CENTRAL HEATING PLANT FOR MURPHY COLLEGE

SEVIERVILLE, TENNESSEE

by

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A THESIS SUBMITTED FOR THE DEGREES OF

BACHELOR OF SCIENCE

MECHANICAL ENGINEERING COURSE

and

BACHELOR OF SCIENCE

ELECTRICAL ENGINEERING COURSE

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PREFACE

For the past few years the heating plant of Murphy College has been inadequate to supply the needs of the campus. An old 60 horse power boiler was installed in a semi-open shed as a temporary solution of the heating problem several years ago. In the Spring of 1928 the plant could supply only one building with steam during the cold weather. Every summer for the past few years those in charge of this institution had been hoping to have the new heating plant installed that year, but as everyone knows, money for a Methodist College is not always to be had for the asking.

The writer visiting this school the first part of May, 1928, was surprised to find they had no heat at all, for the old boiler plant had burned down two days before. Being offered the opportunity to work out a new heating system as a thesis and as an aid to the college in raising the necessary funds, the writer gladly submits the following report.

The President of Murphy College was in Philadelphia and other Eastern cities the first two weeks in June to see about raising funds for the new heating plant and other necessary expenses. Not having this report completed, the first part of our work was sent him in the form of a preliminary proposal. He found this of value to him, as he could show those interested our plan in a superficial way.

The writer would like to express his thanks and appreciation to Mr. A. V. Deaderick for the use of the material he worked out in Sheet No. 3, and to Prof. W. R. Woolrich for his help and suggestions in working up this report.

Entrance to

Murphy College

From "Round Top"

PRELIMINARY PROPOSALS FOR HEATING MURPHY COLLEGE,

SEVIERVILLE, TENNESSEE.

This report is preliminary and somewhat lacking in detail, but will be worked up more completely and in detail shortly. The purpose of this report is to give those interested in this Institution the cost and the relative merits of the following three proposals:

After a careful survey of the requirements three methods of meeting the need of a heating plant are evident:

1. Low pressure boilers in basement of south-west room of Administration building to supply the Boys' Dormitory and this building.

Low pressure boiler in Laundry room of Girls' Dormitory for this building.

2. Low pressure boilers in basement of Administration building to supply entire campus with steam heat.

3. Central heating plant with high-pressure boilers near present well and in building of same style architecture as other buildings on the campus.

1. LOW PRESSURE BOILERS IN BASEMENTS OF ADMINISTRATION BUILDING AND GIRLS' DORMITORY.

From the standpoint of first cost this is the best method of heating the buildings on the campus. The disadvantages are many, and for this reason this system, being the least suitable to the needs of the institution, will not be discussed in detail.

Coal and ash handling around the buildings as well as the loss of two valuable class rooms, are anything but an ideal situation. In any event it will be necessary to cut a door through the buildings in each case to get the coal into the boiler room.

As the chimneys are too small to carry the gases away, either a steel stack at the side of each building must be installed or a forced draft arrangement must be added to each boiler.

The blower equipment would necessitate the use of about 2 horse power in electric motors.

The efficiency of the boiler plant would be lower than either of the other two methods. For this reason it would be the most expensive from the standpoint of cost of steam. The bringing in of coal around the buildings would be noisy as well as dirty. The electric light bill would be increased by the addition of the blower motors.

The approximate cost of such a system would be as follows:

2 United States Radiator Company Boilers, "Smokeless" 6,000 sq. ft. installed at $1,400.00 each,	$2,800.00
Reconstruction work on class rooms,	500.00
Piping in boiler room,	200.00
Pipe line to Boys' Dormitory,	240.00
Return traps,	100.00
Blower equipment.	200.00

Girls' Dormitory.

1 United States Radiator Boiler, "Smokeless" 6,000 sq. ft. installed,	$1,400.00
Work on boiler room,	400.00
Piping in boiler room,	100.00
Return traps,	75.00
Blower,	150.00
Coal bin to be located in rear of Administration Building, capacity 4 cars,	1,500.00
	$7,665.00

2. LOW PRESSURE CENTRAL HEATING PLANT IN BASEMENT OF ADMINISTRATION BUILDING.

From the standpoint of cost of fuel this system has advantages over boilers located in both buildings. This method would require less service, as well as make coal and ash handling somewhat easier. It would, however, require a steam distribution system, connecting all the buildings on the campus. The disadvantages of having the boiler plant in the Administration building were mentioned in the first proposal.

The approximate cost of the central heating plant located in the Administration Building is as follows:

2 American Radiator Smokeless 9,000 sq. ft. Boilers, installed complete, at $1,800.00 each,	$3,600.00
Blower equipment,	300.00
Remodeling room,	500.00
Boiler room piping, fitting, etc.,	600.00
Coal bin to be located in rear of Administration Building, capacity 4 cars,	1,500.00
Distribution system,	1,650.00
	$8,150.00

3. CENTRAL HEATING PLANT USING HIGH PRESSURE BOILERS LOCATED NEAR PRESENT WELL SITE.

Blue print No. 1 shows the location and distribution system in this proposal which should be noted. Sheet No. 2 shows the detail construction of the plant.

By building the plant with the engine room over the present well all the pumping equipment will be in this room. The building will be out of the way of the other buildings as well as the probable location of the new Chapel Building.

The level of the boiler room floor will be below that of the ground. The building will be of brick, and the same style of architecture as the other buildings. A steel stack 60 ft. high will be located near the front of the building.

Sheet No. 2 gives the details of the 200 ton (4 cars) coal storage bin.

With a small additional cost to the plant an electric lighting plant can be installed. The writer has been informed that the cost of electric power is 14¢ per kilo-watt hour in Sevierville. This makes adequate lighting very expensive, and electric power out of the question. With a small turbo-generator the cost of current will be less than 2¢ per kilo-watt hour from the standpoint of fuel. The idea is to run the steam through the turbine before it goes on to the radiators. This turbine would not take over 3% of the heat value from the fuel. The total additional cost of the electrical equipment would be less than $1,400.00, and would save nearly $100.00 per month, taken on the basis of adequate lighting and power to drive the water pump.

Cost Approximation of Heating Plant.

	Minimum	Average
Building, $2,500.00 to $4,000.00	$2,500.00	$4,000.00
Pipe Lines,	2,360.00	2,360.00
Pipe layout in building,	1,200.00	1,200.00
Turbine, 15 Kilo-watt,		1,250.00
Coal Storage,	1,200.00	1,200.00
Auxiliaries,	800.00	800.00
Boilers, $2,400 and $800 Brick wk.	3,200.00	3,200.00
	$11,260.00	$14,010.00

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CENTRAL HEATING PLANT
for
MURPHY COLLEGE, SEVIERVILLE, TENNESSEE.

LOCATION:

The building will be located south of the main college buildings near the present old boiler plant. From sheet No. 1. an idea as to the relative position of the building can best be obtained. This location was chosen because it was out of the way of the other buildings, including the new proposed chapel. The cold water pumping system could be in the engine room, and the elevation would be ideal for the return water. The coal handling equipment, with its noise and dust, as well as the smoke problem, will be reduced by locating the plant this distance from the other buildings. Little trouble will be experienced in unloading coal at this location, even in the worst of weather conditions.

BUILDING:

Sheet No. 2 gives the details of the building, which is 35 X 45 feet, fire-proof brick construction, with either a red tile or asbestos shingle roof. All the flooring is to be of concrete, and the light wall separating the engine room and the boiler room will be brick. The large factory type steel windows will give an abundance of light and will be fire proof. In the design of the building three doors have been provided, one on each end of the building, with another connecting the engine room with the boiler room. In installing the boiler it will be necessary to take them through one of the window frames on the south side of the boiler room.

It will be noted that the level of the boiler room floor will be below that of the surrounding ground level. The reason for this, it will be seen, is to allow the coal bin to be below the ground and at the same time level with the floor of this building. Two arch way doors are located between the boiler room and the coal bin. When filling the coal bin they may be planked up with a small opening to shovel coal to the boilers. As coal is used up the planks may be removed and wheel barrows used through the doors for conveying coal. Another advantage of these doors is that the boiler tubes may be removed for repair by pulling them straight through the doors into the coal room, thus making it unnecessary to tear out that end of the wall, as sometimes is necessary in boiler plants.

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This building would cost near $4,000.00, but if absolutely necessary it could be built for $2,500.00, using lower grade material, which is not advisable.

COAL BIN:

The coal bin runs the entire length of the north side of the building, is of concrete construction, and is entirely below the level of the ground. The bin is 45 ft. long, 20 ft. wide and 10 ft. high and has a capacity of 4 cars or 200 tons of coal. This construction reduces coal handling to a minimum as well as doing away with an unsightly coal pile. The coal bin is filled through the doors on the North end by driving the trucks directly over and dumping it down.

By using student help or cheap labor the coal bin can be built for about $1200.00

CAPACITY OF THE PLANT.

By direct measurement the heating surface of each building was found as follows:

Boys' Dormitory	1945 sq.ft.
Administration Bldg.	2775 "
Girls' Dormitory	2630 "
Total	7,355 "

It will be seen from the following it is safe to take 100 sq.ft. of heating surface as equal to one boiler horse power.

300 B.T.U. are radiated from each square foot of radiation surface per hour according to the American Radiator Company.

$34\frac{1}{2}$ pounds of steam per hour equals one boiler horse power.

971.7 B.T.U. = The heat content in a pound of steam.

$$\frac{34\frac{1}{2} \times 971.7}{300} = 100 \text{ sq. ft.}$$

100 sq. ft. radiation therefore = 1 B.H.P.

The actual present requirement is 73.5 boiler horse power. Taking into consideration the way these boilers will be fired and allowing a margin of expansion, two 60 H.P. boilers are recommended. The double boiler setting allows one to be shut down in mild weather or for repairs, and it costs very little nore than a single setting.

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BOILERS AND STACK.

In a letter to the writer dated April 28, 1928 from Carl Weigle of the Walsh and Weidner Company of Chattanooga, Tennessee, they state they will give us 2 60H.P. Return tubular boilers, with steel cased setting, F.O.B. Sevierville, for $2,400.00. This price includes a steel stack 33 inches in diameter and 60 ft. high. This stack is complete with Y breeching, so both boilers may be connected to the single stack. The additional brick work to the boiler setting would cost about $800.00, making the entire boiler system completely installed cost $3,200.00. This outfit would make a neat and dependable as well as an efficient installation and is therefore recommended. Figure No. 1 below shows the boiler without stack.

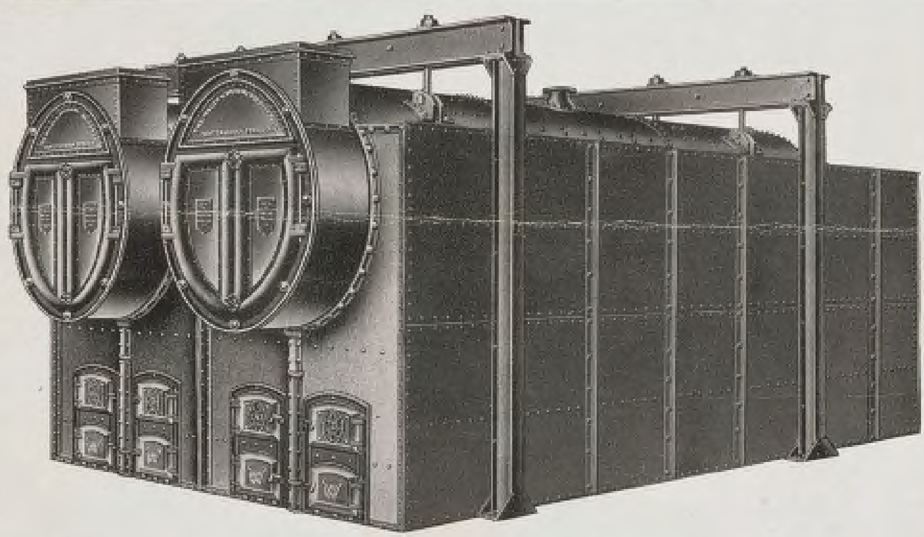

Fig. No. 1 —Box Type Steel Casing

BOILER AUXILIARIES,PIPING, ETC.

The boiler feed pump on the present boiler is practically new and can be used in this plant. A duplicate for heavy loads, and stand-by purposes, costing about $60.00, should be purchased. An injector should be installed so as to be ready for use in case both pumps fail. An open feed water heater costing approximately $500.00 is recommended because the exhaust steam from the pumps could be used to heat the feed water from approximately 120' F. to 140' F. increasing the over all efficiency of the plant about 2 % . This saving in fuel is certainly worth while.

Inside the building some piping will be necessary. The steam connections to the pumps, the cold water piping, as well as the steam mains from the boilers to the engine room must be taken care of. An ample number of valves, including a pressure reduction valve, are included in the estimated cost of $1,200.00 installed.

ELECTRICAL EQUIPMENT;

As will be explained in detail later, with a small increase in first cost, the plant can be arranged to generate electricity at a very low cost to supply the needs of the campus. Steam is produced at 125 pound pressure in the boilers and passed directly through the turbine. Coming out of the turbine at 15 pounds pressure it goes to the heating main on to the radiators. This system gives us nearly 100 % efficiency as the turbo-generator only uses just enough heat value from the steam to equal the demand in electricity required. High pressure boilers are to be recommended, but the radiators should work on low pressure. The turbo-generator can take care of this situation. Direct current equipment is recommended, due to the fact that it is easier to control, in our situation, costs about 40% of that of an alternating current installation, and is so simple it can be handled by student help. A turbine is recommended instead of an engine because of its lower cost and the absence of oil in the exhaust steam. Oil in the heating system would be most undesirable, and would finally come back to the boilers to give more trouble. A turbo-generator installation would require less floor space than an engine set of equal capacity. Maintenance cost on the turbine would be lower.

The Westinghouse Electric and Mfg. Company in a letter dated April 26, 1928, (from its Knoxville office) to the writer, offers us one 15 K.W. Type O Z ≠ E N C - S K, 125 Volt Direct current turbo-generator outfit for $1,015.00 F.O.B. Pittsburgh, Pa., and switchboard complete for $154.00 F.O.B. Atlanta, Ga.

The Southern Sales Company, Knoxville, Tennessee, quote on the following units, (letter dated April 30, 1928, to the writer, from Mr. J. E. Crowder):

15 K.W. Elliot Turbo-generator, F.O.B. Jeannete, Pa.,
Price, $1,139.00

25 K.W? Elliot Turbo-generator, F.O.B. Jeannete, Pa.,
Price, $1,417.00

The switchboards would cost for the above units about

$175.00 and $225.00 respectively.

The above are educational prices, and are from 20% to 35% less than retail prices.

All these turbine outfits are good, but the writer would recommend the Westinghouse installation with provision for a duplicate unit to be installed later on when the one unit can no longer carry the load of the institution.

A 3 H.P. direct current motor may be belted to the pump to run when the turbine is in operation. The present gas engine could be placed on the other side of the pump so the belt could be thrown off the motor and on to the gas engine when the turbine is not in operation.

It must be understood that it is doubtful whether it will be profitable during the late spring to run the plant to produce electricity alone. The reason for this, of course, is due to the fact that the total expense of the plant must be charged up against the electricity when we have no demand for steam. Provision must be made, therefore, to throw the electrical system back on the utility lines when the plant is down. This can be accomplished by a simple switching arrangement at the switchboard in the boiler room.

STEAM DISTRIBUTION SYSTEM.

By calculation and measurement we found the following requirements:

Location	Size Main	Return	Length	Cost Ft*	Total Cost
From P.H. to G. D.	2 ½ "	1 ¼ "	144 '	$5.00	$720.00
From P.H. to A.B.	3 ½ "	1 ½	216 '	6.00	1,300.00
From A.B. to B.D.	2 "	1"	53 '	4.50	240.00
	Total cost of Distribution system				$2,260.00

* Approximated by Prof. W. R. Woolrich from similar conditions on the University of Tennessee campus.

Sheet No. 1 gives the size and location of each of the pipe lines in the above distribution system.

All the lines are covered, and are in split tile as in Sheet 3. Valves and expansion joints are placed at the points where the line enters each building. The heat losses from a distribution system of this type would be relatively low, and, therefore, will be found to be satisfactory.

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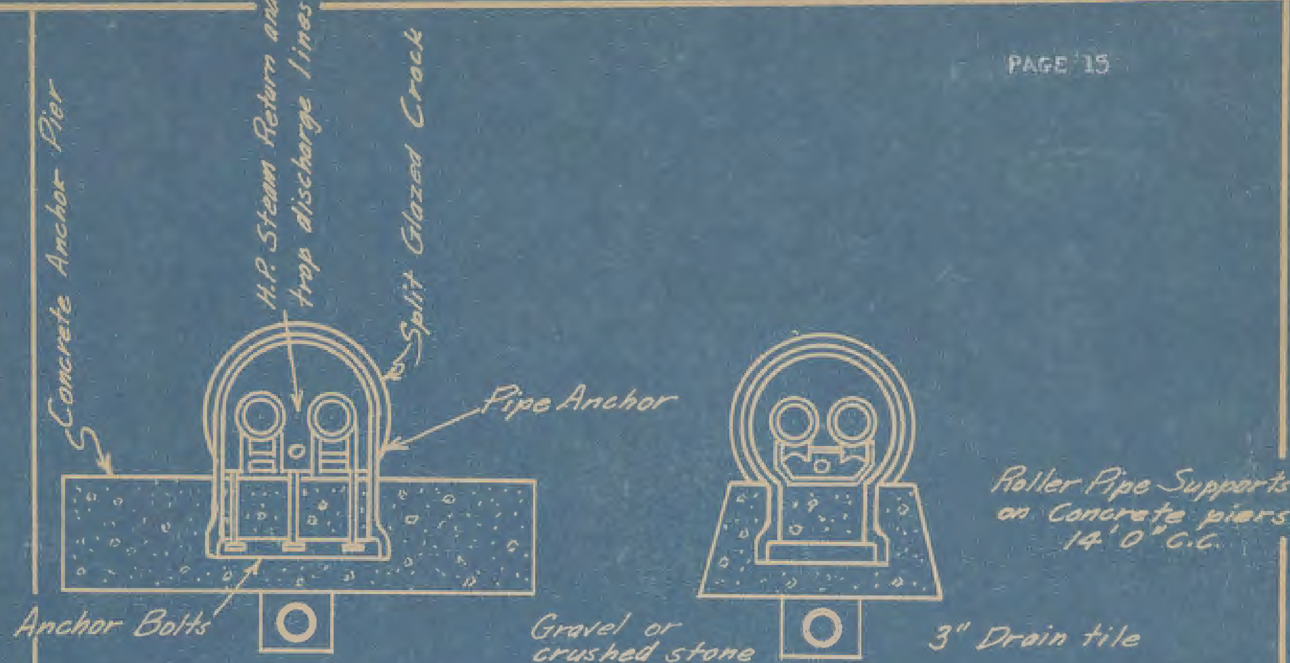
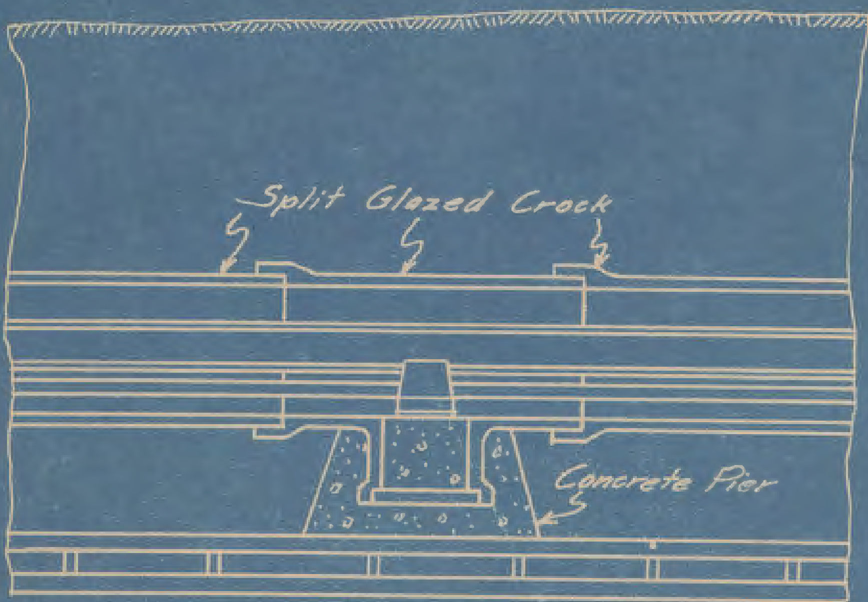


Cross Section thru. H.P. Steam Return and trap-dischargelines at Anchor.
Scale ½" = 1'0"

Cross Section thru H.P. Steam Return and trap-discharge lines at Support
Scale ½" = 1'0"



Longitudinal Section through H.P. Steam Return and trap-discharge Lines at Support
Scale ½" = 1'0"

Fig. 3

ECONOMICS OF CENTRAL HEAT AND POWER.

It is a well known fact that as a better service is given that the demand for that service increases. As lighting and heating conditions are improved there will naturally be a greater fuel bill.

The present lighting conditions are very poor. The halls of the girls' dormitory and Administration building and many of the class rooms have next to no lighting at all. A system of campus lighting would beautify the grounds to a great extent. A well lighted campus would make a good impression on the multitude of turists who pass the campus daily. The school could use to advantage at least four times its present lighting load. If this power was purchased from the utility company it would cost $200.00 to $225.00 a month.

The writer has been informed that power costs the school 14¢ per Kilo-watt hour. If we make the assumption that our boiler will be 60% efficient (the builders say by correct firing we can get 75% efficiency) our electrical equipment is 90% efficient, and at the present price of coal at $4.60 per ton, (12,000 B.T.U.) we have:

$$\frac{3415^{*} \times \$4.60}{.90 \times 12000 \times 60 \times 2000} = \$.00121 \text{ per k.w.H.}$$

* 3415 B.T.U. = 1 K.W.H.

The electricity would cost us on the basis of fuel burned less than 2/10 ¢ per K.W.H. It will be seen, therefore that electricity can be produced at a fraction of its present cost. The new dining hall will probably require electric refrigeration, and more and more demand is going to be made by the Home Economics and Science departments for motor drives on their various devices. All the water for the school could be pumped by electricity with the installation of the lighting plant. The investment in a steam driven generator should pay for itself in two years.

The loss underground of the present system must run very high, so much so the writer would not venture an estimate. With the new distribution system the losses underground will doubtless be less than 6%. From this fact, together with the more efficient boilers, we can expect more heat from a pound of coal.

It must be noted, however, that the proposed installation will not cut down the coal bill. It will certainly cut down the coal bill if required to furnish only the amount of heat now available. Conditions indicate that only enough heat can now be can now be produced to heat one building in the coldest weather. With adequate heating an increase in fuel consumption must be expected.

The man hours of efficient work that can be secured from both faculty and students when working under proper conditions of lighting and ventilation will be the most valuable part of the saving in the proposed investment.

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COST APPROXIMATION OF PLANT.

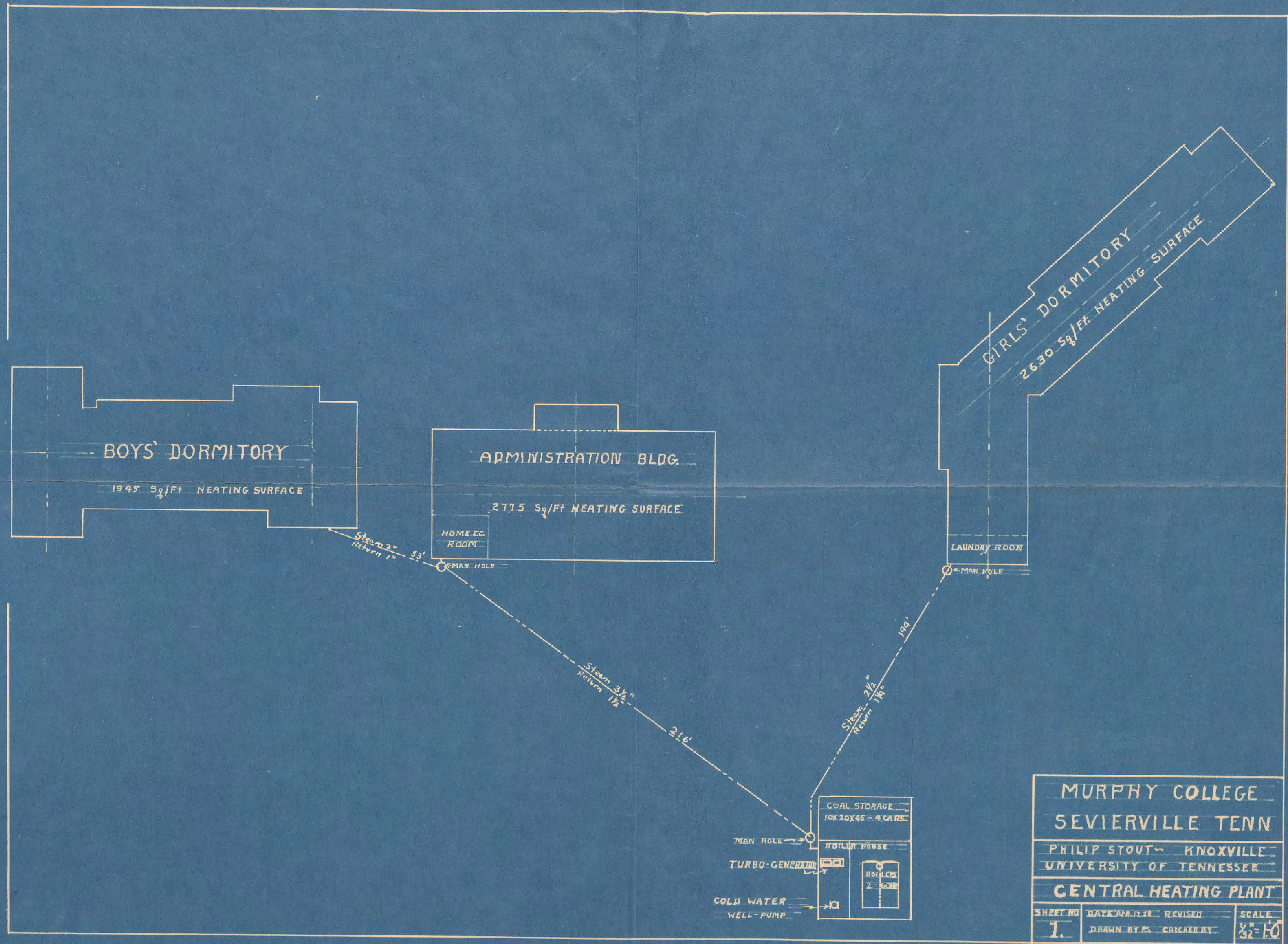
Building	$4,000.00
Pipe lines, (distribution system)	2,260.00
Pipe layout in Building,	1,200.00
Westinghouse 15 K.W. turbine Complete	
with switchboard installed	1,250.00
Coal Bin,	1,200.00
Auxiliaries,	800.00
2 60 H.P. steel cased Walsh and Weidner	
return tubular boilers installed,	3,200.00
(Complete with brick work)	
Supervision of Installation,	420.00
Total Cost.	$14,330.00

APPROVAL.

The foregoing thesis is hereby approved as a creditable study of an engineering subject, carried out and presented in a manner sufficiently satisfactory to warrant its acceptance as a prerequisite to the degree for which it has been submitted. It is to be understood that by this approval the undersigned does not necessarily endorse or approve any statement made, opinions expressed, or conclusions drawn therein, but approves the thesis only for the purpose for which it is submitted.

Name W. R. Woolrich

Title Prof. Mech. Eng.



BOYS' DORMITORY
1945 Sq/Ft HEATING SURFACE
ADMINISTRATION BLDG.
2775 Sq/Ft HEATING SURFACE
HOME EC. ROOM
GIRLS' DORMITORY
2630 Sq/Ft HEATING SURFACE
LAUNDRY ROOM
MAN HOLE
MAN HOLE
Steam 2" Return 1" 53'
Steam 3½" Return 1½" 216'
Steam 2½" Return 1¼" 144'
COAL STORAGE
10X20X45 - 4 CARS
MAN HOLE
BOILER HOUSE
TURBO-GENERATOR
BOILERS 2 - 60HP
COLD WATER WELL-PUMP
MURPHY COLLEGE
SEVIERVILLE TENN
PHILIP STOUT - KNOXVILLE
UNIVERSITY OF TENNESSEE
CENTRAL HEATING PLANT
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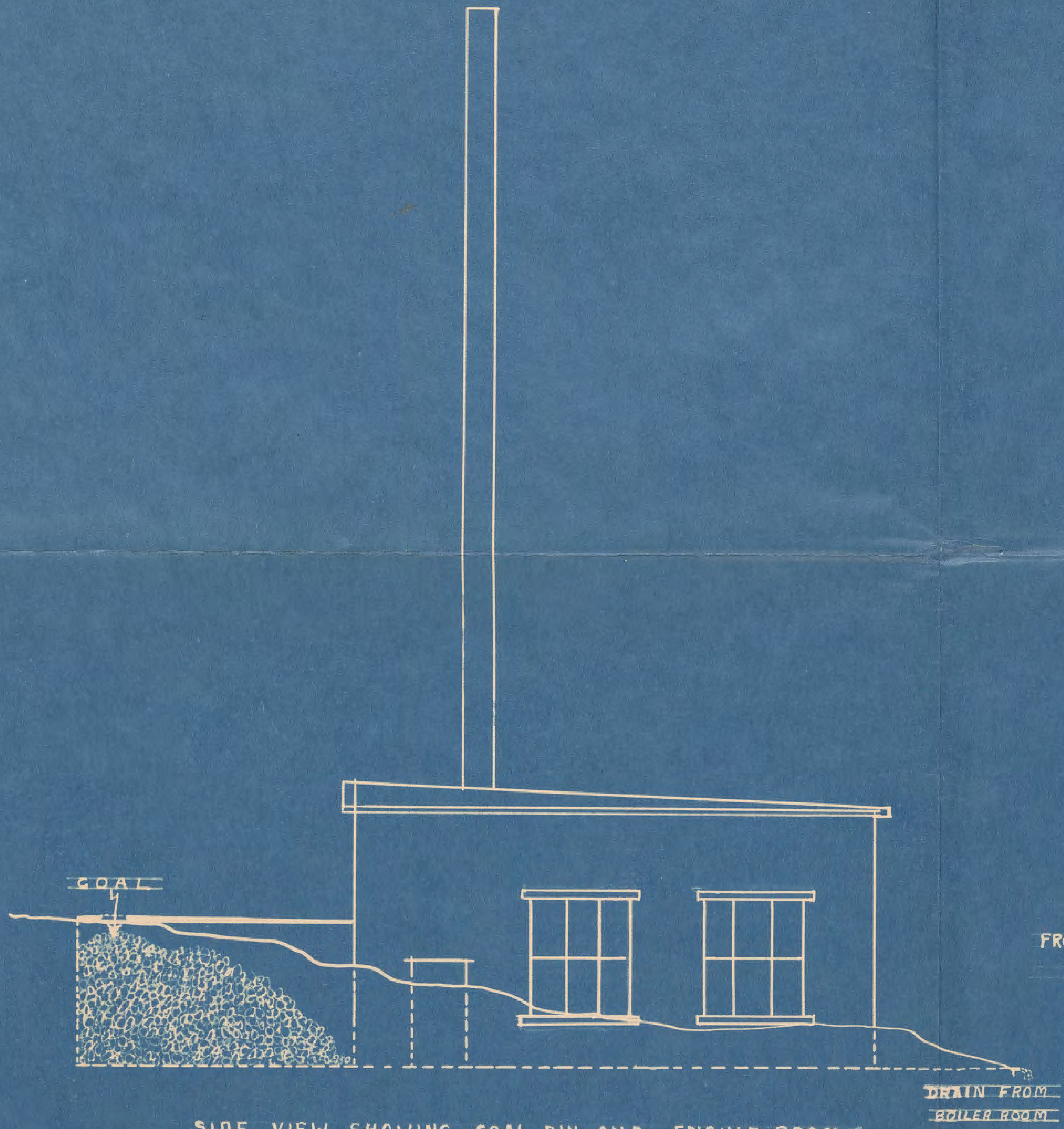
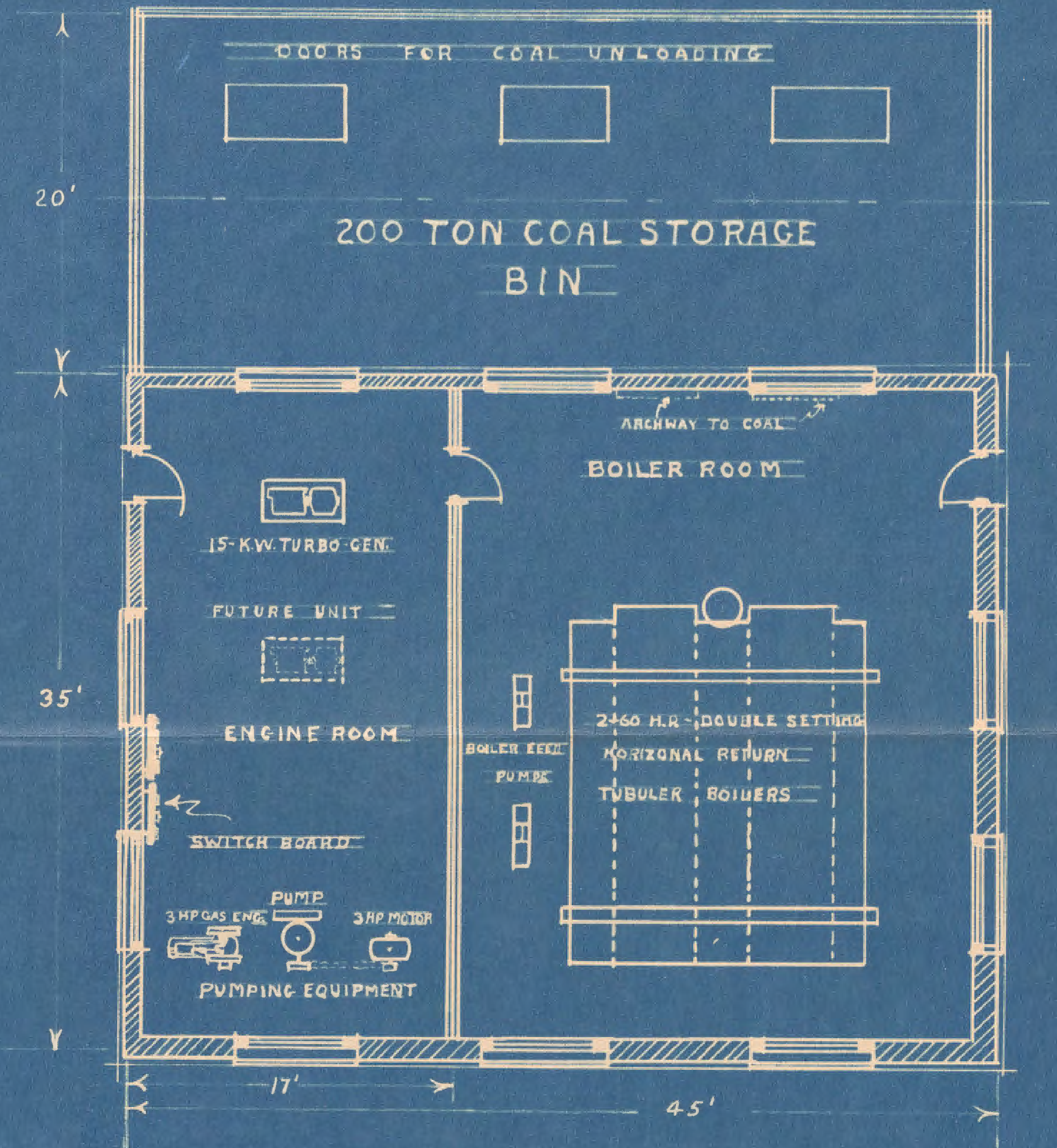
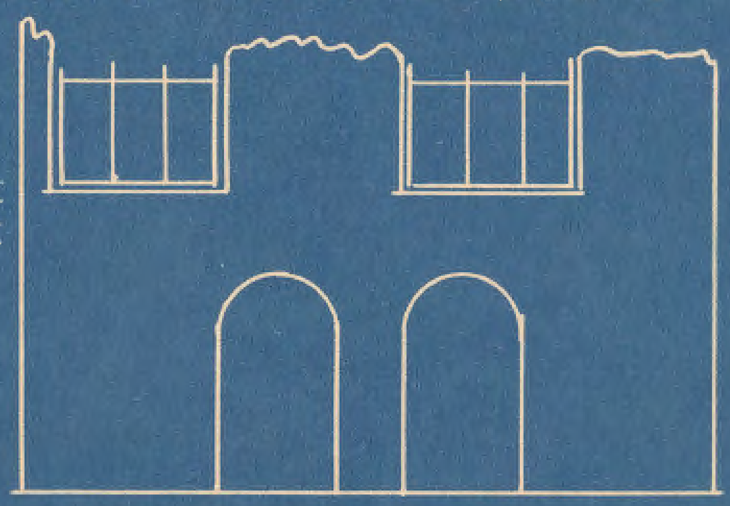


SIDE VIEW SHOWING COAL BIN AND ENGINE ROOM
END OF PLANT



FRONT VIEW-INSIDE BOILER ROOM WALL
SHOWING ENTRANCE TO COAL BIN



MURPHY COLLEGE
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CENTRAL HEATING PLANT

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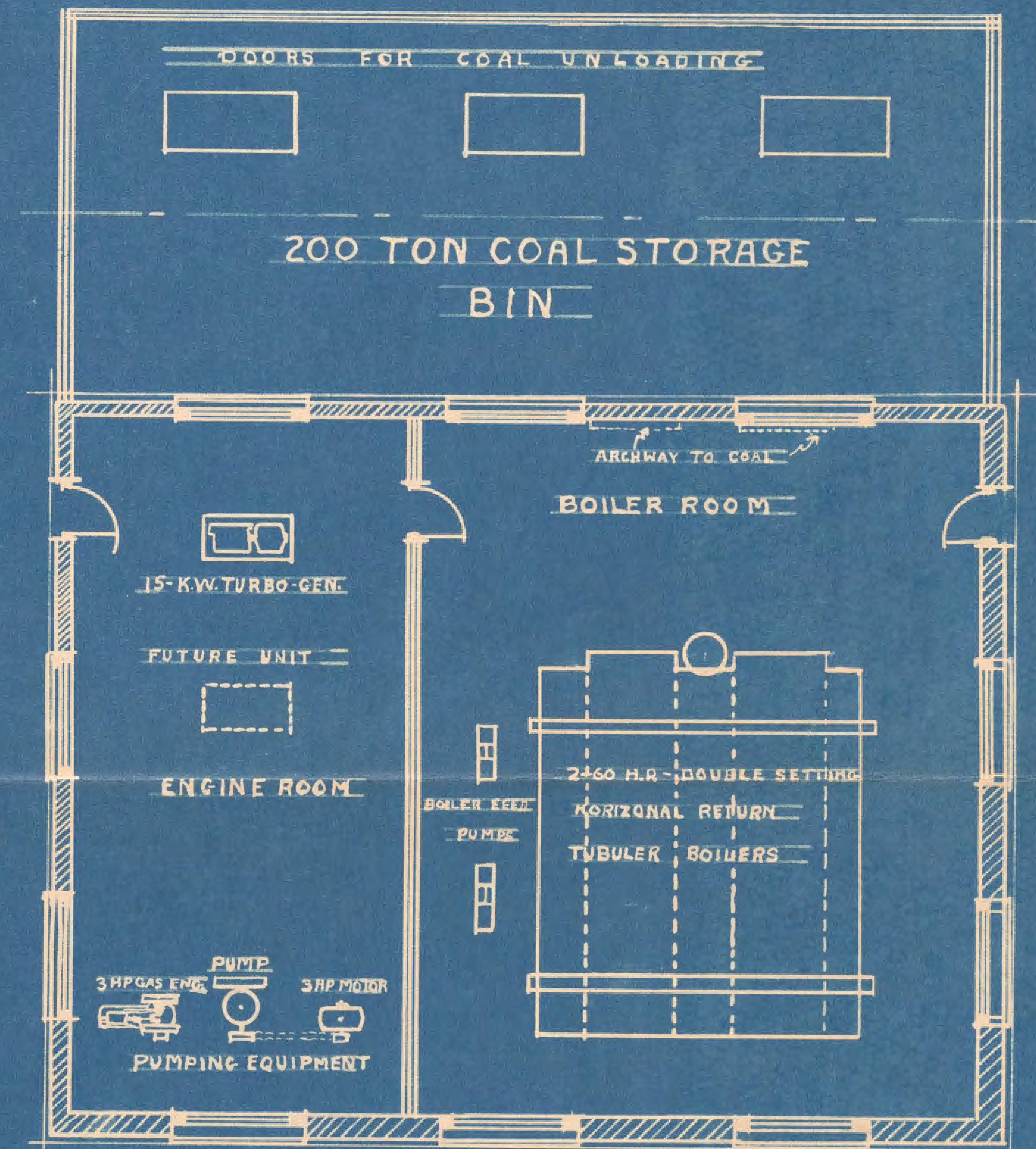
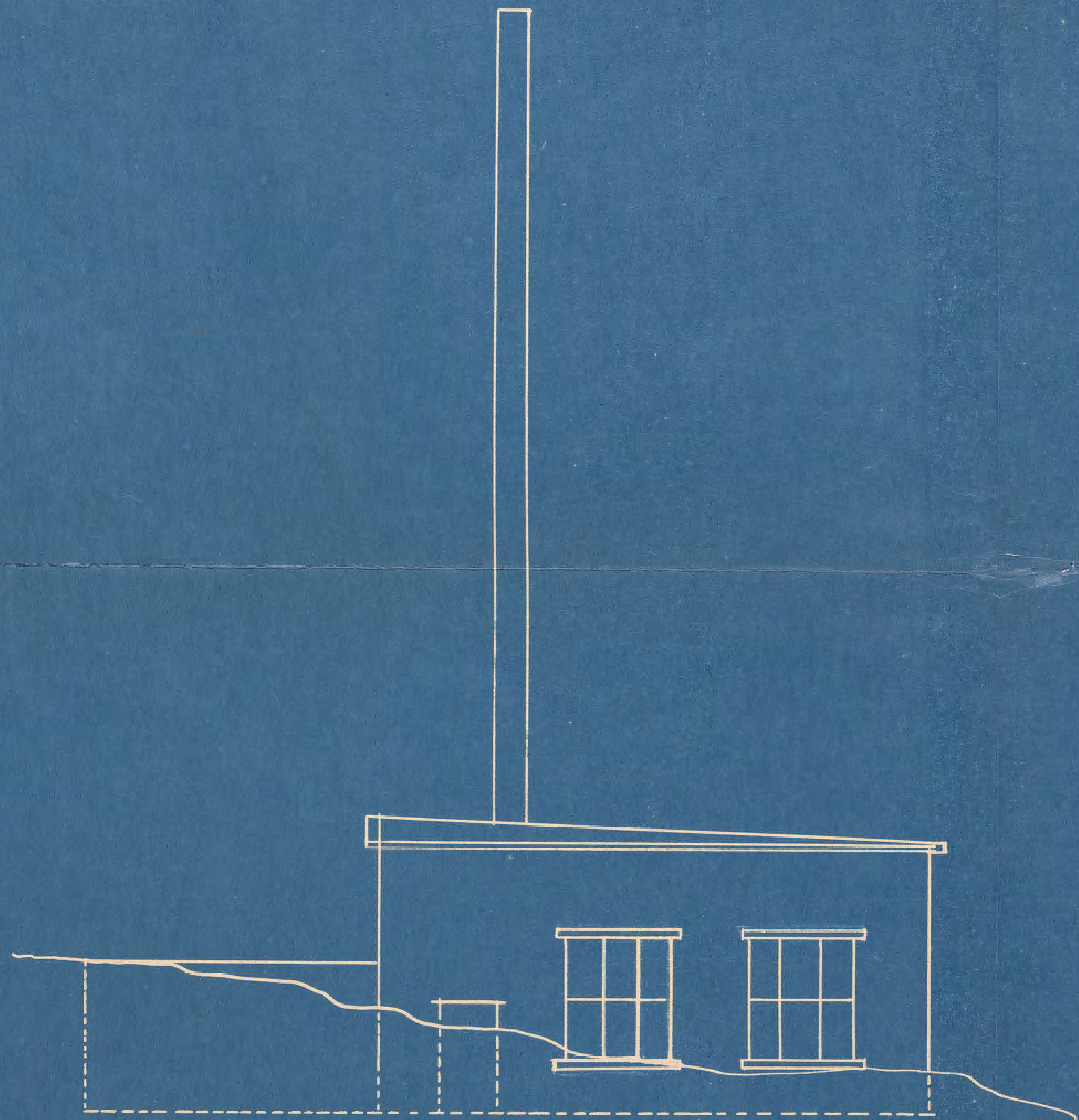
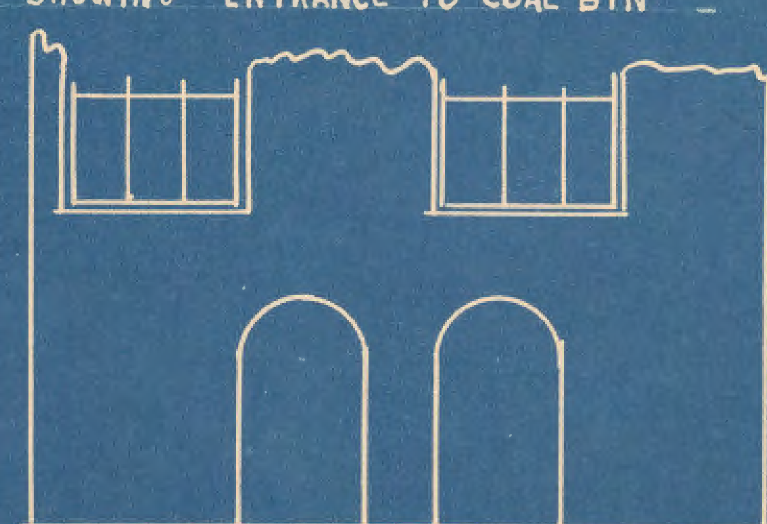




SIDE VIEW SHOWING COAL BIN AND ENGINE ROOM
END OF PLANT

FRONT VIEW—INSIDE BOILER ROOM WALL
SHOWING ENTRANCE TO COAL BIN



MURPHY COLLEGE SEVIERVILLE TENN		
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CENTRAL HEATING PLANT		
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