High Capacity Cable Bus Updates Plant's Primary Power

This electrical modernization project includes installation of multiple runs of cable bus, pulling of 15kV cables, terminations, and switchgear.

Robert J. Lawrie, Senior Editor

High reliability of power was the primary concern during design and installation of a new 6.9kV distribution system at the U.S. Steel Irvin Plant near Pittsburgh, Pa. The major portion of the work was the installation of six long runs of cable bus, each consisting of nine 750kcmil, 15kV, shielded cables; new disconnects for each of three 25/40MVA, dual-secondary transformers; and three new 3000A, 7.2kV-rated switchgear line-ups in the main motor room.

Design teamwork

During early stages of the project, a design team was formed, consisting of engineers from U.S. Steel; R.T. Patterson, an engineering firm in Pittsburgh; and Chapman Corp., a multi-discipline contractor headquartered in Washington, Pa. After comprehensive engineering and cost studies, the team added several other vital factors to the design. These included flexibility for planned changes, ease of troubleshooting and maintenance, and practical costs.

A recurring source of trouble was a large run of 2000A busway that extended from the outdoor substation transformers, through an 800 ft underground and underfloor tunnel, to an existing switchgear lineup. Dampness in the outdoor tunnel, as well as heat and other contaminants inside caused problems at busway section connections, where tape-type insulation had aged. This insulation had deteriorated and no longer insulated and supported the busbar properly. Also the existing switchgear was old and many circuit breakers and fused switches were worn out and needed almost constant maintenance and repair.

The design team agreed that the best way to meet design objectives was to use only the highest value components. For the 6.9kV feeder, they selected cable bus. (See Article 365 of the NEC.) This feeder consists of 54 separate 15kV shielded cables within the cable bus system. The main ad-

▲ **Photo 2.** *Dual runs of bottom section of cable bus are stacked as they leave a disconnect vault out-of-sight at right. Vern Fordice is checking fit of cable support block. Steel support system for cable bus is assembled first; then the bottom 12-ft cable bus sections are installed; then, support blocks are positioned. Next, cables are pulled and set in place on the blocks, and the next level of support blocks are installed. This is repeated until the ventilated top cover of the system is in place. In background, bottom section turns to rise up the steel tower to the roof.*

▲ **Photo 1.** *Two vacuum circuit breakers, installed in an outdoor enclosure in the substation yard are inspected by Bruce Barr, project superintendent, Chapman Corp. Each breaker, rated 2000A, serves as a secondary disconnect for each transformer secondary winding.*

▲ **Photo 3.** *View from above shows stacking of dual-bottom cable bus sections. At left, sections enter supports to vertical tower. Electrician has installed second layer of three conductors of nine to be installed in the cable bus. He is using a ratchet wrench to bolt the maple support block into place.*

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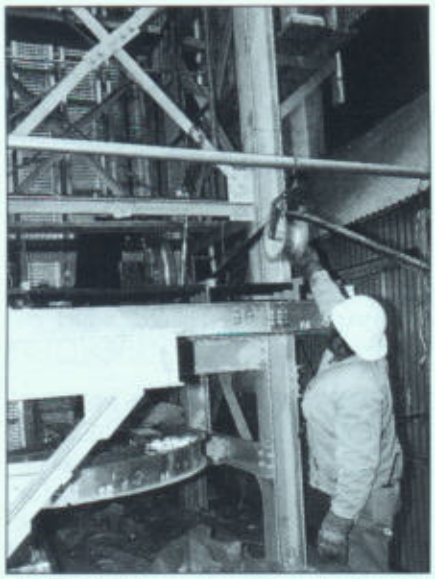
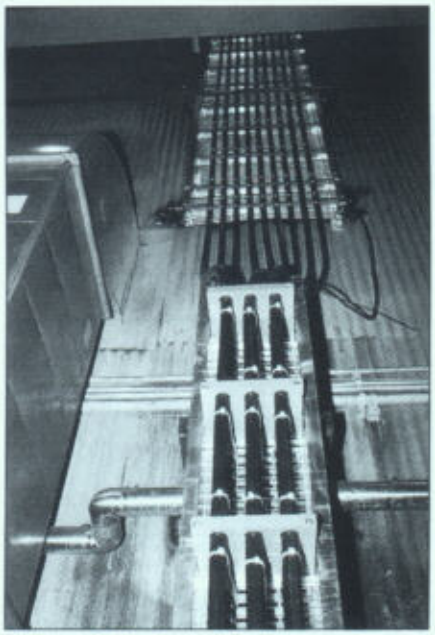


▲ **Photo 6.** *Electricians (one behind steelwork) guide cable through two sheaves and up the tower assembly and in place within the bottom cable bus section. Support blocks are designed to hold vertically installed cable effectively and to withstand any short circuit forces. Chapman engineers also decided to add cable tie supports as an additional measure to keep the cables in place.*



▲ **Photo 9.** *Vertical cable bus tray is used in motor room to provide clearance for movement of large bridge crane. The tray is 36 in. wide × 6 in. deep. Conductors revert to the 12 × 12-in. cable bus at appropriate level and continue to underfloor or to top of 7.2kV-rated switchgear. The arrangement of cables in the cable bus minimizes inductive reactance, which is why this configuration is preferred.*

▲ **Photo 7.** *Pulling winch mounted several feet beyond end of last roof-mounted pullbox provides the power to pull the cable from the ground-located reel. Pulling rope, which is ¾ in. dia, travels over vertical rollers mounted on steel in foreground and sheave near winch.*

▲ **Photo 10.** *Alan Patton, electrical engineer for Chapman Corp, inspects cable bus near floor just before it enters trench that extends to a 7.2kV-rated switchgear in the center of the motor room. The trench, which runs along the length of the switchgear, is 2 ft wide and was cut out of 20 in. thick concrete floor.*

◄ **Photo 12.** *New 7.2kV-rated, 3000A switchgear in center of motor room is being checked by Bill Pruss, U.S. Steel. (Heat-shrink terminations are being installed on opposite side). Cubicles contain 1200A vacuum circuit breaker that supply unit 6.9kV/480/277V substations, 6.9kV rolling mill motors, huge motor-generator sets, or rectifiers that supply DC power for DC rolling mill motors.*

▲ **Photo 8.** *Typical pullbox is about 5 × 4 × 4-ft. Cable bus conductors enter at right through an environmental seal; then electricians carefully feed cable down to teams of electricians at various levels in the motor room. The nine conductors are arranged in a parallel arrangement to enter a 36-in wide vertical cable bus tray going down to the motor room. Grounding conductor from cable bus connects to the box and continues down to the vertical cable bus tray.*

▲ **Photo 11.** *Cables extending up from trench at switchgear terminate at the main 3000A bus. Terminations are being made up with heat-shrink termination kits and long-barrel, double-hole, copper compression connectors. Flat copper braid from each conductor has not yet been connected together and grounded to grounding bus in the switchgear.*

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vantage is that each cable runs continuously for over 800 ft without interruption from the transformer disconnect to the switchgear. Also, these runs are outside and easily accessible so that any change of direction during construction or later during alterations can be easily made. The cable bus also has the capability to withstand heat, weather, and contamination. It has a very high open-air ampacity and is not subject to thermal expansion or contraction problems.

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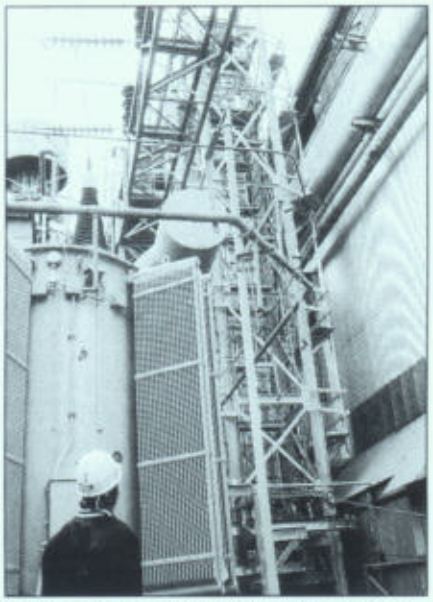
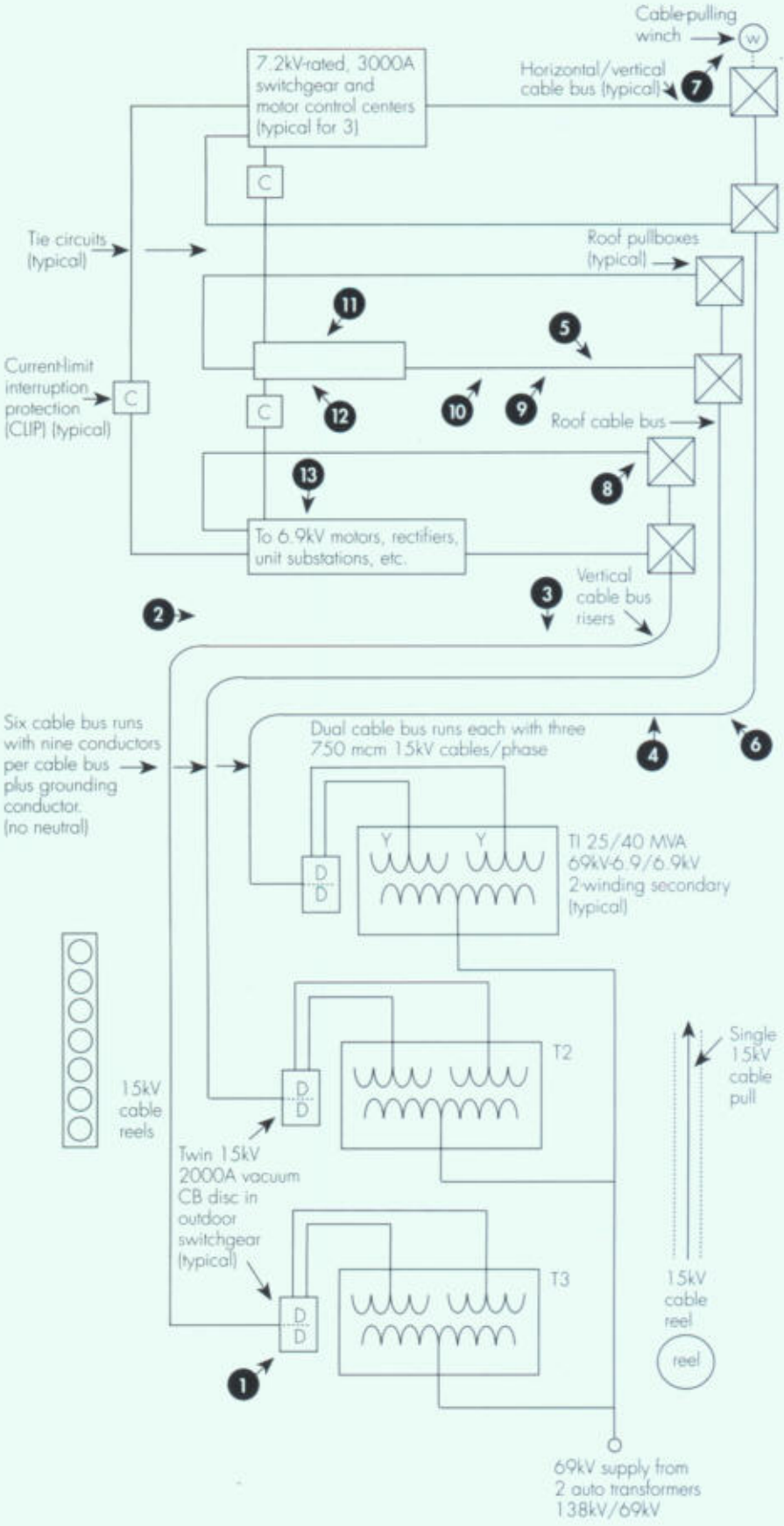


▲ **Photo 4.** *The 60-ft high vertical tower, designed to support the weight of 54 750kcmil, 15kV conductors in the cable bus, was built in three 20 ft sections that were lifted into place with a huge 300 ton crane. One of three 25/40MVA transformers is at left.*

▲ **Photo 5.** *Three-stack cable bus running along the roof area comes from the vertical tower in background. Note that the top cable bus has all nine cables in place. Only the top cover remains to be installed. Just below, support blocks are installed in bottom sections, and the first cable is in process of being pulled into place. Note, behind ladder, how stacked cable bus peels off vertically into pullboxes for descent into plant motor room.*



Modified one-line/plan diagram shows power distribution system with major components arranged to correspond closely to actual layout. Numbered arrows show angle at which photo was taken and are keyed to photos.

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Other distribution equipment includes transformer disconnects, which are dual vacuum circuit breakers. All terminations are of heat-shrink design. The new 7.2kV-rated switchgear lineups have 1200A drawout power circuit breakers, and have tie circuits with current-limiting interrupting protectors (CLIPS), which will allow the plant to continue operation using any one of the three main transformers.

Additional design details, cable bus installation methods, pulling of nearly 1000-ft cable runs, and other installation techniques are shown in the accompanying diagram and photos, which provide a photo tour of the project. •

◄ **Photo 13.** *Two additional 7.2kV-rated switchgear line-ups, located below incoming conductor near a wall in the motor room, also replace old, worn switchgear. Above the switchgear, cables in 36-in. cable bus tray will revert to standard cable bus configuration. The electricians are installing cable bus for dual feeds to each line-up of switchgear.*

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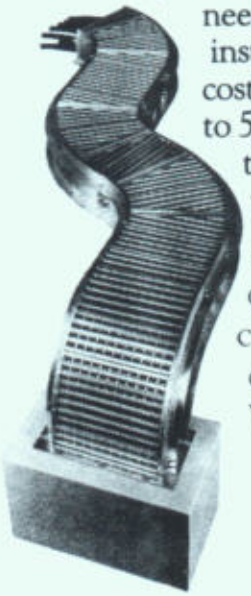

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