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West Breakwater Power Plant

By A. D. Williams

SYNOPSIS—A plant of unusual design installed by the Pennsylvania R.R. Co. to supply power for operating its ore dock and light and power to its yards and stations in the city of Cleveland.

In the design of this plant two classes of power were necessary in addition to both arc- and incandescent-lighting requirements: direct current at 250 volts for the operation of four 17-ton Hulett ore unloaders and a 15-ton ore bridge, and three-phase, 60-cycle, 220-volt power circuits for other requirements. Lighting is furnished from the direct-current supply to the unloaders, bridge and the power house; the yard is lighted from a mercury rectifier supplying 50 magnetite arc lamps, and 110-volt alternating current furnishes light to a machine and repair shop and supplements the yard lights.

nary. Coal is delivered in hopper-bottom cars which are run over and dumped into a track hopper about 60 ft. long on the west side of the building. The siding is 11 ft. above grade and extends along the side of the coal-receiving trough farthest from the building. This trough is so constructed that the coal will fall away from the receiving track into the portion of the trough covered by the monorail grab-bucket trolley, which runs on a track 72 ft. above grade; the bottom of the coal trough is 4 ft. below grade, making the total lift 76 ft. The trough gives a storage capacity of about 1500 tons, and two 100-ton bunkers serve each pair of boilers; provision has been made for a third bunker. The monorail coal trolley carries a three-ton grab-bucket and has a hoisting speed of 300 ft. per min. In order to prevent this heavy bucket from damaging the trough, an armor of old steel rails is placed in the bottom. The coal trolley runs on an I-beam track which forms a letter U. One side of the U is over the receiving trough, the curved portion is to the north of the plant, while the other leg is over the center

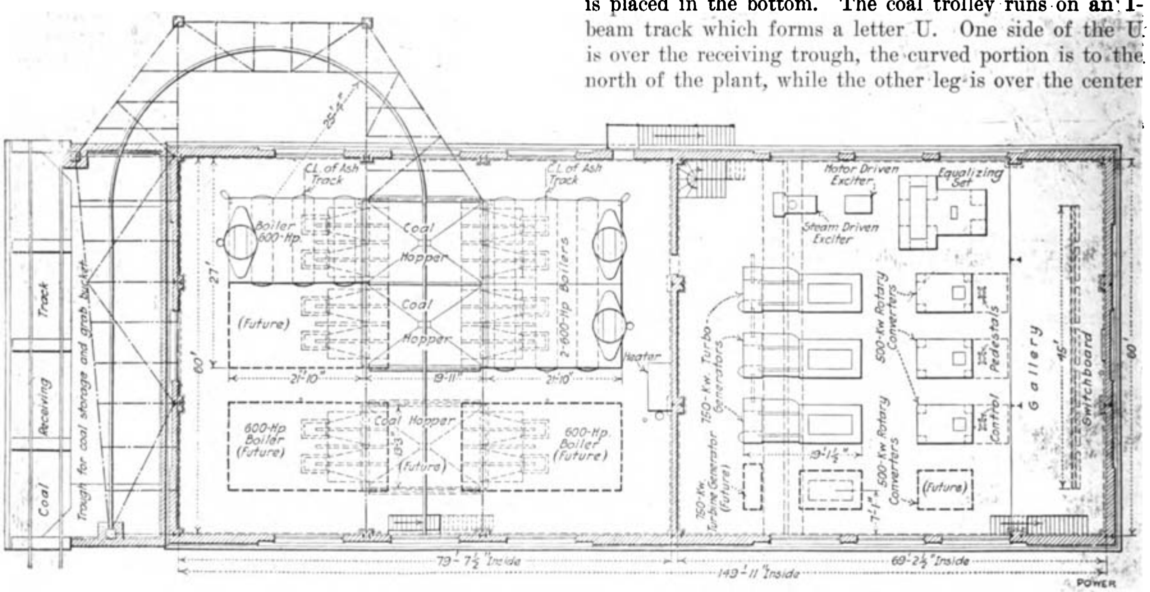

Fig. 1. Plan of Power Plant

Upon the west end of the new ore wharf of the company the plant is situated. The entire site of the wharf, covering about 40 acres, was originally under water, and it required about 1,000,000 cu.yd. of fill to bring the average grade up to about 4½ ft. above mean lake level. The basement floor excepting two trenches for railroad tracks, is six inches above this grade, or from two to six feet above the maximum and the minimum lake levels. The foundations for the building and machinery are carried by three hundred 30-ft. reinforced-concrete piles cast in vertical molds and after seasoning, driven through the fill. The basement structure, to the first-floor level, is of reinforced concrete and carries the boilers, the main machinery and the coal bunkers. The superstructure is of buff brick with cement copings, steel-framed windows and stone and cement trimmings, except the penthouse covering the coal bunkers and crusher, which is inclosed in cement mortar on metal lath.

The coal-handling arrangements are out of the ordi-

of the boiler room (see Fig. 1). This track is supported on high skeleton steel masts outside of the building, and the portion over the boiler bunkers is in a penthouse protecting the trolley when not in use and also containing the motor-driven coal crusher.

This crusher is mounted upon a track and can be moved over either of the bunkers; it is fed through a hopper from the grab bucket and discharges by gravity into the bunker. These bunkers have hopper bottoms and outlets with gates arranged to feed the boilers on each side of the firing aisle through a breeches spout of square cross-section having inverted V-spreaders at their lower ends which cover the full length of the stoker hopper. At first, these breeches spouts clogged and required beating with a slicebar to bring down the coal. This was remedied by drilling holes, pointing upward, close to the points where the scaffolds seemed to form and tapping them. An air line was then run to each spout from the compressed-air supply and connected to a pipe nozzle inserted through the spout holes. A lever whistle valve with a cord led to a convenient location enables the fireman to break up any scaffolds that form, by the air blast with 100 lb. pressure. This method has proved satisfactory.

Each boiler is fired by a Roney stoker set in a 4-ft. "dutch oven" or coking arch. These stokers are driven by small Westinghouse engines supplied with steam from the auxiliary header. The exhaust from the engines is led to perforated pipes from which it blows into the fire bed on the stoker. Live steam is also brought to jets on these stokers and perforated water pipes for quenching the ashes are installed in each ashpit, along both sides and at the center wall. Fig. 8 shows a section through one of these stokers and the steam piping.

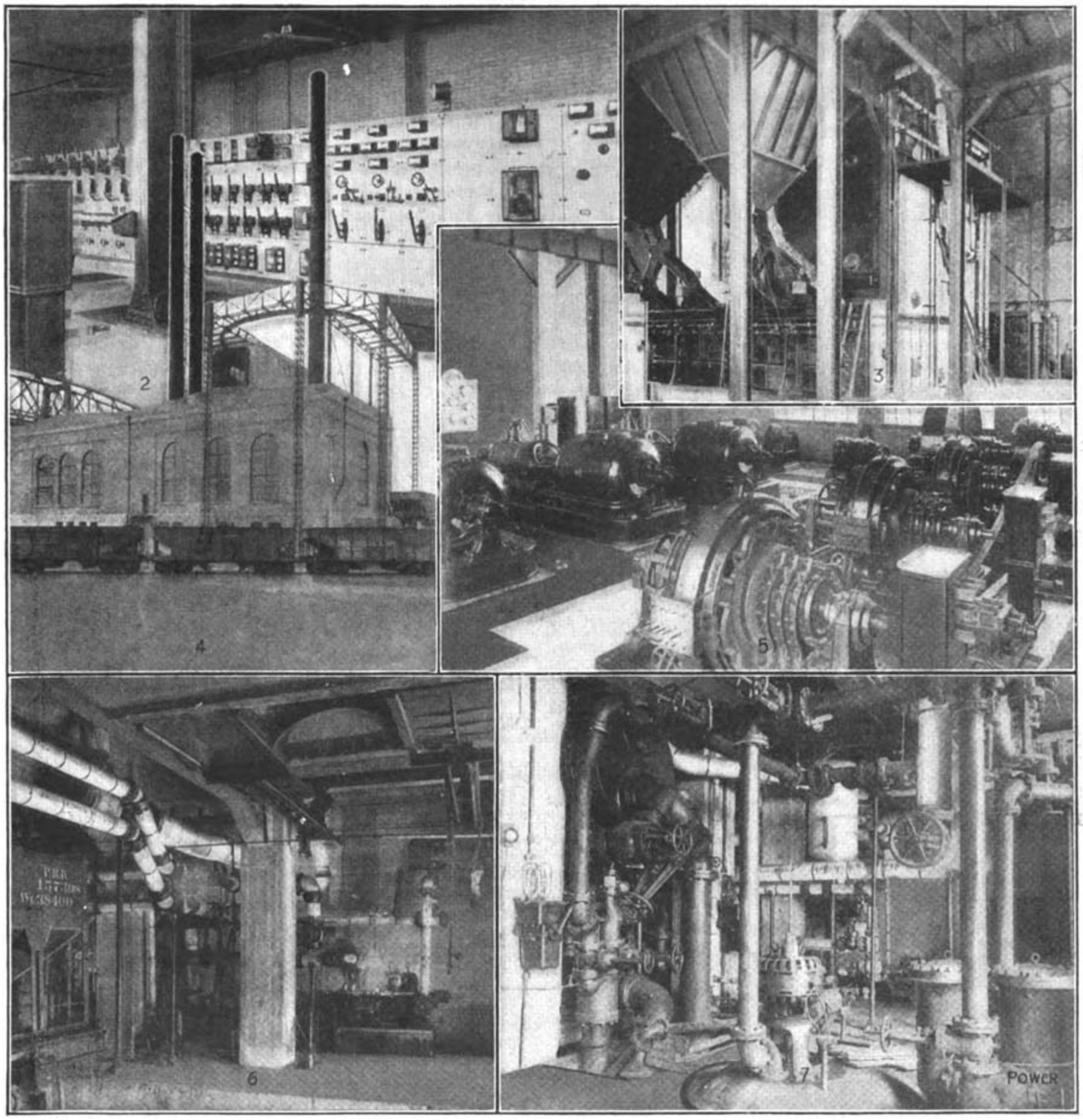

Fig. 2. Switchboard; Fig. 3. Part of Boiler Room; Fig. 4. Power House; Fig. 5. Turbine Room; Fig. 6. Basement beneath Boilers, Showing Means for Removing Ashes; Fig. 7. Pumps and Condensers

A feature of these stokers is their division into two sections with separate ashpits and doors for closing the ashpits and cutting down the draft when the boilers are banked. From the receiving hopper on the stoker the coal feeds down under a coking arch extending one-half the depth of the stoker grate. The rear half is covered by the regular arch gas baffle used in all Stirling boiler settings. Below the front portion of the grate there is a flat portion of the floor from which fine coal dropping through at this point may be recovered. The rear portion of the ashpit forms a chute, built in the reinforced-concrete floor, which is closed by a flat gate sliding horizontally. A railroad track runs under each row of boilers and the ashes are discharged into steel hopper-bottom cars kept standing in the basement. This arrangement eliminates all ash-handling machinery and

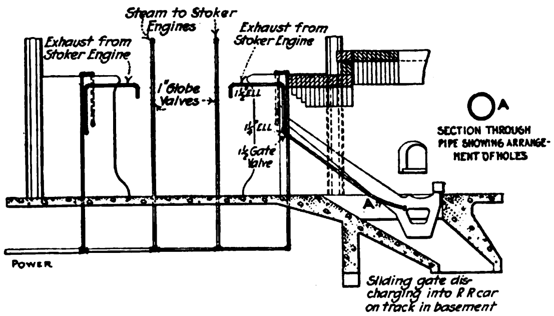

FIG. 8. SECTION THROUGH FURNACE

the loaded cars can be hauled out and dumped on parts of the wharf site where the fill has not yet been completed.

The boiler room contains three 600-hp. boilers with superheaters, each having an independent steel stack 66 in. in diameter and 125 ft. high. Two of the boilers are on the side adjoining the turbine room while the third is on the west side of the boiler room. The floor space is sufficient to install three additional boilers as soon as the demands warrant such extension.

There is a 2500-hp. feed-water heater in the boiler room and the exhaust steam from the feed and circulating-water pumps is led to this heater, which is supplied with water from the house-service system. From the heater, the feed water flows down to the basement to a pair of twin volute turbine-driven boiler-feed pumps controlled by pump governors. The water-supply to each boiler is controlled by feed-water regulators. The boiler-feed lines are in duplicate and normally operate together, but either may be shut down without interfering with the operation of the plant. There are meters in the feed lines.

Of the two steam headers, the main header is furnished with superheated steam but so connected that the superheaters can be short-circuited if desired; an auxiliary header is supplied direct from the drum of the boiler.

In the generating equipment, there are three 750-kv-a. turbogenerators driven by Parsons-type turbines at 3600 r.p.m. and provided with jet condensers. The generators deliver three-phase, 60-cycle current at 2200 volts and excitation is provided by a motor-driven and a turbine-driven exciter, each of 25-kw. capacity.

As previously stated, the unloaders and the ore bridge are operated by 250-volt direct-current motors. The motor equipment of the ore bridge comprises the following:

		Hp.
2	225-hp. hoisting and loading motors	450
2	75-hp. trolley traveling motors	150
2	75-hp. bridge traversing motors	150
2	25-hp. operating gates on loading hoppers	50
	Total	800

The nominal capacity of this bridge is 1000 tons per hr.; the hoisting speed of the 15-ton bucket, 175 ft. per min.; the trolley-travel speed, from 600 to 800 ft. per min., and the bridge travel 50 to 75 ft.

The four ore unloaders, having a capacity of from 35,000 to 40,000 tons per day when operated double turn, are equipped with 17-ton buckets and have the following motors on each machine:

		Hp.
1	300-hp. walking-beam hoist motor	300
1	100-hp. trolley motor	100
1	100-hp. bucket-closing and opening motor	100
1	25-hp. bucket-rotating motor	25
1	150-hp. receiving hopper operating motor	150
1	150-hp. larry car hauling motor	150
1	35-hp. larry car gate operating motor	35
	Total	860

PRINCIPAL EQUIPMENT OF WEST BREAKWATER POWER PLANT, CLEVELAND, OHIO

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
3	Boilers	Stirling water-tube	600 hp.	Main units	150 lb. pressure, 100° superheat	Babcock & Wilcox Co.
3	Stokers	Roney inclined grate	110 sq.ft.		Ohio screenings	Westinghouse Mach. Co.
2	Engines	Vertical, single-acting	4½x4 in.	Stoker drive	150 lb. pressure	Westinghouse Mach. Co.
2	Pumps	Centrifugal 2-stage	350 gal. per min.	Boiler feed	438 ft. head, 3100 r.p.m.	De Laval Steam Turbine Co.
2	Turbines	Reaction	40 hp.	Drive boiler feed pump	150 lb. pressure, non-condensing	De Laval Steam Turbine Co.
1	Coal hoist	Monorail trolley	2.5 tons, 300 ft. per min.	Receiving trough to bunkers	Grab bucket, 66 ft. hoist	Sprague Elec. Co.
1	Coal crusher	2 roll				
1	Feed water heater	Open	2500 hp.	Boiler feed heater	Exhaust from auxiliaries	Harrison Safety Boiler Works.
1	Air compressor	Single stage	12½x12 in.	Railroad switches and house service	100 lb. pressure	Ingersoll-Rand Co.
1	Motor	Induction	75 hp.	Air compressor drive	3 phase, 60 cycles, 220 volts	Westinghouse E. & M. Co.
3	Generators	Alternating current	750 kv.a.	Main units	3 phase, 60 cycles, 2300 volts, 3600 r.p.m., 98% regulation	Allis-Chalmers Co.
3	Turbines	Horizontal reaction	750 kw.	Main unit	150 lb. pressure. 100° superheat, 3600 r.p.m.	Allis-Chalmers Co.
3	Condensers	Jet		On main units	28-in. vacuum	Allis-Chalmers Co.
3	Turbines	Horizontal reaction	50 hp.	Drives circulating water and air pump	150 lb. pressure, non-condensing	Kerr Turbine Co.
1	Generator	Direct current	25 kw.	Exciter	208 amp., 120 volts, 2400 r.p.m.	Allis-Chalmers Co.
1	Turbine	Horizontal reaction	25 kw.	Drive exciter	150 lb. pressure, non-condensing	Allis-Chalmers Co.
1	Generator	Direct current	25 kw.	Exciter	208 amp., 120 volts, 850 r.p.m.	Allis-Chalmers Co.
1	Motor	Induction	34 hp.	Exciter drive	3 phase, 60 cycles, 2200 volts	Allis-Chalmers Co.
3	Rotary converters	6 phase, 60 cycle	600 kw.	A.C.-D.C. transformation	175 volts A.C. to 250 volts D. C., 2000 amp.	Westinghouse E. & M. Co.
3	Transformers	Oil insulated water cooled	550 kv.a.	Rotary converters	3 phase, 60 cycles, 2200 volts to 6 phase, 175 v.	Westinghouse E. & M. Co.
1	Equalizer	Flywheel motor-generator	500 kw., 25,000 hp.-sec.	Peak load on direct current circuits	250 volts, 2000 amp., floats on line 600 to 720 r.p.m.	Westinghouse E. & M. Co.
1	Switchboard	Alternating and direct current	21 panels	Power control		Ft. Wayne Wks., General E. Co.
2	Rectifier sets		50 lamp	Arc lamps D. C. magnetite		General Electric Co.
2	Pumps	Duplex reciprocating	3½x2¼x3 in.	Main unit lubrication	150 lb. pressure, non-condensing	T. M. Prescott Co.
3	Transformers	Oil insulated	5 kw.	Lighting	Delta-delta connections, 2200 volts, 110 volts	Pittsburgh Transformer Co.
3	Transformers	Oil insulated	40 kw.	Power	Delta-delta connection, 2200 volts to 220 volts	Pittsburgh Transformer Co.
1	Strainer	Elliot twin	5 in.	Water service		Elliot Co.
2	Pumps	Vertical twin volute	5 in., 500 gal. per min.	Water service	30 ft. head, 1133 r.p.m.	Watson-Stillman Co.
2	Motors	Induction vertical shaft	15 hp.	Drive service pumps	3 phase, 60 cycle, 1133 r.p.m.	Westinghouse E. & M. Co.
1	Crane	Hand traveler	15 ton	Turbine room		Whiting Foundry Equipment Co.
	Water meters			On boiler feed lines		Henry R. Worthington
	Piping and valves	All				Pittsburgh Valve, Foundry & Equipment Co.

In addition, direct current is supplied to a battery of narrow-gage electric poling locomotives, used to spot cars under the unloaders when they discharge cargo direct into the cars.

The direct-current peak load from the four unloaders will approximate 2000 kw. and that from the ore bridge is about 1600 kw. The fluctuations are rapid, swings of from 1200 to 1500 kw. frequently occurring at intervals of from 15 to 30 seconds. Three 600-kw. rotary transformers supply this direct-current load and to smooth out the violent swings a 500-kw. flywheel motor-generator set is kept floating on the line. This machine has three bearings and the armature shaft carries, in addition, a 20-ton flywheel built up of heavy steel plates. Windage losses are reduced by inclosing the wheel in a steel-plate housing. Under normal conditions, the speed of this machine ranges from 600 to 720 r.p.m., acting as a motor, absorbing power at the higher speeds and restoring power to the line as the speed drops. A liquid field regulator automatically regulates the speed so that the load on the rotary transformers is held within 10 per cent. variation. The storage power of the flywheel is approximately 25,000 hp.-sec. and the machine is designed to carry a 100 per cent. overload 10 sec. out of every 2 minutes.

Design of Ashpits

By T. A. Marsh

SYNOPSIS—Features to be observed in building ashpits. How to figure their capacity. Faults and merits of typical designs.

There are several fundamental principles to consider in connection with any designs or recommendations made for ashpits. As discussed in this article the considerations apply strictly to chain grates, but the general principles hold for practically every kind of stoking apparatus. The features to be observed are:

1. The pits should be of ample capacity.
2. The removal of ash from the pits should be accomplished by a minimum amount of labor.
3. The design should be such that the maintenance cost of valves and doors is minimum.

These features also hold true regardless of the type of carrier or conveyor which disposes of the ashes after they are removed from the pits, although the type of carrier is one of the items which must govern the kind of pit adopted.

Capacity of Ashpit

It is desirable to design ashpits of a sufficient capacity to accommodate the ashes from an 18- or 20-hr. run. Such pits avoid the necessity of a night shift for ash handling and insure the stoker equipment against those ills consequent to permitting ash and clinker to accumulate up to the stoker mechanism.

While it is seldom possible to obtain pits of such ample capacity, with the modern ideas and proportions of designs, pits having capacities of 12 to 14 hr. are usually obtainable. The latter, while not quite safe from an operating standpoint, do away with the night ash-handling shift, providing the ash-disposing system is ample to perform this work in the day time and if the day shift leaves the ashpits clean when it goes off duty.

The problem of providing sufficient capacity is simple. Determine the maximum amount of fuel that can be burned on the grate. This is a product of the pounds of coal burnable per square foot of grate surface per hour and the number of square feet of grate surface. The contractor's specifications usually state both of these items. In the absence of such specifications or guarantees a study of the draft provision will give a basis on which to estimate the combustion rate, as the handbooks and catalogs of the boiler and stoker companies have information regarding the combustion rates obtainable with any given draft.

It is desirable to use the maximum rate on the assumption that some day it will be necessary to operate for a considerable period at that rate regardless of the station's supposed requirements and the designer's intentions. The maximum percentage of ash or refuse should be then considered and ample allowance made for the lowest grade of fuel in the market. The product of the percentage of refuse and the hourly fuel consumption will be the number of pounds of ash and refuse obtained per hour.

A study of average test results with the fuels under consideration will serve as a guide to the percentage of ash and refuse to use in the foregoing calculations. With the high-grade fuels of the Atlantic seaboard it would be safe to provide for refuse to the amount of 10 per cent. of the fuel, with coals of the Pittsburgh district 15 per cent. and of Illinois and Indiana 20 per cent. Coals of Iowa and some Southwestern localities contain as high as 40 per cent. of ash by analysis.

A cubic foot of ash weighs from 40 to 50 lb., depending upon its quality. For safety in allowing ample proportions, 40 lb. should be used. In this way the capacity in cubic feet necessary to accommodate one hour's ash is determined, and an analysis of any proposed design can at once be made from a standpoint of suitable capacity; or a pit can be proportioned to hold the ash and refuse for a given period of operation.

Ease of Cleaning

It is important that the ashes be removed from the pits without unusually hard and disagreeable labor, otherwise the pits will not be cleaned regularly and properly. It will be difficult to retain laborers for this work and the cost of removal will be high, to say nothing of damage to the ashpits and stokers if the pits are habitually permitted to become overfilled.

From this second standpoint the design of pits is largely one of motion study and of the method used in removing ash. From these considerations it is desirable to have the discharge door at a convenient height for the operator to use a hoe or a shovel, whichever the particular design may call for. It is better to have this door too low rather than too high.

Pits must also be so designed that there is ample room