Hydraulic Fishing Machinery Systems for Outboard Motor-Powered Boats

OSU SEA GRANT
STATION BULLETIN 608, NOVEMBER 1971
AGRICULTURAL EXPERIMENT STATION
OREGON STATE UNIVERSITY, CORVALLIS

ACKNOWLEDGMENTS: Several individuals contributed significantly to the project and to this publication. Without their contributions, project and publication success undoubtedly would not have been ensured.

Alan S. Burn, Fisherman, Graduate Student, Department of Fisheries and Wildlife, Oregon State University, captained the prototype dory and was instrumental in initial rigging of the dory with hydraulic gurdies.

Donald Schwantes, Outboard Mechanic and Fisherman, Newport, Oregon, offered constant advice and mechanical expertise.

Paul Hanneman, Fisherman and Dory Builder, Cloverdale, Oregon, provided dory fishing expertise and elicited fishermen support for the project.

Christopher N. Fisher, Fisherman, Newport, Oregon, aided in rigging and fishing the prototype dory.

Captain Craig Cochran, Fisherman, Newport, Oregon, supplied valuable advice in fishing gear rigging and fishing methods for vessels using hydraulic gurdies.

James Broderick, Hydraulics Engineer, Portland, Oregon, aided in the design and specification of hydraulic components during the feasibility phase of the project.

NOTE: Mention of a trademark name or a proprietary product does not constitute endorsement. The products mentioned in this publication were those actually employed in project tests and field operations. No criticism is implied of firms or products not mentioned.

There are many equivalent products offered by hydraulic manufacturers. The products mentioned in this publication were those selected by the authors for field demonstration use as their performance characteristics matched project specifications.

Cover photo courtesy Pam Bladine, Newport, Oregon

This information is published by Oregon State University as part of the National Oceanic and Atmospheric Administration Sea Grant program.

Contents

Summary 2

I. Introduction 3

II. Hydraulic System Uses 4

General Considerations 4

Work Requirements 4

Design Approach 6

III. Specific Hydraulic Dory System Designs 7

Yankee Pedlar—60-hp Johnson 7

Sea Bass—55-hp Fisher-Pierce Bearcat 12

Kiwanda Klipper 8—50-hp Mercury 17

C-Doll—70-hp Chrysler 21

Galliot—40-hp Johnson 24

IV. Project Conclusions and Recommendations 28

V. Recommended Gurdy System for Outboard Motor Trollers 29

VI. Pump Cover Fabrication 31

VII. Other Fishing System Configurations 33

VIII. References 37

Appendix A—Operational Data 37

Appendix B—Outboard Motor Revolutions-per-Minute to Brake-Horsepower Curves 38

Johnson 40-hp Motor 38

Johnson 60-hp Motor 38

Mercury 50-hp Motor 39

Appendix C—Tyrone Model P1-25 Jobmaster Hydraulic Pump Revolutions-per-Minute to Pump Displacement 40

Appendix D—Vickers VTM-27-40-40 Hydraulic Pump Revolutions-per-Minute to Pump Displacement 40

Summary

This publication describes an attempt to secure a reliable, efficient, and relatively inexpensive hydraulic power take-off to drive fishing machinery in outboard motor-powered fishing dories. Five Pacific City-type dories provided with outboard motors equipped with the hydraulic power take-off and gurdies were rigged and fished as trollers during the 1970 salmon trolling season.

Five engines were employed in the project—40- and 60-hp Johnsons, a 50-hp Mercury, a 55-hp Fisher-Pierce Bearcat, and a 70-hp Chrysler. Each engine required the fabrication of a distinct hydraulic pump mount. All motors except the Chrysler 70 hp utilized a direct-drive in-line connection of the flywheel and pump shaft accomplished by a flex coupling. The Chrysler hydraulic power take-off consisted of a belt and pulley system.

A concurrent effort was devoted to the design and testing of light-weight gurdies suitable for dories.

The five dories logged a total of approximately 3,045 hours fishing time during the 1970 season. Subsequent analysis of operational data, engines, and hydraulic components support the conclusion that a reliable, efficient, and relatively inexpensive hydraulic power take-off is attainable from outboard motors to power fishing machinery.

Gurdies of light weight and durable construction suitable for dories were also designed and successfully tested and these gurdies will be offered to fishermen through a commercial source.

"Rory, Rory get your dory
There's a herring in the bay.
Rory got his dory but the
Herring got away.

—Old Newfoundland Fisherman's Chanty

With the hope that this work will help prevent the fish from getting away, this publication is dedicated to the dorymen of the Pacific and Atlantic Oceans.

AUTHORS: R. Barry Fisher is Associate Professor of Fisheries and Charles A. Marshall is Graduate Research Assistant, Department of Mechanical and Nuclear Engineering, Oregon State University.

Hydraulic Fishing Machinery Systems for Outboard Motor-Powered Boats

R. BARRY FISHER and CHARLES A. MARSHALL

I. Introduction

Outboard motor-driven vessels are an important part of the total fishery in the United States and other areas of the world. The gillnet salmon fishery in Alaska, Pacific Northwest trollers, bay scallop dredgers in New England, in-shore hook and line, and pot fisheries in the southeastern United States are a few examples of fisheries where outboard motors can be used to advantage because of their speed, low initial cost, and ease of service and maintenance.

The inherent economic advantages of outboard motor propulsion for certain fisheries have been limited by the inability to secure a power take-off system from the propulsion unit—the outboard motor—which can propel simple fishing machinery such as troll salmon gurdies, line haulers for longline trawl and pot fishing, line pullers for surface trolling, or gillnet lifters and reels.

Fishing capability and productivity of outboard motor-propelled vessels can be greatly improved if the fishing gear can be operated by adequate mechanical power rather than manpower. However, the development of such a power system from an outboard motor must be conducted within certain limited parameters. To be efficient, the system must:

1. *Conserve weight and space,* as most outboard-powered fishing vessels are open skiffs and/or dories where extra weight or sacrificed space might limit fishing efficiency.
2. *Be simple, relatively inexpensive,* and *highly resistant to the corrosive effects* of salt water.
3. *Not affect the operating cycles or life* of the propulsion unit, the outboard motor.
4. *Assure the fisherman* a power supply that can be used for *a variety of fishing operations and fishing machinery* without radical or expensive changes of power take-off equipment.
5. *Deliver adequate fishing machinery propulsion power* over a long time span and offer easy maintenance.

Fishing machinery in larger fishing vessels is usually powered by mechanical, electrical, air pressure, or hydraulic systems. Hydraulic systems, because of their versatility, easy maintenance, space-saving economies, and relatively low power requirements from the propulsion unit, have certain distinct advantages over the other systems in small fishing boats.

The principles and operation of oil hydraulic power systems are well understood. The object of this fishing gear project was to apply this knowledge and capability to vessels powered with outboard motors, and to design a reliable, inexpensive, and effective power take-off system from an obvious but untapped source of power, the outboard flywheel.

The initial application of this hydraulic system was directed to the salmon troll fishery on the Oregon Coast, with the Pacific City-type dory selected as the fishing test platform. (Figure 1 shows two typical Pacific City dories.) These vessels are relatively inexpensive and are rugged sea boats, but they have been limited in productivity because the trolling lines were fished by hand-powered gurdies or reels. Despite this limitation, these dories offer a potential in the fishery that has not yet been fully exploited. When powered by 50- to 70-hp engines, the 20- or 22-foot dories attain speeds of 18 to 30 mph, providing high-speed-at-sea capability for broader fishing-ground coverage. In addition, they can be transported by trailer overnight to different fishing grounds along the coast.

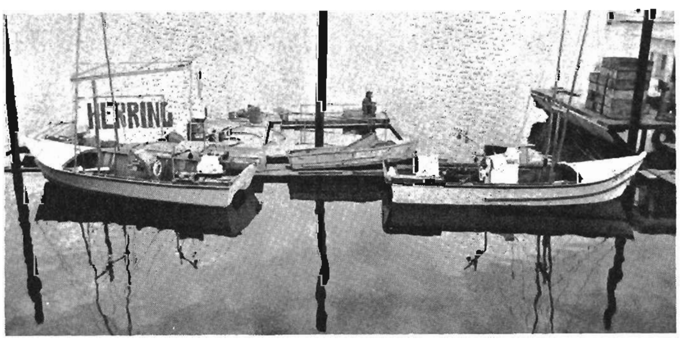


Figure 1.
Pacific City Dories

Outboard motors typical of those employed in the fishery were used in the project. These included 1970 Johnson motors of 40 and 60 hp, a 1970 50-hp Mercury, and a 1970 55-hp Fisher-Pierce Bearcat. A collaborative project was undertaken with Boat Specialties of Salem, Oregon to install hydraulics and salmon gurdies powered by a 1970 70-hp Chrysler engine.

Considerable thought also was given in this project to utilizing the hydraulic power take-off system to drive other fishing machinery, thereby providing the dory and its fisherman with alternative fishing opportunities using powered gear such as tuna pullers (high-speed line haulers for the albacore surface troll fishery), pot and ring haulers for crabbing, and longline trawl haulers for bottomfish.

II. Hydraulic System Uses

General Considerations

Hydraulics has been aptly defined as "the science of transmitting force and/or motion through the medium of a confined liquid." This confined liquid system can offer a variety of power outputs and speeds to operate fishing machinery. A typical hydraulic system consists of a hydraulic pump driven by power delivered from an engine. The pump generally sucks oil from a reservoir through a suction line. The action of the pump forces oil through the pressure line. The oil passes through various control valve systems which can divert the oil into hydraulic motors. The oil enters one side of the motor and exerts pressure upon internal gerotors fastened onto a shaft. The oil turns the gerotor, thereby imparting movement to the shaft upon which spools to work the fishing gear are fixed. The oil then exits from the motor and flows on through a line to other motors in the system or returns to the reservoir for recirculation through the system.

Relatively small amounts of horsepower are required to furnish fishing machinery propulsion power in efficient hydraulic systems. Hydraulic motors offer the distinct advantage of offering various combinations of high line speed and corresponding low torque (which translates into pulling power) to low line speed but greater corresponding torque or pulling power. In a properly designed system these combinations can operate from a uniform source of power, the hydraulic pump.

For purposes of discussion the above example has been simplified.

Work Requirements

The two known constants which must be fully understood in designing a hydraulic-powered fishing machinery system which is to be powered from the vessel's main propulsion unit are: 1) the work cycle the fishing operation requires, or how many pounds pull (pulling force) and at what line speeds (expressed in feet per minute) are necessary to fish the gear; 2) the horsepower required from the main propulsion unit to power the gear without reducing the fishing efficiency of the vessel by slowing or "dragging" the propulsion unit.

The first constant of establishing appropriate work cycles for the fishing machinery resulted in the following initial design specifications.[1] *Salmon trolling gurdies per spool:* Average of 250 feet line speed per minute; maximum total of 100 pounds pulling force. *Tuna pullers:* Average of 360 feet line speed per minute; maximum total of 125 pounds pulling force. *Longline haulers:* Average of 120 feet line speed per minute; maximum total of 250 pounds pulling force. *Pot, trap, or ring haulers:* Average of 90 feet line speed per minute; maximum total of 300 pounds pulling force.

The second constant, the available power resources to provide hydraulic power, was established by studying the brake horsepower versus revolutions per minute curves of the outboard engines. These curve relationships revealed that adequate reserves of horsepower were available to power the hydraulic pumps at the engine-working speeds of 1250 to 2250 rpm.

The engine rpm ranges of 1250 to 2500 rpm were not arbitrarily chosen. This rpm range represents the actual working speed of the engine in the various fisheries described. Pacific City dories troll salmon gear at a speed of 1600 to 2200 rpm. Longline pullers and pot and trap pullers would be pulled at 1200 to 1400 rpm. Dory tuna trollers, or surface trollers, operate at approximately 2300 to 2500 rpm. For example, according to the brake horsepower to rpm curves, the 40- and 60-hp Johnson motors and the 50-hp Mercury

[1] The line speed and pulling force requirements were those judged appropriate for small outboard engine-powered vessels such as dories, skiffs, etc., and are not necessarily appropriate for larger fishing vessels with slower inboard engines.

delivered the following approximate characteristics.[2]

1970 Johnson 40-hp engine

RPM	*Brake Horsepower*
1250	13
1500	15.5
1750	18
2000	20
2250	22.5

1970 Johnson 60-hp engine

RPM	*Brake Horsepower*
1250	11
1500	15
1750	19
2000	23
2250	27

1970 Mercury 50-hp engine

RPM	*Brake Horsepower*
1250	7.5
1500	9.75
1750	12
2000	14
2250	18

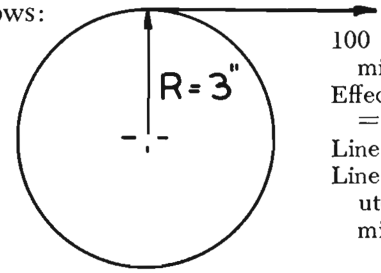
It is obvious that fishing operations such as surface trolling for albacore tuna, which require greater engine speeds, would deliver greater amounts of horsepower to power the hydraulic pump.

At this point the feasibility of obtaining sufficient power to drive the hydraulic pump from the outboard motor was definitely established. The project did not obtain rpm to hp curves for the 55-hp Bearcat because it was realized from the above examples that adequate horsepower was obtainable, and since the salmon fishing season had already begun, the engines and dories had to be rigged immediately.

The next step was to calculate the horsepower required from the engine to power the hydraulic pump which would drive the fishing machinery. The work cycle was known. Troll salmon gurdies were selected as the first system to be designed. It was felt that the gurdies should operate at a line speed of 250 feet per minute and a pulling force of 100 pounds. It was also known that the trolling speeds of a 22-foot dory would average 1800 rpm with a 60-hp Johnson motor.

[2] Complete brake horsepower to rpm curves for the engines cited are contained in Appendix B.

The system may be expressed graphically as follows:



100 pounds at 250 feet per minute
Effective radius of spool (R) = 3 inches
Line pull 100 pounds (P)
Line speed 250 feet per minute (L) = 3000 inches per minute

To calculate the required *torque*, the following formula was used:

Torque (inch pounds) or T = Line pull (pounds) or P times the effective radius of the spool (inches) or R

Thus: $T = P \times R$

$T = 100$ pounds X 3 inches. (A typical gurdy spool has an overall average line wrap effective diameter of 6 inches or a radius of 3 inches.)

$T = 300$ inch pounds

To calculate the speed of the spool, the following formula was used:

Speed (rpm of the spool) or S

$$S = \frac{\text{Line haul-in speed in inches per minute or L}}{\text{Effective spool circumference in inches or } 2 \times \text{pi} \times R}$$

Thus: $$S = \frac{L}{2 \times 3 \times \text{pi (or 3.14)}}$$

So: $$S = \frac{3000}{2 \times 3 \times 3.14} = 150 \text{ spool rpm}$$

Once the required torque (300 inch pounds in this instance) and the spool rotation speed in rpm (approximately 150 rpm in this system) are known, the horsepower requirements can be determined for a hydraulic system by using the standard formula.

Under ordinary fishing circumstances no more than two spools would be operating simultaneously. The system would require two spools concurrently at 300 inch pounds of torque per spool.

The following formula was used:

$$HP = \frac{\text{Torque (inch pounds)} \times \text{Spool RPM}}{63{,}000}$$

Thus:

$$HP = 2 \times \frac{(300 \times 150)}{63{,}000}$$

$$HP = 2 \times 0.72$$

$$HP = 1.44$$

All hydraulic systems lose some power efficiency because of the friction generated by the oil passing through the system. Typically, a hydraulic system has an 83% efficiency factor. The power requirements to run the pump can be expressed as:

$$HP_p = \frac{1.44}{0.83} \text{ or } HP_p = 1.74$$

The required torque from the outboard engine was derived from the following formula:

$$\text{Torque} = \frac{HP_p \times 63{,}000}{RPM_{engine}}$$

$$\text{Thus: } T = \frac{1.74 \times 63{,}000}{1800}$$

$$T = 61.0 \text{ inch pounds}$$

These calculations established that a maximum of 1.74 hp and 61.0 inch pounds of torque were required from the outboard engine at 1800 rpm trolling speed to drive the hydraulic salmon gurdies described.

The figures expressed above constitute a specific system design for an outboard-powered hydraulic gurdy system.

Dynamometer test data was supplied by Outboard Marine Corporation for the Johnson engines and Kiekhaeffer Mercury Corporation for the Mercury engine. This data corroborated project assumptions that ample power was available to drive the hydraulic system over and above the power necessary to propel the boat in the salmon troll fishery. The company-furnished data also substantiated project assumptions that available engine torque at the average trolling speed of 1800 rpm was sufficient to prevent any appreciable pulldown or "lag" of the engine when the hydraulic system was operated. Subsequent operational tests indicated a loss of approximately 50 rpm at an 1800 rpm trolling speed when any two hydraulic spools (salmon gurdy reels) were operating under load.

Although equivalent dynamometer data was not available for the Fisher-Pierce Bearcat, operational tests on the installed Bearcat yielded the same performance results as the Johnson and Mercury engine-equipped dories when equivalent salmon troll gurdies were used.

Design Approach

With the basic system requirements for an outboard-powered hydraulic system established, the next step involved the selection of an appropriate pump and the design of the pump installation and power take-off.

Two basic configurations were considered. The first consisted of a mount design where the pump would be operated with belts and pulleys from the outboard flywheel. The second system was a direct-drive setup with the pump shaft mounted axially in line with the outboard motor crankshaft.

Each of the configurations presented unique problems. Both approaches shared the common problem of inadequate space under the outboard motor shroud to accommodate auxiliary installations.[3] The wide range of speeds or engine rpm of the outboard motors necessitated using a pump with high rpm capability. The top of the crankshafts in all outboard engines are not supported by bearings sufficiently strong enough to bear the side loads which would be generated by belt forces. Finally, the mount system and pumps had to be installed in a manner that would not impart or receive excessive vibrations under operating conditions.

Throughout the design phase the original parameters of relatively low cost, weight and space conservation, simplicity, and effectiveness further conditioned design configurations. These parameters led to a rejection of any clutch-activated drive systems.

Information supplied by the outboard companies indicated that additional outboard bearing supports would be necessary to protect the crankshaft upper main bearing if a parallel belt and pulley power take-off were employed. If these outboard bearings were not built into the power take-off, it was felt that bearing and oil seal failure might well ensue.

Consideration of all the above factors resulted in the selection of the less complex and more compact direct-drive configuration, with the pump being mounted axially in line and concentric with the crankshaft. The pump shaft and a pump extension base plate with stub shaft bolted to the flywheel were to be joined by a flex coupling. (Figure 2 graphically illustrates the pump mount concept.)

A pump had to be selected that was of small size, relatively light weight, and which could be operated under no-load conditions of up to 5500 rpm or maximum outboard motor operating speeds.

After considerable study, a P1 Series pump manufactured by Tyrone Hydraulics, Inc., was selected. This series pump is available in four models with outputs up to 13.3 gallons per minute (gpm), speeds to 6000 rpm, and is capable of operating pressures of up to 3000 pounds per square inch (psi).

The Tyrone Model P1-25 Jobmaster pump provides a hydraulic fluid displacement of approximately 3.6 gpm at 1600 rpm, 4.0 gpm at 1800 rpm. 4.4 gpm at 2000 rpm, and 5.0 gpm at 2200 rpm. These gpm dis-

[3] This is not true with 70-hp Chrysler outboard engines *if* a 105- or 120-hp shroud is substituted for the 70-hp shroud. Adequate space then exists for a pulley and belt pump mount installation.

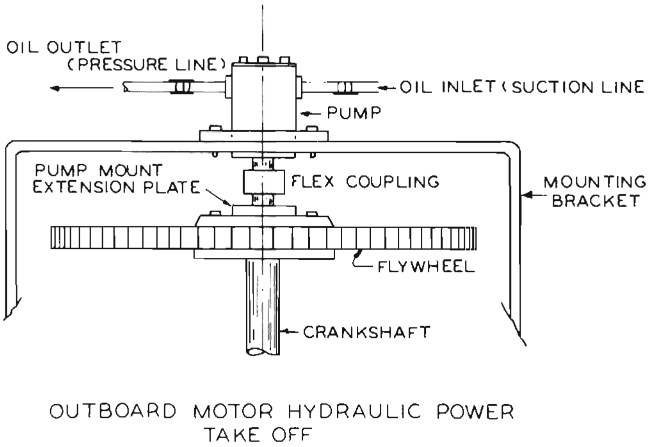


Figure 2.
Outboard Motor Hydraulic Power Take-off

placement figures are more than adequate to power the hydraulic motors in the fishing machinery systems discussed below. (Appendix C, p. 40, illustrates the pump displacement [gpm] to pump rpm curve.)

A Morse N Series Delron flex coupling was chosen to connect the pump shaft and flywheel base plate shaft. This coupling is capable of withstanding speeds of 5000 rpm under load and will transmit 6.5 hp at 1800 rpm. Since the required horsepower to drive the pump at 1800 is only 1.74 hp maximum, an adequate safety margin is assured. The Morse flex coupling has two further advantages. The Delron chain can be quickly removed from the sprockets and links can be changed by driving out the appropriate pins and inserting new links. The flex coupling will also bear misalignment of up to one minute of angle.

III. Specific Hydraulic Dory System Designs

Each outboard motor presented unique problems in designing a pump mount. The pump mount in each instance had to be securely anchored onto the engine blocks, and the top of the outboard shroud altered to allow space for the installation. Hydraulic components had to be selected carefully to obtain equivalent performance from four engines. The project intention was to design a hydraulic gurdy system for any outboard engine in the range of 40 to 70 hp.[4]

[4] A concurrent collaborative effort was being mounted by the author and John Henning of Salem, Oregon, on a 70-hp Chrysler outboard. The Chrysler has enough space under the shroud to allow a side mount pulley and belt attachment *if* the shroud from a 105- or 120-hp Chrysler outboard is used. Also, a 22-foot dory with a 70-hp Chrysler motor trolls at a lower rpm of approximately 950 to 1100. This in turn required a different pump and a Vickers VM27 Vane pump was used. This system is discussed on p. 21.

It soon became apparent that the salmon gurdies used on larger vessels were not appropriate for dories or other small high-speed outboard-powered trollers, as the commercially available gurdies were too expensive (approximately $1,350 for four spools complete) and too heavy.

Accordingly, the project also sought to develop less expensive and lighter gurdies appropriate for dories. Experience acquired as each dory was rigged was incorporated into each succeeding rig. This evolutionary process resulted in a compact, light, and relatively inexpensive gurdy system for outboard-powered trollers.[5]

[5] Pump mount plans, hydraulic system schematics, hydraulic gurdy system illustrations, and photos of the installation for each dory will be found on the pages immediately following discussion of the individual dories.

Dory No. 1—*Yankee Pedlar* 60-hp Johnson

The *Yankee Pedlar* is a standard 22-foot Pacific City dory built by Kiwanda Boat Builders of Pacific City, Oregon. This was the prototype dory and she was equipped with a pair of standard two-spool Kolstrand salmon gurdies. The *Yankee Pedlar* was powered by a 60-hp Johnson motor. (See Figure 3 below for photo details.) Additional equipment included a Raytheon Model DE-725B recording fathometer, a Pierce Simpson Bearcat CB radio, and a Nova Tech battery-operated radio with radio direction finder.

Pump Installation

The design of the hydraulic pump mounting for the 60-hp Johnson was rather straightforward, as mounting points are readily available on the rear of the engine block and a reasonable amount of space is present under the motor shroud. This mount was fabricated from 1/4-inch Alclad 7050 aluminum alloy,

Figure 3.
Yankee Pedlar

although aluminum is not recommended for this application. Another mount was made of 1/4-inch cold rolled steel plate. Two 1/4-inch steel plate side straps were cut in triangular form and welded into a 90° angle of the mount bracket. The straps measured 5 inches by 5 inches. (See plan 2, p. 11, for the recommended mount design.)

It was found during fabrication and later testing that certain critical procedures must be followed *for all* of the pump installations. The prime requirement is proper alignment of mounted pump and motor for vibration-free operation and long component life. The pump shaft and motor crankshaft must be concentric and axially aligned within 1/2 minute of angle. During the fabrication and installation of the shaft extension plate, care must be taken to ensure that the flywheel face is perfectly true to its bore. If this surface is not true to the bore, the flywheel must be spun in a lathe and its face trued. The underside of the extension plate on all the mounts except Mercury engines must be machined out to form a recess for the flywheel locking nut which protrudes slightly above the flywheel. The extension plate is bolted to the outboard flywheel using the existing tapped flywheel puller holes on the flywheel and the appropriate-sized machine bolts with *lock washers.* An immediate check should be made at this point to ensure that pump extension plates will bolt to the flywheel securely and without danger of movement. If such danger exists a slight mating and centering surface of 1/8-inch thickness should be cut on both the flywheel face and extension plate face. Mating and centering surfaces ensure that the pump extension plate shaft and the crankshaft are concentric and aligned.

After the shaft extension is installed on the flywheel, following the mating and centering cuts the whole assembly should be spun in a lathe at high speed and checked for trueness and dynamic balance.

The pump mount rear base leg was cut to fit the contours of the rear of the engine block. The pump mount must be bolted onto solid surfaces on the block itself. The mount *must* be rigid and free of distorting vibrations. Four bolt holes were drilled in the rear base leg after the alignment of the pump shaft and pump extension plate shaft had been checked. The *Yankee Pedlar's* mount was bolted onto the engine head by using the two existing uppermost head bolts and two existing attachment points for the original lifting ring. Appropriate bolts and washers were used to secure a rigid mount. (See Figures 4 through 6 on pp. 9 and 10 for details of the pump mounting.)

The Morse Delron flex coupling sprockets were keyed onto both shafts. The flex coupling sprockets are held in place by Allen screws tightened onto the keys. Additional Allen screw holes were drilled in each sprocket at a 90° angle for extra security. The sprockets should be separated by at least 1/4 inch to guard against binding and to allow the Delron chain belt to absorb minute misalignments. The pump shafts *should not* protrude beyond the base of the sprockets when the sprockets are positioned on the shafts.

The top must be cut out of the outboard motor cover to accommodate the pump and bracket protruding above the flywheel. A cover was fabricated from 16-gauge aluminum sheet to cover this opening on the 60-hp motor. (See Figure 7, p. 10, for the pump mount cover.) The cover was fastened to the shroud with sheet metal screws. This cover can be fabricated from fiberglass over a cardboard core or several types of plastics. (See section on Pump Cover Fabrication, p. 31, for details on fabrication of pump mount covers.)

Finally, two 1 1/2-inch holes were cut in the port lower shroud of the engine to carry the suction line from the reservoir to the pump and the high-pressure line from the pump to the gurdies. Rubber spacers obtained from a Fisher-Pierce Bearcat dealer were inserted on the hoses and placed in the shroud holes to protect the hose from chafing (see Figure 7, p. 10).

Gurdy System Schematics

The plumbing of the *Yankee Pedlar's* gurdies was easily accomplished since the gurdies and control valves were a standard package consisting of Kolstrand two-spool gurdies, Gresen SPW-4 control valves (fully reversible with integral relief valves), Char-Lynn R244 Universal Supply Tank reservoir of three-gallon capacity, and a Gresen FA103 line type hydraulic filter. The suction line and return line were of 3/4-inch hydraulic hose and the pressure lines were 1/2-inch hydraulic hose. (Plans 2 and 3, p. 11, illustrate the hydraulic schematics.)

The oil is picked up from the reservoir and passes through the suction line to the pump. The oil then passes to the first Gresen SPW4 control valve. This valve features an integral relief valve. The relief valve was set to open and by-pass oil when gurdy line forces of 125 pounds were reached. Any excess pressures which develop as a result of this pulling tension being exceeded will be controlled, as the relief valve will simply open and by-pass the oil on through the continuing lines and back to the reservoir. This relief valve feature serves a dual purpose. It prevents excess straining on the gear and ensures that the outboard motor will not be stalled.

The control valve is a four-way tandem center valve which directs a flow of oil to the hydraulic motors. The gurdy motors are hydrostatically locked when the valves are in the neutral position. In this configuration the oil passes in a circuit through the valves and lines and returns to the reservoir under almost zero pressure at trolling speeds and approximately 50 pounds per square inch (psi) at full speeds of 5500 rpm.

Each motor turns a shaft on the Kolstrand gurdy which can turn either one or two spools simultaneously, depending on the position of the mechanical clutches (see Figures 8 and 9, p. 10).

During operation the motors are fully reversible so that an individual troll line can be powered in or out. The spool speeds are proportional to the outboard speed. At the design point of 1800 rpm engine speeds, the gurdy motors rotate at 111 rpm. The line speeds developed on the *Yankee Pedlar* averaged 230 feet per minute.

The oil runs from one control valve across the dory bottom through the second control valve and passes through the return line through the filter and is dumped into the reservoir where it is immediately available for continuing circuits.

The three-gallon reservoir was mounted on two 2-inch by 1-inch firring straps mounted on the port well transom. This mount allows complete air circulation around the reservoir to dissipate any heat buildup in the hydraulic fluid. (See section on Heat Dissipation, Operational Data, Appendix A.)

Later tests of operating pressures revealed that 200 to 600 psi were obtained when both hydraulic motors were under load, returning troll lines at 1800 rpm. Tests conducted before fishing began revealed that the gurdies could easily lift 105 pounds of lead suspended from 30 fathoms of trolling wire while the dory trolled at 1800 rpm.

The *Yankee Pedlar* logged approximately 1,275 hours fishing time during the 1970 salmon season. Some difficulty was encountered with the engine. A failure of ignition under load conditions 3000 to 3500 rpm was corrected when it was discovered that a ground wire was loose in the rotor assembly.

Later in the season the gear pinion nut worked loose and an incorrect diagnosis was made of the problem. This resulted in a lower unit failure.

Finally, a connecting rod bearing retainer assembly fractured (possibly because of the severe shocks put upon the engine by the above malfunctions) and a connecting rod, the bearing assembly retainer, a bearing, and a piston had to be replaced.

The engine did perform creditably after the necessary repairs were made. Deliberate attempts were made to fish boat and engine under adverse conditions.

There were no malfunctions of the hydraulics system. The hydraulics performed beyond expectations. Early experience with the cost and weight of the *Yankee Pedlar* gurdy system dictated a concurrent effort to install a lighter and less expensive gurdy system.

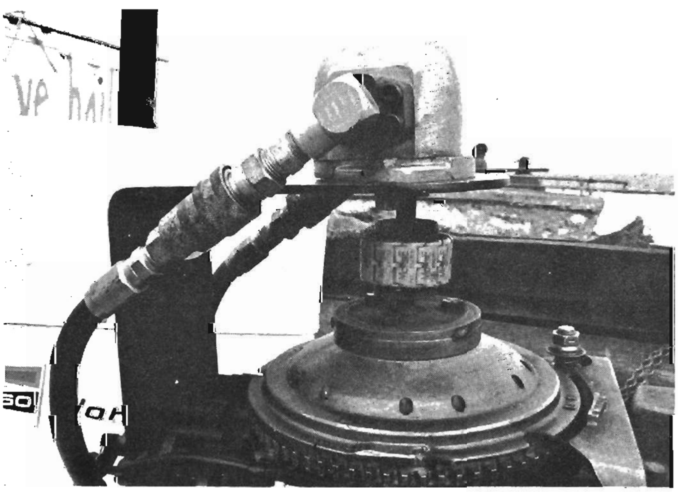


Figure 4.
Hydraulic Pump Mounted 60-hp Johnson, side view

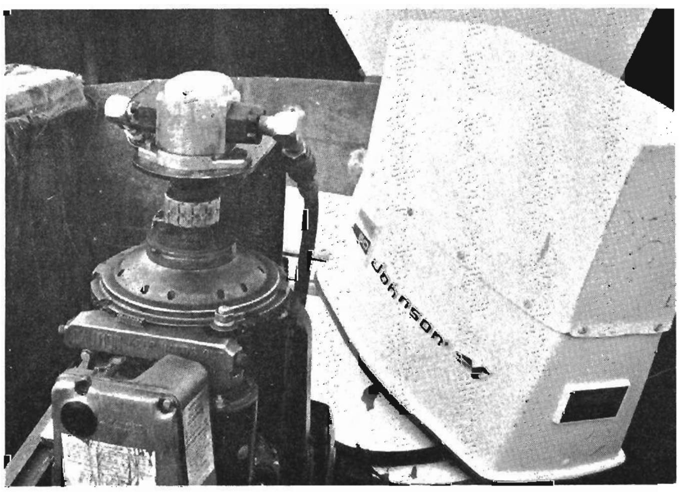


Figure 5.
Hydraulic Mounted 60-hp Johnson, front view

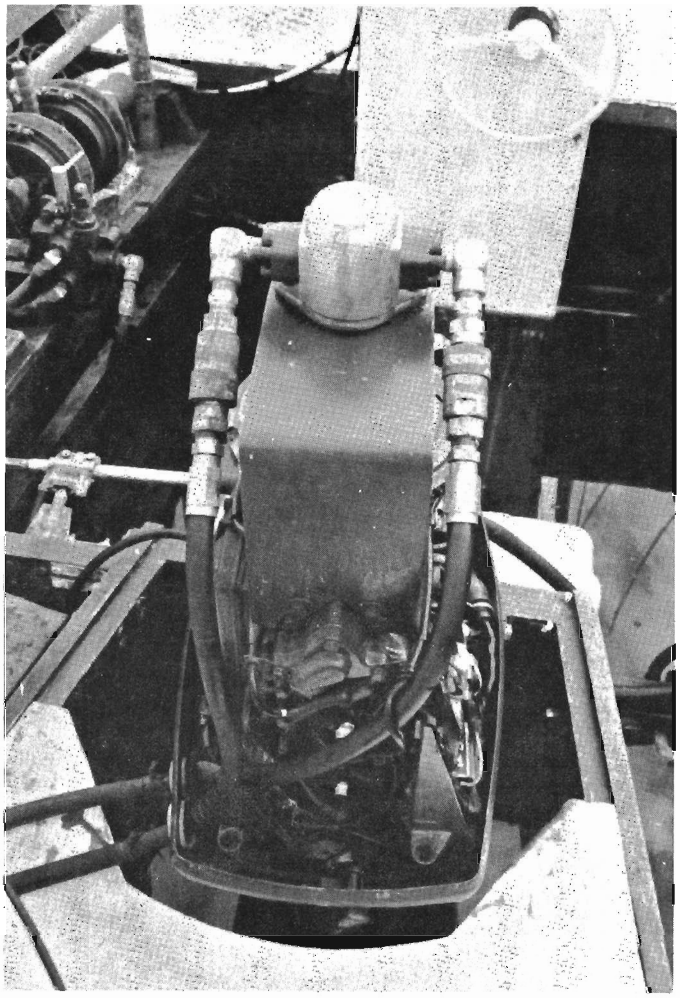


Figure 6.
Hydraulic Pump Mounted 60-hp Johnson, rear view

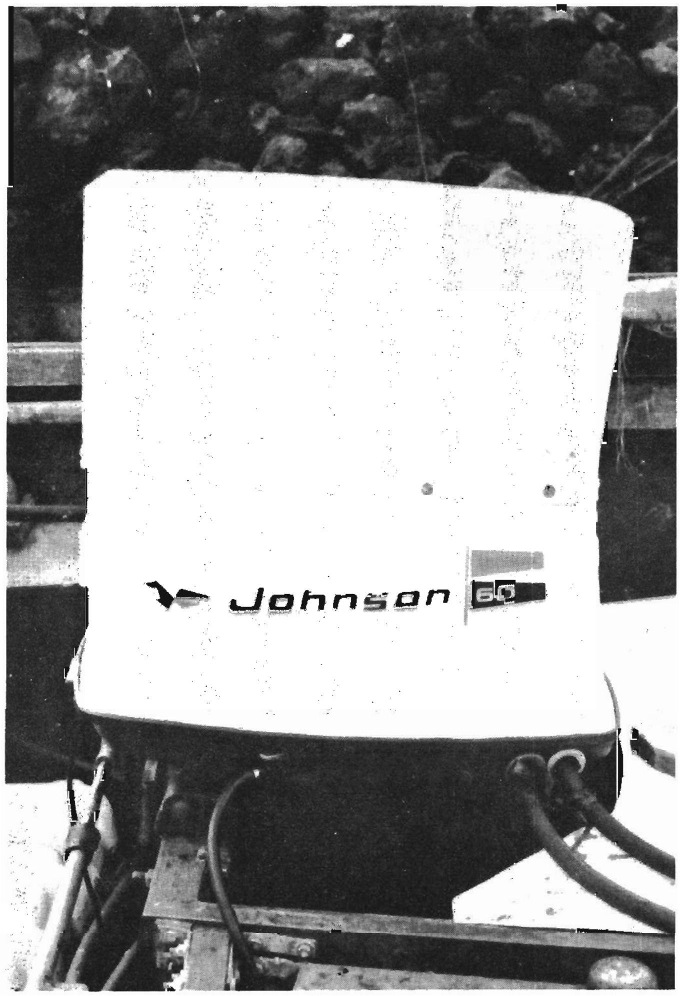


Figure 7.
Hydraulic Pump Cover Attached to Shroud of 60-hp Johnson

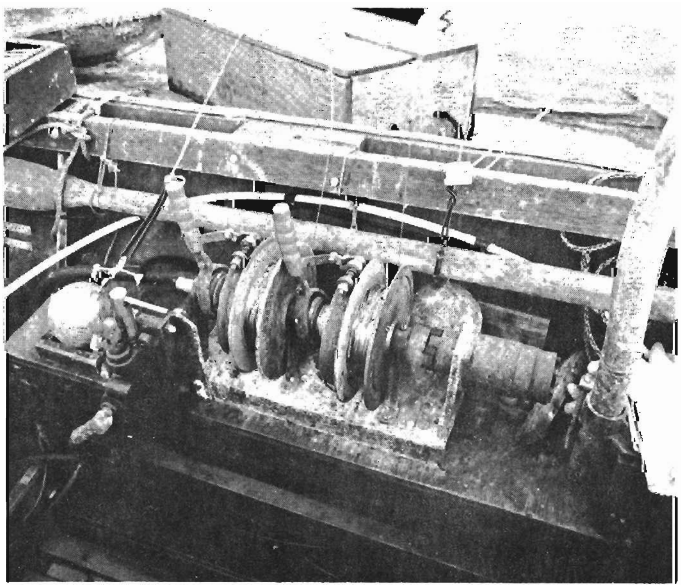


Figure 8.
Yankee Pedlar, Port Gurdies, inside view

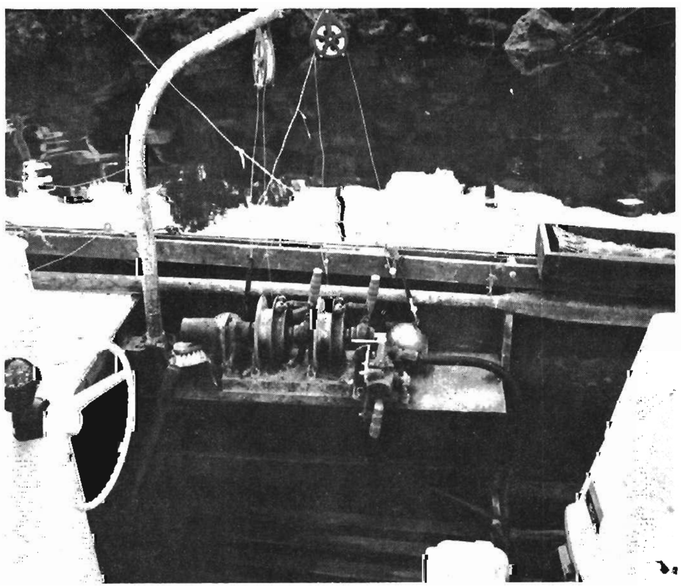
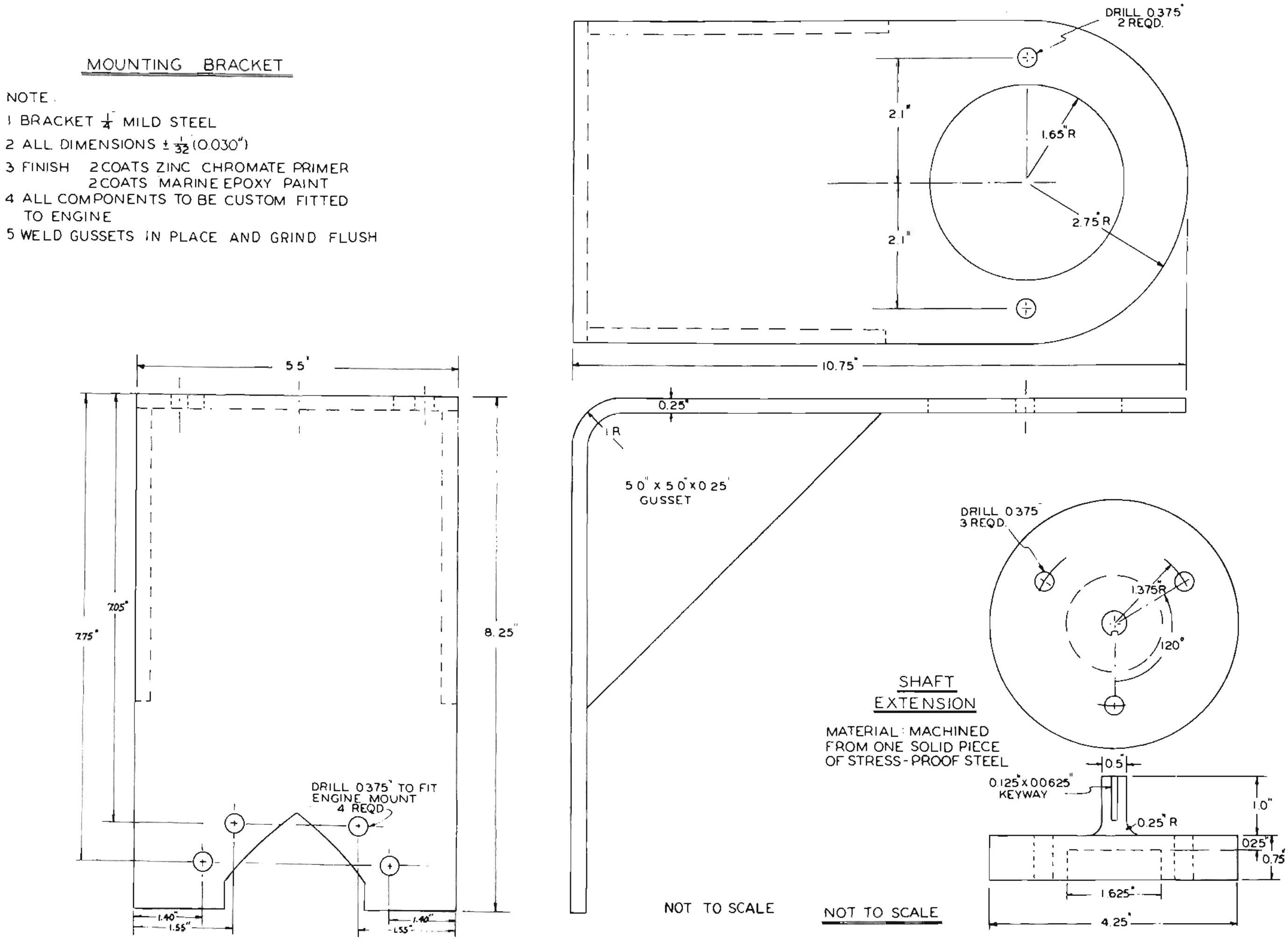
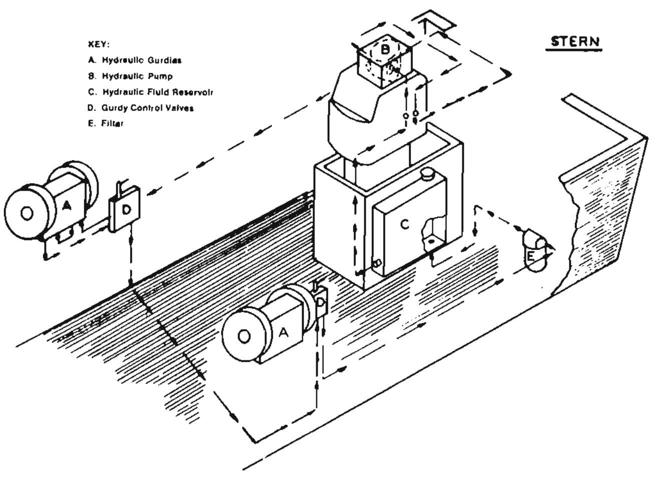


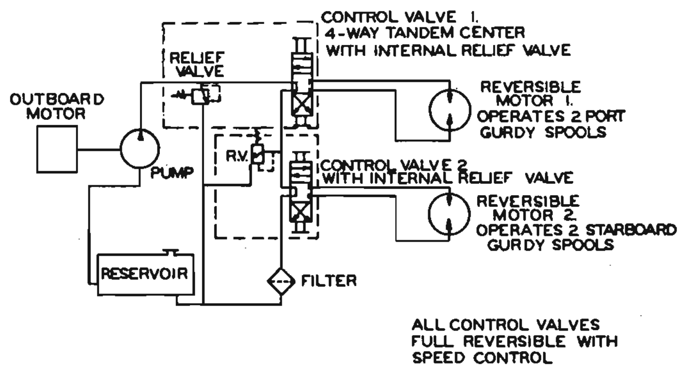
Figure 9.
Yankee Pedlar, Starboard Gurdies and Davit, inside view



Plan 1.
Hydraulic Pump Mount, 60-hp Johnson



Plan 2.
Hydraulic Gurdy System, *Yankee Pedlar*, 60-hp Johnson



Plan 3.
Hydraulic Gurdy System Schematic, *Yankee Pedlar*, 60-hp Johnson

Dory No. 2—*Sea Bass*
55-hp Fisher-Pierce Bearcat

The *Sea Bass* is a 20-foot dory built by Dick and Marvin Yates of Salem, Oregon. The dory was captained by Leroy Bass of Willamina, Oregon.

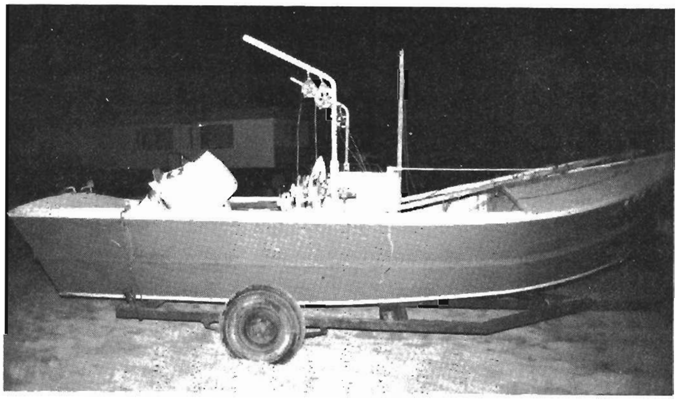


Figure 10.
Sea Bass

The *Sea Bass* was equipped with a pair of Lyons Albacore gurdies manufactured by Captain Jim Lyons of San Diego, California. These gurdies are popular in the Pacific albacore fleet and their light weight and novel simplicity prompted a trial as salmon gurdies aboard a dory. A feature of the Lyons gurdy is the ease with which gurdy parts can be changed in the event of a breakdown. Three tapered pins can be tapped out of the central shaft and any part of the two-spool gurdy can be changed at sea in a matter of minutes. (See Figures 16 through 19, pp. 14 and 15, for details of Lyons gurdies.)

These gurdies feature nylon spools and nylon interlocking clutches and brake assemblies. The brake assemblies are fitted with tension springs to absorb shock (an especially useful feature for salmon trolling since the heavy-weight lines normally require a spring mounting on the davit block to absorb the shocks and prevent troll wire parting).

Pump Installation

All of the procedures and precautions described for the 60-hp Johnson motor hold for the 55-hp Bearcat installation. Care must be exercised to ensure that the pump shaft and crankshaft are concentric and axially aligned. The flywheel face on this engine was found to be not true to the crankshaft, so the flywheel surface was turned slightly on a lathe to achieve a true alignment. The pump extension plate was mounted after a slight mating and centering surface was cut on the flywheel face and pump extension plate. This surface was 1/8 of an inch. The pump extension plate was bolted into the flywheel puller holes and the assembly was spun in a lathe and dynamically balanced.

The pump mount for the 55-hp Bearcat differs from the Johnson 60-hp mount in that the mount is anchored in three places. The mount was constructed of 1/4-inch cold rolled mild steel plate. A 5 1/2-inch steel front strap was bolted to the front of the engine block and two straps of similar plate were welded onto the rear of the mount at a 45° angle. The straps were bent and twisted to allow fastening to the rear of the engine block. A simpler mount was designed and tested and was found to be more than adequate. The mount was bolted in place with similar thread machine bolts long enough to fasten the mount with lock washers. (See Plan 4, p. 16, for the final recommended mount plan.)

The pumps and pump extension plate were aligned, with alignment proceeding up from the extension plate. The pump was bolted in place. The hoses were attached with detachable hydraulic fittings.

The outboard motor top shroud was cut away and a cover was made of Alclad 7050 aluminum alloy plate. (See Figure 14, p. 14, for the hydraulic pump cover.) The entire lip of the new cover was lined with a glued 3/16-inch-thick by 2-inch-wide rubber gasket. Holes were drilled in the pump cover and the motor shroud and the two were fastened with sheet metal screws. Again, it should be emphasized that aluminum sheet makes a good cover, but the cost is believed excessive. Adequate covers can be fabricated from fiberglass and/or plastic.

Gurdy System Schematics (See Plan 5, p. 16, for Hydraulic Gurdy System)

The hydraulic system operates in similar fashion to the system described for the 60-hp Johnson. The conspicuous differences in the *Sea Bass* 55-hp Bearcat rig are:

1. The Gresen SPW-4 control valves were replaced by No. 183 Sta-Rite fully reversible speed control valves. The Sta-Rite control valve is smaller, lighter, less expensive, and is more sensitive to the low gpm output of the dory hydraulic systems than is true of the Gresen SPW-4 valves which operate most efficiently at higher gpm pump output. Operational tests revealed differential line speeds were more easily attained with this valve than is true with the Gresen valve. The control valve was fastened to the after bearing bracket of the Lyons gurdies by bolting the control valve to a 6-inch long by 2 1/2-inch high by 1/4-inch mild steel strap. The strap was in turn bolted to the after gurdy spool bearing bracket.

2. The Sta-Rite control valve does not have an integral relief valve, so a Gresen J-50 relief valve was plumbed into the system. This relief valve was also set for 125 pounds pulling pressure so that excess pressure oil would dump back into the reservoir.

3. A Brand FC51 3/8-inch variable flow control valve, pressure compensated, was plumbed into the system immediately after the relief valve. (See Figure 15, p. 14, for plumbing details of relief valve and flow control valve.) Since smaller diameter hose was to be used, it was felt that any heat build-up in the hydraulic fluid as a result of running at maximum engine speed (5500 rpm) could be controlled by setting the flow control valve at 4 gpm. The Tyrone P1-25 pump will deliver approximately 12.2 gpm at that engine speed. If the flow control valve is set to deliver 4 gpm, any excess delivery beyond that figure occasioned by speeds higher than 1800 rpm is immediately returned to the reservoir for heat dissipation.

4. Smaller-diameter, lower-pressure hose was used for purposes of economy and convenience. Imperial-Eastman medium-pressure Style D7 hose of 3/8-inch inner diameter was used for all pressure lines. The return line and suction lines were of similar hose, but of 1/2-inch inner diameter. All hydraulic fittings in this system were of reusable type. (See Plan 6, p. 16, for the 55-hp Bearcat hydraulic system schematics.)

Operating tests revealed that the spools ran at a speed of 110 rpm when the motor ran at 1800 rpm. Speeds in excess of 1800 rpm did not increase spool speed because of the constant hydraulic fluid delivery of 4 gpm. The gurdies of the *Sea Bass* achieved a constant line speed of 235 feet per minute.

Pressure readings established that pressures of 200 to 600 psi were developed when both hydraulic motors were under load, retrieving gear and fish. The *Sea Bass* successfully retrieved a total weight of 105 pounds of lead weights suspended from one trolling wire prior to actual fishing operations. Lag on the outboard was approximately 50 to 60 rpm when retrieving lines.

The Lyons gurdies performed very well. There is a weight savings of approximately 100 pounds over the system used in the *Yankee Pedlar* because of gurdy weight differences. Weight saving is a desirable feature in a dory. The saving of 100 pounds adds to payload and superior performance characteristics. An additional weight savings could be realized if the base mounts of the Lyons gurdies were to be manufactured of 1/4-inch steel plate instead of the 3/8-inch and ½-inch steel plate base. Lyons gurdies come equipped with swing-in swing-out albacore davits that can be easily modified for carrying salmon gurdy davit blocks.

The Lyons gurdies have an additional feature to prolong hydraulic motor life. The front of the motor seal is protected by a rubber O-ring seal that fits between the motor shaft face and the motor mount bracket. A zirc grease fitting is tapped into the hydraulic motor mount bracket. Grease can be pumped into a cavity which completely protects the seal of the hydraulic motor.

It should be noted again that any part of the Lyons gurdies can be quickly changed at sea by removing three tapered pins and pulling the gurdy drive shaft to the rear. The component is changed, the shaft re-inserted through all component bearings, and the pins re-inserted in place.

A final distinctive feature of the Lyons gurdy is that the drive gear can be quickly disconnected in case of engine failure at sea with the gear overboard. If a nut is welded or threaded onto the gurdy shaft end, the gear can be easily cranked in by disconnecting the drive gear and fitting a rachet wrench on the drive shaft and cranking with the clutch engaged.

The compactness of the Lyons gurdies resulted in a considerable space saving. No breakdowns occurred in the gurdy system. Captain Bass verified that any gurdy component could be easily changed at sea.

The *Sea Bass* logged approximately 550 hours during the salmon season. No difficulties were encountered with either hydraulic system or engine. The only modification that should be made to this system is to remove the relief valve and control valve from the system and replace both of them with a Brand FCR-51 3/8-inch flow control valve. This flow control valve can fulfill an equivalent relief function as it has an integral acorn-type relief valve. The flow control valve should be set to deliver from 0 to 2 gpm when the engine is operating at high speeds and set at 4 gpm when the vessel is trolling.

The performance of the Lyons gurdies is such that they constitute an excellent setup for a dory salmon troller. The costs, according to the manufacturer, probably will be substantially lower for the total hydraulic gurdy system than other standard commercially available gurdies (except for the Lauterbach gurdies described on p. 29).

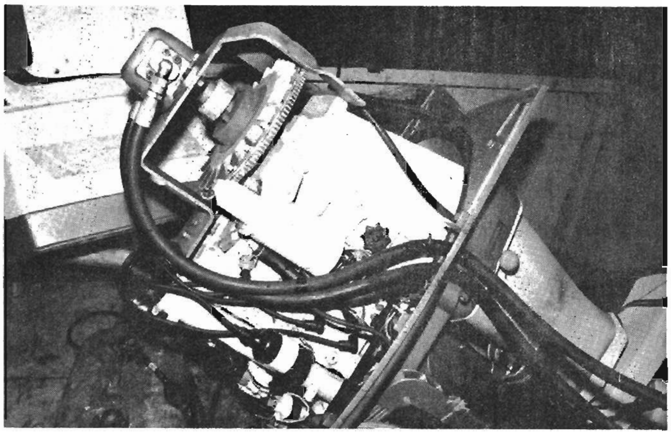


Figure 11.
Hydraulic Pump Mounted 55-hp Bearcat, side view

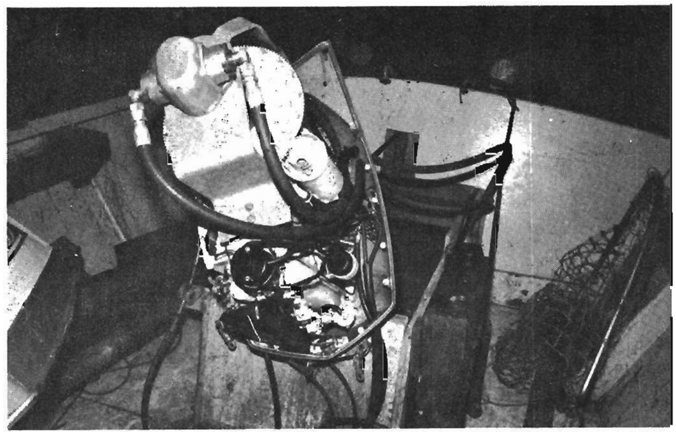


Figure 12.
Hydraulic Pump Mounted 55-hp Bearcat, front view

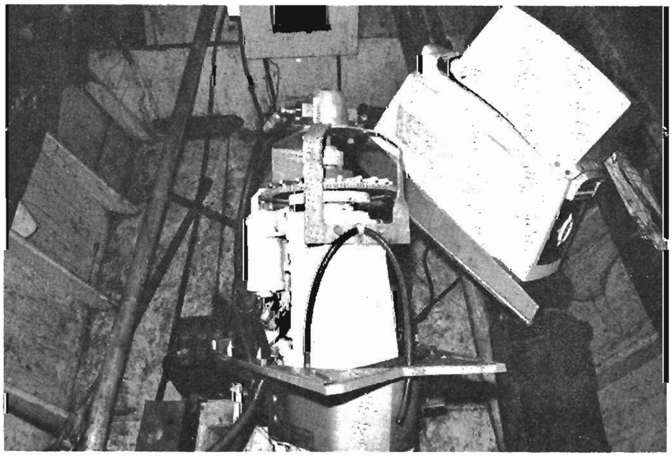


Figure 13.
Hydraulic Pump Mounted 55-hp Bearcat, rear view

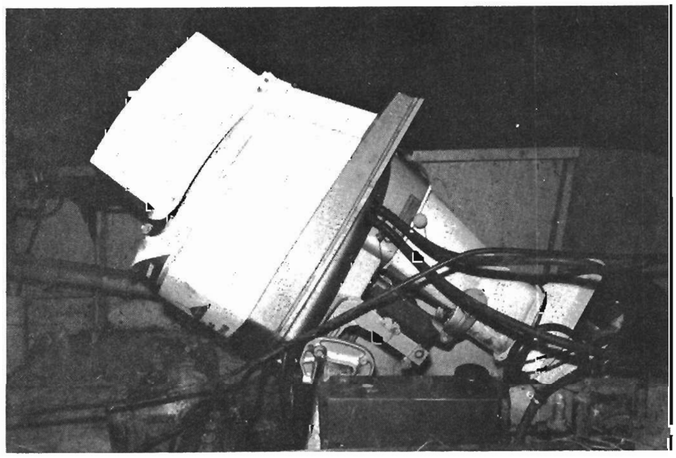


Figure 14.
Hydraulic Pump Cover 55-hp Bearcat

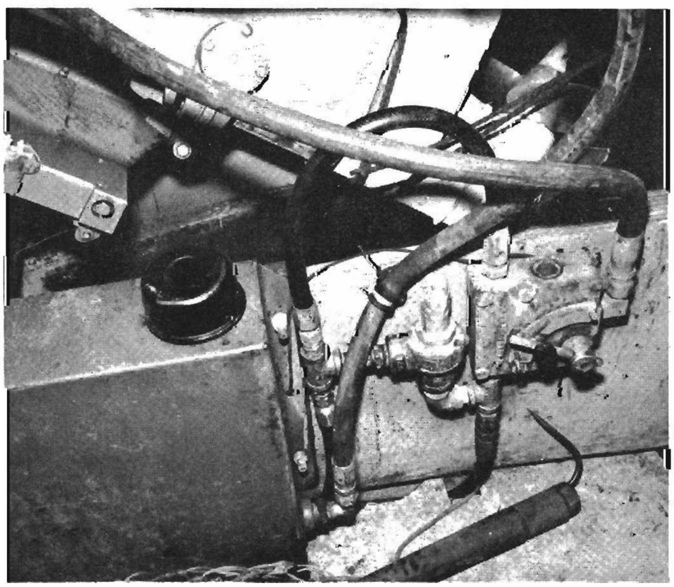


Figure 15.
Plumbing Details, Gresen J-50 Relief Valve and Brand FC-51 3/8-inch Flow Control Valve

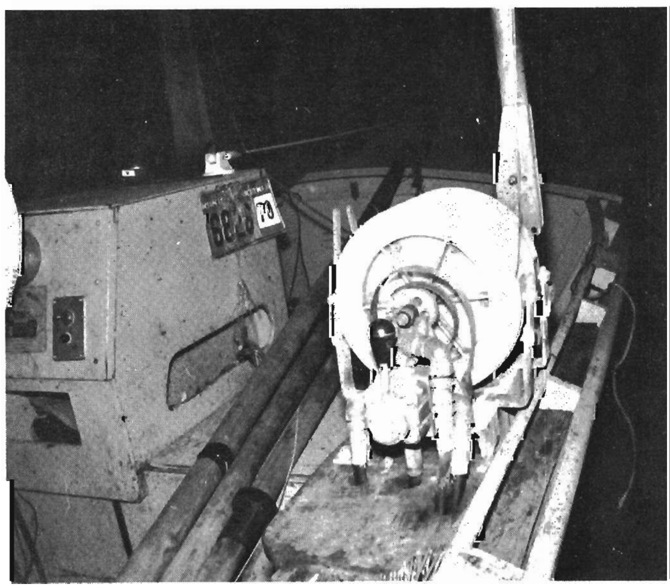


Figure 16.
Lyons Gurdies, rear view, Starboard Spools with Sta-Rite Number 183 Fully Reversible Speed Control Valve

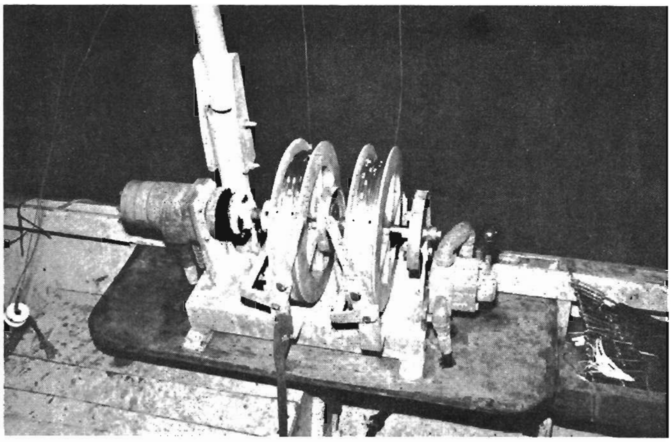


Figure 17.
Lyons Gurdies, Starboard Spools, inside view

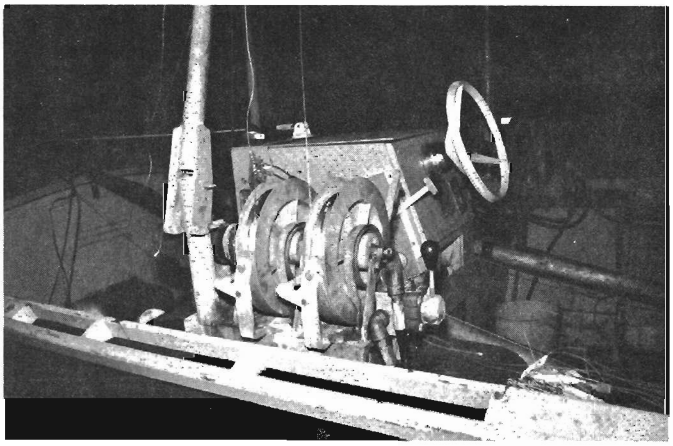


Figure 18.
Lyons Gurdies, Port Spools, outside view

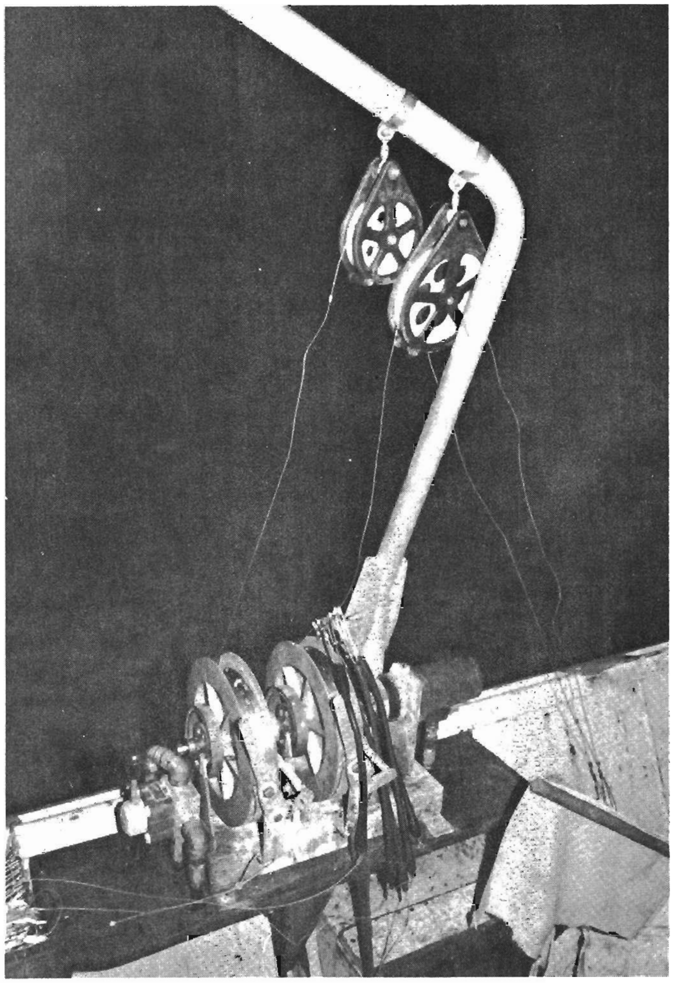
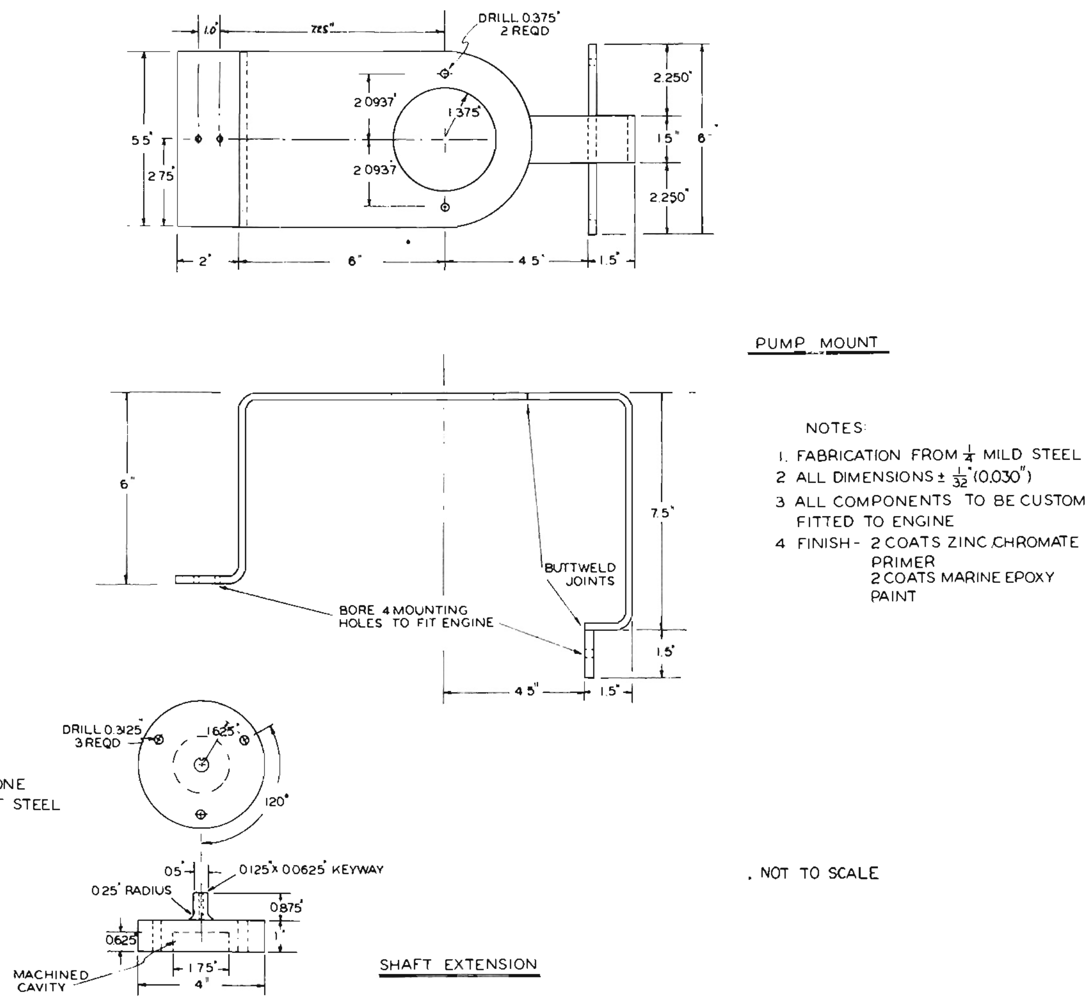
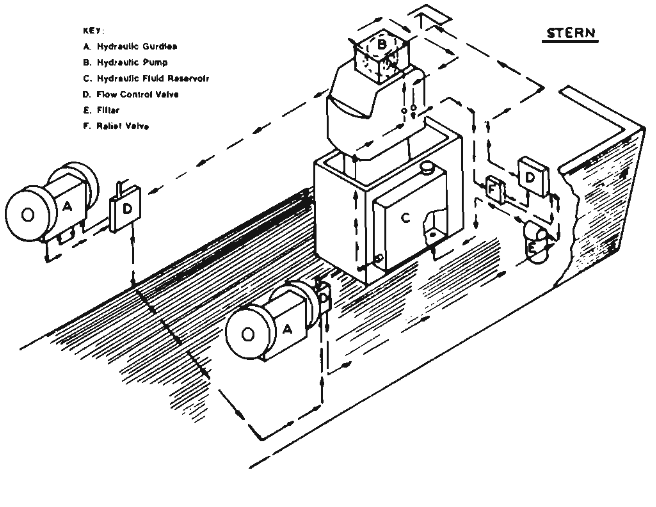


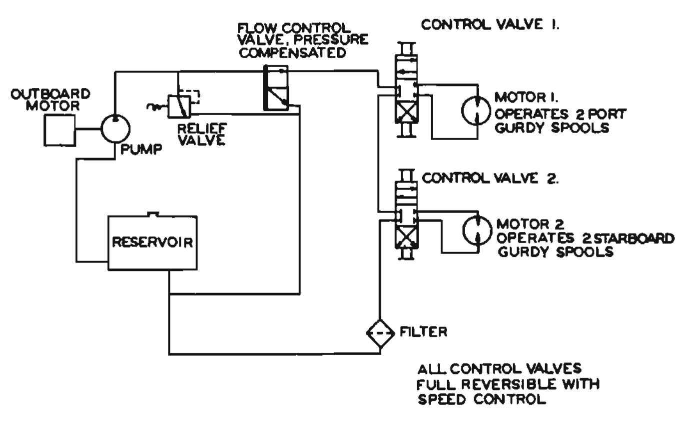
Figure 19.
Lyons Gurdies, Port Spools with Swing-out Davit Details



Plan 4.
Hydraulic Pump Mount, 55-hp Fisher-Pierce Bearcat



Plan 5.
Hydraulic Gurdy System, *Sea Bass*, 55-hp Bearcat



Plan 6.
Hydraulic Gurdy System Schematic, *Sea Bass*, 55-hp Bearcat

Dory No. 3—*Kiwanda Clipper 8* 50-hp Mercury

The *Kiwanda Klipper 8* is a 22-foot dory built by Cape Kiwanda Boat Builders of Pacific City, Oregon. This dory, equipped with a flasher depth sounder and CB radio, was fished by Chris Hanneman of Pacific City. (See photo of *Kiwanda Klipper 8* below.) The *Kiwanda Klipper 8* was equipped with four gurdy

Figure 20.
Kiwanda Klipper 8

spools, with each spool driven independently by a hydraulic motor with a fully reversible control valve. The spools are molded polyethelene and measure 8 inches in diameter with a 4-inch arbor and are 2 1/4 inches wide. The spool flanges taper from 5/16-inch at the outer rim to 1/2-inch at the arbor. The motor side of the spool has a keyway of 1/4-inch by 1/4-inch. The center of the spool has a 1-inch diameter hole to accommodate the shaft of Char-Lynn hydraulic motors. A bushing lip 2 inches in diameter by 3/8-inch thick protrudes from the spool to provide a bearing surface for a bolt. The bolt can serve as a cranking device if engine or hydraulic motor breakdowns occur when the gear is overboard. The spools have a full capacity of 100 fathoms of salmon troll wire.

The polyethelene spools are the standard spools for the gurdies used in the last three dories that were tested. Molded polyethelene was chosen because it is light, strong, and, if produced from molds, is inexpensive in volume production.

The gurdies in the *Kiwanda Klipper 8* represented another step toward the objectives of light weight, compact size, and lower costs. Although four hydraulic motors and control valves are required for this installation, it was felt that the overall system costs could be lowered for outboard-powered dories if development along these lines was pursued. It was believed that the potential saving inherent in dispensing with brake and clutches would more than compensate for the added costs of two more motors and control valves. (See Figures 27 to 29, p. 19, for gurdy details.)

Pump Installation

The mount for the 50-hp Mercury was fabricated from Alclad 7050 aluminum alloy plate of 1/4-inch thickness. The mount is actually a tripod and is quite rigid. (See Plan 7, p. 20, for detailed mount plans.) The legs of the mount are fastened with approximate-sized machine bolts onto the top of the engine block surface. The pump extension plate for the 50-hp Mercury differs from the previous two installations.

The flywheel locking nut does not protrude above the surface level of the flywheel and so the pump extension plate does not need a cavity machined in it. Mercury engines have a two-piece shroud and there is very little space under the shroud cover. Therefore, most of the pump installation must protrude up through the outboard shroud cover. The top of the upper shroud cover was cut away and the cover was fabricated of aluminum. Since little space was available, the pump was turned sideways to run fore and aft so that both hoses could run through one side of the shroud cover (see Figure 24, p. 19). A rubber gasket was again fastened to the entire inner lip of the pump cover and the pump cover was fastened to the shroud top with sheet metal screws. Release connectors were used on the suction line and the pressure line. Mercury engines have a wrap-around shroud cover below the top part and so the engine can be serviced, plugs changed, etc., without disturbing the hydraulic pump installation.

Gurdy System Schematics

The gurdies designed and installed on the *Kiwanda Klipper 8* were the first gurdies designed especially for the dory. The project attempted to secure a more compact and light-weight installation. Base plates were made of 1/4-inch-thick Alclad 7050 aluminum alloy plate.

The hydraulic motors were mounted on the inside of two bearing surfaces with the shaft protruding between the two bearings upon which the spools were mounted. The control valves for both spools were set on the after edge of the gurdy mount. The actual plumbing of the gurdies ran in a continuous circuit around the dory and each spool was driven by an independent Char-Lynn AC hydraulic motor and a Number 183 Sta-Rite fully reversible control valve.

The Mercury gurdy system was similar to that installed in the *Sea Bass* in that a Gresen JLA-50 relief valve was installed as the first component on the pressure line. Oil passed through the relief valve and from there went into a Brand FC-51 3/8-inch flow control valve. The JLA-50 valve could return oil directly back to the reservoir in the event of excess pressure.

Imperial-Eastman medium-pressure Style D7 hoses were used. The suction line and return line were 1/2-inch inner diameter and the pressure lines were 3/8-inch inner diameter. Reusable hydraulic fittings were used throughout the system. The hydraulic oil passes in a circuit from the pump, through the relief and flow control valves, to each control valve, and returns through the filter and then to the reservoir. Any spool is operated by moving the associated control valve. All valves were plumbed so that the valve handle was pulled in to retrieve line and pushed out to pay out line.

The gurdies performed adequately under fishing operations.

Use of the flow control valve allowed an operational test which revealed that this system, too, was capable of easily retrieving 105 pounds of lead suspended on 30 fathoms of trolling wire with little noticeable lag in engine speed. Operating pressures were from 200 to 600 psi when the hydraulic motors were operated. The measured line speed was approximately 250 feet per minute when the dory trolled at 1900 dpm. (See Plans 8 and 9, p. 20, and Figures 27 through 29, p. 19, for details of the gurdy system.)

The only change that would be required in this system is to replace (as in the *Sea Bass*) the relief valve and flow control valve with a Brand FCR-51 3/8-inch flow control valve with integral relief valve.

Kiwanda Klipper 8 logged approximately 350 hours during the 1970 season and there were no malfunctions of either gurdies or outboard motor.

The effectiveness of this type of gurdy system was definitely established, but it was felt that further cost and weight savings could be realized by employing this same gurdy principle but with a different spool mount design and materials.

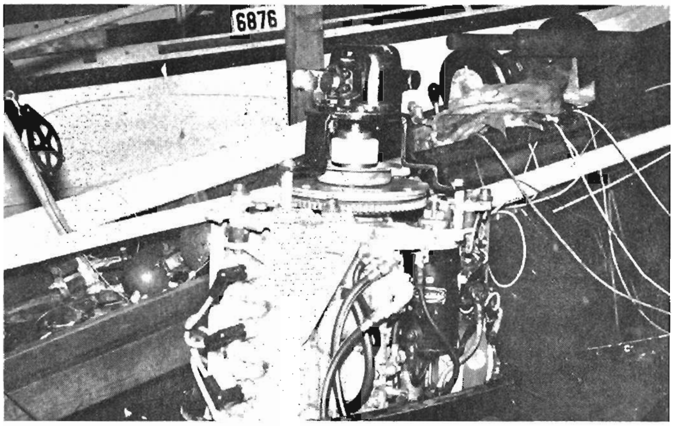


Figure 21.
Hydraulic Pump Mounted 50-hp Mercury, side view

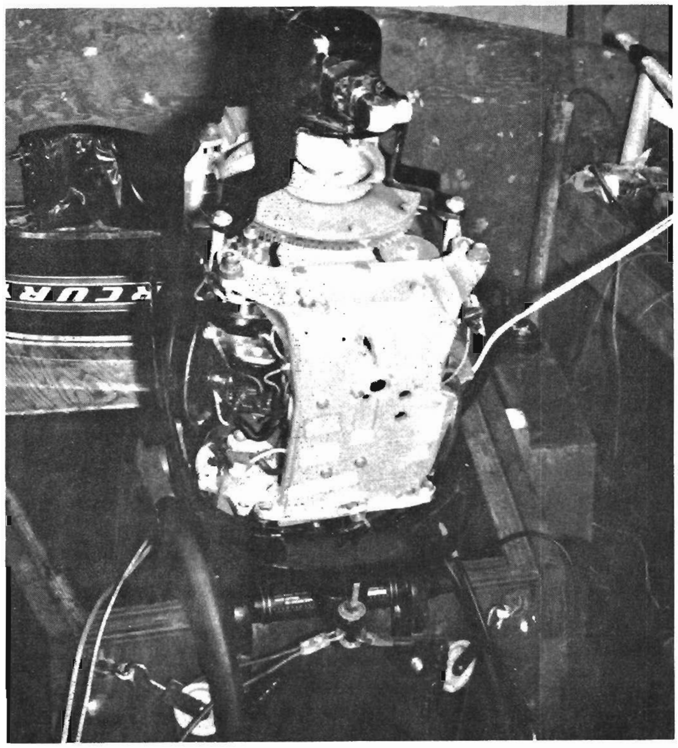


Figure 22.
Hydraulic Pump Mounted 50-hp Mercury, front view

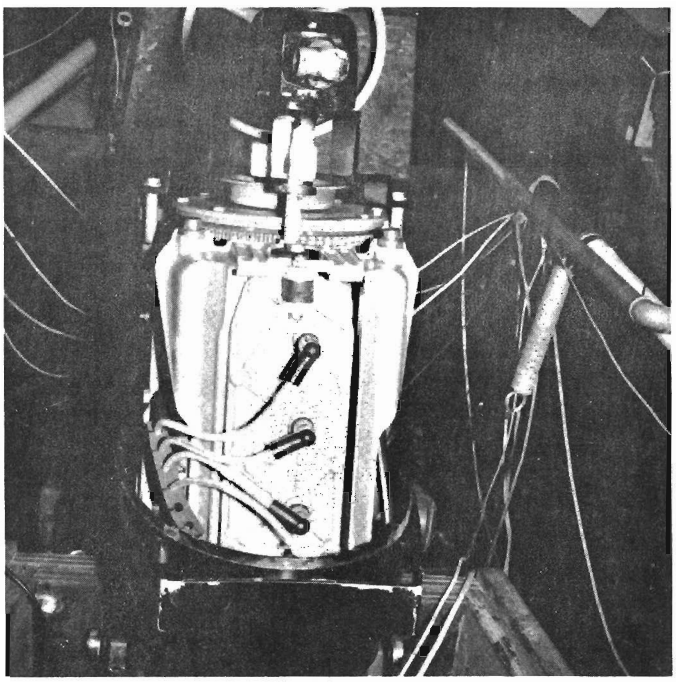


Figure 23.
Hydraulic Pump Mounted 50-hp Mercury, rear view

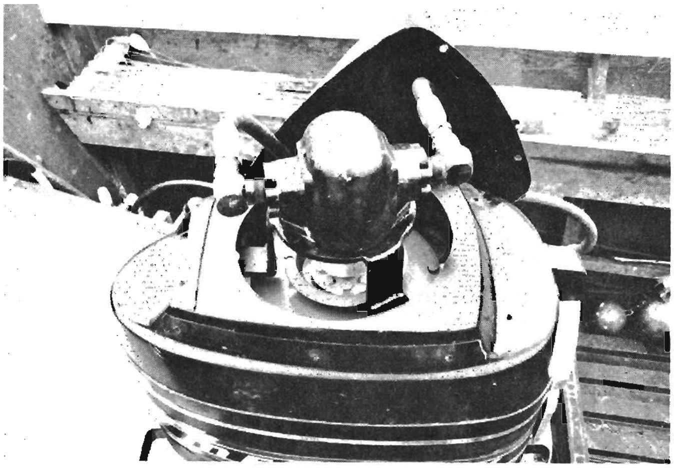


Figure 24.
Hydraulic Pump Mounted 50-hp Mercury, Shroud Attached, side view

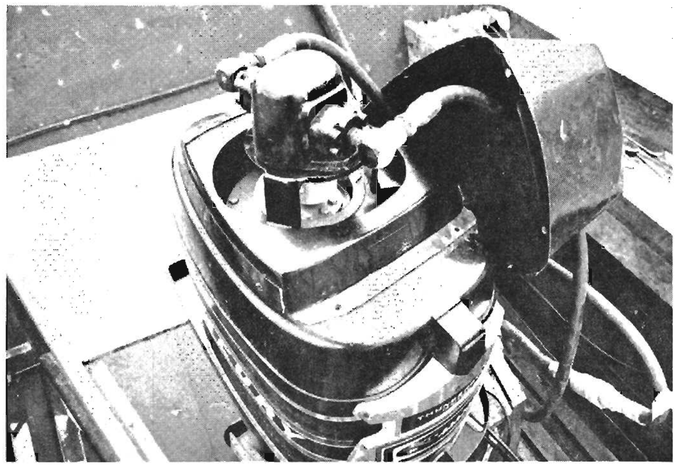


Figure 25.
Hydraulic Pump Mounted 50-hp Mercury, Shroud Attached, front quarter view

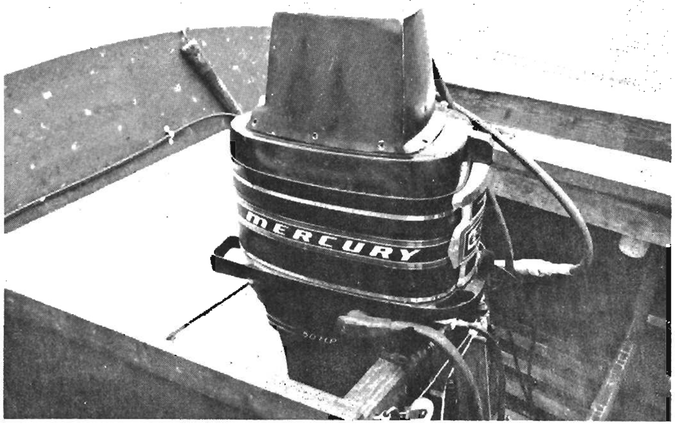


Figure 26.
Hydraulic Pump Cover 50-hp Mercury

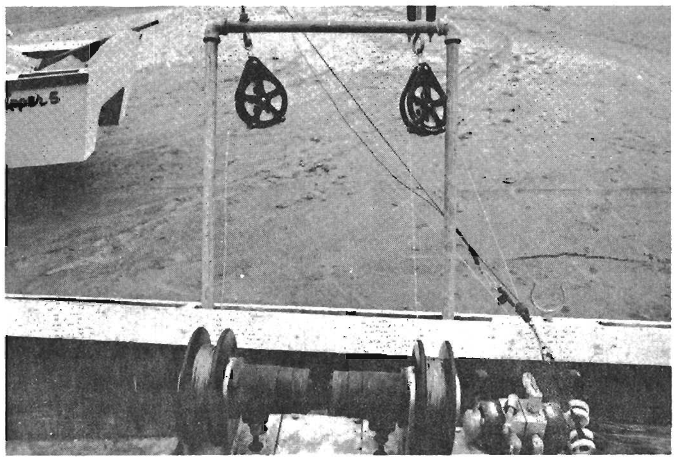


Figure 27.
Kiwanda Klipper 8, Starboard Gurdies and Davit

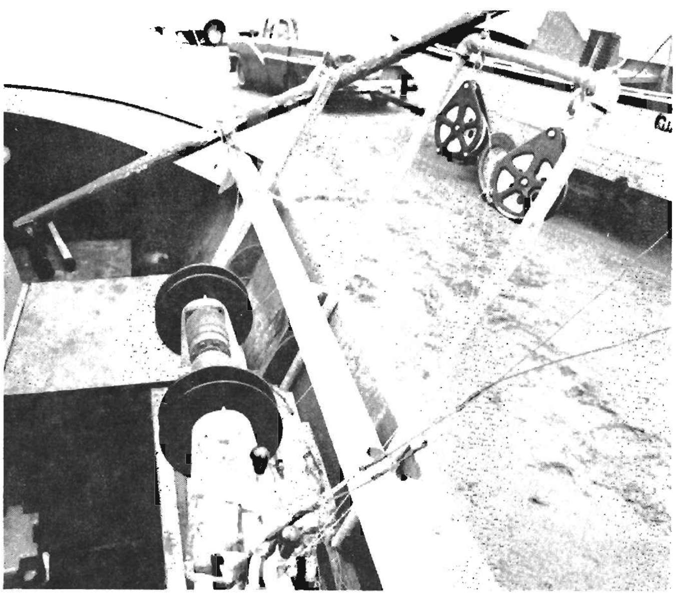


Figure 28.
Kiwanda Klipper 8, Starboard Gurdies and Davit, rear view

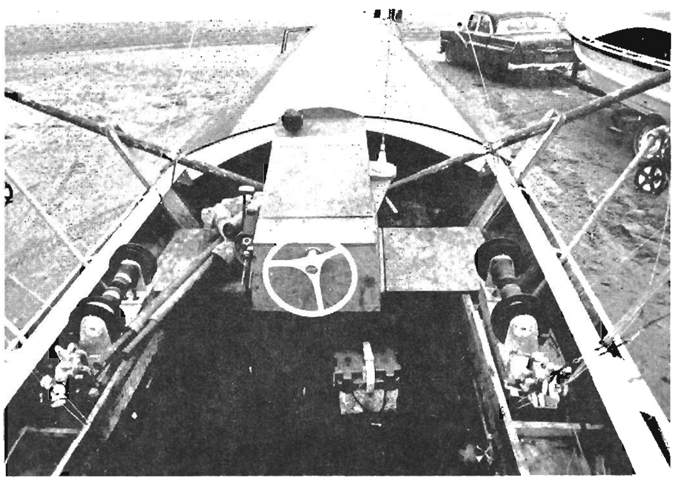
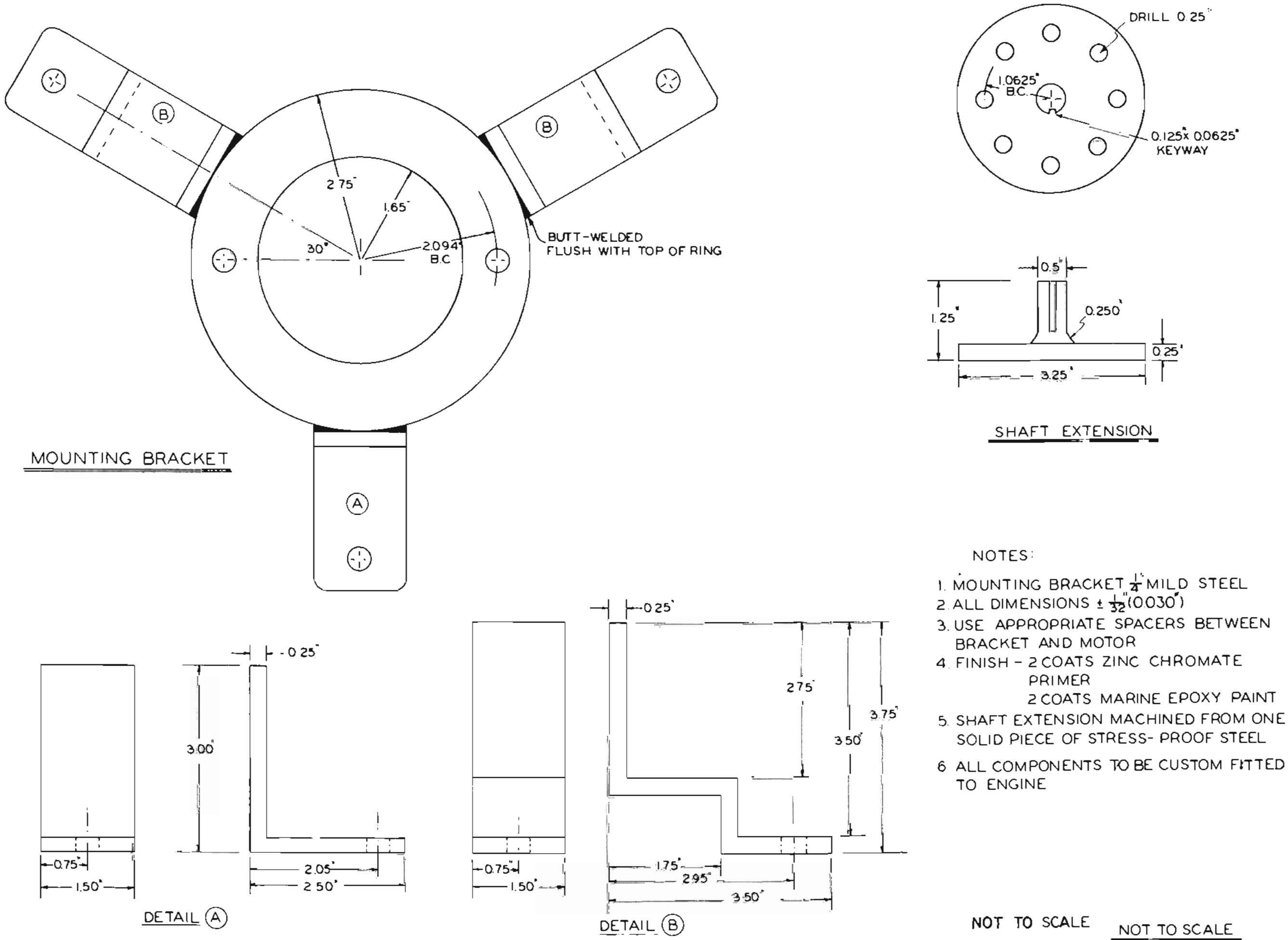
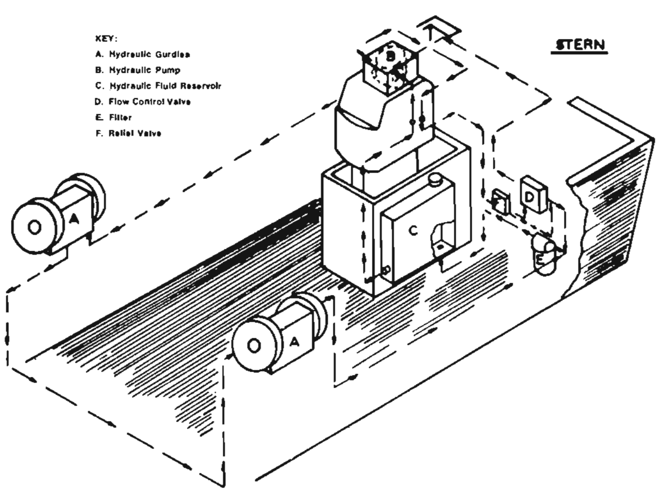


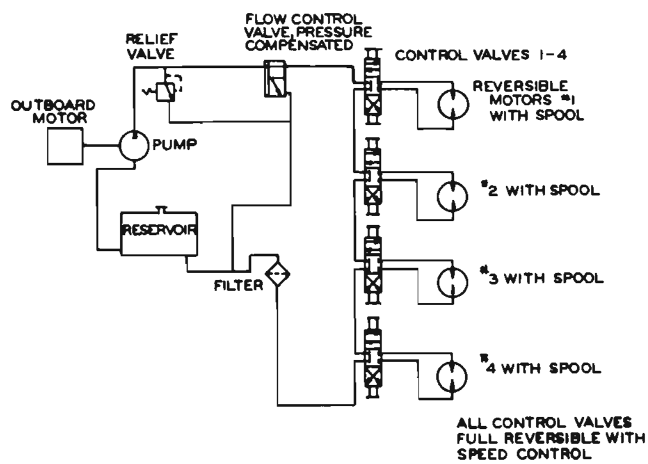
Figure 29.
Kiwanda Klipper 8, Gurdy Installation, rear view



Plan 7.
Hydraulic Pump Mount, 50-hp Mercury



Plan 8.
Hydraulic Gurdy System, *Kiwanda Klipper 8*, 50-hp Mercury



Plan 9.
Hydraulic Gurdy System Schematic, *Kiwanda Klipper 8*, 50-hp Mercury

Dory No. 4—*C-Doll* 70-hp Chrysler

The *C-Doll* is a 22-foot dory built by Boat Specialties of Salem, Oregon. The *C-Doll* is laid out somewhat differently than the standard Pacific City dory in that it features a sport-type configuration of steering controls, fish box, and seat which are mounted forward. The dory has a forward windshield on the whaleback and the poles are supported and fished from an effective A-frame which facilitates handling of the poles and associated rigging. The dory also features a semi-V bottom forward. (See Figure 30 below for photo details of the *C-Doll*.)

Figure 30.
C-Doll

The *C-Doll* was equipped with a Raytheon DE-725B recorder flasher depth sounder and a CB radio.

Pump Installation

The *C-Doll* was powered by a 70-hp Chrysler which, because of different operating characteristics and motor design, led the owner to attempt a different hydraulic pump. The Chrysler 70-hp engine shroud can be interchanged with shrouds from Chrysler 105-hp or Chrysler 120-hp engines. (See Figure 35, p. 23.) This exchange allows sufficient spare space under the shroud for installation of a pump mount featuring belts and pulley. (See Plan 10, p. 24, for details of the mount.)

The pulley is axially aligned and concentric with the crankshaft and flywheel and is supported by a top outboard bearing to prevent side torque. Flat straps run parallel with the flywheel and support the pump mount and pump pulley. The pump is mounted upside down and the entire mount is fastened to the front and rear of the engine block. The pulleys are 3 3/8 inches outer diameter and since there is no difference in pulley size, a 1 to 1 drive ratio is maintained between the pump and the engine flywheel. The belt pulleys are flanged and a 3/4-inch-wide toothed belt is used to prevent slippage (see Figures 31 through 33, p. 22).

The Chrysler installation features a Vickers VTM-27-40-40 Vane pump with a 4-gpm cartridge inserted in the pump. This pump has a rated maximum speed of 7000 rpm and a pressure capacity of 1500 psi. The pump was selected for reasons of economy and because it was known that the *C-Doll* equipped with a 70-hp Chrysler would attain effective trolling speeds at lower engine rpm than the other engines.

The Vickers VTM-27-40-40 Vane pump has greater gallons-per-minute efficiencies at low engine speeds than the Tyrone P1-25 pumps. (See Appendix D, p. 40, for the VTM-27-40-40 rpm to hydraulic fluid displacement curve.) The trolling speeds of the *C-Doll* ranged between 900 to 1100 rpm. The VTM-27-40-40 pump has a displacement of 3 gpm at 900 rpm engine speed, approximately 3.3 gpm at 1000 rpm, and approximately 3.65 gpm at 1100 rpm.

The Vickers pump with a 4-gpm cartridge reaches its rated displacement of 4 gpm at 1200 rpm. Engine speeds in excess of 1200 rpm will not cause a displacement of more than 4 gpm since the 4-gpm figure is the maximum displacement. The outboard motor must turn at a minimum of 600 rpm to actuate the vanes in the pump.

Gurdy System Schematics

The hydraulic system on the *C-Doll* was plumbed in similar fashion to that of the *Kiwanda Klipper 8*. The oil is sucked from the reservoir and passes through the pump to the pressure line. The pressure line in turn passes through a Gresen JLA-50 relief valve which has a direct return to the reservoir to dump oil if pressures in excess of 125 pounds pull are developed. This relief valve is adjustable.

The oil next passes through a Brand FC-51 3/8-inch flow control valve with adjustable settings from 0 to 10 gpm delivery. The oil then passes to independent spool configurations which are powered by a Char-Lynn AC motor and Number 183 Sta-Rite fully reversible speed control valves. After passing through all four gurdy stations, the oil returns through a filter to the reservoir. (See Plans 11 and 12, p. 24, and Figures 36 and 37, p. 23, for details.)

A different base plate mounting was designed for the *C-Doll's* gurdies. They were constructed of 3/16-inch galvanized plates and each spool and motor were mounted on a 3-inch-high by 3-inch-wide square steel pipe which was bolted to each end of the gurdy mount base plate. The spools and hydraulic motor shaft were supported by connecting both shafts into intermediate outboard bearings. An outboard bearing was believed desirable to prevent excessive side torque on the hydraulic motor shaft. However, subsequent operational tests revealed that excessive side torque beyond the capacity of the hydraulic motor was not a problem, and so this practice was discontinued after the installation of the gurdies on the *C-Doll* and the *Galliot*. The utilization of the commercially available and inexpensive 3/16-inch steel plate and pipe did produce an attractive, light-weight, and economical base mount.

Initial operational tests revealed that the 2-gpm cartridge which was originally supplied with the pump was inadequate to operate the gurdy successfully, and it was replaced with a 4-gpm cartridge. Operating tests revealed that the *C-Doll's* gurdies had a line retrieval speed of 157 feet per minute at a trolling speed of approximately 1000 rpm. Line retrieval cannot be increased beyond approximately 172 feet per minute at 1100 rpm (which is the maximum trolling speed possible for a boat similar to the *C-Doll* with a 70-hp Chrysler) in the system as designed. This line retrieval speed is believed to be too slow for efficient operation of power gurdies in a dory when heavy salmon fishing is encountered. Line retrieval speed can be increased for salmon gurdies by introducing a differential pulley ratio to increase the operating revolutions of the pump over the operating revolutions of the drive shaft pulley or by using a different pump which would deliver a greater flow of hydraulic fluid. It should be pointed out that actual line speed of gurdy operation is a matter of preference with fishermen, and some fishermen may be content with a lower line speed. However, under conditions of heavy fishing this lower line speed will be a detriment in a dory. It should also be recognized that any other hydraulic fishing machinery system which requires greater than 4-gpm pump displacement such as the tuna pullers discussed in this paper cannot be attained by using a VTM-27-40-40 pump. The only change recommended in this system would be to remove the flow control valve and the relief valve since the displacement is fixed at a maximum of 4 gpm and the pump features an integral relief valve.

The Chrysler installation has a labor-saving feature in that exchanging the outboard shrouds do away with the need to cut and install a shroud cover to protect the pump. It is not known whether Chrysler dealers can supply a new engine with the larger shrouds at no extra cost. If they cannot, the added cost is more expensive than making a pump mount cover. (The recommended fabricated pump covers are described in Section IV, p. 28).

The *C-Doll* logged approximately 321 hours during the salmon season and there were no malfunctions of the motor or hydraulic system once installed and tested.

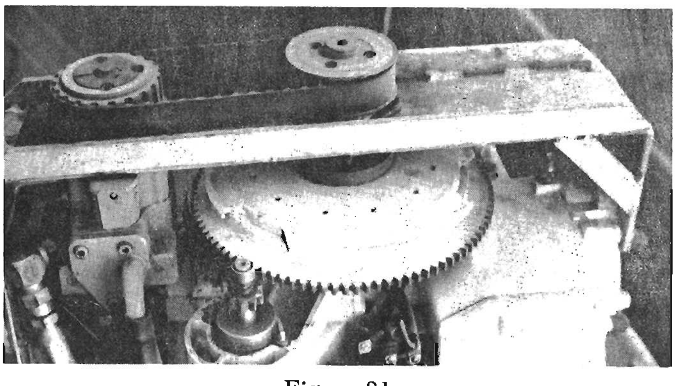


Figure 31.
Hydraulic Pump Mounted 70-hp Chrysler, side view

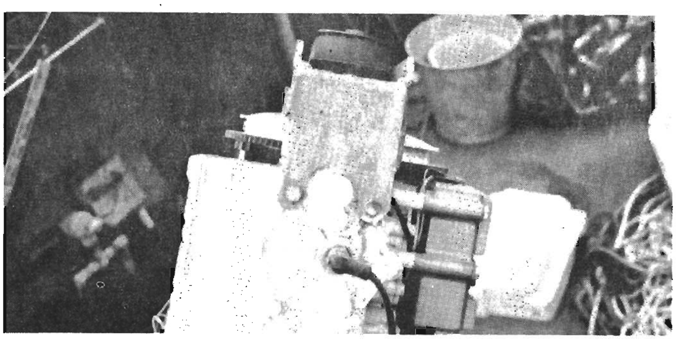


Figure 33.
Hydraulic Pump Mounted 70-hp Chrysler, rear view

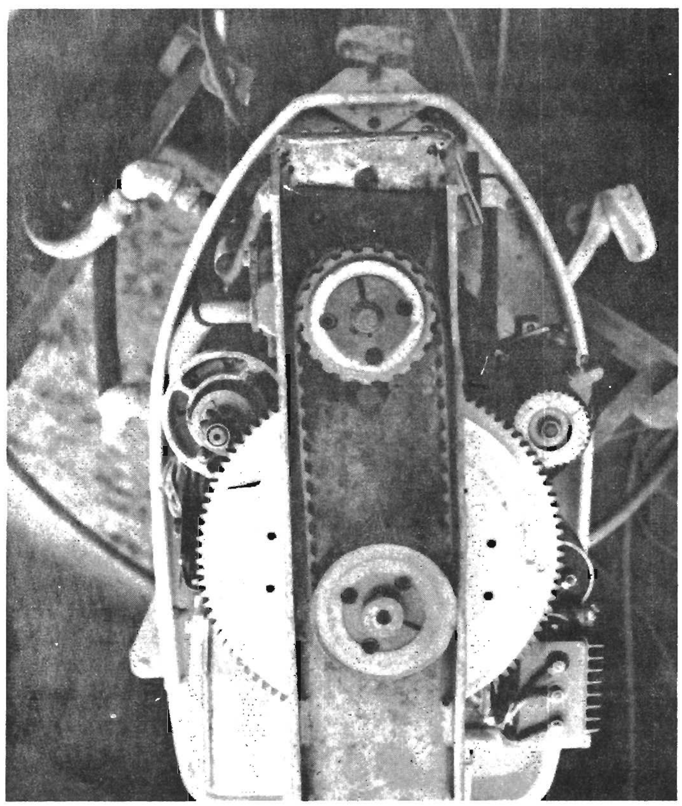


Figure 32.
Hydraulic Pump Mounted 70-hp Chrysler, top view

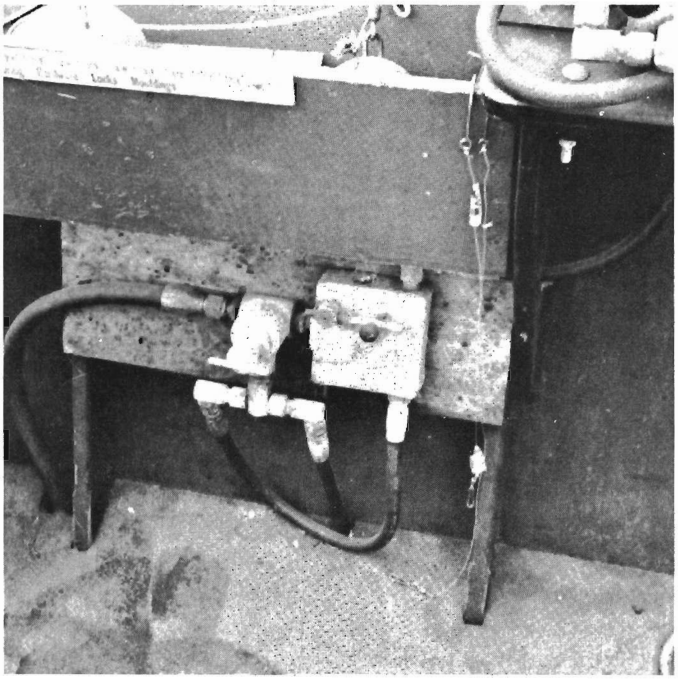


Figure 34.
Plumbing Details, Relief Valve and Flow Control Valve, *C-Doll* 70-hp Chrysler

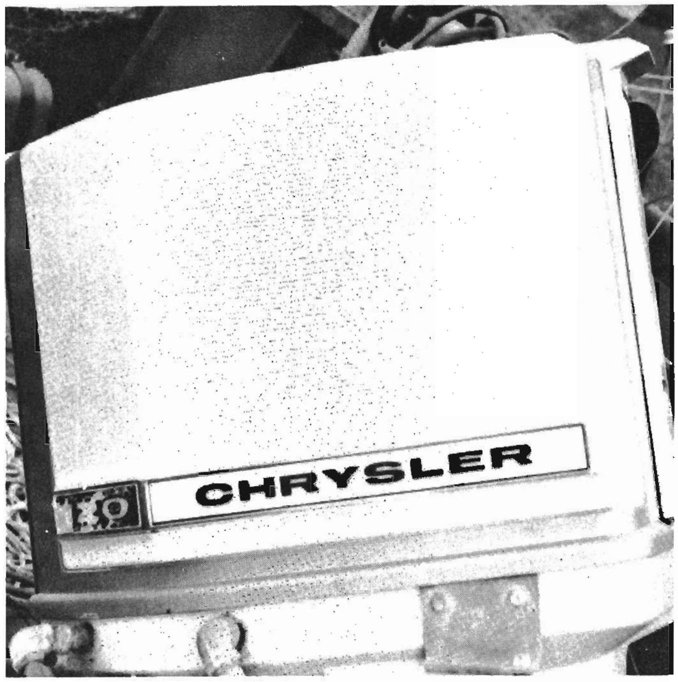


Figure 35.
120-hp Chrysler Motor Shroud Mounted on 70-hp Chrysler

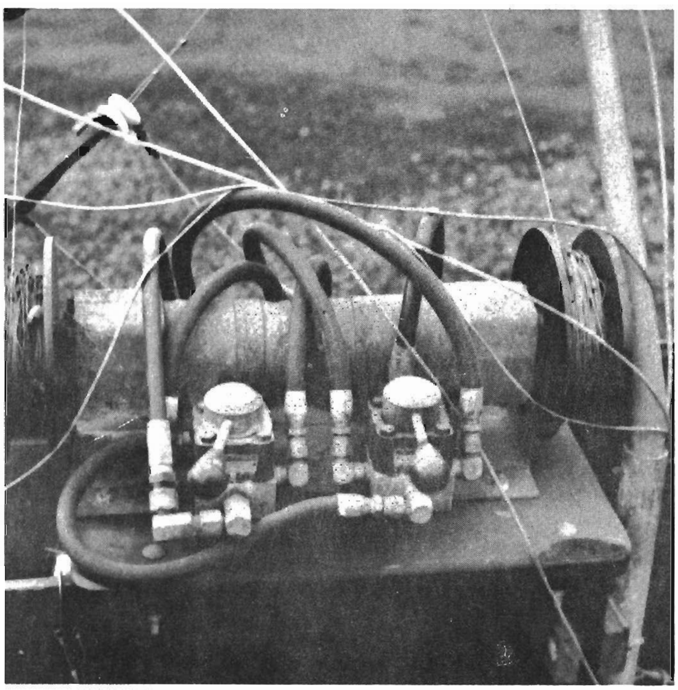


Figure 36.
Starboard Gurdies, *C-Doll* 70-hp Chrysler

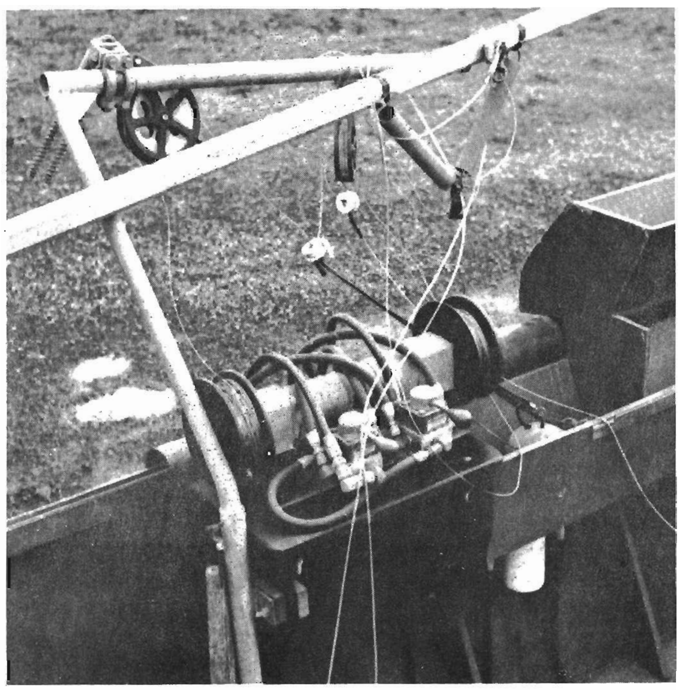
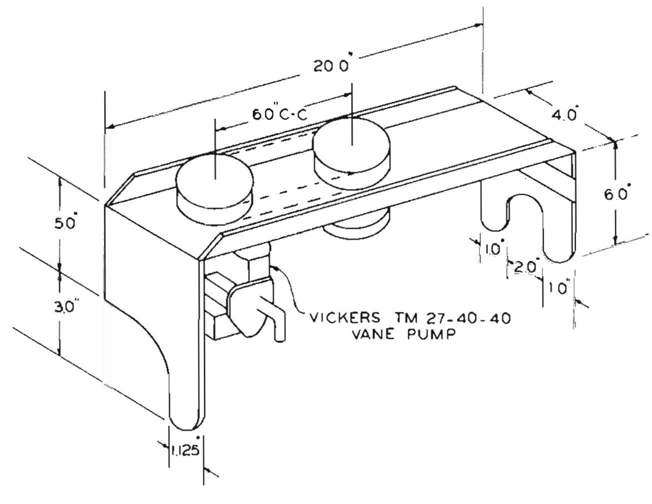
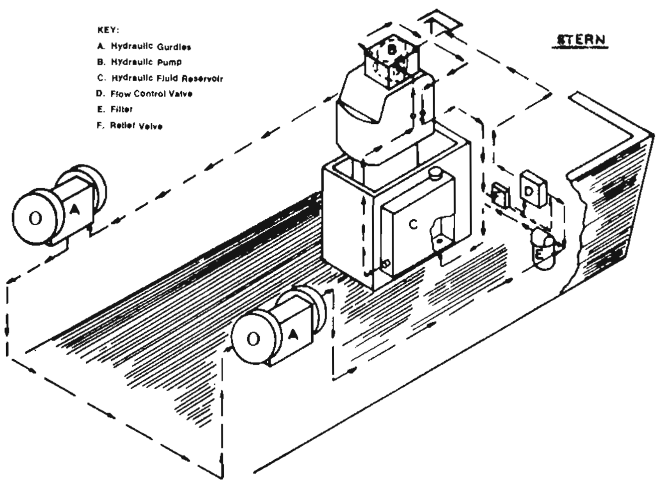


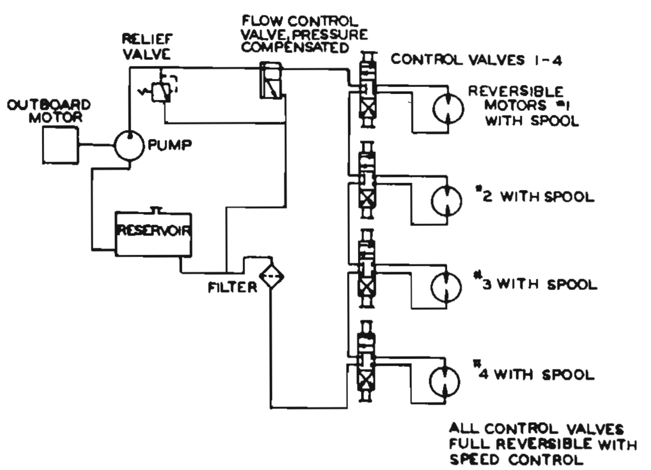
Figure 37.
Starboard Gurdies and Davit, *C-Doll* 70-hp Chrysler



Plan 10.
Hydraulic Pump Mount, 70-hp Chrysler



Plan 11.
Hydraulic Gurdy System, *C-Doll*, 70-hp Mercury



Plan 12.
Hydraulic Gurdy System Schematic, *C-Doll*, 70-hp Mercury

Dory No. 5—*Galliot*
40-hp Johnson

The *Galliot* is a 22-foot dory built by Cape Kiwanda Boat Builders of Cloverdale, Oregon (see Figure 38 below). It was rigged with a 40-hp Johnson outboard and project-designed gurdies. The *Galliot* also had a Ray-Jeff chart recorder flasher depth sounder, a Konel radio direction finder, and a Courier CB radio.

Figure 38.
Galliot

Pump Installation

The 40-hp Johnson presents some special problems in designing an adequate pump mount in that the engine is mounted on a rubber sleeve, causing the engine block to vibrate more than the other engines used in the project. The initial pump mount design was not satisfactory because of this factor, so new front base legs were designed and custom-fitted to the block.

Following these modifications, no further difficulty was encountered. Because of the complicated custom fitting a new pump mount was designed, tested, and found to be adequate. (Details of this recommended mount can be seen in Plan 13, p. 27.)

Figures 39 and 40, p. 26, show the original mount which had a tendency to shear the bolts connecting the front bi-pedal legs of the mount to the engine block. Figures 41 and 42, p. 26, illustrate details of the modified mount which proved to be satisfactory.

The Tyrone P1-25 Jobmaster pump was also utilized in the hydraulic configuration for this dory. The same general mounting procedures were employed on the 40-hp Johnson as were employed on all the other engines. The recoil starter assembly had to be removed to facilitate mounting of the pump. With the removal of the recoil starter accomplished, the pump extension plate was axially aligned and concentric with the crankshaft and flywheel. The alignment proceeded from the flywheel up the pump extension plate shaft, with the pump shaft being carefully aligned to 1/2 minute of angle. The pump was then bolted in place and the flex coupling attached as in the previous installations on the *Yankee Pedlar*, the *Sea Bass*, and the *Kiwanda Klipper 8*. The hoses were attached to the pump and run to the rear down along the pump mount rear leg and out through holes drilled in the port lower shroud of the outboard motor. The top of the shroud was cut away and a pump cover was constructed of aluminum alloy sheet and fastened to the top of the shroud with sheet metal screws. A 2-inch-wide rubber gasket afforded a weathertight seal between the pump cover and the shroud itself (see Figure 43, p. 26).

Gurdy System Schematics

The same general hydraulic system was used in the *Galliot* as was used in the *Kiwanda Klipper 8* and the *C-Doll*. The oil is picked up from the three-gallon reservoir mounted on the side of the transom by pump action and passes from the pump through the Gresen JLA-50 relief valve (which has a return line to the reservoir). The oil next proceeds through a Brand FC-51 3/8-inch flow control valve in a circuit to each independent gurdy spool powered by a Char-Lynn AC motor and Number 183 Sta-Rite control valve. The oil then returns through a Gresen FA-103 filter back to the reservoir. (See Plans 14 and 15, p. 28, for details of the hydraulic systems and Figures 44 and 45, p. 27, for further details of the gurdies.) The same gurdy base mount was employed on the *Galliot* as was employed on the *C-Doll*. Hoses and fittings on the *Galliot* were similar to those used on the *C-Doll* and the *Sea Bass*.

At this point adequate experience had been obtained in the project to forego further utilization of outboard bearings between the spool and the hydraulic motor. The Lauterbach Company of Portland, Oregon, and the project staff designed a gurdy mount which would feature a mount fabricated of polyurethane of 1/4-inch thickness.

Operational tests revealed that the *Galliot's* gurdy system had a line retrieval speed of approximately 245 feet per minute, and operational pressures in the system were approximately 200 to 600 psi. The *Galliot* could also successfully retrieve 105 pounds of lead per spool with no appreciable lag on the engine.

Some malfunctions were noted during fishing trials of the *Galliot* as one Char-Lynn AC motor failed and had to be returned for servicing. In addition, a detachable fitting failed because the fitting had been tightened excessively.

The initial pump mount failure resulted in a further complication. When the custom pump mount was fitted to the engine, the hydraulic pump was hooked up improperly. The Tyrone P1-25 Jobmaster pump must be aligned properly as this pump is not bi-rotational and is supplied by the manufacturer to operate in only a specified rotation—clockwise or counterclockwise. All Jobmaster P1-25 pumps utilized in an outboard hydraulic configuration *must rotate in a clockwise manner* except the Bearcat.[6] The hoses were reconnected improperly and the hydraulic pump failed because of a blown seal on the pump. Care must be taken during the attachment of the hoses to ensure that the suction line is attached to the inlet side of the pump and that the pressure line is attached to the outlet side. Following these corrections, no further malfunctions occurred with either hydraulic system or motor, and the engine and system performed satisfactorily.

The *Galliot* logged approximately 550 hours during the 1970 salmon season and the hydraulic system performed perfectly after the correction of the malfunctions noted. Subsequent disassembly of the engine at the close of the season revealed that there were no abnormal signs of wear on any of the internal parts.

The only change recommended on this system is to combine the relief valve and flow control valve functions by using a Brand FCR-51 3/8-inch flow control valve.

Fishing experience in the *Galliot* led to the conclusion that 40-hp engines are inadequate in this fishery. Engines of 50-hp or better are believed desirable to attain all of the advantages of high speed and mobility. When fully loaded with gear, men, and a payload of fish, the dories are relatively heavy. The maximum speed that the *Galliot* could develop was approximately 12 to 14 mph and this, of course, destroys one of the dory's prime advantages—high speed for broad coverage of the fishing grounds. It was also revealed that total overall engine operating expenses of the 40-hp Johnson were in excess of the total engine operating expenses of the *Yankee Pedlar* in equivalent 22-foot dories. The fuel consumption of the 60-hp Johnson was roughly equivalent to that of the 40-hp Johnson. The *Yankee Pedlar* could develop speeds of up to 24 mph, and so for the same fuel costs could cover much more ground. Also, the 60-hp Johnson consumed fewer sparkplugs than did the 40-hp Johnson. The 40-hp Johnson installation will, however, serve admirably in any other fishery where speed is not a factor and smaller boats are used.

[6] The other outboard motors have clockwise flywheel rotation. The Bearcat rotates in a counter-clockwise fashion. Therefore, pumps mounted on a Bearcat should have counter-clockwise rotation capability.

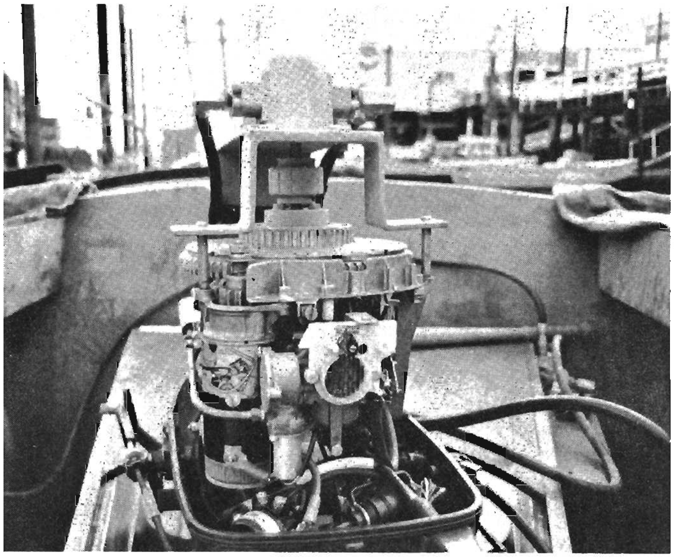


Figure 39.
Original Hydraulic Pump Mount 40-hp Johnson, front view

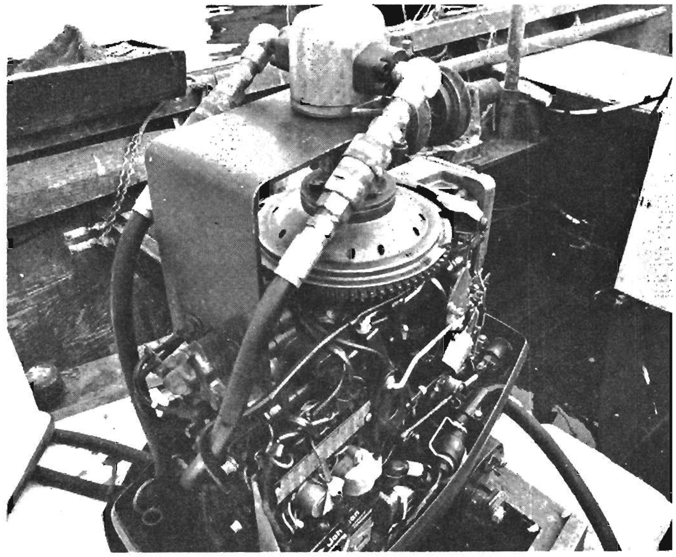


Figure 40.
Original Hydraulic Pump Mount 40-hp Johnson, rear quarter view

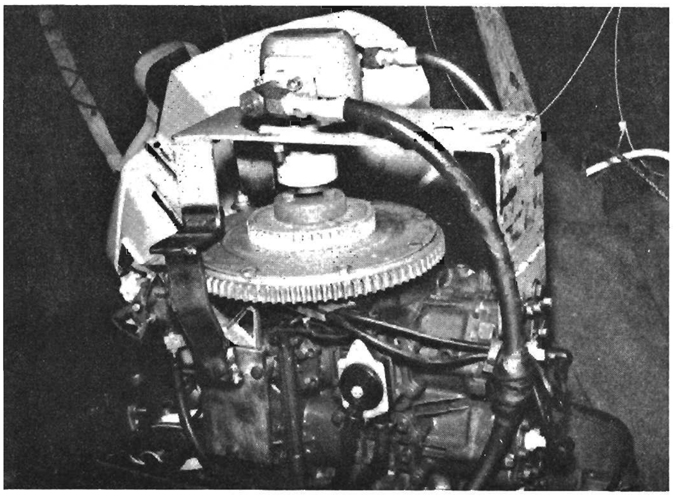


Figure 41.
Modified Hydraulic Pump Mount 40-hp Johnson, side view

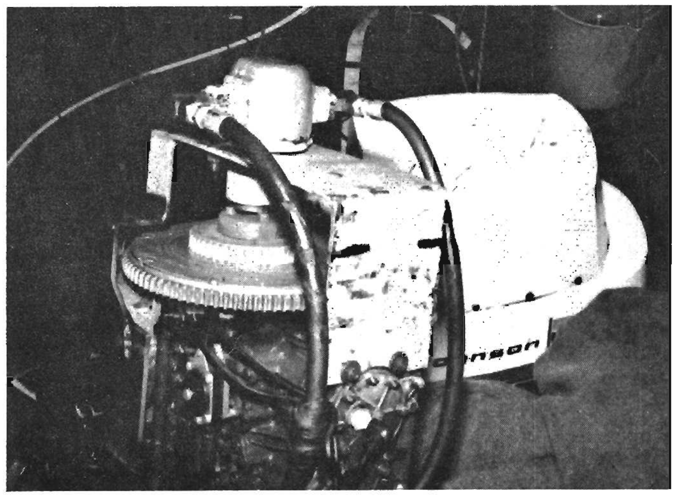


Figure 42.
Modified Hydraulic Pump Mount 40-hp Johnson, side and rear view

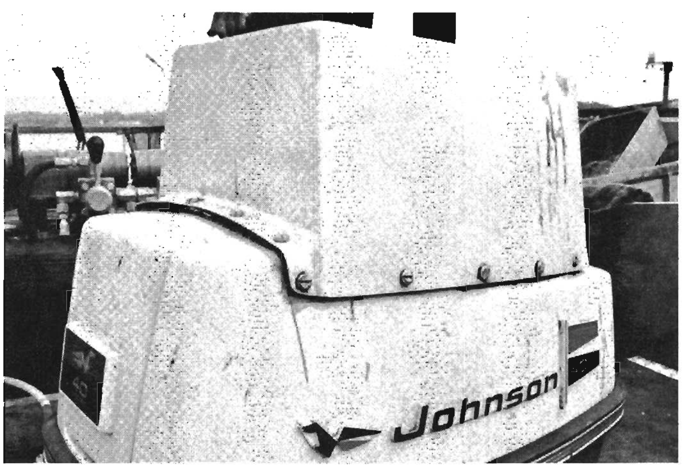


Figure 43.
Hydraulic Pump Cover 40-hp Johnson

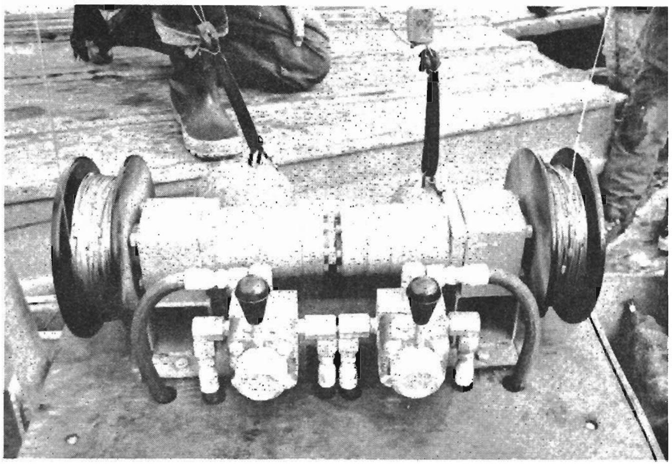


Figure 44.
Starboard Gurdies, *Galliot* 40-hp Johnson

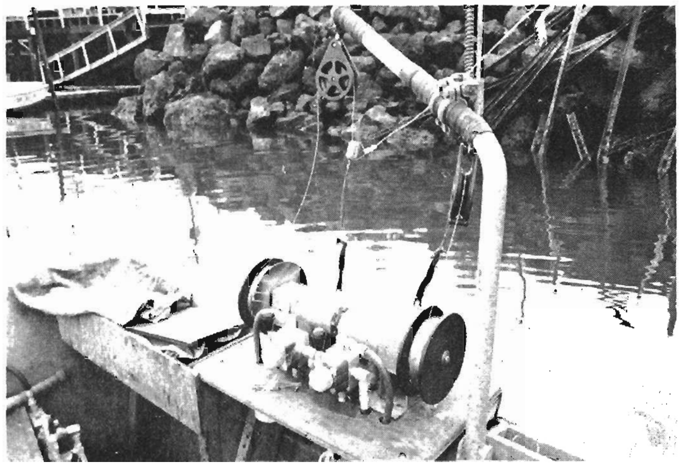
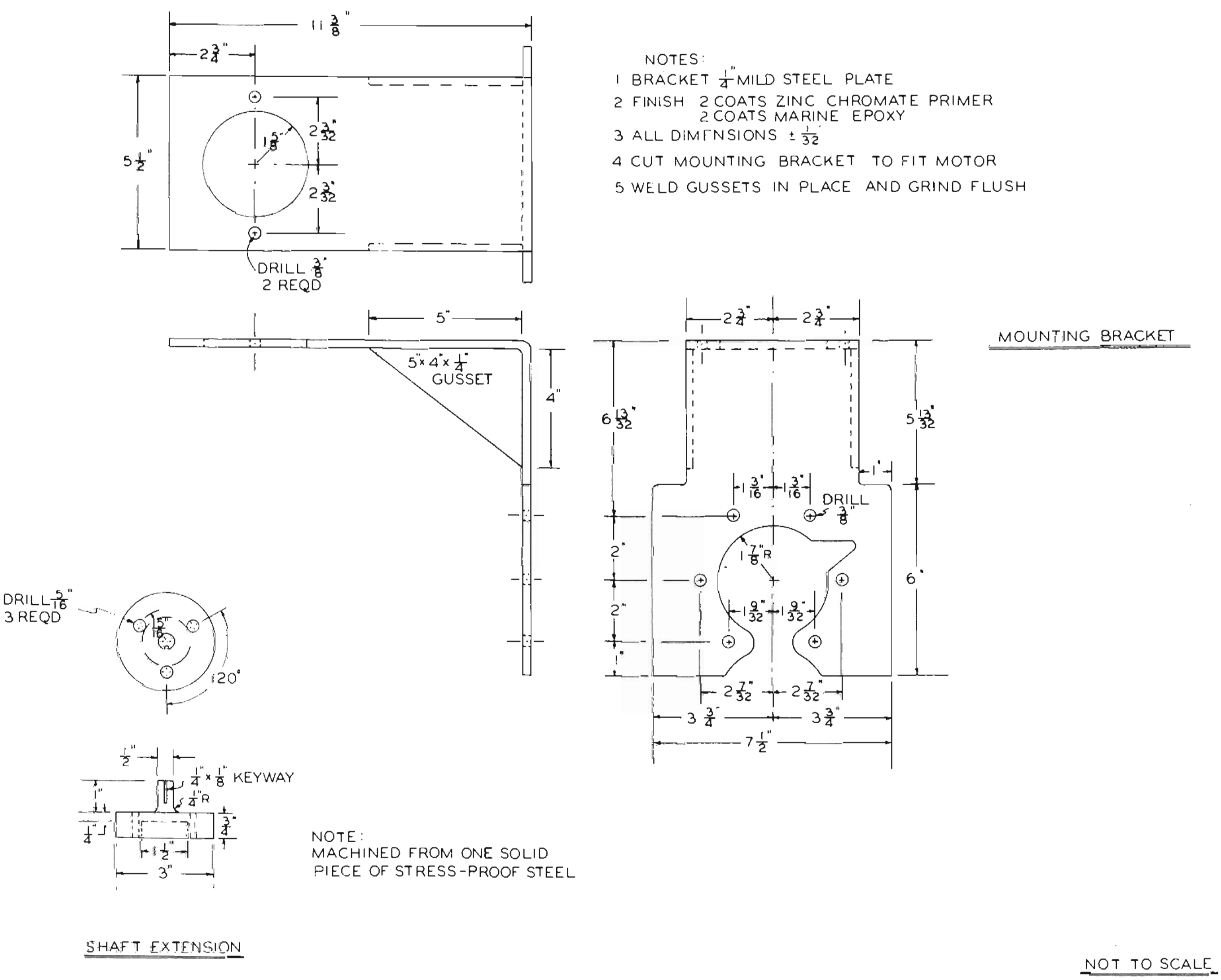
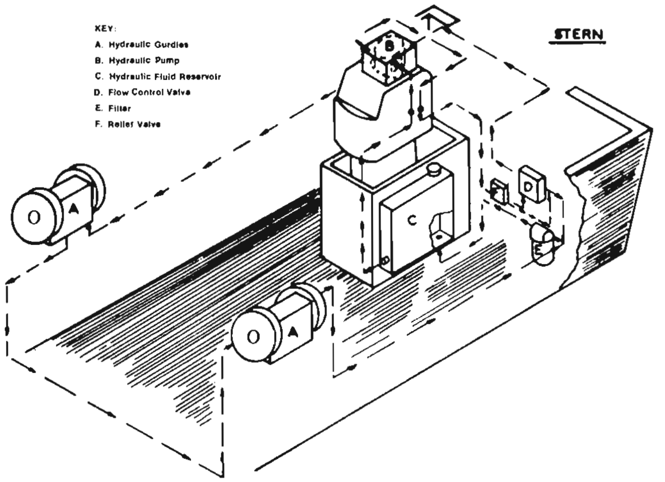


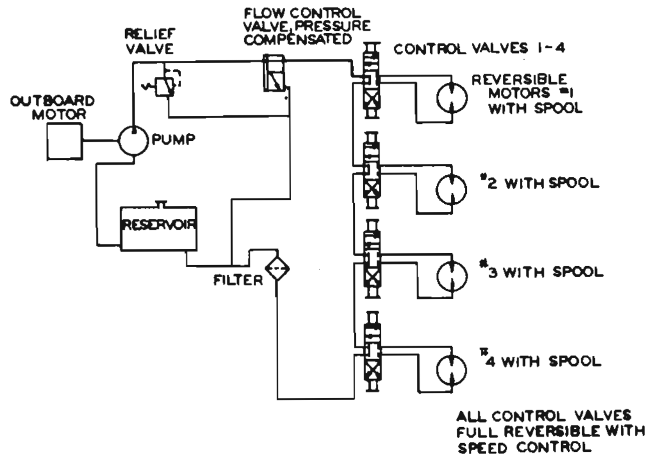
Figure 45.
Port gurdies and davit, *Galliot* 40-hp Johnson



Plan 13.
Hydraulic Pump Mount, 40-hp Johnson



Plan 14.
Hydraulic Gurdy System, *Galliot*, 40-hp Johnson



Plan 15.
Hydraulic Gurdy System Schematic, *Galliot*, 40-hp Johnson

IV. Project Conclusions and Recommendations

The five dories working on the hydraulic project logged a total of approximately 3,045 hours during the 1970 salmon season. Two of the engines were dismantled at the conclusion of the project and no abnormal signs of wear were noted on any of the crankshafts, upper main bearings, lower main bearings, connecting rods, connecting rod bearing retainers, or connecting rod bearing retainer assemblies. The relatively trouble-free operation of all of the engines once initial application problems were overcome supports an over-all conclusion that the hydraulic power take-off system is safe, feasible, and efficient providing the following principles are observed:

1. Care must be taken during the hookup of the pump to ensure that the pump extension plate is axially aigned and concentric to the center of the crankshaft. No wobble of the pump extension plate can be tolerated. The pump extension plate should be bolted to the top of the flywheel utilizing the flywheel bolt pullers after it has been assured that a good mating surface can be obtained.

   The recommended practice is to secure a short piece of pipe whose inner diameter matches that of the pump shaft and the pump extension plate shaft diameters. The pipe should be slipped over the pump extension plate shaft and then fitted over the shaft of the unsecured pump resting on the top of the pump mount. The pump should be moved carefully until a tight and accurate fitting position is obtained on both shafts. Scribe marks should be made on the pump mount with a sharp instrument through the pump mount flanges so that the bolt holes can be drilled with the pump in that exact position. The pump is then removed, the bolt holes are drilled in the mount top, and the pump is bolted to the mount with bolts, nuts, and lock washers.

   The flex coupling is then attached and the hydraulic system is plumbed and hooked up. The engine should be started and immediate operational tests should be conducted to ensure that there is no pronounced wobble of more than 1/2 minute of angle in the pump mount. All components of the system should be checked immediately to ensure adequate performance. During these operational tests attention should be paid to such factors as noise (a properly installed hydraulic system makes little noise beyond a slight whine from the pump), vibrations of hoses (there should be none), or any lag in engine rpm.

2. The pump mounts employed must be rigid and the pump mount attachments must be of such a nature that bolts fastening the pump mount to the engine block will not work loose under engine operation. Lock washers should be employed with all mounting bolts.

3. These bolts should be checked from time to time to ensure that they remain securely fastened. It was found during the life of the project that bolts properly fastened with lock washers did not

work loose, but continued checking is a good safety measure.

4. Normal good hydraulic practices should be followed, such as checking each component in the system by an immediate operational test to assure that each component is working according to specifications. Normal safety practices should be observed, such as the inclusion of a filter in the system as dirty oil can shorten the life of pumps, control valves, and motors. All components, *especially hoses and fittings*, should be inspected for cleanliness prior to system installation and cleaned if necessary.

5. A high-quality hydraulic fluid should be used in the system. SAE 10-30 weight hydraulic engine oil is recommended. This fluid, with a vicosity of 150 to 220 SSU, has a high to low heat range and is the fluid recommended by Char-Lynn for their motors.

6. For multipurpose use of the hydraulic systems described in this paper such as combined trolling-longline-tuna puller gear which require different systems, it is strongly recommended that a pressure gauge be used. This gauge should be "tied" into the system between the pump and the first control valve used. Adequate gauges to obtain pressure readings for the different functions can be purchased for approximately $5 to $6.

7. No hydraulic system should be designed or installed without consulting an engineer knowledgeable in the field of hydraulics.

If all of the precautions and procedures contained in this report are accurately followed, trouble-free and effective results can be obtained.

V. Recommended Gurdy System for Outboard Motor Trollers

Project efforts throughout the summer of 1970 led to the design of a low-weight, relatively inexpensive four-spool gurdy system for outboard-powered salmon trollers. This system, designed by the Lauterbach Company of Portland, Oregon, weighs approximately 140 to 145 pounds installed in a boat. It is compact and its light weight allows high-speed vessels such as Pacific City dories to retain their superior operating characteristics without reduction in speed occasioned by heavy weight.

The system features a Char-Lynn R244 three-gallon reservoir, Imperial-Eastman 1/2-inch and 3/8-inch inner diameter hydraulic lines, a Tyrone P1-25 Jobmaster pump, a Brand FCR-51 3/8-inch flow control valve, Char-Lynn AC motors, Number 183 Sta-Rite control valves, and a Gresen FA-103 filter. The gurdy spools are the standard polyethelene spools and the gurdy mounts are fabricated of 1/4-inch-thick sheets of polyurethane plastic.

This gurdy system also has a large locking nut on the outside edge of each spool so that in the event of a hydraulic motor failure or an engine failure, a ratchet wrench can be attached to the gurdy spool and the trolling gear can be cranked in by hand. To retrieve gear manually, the flow control valve is set on 0 gpm and the pressure line is disconnected at the flow control valve outlet. The disconnected line should be placed above the highest horizontal line of this system to reduce oil spillage. The control valve for the first spool in the circuit is set for line retrieve (other control valves are left in neutral) and the line is cranked in by slipping a wrench over the spool nut and cranking. When the gear is aboard, the control valve is placed in neutral. Each remaining spool is reeled in manually following this procedure.

During a fishing season, rapid removal and exchange of any malfunctioning components is a necessity. These gurdies have been designed so the entire gurdy mount can be quickly disconnected and returned for spare gurdies and mounts if a malfunction occurs. (Plans 16 and 17, p. 31, are schematics of the hydraulic gurdy system and Figures 46 through 49, p. 30, give photo details of the system.)

Installation of this gurdy system appears to be economically feasible for dories in this fishery. At this date, total cost of the gurdy system for an outboard dory is $875.70, according to the manufacturer. Gurdy spools are completely plumbed, and mounting and rigging instructions are supplied. The project had established objectives of coming up with a gurdy system that would weigh no more than 150 pounds total and would cost no more than $900. The gurdy system meets these objectives.

Project experience demonstrated the feasibility in the small boat salmon troll fishery for individual spool units consisting of a hydraulic motor with a special fully reversible speed control valve bolted directly to the motor. The spools will be the standard spools described and will be mounted directly on the hydraulic motor shaft. The mounts for motor and spool will be manufactured of salt water corrosion-resistant aluminum. Provision will be made for zirc grease fittings to protect the seal and shaft of the hydraulic motor.

It is believed that utilization of these independent spools will allow unusual flexibility in gurdy installation aboard salmon trollers.

A further feature of this gurdy is the ability to provide adequate line speeds and torque for both salmon trolling (at 1800 rpm) and albacore tuna trolling (at 2400 rpm) in an outboard-powered vessel. The tuna troll lines have a greater arbor when fastened onto a spool containing the salmon troll wire. Increased arbor and the higher trolling speeds of 2400 rpm will provide a line retrieval speed of approximately 360 feet per minute.

The only components that will not be supplied with this system are the pump mount itself, since there are so many different types of engines in the fishery, and a pump cover shroud. Fishermen will have to have these pump mounts made, and any of the mounts described in this report will work adequately and effectively for the respective engines mentioned. Fishermen having engines different from those employed in the project will have to design their own mounts. This is not a difficult task. If the basic principles and procedures outlined in this project are followed to ensure rigid support and true alignment, any competent marine blacksmith should be able to design a satisfactory mount.

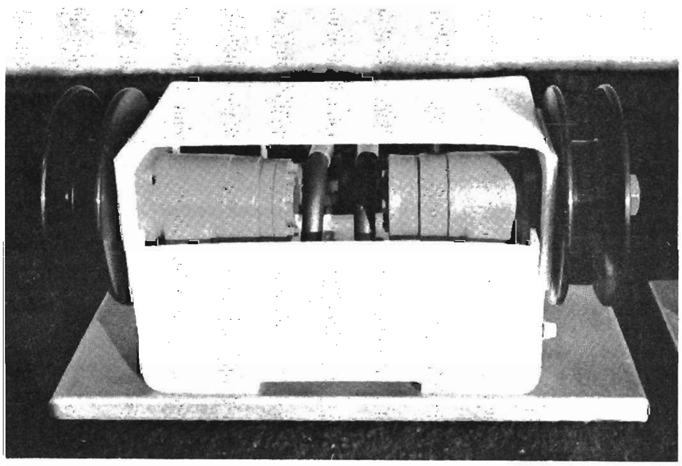


Figure 46.
Lauterbach Gurdies, outside view

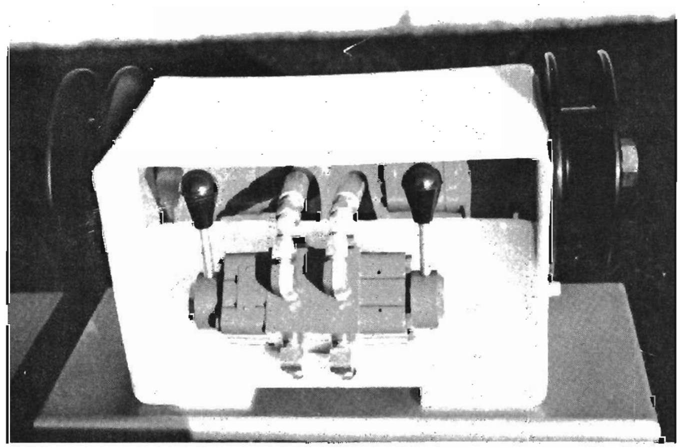


Figure 47.
Lauterbach Gurdies, inside view

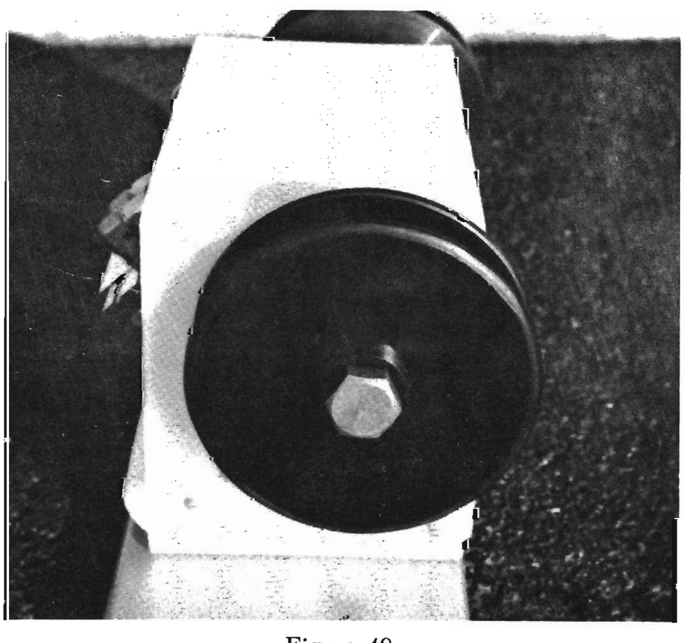


Figure 48.
Lauterbach Gurdies, side view

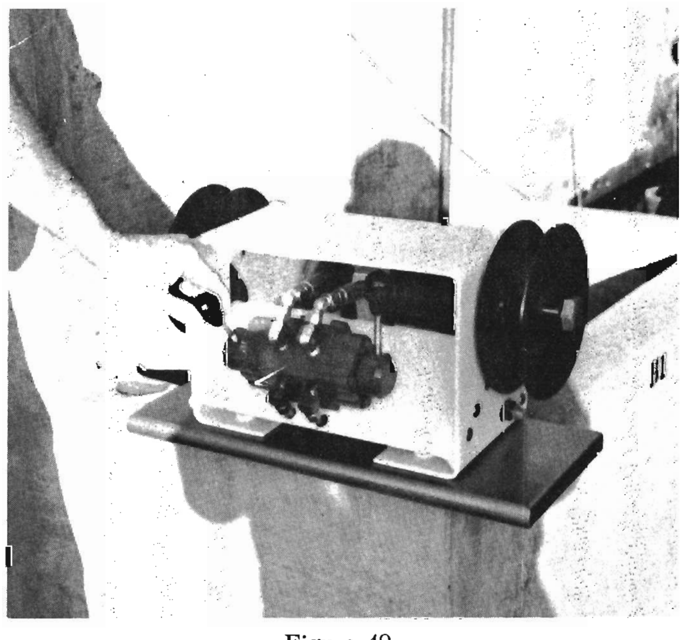
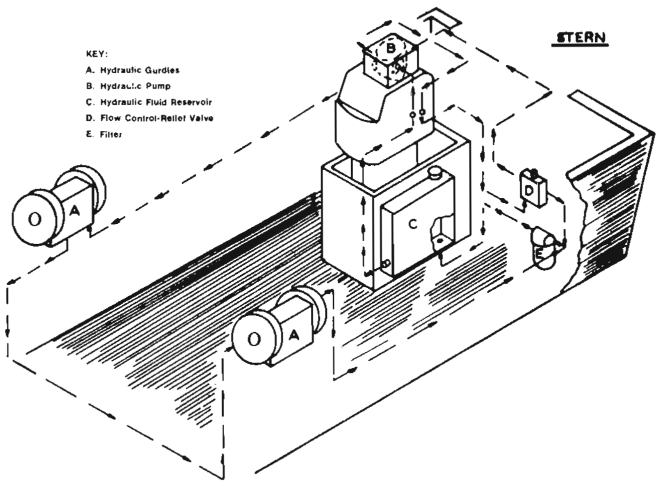
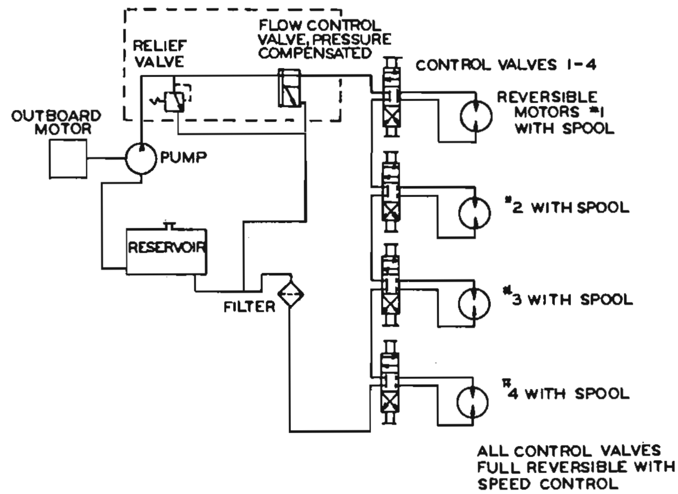


Figure 49.
Lauterbach Gurdies Control Valve Operation



Plan 16.
Lauterbach Hydraulic Gurdy System



Plan 17.
Lauterbach Hydraulic Gurdy System Schematic

VI. Pump Cover Fabrication

Adequate pump covers can be made of any of the following materials:

Light-gauge aluminum sheet. Only alloys of the 7050 series should be used as these alloys withstand the corrosive effect of a salt water environment. This makes an outstanding pump cover, but the material cost is high and if the cover is welded, the total cost is excessive. Consideration should be given to using pop rivets as a joining method if an aluminum shroud is desired. The aluminum sheet can be cut to size from cardboard templates and allowances made for flanges to join the panels. The flanges can be bent to overlap. A strip of rubber gasket can be positioned between edges, glued in place, and the panels joined by pop rivets obtainable from hardware stores. Eight to twelve air intake holes of 1/4-inch diameter each should be drilled in the top rear of the cover to allow adequate air intake for the motor.

Fiberglass. These pump covers can be made by cutting panels of cardboard sufficient to allow space to contain the pump, mount, and hoses. The panels can be joined with a heavy "scotch tape" and should be fitted in place over the mounted pump to ensure that an adequate fit is obtained. The assembly is then removed and is carefully fiberglassed internally and externally with fiberglass cloth and resin. One layer of resin should be applied to each side of the cardboard, allowed to dry, and then a second coat should be applied. Fiberglass cloth can then be laid into the tacky resin and allowed to dry. Two final coats of resin are recommended. The seams and corners of the pump mount should be covered with fiberglass tape and extra coats of resin applied. A rubber gasket of no less than 1 1/2 inches should be glued to the entire inside lip of the pump cover. Air intake holes should be drilled through the pump cover. The cover should be held in place with tape, and holes should be drilled through the bottom lip of the pump cover and the engine shroud cover. Sheet metal screws can then be used to fasten the pump cover to the shroud.

Plastic. An attractive and efficient pump cover can be fabricated of solid sheets of ABS plastic 3/16 inches in diameter. A cardboard model should be made following the procedures outlined above to serve as a template. Panels should be carefully cut of the 3/16-inch-thick plastic. Right angle molding of the same material can be obtained from manufacturers. The panels should be carefully taped together on the inside with masking tape. The right angles are then glued along the butt edges of the panels with MEK solvent mixed with powdered ABS plastic. The pump mount cover should also have a rubber gasket mounted on the inner lip in the manner described above. It is then fastened to the outboard motor shroud in the manner described with stove bolts or pop rivets. Air intake holes should also be drilled in this pump cover. (See Figures 50 through 55, p. 32, for step-by-step details of the construction of a pump mount cover employing ABS plastic.)

Figure 50.
ABS Plastic Mount Cover Fabrication—Scribing on ABS Plastic Panel

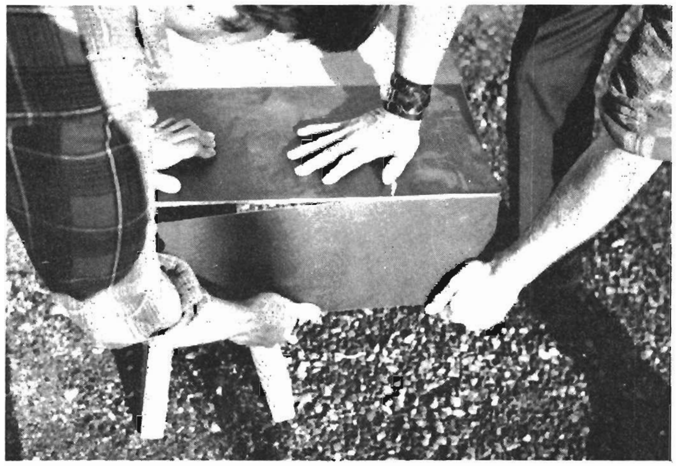


Figure 51.
ABS Plastic Pump Mount Cover Fabrication—Splitting a Side Panel

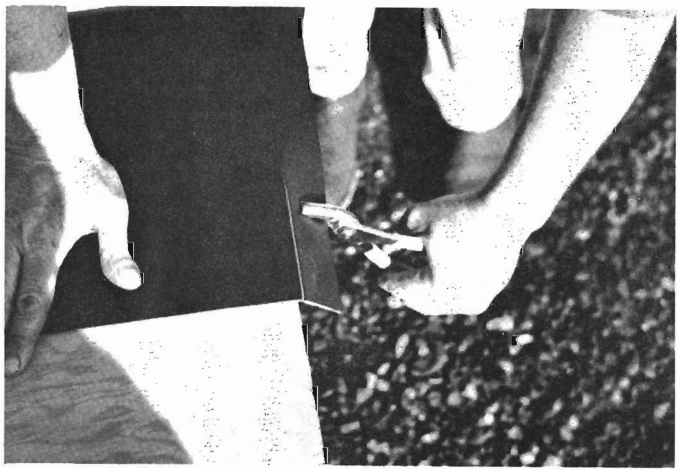


Figure 52.
ABS Plastic Pump Mount Cover Fabrication—Splitting an End Panel

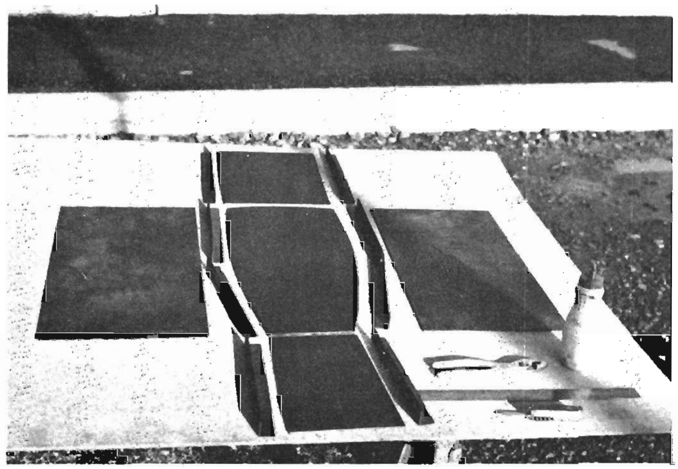


Figure 53.
ABS Plastic Pump Mount Cover Fabrication—All Panels Cut, Plastic Right-Angle Joiners Cut, Adhesive, Tools Required for Pump Mount Cover Fabrication

Figure 54.
ABS Plastic Pump Mount Cover Fabrication—Assembly of Side Panel and Right-Angle Joiners

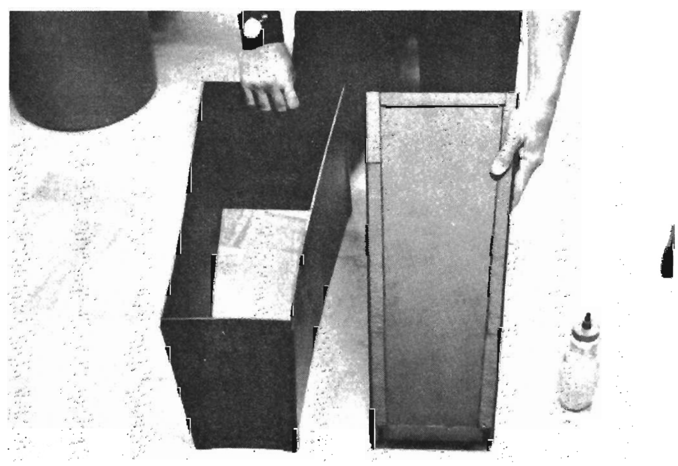


Figure 55.
ABS Plastic Pump Mount Cover Fabrication—Completed Side Panels and Cover

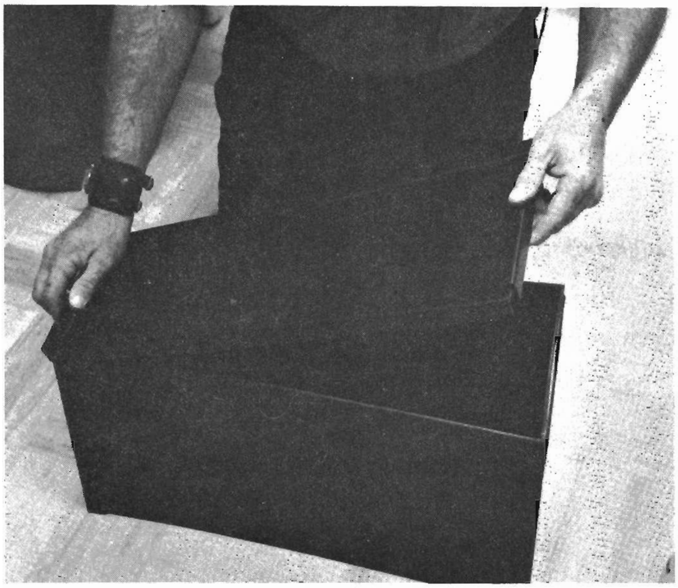


Figure 56.
ABS Plastic Pump Mount Cover Fabrication—
Fastening Pump Mount to Lower Unit

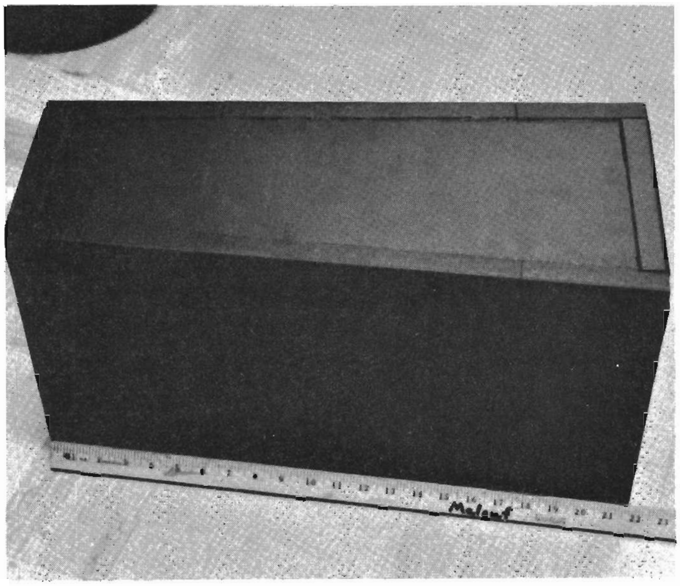


Figure 57.
ABS Plastic Pump Mount Cover Fabrication—
Completed Pump Mount Cover, Side View

VII. Other Fishing System Configurations

A variety of fishing machinery systems can be run off the hydraulic power-take-off designed for this project. The same general procedures and methodology used in the design of the salmon troll gurdies can be used to rate the work cycles to handle other gear. This section will deal with rating additional fishing machinery—a tuna puller for surface trolling, a long-line puller, a shellfish pot and trap lifter, and a gillnet reel—from the same hydraulic systems as those which were installed in the Johnson, Mercury, and Bearcat engines. The systems described below *may not* match the line speed and pulling force requirements of a given fishery. This is particularly true with the gill net reel discussed. If different line speeds and pulling forces are required the same formulas are used with the desired line speed and pulling force substituted. Also, consideration should be given to the effective radius desired on a given spool or sheave as a factor in the computations.

It should be remembered that these systems have not yet been fished. Work is progressing with volunteer help from fishermen to build the machinery and the gear will be operationally tested as it is completed.

The rating of the fishing machinery in the following instances proceeds from some known variables. The direct-drive hydraulic power system has been tested and found adequate. The rpm to pump displacement (gpm) curves have been established, and engine speeds have been selected for each fishing gear that give adequate oil flow in gallons per minute to power the fishing gear efficiently.

The tuna puller would be operated with the dory trolling at 2400 rpm. The other systems would be operated with the engines out of gear and turning at the engine rpm specified for each gear.

Albacore Tuna Puller (Surface Troll Pullers)

Albacore tuna troll lines in Pacific Northwest trollers are pulled by a high-speed pinch-type line puller. A typical puller consists of a stainless steel sheave mounted directly on the shaft of a high-speed hydraulic motor. The motor is controlled with a simple one-way hydraulic control valve.

The fishing line is placed in the deep line recess in the sheave and is gripped by the turning sheave and pulled at a high rate of speed. A "peeler" or metal key tapered to fit the recess in the sheave is mounted on the bottom of the sheave and peels the line off after it has traversed approximately three-fifths of the circumference of the sheave.

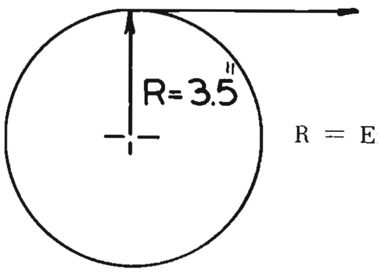
A tuna puller can be mounted and operated from the outboard motor's hydraulic system. The design for such an installation is as follows:

Tuna Puller

Dory trolling at 2400 rpm
pump output = 5.4 gpm

a. *Requirements*
Line Pull = 125 pounds pulling force
Line Speed = 360 feet per minute minimum

Sheave



R = Effective radius of 3.5 inches

b. *Calculations*[7]

1. Torque
Torque (inch pounds) or T = Line pull (pounds) or P multiplied by the effective spool radius in inches, or R
T = P X R
T = 125 X 3.5
T = 439.5 inch pounds

2. Spool rotation speed required
Speed (sheave rpm) or S =

$$\frac{\text{Line haul-in speed in inches per minute or L}}{\text{Effective spool circumference}}$$

$$S = \frac{L}{2 \times 3.5 \times 3.14\ (\text{pi})}$$

$$S = \frac{\text{360 feet per minute or 4320 inches per minute}}{2 \times 3.5 \times 3.14}$$

$$S = \frac{4320}{21.98}$$

S = 197 rpm

The desirable spool speed of the tuna puller will be 197 rpm if the dory is trolling at 2400 rpm. This gives a line haul-in speed of 360 feet per minute. The torque of 439.5 inch pounds will give a line pulling force of 125 pounds on the sheave used in this example.

A Char-Lynn AC motor most closely approximates this theoretical configuration. A pump displacement of 5.4 gpm will give a spool speed of 205 rpm from a Char-Lynn motor at 2400 rpm engine speed. The actual line retrieval speed will be approximately 375 feet.

Variable trolling speeds above and below the engine rpm of 2400 specified will produce higher or lower line speeds on this puller. To compute exact line speed at a given engine speed, count the spool rpm developed at that speed and multiply by 21.98 inches.

The hydraulic configuration for a tuna puller would consist of a tuna puller sheave mounted directly on a Char-Lynn Orbit AC motor (or equivalent), 3/8-inch inner diameter hydraulic pressure lines, 1/2-inch inner diameter hydraulic suction and return lines, and a simple one-way control valve. The motor and sheave should be fastened onto a mount which is fastened to the vessel. The oil would move in a circuit from the reservoir through the Jobmaster pump to the Brand FCR-51 3/8-inch flow control valve with a built-in acorn relief valve. The oil passes to and through the one-way control valve to operate the puller and then returns through the filter and back to the reservoir. The relief valve should be set so that the 125 pounds line pull is not exceeded.

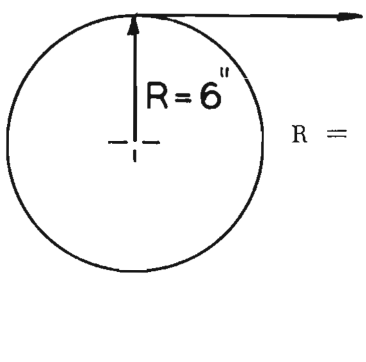
A Longline Puller or Gurdy

Longline gear can be fished from an outboard-powered hydraulic system by utilizing a hydraulic power sheave with an effective radius of 6 inches. The longline would lead inboard through a roller and pass into a sheave and then be peeled in a similar manner as the tuna puller.

Longline Gurdy — Engine speed 1200 rpm
Pump output = 2.7 gpm

a. *Requirements*
Line Pull = 250 pounds pulling force
Line Speed = 120 feet per minute

Sheave



R = Effective radius of 6 inches

[7] *Torque in inch pounds* equals the *line pull* in *pounds* multiplied by the effective spool radius in inches. Spool rotation *speed* in *revolutions per minute* is divided by the *effective spool circumference* in inches.

b. *Calculations*

1. Torque (T)

   T = P X R

   T = 250 X 6

   T = 1500 inch pounds

2. Spool rotation speed required

   $$S = \frac{L}{2 \text{ X } R \text{ X } pi\ (3.14)}$$

   $$S = \frac{120 \text{ X } 12}{2 \text{ X } 6 \text{ X } 3.14}$$

   $$S = \frac{1440}{37.68}$$

   S = 38.4 (approximate) rpm

A Char-Lynn Orbit G motor (or equivalent) would furnish the required line pull and torque for the gurdy. The hydraulic system would be roughly equivalent to the tuna puller. A Tyrone P1-25 Job-master pump would draw oil from the reservoir through a 1/2-inch inner diameter suction line to the pump. The pump puts pressurized oil through 3/8-inch inner diameter lines to the Brand FCR-51 3/8-inch flow control valve. The acorn nut relief valve *should* be set to bypass oil if a pulling force beyond 250 pounds is encountered to safeguard against stalling the engine.

The oil emerges from the flow control valve and is carried to the gurdy by a 3/8-inch inner diameter pressure line. A simple one-way control valve actuates a Char-Lynn AG Orbit motor. The oil would then pass from the motor outlet in a 1/2-inch inner diameter return through the filter back to the reservoir.

Pot and Trap Hauler

Lobster pots, shrimp pots, and crab pots and rings can also be fished from the outboard-powered hydraulic system. The sheave can be mounted on a davit or on a bulkhead. The sheave should have a line peeler installed and a sheave with an effective radius of 5 inches is adequate.

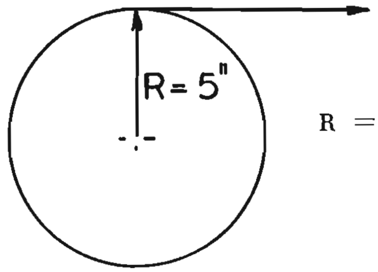
Pot and Trap Power Block	Engine speed = 1400 rpm Pump output = 3.0 gpm

a. *Requirements*

   Line Pull = 300 pounds

   Line Speed = 89 feet per minute

Sheave



R = Effective radius of 5 inches

b. *Calculations*

1. Torque (T)

   T = P X R

   T = 300 X 5

   T = 1500 inch pounds

2. Spool rotation speed (S) required

   $$S = \frac{L}{2 \text{ X } R \text{ X } pi\ (3.14)}$$

   $$S = \frac{1070 \text{ inches per minute}}{2 \text{ X } 5 \text{ X } 3.14}$$

   $$S = \frac{1070}{31.40}$$

   S = 31 rpm

A Char-Lynn AK Orbit motor (or equivalent) is adequate to power the pot hauler. Again, the hydraulic system is equivalent to the earlier examples. The only changes necessary for a pot hauler system would be to substitute a Char-Lynn AK motor for the motors mentioned in the tuna puller or long line hauler example and to set the relief valve to by-pass oil when a pulling force of more than 300 pounds is encountered.

Gillnet Reel

A gillnet reel can be operated from the same hydraulic power take-off. The reel used in this example would have an 8-inch arbor with a reel flange height of 20 inches. For purposes of computation, the average effective radius of the reel is set at 15 inches.

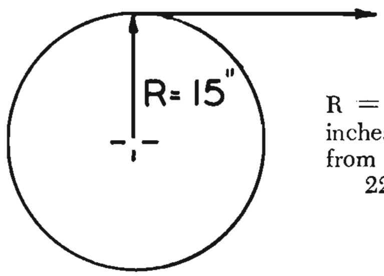
Gillnet Reel	Engine speed = 1400 rpm Pump output = 3.0 gpm

a. *Requirements*

   Line Pull = 250 pounds

   Line Speed = 90 feet per minute

Gillnet Reel



R = Effective radius of 15 inches. Spool diameter varies from 4 inches (bare reel) to 22 inches (full reel)

b. *Calculations*

1. Torque (T)

$$T = P \times R$$

$$T = 250 \times 15$$

$$T = 3750 \text{ inch pounds}$$

.2 Spool rotation speed (S) required

$$S = \frac{L}{2 \times R \times pi\ (3.14)}$$

$$S = \frac{1080 \text{ inches per minute}}{2 \times 15 \times 3.14}$$

$$S = \frac{1080}{94.5}$$

$$S = 11.5 \text{ rpm}$$

In this configuration it is difficult to secure an inexpensive hydraulic motor to provide the low rpm necessary at the required torque. The hydraulic pump displacement in gallons per minute is also a limiting factor. However, a Char-Lynn AP motor (or equivalent) will give the required torque and line speed at the available hydraulic fluid displacement of approximately 3.1 gpm if a 2 to 1 gear reduction is used between the motor and the reel. This can best be done with the sprockets attached to the hydraulic motor and the reel flange. A chain belt would deliver the power from motor to reel.

A Char-Lynn AP motor will deliver approximately 1948 inch pounds of torque and 21 rpm at 700 psi from a 3-gpm pump output.

If the reel is geared down on a 2 to 1 ratio, the system requirements of 3750 inch pounds of torque and an average of 90 feet per minute line speed will be attained. The calculated computation is:

GPM	PSI	TORQUE	RPM	Gear Reduction of 2:1	GPM	PSI	TORQUE	RPM
3.1	700	1938	21	→ ←	3.1	700	3876	10.5

The hydraulic system would utilize the same components as the previous systems. A Tyrone-P1-25 Jobmaster pump would pick up hydraulic fluid from a Char-Lynn R-244 Universal supply tank. The suction line should be 1/2-inch diameter medium-pressure hydraulic line. The pressure lines are 3/8-inch inner diameter medium-pressure lines. The pressurized oil passes from the pump to a Brand FCR-51 3/8-inch flow control valve. The integrated relief valve should be set for 250 pounds pull. The pressure line continues to the reel. A Number 183 Sta-Rite fully reversible control valve would operate the Char-Lynn hydraulic motor. The return line from the motor would pass through a Gresen filter and return via a 1/2-inch inner diameter hose to the reservoir.

These are a few examples of fishing gear that can be powered by the hydraulic power take-off. It should be noted that the operation of specific fishing gear may call for different torque or line speed requirements than those stated above. However, the known constant of hydraulic fluid displacement (which is reciprocal of engine rpm) will allow the selection of hydraulic components which can best accomplish the specific task. It must be repeated that the work cycle expressed in torque and line speed should be known before a gear system is designed. Any competent hydraulics engineer can work out a specific system if he knows the pump displacement figures and the torque and line speed required.

VIII. References

Crandall, Stephan H. and N. C. Dahl (eds.). *An Introduction to the Mechanics of Solids.* New York, McGraw-Hill, 1959. 444 p.

Fontana, Mars G. and Norbert D. Greene. *Corrosion Engineering.* New York, McGraw-Hill, 1967. 391 p.

Kreith, Frank. *Principles of Heat Transfer*, 2nd. ed. Scranton, Penn., International Textbook Co., 1965. 620 p.

Lindberg, Roy A. *Processes and Materials of Manufacture.* Boston, Allyn and Bacon, Inc., 1964. 884 p.

Sharp, H. J. *Engineering Materials.* London, Heywood Books, 1966. 428 p.

Basal, Paul R., Jr. (ed.). *Vickers Mobil Hydraulics Manual*, 3rd ed. Troy, Michigan, Sperry Rand Corporation, 1967. 175 p.

Appendix A
System Operational Data

Testing of these systems under actual fishing loads and speeds revealed some rather surprising information. At normal engine trolling speeds (1500 to 2000 rpm), hauling in a single line equipped with the standard fishing gear, the pump discharge pressure averaged 200 psi. The pump discharge pressure was, as expected, 400 psi hauling in two lines fully rigged. These figures are significantly lower than expected due to initial overestimation of the pulling force required to haul in a fully rigged trolling line.

No more than two lines are ever hauled simultaneously, so maximum system pressure, even with several fish on, does not exceed 600 psi. Consequently, the maximum power required from the outboard engine is approximately 2 hp, considering the system efficiency at 83%.

Pump discharge pressure drop under no-load conditions reaches a maximum of 50 psi operating at the maximum speed of 5500 rpm. This pressure is due to the system internal frictional effects. At a trolling speed of 1800 rpm, the pressure drop through the system is less than 5 psi under no-load condition.

Any hydraulic system generates heat due to friction and pressure drops which do no mechanical work. Typical examples are oil dumping over a relief valve and pressure drops due to oil flowing through lines and valving. Very little heat is generated at points in the system where mechanical work is being done, as at motors or cylinders.

Essentially, the heat generation during system operation under maximum load conditions is equal to 1.0 minus system efficiency multiplied by the power input to the pump. During no-load operation the system pressure is almost completely converted to heat.

For these systems:

1. *Under load*

   Heat Generated = (1.0 minus efficiency) X P_{in}

   $$Q = (1.0 \text{ X } 0.83) \text{ X } 2.0$$
   $$= 0.34 \text{ Hp}$$
   $$= 0.34 \text{ Hp X } 2545 \frac{\text{BTU}}{\text{Hp} \cdot \text{Hr}}$$
   $$Q = 866 \text{ BTU/Hr}$$

2. *No-load conditions*

   $$\text{Heat Generated } \frac{(\text{BTU})}{(\text{Hr})} = 1.5 \text{ X Pressure drop (PSI) X Flow (GPM)}$$

   a. 1800 RPM
   $$Q = 1.5 \text{ X } 5 \text{ X } 4.0$$
   $$= 30 \text{ BTU/Hr}$$

   b. 5500 RPM
   $$Q = 1.5 \text{ X } 50 \text{ X } 13$$
   $$= 975 \text{ BTU/Hr}$$

The heat dissipation from this type of system is almost completely dependent upon convective transfer from the storage reservoir. The governing equation for this heat transfer mechanism is:

$$Q_c = A\bar{h}_c \Delta T$$

Q_c = Rate of heat transfer by convection in BTU/Hr

ΔT = Difference between surface temperature and the ambient temperature of the surrounding air. Ts – Ta

$\bar{h}_c$ = Average convective heat transfer coefficient

BTU/Hr - ft² · °F

So for this case:

$$Q_c = A\bar{h}_c \Delta T$$

Five-gallon reservoir

Effective reservoir surface area = 4.5 ft²

Effective surface area of hose, valving, motors, etc. ≅ 0.5 ft²

A = 5.0 ft²

$$\Delta T = T_{surf} - T_{air}$$

Assuming surface temperature $T_s = 80°$ F

Marine air temperature $T_a = 50°$ F

$\Delta T = 30°$ F

For air and free convection $h_c = 5.0 \frac{BTU}{Hr \cdot ft^2 \cdot °F}$

$Q_c = 5.0 \times 5.0 \times 5.0 \times 30$

$Q_c = 750$ BTU/Hr

The average heat generation for these systems is approximately the time averaged sum of the heat generation in the different operational modes.

Consider an operational day of 12 hours:

Mode—Time		*Heat Generation*
Cruise no-load	3 hrs.	975 X 3 = 2925 BTU
Trolling no-load	6 hrs.	30 X 6 = 180 BTU
Trolling underload	3 hrs.	866 X 3 = 2598 BTU
		5307 BTU/12 hr.

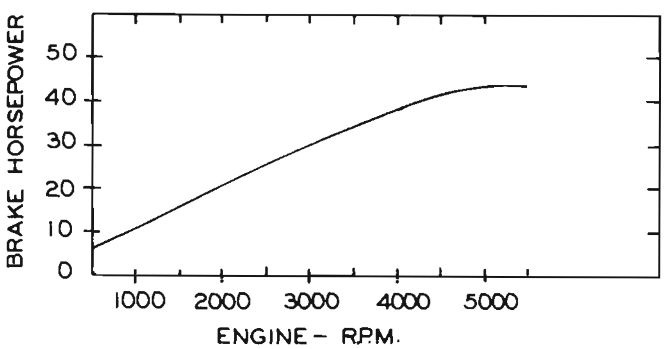
Average heat generation = 475 BTU/Hr.

So, since the average heat generation is less (475 BTU/Hr vs. 750 BTU/Hr) than the average heat dissipation by convection, no temperature build-up will occur over long time periods. The higher heat generation during system operation under load and at cruise will cause short-term rises in oil temperature above the steady state value, but these rises will be slow and can be ignored.

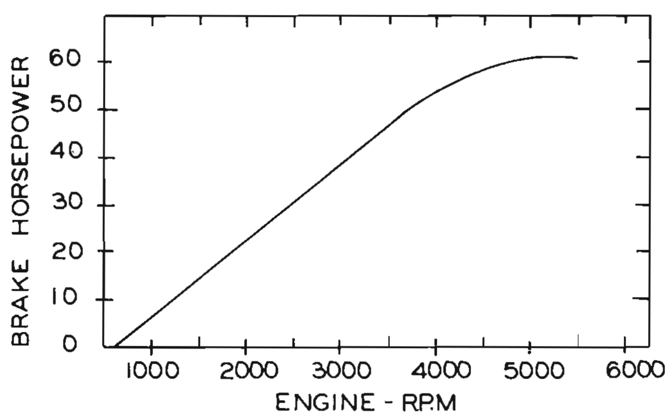
The reservoir must be mounted in such a way as to allow free air flow to all reservoir surfaces for heat dissipation purposes. The heat dissipation must be high enough to keep the oil temperature below 150° at all times. High oil temperatures cause oil breakdown and component deterioration. Adherence to the principles described in mounting the reservoir on strips of firring and then fastening the firring to the hull or transom allows ample air circulation and ensures heat dissipation capability.

Appendix B

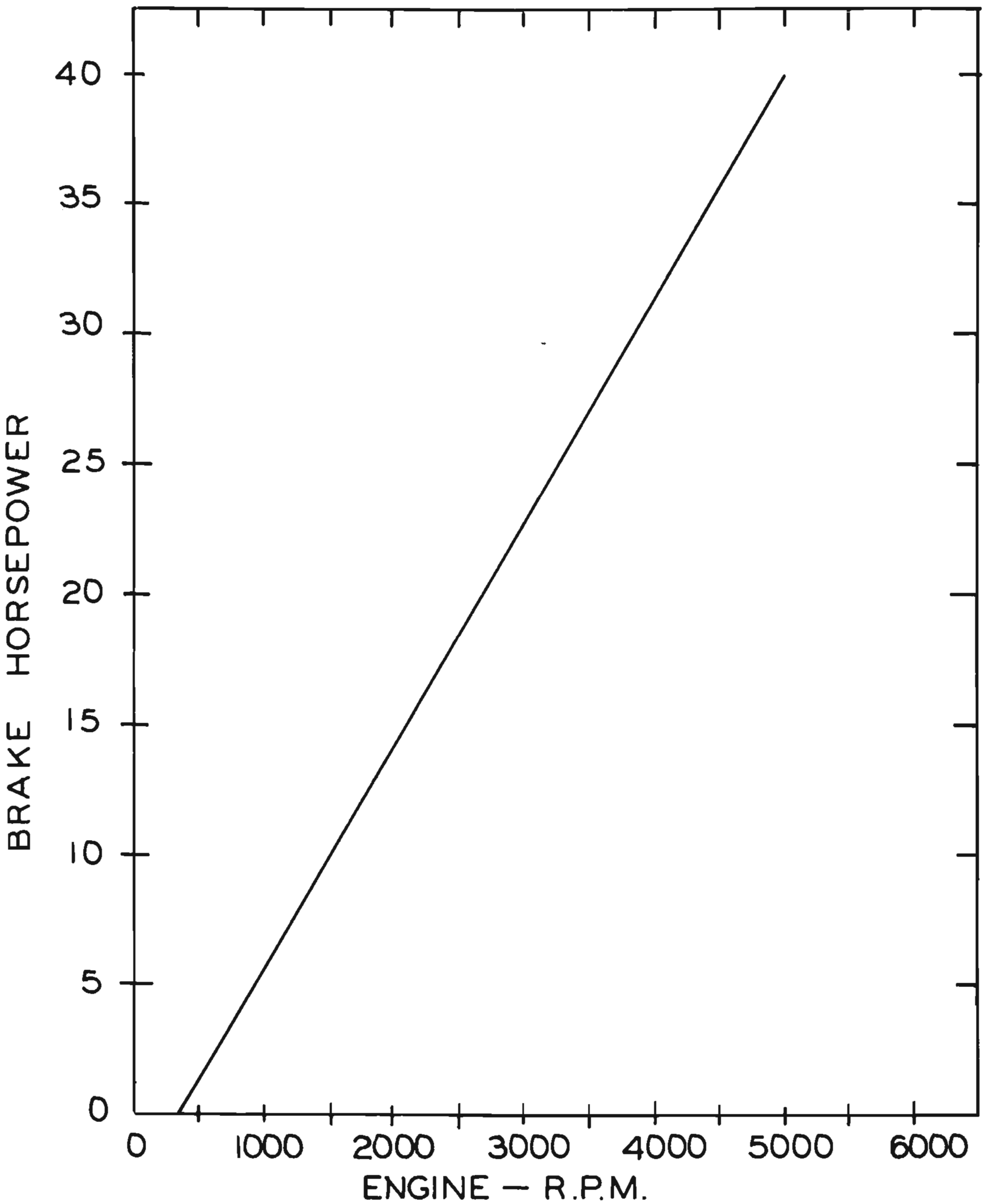
Outboard Motor Revolutions-per Minute to Brake-Horsepower Curves, 40-hp Johnson



Outboard Motor Revolutions-per Minute to Brake-Horsepower Curves, 60-hp Johnson

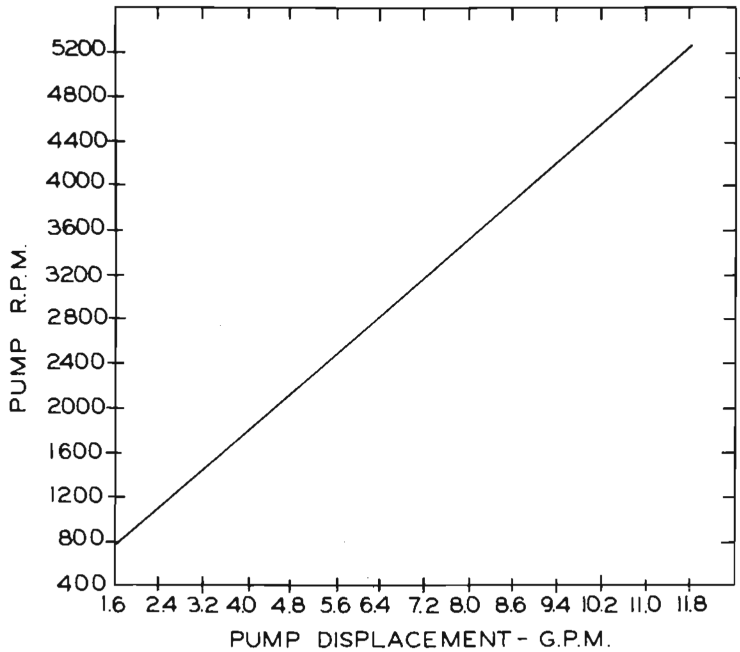


Outboard Motor Revolutions-per-Minute to Brake-Horsepower Curves
50-hp Mercury



Appendix C

Tyrone Model P1-25 Jobmaster Hydraulic Pump
Revolutions-per-Minute to Pump Displacement



Appendix D

Vickers VTM-27-40-40 Hydraulic Pump
Revolutions-per-Minute to Pump Displacement