AMERICAN CONSULTING ENGINEERS COUNCIL'S

AFFILIATE

HEAVY MOVABLE STRUCTURES, INC.

4TH BIENNIAL SYMPOSIUM

NOVEMBER 10TH - 12TH, 1992

SHERATON DESIGN CENTER
FT. LAUDERDALE, FLORIDA

SESSION
WORKSHOP NOTES

#17 Author: John Schultz
Hazelet & Erdal, Inc.
"PLC's Provide Complete Auto. Control of Movable Bridges"

PLC's PROVIDE COMPLETE AUTOMATIC CONTROL OF MOVABLE SPANS

by John A. Schultz Jr., S.E. (IL)
HAZELET + ERDAL, INC.

Our first Low Speed High Torque (LSHT) Hydraulic Motor-Machinery Drive System has been operating a new double leaf Scherzer rolling lift highway bascule bridge.
A rolling lift type bascule bridge operates thru a combination of rotation and translation of the leaves which permit the use of a fixed shear lock at the mating points.

A Scherzer Shear Lock was provided on the ends of the girders at the center of this Bascule span. The Shear Lock is accomplished when the diaphragm castings slide between top and bottom jaws as the leaves reach the fully closed position. There are no moving parts and the locks only require occasional greasing. The Shear Lock is further described and illustrated on Page 4 and Figures 1 through 6.

A Programmable Logic Controller (PLC) was furnished on the subject bridge and had been providing smooth automatic operation except for an occasional "Hard-mating" as the diaphragm castings on one leaf made contact with the lower jaws of the opposite leaf. The castings then slid between the upper and lower jaws as the leaves reached the fully closed position. At the same time, the uplift bearing plates at the rear end of the bascule girders made contact with the uplift headers. Occasionally, there was also a "Hard-mating" of these steel plates, which hold the bascule leaves in a fully closed position.

Consistent operation with "Soft-mating" was required since this bridge will be operated remotely from a new bridge to be built two blocks away. A solution was also needed for similar conditions on other movable bridges in order to provide safe dependable operation.

The original design provided two speeds raising and two speeds lowering (full speed and slow speed). It utilized the smooth dependable deceleration ramp to remove the slow speed signal and reduce the speed of the leaves to zero at the point of contact. This process is usually described as a "Soft-mating". It can happen in two ways; the first being if the leaves are moving so slowly and do not quite come to a stop, this action would be called a "Soft-mating". Or, the second being if the leaves did not touch, they would again accelerate momentarily and be moving so slowly that it would be a "Soft mating".

The introduction of a third speed was needed to provide a consistent "creep" speed at the moment of contact that would always provide a "Soft-mating".

The problem has been solved by installing a four channel analog output module in the PLC. The output voltages of the module are connected to an input terminal on each of the four servo amplifiers, two on each leaf, which in turn control the swashplate angle and therefore the speed of the leaves. The addition of a third speed has proven very satisfactory at a minimum cost.

The servo controls have a built-in feature that allows the Servo to provide adjustable varying ramp voltages between changes in speed signal to provide a smooth transition between speeds. As a test while raising the bridge at full speed (maximum positive voltage), the speed signal was immediately changed to lower at full speed (maximum negative voltage). The bridge leaves decelerated smoothly until they came to a momentary stop followed by a smooth acceleration to full speed lowering.

Field adjustment of the original servo potentiometers to set speeds was "trial and error". The potentiometer can be adjusted by using a voltmeter, but it would require operation of the bridge to verify the new speed. Whereas, the new analog output module requires only a change of numbers in the program to make a change in output voltage and a corresponding change in speed.

The analog output module is capable of providing an "infinite" number of output voltages and therefore an "infinite" variation in speed of the moving leaves. When the software program in the Central Processing Unit (CPU) in the PLC has been reprogrammed, this existing bridge will have the advantage of the latest technology. The existing PLC is continuously receiving data on the moving leaves position, speed and required torque to maintain the speed. Therefore, the CPU will have the data needed to respond immediately thru the analog output module to adjust the speed of the leaves.

During automatic operation on our new bridge projects, the servo amplifiers are being eliminated and the analog output modules are being used to directly control the swashplate and thereby providing "infinite" speed control of the moving leaves.

This complete LSHT-Hydraulic Motor Drive System can be retrofitted into existing bridge drive systems by replacfing the electric motors and speed reducers.

The entire control system can also be used equally well to control hydraulic cylinder drive systems.

ADVANTAGES OF THE HYDROSTATIC DRIVE SYSTEMS

At previous presentations, comments were made that proportional valves could be used to perform the same operations.
The author would like to present some of the advantages of Hydrostatic (HST) Drive Systems over the Proportional Valve Systems as follows:

1. *The horsepower of the electric motor, driving the variable displacement piston pump, is determined by the design Running Torque required of the low speed high torque (LSHT) hydraulic motor.*

2. *The LSHT hydraulic motor speed control is set by the pump output volume. The volume is set by the pump stroker which sets the pump swashplate angle. Variations in load do not change the swashplate position and thus do not change the pump output volume or the LSHT hydraulic motor speed.*

3. *The system pressure varies as the LSHT hydraulic motor torque requirements vary.*

4. *There is a fast response to a command for a change in speed. The rate of change of speed follows a linear ramp that is adjustable. The flow is controlled by the servo valve pump stroker, which smoothly changes the position of the pump swashplate without hunting.*

5. *If there is a loss of signal to the stroker or loss of power to the controller board, the pump stroker destrokes the pump to zero flow and stops the system.*

6. *The heat developed in the system is minimal. It is based on the pump efficiency and the hydraulic motor efficiency.*

7. *The pump stroker varies the pump swashplate angle to control deceleration. Inertia energy is put back into the electrical system.*

8. *The servo controller comes as a pretested package with 8 potentiometers for adjustment as follows:*
   a. *2 speeds raising (full, slow and creep).*
   b. *2 speeds lowering (full, slow and creep).*
   c. *Raising acceleration and deceleration.*
   d. *lowering acceleration and deceleration.*

9. *The stroker has a manual override for raising and lowering up to full speed.*

10. *The reservoir can be much smaller with a closed loop system. It can be sized for approximately 30% of pump volume. The built-in charge or makeup pump can be sized for approximately 20% of the main pump volume because there is much less heat energy to be dissipated.*

SHEAR LOCKS ON SCHERZER ROLLING LIFT BRIDGES

The Scherzer Rolling Lift Bridge Company in the early 1900's patented a "Lock" to transmit shear between the cantilever ends of bascule leaves. These "Shear Locks" must act as hinges while keeping the deflection of the leaves the same. The ends of the bascule leaves must deflect together in order to maintain a smooth riding surface across the center break in floor of bascule spans. As heavy axel loads cross the center break in floor, the loads must be distributed through the "Shear Locks" to maintain equal deflection.

BRIDGE CLOSED

Fig. 1 shows the "Shear Lock" at the center of a double leaf bascule span. The Diaphragm Casting is supported by web plates with flanges only to the outside, to allow the upper and lower jaws on the "Jaw Leaf" to enter between them. Only the casting is shown on the "Diaphragm Leaf".

BRIDGE OPENING

Fig. 2 shows that when the Jaw Leaf is at a 1.5 degree angle of opening, the diaphragm casting will clear the upper jaw and should accelerate up to full speed. The Jaw Leaf should also accelerate but never closer than a 0.5 degree angle of opening to the Diaphragm Leaf.

BRIDGE CLOSING

Fig. 3 shows that the Diaphragm Casting Leaf should not go below an angle of 5.0 degrees (We call this the "CLEAR" position), until the Jaw Leaf is in the "WINDOW" as defined in Figs. 4 and 5. (We call this the "LOCKING POSITION"). If the Diaphragm Leaf goes below a 5.0 degree angle before the Jaw Leaf is in the WINDOW, it has "Overtraveled" and must be raised to 5.0 degrees minimum. It also shows that the Jaw Leaf should not go below 5.0 degrees if the Diaphragm Leaf is below 5.0 degrees.

Fig. 4 shows the Jaw Leaf at an angle of 3.3 degrees where the Diaphragm Casting will make contact with it at a point approximately 6 inches from the end of the Jaw. We define this position as the "Top of the Window".

Fig. 5 shows the Jaw Leaf at an angle of 2.0 degrees where the Diaphragm Casting will clear the Upper Jaw by approximately 3.75 inches. If it goes below this angle before the Diaphragm Leaf is at 2.5 degrees, it has "Overtraveled" and must be raised to be in the "Window". We define this position as the "Bottom of the Window".

Fig. 6 shows that the Diaphragm Casting must be in contact with the lower Jaw in order for it to slide under the Upper Jaw and continue to the "Fully Closed" position as shown in Fig. 1.

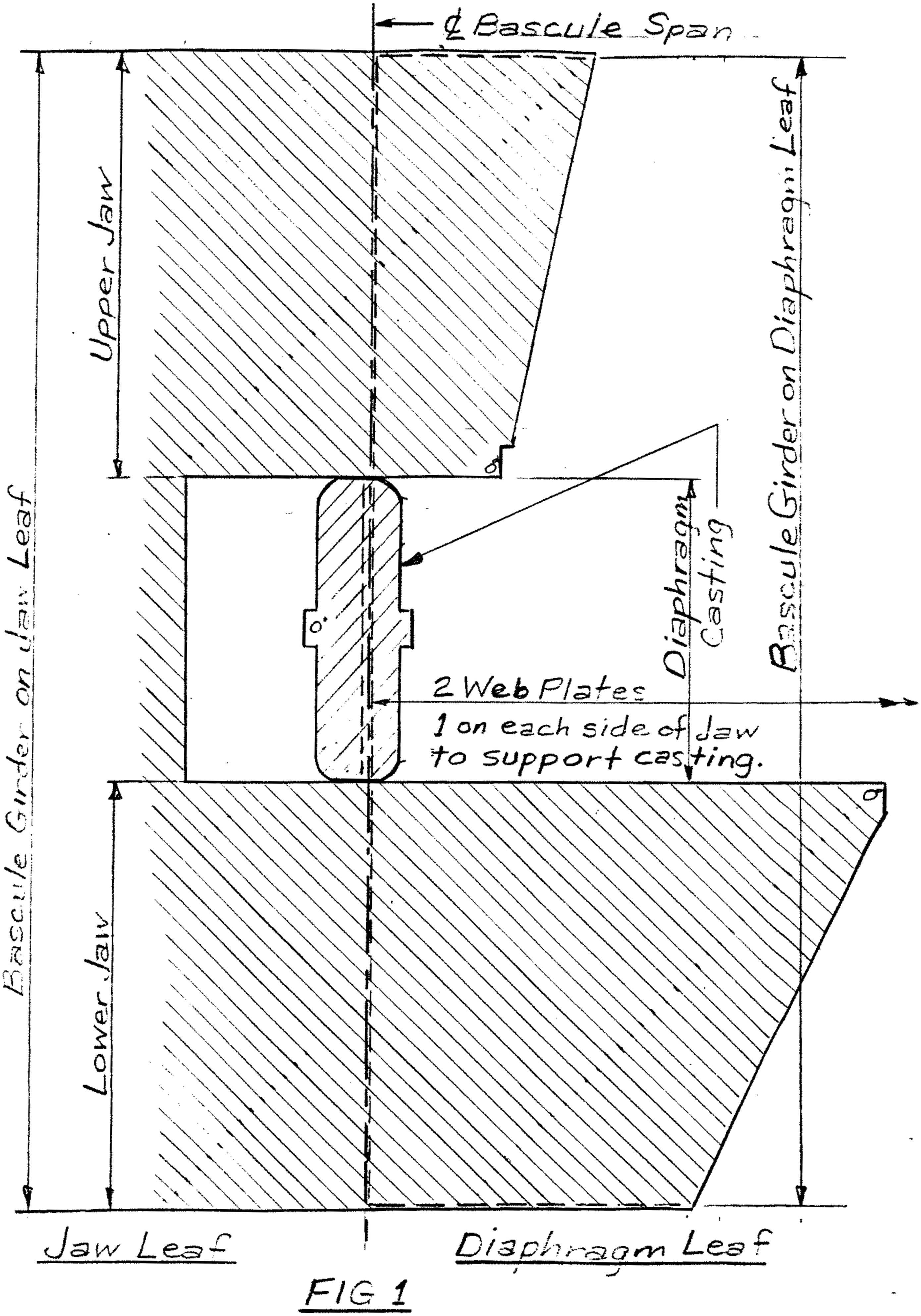

FIG 1

BRIDGE CLOSED (0°)

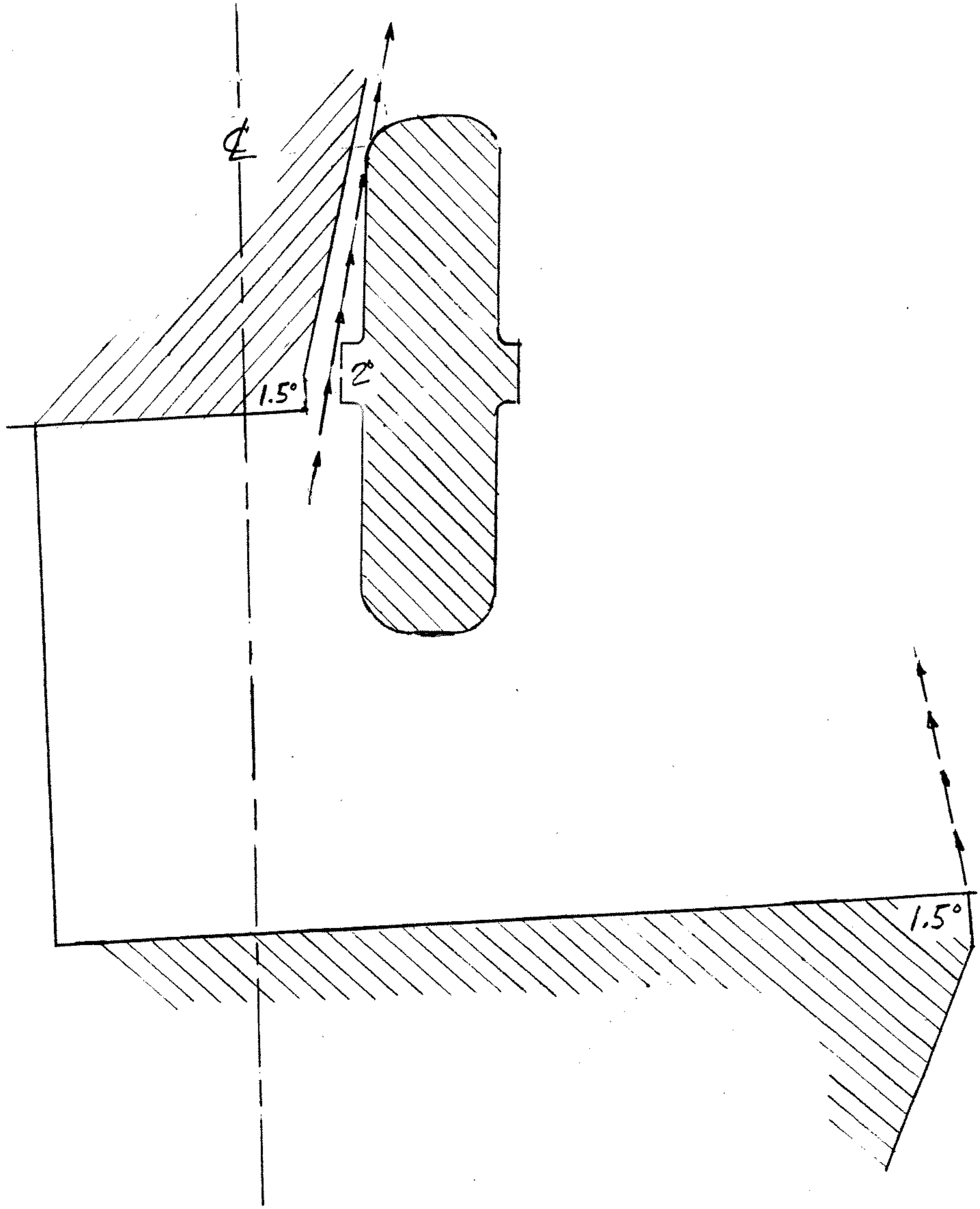

FIG 2

BRIDGE OPENING

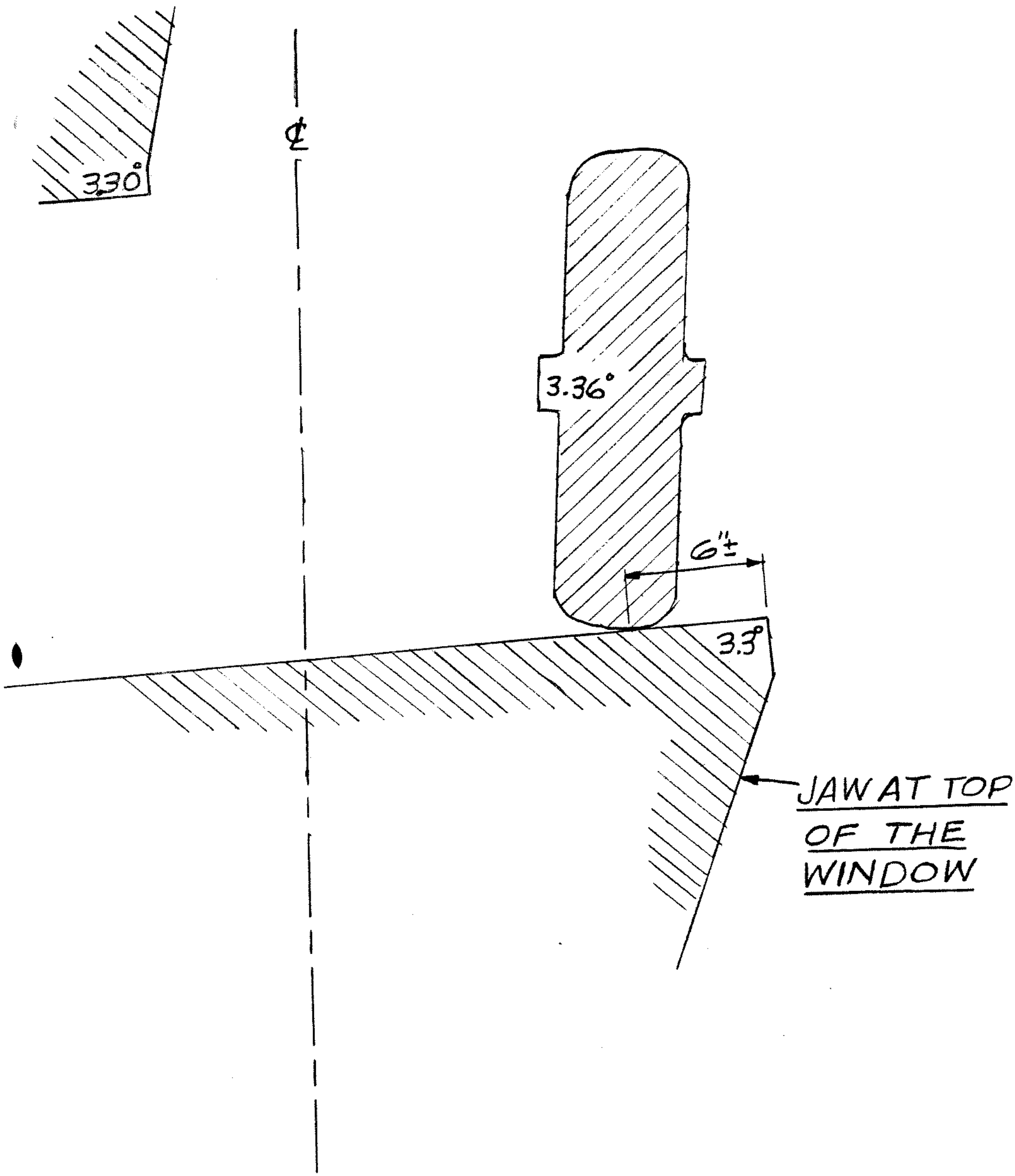

FIG. 4

BRIDGE CLOSING

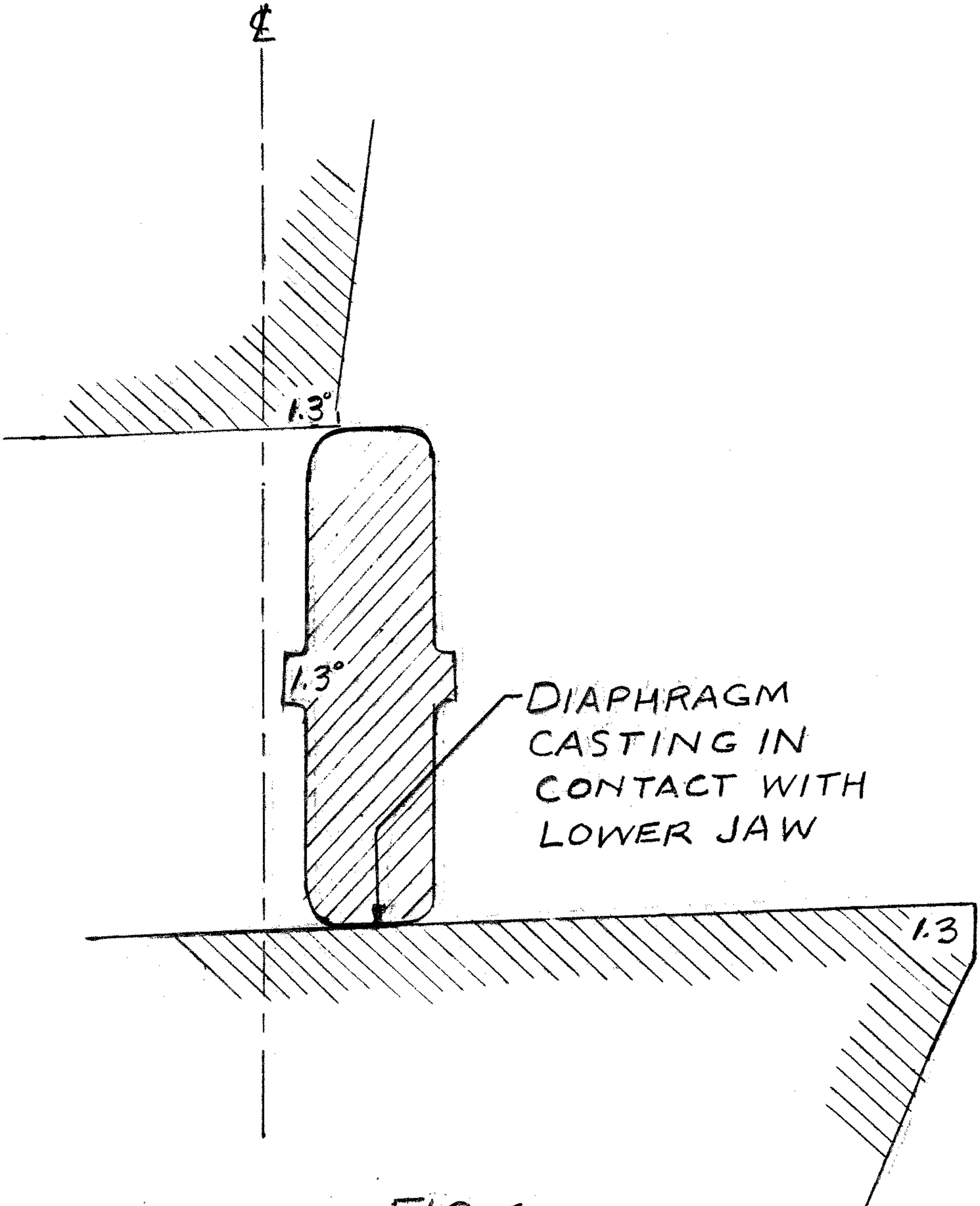

FIG 6

BRIDGE CLOSING