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"DRIVE SYSTEM REPLACEMENT ON THE MAIN STREET LIFT BRIDGE JACKSONVILLE, FLORIDA 1994

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Presented By:

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Introduction

Built in the late 1930's, the Main Street Lift Bridge over the St. John's River, with its 386 foot lift span is truly a show piece of the city. The bridge has been well maintained over the years. Rehabilitation projects were performed to preserve and improve the structure, including deck replacement and operating rope replacement. However, the operating machinery and the electrical system were in need of major rehabilitation or complete replacement. In the spring of 1994 the electrical and span drive machinery systems were both replaced. The span drive machinery replacement and the unique features of its design is the subject of this paper.

Main Street Bridge, Jacksonville, Florida

Evaluation of the Existing Machinery

The original span drive machinery consists of an open gear reducer driven by two 100 horse power wound rotor electric motors. There are two thrustor type motor brakes and one large lever operated machinery band brake. Each end of the output shaft of the open gear unit drives a main pinion, each of which engages two operating drum ring gears. As the drive rotates, the operating ropes wrap around the drums. The wire ropes on the up haul side of the drums are displaced to the down haul side of the drums and the bridge lifts. The span drive machinery also has a back up gasoline engine with an additional reduction gear set.

Inspections of the machinery revealed accelerating gear tooth wear on the open gearing, the main pinions, and on the drum ring gears. The majority of the bronze bushings of the gearing shafts were also heavily worn. Operation of the machinery was extremely noisy and constant maintenance and lubrication was required.

As part of the Florida Department of Transportation's Movable Bridge Rehabilitation Program, it was decided to completely replace the span drive machinery and upgrade the machinery to current AASHTO codes for movable bridges.

Unique Features and Problems

Reducer

Meeting F.D.O.T.'s requirements for redundant drive motors and satisfying AASHTO conditions of section 2.10.14 Motor Torque For Span Operation would prove to be difficult. Calculations showed that the existing motors (Two - 100 H.P.) would not satisfy current AASHTO requirements for torque under single motor operation. This is due to the much reduced maximum starting torque permitted by the current code.

Therefore, the new design would use two 200 horse power D.C. motors each with its own electronic drive. Only one motor will operate at a time and the operation of the motors will be alternated so that each motor and electronic drive will be exercised.

It was decided that the existing open gear drive would be replaced with a modern non-differential oil bath reducer. The new reducer was detailed to have double extended input and output shafts as well as an intermediate shaft extension for the attachment of the hydraulic machinery brakes. The design also called for the reducer to have redundant lubricating oil pumps and motors which will lubricate all the shaft bearings before and during span operation. This feature was deemed necessary due to the infrequent operation and the high shaft bearing loads.

The new reducer assembly would have to fit in the available space as did the existing open gear unit. This required extensive field measurements and precise housing detailing so that the new unit could bolt up to the existing supports and minimize modifications to the machinery floor framing.

Over the course of two night closures, the old machinery was removed and the new reducer, motors, brakes, etc. were hoisted into the machinery house from the roadway below. Much of the machinery floor framework and flooring was removed so that the 10 ton plus assembly could be hoisted into place by four chain fall hoists.

Reducer Data

Input Horse Power = 200 H.P. @ 650
Ratio = 34.5 to 1
Design output Torque = 1,330,000 in-lbs

Reducer Testing

The Florida Department of Transportation requires that all new movable bridge reducers be dynamically load tested to 300% of full load input torque. The Main Street Bridge reducer was dynamically tested to the F.D.O.T. requirements by Clark Engineering. After the conclusion of the load test, the reducer was disassembled and all the internal parts were inspected. No gear tooth or bearing damage was observed. Gear tooth contact was satisfactory. The reducer passed the rigorous load test and was reassembled and ready for installation.

The need for reducer load testing has been a hot topic of conversation among consultants and manufactures for several years. F.D.O.T. officials are quite pleased with the results of their movable bridge reducer load test. They believe that such tests will avoid future gear box failures in the field after

installation. F.D.O.T. affirms that their policy of load testing all bridge reducers will continue.

Brakes

A thrustor operated motor brake was installed at each end of the reducer input shaft. Falk Steel-Flex brake wheel couplings were also used. These were installed such that the brake wheel mounted to the hub on the reducer input shaft. This arrangement will allow both motor brakes to remain in service, even if a drive motor is uncoupled or removed for servicing. Each motor brake was set to provide 400 ft-lbs of continuous braking torque.

Multi-plate clutch type hydraulic brakes were provided as machinery brakes on the new drive system. Hydraulic clutch type brakes were selected for this application due to the braking torque required, approximately 5,000 ft-lbs from each brake. Thrustor type shoe brakes were not selected because then would been to large to fit in the available space. An intermediate shaft on the reducer was extended on both sides of the housing to accommodate the multi-plate brakes. The selected machinery brakes are fail-safe type brakes. Applied hydraulic pressure (approximately 250 psi) fully releases the brakes. The brakes are fully set when the hydraulic pressure is removed.

A small hydraulic power unit was provided to release the machinery brakes. The power unit has redundant hydraulic pumps and electric motors. An orifice was used to bleed off hydraulic fluid and gradually set the both brakes once the power unit is shut down.

Floating Shafts

The original design used two solid steel floating shafts and four large jaw couplings to connect the reducer to the main drive pinions. ASTM A576 Grade 1045 steel was used to fabricate the new floating shafts. In the new design the coupling were upgraded to flex-rigid gear type couplings. These couplings will allow larger loads and greater misalignment capacity.

Main Pinions and Bearings

New main pinion shafts and bronze bearing bushings were installed. The new pinions were machined integral with the shafts. Gear tooth profile would remain unchanged (16 teeth, 2-1/4" C.P., 7-1/2" Face). ASTM A291 Class 2 forged carbon steel

was selected as the new pinion material to provide additional strength.

Replacement of the bronze bearing bushings required advance disassembly and field measurements since no original shop details were available.

Drum Gear

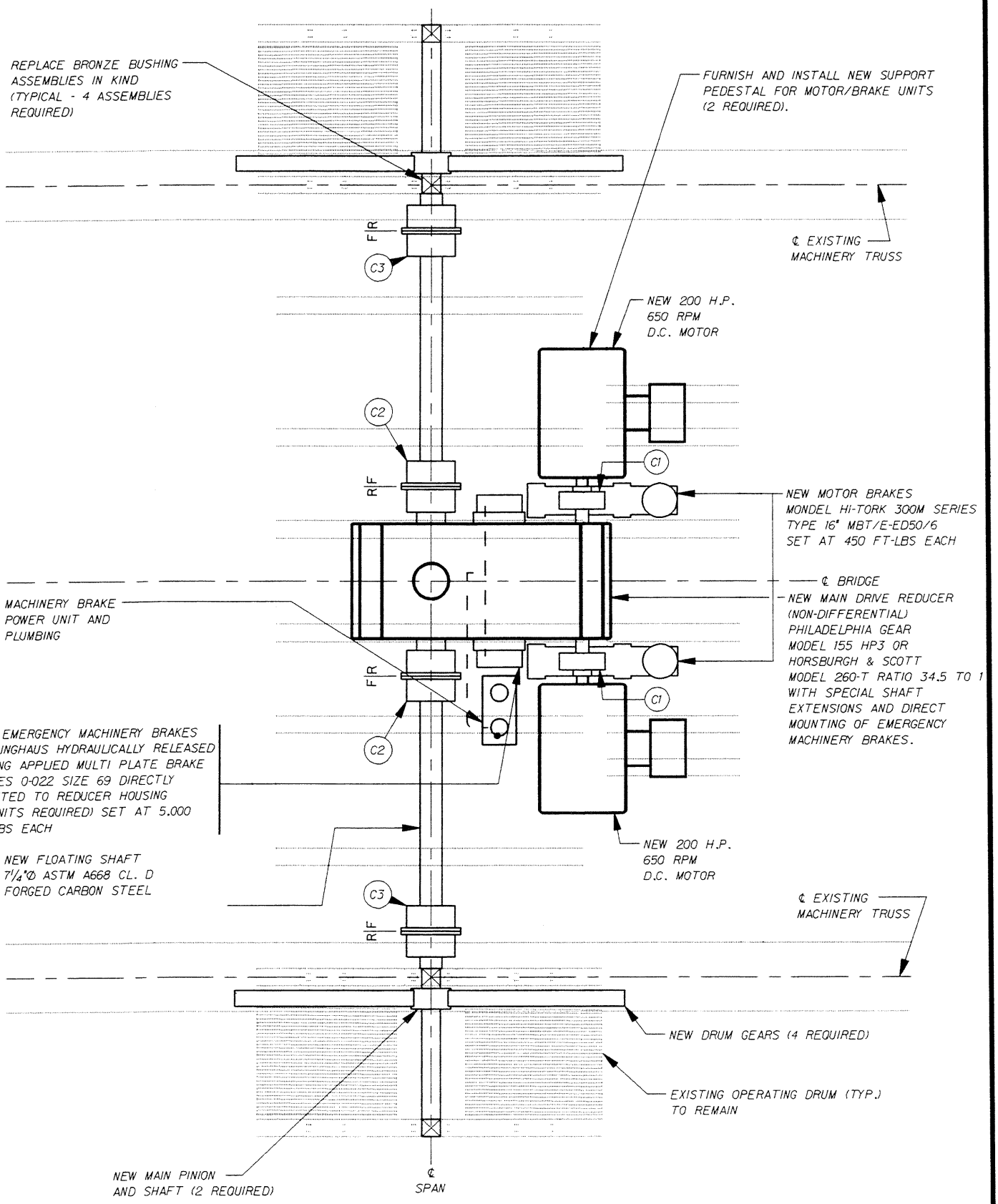
The replacement of the drum gears is probably the most unique feature of the machinery installation. F.D.O.T. had recently replaced the operating ropes on the drums. This was a complicated and intense effort. Since the existing drum gears were one piece castings and were located inboard of the drum shaft bearings, they could not be removed or replaced in one piece without dismantling the entire assembly including the removal of the operating ropes.

To avoid this major disassembly task, the new drum gears would be split into segments, not one piece as were the original gears. The original drum gears had 87 teeth, a 2-1/4" circular pitch, and a 62.309" pitch diameter. The new assembly was broken into three segments, each segment having 29 teeth and 8 mounting bolts. The circular pitch and diameter was unchanged, however, the face width was increased from 4-3/4" to 6" improve the tooth strength. ASTM A148 Grade 80-50 was used to fabricate the four new segmental drum gears.

Survey equipment and pitch radius jigs were used to field align the new segmental drum gears to the existing drums. After final alignment was achieved each mounting bolt was reamed to final size and new A449 high strength turned bolts were installed.

Conclusion

The replacement of the operating machinery on the Main Street Lift Bridge in Jacksonville required unique design concepts and installation methods. Installation was performed with little inconvenience to the public. Proper planning, field measurements and detailing all aided in the relatively trouble free installation of the new machinery on this project. The Main Street Bridge , with its new mechanical system, electrical system and rehabilitated structure should provide many more years of reliable service to the people of Jacksonville and to mariners on the St. John's River.



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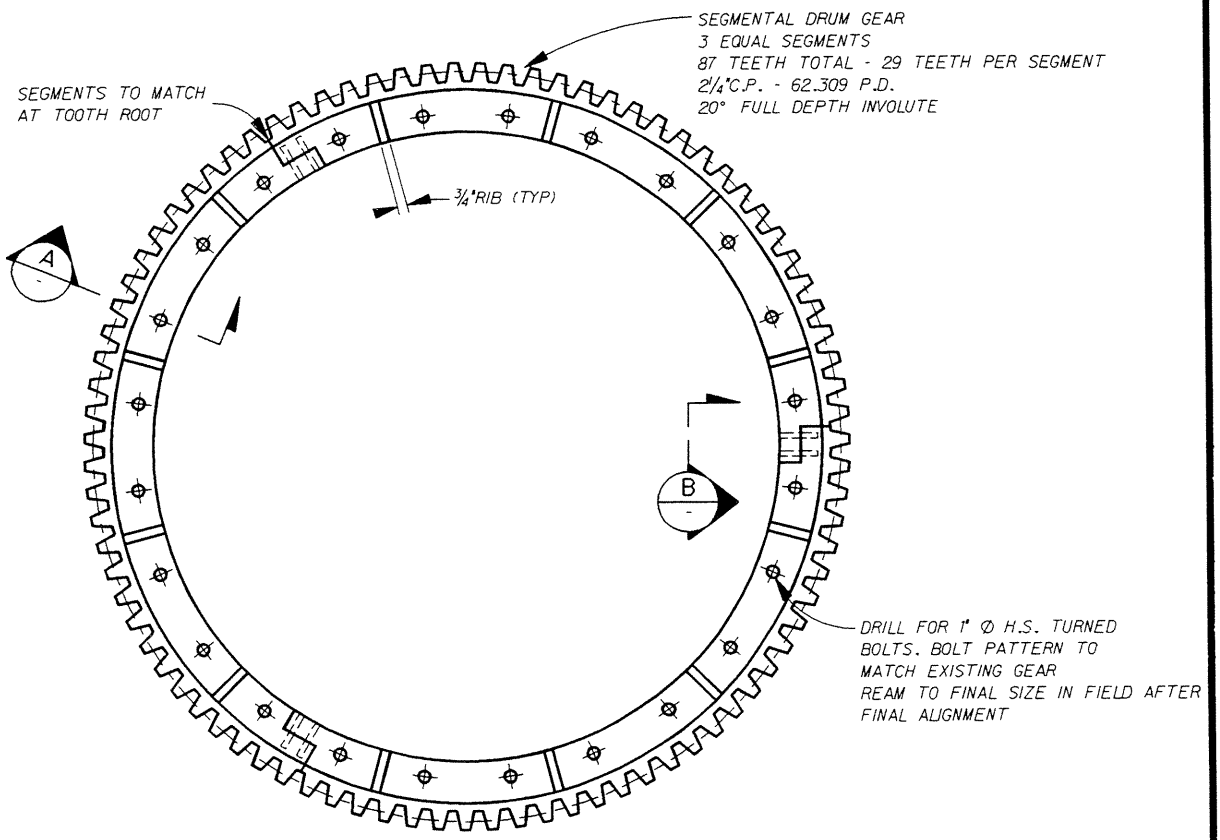
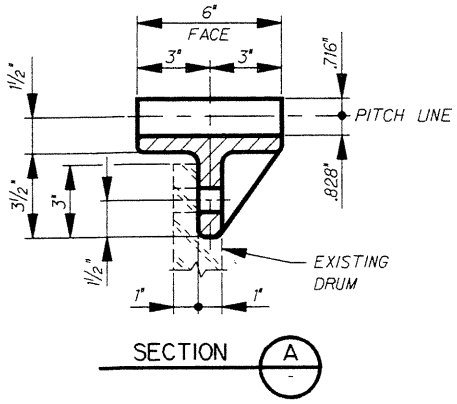
MAIN STREET BRIDGE

MACHINERY LAYOUT

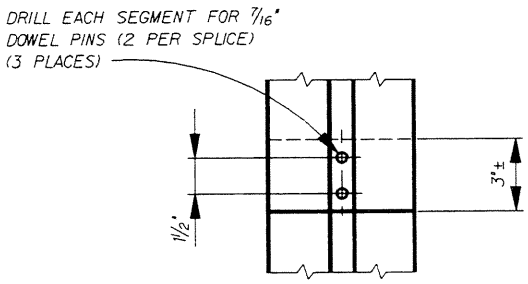


DRUM GEAR - (4 REQUIRED)

CAST STEEL ASTM A148 GR. 80-50



SECTION A



VIEW B

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MAIN STREET BRIDGE

DRUM GEAR DETAILS

Special Thanks

I would like to give special thanks to the following people and companies who all contributed to the successful completion of the machinery replacement on the Main Street Bridge:

Superior Construction
Sea Coast Metal Products
Steward Machine Company
Foote-Jones/Illinois Gear
Clark Engineering

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