the boxes all of the same size, the shelves or racks can easily be constructed to permit the boxes being mounted in tiers. Any individual box can very easily be removed without disturbing the others, which is not the case when the boxes are stacked on top of each other and bolted together.

In the steel mill and other industries, where a shut down for a comparatively short time at a critical period causes the loss of hundreds of dollars, it pays to be prepared for all emergencies. This is especially true of control apparatus. To meet these emergencies spare control panels are installed and the switches and wiring are so arranged that in case any panel fails the motor to which this panel is connected can instantly be connected to the spare panel. Economy will dictate the number of spare panels necessary. One noteworthy instance is a case having only one spare panel for the auxiliary of a blooming mill, in which a total of less than one hour of shut-down of the mill was chargeable to the control during the period of one year. In this installation the change-over switches were hand operated and necessitated an attendant, but more recent developments have called for automatic throw-over devices under the control of the operator.

KNOCKING DOWN A 120-TON ELECTRIC LOCOMOTIVE FOR EXPORT

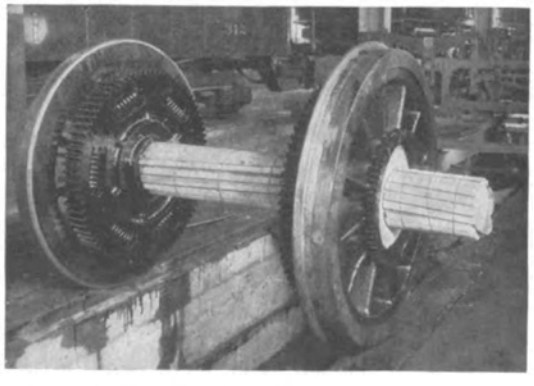
By W. D. Bearce

Railway and Traction Engineering Department, General Electric Company

The electrification of heavy steam railroads is rapidly becoming of world-wide interest. A current installation is taking place in South America where a Chilian ore hauling road is being equipped for electrical operation. The transportation difficulties likely to be encountered in the export shipment of heavy electrification material are well illustrated in the following article which describes the procedure followed in tearing down and shipping a 120-ton electric locomotive to facilitate handling by the existing crane equipment. A brief description of the road upon which these locomotives are to operate is also included.—Editor.

The export of electric locomotives up to the present time has largely been limited to small units of such size that they could be transported completely assembled and ready for service. In the case of the Panama Canal equipment, locomotives weighing 41 tons each were shipped to New York City and loaded completely assembled on the decks of the ocean-going freighters which carried them to the canal locks. Several other complete locomotives have been shipped on the decks of the large liners which are accustomed to handling heavy packages.

In the case of the 120-ton electric locomotives which were recently shipped to the Bethlehem-Chile Iron Mines Company at Tofo, Chile, there were no cranes of sufficient capacity either on the vessel or on the docks at the destination to lift the complete locomotives to and from the deck of the vessel.



Pair of Driving Wheels, showing Method of Protecting Axle



Method of Packing Contactors

The capacity of the unloading crane at Cruz Grande is approximately 35 tons and the capacity of the ordinary deck hoists on the freighter S. S. "Celia" is approximately 5 tons each. It was therefore necessary to disassemble these locomotives in somewhat the

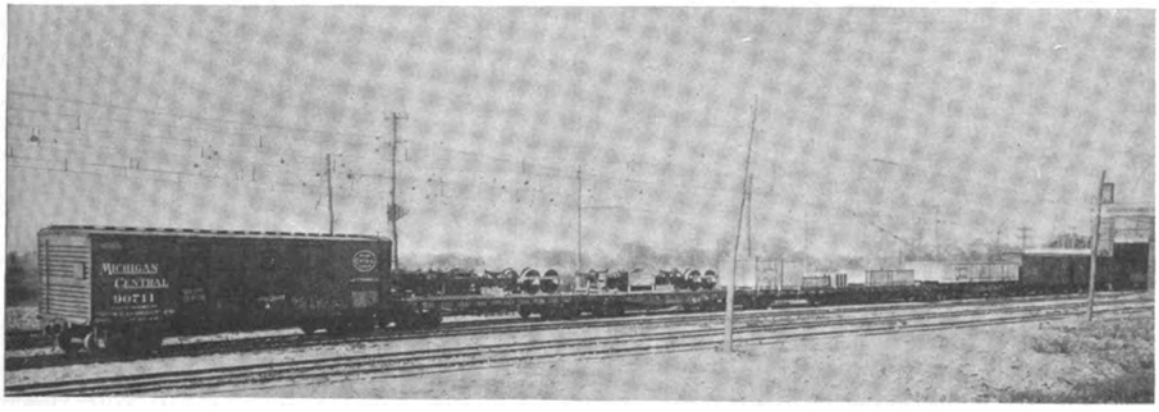
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same manner as "knock-down" furniture, before shipment.

The locomotives were first assembled and tested at the Erie Works of the General Electric Company operating under the various conditions of service expected in actual operation. These tests included operation under load on 2400-volt direct-current trolley, operation of regenerative braking equipment and numerous other tests to determine the reliability of the various parts of the equipment. Other 2400-volt locomotives which were being tested at the same time for the Butte, Anaconda & Pacific and the Canadian Northern electrifications were utilized to fully test out the regenerative braking feature.

process of knocking down this locomotive began with the removal of the pantograph trolleys followed by taking off the hatch covers of the roof, thus exposing the control and regenerative braking equipment. Through these openings the various smaller parts of the equipment were removed, including the motor-generator set, the air compressor and control equipment supports with contactors.

While these parts were being boxed for shipment, the roof was removed in one piece, weighing about 5 tons. In the building of the locomotive cab the roof and sides were assembled by the use of bolts and nuts with suitable inside flanges to facilitate dis-



Locomotive Loaded on Flat Cars

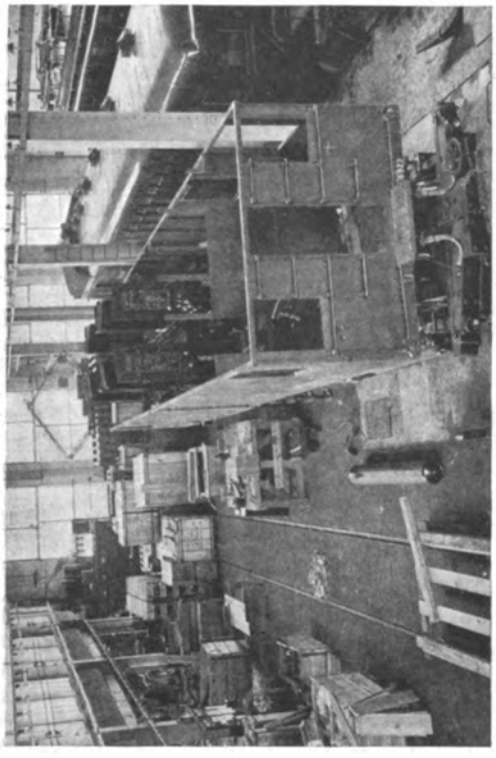
In general, the Bethlehem-Chile locomotives were constructed along the lines of a half unit of the Chicago, Milwaukee & St. Paul locomotive without the guiding trucks and without the provision for the heating of passenger trains. The complete unit weighs 120 tons and is equipped with four GE-253, 1500/3000-volt motors having a normal one hour rating of 240 h.p. on 2400 volts. The locomotives are geared for a speed at rated load of 12.2 m.p.h. and are capable of exerting a tractive effort of 42,000 lb. at the hourly rating. Each locomotive is equipped with Sprague General Electric Type "M" multiple unit control and regenerative electric braking apparatus similar to that used on the Chicago, Milwaukee & St. Paul main line locomotives.

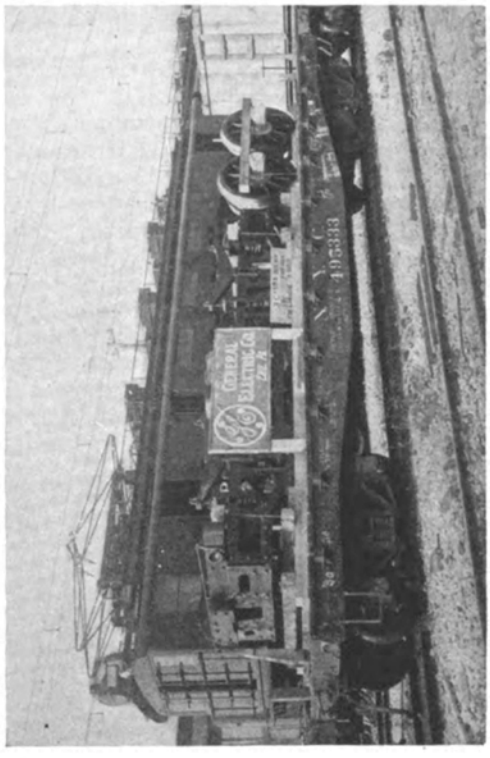
After tests were completed the locomotive was disassembled, care being taken to mark all parts so that the locomotive could be reassembled exactly as it stood in test. The assembling. The usual construction of a cab of this kind would be by the use of solid rivets.

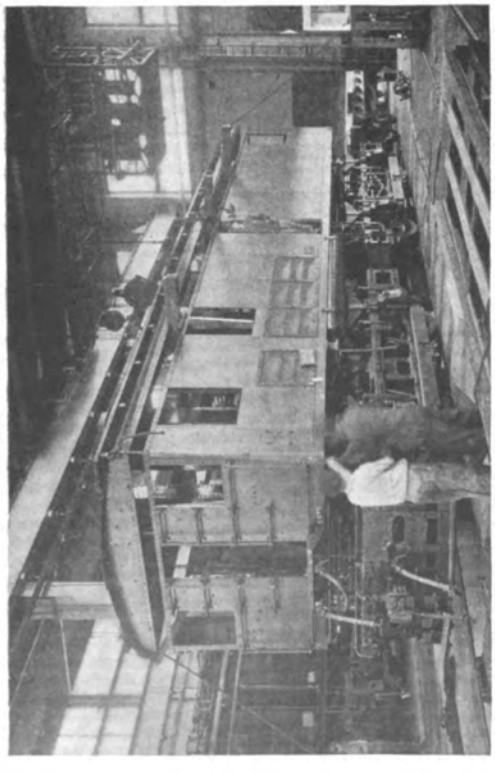
On account of the flexibility of the roof caused by its extreme length (about 45 ft.) this was packed for shipment upon the platform of the locomotive after all equipment had been removed. After the removal of the roof, all electrical connections were opened up, the various panels, contactor compartments and other apparatus was removed and the sides and end framing taken down. The platform proper was the heaviest portion of the shipment weighing about 16½ tons. Together with the roof and the necessary boxing for shipment, this package weighed nearly 23 tons, the heaviest single article in the shipment.

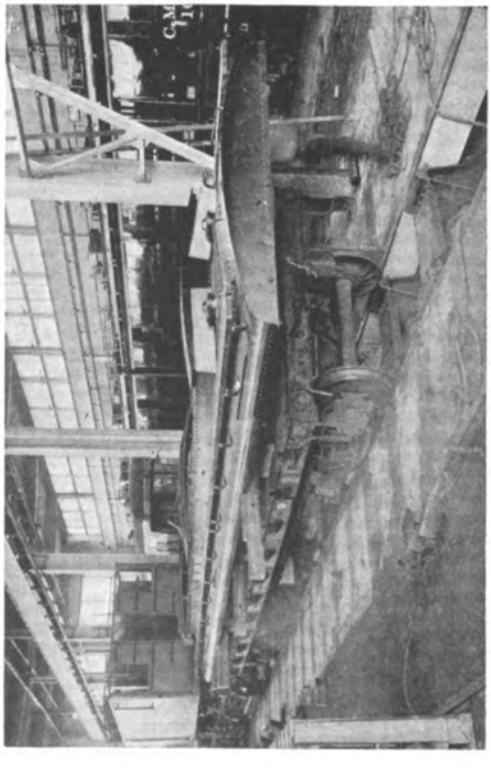
The motors were then removed from the trucks, brake rigging and other accessory apparatus was also disassembled, the trucks separated and the axles removed. The

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Different Stages in Knocking Down a 2400-Volt Locomotive for Export. This Locomotive was Shipped to the Bethlehem-Chile Iron Mines Company, Tofo, Chile

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larger parts of the shipment for a single locomotive, together with weights and dimensions, are given below.

Weights of Principal Packages

Platform and roof (boxed)	45,800 lb.
Truck frame (unboxed)	24,000 lb.
Motor-generator set (boxed)	14,000 lb.
Traction motors (boxed, each)	12,000 lb.
Sides of cab (boxed)	10,000 lb.
Wheel and axle (unboxed, each)	8,000 lb.
Air compressor (boxed)	8,000 lb.

Dimensions of Most Bulky Packages

	Length	Width	Height
Platform and roof	46 ft. 3 in.	10 ft. 6 in.	5 ft. 7 in.
Sides	21 ft. 4 in.	6 ft. 10 in.	4 ft. 2 in.
Contactor compartment	16 ft. 2 in.	9 ft. 3 in.	6 ft. 10 in.
Truck frame	24 ft. 5 in.	10 ft.	4 ft. 7 in.

When completely prepared for rail shipment, the 120-ton locomotive occupied eight cars, including three box cars for the small package shipment and five flat cars for the heavier packages and the unboxed parts. Upon reaching the Harlem River, these cars were unloaded onto one of the harbor lighters and transferred to Pier No. 33 in Brooklyn alongside one of the W.R. Grace & Company's South American freighters. The second locomotive was shipped on a typical boat, the S. S. "Celia," an all-steel vessel 414 ft. in length and 50 ft. beam having a displacement of 8350 tons with a cubic capacity of 10,000 tons. The speed of this vessel is approximately 10 knots requiring about forty days for the trip from New York to Cruz Grande. With the exception of the one 23-ton package, the entire shipment was stowed in the hold of the S. S. "Celia." This package was lashed to the deck and for this purpose the boxing had been so constructed as to make it weather-proof.

A brief description of the railway upon which these 2400-volt direct-current locomotives will be operated may be of interest since there are several features which are not ordinarily met with in railway operation. This road is 15 miles in length extending from the port of Cruz Grande (about 300 miles north of Valparaiso, Chile) to the mining village located about 4 miles inland at Tofo. The iron mine at this point is located about 2200 feet above sea level and consists of two hills of iron ore which is removed somewhat after the manner of trap rock quarrying.

The railroad is standard guage with a uniform grade of 3 per cent for 14 miles and about one mile near the mines with 1 per cent grade. The trains will consist of an electric locomotive and from 12 to 20



Parts of Locomotives on Lighter, Ready for Transfer to Steamship

fifty-ton ore cars. On account of the elevation of the line all the loaded cars come down grade. The motive power consists of three 120-ton, 2400-volt direct-current locomotives operating from a catenary trolley supported on concrete poles on the main line and from a 1200-volt third rail at the docks. It will be noted that while the mines are only four miles inland the railroad is 15 miles long. This circuitous route was necessary in order to limit the grades and the railroad is constructed in four loops, thus restricting the grade to a maximum of 3 per cent.

A power plant has been installed capable of furnishing sufficient power for mining and transporting 5000 tons of ore per day with provision for additional equipment to double the capacity. The present equipment consists of two 3500-kw. Curtis steam turbines generating 3-phase 60-cycle alternating-current and one 300-kw. 60-cycle turbine for lighting and small power service.

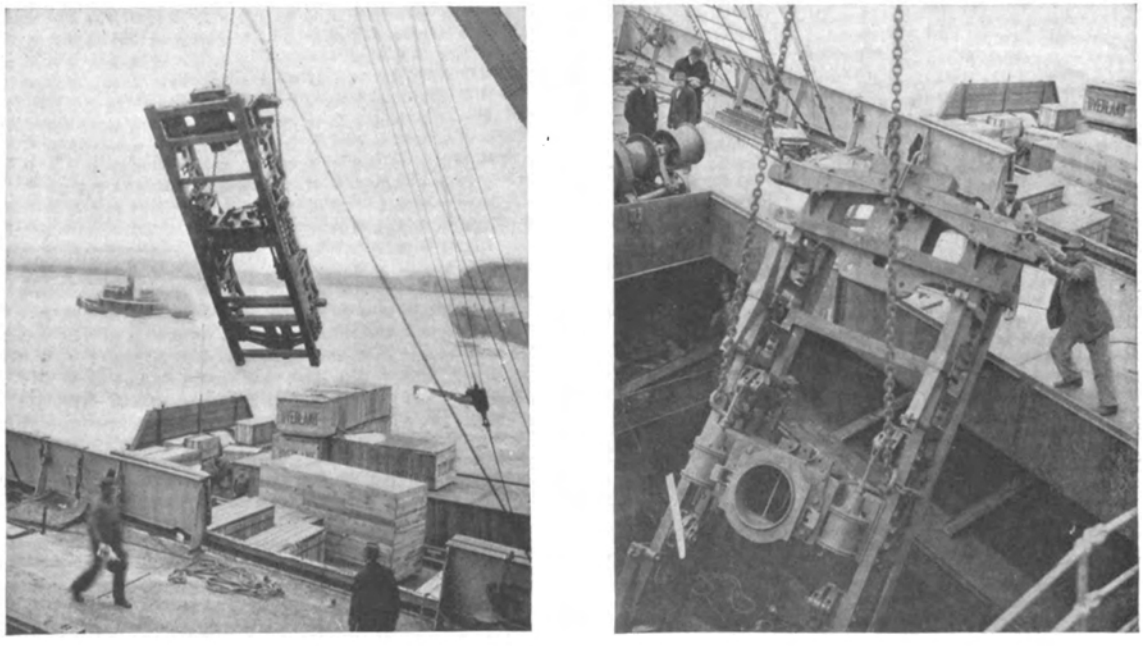
The railway substation equipment is located in the power house and consists of two 1000-kw. 2400-volt direct-current units operating directly from the 2300-volt alternating-current busses. On account of the circuitous route, there is considerable saving in feeder copper since a portion of the feeder takes a direct route from the mines to the docks.

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In order to provide for suitable control on heavy down grades, these locomotives are provided with regenerative braking equipment similar to that supplied the Chicago, Milwaukee & St. Paul Railway for use on its main line electrification. The regenerative braking control will permit the locomotives to descend the grades with ordinary loads without the use of air brakes, thus returning power to the system and also appreciably saving wear on brake shoes, wheels and rails.

descend at about 12 m.p.h. at which speed with a trailing load of 1500 tons the locomotive will return approximately 1000 kw. to the line. The schedule will be so arranged that the empty train going up will take power from a loaded train coming down the hill. Excess power will be absorbed by switching operations at the mines and docks.

At Cruz Grande is a steamer dock equipped with three tracks for delivering the ore to the boats and to the steel bins. On account of the travelling gantry crane which extends



Loading Truck Frame on Steamship Celia

The air brake equipment on these locomotives is also of interest since it contains several new features which will enable the locomotive to descend with a greater load than can be held back by the regenerative braking equipment alone. This outfit provides for either straight or automatic operation either on the train alone, the locomotive alone or both together. In addition to this the cars are provided with an empty and loaded-brake to secure maximum braking power on each car whether empty or loaded. The trains will

over these tracks, it was considered advisable to feed the locomotives on this section of the road from a 1200-volt third rail. Power is supplied from either of the 1200-volt generators of the 2400-volt motor-generator set.

In addition to the railway equipment, a substation is located at Tofo which receives power from a 22000-volt transmission line and supplies the crusher motors, pumps, lighting, large air compressors and 600-volt direct-current motor-generators for operating electric shovels and mine locomotives.

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