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Calcium Carbide Furnace Operation

by James W. Frye

INTRODUCTION

In 1967 Airco Alloys and Carbide was operating seven open top packet-type furnaces producing calcium carbide for acetylene generation. Because of air pollution problems associated with that type of an operation, the decision was made to construct a covered furnace to take the place of the smaller furnaces. By late 1968 Electrokemisk and Airco had agreed on a design, and construction had begun on a covered furnace which would be capable of producing calcium carbide at a load of 50,000 kilowatts. This furnace went on stream in August 1969.

FURNACE DESIGN

Shell

The furnace, as designed by Elkem, has a shell diameter of 32 feet 5 inches and a shell depth of 9 feet from the bottom of the taphole to the top of the shell at the cover sand seal. The furnace bottom consists of 2 feet of Kaiser Refractories high duty firebrick, 1 foot of 70% alumina firebrick, and approximately 5 feet of rammed carbon paste into which graphite runners were set at each taphole. The sidewalls were lined with 1¼-inch mineral wool and 13½ inches of insulating firebrick.

There are four tapholes, three of which are being used and one constructed as a spare. The tapholes were constructed of silicon carbide brick using 70% alumina brick as keys. Each taphole was water cooled by use of a cooling frame and cheek plates. The shell sits atop concrete piers and two 14,000 CFM fans continually blow outside air under the furnace. Fig. 1 shows a view of the inside of the furnace before the carbon paste lining was added. Fig. 2 shows an outside view of the furnace at No. 1 taphole. Note the cooling plate and the concrete piers.

Cover

The cover is water cooled and is made from low carbon steel. Each cover segment is baffled for good water circulation. A recirculating water system, including chemical water treatment, is used for cooling purposes with city water used for makup water. The system operates at a circulating rate of 3,000 gpm at a pressure of 40 to 50 psi. Fig. 3 shows a view of the cover. Please note the water lines run under the operating floor over to the water bosch. There are several blowout doors in case of bad or violent blows in the furnace. There are six small explosion ports on top of the cover and a large explo-

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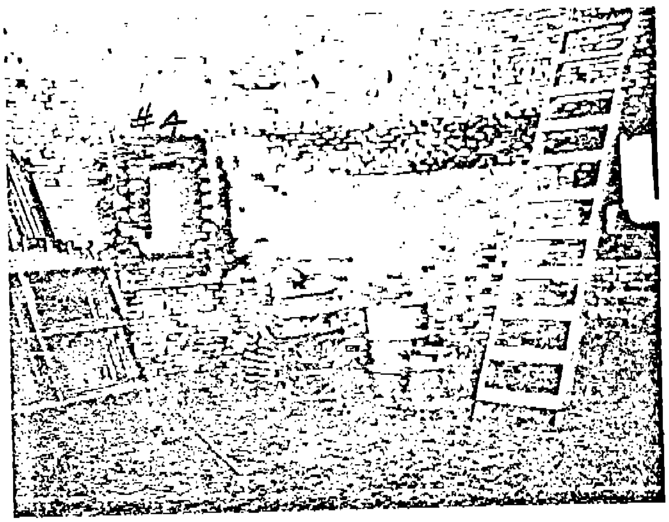

Fig. 1—Inside lining of furnace.

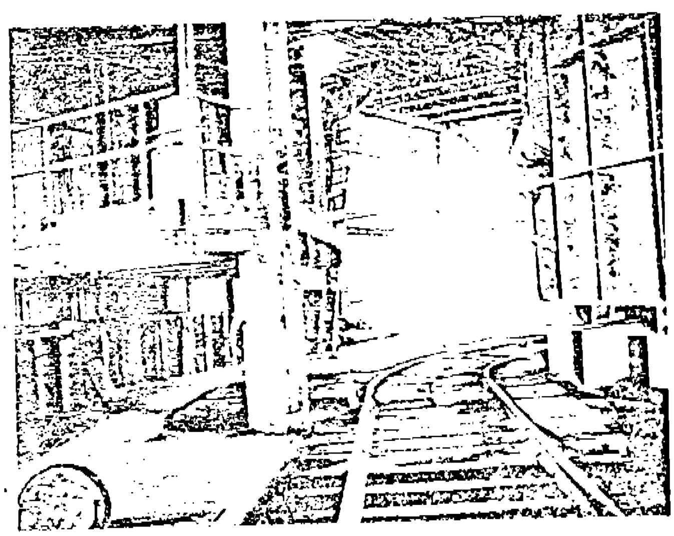

Fig. 2—Ground floor of furnace building.

sion door at each electrode which also serves as access to the inside of the furnace in event of emergencies. The cover is also equipped with nine small clean-out doors.

Off-Gas

CO gas is taken from under the cover through two lines from atop the cover. Fig. 4 shows a view of the two

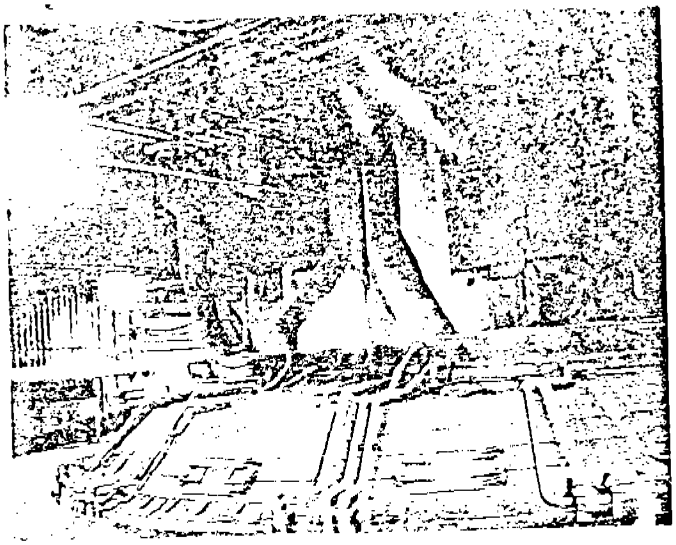

Fig. 3—Furnace No. 8 operating floor and cover.

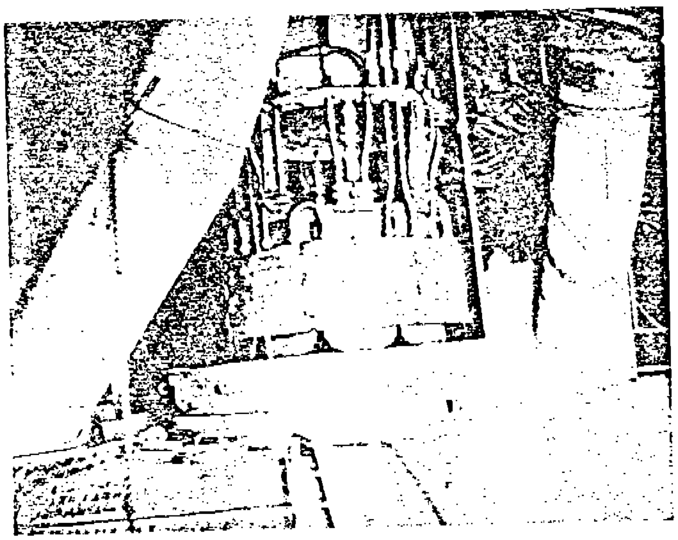

Fig. 4—Furnace cover with two off-gas lines.

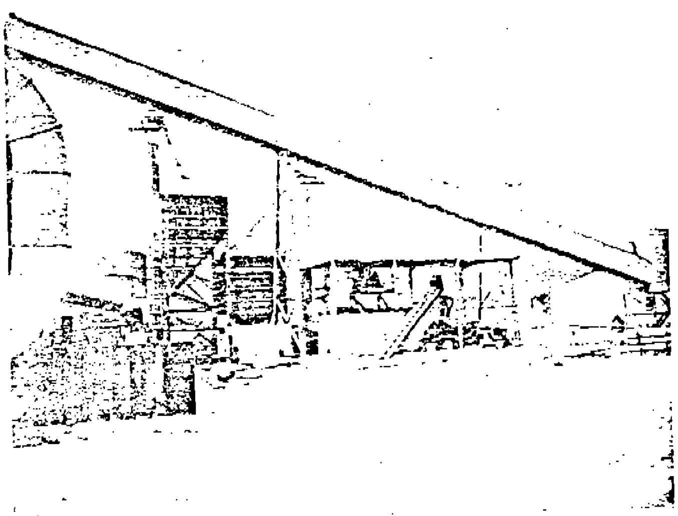

Fig. 5—View of raw material handling system.

off-gas lines. The top-hats, which are refractory lined, sit atop the cover and the gas enters them and passes up the 30-inch lines to the third floor where the two lines combine and pass out of the building. The section immediately over the top-hats has been water cooled. The remainder of the stack is made from type 304 stainless steel 3/16 of an inch thick. It has been found necessary to clean these lines with the use of an air hose approximately once per week.

Once out the building, the gas can be sent in either of two directions. It can be vented directly out the furnace stack by opening a water valve or it can be pumped to a lime kiln with the use of a Garden City blower using an 1800 rpm 100 horsepower motor. Using the latter route, the gas is pumped approximately 370 feet. Normal temperatures in the line vary from 1200°F 38 feet above the furnace, 1000°F 65 feet from the furnace, 800°F 184 feet from the furnace, 700°F 290 feet away, and 600°F at the lime kilns. The gas is sent to the kilns approximately 95% of the time. This serves as an economical fuel supply for the production of lime from lime hydrate and also as an air pollution deterrent. With the strict air pollution enforcement in Jefferson County, Kentucky, we have to keep the pollution board informed as to when we are going to flame the gas, for approximately how long, and what the problem is that is causing the flaring.

MIX SYSTEM

Lime comes from two sources. Approximately 33% of the lime feed is produced at the Louisville plant utilizing hydrate from our acetylene-generating process. This lime is pelletized and analyzes approximately 87% CaO. The other source of lime is purchased lime and analyzes approximately 97% CaO. The mixture of lime is passed over a ¼-inch screen with the fines being reprocessed through pellet presses and the sized portion, approximately 1½ inches by ¼ inch, going into a 250-ton bin. The carbon source is coke purchased on the open market. The size range is limited to 1 inch by ⅜ inch and the fixed carbon averages 88%. This coke is dried to a moisture content of 0.5% maximum in a Roto Louvre dryer recently equipped with a Wheelabrator baghouse type dust collector. Upon drying, the coke is elevated into a 100-ton capacity bin. Both the lime and coke bins are located over a belt conveyor which transfers the weighed charge to the furnace building. Each ingredient is weighed over a Merrick-type belt weighing conveyor. The amount of each ingredient used is controlled electrically by the furnace operator.

Fig. 5 is a view of the raw material handling system showing the coke and lime bins, the coke dryer, and the system of conveyors for moving the charge to the furnace building. Fig. 6 is a view of the Merrick scale system used in weighing the charge.

Fig. 6—Lime and coke scales.

Once the charge enters the furnace building it is emptied onto what we call a "runaround" which is actually a circular conveyor. The furnace operator controls the dumping of the charge from the circular conveyor into one of nine mix hoppers located over the fur-

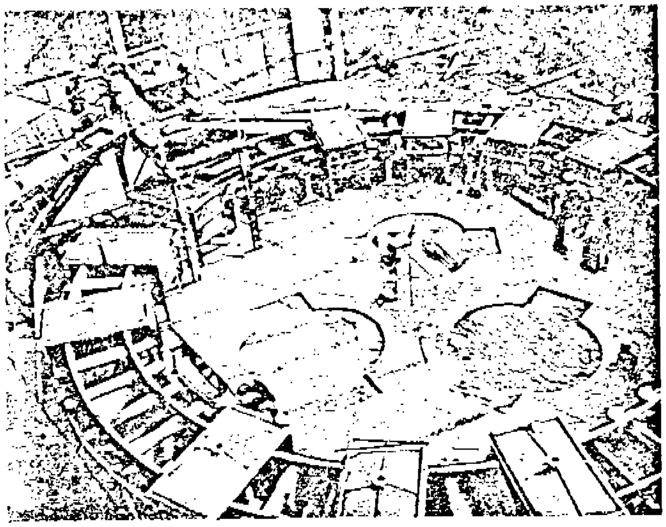

Fig. 7—Makeup floor, rotary converter No 5.

nace. Each hopper holds approximately 1 hour's supply of mix.

Fig. 7 is a view of the runaround and Fig. 8 shows the hoppers for mix storage.

The mix is fed continuously from the nine hoppers into the furnace using a choke feed principle. It is spread evenly around the electrodes through 18 mix spouts and the flow is controlled around the electrode with the use of insulated funnels. Fig. 9 shows the mix spouts and funnels as they have been described.

ELECTRODE SYSTEM

The Louisville furnace utilizes 10-gauge casings and our own manufactured paste to produce 62-inch diameter self-baking electrodes. The electrode columns are suspended from a two-point hydraulic cylinder arrangement as shown in Fig. 10. Fig. 10 also shows the slipping bands which hold approximately 70% of the electrode column's weight. These bands utilize an air-filled membrane to hold the column. The other 30% of the column's weight is held by the eight contact shoes held against each electrode by the clamping band. This equipment is shown in Fig. 9.

Paste additions are made utilizing 1-ton cylinders of cold paste. The paste level under normal operation is maintained 20–25 feet above the bottom of the contact shoes. The electrode length is maintained at 8–8½ feet below the contact shoes and approximately 50 inches off the furnace bottom.

For good solid baking we limit our slipping to a maximum of 1 inch per ½ hour if the secondary amperage is between 100 and 120 kiloamps per phase. This amperage gives a current density of near 35 amps per square inch. Our normal paste consumption is 42 pounds per ton of product or a slipping rate of approximately 1 inch per hour.

POWER SUPPLY

Power is supplied to our plant by Louisville Gas and Electric Company through 13,800 volt lines. Three single-phase Ferranti Packard transformers, rated at 22,000 kilovolt-amperes each, step this voltage down to that normally used in our operation. The furnace can be quickly changed to operate on a low voltage or wye-delta range, 93 to 217 volts, or to a higher voltage or delta-delta range, 180 to 380 volts. The furnace was designed with on load tap changer. The furnace is also equipped with two sets of capacitors which can be easily switched in or out in order to maintain an optimum power factor.

A very short run of copper bus from each transformer delivers power through flexible cables into the power tubes on each contact shoe (Fig. 11).

The furnace is controlled from an operating room located next to the furnace. The electrical controls are

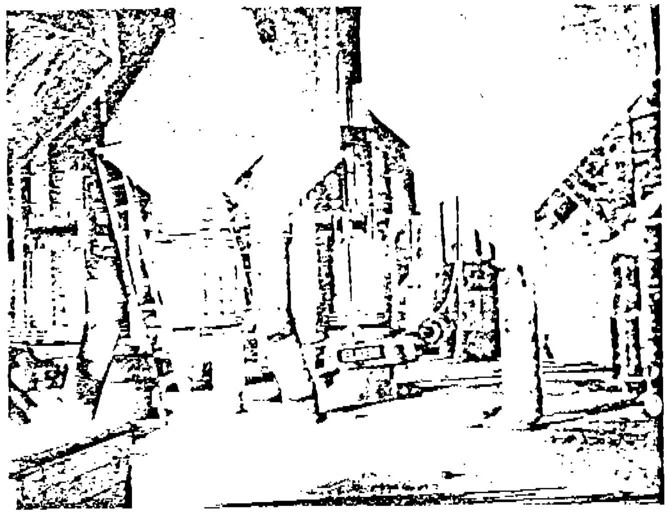

Fig. 8—Slipping floor, hoppers for mix storage.

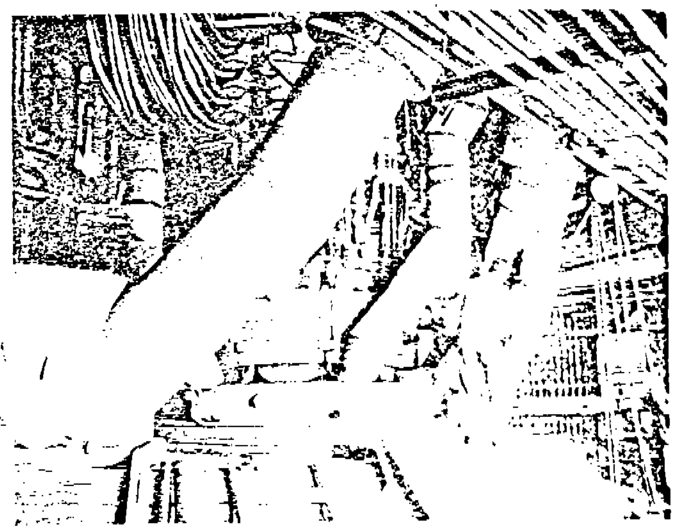

Fig. 9—Furnace charging chutes.

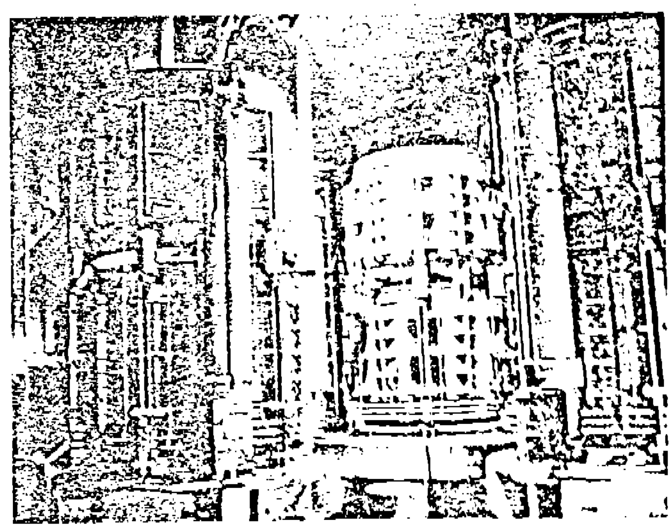

Fig. 10—Electrode slipping mechanisms.

shown in Fig. 12. The electrodes are equipped to operate either manually or automatically so as to maintain a proper amperage-voltage relationship. Under normal operating conditions the load averages 45,000 kilowatts with a secondary amperage of 115,000 amps and a sec-

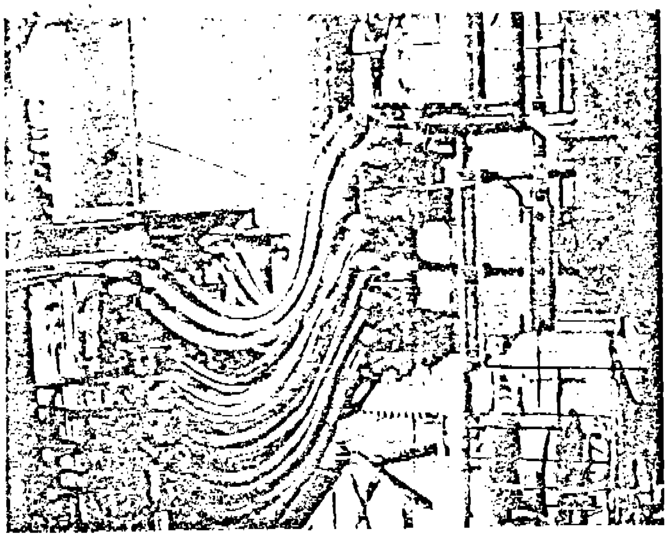

Fig. 11—Electrode holders, bus, flexible water piping.

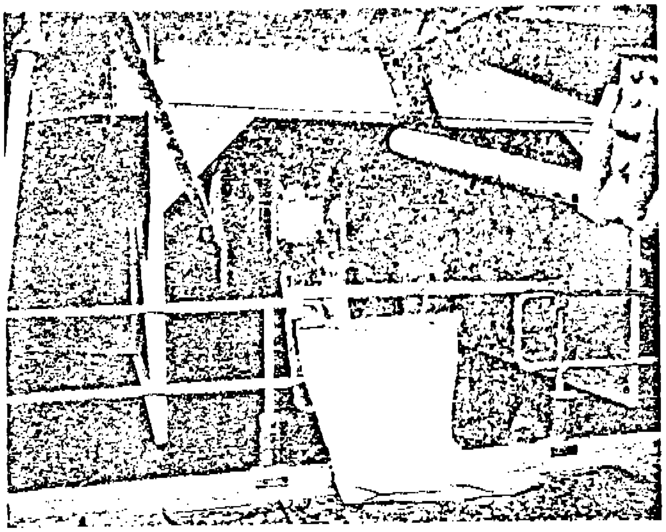

Fig. 13—No. 8 furnace north taphole after first tap.

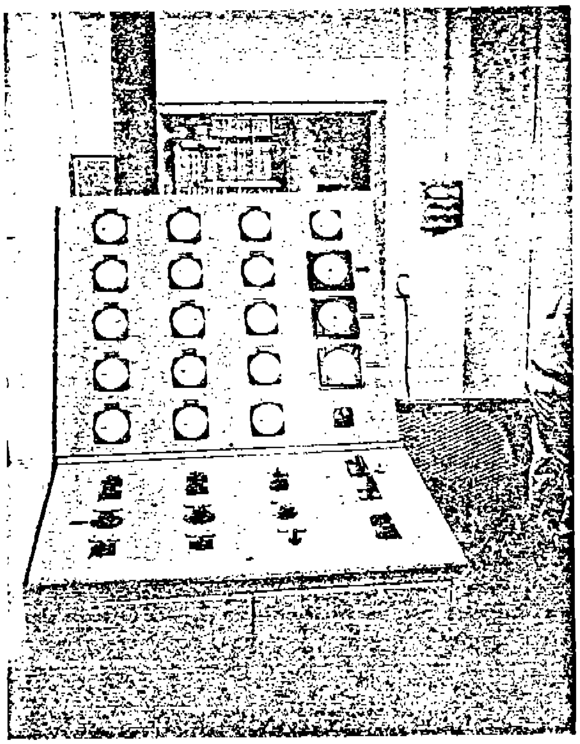

Fig. 12—No. 8 furnace control panel, power on.

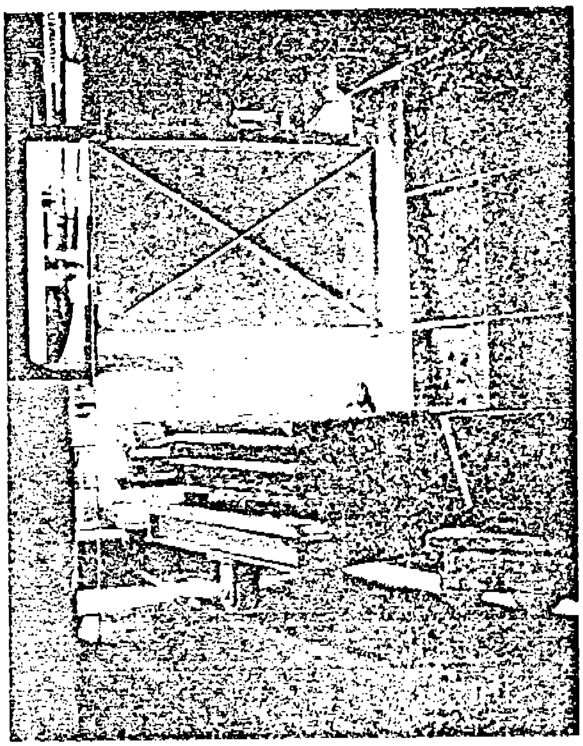

Fig. 14—No. 8 furnace north taphole, chill cars and molds.

ondary voltage of 306 volts. The power factor with a gas yield of 4.80–5.00 cubic feet acetylene per pound of carbide is normally 0.72. At this gas yield the power usage normally runs 2850 kilowatt-hours per ton of carbide.

Standard mix consumption at this higher gas yield and with the mixture of purchased and produced lime has been approximately 1.10 pounds of lime and 0.60 pounds of coke per pound of carbide.

TAPPING OPERATION

The Louisville furnace is equipped with four tapholes although only three are in use. The furnace is continually tapped from one hole at a time and taphole rotation occurs every 4 to 6 hours.

A taphole is opened by the use of a 6-inch graphite stinger which draws power from the main bus supply to one of the electrodes. Normal time required to open a hole is 30 to 45 minutes. Once one hole shows indication of being open, the other hole is plugged off by simply shoveling carbide into it. Fig. 13 shows the taphole and stinger just before opening.

The furnace is tapped into chill cars which run on a track around the furnace into a cooling area. Fig. 14 shows the chill cars with the molds sitting on top. The cars are attached with the use of connecting pins and are moved either by the use of winches (Fig. 15) or with the use of a tow tractor similar to that used in airports (Fig. 16).

Taphole fume hoods have been installed over each taphole in order that the fumes can be collected and transported to a baghouse rather than being allowed to go off into the atmosphere. In addition to the taphole dust, the baghouse also collects dust from the transfer points of the mix system.

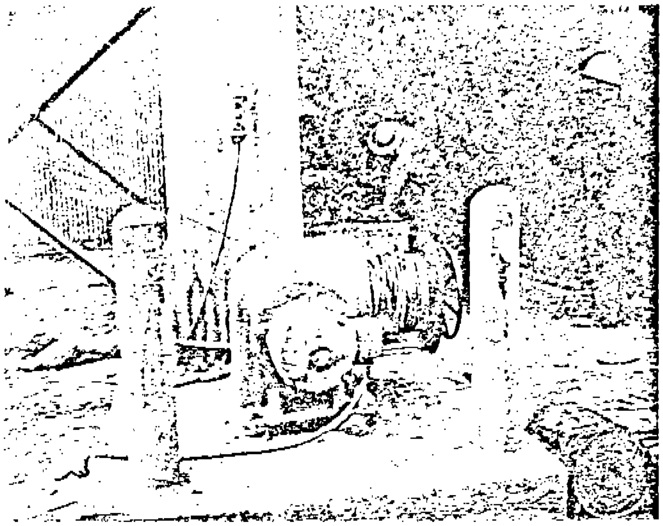

Fig. 15—Winch car puller on west side of furnace building.

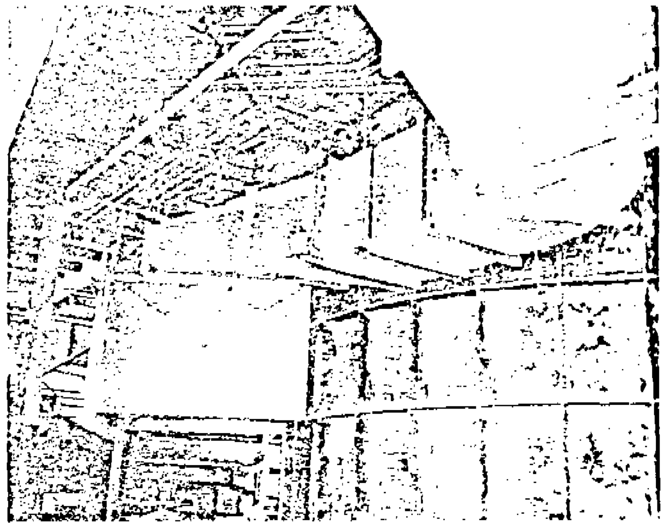

Fig. 17—Fume hood duct.

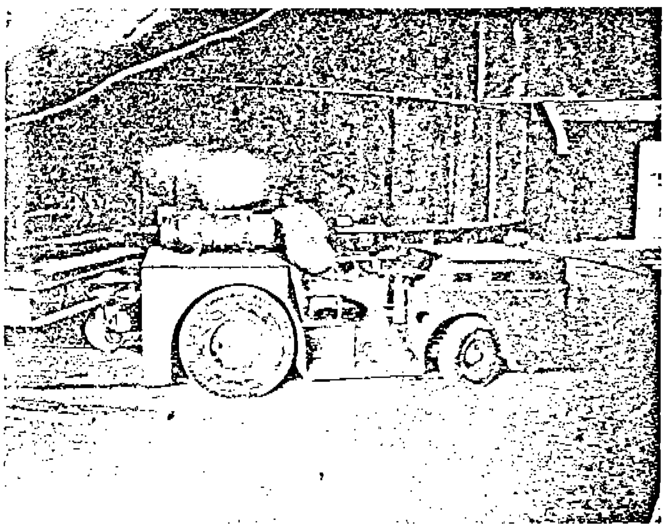

Fig. 16—Tow tractor used for pulling cars.

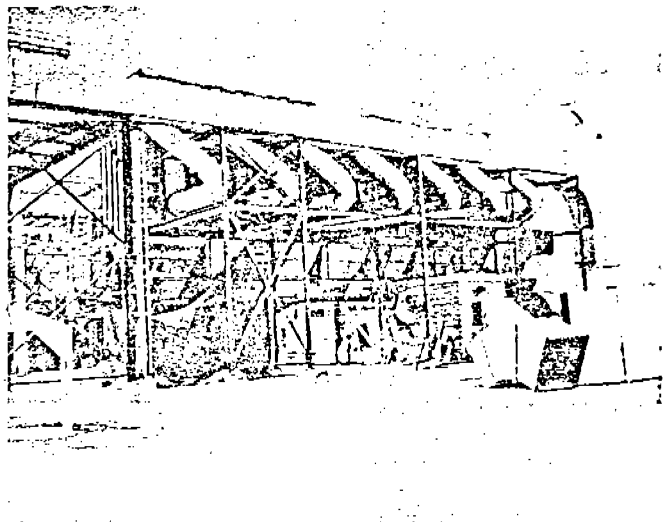

Fig. 18—Dust collector.

Fig. 17 shows a view of the tap hood and Fig. 18 shows the furnace baghouse. There has been an addition of two compartments since this picture was taken in order to pick up additional dust points.

It is estimated that with the gas in the lime kiln and with the coke plant and furnace baghouses in normal operation the dust condition into the atmosphere has been improved nearly 97% over that encountered with the seven smaller open furnaces.

An average of 330 tons of carbide is tapped each day. Each chill weighs 3.4 tons. The track is equipped to handle 35 to 38 cars, so each car is filled once each shift.

After cooling for approximately 8 hours, the chill of carbide is removed from its mold by use of an overhead crane and set in an area for further cooling before crushing. Nearly 24 hours of cooling time are required before crushing.

The standard crew size for operating this furnace is 10 men: one control room operator; one crane operator; four tappers; and four men for moving chill cars, hooking up the crane, and maintaining housekeeping standards.

CONCLUSION

Our operation is not always as good as the picture being painted. The raw materials being offered today on the open market are of much lower quality than that offered 5 to 10 years ago. As a result, metal taps from our furnace have been quite frequent resulting in damage to the taphole area and the track underneath.

An additional problem to consider is that, although this one furnace did replace seven others, the fact that there now is only one leads to problems unencountered before. When this furnace goes down for repair there is no other to fall back on. Production has ceased completely and, until repairs can be made, you have an unproductive plant. So to speak, "All the eggs are in one basket."

In defense of a 50,000-kilowatt furnace, and especially the Louisville furnace, there is no loss in operating characteristics between, say, 30,000 and 50,000 kilowatts; the furnace runs very quietly on top at the higher load if good operating practices are followed.

This furnace is probably the best electrically equipped furnace I have been associated with. The furnace is metered for readings both on the primary and secondary side of the transformers. Meters there tell the operator what his penetration, power factor, volts, amps, load, and possible grounds under the furnace cover are at any given moment. By knowing what his meters are showing him an operator has very little excuse for poor furnace operation.