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"Importance of Lubr/Flushing
....Bascule Trunnion Bearings"

IMPORTANCE OF LUBRICATING/FLUSHING . . . BASCULE TRUNNIONS

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I. Introduction

The following paper demonstrates how a difficult situation that developed due to lack of lubrication at a bascule bridge trunnion, was solved by using low tech and common materials, engineering common sense and persistent efforts.

It will be shown how the imminent disassembling of the trunnion, that would have required great expense and effort and accompanied by land and waterway traffic inconvenience, was avoided.

The presentation will infer the importance of a continuous and proper maintenance and lubrication procedure.

II. Description of the Bridge

The Unionport Bridge built in 1953, is a double leaf trunnion bascule supporting Bruckner Boulevard over Westchester Creek in the Bronx, New York City. Each leaf is about 70 feet center to center of trunnions.

For convenience of description in this paper, the bridge will be considered to be oriented east-west.

III. Description of the Span Drive Machinery and Span Support System

A) Span drive machinery

The two movable leaves of the bridge are each driven by virtually identical, but opposite hand, span drives, (See figure 1). Most drive components are located in a box girder which is part of a fixed trunnion shaft about which the bascule rotates.

Rotation of the rack pinions mounted within the box girder of the trunnion shaft cause the racks, fixed to the bascule girders, to rotate. In this manner, the leaves are raised and lowered by electric motors.

B) Span Support System

The two movable leaves of the Unionport Bridge are each supported by two trunnion shafts or, trunnions, (See figure 2). Each trunnion passes through one of the two bascule girders of each leaf. The girders rotate about the trunnions, which are intended to be co-linear. The trunnions are connected together by a box girder which also serves as the machinery room.

The trunnions do not rotate but are held fixed in pedestals mounted on the bascule pier. The dead load of the movable leaf and a portion of the live load is transferred from the bascule girders onto the trunnions through bearings mounted in the webs of the bascule girders. One end of each trunnion is supported by the trunnion pedestal located outside of the bascule girder. Load on the trunnion passes from the trunnion onto the pedestal, then through the approach girder on which the pedestal is mounted, to the concrete bascule pier.

IV. Electrical System

Each span drive has provisions for three modes of operation: normal operation by a 20 HP AC motor, emergency operation by one 10 HP AC motor, and manual operation by means of a crank. The power derived from each of these sources is inputted into one of the shafts of a primary, parallel shaft, differential speed reducer.

A clutch allows the main motor to operate the drive machinery without back-driving the emergency motor.

The electrical motors are wound rotor motors with secondary resistors.

V. History of the Problem

As part of an inspection, a bridge opening using the electrical emergency drive was requested in May, 1988. The emergency drive was operated and emergency motor current readings were obtained. The east leaf emergency motor was drawing excessive current. The operator could not seat the east leaf with the emergency drive. The normal drive was used to seat the bridge.

In the spring of 1989 a performance test was conducted in which the normal motor current versus bridge position was recorded. The field note sheets for the drive motors and the strip charts revealed that the east normal drive motor was drawing excessive current (almost as much as 150 percent of full load current) during operation of the east leaf. The east emergency drive motor was also drawing excessive current. During the emergency operation the east leaf was unable to be seated with the emergency motor.

The bridge was operated many times to ascertain the functioning of brakes and to listen for unusual sounds indicative of defects in the gearing or interferences between the fixed and movable parts of the bridge. No unusual sounds were heard during operation except some cracking, high pitched noises coming from the northeast trunnion area.

Inspecting the lubrication channels in the northeast trunnion shaft and bushing, that permit flow of lubricant to the trunnion bearing, it was found that all these channels were clogged.

The logical conclusion was that because of total lack of lubrication for most likely a long period of time the friction in the northeast bearing was very high. As a result the electrical motors of this particular leaf (east) were overloaded during opening or closing the leaf. The unclogging of the channels was the first logical step to be undertaken.

VI Description Of Lubrication Channnels

Before further discussion, a more detailed description of the trunnion assembly and its lubrication channels is necessary, (See figure 2).

The *trunnion* assembly is made up of:

a. "the trunnion" (forged steel-nickel alloy), figure 3,
b. "the bushing" (Phos. Bronze), figure 4,
c. "the hub" (cast steel),figure 5,
d. 'the collar" (steel, plate),
e. hardware.

The trunnion (the shaft), as mentioned, is fixed (does not rotate).

The bushing is pressed and bolted into the hub which hub, in turn is pressed and bolted into the main girder of the leaf. When the bridge opens or closes, "the bushing" moves relative to the fixed trunnion.

To lubricate the surfaces subjected to friction there are four lubrication channels. Three channels are machined on the top of the trunnion, 25 degrees apart, which of course are stationary and one in the lower half part of the bushing that moves with the bridge at every opening-closing.

The channels in the shaft sometimes called clean-out channels have the location shape and size shown in figure 2 & 3.

The lubrication channel in the bushing has the location, shape and size shown in figure 2 & 4.

When the bridge is fully opened (71 degrees) the very ends of the spiral grooves in the bushing pass over one of the shaft grooves by 6 degrees.

VII <u>Unclogging attempts</u>

As stated earlier, for one reason or another, none of the northeast trunnion lubricating channels received any lubricant (grease or oil) in even minute quantities.

Since 1989, several attempts were made to lubricate the northeast trunnion. The initial attempts to unclog were made by using various types of standard grease pumps. Both hand and compressed air grease pumps were tried. None of these attempts were successful .
Due to the lack of lubrication, the friction in the trunnion increased. The trunnion became noisier.

NYCDOT Bridge Maintenance was facing the prospect of closing the bridge for dismantling the trunnion, at a cost of at least $100,000 and accompanied by all the related inconveniences (both land and marine traffic interrupted), or continuing to try to unclog the lubrication channels in the trunnion, while taking the risk of getting the bridge stuck in the closed or open position at any time.

We decided to continue to try to unclog any of the four greasing channels.

We did not want to suspend marine or land traffic at any time. The openings required during our efforts to clean the lubrication channels were not longer than the 10 minutes which are allowed by N.Y.C. regulations for each opening-closing of any of its movable bridges.

Several solutions were initially contemplated and the following were tried.

The first and the most obvious attempt was the use of the probes (metallic wire etc.) inserted into the lubrication channels for mechanically removing the hardened grease. At first glance this appears to be a straight forward job. The wire probe should stop only when it hits the hardened grease. This was not exactly what happened.

The detailed drawing of the grease channels of the trunnion, (see figure 3 section AA and detail B) does not show how the lubrication channels are machined in the shaft. Based on standard machine shop procedure we must assume that the "bends" are not a smoothly blended surface but are actually an intersection of two bored cylinders with each of them overshooting the intersection. In addition, they might not be in the same plane. Because of these conditions, a straight probe cannot pass the bend, but bottoms out in the dead end hole.

To bypass this problem, we took a steel band from a pair of headphones which has a natural curved form and rounded tips and without any major problem we managed to pass the bend. We discovered by doing this, that about 12 inches of the initial shaft grease channels were unclogged.

Encouraged by this result the next probe was made by wire (taken from a common hanger) and shaped appropriately to pass the bend. We probed the same channels and obtained the same result (12 inches of the shaft grease channels were unclogged). To try to eliminate the doubts (that we have indeed reached the hardened grease) we probed the other trunnion of the same leaf. No significant resistance was encounted for more than 24 inches (the total length of the wire probe).

Using the same wire probe we went back to the clogged trunnion and we tried to unclog the lubrication channels by "pounding" the hardened grease but without using solvents. The probe was not rotated while inside of the lubrication channel because the rotation motion without advancement of the wire probe would result in repeated bending of the wire in the same place, over sharp edges, with the high probability of breaking the wire probe inside the lubricating channel. Removing a broken wire from inside the lubricating channel would have been impossible without totally disassembling the trunnion.

The "compacted" grease was too hard to be removed by purely mechanical means. We therefore added different types of solvents to the "probe procedure". No visible progress was noticed after hours of hard work.

After all these attempts failed we decided to use a high pressure, hand operated oil pump, which can develop up to 10,000 psi and is used in jacking operations.

We tried to unclog the top grooves (the grooves into the trunnion), but despite the fact that we built up and maintained 10,000 psi for hours while opening and closing the bridge several times, we were unsuccessful in pumping any amount of oil into the greasing channels. We repeated this operation for several days with no success.

Because the trunnion severely needed to be lubricated we abandoned trying to lubricate it from the top and instead focused our efforts in introducing oil into the bushing's grooves, through the trunnion's bottom port.

After about 8 bridge opening-closing cycles, the oil pumped at a pressure of 10,000 psi, burst through the clogged passage of the bushing and the amperes drawn by the electrical motor suddenly dropped down. We kept pumping oil while the bridge was opened and closed another 4 - 5 times. The next step that we undertook was to flush out the helical grooves cut in the bushing as much as possible.

To accomplish this, for several hours we pumped a mixture of compressed air and oil while we opened and closed the bridge many times. Then we pumped grease until it came out clean and free of oil.

Once the bottom channel was unclogged, we refocused our efforts to open top (shaft) channels. Realizing that none of the methods already tried would work, we decided to try a "make-shift snake" power rotated by a variable RPM cordless drilling machine.

As a "snake", we used a strand taken from a wire rope. To ensure that the thin wires of the snake (strand) would not be broken (cut) by the sharp edges of the bend, we inserted in the channel a semirigid plastic tube. Through this tube we inserted the "snake" while it was turning at low RPM. Once it encountered hardened grease, the RPM of the "snake" was increased to maximum .

Cautiously, we inserted the rotating snake into the semirigid plastic tube, while the drill was moved back and forth to see if any jamming would take place. The operation went smoothly. No jamming tendency was noticed.

The direction of rotation was such that the twisted strand had the tendency to "tighten" the strand about its center line. If rotated in the opposite direction, the twisted strand would unravel. After many attempts, one of the passages (the left one looking toward the center line of the bridge) started to unclog and the wire strand probe advanced about 1 inch under the bushing.

The progress was very slow and it became obvious that solvent would be needed . Despite several attempts to introduce solvent by simply pouring into the groove, the unclogging process was not accelerated.

Taking a closer look at the top lubrication channel longitudinal crossection, it can be seen that because of the lubrication channel shape a stationary air bubble forms, thus preventing the solvent to reach the hardened grease. To overcome this, another plastic tube very flexible and having the O.D. smaller than the I.D. of the primary semirigid tube was inserted into the primary tube. It was pushed all the way to the end of the unclogged portion and solvent from a can of regular (commercial) carburetor cleaner was sprayed into the tubing until the solvent came out.

Then the inner tube (secondary one) was slowly removed while continuing to spray the solvent inside the retracting tube. The purpose was to fill the lubrication channel with as much solvent as possible. After the inner tube was removed the snake was carefully introduced into the semirigid tube while the drilling machine was activated at low RPM.

After the snake reached the end of the "dug out" passage, the RPM was increased and pressure (by pushing) was applied to the snake. By repeating this operation with several various length snakes and using about 6 cans of 16oz. solvent (carburetor choke cleaner) the entire length of the groove under the bushing was cleaned. Then we repeated the same procedure from the other side of the trunnion.

Finally we managed to unclog the entire channel by this method. To completely unclog the channel took about 10 hours of effective work. Our next step was the flushing of the hardened grease that was not dislodged by the snake. To flush the remaining grease, we made a T connection using regular plumbing supplies and proceeded to blow compressed air in one leg and kerosene into the other leg of the T. The mixture went through the third leg of the T into the lubrication channel and then collected on the other side, in a container.

When the mixture collected into the container became clean enough we removed the "flushing installation" and installed the greasing pump. First we pumped grease from each side of the trunnion without opening or closing the bridge. We then repeated the operation while opening and closing the bridge until the grease came out on both side of the trunnion.

VIII. Conclusion

The process of unclogging the trunnion's lubrication channels and the subsequent pumping of the grease between the friction surfaces of the trunnion assembly was performed in two steps:

Step 1, when we managed to unclog flush and pump grease through the lower (bushing's) lubrication channel. The result was obvious and sudden; the ampers drawn by the East leaf motor during the openings dropped from 120 amps to 85 amps, only 5 amps more than the number of amperes drawn by the other leaf west during its opening (80 amps).

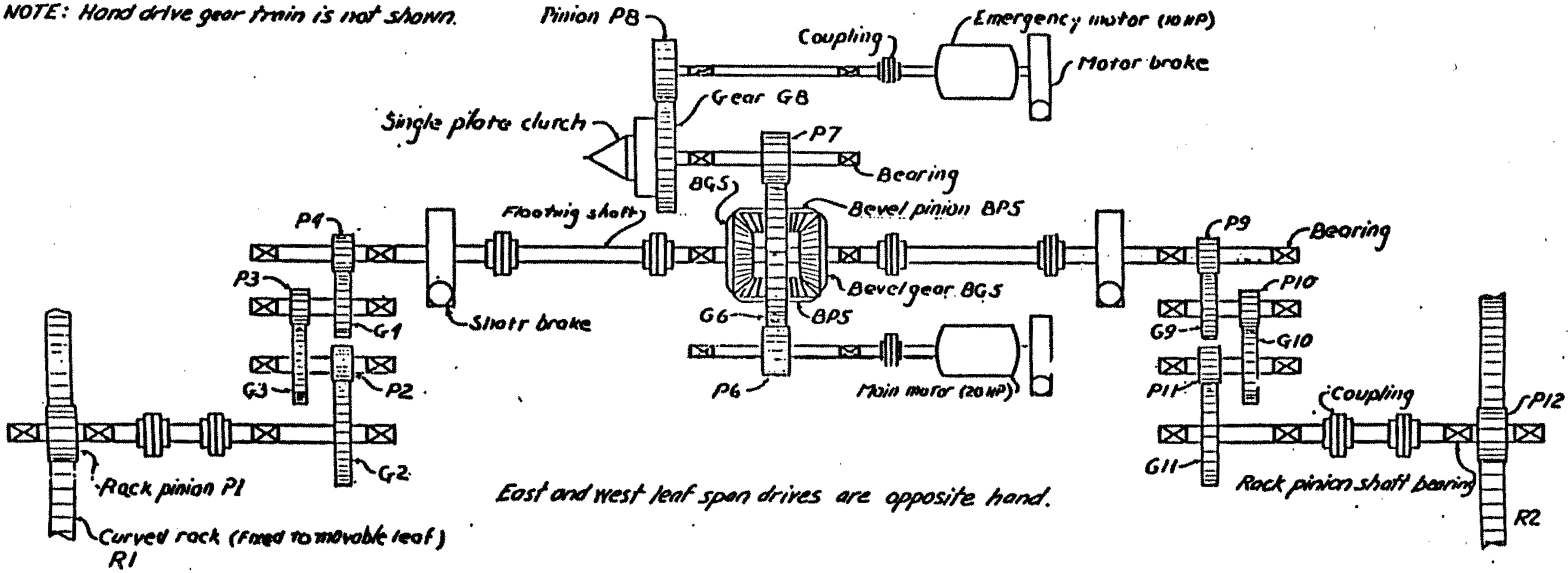
Step 2, when we managed to unclog, flush and pump grease through one of the three top trunnion's lubrication channels.
At this time the amperes drawn during openings remained practically the same: 85 amps.

It came somehow as a surprise to us, the fact that despite directly greasing the top friction surface between the trunnion and bushing, the amperes drawn by the electrical motor during the openings did not change this time. This shows that by pumping a generous amount of lubricant through the lower lubrication port into the bushing, while the bridge is opened and closed repeatedly assured a satisfactory lubrication of this particular trunnion-bushing assembly.

Thus for the time being we have stopped pursuing the task of unclogging the other two top (trunnion) lubrication channels, leaving the fresh grease to wash its way to soften the hardened grease, while we are continuing to monitor the bridge for proper functioning

APPENDIX

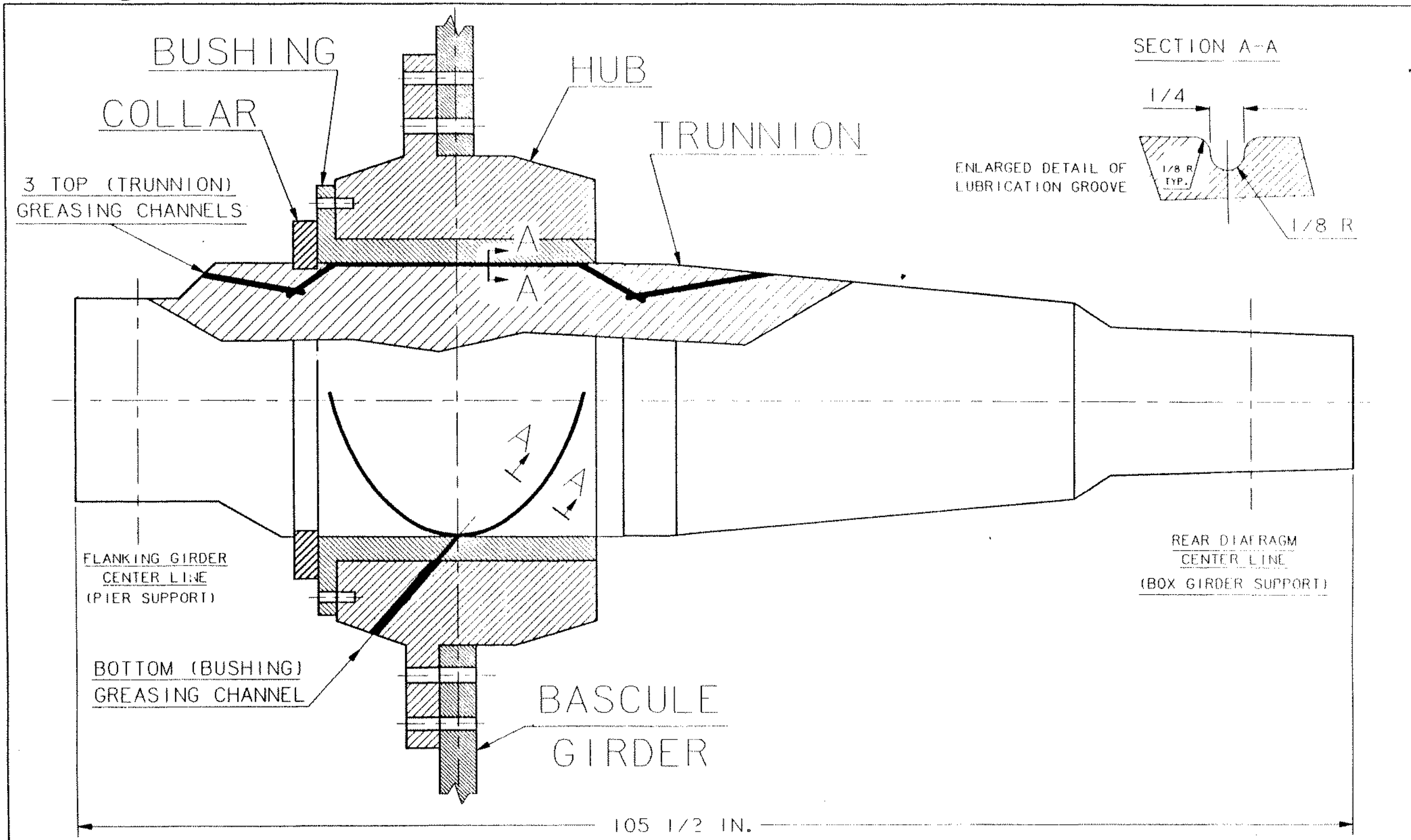
NOTE: Hand drive gear train is not shown.



East and west leaf span drives are opposite hand.

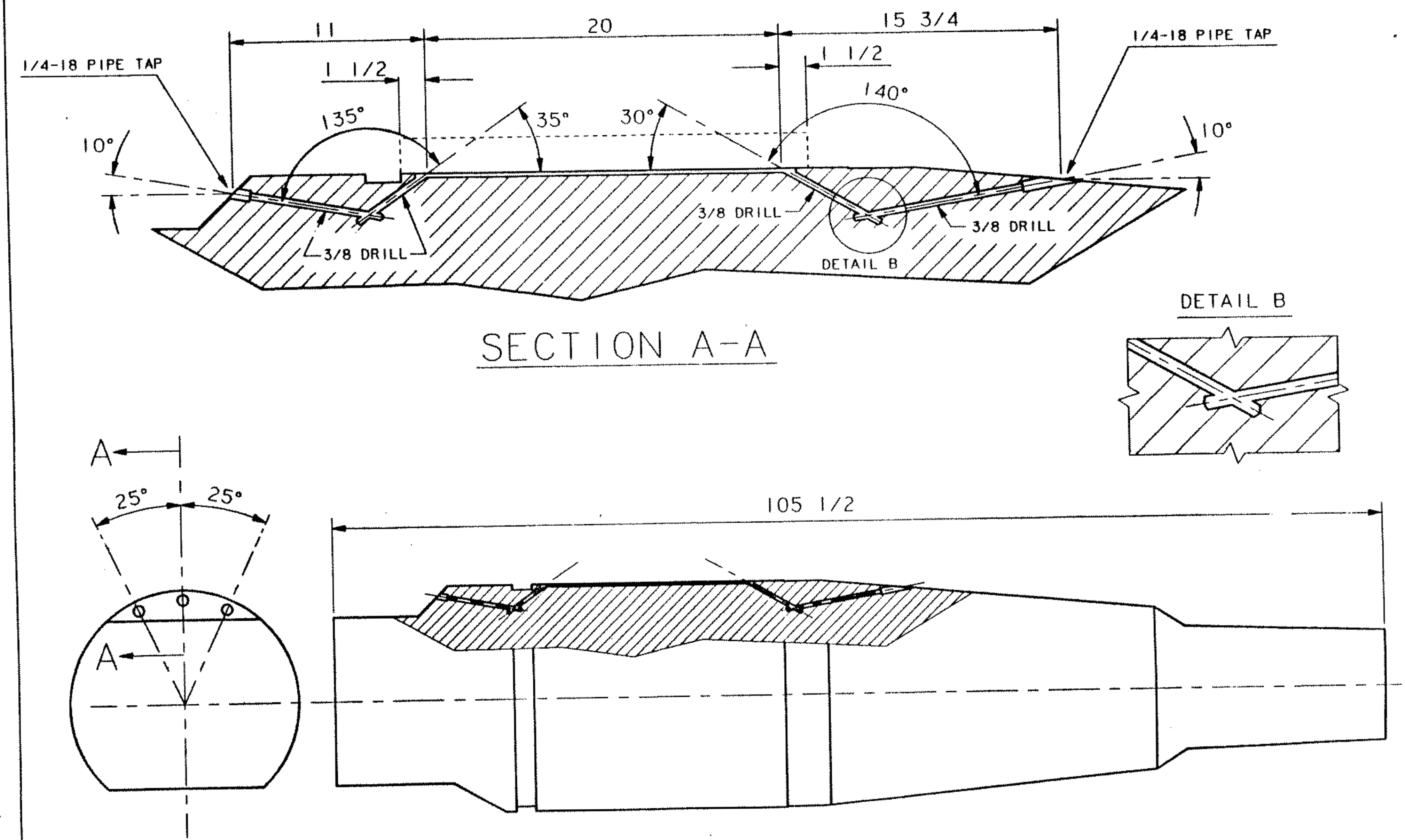
SCHEMATIC DIAGRAM OF TYPICAL SPAN DRIVE

Fig 1



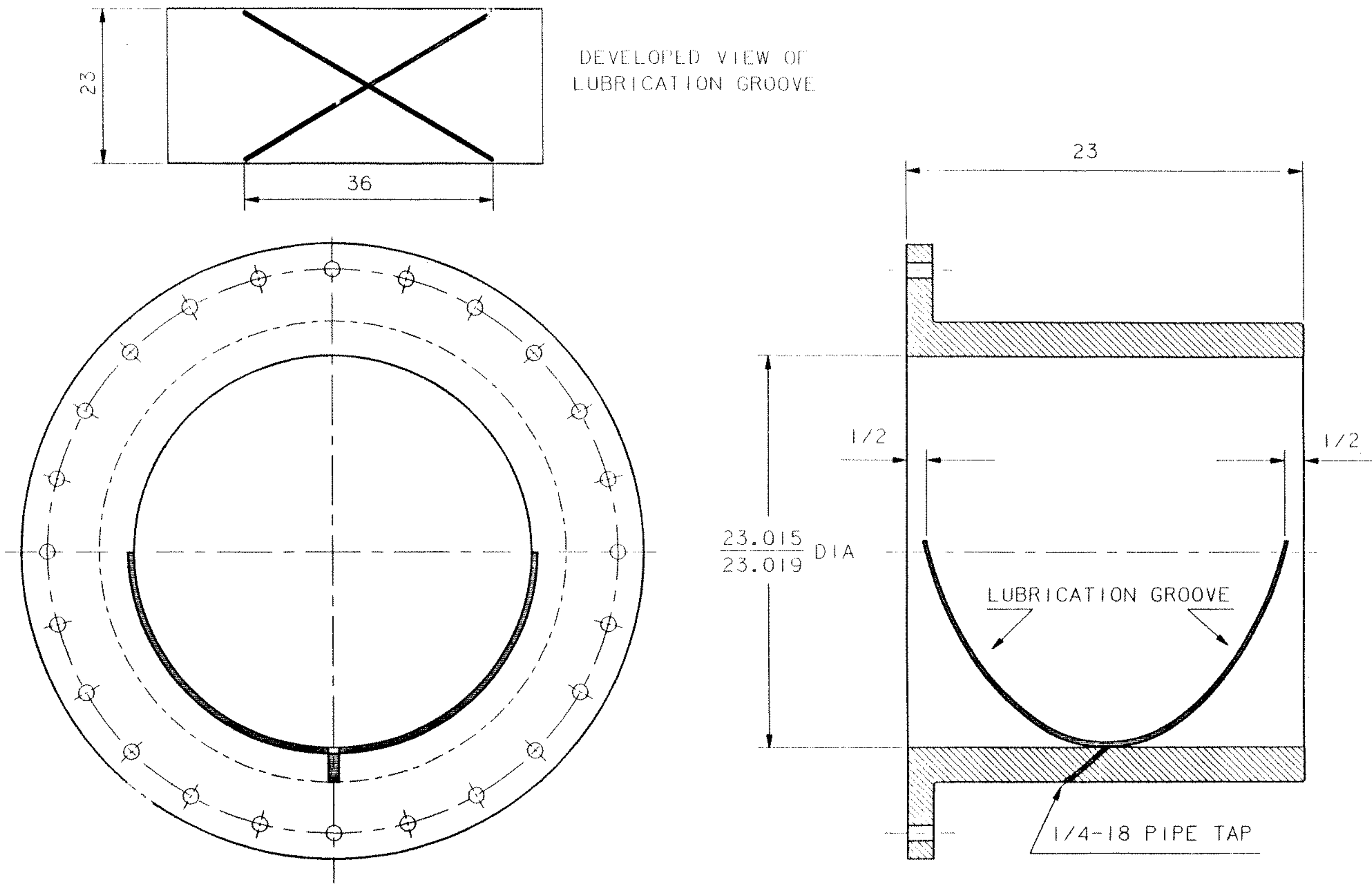
TRUNNION ASSEMBLY

FIG. 2



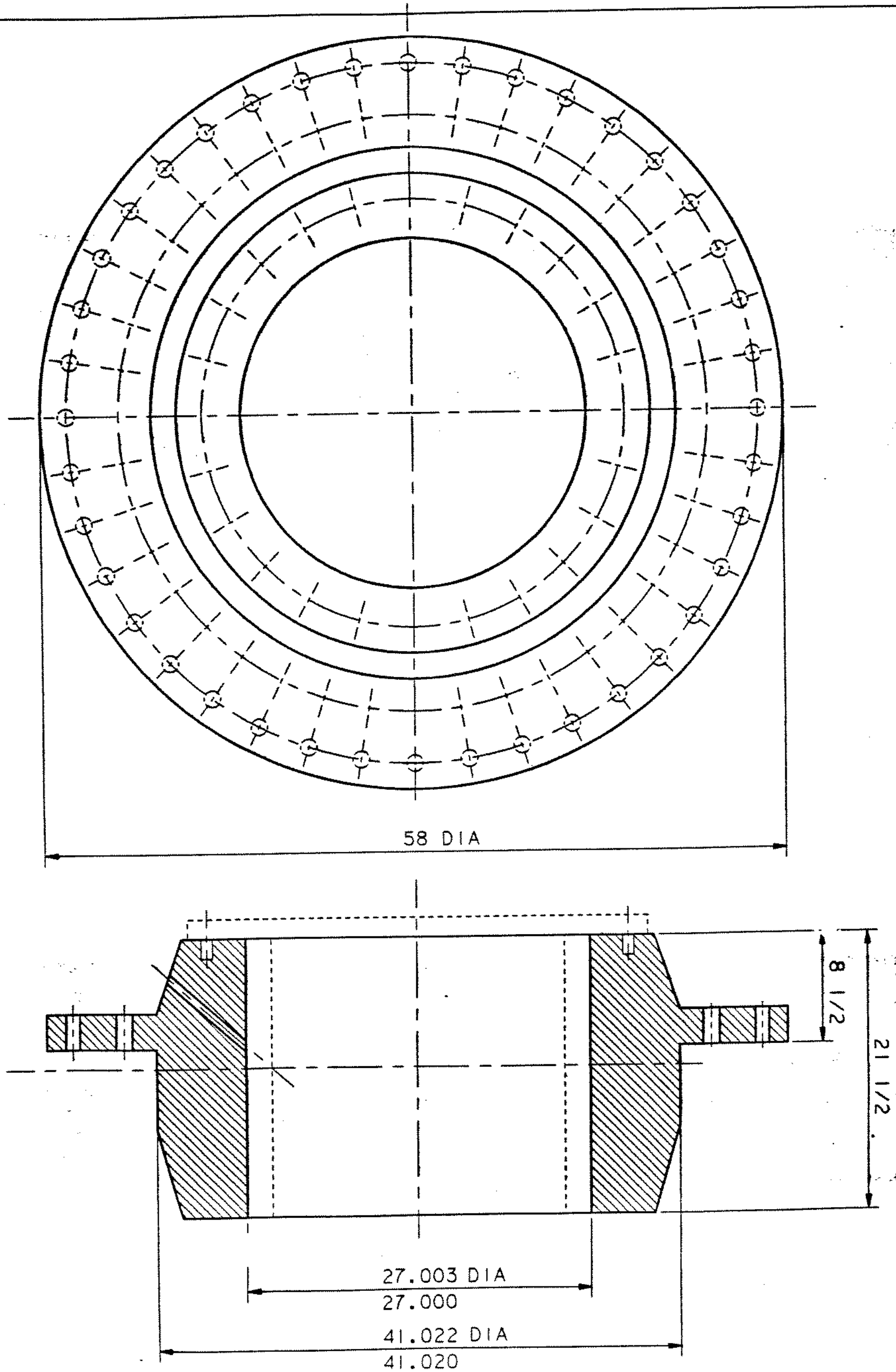
TRUNNION

FIG 3



BUSHING

FIG 4



HUB

FIG 5