TRAVELING SCREENS FOR TURBINE INTAKES

OF HYDROELECTRIC DAMS

By

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INTRODUCTION

A traveling screen was developed in the Pacific Northwest to divert juvenile Pacific salmon, *Oncorhynchus* spp, and steelhead trout, *Salmo gairdneri*, from turbine intakes at Columbia and Snake River Dams. The diverted fish enter gatewells above the intakes and pass through orifices into a central bypass conduit discharging at the tailrace. As envisioned, the system would be capable of diverting up to 90%[1] of the seaward migrants out of the turbine intakes, thereby preventing mortalities attributable to passage through the turbines. Figure 1 presents a transverse section of a dam showing the placement of the traveling screen and other pertinent features in a turbine intake and gatewell.

DEVELOPMENT

The first traveling screen for turbine intakes (of the type described herein) was designed by a commercial engineering firm under contract with the National Marine Fisheries Service (NMFS) and was installed and briefly tested at Ice Harbor Dam near Pasco, Washington, in the spring of 1969. During the spring of 1970 work on testing and development of the screen continued in conjunction with investigations of the effects of the screen on fish. Many problems were encountered, but much useful information was obtained and the developmental work continued.

Although we failed to achieve continuous operation of the traveling screen under full turbine load at Ice Harbor Dam in 1969-70, opportunities for additional testing were realized when a decision was made in the spring of 1971 to install three screens in intakes of one turbine at Little Goose Dam near Dayton, Washington. With the information obtained at Ice Harbor Dam, we felt that by changing gear ratios, bearings, and hydraulic equipment, the screens could be made to operate continuously at Little Goose Dam even though it was known that the forces on the screen would be greater at Little Goose Dam than at Ice Harbor.

During the winter of 1970, the Ice Harbor Dam screen was modified to fit Little Goose Dam and the gear ratios and bearings were changed. Two additional traveling screen assemblies were contracted for and delivered in March 1971.

In the spring of 1971, development of a workable traveling screen continued together with the associated research on fish. At this point, the screens were being driven by a single hydraulic motor on one end of the top shaft. Again, the goal of continuous operation of the screens eluded us. Additional funds were provided by the U.S. Army Corps of Engineers so that work could continue through the summer and fall of 1971 to further develop screen designs and have the three screens operable before the spring of 1972.

Throughout all of the development and testing, inadequate bearings, keys, keyways, gear boxes, hydraulic equipment, drive chains, and screen conveyor chains continued to be a problem. The design criteria called for the screen to travel at 1/2 fps, the speed necessary to move any impinged fish off the screen within 40 seconds. The actual torque on the top shaft was computed by measuring the hydraulic system flow, pressure, and the shaft rpm's.

Using the information obtained in the summer and fall of 1971, the mechanical drive system was redesigned, bearing loads were calculated, and the hydraulic system redesigned. A decision was also made to install another hydraulic motor on the top shaft to drive the shaft from both ends.

By use of the dual drive system, torque is reduced by one half as are some of the bearing loads and the drive chain pull. As a result of these changes, satisfactory mechanical and hydraulic performance of the screens was achieved in the spring of 1972. Problems with bearings and screen conveyor chains continued, however; various types of bearing material were tested and in the end, "Graphalloy[2/] proved by far the most acceptable.

"Graphalloy" bearings were installed on the three screens in the spring of 1973 and resulted in no down time during the 3-month research period. Also, the hydraulic pressure required to drive the screens was only about one-half that in previous years, indicating reduced friction through use of "Graphalloy" bearings. Figures 2, 3, and 4 show the screen assemblies used at Little Goose Dam in 1973.

TRAVELING SCREEN AND SUPPORT

Figure 5 illustrates the traveling screen and its support in the operating position. The traveling portion of the screen measures 20.75 x 22 x 1.5 feet and is contained within a larger screen support framework. The lower support structure, 23 x 30 x 4 feet, bolts to the bottom of the screen support framework and rests on the bottom of the turbine intake. The traveling screen is made up of four continuous conveyor belts of E 42 x 36 x 16 wire, driven at ½ fps by two hydraulic motors connected to 7 to 1 reduction gear boxes. The direction of travel is upward on the upstream face.

Since lifting clearance of the deck gantry crane is limited, installation of traveling screens is achieved as follows:

1. The lower support structure is placed in the gatewell slot and dogged off.
2. The screen assembly is then picked up, brought into position over the lower support structure, and the two are bolted together.
3. The dogging beams are then removed and the complete assembly is lowered into the gatewell and dogged off.
4. The first set of cable pendants and hydraulic hoses are then attached. Successive lengths of pendants and hydraulic hoses are attached and dogged off until the lower support structure rests on the bottom of the turbine intake. The top pendants are then dogged off and the hoses connected to the hydraulic unit.
5. The hydraulic unit is started and the cylinder valve is activated to push the screen out at a 45° angle into the operating position. The valve operating the hydraulic motors is activated to rotate the screen. The turbine, which has been shut down during installation, can then be placed into operation. Removal is the reverse of the above procedure.

Figure 6 in an enlarged view of the area at the top of the intake showing the relationship of the screen with the intake ceiling. The opening between the face of the screen and the top of the turbine intake is 3 feet. All fish diverted by the screen pass through this opening into the gatewell.

HYDRAULIC SYSTEM

The hydraulic system consists of the hydraulic unit, cyclinders, motors, hoses, etc., necessary for operation of the traveling screen. Figure 7 shows a schematic layout of the complete system.

The hydraulic unit consists of a 25-hp electric motor driving a 26-gpm-fixed-volume pump. On activation, hydraulic fluid passes through a relief valve and on to a flow divider. At this point all of the flow can go to the control valves or a portion may be bypassed and returned to the reservoir.

The working fluid passes through the flow divider and enters the control valve assembly. The control valve assembly is made up of two mobile-equipment directional valves. The valve controlling the flow to the cylinders is closed center and spring loaded, whereas the valve controlling the flow to the motors is open center and detented.

When the cylinder valve is moved to raise the screen, the fluid flows to the cylinders through two small hydraulic motors coupled together to provide positive equal flow to each cylinder (see Figure 4). When the valve is moved to other direction, the return flow is also metered through the coupled motors. As the screen drive control valve is moved the flow divides and goes to the motors at the same pressure. Since the motors are coupled together through the drive shaft, the torque delivered by each motor is the same.

Oil returning to the 120-gallon reservoir flows through the control valves, through a flow meter, and thence through a filter. With the flow meter installed in the return line, a positive reading is made on flow being used at various screen travel speeds.

The reservoir tank is equipped with a "low-oil" detection system to protect the hydraulic pump.

BEARINGS

Flows of the Snake River are characteristically heavy with silt and colloidal material, particularly during periods of high river flows when the majority of the downstream migrants are moving. This water also has a highly caustic effect on metals, so protection of all metals inundated in the water is imperative. As a consequence, stainless steel shafts were required to prevent pitting, a prime source of wear in the bearings.

A number of types of bearing material were tried without success. As indicated previously, the bearing that proved to be acceptable from the standpoint of providing a projected minimum of 3 years of service was "Graphalloy." These bearings are manufactured by the Graphite Metallizing Corporation of Yonkers, New York.

SCREEN SUPPORT BARS

"U"-shaped plastic strips of a hard nylon base compound were placed on the original vertical screen support bars for wear strips. These were serviceable, but the same shape in "Polyethlene" proved to be much superior.

SUMMARY

As previously stated, the turbine intake screens ran continuously through the 3-month period of seaward migration of juvenile salmon and trout in the spring of 1973. Minor problems are still to be solved, but the ability to construct "failsafe" turbine intake screens to guide downstream migrating fish has become a reality.

Armed with the information gained in the development of the original three screens, the Corps of Engineers recently constructed and installed six additional screens at Little Goose Dam. Added to the initial compliment of three screens, the recent installation completes the screening of all operational turbines at Little Goose Dam. The design of the Corps' screens has eliminated most of the objectionable features found in previous tests of the prototype.

Design features requiring future attention are screen mesh size (in relation to intake velocities and descaling of fish); screen travel speed for protection of the fish; and life of bearings, chains, and sprockets.

FOOTNOTES

1/ Ebel, Wesley J., et al. Progress report on fish-protective facilities at Little Goose Dam and other studies relating to various measures taken by the Corps of Engineers to reduce losses of salmon and steelhead in the Columbia and Snake Rivers. September 1971. Nat. Mar. Fish. Serv., NW Fisheries Center, Seattle, WA. 58 pp (Processed.)

2/ Trade names referred to in this publication do not imply endorsement of commercial products by the National Marine Fisheries Service.

FIGURES

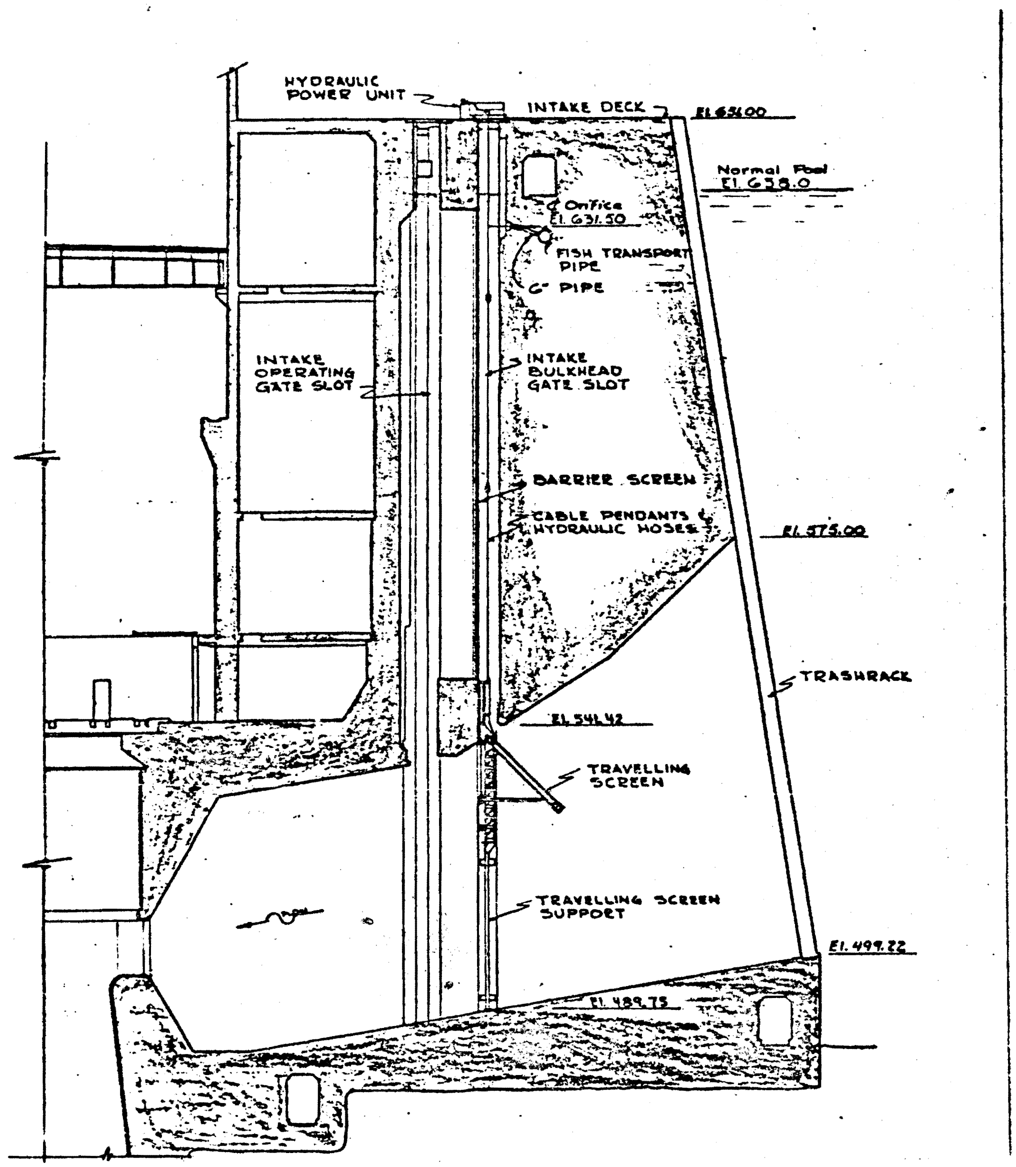


Figure 1.--Transverse section of Little Goose Dam with traveling screen in operating position.

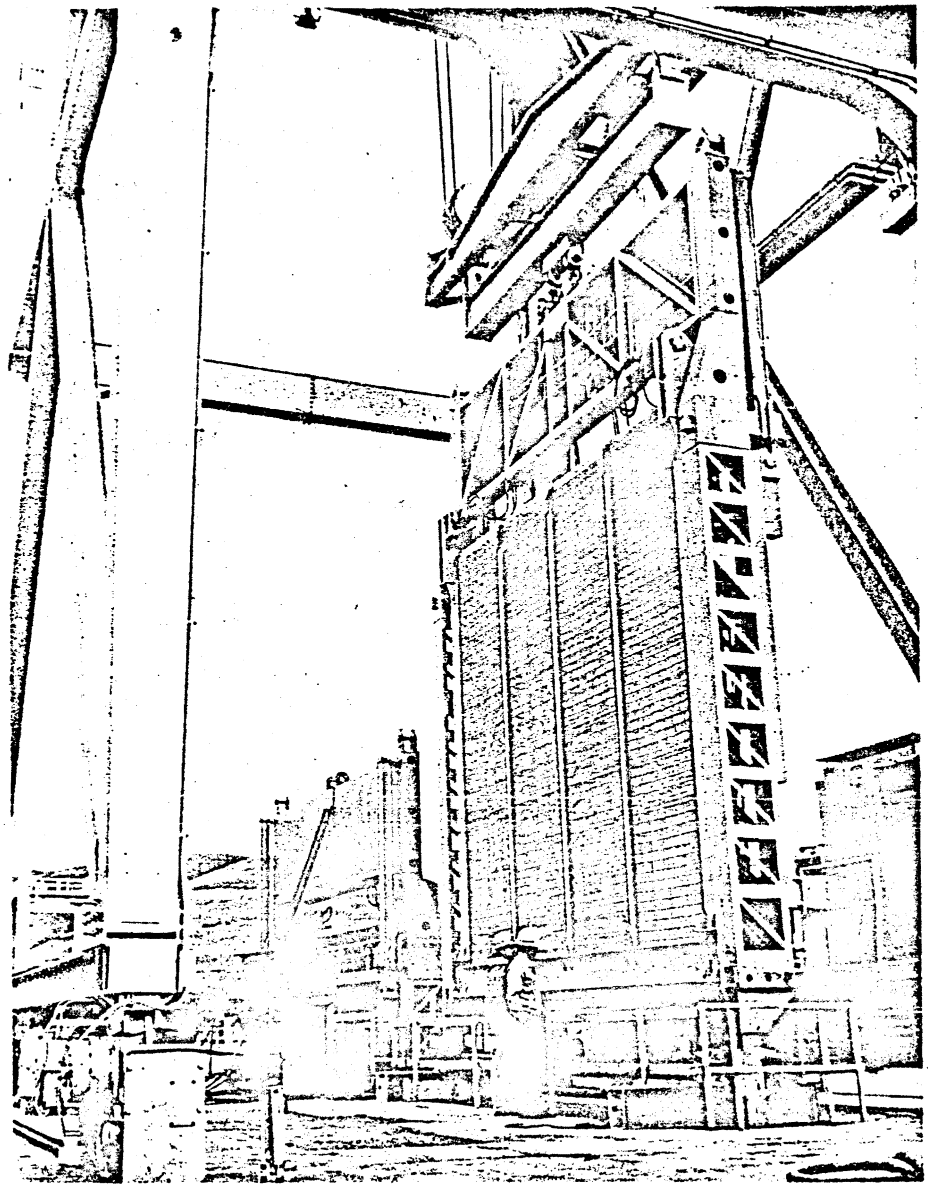


Figure 2.--Intake traveling screen in collapsed position for lowering into turbine intake gatewell.

Figure 3.--Intake screen being raised to operating position.

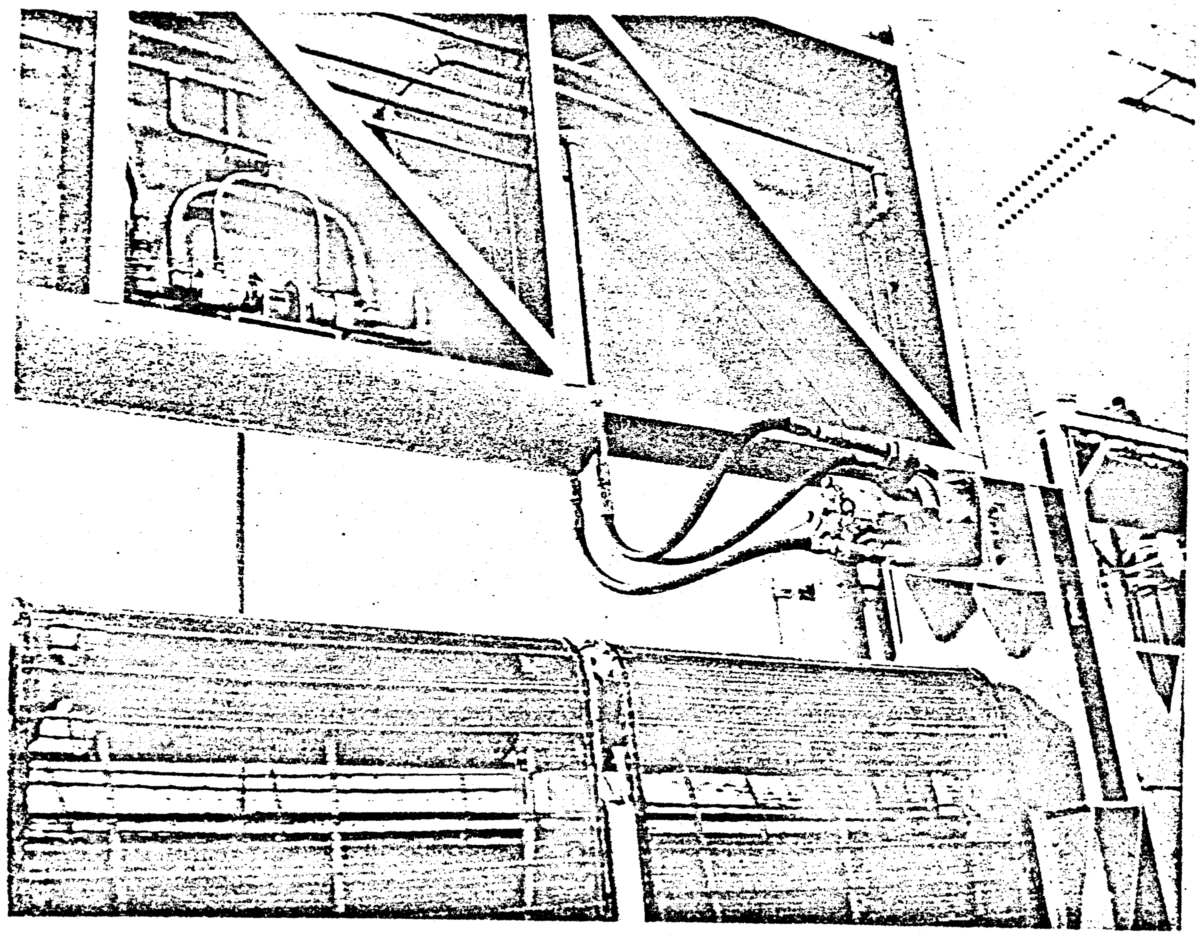
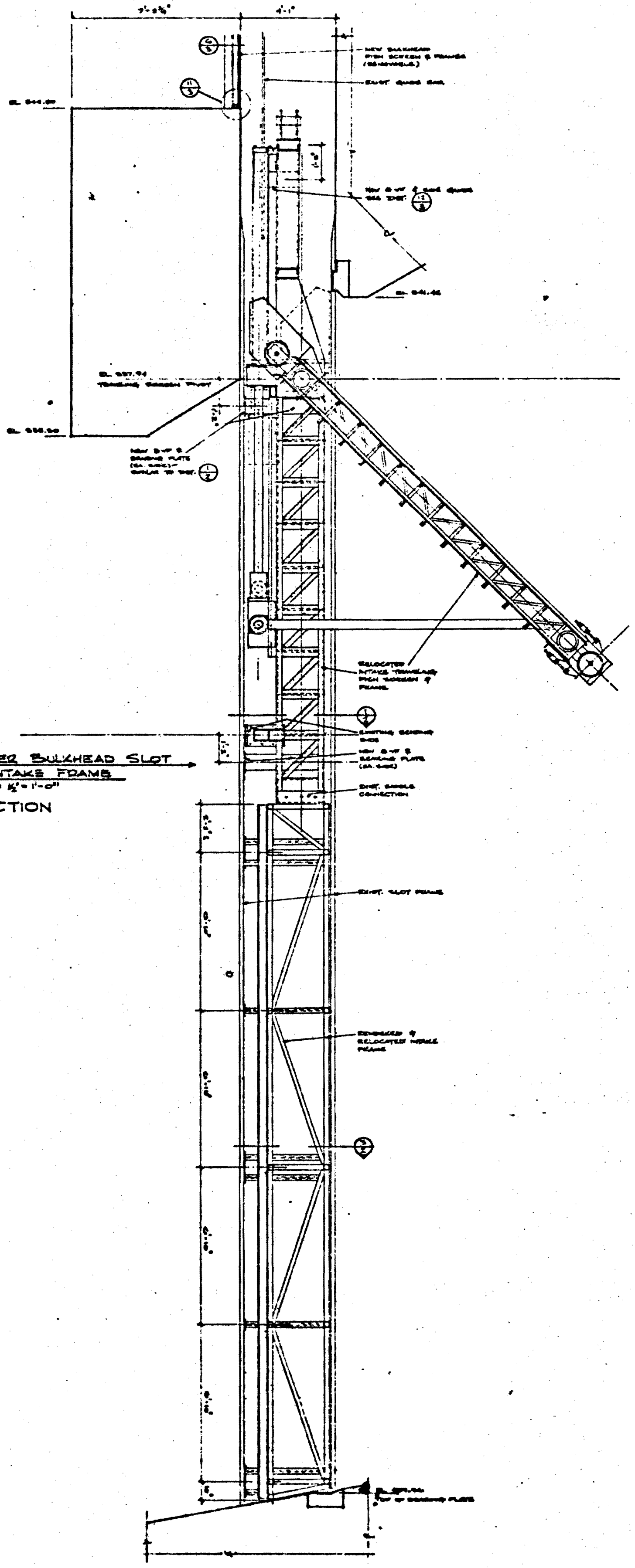


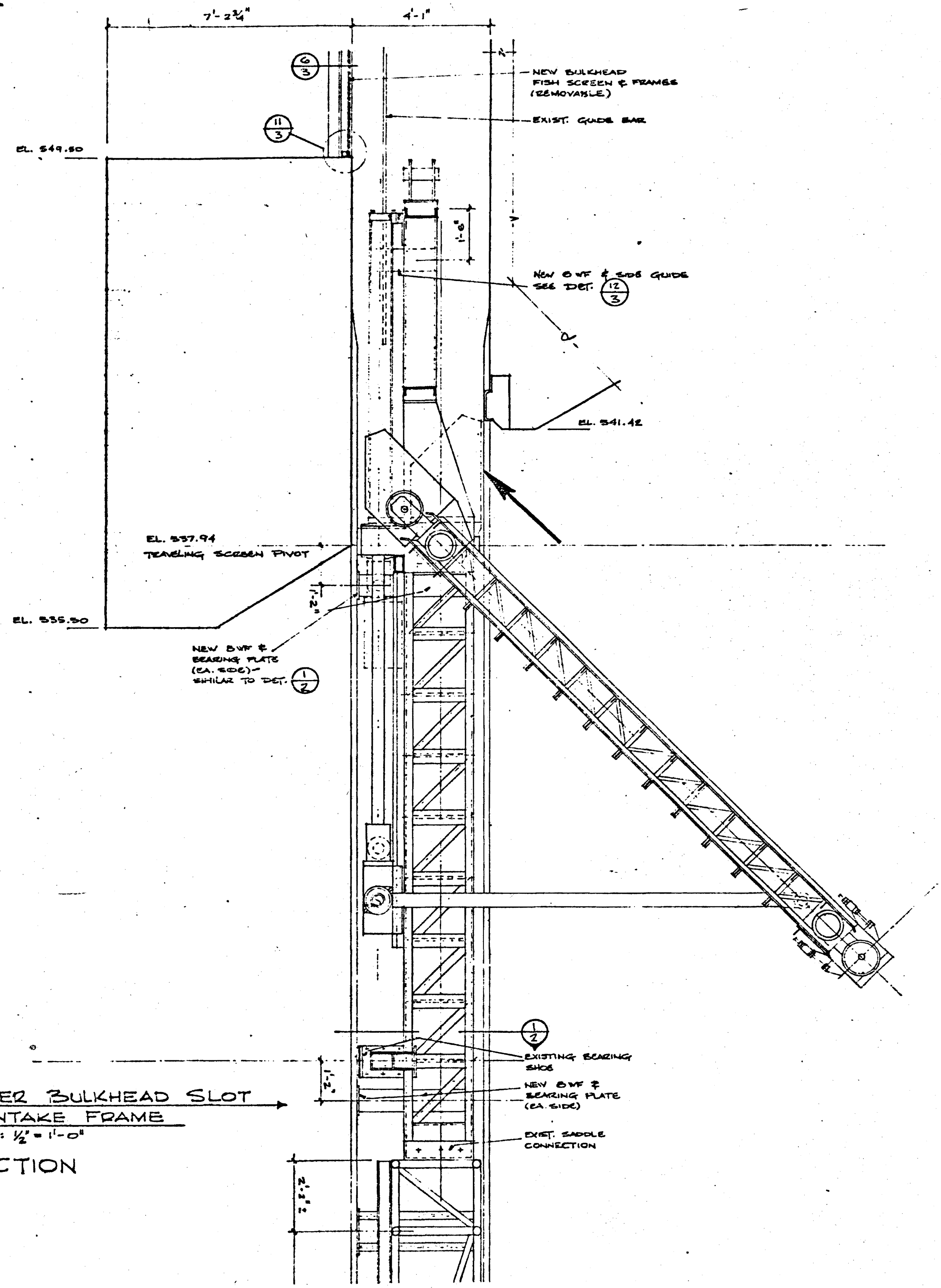
Figure 4.--Cylinder flow control (left at top) and one of two hydraulic drive motors (right side above screen).

Figure 5.--Traveling screen in operating position with support structure below.



LOWER BULKHEAD SLOT & INTAKE FRAME
SCALE: ½" = 1'-0"
SECTION

Figure 6.--Detail of traveling screen at juncture with turbine intake gatewell. Fish diverted by screen pass upward through a 3-ft wide opening (arrow) into the gatewell.



LOWER BULKHEAD SLOT & INTAKE FRAME

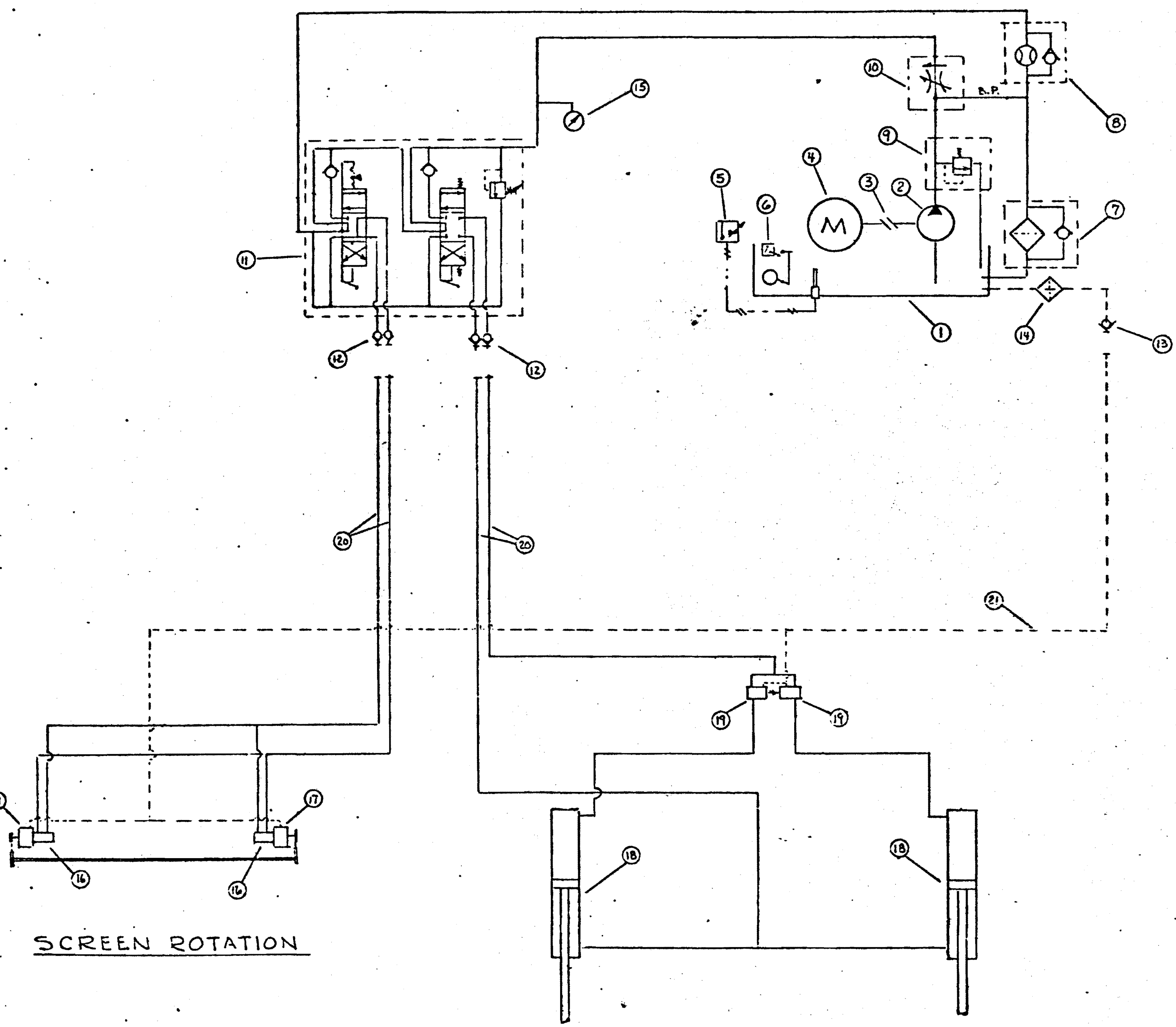
SCALE: 1/2" = 1'-0"

SECTION

Figure 7.--**Schematic of hydraulic system.**

Legend:

1. 120-gallon reservoir
2. 26-gpm hydraulic pump
3. Coupling
4. 25-hp electric motor
5. Thermostat and heater
6. Level switch
7. Filter
8. Flow meter
9. Relief valve
10. Flow divider
11. Flow control valves
12. Quick disconnect coupling
13. Check valve
14. Filter
15. Pressure gage
16. Hydraulic motor
17. Gear box
18. Cylinder
19. Hydraulic motor
20. 1" dia. hydraulic hose
21. 3/4" dia. hydraulic hose



SCREEN ROTATION

CYLINDER OPERATION