APPLICATION OF MARYLAND CLAM DREDGE ON THE MAINE COAST

by

John H. Mathieson
Marine Engineer

and

Paul DeRocher
Technical Engineer

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I. INTRODUCTION

Historically, hydraulic dredging in Maine has never been successful. Despite repeated attempts to start a commercial dredging operation by various individuals, none have survived. (Wood, Kelly, McGreggor, Johnson.)

This could be partly due to a small subtidal clam resource. Dept. of Marine Resources survey records show no data on subtidal soft shell clam populations. Another reason is the extreme variations on the bottom. In certain areas the bottom is made up of sandy sediments while many other areas are made up of clay. Another factor is the large rise and fall of the tides. Many areas are difficult to navigate with a dredge vessel.

The most pronounced problems of hydraulic dredging are economic and social. There are many hand diggers who feel they would be put out of work if hydraulic dredging were to become a reality.

The unknown knowledge of subtidal soft shell clam populations and the difficulties in dredging the various types of bottoms were the initial concerns for the dredge project.

However, before any commercial dredging operation could be started the environmental effects of dredging had to be determined.

The initial stages of this project was initiated through the extension services work in starting a commercial dredging operation.

It was known that Mr. Fletcher Hanks, Jr. had invented and patented a mechanized clam dredge. This dredge was very successful in Maryland. Also, the Canadians had built a similar dredge and were successful in its applications.

As a result, Paul Venno, Dept. of Marine Resources Extension Director, purchased a Maryland-type dredge in the spring of 1971. This was first tried on a World War II personnel landing craft. The dredge did not adapt well on this type of vessel.

It was felt that the best suitable vessel would be a catamaran. The initial expense of building and equipping a vessel of this type proved too great.

In the spring of 1972 a fishing dragger was purchased for the hydraulic dredge. This paper deals with the adapting of the Maryland hydraulic dredge to this vessel for successful use along the Maine coast.

ACKNOWLEDGEMENTS

Special recognition is given to Michael Kyte, Dept. of Marine Resources Biological Project Leader, who is responsible for the photographs.

Also thanks to Don Card, Dept. of Marine Resources Extension Service Specialist who contributed to the operation and biological collecting on the project.

Cooperating with the Dept. of Marine Resources Extension Service was several Bates College students working during the summer season. Project Leader for the students was Phil Averill who worked under Dept. of Marine Resources guidance.

Also many thanks go to the individuals, companies and institutions who contributed to the success of this project.

II. CONSIDERATIONS IN HYDRAULIC DREDGING

The Maine coast varies considerably from that of the Chesapeake Bay area. There are very few sandy subtidal bottom areas. For the most part the bottoms consist of:

Silt:	Particles so fine they cannot be distinguished by sight but can be under a microscope.
Clay:	Particles finer than silt.
Very Soft Clay:	Exodus between the fingers when squeezed in fist.
Soft Clay:	Easily molded in the fingers.
Firm Clay:	Can be molded in the fingers but takes strong pressure.
Stiff Clay:	Cannot be molded in fingers.
Very Stiff:	Brittle and tough.

It is considerably more difficult to dredge in these clays than in sand. The dredge should have the capability of operating under the most difficult of these conditions. Therefore the dredge pump should have the capacity and pressure to dig into the very stiff type of clay.

Also in many areas along the Maine coast, the bottom is irregular. Since the hydraulic head is suspended from the vessel, intermittent readjusting of the hydraulic head level must be made. For this reason a hydraulically (oil) operated winch is a must.

Stability of the vessel is a must. Since the position of the hydraulic head on the bottom is determined by the vessel, any slight change in stability will raise or lower the hydraulic head.

In operating from one dredging site to another, the vessel with the equipment is required to steam outside protected areas. This subjects the vessel and equipment to adverse sea conditions. Consequently, proper means of stowage, securing, shoring and lashing of the dredge equipment to the vessel must be provided for.

Most of the dredging sites are located in and around shoal areas. With a keeled vessel, extreme caution must be exercised so as not to ground out on an ebbing tide. This is another reason, along with stability, why a catamaran would be an ideal dredge vessel.

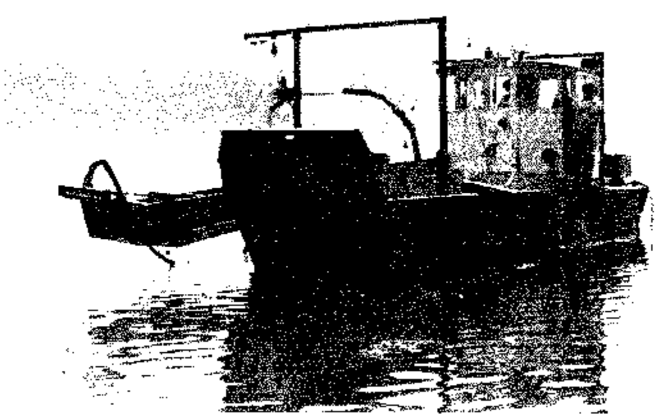
Under the present laws of the state, only those subtidal areas from Cape Elizabeth to Pemaquid Point, and in Hancock County with the permission of the town, can be subtidally dredged commercially for soft shelled clams.

III. ORIGINAL VESSEL IDEAS FOR ESCALATOR DREDGE

Initially the dredge was rigged aboard a World War II personnel carrier shown in Figure 1. This proved too unstable for this type of equipment. In addition it was awkward for personnel to pick the clams from the conveyor. Figure 2 shows the positions of the personnel picking clams off the conveyor.

From this initial experience it was determined that the best suitable vessel for the dredge equipment would be a catamaran. Three preliminary catamaran plans were developed for planning purposes.

Figure 1. Guy Johnson's Personnel Landing Craft (PCL) to which the dredge was first adapted.



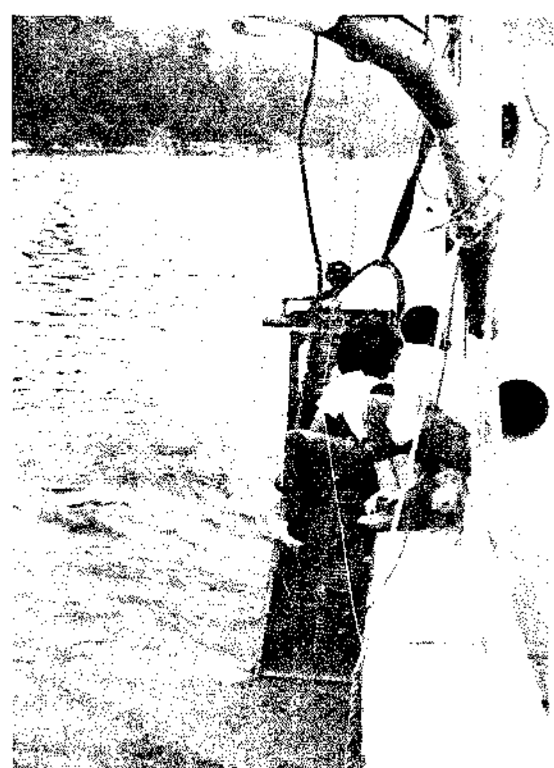


Figure 2. This is the inadequate picking positions of personnel aboard the (PCL).

Figure 3 shows a simple twin hull catamaran. The deck is constructed of wood timbers. A cockpit is provided in one hull for standing while picking the clams off the conveyor. Deck space is provided on the opposite hull for the dredge's main pump and drive. Propulsion would be two outboard motors mounted on the stern of the catamaran. The expense on this type catamaran would be minimal.

Figure 4 shows a single hull profile of the Sea Harvester I catamaran. This would be a more versatile vessel since its main propulsion is a utility drive unit. The propeller on this unit can be rotated 360^o providing full thrust in any direction. A cabin shelter with all controls for main propulsion unit and the dredge unit is provided. This vessel would be a considerable investment.

Figure 5 shows a single hull profile and a deck plan of a Sea Harvester II catamaran. In this case the main propulsion units are inboard outboards. There are two cabin shelters. One for the operational functions and the other for berthing. Considerably more equipment is built into this catamaran and consequently the higher the price.

Original plans were to build a catamaran for this project. The initial expense and time to build a vessel of this type proved too great.

The next best thing was to adapt the dredge to a common type fishing dragger. The vessel DUCHESS shown in Figure 6 was found and purchased for this project in the spring of 1972. This vessel had the stability to handle the dredge equipment. The only drawback was that the vessel is a deep-keeled vessel and would present problems as far as navigating tidal areas.

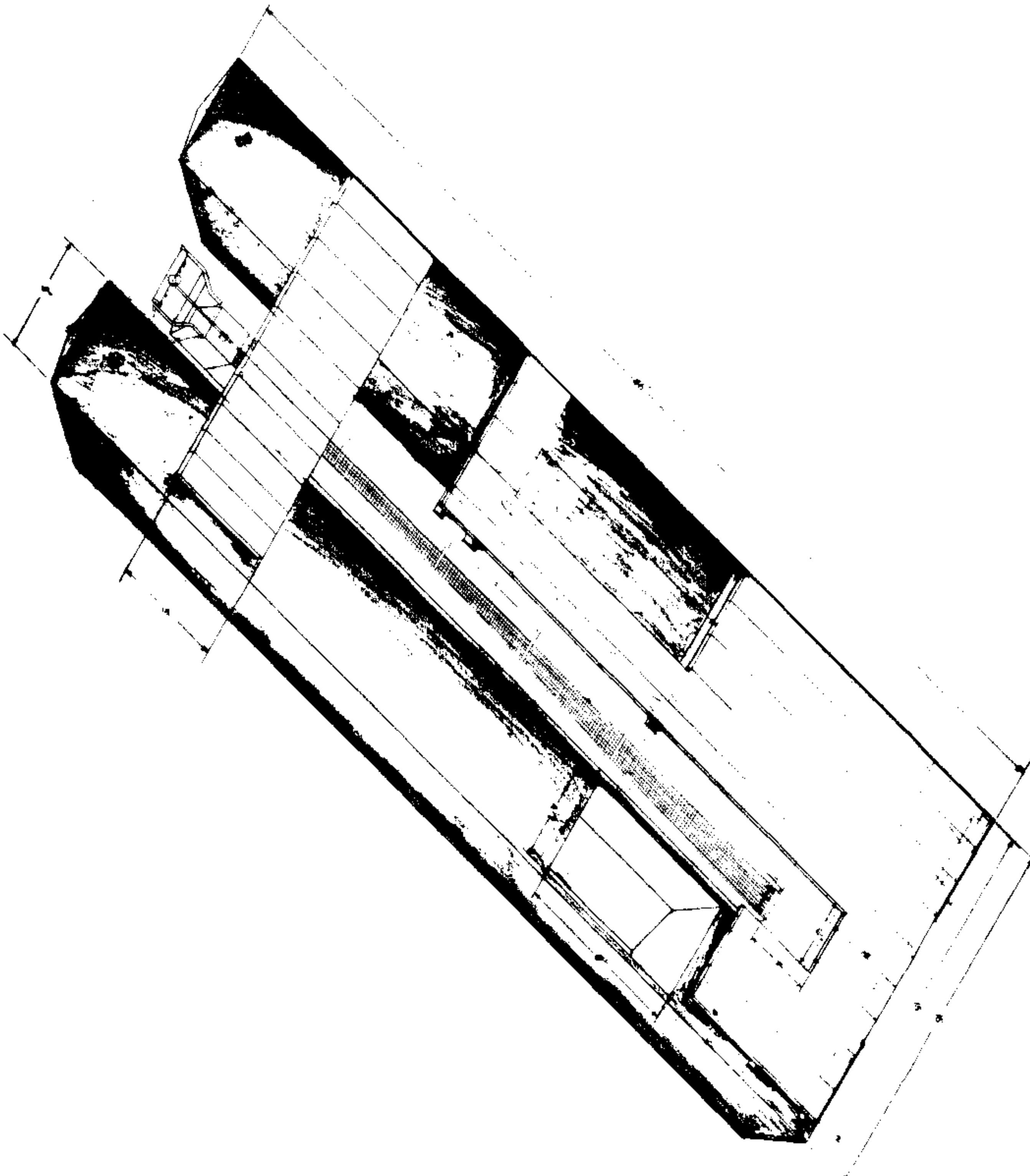


Figure 3. Simple Twin Hull Catamaran.

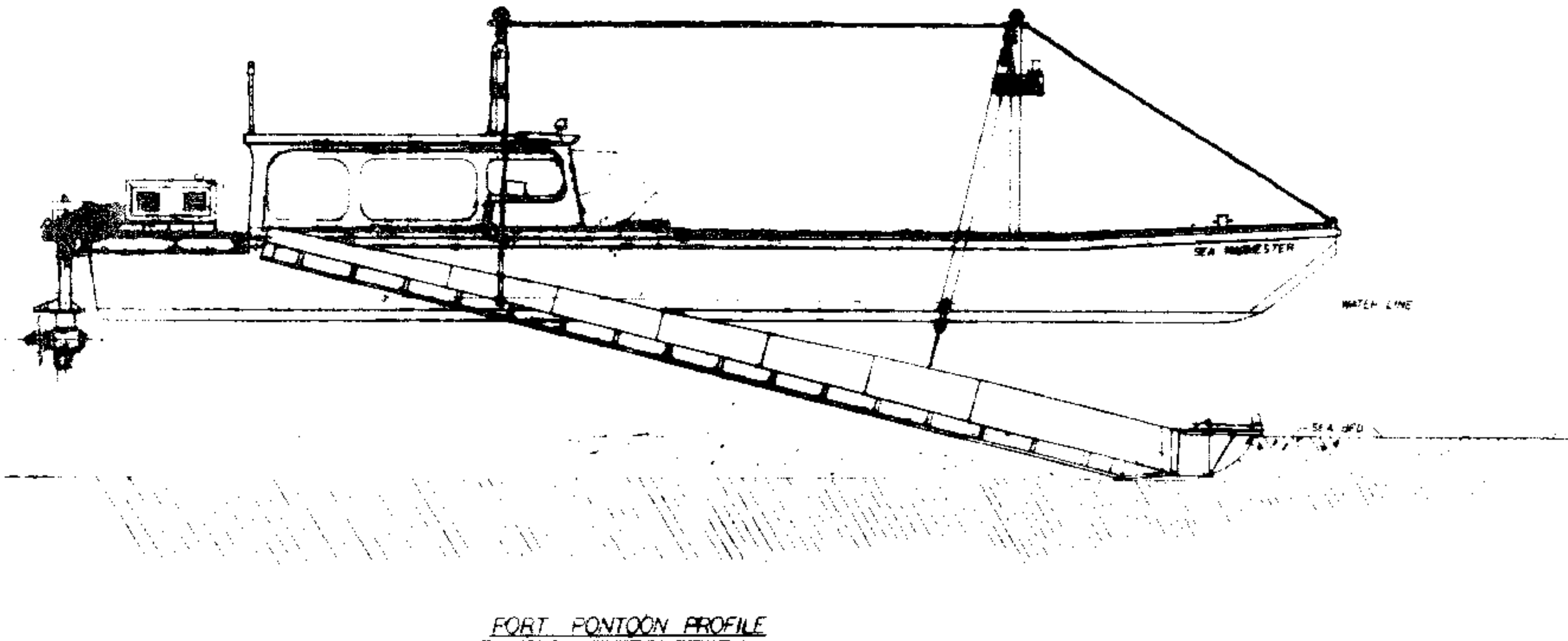
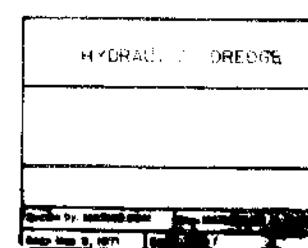


Figure 4. Single hull profile of the Sea Harvester I catamaran.



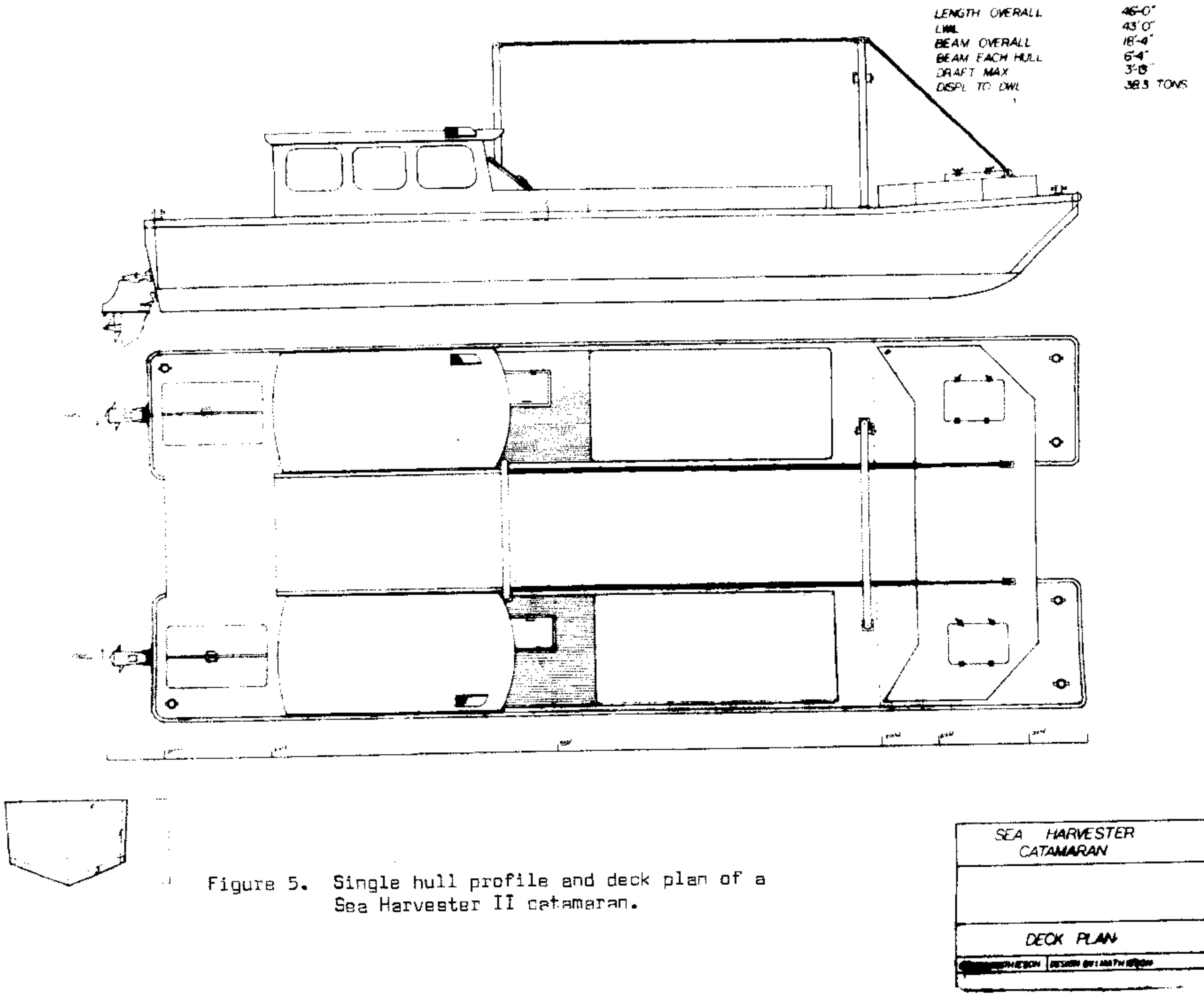


Figure 5. Single hull profile and deck plan of a Sea Harvester II catamaran.

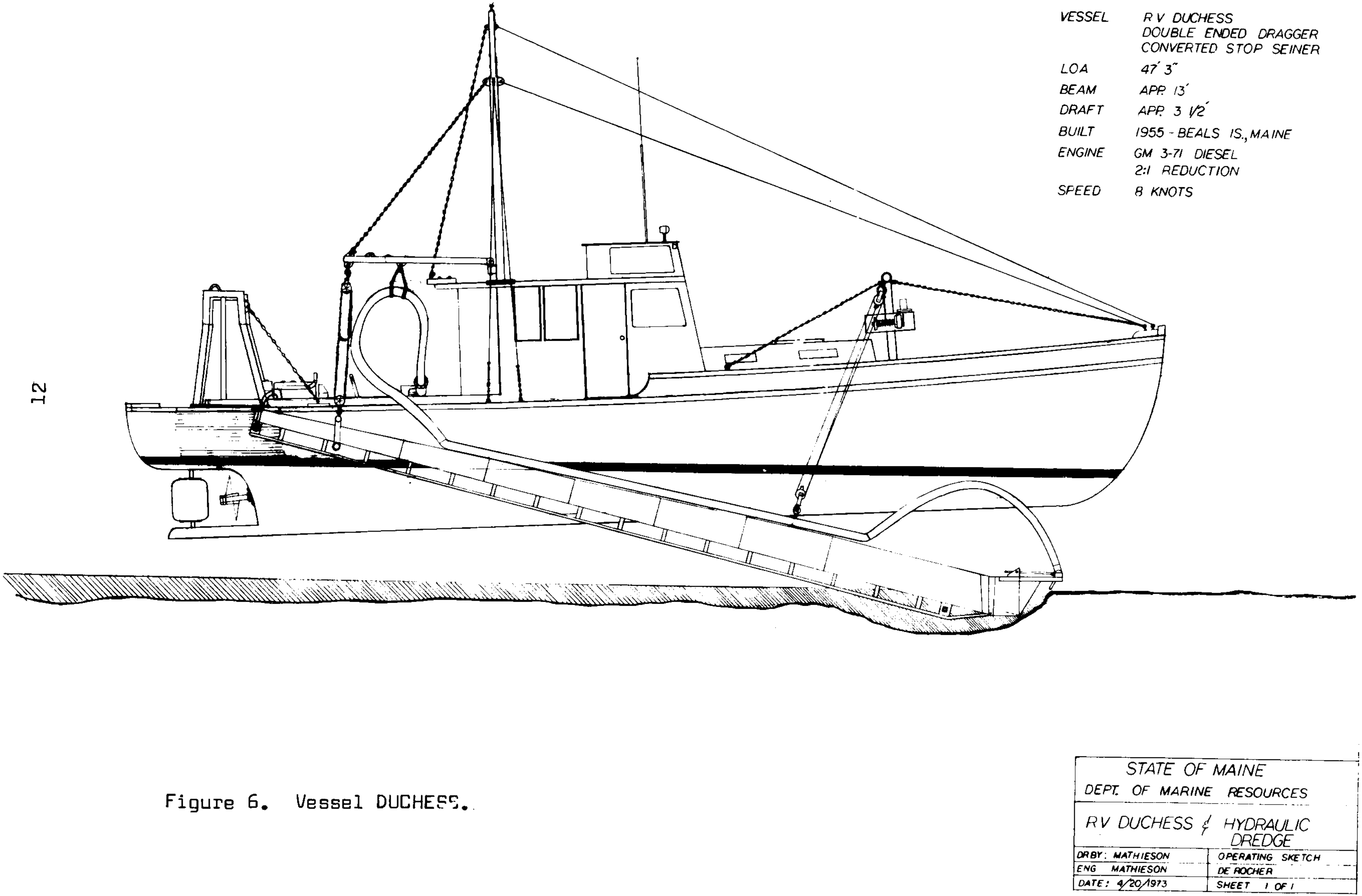


Figure 6. Vessel DUCHESS.

The conveyor assembly and hydraulic head shown in Figure 7 was mounted on the starboard side of the vessel DUCHESS. The total weight of the dredge equipment is 800 pounds. Since this weight is located 7' from the longitudinal center line, the total weight effect on the starboard side is 5600 pounds. Compensation for this unstable condition was made by locating the dredge's main pump and engine as far as possible on the port side. In addition to this, ballast blocks were added to the port side until the vessel was in stable equilibrium.

The dredge main pump and engine (MP&E) shown in Figure 8, was located in the vessel's after cockpit area. The MP&E was mounted on steel channel beams and lag bolted into oak transverse beams located beneath the after cockpit deck.

The forward davit assembly, shown in Figure 8, was mounted on fixed pintles bolted through the forward deck to oak transverse beams.

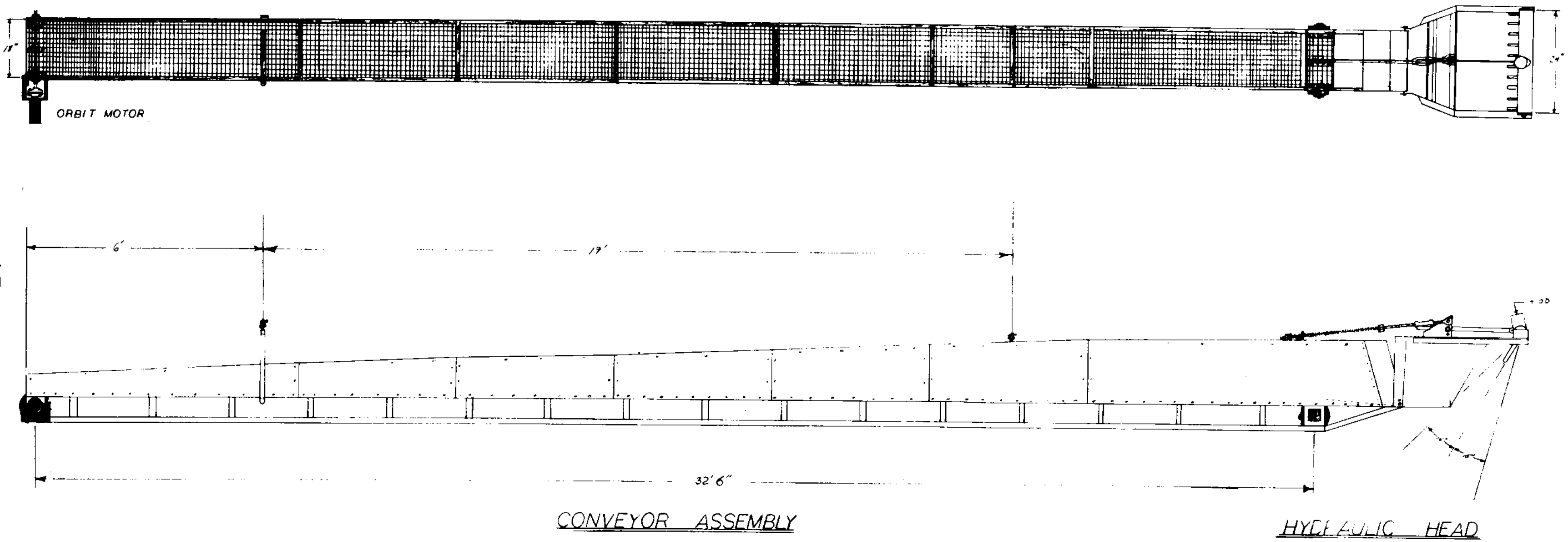


Figure 7. Conveyor assembly and hydraulic head.

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ENG MATHIESON AND	DE ROCHER
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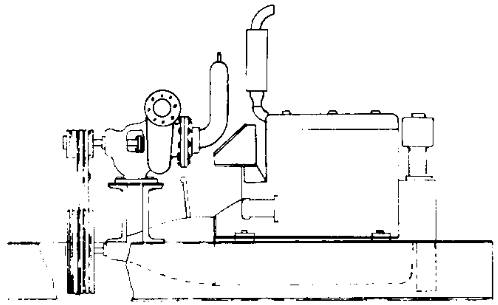
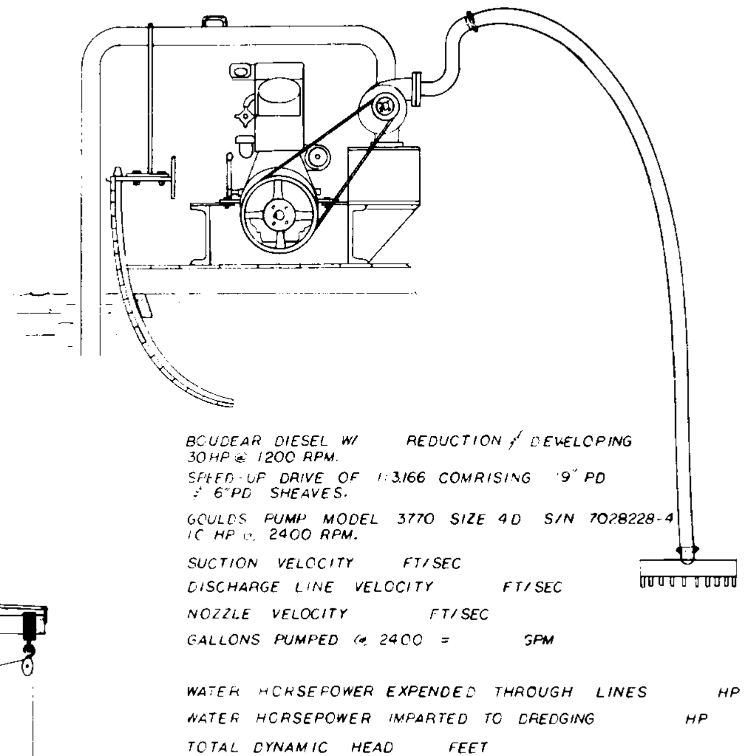
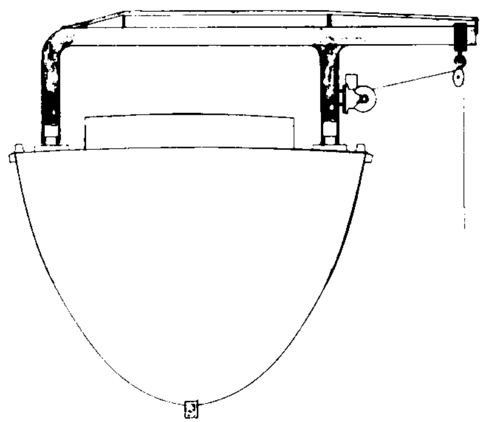


MAIN ENGINE & PUMP





FWD. DAVIT ASSEMBLY W/ WINCH

MATERIAL LIST AND APPROXIMATE COST TO DMR

1 VESSEL (SEE SPECS FRONT SHEET)
2 HYDRAULIC SYSTEM RUN OFF MAIN ENG.
3 DEPTH RECORDER
4 MAIN PUMP AND ENG. (MPE)
5 SUCTION AND DISCHARGE LINES & HOSES
6 CONVEYOR ESCALATOR
7 HYDRAULIC HEAD
8 FWD. DAVIT ASSEMBLY W/WINCH
9 AFTER MAST & BOOM APPRANGEMENT
10 HULL FITTING MPE COOLING SYSTEM

ACTUAL COSTS*

1	VESSEL	4,200.00
2	MAIN PUMP SUCTION LINE CONVEYOR ESCALATOR HYDRAULIC HEAD FWD. DAVIT ASSEMBLY W/ WINCH	3,150.00
3	CONVEYOR BELT	129.00
4	MAIN ENGINE DONATED	
5	MISCELLANEOUS COSTS SUCH AS REPAIRS, FITTINGS, HOSES AND EXTRA EQUIPMENT	1,521.00
*	TOTAL ACTUAL COSTS TO DMR	10,000.00

Figure 8. Dredge main pump and forward david assembly.

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IV. DESCRIPTION AND ENGINEERING DATA FOR DREDGE

DREDGE MAIN PUMP AND DRIVE

On most of the dredges in Maryland the dredge's main pump was direct coupled to the driver with a flexible joint in between. Most of the drivers were gasoline engines which turn up to relatively high RPMs compared to diesel engines.

In this case a small Buda diesel was obtained for the driver. Since this diesel only developed 30 hp at 1200 RPM and 2400 RPM was needed on the pump for peak efficiency, a speed-up drive shown in Figure 9 had to be designed.

From the Browning Engineering Data Catalog for speed-up drives, the following information was determined:

1. It is recommended for a 30 hp driver at 1750 to 3500 RPM that a minimum of "3V" belts be used.
2. The recommended overload service factor for a centrifugal pump with a diesel driver is 1.2.

   $$1.2 \times 30\text{hp} = 36 \text{ hp normal rating}$$

3. With a 1.5 to 1 reduction on the diesel, a 19" pitch diameter (P.D.) sheave on the driver and a 6" pitch diameter (P.D.) sheave on the pump, the resultant driven speed will be 2538.33 RPM. This is slightly over the peak performance RPM of 2400 RPM.

   The speed-up drive ratio will then be:

   $$\frac{2538.33}{800} = 1 \text{ to } 3.166$$

4. The determined belt length based on 30" centers between the driver and driven shafts is:

   $$L = 2(30) + 1.57(19-6) = 80.41 \text{ inches}$$

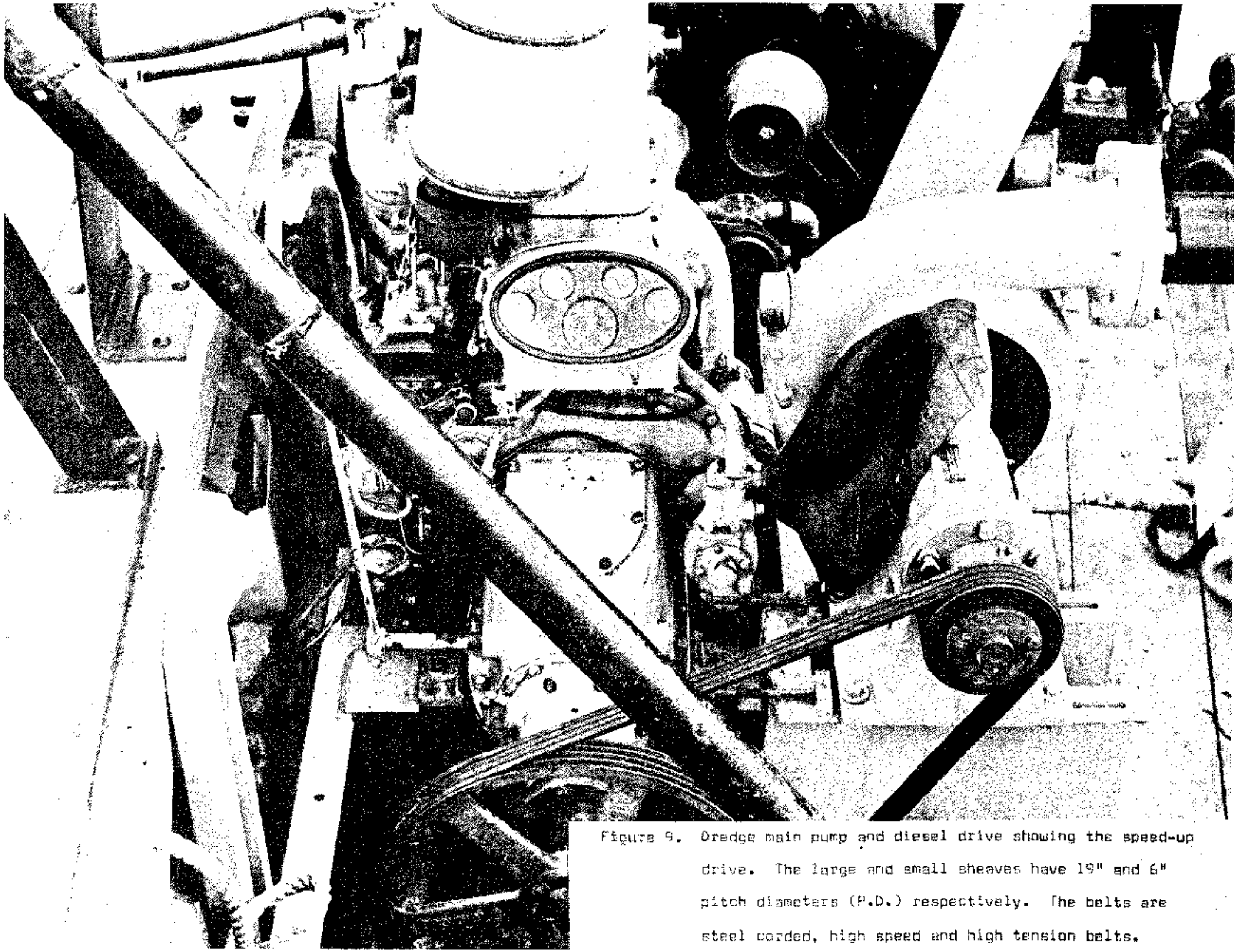


Figure 9. Dredge main pump and diesel drive showing the speed-up drive. The large and small sheaves have 19" and 6" pitch diameters (P.D.) respectively. The belts are steel corded, high speed and high tension belts.

Note: Due to flexibility with jackscrews for tightening belts, select belt size which best approximates 80.41 inches.

5. The belt type selected for this speed-up drive is a high speed, high tension and steel corded belt. At 2400 RPM on the driven 6" P.D. sheave this belt would transmit 9.11 hp. At 2600 RPM it would transmit 9.66 hp. The higher the speed the more horsepower transmitted.

   The "Drive Ratio Correction" for a 1 to 3.16 ratio is .51.

   9.11 hp + .51 hp = 9.62 hp ber belt

   Correcting for loss in arc contact factor .93 and belt length factor 1.08 (Corrections obtained from Browning Engineering Data Catalog).

   .93 x 1.08 x 9.62 = 9.66 hp per belt

6. Since 9.66 hp can be carried by one belt the total number of belts can be determined by:

   $$\frac{30}{9.66} = 3.10 \text{ or } 4 \text{ belts needed}$$

The total rated capacity = 4 x 9.66 = 38.64 hp. This is slightly more than the corrected normal rated 36 hp. It is better to be conservative in the hp ratings than to overate the belts.

DREDGE SYSTEM DESCRIPTION

Water for the dredge was picked up through a retractable 6" suction line, Figure 10. The suction line was extended over the side by tightening a threaded connection between the suction pipe and a flange on the pump. Retracting the suction line loosened the connection allowing this line to be pulled into the boat.

Figure 10. Retractable 6" suction line for the dredge's main pump.

Priming the dredge's main pump was accomplished with a lever actuated manual vacuum pump shown in Figure 11. It is important to remember to lower the dredge's nozzels into the water in order to get a vacuum seal on the entire system. Also, insure that the gland on the pump is tight as a loose gland is means by which vacuum can be broken. Also shown in Figure 11 is the dredge's main pump and 4" discharge line.

The pump discharges to a flexible PVC hose which runs to an iron pipe on the escalator, shown in Figure 12. The flexible hose allows for the movement of the escalator alongside the boat. Where possible long radiuses and 45 degree bends were used in place of 90 degree elbows. This allows for more efficient flow in the discharge line.

Also shown in Figure 12 is a depth guage for determining depth of water. Since the dredge is on a keeled vessel extreme caution was exercised in watching the tide.

The sag in the conveyor belt shown in Figure 12 was formed by the stretching of the belt on the conveyor. The sag held the belt tight on the excalator and was a normal condition of operation. Hydraulic lines (oil) for the conveyor belt motor are shown in Figure 12. These allow for the movement of the escalator alongside the boat.

The iron pipe on the escalator runs to within 4' of the escalator head and is "U" bolted to the cross frame work shown in Figure 13. The after section of the escalator is suspended by a pivot rigged to the vessel's boom arrangement. A chain fall was used to raise or lower this pivot point when dredging in shallow or deep water.

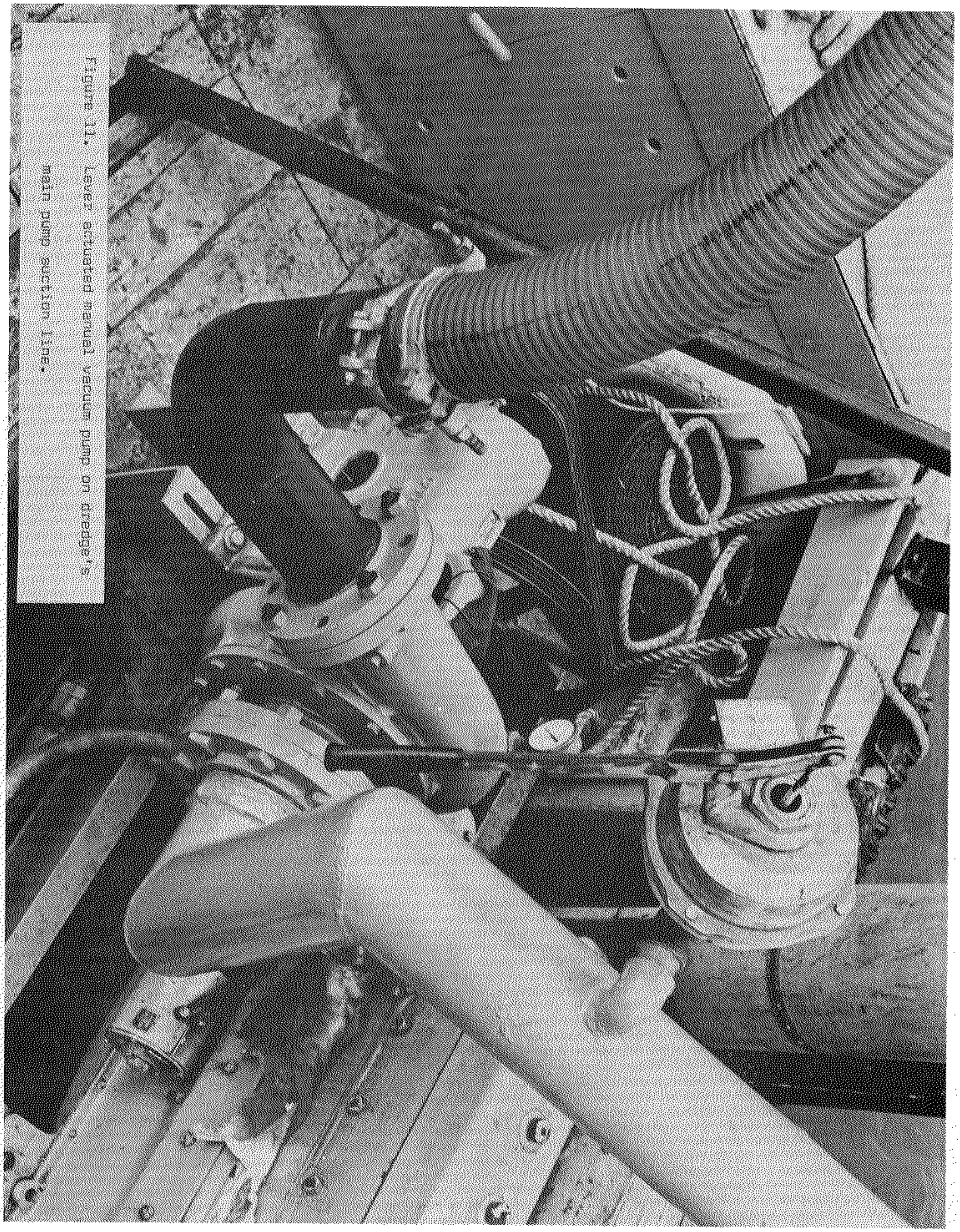


Figure 11. Lever actuated manual vacuum pump on dredge's main pump suction line.

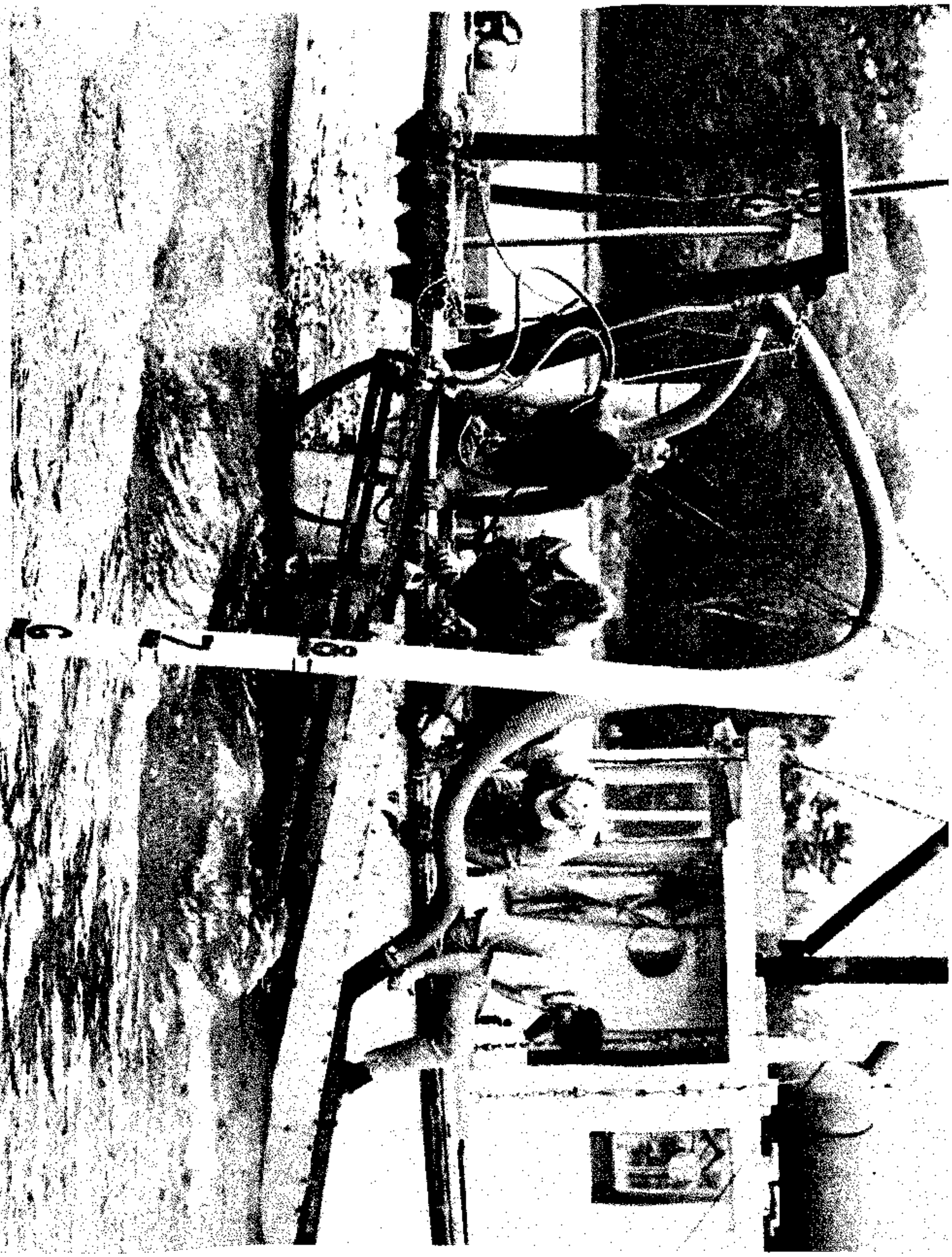


Figure 12. Flexible discharge hose from pump to escalator.

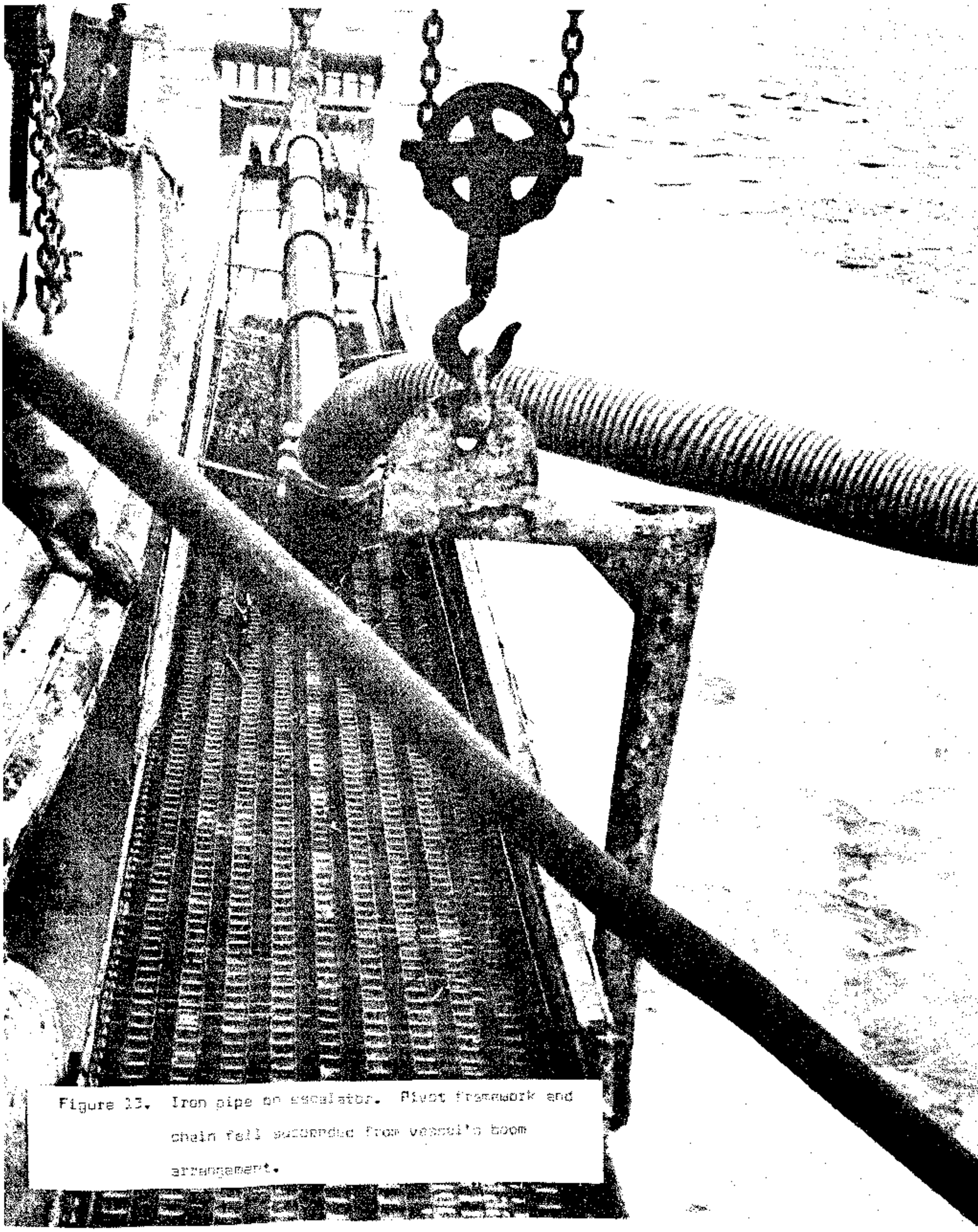


Figure 13. Iron pipe on escalator. Pivot framework and chain fall suspended from vessel's boom arrangement.

Another section of flexible (PVC) hose was used to connect the iron pipe on the escalator to the nozzle manifold on the dredge head shown in Figure 14. This allowed for the tilting action of the dredge head. The spring arrangement between the dredge head and escalator is a shock absorber. This allows the head to absorb the sudden shock resulting from striking hard objects on the bottom. The bar lever on the dredge head is for setting the nozzle angle. These nozzles are usually set so they discharge a stream 4" in front of the deflector plate in the head. There are two pivot points on the dredge head. One is for the nozzle manifold and the other is for the dredge head. The dredge head pivot point can be lowered or raised. Lowering the hydraulic head on the pivot point brings the nozzles closer to the bottom. It was found that by lowering the nozzles in this way the dredge worked better in the hard blue clay.

The escalator is lowered and raised by the forward winch and davit arrangement shown in Figure 15. The sheaves for this were machined on a lathe to form deep grooves for the wire cable. Extra large wire guides were then made for the sheaves. Each sheave was fitted with a grease fitting to prevent seizing. A bracket was welded on the davit post to which the winch was mounted. The entire forward davit assembly was arranged for easy installation and removal. This was accomplished by designing a mounting on the deck to which the davit was fitted. The davit was held in place by chain and turn buckles shackled to eye bolts in the deck. The hydraulic winch was connected to permanent lines with flexible hoses for easy disconnecting.

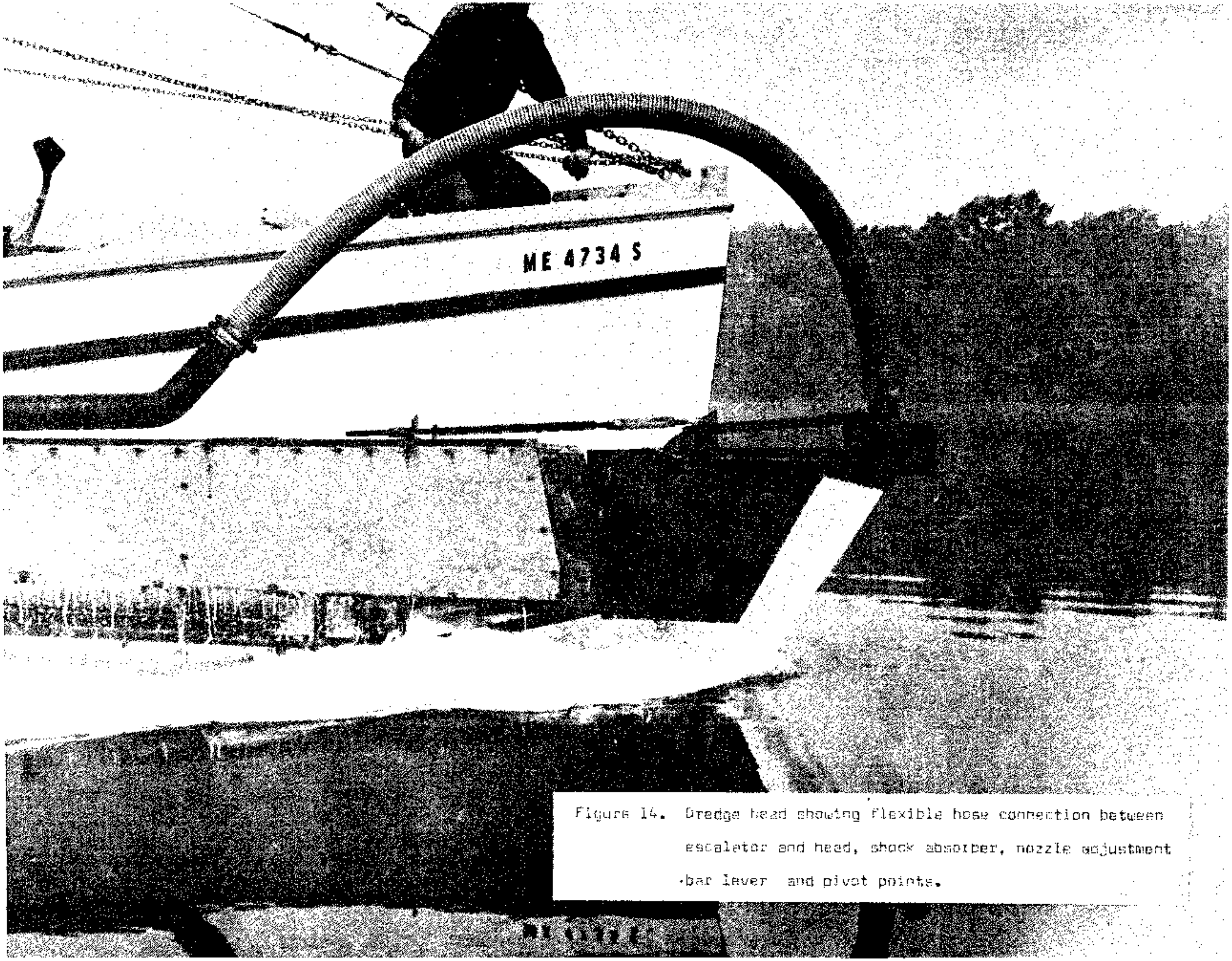


Figure 14. Dredge head showing flexible hose connection between escalator and head, shock absorber, nozzle adjustment bar lever and pivot points.

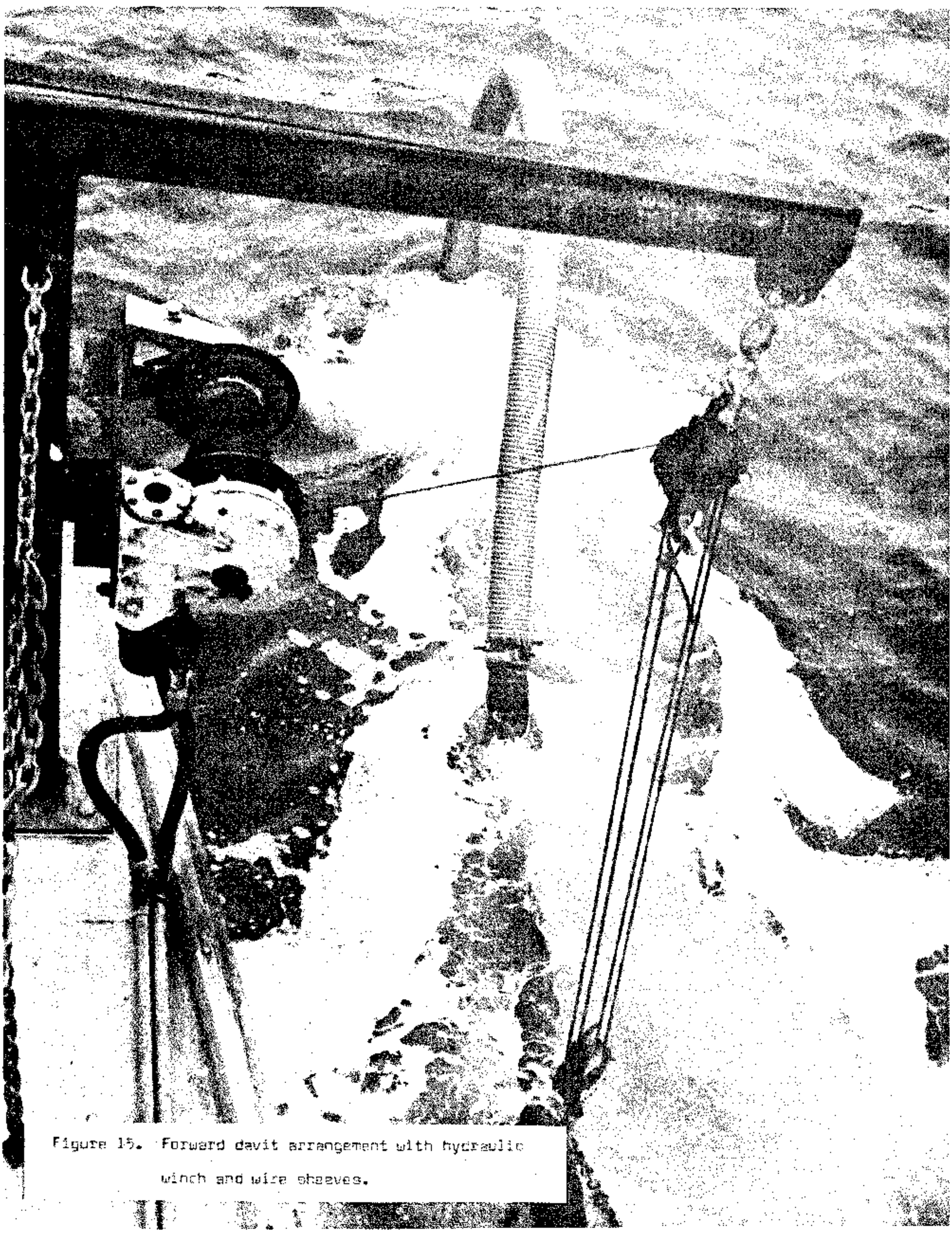


Figure 15. Forward davit arrangement with hydraulic winch and wire sheaves.

With the escalator lowered on bottom the resultant material that came up on the conveyor was medium size chunks of soft clay shown in Figure 16. The most efficient operation was achieved when the belt was discharging small nodules of clay. With this happening the dredge was digging to a 14"-18" depth with a fairly good production of soft shell clams. Sometimes to achieve this condition several passes had to be made over an area.

DREDGE HYDRAULICS

Figure 17 is a schematic of the dredge's pumping system from which the various head losses were computed. The following heads are approximations of the true heads since the dredge system only had one pressure guage at the discharge of the pump.

Head Loss and Friction

A familiar equation for head loss in pipelines is the Darch-Weisbach equation:

$$H = \frac{(f)\ (L)\ (V^2)}{(d)\ (2g)}$$

Where: H = Head loss, in feet of fluid.

L = Length of pipe, in feet.

d = Inside diameter of the pipe, in feet.

V = Average velocity of the water, in feet per second.

g = Acceleration of gravity, in feet per second per second.

f = Friction factor (Reynolds number & Pipe roughness), see friction factor chart Figure 18.

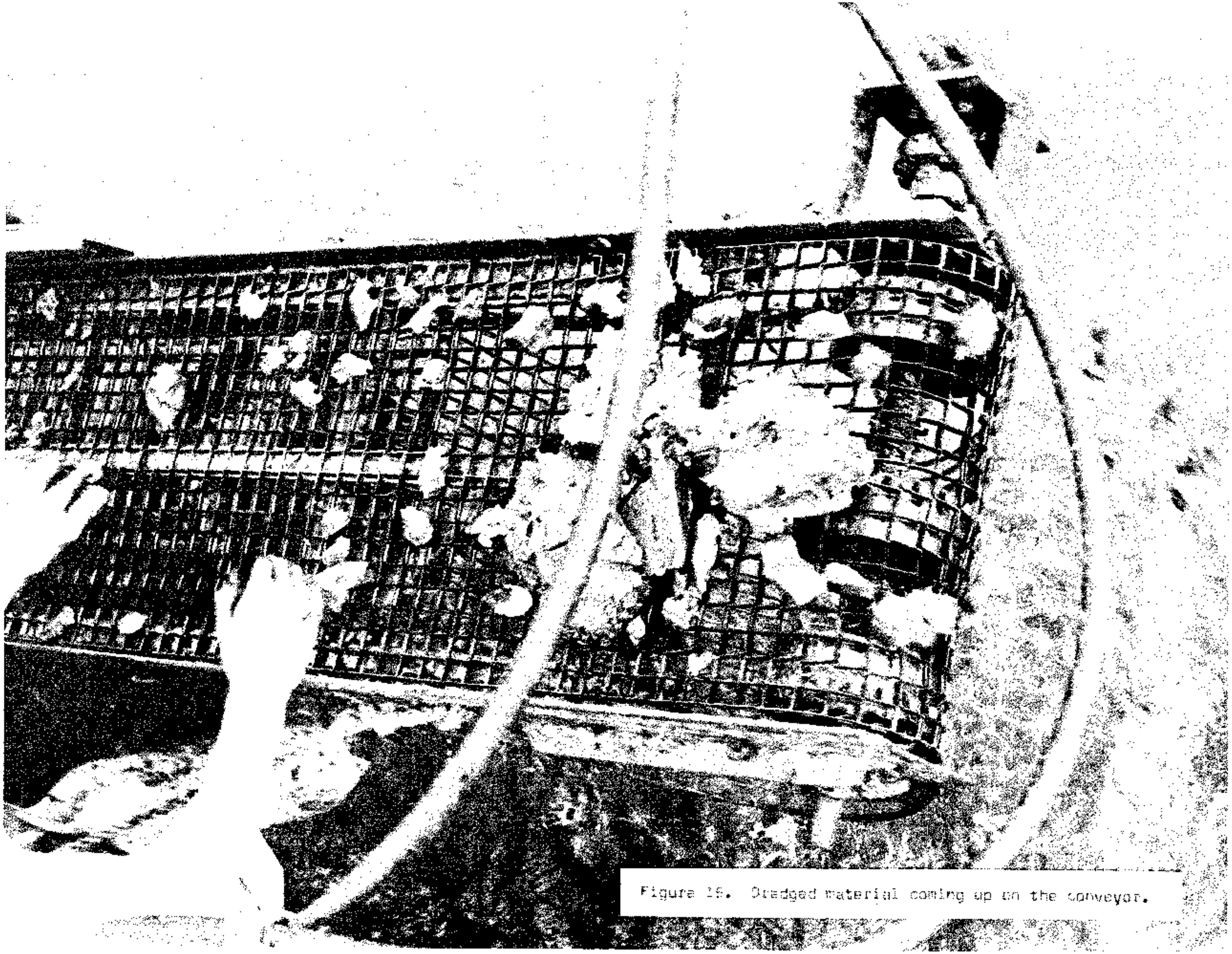


Figure 15. Dredged material coming up on the conveyor.

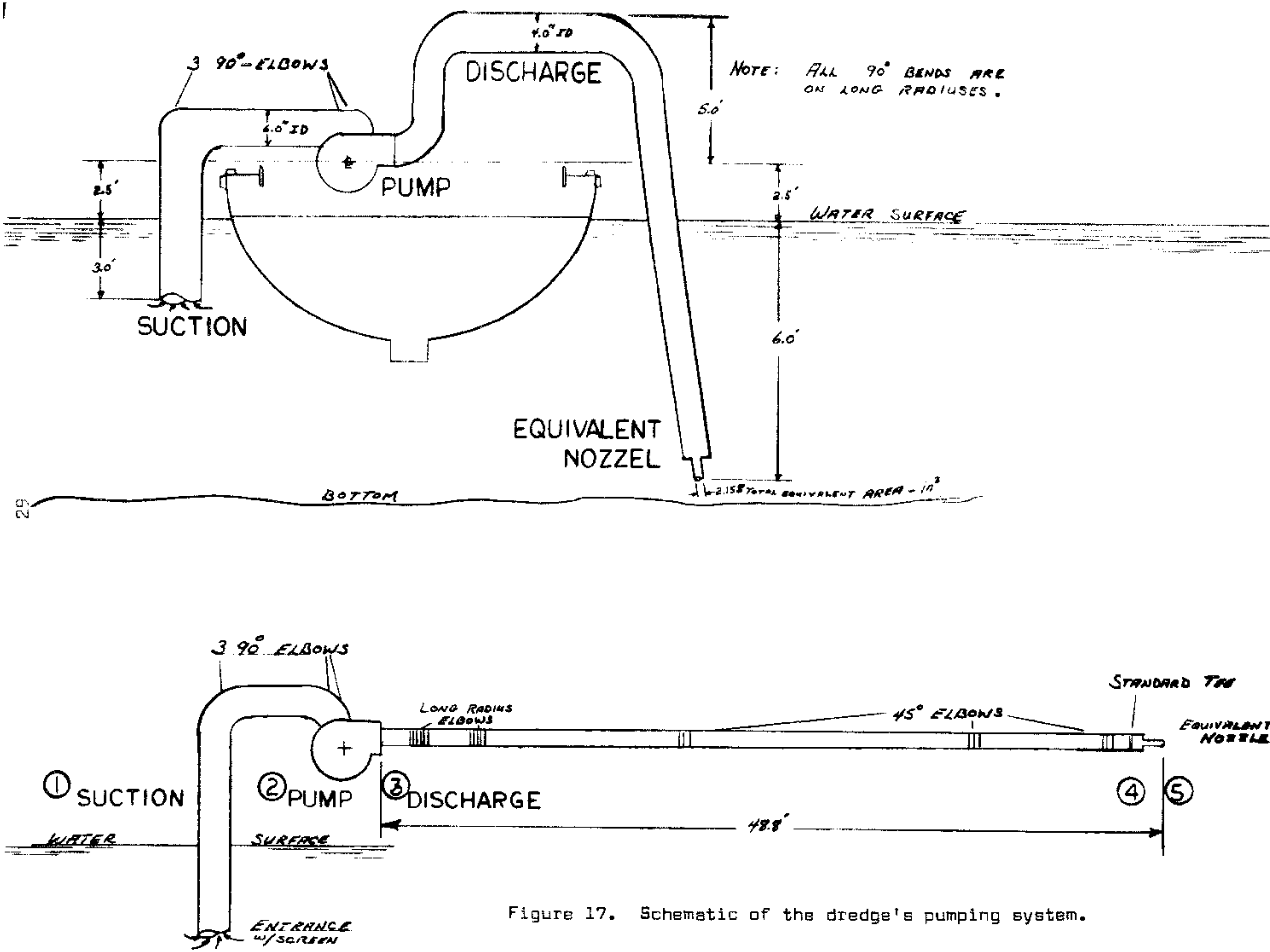


Figure 17. Schematic of the dredge's pumping system.

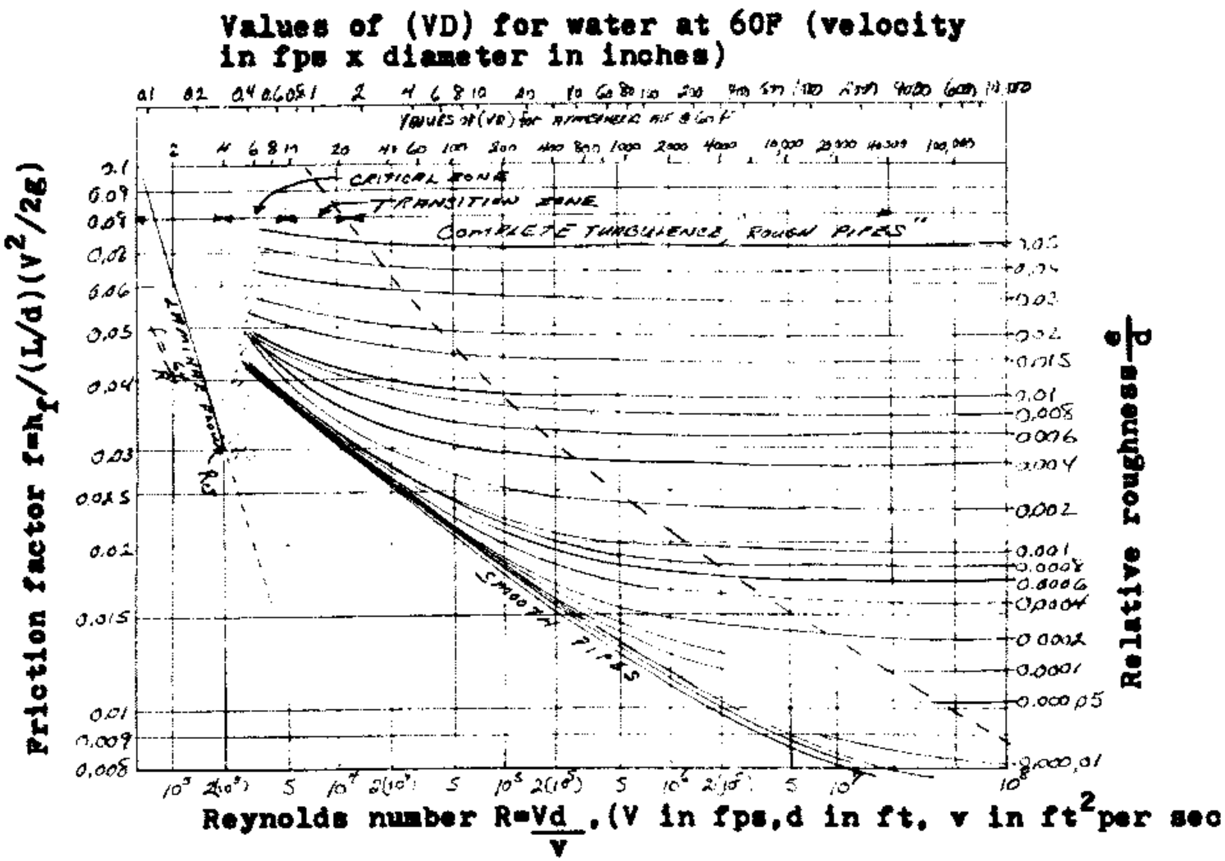


FIG.18. Friction factors for flow in pipe.

A. Suction static head. The pump center line is 2.5 feet above the loaded water line. Therefore the suction static head is positive.

$$H_{ss} = SG_{sw} \times ht$$

$$H_{ss} = 1.025 \times 5.5 = \underline{5.64 \text{ feet}}$$

B. Suction velocity head. This is the head (H_{sv}) which the fluid would have to fall to acquire the velocity it has in the suction. Suction velocity head will consequently be:

$$H_{sv} = SG \frac{(V_s^{\,2})}{2g}$$

$$H_{sv} = \frac{1.025 \times 2.85}{64.4} \text{ ft/sec}$$

$$H_{sv} = \underline{0.045 \text{ feet}}$$

C. Suction friction head. The head required to overcome friction in the pipe is called friction head (H_{sf}). Suction friction head can be computed from the Darcy-Weisbach equation:

$$H_{sf} = (SG)\ (f)\ \frac{(L+L_1)\ (V_s^{\,2})}{(d)\ (2g)}$$

Where: H_{sf} = friction head, (in feet).

L = actual length of suction line, (in feet).

d = inside diameter, (in feet).

V = velocity ft/sec.

f = friction factor (See Figure 3).

L_1 = additional pipe length to add to actual length (L) due to fittings.

Solving for L_1:

$$L_1 = \frac{(D)\ (K)}{4(f)}$$

Where: D = diameter of pipe (in feet)

f = friction factor (Reynolds number & relative roughness)

K = head loss coefficient

a) Standard 90^{0} - elbow $K_{90} = 0.90$

b) Standard 90^{0} - elbow $K_{90} = 0.90$

c) Standard 90^{0} - elbow $K_{90} = \underline{0.90}$

$K = 2.70$

$$L_1 = \frac{(.5)\ (2.70)}{(4)\ (.007)} = 48.21 \text{ feet}$$

Then

$$H_{sf} = (1.025)\ (0.0199)\ \frac{(10.0 + 48.21)\ (2.85)}{(.5)\ (64.4)} = \frac{3.39}{32.2}$$

$$H_{sf} = \underline{0.105 \text{ feet}}$$

D. Suction entrance head. Suction entrance losses are generally small. However while dredging in shallow areas a screen was needed over the suction intake. This increased the suction entrance head greatly.

Head loss at the suction entrance can be obtained from;

$$H_e = K_e \frac{V_s^2}{2g}$$

Where: K_e = coefficient of the mouthpiece
V = suction velocity

Note: A short cornered entrance, such as a straight piece of pipe, has a K_e of 1.42.

Solving for $H_e = (1.42)\ \frac{(2.85)}{(64.4)}$

$$H_e = \underline{0.063 \text{ feet}}$$

E. Suction total head. The suction total head is the algebraic sum of all the suction heads.

Therefore;

$$H_{st} = H_{ss} + H_{sv} + H_{sg} + H_e$$

$$H_{st} = 5.64 + 0.045 + 0.105 + 0.063$$

$$H_{st} = \underline{5.830 \text{ feet}}$$

F. Discharge static head. This is the vertical distance, in feet, between the center line of the pump and the point of discharge. The center line distance from the pump to the point of discharge is -8.5 feet. However, the pump first pumps 5.0 feet above its center line distance so the net effect is -8.5 + 5 = -3.5 feet.

$$H_{ds} = SG \times D$$

Where: D = distance from L_p to dredge discharge

$$H_{ds} = 1.025 \times (-3.5) = \underline{(-)3.587 \text{ feet}}$$

G. Discharge velocity head. Discharge velocity head (H_{dv}) is defined exactly as suction velocity head. In simplest terms it is the head created by the pump, being the output head less the head created by the pump, and is proportional to the ratio of the diameters of the suction and discharge pump openings.

$$H_{dv} = (SG)\,\frac{(V_d^{\,2} - V_s^{\,2})}{(2g)}$$

Where: V_d = discharge velocity (in ft/sec)

V_s = suction velocity (in ft/sec)

$$H_{dv} = (1.025)\,\frac{(14.4^2 - 2.85^2}{64.4}$$

$$H_{dv} = 3.429 \text{ feet}$$

H. Discharge friction head. The discharge friction head (H_{df}) is the head required to overcome friction losses in the discharge line. It can be computed from the Darcy-Weisbach equation:

$$H_{df} = \frac{(SG)(f)\ (L+L_1)(V_d^2)}{(d)(2_g)}$$

Where H_{df} = friction head, (in feet).

L = actual length of discharge line, (in feet).

L_1 = additional pipe length to add to actual length (L) due to fittings.

d = inside diameter, (in feet).

V = velocity (ft/sec).

f = friction factor (see Figure 3).

Solving for L_1:

$$L_1 = \frac{(D)\ (\Sigma K)}{4\ (f)}$$

Where D = diameter of pipe, (in feet).

f = friction factor (Reynolds Number & Relative Roughness).

K = head loss coefficient

a)	long radius (90^o bend)	$K_{lr} = 0.60$
b)	long radius (90^o bend)	$K_{lr} = 0.60$
c)	45^o elbow	$K_{45^o} = 0.42$
d)	45^o elbow	$K_{45^o} = 0.42$
e)	45^o elbow	$K_{45^o} = 0.42$
f)	standard-tee @ manifold	$\Sigma K_{st} = \underline{1.80}$
		$K\quad 4.25$

$$L_1 = \frac{(.25)(4.26)}{(4)(.007)} = 38.03 \text{ feet}$$

Then $$H_{df} = (1.025)\ (.007)\ \frac{(38.03 + 48.8)\ (14.4)}{(.25)(64.4)} = \frac{129.18}{16.1}$$

$$H_{df} = \underline{8.02 \text{ feet}}$$

I. Discharge total head. The discharge total head is the algebraic sum of all the discharge heads.

Therefore:

$$H_{df} = H_{ds} + H_{dv} + H_{df}$$

$$H_{df} = -3.587 + 3.429 + 8.02$$

$$H_{df} = \underline{7.862 \text{ feet}}$$

J. Entrance losses (H_{en}) (nozzles). This is the head loss as the fluid enters the nozzles. Its computed for a sharp edged entrance having a K of (.5).

$$H_{en} = \frac{(K)\ (V)}{2g}$$

Where H_{en} = entrance head loss in (ft).

K = loss factor.

V = velocity ft/sec.

$$H_{en} = \frac{(.50)(14.34)}{64.4} = \underline{1.59 \text{ feet}}$$

K. Sudden contraction losses (nozzles) H_x. This is the head loss as the fluid passes through the nozzles. It is computed by:

$$H_x = \frac{(V_2 - V_1)}{(2g)}\ (C_1)$$

Where V_1 = input velocity, in feet per second.

V_2 = output velocity, in feet per second.

g = acceleration of gravity in feet per second.

C_1 = nozzle constant.

Then: $$H_x = \frac{(84.7 - 14.34)}{64.4} \times 0.4 = \underline{30.75 \text{ feet}}$$

L. Exit losses H_{ex} (nozzles). This is the head loss as the fluid exits the nozzles. It is computed with a K of (1.0).

$$H_{ex} = \frac{(K)(V)}{2g}$$

$$H_{ex} = \frac{(1)(14.34)}{64.4} = \underline{3.19 \text{ feet}}$$

M. Total dynamic head (H_f). This is the algebraic sum of the total suction head, the total discharge heads and the miscellaneous heads.

$$H_f = H_{st} + H_{df} + H_{en} + H_x + H_{ex}$$

$$H_f = 5.850 + 7.862 + 1.59 + 30.75 + 3.19 = \underline{49.242 \text{ feet}}$$

Total Head Loss Summary

H_{ss} = 5.64 ft	H_{ds} = -3.587 ft	H_{en} = 1.59 ft
H_{sv} = 0.045 ft	H_{dv} = 3.429 ft	H_x = 30.75 ft
H_{sf} = 0.105 ft	H_{df} = <u>8.02 ft</u>	H_{ex} = <u>3.19 ft</u>
H_e = <u>0.063 ft</u>	H_{dt} = 7.862 ft	$H_{misc\ t}$ = 35.53 ft
H_t = 5.850 ft		
H_f = 49.242 feet total loss		

49.242 feet is the theoretical total dynamic head on the system. This is equivalent to (.434 x 49.242 = 21.37 PSI) pressure at the nozzle outlet.

From the pump curve figure 19 then the approximate capacity is 575 GPM. So the pump is discharging 575 GPM @ 21 PSI at the nozzles.

From the continuity equation the velocities in the various line sections are:

Suction	V_1 = 2.85 ft/sec	Area Equivalent = 28.26 in^2
Discharge @ pump	V_2 = 14.40 ft/sec	" " = 12.56 in^2
Discharge manifold	V_3 = 14.34 ft/sec	" " = 12.56 in^2
Discharge nozzles	V_4 = 84.7 ft/sec	" " = 2.158 in^2

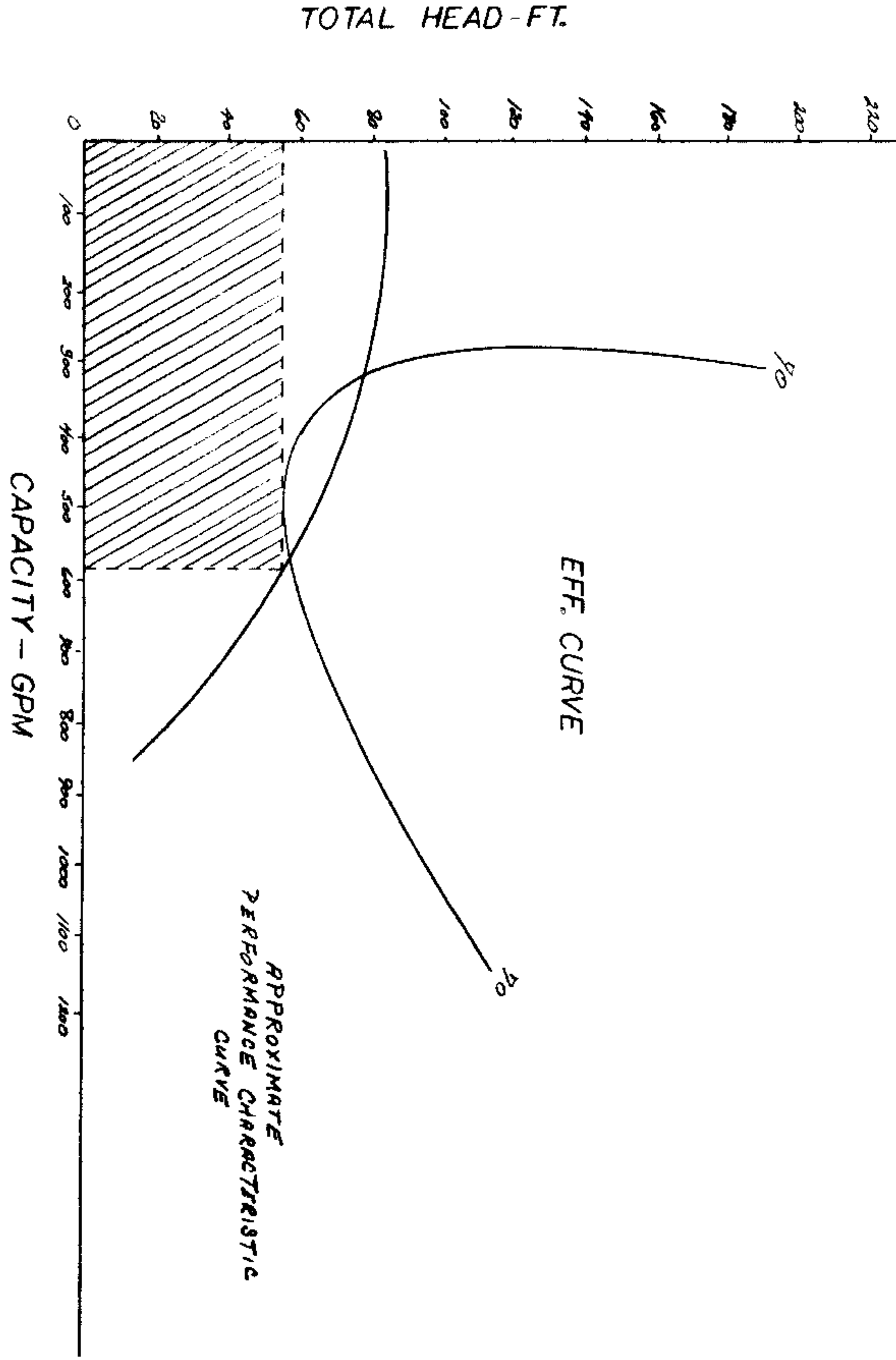


FIGURE 19. Pump curve.

The horsepower requirements were determined from this data as follows: First water horsepower, the power actually expended in forcing the fluid out the nozzle discharge, as

$$HP_w = \frac{(SG)(Q)(H_f)}{3960}$$

$$HP_w = \frac{1.025 \times 575 \times 49.242}{3960} = 7.33 \text{ HP}$$

and second brake horsepower, the power expended in forcing the fluid ou the discharge, plus the power required to turn the pump and supply a l losses, as

$$HP_b = \frac{HP_w}{EFF}$$

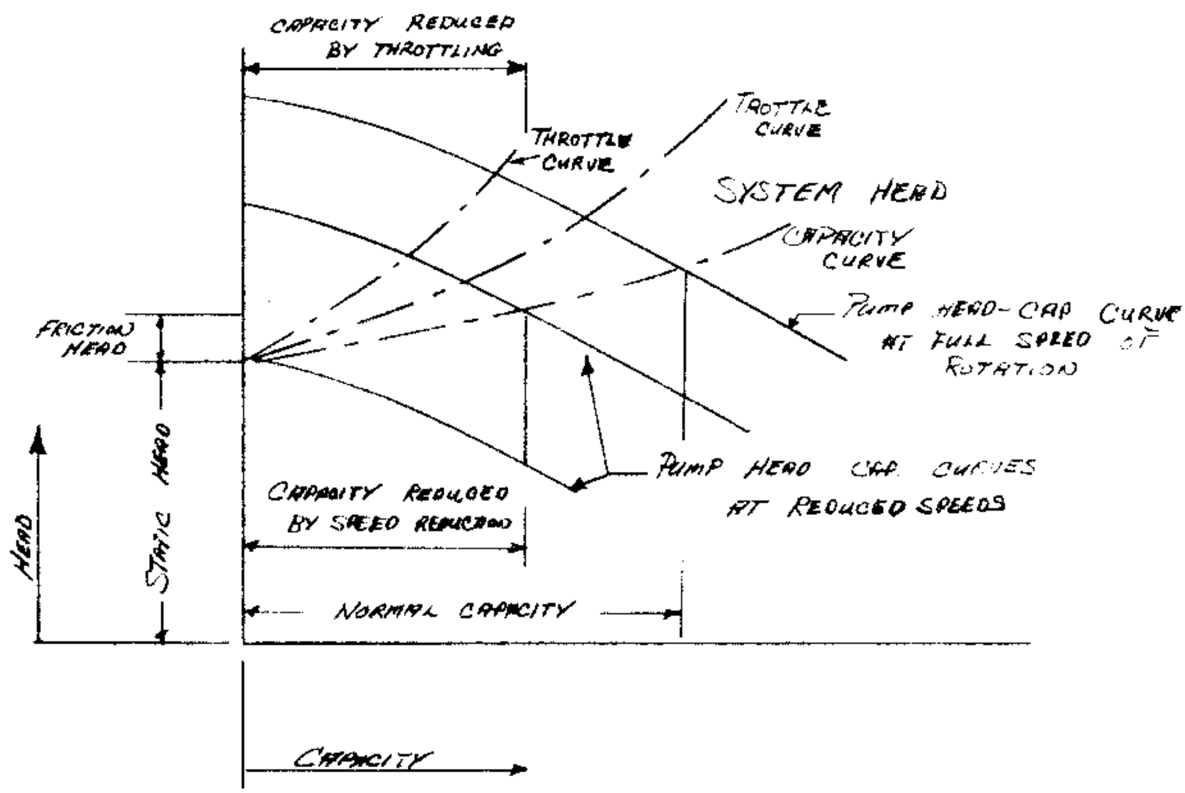
$$HP_b = \frac{7.33}{.7?} = 10.47 \text{ HP}_b$$

orsepower will increase for any point moving from left to right the pump curve.

Fi...e 20 shows how the pump operates in a system. Reducing the speed of the pump lowers the head while reducing the capacity. Throttling the pump discharge, such as with the nozzles, increases the head and reduces the capacity.

Figure 21 shows how the capacity varies with efficiency. The efficiency will depend upon the revolutions per minute of the pump and head for any given capacity.

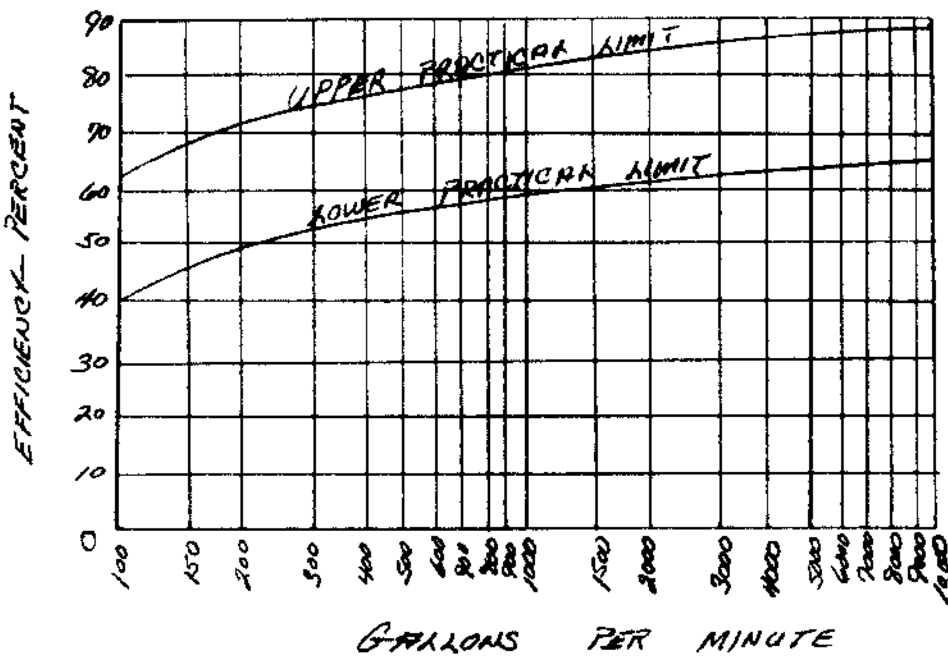
FIGURE 20.



PUMP OPERATION IN A SYSTEM

FIGURE 21.

Shows how the capacity varies with efficiency.



NOTE: ACTUAL EFFICIENCY WILL DEPEND UPON RPM & HEAD FOR ANY GIVEN CAPACITY.

V. OPERATION AND PERFORMANCE

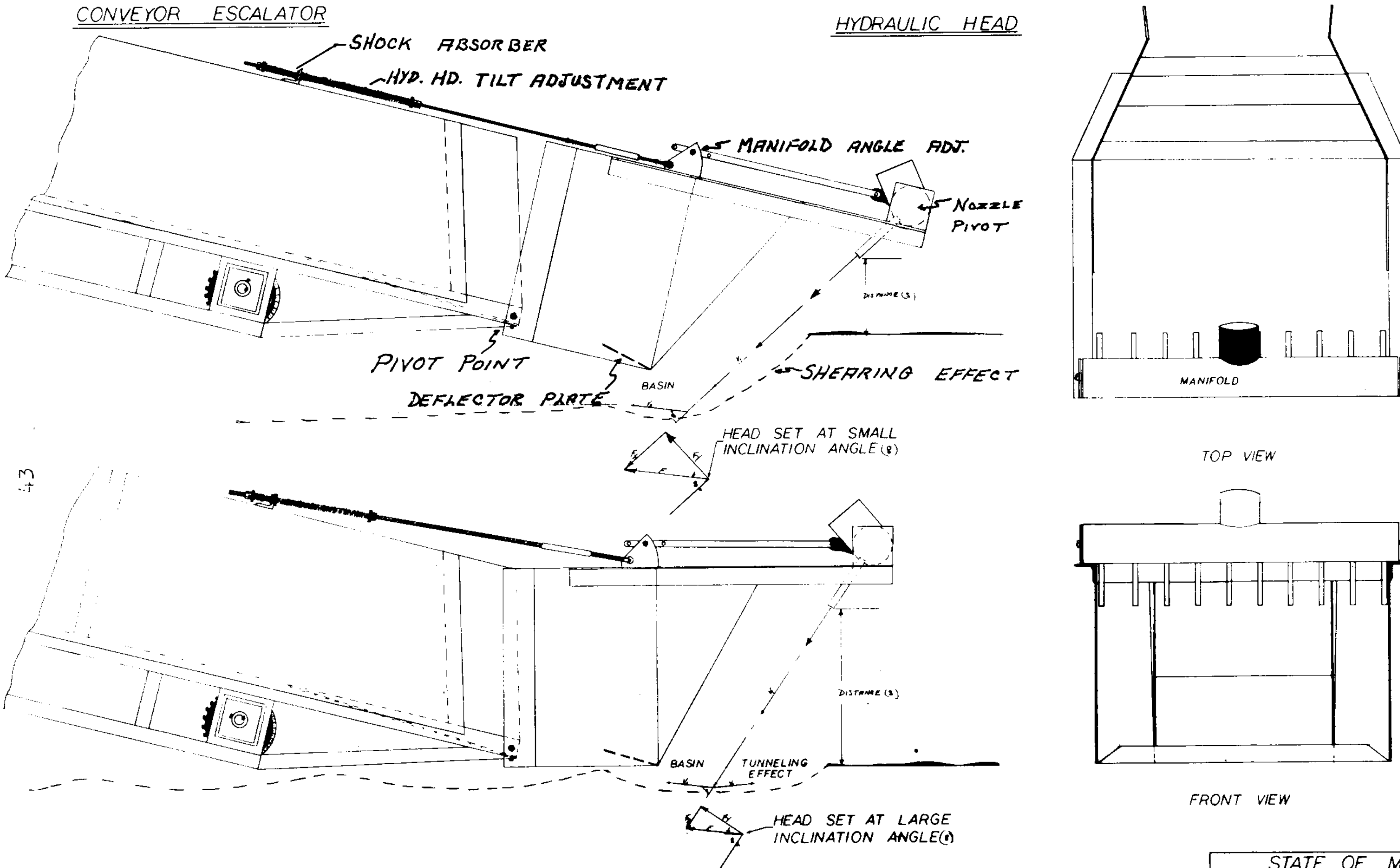
During the summer months of 1973, the R.V. DUCHESS shown in Figure 22 , with the hydraulic dredge, operated in the Harraseeket River on an experimental plot. This plot was under study by Dept. of Marine Resources Scientist, Michael Kyte, and a number of Bates College students under the student direction of Phil Averill.

It was during this operation that the observations and evaluations of the hydraulic dredge were made. The bottom was a combination of silt and various clays. Among the various types of clay was a layer of very stiff blue clay. The objective was to operate the dredge under the most difficult dredging conditions and achieve the best possible performance.

Achieving the best performance was one of getting the hydraulic head in the right position so it would dig into the lower layers of the very stiff blue clay. Two adjustments were made in positioning the hydraulic head. The first was to tilt the hydraulic head on its pivot point forward. The second was to lower the hydraulic head on the pivot point. See Figure 23 . Both adjustments reduced the nozzle to bottom distance thus reducing the distance the water jets had to travel through a liquid medium. Tilting the hydraulic head forward also reduced the water jet incident angle with the bottom. This small incident angle created a shearing effect on the very stiff blue clay and proved to be a more efficient method of digging.

With these adjustments made and the hydraulic head lowered to the bottom, a half minute was allowed for the water jets to dig into the bottom sediments. It was found, due to the cohesiveness of the clay, that the propulsion of the vessel wasn't enough to move the dredge along the bottom. This problem was solved by a simple zig-zagging pattern

Figure 22. R/V DUCHESS under full dredging operation in the experimental Harraseeket River plot August, 1973.



STATE OF MAINE DEPT. OF MARINE RESOURCES	
PRINCIPLES OF HYDRAULIC DREDGING	
DR:BY MATHIESON	OPERATING SKETCH
ENG: MATHIESON AND	DE ROCHER
DATE 4-20-1973	SHEET 3 OF 4

Figure 23. Hydraulic head schematic.

accomplished by steering the vessel hard-over left to hard-over right. This moved the nozzle manifold on the hydraulic head enough to break the cohesive grip of the clay and allow forward motion.

The trench dug by the dredge in this manner is shown in Figure 24. The hydraulic head dug down 18". The last 6-10" was in the very stiff blue clay. The very stiff blue clay was broken into small nodule-like chunks. See Figure 25. With nodule-like chunks of clay coming up on the conveyor belt, the hydraulic head was operating properly by breaking apart the bottom sediments and freeing the soft shelled clams.

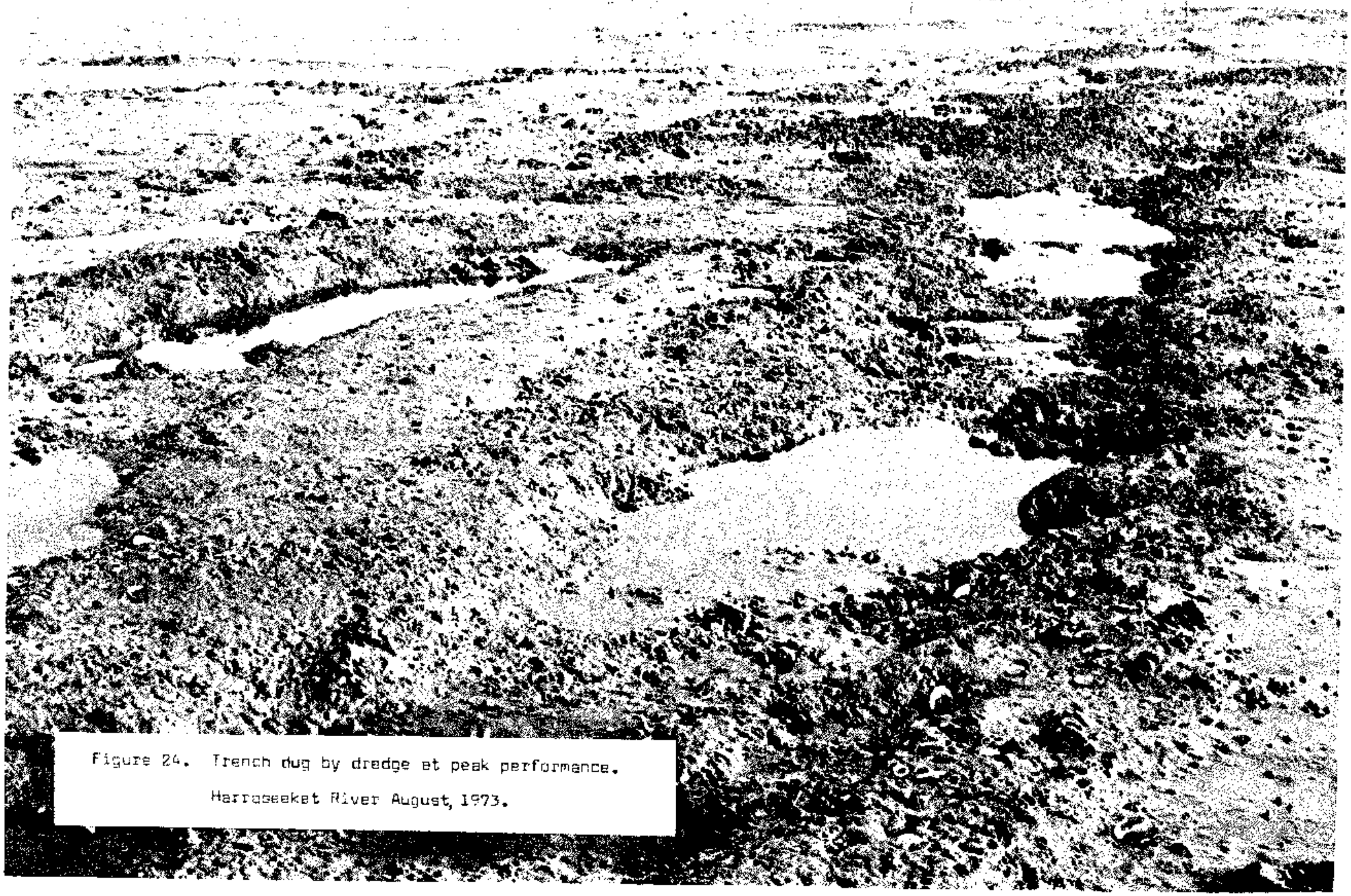


Figure 24. Trench dug by dredge at peak performance.
Harraseeket River August, 1973.

Figure 25. Showing small nodule-like chunks of very stiff blue clay.

VI. COST

The costs of setting up a commercial dredging operation will vary from one situation to another. The one primary factor in cost is the resourcefulness of the creators.

For this particular dredge project the cost breakdown is as follows:

1. Vessel - T.V. DUCHESS, 47'3" LOA, beam 13', draft 3½', built 1955 Beals Island, engine GM 3-71 diesel w/2:1 reduction, speed 8 knots & hydraulic system — $4,200.00
2. Dredge unit - pump, conveyor, hydraulic head, davits, suction line, vacuum line, vacuum pump and winch — $3,300.00
3. Miscellaneous costs such as repairs, fittings, hoses and extra equipment — $2,500.00

Total: $10,000.00

VII. SUMMARY

The attempts at hydraulic dredging by Wood, Kelly, McGregor and Johnson have never materialized into any significant commercial operation. The reasons in most of these cases are social, inconsistant supply and equipment inefficiency.

The social problems arise out of not knowing the harmful effects of dredging. This was the basis for the environmental effects study project conducted by this department in the Harraseeket River.

Because of the law that only permits subtidal dredging in limited areas it is difficult to explore and maintain consistant clam resources. In view of these two problems dredge owners are reluctant to invest in adequate equipment. Consequently, in addition to the social and inconsistant supply problems, the dredge operators are also plagued with equipment breakdowns and inefficiencies.

The DMR Extension Services assistance in applying the Maryland type dredge to the Maine coast helped clear up some of these uncertainties of subtidal clam dredging.

The environmental effects project, when complete, will determine to what extent hydraulic dredging is harmful to the environment. Hopefully, this knowledge will answer some of the social questions about dredging.

A survey of subtidal clam populations is also being conducted by the Department of Marine Resources and when complete will answer whether or not there exists sufficient areas of subtidal clam populations to support a dredging operation.

Equipment breakdowns and inefficiencies can be overcome as demonstrated by the proper adaptation and application of this Maryland-type dredge aboard a common Maine fishing vessel.

It was found that by applying conservative engineering practices the hydraulic dredge was made to work under the most severe condition. This condition being in the very stiff blue clay. Modifications were made to the hydraulic head to obtain the distance the water jets travelled through a liquid medium down to a minimum. This modification also caused the water jets to shear the very stiff blue clay. The combination of these two effects resulted in the very stiff blue clay being broken up into nodule-like chunks. Under this condition, the soft shell clams were being floated out of the sediments and carried up the conveyor for easy picking.

Ideally, a catamaran would be the best suitable dredge vessel. This is because of its large working area, its stability and its shallow draft. The three catamaran versions were shown as a guide in determining to what extent one could go in building a vessel of this type.

In the demonstrated application of the Maryland dredge on a common Maine fishing dragger, it was found that the dredge was flexible enough so it would work in most areas found along the Maine coast. The production rate during the Harraseeket River project reached a high of two bushels per hour. The dredging condition under which this rate was achieved was in the very stiff blue clay. The more the area was dredged, the higher this production rate climbed.

The single factor limiting the production rate in the very stiff blue clay is the pump pressure point at which clams are blown apart. During the Harraseeket River project, with the previous described equipment running at peak performance, the total percentage of clams that were blown apart was 0.3%.

The pumping equipment demonstrated in this project is just about the minimum size needed for a subtidal dredging operation at this scale on the Maine coast. The methods and equipment used need not be duplicated in order to obtain the same results. The best advice for anyone wishing to get into a subtidal dredging operation is to take advantage of existing equipment and build from that based on the material contained in this report.

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