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"Replacement of a Electric Relay Based Control System and Distribution System to an Electric Control System with PLC and Solid State Drive Controllers on a Railroad/Highway Swing Span"

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Replacement of an Electric Relay Based Control System and Distribution System to an Electric Control System with a PLC and Solid State Drive Controllers on a Railroad/Highway Swing Span

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INTRODUCTION

In partnership with the Burlington Northern Santa Fe Railroad, HNTB has completed a major renovation of the electrical control system and drive system on their bridge located on a major North-South route between Chicago, IL and Fort Madison, IA. Bridge 231.4 is a 65 year old, double track, double deck 434 foot swing span located in Fort Madison Iowa. The existing control system consisted of machine tool relays, drum switch drive motor controls and four 75 horsepower wound rotor motors. The rehabilitation was scheduled to be a three phase, four year project. All construction was performed by contract.

The objective of this paper is to inform the reader of the key elements involved in the design and construction of the three phase project. This paper will discuss the design concept and the construction sequencing to complete the rehabilitation of BNSF Bridge 231.4

HISTORY

The original bridge structure was built in 1934. The original bridge electrical control system was replaced in the 1954 with additional modifications to permit operation of the bridge from a toll house located on the roadway level in 1973. The bridge electrical control system had deteriorated to a level that resulted in numerous maintenance requirements, bridge operational failure and train delays on the BNSF main line from Chicago Illinois to Los Angeles California. After a failure resulted in the delay of several trains in March, 1997, HNTB asked to make recommendations for the repair of the control system to eliminated the system failure and train delays.

INSPECTION

HNTB conducted an inspection of the bridge and determined that the existing control system was in a state if disrepair with several conductors deteriorated to a level resulting in poorly grounded circuits and many electrical components in need of replacement. The railroad had experienced several system failures in the months prior to the inspection which resulted in the delay of trains throughout the BNSF system. The electrical control system had been modified several times over the years and was a mix of electrical equipment with different levels of control voltages.

SOLUTION

The solution was to replace the existing distribution system and relay based control system with a new Motor Control Center, a Programmable Logic Controller (PLC) and Thyristor Drive Controllers for the existing wound rotor motors. The existing electrical control system would need to remain in service during the installation of the new electrical system while the new system was installed in a phased installation process. The existing equipment house would need to be slightly modified to permit the installation of the new electrical equipment and provisions to permit temporary operation of the span with the new equipment from the equipment house would be required. The new control system would require a design approach that would permit the bridge to remain in operation under the existing control system while implementing the new control system without experiencing a closure to either rail traffic or marine traffic. Since the bridge had four drive motors, it was determined that 2 (two) drive motors could operate the bridge under all but Condition C situations as described by AREMA specifications. Therefore, during the change-out and start-up period, the existing control system would utilize only 2 drive motors to operate the bridge while the new control system would go through start-up utilizing the remaining 2 drive motors. To facilitate this change out sequence, one drive controller would be used to control two of the drive motors. Since the four drive motors were located equally spaced in quarter sections at the center of the swing span, each drive controller would operate the two drive motors that are diagonally opposite of each other. This would insure that the torque applied to the turning machinery during the two motor operation would be equally distributed.

PHASE 1 INSTALLATION

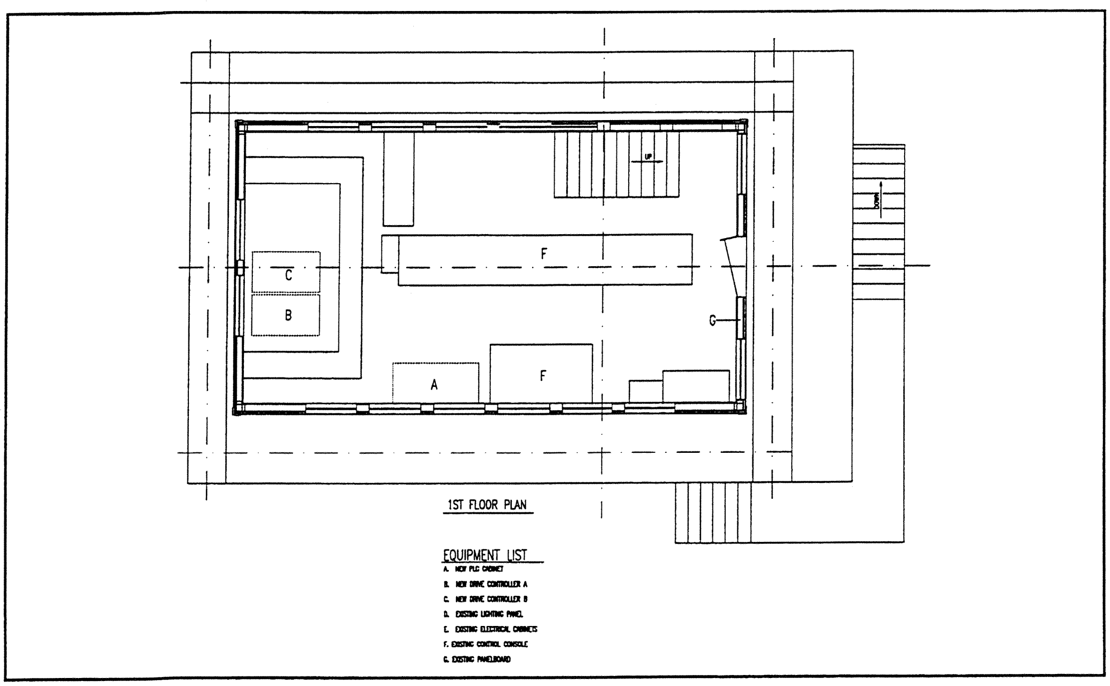
The first phase of the rehabilitation would be the installation of all field wiring for all devices on the bridge. These included the traffic signals, traffic gates, rail locks, end wedges drive motors and span control equipment. This required the design of the electrical control system to a level the contractor could order all necessary wiring and conduit which would be a part of the new system. New service platforms were built and terminal boxes were placed near the field equipment. All conductors were terminated both in the equipment house terminal box and in terminal boxes located near the field equipment. To facilitate the installation of the new conductors, cable tray was utilized to route the cables from the equipment house to the center area and to each end of the bridge. This method allow for the major portions of field wiring to be installed so that all remaining final connections would require short connections using flexible conduit during the final change-out period in the final phase.

The new control system as established around a standard control voltage of 120VAC and would have a remote control panel located in the toll house as the primary location for bridge operation once the new system was installed.

Since the contractor would be installing much of the equipment during the early phases of the work, the design need to be prepared very similar to a design build project and close coordination with the contractor would be required during all phases of the project.

PHASE 2 INSTALLATION

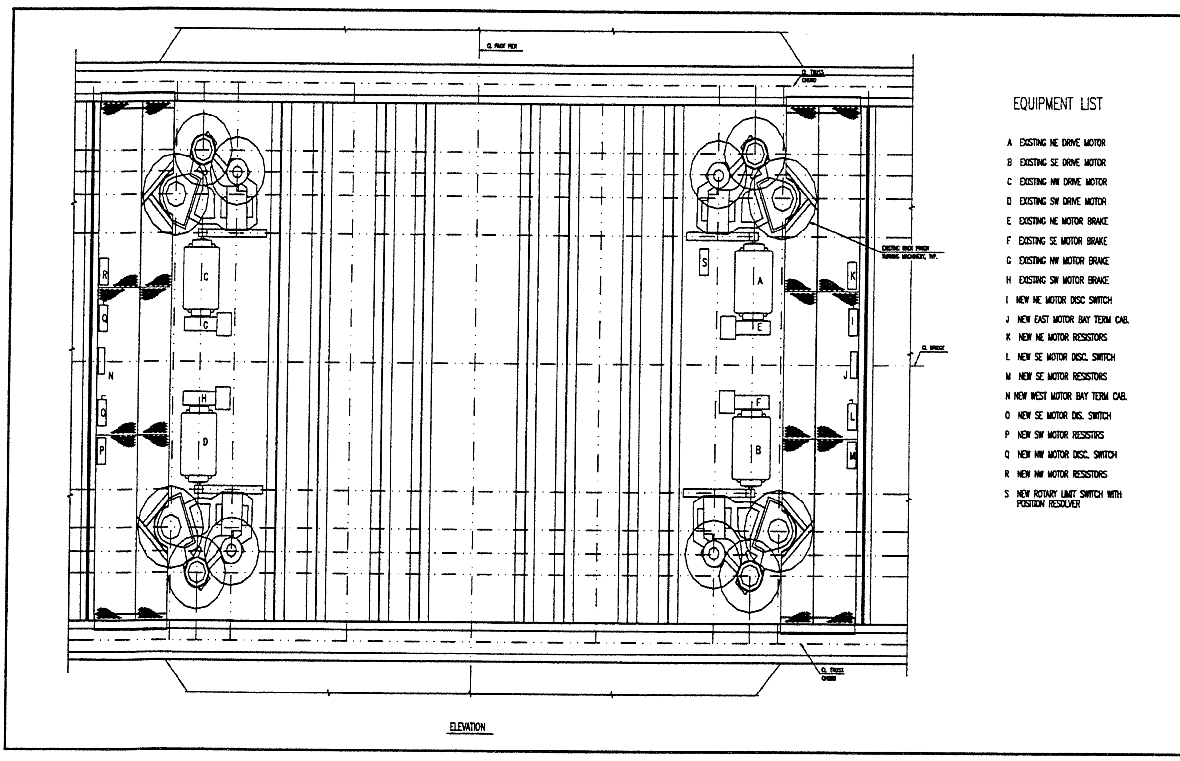
The second phase of the project consisted of making modifications to the equipment house that would permit the installation of the new electrical control equipment and drive controllers without disturbing the existing electrical control equipment. New access doors were added to the equipment room to permit the installation of the new PLC Cabinet and the two Thyristor Drive Controller Cabinets. Additional modifications were made to the equipment house, toll house and swing span in preparation for the installation of the new electrical control equipment during the third phase. Prior to the installation of the new control equipment, the PLC equipment and drive controllers were given a thorough operational test at the system vendor's facilities to eliminate as many problems as possible and ensure the system is operational prior to final installation and start-up in phase 3. In addition, new limit switches were installed on the rail locks and end lifts to permit operation of the swing span under the new system while retaining the old control system in operation during the change over period.



Equipment House with Existing and New Control Equipment

PHASE 3 INSTALLATION

Phase 3 consisted of installing the PLC equipment and Thryistor Drive Controllers. Field connections were made to the equipment and two of the drive motors were electrically connected to their respective drive controller in preparation for system start-up. The electrical system was designed to permit the operation of the bridge under the existing control system in addition to the new control system. A system of "transfer switches" were incorporated in the installation to permit a quick change of the control system for operation of the traffic signal, traffic gates, end lifts and rail locks. The first stage of the start-up process involved the operation of the bridge with two motors on the new drive controller. Once operational on the new control system, the remaining traffic control equipment, end lifts and rail locks were changed over to the new control system with little complications due to the transfer methods developed for the first stage of the start-up procedure. During these final stages of work the BNSF experienced no delays or significant slow downs to rail traffic.



Existing Drive Machinery Layout at Center of Span

PLC AND DRIVE SYSTEMS

The control system used and Allen Bradley PLC 5/20 processor. The system was programmed to automatically draw all rail locks, pull both end lifts. Once accomplished, the control system issued a permissive to permit the operation of the main drive motors and open the span. Since the bridge as a double deck structure and the bridge operator was located on the highway level of the bridge, a safety process was designed into the control system which would sound warning sirens located on the track level prior rotating of the bridge. This would allow maintenance personnel adequate time clear the areas of moving machinery before the movement process would start. Once the system has sounded the warning sirens, confirmed that all systems have properly unlocked the bridge, the bridge operator can start the four main drive motors to start the bridge. The main drive motors were controller in pairs by two Hubbell, 150 HP Thyristor drive controllers. In addition, the PLC was programmed to monitor the operation of the bridge at all times and to alert the bridge operator via alarm indications to potential problems. The new control system also provided to the operator span position via digital display units that were accurate to one tenth of a degree using a Gemco model 1994R decoder display with a 1000 count resolver encoder. The resolver encoder was a Gemco model SD028 resolver encoder mounted within a Gemco model 1980 rotary limit switch enclosure.

CONCLUSION

Each phase of the process presented minimum problems. Phase 1 took less that 5 months to complete in spite of the amount of trains the contractor had to contend with during this installation process. This completion time placed the construction process ahead of schedule and permitted the phase 2 procedure to begin earlier that scheduled. With the advancements made during the phase 1 work, the final start-up was able to take place approximately 3 months ahead of the original schedule. The new electrical control system has, to date, proved to be a highly reliable system. The success of the project can directly be attributed to the efforts of the design team, the electrical contractor and the control system vendor. The careful analysis and planning of the construction sequence resulted in a minimum of inconvenience to the mariners and no train delays to the railroad. Since the bridge has been in operation under the new control system, operational problems experienced have been less that the normal problems expected with a new electrical control system and drive system.