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Extension to

RIVERSIDE STATION of The United Power Mfg. Co.

PLAINTIFF'S EXHIBIT

RS-261

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(C. A. Butler)

This addition consists of a 28,571-kva condensing turbine-generator supplied with steam at 825 lb, 825 F, from a single steam-generating unit fired with pulverized coal and having a continuous slagging furnace. The turbine design permits steam extraction to the existing 400-lb station header. The article reviews the preliminary engineering studies involved and traces the progress in design of steam-generating equipment since the initial installation was made in 1925.

generators is now 82,142 kva which, together with that of an older steam station and several small hydroelectric plants, serves Davenport, Ia., Rock Island and Moline, Ill., and the surrounding territory.

History

THE rapid progress which has been made in the design of steam-generating equipment in a comparatively few years is shown by the development of the Riverside Station of the United Power Manufacturing Company. This station is located on the west bank of the Mississippi River about eight miles north of Davenport, Iowa. Its combined capacity of main

Riverside Station is a comparatively new power plant, it having been placed in service in 1925. The original installation consisted of four 1044-hp Heine boilers and one 25,000-kva turbine-generator. These boilers were of the cross-drum box-header type, designed for a maximum drum pressure of 440 lb per sq in., with combination convection and radiant superheaters arranged to raise the steam temperature to 700 F. A high-pressure economizer and a steel-plate induced-draft fan were installed in connection with each boiler. The fuel-burning equipment consisted of four 10-retort, 33-tuyère underfeed stokers. There were four forced-draft fans, con-

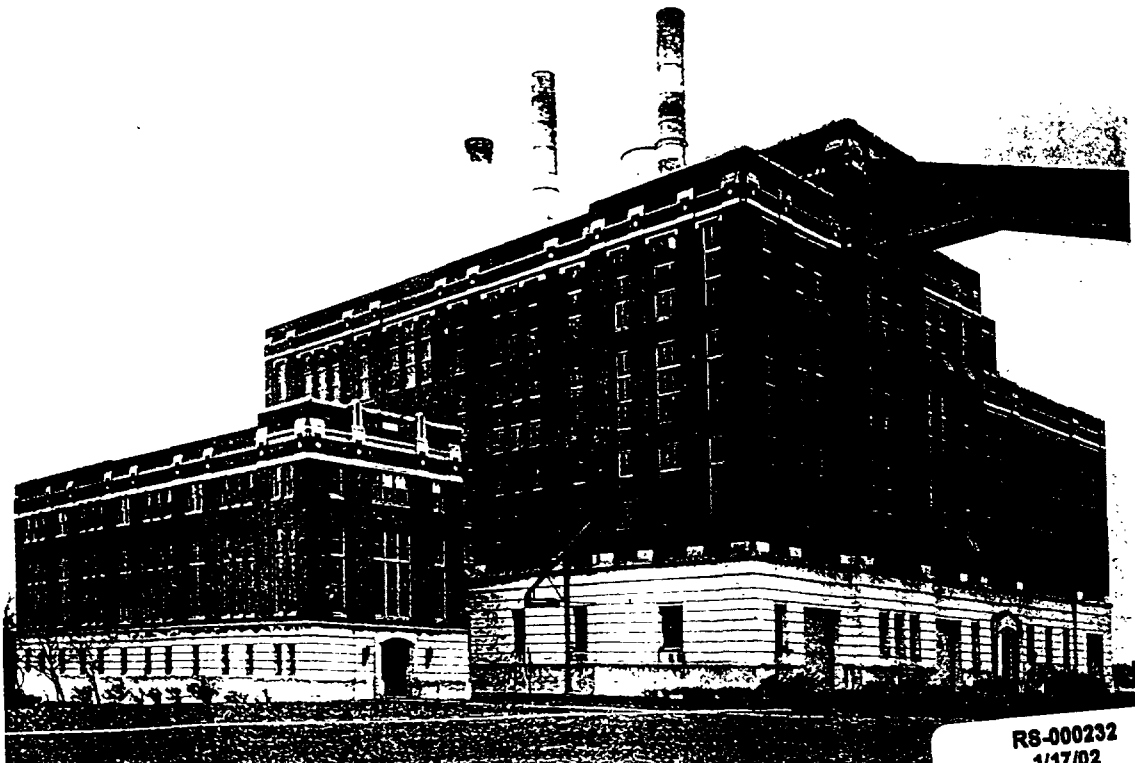


Fig. 1—Exterior view of Riverside Station

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EDITORIAL

Coal Research

With advancement in power plant practice the efficiency of coal utilization has steadily improved, as measured on an input-output basis. Further improvement upon the performance of the most up-to-date installations must be progressively less as the limitations inherent in the steam cycle are approached. This is demonstrated by the statistics issued by the Federal Power Commission covering the generation of electricity for public consumption. From 1920 through 1937 the pounds of coal per kilowatt-hour steadily decreased from 3 in 1920 to 1.43 in 1937, but during the last five years the reduction has been only from 1.47 to 1.43. This, of course, is an average for nearly 3800 plants, the most efficient of which are far under this figure. Much remains to be accomplished, however, in raising the efficiency of the poorer plants, particularly among industrials, to the level of the leaders in their class.

With further improvements in thermal performance limited, there is still opportunity for increasing the commercial or dollar efficiency through the selection of the correct coal for the particular conditions, thereby simplifying operating problems by reduced maintenance and outage. Credit for achieving the marked reduction in coal consumption per kilowatt-hour belongs to the designers and operators of power plants and their equipment, but as an aid to further progress specific information on the behavior of different coals under various conditions of burning is needed and would be welcomed not only by the designer of equipment but also the user as a guide to the selection of the most suitable equipment.

With some six thousand mines in the United States producing coals of various characteristics and sizes, and hardly any two power plants identical in design and operation, the great multiplicity and combination of factors involved becomes apparent.

The chemistry of coal has long been studied and data are available covering the analyses and other properties of coals from practically all seams. Also, some operating companies have accumulated helpful information on the performance of certain coals by trials in individual plants. But, despite this, there has been a dearth of information on just what goes on during the process of burning these various coals.

There is a growing appreciation of the desirability of giving more attention to coal selection, predicated upon a knowledge of its behavior in storage, in handling and in the furnace, its caking and clinkering characteristics and the mechanism of combustion. This has been brought about partly by developments in power station design and changes in operating practice and partly by the new marketing situation resulting from application of the National Bituminous Coal Act.

Constructive work in fundamental coal research has been conducted for some time at Carnegie Institute of Technology and the U. S. Bureau of Mines, but an added impetus to the solution of coal utilization problems was

provided in 1935 by the formation of Bituminous Coal Research, Inc., under whose sponsorship projects are now being carried out by several universities and by Battelle Memorial Institute. Much of this research extends beyond the laboratory into the field of coal utilization where surveys are being made and tests conducted in actual installations. The question of coal segregation has been attacked, sizing has been studied and for the first time the reactions and behavior of coal on an underfeed stoker have been ascertained under service conditions. The program is far-reaching and much still remains to be accomplished.

During the eighteen-year period, from 1920 through 1937, despite a three-fold increase in electric output, the consumption of coal by the plants previously mentioned has remained practically the same. This has been due partly to improved efficiency and partly to the inroads of competitive fuels, particularly gas. In meeting this challenge the coal industry through the promotion of research in utilization is rendering a service to the power plant field as well as to itself.

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Steam Washing

The extensive use of higher boiler pressures has been accompanied by the necessity of providing clean steam in order to avoid troublesome turbine deposits—a condition seldom obtaining with pressures under three hundred pounds. This has led to the wide use of steam washers by means of which the steam is washed by the relatively pure feedwater and the solids entrained in the steam are reduced to a minimum.

Many tests have been made on the purity of steam thus washed and have shown remarkably low solids content, ranging from 0.5 to 1 ppm when operating with very high boiler-water concentrations. From this it should not be inferred, however, that high boiler-water concentrations are always permissible, as this depends upon several factors including pressure, analysis of the boiler water, the steam liberation per cubic foot of drum and the type of boiler. Therefore, each case requires individual consideration.

Several methods have been evolved for testing the purity of steam. Among these are evaporation of the sample and testing by electrical conductivity. In the former method considerable time is required and much care is necessary in order to avoid contamination, whereas with the latter the presence of dissolved gases must be guarded against or corrections made for them. While it is possible to determine the purity of steam down to 0.5 ppm, or perhaps less, those experienced in making such measurements usually advise checking by two or three methods when the indicated purity is less than 1 ppm.

In the final analysis, however, the object is to reduce the steam purity to such a figure as will avoid trouble in operation. This should be the ultimate criterion of performance.

connected to a common air duct serving all the boilers. Air-cooled refractory settings were employed.

It was found that the maximum continuous output of each boiler as originally installed was 90,000 lb per hr and that operation at higher ratings, even for short periods, resulted in excessive furnace and stoker maintenance.

In 1929 a second turbine-generator of 28,571 kva capacity was installed. No additional boilers were put in at that time because the system load did not make it necessary to carry full load on both generating units simultaneously. About the same time one of the boilers was equipped with a water-cooled furnace. This change increased the availability of this boiler, as was expected, and greatly reduced furnace maintenance. The remaining three boilers were equipped with water-cooled furnaces in 1930 and 1931.

The fuel burned on the underfeed stokers was principally southern Illinois coal. In 1932 a strip mine was opened approximately sixty miles from the power plant. The coal from this mine could be delivered to the plant at considerably less cost than that then being used, but it ran high in moisture and had a low ash-fusion temperature; hence it could not be successfully burned on the underfeed stokers.

In order to take advantage of this supply of low-priced fuel, the stoker was removed from one of the boilers, the water-cooled furnace was altered and two pulverizers were installed. Direct firing and the intermittent slag tap method of removing the ash were employed. To provide preheated air for the mills, a small Ljungstrom air heater was installed with the gas passage in parallel with the economizer. This equipment was placed in service early in 1933. With the increased fuel burning capacity, and the reduction in draft loss through the economizer, as a result of diverting part of the flue gas through the air heater, the steaming capacity of the boiler was increased to 140,000 lb per hr. This installation was so successful that a second boiler was similarly altered later in the same year.

In 1934 natural gas became available at Riverside. This was supplied on a typical "dump gas" basis, and did not entirely replace coal as fuel. All the boilers were equipped for burning gas. The burners on the two boilers that had been provided with pulverizers were converted to combination gas and coal burners, and in the other boilers gas was burned over the stokers.

With both pulverized coal and gas firing, the superheat added to the steam in the radiant superheaters was reduced. Therefore these radiant superheaters were rebuilt not only to regain the lost superheat, but to raise the final steam temperature to 740 F.

By 1936 the increase in industrial and domestic use of gas had limited the amount available for use in the power plant. This fact, together with increased system load, made it necessary to remodel the remaining two boilers for pulverized coal firing, despite the fact that plans for additional boiler and turbine capacity were already being made. The changes were similar to those previously made on the other two boilers.

As a result of the changes in these four boilers since they were first installed, they can now carry both 400-lb turbines at maximum emergency capacity, and three boilers can carry both turbines at normal full load capacity, namely, 20,000 kw each. In the installation

as originally made, three boilers were required to carry the original turbine at full load continuously.

1936-1937 Addition

Increased load on the system made it necessary to generate an appreciable amount of power at the Moline steam plant, located farther down the river on the east bank. Compared with Riverside, the economy of the Moline plant is poor and maintenance costs are high. The increase in load also indicated early need of increased capacity on the system. Modernization of the Moline plant by installing a superposed unit was considered. But investigations showed that it was more desirable to concentrate operations at the more modern Riverside Station and maintain the Moline plant for power-factor correction and standby service only.

Although the equipment at Riverside could not be considered obsolete, and the station was operating at a heat consumption of approximately 16,500 Btu per kw hr generated, it was obviously unwise to add new equipment designed for the steam conditions of 440 lb per sq in. and 740 F, without giving serious consideration to the possibilities of more economical operation obtainable with equipment designed for higher steam pressure and temperature. The use of a high-pressure superposed unit exhausting to the 400-lb header did not prove attractive for several reasons. First, with 400 lb exhaust pressure, the capacity of a superposed unit using steam at 1400 lb or less at the throttle would be too small to provide the additional system capacity required. Furthermore, the blading efficiency of so small a high-pressure turbine would have been comparatively low. It was thought that there was insufficient operating experience with pressures in excess of 1400 lb per sq in. to justify consideration of a higher pressure in order to increase the capacity of the superposed unit. Secondly, due to the fact that a portion of the base load of the system is carried by the hydroelectric plants, the new equipment would at times be required to operate at comparatively light loads. Finally, it would obviously be impractical to make the superposed turbine-generator available for use with steam from the 440-lb boilers.

The New Turbine-Generator

Further studies, taking into consideration fuel cost, equipment cost, expected character and amount of load, and other important factors, led to the selection of a 3600-rpm condensing turbine-generator designed for throttle steam conditions of 825 lb per sq in. and 825 F total temperature. Specifications were drawn up requiring that the turbine should be designed for these steam conditions, but should be able to carry full load, at reduced economy, with throttle steam of 400 lb and 740 F.

The turbine selected is a 21-stage G-E tandem-compound machine using impulse blading throughout. Eighteen stages are in the high-pressure cylinder. There are two rows of moving blades in the first stage and the other 17 stages in the high-pressure cylinder have one row of moving blades each. The low-pressure cylinder is of the double-flow type. There are nine admission valves in the steam chest. The eighth and ninth valves, which are used only when the turbine is operating with 400-lb steam at the throttle, admit steam directly to the fourth stage. A fulcrum shifting device, actuated by the steam pressure at the throttle, is incorporated in the

governing mechanism. At pressures above 500 lb the eighth and ninth valves are prevented from opening, and the full range of the governor is made available for operating the first seven valves. At pressures below 500 lb the governor is able to open all of the admission valves.

When the turbine is operating with 825 lb steam pressure at the throttle, all of the steam passes through the first stage. Inasmuch as the pressure in the first stage chamber under the heavier loads rises above 400 lb, it was found practical to provide for extracting steam from this turbine into the 400-lb header when the high-pressure steam generating equipment is in service and the machine is loaded above 22,000 kw. The design of the turbine permits 166,500 lb of steam per hour to be extracted at 400 lb per sq in., but until a second 900-lb pressure boiler is installed, the amount of high-pressure steam available will limit the extraction to 126,500 lb per hr.

Despite its versatility, this turbine has an economy under normal operating conditions, which is within one per cent of that of a turbine not having these features of large high-pressure steam extraction and the ability to carry full load with reduced throttle pressure. Furthermore, the economy when operating on 400 lb per sq in. is better than that offered by any turbine manufacturer when the machine installed in 1929 was under consideration.

The main generator driven by this turbine produces 13,800-volt, 3-phase, 60-cycle energy. Its capacity is 28,571 kva at 70 per cent power factor. Excitation for the main generator is provided by an exciter on the main shaft of the unit and the excitation for this main exciter is, in turn, provided by a pilot exciter which is also driven by the main shaft. This eliminates losses in the generator field rheostat during normal operation.

Since the major portion of the power from Riverside Station is transmitted by overhead lines, it was necessary to provide a source of power supply for the essential auxiliaries independent of the main generators and the main bus. The 1500-kw house-service generator driven by a non-condensing turbine, which was a part of the original installation, was inadequate to serve the enlarged plant; hence, a 2500-kw house-service generator was incorporated in the new turbine-generator unit. This is located between the main generator and the exciters. All of the auxiliaries in the station are supplied with power at 440 volts, 3-phase, 60-cycles, and the new house-service generator supplies power of these characteristics direct to the house-service bus.

Steam Generating Equipment

Since the new turbine could be operated at full load on steam from the existing boilers, only one 900-lb pressure boiler was considered. A boiler having sufficient capacity to carry full load on the new turbine, without extraction to the 400-lb header, was first contemplated. Due to the character of the coal to be burned, pulverizers were the only type of fuel burning equipment considered. The steam generating unit offered originally had a capacity of 225,000 lb of steam per hour, and was fired by two pulverizers. As the coal at times contains excessively high moisture, a considerable margin in pulverizer capacity was necessary to insure full boiler capacity under such conditions. Furthermore, with only one high-pressure boiler, it was desirable to be able to take

a pulverizer out of service for maintenance without drastically reducing the capacity of the steam generating unit. Therefore, three pulverizers were finally selected of a capacity such that under ordinary conditions two would supply enough steam to carry normal load on the turbine. With three pulverizers in service ample capacity is provided to take care of adverse fuel conditions.

By providing more capacity than originally planned in the forced- and induced-draft fans, it is possible to utilize most of the capacity of the three pulverizers under normal fuel conditions, and increase that of the steam generating unit to 300,000 lb of steam per hour.

The boiler installed is a C-E bent-tube three-drum type designed for a maximum pressure of 900 lb per sq in. Its drums are of welded construction and the heating surface in the boiler proper is 8020 sq ft. The superheater, which is located between the first and second banks of tubes, has sufficient surface (6400 sq ft) to raise the total steam temperature to 825 F when the output is 112,500 lb of steam per hour. At higher outputs the steam temperature is controlled through bypassing a portion of the gas around the superheater and thus maintaining the temperature at 825 F.

A 9480-sq ft continuous-loop economizer is located within the boiler setting in space provided between the two rows of tubes constituting the last bank. A gas bypass located entirely within the setting makes possible partial bypassing of the economizer. This serves two purposes. At low ratings gas is bypassed so as to increase its temperature entering the air heater and thus prevent its being cooled below the dew-point in the air heater. This reduces the danger of corrosion and plugging in the air heater. Since approximately one-third of the total draft loss occurs in the economizer, the gas bypass can be used if necessary at extremely high ratings to reduce the draft required at the induced-draft fan under adverse conditions. The feedwater enters the economizer at 212 F and is heated to 398 F at maximum rating. The feedwater regulating valves are located between the economizer and the boiler drum to prevent steam being generated in the economizer when bringing the boiler up to operating pressure.

The air preheater is of the Ljungstrom type, with its shaft horizontal. It is placed above the boiler and contains 14,400 sq ft of heating surface. The air temperature is raised to 305 F at 112,500 lb per hr steam output and to 394 F at the maximum steam output of 300,000 lb per hr.

The furnace is completely water cooled. It has a volume of 12,650 cu ft and the effective heat-absorbing surface in the furnace walls is 3825 sq ft. A steel casing encloses the entire furnace, boiler, economizer and superheater. The waterwall circulating tubes are located within the casing behind the furnace tubes, and are protected from the furnace heat by insulation in addition to the protection afforded by the furnace tubes.

Fuel is fired tangentially by twelve burners, three in each corner of the furnace. One burner in each corner is connected to each of the three pulverizers, so that one, two or three mills may be used as required without upsetting the tangential effect. In each burner provision is made for burning gas as well as coal. Gas and coal may be burned either individually or simultaneously. This feature is especially valuable because at times a limited amount of gas is available, but the amount is not

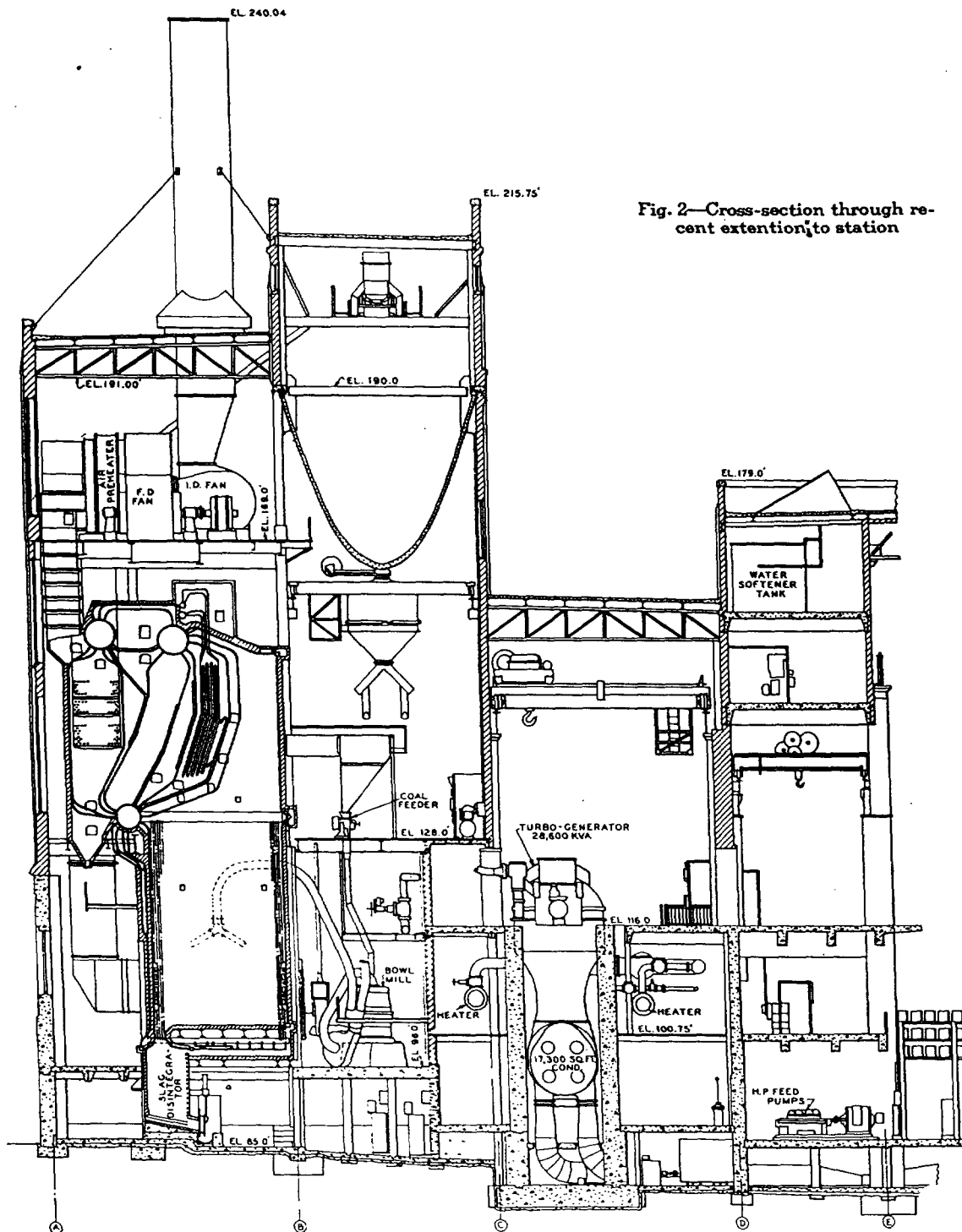


Fig. 2—Cross-section through recent extension to station

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sufficient to supply the entire fuel requirements of the new boiler.

The tubes in the furnace bottom are covered with cast-iron blocks. Ash is removed in viscous form through an opening fifteen inches wide at the back of the furnace floor, this opening extending entirely across the furnace. The viscous slag drops into a water filled ashpit, where it is cooled to produce a cinder similar to the ash from a stoker. The ash is removed from the pit periodically by draining the pit and feeding the ash to the suction of an ash pump by means of hydraulic jets.

During the period when the ash is being removed, the slag dripping from the furnace floor is cooled by water sprays in the upper portion of the pit.

The three pulverizers, each of 15,000 lb per hr capacity, are of the Raymond bowl-mill type. Each exhaustor is directly connected to its mill so that both mill and exhaustor may be driven by the same 150-hp. 1200-rpm motor. The average heating value of the coal is 10,400 Btu per lb. In order to provide the best possible mill foundations, simplify coal piping and afford space on the operating floor, the pulverizers were located in the boiler

room basement. Each is served by an independent coal feeder located on the boiler operating floor where it can be easily inspected and adjusted by the fireman.

Boiler Auxiliaries

The new boiler is served by a single induced-draft fan located above the unit. At maximum capacity this fan handles 212,000 cfm of flue gas at 407 F with a draft at the fan inlet of 17.2 in. of water. It is driven by a 900/400-hp, 720/514-rpm 440-volt, 3-phase 60-cycle motor, through a 42-in. variable-speed hydraulic coupling.



Fig. 3—Boiler room instrument panel

The speeds of the motor were selected so that the low-speed winding may be used in normal operation when the steam output of the boiler is below 225,000 lb per hr.

The fan blades have abrasion-resistant steel wearing pads formed over the inside edge of each blade and tack-welded to the outside edge. Stay rods in the fan wheel are protected by pipe sleeves. The fan housing, inlet boxes and gas ducts are made oversize to permit lining of these parts with concrete applied by means of a cement gun. This concrete is reinforced with bars and wire mesh securely anchored to the plates of the housing, inlet boxes and ducts. These special features of construction should greatly reduce maintenance caused by erosion from fly ash. The hydraulic coupling was selected rather than inlet vanes in order to reduce to a minimum the number of parts subject to erosion, and because previous experience in other plants has indicated that the erosion of parts in a variable-speed fan is appreciably less than in a fan operating under variable

load conditions, but driven by a constant-speed or a two-speed motor.

The forced-draft fan, of 104,300 cu ft maximum capacity at 11.75 in. of water, is located adjacent to the induced-draft fan and air heater. It is equipped with inlet vanes and driven by a 300/125-hp, 1200/900-rpm motor. The blades of this fan are backwardly curved to produce a non-overloading power characteristic.

Due to the size and comparatively low voltage of the induced-draft fan motor, an auto-transformer has been installed with proper control equipment to reduce automatically the voltage at the motor terminals on starting, and also when the speed of the motor is changed. This arrangement limits the maximum inrush of current to approximately 1500 amp.

Two boiler-feed pumps, each of sufficient capacity to supply feedwater to the new boiler at maximum output are installed in the pump bay of the extension. Each is rated at 700 gpm against 2600 ft total head at 212 F. Double-suction impellers are employed throughout, thus insuring good hydraulic balance. Each pump is driven by a 700-hp 3600-rpm wound-rotor motor. The principal reason for employing this type of motor was to reduce the starting current. However, the motor controls are designed to permit variable-speed operation of the pumps, in order to take care of varying load conditions most efficiently. The pumps are designed for approximately 100 lb per sq in. greater excess pressure than required for maximum operation so as to provide for decreasing total available head due to wear between periods of overhaul. The variable-speed motors permit operation at reduced speed when the pumps are in best condition, to maintain normal excess of boiler feed pressure over the drum pressure.

The new boiler is equipped with complete Bailey air-operated combustion control equipment designed to maintain the best operating conditions whether the boiler is being fired with coal, gas or coal and gas in combination.

Valves and Piping

Carbon-molybdenum tubing, fittings and valve bodies are used in the high-temperature steam piping, and seating surfaces on all high-temperature valves are faced with stellite. Where joints were required in the steam piping, 900-lb Standard flanges with small tongue and groove facing were used. All high-pressure valves greater than 2-in. are flanged, and small drain valves were machined with socket ends for welding.

A novel arrangement of two reducing valves and one desuperheater was used to make the capacity of the high-pressure boiler available to operate the 400-lb turbines. In order to insure maximum flexibility, two reducing valves were installed. The valve which opens first has a venturi-type desuperheater installed at its outlet. The other reducing valve, which starts to open only after the first valve is nearly wide open, discharges steam beyond the desuperheater outlet. The thermostat which controls the water to the desuperheater is installed beyond the point where the discharge from the desuperheater joins the outlet pipe from the second reducing valve. Thus the temperature of the steam to the 400-lb header is always automatically controlled, but only one-half of the maximum flow of 300,000 lb of steam per hour passes through the desuperheater. This makes

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or a it possible to use a smaller desuperheater which will control the steam temperature more accurately than a full-size desuperheater at low steam flows. Besides, the smaller desuperheater costs less.

The reducing valves are air-operated and controlled by two pilot regulators. One of these pilots is connected to the 400-lb header and normally controls the reducing valves to maintain a pressure of 390 lb in this header. In case of trouble in the 400-lb steam system which would produce an excessive steam demand on the 900-lb header, the first pilot will open wide both reducing valves. When the pressure in the 900-lb header drops to 800 lb

boilers. Therefore the boiler room was extended two bays, using the same column spacing in both directions as was used in the original installation. This provided space for the new boiler and for a future boiler, both on the side of the firing aisle farthest from the river. The space between the firing aisle and the existing turbine room, which would have been used for two more boilers, if the boiler arrangement used in the original installation had been continued, was made a part of the turbine room. The new turbine-generator was installed in this space.

The suspended parabolic coal bunker construction

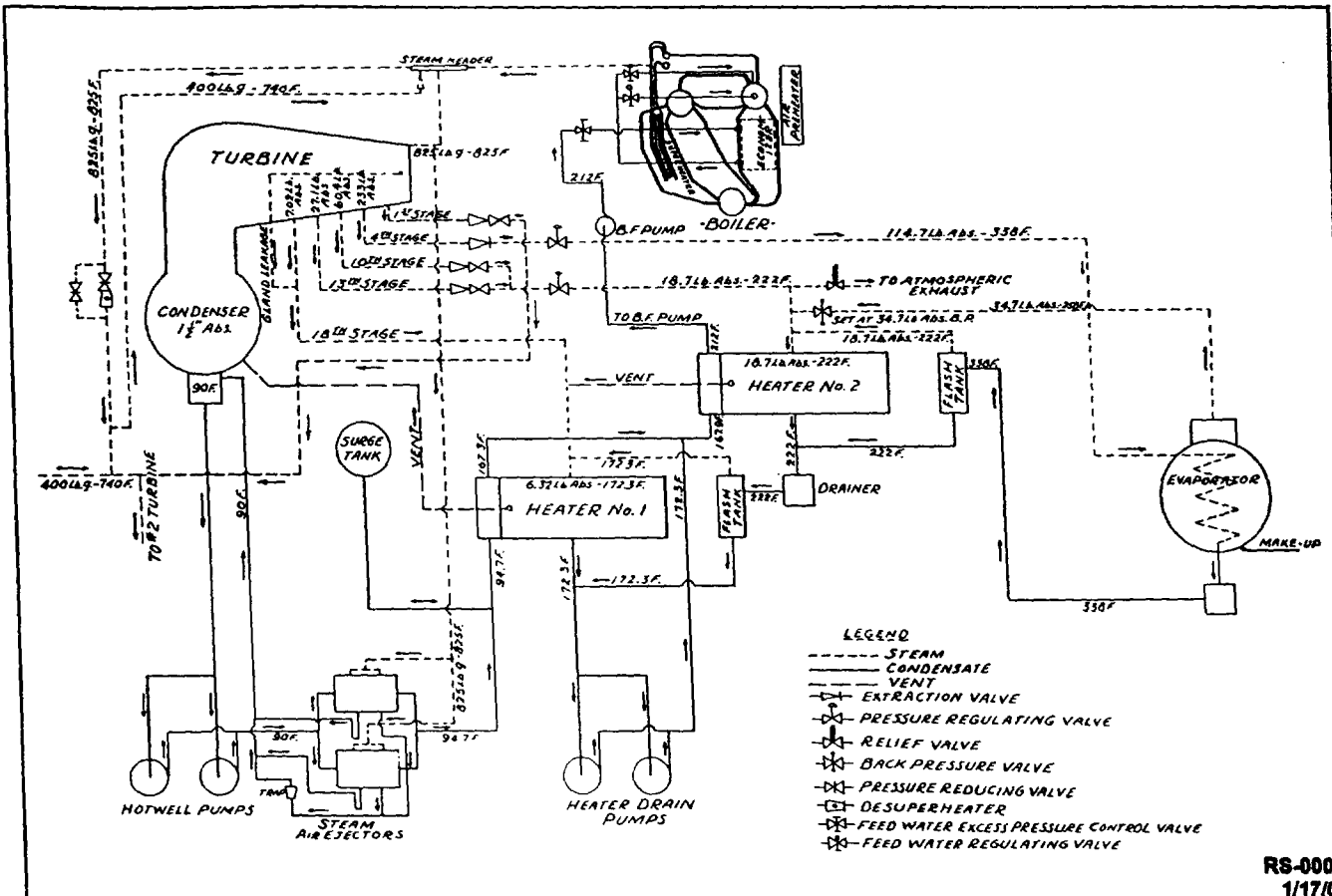


Fig. 4—Heat-flow diagram of high-pressure extension

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the second pilot, which is connected to the 900-lb header, takes control of the main valves and operates them as back-pressure valves to maintain the pressure in that header at 800 lb, but still pass to the 400-lb header that portion of the high-pressure boiler capacity not required by the high-pressure turbine.

Building

In the original installation the four boilers were placed two on each side of a common firing aisle. The original turbine and the second turbine were installed in a turbine room located between the boiler room and the river. The turbine shafts are all parallel to the firing aisle; hence, after the second turbine was installed the turbine room was approximately 72 ft longer than the boiler room.

Despite its greater capacity, it was found possible to put the new steam generating unit in a space the same size and shape as that occupied by one of the other

employed in the original installation was duplicated, using the same cross-sectional dimensions and the coal conveyor over the original bunker was extended to serve the new bunker. The height of the building extension over the boiler and bunker was made the same as in the original part of the building, and the section over the new turbine was made considerably lower.

This method of extending the building for the new equipment not only reduced building costs, due to the decreased space required, but further reduced this cost because the construction was far enough from the river to eliminate the necessity of a cofferdam.

In order to install the turbine and its auxiliaries in the space provided, the condenser was located with its tubes parallel to the turbine shaft. A single-pass condenser with 17,300 sq ft of surface, made up of 7/8-in. diameter tubes 26 ft long was selected, as a long narrow condenser was best suited to this arrangement. The condenser was

- than its final position before the turbine foundation was built. The reinforced-concrete foundation was then built around the condenser. After the turbine was erected the condenser was raised to its final location and attached to the turbine exhaust nozzle by welding. The entire weight of the condenser is supported by the turbine exhaust nozzle.

Two horizontal circulating pumps serving the second turbine were removed and replaced by two vertical propeller type pumps which were built into the existing 42-in. suction pipes that had served the pumps removed. The capacity of the pumps removed was approximately 26,000 gpm each. The new pumps have a capacity of 55,000 gpm each and can supply sufficient water for the condenser of the new unit as well as for the condenser which the horizontal pumps had served. Therefore the expense of installing additional suction pipes was avoided, and no additional space was required for circulating pumps for the new unit.

The resulting decrease in building volume required per pound of steam generated per hour, and per unit of installed capacity is shown in the accompanying table. This tabulation does not include the switchhouse, screen house or the space, unoccupied at present, which has been provided for a future boiler. Although there has been a substantial reduction in space occupied by turbine-generators and turbine auxiliary equipment per unit of capacity, a considerable proportion of the reduction in total plant volume per kva of capacity has been due to the reduction in building space required per pound of steam generated.

COMPARISON OF BUILDING SPACE PER UNIT OF STEAM AND ELECTRIC GENERATING CAPACITY

	Original Installation	Plant Immediately Preceding 1936-1937 Addition	1936-1937 Addition Only	Plant Including 1936-1937 Addition
Steam generating capacity, lb per hr	360,000	560,000	300,000	860,000
Space occupied by steam generators and their auxiliaries, cu ft	908,000	908,000	269,000	1,177,000
Space occupied by steam generators and their auxiliaries in cu ft per lb of steam per hr	2.52	1.62	0.89	1.37
Capacity of main and auxiliary generators (kva)	26,875	55,446	31,696	87,142
Space occupied by turbine-generators and their auxiliaries, cu ft	632,000	1,187,000	239,000	1,426,000
Space occupied by turbine-generators and their auxiliaries in cu ft per kva	23.6	21.4	7.5	16.4
Total volume of main power house (exclusive of space provided for future equipment), cu ft	1,540,000	2,095,000	508,000	2,603,000
Total volume of main power house in cu ft per kva	57.4	37.8	16.0	29.9

Conclusions

The latest addition to Riverside Station shows that superposition is not the only way of increasing the economy of an existing steam-electric generating station. The important features may be summarized as follows:

1. The new boiler and turbine-generator operating at \$25 lb per sq in. 825 F steam conditions produce power at the lowest total cost considering fuel cost, load factor and investment charges in this particular case.

2. Steam may be extracted from the new turbine to the older 400-lb steam header, thus making the new

unit share to some extent the advantages of a superposed turbine in increasing the economy of the older turbines.

3. The new unit may be operated alone when the load is light. This would not be possible in a superposed installation and makes this unit much more economical under light load conditions than a superposed plant.

4. The new unit may be operated with steam from the old boilers, thus making it unnecessary to install more than one high-pressure boiler to insure maximum availability of the new turbine. This makes better use of existing investment in lower pressure boiler equipment than is usually possible with superposition.

5. The arrangement of turbine governing mechanism, piping and steam-pressure reducing and desuperheating equipment makes the capacity of the high-pressure boiler instantly available to supply steam to the 400-lb header in case of trouble with the high-pressure turbine, and also makes it possible to maintain the new turbine in operation, without loss of load, with steam from the 400-lb boilers in case of trouble with the high-pressure steam generator.

The equipment described was placed in operation late in 1937. Operation to date has shown that the expected increase in plant economy due to this equipment has been fully realized.

Program for A.S.M.E. St. Louis Meeting

The summer meeting of the American Society of Mechanical Engineers will be held in St. Louis, June 19 to 23, inclusive. Informal conferences and committee meetings will occupy Sunday and on Monday morning the first of two Fuels Sessions will be held. Papers at this session include: "A Down-Draft Conversion Burner for Domestic Furnaces," by J. R. Fellows; "Coal Carbonization and Its Relation to the Smoke Problem," by M. D. Curran; and "Smoke-Density Measurements," by H. E. Bumgardner.

On Tuesday morning there will be a Boiler Feedwater Session at which the following papers will be presented: "Carbonaceous Zeolites—An Advance in Boiler-Feedwater Conditioning," by Howard L. Tiger; "Boiler-Water Treatment—New Methods for Preventing Embrittlement," by F. G. Straub and T. A. Bradbury; "Boiler Operation as It Affects Prime Movers," by S. E. Tray; and "The Behavior of Sodium Sulphite in High-Pressure Boilers," by R. M. Hitchens and J. W. Purssell.

A combined Hydraulic and Power Session is scheduled for Tuesday afternoon at which will be presented two papers, one on "Trends in Design of Large High-Pressure Boiler Units" by John Van Brunt, and the other "Operating Methods and Problems of a Combined Hydro- and Steam-Electric System" by H. Harrington and E. B. Strower.

On Wednesday morning the second Fuels Session will be held at which the following papers will be presented: "Fuels for Industrial Heating Furnaces," by Matthew H. Mawhinney; "Power-Plant Requirements of a Distillery," by H. L. Walton; "Experiences and Difficulties in Processing Coal," by L. C. McCabe.

A session on Welding and Flame-Cutting will comprise papers on "Oxy-Acetylene Surface Hardening," by A. K. Seemann; "Welding Applied to Plant Maintenance and Repairs," by H. R. Wass; and "Arc-Welding Costs," by E. W. P. Smith.