Note: This is a reference cited in *AP 42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources.* AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

The file name refers to the reference number, the AP42 chapter and section. The file name "ref02_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference may be from a previous version of the section and no longer cited. The primary source should always be checked.

AP42 Section:	11.3
Reference:	6
Title:	Written communication from B. Shrager, Midwest Research Institute, Cary, NC, to R. Myers, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 1993.

AP-42 Section 11.3
Reference 6

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Date: July 13, 1993
(Finalized September 3, 1993)

Subject: Site Visit--Belden Brick Company
Review and Update Remaining Sections of Chapter 8
(Mineral Products Industry) of AP-42,
EPA Contract 68-D2-0159, Work Assignment 12
MRI Project 3612

From: Brian Shrager BS

To: Ron Myers
EPA/EIB/EFMS (MD-14)
U. S. Environmental Protection Agency
Research Triangle Park, NC 27711

I. Purpose

The purpose of the visit was to evaluate the feasibility of emission testing at this site for the purpose of developing emission factors for AP-42.

II. Place and Date

Belden Brick Company
Dover Road
Sugarcreek, Ohio 44681

Date: June 9, 1993

III. Attendees

Belden Brick Company (Belden)

John Jensen, Environmental Engineer

Midwest Research Institute (MRI)

Richard Marinshaw
Brian Shrager

IV. Discussion

The group began a tour of Belden's Sugarcreek, Ohio operations by viewing the mining operations that provide the raw materials for all of Belden's Sugarcreek plants. Belden has 32 open pits, one of which is shown in Figure 1, from which the materials are mined. The pits include deposits of three types of shale (Nos. 5A, 4, and 3A), No. 4 fire clay, and No. 5 fire clay, in addition to limestone, sandstone, and coal. Figure 2 shows the profile of a typical "Belden hill" from which these raw materials are mined. The raw materials are mined by power

shovels and transported to the plants by truck. Figure 3 shows an exposed seam of 3A shale at a "Belden hill" or open pit mine. Mr. Jensen pointed out the regional geologic formations and emphasized Belden's use of different raw material blends for production of different types of brick. The group proceeded to a facility where the raw materials are test fired on a weekly basis. Belden maintains detailed records of the material characteristics and locations within the pits. Mr. Jensen explained that it is vital to the production operations to know exactly how a particular material will look when it is fired in a kiln. The group then visited Plant 6, which consists of a central crushing, grinding, and screening operation, a central brick forming operation, eight brick dryers, and three kilns. Plant 6 produces 36 to 40 million bricks per year. The grinding room operates 8 hours per day, 5 days per week, and the kilns operate continuously. The typical raw material moisture content was not known at the time of the visit.

From Plant 6, the group proceeded to Plant 8, which consists of two primary crushers in a separate building; a central grinding, screening, and raw material storage area; a central brick forming operation that includes two extruding lines; a soft mud line; a dryer for the soft mud line; six drying tunnels for the extruding lines; a preheater for the soft mud line; and three kilns. Plant 8 produces 70 million bricks per year. The grinding room operates 8 hours per day, 5 days per week, and the kilns operate continuously.

The group also visited Plants 3 and 4, but these plants are not typical of the brick manufacturing industry and are not good candidates for testing. Plant 3 is a new facility that has a very large grinding room and tunnel kiln, and Plant 4 uses periodic kilns to fire bricks. Figures 4 and 5 show the Plant 4 brickyard and periodic kilns. Figure 6 shows a periodic kiln. The following paragraphs describe the process operations in Plants 6 and 8 in more detail.

Plant 6

Figure 7 presents a process flow diagram for Plant 6. Production begins at the grinding room, which is a large metal building that contains separate fire clay and shale processing lines. Each identical line consists of a hopper, double-roll primary crusher, crushed material storage bins, a grinder, and three screens. The raw material is transported from the mine by truck in loads of approximately 23 Megagrams (Mg) (25 tons). The trucks dump the material into the fire clay or shale hoppers from which the material transported by drag chains to double roll primary crushers. From each crusher, the material is conveyed to storage bins, then to the grinder and screens. All material is ground prior to screening. Oversize material from the screens is conveyed back to the grinder for further size reduction. Undersized material from the screens is conveyed to the fine

clay/shale storage bins located in an adjacent building. Emissions from each line (crusher, grinder, screens and conveyor transfer points) are ducted to separate fabric filtration systems that are located just outside of the grinding room. Figure 8 shows a vibrating screen with the hood and ductwork that leads to the fabric filter. Figure 9 shows the fabric filter inlet duct for the clay processing line. The duct is of sufficient length for testing, but two smaller ducts from the processing line tie into the main duct downstream of the potential test area. Figures 10 and 11 show the fabric filter outlet ducts for the clay and shale processing lines, respectively. The shale line outlet duct is 0.84 meters (m) (29 inches [in.]) in diameter and is 3.7 to 4.0 m (12 to 13 feet [ft]) in length. The clay line outlet duct is 0.74 m (33 in.) in diameter and is 3.8 m (12.3 ft) in length. The air flow rate for each screen hood is about 2,400 cubic feet per minute (ft^3/min) and the air flow rate through each crusher and grinder pickup point and conveyor transfer point hood is 600 ft^3/min. The system carrying velocity is 4,500 feet per minute (ft/min). Because nearly all of the emission points in the grinding room are hooded, fugitive particulate matter (PM) emissions are negligible.

The grinding room product is conveyed to the fine clay/shale storage bins located in a building adjacent to the grinding room. The grinding room and conveyors are shown in Figure 12. Material from the fine clay/shale storage bins is conveyed to the mill room.

In the mill room, the material is conveyed to one of four extrusion lines. Lines 1 and 4 process shale, and lines 2 and 3 process fire clay. However, clay and shale can be mixed on any of the four lines. Approximately one-third of the bricks produced in Plant 6 are made from a blend of shales, one-third are made from fire clay blends, and the remaining third are made from a mixture of fire clays and shales.

Each extrusion line includes a pug mill, vacuum chamber, and die. The pug mills mix the material with water to raise the material moisture content and discharge the material directly into the vacuum chambers. The vacuum chambers de-air and compact the material. Next, the material is continuously augered through the dies. This is referred to as the "stiff extrusion process." The material is extruded in four continuous columns, the outsides of which are lubricated with No. 2 oil, which facilitates cutting. The columns then pass through rotating wire cutters and are cut into the desired brick dimensions.

Several additives are mixed with the raw material (as needed) before extrusion. Iron chromite and manganese dioxide are used for coloring purposes, and barium carbonate is added to keep sulfates from rising to the surface of the brick. Additive feed is controlled by computer.

After cutting, the bricks are stacked by hand onto the kiln cars. On average, each car carries 3,472 bricks. From the stacking area, the bricks are transported to eight dryers (shown in Figure 13), which are heated by waste heat from the cooling section of the kilns and by Dutch oven type heaters, which are additional gas-fired burners located on the top of the dryers. These dryers maintain temperatures ranging from 49°C (120°F) at the entrances to 177°C (350°F) at the exits. Three stacks (shown in Figure 14) vent emissions from the eight dryers to the atmosphere. Dryers 1, 2, and 3 share a stack, dryers 4 and 5 share a stack, and dryers 6, 7, and 8 share a stack. The dryer stacks are circular in cross section and are made of steel. From the dryers, the cars are transported to the kilns for firing.

Plant 6 has three natural gas-fired tunnel kilns that are used to fire the bricks. Kilns 1 and 2 are 104 m (340 ft) long, and kiln 3 is 119 m (390 ft) long. Each kiln consists of six sections, including the offtake, oxidation, preheat, firing, rapid cool, and cooling sections. Kilns firing fire clay products maintain temperatures ranging from 204°C (400°F) at the offtake section to about 1149°C (2100°F) at the hottest point of the firing section. Kilns firing shale products maintain temperatures ranging from 204°C (400°F) at the offtake section to about 1071°C (1960°F) at the hottest point of the firing section. Between the firing and rapid cool sections is the zero point of each kiln. The zero point is the theoretical point beyond which combustion gases do not pass. Beyond the zero point, only the waste heat (no combustion gases) from the fired bricks in the cooling section is ducted to the brick dryers.

Emissions from the kilns are ducted to two stacks (shown in Figure 15), one serving kilns 1 and 2, and one serving kiln 3. The stack serving kilns 1 and 2 is brick and has dimensions of 1.5 x 1.6 m (60 x 64 in). This stack is split in the center, effectively creating two 1.5 x 0.81 m (60 x 32 in.) stacks. The side of the stack that vents emissions from kiln 2 is equipped with 5 in. sampling ports. The stack serving kiln 3 is also brick and is 1.7 m (68 in.) square in cross section. This stack is equipped with 5 in. sampling ports. There are no emission control devices on either of the two stacks. Emissions from the kiln are likely to be PM, sulfur dioxide, nitrogen oxides, carbon monoxide, fluorides, and other inorganic and organic compounds from combustion or vaporization of the raw materials.

Plant 8

Figure 16 presents a process flow diagram for Plant 8. Production begins at the primary crusher building. The raw material is dumped by truck into the fire clay or shale hoppers that feed the primary crushers. From each crusher, the material is conveyed to storage bins that are located in the grinding room. The grinding room is a large metal building that contains separate fire clay and shale processing lines and includes four

baghouses, two of which contain dual fabric filters. Figure 17 shows a rim discharge grinder, Figures 18 and 19 show some of the vibrating screens and hoods, Figure 20 shows several screens and a fabric filter, and Figure 21 shows a fabric filter. Because of the number of fabric filter ducts that would require testing, this grinding room is not considered a good candidate for an emission test.

The grinding room product is conveyed to the fine clay storage bins. Material from the fine clay storage bins is conveyed to the mill room.

In the mill room, the material is conveyed to one of two extrusion lines or to the soft mud line. Most of the bricks produced in Plant 8 are made from a blend of clays and shales. The extrusion lines are similar to the Plant 6 extrusion lines. The soft mud line uses a completely different method to form bricks. A double pug mill increases the material moisture content to about 28 percent. This "soft" material is forced into sand-lined molds, which are inverted, depositing the molded material onto wooden pallets that support the material so that it will retain the proper brick dimensions. The pallets transport the "soft" bricks to a dryer, which hardens the bricks so that they can be mechanically set onto kiln cars. The drying process takes 20 hours, and the finishing temperature in the dryer is about 66°C (150°F).

After forming and drying, the soft mud bricks are mechanically set onto kiln cars. After forming and cutting, the extruded bricks are hand set onto kiln cars. On average, each car carries 5,616 bricks. From the stacking area, the soft mud bricks are transported to a holding area and then to a preheater, and the extruded bricks are transported to six holding rooms/dryers, which are heated by waste heat from the cooling section of the kilns. These dryers maintain temperatures ranging from 49°C (120°F) at the entrances to 177°C (350°F) at the exits. Three stacks vent emissions from the preheaters and dryers to the atmosphere. The preheater has one stack; dryers 1, 2, and 3 share a stack; and dryers 4, 5, and 6 share a stack. From the dryers, the cars are transported to the kilns for firing.

Plant 8 has three natural gas-fired tunnel kilns that are used to fire the bricks. The kilns have a considerably larger capacity than the Plant 6 kilns, and they include a flashing zone, where coal, natural gas, or zinc can be introduced into the kiln atmosphere, creating smoke that adds color to the surface of the bricks. The smoke is drawn into the firing section of the kiln. Kilns firing fire clay products maintain temperatures ranging from 204°C (400°F) at the offtake section to about 1149°C (2100°F) at the hottest point of the firing section. Kilns firing shale products maintain temperatures ranging from 204°C (400°F) at the offtake section to about 1071°C (1960°F) at the hottest point of the firing section. Between the firing and

rapid cool sections is the zero point of each kiln. At the zero point in each kiln, the combustion gases are drawn away from the cooling zone, and the waste heat (no combustion gases) from the fired bricks in the cooling section is drawn to the ducts that lead to the brick dryers and preheaters.

Emissions from the kiln are ducted to two stacks, one serving kiln 1 (shown in Figure 22), and one serving kilns 2 and 3 (shown in Figure 23). Both stacks are constructed with brick and are 1.4 m (56 in.) square in cross section. The stack serving kilns 2 and 3 is equipped with a 5-in. sampling port. There are no emission control devices on either of the two stacks. Figure 23 shows both kiln stacks above the roof of Plant 8. Emissions from the kiln are likely to be PM, sulfur dioxide, nitrogen oxides, carbon monoxide, fluorides, and other inorganic and organic compounds from combustion or vaporization of the raw materials.

V. Conclusions

The sources being considered for testing are the grinding room and the kilns. It appears feasible to test controlled PM and PM-10 emissions from the Plant 6 grinding room. The grinding room appears typical of the industry, except for the separate processing lines for shale and fire clay. The Plant 8 grinding room is not typical of the industry and is not a good candidate for testing.

Testing of emissions from the dryers and kilns at either plant should be relatively straightforward. However, the flashing process used in the Plant 8 kilns is not standard industry practice, and may effect kiln emissions. Sampling ports would have to be installed in the dryer stacks at either plant.

Trucks carrying raw material to the primary crushers produce some fugitive dust emissions at both plants, but fugitive dust emissions from plant traffic appear to be minimal. Also, there are no open storage piles at either plant.

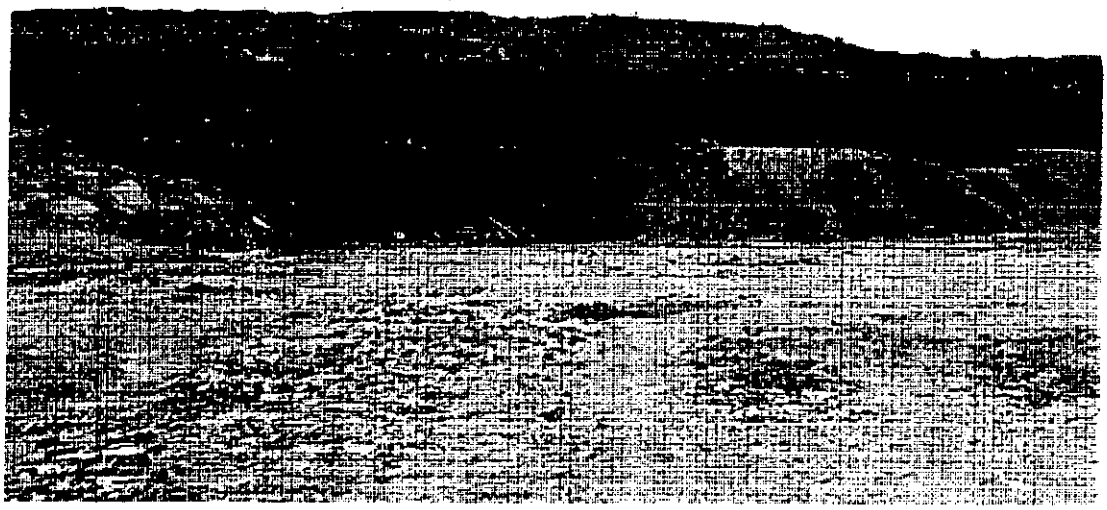

Figure 1. Belden Brick Company open pit mine.

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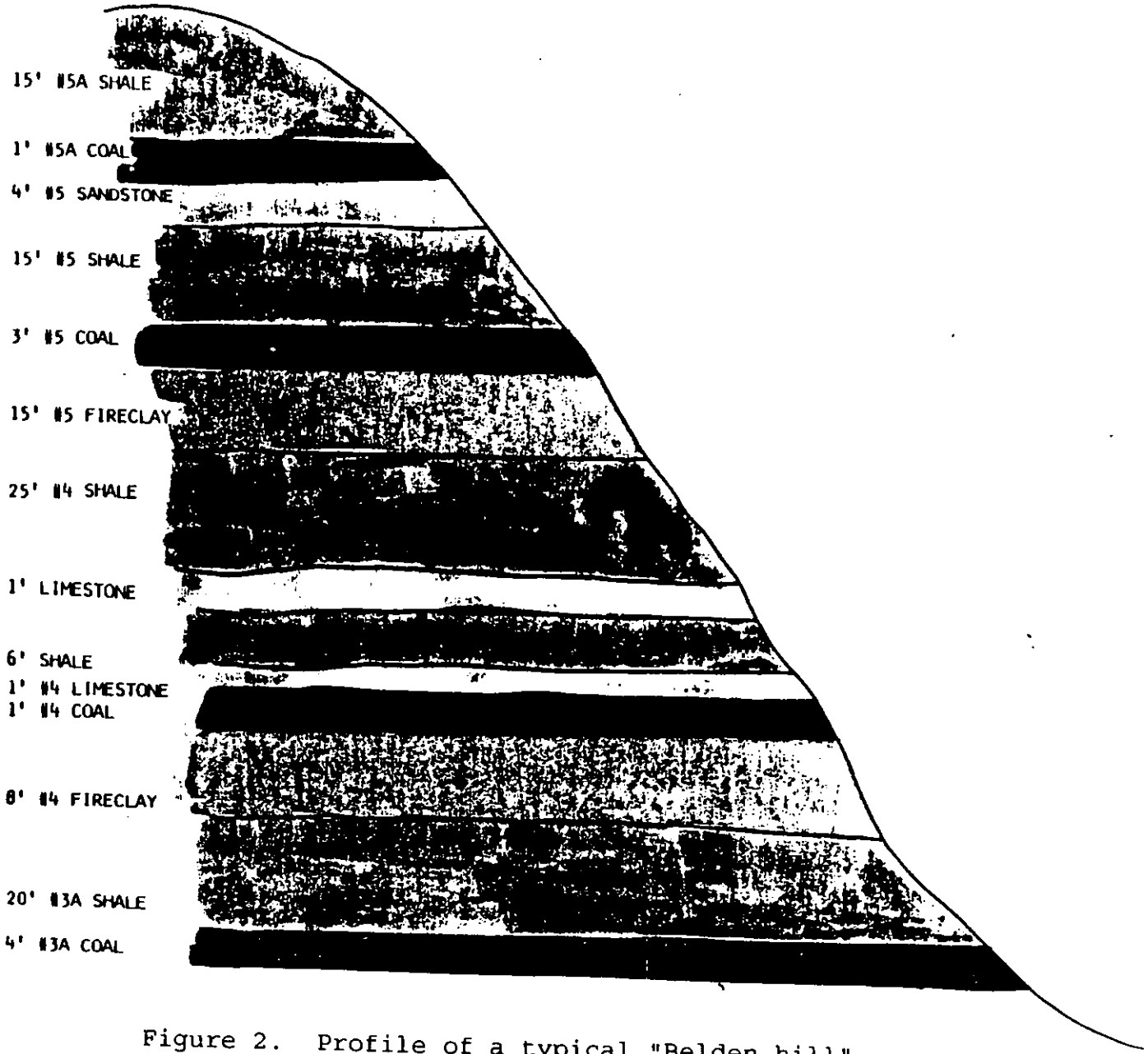

Figure 2. Profile of a typical "Belden hill".

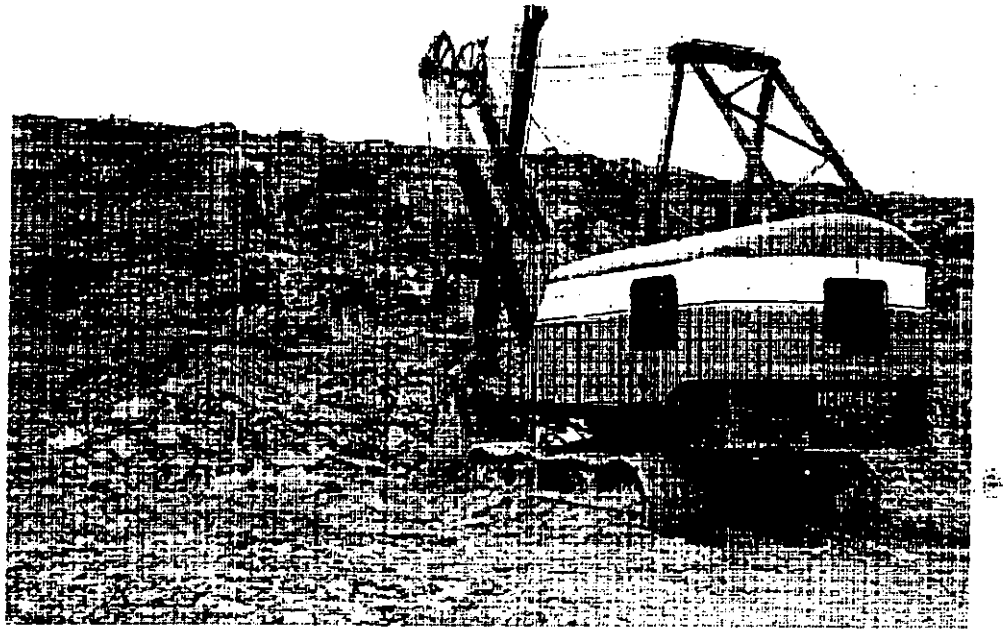

Figure 3. Exposed seam of 3A shale at a Belden open pit mine.

Figure 4. Plant 4 brickyard and periodic kilns.

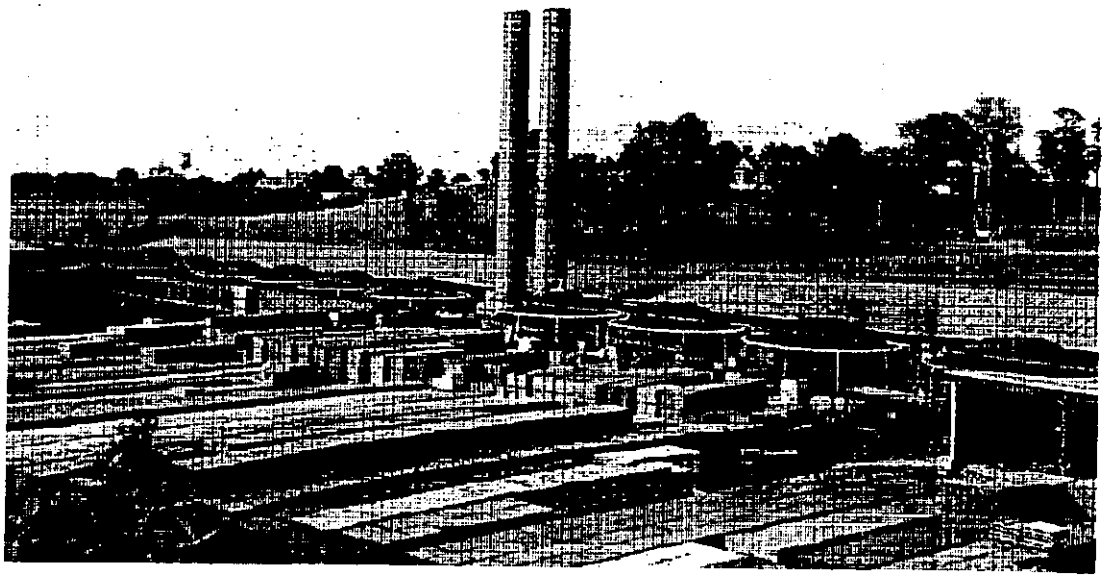

Figure 5. Plant 4 brickyard and periodic kilns.

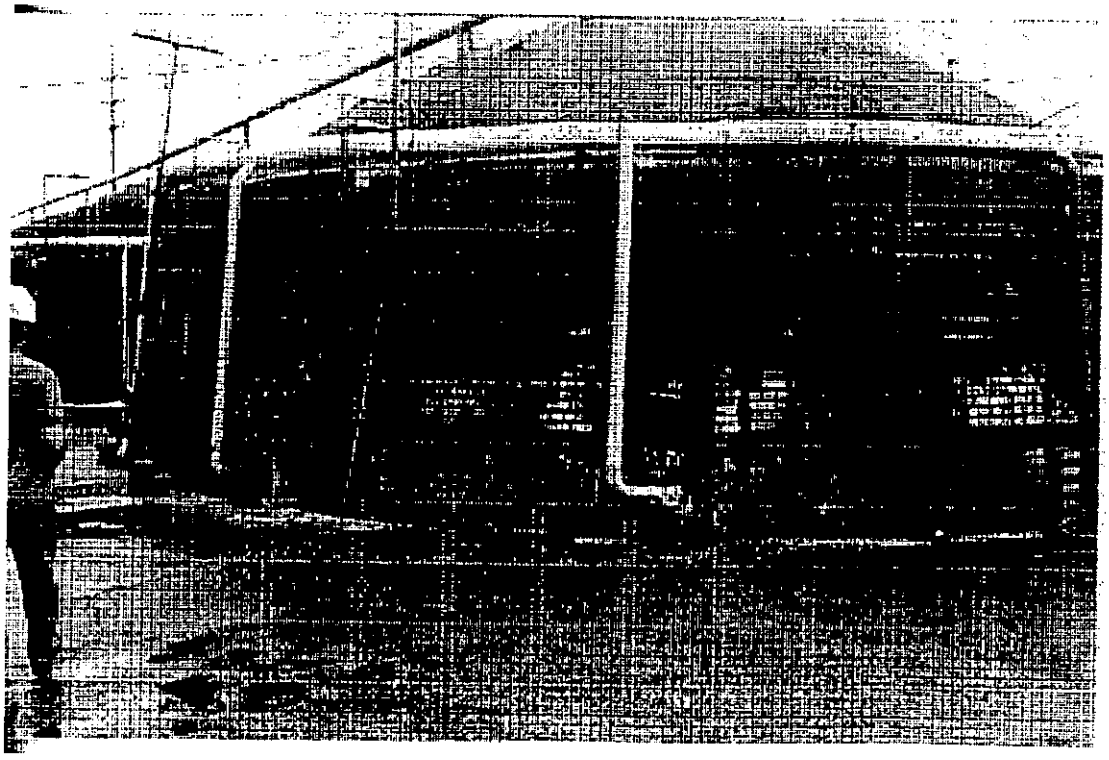

Figure 6. Plant 4 periodic kiln.

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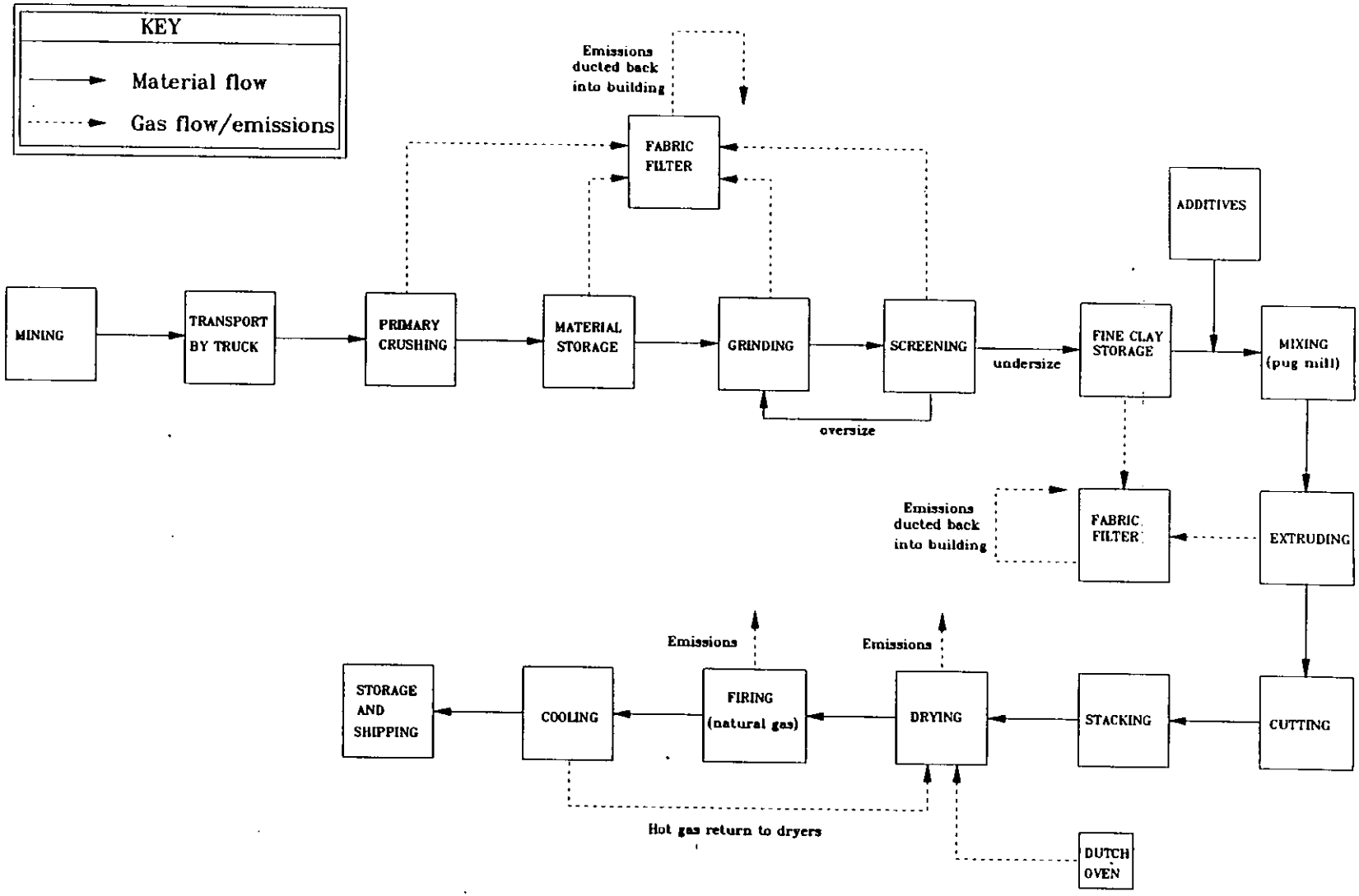

FIGURE 7. PROCESS FLOW DIAGRAM FOR BELDEN BRICK, PLANT 6, SUGARCREEK, OHIO.

Figure 8. Plant 6 vibrating screen with hood and ductwork.

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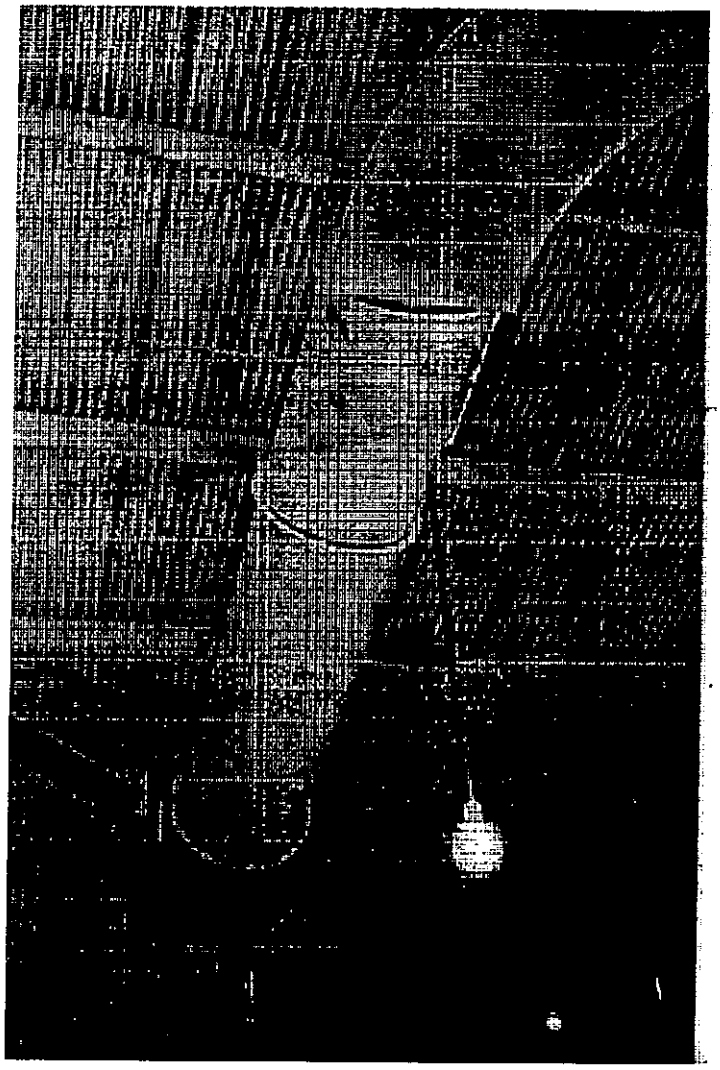

Figure 9. Plant 6 fabric filter inlet duct for the clay processing line.

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Figure 10. Plant 6 clay processing line fabric filter outlet duct.

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Figure 11. Plant 6 shale processing line fabric filter outlet duct.

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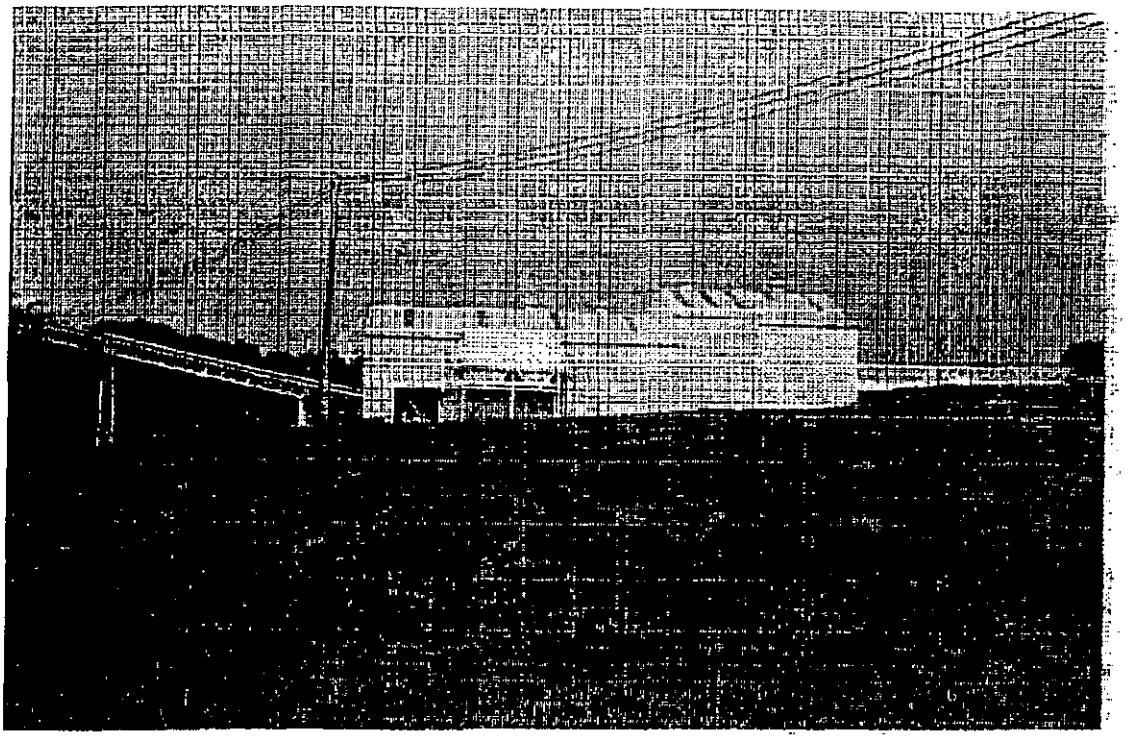

Figure 12. Plant 6 grinding room and conveyors to fine clay storage.

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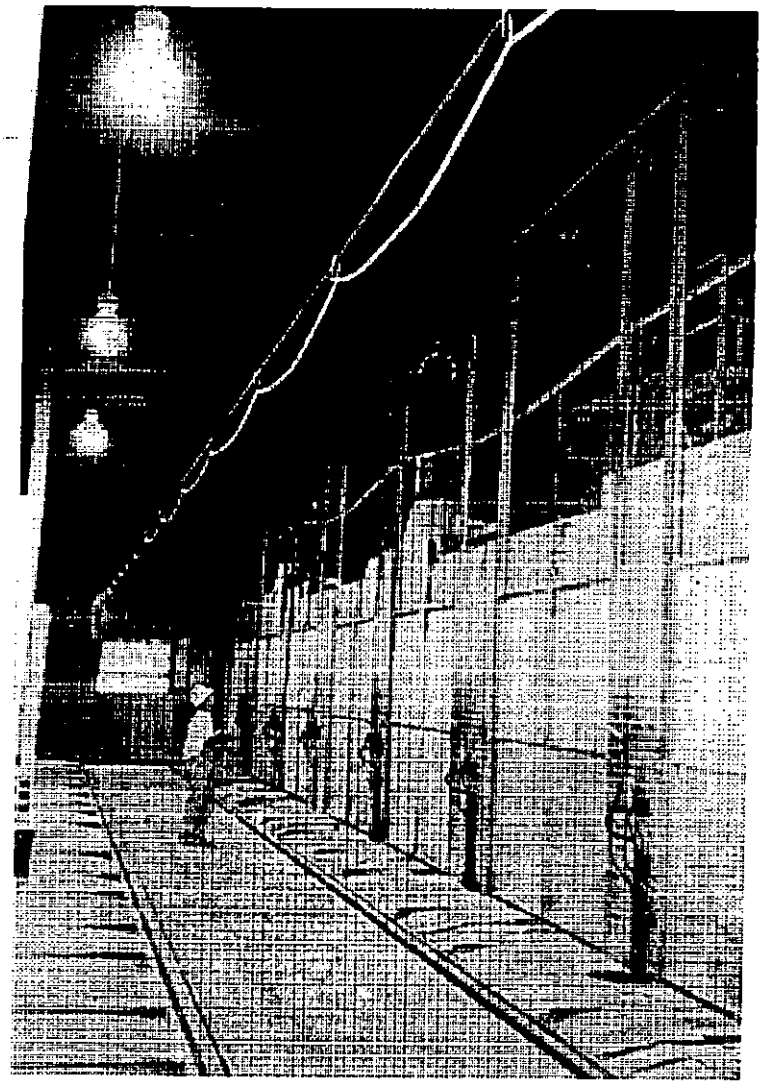

Figure 13. Plant 6 brick dryers.

Figure 14. Plant 6 dryer stacks.

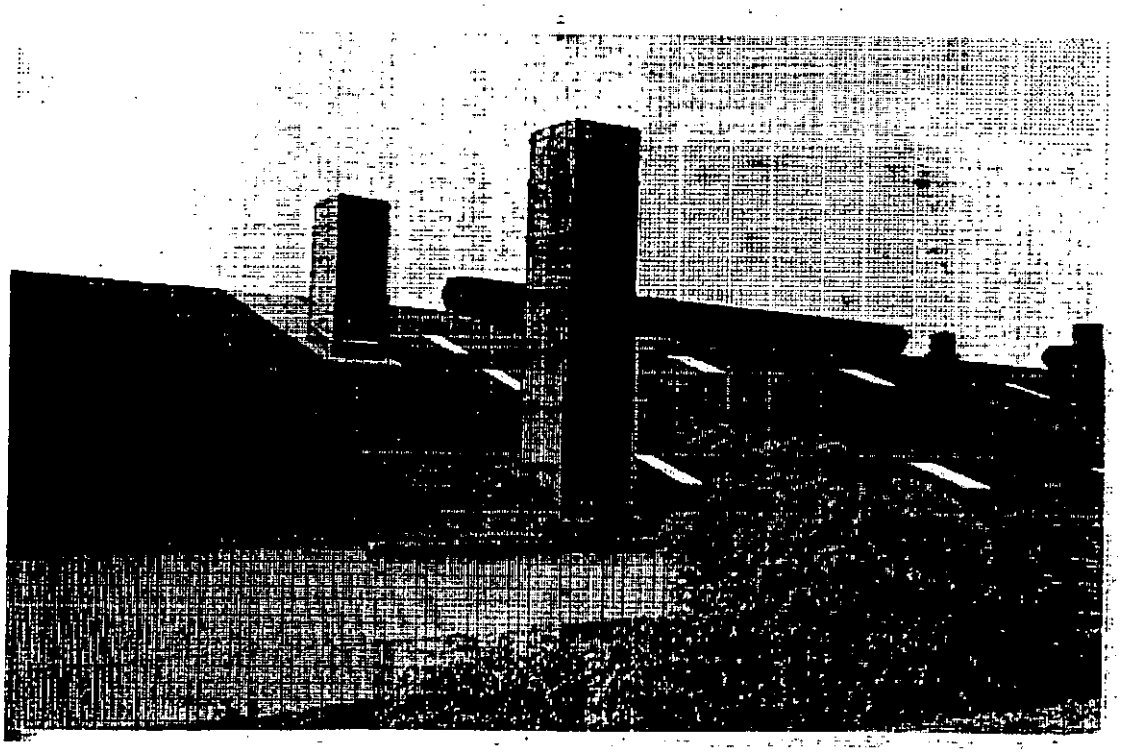

Figure 15. Plant 6 kiln stacks.

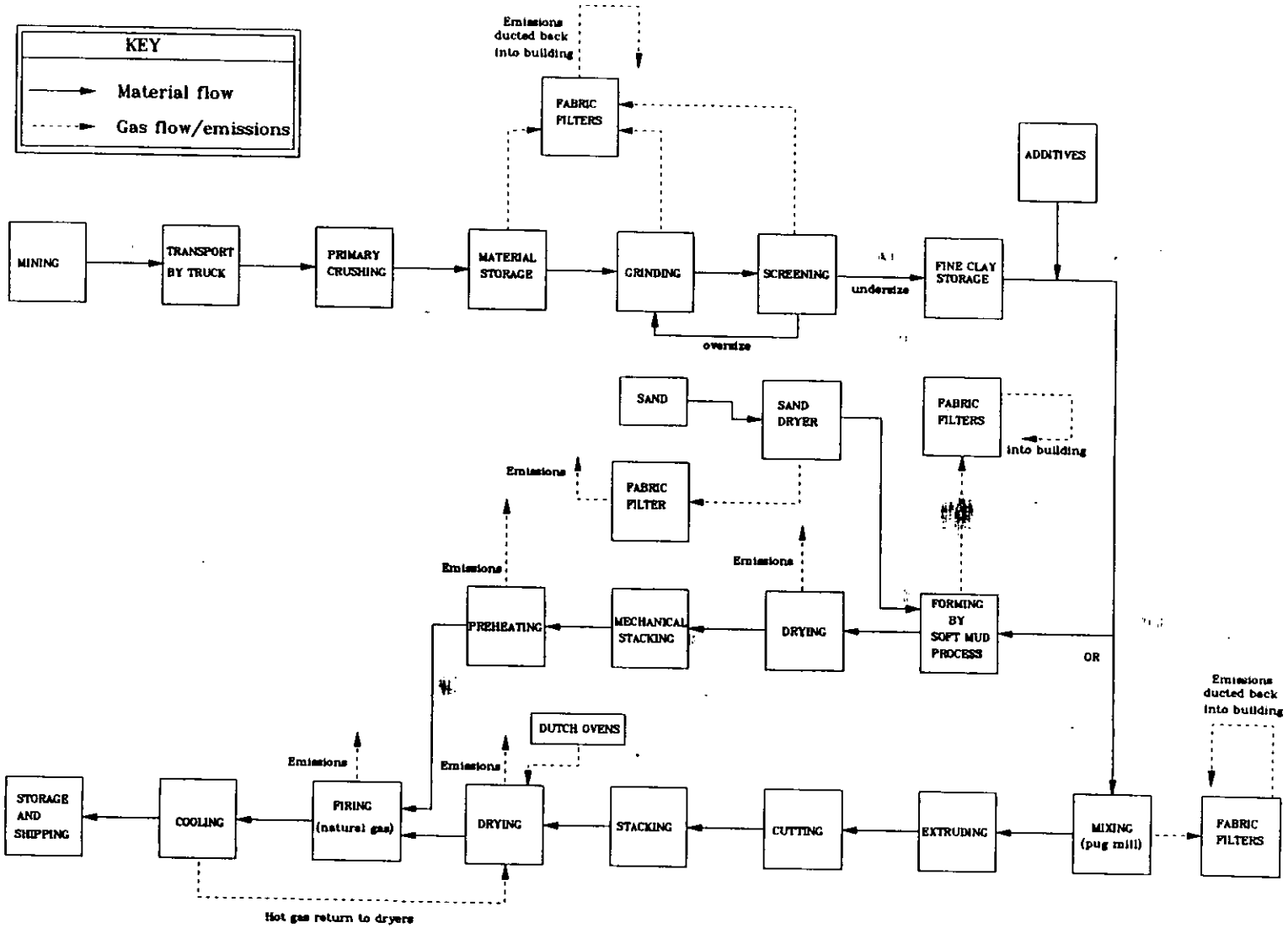

FIGURE 16. PROCESS FLOW DIAGRAM FOR BELDEN BRICK, PLANT 8, SUGARCREEK, OHIO.

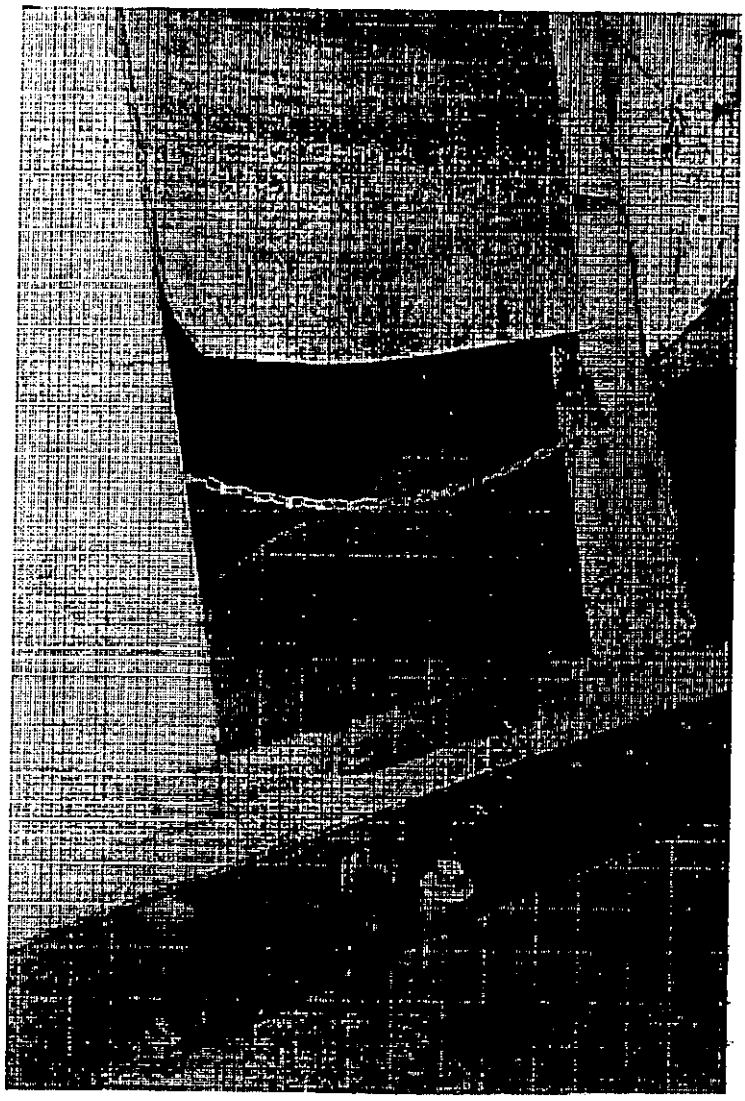

Figure 17. Plant 8 rim discharge grinder.

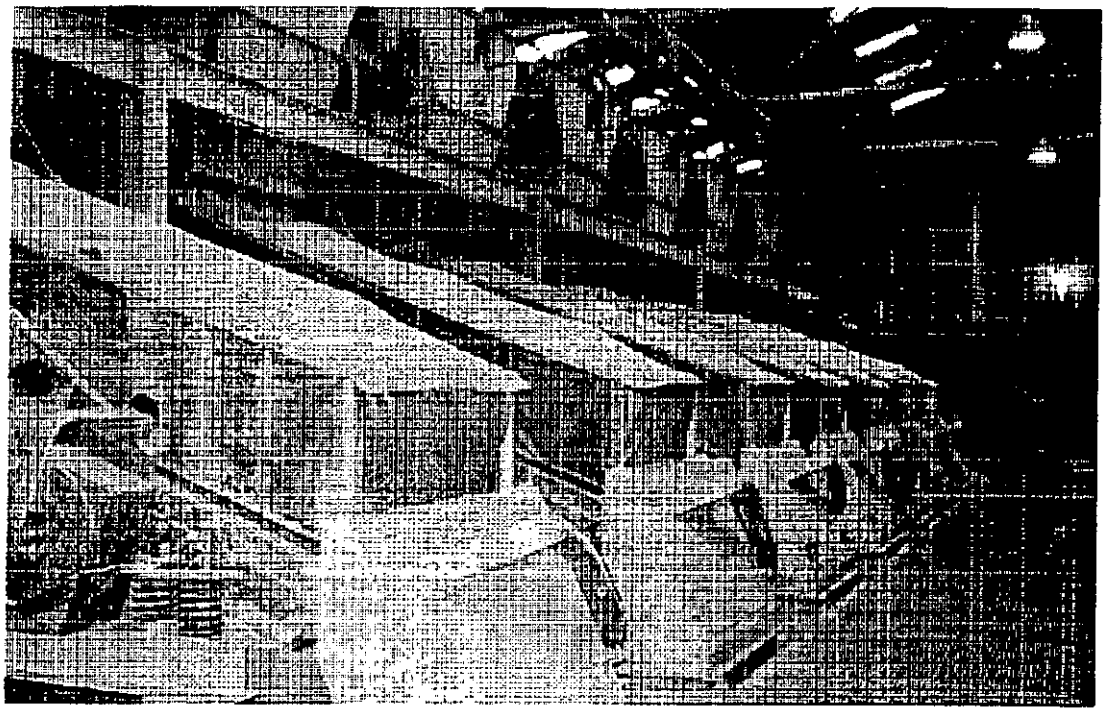

Figure 18. Plant 8 screens and hoods.

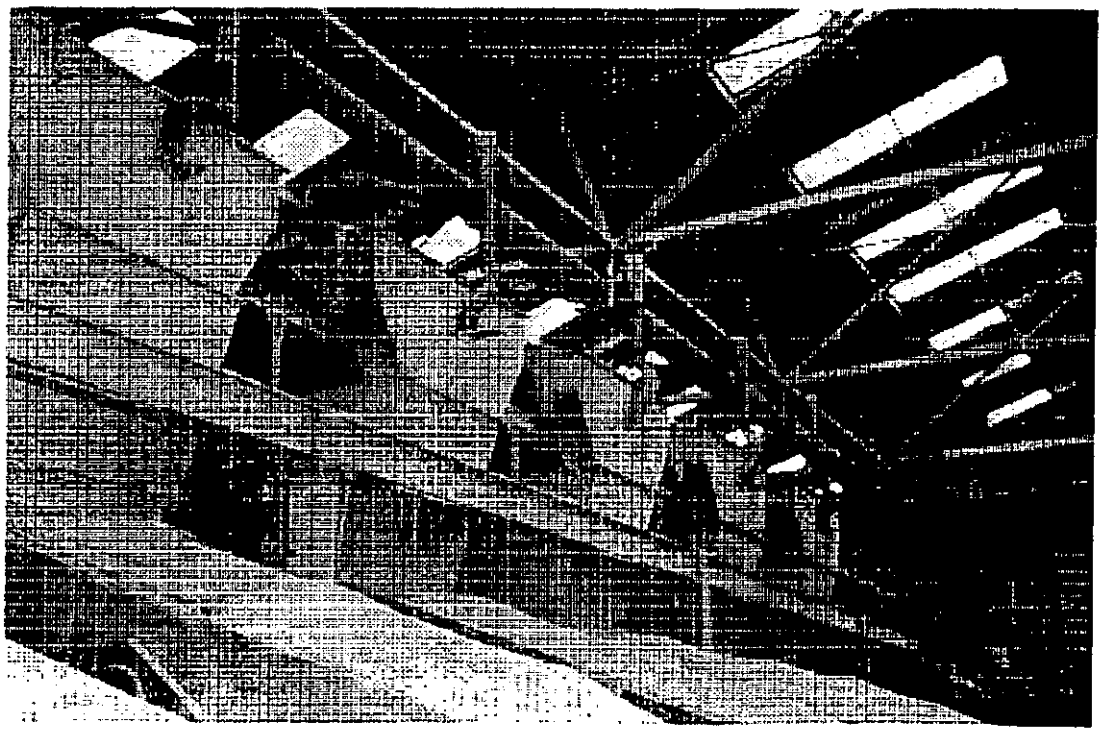

Figure 19. Plant 8 screens and hoods.

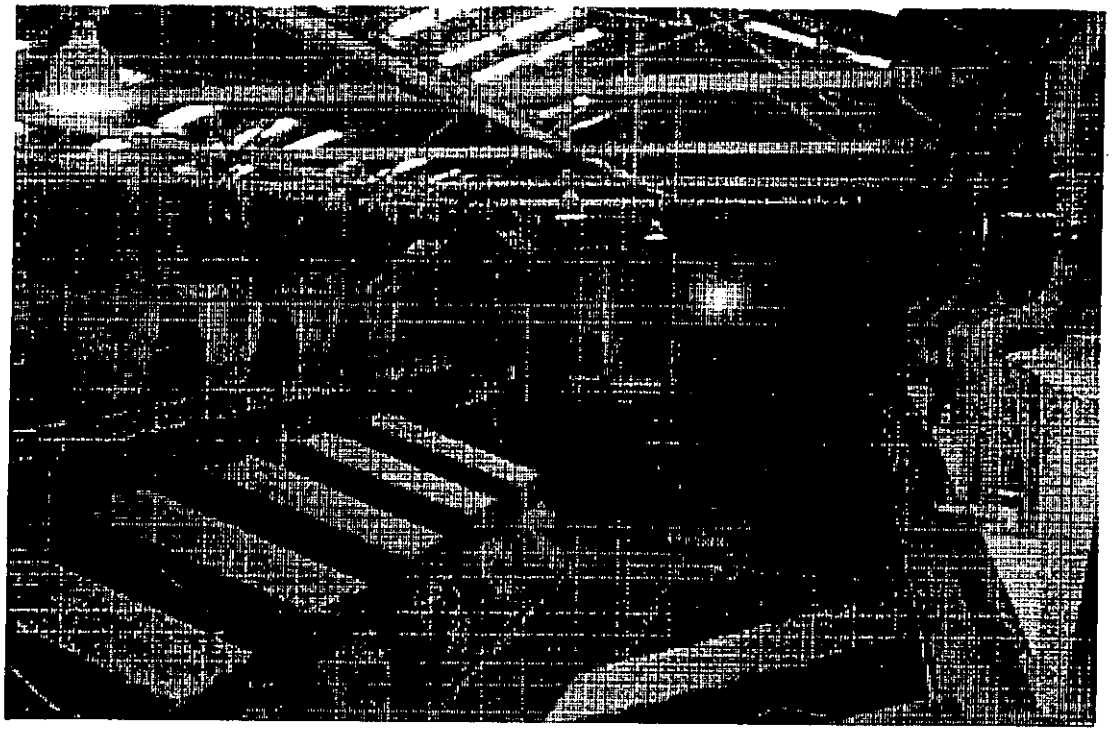

Figure 20. Plant 8 vibrating screens, hoods, and fabric filter.

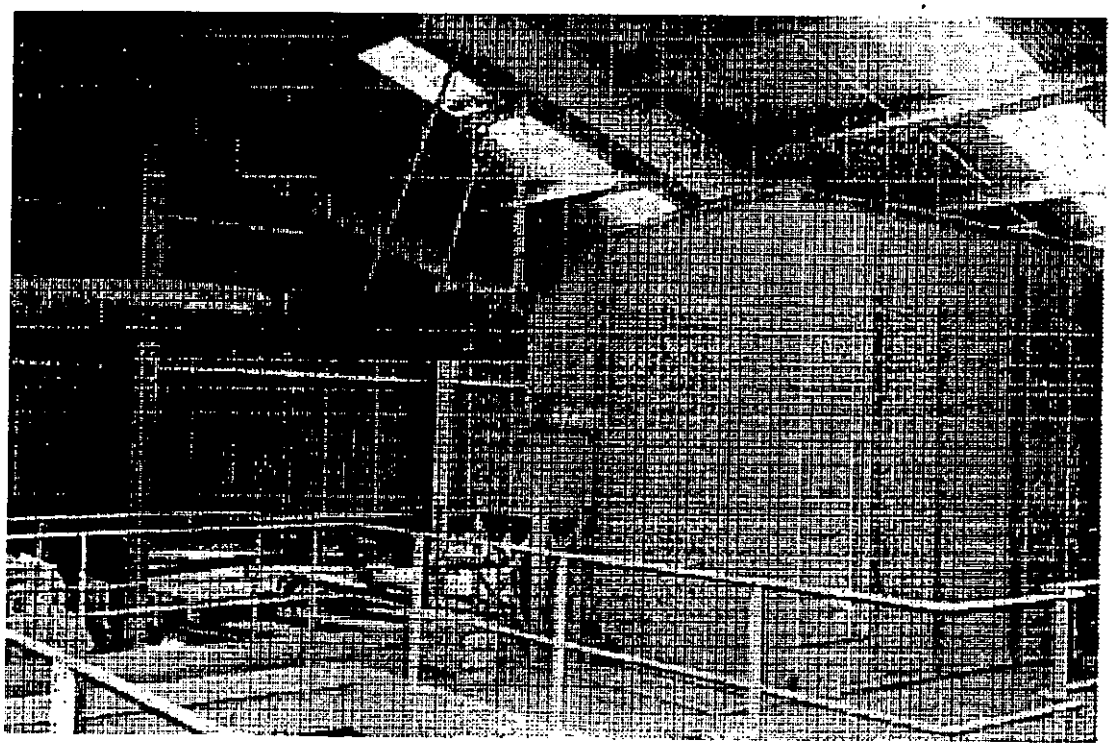

Figure 21. Plant 8 fabric filter.

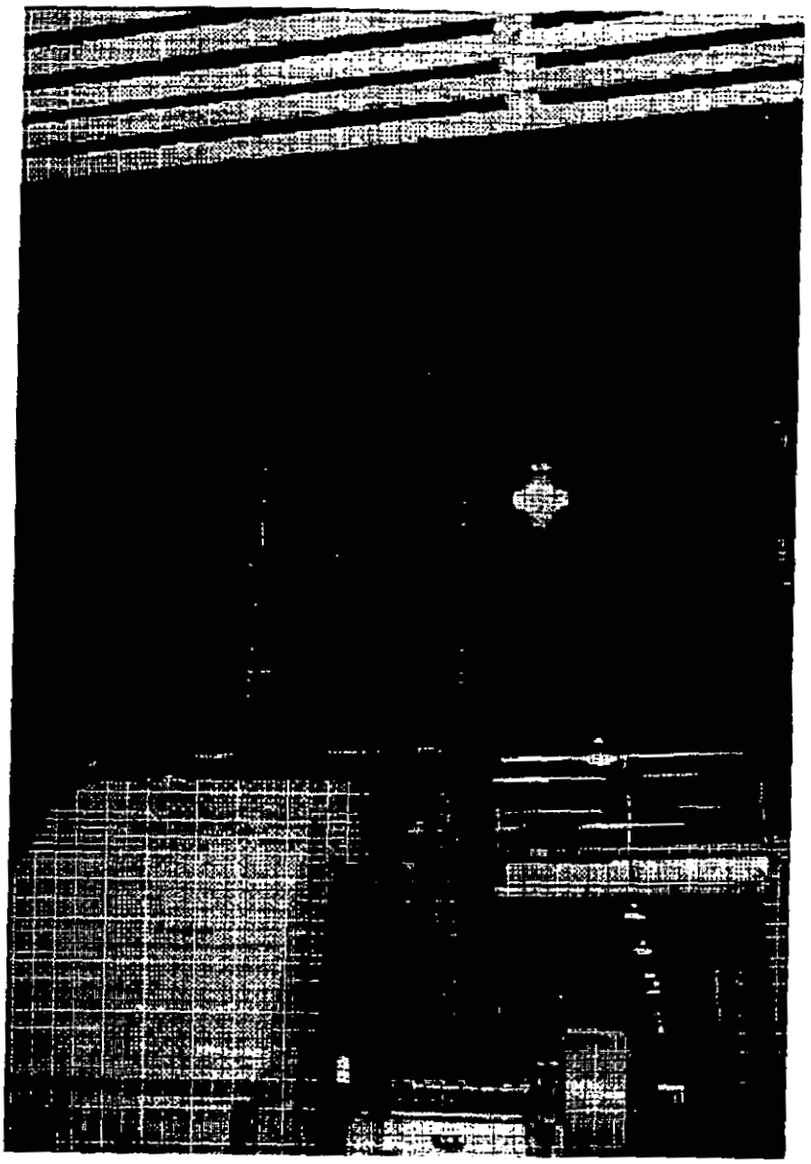

Figure 22. Plant 8 stack serving kiln 1.

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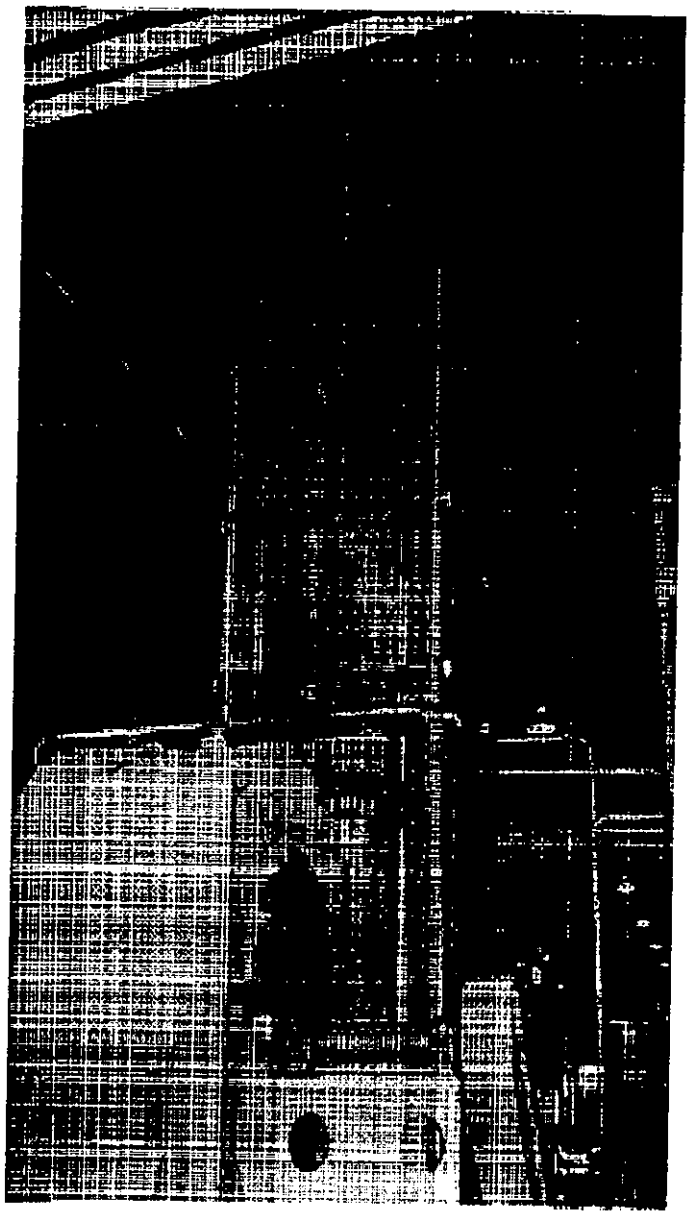

Figure 23. Plant 8 stack serving kilns 2 and 3.

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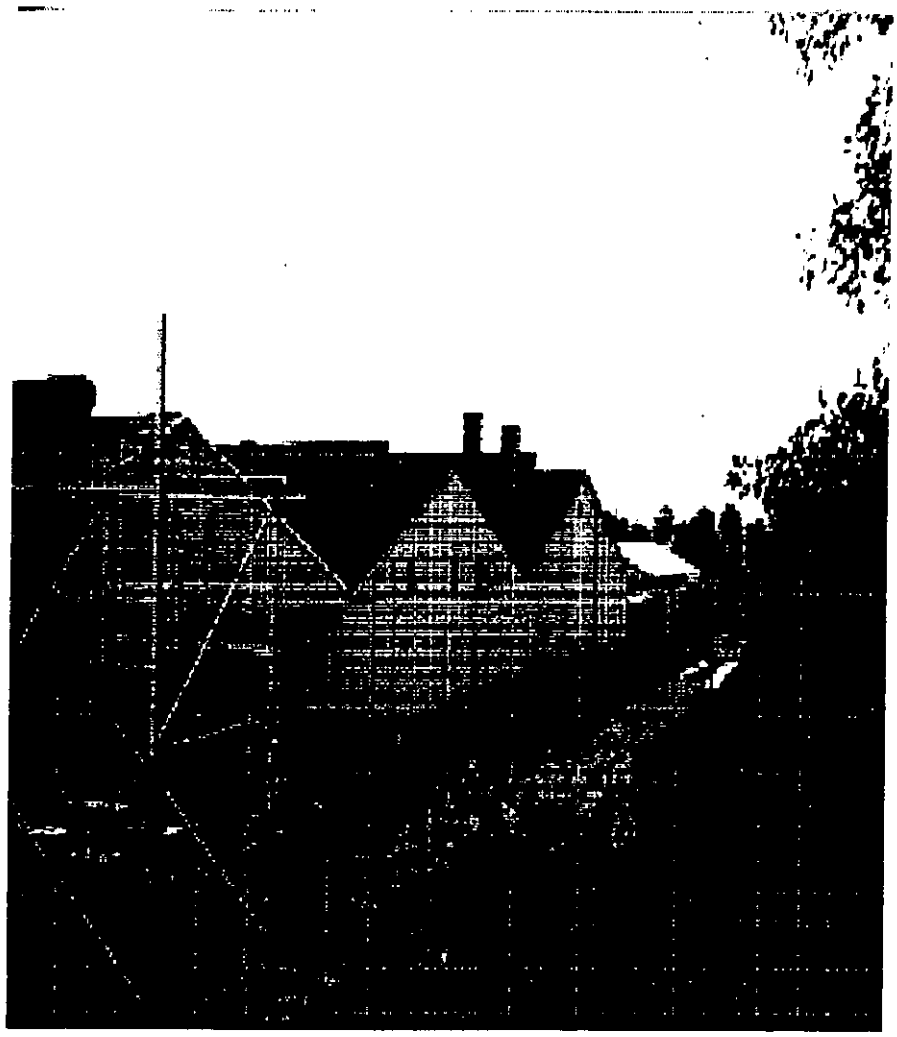

Figure 24. Plant 8 kiln stacks.

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SEP 3 - 1993 **DRAFT**

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

Mr. John Jensen
Environmental Engineer
Belden Brick Company
Post Office Box 430
Sugarcreek, Ohio 46701-0430

Dear Mr. Jensen:

Enclosed is a copy of the final trip report for the visit to the Belden Brick Company (Belden), Sugarcreek, Ohio, on June 9, 1993. The report has been revised in accordance with your comments, dated August 25, 1993. Because Belden made no claim of confidentiality, none of the information contained in the report is considered confidential by the U. S. Environmental Protection Agency.

We respectfully request that you submit any additional comments on the final trip report by September 30, 1993. If we do not receive a response by September 30, 1993, the final report will be considered correct.

Thank you for your cooperation in this matter. The information Belden provided during our visit has been most helpful to us. If you have any questions, please call me at (919) 541-5407.

Sincerely,

Ronald E. Myers
Emission Inventory Branch
Technical Support Division

Enclosure

OAQPS/TSD/EIB:RMyers, rm 455B, 4201 Bldg., 541-5407, MD-14
(MRI/RMarinshaw/LKaufman/677-0249/09/03/93)