orifices (in the order of 20 to 30 ft per second) also prevents smaller particles from clogging the orifice proper.

Experience with the very large number of Controlled Circulation units in operation under the widest range of power plant operating conditions has shown that chemical buildup in orifices does not occur if proper feedwater treatment is followed.

In addition, the differential head across the pump which is measured and monitored acts as a reliable and clearly recognizable signal concerning the absence or presence of any deposition in the orifice or heating surface. If deposition does occur, this differential will gradually increase and indicate the need for a remedial action long before the tube circuits themselves fail.

Circulating Pumps

Because circulating pumps are the key element in the furnace-wall system and are essential to tube protection under all operating conditions, a multiple pump arrangement with shutoff valving for each pump is provided. This in itself insures that availability is not impaired by possible failure of any individual pump.

The number of pumps selected for any system may vary between two and four. Because experience with Controlled Circulation units has established the reliability of modern circulating pumps, spare pumps are not normally provided. Each installed pump can be isolated by a motor-operated suction valve and a discharge stop-check valve. In case of failure, a pump may be isolated for a sufficient length of time to effect repairs without impairing the full-load capacity of the unit. It is recommended that for overall safety of the furnace-wall system,

the repaired pump be returned to service as soon as possible. It is also recommended that a spare rotor assembly be available at the plant.

Furnace-wall-system protection by the circulating pump is further insured by various interlocks and other protective devices. The details of these depend on the particular tupe of pump installed. A device common to all Controlled Circulation units is a firing interlock which will not permit heat input without having the minimum number of pumps in operation. This is evidenced by the measured pressure differential between the pump suction header and the wall inlet header. This also provides a signal on loss of any pump.

Welded Walls

The welded wall design, Fig. 5, has proven practical in fabricating panels in large quantities, with commercially available tubing. The panels have proven their long-term reliability, under practically all possible operating conditions. Experience and development have permitted design, support, and erection techniques to grow simultaneously with the rapidly increasing size and pressure requirements.

With increased use of pressurized firing and because of design simplification as well as easier erection procedures, the past decade has seen a continuous increase in the use of welded furnace walls until today it has become a standard C-E component for all utility contracts (Fig. 6).

Typical 370 Mw Controlled Circulation Unit

Figure 7 shows a 370 Mw Controlled Circulation pulverized-coal-fired steam

generator purchased in the early 1960's. It is designed for 2.5 million lbs/hr of steam at 2500 psig and 1005 F with reheat of 1005 F. The furnace is 55 ft wide, with a division wall at the center and a complete tangential firing circle in each half. The superheater has a horizontal section, intermediate platen and finishing pendant sections while the reheater is composed of a horizontal and a finishing pendant section. The furnace-wall system is fabricated utilizing fusion welded panel construction consisting of 1 3/4-in. dia tubes on 2 1/8-in. centers. The furnace is a gas tight enclosure including the roof where welded seals are provided for entrance of superheater and reheater elements.

Industrial Boilers

In the industrial boiler field, a variety of drum tupe boilers are being manufactured in the United States. The increasingly popular shop assambled or package tupe have now reached steam capacities of over 200,000 lbs/hr. They are being used where previously only conventional field erected boilers were available. Mass production methods and other economics of factory assembly have brought costs and erection time of such boilers down well below that of comparable capacity field erected tupes.

Our experience with the shop-assembled boilers brought about our modular concept of partial shop assembly and standardization of component parts for the larger field erected industrial boilers.

Modular Design Concept

A modular design is one in which a product is built with a combination of

various building blocks or modules. Each module must perform its intended function within a defined degree of flexibility and must be capable of being fitted to adjacent modules to form an integrated final product. The main purpose of applying this design concept is, of course, to produce a better product at lower cost. With a properly conceived and executed program, better quality and lower cost are compatible.

For this modular design concepto, welded-wall construction was ideally suited because it allowed the fabrication of large tube panels in the shop. Backed up by the necessary buckstays, the welded wall, because of its continuity, provides structural strength for support of the boiler and also a tight gas enclosure for pressurized firing of fuel. It eliminates the need for, and attendant problems with, a pressure casing. Welding the modular inlet and outlet headers to the sidewall tube panels in the shop minimized the field welding to a limited number of large dia feeder and relief tubes, completing this portion of the circulation system. Fins on edge tubes of the individual shop-assembled panels are welded together in the field to complete an integral pressure-tight envelope around not only the furnace, but the boiler section as well. This gas-tight envelope, made up of tubes and fins, operates at a saturation temperature corresponding to the operating pressure of the boiler. This temperature is well above the dewpoint of the corrosive gases in the products of combustion. Insulation on the welded walls is isolated from this corrosive atmosphere on the hot side and covered by a preformed metal casing on the cold side.

VU-60

This modular concept was applied in developing the VU-60 in the early 1960's (Fig. 8). This is a bottom-supported, field-erected, natural-circulation,