EPA-R2-73-166
APRIL 1973

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Oil/Sorbent Harvesting System for Use on Vessels of Opportunity

Office of Research and Monitoring
U.S. Environmental Protection Agency
Washington, D.C. 20460

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OIL/SORBENT HARVESTING SYSTEM FOR USE ON VESSELS OF OPPORTUNITY

By

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OFFICE OF RESEARCH AND MONITORING
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
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ABSTRACT

A system for harvesting mixtures of oil and sorbent materials, primarily straw, which could be utilized for the recovery of floating oil from water was developed for use on vessels of opportunity.

A three-phase test program was conducted to evaluate candidate system components and operating specifications for the oil/sorbent harvesting system. The first phase of the program involved testing individual system components and operating parameters as to their effectiveness in picking up sorbents only. The first phase was conducted under actual conditions in a saltwater slough. The second phase of the test program entailed evaluating those operating characteristics of the harvesting system components selected in the first phase using crude oil and various sorbents in a test tank. The third phase of the test program entailed the installation of the complete system on a vessel of opportunity (an LCM), and demonstration of the ability of the system to operate under actual conditions. The system was evaluated both in the San Francisco Bay and off Coal Oil Point (Santa Barbara) where sorbent materials were dispersed over natural oil slicks.

The system utilizes commercially and readily available equipment which, with minor modifications, was assembled on-site onto available vessels. The system was found to be very effective in recovering sorbents (straw and polyurethane foam) from the water surface.

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Section I

CONCLUSIONS

The oil/sorbent harvesting system operated and evaluated in this study proved to be very effective in recovering sorbents (straw and polyurethane foam) from the water surface. In the test program, various system components were evaluated, leading to the following findings.

1. The wire mesh type of conveyor belting was the only belting material tested which would pick up straw from the water surface without manual assistance.

2. The depth in the water of the conveyor and deflector wings should be at least 6 in. to minimize loss of straw under the wings and conveyor.

3. Forward speed of the vessel and speed of the conveyor belt did not appreciably affect the pickup capability of the conveyor belts.

4. The openings in the wire mesh belt did not clog with a Bellridge crude oil which has an API gravity of 15. The presence of oil did not affect the system's performance in recovery of sorbents.

5. The optimum horizontal angle for the deflector wings is 45 deg. At larger angles, sorbent is lost under the wings. At smaller angles, the sweeping path is reduced.

6. The vertical angle between the conveyor belt and the water line should not exceed 25 deg. At a larger angle, the straw will not go up the wire mesh belt.

7. If all components of the oil/sorbent harvester system are readily available, the system can be installed on board a vessel of opportunity in 9 hours or less.

8. The use of the side-loading conveyor installation allows the oil/sorbent harvester system to be used on a wide assortment of vessels of opportunity.

9. In the three West Coast ports that were surveyed, sufficient suitable vessels of opportunity were located on which the oil/sorbent harvester could be installed to handle a major oil spill.

10. The oil/sorbent harvester system was easily able to pick up sorbents under different sea conditions ranging from the quiescent state of a protected harbor to open ocean conditions with 2- to 3-ft swells.

Section II

RECOMMENDATIONS

On the basis of the findings of this study, the following recommendations are offered.

1. It is recommended that oil companies and oil spill consortiums implement the oil/sorbent harvester system through the purchase of the necessary wire belt materials and through contingency contracts with local suppliers of the various components.

2. It is recommended that further research be conducted on the oil sorbing ratios of various sorbents under actual open water conditions and on the dispersal rates of sorbents under actual open water conditions.

3. It is recommended that the oil/sorbent harvesting system described in this report be evaluated on other types of vessels of opportunity.

Section III

INTRODUCTION

BACKGROUND

An increasing hazard of contamination of the environment with oil has accompanied the worldwide growth of the petroleum industry, a growth that has occurred in response to steadily increasing energy demands of the more advanced societies of the world. A recent tentative conclusion by a Massachusetts Institute of Technology-sponsored study group states:

> "It is likely that up to 1.5 million tons of oil are introduced into the oceans every year through ocean shipping, offshore drilling, and accidents. In addition, as much as two or three times this amount could eventually be introduced into waterways and eventually the oceans, as a result of emissions and wasteful practices on land."

The environmental impact of a major oil spill was most dramatically demonstrated by the Torrey Canyon disaster in 1967 which is reported to have cost the British Government $8 million in cleanup costs alone. In another incident, the Santa Barbara Platform A release in 1969 resulted in a research and development program directed towards development of oil spill recovery techniques.

A considerable amount of effort has been expended on the development of methods for the direct recovery of oil from the water surface; two basic approaches have been used:

- Skimming the oil directly using specially designed pickup heads, weirs, pump systems, and oil/water separator equipment
- Removal with the aid of sorbent materials.

Direct oil skimming requires no materials to be added to the oil slick; however, this technique usually fails when wave height approaches 2 ft and current velocity is in the 2-3 knot range. Under these conditions, the water to oil ratio becomes so large that the volume of oil recovered is insignificant.

Sorbents, however, are not affected to such a degree by adverse weather and sea conditions. In fact, the sorption process is enhanced when subjected to mixing. When applied early in an oil spill incident, sorbents reduce the spread of the slick and the oil/sorbent mixture is easier to contain.

A compendium on oil spill treating agents by the Battelle Memorial Institute lists some twenty-six sorbent materials available for use on oil spills. For each sorbent, the compendium gives the chemical and physical properties, cost, application rate, availablity and spill experience. The Dillingham Corporation has compiled a comparative description of the most promising of the sorbents currently available.

Straw is considered to be one of the best of the sorbents currently available. It is inexpensive, generally available and relatively easy to apply. Laboratory test have shown that straw will absorb over five times its weight of oil at air and water temperatures as low as 40^{o} to 45^{o}F. Straw has been used on several oil spills as a sorbent, including the Santa Barbara incident where some 100 tons/day of straw was utilized on both water and beach areas.

The principal problems in the use of sorbents are:

- Uniform dispersal
- Adequate contact with oil
- Recovery methods.

Wind is a major factor in distributing sorbents because of their low density.

Recovery of sorbents on a large scale in open water has never been attempted. At Santa Barbara, straw was dispersed onto oil near the surf line and allowed to wash ashore with the incoming tide. URS Research Company, in a study directed towards the evaluation of beach restoration methods, developed procedures for removing oil-soaked straw from beach areas. In the harbor area at Santa Barbara, straw was recovered from the water by personnel operating out of small "duck" boats, each containing a 55 gal. drum. The oil-soaked straw was lifted out of the water with rakes and placed into the drums. This manual procedure has been widely used in harbors by commercial oil-spill cleanup contractors.

The necessity of developing techniques for the rapid and effective removal of oil spills to prevent the contamination of large water and coastal areas has been recognized. In 1971, the Environmental Protection Agency issued five research contracts to develop efficient systems for the removal of floating oil with the aid of sorbent materials.

OBJECTIVES

The objectives of this study were to design, develop, and proof-test a system for the harvesting of mixtures of oil and sorbent materials which are used to aid in the recovery of floating oil from water.

Specifically, the study was to develop a system for mechanical harvesting of oil/straw mixtures utilizing vessels of opportunity. In addition, the system was evaluated for the harvesting of oil/polyurethane foam mixtures and oil/rice hull mixtures.

Section IV

SYSTEM DEVELOPMENT

A three-phase test program was designed to evaluate candidate system components and operating specifications for the oil/sorbent harvesting system. The first phase of the program involved testing individual system components and operating parameters as to their effectiveness in picking up sorbents only. A specially built test platform was utilized with all Phase I tests performed under actual conditions (i.e., a saltwater slough - or channel - in the southern portion of San Francisco Bay). The second phase of the test program entailed evaluating those operating characteristics of the harvesting system components selected in the first phase using crude oil and various sorbents. These tests were conducted in the wave tank facilities at the URS Research Company laboratory. The third and final phase of the test program involved demonstrating the full-scale harvesting system installed on board a vessel of opportunity as it would be used in the event of an oil spill incident. This phase was performed at two different locations. The first series of tests was conducted in the Richmond (California) harbor and in San Francisco Bay using sorbents only (straw and polyurethane foam). The second series of full-scale tests was conducted in the Pacific Ocean off the coast of Santa Barbara where oil seeps from the ocean bottom provide natural oil slicks extending over several square miles.

PHASE I TESTS

The principal objective of the Phase I test was to determine the components and operating parameters that would be best suited for incorporation into the oil/sorbent harvester system. To enable testing under real-world conditions with the inherent problems of wind, current and sea state normally encountered, a special floating test platform was constructed. The platform (shown in Figs. 1 and 2) was designed to allow the various operating parameters of the harvesting system to be easily varied. A 16 ft long frame conveyor (16 in. wide) was installed on the test platform in a manner which allowed variation of the conveyor's depth in the water and its angle of inclination. Deflector wings were installed on the front of the test platform in a mode that allowed the horizontal angle and the depth in the water to be adjusted. A test site was selected in San Francisco Bay (Steinberger Slough, Fig. 3) near Redwood City which provided somewhat protected water but still presented the wind and current problems that are normally encountered on open water.

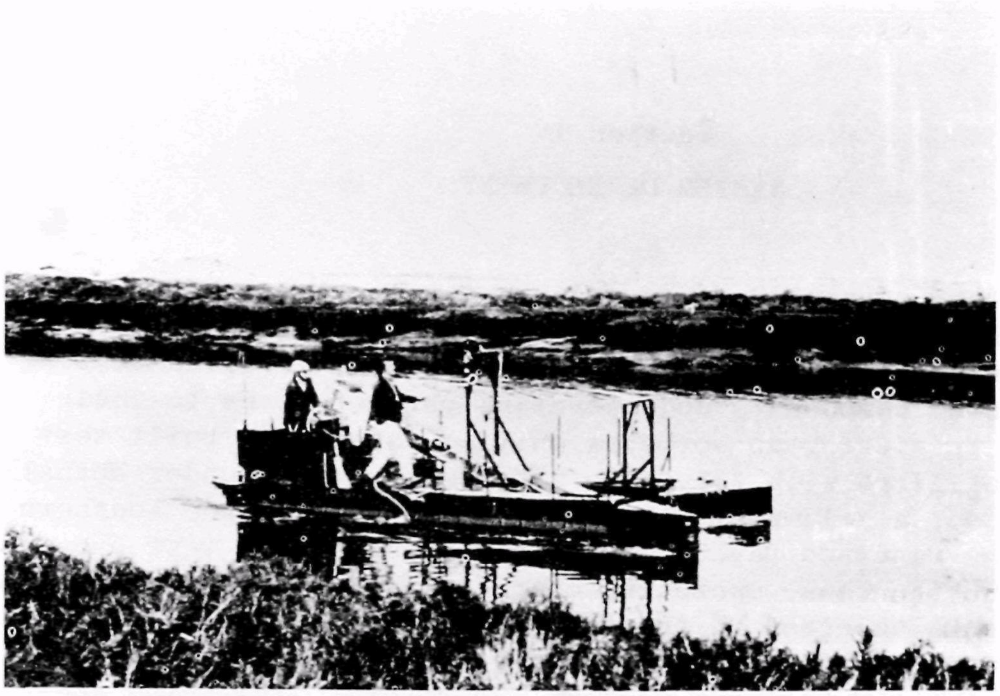


Fig. 1. Test Platform

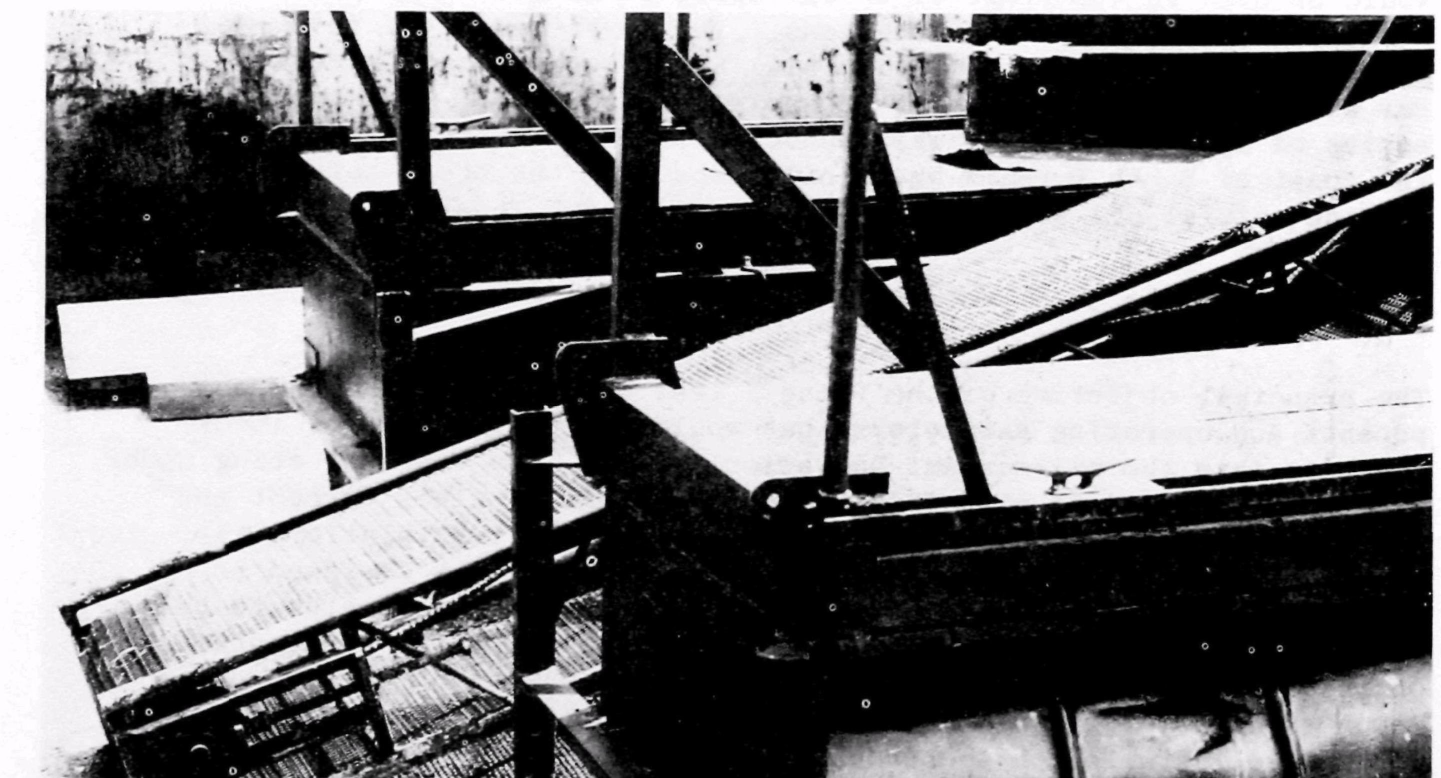


Fig. 2. Test Platform - Deflecting Wings Removed

Fig. 3. Phase I Test Site (Redwood City, Calif.)

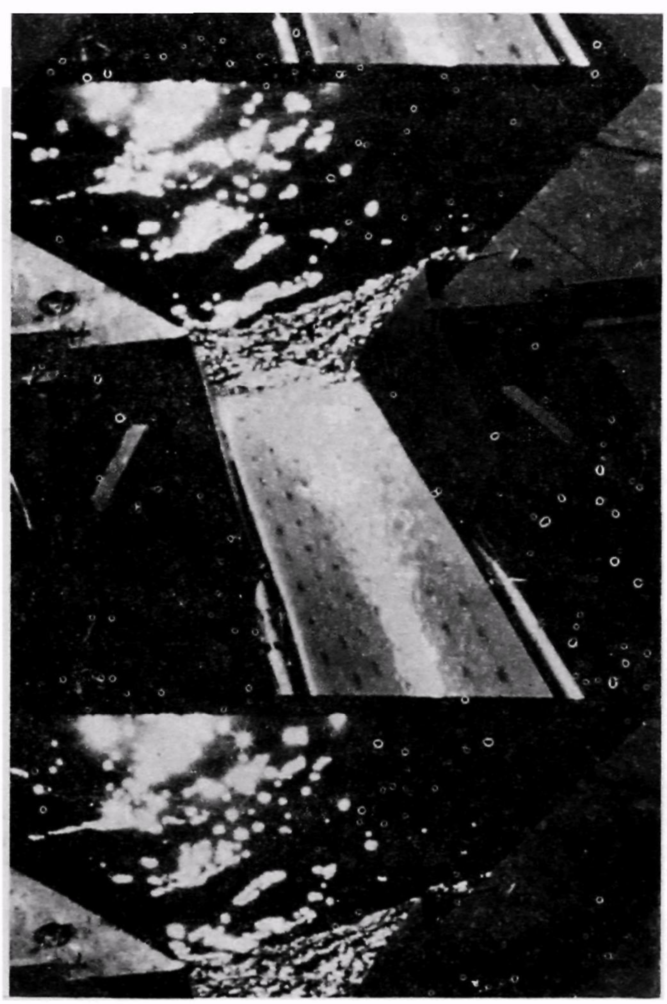


Fig. 4. Rubber Belt with Holes

Conveyor Belts

The effectiveness of four different types of conveyor belts was evaluated for removing straw from the water surface. The belts tested included:

- Smooth rubber belt
- Smooth rubber belt, with punched holes, approximately 7 percent openings (Fig. 4)
- Rubber belt with 2 in. high flights every 1 ft (Fig. 5)
- Wire mesh belt, equalized spiral wound, 3/8 in. mesh (Fig. 6).

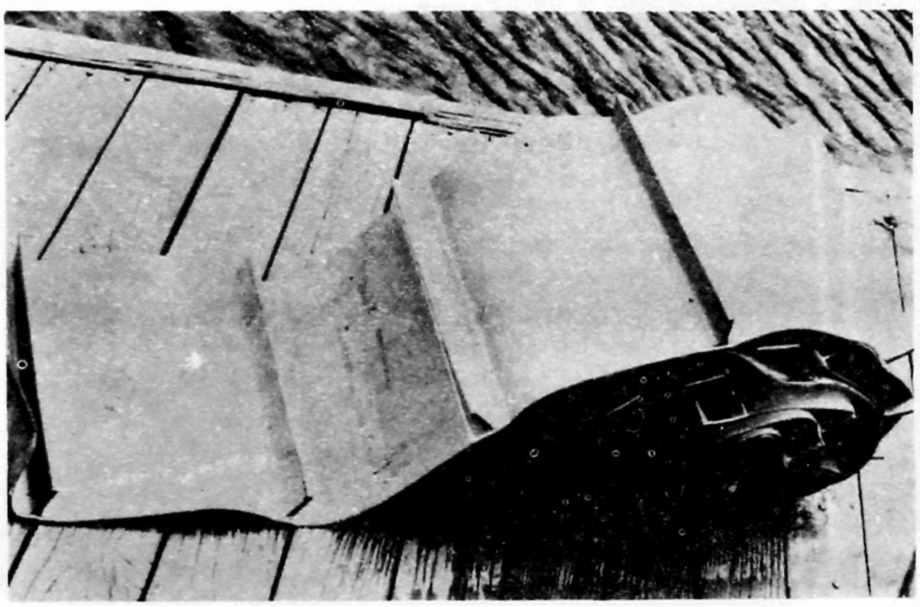


Fig. 5. Rubber Belt with Flights

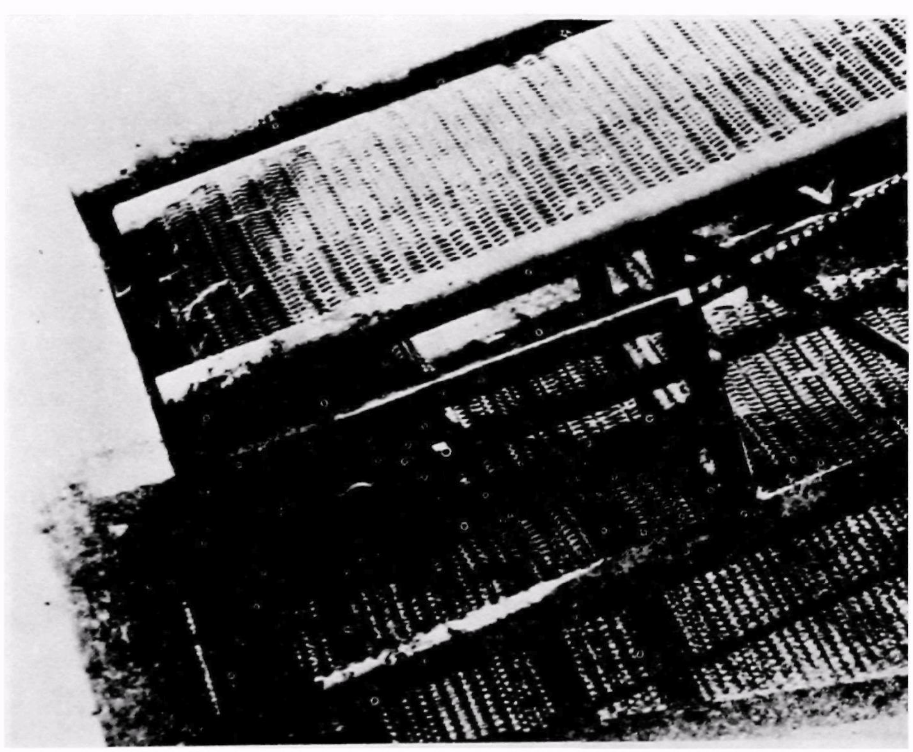


Fig. 6. Wire Mesh Belt

Operational Parameters

The various operational parameters of the pickup vessel, the conveyor system, and the deflecting wings evaluated are listed below:

1. Pickup vessel: forward speed
2. Conveyor system: angle of inclination, speed of belt, and depth of conveyor in the water
3. Deflecting wings: horizontal angle, and depth in the water.

These parameters were varied during the series of tests to determine the pickup efficiency of the oil/sorbent harvesting system.

Test Procedure

A known amount of pre-wetted straw was hand-dispersed in a 2 to 3 ft wide path approximately 50 ft long (Fig. 7). The test platform then was passed through the straw covered area; the time of the pass and the amount of sorbent recovered were recorded.

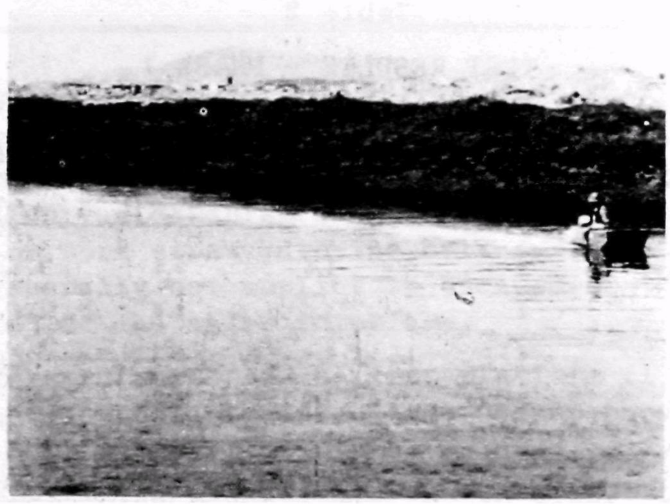


Fig. 7. Straw on Test Area

Test Results and Findings

The results of the Phase I test program are given in Tables 1 through 3.

Table 1

TEST RESULTS - PHASE I
WING DEFLECTOR ANGLE AND DEPTH

TEST NO.	HORIZONTAL ANGLE (°)	DEPTH OF DEFLECTOR IN WATER (in.)	FORWARD SPEED OF VESSEL (knots)	STRAW DISPERSED (lb wet)	STRAW RECOVERED (lb wet)	COMMENTS
A-1	65	4	1.5	3.0	0.25	Straw went around and under deflector wings. (A-1 to A-7)
A-2	65	6	1.5	2.0	0.5	
A-3	65	6	3.0	2.0	0.4	
A-4	65	12	1.5	2.5	0.5	
A-5	65	12	3.0	2.0	0.4	
A-6	60	8	3.0	3.0	0.6	
A-7	60	12	3.0	3.0	0.5	
A-8	55	4	3.0	2.5	1.5	Some straw lost around and under wings. (A-8 to A-9)
A-9	55	8	3.0	2.0	1.7	
A-10	45	6	1.3	3.0	2.8	Picked up almost all straw.
A-11	45	12	3.0	3.0	2.9	No loss around edges.

Note: All tests were run with 3/8 in. wire mesh belt.

Table 2

TEST RESULTS - PHASE I
CONVEYOR VERTICAL ANGLE AND DEPTH IN WATER

TEST NO.	VERTICAL ANGLE OF CONVEYOR TO WATER (°)	DEPTH OF CONVEYOR TIP UNDER WATER (in.)	FORWARD SPEED OF VESSEL (knots)	STRAW DISPERSED (lb wet)	STRAW PICKED UP (lb wet)	COMMENTS
B-1	16	2	1.5	2.5	1.5	Some straw lost under belt. (B-1 to B-2)
B-2	16	4	3.0	3.0	2.4	
B-3	16	6	2.0	3.2	3.0	
B-4	16	8	4.0	3.0	2.9	
B-5	20	4	3.0	2.7	2.1	Some straw lost under belt.
B-6	20	6	3.0	3.0	2.8	
B-7	20	8	3.0	2.5	2.2	
B-8	25	6	2.0	3.5	3.1	Some straw did not go up belt. (B-8 to B-9)
B-9	25	8	4.0	2.5	2.0	
B-10	27	6	2.0	3.0	0.3	Most of the straw would not go up belt at this angle. (B-10 to B-12)
B-11	27	8	2.0	3.5	0.2	
B-12	27	10	4.0	4.0	0.2	

Note: All tests were run with 3/8 in. mesh wire conveyor belt with deflector wings at 45° angle and 6 in. depth in water.

Table 3

TEST RESULTS - PHASE I
EVALUATION OF CONVEYOR BELTS

TEST NO.	ANGLE OF CONVEYOR (°)	DEPTH OF CONVEYOR TIP UNDER WATER (in.)	FORWARD SPEED VESSEL (knots)	SPEED OF CONVEYOR BELT (ft/min)	AMOUNT STRAW DISPERSED (lb)	AMOUNT STRAW PICKED UP (lb)	STRAW RECOVERED (lb/hr)	COMMENTS
					Smooth Rubber Belt			
C-1	20	8	2	190	20	0	0	Straw would not go up belt.
C-2	20	6	2	250	20.5	8.5	660	Recovery rate with straw manually forced onto belt.
C-3	18	8	2.5	190	20	0	0	Straw would not go up belt.
C-4	18	6	2.5	250	21	9.0	841	Recovery rate with straw manually forced onto belt.
					Smooth Rubber Belt with Holes			
D-1	21.5	8	3	190	21.5	0	0	Straw would not go up belt.
D-2	15	4	2.5	330	19.5	5.5	330	Some straw lost under conveyor tip. Straw manually forced onto belt.
D-3	20	8	2.5	190	21	10.4	772	
D-4	21.5	8	2.3	330	21	12.8	1,248	
					Rubber Belt with 2 in. Flights			
E-1	17	2	1.5	240	15	0	0	Straw would not load onto belt.
E-2	17	6	3.0	280	15	1.5	30	The flights on the belt caused a great deal of turbulence at the waters interface forcing straw under belt.
E-3	16	6	3.2	140	22	1.5	40	
					3/8 in. Wire Mesh Belt			
F-1	22	2	2.7	220	24	10	590	Some straw lost under belt.
F-2	22	4	3.5	220	19	9.5	1,114	Some straw lost under belt.
F-3	22	6	3	220	20	15.2	1,710	
F-4	20	6	1.5	220	22	19	1,628	
F-5	18	6	3.0	220	18	15.2	1,824	
F-6	18	8	4.5	220	23	20.3	1,620	

The major findings of the test program are given below.

1. The wire mesh belt proved to be the most effective. The smooth rubber belt and the rubber belt with holes in it would only pick up straw with manual assistance (i.e., rake or fork straw onto the belt surface). Flighted belts are generally not applicable because of the turbulence created at the water interface.

2. The forward speed of the test platform (1.5 to 4.5 knots) did not appreciably affect the pickup capability of the wire belt system.

3. Varying the conveyor angle to the water resulted in the determination of a maximum practical value of around 25 deg. Above this angle, pickup efficiency rapidly decreases.

4. Varying the conveyor belt speed (between 200 and 500 fpm) did not materially affect pickup capability of the wire mesh belts. However, higher speeds (e.g., 400 fpm) increase the belt's capacity to move large volumes of straw.

5. The depth of the conveyor in the water is an important parameter. The tip of the conveyor should be at least 6 in. under the water level to minimize turbulence at the

water interface, to keep straw from going under the belt, and to keep the belt in the water during rough conditions.

6. The horizontal angle between the conveyor and the deflector wings should be less than 55 deg. At angles greater than 55 deg, the straw tended to go under the wings. A 45 deg angle was found to be very satisfactory. Smaller angles decrease the harvesting path.

7. The depth of the deflector wings in the water should be at least 6 in. to prevent straw from going under the wings and to keep the wings under water in rough conditions. Greater depths increase the drag resistance of the wings and slow the vessel.

PHASE II TESTS

The objective of the Phase II tests was to evaluate the performance of the wire mesh conveyor system with oil-soaked sorbents. The tests were performed in a test tank located in the URS Research Laboratory in San Carlos, California. The conveyor system with the wire mesh belt was installed in the test tank (36 ft x 4 ft x 4 ft) in such a manner as to allow the conveyor's vertical angle and depth in the water to be varied. Figure 8 shows the conveyor in position. An 18 hp outboard motor was installed at one end of the test tank approximately 6 ft from the end of the conveyor. The motor, when operating, provided a current of up to 2 knots in the tank and directed the oil-soaked sorbents onto the conveyor belt.

Test Parameters

Two series of tests were performed. The first test series was to re-evaluate the various operating parameters previously evaluated in Phase I, utilizing straw only. The second test series evaluated the performance of the system utilizing crude oil and three types of sorbent: straw, rice hulls, and polyurethane foam.

Test Procedure

Two small booms were placed across the test tank, one directly behind the motor and the other, a removable boom, right in front of the conveyor. A known amount of San Joaquin crude oil (API gravity of 15.9 at 60^{o}F) was poured into the boomed area. Then a known amount of sorbent was dispersed manually onto the oil and allowed to soak for a 5-minute period. The outboard motor (current generator) and conveyor system were started and the boom in front of the conveyor was removed, allowing the oil-soaked sorbent to move onto the conveyor belt. The sorbent was collected, allowed to drain of water for 1 hr, and then weighed.

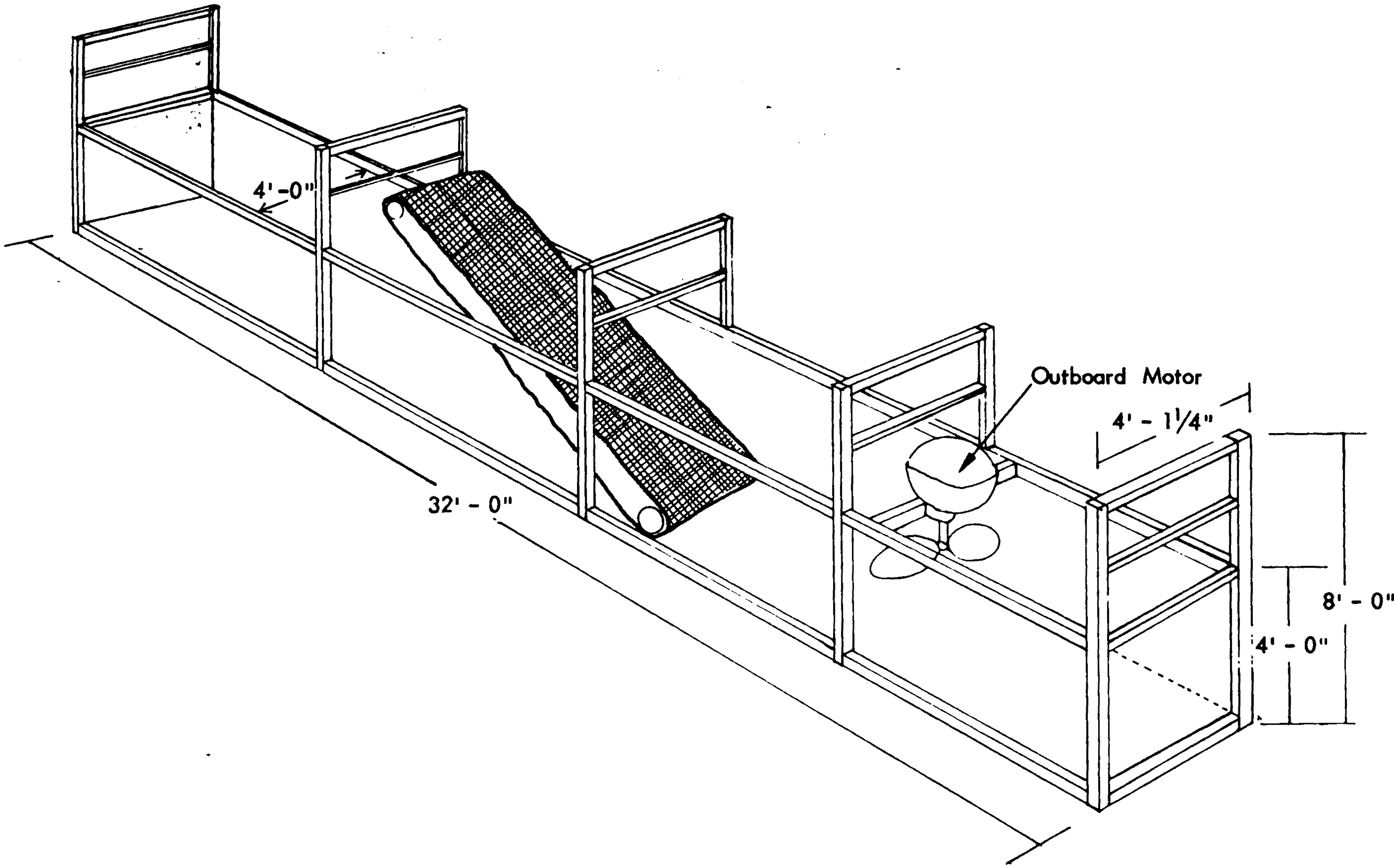


Figure 8. Test Tank Setup for Phase II Testing

Test Results and Findings

The results of the tests are given in Table 4. Phase II test findings during the conveyor system performance included:

1. Confirmation of the open water Phase I tests: that the depth of the conveyor in the water should be at least 6 in. to minimize loss of straw under the belt.

2. The heavy crude oil and oil-soaked sorbents did not clog the openings in the wire mesh belt. The wire belt initially picked up a thin coating of oil, but no further oil buildup was observed through the remainder of the tests.

3. The wire mesh belt effectively picked up oil-soaked rice hulls and oil-soaked 2-in. square pieces of polyurethane foam. Although the rice hulls were smaller than the 3/8 in. mesh openings of the wire belt, the oil/hull mixture agglomerates were easily picked up.

Table 4

TEST RESULTS - PHASE II

TEST NO.	ANGLE OF BELT (°)	SORBENT	QUANTITY OF OIL (gal.)	CURRENT SPEED (knots)	CONVEYOR DEPTH TIP (in.)	TIME REQUIRED (min)	MATERIAL DISPERSED PRE-SOAKED (lb)	MATERIAL PICKED UP DRAINED (lb)	LBS/HR (wet)
WT-1	23	Straw	0	1	3	2:20	80	78	2,008
WT-2	23	Straw	0	1.5	6	1:07	78	77	4,137
WT-3	23	Straw	0	2	6	1:07	77	70	3,761
WT-4	16	Straw	0	1.5	½	0:49	35	20	1,469
WT-5	17	Straw	0	2	2	1:30	70	52	2,080
WT-6	20	Straw	0	1.5	8	0:53	52	48	3,260
0-1-1	20	Straw	8	1.6	8	0:53	20	50	3,396
0-1-2	20	Straw	8	1.6	8	0:57	50*	60	3,789
0-1-3	20	Straw	8	1.6	8	0:52	60*	67	4,638
0-1-4	20	Straw	4	1.6	8	1:17	67*	74	3,460
0-1-5	20	Straw	4	1.6	8	15:00	400*	--	--
0-2**	20	Rice Hulls	2	1	8	--	3		
0-3**	20	Foam 2" Squares	2	1	8	--	1		

Note: Constant belt speed of 240 ft/min in all tests.

* Straw + oil weight.
** These two tests were qualitative only and were run just to determine if the system could recover these sorbent materials, which it did.

PHASE III TESTS

The principal objective of the Phase III tests was to evaluate the performance of the full-scale harvesting system installed aboard a vessel of opportunity under actual open water conditions using oil and sorbents.

The test program was initially designed to be wholly performed in the Richmond Inner Harbor and on San Francisco Bay near Angel Island. However, failure to receive the necessary permission from the local regulatory agencies to spill oil forced a change in plans with the subsequent result that two full-scale test series were performed. The first, using sorbents only, was carried out in the original test site location (Figs. 9 and 10). The second series of tests were performed off Coal Oil Point, 10 miles north of Santa Barbara (Fig. 11), where natural oil seeps result in oil slicks which were utilized as the oil source onto which sorbents were dispersed and then picked up.

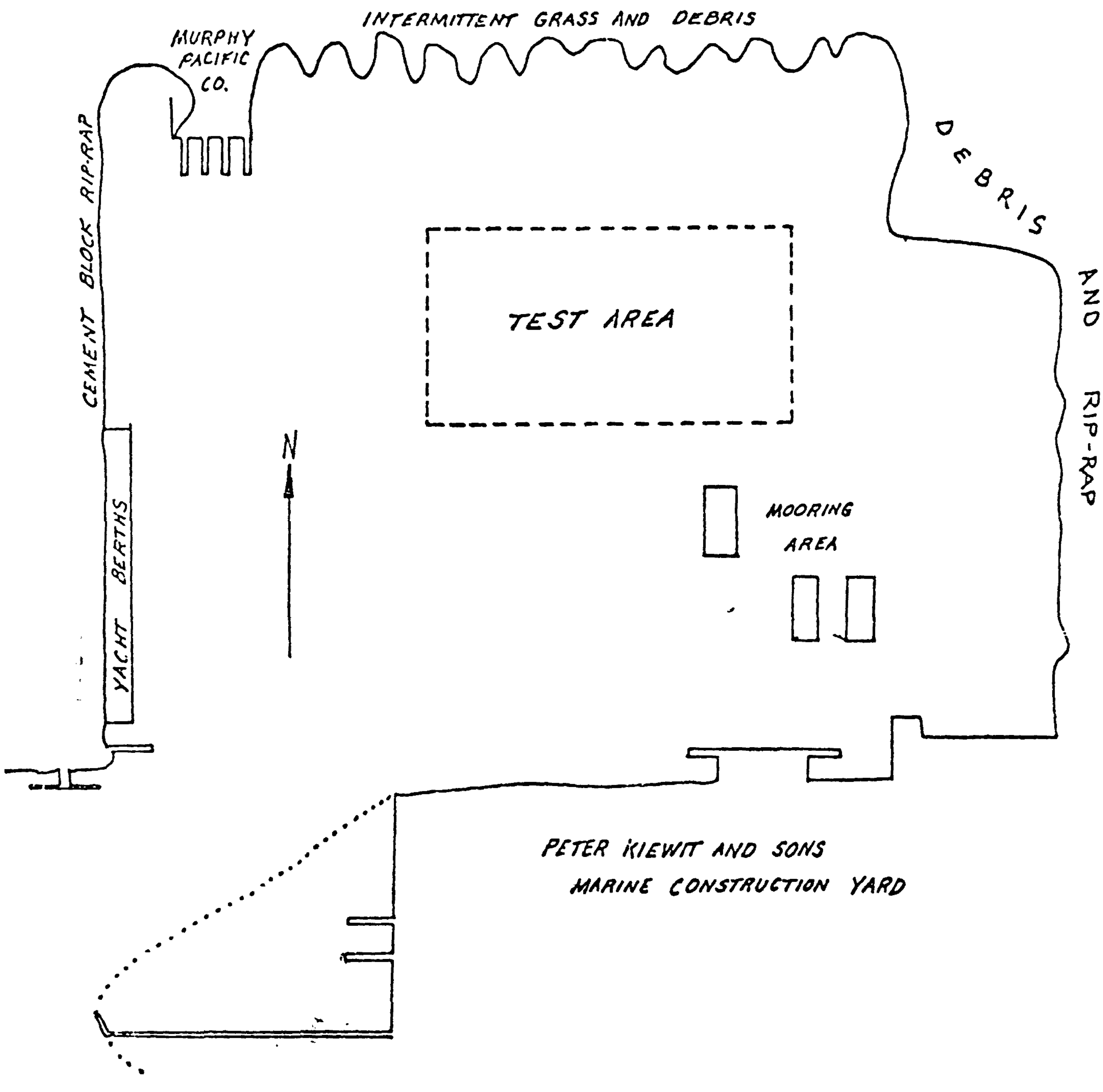


Fig. 9. Richmond Inner Harbor Basin

Fig. 10. Richmond Test Site

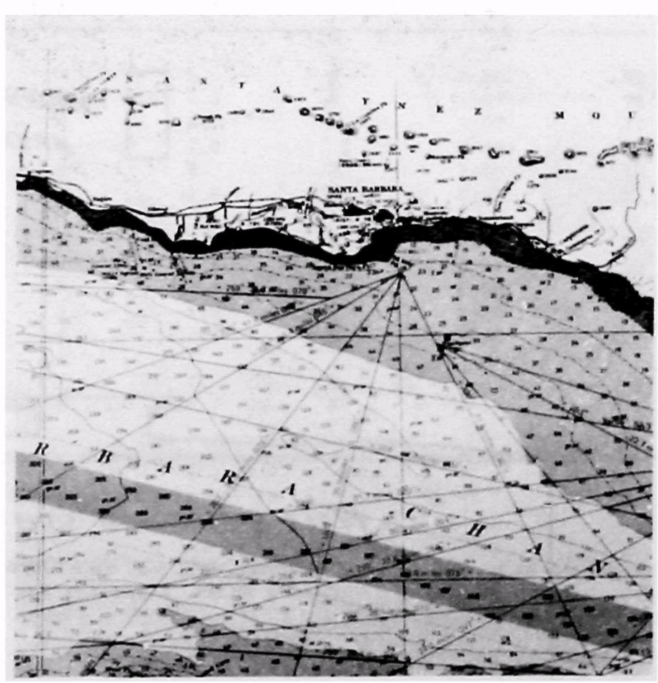


Fig. 11. Coal Oil Point

Test Series No. 1

For this test series two different conveyor mounting configurations were tested. The first mounting configuration involved removing the gate or ramp from the front of an LCM landing craft and installing two wire mesh belt conveyors with deflector wings off the front of the vessel (Figs. 12 and 13). The second type of mounting configuration required installing a single wire mesh belt with one deflector wing on the starboard side of the LCM (Figs. 14 and 15). In this configuration, the hull of the LCM acts as the other deflector wing. The side-mounted conveyor system is applicable to a wide variety of vessels with low freeboards (i.e., barges, work boats, etc.)

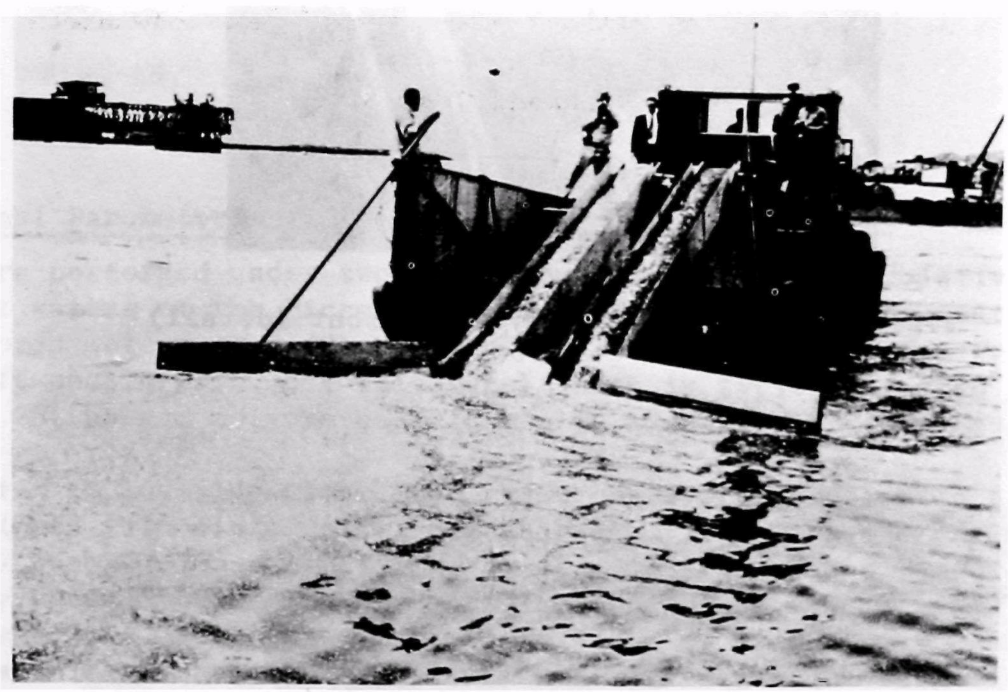


Fig. 12. LCM with Conveyor in Front

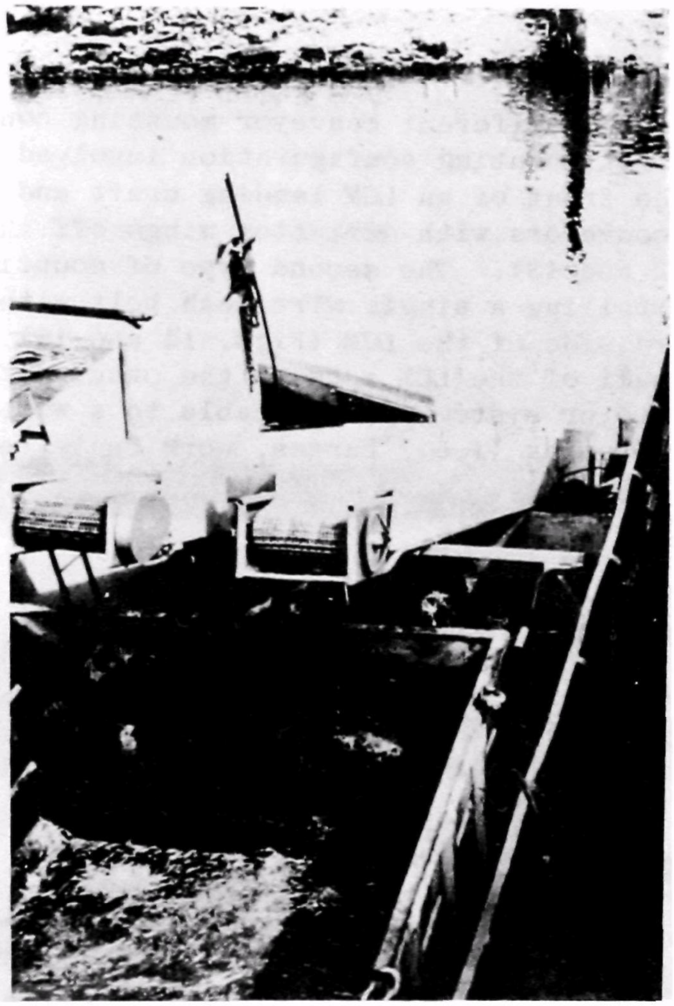


Fig. 13. LCM with Conveyor in Front (detail)

Fig. 14. LCM with Conveyor on Side

Fig. 15. LCM with Conveyor on Side (detail)

Operational Parameters

Tests were performed under two water conditions: (1) the relatively quiescent waters of the Richmond inner harbor which is representatave of protected waters, and (2) the choppy waters of central San Francisco Bay (≈2 ft swells with some whitecaps) which is typical of open harbors. Straw and polyurethane foam were evaluated as sorbents.

Two 26 ft x 16 in. wide Clearfield frame conveyors were rented and each equipped with different wire mesh belts. One wire mesh belt (Fig. 16) was a 1/2 in. mesh spiral equal wound which was friction driven by the conveyor head pulley. The other wire belt was a 1/2 in. x 1/2 in. flat wire belt (Fig. 17), gear driven by toothed sprockets which were added to the conveyor drive assembly.

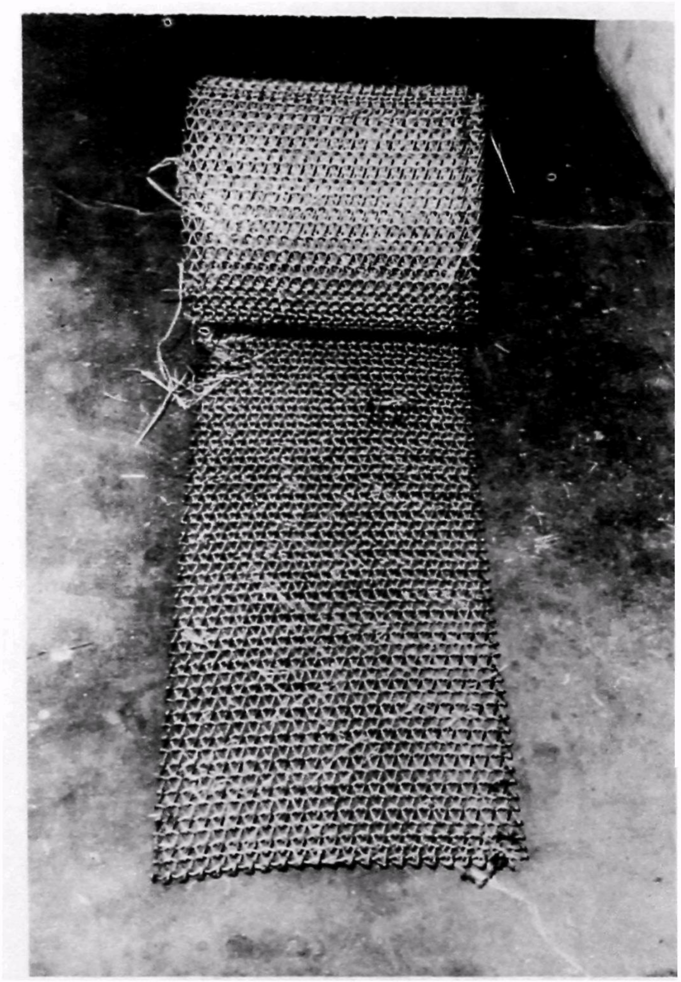


Fig. 16. Spiral Wire Mesh Belt

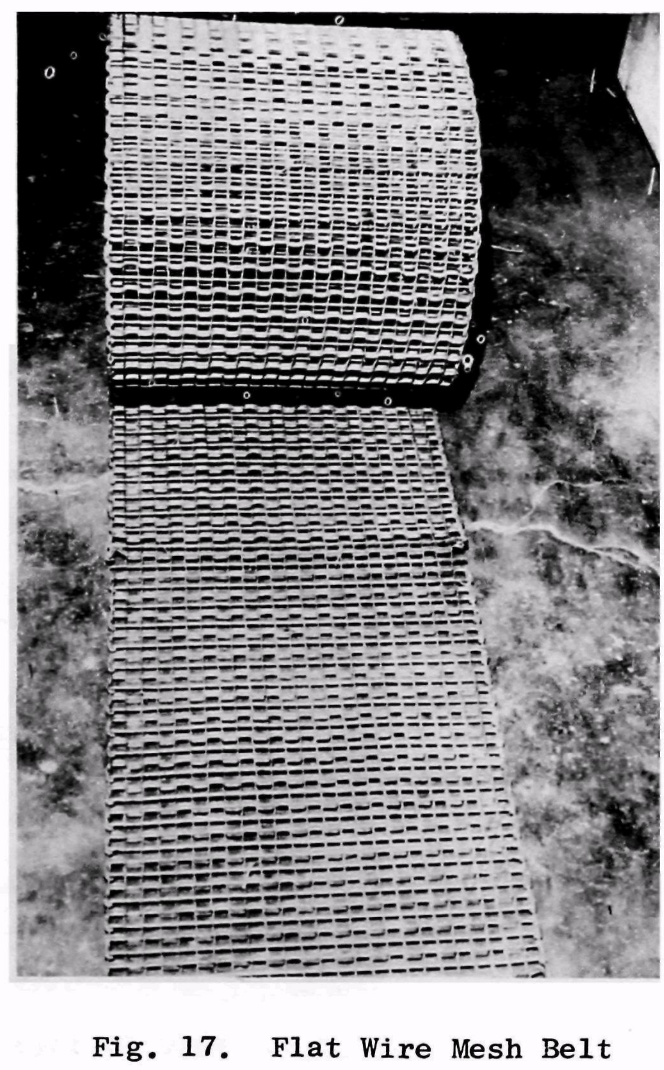


Fig. 17. Flat Wire Mesh Belt

Test Results and Findings

Results for the full-scale tests are given in Table 5. Observations of the oil/sorbent harvester performance are given below.

- Under all conditions tested, both mounting configurations picked up more than 90 percent of the straw and polyurethane foam that was dispersed (the remainder being too widely scattered by wind and current to recover).
- A completely quantitative analysis of straw dispersed versus straw picked up was impossible. As Table 5 shows, the straw picked up retained over four times its initial dry weight of water even after 1 hr draining time.
- An estimated 80 to 90 percent of the sorbent was recovered on the first two passes of the harvesting system.
- A recurring problem with the side-mounted conveyor configuration was that straw passing under the hull on the side that had no conveyor would plug up the cooling water intake of the port engine, necessitating the engine being shut down. This occurred after 15 to 20 minutes of operation. This problem did not occur with the front-mounted installation. A possible solution would be to install deflector plates in front of the cooling water intakes on the bottom of the hull. (Newer model LCMs and many converted older models are equipped with closed cooling systems, eliminating this problem.)

Table 5

FULL-SCALE TEST RESULTS - PHASE III
San Francisco Bay

TEST NO.	DATE	SEA STATE	LOCATION	WT STRAW DISPERSED DRY (lb)	TIME 1ST PASS (min)	PERCENT STRAW RECOVERED	TIME 2ND PASS (min)	PERCENT STRAW RECOVERED	WT STRAW PICKED UP WET (lb)	COMMENTS
				Front-Mounting Configuration						
1	4/3/72	2	S.F. Bay	85	2	--	2½	--		Preliminary test to check current and wind
2	4/4/72	0-1	Richmond Inner Harbor	480	3½	50	1	40	1,850	
3	4/4/72	1	Richmond Inner Harbor	25 cu ft polyurethane foam	2½	85				
4	4/5/72	1-2	Richmond Inner Harbor	540	3	45	3½	45	2,100	
5	4/6/72	1	Richmond Inner Harbor	15 cu ft foam	2-3	90				
				Side-Mounted Configuration						
6	4/6/72	1	Richmond Inner Harbor	300	2	55	1½	40	1,200	Engine cooling; filters plugged up with straw after 1/2 hour
7	4/7/72	1-2	S.F. Bay	180	2	85	--		650	

Note: In all tests: vessel speed = 2 kt.
conveyor: angle = 20 deg; speed = 350 fpm; depth of conveyor tip = 6 in.

Test Series No. 2

A second series of full-scale tests was performed off Coal Oil Point, 10 miles north of Santa Barbara (Fig. 11). This area not only provided natural oil slicks but also allowed the oil/sorbent harvesting system to be tested in open sea conditions. The test procedure and test equipment were essentially the same as used in the San Francisco Bay test series. The front-loading dual conveyor mounting configuration was used with one major difference. Instead of removing the front gate or ramp of the LCM, an opening 6 ft long by 2 ft high was cut in the gate and the conveyors installed through the opening (Fig. 18). This installation mode provided better watertight integrity for the LCM. The entire oil/sorbent harvesting system was installed on board the LCM in one 9-hour working day.

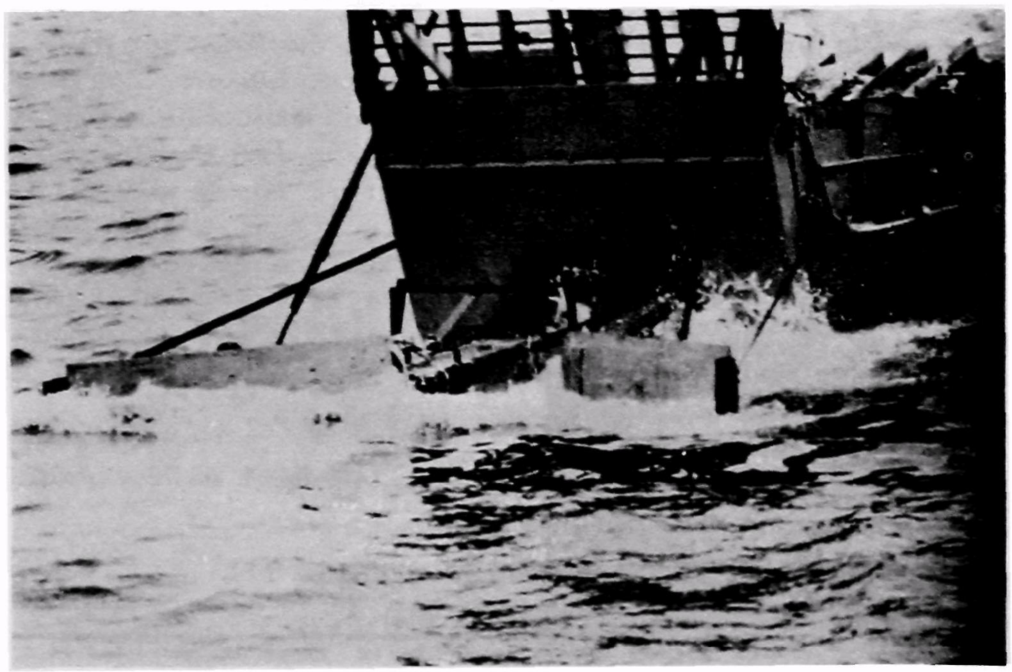


Fig. 18. Opening Cut in Front of LCM

Test Results and Findings

Table 6 gives the results of the Santa Barbara tests. Observations of the system's performance are listed below.

- The oil/sorbent harvesting system was able to pick up an estimated 90 percent of sorbents dispersed under open sea conditions (ocean swells were 3 to 4 ft high).
- The LCM with the oil/sorbent system attached was able to travel at a speed of 5 knots in open sea conditions without damaging the deflecting wing supports or shipping any water into the vessel.

- The oil/sorbent conveyor system easily picked up numerous "oil patties" which were present in the natural oil slicks.

Table 6

TEST RESULTS - PHASE III
Coal Oil Point

TEST NO.	PICKUP SPEED (knot)	SORBENT DISPERSED	ESTIMATED VOLUME OF OIL ON WATER	TIME OF FIRST PASS (min)	ESTIMATED PERCENT SORBENT RECOVERED	TIME OF SECOND PASS (min)	ESTIMATED PERCENT SORBENT RECOVERED
SB-1	2	300 lb straw	2,000 gal./sq mi	2	55	3	40
SB-2	3	500 lb straw	500 gal./sq mi	2	50	2½	40
SB-3	3	20 cu ft of foam	500 gal./sq mi	1½	65	2	30

Section V

COMPONENT REQUIREMENTS AND AVAILABILITY

As a result of the system development program described in the previous section, a survey of component availability and specifications was conducted. The oil/sorbent harvesting system designed and evaluated in this study has four major components: the vessel of opportunity, the conveyors and belts, the sorbent distributor, and sorbent storage and handling equipment. All of the major system components are "off the shelf" items that can be assembled in one day to form the oil/sorbent harvesting system. A discussion of the general requirements, specifications, and availability of the system components follows.

VESSEL TYPES

It is impossible to define a particular type of vessel as optimum for the oil/sorbent harvester system because of the diversity of types found both locally and regionally and because of the varying conditions under which the vessels would be required to operate. Generally, there are a number of requirements which must be met for conveyor installation, including:

- Low freeboard or main deck level
- Draft commensurate with working water depth
- High degree of maneuverability
- Large capacity
- Clear deck space amidships and aft (preferably forward also)
- Preferably metal hulled (for easy attachment of the system)

A survey of vessels indicated a number of types that would be suitable for the oil/sorbent harvesting system, as listed below.

- Converted surplus landing craft - LCMs, LCVPs, LCUs
- Gulf Coast work boats
- Deck and hopper barges

Surplus Landing Craft

The LCM (Landing Craft Mechanized, Figs. 19 and 20) is a surplus naval vessel commonly used by marine salvage and construction organizations as a work boat. It is a diesel-powered, twin-screw, shallow-draft vessel with a high degree of maneuverability. The well deck allows sufficient room for installation of the dual conveyor system and a storage container for the harvested oil/sorbent mixture. Many commercial LCMs have had the landing ramp welded shut; however, this does not affect their suitability as a recovery vessel as an opening can be cut in the ramp for the conveyors or a side-mounted configuration may be used.

The LCVP (Landing Craft Vehicles and Personnel, Fig. 21) is a diesel-powered, single-screw shallow-draft vessel used commercially as a small work boat or a water taxi. Because it is a single-screw vessel it is not as maneuverable as an LCM. A single conveyor system can be installed on the front of the LCVP; however, due to its small size (36-ft length) it would have a very limited capacity for oil-soaked sorbent and would have to be unloaded frequently.

The LCU (Landing Craft Utility, Fig. 22) is a diesel-powered, triple-screw, shallow-draft, highly maneuverable ship originally designed to land tanks and artillery on beaches. The LCU has a well deck 76 ft long by 31 ft wide which could conveniently accommodate 8 to 10 large storage containers. A dual conveyor system could be easily mounted on the front of the vessel and chutes or side-loading conveyors utilized to shift the collected sorbents to the various storage containers. LCUs are not as commonly available as the smaller LCMs. They are found more frequently in remote areas where they are used to transport equipment and vehicles to beach areas.

Specifications of the various types of landing craft are presented in Table 7.

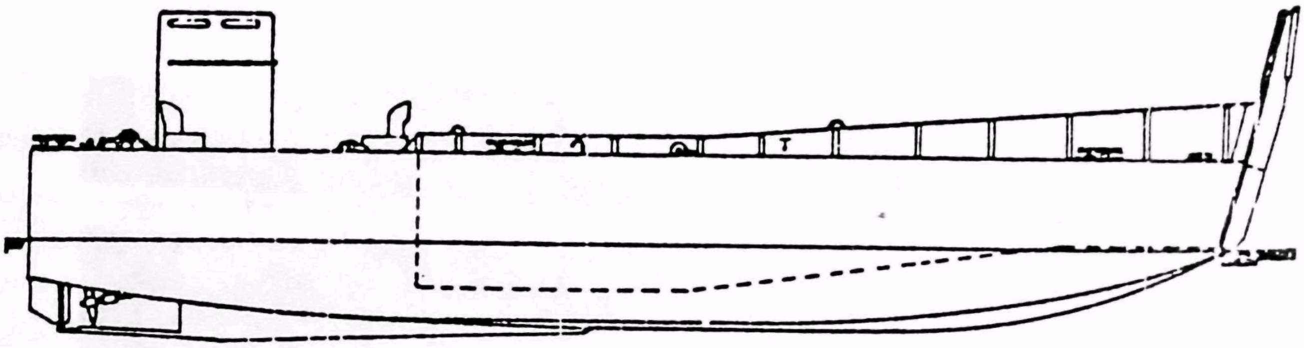


Fig. 19. LCM-3

Fig. 20. LCM-8

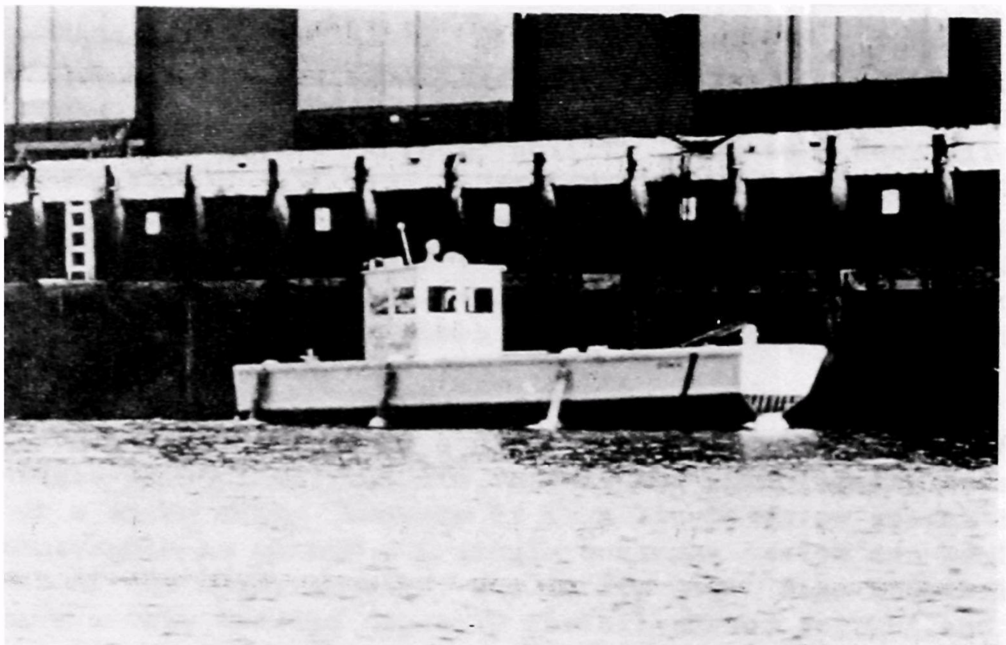


Fig. 21. LCVP

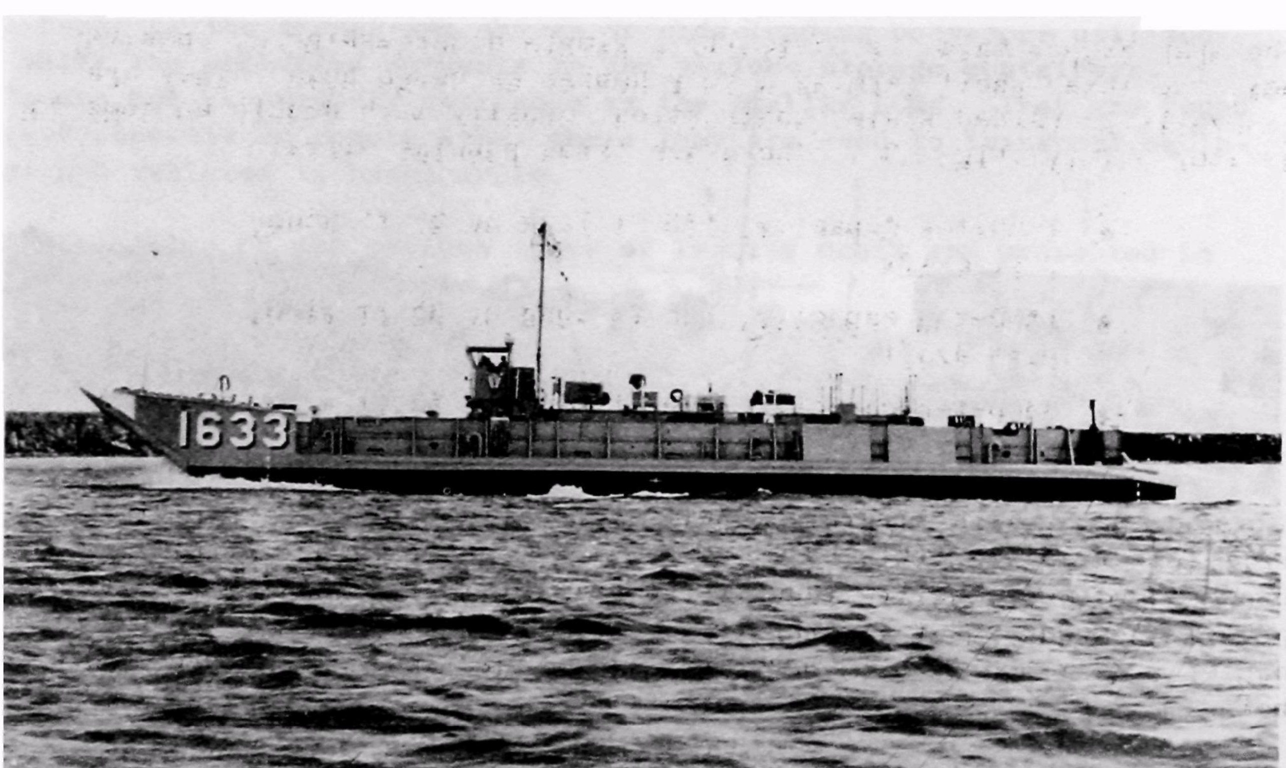


Fig. 22. LCU

Table 7

LANDING CRAFT SPECIFICATIONS

VESSEL TYPE	LENGTH (ft)	BEAM (ft)	DRAFT (ft)	SIZE OF HOLD (ft) (L × W × H)	SPEED (knots)	CAPACITY (tons)	CREW	ENDURANCE OR RANGE (mi)
LCM-3	50	14	4	31 x 9 x 6	9.5	30	2	130
LCM-6	56	14	4	37 x 11 x 6	9	34	2	130
LCM-8	74	21	5	45 x 15 x 4	9	60	2	190
LSU #1466	115	34	5	76 x 31 x 6	8	167	4-5	1200
LCU #1608	115	34	4	76 x 31 x 6	8	183	4-5	1200
LCU #1610 & 1626	135	29	4.5	n.a.	11	168	4-5	n.a.
LCVP	36	10	3.5	18 x 6 x 5	9	4	1	110

n.a. = not available.

Barges

Barges are by far the most readily available type of vessel on which to install the sorbent harvester system. Two types are suitable for the system: hopper barges and deck barges.

The open hopper barge is basically a simple double-skinned, open-top box, the inner shell forming a long hopper or cargo hold. They are generally of welded plate construction, usually with double bottoms for greater safety (Fig. 23). There are three popular sizes:

- 1000-ton capacity, 175 ft long by 26 ft wide, 9-ft draft
- 1500-ton capacity, 145 ft long by 35 ft wide, 9-ft draft
- 3000-ton capacity, 290 ft long by 50 ft wide, 9-ft draft

The deck barge is a simple box hull, generally with a heavy-plated, well-supported deck (Fig. 24). A great number of these vessels are used by the construction industry as work platforms and for moving and storing equipment and supplies. Generally deck barges range in capacity from 350 tons to more than 1500 tons, the most common sizes being:

- 100 ft long by 26 ft wide
- 130 ft long by 30 ft wide
- 195 ft long by 35 ft wide.

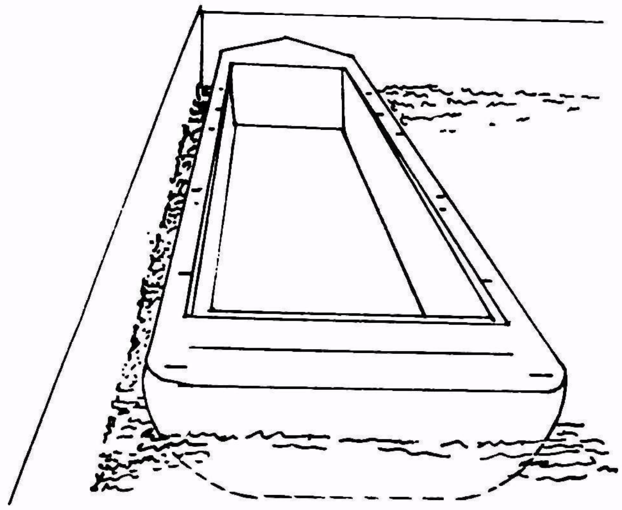


Fig. 23. Open Hopper Barge

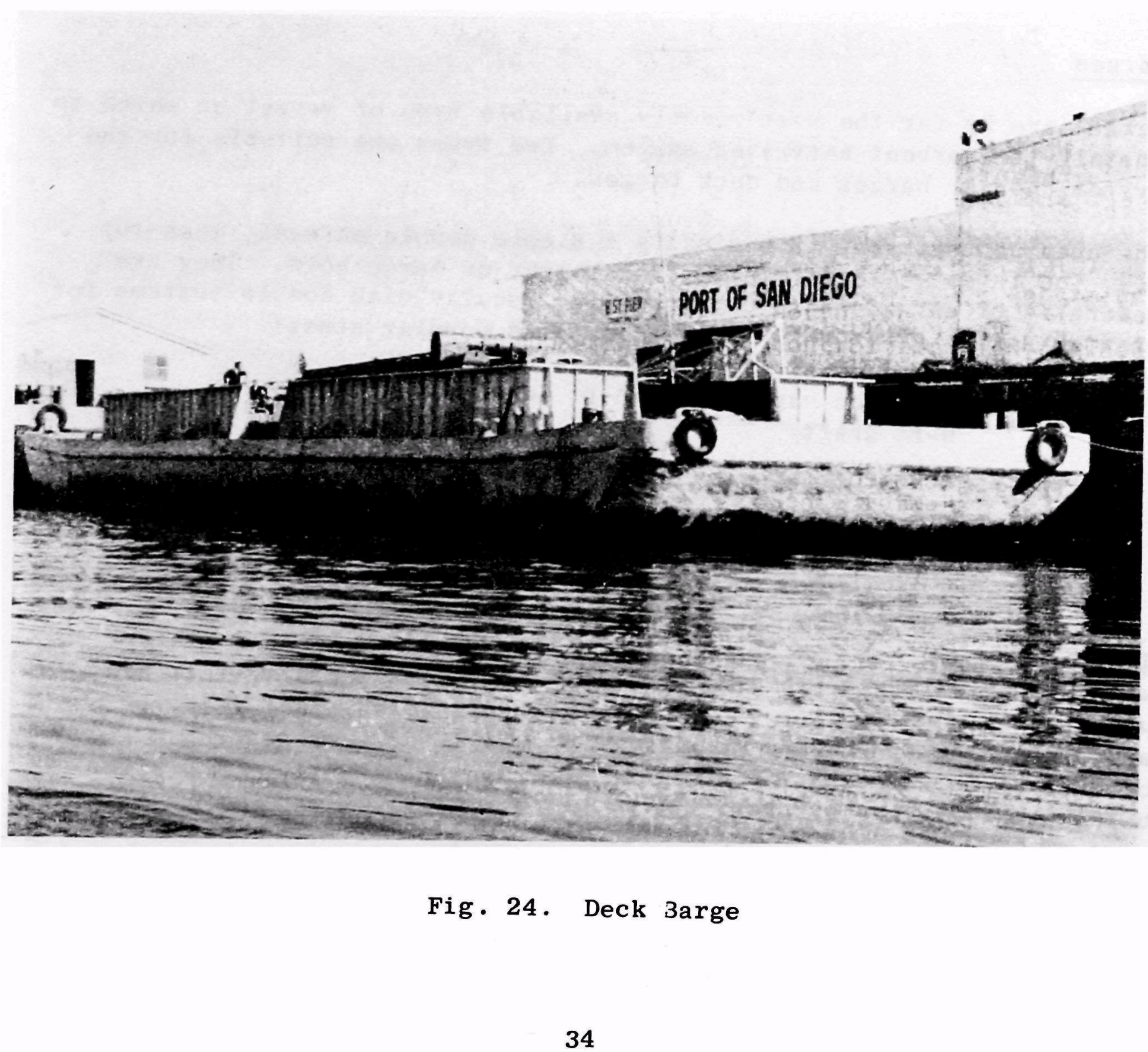


Fig. 24. Deck Barge

Hopper and deck barges could be used either as support vessels or as the primary pickup vessel. Conveyors could be installed in the side-mounting configuration and would be capable of picking up and storing oil-soaked sorbents. The major advantages of the barges are:

- The wide beam acts as a directing boom as well as allowing the use of several recovery devices on one hull
- Hulls and deck are usually metal, allowing easy attachment of the conveyors by welding
- Decks are clear and large, allowing utilization of a wide variety of support equipment
- Freeboard is adjustable by adding or pumping ballast water. This is very significant in that it allows maintenance of the proper depth of the recovery equipment despite the loading of the vessel
- The large capacity permits the use of fewer systems in the event of a large incident
- The barges are readily available.

The major disadvantages are:

- Poor maneuverability; a tugboat would be required for propulsion
- Poor visibility of the pickup area from the pusher tugboat
- Slower transit speeds.

Gulf Coast-type Work Barges

This type of vessel is typically a diesel-powered, single-hull, twin-screw configuration with a large open deck area aft (Fig. 25). These vessels are quite variable in size; however, deck configurations are very similar. The low freeboard work area would provide sufficient room for side-mounted conveyor installations and moderate to large sorbent storage capacity. These vessels have typically shallow drafts, high speed, moderate to long range, and navigation equipment. The availability of the Gulf Coast-type work boat is closely related to offshore oil activity. If offshore wells are being drilled in an area there will be many vessels of this type available.

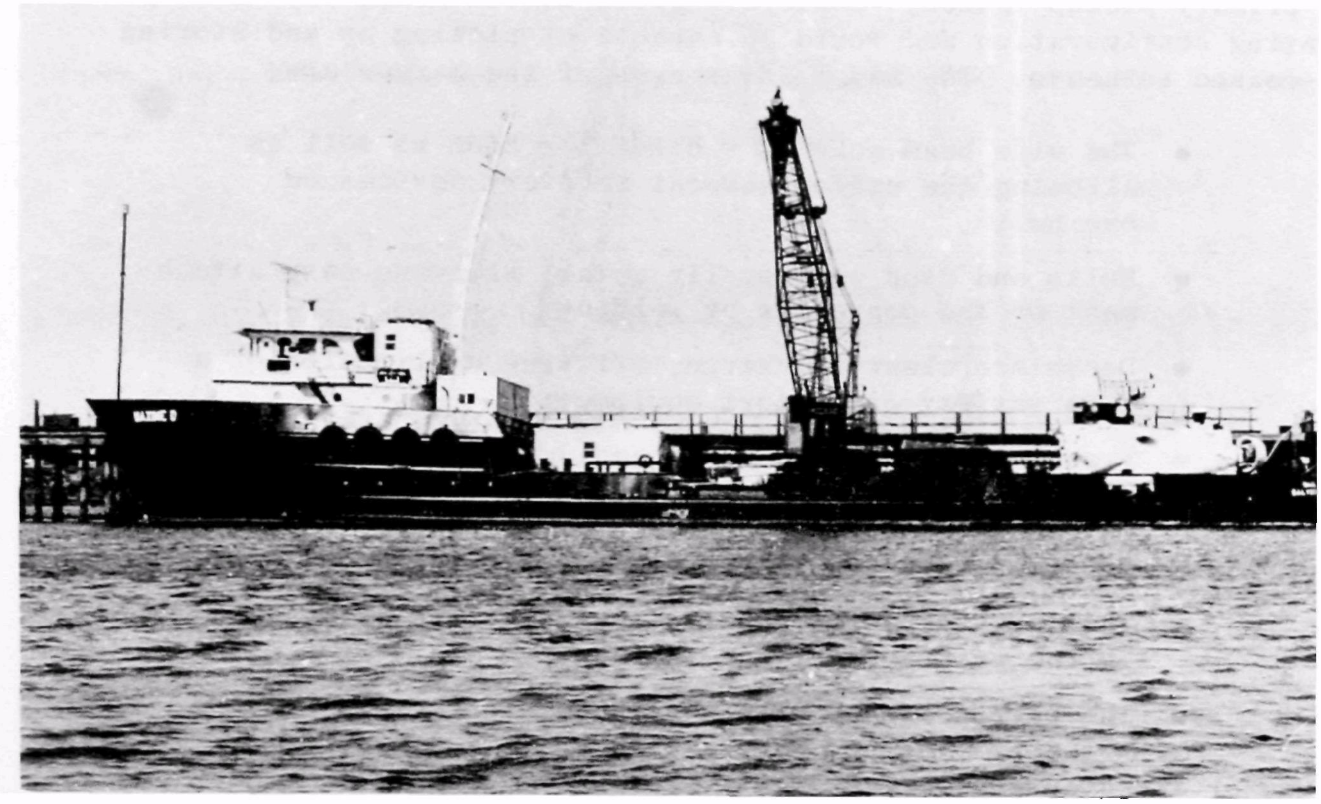


Fig. 25. Gulf Coast Work Boat

VESSEL SURVEY

A brief vessel survey was performed in three West Coast ports to check on the availability of the proper type of "vessels of opportunity" on which to mount the oil/sorbent harvester system. The three ports in which the survey was conducted were San Francisco/Oakland, Long Beach/ Los Angeles and San Diego, California. The survey procedure was simply to rent a small boat with outboard motor and cruise the entire waterfront area of each port. LCMs, LCVPs, LCUs, Gulf Coast work boats and deck barges (considered the prime candidates for the oil/sorbent harvester system) were the types of vessels included in the survey. In all three ports deck and hopper barges were so numerous that an exact count would have been superfluous. The number of vessels counted in the three ports should be considered conservative (i.e., the minimum number of vessels that would be available), since by the very nature of the survey (a one-day vessel count) many other suitable vessels that normally homeport in the three ports could have been out working and would not show up in the count.

The U.S. Navy has large facilities in all three of the ports visited and many Navy LCMs, LCUs and LCVPs were seen; however, all U.S. government vessels were specifically excluded from the vessel survey. Results of the vessel survey shown in Table 8 indicate that in all ports surveyed a sufficient number of vessels were found to handle a large oil spill.

Table 8

VESSEL SURVEY IN WEST COAST PORTS

PORT	VESSEL LCM- 3 or 6	LCM-8	LCU	Gulf Coast Work Boat	LCVP	Deck Barges
San Francisco Bay	10				2	Numerous
Long Beach	7		4*	4	4	Numerous
San Diego	3	5	1	1	1	Numerous

* Two of the LCUs were severely modified - no propulsion

OTHER TYPES OF VESSELS

In addition to the aforementioned types of vessels, occasionally other suitable craft may be locally available, such as:

- Naval seaplane wreckers (YSDs or MaryAnns)
- Self-powered barges
- Some tug and tow boats with large open decks
- Some small coastal lighters
- Miscellaneous special purpose craft.

Essentially, any craft meeting the requirements listed in the beginning of this section may be adapted. Modifications to these variable types are expected to be the same as outlined for the primary vessels, with minor variations.

SUPPORT VESSELS

Support vessels will depend on spill characteristics such as spill size, weather conditions, etc. These vessels will consist of supervisory craft, boom tenders, and supply craft, and may range in design from pleasure yachts to supply and tug boats. Where direct land discharge of oil/sorbent picked up by the harvesting vessels is not practical, additional storage vessels such as deck barges equipped with cranes would be required. Such vessels should be strategically positioned with regard to initial slick location and predicted oil spill movement. These large deck barges could act both as storage vessels for recovered sorbent and as storage vessels for fresh sorbents.

CONVEYOR SYSTEM REQUIREMENTS

A survey of selected conveyor manufacturers was made and literature collected in order to determine the various types of conveyors that are commonly available and could be considered candidates for the oil/sorbent harvester system. Based on this survey, specific conveyor requirements were defined and are listed below:

- Portable or mobile conveyor
- Driving motor on discharge end or center of conveyor
- Conveyor length between 10 and 60 ft
- Loading (or lower) end of conveyor free of hydraulic connections.

The light frame conveyor (Fig. 26) was found to be ideally suited for the oil/sorbent harvester system as it met all of the above requirements.

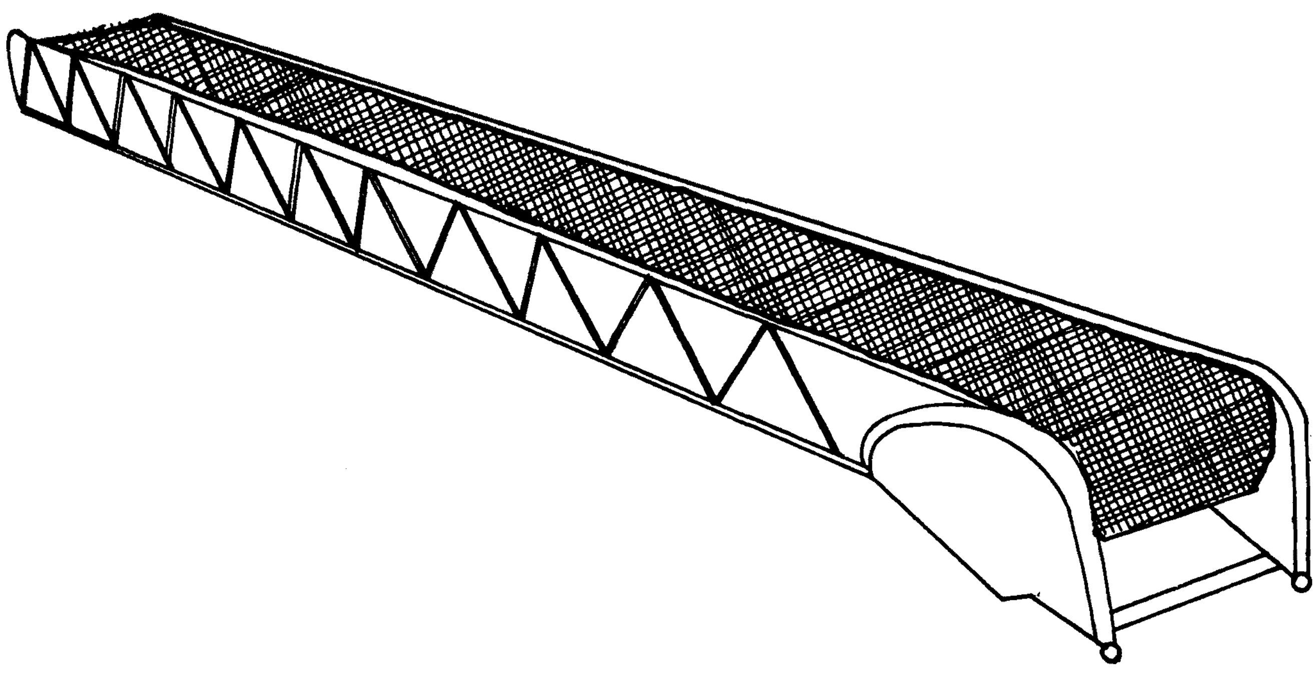


Fig. 26. Frame Conveyor

Furthermore, a check of construction equipment rental yards in the San Francisco Bay area found that the frame conveyor in 16-ft and 26-ft lengths was the most readily available for rent of any type of portable conveyor (the largest rental agency in the area has 60 of them in his inventory). The mobile or portable conveyor was the other type found to be suitable for incorporation into the oil/sorbent harvesting system. This type of conveyor is essentially a frame conveyor mounted on an undercarriage with wheels (Fig. 27) allowing the conveyor angle and height to be adjusted. The availability of this type of conveyor is not as great as the frame conveyor; however, most rental yards contacted had several in stock. For LCM application, the undercarriage and wheels of the portable conveyor could be retained with the whole assembly affixed by turnbuckles or cables. For any side-mounted configuration, it would be best to remove the undercarriage before installing the conveyors. Specifications of various conveyors found suitable for the oil/sorbent harvester system are given in Table 9.

Table 9

SUMMARY OF PORTABLE AND FRAME CONVEYOR EQUIPMENT SPECIFICATIONS

COMPANY AND MODEL	LENGTH OF CONVEYOR (ft)	WIDTH OF CONVEYOR (in.)	BELT SPEED (fpm)	ENGINE SITE (hp)	CAPACITY cu/yds/hr
Farquhar-343T	20 - 40	18 - 24	100	11 15	60 - 90
Rapistan General Duty	10 20	10 - 16	55	1 1/2	15
Morgan	40 56	16	400	17*	40 80
Morgan EB	24 - 32	16	100	3	40 - 80
Kolberg-200	30 50	18 - 36			
Rapistan-4121	15 25	12 - 18	150	2	27 - 50
Pioneer	10 - 100	18 42	100 - 500	3 - 50	38 1000
Blackwell Creteveyor	42 - 57	16	400	17*	40
Clearfield C&H Series	16 - 41	12 - 24	250	3 - 20	20 30
Clearfield D-2,3	16 - 33 1/2	16	350	7 1/2	60

* Hydraulic

Note: All conveyors are portable except the Clearfield D-2,3 which is a frame conveyor.

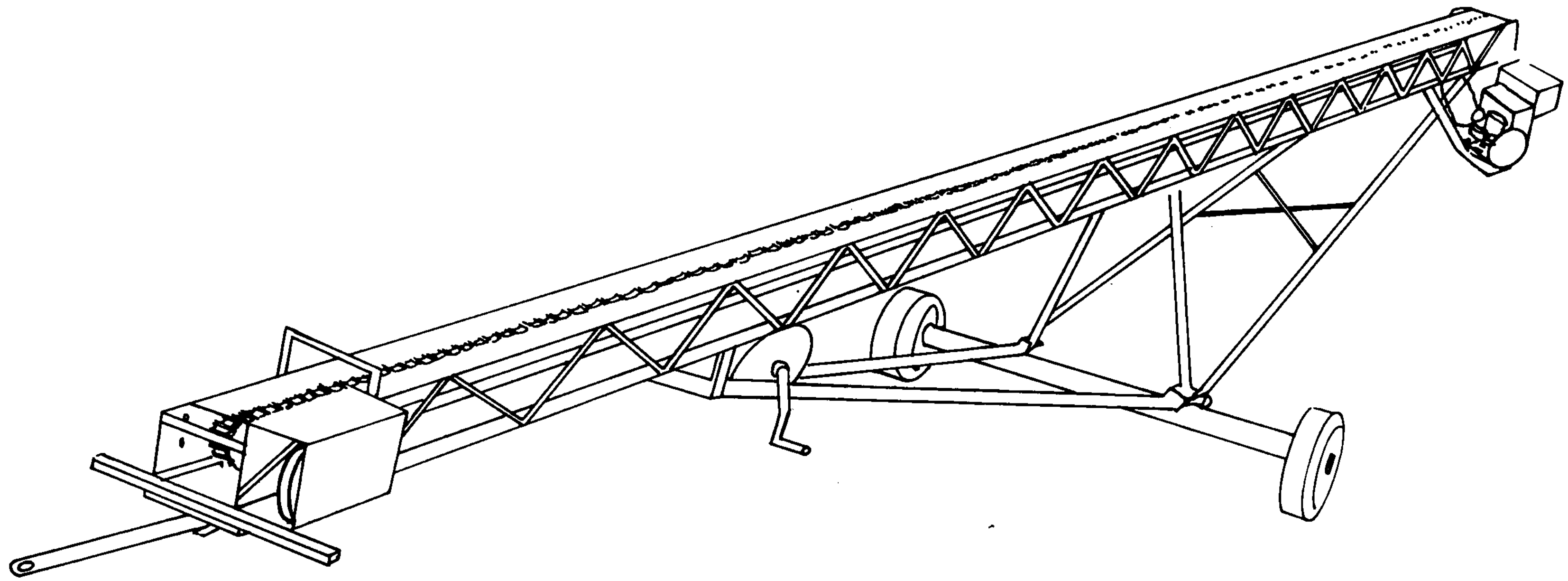


Fig. 27. Mobile Frame Conveyor

CONVEYOR BELTING MATERIAL

As previously discussed, four different types of conveyor belts were tested to evaluate their performance in harvesting oil/sorbent materials. The only type of belt that would self-load oil sorbents was the wire mesh belt, and therefore it was the only one included in a survey of availability.

Three different sizes and two types of wire mesh (Figs. 16 and 17) were evaluated in the test program. They all performed equally well and are recommended for use. The specifications of these belts are given in Table 10. There are literally several hundred different sizes and types of wire belts available commercially from manufacturers throughout the country. Time and funding did not permit the evaluation of more than a few belts. However, some recommendations concerning the proper belting to use are given below.

- Openings in the wire belts should between 1/4 in. and 1 in. Smaller openings might clog when used with very viscous oils, and openings greater than 1 in. might allow certain sorbents to pass through.
- The wire gauges of the wire belts should be between 8 and 20. Lighter gauges might break with heavier use and heavier gauges might not be flexible enough to bend around the head and tail pulleys of the conveyor.
- Use of the flat wire belt requires removing the friction pulley at the other end of the belt and replacing it with appropriately sited gears for a direct drive.

Table 10

SPECIFICATIONS OF WIRE MESH BELTS

MESH DESIGNATION	APPROX. MESH SIZE (IN.)	DIA OF WIRE (IN.)	ULTIMATE STRENGTH (IN.)	APPROX. WT/SQ FT OF BELT (LB)
E 18-16-12 (equalized spiral wound)	3/4	0.1055	11050	2.04
F-1/2 x 1/2 (flat wire)	1/2	0.1205	700	2.50
E 30-30-44 (equalized spiral wound)	3/8	0.08	12880	1.35

The biggest drawback in using wire mesh belting on the conveyors is relative availability. Almost all frame and portable conveyors available for rent come with smooth rubber or flighted rubber belts. This requires that the rubber belts be removed and replaced with wire mesh belts, a procedure which takes two men approximately 1/2 hour. Normally proper wire mesh belts are not readily available for purchase or rental in a few hours' time. Most wire mesh belting is made to order. The lag time on ordering wire belting is from 5 days to 3 weeks. It is therefore recommended that intended users of the oil/sorbent harvester system purchase the required wire mesh belting before an oil spill incident occurs and stockpile the belting at their own facilities. Wire mesh belting costs between $1.50 and $3.00 per sq ft, depending on the type and quantity purchased. Table 11 lists some of the major manufacturers of wire mesh belts.

Table 11

LARGE MANUFACTURERS OF WIRE MESH BELTS

FMC Corp., Link Belt Division, Chicago, Ill.
Alloy Wire Belt Co., San Jose, Calif.
U.S. Steel, Cyclone Fence Division, Pittsburgh, Pa.
Conveyor Systems, Inc., A.B. Farquhar, Morton Grove, Ill.
Cambridge Wire Cloth Co., Cambridge, Maryland
Ashworth Products, Inc., Metal Products Div., Worcester, Mass.
Allied Steel & Conveyors, Detroit, Mich.
Rapistan, Inc., Grand Rapids, Mich.
Standard Conveyors, St. Paul, Minn.
Hytrol Conveyor Co., St. Louis, Mo.
Robins Conveyor Co. - Hewitt Robins Div., Passaic, N.J.
CF&I Steel Corp., Trenton, N.J.
E.W. Bushman Co., Cincinnati, Ohio
Matthews Conveyor Co., Div. Rex Chain Belt, Ellwood City, Pa.

SORBENT SPREADING EQUIPMENT

The only type of sorbent spreading equipment tested was the power mulcher, a machine which has gained wide acceptance in oil spill control for its ability to disperse large quantities of sorbents onto a spreading oil slick.

Mulch spreaders (Fig. 28) are designed specifically for the fast distribution of mulch materials to assist in the control of soil erosion. They are equipped with a discharge spout designed to move a full 360 degrees horizontally and 75 degrees vertically, thus allowing the operator to spread the mulching material without repositioning the mulcher. Mulchers have been used in oil spill control by mounting them

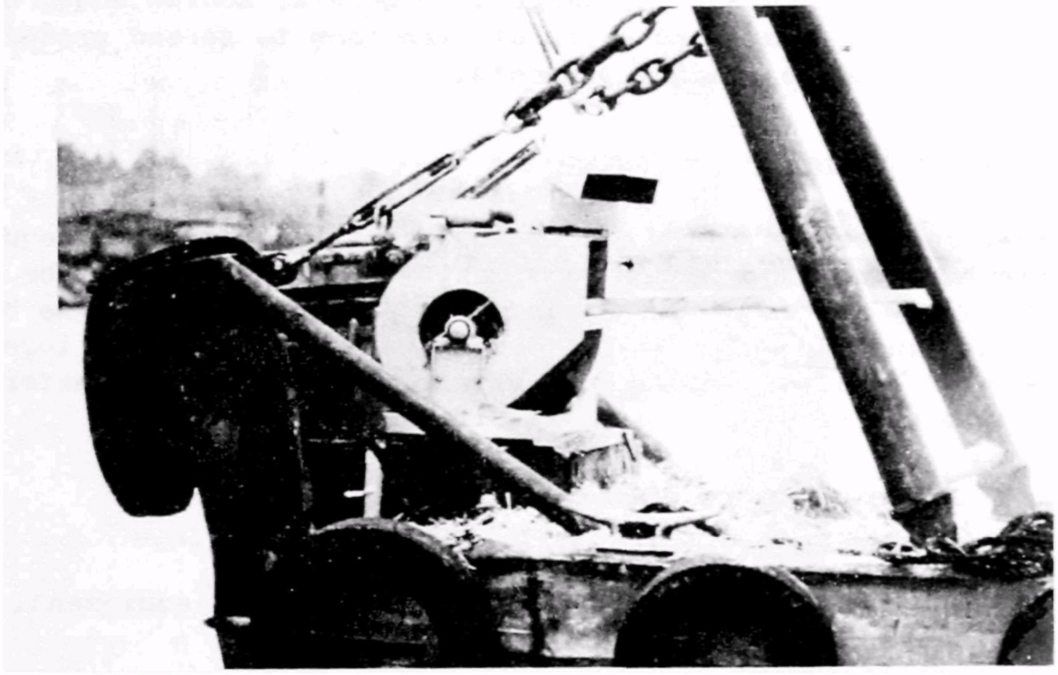


Fig. 28. Mulch Spreader

on boats and dispersing straw and/or polyurethane foam over oil slicks. Two sizes are generally available: a large trailer-mounted mulcher with a 9-ton/hr (straw) capacity, and a smaller skid-mounted mulcher of 4 ton/hr capacity. Table 12 presents the specifications of mulching equipment.

Table 12

POWER MULCHER SPECIFICATIONS

MODEL AND MANUFACTURER	MOTOR SIZE (HP)	MOUNTING	CAPACITY (TONS STRAW/HR)
Finn-Bantam	30	Skid or Trailer	4
Finn Mulch Spreader	110	Trailer	10
Reinco. TM7-30	30	Skid	4
Reinco. M60F6	124	Trailer	9

The short-term availability of power mulchers is somewhat less than that of the other oil/sorbent harvester components. The largest source would be the State Highway Department which uses them for erosion control on steep highway cuts. The largest commercial source would be professional seeding companies which utilize them to spread protective covers over large-scale seeding projects.

SPECIAL MATERIAL-HANDLING EQUIPMENT

The physical recovery of large quantities of oil and sorbents requires appropriate handling and storage equipment. Most vessels will be limited in their capacity and require periodic unloading. In the course of the study various handling and storage systems were investigated, together with associated onshore support facilities. The oil/sorbent material-handling equipment can be broadly classified as:

- Onboard storage equipment
- Onboard material-transfer equipment
- Onboard and/or onshore lifting or hoisting equipment.

Onboard Storage Equipment

Large metal bins such as high-volume trash containers commonly called "debris boxes" (Fig. 29) were utilized during Phase III of the test program and found to be very suitable for use in the oil/sorbent harvesting system. The debris boxes range in size from 5 to 40 cu yd capacity with 10- and 15-cu yd boxes being the most common size. For general application on LCM-size vessels the debris boxes are simply placed under the unloading end of the conveyors collecting and storing the oil/sorbent coming off the conveyor belt. When the debris box is full the vessel goes to an unloading station, unloads the full box and receives an empty one. For use on larger pickup vessels such as deck barges, LCUs, and Gulf Coast work boats, a multiple array of debris boxes can be placed on the open deck areas and loaded by using transfer equipment between the pickup conveyors and the debris boxes. The availability of debris boxes is generally very good as there are many firms in metropolitan areas that specialize in renting them for commercial use. Table 13 lists the specifications of some debris boxes.

Another possible oil/sorbent storage method applicable to smaller pickup vessels such as LCMs and LCVPs is the use of a cargo net or tarpaulin. The large nets or tarpaulins can be lined with polyethylene plastic and placed underneath the unloading end of the conveyors. Fresh tarps or nets would be placed on the straw pile for every 2 ft of height. The tarpaulin or net could be offloaded by crane at an unloading point.

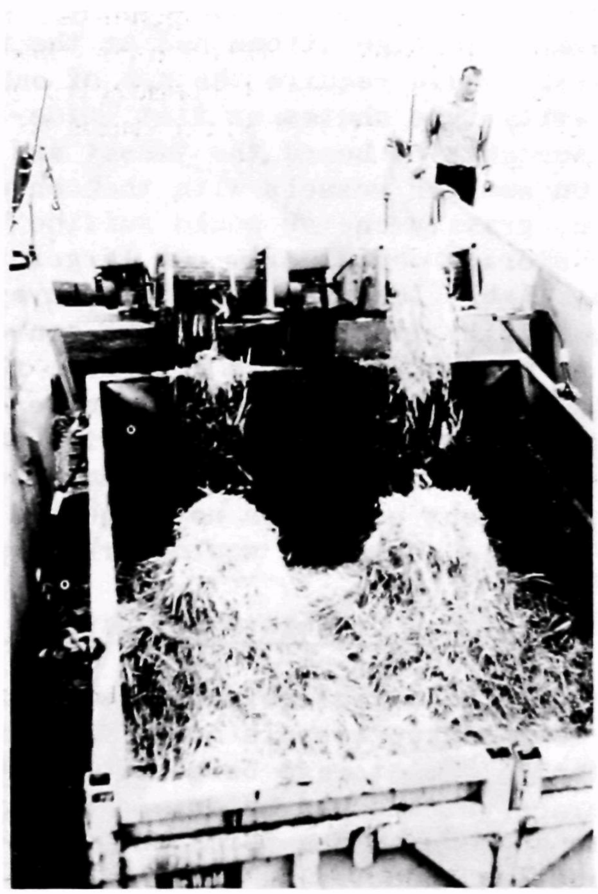


Fig. 29. Debris Box

Table 13

SPECIFICATIONS OF CONTAINERS AND BINS

COMPANY & MODEL	DIMENSIONS (WxLxH)	CAPACITY (cu yd)	WEIGHT (lb)
Hobbs CO 300	8' x 16'8" x 6'8"	30	5800
Hobbs HFL 2	3' x 6' x 3'	2	
3		3	
4		4	
5	to	5	
6		6	
7		7	
8	5'6" x 6' x 6'8"	8	
Anchor Pac. 2022	22' x 8' x 41"	20	6350
2522	22' x 8' x 51"	25	6600
3022	22' x 8' x 61"	30	6910
4022	22' x 8' x 81"	40	7740

MATERIAL-TRANSFER EQUIPMENT

The side-mounted conveyor configurations and/or the utilization of high-storage-capacity vessels would require the use of onboard transfer equipment such as gravity-type chutes or flat (side-loading) conveyors, to direct harvested sorbents on board the vessel and into the proper storage container. On smaller vessels with the conveyors in the side-mounted configuration, gravity chutes would suffice to direct the collected sorbents into storage containers. On larger vessels with multiple storage containers available for use, the flat conveyors with adjustable discharge chutes essentially identical to frame conveyors would be ideal for sorbent transfer. Figure 30 depicts a typical flat conveyor transfer installation on a deck barge. The flat transfer conveyor is fixed to the tops of the debris boxes it fills. Gravity chutes direct the collected sorbent from the unloading end of the pickup conveyor to the transfer conveyors. Since sorbent pickup is not required, smooth rubber belts which normally come on this equipment would work very well.

Onboard and/or Onshore Lifting or Hoisting Equipment

The major requirement for hoisting equipment is to transfer oil/sorbent-loaded debris boxes from pickup vessels on to floating storage barges or a shore storage facility. Storage barges could use a portable truck or crawler-mounted crane which could be driven onboard or lashed down to the barge, or utilize a barge with a permanent crane installed (common in the marine construction industry). Shore storage facilities could use the same truck or crawler-mounted cranes or the larger portable and locomotive cranes which run on tracks by dockside. Since there is a great variety of cranes available in any port facility, individual types will not be considered in this report. The major requirement in crane selection is that the heaviest lift that has to be made does not exceed the crane's hoisting capacity. This could become a problem if the larger (30-to-40-cu yd) debris boxes were used as the primary storage containers. The combined weight of a 40-cu yd debris box and its contents could be as great as 30 tons, which would exceed the capacity of many mobile (i.e., truck/crawler-mounted) cranes. Therefore, selection of the proper size debris boxes should also consider the lifting capacity of available cranes.

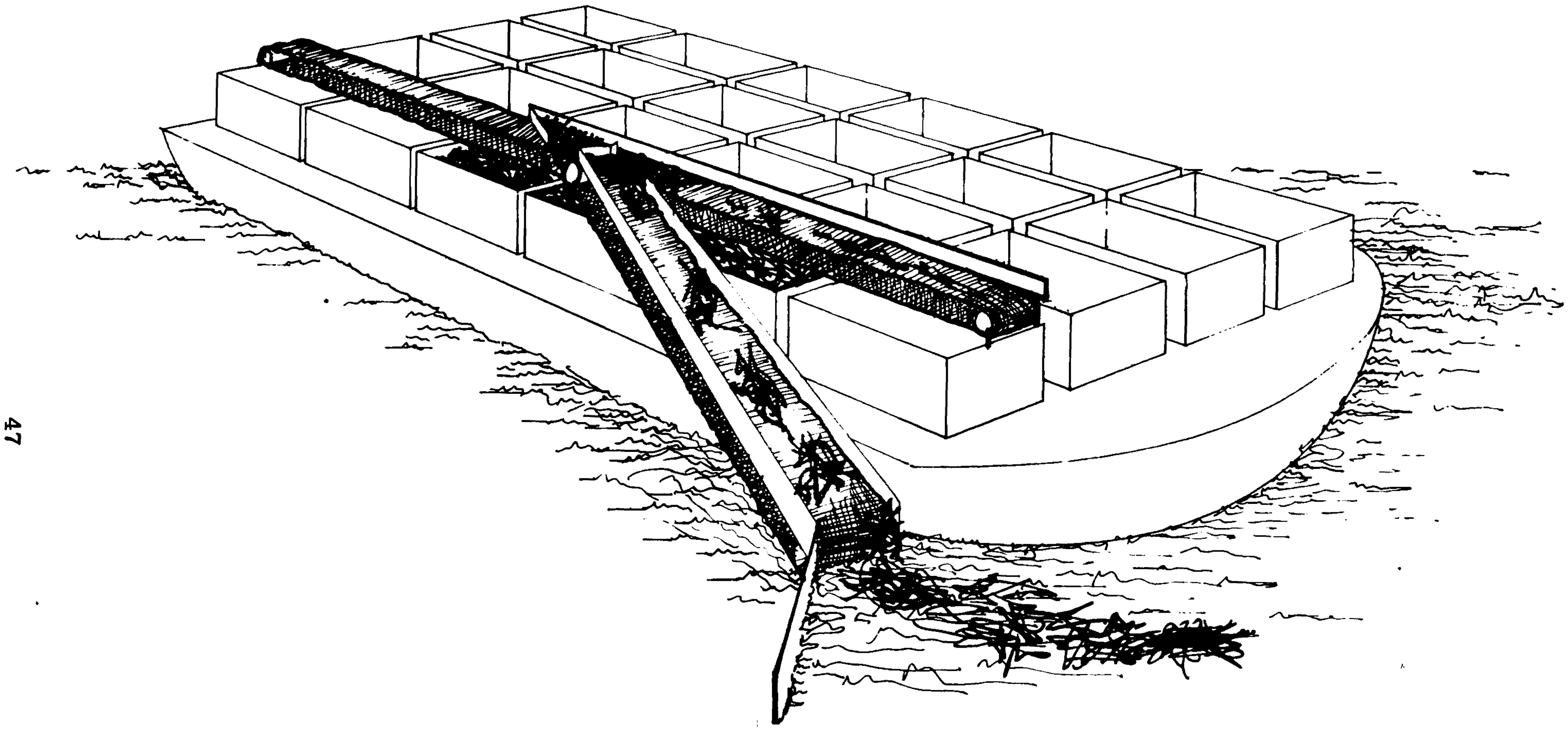


Fig. 30. Flat Conveyor Installed on Deck Barge

Section VI

INSTALLATION PROCEDURES (LCM)

The installation procedures required to install conveyors and associated equipment onto a landing craft (LCM) are given in this section. Table 14 lists the various operations required to complete an installation. Table 15 lists each operation, the labor skill and number of each skill required, and the time required under normal conditions to complete the operation. A flow chart is given in Figure 31 describing the actual path for the installation operation on an LCM. As shown, the entire system can be completely assembled in 9 hours.

A detailed description of each operation follows.

Table 14

OPERATIONS REQUIRED FOR INSTALLATION OF OIL/SORBENT RECOVERY SYSTEM ON LANDING CRAFT

OPERATION	DESCRIPTION
A	Fabricate Wing Support Structure
B	Cut Hole in LCM Ramp and Convert Conveyors to Wire Belts
C	Construct Rear Conveyor Support and Install Conveyors and Wing Support Brace
D	Fabricate Wings and Install
E	Fabricate Absorbent Guides and Splash Shield
F	Fabricate Flashings and Bullnose
G	Install Debris Box
H	Install Pumps - Separator
I	Install Straw Blower
J (alternate)	Gate-Removed Installation
K (alternate)	Installation of Side-Mounted Conveyor System

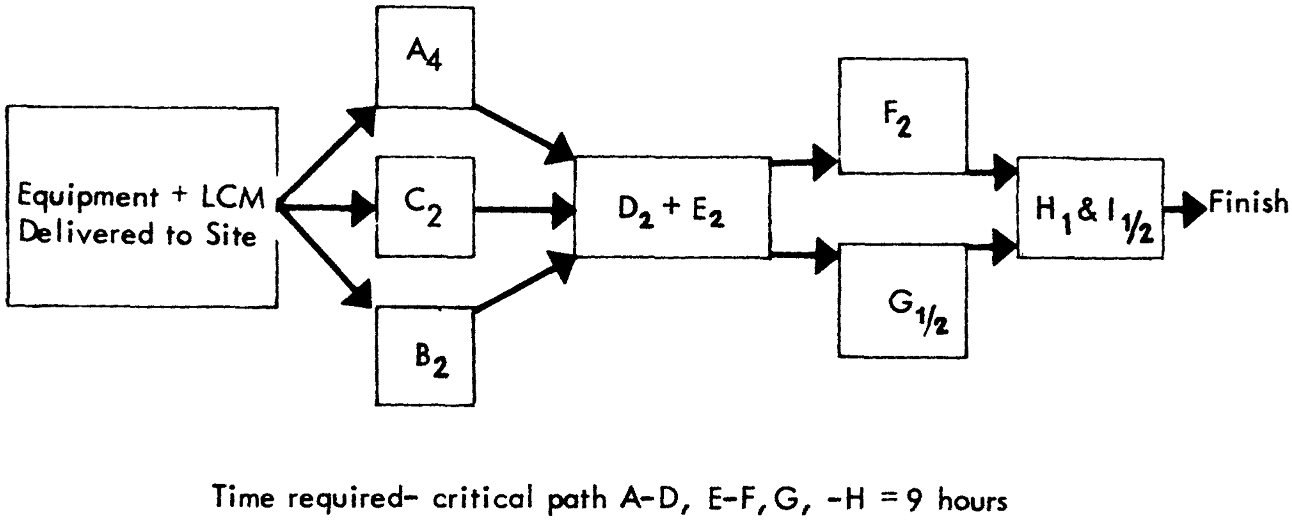


Fig. 31. Flow Diagram of Installation Aboard an LCM

Table 15

LABOR AND TIME REQUIREMENTS FOR INSTALLATION ON LCM

OPERATION	LABOR SKILLS REQUIRED	NO. OF LABOR SKILL	ELAPSED TIME (HR)	LABOR HRS REQUIRED (MAN HR)	COMMENTS
A. Fabricate Wing Support Structure (Dual Mount)	Welder	3	4	12	Includes measuring, cutting and assembly
B. Cut Opening in Gate of LCM and Convert Conveyors to Wire Belts	Welder	2	2	4	Includes initial
	Mechanic	1 }	1	2	adjusting of tension
	Laborer	1 }			both operations done simultaneously
C. Install Wing Support Structure and Conveyors in LCM	Welder	1 }	2	8	Includes installing conveyor motors
	Laborers	2 }			
	Equipt. Opr.	1 }			
D. Fabricate Plywood Wings and Bolt to Supporting Structure	Carpenter	1 }	2	4	
	Laborer	1 }			
E. Fabricate Guides and Splash Shield	Carpenter	1 }	2	6	
	Laborer	2 }			
F. Fabricate Flashings and Bullnose	Welder	1	2 }	6	Operations conducted simultaneously
	Sheetmetal worker	1	1 }		
	Laborer	1	2 }		
	Carpenter	1	1 }		
G. Install Debris Box	Laborers	2	1/2	1	
H. Install Pumps - Separator	Mechanic	1	1	1	
I. Install Strawblower	Laborer	1	1/2	1/2	Installed on separate vessel
	Welder	1	1/2	1/2	

Operation A. Fabricate Wing Support Structure

This structure is a heavy-duty welded steel unit required to attach and support the deflection wings. It must be sufficiently rigid to withstand both vertical and tangential forces, as well as the forward stress resulting from motion through the water. A sketch of this apparatus is shown in Figure 32.

1.0 Using 3-in. by 2-in. channel, weld together a rectangular structure with the dimensions shown in Figure 32. Brace this structure with steel plate triangles as required. Flanges in the upper corners are used in the illustrated structure. The purpose of this structure is to prevent twisting of the deflector wings and conveyors.

2.0 Cut the conveyor tracks and supports to the dimensions shown from at least 1-1/2 in. right angle stock. Weld the outer supports to the frame constructed in Step 1.0 at an angle of 70 degrees minimum. Cut and weld 1 by 2 in. channel supports as shown to complete this structure. Attach the conveyor tracks to this frame. The spacing between the tracks should fit the conveyor frames snugly. These tracks will allow later installation of the conveyor with U-bolts and provide for any required final adjustment.

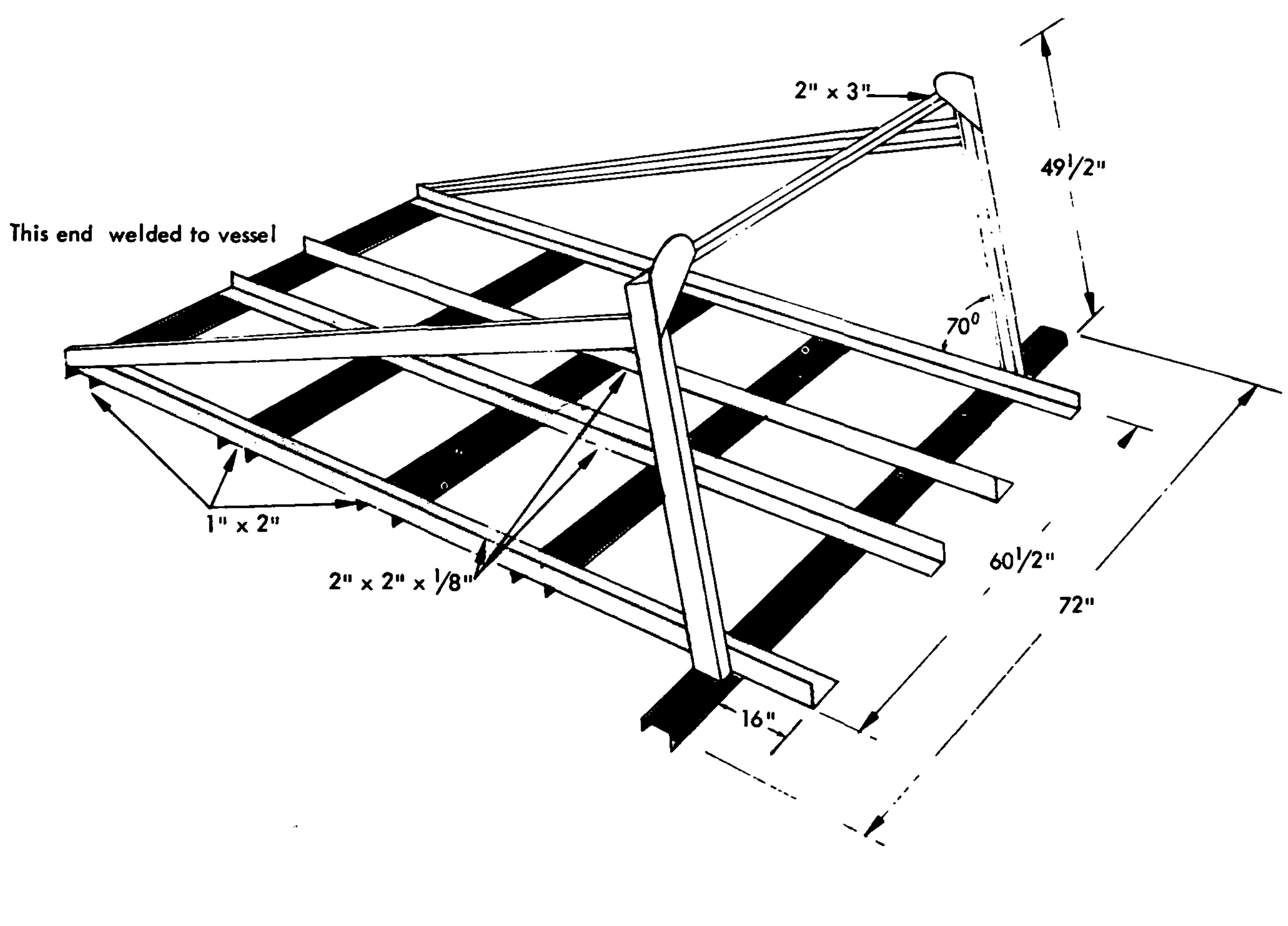


Figure 32. Wing Support Structure

3.0 Attach right angle or light channel braces to complete support of the structure.

4.0 Fabricate wing attachment pads out of 24 in. by 8 in. by 1/4 in. steel plate. Four plates will be required. Drill at least four 3/8 to 1/2 in. bolt holes (in pairs) in these plates to allow for later matching. Set aside one of each pair for Operation E. Weld remaining plates to the frame at an angle of approximately 30 degrees, as depicted in Figure 33.

5.0 Add braces and drill holes to complete structure shown in Figures 32 and 33.

6.0 A coat of primer is recommended if time permits.

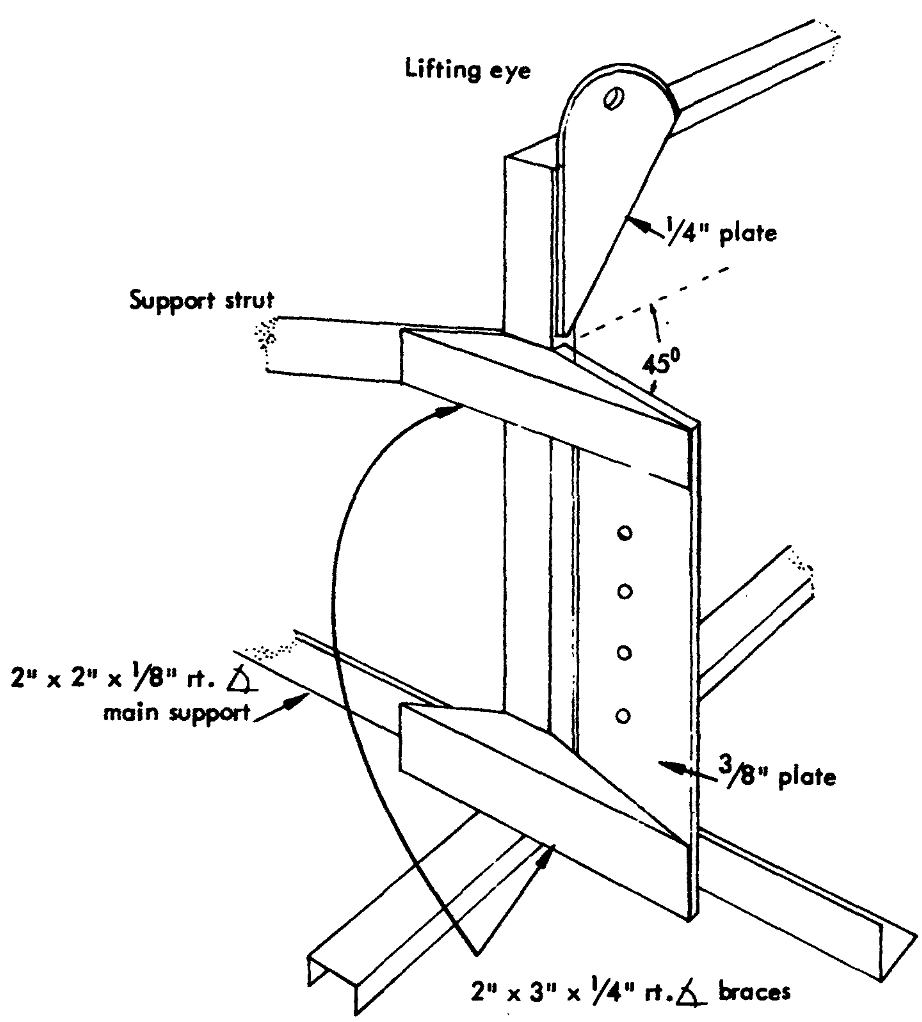


Figure 33. Wing Attachment Plate Detail

Operation B. Cut Hole in LCM Ramp and Install Belts

1.0 Mark the location of the hole (60 in. by 20 in. approx.) on the inside and outside of the ramp. The bottom of the hole should be just above the hinge line (Figure 34).

2.0. Using one welder inside and one outside in a small boat, cut out hole, using cutting torches as shown in Figure 35.

3.0 Install belt.

3.1 Spiral woven belt (shown in roll in Figure 36).

3.1.1 Check conveyor drive pulley for surface roughness. Prominent welded beads are necessary to prevent belt slippage, especially when oily. Surface roughness may be improved by welding additional beads on as shown in Figure 37.

3.1.2 Install belt and cut to proper length if necessary.

3.1.3 Adjust tensioning bolts until 1 to 2 in. of play is obtained between any two adjacent rollers. Fine adjustment may be required during operation.

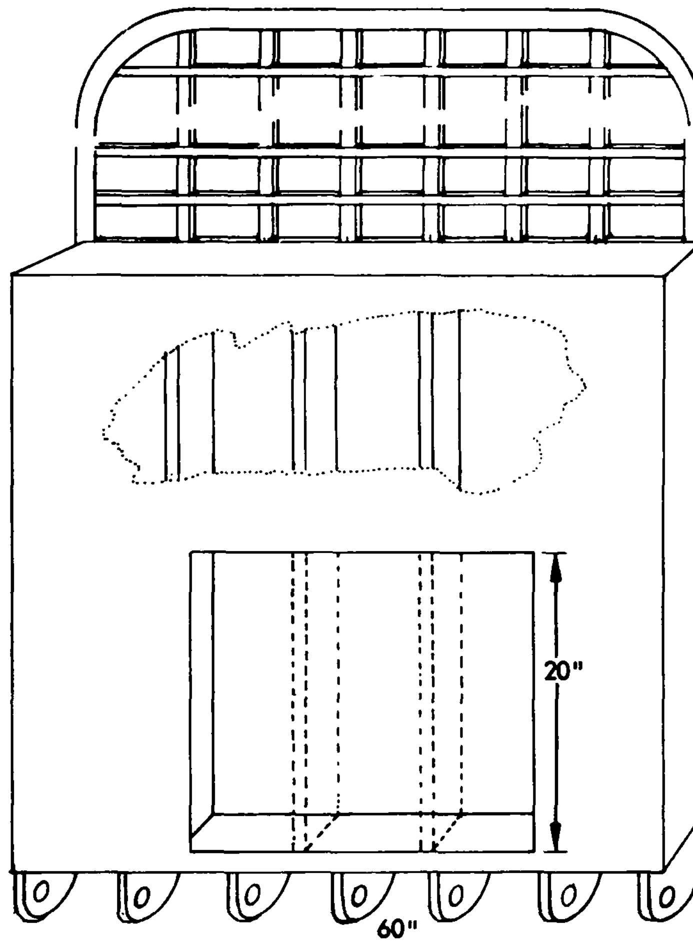


Figure 34. Typical Internal Structures Encountered in Hole Cutting

3.2 Flat wire belt (shown on conveyor in Figure 36). Flat wire belts require the installation of drive gears.

3.2.1 Remove standard drive pulley, bearings and shaft.

3.2.2 Mount drive gears and bearings on a keyed shaft, adjust to mesh with belt, and install on conveyor as shown in Figure 38.

3.2.3 Install wire belt and cut to proper length if necessary.

3.2.4 Adjust tension as in Step 3.1.2.

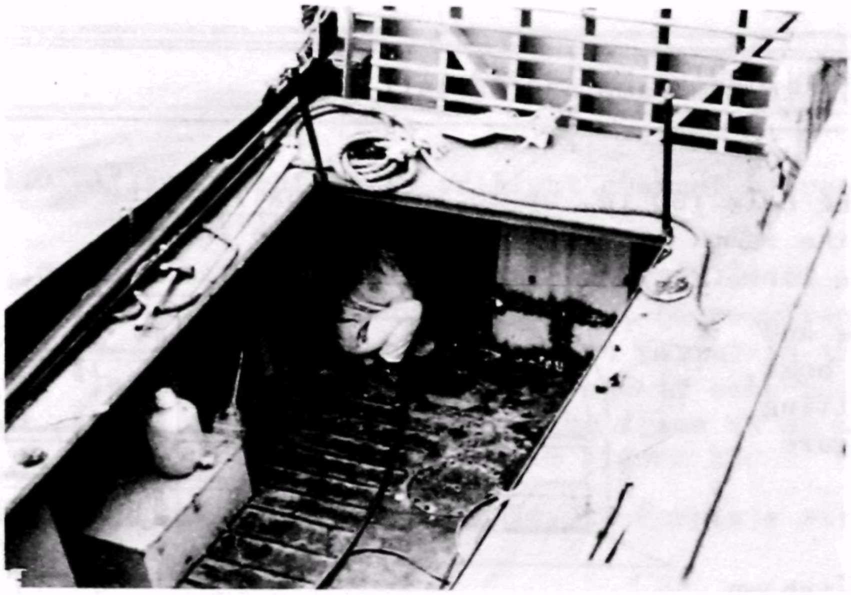


Fig. 35. Cutting a Hole in the LCM Ramp

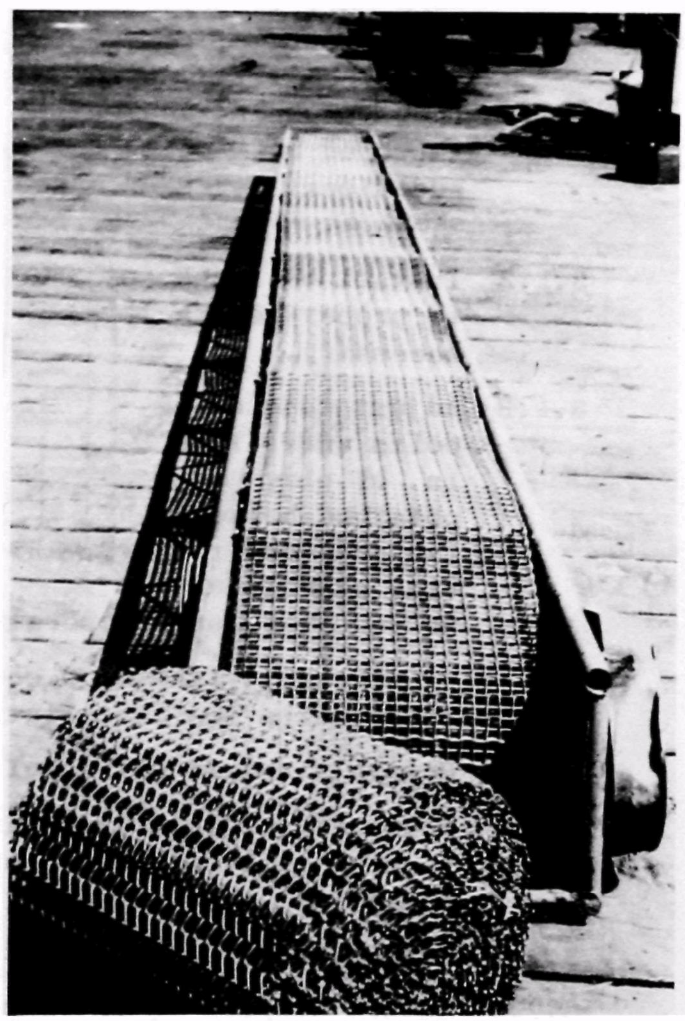


Fig. 36. Recommended Conveyor Belt Types

Fig. 37. Increasing Surface Roughness of Drive Pulley

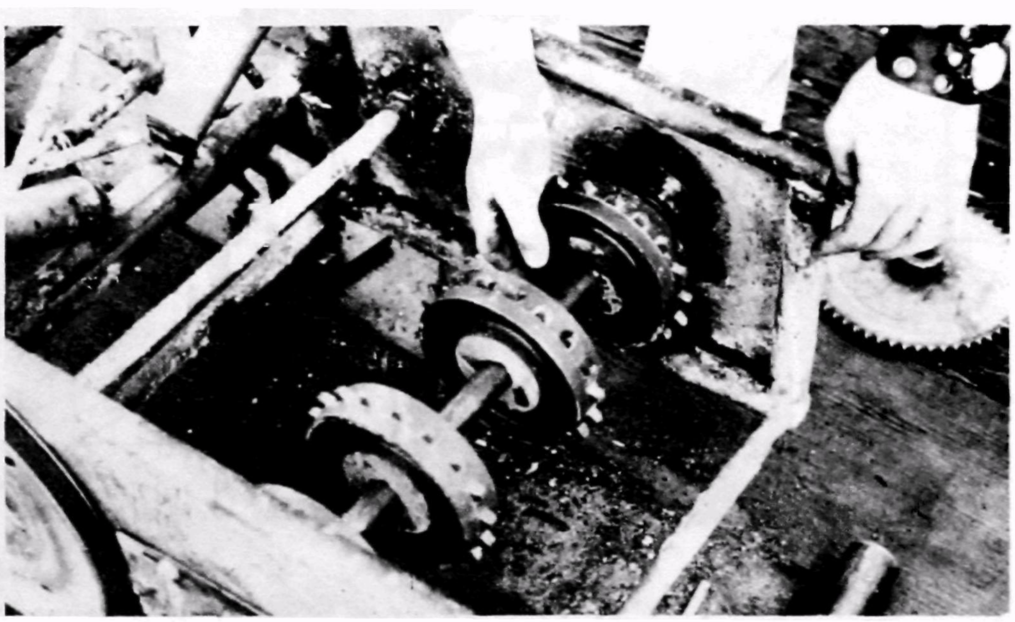


Fig. 38. Installation of Drive Gears

Operation C. Construct Rear Conveyor Support and Install Wing Support Structure and Conveyors

1.0 Sling the wing support structure into position as shown in Figure 39.

Figure 40 presents critical angles required in this operation. Weld the rear of the wing support structure to the ramp as shown.

2.0 Using another crane, swing the converted conveyor belts into position from the well deck side through the hole in the ramp.

3.0 Using U-bolts attach the conveyors to the conveyor tracks on the wing support frame.

4.0 The rear conveyor support consists of a piece of thick wall steel pipe or box section channel. Its location is arbitrary, but should be under or aft of the conveyor motors, if possible. It is most convenient to rest the support across the top of the well deck and slide it forward until the proper position is obtained. The support is then welded in place. If the specific LCM does not permit this, the pipe may be attached to the walls of the well deck. This is best accomplished by cutting the support narrower than the width of the well deck and attaching it to the conveyors with U-bolts. The ends of this support are in turn welded to the sides of the well with right angle brackets as shown in Figure 41.

5.0 Install a support attached to the center of the rear support at right angles to the conveyors and running to the well deck.

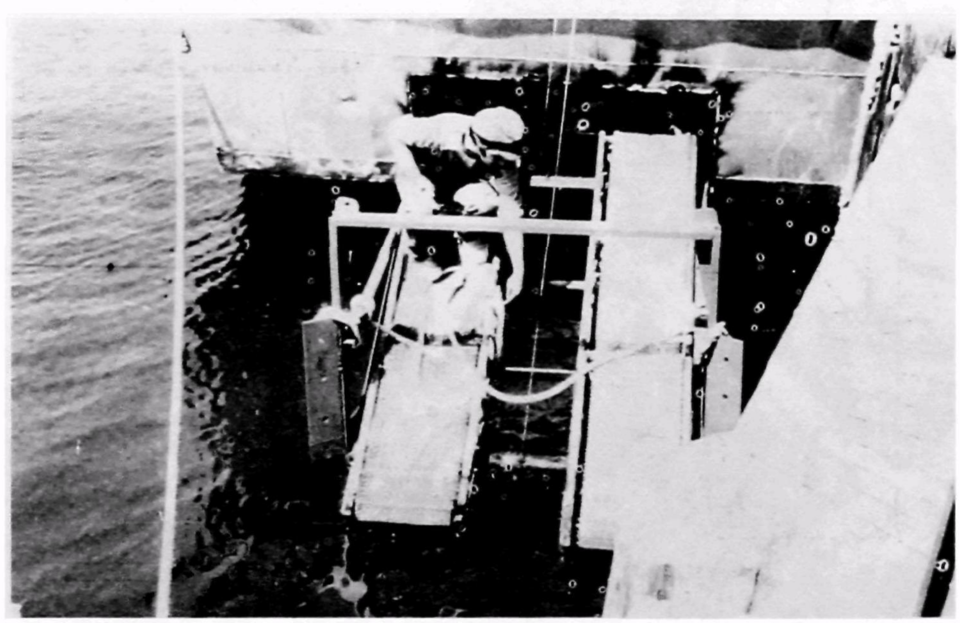


Fig. 39. Installation of Wing Support Structure and Conveyor Belts

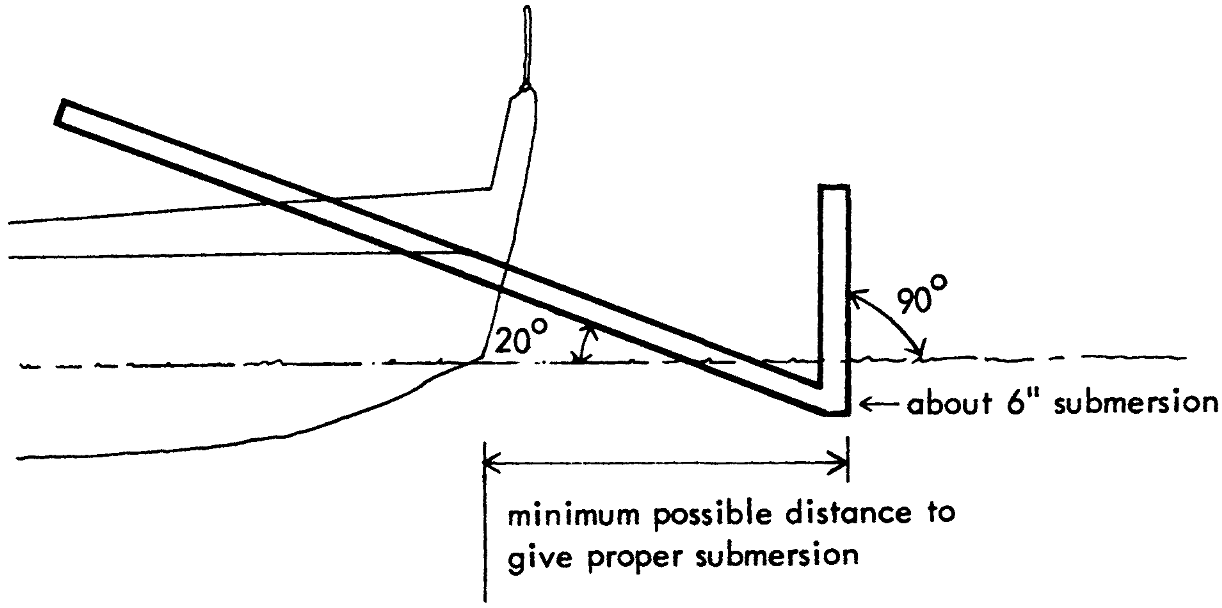


Fig. 40. Critical Installation Angles

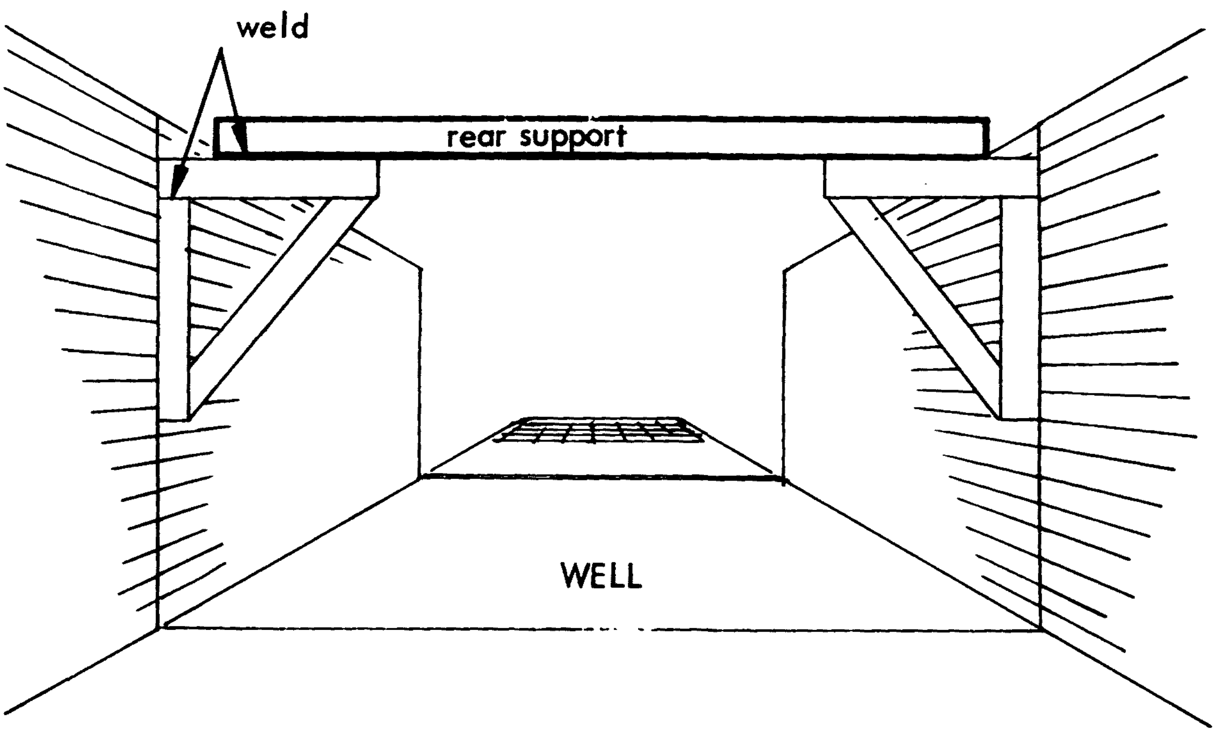


Fig. 41. Bracket Attachment of Rear Conveyor Mount

Operation D. Fabricate Wings and Install

Standard wing size for relatively calm operating conditions is 2 ft by 8 ft. For rougher water, a greater wing height will be required to prevent material from passing underneath. The material to be used is either 1-1/2 in. or (preferably) two 3/4-in. sheets of laminated exterior plywood.

1.0 Saw plywood into proper sizes.

2.0 Construct a rectangular supporting structure for each wing, as shown in Figure 42. This structure should be at least 1-1/2 in. right angle steel, with the exception of the attachment plate which was constructed in an earlier operation. The size of the frame should be slightly less than that of the plywood wing.

3.0 Drill holes in the frame as required to attach the plywood.

4.0 Assemble and bolt wings to LCM, as shown in Figure 43.

5.0 Construct deflector tips from at least 1/8 in. sheet metal. These deflectors reduce the loss of sorbent around the wing tips. They must be bent to parallel the keel of the vessel when bolted in place.

6.0 Install channel iron struts to support the wings. These struts must be installed to meet the requirements for each installation. A typical installation is shown in Figure 44.

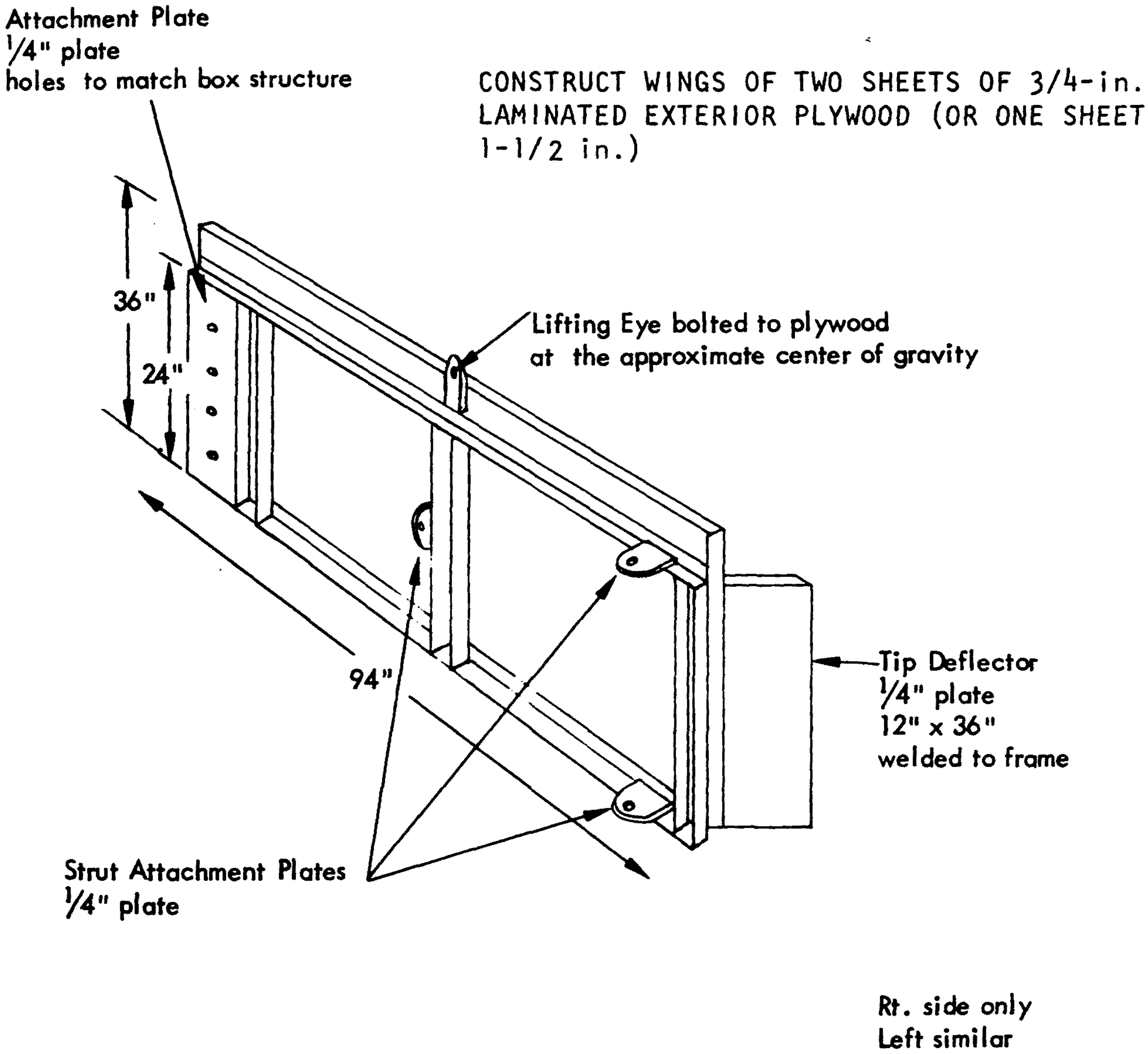


Fig. 42. Wing Support Detail

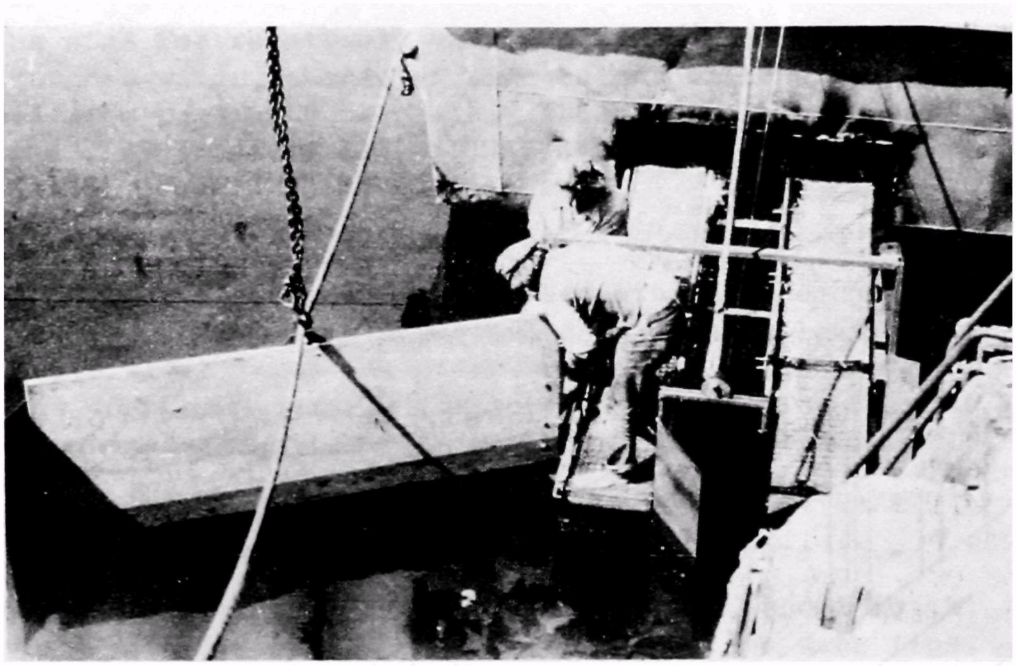


Fig. 43. Installation of Wings

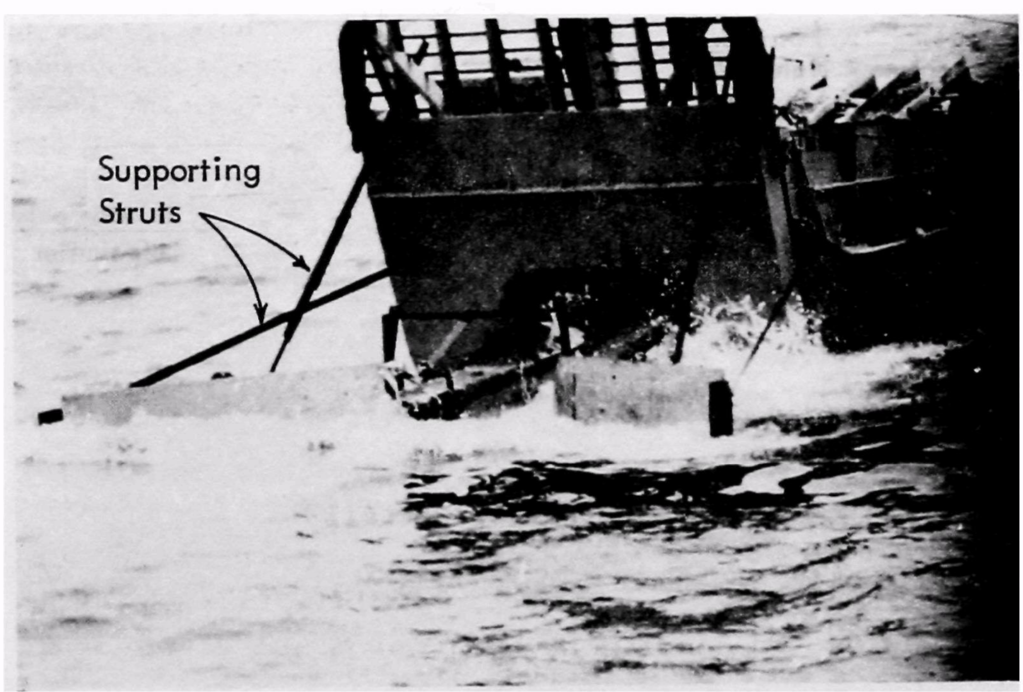


Fig. 44. Finished Installation Showing Supporting Struts

Operation E. Fabricate Guides and Splash Shield

Auxiliary guides along each side of the conveyors are required to prevent spillage of sorbents before reaching the debris box. The installation of a splash shield is required when the ramp is removed or has a hole cut in it. This shield consists of a false bulkhead to keep water out of the well deck.

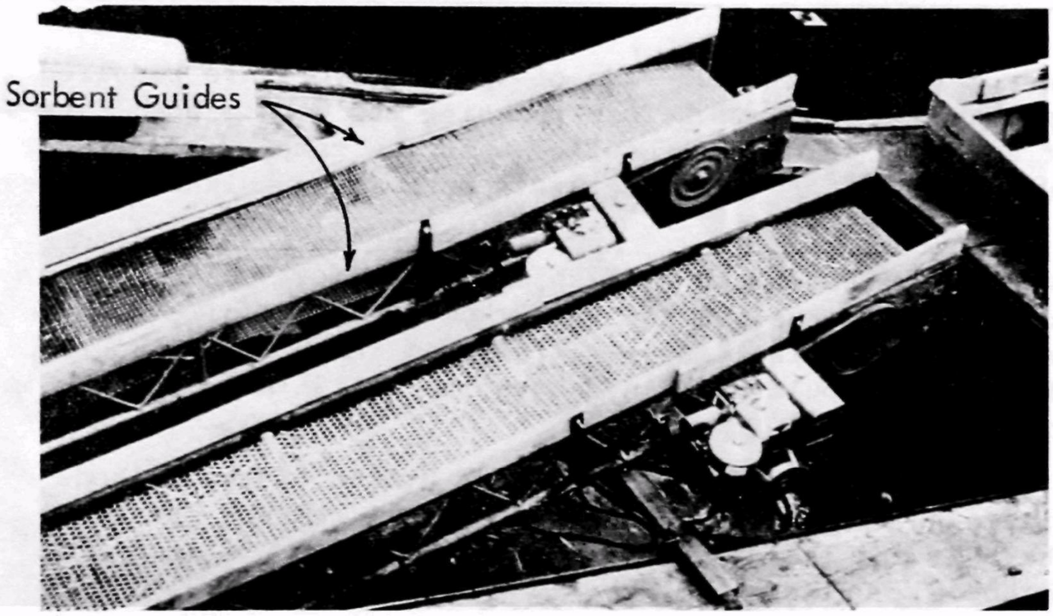
1.0 Sorbent guides should be fashioned out of 1/2-in. exterior plywood. Cut notches at the roller positions to allow the guides to fit between the conveyor frame and the belt. The height of the guides should be 6 in. above the belt. A typical installation is shown in Figure 45.

2.0 Attach the guides to the conveyors by one of the methods shown in Figure 46, using steel bolts. Method A reduces the space between the belt and the guide to a minimum, but is not as sturdy as Method B. Guides should be installed the entire length of the conveyors. The inboard guide is not needed with side-mounted installations.

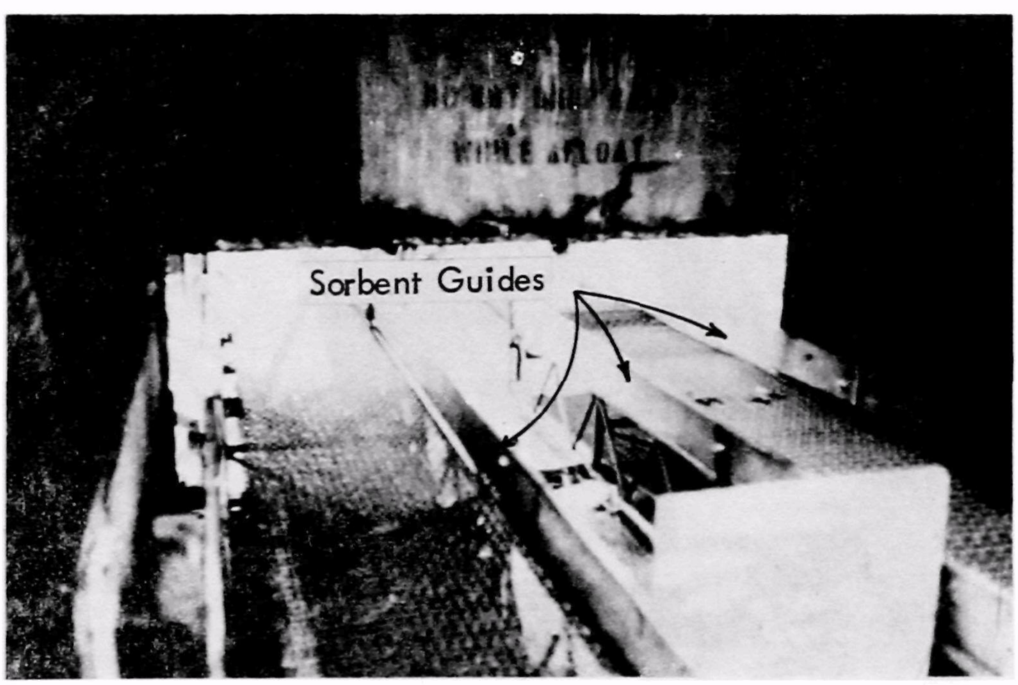
3.0 The splash shield should be constructed of 3/4-in. exterior plywood and fastened to the vessel as securely as possible.

3.1 Gate Removed. Fashion a false bulkhead to fit across the width of the well deck at a point that is usually about 3 to 4 ft from the bow. A representative installation is shown in Figure 47. Joints between the bulkhead and the LCM should be sealed with foam rubber.

3.2 Hole Cut in Gate. This mode greatly reduces the amount of water shipped. The shield in this case consists of a box attached to the bottom of the conveyors, as shown in Figure 48.



Method A



Method B

Fig. 45. Sorbent Guide Installation

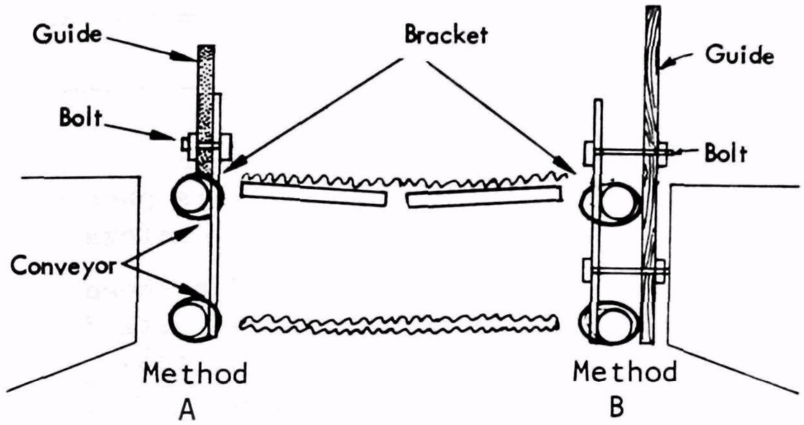


Fig. 46. Installation of Sorbent Guides

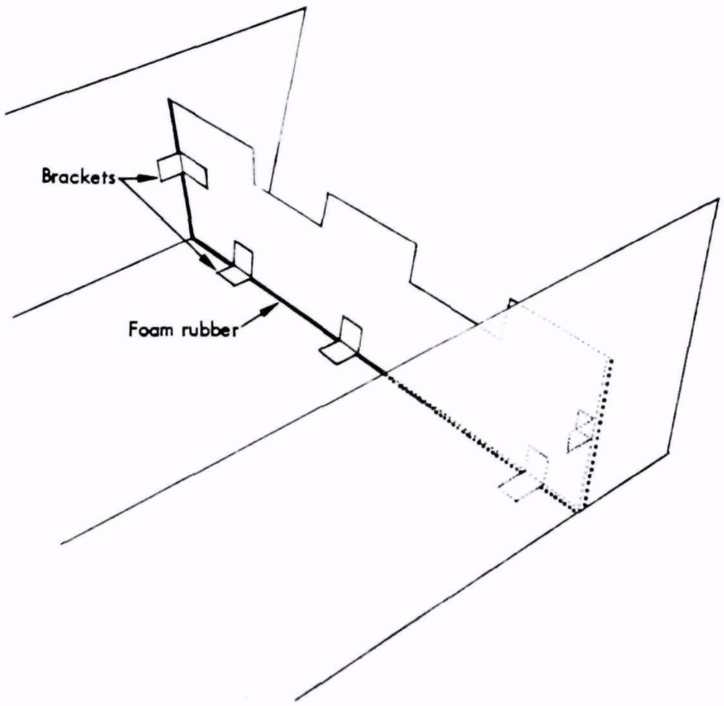


Fig. 47. Splash Shield, Gate Removed

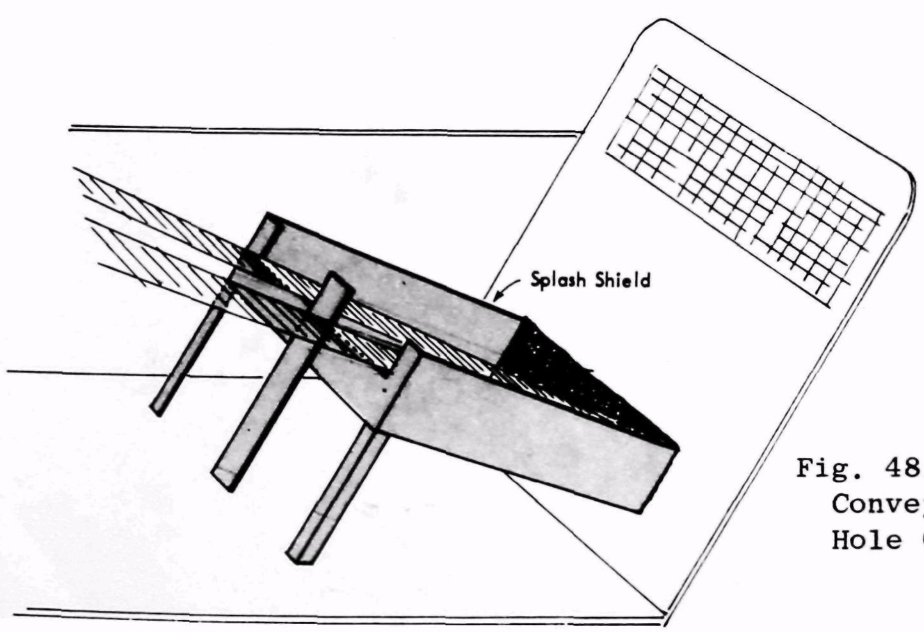


Fig. 48. Splash Shield, Conveyor Installed Through Hole Cut in Gate

Operation F. Fabricate Flashings and Bullnose

The lower end of the conveyor presents an irregular surface that tends to entrap and entangle absorbents and create turbulence. This phenomenon can be overcome by adding sheetmetal streamlining or flashings.

1.0 A streamlined structure (bullnose) must be constructed between the conveyors. This structure should be designed to withstand side as well as head-on forces. A schematic diagram of the installation is presented in Figure 49.

1.1 Construct the framework from 1 by 2-in. channel to the dimensions indicated.

1.2 Attach 2 by 3-in. channel to secure the bullnose to the wing support structure.

1.3 Cover the leading edge of the bullnose with heavy gauge sheetmetal.

1.4 Install the bullnose as shown in Figure 50. Attach support strut from top of bullnose to top of wing support structure.

2.0 Additional plywood flashing must be attached to the bullnose to prevent loss of absorbent between conveyors. The approximate shape and location of these flashings are shown in Figure 51.

2.1 Cut and install the triangular side pieces from 3/4-in. exterior plywood to suit individual installation.

2.2 Brace the structure internally with 2 by 4s.

2.3 Install a rectangular piece to complete the structure. In addition to strengthening the structure, this piece provides an emergency work platform.

3.0 Additional flashings must be added around the conveyor tips, using sheetmetal. A typical installation is shown in Figure 52.

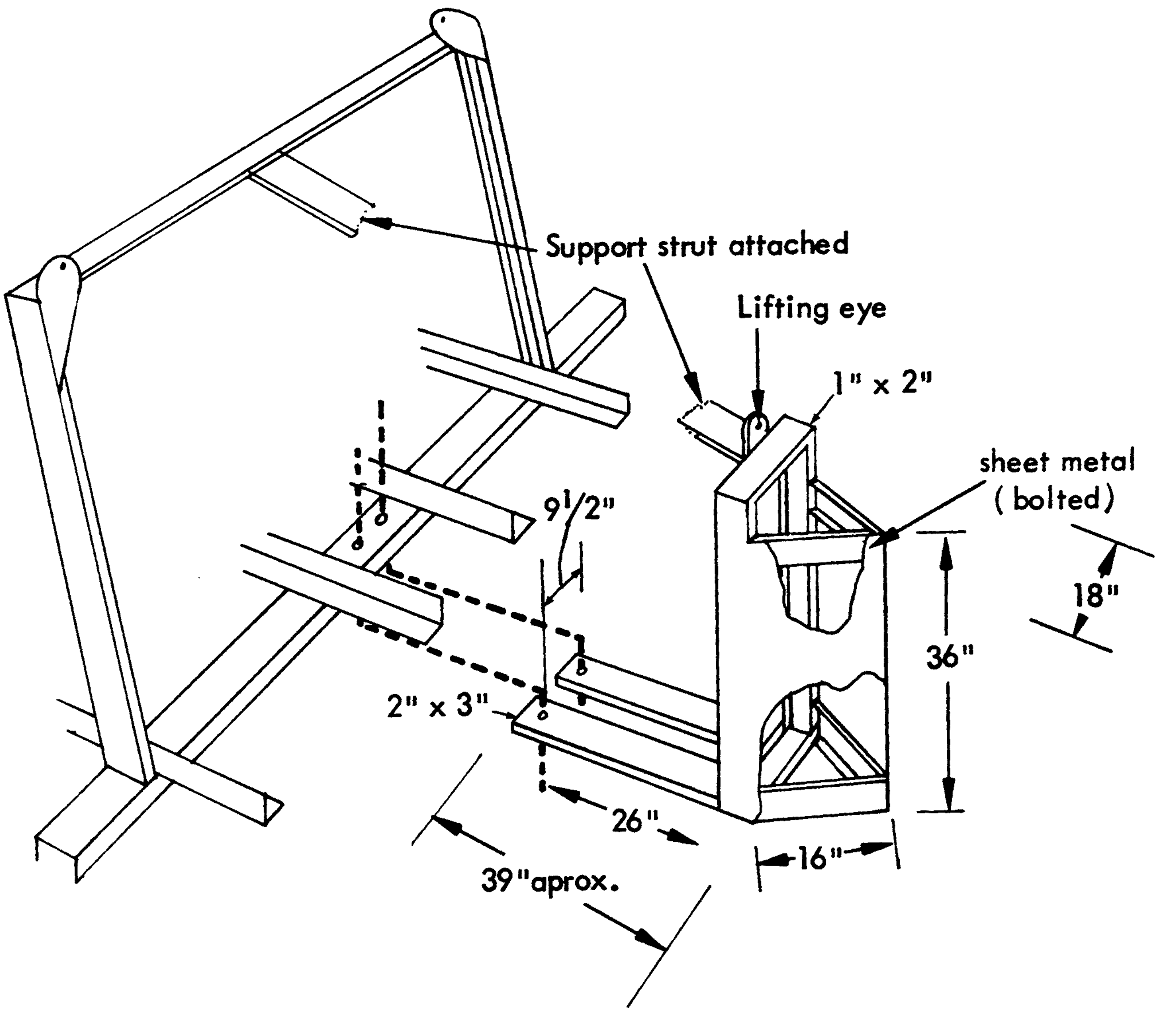


Fig. 49. Bull Nose

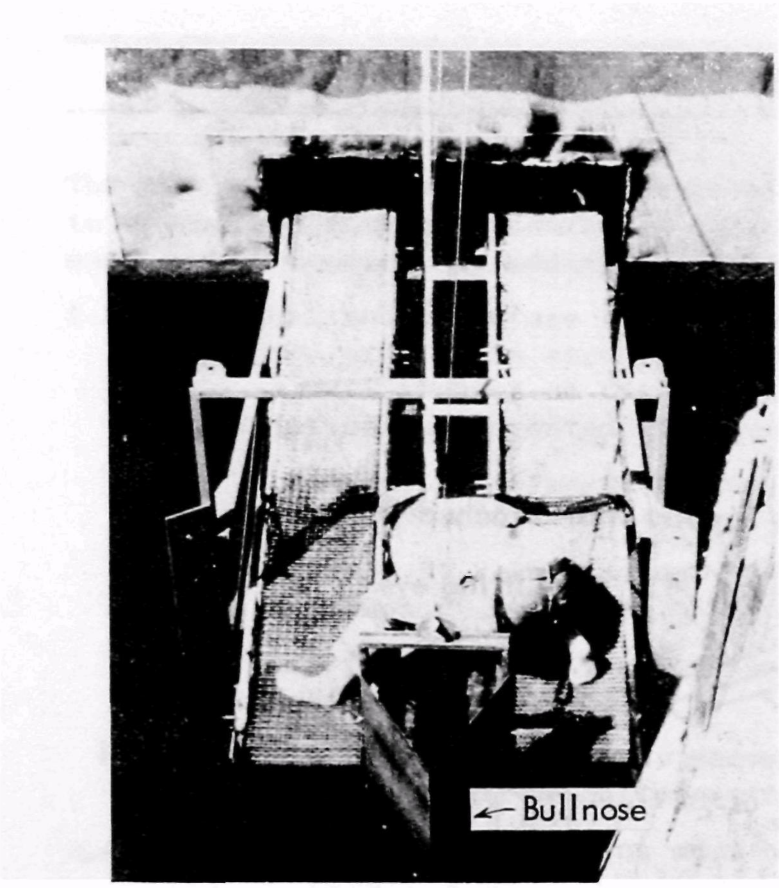


Fig. 50. Installation of Bull Nose

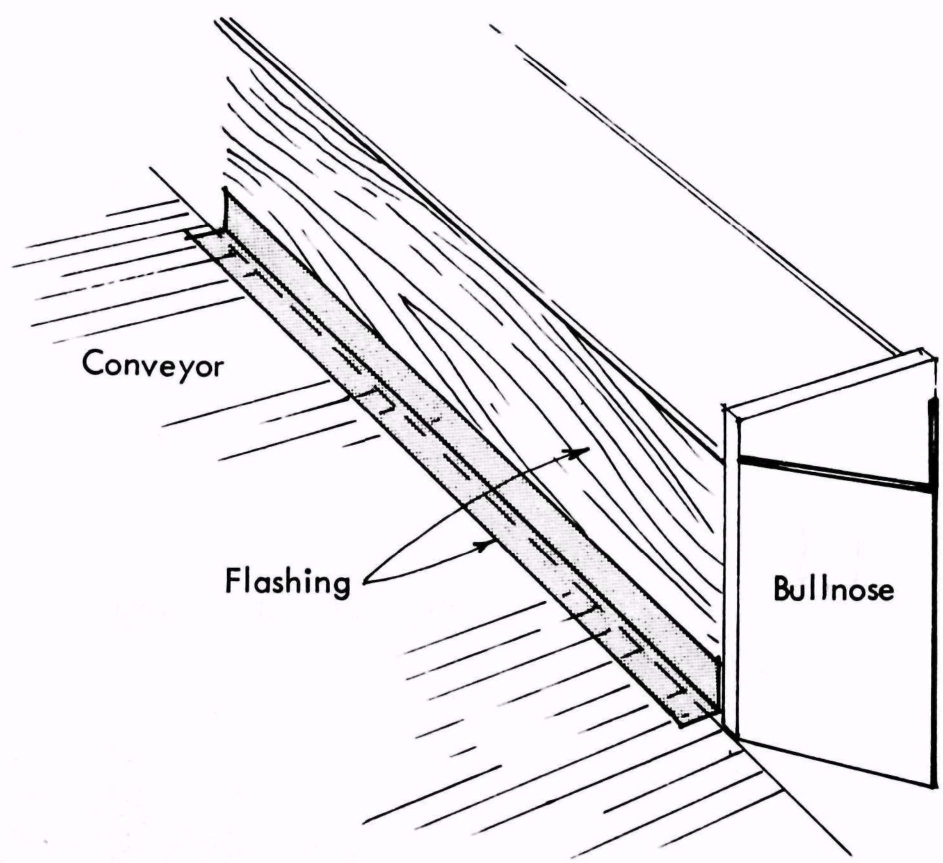


Fig. 51. Bull Nose Flashings

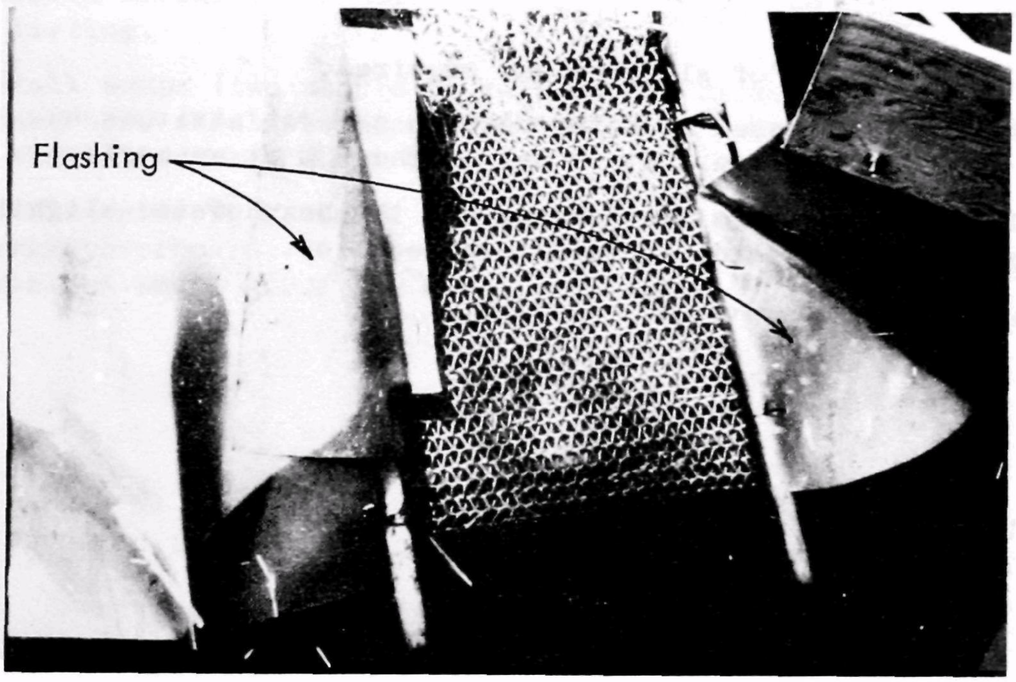


Fig. 52. Additional Bull Nose Flashings

Operation G. Installation and Removal of Debris Box

1.0 Select debris boxes 3 to 4 ft shorter than the available space (Figure 53) to allow for easier manipulation of the box, especially during an at-sea transfer.

2.0 Usually, two stages of slinging are required.

  2.1 The box is lowered from the dock in a level attitude by 4-point suspension. It is set in the LCM at an angle.

  2.2 The forward slings are removed and the box hoisted slightly, causing it to slide forward into position.

3.0 Removal requires a reverse operation.

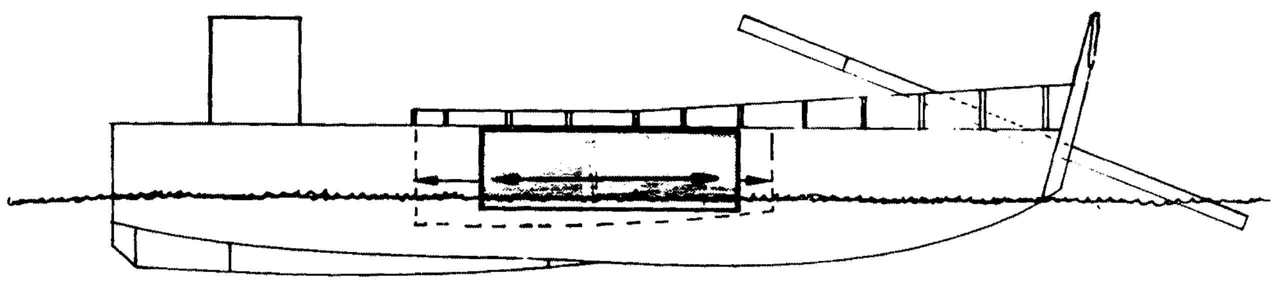


Figure 53. Installation of Debris Box

Operation H. Install Pumps and Storage Tanks or Separator

During operation water will be taken aboard from a variety of sources, including water brought aboard by the wire belts, water draining from the recovered sorbent, and spray. This water must be removed to prevent serious listing.

1.0 Install pumps (two should be carried for backup purposes). The intake hose should be placed in the bilge access at the rear center of the well deck (Figure 54).

2.0 As this water will almost certainly be oily, it should not be discharged overboard. Either install tanks to receive this material or install a small A.P.I. or C.P.I. separator.

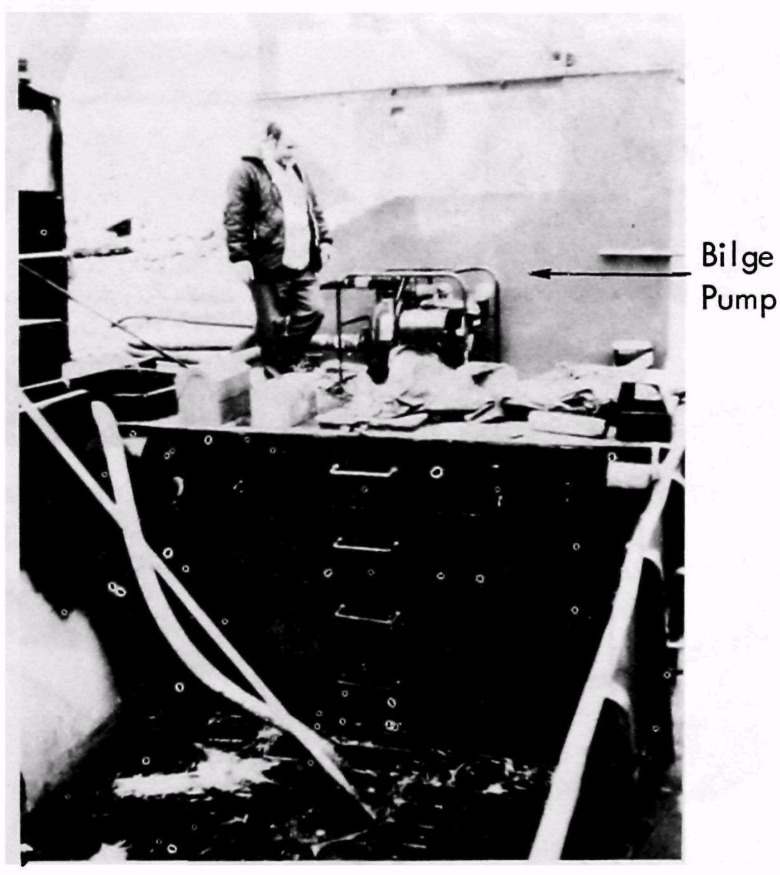


Figure 54 . Installation of High Capacity Bilge Pumps

Operation I. Install Straw Blower

1.0 The straw blower should be installed aboard any vessel of sufficient size to carry a large cargo of straw. (Another LCM would be ideal.) It may be mounted in the bow or the stern.

2.0 Position the blower to allow easy loading (Figure 55) of sorbent.

3.0 Weld the blower to the vessel if possible or lash it securely.

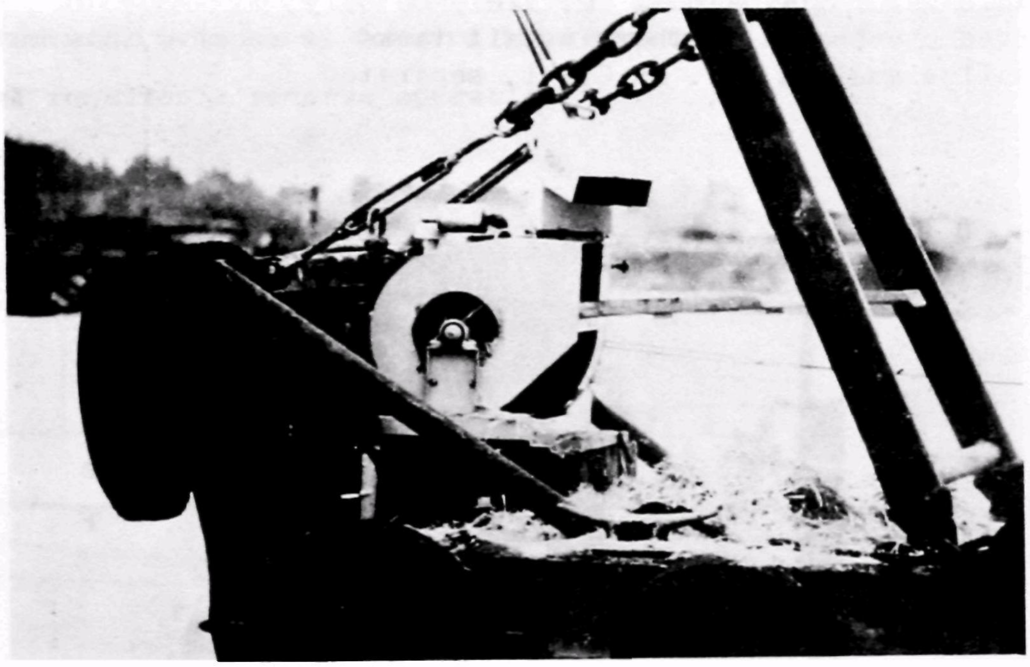


Figure 55. Typical Strawblower Installation on Bow of Modified LCM

The harvester system may be installed by completely removing the LCM loading gate. This configuration has the advantage of allowing greater visibility. It does, however, severely limit the sea state in which safe operation is possible. Other than for calm harbor applications, this installation is not recommended.

1.0 Remove the gate by lowering partially on sling and removing hinge pins.

2.0 Assemble the conveyor's wing support and wings on the dock. Bolt the rear conveyor mount (a heavy pipe or channel) to the conveyor.

3.0 Sling the conveyor into approximate position as shown in Figure 56.

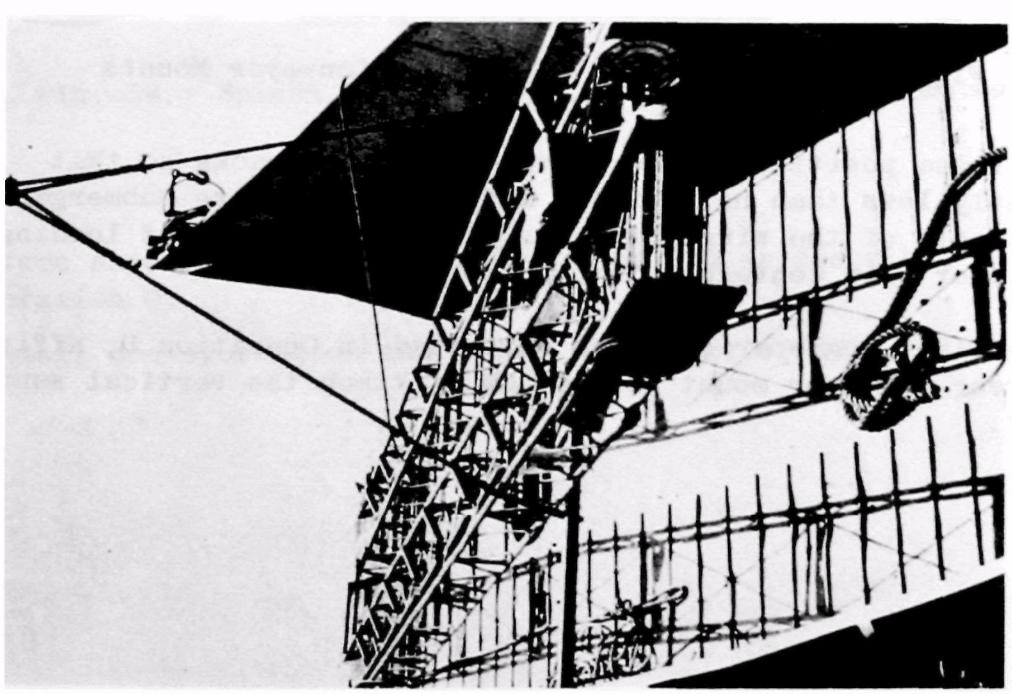


Fig. 56. Installation of Conveyor Assembly, Gate Removed

4.0 Adjust the position of the assembly to a maximum of 20 degrees to the water surface.

5.0 Weld short lengths of right angle stock to the hinge line to form tracks for the conveyors, as shown in Figure 57.

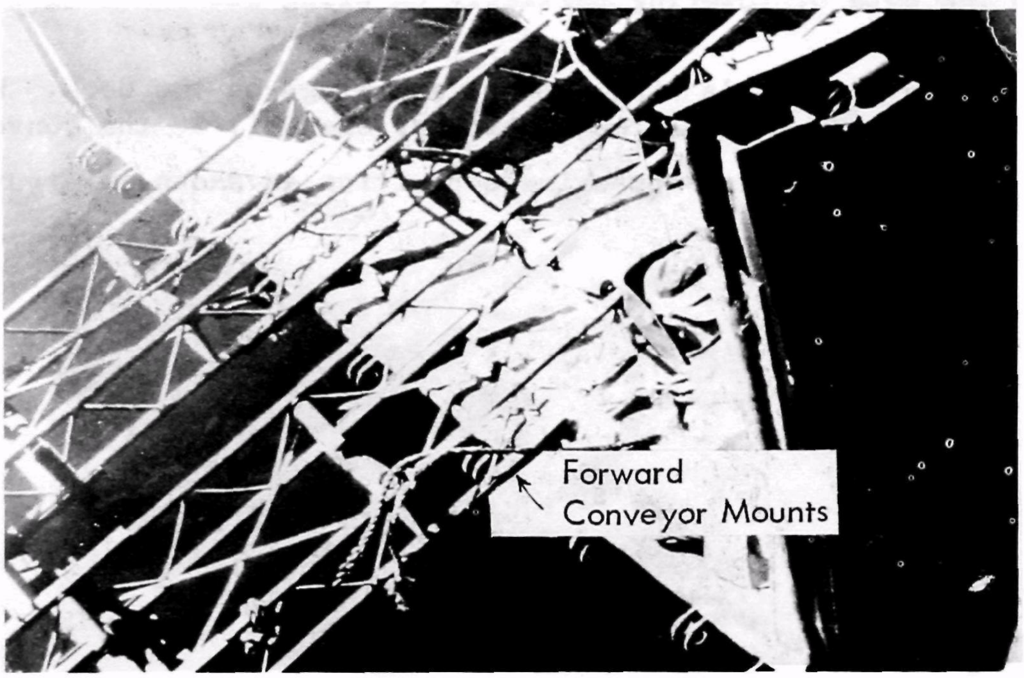


Fig. 57. Installation of Forward Conveyor Mounts

6.0 Adjust the position of the conveyors on the tracks so that slightly less than half of the deflector wings are submerged. (The depth of the wings will increase with subsequent loading.) U-bolt or weld conveyors in place.

7.0 Using right angle brackets as described in Operation D, affix the rear conveyor mount to the LCM. Attach the vertical support strut.

8.0 Install a false bulkhead under the conveyor assembly to prevent shipping of water. Seal all joints with 1/4-in. neoprene gaskets. Note chain for ballast (Figure 58) used to adjust final trim of vessel.

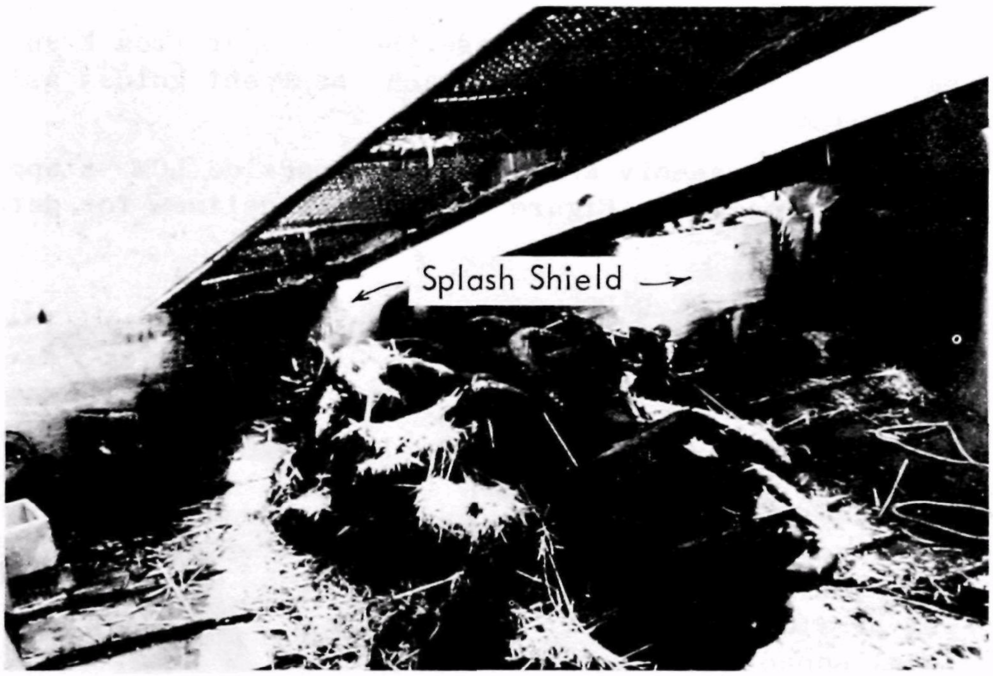


Fig. 58. Splash Shield Installation with Gate Removed

9.0 Attach sheetmetal flashing to conveyor tip as described in Operation G.

10.0 Install conveyor motor and adjust alignment of belt.

The wing supporting structure consists essentially of one half of the standard bow support structure.

1. Construct either left, right, or both halves of the wing supporting structure, as outlined in Operation A.
2. Attach wire belt-modified conveyor to wing supporting structure (26 ft conveyors required).
3. Fabricate a deflector wing as described in Operation E and attach to wing supporting structure. Attach absorbent guides as outlined in Operation F.
4. Sling completed assembly and position alongside LCM in approximate installation position. Figure 59 gives guidelines for determining this position.
5. Weld steel channel or pipe to LCM in approximate installation position as shown in Figure 60 to form rear support for conveyor. An additional channel brace from the deck level to the outboard side of this mounting provides additional support.
6. Weld forward end of assembly to hull as close as possible to waterline (Figure 61).
7. Fabricate wooden chute to direct absorbent into debris box (Figure 62).
8. Attach cables and channel iron as required to support wing structure. A typical installation is shown in Figure 63.

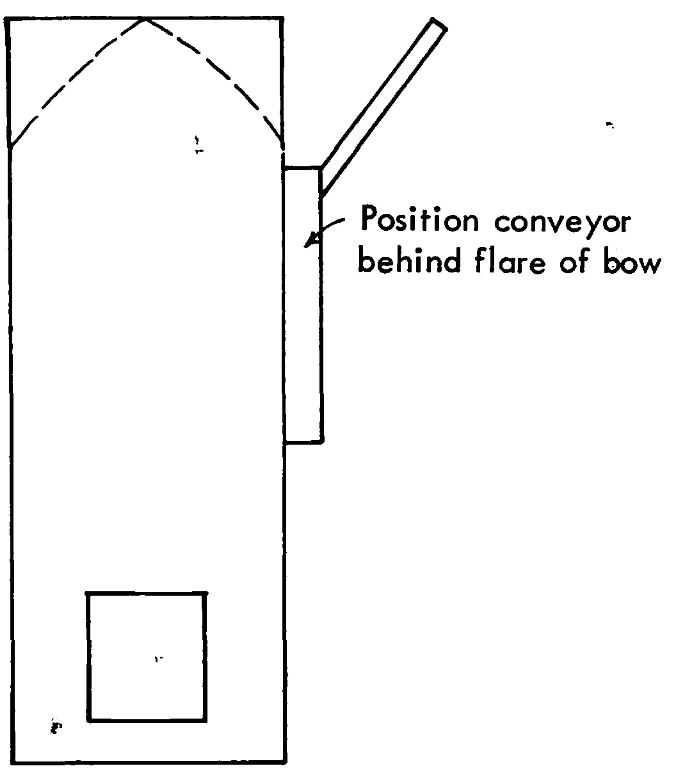


Fig. 59. Positioning Side-Mounted System on LCM

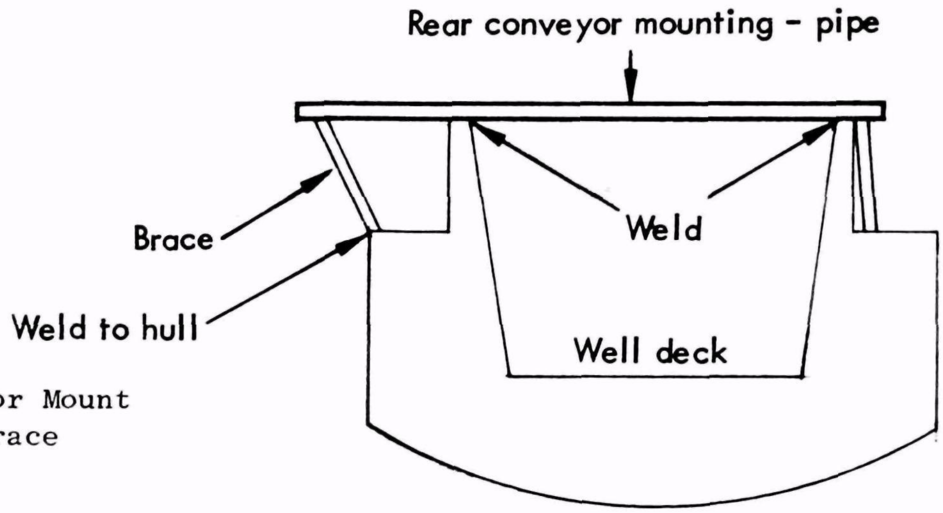


Fig. 60. Rear Conveyor Mount and Supplementary Brace

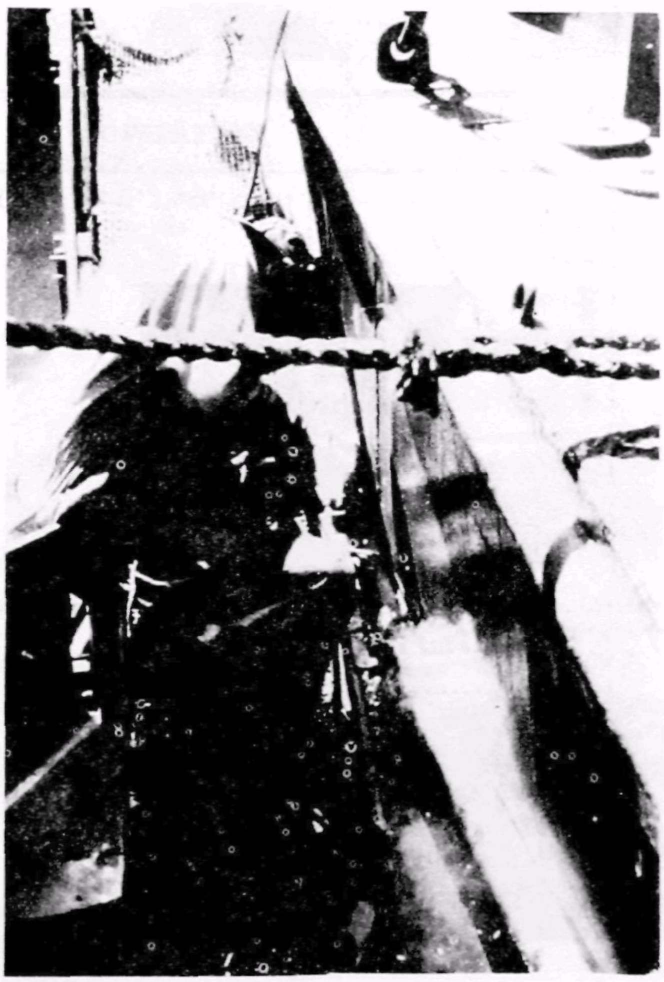


Fig. 61. Forward Waterline Attachment of Assembly

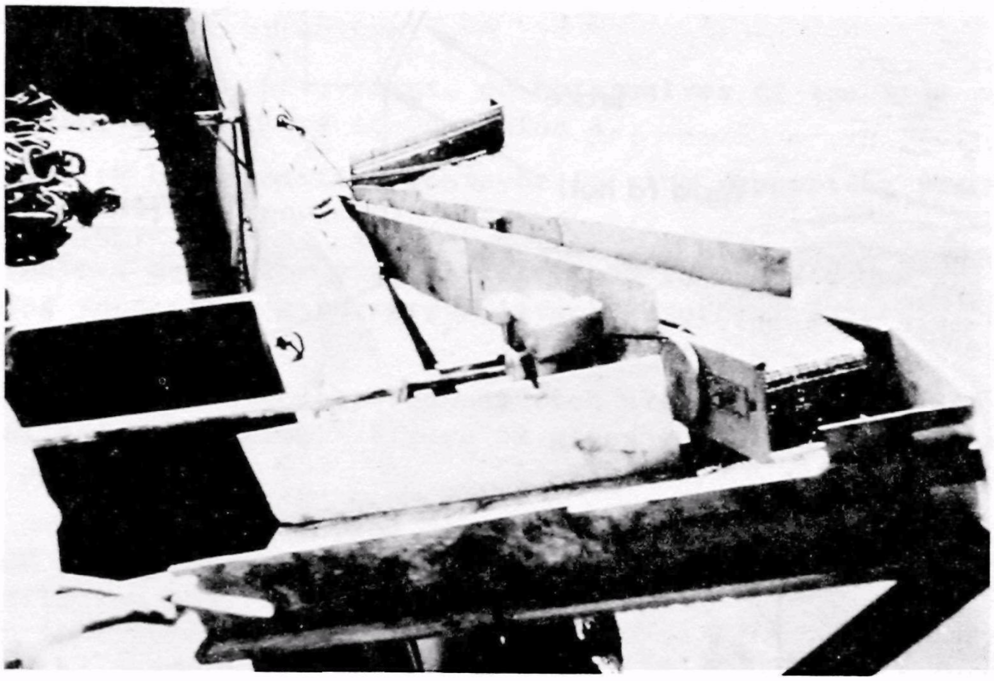


Fig. 62. Chute Detail

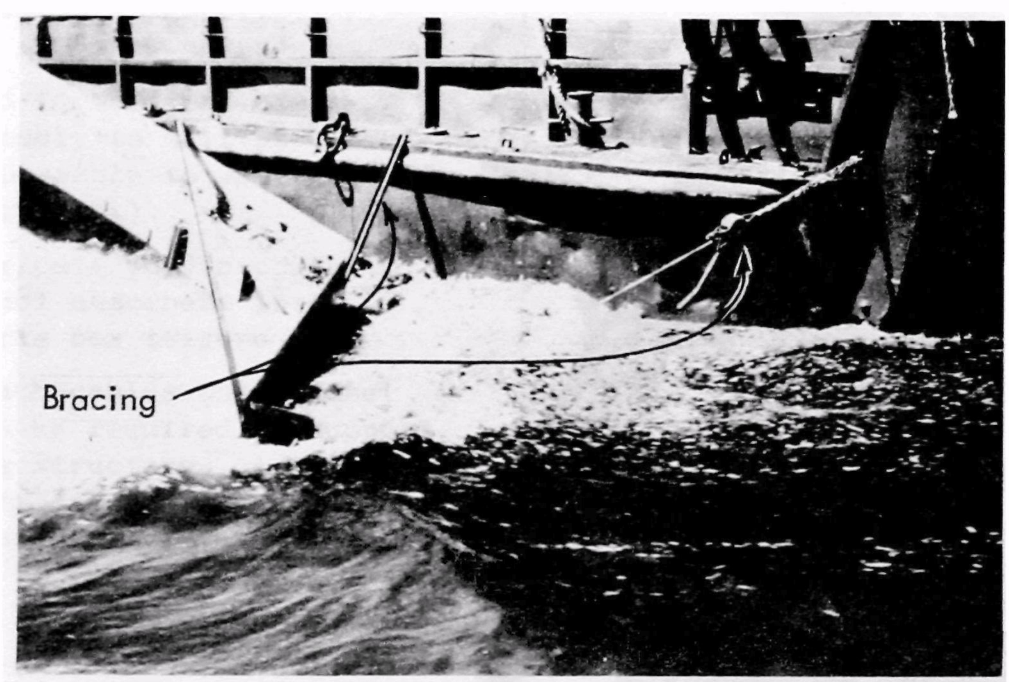


Fig. 63. Finished Installation Showing Supplementary Braces

Section VII

INSTALLATION PROCEDURES (CONVENTIONAL VESSEL)

The installation procedures required to install conveyors and associated equipment onto any vessel of opportunity (e.g., Gulf Coast work boats, deck barges, large tug boats, etc.) other than an LCM are given in this section. The procedures are similar to those for the side-mounted installation on an LCM type vessel. Table 16 lists the various operations required to complete an installation. Table 17 lists each operation, the labor skill and number of each skill required, and the time required under normal conditions to complete the operation.

A detailed description of each operation follows.

Table 16

OPERATIONS REQUIRED FOR INSTALLATION OF OIL/SORBENT RECOVERY SYSTEM ON VESSELS OTHER THAN LANDING CRAFT

OPERATION	DESCRIPTION
A	Fabricate Wing Support Structure
B	Convert the Conveyors to Wire Belts
C	Construct Rear Conveyor Supports
D	Fabricate Wings and Install
E	Fabricate Absorbent Guides
F	Attach Assembly to Vessel
G	Fabricate Flashings
H	Construct Debris Chute
I	Installation and Removal of Debris Box
J	Installation of Pumps and Separator

Table 17

LABOR AND TIME REQUIREMENTS FOR INSTALLATION ON CONVENTIONAL VESSEL

OPERATION	LABOR SKILLS REQUIRED	NO. OF LABOR SKILL	TIME REQUIRED (MAN HR)	TOTAL TIME (MAN HR)	COMMENTS
A. Fabricate Wing Support Structure (Dual Mount)	Welder	3	4	12	Includes measuring, cutting and assembly
B. Convert Conveyors to Wire Belts	Mechanic Laborer	1 1	1	2	Includes initial adjusting of tension
C. Construct Rear Support	Laborer Welder	1 1	1	2	
D. Fabricate Plywood Wings and Bolt to Supporting Structure	Carpenter Laborer	1 1	2	4	
E. Fabricate Sorbent Guides	Carpenter Laborers	1 2	1	3	
F. Install Assembly on Vessel	Welder Laborers Equipt. Opr.	1 2 1	2	8	Includes installing conveyor motors
G. Fabricate Flashings	Sheetmetal worker	1	1	1	
H. Construct Chute	Carpenter	1	2	2	
I. Install Debris Box	Laborers	2	1/2	1	
J. Install Pumps	Mechanic	1	1	1	

Operation A. Fabricate Wing Support Structure

This structure is essentially the same heavy duty welded steel unit utilized in the LCM installation. One half of this structure is required for each side mounting.

1.0 Using 3-in. by 2-in. channel, weld together a rectangular structure with the dimensions shown in Figure 32. Brace this structure with steel plate triangles as required. Flanges in the upper corners are used in the illustrated structure. Cut this structure into mirror halves, one for each side of the vessel.

2.0 Fabricate wing attachment pads out of 24 in. by 8 in. by 1/4 in. steel plate. Four plates will be required. Drill at least four 3/8 to 1/2 in. bolt holes (in pairs) in these plates to allow for later matching. Set aside one of each pair for Operation E. Weld the remaining plates to the frame at an angle of approximately 30 degrees, as depicted in Figure 33.

3.0 Add braces and drill holes to complete structure shown in Figures 32 and 33.

4.0 A coat of primer is recommended if time permits.

Operation B. Convert Conveyors to Wire Belts

1.0 Install belt.

1.1 Spiral woven belt (shown in roll in Figure 36).

1.1.1 Check conveyor drive pulley for surface roughness. Prominent welded beads are necessary to prevent belt slippage, especially when oily. Surface roughness may be improved by welding additional beads on as shown in Figure 37.

1.1.2 Install belt and cut to proper length if necessary.

1.1.3 Adjust tensioning bolts until 1 to 2 in. of play is obtained between any two adjacent rollers. Fine adjustment may be required during operation.

1.2 Flat wire belt (shown on conveyor in Figure 36). Flat wire belts require the installation of drive gears.

1.2.1 Remove standard drive pulley, bearings and shaft.

1.2.2 Mount drive gears and bearings on a keyed shaft, adjust to mesh with belt, and install on conveyor as in Figure 38.

1.2.3 Install wire belt and cut to proper length if necessary.

1.2.4 Adjust tension as in Section VI, Operation B.

1.0 Determine location of rear mount.

Figure 64 indicates the general configuration required. Location of the rear mount may be determined mathematically or by physically placing the conveyor in position and marking the mount position.

2.0 Weld or otherwise attach a large diameter pipe to the deck of the vessel at the position determined in Step 1.0. The support should extend at least 6 in. plus the width of the conveyor frame beyond the hull of the vessel.

3.0 An auxiliary brace from the outboard end of the rear support to the hull is recommended.

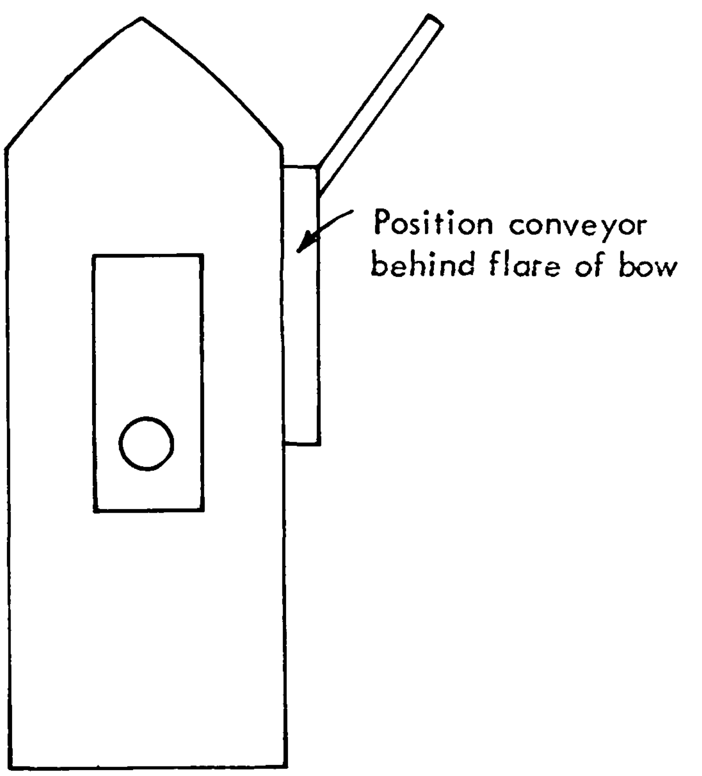


Fig. 64. Positioning Side-Mounted System on Conventional Vessel

Operation D. Fabricate Wings and Install

Standard wing size for relatively calm operating conditions is 2 ft by 8 ft. For rougher water, a greater wing height will be required to prevent material from passing underneath. The material to be used is either 1-1/2 in. or (preferably) two 3/4-in. sheets of laminated exterior plywood.

1.0 Saw plywood into proper sizes.

2.0 Construct a rectangular supporting structure for each wing, as shown in Figure 42. This structure should be at least 1-1/2 in. right angle steel, with the exception of the attachment plate which was constructed in an earlier operation. The size of the frame should be slightly less than that of the plywood wing.

3.0 Drill holes in the frame as required to attach the plywood.

4.0 Assemble and bolt wings to support structure.

5.0 Construct deflector tips from at least 1/8 in. sheet metal. These deflectors reduce the loss of sorbent around the wing tips. They must be bent to parallel the keel of the vessel when bolted in place.

Operation E. Fabricate Guides

Auxiliary guides along each side of the conveyors are required to prevent spillage of sorbents before reaching the debris box.

1.0 Sorbent guides should be fashioned out of 1/2-in. exterior plywood. Notches must be cut at the roller positions to allow the guides to fit between the conveyor frame and the belt. A typical installation is shown in Figure 45.

2.0 Cut "bracelet" from strap steel stock to a sufficient length to allow attachment of sorbent guides as shown in Figure 46.

3.0 Attach the brackets to the conveyors by one of the methods shown in Figure 46, using steel bands. Method A reduces the space between the belt and the guide to a minimum, but is not as sturdy as Method B. Guides should be installed the entire length of the conveyors.

Operation F. Attach Conveyor Assembly to Vessel

1.0 Lower the assembly into position alongside hull. Adjust the angle of the conveyors to the water to 20 degrees and have the conveyor tip about 6 in. below the water.

2.0 Attach the conveyor support structure to the vessel near the water line.

3.0 Attach the assembly to the rear mount with U-bolts.

4.0 Attach additional struts and/or cables to support the deflecting wings.

Operation G. Fabricate Flashings

The lower end of the conveyor presents an irregular surface that tends to entrap and entangle absorbents and create turbulence. This phenomenon may be overcome by adding sheetmetal streamlining or flashings. Application of streamlining is as required by the individual installation.

Operation H. Construct Debris Chute

A chute is required to transfer material from the end of the conveyor to the collection container. Detail of a typical installation is indicated in Section VI.

Construct the chute of 3/4 in. exterior plywood. The assembly is bolted to the rear of the conveyor.

As each installation will vary, this chute will vary in size and position. Ideally, gravity feed is intended; however, manual assistance in moving the material down the chute may be required.

Operation I. Installation and Removal of Debris Box

1.0 Select debris boxes 3 to 4 ft shorter than the available space (Figure 53) to allow for easier manipulation of the box, especially during an at-sea transfer.

2.0 Lower the box from the dock in a level attitude by 4-point suspension. It is set on the deck of the vessel and the slings removed. Removal of the debris box requires a reverse operation.

Operation J. Install Pumps and Storage Tanks or Separator

During operation water will be taken aboard from a variety of sources, including water brought aboard by the wire belts, water draining from the recovered sorbent, and spray. This water must be removed to prevent serious listing.

1.0 Install pumps (two should be carried for backup purposes). The intake hose should be placed in the ship's bilge.

2.0 As this water will almost certainly be oily, it should not be discharged overboard. Either install tanks to receive this material or install a small A.P.I. or C.P.I. separator.

Section VIII

OPERATIONAL PROCEDURES

Based on the limited full-scale test program conducted in this study, both the operational procedures and cost estimates for implementing the oil/sorbent harvesting system are presented in this section. The proper utilization of the proposed system depends upon several factors, including

- Sea state (wind and currents)
- Availability of vessels of opportunity
- Characteristics of oil spilled
- Type of sorbents available.

An oil spill is typified by the rapid dispersion of the spilled oil through the combined action of currents, wind, and the oil's own spreading force.

In previous oil spill incidents where sorbent material (principally straw) has been used, no effective method was available for the recovery of the oil-soaked sorbent and large quantities washed ashore, necessitating additional expenditure of cleanup effort. The effective use of sorbents requires a system that considers both rapid dispersal of sorbents and effective and rapid harvesting techniques.

The operational procedures described in the following paragraphs have been included to assist in the effective utilization of the oil/sorbent harvesting system evaluated in this study.

SORBENT DISPERSAL

During the course of this research study, two types of sorbents were tested: straw and polyurethane foam. Both of these sorbents were dispersed utilizing a power mulcher (described in Section V). The most efficient method of dispersal found was to disperse the sorbent downwind onto the oil slick. The forward speed of the vessel on which the power mulcher is mounted should be between 1 and 2 knots; faster speeds would inhibit proper coverage of the oil. In the case of straw, one power mulcher can disperse up to 10 tons of straw per hour; this would effectively cover an area of 120,000 sq ft. The contact time (i.e., the time the sorbent is allowed to remain in contact with the oil before harvesting is initiated) varies considerably with different sorbents and different oils, ranging from less than 1 minute with certain types of polyurethane foam to at least 1/2 hr when straw is used. Contact time can best be judged on-site during actual operations through visual observation; when the sorbent appears to be oil-soaked, commence harvesting operations.

HARVESTING PROCEDURES

The major consideration involved in harvesting oil/sorbents is to work with the prevailing elements (i.e., wind, currents). The sorbent recovery vessel should initiate the harvesting operation on the downwind side of the oil slick making as long a pass through the oil/sorbent area as is feasible.

In most cases, the prevailing wind on a coast is onshore (i.e., blows toward the shoreline); therefore, the above procedure would help alleviate oil contamination of beaches and shorelines. If currents are present in the affected area, it is best to have the sorbent recovery vessel work into or against the current in order to maximize recovery. The forward speed of the sorbent recovery vessel should be between 2 and 4 knots; higher speeds might place undue strain on the deflecting wings and also cause loss of sorbents under the wings due to turbulence.

SORBENT RECOVERY RATE

The recovery rate of the oil/sorbent harvester system is highly variable depending on many factors such as wind, thickness of sorbent spread, curents, etc. However, the tank tests and full-scale tests conducted in this study indicate a pickup range between 4,000 and 7,000 lb of dry straw per hour for a dual conveyor system. The actual operating rate of the oil/sorbent system would also depend on the storage capacity of the pickup vessel. Smaller vessels that can hold only a single debris box, such as the LCM-6, would require more frequent unloading, thus necessitating longer time spent in transit to and from an unloading area. The sorbent recovery rate of the LCM-6 would be approximately 3,000 lb of dry straw per hour or 400 cu ft of polyurethane foam. Oil recovery rate would depend on the sorbing ability but could range from 940 gal/hr for straw with a 2.5 to 1 (weight basis) sorbing ratio to 20,000 gal/hr for a polyurethane foam that has a sorbing ratio of 25 to 1 (by weight). A larger pickup vessel, such as Gulf Coast work boat that could store 14 to 15 cu yd debris boxes, thus requiring fewer unloading trips, would be capable of picking up an average of 4,500 lb/hr of dry straw. Figures 65 and 66 show typical vessel and power mulcher requirements for different sized oil spills and cleanup times.

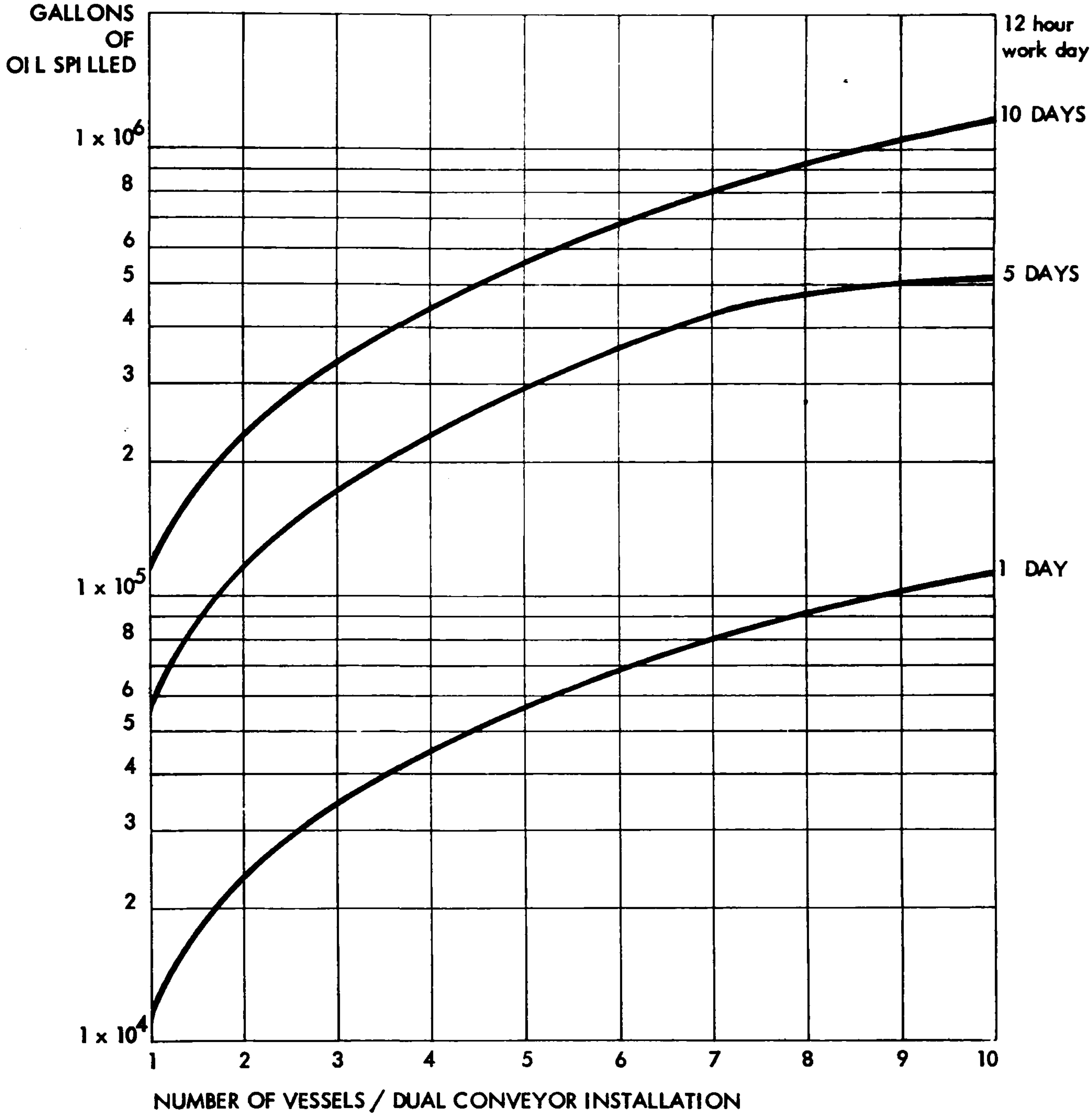


Fig. 65. Vessel Requirements for Various Oil Spill Sizes and Cleanup Times

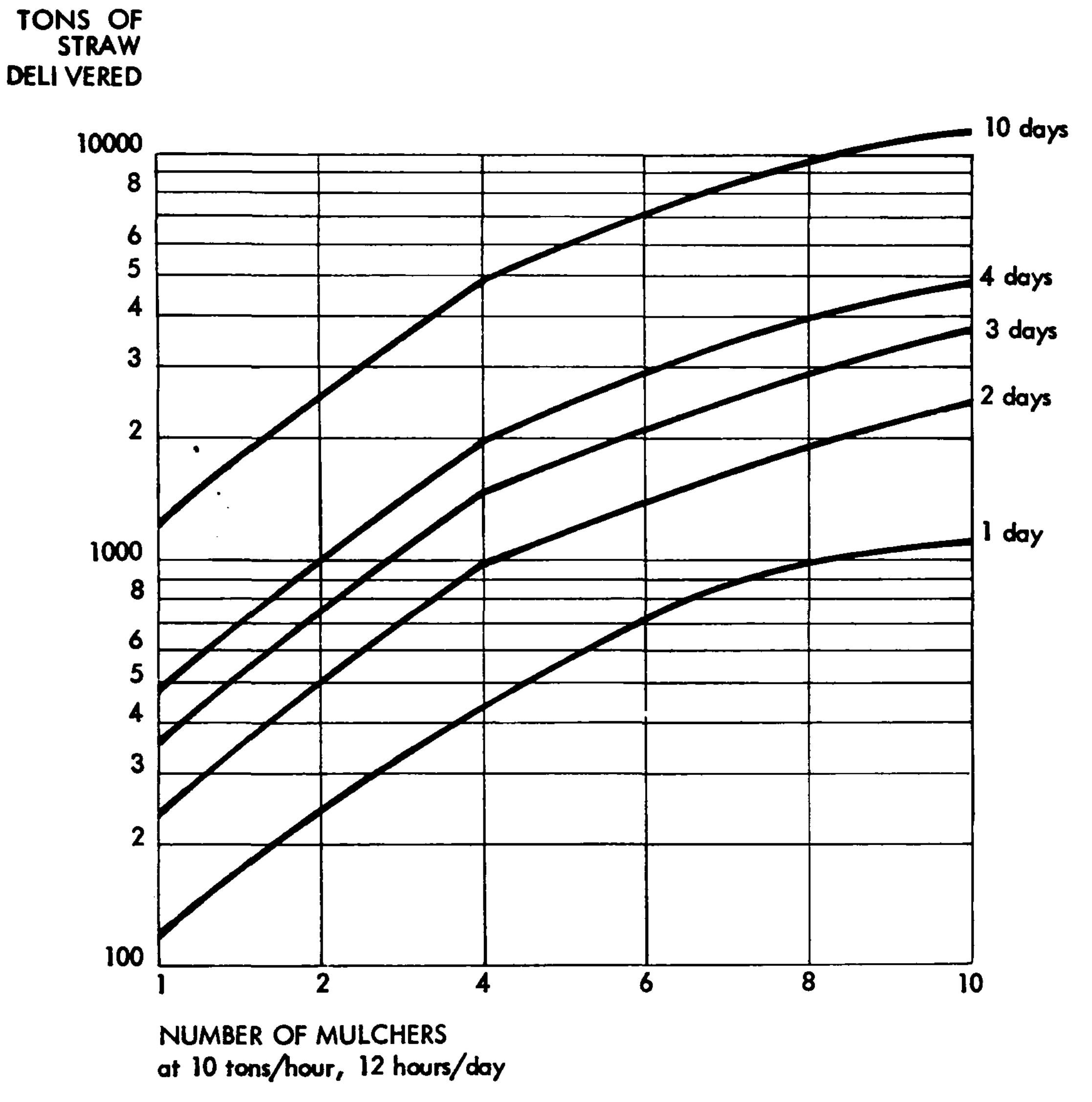


Fig. 66. Number of Mulchers Required for Different Cleanup Times

SUPPORT VESSELS

The primary support vessel for the system should be a large hopper or deck barge equipped with a crane that can act as a floating storage area for recovered oily straw or as a recycling plant for recovered polyurethane foam. A barge 200 ft by 35 ft could store sixty-four 15-cu yd debris boxes, giving it a capacity of 960 cu yd. This is sufficient to support five LCMs for a 12-hr work day.

COST ANALYSIS

The cost of fabricating and operating the oil/sorbent harvesting system evaluated in this study can vary considerably depending on the vessel(s) of opportunity utilized and the type of sorbent used. Geographical and physical factors such as spill location, weather conditions, type of oil spilled, and availability of equipment all tend to make accurate cost estimates of the oil/sorbent harvester system difficult to forecast.

However, Table 20 presents an estimate of costs for individual components of the oil/sorbent harvester system. Almost all the costs are for a daily rental rate or labor rate based on a 12-hr day. The main exception is the initial installation cost where the two conveyors are presumed to be rented for two weeks and the material and labor for fabricating the systems comes to a one-time charge of $9000.

Table 21 shows four separate cost estimates for cleanup of a 200,000 gallon oil spill in 5 days. An analysis of the table indicates that the largest single cost factor is the capability of the sorbent to sorb oil. In the least-cost case, the use of polyurethane foam that could sorb up to 25 times its own weight in oil(5) would enable the oil spill to be cleaned up for approximately $30,000. However, other sources,(6,7) citing more recent work, indicate that under actual conditions, much lower sorbing ratios could be expected, such as 2.5 or 5 to 1 (by weight). Using a lower sorbing ratio (i.e., 2.5 to 1), the cost of cleaning up a 200,000 gallon oil spill would be more than tripled, to over $100,000. (Sorbing ratios are based on weight of oil sorbed versus weight of sorbent. One cubic foot of straw weighs eight times as much as 1 cubic foot of polyurethane foam.)

The major reason for the large increase in cost is the low sorbing ratio of the foam. In this case 1 cu ft of polyurethane foam would pick up only approximately 0.6 gallon of oil, with the result that a full boatload of oil-soaked foam would represent only 250 gallons of oil. Therefore, in order to clean up the 200,000 gallon spill in 5 days, 14 LCMs would be required. Cost estimates were also prepared for different types of pickup vessels, using straw as a sorbent. The cost differences between the LCMs and Gulf Coast work boats were slight ($56,000 vs $59,000). The cost estimates that have been prepared are estimates based on ideal conditions and do not include supervision and shore cleanup and support.

Table 20

COST ESTIMATE FOR INDIVIDUAL COMPONENTS
OF OIL/SORBENT HARVESTER SYSTEM

Initial Costs - Sorbent Harvesting System

Belts	$ 250
Deflector Wing Material	200
Fabrication - Labor	450
	$ 900
Conveyor Rental (2 units)	700/2 wk period
	$ 1600/vessel

LCM Daily Operating Costs

LCM	$400/day
Pumps and fittings	100/day
Labor	120/day
	$620/day

Gulf Coast Work Boat

Boat and Crew	$ 800/day
Pumps and fittings	100/day
Labor	120/day
	$1120/day

Sorbent Boat Operating Costs

Boat	$400/day
Mulcher	30/day
Labor	120/day
	$550/day

(Sorbents: straw = $50/ton; polyurethane foam = $1/cu ft,
2 lb/cu ft density)

Storage Barge (100' long) and Tugboat Operating Costs

Debris box (18 units) @$30	$540
Crane	120
Barge and Tugboat	700
Labor	310
	$1670/day

200'-long Barge

Debris box (64 units) @$30	$1920
Crane	120
Barge and Tugboat	1000
Labor	310
	$3350/day

Table 21

COST ESTIMATE FOR VARIOUS COMBINATIONS OF
OIL/SORBENT HARVESTER SYSTEM
200,000 gallon oil spill, 5-day cleanup cycle, 12-hr day

1. 4 LCM's*, 1 Straw Boat, 1 200-ft Barge with Tug
Sorbent: Straw, sorbing ratio 2.5:1

4 LCM's - 5 days	
Initial Cost - 4 x $1,600	$ 6,400
Daily Cost - $620 x 4 x 5	12,400
1 Straw Boat - 5 days x $550	22,750
Straw - 72 tons/day x 5 days x $50/ton	18,000
1 - 200-ft Barge and Tug, $3,350/day x 5	16,750
	$56,300

2. 14 LCM's, 5 Sorbent Boats, 1 200-ft Barge and Tug with Recycling Equipment
Sorbent: Polyurethane foam, sorbing ratio 2.5:1 with total recycling

14 LCM's - 5 days	
Initial Cost - 14 x $1,600	$22,400
Daily Cost - $620 x 14 x 5	43,400
5 Sorbent Boats - 5 x 5 x $550	13,750
Foam - 14,000 cubic ft at $1.00/cubic ft	14,000
1 - 200-ft Barge, Tug, and Crane at $1,430 x 5	7,150
28 Debris Boxes - $840	840
	$101,540

3. 2 LCM's, 1 Sorbent Boat, 1 200-ft Barge and Tug with Foam Recycling Equipment
Sorbent: Polyurethane foam, sorbing ratio 25:1 with triple recycle

2 LCM's - 5 days	
Initial Cost - 2 $1,600	$ 3,200
Daily Cost - $620 x 2 x 5	6,200
1 Sorbent Boat - 5 x $550	2,750
Foam - 11,000 cubic ft at $1.00/cubic ft	11,000
1 - 200-ft Barge, Tug, and Crane $1,430 x 5	7,150
4 Debris Boxes at $30	120
	$30,420

4. 3 Gulf Coast Work Boats, 1 Straw Boat, 1 200-ft Barge and Tug
Sorbent: Straw, sorbing ratio 2.5:1

3 Gulf Coast Work Boats at $800/day x 5 days	
Initial Cost - 3 x $1,600	$ 4,800
Daily Cost - 3 x $1,120 x 5 days	16,800
1 Straw Boat - 5 days x $550	2,750
Straw - 72 tons/day x 5 days x $50/ton	18,000
1 - 200-ft Barge and Tug - $3,350/day x 5	16,750
and Debris Boxes	$59,100

* Pick-up rate for LCM's: 72 tons dry straw/day = 45,000 gallons oil/day.

Section IX

ACKNOWLEDGMENTS

This report summarizes research conducted by URS Research Company for the U.S. Environmental Protection Agency, under Contract No. 68-01-0069 during the period June 14, 1971 through June 14, 1972. The work was performed under the direction of Dr. Franklin J. Agardy, Executive Vice President and Director of the Environmental Systems Division. Mr. James D. Sartor served as Project Manager and Mr. Carl Foget and Mr. Robert Castle were Assistant Project Managers.

We also wish to thank the following URS Research Company staff members who assisted in the full-scale field testing:

Robert Pitt	Photography
John Butt	Boat Handling
Charles Brennen	Sorbent Dispersal
Dan Walters	Test Engineer

Mrs. Patty Reitman was responsible for editing and production of the report and Miss Sherry Hossom and Mrs. Ceevah Sobel prepared the illustrations.

Murphy Pacific Salvage Co. provided on-site support services in the San Francisco Bay and the Black Diamond Towing Service supplied the LCM for use both in the San Francisco Bay tests and at Santa Barbara (Coal Oil Point).

Mr. Charles Wilton of Scientific Services was responsible for the construction of the test platform and also provided on-site support during the full-scale field testing at both the San Francisco Bay and Santa Barbara (Coal Oil Point).

URS Research Company also wishes to thank Mr. Stephen Dorrler, of the Edison Water Quality Laboratory, Environmental Protection Agency, for his generous assistance and guidance while serving as Project Officer.

Section X

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SELECTED WATER RESOURCES ABSTRACTS

INPUT TRANSACTION FORM

1. Report No. | 2. | W

OIL/SORBENT HARVESTING SYSTEM FOR USE ON VESSELS OF OPPORTUNITY

5. Report Date

8. Performing Organization Report No.

Sartor, James D., Foget, Carl R., Castle, Robert W.

15080 HER

URS Research Company
155 Bovet Road
San Mateo, California 94402

68-01-0069

Type of Report and Period Covered

12. Sponsoring Organization U.S. Environmental Protection Agency OR&M

Environmental Protection Agency report number, EPA-R2-73-166, April 1973.

A system for harvesting mixtures of oil and sorbent materials, primarily straw, which could be utilized for the recovery of floating oil from water was developed for use on vessels of opportunity.

A three-phase test program was conducted to evaluate candidate system components and operating specifications for the oil/sorbent harvesting system. The first phase of the program involved testing individual system components and operating parameters as to their effectiveness in picking up sorbents only. The first phase was conducted under actual conditions in a saltwater slough. The second phase of the test program entailed evaluating those operating characteristics of the harvesting system components selected in the first phase using crude oil and various sorbents in a test tank. The third phase of the test program entailed the installation of the complete system on a vessel of opportunity (an LCM), and demonstration of the ability of the system to operate under actual conditions. The system was evaluated both in the San Francisco Bay and off Coal Oil Point (Santa Barbara) where sorbent materials were dispersed over natural oilslicks.

The system utilizes commercially and readily available equipment which, with minor modifications, was assembled on-site into available vessels. The system was found to be very effective in recovering sorbents (straw and polyurethane foam) from the water surface.

17a. Descriptors

*Oil pollution, *Oil sorbents, *Conveyor systems

17b. Identifiers

*Oil recovery systems, *Oil/sorbent recovery

17c. COWRR Field & Group

18. Availability | 19. Security Class. (Report) | 21. No. of Pages
20. Security Class. (Page) | 22. Price

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