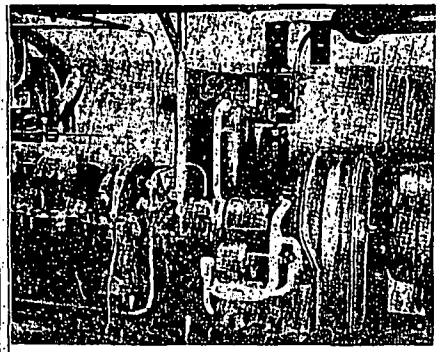
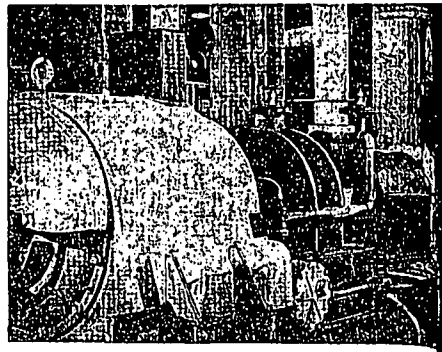
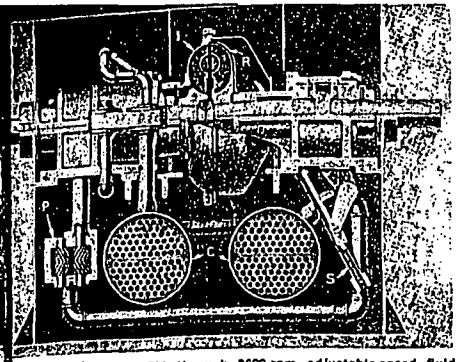


FIRST APPLICATION TO FEED PUMPS of an adjustable-speed fluid drive connects a constant-speed squirrel-cage motor, rated 700 hp at 1200 rpm, to a booster pump



CONSTANT-SPEED MOTOR: One of three 1800-hp 1800-rpm units connected through adjustable-speed fluid drives and gears to 3800-rpm high-pressure boiler-feed pump



CROSS SECTION through 3600-rpm adjustable-speed fluid drive for boiler-feed pumps. R is runner; I, impeller; P, oil pump; C, oil coolers; S, speed controller

3600-Rpm Fluid Drives Adjust Feed-Pump Speed to Boiler Load

High-pressure boiler-feed-system losses are reduced to a minimum with adjustable-speed fluid drives for 3600-rpm pumps. They hold correct boiler level automatically without throttling.

By J D ROSEBROUGH
Staff Engineer, American Blower Corp

▶ ADJUSTABLE-SPEED DRIVES for draft fans and boiler-feed pumps form a major consideration in steam-plant design. With rising fuel costs and the consequent trend to higher steam pressures for maximum economy, adjustable-speed drives for boiler feed pumps are even more important than for draft fans. In a high-pressure plant about twice as much power is required to drive boiler-feed pumps as draft fans.

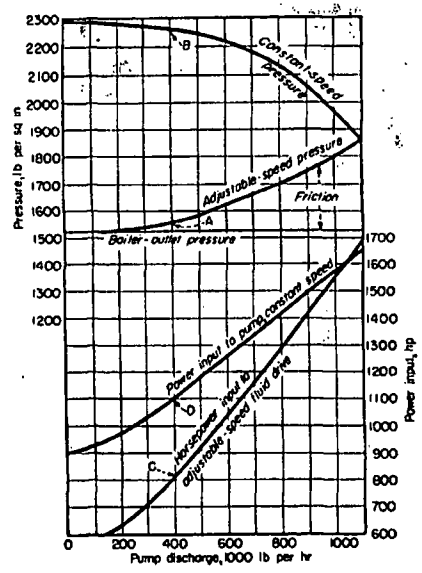
For example, a boiler designed for 900,000 lb of steam per hr at 1500 psi requires 1600-hp on induced-draft fans, 1000 hp on forced-draft fans, with two 1750-hp feed pumps in operation and a third for standby. These pumps develop about 1800 psi when discharging at maximum rate. When they operate at constant speed and are throttled to reduce flow, pressure may rise to 2000 psi or higher.

If the pumps have a flat head-capacity characteristic to keep down pressure rise when throttled, they are less efficient and require more power at reduced flow, and may be unstable. Also, throttling centrifugal pumps for long periods to reduce flow through them may seriously increase their maintenance costs.

Fluid-Drive Installations. The hydraulic coupling, more popularly known as a fluid drive, has been used extensively for draft-fan and feed-pump variable-speed drives with constant-speed motors. It has two identical vaned rotors, shaped like the halves of a grapefruit, and uses oil as the power-transmission medium. One rotor, the impeller, connects to the driving motor, and the other, the runner, is attached to the output shaft and drives the load (fan or boiler feed pump). The impeller pumps oil into the runner driving it like a turbine through a fluid circuit so arranged that oil circulates continuously from runner to impeller. Efficiency of power transmission at full load is 96 to 97%.

Fluid drives were first applied to boiler feed pumps more than ten years ago, photo at left, in the Philadelphia Electric Co's plant. The two 30-in.-dia drives, used with 700-hp 1200-rpm motors on booster pumps, are still operating. The impeller of each drive is mounted directly on the motor shaft and a heavy casting supports the runner shaft bearings and acts as a manifold for the oil to enter and leave the rotor. The output shaft connects to the pump through a flexible coupling. A small motor-driven control pump transfers oil from the sump to the rotor and also reverses to withdraw oil from the rotor to slow down the speed.

In 1940, three 3600-rpm adjustable-speed boiler feed pumps were installed in the Oswego plant of the Central New York Power Co. These are driven through step-up gears by 1800-hp 1800-rpm motors and fluid drives, photo at right. The control is so arranged that pump speed can be adjusted (1) directly to hold water level constant (2) to control feedwater level by the feedwater regulator valve, and then, with control of pump speed, hold a constant-pressure drop across the regulating valve.



HIGH-PRESSURE boiler feed pump performance during constant- and adjustable-speed operation. With adjustable-speed control, only required feed pressure need be held

This installation marked an advance in feed-pump drives because complete control of feedwater flow to the boilers could be obtained by regulating pump speed with the automatic feedwater-control system. Previously there was doubt as to how fast this type of adjustable-speed drive could change pump speed under such severe service. This installation removed the doubts so several similar installations were made. These drives led to the development of the 3600-rpm fluid drive, cross section above, which is directly responsive to feedwater control and which thus offers full benefit of adjustable speed.

Speed Control. The curves, on this page, show why speed control is desirable for boiler feed pumps. Constant-speed pressure curve is the rising head-capacity characteristic of the boiler feed pump as it is throttled to reduce flow to the boiler. From a flow of 1,100,000 lb per hr down to zero, pump-discharge pressure increases from 1850 to 2300 psi. This sharp rise in pressure is partly caused by decreased friction losses on the suction side of the pump at reduced flow, and by the rising head characteristic of the condensate pump.

Feed pumps must be selected to develop required boiler-outlet pressure, plus friction losses in superheater, boiler, economizer, feedwater valve, piping and high-pressure heaters, with a margin for blowdown. The pump selected for these requirements is good for much greater capacity than is needed for normal steaming conditions. The adjustable-speed-pressure curve, above, shows the required discharge pressure. With adjustable-speed control, only the required pressure need be held and a reduction in pressure of 500 to 700 lb results at low flows, with a corresponding saving in power as indicated by the two bottom curves. For example, at 400,000 lb per hr with adjustable-speed drive, pump-discharge pressure is 700 lb less, points *A* and *B*, and power input is 300 hp less, points *C* and *D*, than with constant-speed drive.

Other savings are also important to the operating department. These are: (1) flexibility of control for starting up and paralleling pumps (2) reduced pump maintenance as a result of lower pressures between stages and less water churning in the pump (3) lower average pressures in the high-pressure feedwater heaters (4) less feedwater valve maintenance.

Demands of 3600-Rpm Pumps. To meet the demands for 3600-rpm boiler feed pumps for 500 to 2350 hp, a fluid drive was developed to give: (1) speed response of less than 30 sec over the full range of pump capacity—20 to 25% speed change (2) close, accurate speed control, because of the narrow range of speed over which a pump operates (3) packaged power unit requiring no accessories other than the linkage to the automatic control and the water connections to the oil cooler (4) simple design to keep all maintenance factors out of the adjustable-speed drive.

This drive is enclosed, as in cross section above, in a heavy welded-steel housing. This acts as an oil reservoir, a support for the Kingsbury bearings, and a container for the oil cooler and oil-supply pump. Speed change is by a speed controller that skims oil out of the rotating parts and sets the level according to its position. A continuous supply of cooled oil is fed into the impeller by the oil-supply pump.

Condensate Pumps. While the most important advantages of stepless speed control are realized on the main boiler-feed pumps, there are fluid drives on booster condensate pumps or primary (low-pressure) boiler-feed pumps where good results are achieved at relatively low investment. In these applications the main boiler feed pump operates at constant speed. Since booster condensate pumps feed into the suction of the main boiler-feed pump, the combined total outlet pressure can be lowered by reducing the speed of the low-pressure pump. Most applications of fluid-drives, however, have been on main boiler feed pumps, where full advantage can be taken of adjustable speed.