220

See me

PITTSBURGH'S POWER PREPAREDNESS
AND A DESCRIPTION OF THE COLFAX POWER STATION

---o---

by Maurice R. Scharff,
Chief Engineer, Pittsburgh Branch
Byllesby Engineering & Management Corporation

May ?, 1927

---o---

Widespread interest has been aroused during the past year in the opinions that have been expressed by various visiting commissions and publicists from abroad as to the reasons for the phenomenal prosperity we are enjoying here in the United States. It is noteworthy that, although these opinions have differed in certain respects, practically every one of them has emphasized the relatively large amount of power put at the disposal of the American workman as one of the most important factors in the situation. And there is, indeed, a striking correspondence between the ratio of the 3.8 horsepower per wage earner in manufacturing industries in the United States (as reported by the Census Burdua for 1923) to the 2.4 horsepower per worker in Great Britain, the 1.5 horsepower per worker in Germany, and the 0.1 horsepower per worker in China, and the relative productiveness and prosperity of these countries.

Is it not likely that there is a similar correspondence between the industrial leadership of the Commonwealth of Pennsylvania and its provision of 4.7 horsepower per industrial worker as compared with the average of 3.8 horsepower per worker for the United States?

But if power is a prime factor in production and prosperity, it is even more vital as a factor in preparedness. And if any argument were needed to establish this self-evident fact, it could found in our experience in the Great War. Within six months after our entry into the conflict, every industrial district in which raw materials, labor, equipment and transportation had been mobilized for the delivery of the finished products required for our army in Franch, began to fall off in the ratio of production to manufacturing capacity as a result of power shortages, notwithstanding that the needs of the nation, as reflected in war orders, called for capacity production, or better.

The complete story of this phase of those trying days has been told in a report on "The Power Situation During the War," by Col. Charles Keller, published by authority of the Secretary of War in 1921, to which reference may be made for further details. For the purposes of this talk, suffice it to say that notwithstanding the curtailment of war orders by the War Industries Board, on account of shortage of power, the central station power systems operated by the Duquesne Light Company and the West Penn Power Company in the Pittsburgh District were estimated to be 130,000 K.W. short of sufficient capacity to meet the demands upon them by the end of 1918; and it was estimated that, if the war had continued, this shortage would have been increased to 360,000 K.W. by the end of 1919.

At the outset of the war, these two systems in the Pittsburgh District had a combined installed capacity of about 186,590 K.W. and although they were interconnected with one another by four 22 K.V. connections of a total capacity of 25,000 K.W., they were not interconnected with any other systems (except to the extent that the joint use by the West Penn Power Company and the American Gas & Electric Company of the Windsor power station might be considered as constituting an interconnection.) A substantial portion of their generating capacity, also, was in old, relatively inefficient units, replacement of which had already to be envisaged.

The Power Section of the War Industries Board developed a comprehensive plan for the solution of this situation, by the construction of 180,000 K.W. of additional generating capacity on the Duquesne and West Penn systems, of 150,000 K.W. of additional generating capacity on adjacent systems in Eastern Ohio, and of high tension transmission tie lines to these other systems. The plan also provided for financial aid by the Government. But this plan was only initiated to a small extent when the Armistice put an end to these arrangements.

It is interesting to compare these conditions and plans with the present situation, when 270,000 K.W. of generating capacity has been constructed, or is now nearing completion, on the Duquesne Light Company system, and over 400,000 K.W. of generating capacity has been added to the West Penn system, bringing the combined capacities of the two systems, after allowing for the abandonment of old plants and the completion of work now nearing completion, to a total of 799,700 K.W. Moreover, the two systems are now interconnected by a 66 K.V. tie line of 30,000 K.W. capacity, in addition to three 22 K.V. ties of 20,000 K.W. capacity. And the combined system is also tied in by high tension lines, both on the east and on the west, to an interconnected super-power system that already reaches from Boston to Chicago, and is being extended almost daily.

Furthermore, practically the entire capacity of the two systems now supplying the Pittsburgh District is now in modern turbo-generator or hydraulic equipment of the most modern design and of high efficiency. One of these plants you are to visit tomorrow, and the remainder of this paper will be devoted to a brief description of this plant.

THE COLFAX POWER STATION
OF THE DUQUESNE LIGHT COMPANY

The Colfax power station of the Duquesne Light Company is a typical "mine mouth" station. Located about fifteen miles from the center of Pittsburgh on the north bank of the Allegheny river, (the low-water flow of which is sufficient to provide condensing water for more than 300,000 kilowatts of plant capacity); distant only about one mile from the Harwick mine, (also owned by the Duquesne Light Company and affording, with its present acreage, at the present rate of consumption, more than forty years' supply of steam coal of satisfactory quality); and connected with this mine by the Cheswick & Harmar railroad (a private road owned by an affiliated company), it conforms to the highest ideals and the best traditions of modern super-power practice.

First Unit

The construction of the first installation at Colfax was started in 1919, and the first unit, consisting of one 60,000 kilowatt threecylinder cross-compound Westinghouse turbo-generator, with seven Babcock & Wilcox boilers of 20,876 sq.ft. of heating surface each, equipped with Foster superheaters and Westinghouse underfeed stokers, and designed to operate at 275 pounds per square inch pressure and 600 degrees Fahrenheit temperature, was put into operation on December 18, 1920.

Second Unit

The second 60,000 kilowatt unit was practically a duplicate of the first unit, excepting that six Babcock and Wilcox boilers of 22,914 sq.ft. of heating surface each, equipped with Babcock & Wilcox interdeck type superheaters and Westinghouse underfeed stokers were used. In connection with this extension, an extensive outdoor coal handling and storage plant was installed, including a travelling rope-operated bridge of 330 foot span, and 1,000 foot travel, with an average capacity of 267 tons per hour. The second unit was placed in operation October 21, 1922.

Third Unit

The third unit, of 70,000 kilowatt capacity, was started in 1923 and placed in operation in several steps during the latter part of 1924 and the early part of 1925. This unit consisted of two 35,000 kilowatt single-cylinder Westinghouse turbo-generators, connected to a single common transformer bank; one 22,914 sq.ft. Babcock & Wilcox boiler, similar to those installed with the second unit (to fill a vacant space in the boiler house); and five 27,680 sq.ft. Babcock & Wilcox boilers equipped for pulverized fuel firing with two six-ton Raymond Mills and fourteen Lopulco feeders per boiler. This unit was equipped with four-stage bleeding for feed water heating, and air heaters for heating the air for combustion.

In connection with the third unit, a Heyl & Patterson river coal unloading tower and a belt conveyor, of an average capacity of 250 tons per hour, were installed, to provide for the handling of coal from barges on the river to the coal crushers in the station.

During the progress of the work on the third unit, also, a 66,000 volt transmission line tie, of 30,000 kilowatt capacity, was installed between the Colfax power station and the adjacent Springdale station of the West Penn Power Company, over which the interchange of power under an interchange agreement was begun. Since this time, the voltage on this line has been raised to 132,000 volts by the installation at Colfax of a bank of 132,000 to 66,000 volt transformers, in order to conform to the raising of the voltage on the transmission system of the West Penn Power Company.

Upon the completion of the third unit, then, the Colfax power station contained eight turbo-generators of a total capacity of 190,000 kilowatts, and nineteen boilers, fourteen of them stoker fired and five equipped for pulverized fuel, with complete coal handling and storage equipment for both railroad and river coal, and with a 30,000 kilowatt 132 kv. interchange connection to theWest Penn Power system.

Fourth Unit

Early in 1925 it was determined that it would be necessary to provide additional generating capacity at Colfax for the fall of 1926, and preliminary authorizations were granted for commencing work upon a fourth-unit extension, to consist of two 40,000 kilowatt single-cylinder turbo-generators, and three additional pulverized fuel boilers. In June, 1925, work was started on the foundations and river wall extension, including an extension down stream of the condensing water discharge tunnel in order to avoid possible difficulties from recirculation. This work was carried through and completed in April, 1926. During its progress, a contract was negotiated for the purchase of 30,000 kilowatts of firm power from the West Penn Power Company, over the 132,000 volt connection with their system, during the period from September 1, 1926, to September 1, 1927; and this arrangement made it possible to postpone the provision of any additional generating capacity at Colfax from the fall of 1926, as originally planned, until the fall of 1927. Construction work was therefore stopped upon the completion of the foundations and the extension of the river wall and discharge tunnel, and plans carried forward for the completion of the fourth unit extension on a schedule calling for the operation of the first 40,000 kilowatt turbo-generator (which has been designated as 4-A) in June, 1927 (in order to facilitate the summer maintenance program of the operating department on the first three units); and for the operation of the second 40,000 kilowatt turbo-generator (designated as 4-B) and the three additional boilers in November, 1927.

The fourth unit, when completed, will consist of two 41,250 kilowatt single-cylinder Westinghouse turbo-generators (of 40,000 kilowatt net capacity each, as 1250 kilowatts of the gross capacity of each generator is to be taken through a transformer bank to the house service bus; there being no separate house generators in the fourth unit, as in the cases of the first, second and third units); three Babcock & Wilcox boilers of 27,786 sq.ft. of heating surface each, designed to operate at 275 pounds pressure and 650 degrees Fahrenheit temperature, with Babcock & Wilcos interdeck type superheaters, and equipped for pulverized fuel firing, with three fifteen-ton Raymond mills, discharging by duplicate screw conveyors into any of the three pulverized fuel bins, each serving one boiler.

Two boilers are equipped with seven Couch burners each, served by Lopulco feeders and firing furnaces having Combustion Engineering Corporation's fin-type rear and side cooling walls. The third boiler has five Bailey intertube burners, served by Bailey feeders, and firing a furnace having Bailey front, rear and side cooling walls.

Two Ljungstrom air preheaters are provided for this boiler, the other two having Combustion Engineering Corporation plate air heaters.

All boiler equipment is designed for a normal continuous capacity of 300,000 pounds of steam per boiler per hour, and peak capacity of

330,000 pounds per hour.

Current will be taken from the generators at 11,000 volts, through Westinghouse type O-44 and O-55 electrically operated cell-mounting oil circuit breakers, (the O-55 breakers, designed for interruption of short circuit currents of 120,000 amperes at 12,000 volts, being the largest breakers of this type ever built by the Westinghouse company) to a single common bank of three 31,400 kva. oil insulated water-cooled single-phase transformers. The high tension side of these transformers will be connected to a 66,000 volt bus on the roof of the power station, from which the 66,000 volt transmission lines fed by this unit will be taken out through Westinghouse type G-11 and G-12 oil circuit breakers, located in a new switching structure at the east end of the power station building.

In connection with the installation of this equipment, it has been necessary to extend the turbine room and electrical bay approximately 144 feet in length, adding 1,691,712 cubic feet to the main power station building. It will also be necessary to extend the boiler room 144 feet in length, adding 659,360 cubic feet to its volume.

During the progress of the work on the fourth unit, a new storehouse building is also being constructed alongside the main power station building, with 6,000 square feet of floor area and 151,000 cubic feet of volume. This addition will afford ample and convenient storeroom facilities for the entire plant, the inadequacy of the facilities previously provided having proved a substantial handicap to the operating organization.

The estimated total cost of the fourth unit extension, including the foundation and river wall work done prior to the resumption of construction on the main project, is $8,300,000.

Design Features

Although, in a general way, the development of plans for the fourth unit has followed more or less along lines laid down in the previous installations, a considerable number of new features have been introduced in the design, among which the most important, perhaps, relate to the cooling water supply system, the draft and feed water pumping systems, the station auxiliary electric service system, and the main system of electrical connections.

Cooling Water Supply:

Heretofore, the generator air coolers and the heat exchangers for the recovery of transformer heat and for bearing oil cooling have been operated with condensate, with emergency connections for the use of river water during extreme hot weather. The use of river water for these purposes is unsatisfactory because of the possibility of outages due to clogging by leaves or scum. In connection with the installation of the fourth unit, a reinforced concrete well, 24 feet in diameter, has been sunk into the gravel underlying the bed of the Allegheny river, at a point adjacent to the east end of the power station site, and two 6,000 gallon per minute horizontal motor-driven centrifugal pumps are being installed, from which tests have indicated that it will be possible to supply an ample quantity of clear, cold, underground water for all cooling and washing purposes in the power station, completely eliminating the necessity of using raw river water for any of these purposes.

Draft and Feed Water Pumping Systems:

All the present boilers operate on natural draft, whereas the three boilers with the fourth unit will make use of induced draft. Also, the air preheaters on the fourth unit boilers will be much larger than those on the present boilers.

The third unit was equipped with two motor-driven boiler feed pumps, whereas the fourth unit will be equipped with three steam-driven boiler feed pumps. This change was made to increase reliability of operation.

Station Auxiliary Electric Service:

Electrically-driven auxiliaries of units 1 and 2 are supplied with current by independent turbo-generator units of 2,000 kilowatt capacity each, and the auxiliaries of unit 3 are supplied by house generators of similar capacity attached to the generator ends of the shafts of the main turbo-generator units. Emergency service may be obtained in each case from the main 11,000 volt bus, through the station service transformers.

In the case of Unit 4, no house generators are provided, but three independent sources of power will be available to operate the electrically-driven auxiliaries. The normal power supply will be through two step-down transformer banks, each connected through oil circuit breakers to the main leads of one of the main generators. Emergency supply will be from a separate bus, which may be fed either through a bank of step-down transformers connected to the main 11,000 volt bus, or directly from either one of the two independent turbine-driven house generators installed on units 1 and 2.

Main Electrical Connections:

The changes that have been made in the main system of station connections affect not only unit 4, but also all three of the previously installed units. Units 1, 2, and 3 were originally connected each through its own bank of step-up transformers to continuous main and auxiliary 66 kv. buses, from which all outgoing transmission lines were supplied. With the completion of unit 4, each pair of outgoing 66 kv. transmission lines will be supplied by one generating unit and its step-up transformer bank, the generator units being tied together only through current limiting reactors, connected to a common, or "synchronizing" 11 kv. bus. This arrangement will have two principle advantages over the previous one; namely, it will reduce the maximum possible current concentration on short circuits to values that can be handled by the oil circuit breakers, and it will so sectionalize the main transmission system that the disturbance created by the failure of a 66 kv. transmission line will be practically limited to the generators and transformers feeding that particular line, protecting the balance of the system from violent voltage disturbances and enabling the remaining generators and lines to continue in stable operation

Upon completion of the fourth unit, the Colfax power station will contain a total of ten turbo-generators, with a combined capacity of 270,000 kilowatts, and 22 boilers, fourteen of which will be stoker fired and eight equipped to burn pulverized coal. The estimated total cost of the entire plant upon completion of the fourth unit, including land, buildings, equipment, coal handling facilities, overhead costs, and interest during construction, will be about $33,000,000.

----o----