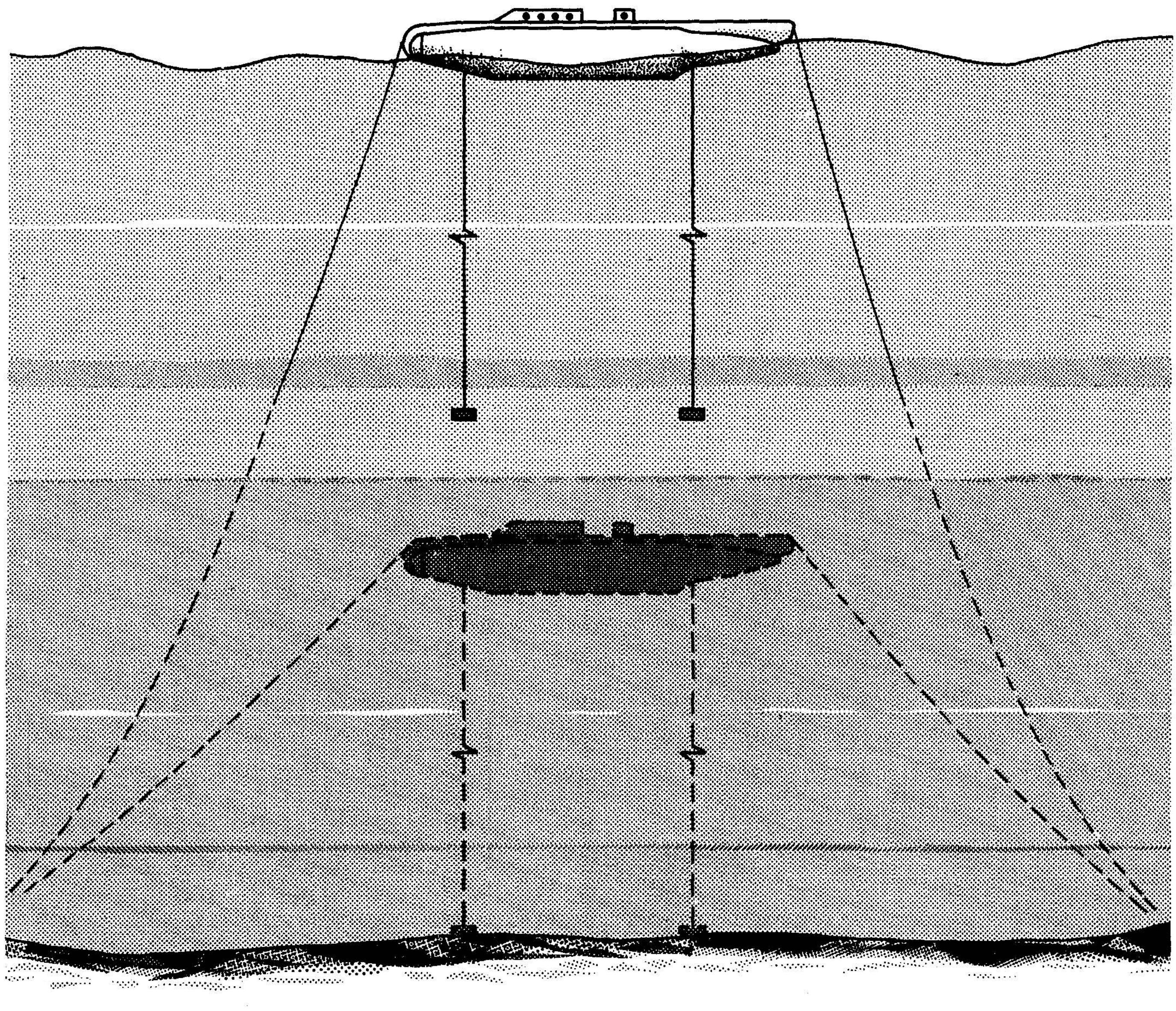
NAVSHIPS 0994-011-2010

THE SQUAW

**Technical Report
on
Submerged Submarine Hull Target**



**Department of the Navy
Naval Ship Systems Command
Washington, D.C.**

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This report was created and produced by

POTOMAC RESEARCH, INCORPORATED

under the supervision of

MURPHY PACIFIC
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DEPARTMENT OF THE NAVY
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FOREWORD

This report describes COMSERVPAC underwater mooring operations and associated activities conducted in November of 1970 off the coast of San Diego, California, under the technical direction of the Supervisor of Salvage, Office of the Director of Diving, Salvage and Ocean Engineering Projects (Ships OOC), Naval Ship Systems Command. Materials, techniques, procedures, related activities, and results are described herein, as well as an overall assessment of the completed project. Information gathered, data compiled, and knowledge gained in connection with this undertaking are intended for use by those Commands engaged in similar activities or by those contemplating such operations.

E. B. Mitchell
Captain, USN
Supervisor of Salvage, U.S. Navy

ACKNOWLEDGEMENTS

The combined efforts of many individuals and groups contributed to the successful completion of this project. Highly professional and competent talents in many fields and disciplines were enlisted to bear upon the complexities involved in this operation; and the smooth, efficient, and effective manner in which all phases of the work were carried out attests to those abilities.

Captain Eugene B. Mitchell, Supervisor of Salvage, and his capable staff developed the basic mooring plan and coordinated the effort throughout. In this regard, Mr. Earl F. Lawrence, Senior Salvage Master in the Office of the Supervisor of Salvage, played an important role, bringing to the task at hand a broad and invaluable experience and a technical knowledge applicable to all functions of the project.

Special recognition is given to the officers and men of the on-site mooring group who, by their superior and outstanding skills, assured successful realization of the objective within the contemplated time-frame. Vessels and their respective Commanding Officers assigned to the mooring group were: USS CHOWANOC (ATF 100), Lieutenant Commander P. W. Wolfgang; USS KALMIA (ATA 187), Lieutenant Commander F. R. Sanderlin; and USS MOLALA (ATF 106), Lieutenant K. C. Roberts.

Able direction, leadership, and assistance in all aspects of active operations were provided by Commander Everhart, CINCPAC Fleet; Lieutenant Commander Carol Whitner, COMTRAPAC; Lieutenant Commander J. W. Warren, COMSERGRU ONE; and Commander Moore, Operations Officer, COMSERGRU ONE.

For SQUAW preparation and rigging and the myriad of other details attended to prior to actual move to the target site, high praise is reserved for all concerned at the U. S. Public Works Center, Naval Station, San Diego, California, as well as for those who provided supporting technical and logistic services. Among such groups and their corresponding services were: Public Works Center, Naval Station, San Diego, California, Logistic Support; Pearl Harbor Naval Shipyard, Fabrication of Equipment; Naval Ship Undersea Research and Development Center, Instrumentation; Naval Ship Yard, Long Beach, California, Engineering Services; Naval Ship Undersea Research and Development Center, Oceanographic Surveys; and Naval Ship Yard, Long Beach, California, SQUAW Drydocking.

ABSTRACT

Successful underwater mooring of a buoyant submarine hull 300 feet below the surface in water depths of 3,492 feet is accomplished in a seven-day period by U. S. Navy vessels and personnel. The hull, used as a sonar training target and identified as the SQUAW, is held in fixed position beneath the surface by means of four mooring legs which are attached to it and which extend to the ocean floor. A stationary condition is achieved and reasonable stability is assured by arranging the legs in such a manner that they resist vertical, horizontal, and lateral movements of the hull. Two inner vertical legs with heavy counterweights resting on the ocean bottom provide the necessary vertical restraint needed to prevent the hull from rising to the surface, while two outer legs--legs which assume an underwater catenary contour configuration--attached to the bow and stern and securely anchored to the bottom restrain horizontal movement. An evaluation of the results of the mooring shows that all design specifications pertinent to the project were met. It is estimated that the SQUAW will remain in its present position from five to ten years, barring premature failure of two or more legs or accidental damage to the structure proper, in which event the hull will overcome any remaining restraints imposed on it and will rise to the surface.

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Frontispiece. SQUAW, the model experimental submarine hull, being readied for mooring operations at the Naval Ship Yard, Long Beach, California.

SECTION 1

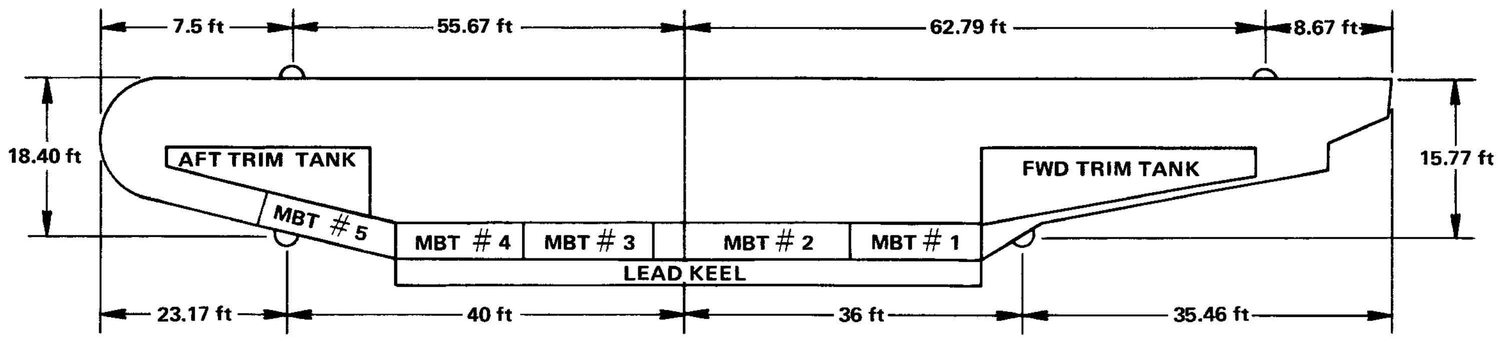
INTRODUCTION

Background. The SQUAW, a model experimental submarine hull, has been used in the past by the Navy both as a structural target in underwater atomic tests (Operations WIGWAM and HARDTACK) and as a sonar target off the Pacific Coast. Since 1959, the hull has been employed exclusively as a sonar training device by COMTRAPAC at two separate locations off the coast of California. From 1959 to 1964 the SQUAW was submerged 200 feet below the surface of the water in an area southwest of San Diego, California. At the end of that time it unexpectedly surfaced when the stern pad eye holding the stern vertical leg failed. In December of 1965 the hull was remoored 20 miles west of Point Loma, California, but again suddenly resurfaced in 1970. Immediate inspection of the hull following this event indicated that leg failures were the principal cause in this case also. At this point, remooring was again considered, chiefly on the basis that the hull was not only important but also essential to submarine and other Navy training programs being carried out in that area.

Subsequent favorable discussions among various groups and individuals interested in this matter led to a decision by the Supervisor of Salvage, Office of the Director of Diving, Salvage and Ocean Engineering Projects (Ships OOC) to proceed with the proposed effort. The Supervisor of Salvage then prepared a mooring plan and a materials list covering the entire operation.

In September of 1970, representatives from agencies involved in the proposed undertaking, and others, met in San Diego, California, for a complete and thorough review of the plan. Modifications and suggestions were incorporated at that time which eventually led to finalization and approval of the proposal.

The Current Report. Information contained in this report describes pre-operational and operational conduct of the project. A description of the SQUAW, the mooring system, design calculations, preparations, on-site operations, results, and conclusions are included as part of the overall presentation of all phases of the endeavor.



(NOTE: MBT INDICATES MAIN BALLAST TANK)

Figure 2-1
Profile View of the SQUAW

SECTION 2

THE MOORING SYSTEM

General Considerations. Mooring design and material specifications were governed by established prerequisite conditions (noted below), and, furthermore, by equipment and storage limitations aboard the ships involved in the on-site operation. To reduce costs, the Supervisor of Salvage recommended that available surplus mooring materials be used where possible. On the basis of past experience, which showed that materials will deteriorate to the extent that eventual failure will occur, submerged life expectancy was set at from five to ten years. The electronic package installed on the hull for sonar training purposes was also estimated to last about five years.

The basic requirements set forth were:

1. Site location--------------32° 51' N Latitude
   117° 44' W Longitude
2. Site water depth-----------3,492 feet
3. Submerged depth of hull----300 feet

The Hull. Figure 2-1 presents a profile view of the SQUAW, its structural units, and the applicable dimensions. Buoyancy is furnished by the pressure hull and adjustments are made by the lead keel and the trim tanks which are filled with fresh water. The five main ballast tanks (MBT'S) are used to control ascent and descent movements of the hull. The four pad eyes which are welded to the hull serve to connect the mooring legs.

Mooring Configuration. Surface and submerged positions of the SQUAW and the relative arrangement of the four legs at each position are shown in Figure 2-2. Note that the outer legs are identified as legs A-1 and A-2, and the inner legs as B-1 and B-2. Legs are attached to the hull before it is submerged. The SQUAW is then sunk to its design depth by flooding the ballast tanks with salt water. Upward forces are restrained and level trim is assured at the fixed 300-foot level by the two vertical counterweights, and horizontal movement is restrained by the two anchored catenary legs which are attached to the bow and stern of the hull.

Mooring Materials. A list of materials and leg composition details are incorporated in Figure 2-3. Anchor chain lengths permit leg connections to be made at the surface. Chain leaders, which resist destructive hull motions, connect each leg to the hull. Wire rope pendants connected to ground rings at the chain-wire-rope juncture serve to raise and lower the legs during the installation process. At the submerged 300-foot level, the wire rope remains clear of the ocean bottom.

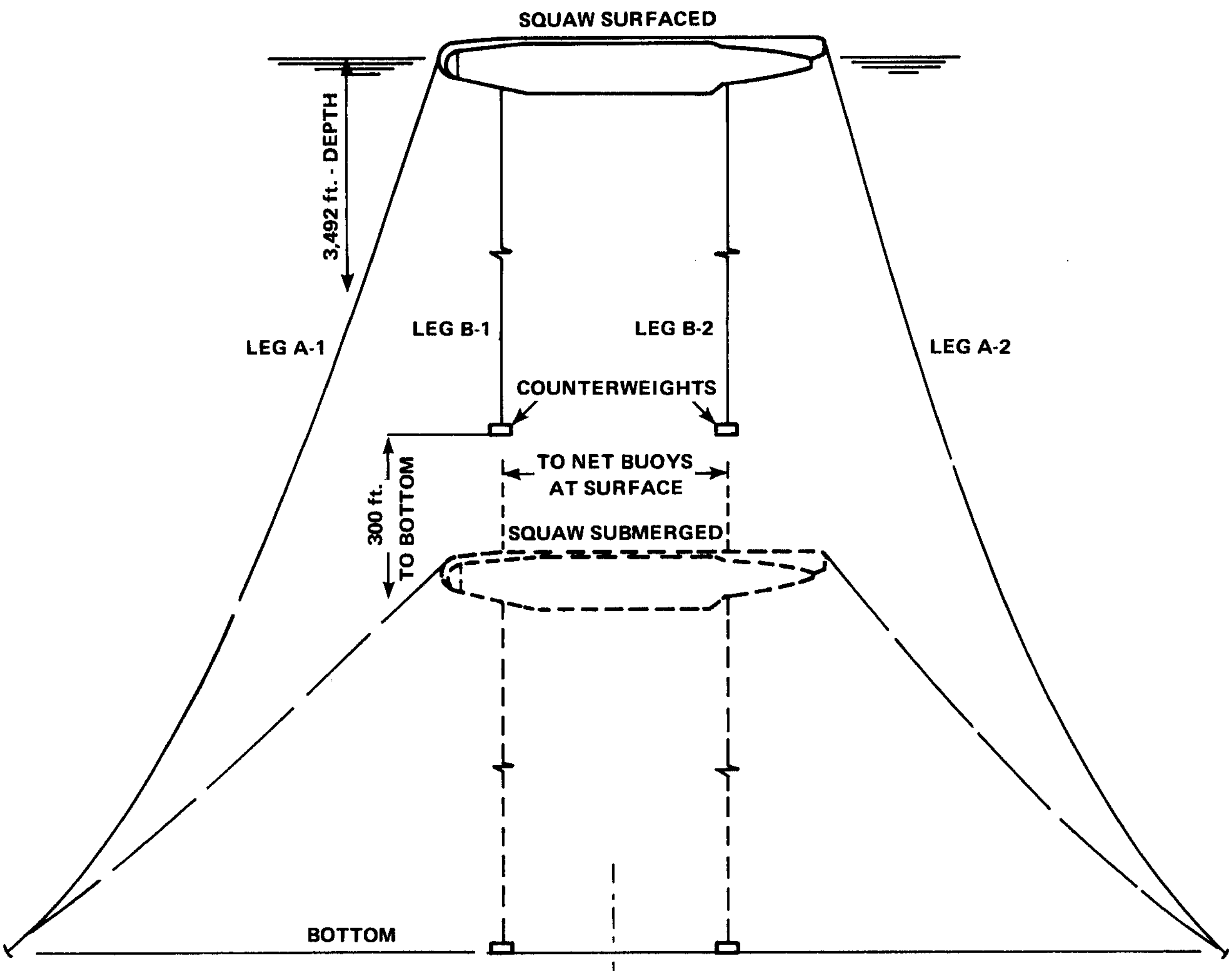


Figure 2-2
Surface and Submerged Mooring Configuration

Materials List

Piece No.	Description	Amount	Spare	Total
1	2" bolt pin shackle	38	6	44
2	1-1/4" x 294 ft w/ ⑧ each end	2	-	2
3	1-3/4" detachable link	14	2	16
4	1-1/2" x 90 ft stud chain	22	2	24
5	2" ∅ x 7-1/2" I.D. ring	4	2	6
6	1-1/4" x 500 wire rope w/ ⑧ each end	4	-	4
7	1-1/4" x 3000 ft wire rope w/ ⑧ each end	4	1	5
8	1-1/4" wire rope closed socket	32	4	36
9	Miller Swivel		-	4
10	1-1/4" x 2850 ft w/ ⑧ ⑫	2	-	2
11	1-1/4" x 2850 ft w/ ⑧ each end	2	-	2
12	1-1/4" wire rope open socket	4	1	5
13	6000 lb clump	2	-	2
14	8000 lb Eell	2	-	2
15	Buoy, mooring mark 4	4	-	4
16	Pear shape anchor shackle		-	2
17	18,330 lb clump	2	-	2
18	1-1/2" detachable link	12	2	14
19	1-1/4" x 1000 wire rope w/ ⑧ ⑫	2	-	2
20	1-1/4" x 50 wire rope w/ ⑧ each end	2	-	2

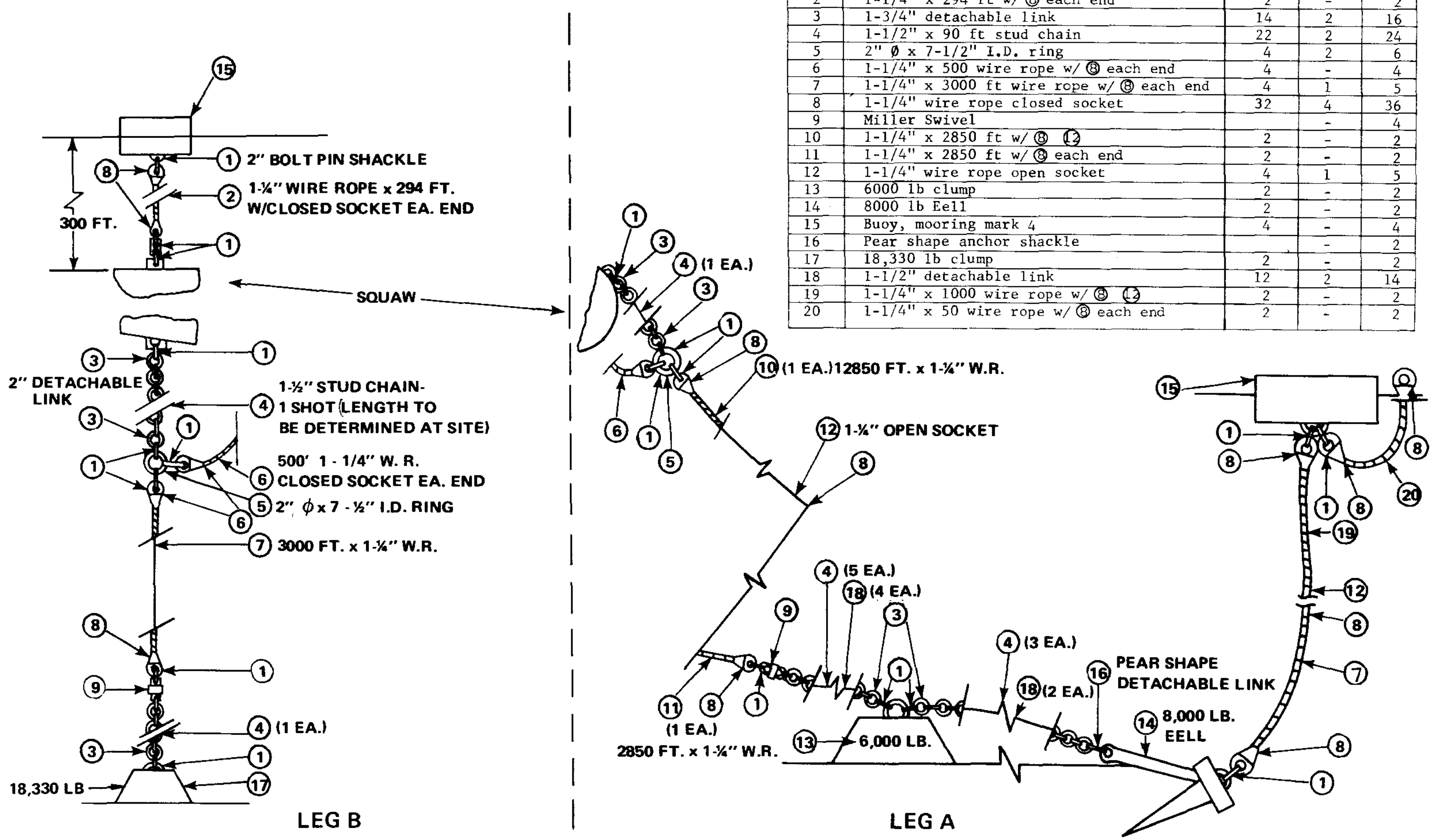


Figure 2-3
Leg Components

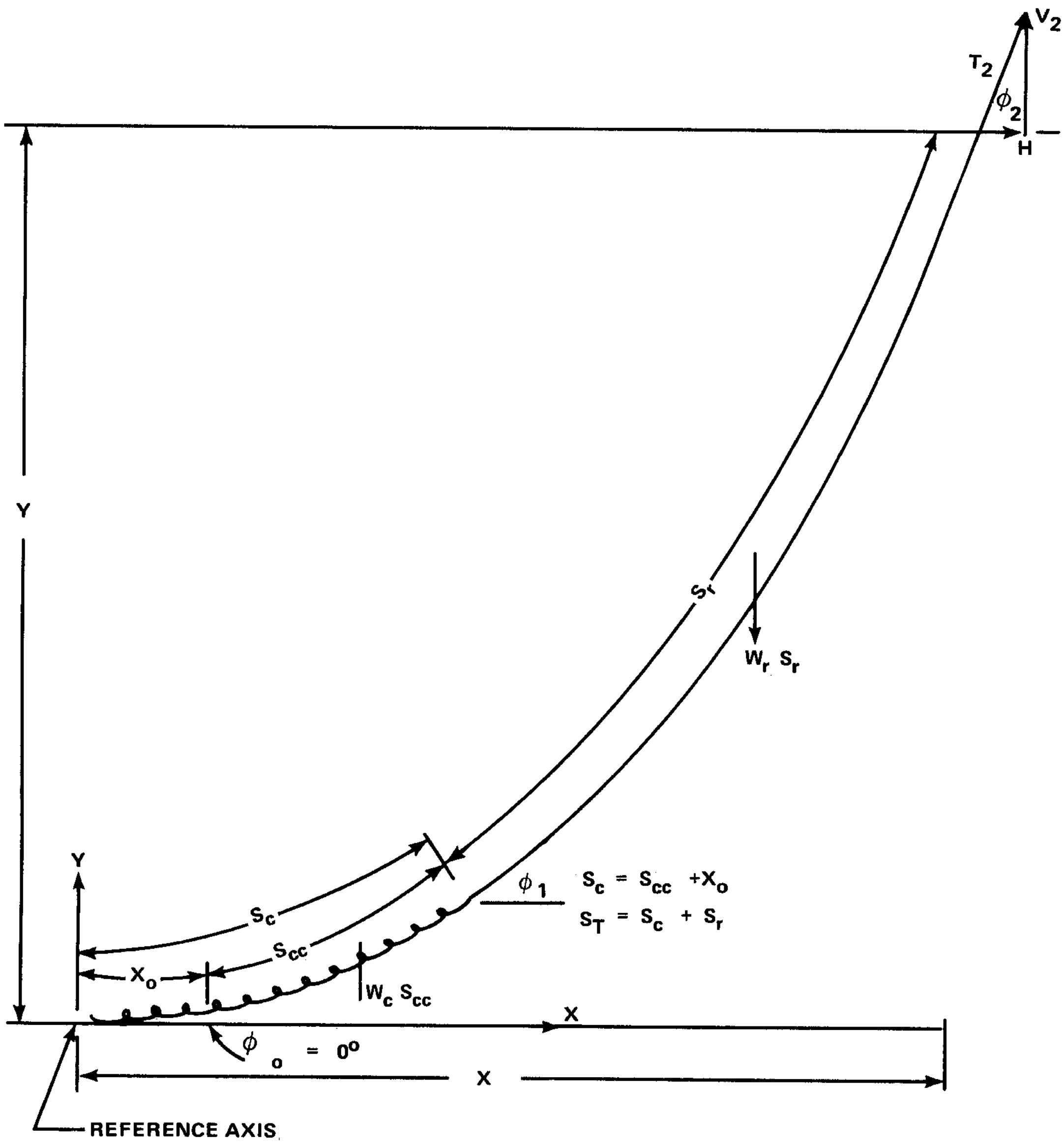


Figure 3-1
Catenary Leg Configuration

SECTION 3

DESIGN CALCULATIONS

Restrictions. Mooring design calculations were directed toward determining:

1. Ballast and trim
2. Leg composition and configuration
3. Acceptable tolerances under design conditions

Computations were affected by such factors as ship storage capacities, ship equipment capabilities, the physical characteristics of the ground tackle, the provision that wire-rope noncontact with the ocean bottom be maintained at all times, and more specifically, by the maximum length and tension of the wire-rope and the parallel force exerted at the anchor shaft at the ocean bottom.

Bow and Stern Legs. Since the effects of ocean currents on the moorings were of negligible magnitude, the outer mooring legs assumed the configuration of a weighted catenary. See Figure 3-1 for leg contour configuration. The general equations that relate the depth (Y), the span (X), and the scope (S), are given by

$$Y = \frac{H}{W} (\sec \phi_1 - \sec \phi_o) \tag{3-1}$$

$$X = \frac{H}{W} \ln \left[\frac{\tan \phi_1 + \sec \phi_1}{\tan \phi_o + \sec \phi_o} \right] \tag{3-2}$$

$$S = \frac{H}{W} (\tan \phi_1 - \tan \phi_o) \tag{3-3}$$

where:

H is the horizontal component of tension

W is the leg weight in water per unit length

ϕ_o is the lower angle with horizontal

ϕ_1 is the upper angle with horizontal

An important characteristic of the catenary is that H is constant at any point in the scope. The tension (T) at any point (P) is

$$T_P = H \sec \phi_P \qquad (3\text{-}4)$$

and the vertical force (V_P) is

$$V_P = H \tan \phi_P \qquad (3\text{-}5)$$

$$V_P = T_P \sin \phi_P \qquad (3\text{-}6)$$

The following formulas are developed from the previous equations when applied to the compound catenary in the chain-wire-rope leg on a level bottom (i.e., $\phi_o = 0$). Referring to Figure 3-1:

(NOTE: In equations 3-7, 3-8, and 3-9, brackets designated number one (1) refer to the chain portion of the leg; number two (2) brackets refer to wire portion.)

$$Y = \left[\frac{H}{W_c}(\sec \phi_1 - 1)\right]_1 + \left[\frac{H}{W_r}(\sec \phi_2 - \sec \phi_1)\right]_2 \qquad (3\text{-}7)$$

$$X = \left[X_o + \frac{H}{W_c}\ln(\tan \phi_1 + \sec \phi_1)\right]_1 + \left[\frac{H}{W_r}\ln\left[\frac{\tan \phi_2 + \sec \phi_2}{\tan \phi_1 + \sec \phi_1}\right]\right]_2 \qquad (3\text{-}8)$$

$$S = \left[X_o + \frac{H}{W_c}(\tan \phi_1)\right]_1 \qquad (3\text{-}9)$$

$$+ \left[\frac{H}{W_r}(\tan \phi_2 - \tan \phi_1)\right]_2$$

$$T_2 = H \sec \phi_2 \qquad (3\text{-}10)$$

$$V_2 = H \tan \phi_2 = T_2 \sin \phi_2 \qquad (3\text{-}11)$$

where:

X_o is the chain scope lying on the bottom

ϕ_1 is the cable angle with horizontal at the chain-wire rope junction

ϕ_2 is the cable angle with horizontal at the upper end

W_c is the weight of chain per unit length

W_r is the weight of wire-rope per unit length

T_2 is the tension at the upper end

H is the horizontal component of tension

V_2 is the vertical component of tension at the upper end

The approach to a solution of equations 3-7 through 3-11 is to select values of H at the surface and subsurface positions. A unique chain-wire rope scope is thus obtained. However, the solution obtained may not necessarily be acceptable, since it may exceed the mooring restrictions. In this case, a new set of values for H is selected and the process is repeated.

Vertical forces are obtained by summing the weight of the chain and wire-rope in the catenary. Tension is obtained by vector addition of vertical and horizontal forces.

Ballast and Trim. The required net buoyancy of the hull (surface and subsurface) was computed by summing the vertical reactive forces at these positions. Vertical rigidity at the submerged position was achieved by exerting an upward force of 5.46 tons* on the vertical legs. Design reactive forces (deballasting required, submerged mooring condition, submerged condition loading data, and surface mooring condition) were calculated as shown in Tables 3-1, 3-2, 3-3, and 3-4. Trim tank capacities are presented in Table 3-5. At the surface position, forces indicated the buoyancy that was needed to bring the SQUAW awash. An additional amount of buoyancy was required for a working freeboard.

With reference to the calculations indicated in the following tables, all ballast tanks were assumed to be 100% full before deballasting. Weight increase due to "water-logged" hull, painting modifications, and to alterations were not included. Forward and after trim tank loads (1965 loadings) were adjusted in order to effect an even trim of the vessel. Tank capacity tables for these tanks were used to determine the necessary loading adjustment for proper trim.

Table 3-1
Calculation of Deballasting Required

Item	Weight (tons)	Remarks
Light ship......................	409.55	1965 test
Five (5) main ballast tanks (salt water) 100%.............	246.38	1965 loads
Forward trim tank (fresh water)..	10.15	1965 loads
After trim tank (fresh water)....	5.13	1965 loads
Two (2) anchor legs.............	20.98	1970 requirement
Two (2) counterweight legs.......	10.20	1970 requirement
TOTAL	702.39	
Submerged buoyancy..............	-700.66	Form curves
OVERWEIGHT	1.73	
Reserve buoyancy................	+ 8.94 *	
DEBALLAST	10.67	

*Final corrected figure (see mooring problem 4, page 47)

Table 3-2
Calculation of Submerged Mooring Condition

Item	Weight (tons)	Remarks
Light ship......................	409.55	1965 test
Five (5) main ballast tanks......	246.38	1965 test
Forward trim tank................	(slack)	1970 requirement
After trim tank..................	5.13	1965 test
Two (2) anchor legs..............	20.98	1970 mooring
Two (2) counterweight legs.......	10.20	1970 mooring
TOTAL SUBMERGED WEIGHT	692.24	
Submerged displacement...........	700.66	
RESERVE BUOYANCY	8.42*	

*Corrected buoyancy 5.46 tons (see mooring problem 4, page 47)

Table 3-3
Submerged Condition Loading Data

Item	Gallons	Weight (tons)	Remarks
A. Trim tanks (fresh water)			Fresh water at 269.28 G/T
After trim tank.....	1382	5.13	SDG: 3 ft-1 in
B. Main ballast tanks			Salt water at 261.8 G/T
No. 1, 100%.........	12574	48.03	
No. 2, 100%.........	18288	69.85	
No. 3, 100%.........	11428	43.65	
No. 4, 100%.........	12574	48.03	
No. 5, 100%.........	9636	36.81	
TOTAL WEIGHT	---	246.37	
C. Two anchor legs.....	---	20.98	Two (2) at 23,500# each
Two (2) counter-weight legs.......	---	10.20	Two (2) at 11,420# each
TOTAL WEIGHT	---	31.18	

Table 3-5
Trim Tank Capacities

Forward Trim Tank (FR 2-14½ Ø)													
CG of Vol Above Bottom of Keel (ft)	Feet	Gallons Corresponding to Each Inch of Sounding											
		0"	1"	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"
3.20	0	80	94	109	123	137	152	166	180	195	209	223	238
3.65	1	252	289	327	364	401	439	476	513	551	588	625	663
4.53	2	700	765	830	895	960	1128	1295	1463	1630	1798	1965	2133
5.45	3	2300	2473	2646	2819	2992	3165	3339	3512	3685	3858	4031	4204
6.14	4	4377	4550	4273	4896	5069	5242	5415	5588	5761	5934	6107	6280
6.83	5	6453	6626	6799	6972	7145	7318	7492	7665	7838	8011	8184	8357
7.52	6	8530	8693	8856	9019	9183	9346	9509					
		SNDG at 100% = 6'-6 7/8" = 9672 CG = 7.92'											

After Trim Tank (FR 38½-51)													
CG of Vol Above Bottom of Keel (ft)	Feet	Gallons Corresponding to Each Inch of Sounding											
		0"	1"	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"
3.17	0	73	85	97	109	121	133	145	157	169	181	193	205
3.63	1	217	253	289	325	361	397	434	470	506	542	578	614
4.44	2	650	708	765	823	880	918	955	993	1030	1068	1105	1143
5.41	3	1180	1382	1583	1785	1987	2188	2390	2592	2793	2950	3197	3398
6.10	4	3600	3801	4003	4205	4407	4608	4810	5012	5213	5415	5617	5818
6.79	5	6020	6222	6423	6625	6827	7028	7230	7432	7633	7835	8037	8238
7.50	6	8440	8606	8771	8937	9103	9269	9434	9600				
		SNDG at 100% = 9672 CG = 7.92'											

Total surface displacement and reserve buoyancy were calculated as shown in Table 3-4 below. Refer to Figure 3-2 for sketch of freeboard measurement. The subsurface mooring condition of the SQUAW is illustrated in Figure 3-3, and the form curves appertaining thereto in Figure 3-4.

Table 3-4
Surface Mooring Condition

Item	Weight (tons)	Remarks
A. Surface mooring condition		
Light ship....................	409.55	
Main ballast tanks 1, 3, and 4, 100% full..................	139.71	
Two (2) anchor legs...........	20.98	1970 requirement
Two (2) counterweight legs....	10.20	1970 requirement
Two (2) counterweights at 18330# each....................	16.37	1970 requirement
After trim tank...............	5.13	1965 test
TOTAL SURFACE DISPLACEMENT	601.94	
Mean draft (15.01 ft + 4.56 ft)	19.57 ft	Form curves
Draft awash..................	23.04 ft	
Freeboard....................	3.49 ft	
Freeboard....................	3.5 ft	See Figure 3-2
B. Reserve buoyancy		
Total displacement............	700.66	
Surface displacement..........	601.94	
RESERVE BUOYANCY	98.72	

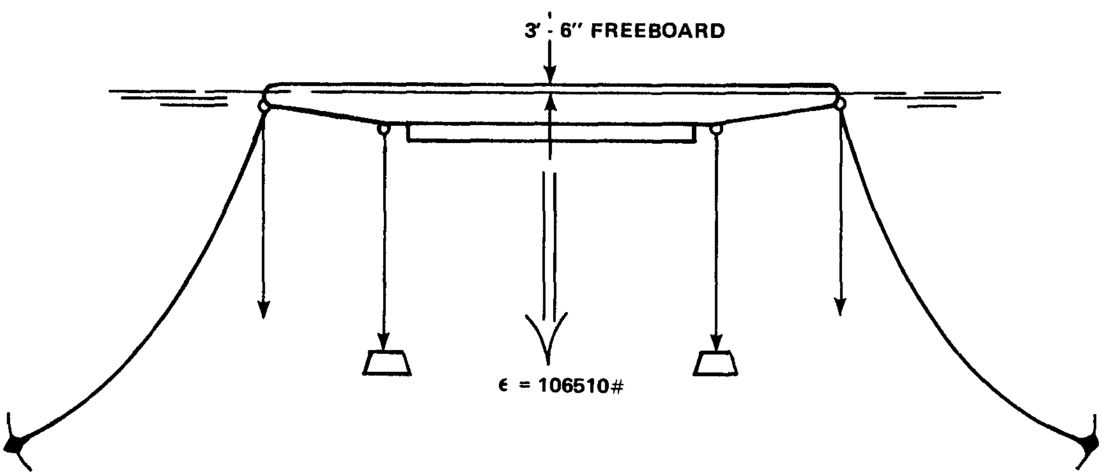


Figure 3-2
Freeboard Measurement

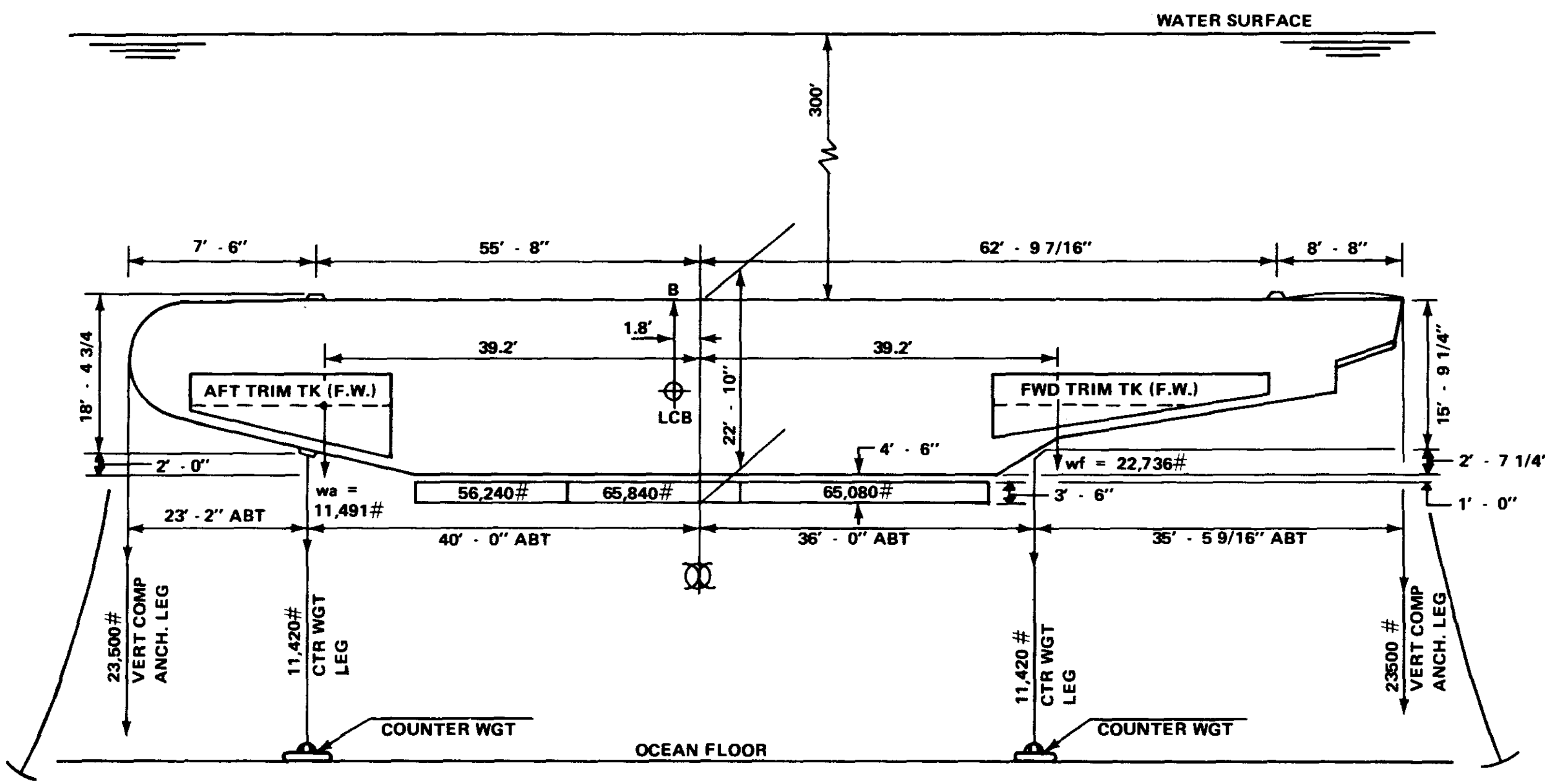


Figure 3-3
Subsurface Mooring Condition

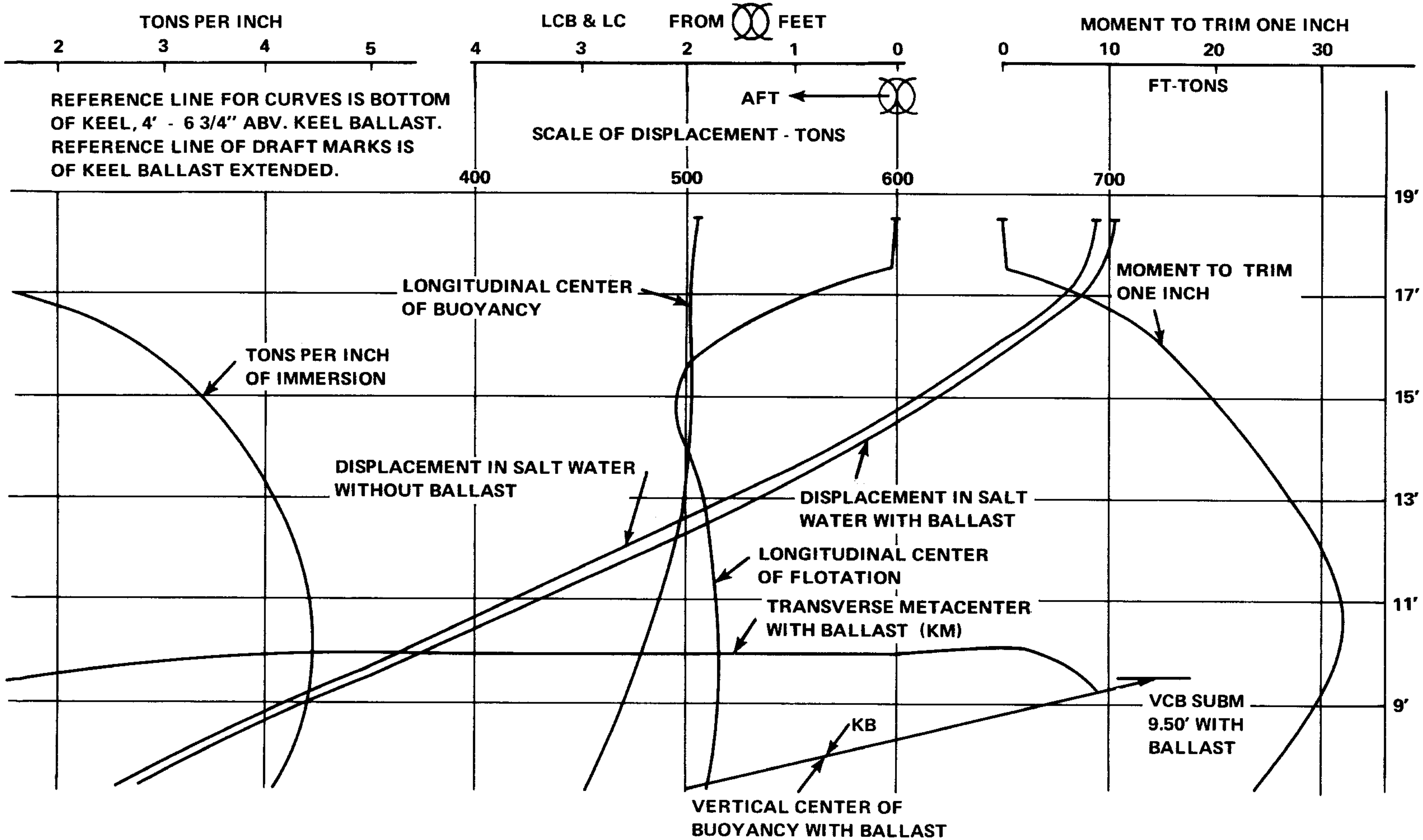


Figure 3-4
Form Curves

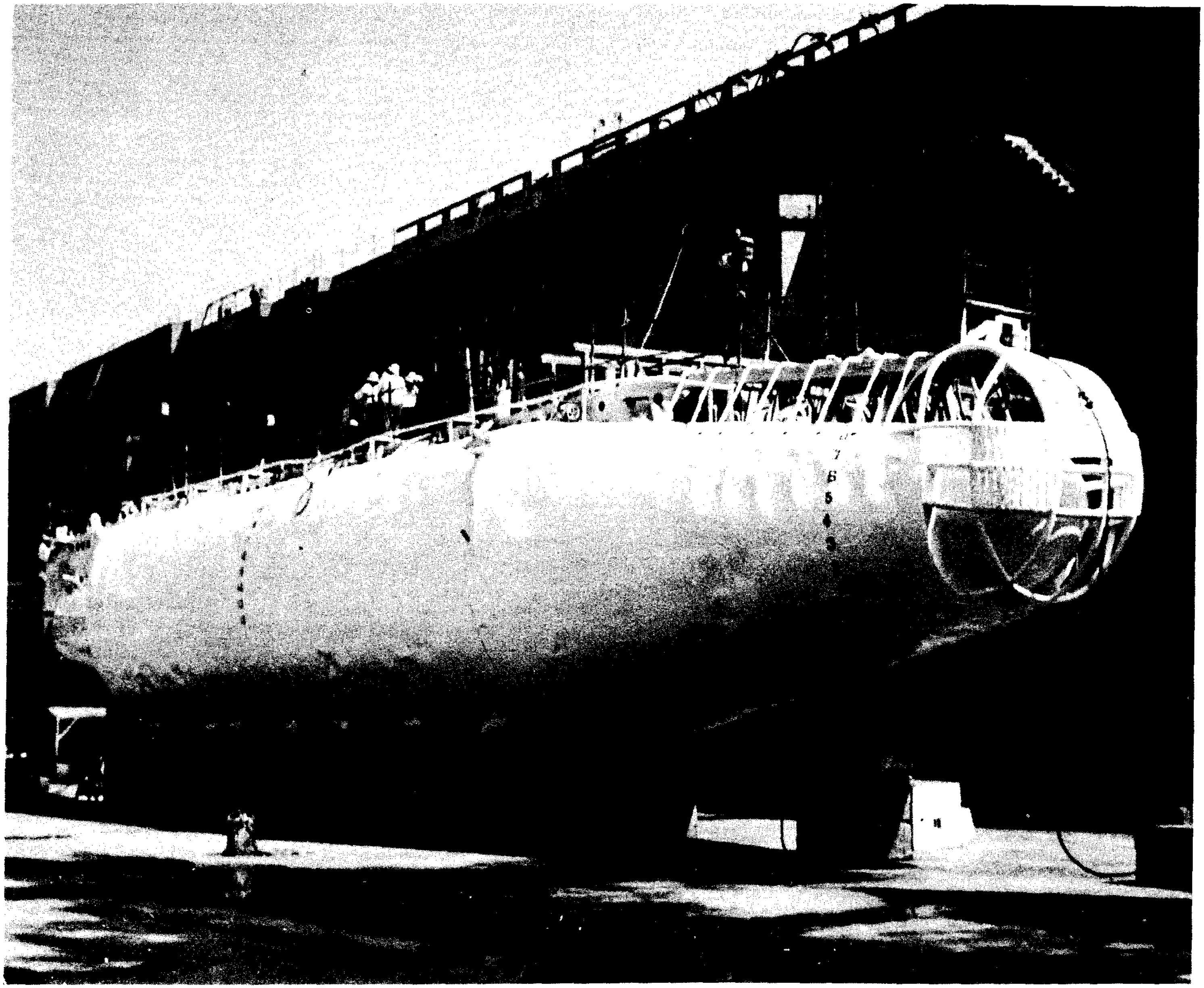


Photo # 1
SQUAW in Drydock

SECTION 4

THE MOORING OPERATION

Preparations. The magnitude and complexity of the contemplated project demanded extensive as well as intensive planning and preparation prior to on-site installation of the hull. Important matters such as funding; obtaining materials and equipment; loading and scheduling ships; procuring required instrumentation (tensionmeters and footage indicators, depth recorders, surveying equipment) and securing the specialized personnel needed to monitor measurements and record data; drydocking the SQUAW for repairs, and ballasting and trimming it to the specified design conditions; and coordinating all aspects of the operation were completely and thoroughly considered and discussed. All actions taken in this regard were directed toward and pointed to a smooth operational performance during the entire activity and to a successful achievement of the objective.

The Operational Plan. Operations were launched from the U. S. Naval Station, San Diego, California, and mooring was effected by proceeding through eight distinct phases (graphically illustrated in Figures 4-1 through 4-10) as indicated below.

Phase	Activity
1	Load ships
2	Lower leg A-1
3	Lower leg A-2
4	Lower leg B-2; measure and cut for depth
5	Lower leg B-1
6	Transfer all legs to SQUAW
7	Flood ballast tanks and correct catenary
8	Remove surface buoys

Procedures applicable to each phase were implemented by following a "sequence of events" which established the orderly, successive step-by-step actions to be taken by ships and personnel. Such scheduling, of course, did not preclude the use of initiative by officers and men involved if, during the operation, unexpected or unusual circumstances, conditions, or occurrences forced departures or deviations from the prescribed standards, specifications, or routine set forth.

The Phasing Process. All details and activities relative to ship movements, personnel assignments, and equipment readiness were coordinated so that a smooth, steady, and uninterrupted overall operation would be assured within the planned time-frame. Each phase was designed to succeed the preceding one in a merging fashion.

<u>PHASE 1 -- LOAD SHIPS</u>

(NOTE: Refer to Figures 4-1, 4-2, and 4-3 for illustrations of location and arrangement of materials and equipment on each of the three ships actively involved in the mooring operation prior to their departure from port. Also refer to the "Materials List" inserts for easy identification of "piece numbers" noted in the description of procedures which follows.)

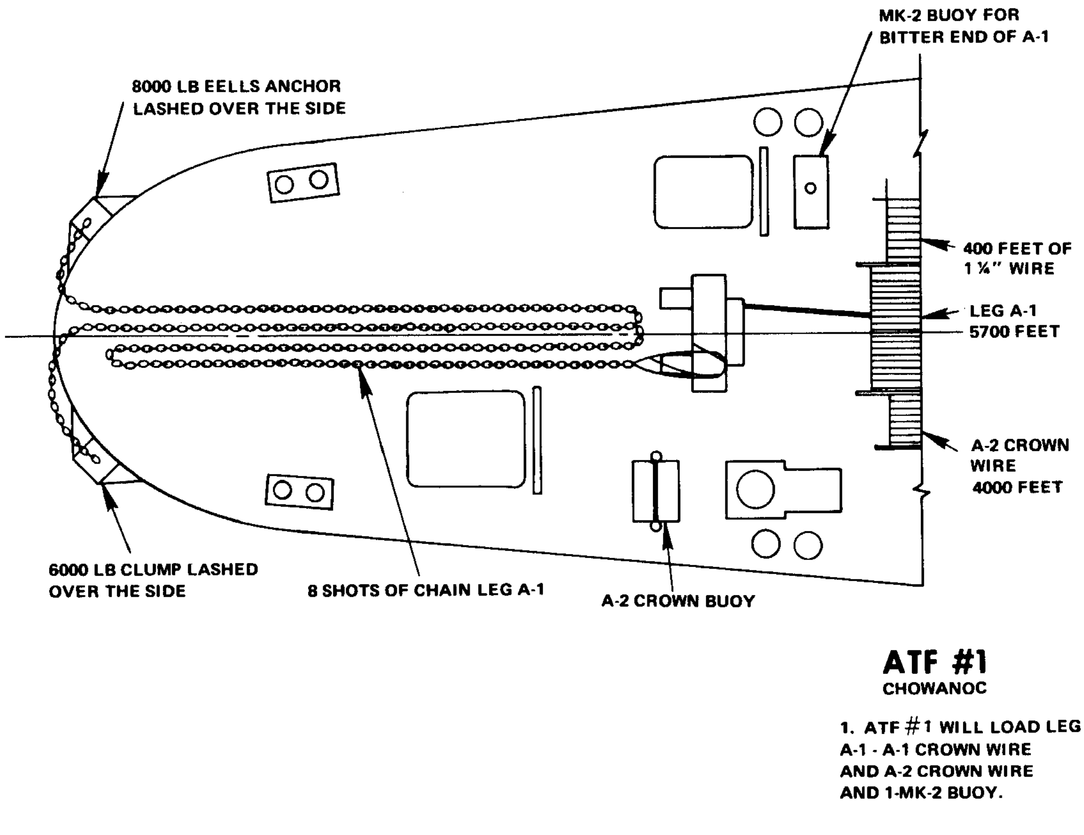


Figure 4-1
Loading of ATF # 1 (CHOWANOC)

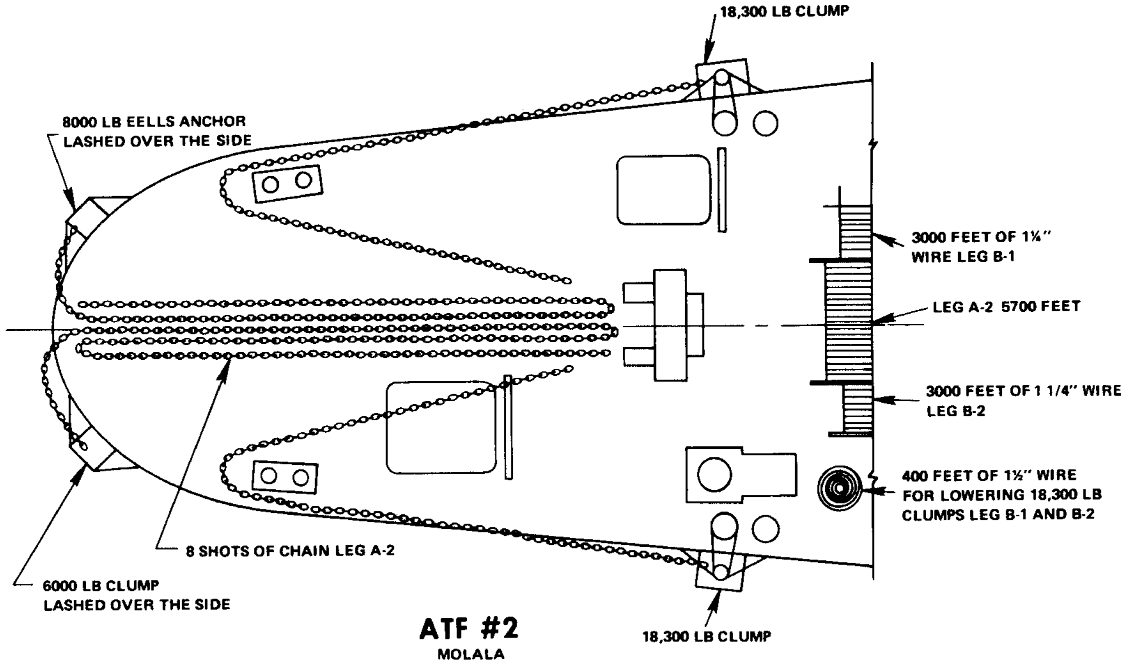


Figure 4-2
Loading of ATF # 2 (MOLALA)

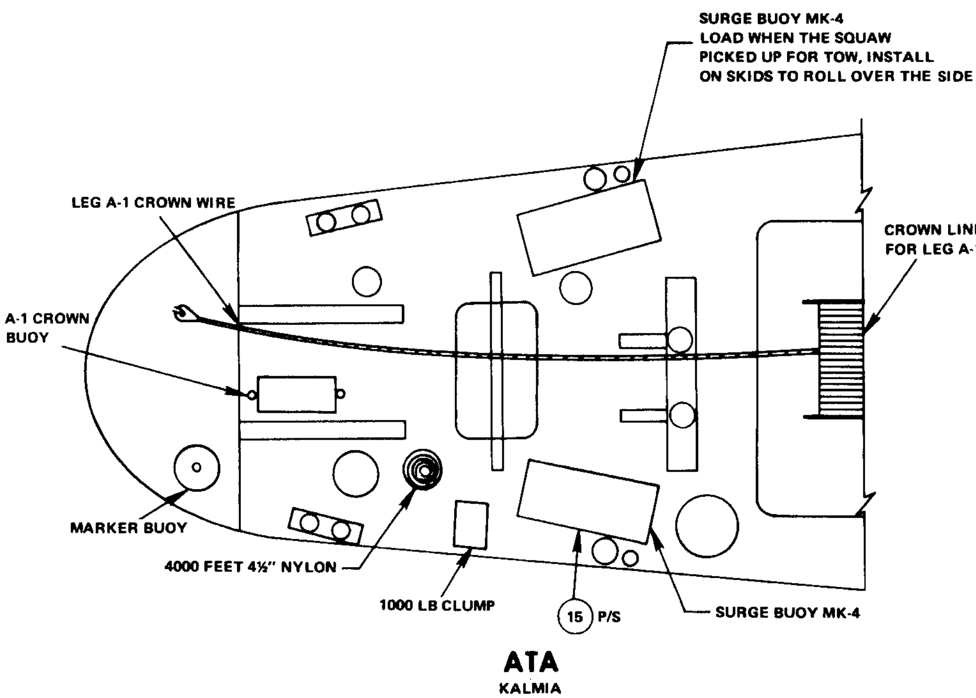


Figure 4-3
Loading of ATA (KALMIA)

Loading of each ship and rigging of the SQUAW were accomplished in the following manner:

ATF #1 (CHOWANOC)

1. Two-inch two wire from drum and wire from wing drums were removed and stored on power reels. (Photo #2)

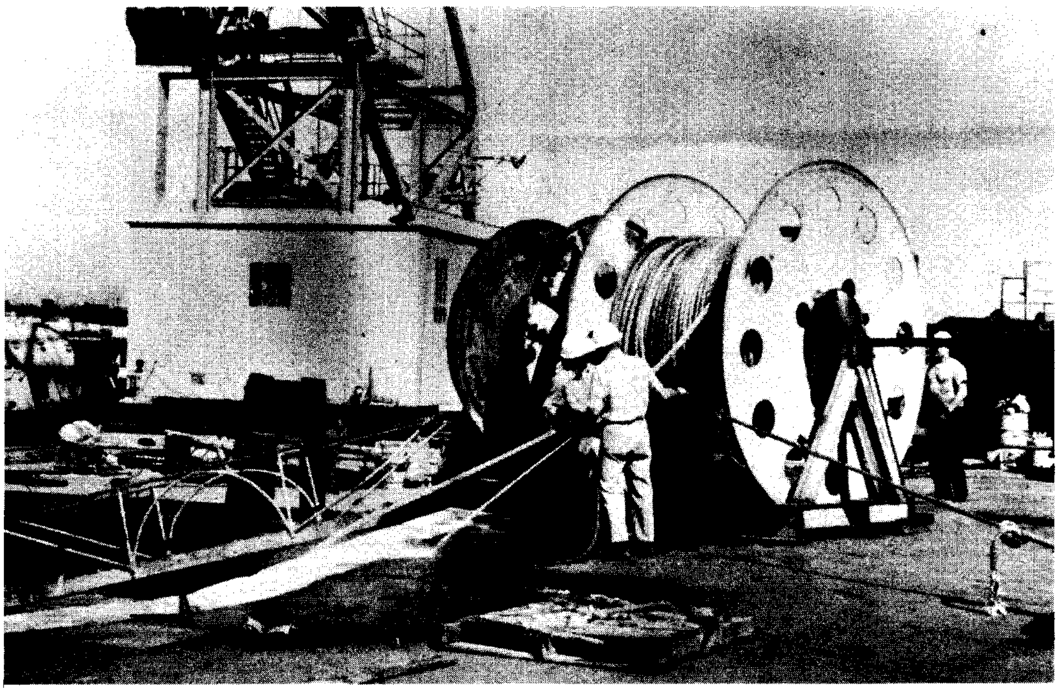


Photo # 2
Two-inch Tow Wire on Power Reels

2. Loaded leg A-1 (pieces 6 through 14) and stored pieces 6, 1, 5, 10, and 11 on towing drum in that order. Stored eight pieces of number 4 on deck and secured and lashed pieces 13 and 14 over the side ready for release.

3. Loaded leg A-2 crown wire and buoy pieces 7, 15, 19, and 20. Stored pieces 7, 19, and 20 on wing drum in that order. When leg A-1 is layed, leg A-2 crown wire is to be transferred from wing drum to empty A-1 towing drum.

4. Loaded Mark 2 buoy (not listed in "Materials List") to secure bitter end of leg A-1.

ATF #2 (MOLALA)

1. Two-inch tow wire from drum and wire from wing drum were removed and stored on power reels.

2. Loaded leg A-2 (pieces 6 through 14) and stored pieces 6, 1, 5, 10, and 11 on towing drum in that order. Stored eight pieces of number 4 on deck. Secured and lashed pieces 13 and 14 over the side ready for release.

3. Loaded legs B-1 and B-2 by securing and lashing piece 17 to quarter bitts ready for lowering (done both port and starboard sides). Stored pieces 7 and 6 on wing drums leg B-1 starboard and leg B-2 port).

4. When leg A-2 is layed, leg B-1 will be transferred from wing drum to empty leg A-2 towing drum ready for lowering. When leg B-1 is removed, leg B-2 will be transferred from wing drum to empty leg B-1 towing drum for lowering.

Materials List

Piece No.	Description	Amount	Spare	Total
1	2" bolt pin shackle	38	6	44
2	1-1/4" x 294 ft w/(8) each end	2	-	2
3	1-3/4" detachable link	14	2	16
4	1-1/2" x 90 ft stud chain	22	2	24
5	2" Ø x 7-1/2" I.D. ring	4	2	6
6	1-1/4" x 500 wire rope w/(8) each end	4	-	4
7	1-1/4" x 3000 ft wire rope w/(8) each end	4	1	5
8	1-1/4" wire rope closed socket	32	4	36
9	Miller Swivel		-	4
10	1-1/4" x 2850 ft w/(8) (12)	2	-	2
11	1-1/4" x 2850 ft w/(8) each end	2	-	2
12	1-1/4" wire rope open socket	4	1	5
13	6000 lb clump	2	-	2
14	8000 lb Eell	2	-	2
15	Buoy, mooring mark 4	4	-	4
16	Pear shape anchor shackle		-	2
17	18,330 lb clump	2	-	2
18	1-1/2" detachable link	12	2	14
19	1-1/4" x 1000 wire rope w/(8) (12)	2	-	2
20	1-1/4" x 50 wire rope w/(8) each end	2	-	2

ATA (KALMIA)

1. Two-inch towing wire from drum was removed and stored on power reel.

2. Loaded leg A-1 crown wire on towing drum starting with pieces 20, 17, and 19. Faked out piece 19 on deck. Loaded piece 15 on deck ready for attaching.

3. Loaded 1,000-pound clump, 4,000 feet of 4-1/2-inch nylon, and marker buoy on deck.

4. Loaded two pieces of number 15 on deck on skids for launching without lifting. (Photo #3)

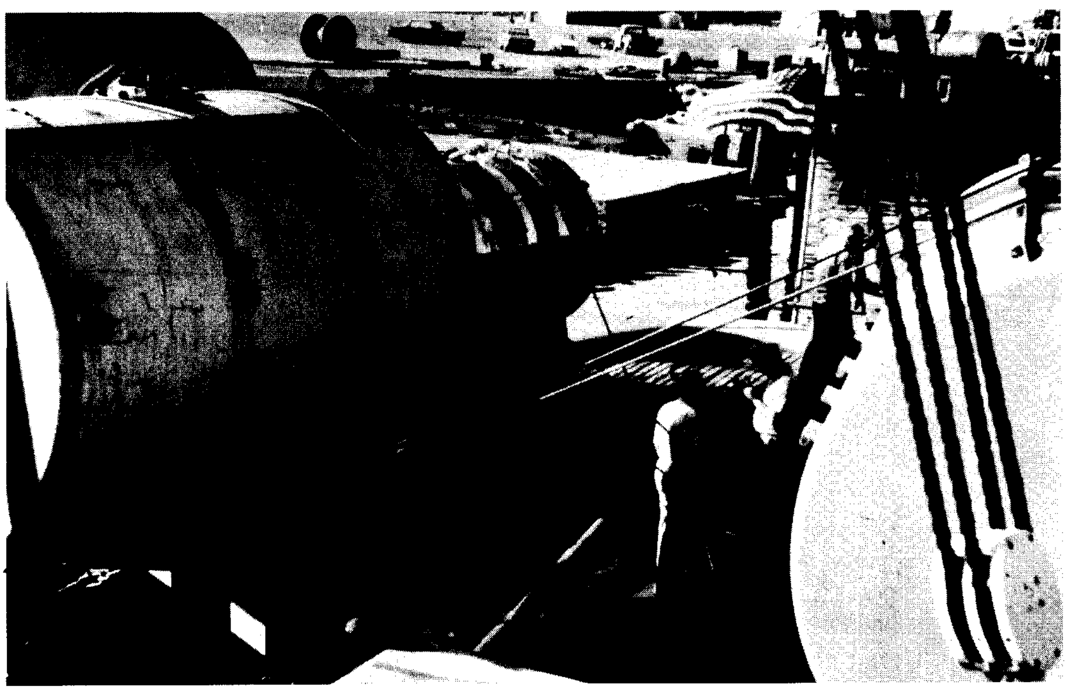


Photo # 3
Mark-4 Buoys Ready for Launching

SQUAW

1. Made fast all pieces number 4 and made fast lower ends on deck. Made up short shot of chain through bull nose for the tow line. (Photo #4)

2. Rigged with fender (removed before flooding).

3. Rigged, coiled, and lashed pieces number 2 before getting underway. (Photo #5)

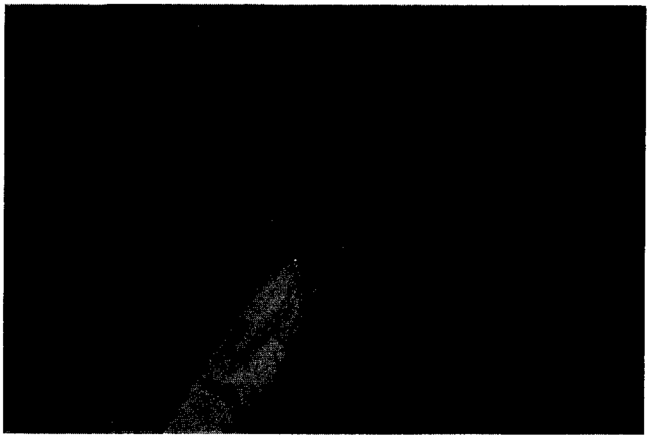


Photo # 4
Short Shot of Chain Through Bull Nose

Photo # 5
Wire Rope Rigged, Coiled, and Lashed

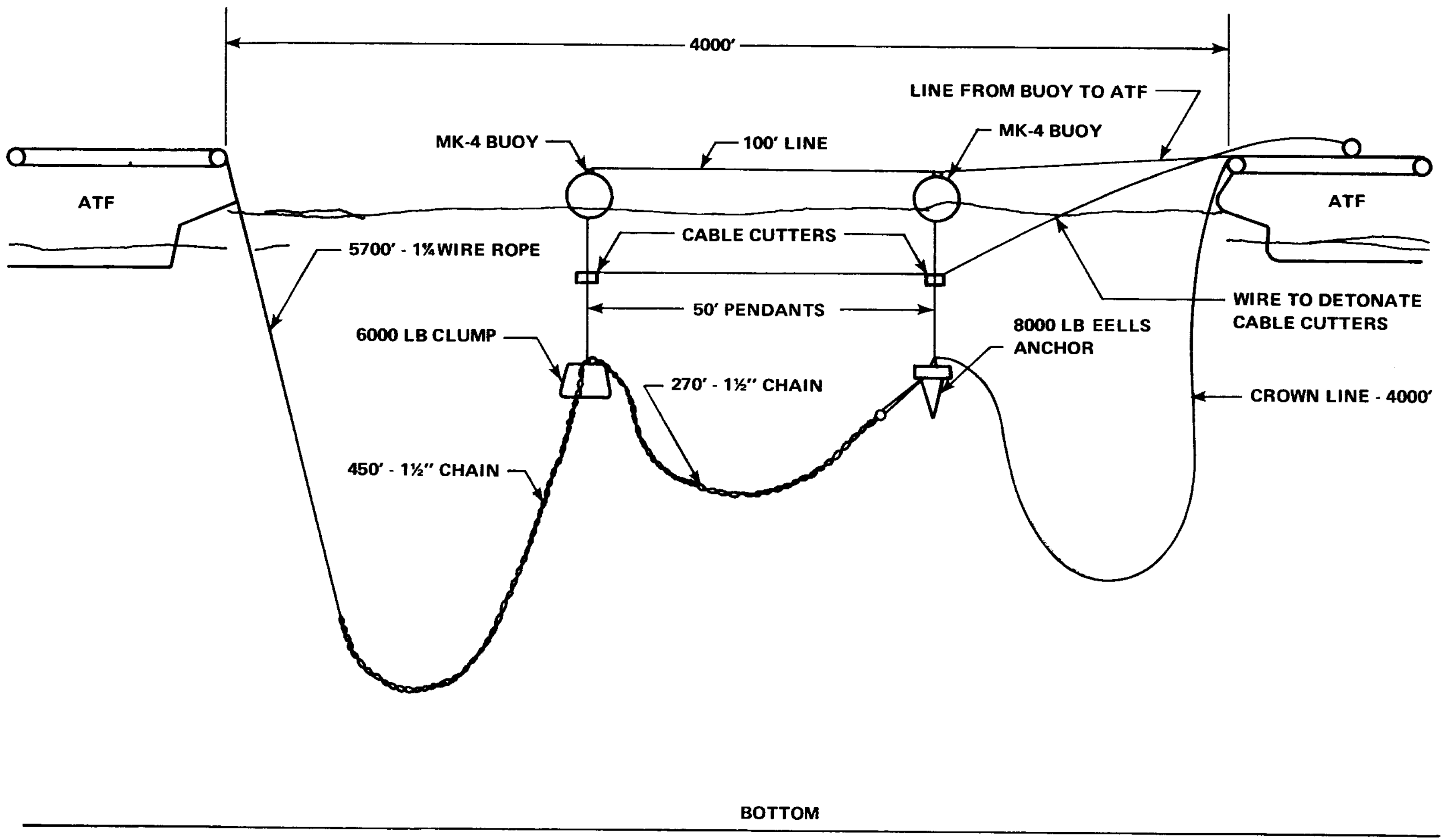


Figure 4-4
Lowering Leg A-1

PHASE 2 -- LOWER LEG A-1

1. KALMIA departed for operations area and on arrival layed positioning buoy and made fathometer survey.

2. CHOWANOC and MOLALA arrived the following day and layed leg A-1 (see Figure 4-4).

3. Operational movement proceeded as follows:

   (A) CHOWANOC kept in vicinity of position buoy.

   (B) KALMIA closed CHOWANOC and launched two surge buoys piece 15. (Photo #6)

   (C) CHOWANOC retrieved surge buoys and brought them alongside. (Photo #7)

   (D) KALMIA passed messenger to CHOWANOC and payed out crown wire to CHOWANOC.

Photo # 6
Surge Buoys Being Launched

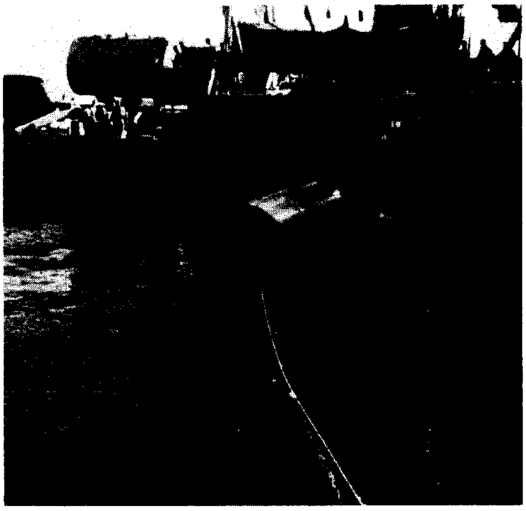


Photo # 7
Surge Buoys Being Retrieved

(E) CHOWANOC made up crown wire to Eells anchor. (Photo #8)

(F) KALMIA payed out crown wire to about 1,000 feet.

(G) CHOWANOC shackled surge buoy pendant to Eells anchor and lowered anchor over side (Photo #8) until buoy supported weight of anchor.

Photo # 8
Crown Wire Being Made up to Eells Anchor

Photo # 9
CHOWANOC Lowering Anchor over Side

(H) CHOWANOC secured nylon distance line to buoy.

(I) CHOWANOC lowered three shots of chain over side. (Photo #10)

(J) CHOWANOC secured wire pendant from #2 surge buoy to 6,000-pound clump.

(K) CHOWANOC secured 100-foot distance line to #2 surge buoy.

(L) CHOWANOC lowered 6,000-pound clump over side until buoy supported its weight.

(M) CHOWANOC let go surge buoy, payed out five shots of chain, and transferred weight of chain to towing drum wire.

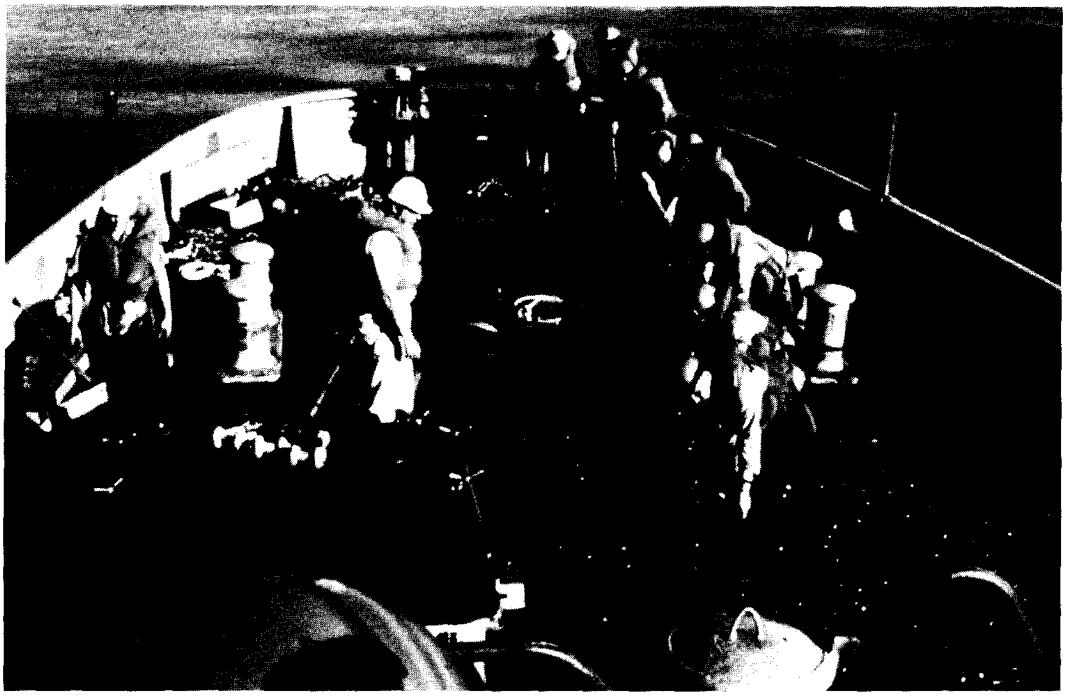


Photo # 10
CHOWANOC Lowering Chain over Side

(N) CHOWANOC station kept and payed out 5,700 feet of wire and KALMIA payed out 4,000 feet of crown wire (both wires payed out to their full length). (Photo #11)

(O) KALMIA put boat in water and secured nylon line to #1 surge buoy.

(P) UDT personnel readied wire cutters. (Photo #12)

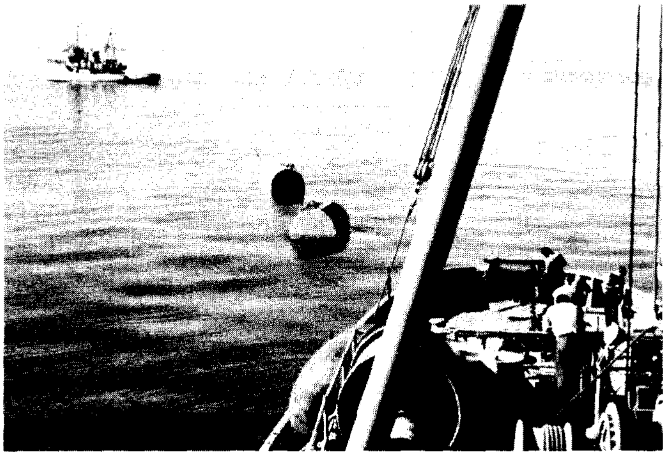


Photo # 11
CHOWANOC and KALMIA Paying Out Wires

Photo # 12
UDT Readying Wire Cutters

(Q) KALMIA took station 4,000 feet upwind from CHOWANOC.

(R) UDT placed cutters and fired. (Photo #13) Anchor leg settled to bottom and KALMIA retrieved both surge buoys, brought buoys alongside, and stretched out anchor and clump.

Photo # 13
UDT Placing Cutters

(S) KALMIA secured crown buoy to crown wire and let crown buoy go into water.

(T) KALMIA delivered surge buoys to CHOWANOC.

(U) CHOWANOC took one buoy, secured it to ring of anchor leg (piece 5), and slacked off wire until surge buoy supported bitter end of anchor leg.

(V) CHOWANOC attached lazy pendant of #2 surge buoy to #1 Mark-4 buoy and let them ride free.

(W) KALMIA remained in area and assisted until moor was set.

(X) KALMIA returned to port and picked up SQUAW and surge buoys (piece 15).

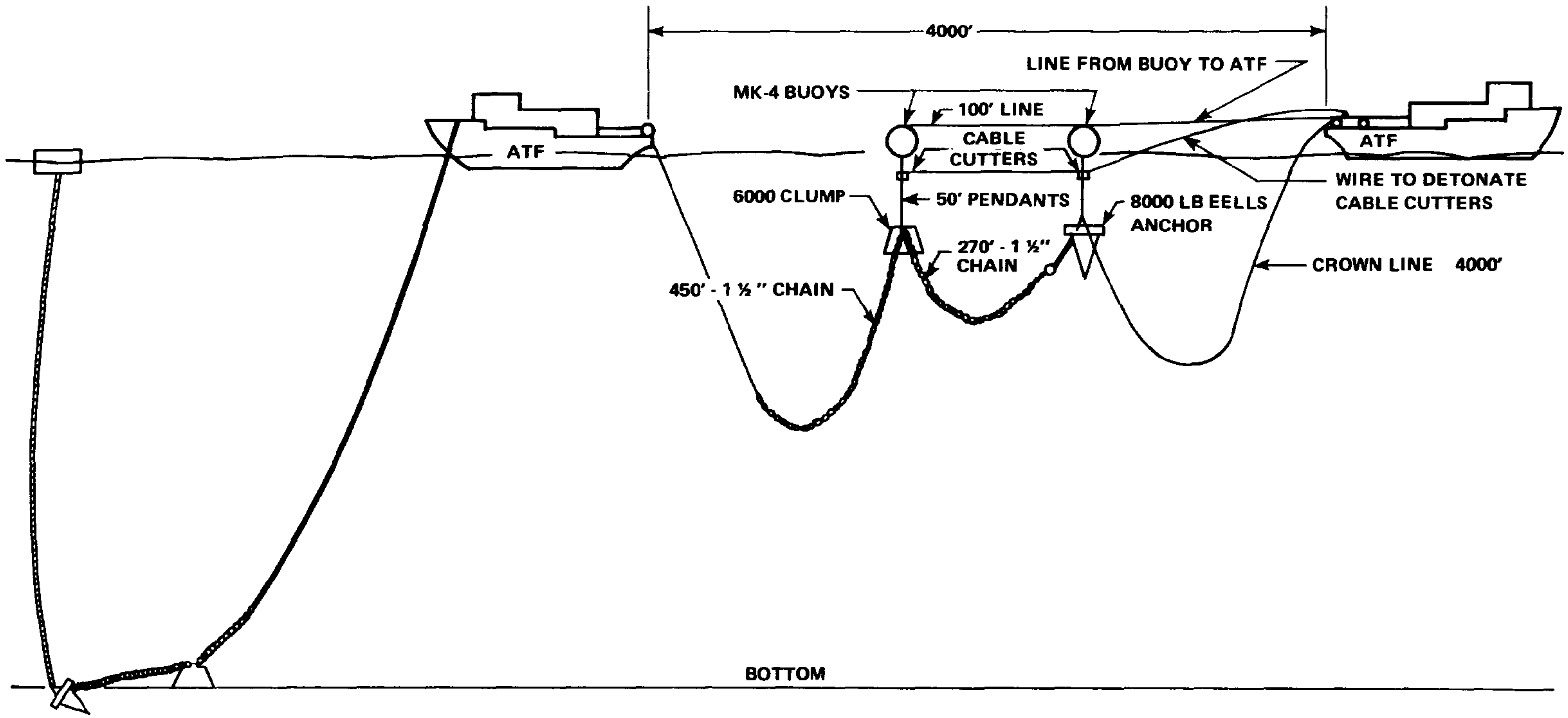


Figure 4-5
Lowering Leg A-2

PHASE 3 -- LOWER LEG A-2

1. CHOWANOC and MOLALA layed leg A-2 as shown in Figure 4-5.

2. Operations proceeded as follows:

   (A) MOLALA picked up lazy pendant from #2 surge buoy to her bow chock until piece 5 (big ring) was just outside of gunwale. (Photo #14)

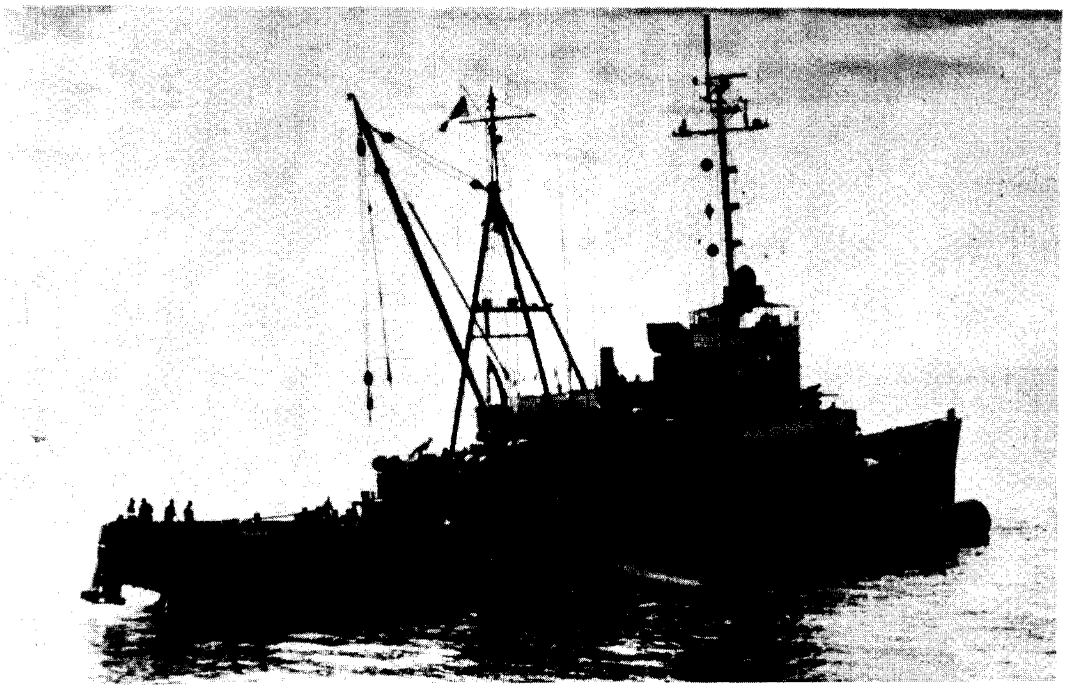


Photo # 14
MOLALA Picking up Lazy Pendant from # 2 Surge Buoy

(B) MOLALA secured both surge buoys alongside.

(C) CHOWANOC passed leg A-2 crown wire to MOLALA. (Photo #15)

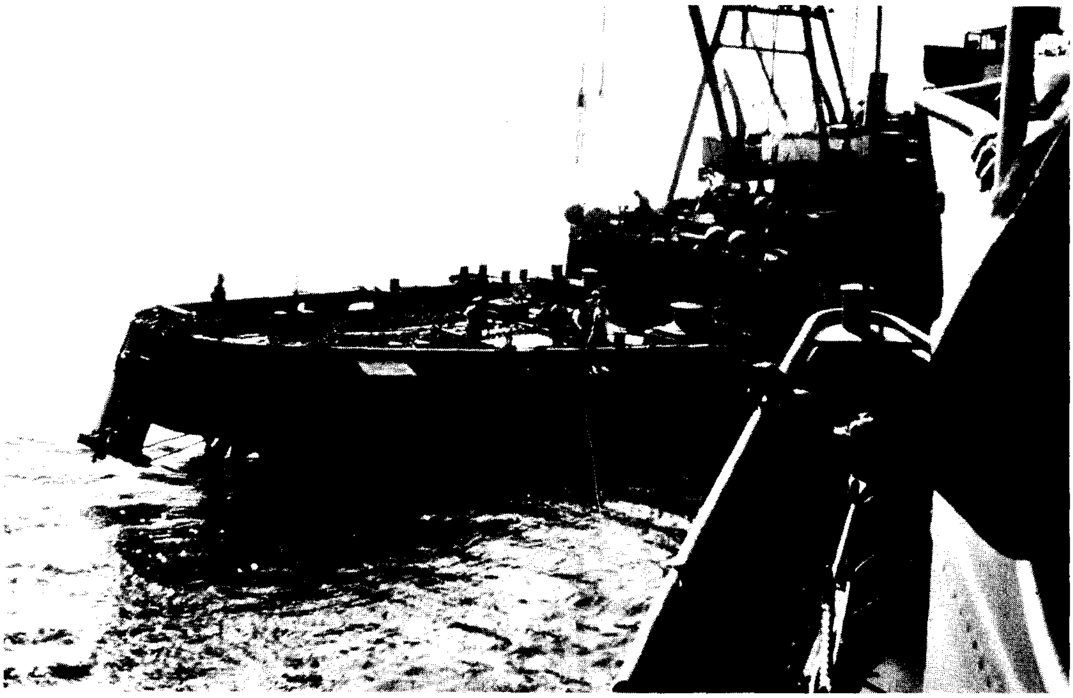


Photo # 15
CHOWANOC Passing Leg A-2 Crown Wire to MOLALA

--AT THIS POINT, REPEAT STEPS TAKEN IN PHASE 2, 3(A) THROUGH 3(W), WITH THE CHOWANOC TAKING THE PLACE OF THE KALMIA IN THIS PHASE--

(D) CHOWANOC and MOLALA installed tensiometers in legs. (Photo #16)

Photo # 16
Tensiometers Being Installed on Legs

(E) CHOWANOC went downwind heading and took a strain.

(F) CHOWANOC observed tensiometer readings until leg A-2 was on bottom.

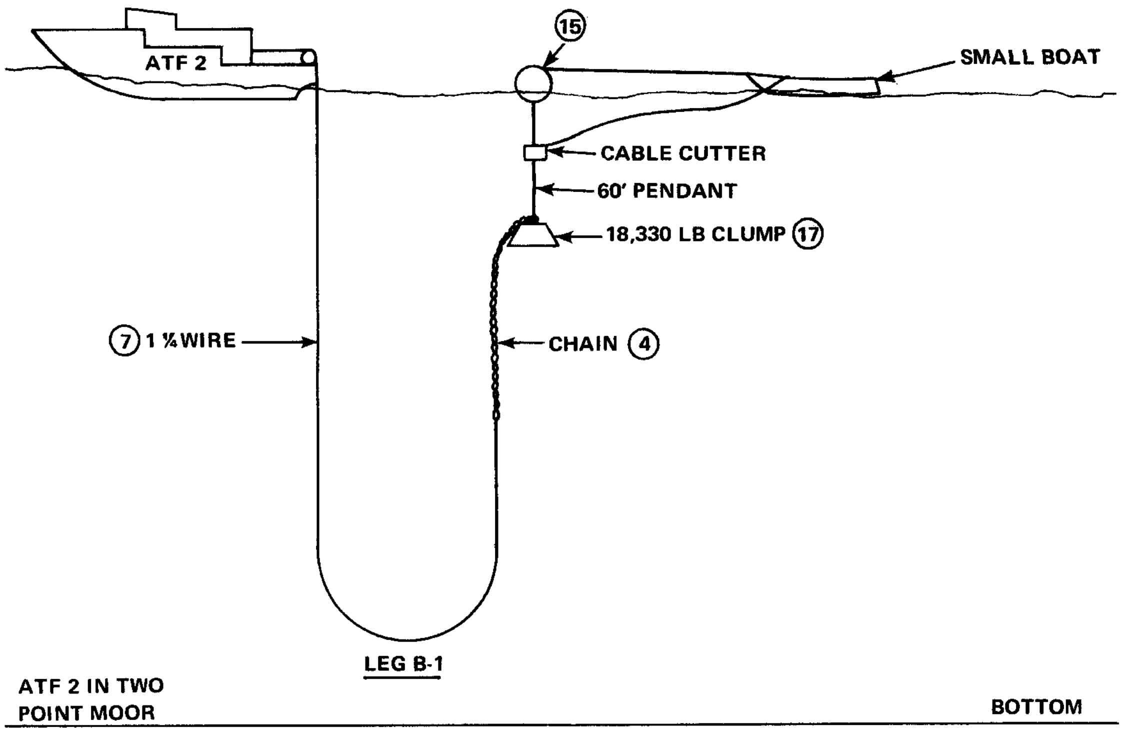


Figure 4-6
Lowering Leg B-1

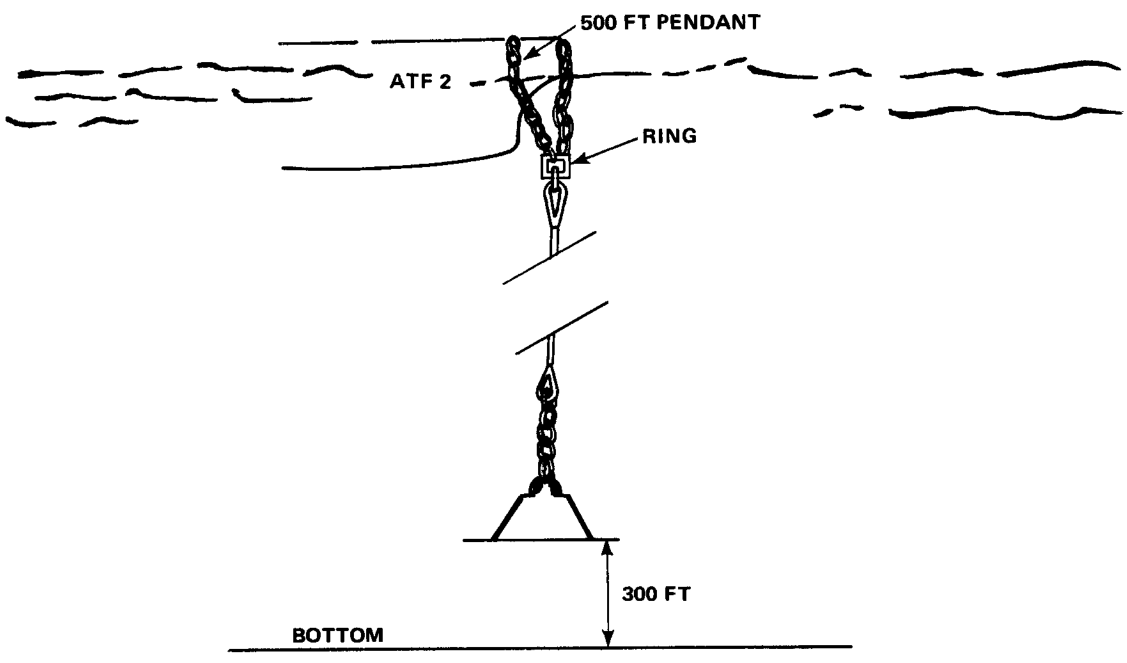


Figure 4-7
Raising Leg B-1 and Cutting for Proper Depth

PHASE 4 -- LOWER LEG B-2; MEASURE AND CUT FOR DEPTH

1. MOLALA lowered leg B-1 and made final depth calculation for cutting SQUAW's chain pendants to proper length for both legs B-1 and B-2. (See Figures 4-6 and 4-7.)

2. Operations proceeded as follows:

   (A) Pieces 9, 4, and 17 were attached to leg B-1 and cable readout was placed on leg B-1.

   (B) Lowering procedures began, but were interrupted by a wire mishap (see Mooring Problem #3, page 47). Operational method was revised (see Figure 4-6) to similar lowering plan used for legs A-1 and A-2, and leg B-2 was used in lieu of leg B-1.

   (C) A 60-foot pendant was attached to the surge buoy (piece 15) and the 18,000-pound clump (piece 17) was attached to the pendant. Leg B-2 was attached to the clump.

   (D) Clump was lowered until buoy supported the weight.

   (E) Buoy was floated forward to the bow and leg B-2 was payed out.

   (F) UDT personnel placed cutters on pendant and fired, allowing leg to settle on bottom.

   (G) Leg B-2 was measured. SQUAW chain (piece 4) cut for placing on the SQUAW. Leg B-2 was secured to deck.

PHASE 5 -- LOWER LEG B-1

1. CHOWANOC and MOLALA lowered leg B-1.

2. Operations proceeded as follows:

   (A) MOLALA attached 60-foot pendant to surge buoy. (Photo #17)

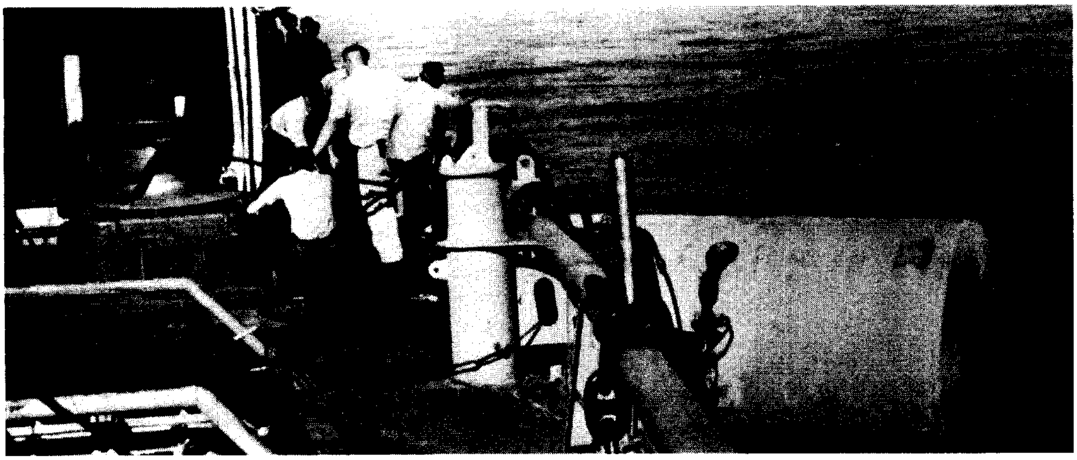


Photo # 17
MOLALA Attaching 60-foot Pendant to Surge Buoy

   (B) CHOWANOC moored to MOLALA's starboard side and passed anchor end (Photo #18) of leg B-1 (piece 8) to MOLALA.

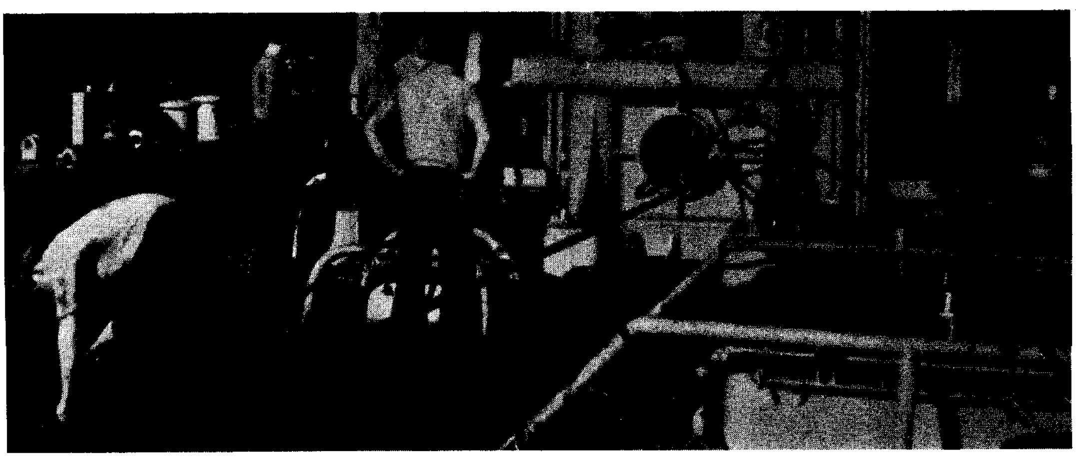


Photo # 18
CHOWANOC Passing Anchor End of Leg B-1 to MOLALA

(C) MOLALA shackled leg B-1 to Miller Swivel (piece 9) and lowered overboard with 18,000-pound clump (piece 17) until buoy supported weight.

(D) CHOWANOC's small boat took a position off MOLALA's port bow with buoy in tow. (Photo #19)

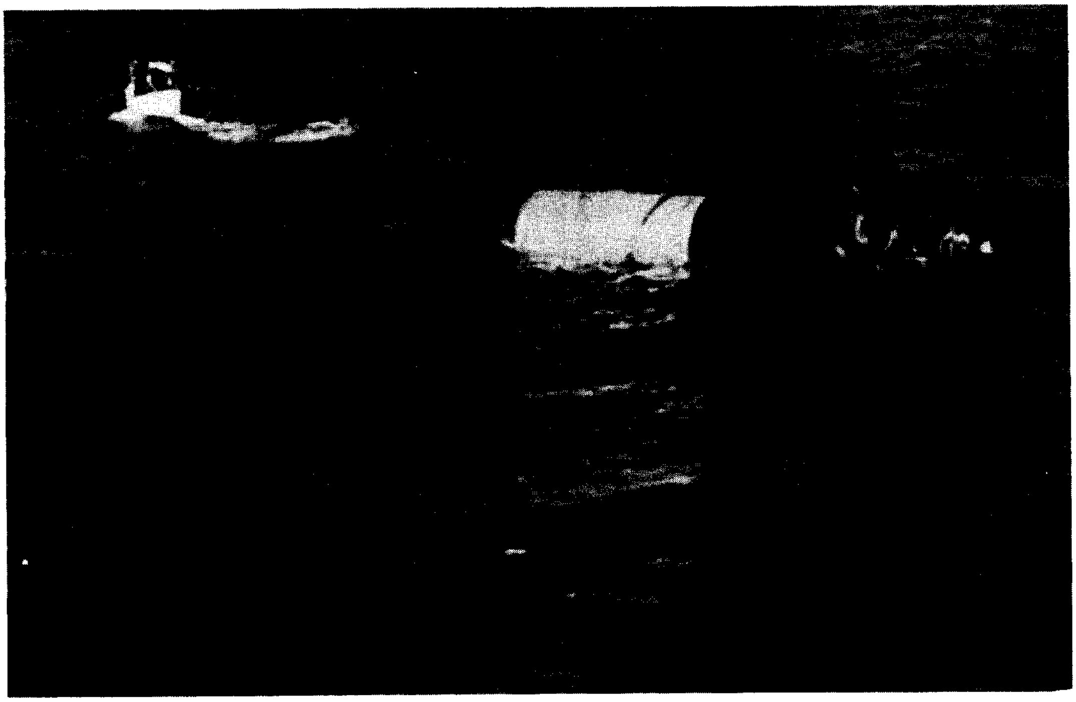


Photo # 19
CHOWANOC's Small Boat with Buoy in Tow

(E) CHOWANOC payed out leg B-1 and passed ring (piece 5) to MOLALA which secured it to the deck.

(F) UDT personnel placed cutters on pendant and fired, allowing leg to settle on bottom.

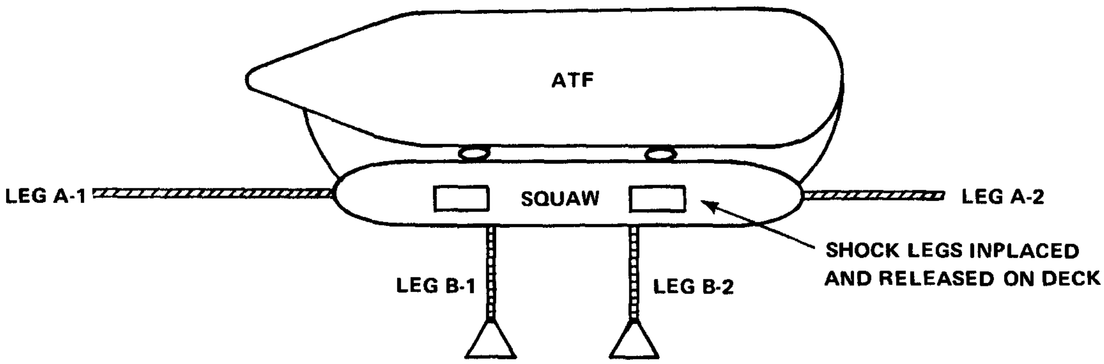


Figure 4-8
Mooring Legs Being Transferred to SQUAW

PHASE 6 -- TRANSFER ALL LEGS TO SQUAW
(See Figure 4-8)

1. KALMIA brought SQUAW to MOLALA. MOLALA cut SQUAW chain pendants to proper length and secured legs B-1 and B-2 to SQUAW chain pendants. MOLALA slacked leg B-1 until SQUAW had weight of leg. Procedure was repeated for leg B-2. MOLALA placed her mooring lines to SQUAW. MOLALA transferred leg A-2 to SQUAW and let SQUAW take weight of leg. Procedure was repeated for leg A-1. MOLALA secured retaining lines to the three fenders on the SQUAW and cut fenders free from the SQUAW. MOLALA retrieved fenders and cleared side of SQUAW.

2. Operational movement proceeded as follows:

   (A) KALMIA brought SQUAW alongside MOLALA. (Photo #20)

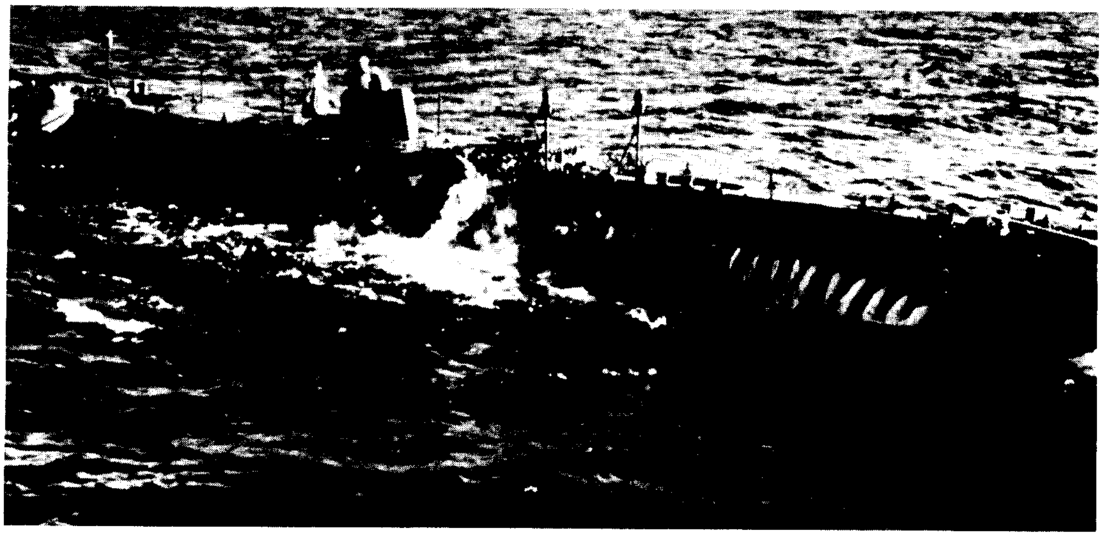


Photo # 20
SQUAW Being Readied for Mooring

   (B) KALMIA kept pieces #15 alongside until time to attach SQUAW.

   (C) MOLALA transferred legs B-1 and B-2 by making up pieces 1 and 5 and lowering weight to SQUAW.

   (D) When the SQUAW was supporting weight of leg B-1, piece 6 was cut.

   (E) Procedure was repeated for leg B-2.

(F) At this point, ship mooring lines were made up to the SQUAW.

(G) Pieces 1 and 6 were made up and leg A-2 was transferred to the SQUAW.

(H) Weight was lowered to the SQUAW on piece 6.

(I) Piece 6 was cut when SQUAW had weight of the leg.

(J) Procedure was repeated for leg A-1.

(K) MOLALA remained moored alongside and assisted in rigging the surge buoys (piece #15). (Photo #21)

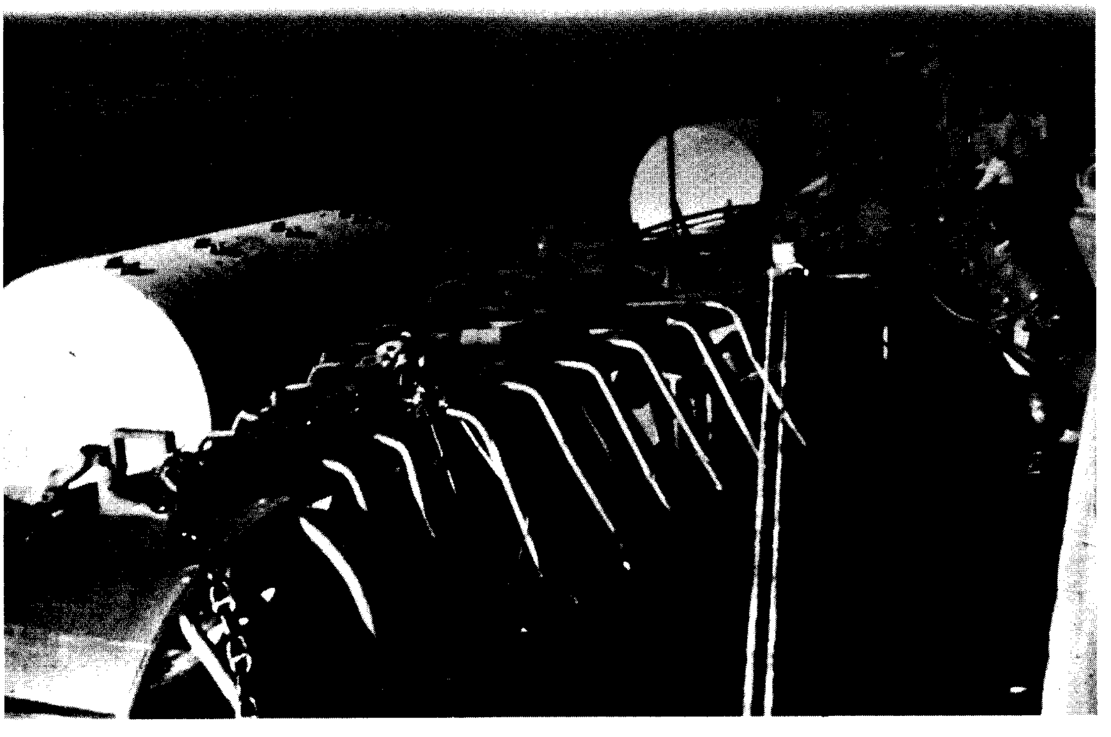


Photo # 21
MOLALA Assisting in Rigging Surge Buoys

(L) CHOWANOC recovered leg A-2 crown buoy and took strain to predetermined mooring tension.

(M) MOLALA removed rubber fenders and cleared side of SQUAW. (Photo #22)

Photo # 22
SQUAW, Mooring Legs in Place, Ready to Submerge

(N) Rubber boat was launched to pay out sonar sensor and prepared to open flood valves.

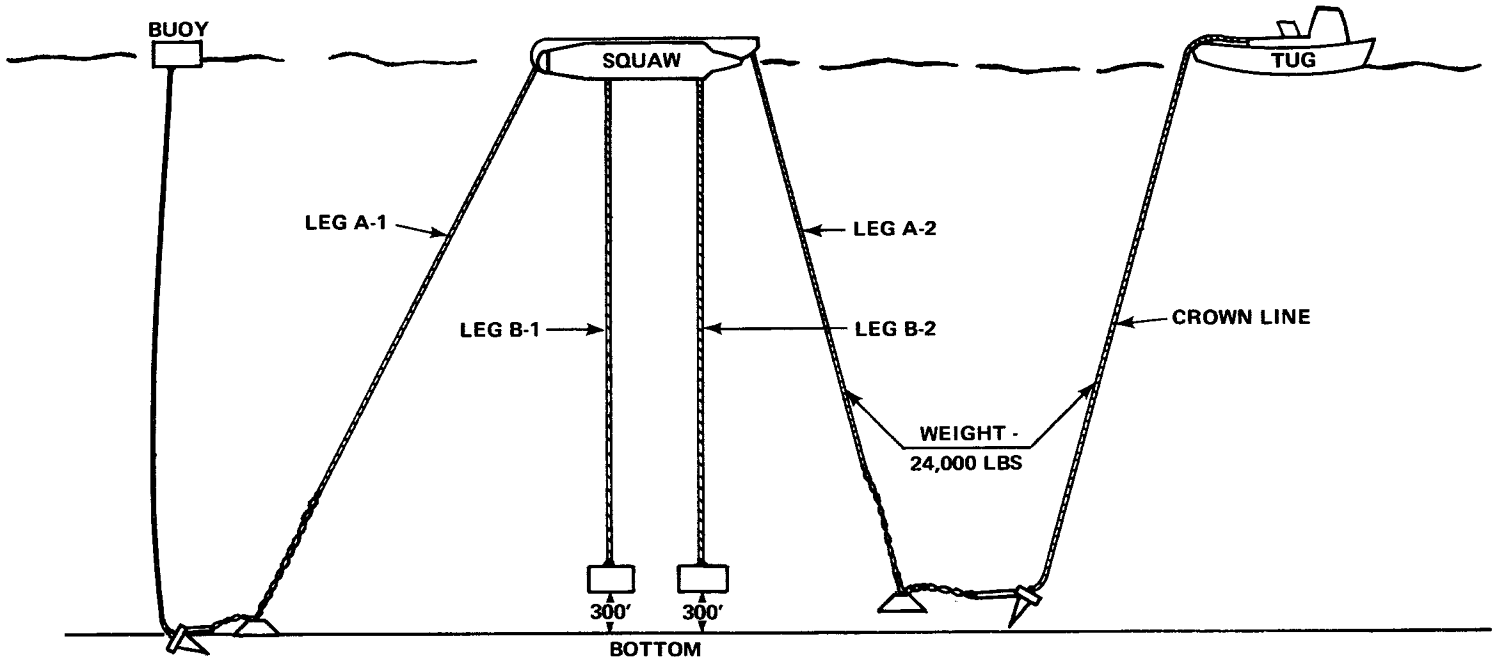


Figure 4-9
SQUAW Configuration Before Submerging

PHASE 7 -- FLOOD BALLAST TANK AND CORRECT CATENARY

1. Ballast tanks were opened and SQUAW was submerged to proper depth while CHOWANOC took proper tension to correct catenary.

2. Operational movement proceeded as follows:

   (A) CHOWANOC retrieved crown buoy and took crown line (piece 19) on board and lifted anchor and clump (pieces 13 and 14) off bottom.

   (B) CHOWANOC took necessary pull on leg A-2 to reach the predetermined tension necessary to pull the SQUAW down to depth.

   (C) Signal was given to open flood valves. SQUAW did not reach prescribed depth on first attempt (see Mooring Problem #4, page 47). (Photo #23)

Photo # 23
SQUAW, Partially Submerged in First Mooring Attempt

   (D) CHOWANOC reduced tension on leg A-2 and SQUAW surfaced. Ballast was recalculated.

   (E) MOLALA added additional ballast needed on SQUAW by using 2-1/4-inch anchor chain.

(F) Procedures (A), (B), and (C) above were repeated. SQUAW submerged to the 300-foot mooring depth. (Photo #24)

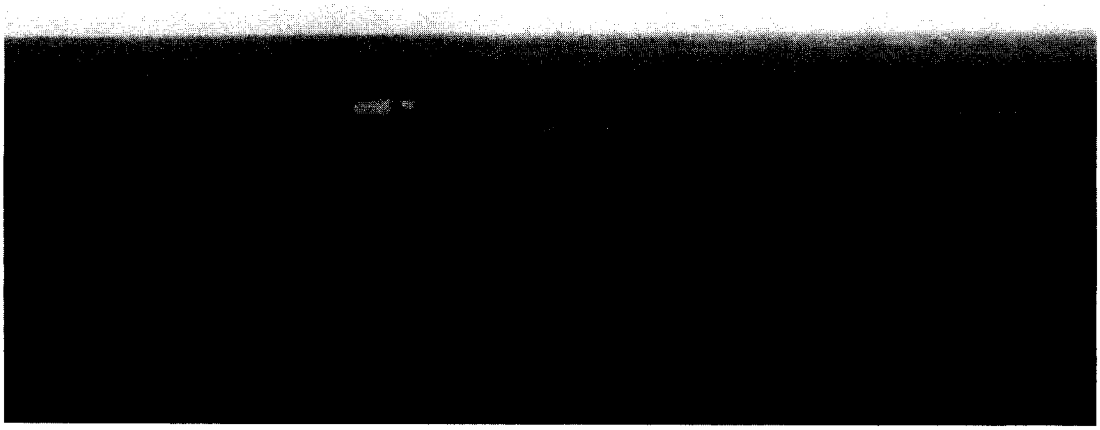


Photo # 24
Mark-4 Buoys Identifying Location of SQUAW Now Moored at 300-foot Depth

PHASE 8 -- REMOVE SURFACE BUOYS
(See Figure 4-10)

1. All vessels stood by for navigation fixes on final position of the SQUAW target.

2. Crown buoys were removed (Photo #25) and all ships returned to port.

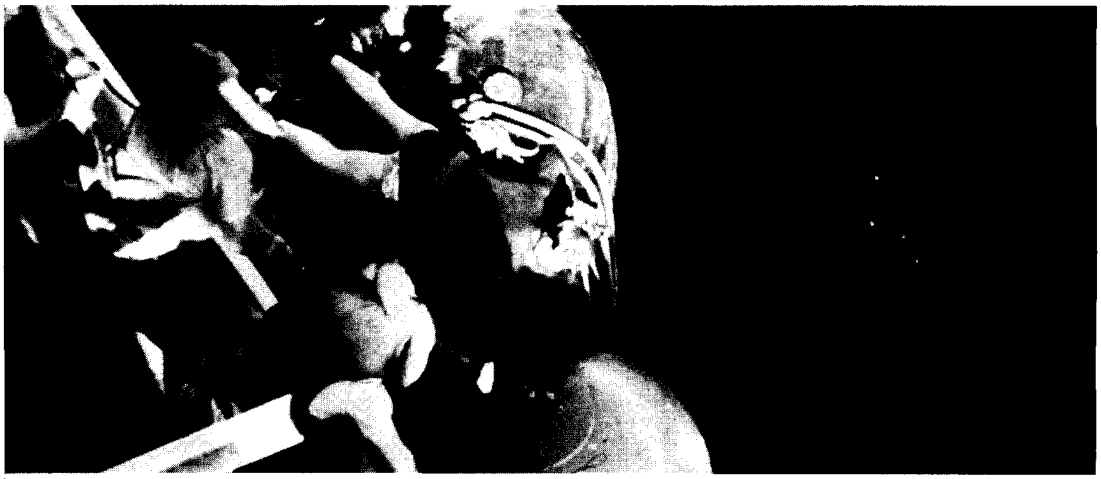


Photo # 25
Crown Buoys Being Removed

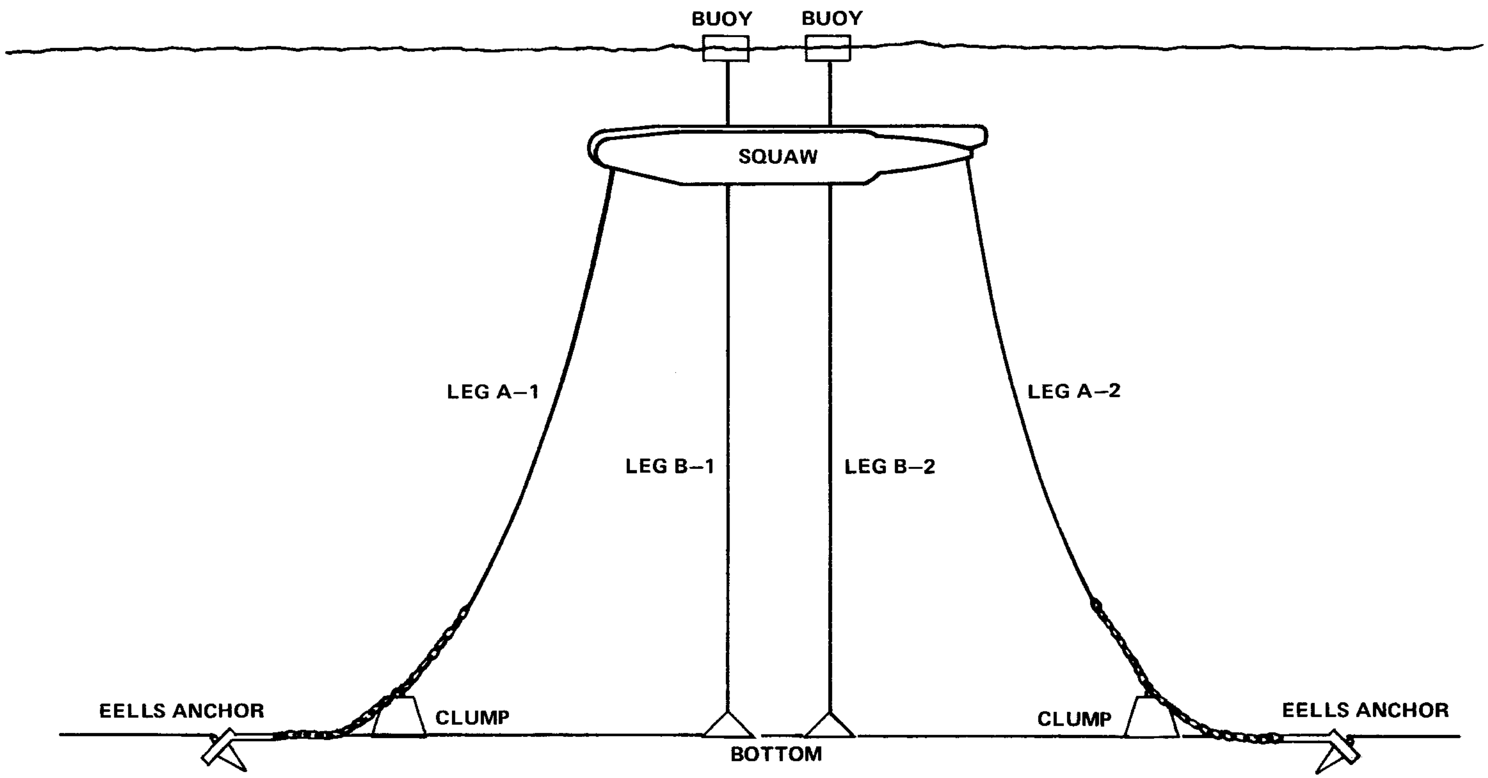


Figure 4-10
Final Configuration After Removal of Surface Buoys

Specific Procedural Recommendations. Safety was of utmost and of primary concern throughout all phases of the operation. Dangers and hazards inherent in moving and handling heavy equipment and cumbersome weights, precision timing required in performing assigned tasks, and many other factors related to safety considerations were taken into account, and measures and care taken in advance to minimize and reduce the probability of injuries to personnel or damage to equipment. In addition to the rules and regulations set down in this regard, two specific recommendations were made as indicated below.

With regard to the heavy anchor weights and the 18,330-pound weights, it was recommended that:

1. The anchor weights and chain be lowered over the side by using the wire on the towing drum. Pelican hooks would be used for this purpose.

2. The 18,330-pound weights be lowered from the stored position at the quarter bitts to the main legs by using 1-1/4-inch wire on the wing drum. Wire and snatch blocks were furnished for this purpose.

Instrumentation and Other Aids. Various measuring devices indispensable to the operation were utilized to obtain information, record data, and maintain constant monitoring of changes that occurred. Accuracy required in crucial and critical moments dictated the use of such instruments as tensiometers and footage indicators for measuring cable tension and length. Recording capacities of these particular devices were 100,000 pounds. In addition to the foregoing, a depth recorder was used to produce a bathymetric chart of the mooring area.

Of equal importance were the many activities associated with communication, navigation, and distance measurements. Means were provided by which all ships in the task force could at any time quickly determine their relative and absolute positions and the distance between them. Ocean currents were investigated (surface, midwater, and bottom) to determine direction and magnitude, and ocean bottom characteristics were studied and examined. Accurately positioned buoys served to guide and aid ship movements and provided visual reference when vessels maintained their stationary positions.

Mooring Problems. An operation of this size and magnitude did not escape the unexpected problems which somehow appear despite all precautions taken and preparations made. Mooring problems encountered were not of a major character and are listed as follows:

1. All wire rigging was made up with fittings in place, which created a storage problem. The wire was stored on the towing machine drums.

2. The total rigging/towing gear was difficult to work in that the crews of the ships were not sufficiently experienced in this aspect of the operation.

3. One 3,000-foot wire was damaged while it was being removed from the stowage drum and had to be replaced.

4. The lack of exact light ship weight required an adjustment in ballast after the first attempt was made to put the SQUAW in its moored condition.

SECTION 5
CONCLUSIONS AND RECOMMENDATIONS

Realization of Objective. Achievement of the objective was realized as planned. The SQUAW was moored at the specified design depth within the time period allotted and without any major setbacks or mishaps. Planning, coordination, personnel skills, and leadership were combined in a closely knit operation to bring about a successful conclusion to this activity.

Recommendations. On the basis of this mooring experience, it is recommended that:

1. The drop system be utilized in the deployment of large mooring systems.

2. When any mooring system is recovered following long use, inspection should be made for causes of failure and a report prepared on the findings.

3. All equipment should be made up and secured on deck prior to arrival on the site.

4. More time be allotted in advance of the task to crew training.

Conclusions. It is concluded that:

1. Crew training and crew efficiency are critical elements in the procedural process.

2. The drop system makes the handling of huge amounts of mooring equipment safer, even in rough seas.

3. Safety is of prime importance, and rules and regulations appertaining thereto should be adhered to without exception.