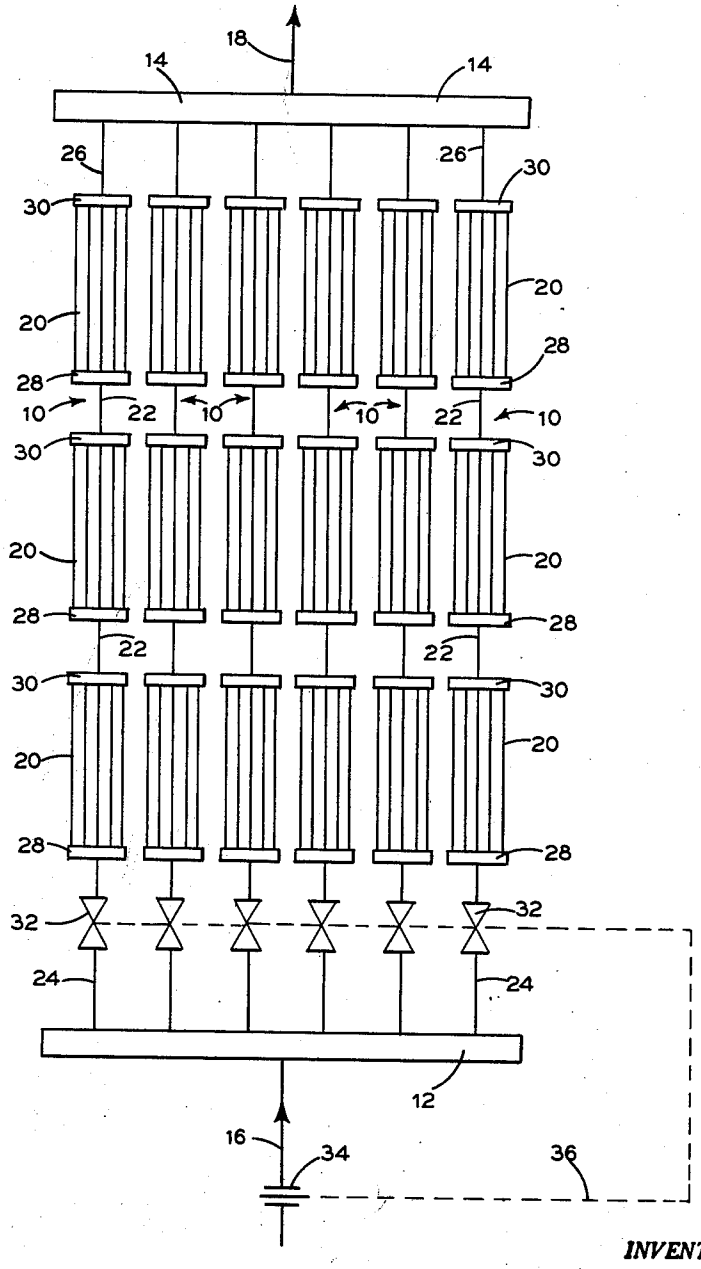
March 10, 1964 H. VON BENTEN 3,124,109

ONCE-THROUGH STEAM GENERATOR

Filed Sept. 30, 1960



INVENTOR.

Hans von Benten

BY

ATTORNEY

United States Patent Office 3,124,109 Patented Mar. 10, 1964

3,124,109

ONCE-THROUGH STEAM GENERATOR

Hans von Benten, Ratingen, Germany, assignor to Durrwerke Aktiengesellschaft, Ratingen, Germany, a corporation of Germany

Filed Sept. 30, 1960, Ser. No. 59,752
1 Claim. (Cl. 122—406)

This invention relates in general to forced flow fluid heating units and more particularly to improvements in the construction and operation of fluid heating circuits adapted for use in a forced circulation once-through vapor generating and superheating unit.

The construction of forced circulation high pressure steam generators requires the use of a large number of parallel flow circuits connected between inlet and outlet headers. One of the fundamental problems involved in the design of such a steam generator is the control of the flow through the various parallel circuits in order that the flow in each circuit will be stable and the enthalpy of the fluid discharged from any individual circuit will be close to the average of that from all circuits, in which case the circuits will be in a balanced flow condition. When steam or water, or mixtures thereof, is heated in parallel flow paths provided by, for example, the furnace wall tubes or tubular panels disposed in the furnace, unbalanced fluid flow distribution may lead to excessive localized tube metal temperatures and/or to excessive temperature differentials between adjacent furnace wall tubes and, thereby, to undue thermal stresses in the furnace wall-forming components. If the flow of the working medium or fluid through the individual tubes of the parallel flow circuits is to be properly balanced, care must be taken that the fluid pressure drop between the inlet and outlet headers, due largely to friction, is sufficiently high. But since the friction loss is proportionate to the square of the rate of fluid flow, partial load operation presents the danger that the pressure drop necessary for adequate and balanced fluid flow distribution will not be attained.

To overcome the problem of unbalanced fluid flow distribution in a steam generator of the character described, attempts have been made to provide for an adequate pressure drop at partial loads by keeping the velocity of flow appropriately high or by installing flow restrictors of a fixed size in the tubes of the parallel flow circuits. These restrictors impose a resistance to fluid flow which has a proportioning and equalizing effect on the amount of fluid entering each tube.

While selection of an appropriate high velocity of flow offers the advantage of adequate cooling of the tubes throughout the load range, it entails the drawback of a very high pressure loss in the upper portion of the load range, which means increased auxiliary power by reason of the work done by the feed pump. Although this disadvantage can be compensated in some measure by alternatively installing flow restrictors, nevertheless a substantial pressure drop will occur with increasing rate of fluid flow.

It has further been proposed to make the headers of the parallel flow circuits relatively short so that each header supplies but a few parallel flow tubes. While this construction results in considerable improvement in the distribution of the working medium to the tubes, the circuits are very susceptible to unstable flow, under which condition more than one flow can occur for the same pressure drop.

The present invention solves the problem of unbalanced flow and overcomes the drawbacks of prior constructions. In accordance with the invention a steam generator having a forced circulation fluid circulation

system is provided with a multiplicity of fluid heating circuits arranged for parallel flow of fluid therethrough and connected into the circulation system, with the circuits supplied with fluid from a common source. Automatically adjustable throttling members are provided in each of the parallel flow circuits and are responsive to variations in the rate of fluid flow for maintaining the pressure drop of the fluid in flowing through the circuits substantially constant throughout the load range, thereby effecting balanced distribution of fluid from the common source to the circuits. This arrangement makes it possible to operate the steam generator at part loads as low as 30% of normal load in a simple and dependable manner, with balanced distribution of fluid to all circuits being assured and the fluid pressure drop necessary for balanced distribution being automatically maintained at the proper level.

The various features of novelty which characterize my invention are pointed out with particularity in the claim annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawing and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

The accompanying drawing is a schematic representation of fluid heating circuits constructed and operable in accordance with the invention and particularly adapted for use in a forced circulation once-through steam generator. According to the invention, a steam generator of the character described comprises a multiplicity of fluid heating circuits **10** arranged for parallel flow of fluid therethrough relative to each other and normally subject to the heat of high temperature gases. The parallel flow circuits **10** have their supply and discharge ends respectively connected to common inlet and outlet headers **12** and **14**, with a conduit **16** connected to the header **12** for supply of fluid thereto from a common source by means of a feed pump, not shown, and with the header **14** being arranged for discharge of fluid to an outlet conduit **18**, which passes the fluid to other heating circuits, not shown, of the steam generator. Each circuit **10** comprises three tube panels **20** serially connected with one another by tubes **22** and with the headers **12** and **14** by tubes **24** and **26**, respectively, with each tube panel comprising a group of laterally spaced tubes arranged in parallel flow relation and extending between common inlet and outlet headers **28** and **30**, respectively, of relatively short length. Each circuit **10** also includes a valve **32**, or other suitable throttling member, disposed in the tube **24**. Tube **16** is provided with an impulse generator or controller **34** which automatically and continuously measures the value of the rate of fluid flow to the parallel flow circuits, and translates any deviation from some pre-set value of rate of fluid flow into an impulse force change, which is transmitted to the valves **32** by way of line **36** to move all of the valves simultaneously, thereby automatically regulating the fluid pressure drop across the valves **32** in accordance with the demand on the steam generator. Alternatively, the valves **32** may be disposed between the tube panels or downstream flow-wise of the last tube panel of each circuit. Each valve **32** is preset so that it is at its maximum open position at full load and at its minimum open position at a predetermined partial load.

In operation, fluid is supplied to the header **12** by way of the conduit **16**, then passes in parallel flow relation through the tubes **24** and valves **32** to the tube panels **20**, with the fluid stream of each circuit then passing serially to the header **14** by way of the tube panels **20**, while subdividing into a multiplicity of parallel flow streams and then combining into a single stream as it

passes into and out of each tube panel **20**. At full load each of the valves **32** is at its maximum open position since the velocity of flow at this load is high enough to provide a pressure differential between the inlet header **12** and the outlet header **14** sufficient to assure balanced distribution of fluid to the parallel flow circuits. As the load decreases, the impulse generator **34** automatically transmits an impulse by way of the line **36** to simultaneously move the valves **32** toward their minimum open positions to the extent that the fluid pressure drop between the headers **12** and **14** is maintained substantially constant from full load to some predetermined partial load, preferably one-third load, which assures balanced distribution of fluid to the tubes of the panels **20** throughout this load range.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form and mode of operation of the invention now known to me those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claim, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

In a steam generator having a forced circulation fluid circulation system, a plurality of fluid heating circuits arranged for parallel flow of fluid therethrough and connected into said circulation system and subject to the heat of high temperature gases, a common source of vaporizable fluid, means for supplying the fluid in parallel flow relation from said common source to said circuits, and means for maintaining the pressure drop of the fluid due to flow through said circuits substantially constant from full load to a predetermined partial load to effect balanced distribution of the fluid from the common source to said circuits, said last named means including a valve member in each of said circuits, means interconnecting all of said valve members, and means responsive only to variations in total rate of fluid flow to said circuits for simultaneously moving the valves in a closing direction as the rate of fluid flow to said circuits decreases.

References Cited in the file of this patent

UNITED STATES PATENTS

2,098,913	Dickey	Nov. 9, 1937
2,170,347	Dickey	Aug. 22, 1939
2,626,627	Jung	Jan. 27, 1953
2,805,653	Junkins	Sept. 10, 1957
2,985,151	Dickey	May 23, 1961

FOREIGN PATENTS

300,656	Great Britain	Nov. 28, 1929
384,832	Great Britain	Dec. 15, 1932
779,335	Great Britain	July 17, 1957
1,001,284	Germany	Jan. 24, 1957