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Generation and Distribution of Power for Electric Railway Service in San Francisco.

Now that all of the street railway service of San Francisco, with the exception of the Geary Street cable line, is operated with electric power, a description of the power station equipment and distribution system of the United Railroads is of particular interest. Under present conditions, all of the power used is either generated in their own steam plants or comes from the system of the San Francisco Gas and Electric Company, which, in turn, is connected with the transmission lines of the California Gas and Electric Corporation. The new gas engine reserve plant, known as the Martin Station, will probably be available within a very short time, which will very materially increase the amount of electric power available for the operation of electric cars. The North Beach and Bryant Street plants of the United Railroads were not materially damaged by the fire, and at the present time are giving excellent service.

Early in 1902 the Market Street Railway Company, the San Francisco and San Mateo Railway Company, the Sutter Street Railway Company, and the Sutro Electric Railway Company, were consolidated into what is now known as the United Railroads of San Francisco. Soon after the reorganization it was evident that more power was necessary in order to give San Francisco a good street railway service, and the need of a new central station became imperative. At that time the power was derived from the following sources:

1. Bryant Street power house, consisting of four 1400 horsepower engines, direct connected to two 400 kilowatt Siemens and Halske generators; two 600 horsepower engines each belt connected to an M. P. 200 kilowatt generator, and two 300 horsepower engines each belted to an M. P. 200 kilowatt generator.

2. Carl Street power house consisting of a 250 horsepower and a 500 horsepower engine.

3. Oak Street and Broderick Street power house consisting of a 750 horsepower engine.

4. Sutro power house, which contains one direct connected 400 kilowatt and one direct connected 200 kilowatt generators.

5. Power house rented from the Pacific Power Company, having output of 600 kilowatts.

6. From the Independent Electric Light and Power Company, now the San Francisco Gas and Electric Company, about 1600 kilowatts.

It soon became apparent that the operation of many small plants was uneconomical, and that more power was needed in order to keep up with the growth of San Francisco. Thus plans were made for a new central power station and three sub-stations. The Bryant power station was still to be used, but the other plants were to be disposed of.

This new power station is located at North Beach. The alternating current is transmitted at 12,300 volts: 1st, to sub-station at Tunk and Fillmore Streets; 2nd, to a sub-station at Geneva Avenue and San Jose Avenue; 3rd, to a sub-station at Millbrae. The Bryant Avenue station supplied all lines south of Market street to Thirteenth street.

The North Beach station is located at the corner of Beach and Buchanan Streets. Its dimensions are 113½ feet by 337 feet. It is located very near salt water, and condensing water is pumped from the bay about 400 feet from the power house. There is also a wharf close by where fuel oil and coal may be landed. The building is modern, the material used in its construction being concrete, brick, steel, iron and slate, making it fire-proof. The foundations are of the best material. The foundation of one engine is a solid block of concrete sixty-three feet long, twenty-four feet wide, and fifteen feet deep. The roof trusses are steel, and the roof is covered with slate. The chimney of brick was 152 feet high and 14⅔ feet inside diameter. The engine room is 48 feet by 287 feet, machine shop 48 by 45 feet, and the boiler room 58½ by 331 feet. Both engine and boiler rooms are 43 feet high from floor line to bottom of trusses.

There are four batteries of Babcock and Wilcox boilers, but four more batteries can be added in the future. Each battery has a capacity of 2500 horsepower, or total for all boilers is 10,000 horsepower. They are all oil burners, but provision has been made to burn coal when necessary.

The supply of oil is stored in a storage tank at a distance of 150 feet from power house. The tank dimensions are twenty-seven feet high, eighty feet in diameter, having capacity for 1,500,000 gallons. The oil is pumped directly from oil barges at the wharf through a five inch pipe line.

The main storage tank is connected by independent 5-inch pipes and blow pumps to two auxiliary feed tanks, each of 20,000 gallons capacity. Each tank is connected independently to each furnace. All tanks are equipped with heating cribs, and when necessary exhaust steam may be used to heat the fuel oil.

Water is supplied by mains from the Spring Valley Water Company. The water from the surface condensers is filtered and used again. This filter consists of a number of felt strainers which catch the oil and scum. One strainer may be taken out of the filter at a time, cleaned, etc., without interfering with the process of straining.

The plant was originally designed for four engines, two of which are now in operation. They are the vertical marine type, built by the Union Iron Works, and are triple expansion with 32-inch, 52-inch and 80-inch cylinders with 42-inch stroke, built for a working pressure of 200 pounds, at a speed of 136 revolutions per minute. Their normal capacity is 4080 horsepower each, with a capacity for 25 per cent. overload. Thus when the four engines have been installed there will be an aggregate of 20,000 horsepower. These engines are the largest stationary steam engines that have ever been built or used on the Pacific Coast.

The condensers are the marine type surface condensers, having 3031 tubes three-quarters of an inch in diameter, having cooling surface of 7200 square feet. It is also arranged that they can be used as jet condensers. The air pump has a thirty-four inch cylinder and a twelve inch stroke. The water for condensers is pumped from the bay through two 32-inch pipe lines. The pump is electrically driven.

Each engine is direct connected to two 20 pole 1200 kilowatt, 136 revolutions per minute, 13,200 volts, 25 cycle, three phase General Electric revolving field generators; the fields being excited by an M. P. six pole 100 kilowatt 500 revolutions per minute, 125 volt exciter, driven by a six

pole, 150 horsepower, 500 revolutions per minute, 350 volt induction motor when under light load. Under full load the field is excited by an M. P. eight pole 200 kilowatt 500 revolutions per minute 125 volt exciter, driven by a six pole 300 horsepower 500 revolutions per minute, 350 volt induction motor. The fields are excited on starting by a six pole, seventy-five kilowatt, 250 revolutions per minute, 125 volt exciter, driven by an engine. For the induction motors driving the exciters and blowers there are two air blast transformers. They are three phase, twenty-five cycle, 150 kilowatt and 300 kilowatt, and transform down from 13,200 volts to 370 volts, and are air cooled. The two motors driving the fans are four pole type, two horsepower, 750 revolutions per minute, 350 volt induction motors.

There are eight General Electric oil switches, which are controlled by motors, four being connected to the generators, two to the outgoing lines, and two to the exciter panels. The switchboard consists of four generator panels, one exciter feed panel controlling the four generators, two blower motor starting panels, and two induction motor panels. All electrical equipment was made by the General Electric Company. There is also installed a traveling crane of thirty tons capacity.

The line is run from the North Beach power house to Fillmore Street and Turk Street. The poles are of redwood 16 inches by 16 inches at base and 10 inches by 10 inches at top. They are set in concrete, having been treated with crude oil. The cross arms are of Oregon pine, 4 inches by 6 inches by 5 feet 5 inches, and one 4 inches by 6 inches by 7 feet 5 inches.

From the main station there are two circuits each of three No. 000 solid, triple braided, water-proof wire. The wires are arranged as follows: Each circuit on one side of the pole, one wire on the top cross arm, and two on lower cross arm.

Iron pins with porcelain bases are used. The insulators used are the Locke No. 100 broom porcelain, having been tested for 50,000 volts.

The Turk and Fillmore sub-station is 45 by 109 feet, and is entirely fireproof. It is equipped with six rotary converters, each being a ten pole, 750 kilowatt, 300 revolutions per minute, 600 volt on D. C. side, and compound wound.

There are eighteen transformers, twenty five cycles, ratio of transformation is 13,200 to 440 and are air cooled. There are three blower motor sets each consisting of 1-four pole, five horsepower, 750 revolutions per minute 350 volts induction motor. The blowers are fifty-one inches in diameter.

There are ten motor controlled oil switches. The number of A. C. panels on the switchboard is 10—two panels for in-coming line, two for out-going, and six for A. C. side of rotaries.

The rotaries are started from the A. C. sides in the following manner: First the oil switch is closed. The transformers are so wound that there is transformation from 3 phase Delta to 6 phase Delta.

In starting then the fields of the rotary are open, so as to get rid of the danger of puncturing insulation of the fields by the high induced voltage.

The rotary starts up as an hysterisis motor, the A. C. current in armature inducing eddy currents on pole pieces. The positive brush from the D. C. side is brought to the side of the machine, and also the positive bus bar or equalizer and the above two leads are here connected. The use of the bus bar is as follows: If for some reason one machine should be generating a lower voltage than the other, the higher voltage machine would start to take load while the other would decrease in load. This difference of potential, however, could not be very different on account of the constant A. C. voltage. Still it is very desirous that both machines take an equal load. Thus by bringing the equalizer bar to the positive terminals current would flow from higher potential machine to the lower potential machine around through the compound field and thus raising its voltage, and thus making it take its share of the load. In each A. C. panel of the rotary there is a power factor indicator, and it is very desirable to keep this about unity. This is done by varying the shunt field. On each A. C. rotary there is a resistance box connected in parallel with the compound field and by varying this resistance the amount of compounding can be changed. By varying the shunt field resistance, which is done by a hand regulator on each A. C. rotary panel, we can get practically unity power factor.

The switchboard is as follows: Taking first the front view there are ten A. C. panels and twenty-six D. C. feeder panels, and six rotary panels feeding to the bus bar. Starting from the left there are, 1st, four high tension panels, the first two being the out-going lines, each panel having three ammeters, one for each leg. The next two panels are for the in-coming lines, each having one ammeter. The next six panels are for the primary side of the transformers of each machine. Each panel has a power factor indicator, an ammeter and voltmeter whose constant is 120. From these instruments we are able to get the input for each machine and transformer. All of the above panels for the machines have a hand regulating resistance box. The resistance itself is beneath the floor and is operated by a chain running to the switchboard. On each of these ten A. C. panels there is a switch for operating a motor which controls the oil switches. Above and below this motor control switch are lights, the red light being above; the green light below. When the red light is burning it signifies that the oil switch is closed, and when the green light is burning it signifies that switch is open. The control motor is placed upon the casing of the oil switch.

The next six panels are for the D. C. side of the rotaries and each panel is equipped with the following: A circuit breaker, an ammeter, also receptacle for voltmeter plug, the voltmeter being placed a little to the left of the switchboard. Then there is the knife blade switch for throwing rotary onto the bus bar, and below this is an integrating wattmeter. The ammeter does not carry the whole line current but is shunted across a small portion of the line. Each of these ammeters have a scale running up to 3000, the smallest division being 100 amperes.

Then the next twenty-six panels are for the feeder lines. Each of these panels have a circuit breaker, an ammeter, and a single pole, single throw switch. The ammeters have a capacity of 100 amperes.

Directly beneath the transformers is the air blast room. The blowers force the air into this chamber and the only exit is out through the transformers, part going out the side and part out the top of the transformers.

NOVEL SUGGESTION FROM BERKELEY.

Ex-Secretary of the Treasury Charles Stebbins Fairchild, informed the Berkeley College Commerce Club recently in an informal address, that the only action he could suggest to stop the concentration of power in the hands of a limited number of financiers is to stop the use of steam and electricity. "In my opinion," said Mr. Fairchild, who was in Cleveland's first Cabinet, and who is a banker of renown, "the so-called concentration of power in the industrial and financial world today is due almost entirely to the improvements in transportation methods. The foundation of these improvements are the use of electrictiy and steam. If we want to do away with concentration, then I am afraid we will have to dispense with electricity and steam."

James W. Warren, general superintendent of the Los Angeles Gas and Electric Company, has resigned and severed his connections with the company with which he has been connected during the last twenty-five years.