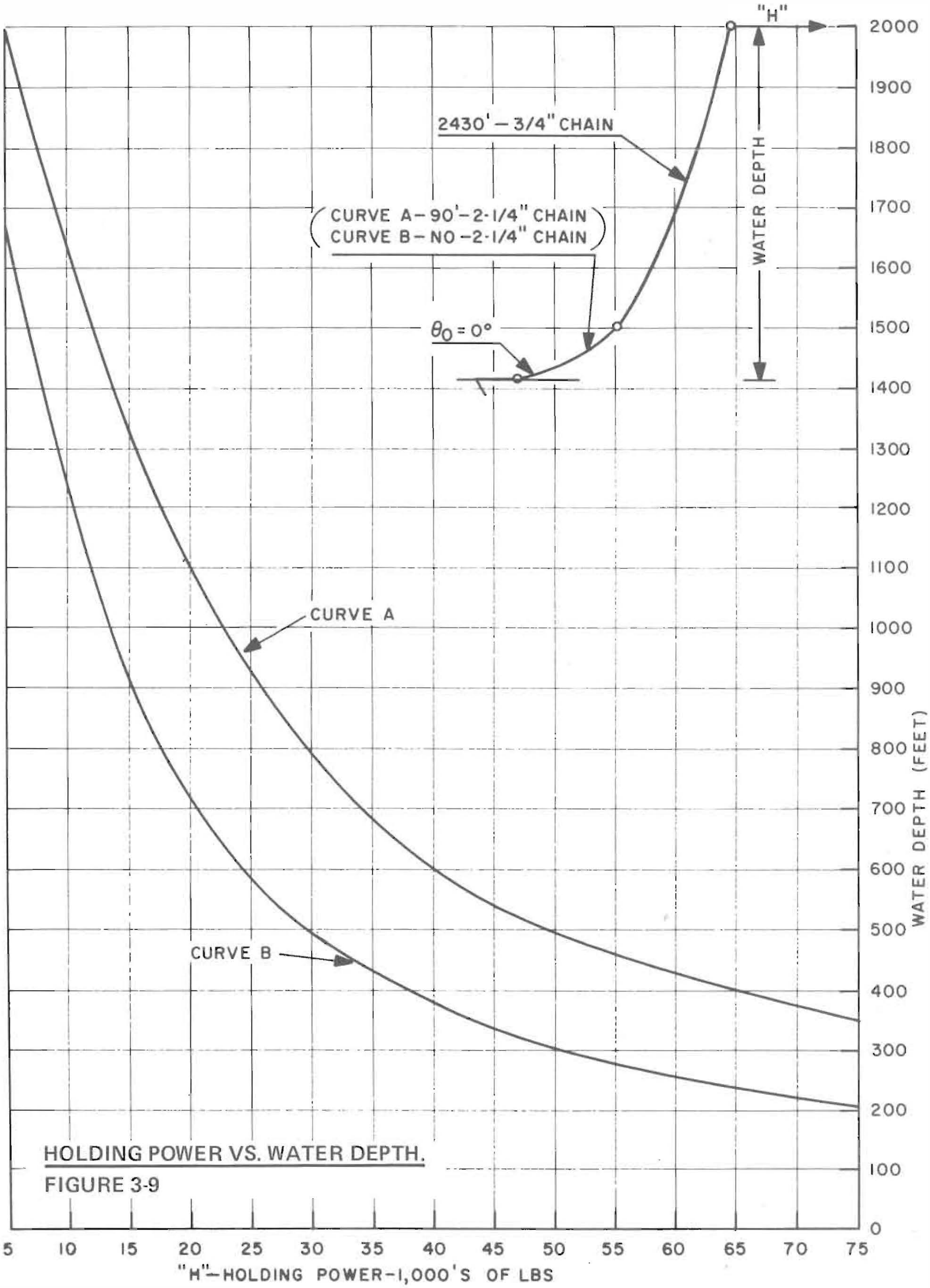
$\sec \theta_1 = 1.0083$

from Trigonometric Tables

$$\tan \theta_2 = \frac{S_b W_b}{H} + \frac{S_a W_a}{H} + \tan \theta_o = \frac{3879 - 12903}{H} + 0$$

(from eq. 3-13)

$$\tan \theta_2 = \frac{16782}{30{,}000} = .5594$$



HOLDING POWER VS. WATER DEPTH.

FIGURE 3-9

$$\theta_2 = 29^\circ\ 13'$$

$$\sec \theta_2 = 1.1458$$

from Trigonometric Tables

$$Y_a = \frac{H}{W_a} (\sec \theta_1 - \sec \theta_o) \qquad \text{(from eq. 3-9)}$$

$$Y_a = \frac{30,000}{43.1} (1.0083 - 1.0000) = 5.78 \text{ ft}$$

round off Y_a to 6.0 ft

$$Y_b = \frac{H}{W_b} (\sec \theta_2 - \sec \theta_1) \qquad \text{(from eq. 3-10)}$$

$$Y_b = \frac{30,000}{5.31} (1.1458 - 1.0083)$$

$$Y_b = 777 \text{ ft}$$

$$\text{water depth} = Y_a + Y_b \qquad \text{(from eq. 3-11)}$$

$$\text{water depth} = 777 + 6 \text{ ft}$$

$$\text{water depth} = 783 \text{ ft}$$

Returning for a moment to Figure 3-9, it should be noted that curve B was calculated using the method set forth in Example 3-1. Curve A was calculated using the method of Example 3-2. These two examples were chosen to permit a direct comparison of the holding power of a standard ASR moor at any given depth to the holding power which could be developed by simply adding one 90-foot shot of 2-1/4-inch chain between the standard ASR moor leg and the anchor.

The previous sections of this chapter have dealt with some of the factors affecting holding power, but it may be well to reiterate at this time that the holding power calculated using equations 3-3 through 3-13 merely represents that horizontal force which would create a catenary under static conditions described by those formulas.

Any number of conditions may prevent the moor from behaving as predicted by catenary calculations. These conditions include the following:

1. An anchor of inadequate holding power for bottom conditions actually encountered is employed.

2. Dynamic forces imposed by wind, wave, or current impose excessive transient forces on the anchor or tend to cause it to break out.

3. Current conditions are such that the catenary is not two dimensional as assumed by Equations 3-3 through 3-13, but is actually a three-dimensional curve.

Having listed some of the factors which will influence the actual behavior of the moor, it is well to restate the aim of this chapter which is not to make the reader a mooring designer, but to equip the Salvage Officer with rudimentary tools that may help him evaluate the effect of changing any element of a pre-designed moor.

3.5. The ASR Moor

The ASR moor consists of a 4,000-pound LWT anchor and the required scope of 3/4-inch dielock chain. Each ASR is provided with 108 shots so that in a four-leg moor, an ASR could deploy 27 shots of chain on each leg. The ASR moor is generally laid out in a circle whose diameter depends upon the depth of water in which the moor is to be deployed. Each leg is generally dropped at points corresponding to 0 degrees, 90 degrees, 180 degrees, and 270 degrees about the circle parameter. (Refer to the NWP search and rescue series for information concerning the laying of a moor.)

3.6. Mooring Equipment

To supplement mooring equipment available on a salvage ship, the Salvage Officer can request the use of emergency equipment stockpiled and available on a loan basis from the many Emergency Ship Salvage Pools (ESSP), and Material Bases.

NOTE: A list of Emergency Ship Salvage Pools and Material Bases is presented in Table 3-3. All materials stored in the above mentioned pools are listed in allowance and inventory control lists every six months. These inventory lists are available to the Salvage Officer; he should request them when he is contemplating a loan of equipment.

The following equipment is generally available in the emergency pools and can be obtained to supplement the salvage equipment on the site:

Item	Description
Anchor	8,000 lb. Eells
Anchor	6,000 lb. LWT
Chain	2-1/4-inch
Wire rope	1-5/8-inch x 600 feet (& x 300 feet)
Wire rope	5/8-inch x 1200 feet

Salvage pools can supply much additional equipment which may be necessary for the moor.

TABLE 3-3

LOCATION OF EMERGENCY SHIP SALVAGE POOLS AND MATERIAL BASES

Salvage Material Pools:

NSD Newport Annex, Bayonne, New Jersey, USA
U.S. Naval Supply Center, Oakland, California, USA
U.S. Naval Supply Center, Pearl Harbor, Hawaii, USA
U.S. Naval Supply Depot, Guam, Mariana Islands
U.S. Naval Supply Depot, Subic Bay, Republic of the-Philippines
U.S. Naval Supply Depot, Guantanamo Bay, Cuba
U.S. Naval Station, Rodman, Canal Zone
U.S. Naval Station, San Juan, Puerto Rico

Salvage Material Bases (Fleet controlled):

Camp Darby, Livorno, Italy
U.S. Naval Ship Repair Facility, Yokosuka, Japan
Fleet Activities (SRD), Sasebo, Japan
U.S. Naval Support Activity, Danang, Republic of Vietnam
Philadelphia Naval Shipyard, Philadelphia, Pennsylvania, USA
Long Beach Naval Shipyard, Long Beach, California, USA
San Francisco Bay Naval Shipyard, Hunters Point Division,-San Francisco, California, USA
Puget Sound Naval Shipyard, Bremerton, Washington, USA
Boston Naval Shipyard, Boston, Massachusetts, USA
Charleston Naval Shipyard, Charleston, South Carolina, USA
Destroyer Submarine Base, Norfolk, Virginia, USA
U.S. Naval Station, Adak, Alaska, USA

Submarine Salvage Material Pools (Pontoons and associated equipment):

Boston Naval Shipyard, Boston, Massachusetts, USA
Charleston Naval Shipyard, Charleston, South Carolina, USA
Pearl Harbor Naval Shipyard, Pearl Harbor, Hawaii
Naval Base, San Diego, California, USA

Special Salvage Material Pools:

(Load Measuring Instruments) Naval Ship Research and Development Center, Carderock, Maryland, USA
(Underwater Gas Generators) Naval Ordnance Test Station,-China Lake, California, USA
(Foam-in-Salvage) San Francisco, California, USA