New 600-Ton Blast Furnace Plant

The Trumbull-Cliffs Furnace Company New Plant at Warren, Ohio, Now Completed—Many Interesting Features Constructed in This Plant—Record Time Made on Construction Work.

THE new 600-ton blast furnace plant of The Trumbull-Cliffs Furnace Company was completed on June 14, 1921. Work on the plant was started August 15, 1920. On that date the site was an open field on the Mahoning river across from the Trumbull Steel Company and without railroad connections. In one day less than ten months the material and equipment was erected and placed in position, the tracks in, the yard graded and fenced in, machinery turned over and plant ready to make pig iron—in short, everything completely finished. This is record time for construction of a complete blast furnace plant.

The plant arrangement is laid out for future installation of additional blast furnaces as well as for a by-product coke plant. Throughout the design, provision is made for extension without interruption at the pumping, power and boiler houses, furnace and cast house, stock house and stock yard, casting, switching and other operations. Moreover, an extension of water lines, sewers, transmission lines, tracks, stock house and stock yard developes with minimum expense and effort from existing units. As a typical example of provision for expansion, the boilers are so designed with high settings and distinct combustion chambers for gas and coal firing, that stokers may be installed in the existing settings and the electric power output of the plant increased up to 12,000 kw.

Throughout the plant the professional man as well as the casual visitor is impressed with the exceedingly careful study devoted to details, the coördination of groups of allied occupations, provisions for safety, cleanliness and easement of conditions of labor and the provisions for elimination of hand labor in the handling of raw materials, products and waste.

The plant is especially notable for having embodied in its design all the proven and sound elements developed in years of American blast furnace plant construction and operation, and in addition many improvements which experience of the last few years has taught. These new features are not experimental. On the contrary, they go to make up a fully reliable plant built on accepted and conservative lines. Every guaranty is embodied that goes to insure good tonnage, economical practice and continuous operation. The plant is remarkable for the absence of the crudities such as usually accompany design and building for rough manufacturing such as blast furnace operation is usually assumed to be. Considerable attention has been given to appearance and there has been a successful application of architectural design to offices, power buildings, trestles and bridges so that they present a dignified and pleasing appearance.

The layout of the plant is apparent from Fig. No. 1. Present rail connections are the Pennsylvania and Erie railroads across the Mahoning river, but an additional connection is to be provided in the future at the opposite end of the plant by the Baltimore & Ohio railroad. As will be seen, the plant is laid out primarily for delivery of hot metal to the mixer at the open hearth building of the Trumbull Steel Company, and for the time being all raw materials are routed into the plant over the three-track reinforced concrete bridge which also serves as the delivery track for hot metal to the Trumbull Steel Company.

Approaching the plant over the bridge affords a most comprehensive view of the entire layout. As one goes through the plant, he is impressed with the substantial construction, with the completeness of the equipment and the new appliances and practices introduced to better

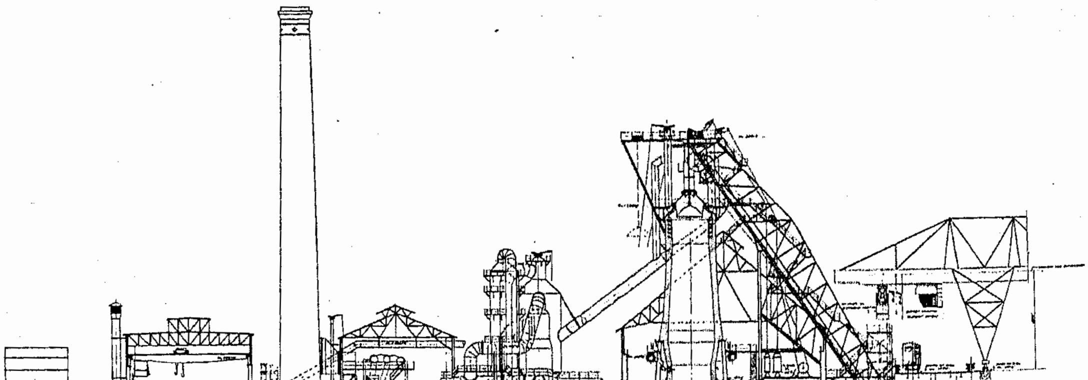


Fig. 1—Section through the new plant.

the practice and economy of operation. A new feature is to be found in the provision for screening of the coke at the furnace bins. This consists of two rotary grizzly screens, each screen having eight motor driven shafts. These shafts carry discs, and the shafts and discs are so spaced that the rotary grizzly removes material under ¾" in size. The flow of coke from the bin to the grizzly is controlled by a cut-off gate and also by a rotary vane feeder. This provides a steady and even flow of coke over the grizzly. Emergency operation is provided for in a gate and a dead plate furnished over each grizzly so that coke may be by-passed direct from the bin to the skip hoist bucket in case the grizzly is out of operation. Underneath each grizzly is a hopper, one hopper delivering braize direct to a braize elevator, the other delivering braize to an 18" belt conveyor discharging to the braize elevator boot. The elevator is a belt and bucket type delivering to a 24-hour capacity bin. The motors driving the rotary grizzlies, the feeders and the belt conveyor and elevator are electrically interlocked so that the motor driving the vane feeder and belt conveyor cannot be started until the motor driving the rotary grizzlies and the belt and bucket elevator is running. There is also provided a 20% speed variation on the motors operating the rotary grizzlies.

The arrangement of cast house is the next outstanding feature. The cast house is very modernly constructed and has a 94'6" span, 4-motor Cleveland Crane & Engineering Co. crane of 25-ton main hoist capacity, with a 5-ton auxiliary hoist. It spans not only the cast house proper from the foot up to the furnace front, but also spans two tracks, one of which constitutes the hot metal track and the other a track for spotting of cars, for removal of scrap and rubbish, and for unloading into cast house of coke braize, clay and sand. This same crane is also utilized at the slag granulating pit at the foot of the cast house and for this purpose is equipped with a Hayward 1½ cu. yd. bucket, having perforated bowl and manganese steel lips. The crane serves to unload from car or truck and places upon the skip hoist house platform, the motor armatures for the skip hoist or other material required. In the cast house is a brick and concrete structure providing storage for sand, clay and coke braize, in which there is also provided a mixing room for the preparation of these materials.

Convenient access is provided not only by means of stairway, but also by means of an easy incline up the stove foundation to the cast house floor. The grouping of a number of allied operations which must of necessity come under the eye of the blower at the furnace is very noteworthy at this point. The stove platform is at practically the same elevation as the cast house, the cast house being reached by an easy incline not over 2 ft. in height from the stove platform. The stock bins are easily reached by a walkway from the cast house. This walkway passes the skip hoist house where the skip hoist, bell operating cylinders, and distributing mechanism are placed, and also passes the skip incline proper. The blower foreman is thereby able to watch not only the work in the cast house and about the furnace, but, without getting more than a few steps from the cast house, he can always check up on stove practice, or by watching the skip buckets, on the regularity of filling.

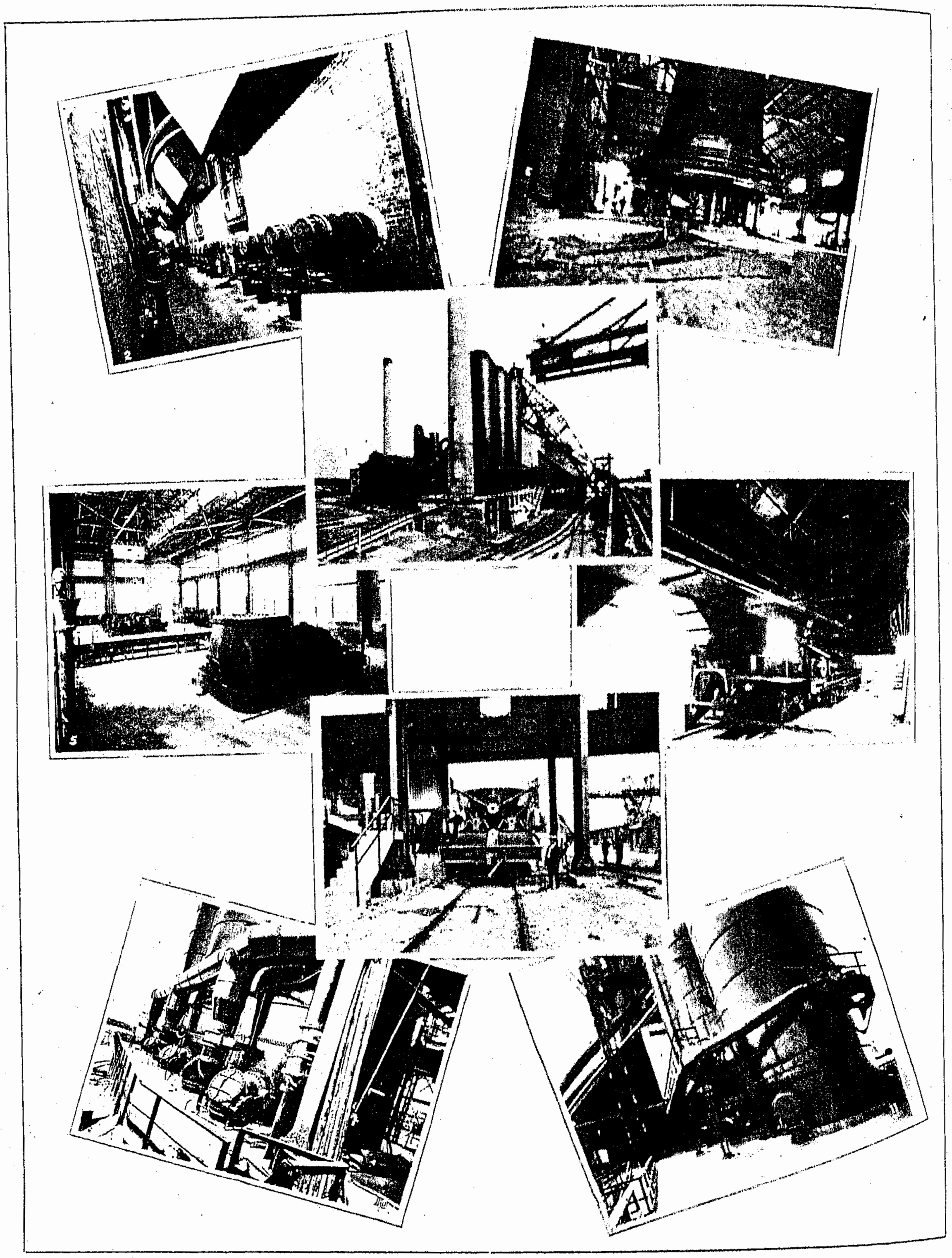
Provision is made so that the furnace can be rodded from the cast house as a check upon the men in the stock house. The shutters in the iron runners are opened and closed by steam cylinders, these being operated from the central control station at the furnace front where the snort valve wheel, the control for the Berg mud gun and signal apparatus are located as one unit. The cast house is supplied with a complete set of blast furnace tools designed by the engineers.

A new type of boiler setting has been installed by the engineers as shown in Fig. No. 6. This provides a high setting of the boiler and gives an exceptionally large volumetric space per bo. hp for complete combustion either of blast furnace gas or solid fuel. The gas burners, consisting of four 14" Birkholz-Terbeck burners, are installed at the back of the boiler. The combustion chamber for gas is under the mud drum, there being provided a distinct combustion chamber of large volume for the burning of the blast furnace gas without dilution by excess air through grate bars, or restriction of combustion by insufficient space, as in the usual setting. At the front of the boiler, grates are provided for auxiliary hand firing. The boiler is so designed that if increased power generation is desired stokers may be installed in the place of ordinary grates, without any work being done on the boiler other than simply building on a Dutch oven extension. The design has proven to have several very important advantages; it enables the boiler to be run at very high efficiency due to complete combustion obtained in the large volumetric space, it enables considerable overload to be carried on boiler due to the generation of high temperatures, and it minimizes the difficulties due to encrustation of the tubes with dust or ash.

In the power house considerable advance in design is shown. Special attention has been paid to daylight lighting. Ample floor space is provided and the engineers have incorporated all the successful features of modern power plant design. These are described in detail in another part of the article, but special mention should perhaps be given to the high intakes provided for the turbo blower, the advanced type of turbo blower installed, the completeness of the electrical equipment, and the well worked out system of water circulation and re-use.

In the blast furnace proper the engineers have designed a furnace which represents the best development in recent years with similar stacks built by them. The arrangement on the furnace top has been very materially improved as regards safety and convenience in work. The mantle and column has been increased in section and the manner of hanging the circle pipe, discharge trough and bustle pipe has been improved. An auxiliary cinder notch is provided. The iron and steel work of the furnace is so designed that the furnace can be enlarged at succeeding blasts if it should be found advisable. Other matters that are described later, but which should received particular mention, would be the evident care devoted to economy in quantity of concrete in the foundations, trestle approach, highway bridge and pig casting machine; and the new type of cantilever skip incline which affords greater rigidity of construction, and increased room in the cast house and on the furnace top.

Particular mention should be made of the improved gas main system which originated with Mr. D. T. Croxton. Contrary to the usual arrangement where gas mains are led overhead both at the boilers and stoves, the Trumbull-Cliffs gas mains are placed underneath or outside of the stoves and boiler house. At the stoves the large gas main from the gas cleaning plant goes to a water seal separator whence it is led along the piers of the skeletonized stove foundation. From this main pipes are led directly up through the stove platform to the stove gas burners. The main is given a slope which makes it easy to clean. On the boiler house side the large gas main



from the cleaning plant goes to a similar water seal separator whence it is led along at about yard elevation outside of the boiler house between the engine and the boiler house. This main is also given a slope and provided with downlegs for cleaning. From this main individual leads are taken to each boiler, the pipe for the gas burners coming up through the boiler house floor. This arrangement of mains is conducive both to cleanliness of the plant, ease in cleaning of mains and freedom from gas about the stove operating platform and inside the boiler house.

The grouping together as one unit of all elements of gas cleaning, the very complete maintenance and repair shop, and the excellent provisions made for the housing of the executive, general office, chemical and police departments should also be given special mention.

Starting in with the receipt of raw materials, the ore and limestone are unloaded by means of a Mead-Morrison movable car dumper. This dumper has a 57-ft. cradle and a capacity of 320,000 lbs. and is guaranteed to handle 30 cars per hour. The cradle is provided with both dynamic and air braking and has a travel the entire length of the ore and limestone yard.

Spanning the yard is a Mead-Morrison 11-ton man trolley ore bridge. It has a capacity of 600 tons per hour from the dumping pile to the storage pile or from the storage pile to the bins. The method of handling the ore and limestone consists in the movable car dumper placing material in a concrete dumping trough beneath the shear leg cantilever of the bridge. The 11-ton bucket picks up the material and delivers it to the main storage pile under the span of the bridge, or to the stock bins, or to the 50-ton Atlas transfer car when the materials being handled out of the stock pile are not directly in front of the stock bins into which they are being delivered.

The ore bridge has a cantilever at the shear leg end of such length as to permit delivery by the grab into railroad cars on the track approximately 32 ft. from the foot of the shear leg. This enables ore buckets to be changed and also enables the ore bridge to handle repair work at the car dumper. It has a similar cantilever at the pier leg end so that the ore bridge can handle the skips when they have to be replaced on the skip incline. The bridge has a travel speed of 70 ft. per minute and is of the skewing type, permitting either the shear leg or the pier leg to advance five degrees ahead of the other. It is completely equipped with safety devices to prevent over-travel of either leg, to prevent over-travel of trolley, and is equipped with magnetic solenoid brakes and rail clamps for provision against high winds.

The stock yard is 270′ wide by 505′ long and has a storage capacity for 250,000 tons of ore and 80,000 tons of limestone. Operating upon the ore bins is an Atlas 50-ton capacity side dump electric ore car, equipped with air operated brakes, doors and car pusher arm. The bins are provided with a cross-over and suitable conductors so that the transfer car can work on either of the two tracks on the bins.

The ore bins were designed and installed by the Hoover & Mason Co. They consist of nine ore pockets having a capacity of 3,120 cu. ft. each, four limestone pockets having a capacity of 2,900 cu. ft. each, and five coke pockets having a capacity of 2,900 cu. ft. each. In addition there is one central double compartment coke pocket, each compartment chuting coke to the skip bucket over a rotary grizzly screen. The rollers underneath the limestone pockets are perforated for screening.

The scale cars are Hoover & Mason double compartment type, equipped with air brakes, air operated doors and dial indicating and recording scales. Turn-out tracks for the spare scale car are provided under one part of the reinforced concrete trestle approach, the other part of the approach being bricked in to afford housing for riggers' tools, blast furnace spares, etc.

The control station for the skip hoist is on the yard level in proximity to the skip incline so that the skip operator has a view of the skip pit, as well as of the skip hoist track and the furnace top. The same station houses the control for the bell operating cylinders, the McKee distributor, the grizzly coke screens and the bell indicating and rodding devices. Connection is provided to the cast house and furnace top by speaking tubes.

The skip incline is of the cantilever type. It is supported entirely independent of the blast furnace so as to avoid any side thrust on the shell, and is 171 ft. 6 in. long with double track for skip cars of the trailer truck type. Skips are operated by a Lidgerwood electric double drum hoist, driven by a Westinghouse 200 hp d. c. motor. The hoist has a rope speed of 300 ft. per minute and is designed for an unbalanced load capacity of 20,000 lbs. Cutler-Hammer control is supplied. This hoist is located in a concrete and brick house under the skip truss and above the tracks. This structure also houses the bell operating cylinders which are actuated by air from the cold blast main. An auxiliary air supply is provided from the high pressure compressor line, and this is automatically admitted through a pressure regulating valve in the event of drop in the blast line pressure. The control board for the McKee distributor is located in this house. This control is for six-station, six-cycle operation, but provision is made for installation of additional panels for different cycles of charging.

The furnace top is of the standard double bell Freyn-Brassert design, having also a McKee distributor. The design of the receiving hopper and throat is worked out to give correct distribution even when the charge is not revolved. The entire top of the furnace has solid plate guard rails and special attention has been paid to accessibility of all working parts and for observing the distribution of material in receiving hopper and for observing the dumping point of skip. Bleeders are provided with permanent rail platforms, as is also the outrigger. The outrigger is provided with a trolley for facilitating work of repair or relining. Access to the furnace top is by means of interrupted flight stairs up the skip incline and also by means of a bridge from the furnace top direct to the Otis elevator, and by a bridge to the stove top. An extra large door is provided as the gas seal.

The six-passenger Otis elevator is a worm geared traction type, having a capacity of 1,500 lbs. load, fully equipped with interlocking devices and emergency safety features. It has push-button control and four landings.

The furnace is 92′x22′6″ and has a capacity of 25,500 cu. ft. The iron and steel work includes a heavy continuous cast iron sub-base. The concrete foundation is reinforced by tension bands and the column base and columns are encircled by a reinforced concrete beam, extending between the columns up to within a short distance of the hearth jacket segments. There are ten cast iron columns and ten tuyeres, tuyeres being placed centrally between columns, thus affording good working room. The columns are offset, which not only allows more room for work about the tuyeres and places the columns and col- breakout, but affords the possibility of enlarging the fur-
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nace hearth and bosh in the future. The columns are one piece and entirely free from any cast-on iron lugs. The bustle pipe, circle pipe and waste water trough are suspended from the mantle. Special attention has been given the location of circle pipe connections and waste water trough overflow so that there is ample room on the bustle pipe walk and it is free from obstructions. The hearth jacket is of the standard Freyn-Brassert cast iron segment design, having cooling pipe cast in, and heavily wedged, banded and bolted. It is tapered, thus maintaining a safe thickness of hearth wall against erosion and breakouts and also maintaining ample brick at the bottom to prevent short holes and to prevent the hearth block from rising. The tuyere breast consists of a solid armor of 1½" plates with openings for the 10 tuyeres and for the bronze cooling plates. The bosh is reinforced with eight 1½" thick bands, the bands being held by cast steel distance pieces to prevent slipping. The mantle is of a specially heavy built-up plate angle construction and is provided with a trough with drainage provisions for collecting shell spray water. The furnace shell, which is especially designed to meet modern furnace lines, is of butt strap construction on both the two bottom rings and the top ring. The intermediate rings are of double lap riveted construction. The shell is surmounted by a dome on which the large bell hopper ring is riveted.

The furnace is lined with General Refractories Olive Hill steam pressed fire brick, the thickness of lining being heavier in the lower inwall, to afford maximum thickness where required, than in the upper part where an excessive depth of lining would be detrimental. No interior water cooling is given the lining above the mantle, but a permanent pipe spray with connection is affixed to the shell and a permanent platform is also provided at the spray. This platform is reached by a short bridge from the skip incline steps. A new design of bosh and tuyere breast plate is used, having baffles that give more positive circulation of water and enable the plate to be more easily withdrawn in the event of its becoming cracked or burned. The hearth walls are cooled by the cast iron cooling pipe of the hearth jacket, which extend approximately 9 ft. below the elevation of the tapping hole. The stock line is afforded protection by cast iron wearing plates of high combined carbon content. These plates are laid integral with the lining and are of small surface dimension in each unit.

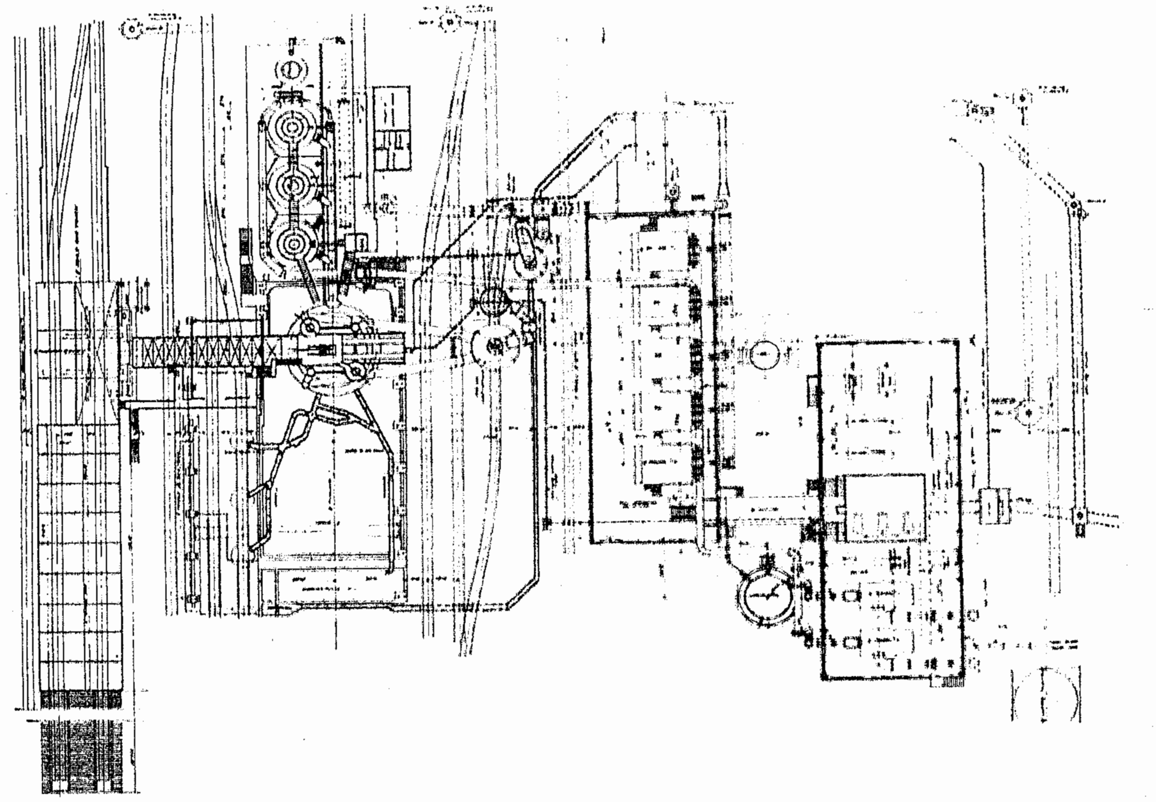

Fig. 12—General arrangement of Blast Furnace.

The bustle pipe is insulated with Johns-Manville Vitro Fire Felt and easement against thrust against the columns by expansion of the hot blast main is provided in an expansion joint.

"Green" unlined tuyere stocks are used.

The hot blast stoves are three in number, with a total heating surface of 285,000 sq. ft. They are of the two-pass side combustion type of the standard Freyn-Brassert design. The stoves have a built in draft flue in the skeletonized reinforced concrete foundation, this flue leading to an 8'x225' Heine reinforced concrete stack, brick lined throughout. The stoves are equipped with blow-off valves turned down into the chimney flue, standard Freyn-Brassert equipment of quick closing chimney valves, gas burners and gate type hot blast valves. Provision is made for the future installation of an additional hot blast stove. These stoves have 3½" checkers with 2" checker walls, the design of checkers, arch and draft chamber equalizing the flow of gas down through the checkers, thus overcoming the usual tendency toward segregation of flow of gas in a limited number of checker openings. The stoves are insulated with Sil-O-Cel powder and brick and are lined with General Refractories fire brick; hand made inwall quality is used in the combusiton chambers and dome, and steam pressed inwall quality in the top of the checkers. The ring wall and bottom of checkers as well as draft chamber piers and arches are made of stove quality. The gas main leading to the stoves is equipped with a butterfly valve which is intended later on to attach to a new Freyn-Brassert design of gas pressure equalizing equipment to maintain constant pressure in the stove gas main.

The cast house, which is on the same elevation with the hot blast stove operating platform, is laid out to run cinder either to cinder ladles or to a cinder pit at the foot of the cast house. The iron runners are laid out to deliver to three 75-ton Pollock short-pour hot metal ladles. The runners have a fall of ⅝" to the foot to give a minimum amount of scrap. Coke dust, sand, loam, clay, furnace tools, copper, etc., are brought to the cast house, and the 25-ton crane, spanning the cast house, the hot metal track adjacent to the retaining wall of the cast house, and the working track outside of the hot metal track. The materials are placed in a permanent brick and concrete shed inside of the cast house. The equipment of the cast house includes a Berg-Brosius clay gun, which was specified not only as a safety measure but also for the purpose of keeping the blast on the furnace and gas on the boilers over casts. The working cinder notch is 45 degrees from the iron notch. An auxiliary cinder notch is provided, this being fitted up with a standard cooler and intermediate cooler so that cinder can be withdrawn here in an emergency. The shutters are all of the Fraser remote control type, and snort valve wheel, mud gun control and shutter control are all located at one point. Special lighting facilities have been provided and there are an abundant number of hose connections for both high and low pressure water. Steam and air are piped to the cast house for use on mud gun and for other casual requirements. For the purpose of communication there is a speaking tube from the cast house to the nearby operator's house and to the furnace top, and there is also a duplex signal apparatus connecting the cast house with the boiler house and power house.

The gas is taken off the furnace by four offtakes from an annular space about the big bell hopper, which reduces the average gas velocity and reduces the production of flue dust. These four offtakes lead to four uptakes, two of which are surmounted by Baer safety explosion valves. The uptakes lead into four downtakes, each two combining into one downcomer. The two downcomers enter the dust catcher radially.

The gas cleaning system is located between the boiler house and the blast furnace. It consists of one 22'x40' dust catcher for primary cleaning of gas. The gas is then led to a 12'6" Brassert tangential whirler where further amounts of fine flue dust are removed. From the whirler the gas is led through a series of goggle valve by-passes so arranged that the gas can be handled in a variety of ways. It is contemplated to run—and the system is thus arranged—so that all the gas is led through the Brassert gas washer, thence through a water seal separator to the main leading to the hot blast stoves and to the boilers. If desired, only the stove gas may be washed and gas sent from the whirler direct to the boilers, or in an emergency rough gas may be sent to both stoves and boilers. All these gas cleaning elements are located in one unit, completely equipped with platforms, thus making easy their supervision and care, and are standard equipment that have been used on upwards of 90 installations embodying well worked out means for obtaining gas with not to exceed 0.2 grains of dust per cu. ft. The washer is of the latest type of Brassert washer and has a novel arrangement of sprays which produces a large mass of spray having an intense whirling action. Not only is there an appreciable economy effected in the use of water, but the washer handles and cleans dirty gas even better than heretofore. To eliminate the nuisance of dust, which has always been such an annoyance at blast furnace plants when the dust catchers are dumped, Mr. D. T. Croxton has evolved an arrangement which will deliver the dust from the dust catcher and whirler to the cars in a moist state. This consists of a Bartlett-Snow double screw enclosed conveyor which is attached to the dust catcher by means of a special screening casting. The dust flows through this screen and falls into the first stage of the double screw conveyor. This conveys the dust down into an enclosed trough of water and delivers it to the second screw conveyor which again lifts the dust out of the enclosed trough and delivers it to the car. The dust in passing through the double screws submerged in the trough of water becomes thoroughly pugged and saturated with moisture. The coarse materials that do not pass the screen leading to the pug mill go to the bottom of the dust catcher where they are removed by occasional dumping of the main dust catcher bell. In an emergency the entire contents of the dust catcher may be removed in the usual way.

The gas main system consists in branches from the gas cleaning plant to both the stove and boiler gas mains. At both the stoves and boilers water seals are provided; in addition a further complement of water seals is installed so that the stoves or boilers may combinedly cut off from the entire gas cleaning system at cast or shut down, so that the wet cleaning system may be isolated from the dry cleaning system, and so that the entire system may be isolated from the furnace. These water seals are provided with large capacity lines so that water can be admitted and the seals filled in a very short time.

The blast main system starts at the turbo blowers. The discharge from the turbo blower is provided with an Ingersoll-Rand multiple port disc check valve. Motor operated cold blast valves are provided outside of the power house building. The cold blast main leads directly to the hot blast stoves, being provided with two counterweighted blast relief valves and the usual snort valve. The snort valve discharge is turned down into the stove flue. The by-pass leaves the cold blast main at its end and leads around No. 3 stove, entering the hot blast main at the extreme end from the furnace. It is provided with a McCarthy check and regulating valve.

The boiler house is 150 ft. long by 55 ft. wide and 43 ft. high. It is of brick and steel construction with corrugated steel monitor type roof. All window sash is of steel, Truscon type, glazed with factory rib glass.

There is provided 4,000 hp in units of 800 Class "M" Stirling four-pass boilers, built for 231-lb. pressure and 125 degrees superheat. All boilers are gas fired, being equipped with four improved 14" Birkholz-Terbeck burners. These burners are placed at the rear of the boiler under the mud drum, the mud drum being set at an elevation of 10 ft. to provide large distinct gas combustion chamber. The burners are provided with means for removal of cone for cleaning. Control of gas at the burners is by means of butterfly valves on the individual legs to each burner, and shut-off of gas is by means of one large gate valve in the main leading from the large boiler house gas main outside of the building. In addition this main can be filled with water to form a water seal valve, thus safely isolating any particular boiler when it is to be entered for cleaning or repairs. The boiler house gas main itself is outside of the building at yard level, and dust removed from the main is washed through a concrete trench direct to the sewer. The main has an auxiliary bleeder at its end as does also the stove gas main.

The boilers have provision for auxiliary coal firing, being equipped with Marion shaking grates. Coal is brought into the boiler house by means of a track hopper which discharges onto a Jeffrey belt conveyor. This conveyor was used in the construction work for handling brick and has been reinstalled at the boiler house to eliminate the large amount of hand labor usually employed in unloading coal. This Jeffrey belt in turn discharges to a Weller Manufacturing Company shuttle conveyor which runs along inside of the boiler house, by means of which coal can be discharged to any point along the boiler house floor. There are ash hoppers attached to the ash pits of each of the boilers. These hoppers are provided with gates at such elevation in the boiler house basement that a large truck can run beneath the hoppers. There is provided a concrete runway from yard elevation down into the basement floor of the boiler house, and ashes will be dumped direct from these hoppers into an auto truck and used for fill on the property.

The boiler draft requirements are furnished by a 225'x12'6" reinforced concrete stack built by the Heine Chimney Company, brick lined throughout. The boilers are connected to this stack by an insulated steel breeching. Other equipment in the boiler house consists of Williams feed water regulators and Babcock & Wilcox bare tube superheaters. The boilers are substantially built with particular reference to resisting gas explosions, and the front so constructed that by addition of a Dutch oven any standard type of stoker can be placed in the boilers in the event either of expansion of the plant or desire to generate additional electric power with the existing unit. The boilers are placed singly, right and left settings, 6' aisles.

The boiler feed water is normally taken from the service water mains of the blast furnace plant, it being delivered under standpipe pressure to the We-fu-go water treating system installed by Wm. B. Scaife & Sons Co. This is an intermittent cold process having a capacity of 20,000 gal. of water per hour. From the We-fu-go system a 500-gal. capacity pump, provided with a spare, pumps water to two Cochrane 4,000-hp open type feed water heaters. From the heater water is delivered to the boiler feed pumps. These are 4" four-stage double suction 500-gal. 600' head Worthington pumps, driven by Terry turbines. From the boiler feed pumps water is delivered to the boilers by means of an insulated boiler feed line. An auxiliary boiler feed line is also provided for emergencies. The two centrifugal boiler feed pumps are supplemented by a Worthington Duplex 500-gal. 300-lb. head reciprocating pump, which is connected up so that for normal operation it can furnish high pressure water for fire service, or at the top of the furnace, or around the blast furnace and cast house for flushing, cooling copper, etc. All these pumps are in the power house basement and one operating suffices to take care of the boilers.

The boiler house is laid out to permit expansion to the south for additional boilers, additional blast furnace units and coke ovens.

The power house, which is 154 ft. long by 60 ft. wide by 33 ft. from first floor, 18 ft. high basement, is also of brick and steel construction. Particular attention was paid to day lighting and ventilation. The blowing equipment consists of two Ingersoll-Rand turbo blowers. The air blower has five stages and the steam turbine seven. These blowers have a nominal capacity of 45,000 cu. ft. of air per minute at 30-lb. pressure, and will blow 55,000 cu. ft. of air per minute at 22-lb. pressure. The turbines are of new Ingersoll-Rand design, having but two steam admission valves, one for normal load and one for overload. The regulating device is also of an improved type, consisting of a single venturi instead of the old type of triple venturi. The single venturi is not so sensitively affected by leaks in the intake line, nor by dust or dirt in the air. There is a separate air intake for each blower which is led up to a considerable distance above the power house roof. Recording gauges are provided on each intake to record the amount and regularity of blast volume blown.

Electric power is generated in either of two Allis-Chalmers 1250 k. v. a., 80% p. f., 2300-volt, 3-phase, 60-cycle 3600 r. p. m. turbine generators equipped with direct connected exciters. A portion of this power is transmitted to the river pump house at which there are installed three 250-hp 2300-volt, 760 r. p. m. induction motions driving the centrifugal pumps. These motors are of the wound rotor type and are equipped with primary oil switches and secondary drum control, electrically interlocked. The motors were furnished by the Allis-Chalmers Manufacturing Company and the control switchboard was assembled by the engineers from parts furnished largely by the Westinghouse Electric & Manufacturing Co.

The bulk of the electrical power required at the plant is d. c. and to furnish this there were installed in the power house two Allis-Chalmers 750-kw, 720 r. p. m. motor generator units, supplying direct current at 250 volts. The driving units are 1160-hp 220-volt synchronous motors, excitation being taken from the d. c. units. The synchronous motors are started from auto transformers at 33% voltage in order to minimize the starting demand on the generator units. The power house switchboard contains 16 panels divided into an a. c. section of eight panels and a d. c. section of eight panels. The arrangement is such that future additions may readily be accommodated.

The a. c. switchboard is of the remote electrical control type. The oil switches are mounted in the rear of the board, liberal space being allowed for access. Of particular interest perhaps is the arrangement of a plug switch on each a. c. panel connecting with the power factor meter, thereby enabling the total power factor to be determined as well as the power factor of the individual generators, synchronous motors and feeders.

The d. c. feeders emanate from the power house direct to the car dumper and ore bridge and also to a distribution center at the blast furnace. Here the skip hoist, transfer car and scale cars, coke braize system, and cast house crane are fed. Another feeder terminates in a distribution center at the pig casting machine, from which the strand drives and ladle house crane are fed. The machine shop, office and power house auxiliaries are fed from the distributing panel of the power house switchboard. The greater portion of the electrical distribution is underground, liberal duct space being allowed for future growth of the entire system. The transmission to the river pump house was installed overhead for the reason that a portion of this line passes through territory subject to flooding. Duplicate feeder panels and feeders are supplied for this line to ensure continuity of service and to further protect the primary service pumps provision is made for connection to the Trumbull Steel Company across the river.

The lighting system for the plant is exceptionally complete and effective. A three-wire 115-230-volt system is installed. There are two transformers at the power house, one at the skip hoist and one at the pig casting machine. In case a transformer burns out, one of the units at the power house may be utilized for replacement and the lighting in the power house district temporarily reduced. Wherever necessary lamps are protected from moisture; all lamps have suitable reflectors and all inaccessible lamps have disconnected hangers. There is furthermore installed an auxiliary lighting system for emergency use, this being supplied from the exciter bus. The power and lighting installation is of exceedingly high type and safety for the men is provided in the shape of Leonard safety switches installed ahead of all starting and control equipment. Every detail has been arranged and installed in a most thorough manner.

Steam lines for the plant are in duplicate, consisting of a large main header having capacity for the entire steam demands of blower, generator, pumps and auxiliary machinery in the power house. This is supplemented by another header tied in at four points so that in the event of replacement of any fitting or gasket on the main header, a sufficient number of boilers can be tied to the power house, cast house and pig machine operation. This auxiliary line has sufficient capacity to run the blower and pumps with some reserve for partial load on the generator. The main steam lines are carried on brackets in the boiler house up to the tunnel which connects the power house and boiler house, where they are led direct to the power house. This same tunnel also serves for the boiler feed lines, high pressure water lines, service water lines and electric conduit, and is the regular means of communication between the power house and boiler house. All steam lines to blowers and turbines are underneath the main power house floor, thus presenting a very neat appearance. Steam lines and boiler feed lines are all covered with 85% magnesia insulation and have a very adequate equipment of drains and separators. The existing lines, inclusive of the main steam header in the boiler house with its lead to the power house, from the first element of the eventual power and boiler plant, when the header will expand into a complete loop system with additional cross connections between the power house and boiler house.

The power house is served by a Cleveland Crane & Engineering Co. 15-ton 4-motor crane, having 5-ton auxiliary hoist. Other equipment in the power house consists of a Worthington steam driven air compressor having capacity of 300 cu. ft. of free air per minute; the double Cochrane feed water heater; a 100-gal. Worthington reciprocating pump that pumps treated water to the offices for washroom and laboratory service; two 5" 500-gal. motor driven water circulating pumps delivering water from the water treating system to the heaters; and a set of Richardson-Phenix continuous by-pass turbine oil filtering system units. All of the equipment in the power house excepting the turbo blowers, turbo generators, motor generator sets and the switchboard, are housed in the basement of the power house, where in addition are the three 10" 4500-gal. 158-ft. head 1900 r. p. m. Worthington centrifugal pumps which pump the water for the plant use. These are driven by Terry turbines. The exhaust steam from the service pumps, from the boiler feed pumps, from the office water pump and from the compressor, all exhaust to the Cochrane feed water heater. In the basement are also the condensers for the turbo blowers and generators. There is provided at each blower an Ingersoll-Rand low level multiple jet condenser, and at each of the turbo generators there is a similar low level multiple jet condenser. These are installed for 28" vacuum and due to the design of the condenser no air removal nor water removal pump is required. Both the turbine floor and auxiliary basement floor present a very neat appearance, there being ample room and entire absence of pipe interferences.

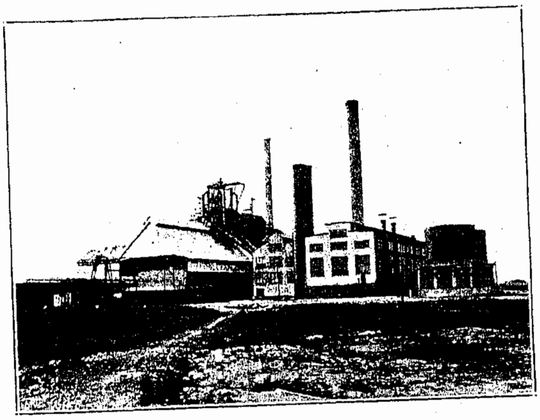

Fig. 13—General view of the plant.

The water system of the plant deserves particular mention as considerable economy is effected in the use of water, at the same time retaining the very desirable element of simplicity of circulation and furthermore obtaining the possibility of using different sources of water at many points in the event of failure of any particular source.

The water system starts in at the river pump house, which is of novel design in that considerable space is saved, consequently eliminating considerable concrete and excavation work. The suction well for the pump is inside of the pump house, water being led from the pool outside into the tunnel though two 72" link-belt vertical traveling refuse screens. These are fitted with ⅜" screens and driven by 5-hp motors.

In the pump house are installed three 12" 6,000-gal. 115-ft. head Worthington pumps, motor driven. Two of these pumps operating deliver water to the turbo blower and to the turbo generator condensers. Tail water from the condensers is led by means of a weir to a sump running lengthwise of the pump basement. From this sump the three 4,500-gal. Worthington service pumps, two operating draw their supply and pump through a 20'x120' standpipe located between the power and boiler house.

This standpipe in turn delivers water to the blast furnace, cast house, hot blast stoves, cinder pit, gas washer, pig casting machine and water purifying plant, together with all other miscellaneous uses. The flexibility of this system may be appreciated by stating that the lines are so arranged that, if desired, the standpipe can be by-passed altogether or it can be used simply as a floater on the service line, no water being actually pumped through it. Safety provisions are adequately taken care of by connecting the line that leads from the river pumps to the condensers to the service water line into which the power house service pumps discharge. In the event of these pumps for any reason being out of commission, the river pumps have sufficient head to keep water on the blast furnace bosh, stoves, water seals and to supply water to the feed water treating plant, thus assuring a supply of water that will prevent damage or serious accident. A further safety provision is afforded in having this same by-pass line from the river pumps discharge, if desired, into the sump from which the basement service pumps draw their supply. This may be found useful in case the condensers have to be taken off. A further safety provision is found in an ingenious method of returning the bosh water. The overflow water from the furnace is all conserved and led by means of a separate pipe line back to a cistern at the extreme end of the basement sump. As long as the level of water in the basement sump is kept up to the mark by the water coming from the condenser tail water pits, then the return water from the furnace overflows into the sewer and back into the river. However, if the amount of water coming through the condensers and thence to the sump should for any reason be deficient, then the return water from the blast funace runs into the sump from which the service pumps pull their supply. Under normal conditions of operation there is about a 40% surplus of condenser tail water going into the sump over and above the amount of water required at the plant exclusive of condensers. To still further safeguard the plant supply of water the lines of the standpipe are equipped with check valves which will prevent the standpipe from emptying in the event of a break in the line. A final safeguard at the furnace is found in the provision of check valves in the two distinct water supply lines leading to the circle pipe. Between the circle pipe and these check valves is connected a line from the Worthington high pressure pump and inasmuch as this is in normal operation continually kept floating on the high pressure line, then in the event of failure of lines or service pumps the furnace bronze can be preserved by opening up the line admitting high pressure water to the circle pipe, the check valve preventing escape of this water back into the main service water line. This high pressure water is similarly piped up to the stove fittings and to the main isolating water seal valve, and in an emergency the high pressure pump can draw its supply of water from the standpipe which, in the event of a very bad accident or breakdown at the pumps or lines, would still remain full of water. It will be seen that the plant is assured of a supply of water that will last almost indefinitely in an emergency by virtue of the provisions for recirculation of water.

The boiler feed pumps similarly have a triple source of supply. Normally they take from the feed water heater. In emergency they also draw from the basement sump, from the blast furnace service water lines or from the line leading from the river pumps to the condensers. The turbines similarly draw on two sources for their supply of cooling water, i. e., the service water supply line and the condenser water supply line.

In addition to the link belt traveling screens at the river pump house, the lines are further provided with Elliott twin basket strainers at both of the supply lines to the furnace circular pipe and to the stoves, and also at the line leading to the gas washer. The boiler feed line, the gas washer line and the furnace supply water line are provided with venturi meters.

A tank is provided at the machine shop to which treated water is pumped from the power house basement for the use of the yard locomotives.

The sewerage system is very largely an open one, this type being decided upon on account of the many unfortunate experiences with closed sewers about blast furnace plants where so much rubbish, such as graphite, granulated cinder, etc., is liable to plug the sewers. Special pains are taken at the cinder pit to avoid escape of granulated slag into the sewer system, there being provided a settling basin and submerged weir to prevent as much as possible the escape of cinder. The overflow water from the pit runs through a screened open sewer to the sump beneath the gas washer. Here the cinder pit water joins the discharge from the gas washer and is led in an open sewer to the boiler house. A sewer, which carries off ash-up water and also the drainage water from the hot blast valve fittings is led from the furnace and stove foundations to intercept the main open sewer. At this point the sewer runs underground a distance of about 500 ft. through 48" reinforced concrete sewer furnished by the Massey Concrete Products Corporations. The boiler house and the trench underneath the gas main in the rear of the boiler house are drained into this sewer. As it passes beyond the corner of the power house it emerges again into an open sewer which is led down to the river. Into this sewer also drains the surplus condenser water; any surplus bosh return water, and the drainage from the power house basement. The sewer is of ample capacity to handle all surplus and waste water as well as storm water about the plant.

Hot metal is normally shipped to the mixer of the Trumbull Steel Company, but there is also provided for the casting of chill iron a double strand pig casting machine. This is standard Heyl & Patterson equipment having manganese links and pins. The pig machine strands are mounted on a reinforced concrete structure. This type of construction was originated at the blast furnace plant of the Otis Steel Company and was chosen because of elimination of deterioration encountered with structural steel supports by reason of the large amounts of steam and water about the operation. The concrete structure provides a continuous platform under the strands, makes for an easy replacement of molds, and provides a channel for spray water which is carried into a sump at the pouring end. The length of rails is limited to 11 ft. to make a convenient length for handling when replacements are necessary. All castings used in connection with the machine and in connection with the structure can be replaced with open sand castings poured at the cast house of the plant. The machine is laid out for additional strands with the growth of the plant. Integral with the pig casting machine is a combined ladle and pouring house. In this is a 55-ton Morgan pouring and ladle handling crane having 100% overload capacity. This serves both to pour the ladles by means of the patented Pollock short pour device and also serves for removing the ladles from the trucks for relining. A spare ladle is provided to be held in reserve for lining.

Considerable study was given the location of the track scales and these were so located that they serve admirably both for the light and heavy weighing of pig iron cars as well as for check weights on receipt of raw material into the yard. A well designed scale house is noteworthy, in which is also incorporated the yardmaster's office, locker rooms for train crews and washroom facilities. The facilities at the scale house office are supplemented by a larger locker and service room for the furnace men located in proximity to the incline leading from yard level up to the furnace and stove foundation top. Additional toilet and locker rooms are located in the basement of the power house and boiler house for the men, and at the machine shop.

Provisions for repair and maintenace of the plant and its equipment are all grouped in one large central machine shop building. In the center bay of this building is the machine shop proper which is arranged for a traveling crane spanning a very complete complement of machine tools adequate to machine and repair all parts of equipment and castings going into the construction or repair of the plant. There are two lean-tos which house the chief engineer's and general master mechanic's office, and which also have the pattern shop, electrical shop, pipe fitting shop, blacksmith shop and storeroom. The storeroom for large castings and bronze parts is in a bricked-in house under the trestle approach and the storage for rigger tools is in a similar brick house. The general administrative and executive offices are in a large well designed building at the plant entrance. Here is placed the general superintendent's and his assistant's office, the office of the chief clerk and the timekeeping, distributing and clerical force, the laboratory, police and employment offices, and the cafeteria.

The quantities of material used in connection with this job are of interest. There were placed 2,246 20' to 30' Raymond reinforced concrete piles; a total of 61,974 cu. yd. of excavation; 31,601 cu. yd. of concrete; 224,365 cu. yd. of fill; 750 tons of reinforcing steel; 1,270 tons of plate; 729 tons of castings; 145 tons of structural shapes; 65 tons of forgings; 1,251 tons of structural steel in buildings 1,020 M building brick; 2,083 M fire brick, and an average of 371 men were employed per day for the 10 months' period of construction.

The contractors engaged in this work were as follows: Fabrication and erection of iron and steel work other than structural, the William B. Pollock Company; fabrication and erection of structural steel in buildings and skip incline, Lackawanna Bridge Company and Hill Clutch Company; Phenix Iron Works and the Pennsylvania Engineering Works furnished some of the iron and steel castings. All brick work in furnace, stoves, boilers, power house and offices was placed with the P. J. Brown Construction Company; the concrete was put in by Arthur G. McKee & Co.; car dumper and ore bridge, Mead-Morrison Manufacturing Company; ore bins and scale cars, Hoover & Mason. Piping was installed by B. Floersheim & Co. Instruments for the blast furnace and power and boiler houses were supplied by The Bristol Company. The Trumbull-Cliffs Furnace Company, in the person of Mr. J. S. Fraser, works manager, and Mr. O. C. Callow, electrician, supervised and directed the placing of most of the equipment wiring and switchboard.

The construction of the plant was directed by the organization of the Cleveland-Cliffs Iron Company through Mr. D. T. Croxton, manager of their pig iron sales department. The plans and specifications for the complete plant and plant equipment were drawn up by Freyn, Brassert & Co., Chicago. These engineers also had supervision of construction, Mr. Roy W. Clark being chief resident engineer, for the firm.

The Trumbull-Cliffs Furnace Company, through its executive and its superintendent, coöperated with the engineers in all details of planning the work, in purchase and delivery of materials, and in expediting the work in the field.

On completion the Trumbull-Cliffs Furnace Company held "open house" and the plant was visited by a large number of executive and operating officials of the iron and steel plants of the country. The many features and the remarkably quick time of construction have been the object of much favorable comment and the Trumbull-Cliffs Furnace Company is not only to be commended for the opportunity it has given the men in the industry for personal inspection of the plant, but is also to be congratulated upon the ownership of a plant that represents such a conservative and successful application of sound operating and engineering features.

QUESTIONS AND ANSWERS.

Question recently submitted to the Blast Furnace and Steel Plant.

"What is the cause of negative brushes pitting and the positive brushes picking copper on a D. C. generator 800 kw. 83 rpm. 3,200 amps? Machine is not overloaded.

Answer: The condition experienced above is in the nature of an electralytic action. Where the electric current flows from one surface to another, there is a tendency for small particles from the substance out of which the current flows to the other conductor.

Thus in a generator, negative brushes are eaten away and the carbon in some cases deposited on the surface of the commutator causing it to blacken.

If the action is more severe, copper is taken away from the commutator and deposited on the positive brush, and the commutator takes on a bright surface but does not polish.

This action is due to too high current density under the brush. This may not necessarily mean that the load current is too high, but rather that the short circuit current—due to improper commutation of the voltages generated by the process of commutation is excessive.

This may be caused by improper brushes, wrong and gap between armature and interpole, saturation of the interpole circuit, interpoles not properly adjusted as to the ampere turns, and brushes not on the electrical neutral.

This action will also be noted on revolving field alternators, where one ring becomes very rough and is eaten away while the other ring takes on a bright polish.

This action also comes into play on the slip rings of rotary converters, causing them to become eccentric and the brushes to chatter.

This explains why brushes should be staggered in pairs and not alternately. In staggering brushes alternatively the positive brushes will run in the same track, thus grooving the commutator.

A large majority of comutator wear is due to this and not to the abrasive material in the brushes as often supposed.