AMERICAN CONSULTING ENGINEERS COUNCIL'S

HEAVY MOVABLE STRUCTURES
MOVABLE BRIDGES AFFILIATE

3RD BIENNIAL SYMPOSIUM

NOVEMBER 12TH - 15TH, 1990

ST. PETERSBURG HILTON & TOWERS
ST. PETERSBURG, FLORIDA

SESSION
WORKSHOP NOTES

Session (4-3)
"Two New Hydraulic Systems for Florida Bridges", Michael A. Hanley,
Circuit Engr'g, Inc., Tampa, Fl.

"Two New Hydraulic Systems For Florida Bridges"

Michael Hanley
Circuit Engineering, Inc.

This paper is a follow-up to "Modern Moveable Bridges in the United States" paper presented by Jim Phillips with Parsons Brinckerhoff. Details for the hydraulic systems of two particular Florida bridges will be discussed in detail. Their hydraulic drive machinery is somewhat unique compared to other bridges in the area.

Perhaps the most desirable characteristic of hydraulic drive machinery for the State of Florida DOT is it's ability to provide drive redundancy. This feature makes an already reliable drive system even more attractive for really very minimal cost increase. In addition, the flexibility of designing with standard hydraulic components allows creative solutions to application problems for both new and existing bridges.

The Seabreeze Bridge in Daytona, Florida was a good example of such creative design using the flexibility of hydraulic muscle. Here was a situation of an older existing bridge with very little machinery space and no time for lengthy solutions. The crippled Hopkins Frame machinery had the bridge operation down to an absolute minimum.

Designers for the project wanted to apply the torque directly to the rack pinions without the drive stresses being transferred back into the mounting frame. The concept of a torque arm mounted hydraulic motor was adopted. From there, the next step was to select hydraulic motors capable of transmitting the required torque which could also fit into the extremely confined space requirements dictated by the location of the existing racks.

The power requirement at each pinion was for 33,300 foot pounds of torque at an infinitely variable 0-3rpm. Good smooth low speed performance of the hydraulic motor was imperative since the creep speeds of the drive pinion can be as low as 1/20 of an rpm. Even with the addition of a planetary gearbox to reduce size, weight, and brake size, the motor must have minimal torque ripple with excellent slow speed capability. The drive package chosen to meet all requirements was a hollow shaft - shrink disc planetary speed reducer with a radial piston - cam curve design hydraulic motor (See figure 1). A multiple disc spring applied hydraulically released brake was an integral part of the entire assembly. Each of these assemblies was capable of operating the bridge completely independent of the other.

Once the hydraulic motors were chosen, the pumps and valves could be properly sized. Two 10 h.p. electric motor/hydraulic pump groups were chosen to enhance system redundancy. An axial piston - pressure compensated hydraulic pump with horsepower limiting control was selected. This horsepower limiting control assures maximum bridge speed under varying load conditions with no possibility of exceeding the maximum rated current draw of the electric motor. Either one of the motor/pump groups is capable of operating the span at near full speed.

The control valving was comprised of a single proportional directional control valve and one set of filter, counterbalance, relief, and anti-cavitation valves. It was decided that redundant valves was unnecessary for several reasons. These valves have an excellent track record and are small, light weight, and inexpensive items readily available from numerous manufacturers. The increased complication associated with dual redundant valving could not be justified here.

This entire valve system was incorporated into a single steel manifold which greatly reduced the space requirements. A unique feature of the

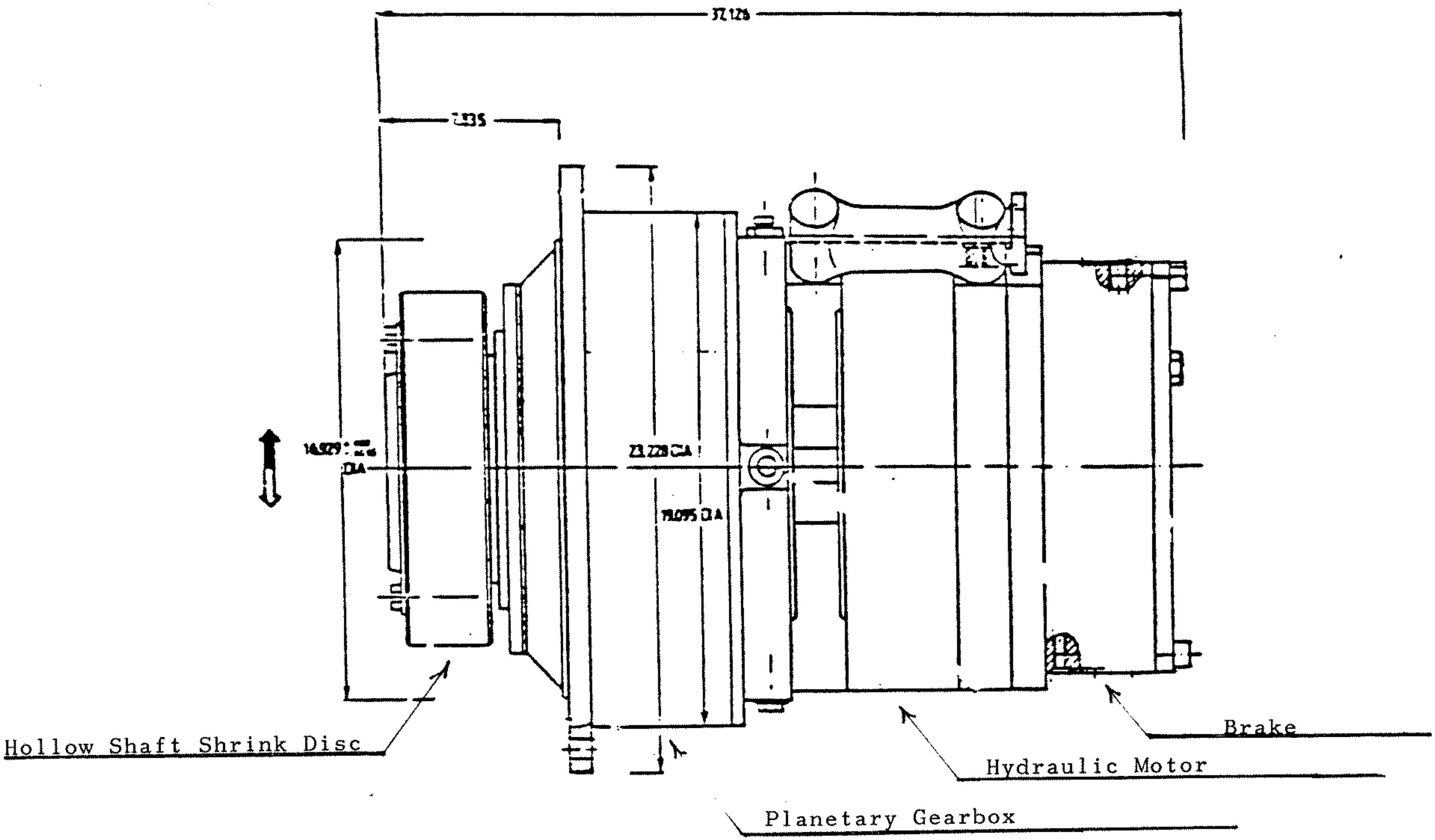

Hollow Shaft Shrink Disc
Planetary Gearbox
Hydraulic Motor
Brake

Figure 1

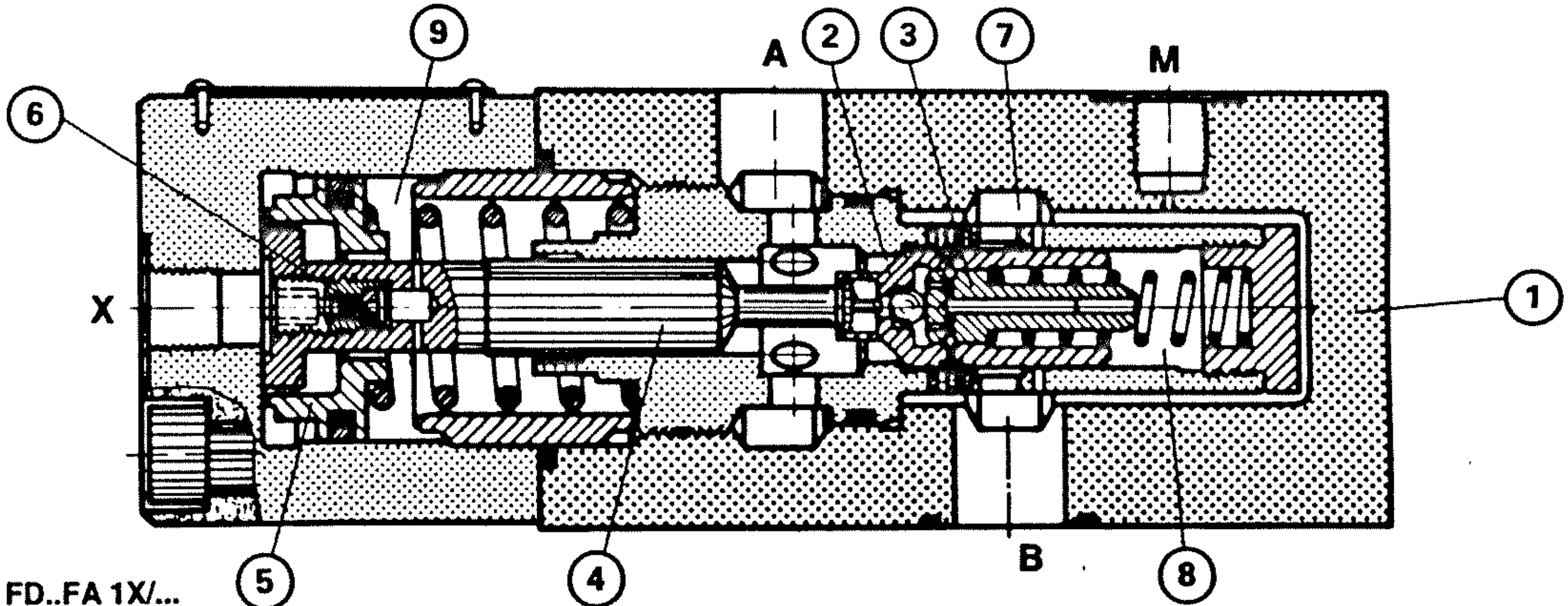
valving was a simple flow control valve to release the brakes. Whenever there is sufficient pressure to operate the drive system, fluid flows through the check valve to release the brakes. Upon loss of sufficient pressure (300psi./min.) the flow control meters out fluid thereby gradually setting the spring applied brakes. This was a very simple and reliable method of actuating the thrustor brakes.

The entire hydraulic system consisted of five modules which could be mounted within the new machinery frame and shop tested prior to installation under the bridge. These modules consisted of the two motor/gearbox/brake combinations, the two electric motor/pump groups, and the valve manifold/reservoir module. Each of these modules are small enough to be removed for maintenance without the need for major lifting equipment. Normal maintenance items are located at a convenient height and location on the front of the machinery frame. This entire "Hydraframe" design could prove to be an economical solution to the problems being encountered on the many aging "Hopkins Frame" machinery drive systems in existence today.

The next project of interest was the Lansing Island Bridge in Satellite Beach, Florida. Due to the special design considerations already detailed in Jim Phillip's paper, this span was unbalanced and extremely tip heavy. At first thought, one might consider this as cause for some special hydraulic circuitry to handle the overrunning loads. In actuality, there was no need for anything to be different from a standard hydraulic circuit to operate a fully balanced leaf design. The demands on the hydraulic counterbalance valves in this tip heavy span design are very much like certain wind load conditions on a balanced leaf design. The hydraulic counterbalance valve must respond to this increased load by providing the necessary back pressure to smoothly lower the span. A non-adjustable hydraulically dampened counterbalance valve with good flow metering capability was chosen (See figure 2).

The overcenter counterbalance and lock valve Model FD is used in hydraulic systems to control the motion of overrunning loads on hydraulic cylinders and motors. When closed, a leak-free check valve function prevents cylinder drift. In addition, when mounted in close proximity to the cylinder (or motor), this valve provides additional protection against hose and plumbing failures on the load side of the cylinder. The valve is crossline pilot and opens over a pilot pressure range of 290 PSI (20 bar) to 510 PSI (35 bar).

The counterbalance and lock valve basically consist of the housing (1), main poppet (2), control spool (3), pilot piston (4), follower piston (5), and dampening orifice (6), which works in conjunction with a dampening oil volume (9).



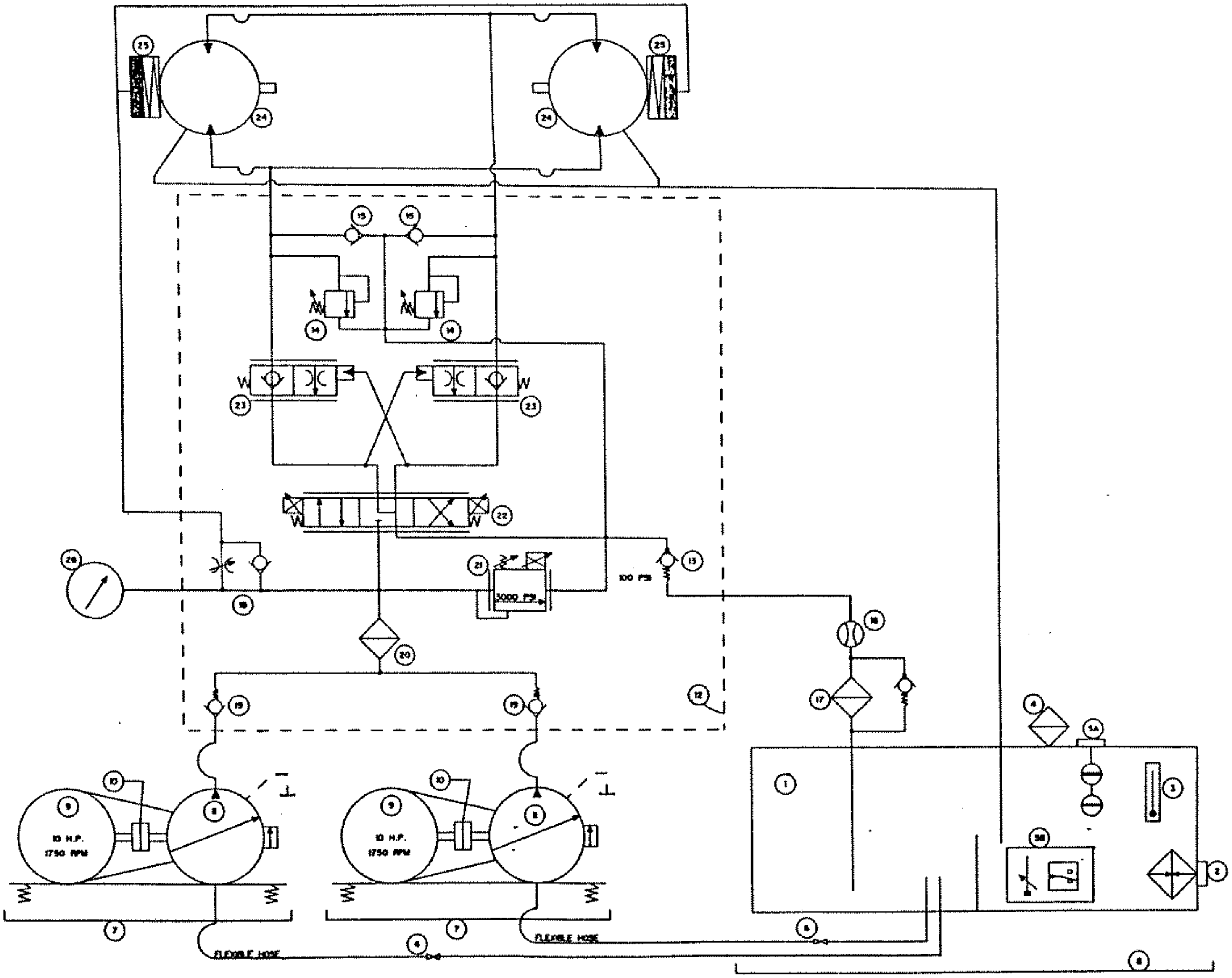
Model FD..FA 1X/...

Figure 2

The power unit construction for the Lansing Island Bridge was of a standard free-standing type. A look at the hydraulic schematics (See figure 3 & 4) shows it to be very similar to that of the Seabreeze Bridge previously mentioned. The only real difference other than horsepower and component size is the brake circuitry.

In a hydraulic motor design a conventional disc-type brake is essential since you cannot rely on the hydraulic motor pistons to adequately hold the bridge under load for any length of time. Conversely with the hydraulic cylinder drives it is extremely reliable to hold the bridge under load with only the fluid locked behind the cylinder piston. This can be accomplished quite easily with only a pilot operated check valve. This valve was incorporated into a small manifold block which was then hard piped directly to the hydraulic cylinder. Now each cylinder has it's own integral brake so to speak. This made it extremely easy to meet the requirement of being able to lower this span without power. A small hand operated needle valve was fitted behind the pilot operated check valve allowing the trapped fluid to be bled back to the tank slowly. This brake release function worked extremely well, even to the extent that the most inexperienced personnel could smoothly lower the bridge in case of emergency.

Wether you're considering a new design or rehabilitation, hydraulic operating machinery has proven itself to be a reliable drive alternative for movable bridges. The flexibility of design and ability to have redundant systems makes it the drive of choice for almost all bridge drive problems.



BASCULE SPAN HYDRAULIC SCHEMATIC

(2 REQUIRED - 1 PER SPAN)

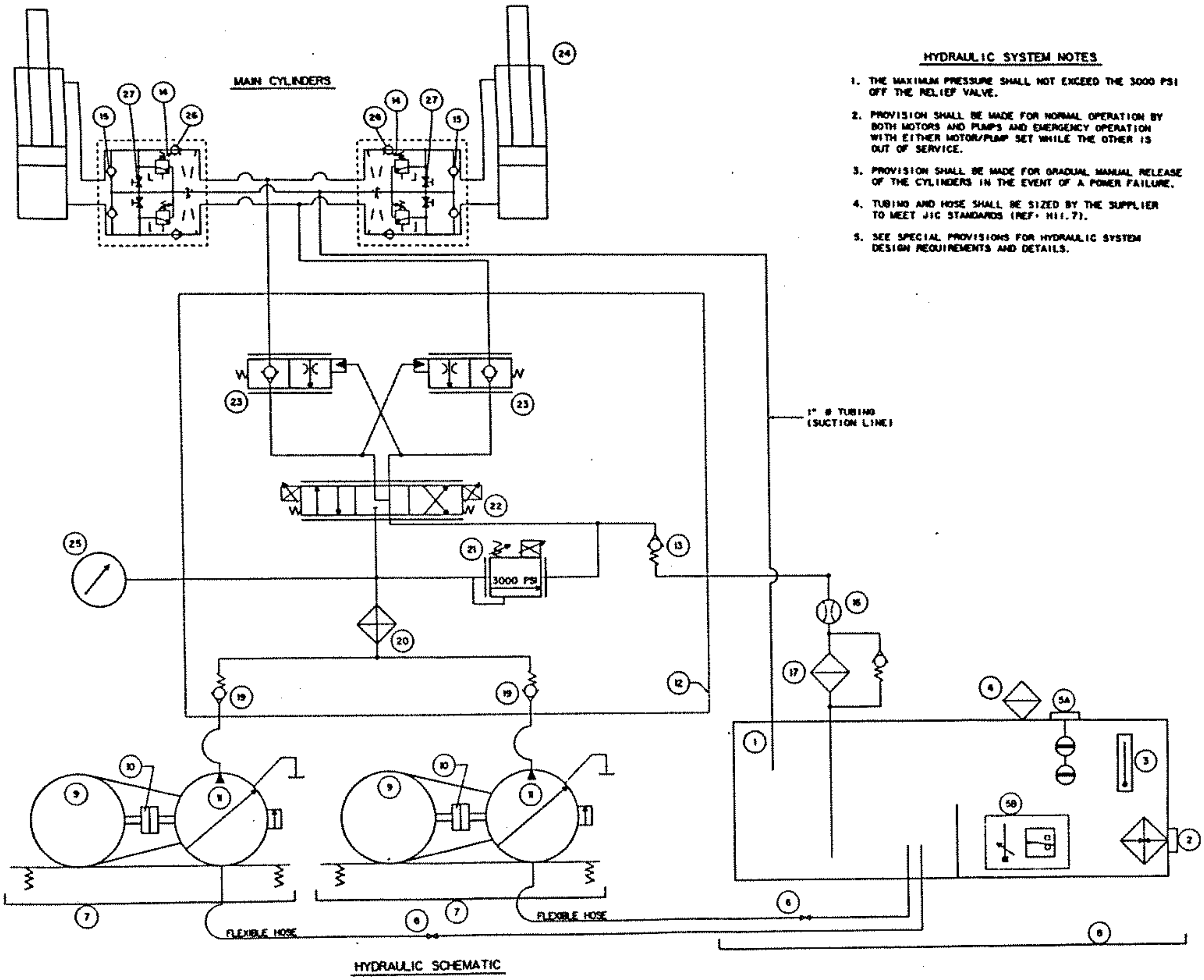
TABLE OF HYDRAULIC EQUIPMENT		
ITEM NO.	QTY	DESCRIPTION
1	1	RESERVOIR ASSEMBLY (20 GAL)
2	1	IMMERSION HEATER 120V
3	1	TEMPERATURE GAUGE/SIGHT GLASS
4	1	DESSICANT BREATHER
5	2	TEMP FLOAT SWITCH ASSEMBLY (5A & 5B)
6	2	SUCTION BUTTERFLY VALVE
7	2	PUMP/MOTOR DRIPTRAY
8	1	RESERVOIR DRIPTRAY
9	2	ELECTRIC MOTOR 10HP @ 1750 RPM
10	2	FLEXIBLE COUPLING
11	2	PUMP (VARIABLE DISPLACEMENT PISTON TYPE)
12	1	VALVE MANIFOLD
13	1	BACK PRESSURE CHECK VALVE 100 PSI
14	2	CROSS-PORT RELIEF VALVE
15	2	ANTICAVITATION CHECK VALVE
16	1	FLOWMETER
17	1	RETURN FILTER W/ELECT. - VISUAL INDICATOR
18	1	BRAKE RELEASE FLOW CONTROL
19	2	CHECK VALVE
20	1	PRESSURE FILTER W/ELECT. - VISUAL INDICATOR
21	1	SOLENOID RELIEF VALVE
22	1	4 - WAY PROPORTIONAL VALVE
23	2	COUNTERBALANCE VALVE
24	2	HYDRAULIC MOTOR (RADIAL PISTON LSHT)
25	2	HYDRAULIC DISC BRAKE
26	1	PRESSURE GAUGE
EQUIPMENT SHOWN IS FOR ONE SPAN. TWO SYSTEMS ARE REQUIRED		

HYDRAULIC SYSTEM NOTES

1. THE CONTRACTOR SHALL SUPPLY TWO HYDRAULIC SYSTEMS DESIGNED IN ACCORDANCE WITH THE SPECIAL PROVISIONS AND MEETING THE REQUIREMENTS OF THIS SHEET.
2. THE SYSTEM SHALL DELIVER TO EACH PINION SHAFT 18,500 FT-LBS OF TORQUE AT 2.13 RPM (NORMAL OPERATING SPEED) OR 33,300 FT-LBS OF TORQUE AT 1.10 RPM (ONE HALF NORMAL SPEED). FOR THESE CONDITIONS, THE MAXIMUM PRESSURE SHALL NOT EXCEED THE 3000 PSI OF THE RELIEF VALVE.
3. THE BRAKE SHALL BE ADJUSTED TO DELIVER TO THE PINION SHAFT 51,400 FT-LBS STATIC BRAKING FORCE +5%. BRAKES SHALL BE FULLY RELEASED AT 280 PSI.
4. PROVISION SHALL BE MADE FOR NORMAL OPERATION BY BOTH MOTORS AND PUMPS AND EMERGENCY OPERATION WITH EITHER MOTOR/PUMP SET WHILE THE OTHER IS OUT OF SERVICE.
5. PROVISION SHALL BE MADE FOR GRADUAL MANUAL RELEASE OF THE BRAKES IN THE EVENT OF A POWER FAILURE.

SEABREEZE BRIDGE
EMERGENCY REPAIRS

Figure . 3



HYDRAULIC SYSTEM NOTES

1. THE MAXIMUM PRESSURE SHALL NOT EXCEED THE 3000 PSI OFF THE RELIEF VALVE.
2. PROVISION SHALL BE MADE FOR NORMAL OPERATION BY BOTH MOTORS AND PUMPS AND EMERGENCY OPERATION WITH EITHER MOTOR/PUMP SET WHILE THE OTHER IS OUT OF SERVICE.
3. PROVISION SHALL BE MADE FOR GRADUAL MANUAL RELEASE OF THE CYLINDERS IN THE EVENT OF A POWER FAILURE.
4. TUBING AND HOSE SHALL BE SIZED BY THE SUPPLIER TO MEET JIC STANDARDS (REF: H11.7).
5. SEE SPECIAL PROVISIONS FOR HYDRAULIC SYSTEM DESIGN REQUIREMENTS AND DETAILS.

TABLE OF HYDRAULIC EQUIPMENT

ITEM NO.	QTY.	DESCRIPTION
1	1	RESERVOIR ASSEMBLY (100 GAL.)
2	2	IMMESION HEATER 120V
3	1	TEMPERATURE GAUGE/SIGHT GLASS
4	1	DESSICANT BREATHER
5	2	TEMP FLOAT SWITCH ASSEMBLY (5A & 5B)
6	2	SUCTION BUTTERFLY VALVE
7	2	PUMP/MOTOR DRIPTRAY
8	1	RESERVOIR DRIPTRAY
9	2	ELECTRIC MOTOR (25 HP)
10	2	FLEXIBLE COUPLING
11	2	PUMP (VARIABLE DISPLACEMENT PISTON TYPE)
12	1	VALVE MANIFOLD
13	2	CHECK VALVE
14	2	CROSS-PORT RELIEF VALVE
15	2	ANTICAVITATION CHECK VALVE
16	1	FLOWMETER
17	1	RETURN FILTER W/MANUAL INDICATOR
18		RESERVED
19	2	CHECK VALVE
20	1	PRESSURE FILTER W/MANUAL INDICATOR
21	1	SOLENOID RELIEF VALVE
22	1	4 - WAY PROPORTIONAL VALVE
23	2	COUNTERBALANCE VALVE
24	2	HYDRAULIC CYLINDER (12" DIA. MILL TYPE)
25	1	PRESSURE GAUGE
26	2	PILOT OPERATED CHECK VALVE
27	2	BUTTERFLY VALVE

LANSING ISLAND BRIDGE

Figure 4