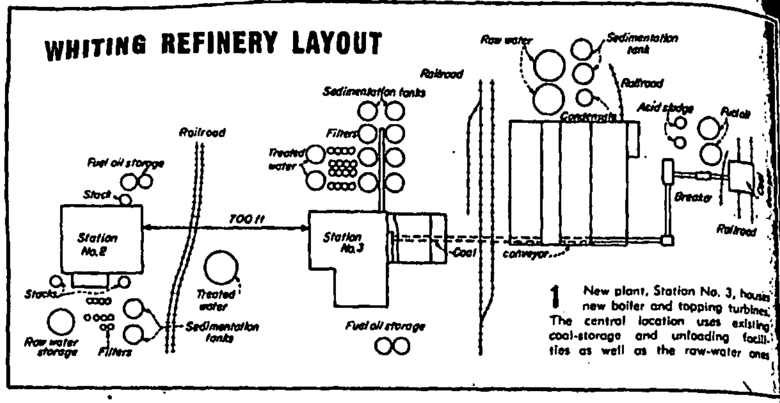

1 New plant, Station No. 3, houses new boiler and topping turbines. The central location uses existing coal-storage and unloading facilities as well as the raw-water ones

Topping Stretches Refinery Steam

Standard Oil of Indiana meets need for more electrical energy per lb of process steam; solves problem of 1350-psi 900-F operation with 100% makeup by carefully studied water-treatment program and installation of dual-circulation steam generator

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▶ REFINERY OPERATION over a period of years has been marked by a rapidly increasing demand for electrical energy paired with a much slower increase in steam requirements. The Whiting, Indiana refinery of the Standard Oil Co of Indiana applied a high-backpressure cycle for byproduct generation of electricity as early as 1928. Plant growth soon consumed all available energy.

Two plans presented themselves for meeting this situation: (1) condensing turbine-generators operating at the 400-psi plant pressure (2) topping units to exhaust into the existing 400-psi level.

With a condensing cycle, power generation alone demands 11 lb of steam per kw, and about 70% of the heat in this steam is lost in the condenser.

Byproduct Power. A topping cycle gives additional power with no increase in steam production and only a small increase in fuel consumption to meet the increased steam pressure. For example, steam at turbine throttle conditions of 1250 psi, 900 F, generates an additional kw for each 34 lb of steam exhausted into the 400-psi header. Taken another way, for each 1000 lb of 1250-psi steam used at 400 psi by the refinery, about 30 kw of byproduct power is available. Extra fuel for generating steam at 1250 psi as compared to that for 400 psi amounts to 10%.

Selecting Pressure. Once the topping cycle plan was adopted the next step was selection of topping pressure level. As the difference between initial and exhaust pressures of the topping turbine decreases, amount of byproduct power available also drops off. For instance, the power available from 1000 lb of 900-psi 825-F steam exhausting at 400 psi comes to about 70% of that from 1250-psi 900-F steam at the turbine throttle for the same exhaust.

At Whiting boilers already operating set the exhaust conditions for the topping unit at 400 psi, 650 F. Talks with boiler and turbine makers led to the decision to hold turbine throttle pressure and temperature within the range of established pressures.

Performance data, for topping turbines of the size, type and efficiency suitable for exhaust at 400 psi, 650 F, indicated a selection of throttle conditions from 900 psi, 825 F; 1250 psi, 900 F; 1385 psi, 925 F; 1525 psi, 950 F; 1850 psi, 1000 F.

Although temperatures at the throttle could be raised by using a thoroughfare desuperheater in the exhaust, we decided against 900-psi throttle conditions because available power seemed too small for future needs. On the other end of the scale, the 1850-psi 1000-F possibility, equipment capable of handling such a temperature was not sufficiently developed at the time.

That narrowed it down to a range of pressures from 1250 psi to 1525 psi. Economic advantage possible from pressures above 1250 psi were slight.

Fitting Plant Load. We were now ready for a study of operating conditions. Available condensate from refinery operations is small, likely to be contaminated, too widely distributed to collect. That meant almost 100%

(*Continued on page 86*)

HERE'S THE HEART OF THE PLANT — DUAL-CIRCULATION DESIGN

Three dual-circulation steam generators deliver 300,000 lb per hr each of 1350-psi 900-F steam, with essentially 100% makeup. While ability to generate steam with minimum blowdown made this unusual design economically attractive, the ability to operate with low concentrations in highly heated tubes and low silica concentration in the steam influenced selection.

In outward appearance the unit resembles a conventional 3-drum boiler. It has, however, two separate heat-absorbing sections, each with its own independent circulation system. One section, the primary or high-duty one, comprises the radiant-heat-absorbing furnace. The second, low-duty section consists of convection surface.

One Steam Outlet. All feedwater enters the primary section and all steam for the plant is delivered from it. Continuous blowdown from this section feeds the secondary, and steam produced in the secondary section is condensed in the primary. Total blowdown leaves the unit from the secondary section.

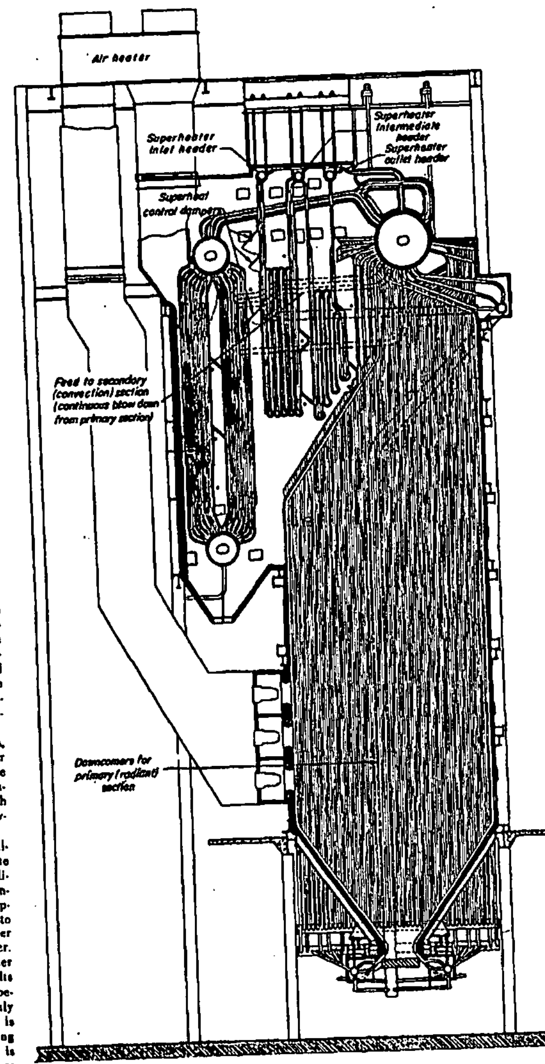
Feedwater at 240 F enters a compartment in the primary-section main drum. There it is heated by condensation of steam produced in the secondary section. From this point it passes into the main body of the drum. Pipes distributed along the drum carry the water to two large external downcomers.

Independent circuits for each of the corner tubes and the adjacent pairs insure positive circulation in these relatively low heat-absorption-rate portions of the waterwall. Flow in wall tubes is upward.

Special Blowdown. Steam-water mixture leaving wall tubes passes through washing and separating compartments in the primary drum. Water of high concentration is collected and sent through external circulating tubes to the secondary-section upper drum. Thus blowdown of the primary section forms feed for the secondary. Since its magnitude in relation to steam generated in primary section is high, concentration is kept low.

Absorbing heat from convection surfaces, the secondary section generates steam for delivery to the primary section. Because rate of heat input is relatively low, concentration in this section can be much higher than in the primary. Final blowdown is from the secondary section.

Boiler Advantages. Summing up, dual-circulation design reduces blowdown rate and heat loss from it, and lessens likelihood of tube failures by keeping concentration low in areas of high heat absorption. Silica carryover has been shown* to depend on: silica concentration in boiler water, pressure, and pH of boiler water. With pH properly controlled by feedwater treatment, dual-circulation design results in minimum production of silica vapor because: (1) steam generated from highly concentrated secondary-section water is completely condensed in heating incoming feed, and (2) steam leaving the boiler is produced in the primary section where boiler-water concentration is low.



* Steam Turbine Blade Deposits by Professor F G Straub, University of Illinois.