Oct. 25, 1966 C. F. ROSENBLAD 3,280,906

FLEXIBLE PLATE HEAT EXCHANGER

Filed July 30, 1965 2 Sheets-Sheet 1

FIG. 1

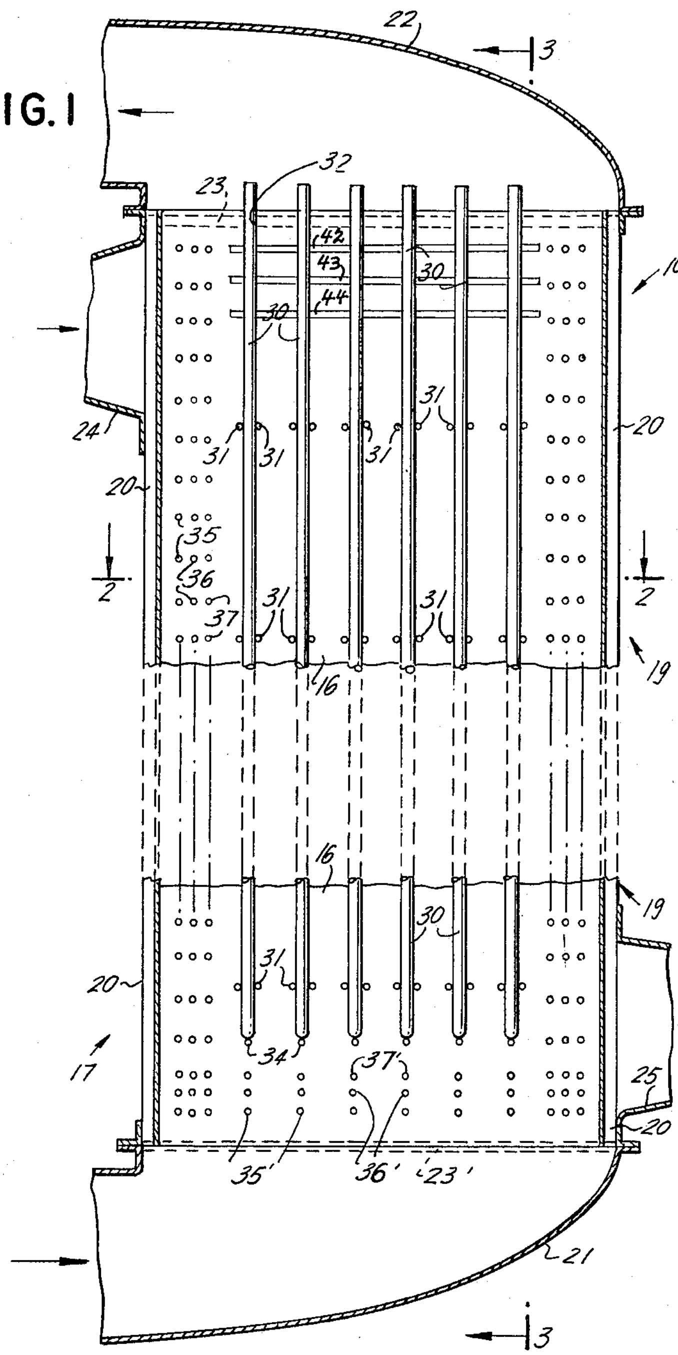


FIG. 3

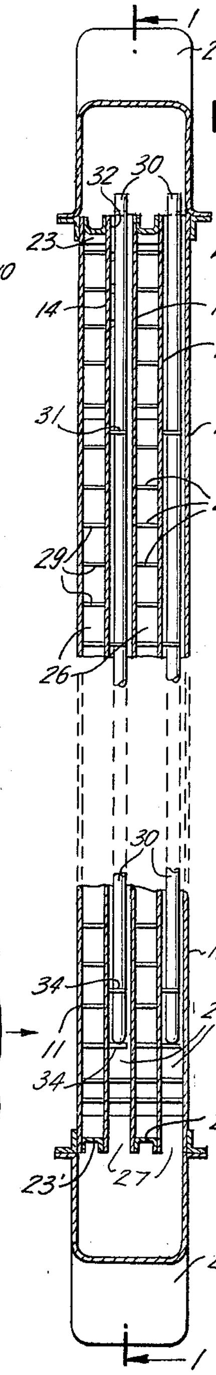
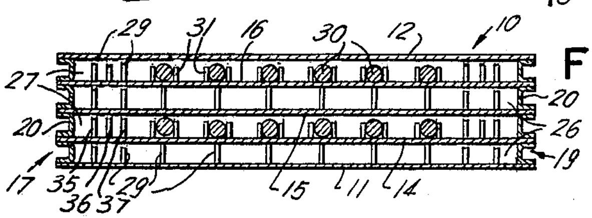


FIG. 2



INVENTOR.
CURT F. ROSENBLAD

BY Albert M. Parker

ATTORNEY

FLEXIBLE PLATE HEAT EXCHANGER

Filed July 30, 1965 2 Sheets-Sheet 2

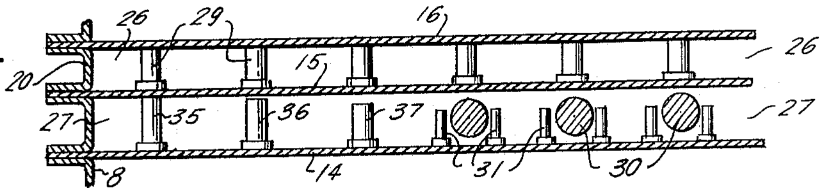


FIG. 4

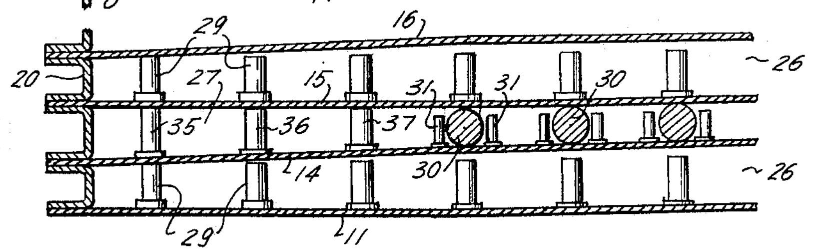


FIG. 5

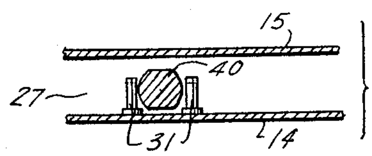


FIG. 7

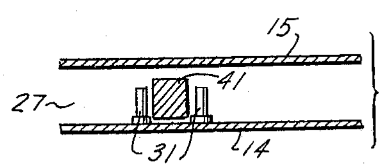


FIG. 8

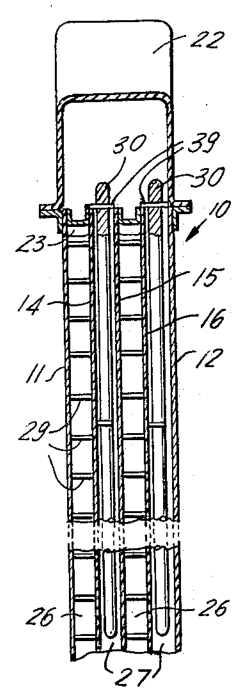


FIG. 6

INVENTOR.
CURT F. ROSENBLAD

BY Albert M. Parker

ATTORNEY

United States Patent Office 3,280,906 Patented Oct. 25, 1966

3,280,906
FLEXIBLE PLATE HEAT EXCHANGER

Curt F. Rosenblad, % Rosenblad Corp., P.O. Box 585, Princeton, N.J.

Filed July 30, 1965, Ser. No. 476,005
13 Claims. (Cl. 165—166)

This application is a continuation-in-part of application Ser. No. 355,705, filed March 30, 1964, now Patent No. 3,211,219, dated October 12, 1965.

This invention relates to flexible plate heat exchangers, and is particularly concerned with such heat exchangers which are equipped with removable spacer members between the flexible plates thereof, such spacer members limiting the flexing of the plates toward each other.

Heat exchangers with flexible plates have proved advantageous in a number of applications because of the high efficiency of heat transfer through the thin plates thereof and because of the economy permitted by employing thin exchanging plates. Because the different sets of channels presented between the flexible plates in heat exchanging relationship with each other are ordinarily subjected to marked differences in pressure, it is necessary to provide the channels of the set subjected to the lower pressure with spacer means distributed generally over their extents so as to prevent the undue approach of the plates toward each other. Very frequently the channels which are thus provided with spacer means are employed to conduct a heat transfer medium such as spent pulp digesting liquor which contains solid or scale forming material so that such channels must periodically be cleaned. Although removable spacer means for this purpose have been provided in the past, in general they have been hard to remove after the heat exchanger has been in operation for any considerable length of time.

In accordance with the present invention the removable spacer means are made in the form of a plurality of separate elongated members such as rods which may be removed one by one from the channels of the heat exchanger. As a result, the pull required to remove each of such spacer elements is much less than it would be if the spacer means were made integral and occupied a substantial part of the total space within the channels.

It is, accordingly, the over-all object of the invention to provide improved, more readily removed spacer means for flexible plate heat exchangers.

Another object of the invention is to provide novel spacer means for flexible plate heat exchangers, such spacer means being composed of a plurality of separate spacer members which may be individually removed from the channels of the heat exchanger.

Still another object of the invention is to provide novel spacer means which are more economically made than those of the prior art.

A still further object of the invention is to provide for achieving the foregoing objects in a simple and economical manner with regard to construction, operation, and maintenance.

The above and further objects and novel features of the invention will more fully appear from the following description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for the purpose of illustration only, and are not intended as a definition of the limits of the invention.

In the drawings, wherein like reference characters refer to like parts throughout the several views,

FIG. 1 is a view in vertical longitudinal section through a flexible plate heat exchanger in accordance with the invention, an intermediate portion of the heat exchanger being shown in phantom lines, the section being taken

along the line 1—1 of FIG. 3 looking in the direction of the arrows;

FIG. 2 is a view in horizontal section through an intermediate portion of the heat exchanger, the section being taken along the line 2—2 of FIG. 1 looking in the direction of the arrows;

FIG. 3 is a view in vertical transverse section through the heat exchanger of FIGS. 1 and 2, the section being taken along the line 3—3 of FIG. 1 looking in the direction of the arrows;

FIG. 4 is an enlarged fragmentary view in horizontal section through the heat exchanger taken in the same manner as in FIG. 2, only three of the plates of the heat exchanger defining two successive channels thereof being shown, the plates of the heat exchanger being shown in the relaxed positions which they occupy when the pressures within the two channels are equal;

FIG. 5 is a fragmentary view in cross section through the heat exchanger taken generally in the same manner as that of FIG. 4 but showing four plates of the heat exchanger, the plates being shown in the positions which they occupy when the channels **26** are subjected to a pressure which markedly exceeds the pressure within the channel **27** there shown;

FIG. 6 is a fragmentary view in vertical transverse section through the upper and intermediate portions of a heat exchanger having an alternative means for supporting the elongated vertical rods composing the spacer means for channels **27**;

FIG. 7 is a fragmentary view in transverse section through a portion of the heat exchanger showing a first alternative spacer rod in accordance with the invention; and

FIG. 8 is a view similar to FIG. 7 showing a second alternative embodiment of rod employed in the spacer means in accordance with the invention.

Turning now to the drawings, there is shown in FIGS. 1, 2, and 3 a flexible plate heat exchanger in accordance with the invention, such heat exchanger being generally designated by the reference character **10**. For simplicity, the heat exchanger is shown as having only five plates which define alternate channels **26** and **27**. It will be understood that heat exchangers in accordance with the invention may be made with any number of plates to provide the requisite number of alternating channels **26** and **27**. The heat exchanger **10** is provided with forward and rear sidewalls **11** and **12**, respectively, such sidewalls being disposed in spaced parallel aligned relationship, as shown. Disposed between plates **11** and **12** are intermediate plates **14**, **15**, and **16** which likewise are mounted in spaced parallel relationship. The edges of the plates **11**, **14**, **15**, **16**, and **12** are connected and sealed at their left-hand and right-hand edges **17** and **19**, respectively (FIGS. 1 and 2), by U-bars **20** which are telescoped between the edges of successive plates and are welded thereto. The plates, their edge closures **17** and **19**, and the upper and lower closure members **23** and **23'**, to be described, thus form two heat exchanging channels **26** which alternate with two further channels **27**. It will be assumed in the subsequent description that the channels **26** are subjected to higher pressures during the operation of the heat exchanger than are the channels **27**.

The heat exchanger **10** is provided at its bottom and top with an inlet header **21** and an outlet header **22** for a first heat exchanger medium which is introduced into the bottom of the channels **27** and passes upwardly therethrough so as to be discharged from the header **22**. The heat exchanger is further provided adjacent its upper and lower ends with an inlet header **24** and an outlet header **25**, respectively, by means of which a second heat exchanger medium is introduced into and removed from the channels **26**. The upper and lower ends of the channels **26** are closed and thus isolated from the headers **21** and **22** by upper and lower U-bars **23** and **23'**, respectively, as shown in FIGS. 1 and 3.

The plates forming the channels **26** are held in spaced parallel relationship when they are relaxed as shown in FIG. 4 by means of a plurality of spacer studs **29** of uniform length, one end of each stud being attached to one of the plates and the other end of the stud being free of attachment to the confronting plate. In the embodiment shown the studs **29** have enlarged heads which are secured to one of each of the pair of confronting plates forming the channels **26** as by being welded thereto. Adjacent the opposite side and also the bottom edge of the channels **27**, the plates forming such channels are held spaced from each other at varying distances when the channels **26** are subjected to a greater pressure than channels **27** as shown in FIG. 5. Such spacer means in the embodiment shown is formed of three laterally spaced vertically disposed rows of spacer studs **35**, **36**, and **37** at the side edges of channels **27**, the studs **35**, **36**, and **37** uniformly decreasing in height. As with studs **29**, the studs **35**, **36**, and **37** are provided with enlarged heads which are secured as by welding to one of the plates of each pair of confronting plates forming a channel **27**, the other end of each of such studs being unattached to the other, confronting plate. As a result of such construction the flexing of the plates which form the channels **27** is distributed over an appreciable distance extending inwardly from the side edges thereof, thereby minimizing the tendency of the plates to fail after repeated flexing. The bottom edges of the plates forming the channels **27** are similarly spaced by spacer studs **35'**, **36'**, and **37'**, as shown in FIG. 1, such studs decreasing in height in an upward direction.

In accordance with the invention the intermediate portion of each of the channels **27** is provided with a novel spacer means which when the channels **26** are subjected to an appreciable higher pressure than are channels **27** restrains the plates forming the channels **27** from approaching each other beyond a desired predetermined distance. In the illustrative embodiment such predetermined distance is slightly less than that of the height of the spacer studs **37**. Such novel intermediate spacer means is made up of a plurality of laterally spaced parallel rods **30** which in the first embodiment are round and have a diameter equal to such desired predetermined distance.

In the embodiments of heat exchanger shown, the heat exchanger plates lie in vertical planes and the rods **30** are supported between the plates forming channels **27** in such manner as to provide some freedom of motion of the rods both in the direction normal to the plates and longitudinally of the channels. Such freedom of motion of the rods is valuable not only in making their insertion into and removal from the channels **27** more easily accomplished but tends to prevent their becoming bound in place by deposits of solid material during use of the heat exchanger. The rods **30** and at least intermediate portions thereof thus lie spaced from the plates forming channels **27** when the plates are relaxed as shown in FIG. 4 but engage the plates when the heat exchanger is in use as shown in FIG. 5. Rods **30** are guided and retained from undue travel in a direction longitudinally of the plates by a plurality of vertically aligned spaced rows of short pins **31**, one end of which is secured as by being welded to one of the plates of each pair which form the channels **27**. Pins **31** have an effective height which is somewhat less than the diameter of rods **30**. Rods **30** in the first embodiment shown rest upon pins **34** which are disposed beneath the lower ends of the rods as shown in FIGS. 1 and 3. The upper ends of the rods **30** extend somewhat above the upper ends **32** of the channels **27** and into the outlet header **22**.

When it is desired to clean the channels **27** of the heat exchanger, the heat exchanger is removed from service and the upper header **22** is removed therefrom. The upper ends of the rods **30** are thus exposed and may be readily grasped as by a suitable extracting tool and pulled upwardly, thereby permitting the channels **27** to be thoroughly cleaned. The rods may then readily be reinserted within the channels **27**, the upper header **22** replaced, and the heat exchanger placed in service. During the cleaning of the channels **27** the channels **26** may be subjected to vacuum so that the channels **27** are fully opened by flexing their plates outwardly. It is desirable that the plates forming the channels **27** be provided with spacer means adjacent their upper edges inwardly of the U-bars **23** which provide for the variable spacing of such portions of the plates. Thus such plates at their upper edges may be provided with a plurality of vertically spaced horizontal rows of pins between the rods **30**, such pins progressively decreasing in height from the top down in the same manner as pins **35**, **36**, and **37** decrease in height in a horizontal direction. In FIG. 1, however, there is shown another manner for securing such variable spacing of the plates adjacent their upper edges, such spacing being provided by means generally similar to that shown in FIG. 2 of my prior application Ser. No. 355,705. Thus there are provided on one of the plates forming each of the channels **27** a plurality of horizontally extending strips (three shown) designated **42**, **43**, and **44** which are secured as by welding to the plates. The strips **42**, **43**, and **44** decrease in thickness in that order so that taken with the rods **30** they provide for the described variable spacing of the plates. As an alternative construction, not illustrated herein, such strips **42**, **43**, and **44** may be dispensed with entirely, the upper ends of the rods **30** then being made of frusto-conical shape and increasing in an upward direction whereby the upper ends of the thus modified rods themselves provide for the desired variable spacing of the upper ends of the plates forming channels **27**.

In FIG. 6 there is shown an alternative embodiment of means for supporting the spacer rods, there designated **30'**, in the channels **27**. As there shown each of the rods **30'** are provided with a cross pin **39** which extends therethrough adjacent the top of the rod, the ends of the pins **39** resting upon the upper edges of the plates forming the channels **27** and thereby supporting the rods **30'**. No pins corresponding to the pins **34** which engage the lower ends of the rods **30** in FIG. 1 are necessary in the embodiment of FIG. 6.

In FIGS. 7 and 8 there are shown two alternative embodiments of spacer rods there designated **40** and **41** which may be substituted for the round rods **30** and **30'** of the first described embodiments. Thus in FIG. 7 the single rod there shown which is designated **40** is of generally rounded shape but has flat parallel opposite side surfaces which confront the plates **14** and **15** forming the channel **27** there shown. In FIG. 8 the spacer rod, there designated **41**, is of square cross section and has two opposite flat parallel surfaces confronting the plates **14** and **15**. The flat surfaces of rods **40** and **41** which confront and engage the plates **14** and **15** permits the pressure exerted upon such rods to be distributed over an appreciable area. Thus rods **40** and **41** may be made of cheaper, more economical material than may be feasible when rods **30** which in effect engage the plates along lines are employed.

Although a limited number of embodiments of the invention have been illustrated in the accompanying drawings and described in the foregoing specification, it is to be especially understood that various changes, such as in the relative dimensions of the parts, materials used, and the like, as well as the suggested manner of use of the apparatus of the invention, may be made therein without departing from the spirit and scope of the invention, as will now be apparent to those skilled in the art. Thus although the illustrative embodiments of heat exchangers are shown with the plates lying vertical, it is to be understood that they may be disposed at any desired angle including horizontal.

What is claimed is:

1. In heat exchanger construction, a pair of spaced flexible heat exchanger plates forming a channel for the passage of heat exchange medium therebetween, and removable spacer means mounted in said channel for limiting the flexing of said plates toward each other, said spacer means comprising a plurality of spaced generally parallel rods each extending through a substantial part of the length of the channel generally parallel to the broad extents of the plates, and means retaining said rods in position between said plates, the rods having a dimension normal to the plates which is somewhat less than the distance between the plates in their relaxed condition.

2. In heat exchanger construction as in claim 1, the means for retaining the rods in position between the plates comprising means for retaining the rods from appreciable movement laterally between the plates, and means for preventing endwise movement of the rods.

3. Heat exchanger construction as in claim 1, wherein said rods are circular in cross section.

4. Heat exchanger construction as in claim 1, wherein said rods have opposite parallel side surfaces which confront and engage the inner surfaces of the plates when the plates are fully flexed inwardly toward each other.

5. In heat exchanger construction, a housing, a pair of spaced flexible heat exchanger plates within said housing having portions forming a channel for the passage of heat exchange medium therebetween, means for introducing said medium into and removing it from said channel, at least a portion of said housing generally in alignment with said channel beyond an edge thereof being removable to provide an opening through the housing, and spacer means removable through said opening mounted in said channel for limiting the flexing of said plates toward each other, said spacer means comprising a plurality of spaced rods each extending generally toward said opening generally parallel to the broad extents of the plates, and means retaining said rods in position between said plates, the rods having a dimension normal to the plates which is somewhat less than the distance between the plates in their relaxed condition.

6. In heat exchanger construction as in claim 5, said plates being disposed generally parallel and vertical, and the rods of the spacer means being disposed generally vertically.

7. In heat exchanger construction as in claim 6, the removable portion of the housing being disposed at the upper edges of the plates.

8. In heat exchanger construction as in claim 6, the means retaining the rods in position holding them for withdrawal upwardly through said opening in the said housing.

9. In heat exchanger construction as in claim 8, the means retaining the rods in position including means holding the rods under the action of gravity whereby they may be freely withdrawn upwardly through said opening in the housing.

10. In heat exchanger construction as in claim 6, the means for retaining the rods in position between the plates comprising guide means positioned on each side of each rod for retaining the rods from appreciable movement laterally between the plates, and means sustaining the weight of the rods for preventing downward vertical movement thereof.

11. Heat exchanger construction as in claim 10, wherein the guide means are mounted upon the inner surface of at least one of the plates and are disposed along a substantial part of the length of the rods.

12. Heat exchanger construction as in claim 10, wherein the means sustaining the weight of each of the rods is a member projecting from the inner surface of one of the plates and underlying the lower end of the rod.

13. Heat exchanger construction as in claim 10, wherein the means sustaining the weight of each of the rods is a member projecting laterally from the rod at the upper end thereof, said laterally projecting member overlying and engaging the upper edge of at least one of said plates.

References Cited by the Examiner

UNITED STATES PATENTS

1,770,208	7/1930	Kemnal	165—95
1,805,652	5/1931	Caracristi	165—166
2,236,976	4/1941	Rosenblad	165—166 X
2,267,619	12/1941	Strom	165—166
2,921,774	1/1960	Glasgow et al.	165—84

ROBERT A. O'LEARY, *Primary Examiner.*

FREDERICK L. MATTESON, Jr., *Examiner.*

T. W. STREULE, *Assistant Examiner.*