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DESIGNS AND SPECIFICATIONS FOR AN EXPERIMENTAL BOILER FOR THE MECHANICAL ENGINEER- ING LABORATORY

BY

EDGAR WHITE WAGENSEIL

AND

HALBERT EVANS BONER

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE
IN MECHANICAL ENGINEERING

IN THE
COLLEGE OF ENGINEERING
OF THE
UNIVERSITY OF ILLINOIS
PRESENTED JUNE, 1905

UNIVERSITY OF ILLINOIS

May 26, 1905 190

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

HALBERT EVANS BONER and EDGAR WHITE WAGENSEIL

ENTITLED DESIGNS AND SPECIFICATIONS FOR AN EXPERIMENTAL BOILER

FOR THE MECHANICAL ENGINEERING LABORATORY

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Mechanical Engineering

L. P. Brockmidge

HEAD OF DEPARTMENT OF Mechanical Engineering

DESIGN AND SPECIFICATIONS FOR AN EXPERIMENTAL BOILER FOR THE
MECHANICAL ENGINEERING LABORATORY OF THE UNIVERSITY OF ILLINOIS

This boiler and equipment shall consist of one Heine 210 horse power, water-tube boiler, equipped with a Green chain grate and a McClave-Brooks hand-fired grate, to be used interchangeably, a Greene Economizer, induced and forced draft systems, and a Foster direct-fired superheater. This boiler is to be a duplicate of that used at the United States Geological Survey's Coal Testing Plant in St. Louis, Missouri, 1904. Its use is to be confined to experiments for investigation and instruction.

The location of the apparatus is to be in the south-west corner of the Mechanical Engineering Laboratory, in a space 38 1/2 x 44 feet.

The general arrangement of the plant is to be such as will facilitate the observations necessary in the experimental work.

DESIGN AND SPECIFICATIONS FOR AN EXPERIMENTAL BOILER FOR THE
MECHANICAL ENGINEERING LABORATORY OF THE UNIVERSITY OF ILLINOIS

Mechanical Engineering Department Thesis

by

HALBERT EVANS BONER and EDGAR WHITE WAGENSEIL

- Part 1. 210 Horse Power Water Tube Boiler.
- Part 2. Chain Grate Stoker.
- Part 3. Hand-Fired Grate
- Part 4. Foundations.
- Part 5. Economizer.
- Part 6. Mechanical Draft.
- Part 7. Superheater.
- Part 8. Brickwork.
- Part 9. Piping.

EXPERIMENTAL BOILER
for the
UNIVERSITY OF ILLINOIS, URBANA, ILLINOIS

Specifications for the material and labor required in installing an Experimental Boiler and equipment in the Mechanical Engineering Laboratory of the University of Illinois, Urbana, Illinois.

Prepared as a thesis for the degree of B.S. in Mechanical Engineering, University of Illinois, by Halbert Evans Boner and Edgar White Wagenseil.

GENERAL DESCRIPTION

Location.- The work herein specified is for the Mechanical Engineering Laboratory of the University of Illinois, Urbana, Illinois, at the junction of the I. C. R. R., the C. C. C. & St. L. R. R., and the Wabash R. R., located 128 miles south of Chicago. The distance from the railroad depots to the University by paved streets is one mile.

Return of Plans.- All plans and specifications are to be returned to the Consulting Engineer's office, Engineering Hall.

Drawings.- Plate No. 1. Plan and elevation of the Mechanical Engineering Laboratory, showing arrangement of apparatus, location of boiler, economizer, superheater, mechanical draft apparatus and stack.

Plate No. 2. Plan and elevation of the apparatus, showing flue connections, etc.

Plate No. 3. Plan and elevation of boiler, showing chain grate stoker.

Plate No. 4. Elevation of furnace, showing hand-fired grate carriage, and furnace front.

Plate No. 5. Foundations.

Subdivision of Specifications.- These specifications are subdivided into several parts as outlined on previous page. All bids must be divided so that any part may be omitted from the contract if deemed advisable or necessary by the Board of Trustees.

GENERAL CONDITIONS

These specifications and the accompanying drawings are hereby made a part of the contract between the contractor and the Trustees of the University of Illinois.

Supervision of Work and Materials.- The Consulting Engineer, representing the University of Illinois, will exercise general supervision for the University over all materials and work, and will reject any defective material or work wherever found. No portion of either work or materials will be finally accepted until the final acceptance by the Board of Trustees and the discharge of the contractor from his responsibility therefor.

Omissions.- Any work drawn and not specified, or specified and not drawn or particularly mentioned, necessary to the full completion of the work according to the spirit and intent of the drawings and specifications, is to be done without extra charge.

Damage by Accidents.- The contractor shall put up and maintain such barriers or take such precautions as will prevent accidents in consequence of his work; and he hereby assumes all liabilities for all damages occasioned in any way by his neglect or that of his agents, employees or workmen.

Damage to University Property.- The work of the contractor shall be restricted on the grounds of the University within the limits designated by the Consulting Engineer. Any damage done by the contractor or his employees to any property of the University must be paid for by the contractor and the University will deduct from the payment for any such damages as estimated by the Consulting Engineer.

Interpretation.- Upon all questions concerning the execution and completion of the work, and the interpretation of the drawings the decision of the Consulting Engineer shall be final and binding.

P A R T 1

BOILERS

Number and Type.- There will be one Water Tube Boiler of Heine make.

Pressure.- Boiler to carry safely a working pressure of 160 lbs. per sq. in.

Heating Surface and Grate Area.- The boiler is to have 2100 sq. ft. of heating surface and 37 sq. ft. of grate area.

Design of Pressure Parts.- The boiler is to have one shell 42 inches in diameter, 21 feet 6 1/2 inches long of 7/16 inch plate; heads 1/2 inch thick and dished; reinforced man-hole in rear head, with pressed steel cover. Longitudinal seams to be double-rivited lap; girth seams to be single-rivited. Water-legs made of flanged steel plate 1/2 inch thick, properly stayed with hollow bolts. Boiler to have 116 straight special mild steel water-tubes, 3 1/2 inches in diameter by 18 feet long.

Material and Workmanship.- All material and workmanship must in every particular be first-class.

Working and Test Pressure.- Boiler to be designed to carry a safe working pressure of 160 lbs. per sq. in., and to be tested and made tight at 225 lbs. per sq. in., hydrostatic pressure before leaving the shop.

Ornamental Front and Castings.- Boiler to be provided with an ornamental front casing; rear and top cleaning doors; brick stays and anchor rods. Front to be so arranged that chain

grate can be installed.

Name required on front:

"University of Illinois"

1905.

Valves and Fittings.- One 3 1/2 inch nickel-seated pop-safety valve (Ashton). Main steam outlet 5 inches in diameter. One 10 inch steam gage (Standard). One 1 1/2 inch blow off cock (asbestos sashed). One 1 1/2 inch feed-water valve (Fairbanks). One 1 1/2 inch check-valve (P & C). One Reliance water Column complete with three gage-cocks and one P. B. H. quick closing water gage, all with chains and handles for operating from floor. Necessary pipe for attaching above fittings to boiler.

Tile.- Full set of baffle tile.

Tools, etc.- Soot blower with steam hose and nozzle. Two 1/2 inch valves and pipe and fittings necessary to connect blower to boiler. One "S" wrench, set of firing tools, consisting of slice-bar, hoe and two pronged hook, tube scraper with long handle.

Erection.- The boiler is to be erected in the Mechanical Engineering Laboratory upon a foundation furnished by the University.

Brick Setting.- The brickwork above floor-line to be provided by the University.

Frame Work.- Frame work to be Heine Standard as shown on Plate 3. Furnace walk to be reinforced by I beams and channels as shown in detail on Plate 4.

Furnace.- Furnace to be constructed as shown on Plate 3.

P A R T 2

CHAIN GRATE STOKER

There will be one Green chain grate mechanical stoker provided with mechanical apparatus for operating same.

Area of effective grate surface to be 37 sq. ft., dimensions as shown in drawing on Plate 3.

Erection of Stoker.- The stoker shall be erected under the supervision of the contractor's representative. The University shall pay for the work and expenses of the representative, the amount being determined by agreement between the representative and Consulting Engineer.

P A R T 3

HAND-FIRED GRATE

There will be a McClave-Brooks hand-fired, rocking grate. Area of effective grate surface to be 37 sq. ft., dimensions as shown in drawing on Plate 4.

Carriage.- The grate to be mounted on a carriage made of steel-shaper and provided with wheels to run on track of chain grate stoker. Dimensions of carriage and details of construction shown in drawing on Plate 4.

Erection.- The carriage to be erected under the supervision of the Consulting Engineer. The grate shall be erected under the supervision of the contractor's representative. The University shall pay for the work and expenses of the representative, the amount being determined by agreement between the representative and the Consulting Engineer.

Castings.- The castings for dead plate and back plate are to be as shown in drawing on Plate 4. Made of gray cast iron free from blow holes or other imperfections.

P A R T 4

FOUNDATIONS

Boiler.-- Foundation of the boiler shall consist mainly of concrete as shown on Plate 5.

Economizer.-- Foundation of the economizer shall consist mainly of concrete and brick as shown on Plate 2.

Superheater.-- Foundation of superheater shall consist mainly of concrete. Drawing to be furnished by contractor.

Induced Draft Fan and Engine.-- Foundation shall consist of concrete and brick as shown on Plate 2.

Forced Draft Fan.-- Foundation shall consist of concrete and brick as shown on Plate 2.

Construction.-- The work of laying the foundations shall be done by the University.

Ash Pit.-- The ash pit of boiler shall be made as shown in drawing on Plate 5 and will have the greatest depth of 4 feet.

Concrete.-- The concrete shall be made in the proportions: one (1) of cement, three (3) of broken stone and six (6) of sand.

P A R T 5

ECONOMIZER

The economizer shall be of the "Greene" type consisting of eighty pipes, having a total heating surface of 960 sq. ft.

Tube-scrappers.- The economizer shall be fitted with a mechanical-ly-operated tube scraping device.

By-pass.- A by-pass shall be provided under the economizer, as shown on Plate 2, and shall have a cut-off to allow gases to go through either the economizer or by-pass. The by-pass shall be built of common brick, with arched top.

Deflectors.- There shall be two deflectors fitted as shown on Plate 2.

Removable Casing.- There shall be "sectional retaining-covers" provided for the outer wall of the economizer, for purpose of facilitating inspection and repairs. These covers shall consist of steel plates of No. 10 and No. 11 gage, filled between with 2 inch packing of asbestos.

P A R T 7

SUPERHEATER

The superheater shall be of the direct-fired Foster type built by the Powers Specialty Company of New York.

Capacity.- The superheater shall have a capacity of raising the temperature of 4500 lbs. steam per hour at a pressure of 160 lbs. per sq. in. to 570° F. corresponding to a superheat of 200°; and to increase this superheat to 300° for short spaces of time.

Construction.- The superheater shall be of composite construction and shall consist of a series of straight elements connected to return boxes and steel connecting headers.

The joints between the elements and the headers shall be metal to metal, obtained by expanding the ends of the elements into reamed holes in the headers. The elements to consist of seamless cold drawn steel tubing to be outside of which are fitted a series of annular gill-flanges, placed close to each other and forming an external covering of cast iron.

P A R T 6

MECHANICAL DRAFT APPARATUS

Induced Draft.- The induced draft apparatus shall consist of an "American Blower Company's" No. 90 "steel-plate" type, full-housed, top vertical, discharge fan, with direct-connected, vertical, cylinder above shaft engine. The fan to be connected to economizer and by-pass by means of a steel-plate flue 34 inches in diameter, as shown on Plates 1 and 2. Fan to discharge into a 34 inch steel stack set on fan, and extending 15 feet above the roof.

Forced-draft.- The forced-draft apparatus shall consist of a No. 9 "A. B. C." cast iron volume blower, driven by a direct connected alternating current, variable speed motor. The fan shall discharge vertically downward into a brick conduit leading to bridge wall as shown on Plates 2 and 3.

P A R T 8

BRICKWORK

Boiler.- The rear wall shall be 22 inches thick, of common brick, with fire brick lining from floor-line to bottom of water-leg, and 13 inches thick of common brick the remaining height.

The side walls shall be 19 inches thick, of common brick with fire-brick lining to top of tubes. Forward of bridge wall the side walls are to be 15 inches thick of common brick up to grate level as shown in drawing on Plate 3 and 19 inch wall as specified from grate level to top of tubes. A 1 1/2 inch air space to be provided from floor-line to within 4 inches of top row of tubes.

Top of shell to be bricked over with one course of fire-brick. Remaining space on top of boiler, except such space as shown in drawing on Plate 3, to be covered with 4 inch course of common brick.

Bridge wall shall be 38 inches thick of common and fire brick and provided with a conduit 16 inches by 16 inches for forced draft, also an opening for same in front side as shown on Plate 3. Overhanging part of bridgewall, built to accommodate chain grate stoker, shall be entirely of fire brick.

Arch shall be built of common and fire brick as shown on Plate 3.

There shall be an adequate number of cleaning doors in side and rear walk.

The brickwork shall extend ten inches below the floor-

line in all walls.

Economizer.- The economizer shall have a 4 inch wall of common brick built against the boiler wall as shown on Plate 2. There shall be a brick flue with 13 inch walls connecting economizer with boiler and superheater. Other walls of economizer to be of common brick as shown on Plate 2.

Superheater.- The superheater shall have 13 inch walls built of common brick lined with fire brick. There shall be a 9 inch arch of fire brick extending over the full length of grates and bridge wall. The bridge wall shall be 18 inches thick built of fire brick supported by common brick below the grate level.

P A R T 9

PIPING

Connections shall be made with feed connections and steam outlet. The feed water pipe shall be attached to the rear end of shell. The steam pipe shall be run from the steam outlet on the top of shell at the front and by means of a Tee both to superheater and directly to main. The pipes shall be covered with 85% Magnesia coverings. The contractors may submit bids for such coverings. Durability as well as insulating qualities desired. Only first-class material and work will be considered.

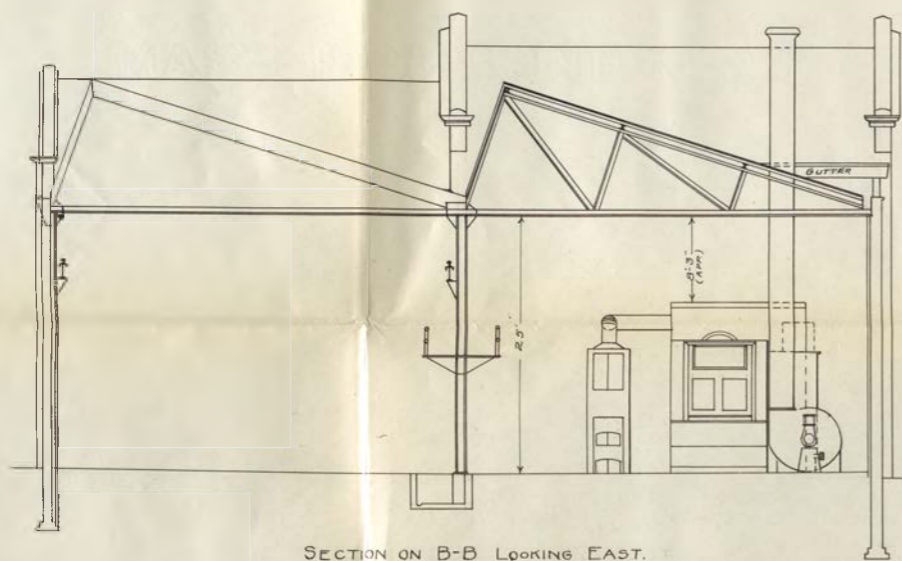
Pressures.- A working pressure of 160 lbs. will be carried on the boiler.

Valves.- There shall be a gate valve on each lead from Tee on main steam outlet.

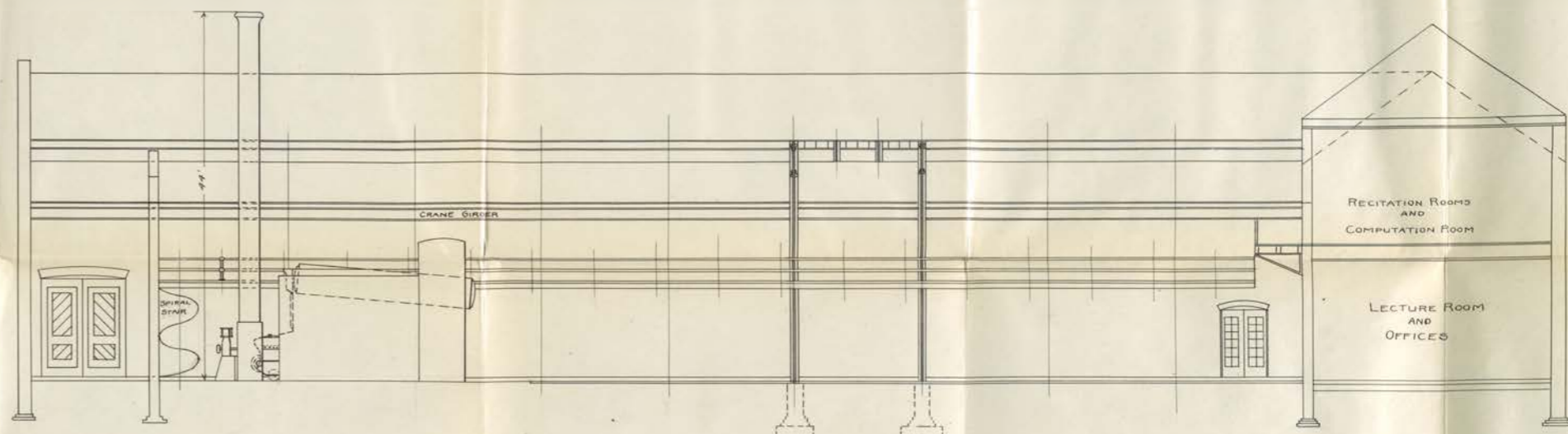
Blow-off.- The blow-off connections shall be so arranged as to permit all escaping water and steam to be caught and measured.

Sweeps.- Sweeps shall be used in the main steam connections in place of elbows, eliminating expansion joints.

Paint.- All coverings to be painted two coats of asphaltum of color approved by the Consulting Engineer.



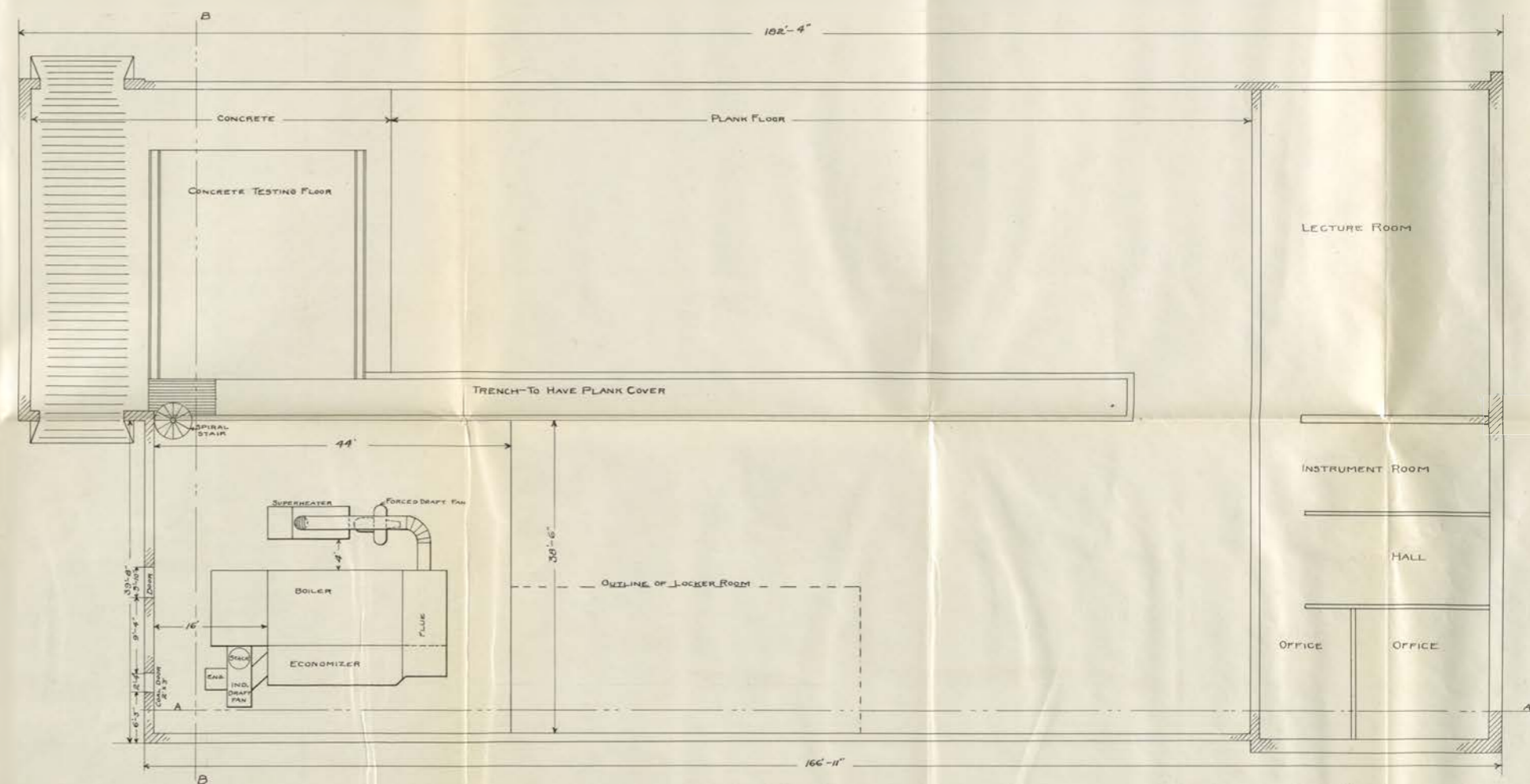
SECTION ON B-B LOOKING EAST.

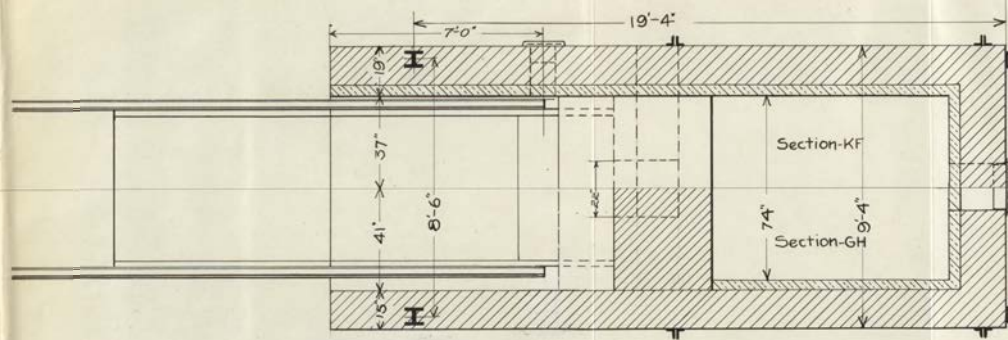
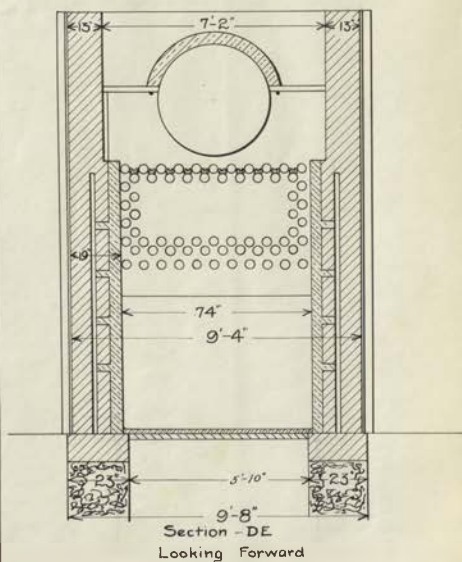
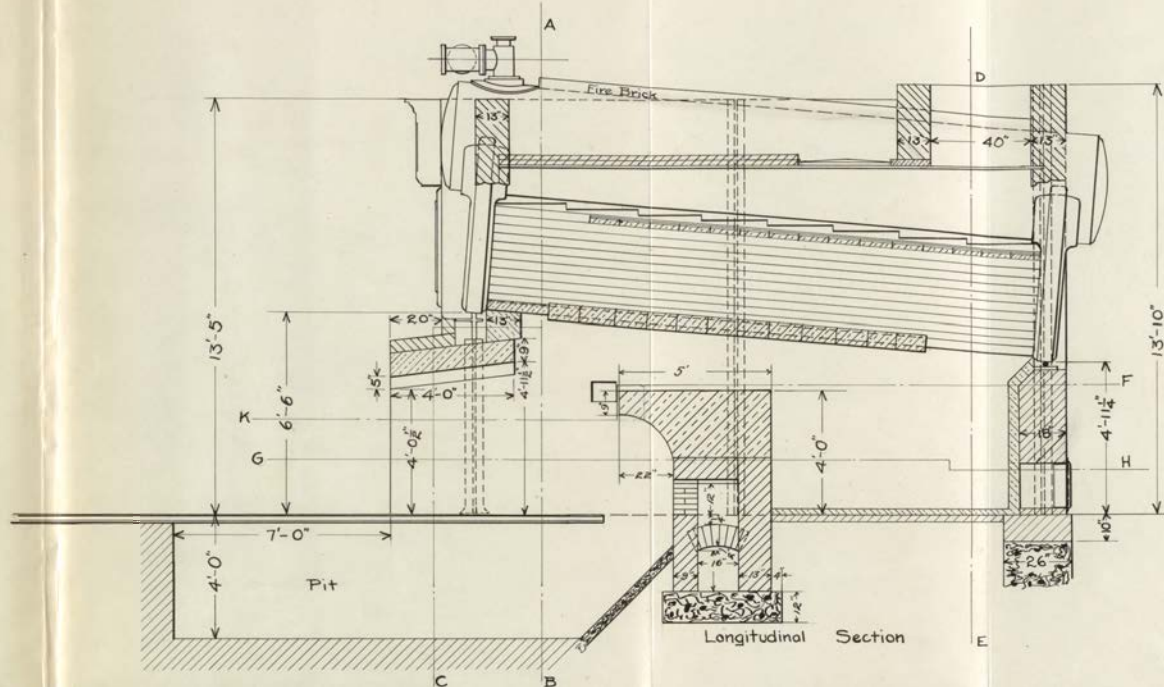
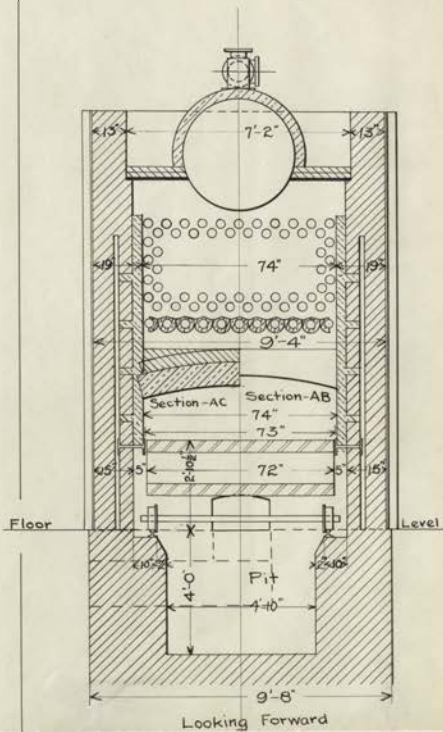


SECTION ON A-A LOOKING NORTH

PLAN AND ELEVATION
OF
MECH. ENG. LABORATORY
SHOWING
LOCATION OF BOILER AND EQUIPMENT
THIS DRAWING

SCALE $\frac{1}{8}'' = 1'$ MAY 24, 1905.
UNIVERSITY OF ILLINOIS
Halbert S. Bonser '05 Edgar H. Ferguson '05

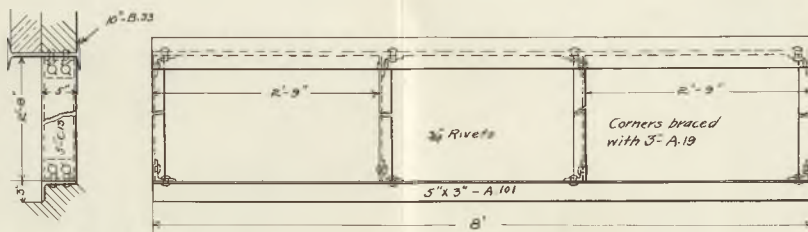




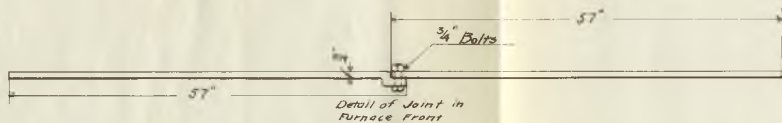
PLAN AND ELEVATION
OF
EXPERIMENTAL BOILER
FOR
MECH. ENG. LABORATORY
UNIVERSITY OF ILLINOIS
THESIS DRAWING
SCALE: $\frac{3}{8}$ " = 1'-0"

MAY 24, 1905

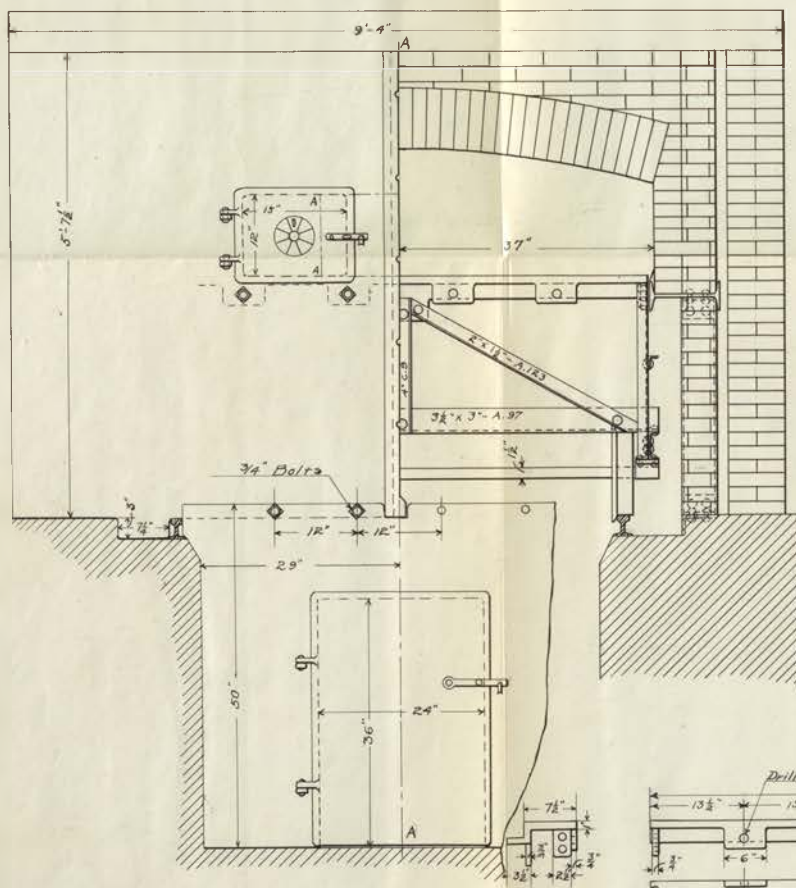
H. E. Boner '05 C. F. Hayward '05



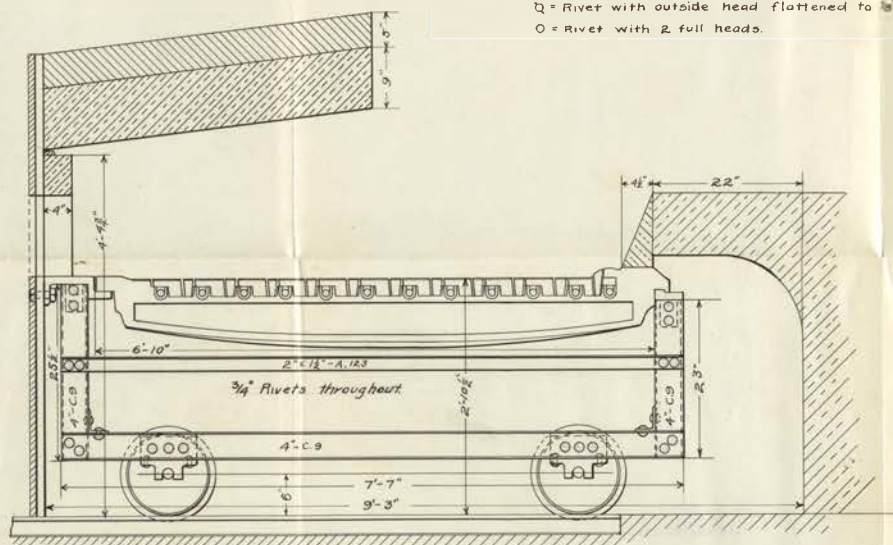
WALL REINFORCEMENT DETAILS



Detail of Joint in Furnace Front



ELEVATION OF FURNACE AND FRONT SHOWING GRATE CARRIAGE IN POSITION

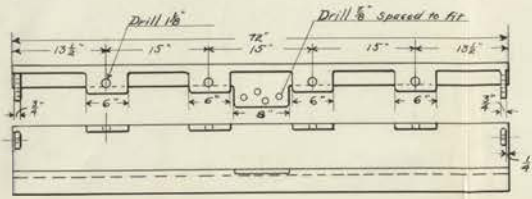


SECTION OF FURNACE ON A-A SHOWING ELEVATION OF GRATE CARRIAGE

Q = Rivet with outside head flattened to 1/2" high.
O = Rivet with 2 full heads.



BACK PLATE



DEAD PLATE

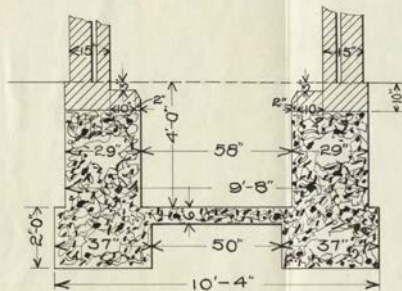
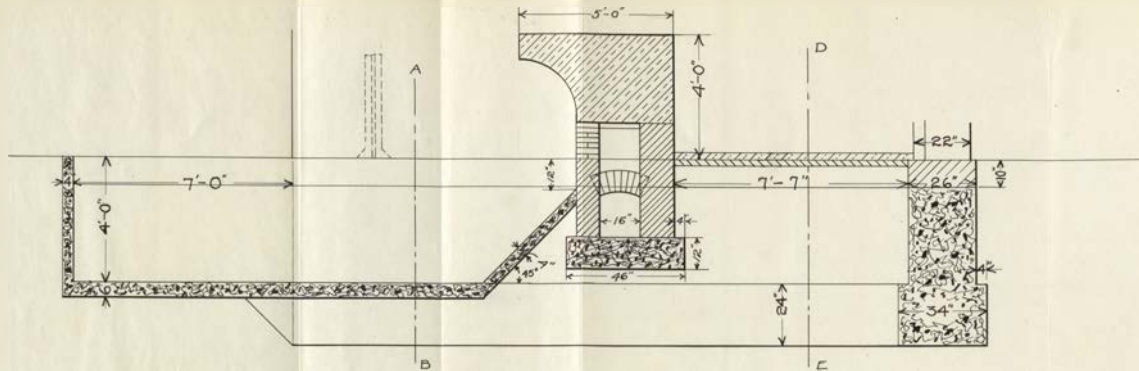
ELEVATION OF FURNACE
SHOWING
GRATE CARRIAGE AND FURNACE FRONT
FOR
EXPERIMENTAL BOILER, M.E.LAB.
UNIVERSITY OF ILLINOIS
THESIS DRAWING

SCALE 1" = 1'

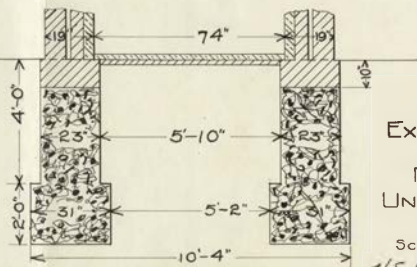
H. E. Boner '05

C. H. Ferguson '05

MAY 24, 1905.



SECTION ON A-B



SECTION ON D-E

FOUNDATION
OF
EXPERIMENTAL BOILER
FOR
ME LABORATORY
UNIVERSITY OF ILLINOIS
THESIS DRAWING
SCALE $\frac{3}{8}'' = 1'-0''$ MAY 24, 1905.

H. E. Bonner, 05 O. H. Hagaman, 05