July 9, 1935. J. H. SENGSTAKEN 2,007,309

ECONOMIZER

Filed May 15, 1934 3 Sheets-Sheet 1

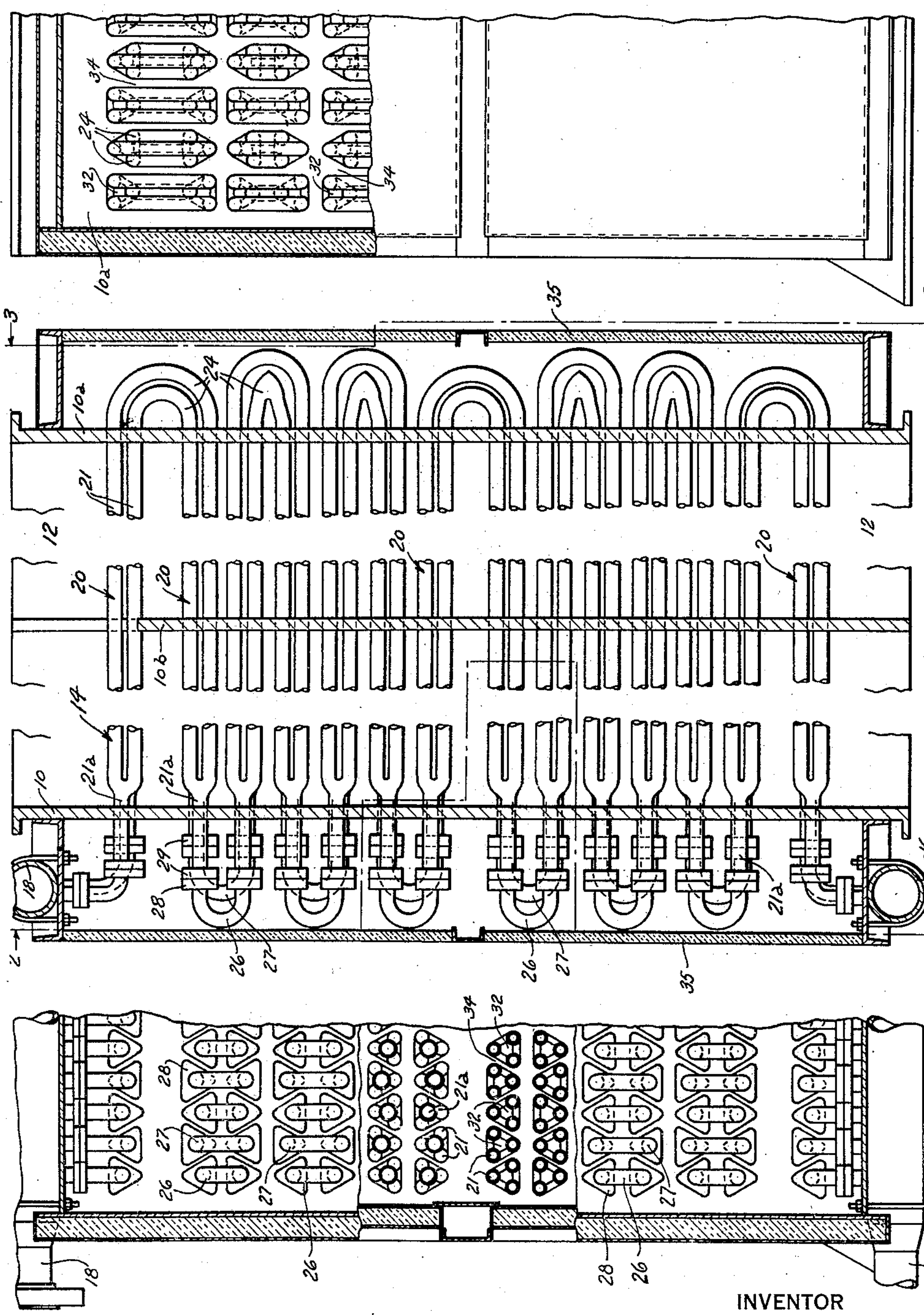

Fig. 3

Fig. 1

Fig. 2

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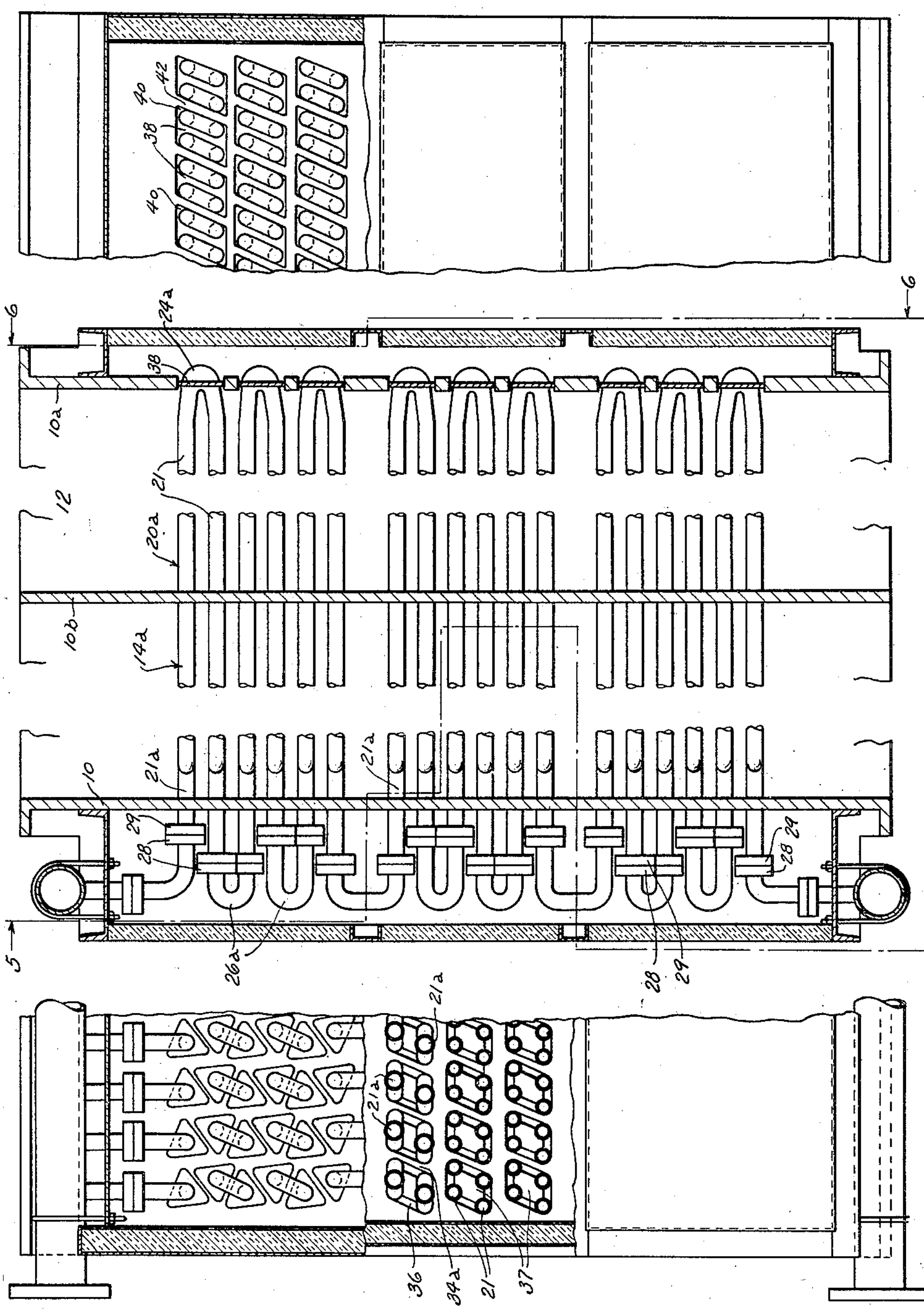

Fig. 6.

Fig. 4.

Fig. 5.

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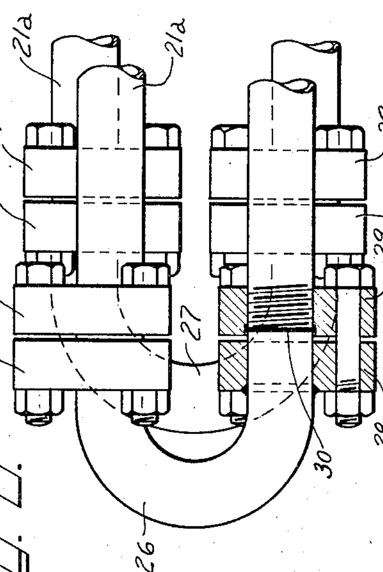

Fig. 8.

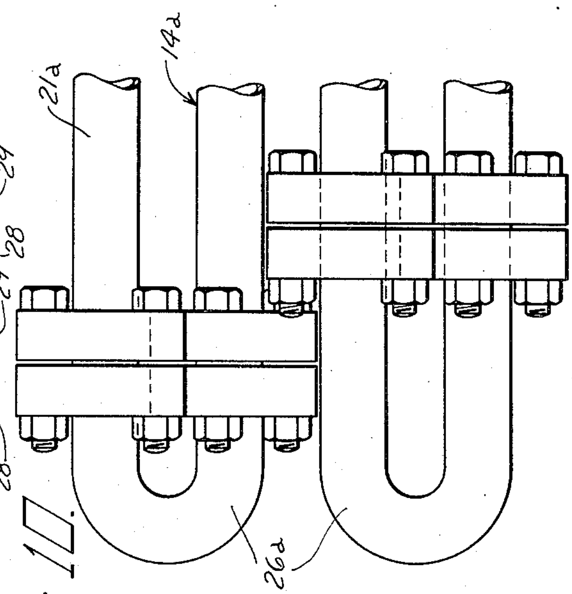

Fig. 10.

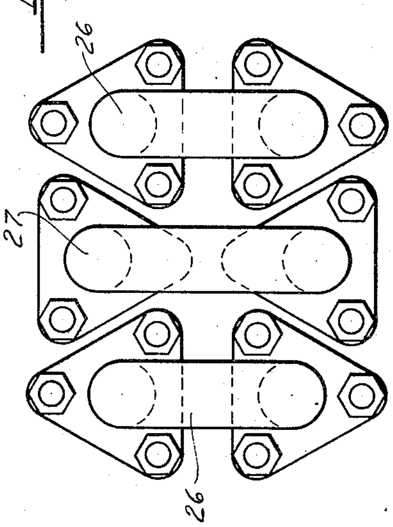

Fig. 7.

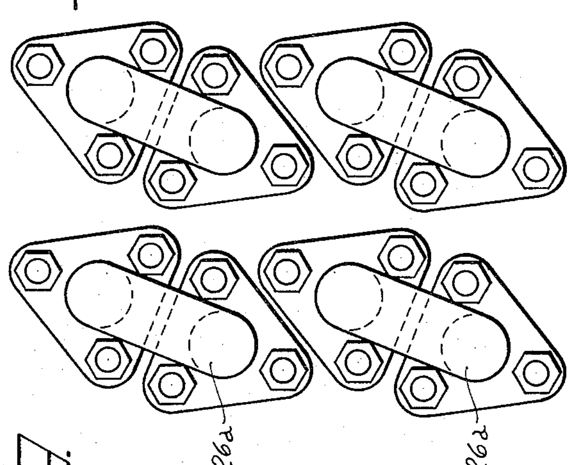

Fig. 9.

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UNITED STATES PATENT OFFICE

2,007,309

ECONOMIZER

John H. Sengstaken, Plandome, N. Y., assignor to The Superheater Company, New York, N. Y.

Application May 15, 1934, Serial No. 725,765

17 Claims. (Cl. 257—230)

The present invention relates to fluid heaters and more particularly to those having serpentine units and to be employed for boiler economizers.

Heaters intended for use as economizers require, for economic reasons, to have a high rate of heat absorption per cubic foot of heater volume and therefore a large amount of heating surface per cubic foot. The pipe runs of economizers, however, need to be inspected and cleaned from time to time and hence need to be connected in large measure by breakable joints. In spite of certain advantages of a bare tube economizer as compared to an extended surface economizer, it has been found difficult to introduce sufficient heating surface per cubic foot into a bare tube design of economizer because of the room required for the joints. The water passing to an economizer varies in temperature and so also do the heating gases, so that the breakable joints in such structures are liable to develop leaks due to differential expansion and contraction of the parts. As a result of experience, many economizers have their breakable joints of the multi-bolt flanged type. The flanges of such joints, however, occupy considerable space and have thereby limited the spacing of the tubes of the units and thereby also the surface of bare tubing per cubic foot to the disadvantage of the bare tube design.

It is an object of my invention to provide a design of heater or economizer structure adapted to absorb a large amount of heat per unit volume of flue space even with only bare tubes and without extended surfaces. A further object of my invention is to provide a heater design adapted to include a multiple bolt type of joint to insure against leaks.

In order that my invention, together with its objects and advantages, may be fully and readily understood, I will now describe in detail and in connection with the accompanying drawings, two exemplifications of my invention selected from a number of possible embodiments thereof. In the drawings,

Fig. 1 is a sectional elevation through one form of heater in accordance with my invention.

Fig. 2 is an end view, partly in section, of the heater shown in Fig. 1, the sectioned portion being taken on the line 2—2 of Fig. 1.

Fig. 3 is an elevation partly in section taken on the line 3—3 of Fig. 1.

Fig. 4 is a sectional elevation of a second form of heater in accordance with my invention.

Fig. 5 is an end elevation partly in section taken on line 5—5 of Fig. 4.

Fig. 6 is a portion of an end elevation partly in section taken on line 6—6 of Fig. 4.

Fig. 7 is an enlarged detail of some of the end connections appearing in Figs. 1 and 2.

Fig. 8 is a view taken at right angles to Fig. 7, parts being broken away to illustrate the details of the joint.

Fig. 9 is an enlarged detail of some end connections appearing in Figs. 4 and 5.

Fig. 10 is a view taken at right angles to Fig. 9.

The heater illustrated in Figs. 1, 2 and 3 comprises vertical plates **10** and **10***a* defining a flue **12** within which are mounted a considerable number of serpentine units **14**, shown each in a given vertical plane. Fluid to be heated, for instance boiler or feed water, is conducted to the inlet ends of said units **14** through a header **16**. Fluid which has been heated in units **14** is delivered by them into an outlet header **18**. In the arrangement shown, each of the units **14** includes a plurality of straight tube runs **20**, **20** which are illustrated as lying horizontally. Each tube run **20** extends through both the plate **10** and plate **10***a*. For most of its length, each such run is composed of a plurality of tubes **21**, **21** arranged to conduct fluid therethrough in parallel. Near at least one of its ends, each tube run **20** is, at a point in flue **12**, reduced to a single tube section **21***a* which extends through one of the plates **10**, **10***a*. As illustrated, the single tube sections **21***a* all extend through the plate **10**. In the arrangement illustrated in Figs. 1, 2 and 3, the plural tube runs **20** forming the major portions or sections of units **14** each have three tubes **21** in parallel. However, I do not limit myself to any particular number of tubes in parallel in such portions of the apparatus altho I prefer to use either two or three.

At the ends of the runs **20** nearer the supporting plate **10***a*, the tubes of such runs are connected in pairs by return bends **24**, **24**, preferably of the integral type, so that the units illustrated are formed of a plurality of U-loops. On the outside of the plate **10**, the single tube sections **21***a* at the ends of the runs are connected by removable return bends **26**, **26** and **27**, **27**. Bends **26** have different lengths and different spans than the bends **27** because alternate loops have a slightly different arrangement. As appears in Fig. 2, the three tubes **21** of each run **20** are set so that their centers form a triangle, the center of one tube lying on the central vertical plane of the unit and the other two on opposite sides of such plane. However, alternate runs **20** of each horizontal row of runs of units **14** have the tubes on their central vertical planes at the top sides of the runs and alternate runs have the tubes on their central planes on the bottoms of the runs. By making some units with their top runs 20 of one arrangement and some of the other, and assembling the units so that one arrangement alternates with the other across the width of the heater, the tubes 21 are given the same horizontal spacing throughout each horizontal row; that is, the horizontal distances between centres is the same between a pair of tubes of adjacent units as between a pair of tubes of a given unit, as clearly shown in Fig. 2. The single-tube end sections 21*a* of alternate units 14 are connected by the removable return bends 26, and sections 21*a* of the remaining units are connected by removable bends 27.

In order to ensure against leaks at the bends between the removable return bends and sections 21*a*, I employ bolted flange joints to connect such parts and preferably employ three-bolt joints. The flanges for such joints appear at 28 and 29 of Fig. 1, flanges 28 being carried by the ends of the removable U's 26 and 27 and the flanges 29 being carried by the single-tube end sections 21*a*. Flanges 29 need to be removable and are shown as threaded onto parts 21*a*. Flanges 28 can be fixed on bends 26 and 27 by weld metal as shown if so desired. The three-bolt flange joint is very reliable because it eliminates any tendency to tilt about the line joining the bolts, as occurs in two-bolt flange joints. However, I do not limit myself in all cases to the use of three-bolt joints, as at times I may use two bolt flange joints, or joints of any number of bolts more than one. Preferably I prefer to employ a gasket 30 as shown at the detail of the joint appearing in Fig. 8. However, I do not limit myself to this and it will be understood that I do not claim to have originated the joint illustrated in Fig. 8, or the three-bolt flange construction. However, such a construction requires relatively more space at the side or sides of the economizer where the removable return bend is employed than does the two bolt flange arrangement. Due to the space saved by the use of single-tube end sections for the tube runs, I am, however, able to employ the three-bolt flange joint and still obtain the large amount of bare tube surface per cubic foot of flue volume needed to improve the competitive position of the bare tube design of economizer. The three bolt flange naturally leads to flanges of the form of equilateral triangles as shown.

It will be seen that, in spite of the three bolt flanges illustrated, tubes 21 are set, except where space is provided for tube cleaners or blowers, less than two diameters apart between horizontal centres and two diameters between vertical centers, or slightly more. If two bolt flanges were used, the spacing could be even less.

It will be seen that as water or other fluid flows through units 14 from header 16 to header 18, the single-tube sections 21*a* will offer more resistance to the flow per unit of length than will the runs 20 containing a plurality of tubes such as 21. The sections 21*a* therefore will help to prevent an unequal distribution of fluid between the different units 14 and so avoid one of the practical difficulties in the operation of economizers and like heaters wherein certain units, when they are of uniform free cross section throughout, receive more than their proper share of the fluid, thereby robbing certain other units and causing such latter units to become overheated. Of course, if steam forms in any unit or group of units, such a tendency to unequal distribution of water, or other fluid to be heated, is greatly aggravated. The arrangement illustrated in which the single-tube sections 21*a* have only a fraction of the free cross sectional area of the tubes 21 with which they unite affects the design favorably in two different directions, one as to the room available for joints between tube runs and the other as to the operation by promoting equal distribution of water between the units. I prefer, further, to increase the effect of the sections 21*a* as to distribution of fluid between the units 14 by making them with somewhat thicker walls than the tube portions or sections 21 but of the same external diameter, thereby not only reducing the flow area in sections 21*a* relatively to the total area per tube run 20, but absolutely reducing the free flow area of sections 21*a* as compared to individual sections 21. Such reduction of free area of sections 21*a*, however, does not prevent the use of tube cleaners in the runs 20. Neither does the branching of tubes 21 from sections 21*a* hinder the use of tube cleaners. The tube cleaners available are both flexible and expansible so as to accommodate themselves to both conditions. The bends 26 and 27 may conveniently be made of the same tubing as single tube sections 21*a* so as to add to the flow restricting effect of the sections 21*a*. However, I do not limit myself to this.

No difficulty is experienced in removing the flanges 29 of a given unit 14 whenever it is desired to remove part or all of such unit from flue 12. As is clear from the drawings, the flanges 29 can be unscrewed whenever desired, because there is sufficient distance between sections 21*a* of a given unit to permit adjacent flanges 29 to pass in a given transverse plane, while the sections 21*a* of different units 14 are alternately long and short, thereby throwing the flanges 29 of adjacent units 14 into different vertical planes transverse to the units so that the flanges on adjacent units turn past each other, altho their projections on the plane of plate 10 overlap.

The flue 12 is bounded on opposite sides by the walls 10 and 10*a* and I prefer to utilize such walls for sustaining a large portion of the weight of units 14. For this purpose, walls 10 and 10*a* may conveniently be made of cast iron and made thick enough to support the weight expected to fall on them. In the average case, however, the walls 10 and 10*a* will be spaced a sufficient distance apart so that a considerable portion of the weight of the units 14 will need to be carried by an intermediate partition or partitions 10*b*. Partitions 10*b* can be of the same construction as walls 10 and 10*a*.

The single tube sections 21*a* pass through holes (not shown) in wall 10, one section 21*a* in one such hole so that the weight of one portion of each tube run 20 is transferred to wall 10 by a section 21*a*. In the case of walls 10*a* and 10*b*, however, a somewhat different arrangement is necessary. At the planes of such walls, the tube runs 20 of the arrangement illustrated in Figs. 1, 2 and 3 are composed of three tubes 21 so that the openings through each of plates 10*a* and 10*b* for each of the tube runs 20 is preferably of a triangular shape as indicated in Figs. 2 and 3. In order to brace the tube runs at the walls 10*a* and 10*b*, however, and better to transfer the weight of the tube runs to the walls 10*a* and 10*b*, I provide triangular plates 32, 32 which space the tubes 21 of each tube run 20 at the planes of walls 10*a* and 10*b* and help transfer the weight of the tube runs to such walls. Of course, there are inclined webs 34 left between adjacent holes through the walls 10a and 10b so that such walls shall not be unduly weakened by the openings for the tube runs. It will be noted in Fig. 1 that the tube runs 20 of each unit are arranged in groups of 6, adjacent groups being spaced somewhat more widely in a vertical direction than the adjacent tube runs of each group. Such spaces are provided for soot blowers and form no part of the invention. Outer insulating walls 35, 35 for confining the heating gases and preventing loss of heat by radiation are also shown in Figs. 1, 2 and 3.

The embodiment of the invention illustrated in Figs. 4, 5, 6, 9 and 10 is similar in many respects to the embodiment already described and illustrated in Figs. 1, 2, 3, 7 and 8. In the arrangement of Fig. 4, the tube runs 20a of the units 14a contain only two tubes 21, 21 in parallel instead of the three tubes in parallel in the units 14, the plurality of tubes 21 in each run 20a being connected to a single tube portion 21a the same as in Fig. 1. The tubes 21 of each tube run are preferably arranged in a horizontal plane as shown, but a given tube run 20a is staggered horizontally with respect to the ones immediately above and below it, as shown in Fig. 5, so as to force the heating gases in the flue 12 to follow a tortuous path. Each single tube section 21a extends through a hole in and rests on the wall 10. The sections 21a outside the wall 10 are connected together in pairs by flanged return bends 26a, 26a in a manner similar to the connections employed in Fig. 1, and due to the staggered setting of runs 20a of a given unit 14a, the bends 26a lie in planes at an angle to the vertical. At the ends of the runs 20a opposite the single tube sections 21a, the individual tubes 21 are preferably connected by integral forged return bends 24a so that adjacent runs 20a are connected together in pairs by integral bends 24a to form U-loops, adjacent U-loops being connected in pairs by said removable return bends 26a. The spacing of tubes 21 in the arrangement shown in Figs. 4, 5 and 6 is, in terms of tube diameters, substantially that of the corresponding tubes 21 in the arrangement of Figs. 1, 2 and 3.

Where the runs 20a pass through an intermediate wall 10b, the wall is cut out to form rhomboidal openings 36 (Fig. 5) separated by webs 34a. In such openings 36 the pipes 21 of each U are spread and braced by a plate 37. At each point where the return bends 24a pass through the wall 10a, the two integral bends 24a belonging to a given unit 14a are set in a plate 38 which rests on the lower edge of an opening 40 in the wall 10a and is slidable therein to facilitate insertion and removal of the runs 20a. The openings 40 are spaced by the webs 42 integral with the body of plate 10a so that the wall 10a is not unduly weakened by such openings.

The return bends 26a and the associated joints between such bends and the tube sections 21a of units 14a are illustrated on an enlarged scale in Figs. 9 and 10. It will be seen that the relative offsetting of adjacent runs 20a to force the gases going up or down in flue 12 of Fig. 4 to follow a tortuous path results in placing the bends 26a in planes inclined to the vertical instead of in the vertical as in the case with bends 26 and 27 of Figs. 1 and 2. In the arrangement shown, the triangular flanges 28 and 29 associated with bends 26a and sections 21a respectively of Figs. 9 and 10 can turn past the flanges on the units adjacent to a given unit, because the units are assembled with sufficient clearance to permit it. The sections 21a of tube runs 20a connected in pairs by integral bends 24a to form U's are of different lengths so that the flanges on the ends of sections 21a of a given U can be turned without interference, because they lie in different planes. Interference will occur, however, in the arrangement shown in Figs. 4, 5 and 6, between flanges on sections 21a of adjacent U's. When it is desired to remove a given U therefore, after taking off the removable return bend 26a connected thereto, it is necessary to push such U longitudinally enough to let its flanges clear those on the adjacent U's and they can thereupon be unscrewed and the given U removed.

It will be seen from the drawings that designs in accordance with my invention provide a large amount of heating surface per cubic foot of flue volume without necessitating the weight and expense attendant upon the use of extended surface and at the same time permit the use of thru bolt flange joints for the removable return bends. The features of construction and arrangement herein disclosed are, however, well adapted for use with tubes having extended surface and may be used with such extended surface tubes without departing from my invention.

While I prefer to use integral bends along one side or end of the unit bundle, thereby dividing the units into U's, I do not limit myself to this in all cases.

While I have disclosed a number of novel features of construction and arrangement, I do not limit myself to the use of all such features in a given installation.

What I claim is:

1. A heater having a flue, a plurality of serpentine units in said flue connected for parallel flow therethrough of fluid to be heated, each of said units having substantially straight tube runs and return bends for joining said runs, each of said runs comprising throughout its major portion a group of tubes in parallel and each such group of tubes united near at least one of its ends to a single tube section having a free cross-sectional area not much more than half the total free area of the group to which it is joined, those of said return bends along at least one side of the heater being removable and connected directly to said single tube section.

2. A heater having a flue, a plurality of serpentine units therein connected for parallel flow therethru, each of said units having substantially straight tube runs and return bends for joining said runs, each of said runs comprising throughout its major portion a group of tubes in parallel and each such group of tubes united near at least one of its ends into a single tube section having a free cross-sectional area not much more than half the total free area of the group to which it is joined, those of said return bends along at least one side of the heater being removable and connected directly to said single-tube sections, said sections having polygonal flanges threaded thereon and said removable bends also having polygonal flanges thereon, said flanges adapted to be bolted together to secure said removable bends in place.

3. A heater having a plurality of serpentine units connected for parallel flow of fluid therethrough, each of said units having U-loops including pipe runs and integral return bends for joining said runs, and removable return bends along one side of the units having polygonal flanges thereon, complementary polygonal flanges threaded on the end sections of the loops and adapted to be bolted to the flanges on said bends,

said loops so proportioned and placed that each end section is not more than two and one-half diameters from the end section closest to it but the polygonal flange on each of said end sections arranged to clear the end section closest to the one supporting it and alternate flanges in a given direction in different planes transverse to such loops whereby the flanges may be threaded into place without interference.

4. A heater having a plurality of serpentine units connected for parallel flow therethrough, each of said units having U-loops including pipe runs and return bends for joining said runs, each of said loops comprising throughout the major portion of its length a plurality of tubes in parallel and such tubes united near the ends of the loops into single tube sections having a free cross section not much more than half the total free cross section of the plurality of tubes to which they are joined, removable return bends connecting the unitary tube sections of adjacent ends of different U-loops, polygonal flanges threaded on said unitary tube sections at the ends of the loops, complementary polygonal flanges carried on the ends of said removable return bends and adapted to be bolted to the flanges on said sections, said loops having such dimensions and being so arranged that each of said unitary tube sections is spaced not more than two and one-half diameters from the tube section closest to it, but said unitary tube sections at the ends of the loops having different lengths whereby the flanges on a given loop lie in different planes transverse to the loop to permit the flanges on its unitary tube sections to be threaded into place without mutual interference.

5. A heater as set forth in claim 4 and in which each of the U's comprises a relatively long section having a plurality of tubes in parallel and relatively short sections having unitary tubes joined to the plural tubes of said first mentioned sections.

6. A heater comprising serpentine units each formed of a plurality of U-loops connected by removable return bends, the major portions of said loops having two pipes in parallel, said loops each having their two pipes set not more than two tube diameters between horizontal centers and said units set so that the tubes of adjacent units are also not more than two tube diameters between horizontal centers, the said U's having single-tube end-sections united to said two pipes, said end sections terminating at different distances from the closed ends of the U's, and bolted-type flange joints having more than two bolts each between said sections and said removable return bends.

7. A heater comprising serpentine units each formed of a plurality of U-loops connected by removable return bends, the major portion of said loops having two pipes in parallel, said loops each having their two pipes set not more than two and one-half tube diameters between vertical centers and not more than two tube diameters between horizontal centers and the units set so that the tubes of the adjacent units are not more than two tube diameters between horizontal centers, the said U's having single-tube end sections united to said two pipes, said end sections terminating at different distances from the closed ends of the U's, and bolted-type flange joints having more than two bolts each between said sections and said removable return bends.

8. A heater as set forth in claim 1 and in which the single-tube end sections of the pipe runs have a greater wall thickness than the tubes of the remaining sections of the tube runs but have no greater external diameter than such remaining sections.

9. A heater comprising serpentine units each formed of a plurality of U-loops connected by removable return bends, the major portions of said loops having three pipes in parallel, said loops having their three pipes arranged so that alternately a single pipe is at the outside of the loop and so that alternately two pipes are at the outside of the loops, said loops having two pipes set not more than two tube diameters between horizontal centers and the units all set so that tubes of adjacent units are not more than two tube diameters between the horizontal centers, said tubes being so formed and said units being so arranged that none of the tubes are spaced more than two tube diameters between vertical centers, the said U's having single-tube end sections united to said three pipes in parallel, said end sections in one unit terminating at a different distance from the closed ends of the U's than in the unit on each side of said one unit, and three-bolt flange joints between said sections and said removable return bends.

10. A heater as set forth in claim 1, together with supporting walls lying transverse to the tube runs, the single tube end section projecting thru and resting in one of said walls and another of said walls having enlarged openings, integral bends joining the tubes at one side of the tube bundle and plates each embracing the integral bends of at least one tube run and resting in one of said openings.

11. An economizer comprising a plurality of units in parallel, each of said units including a plurality of U-loops, each such loop having a main portion providing a plurality of paths in parallel for fluid to be heated and having integral throats one for delivering fluid to the other for receiving fluid from said paths.

12. An economizer as set forth in claim 11 and in which the throat portions of the U-loops have a free internal cross sectional area less than the free area of the plurality of paths comprised in a given U-loop.

13. An economizer as set forth in claim 11 and in which the throats of adjacent U's are connected by removable return bends having free cross-sectional areas equal to those of the throats to which they connect.

14. An economizer as set forth in claim 11 together with plates embracing and supporting the throats at one end of the U's and the return bends at the opposite ends of the U's.

15. An economizer as set forth in claim 11 and in which the U-loops have two paths in parallel for fluid to be heated and integral return bends at the closed ends of the U's, plates embracing the throats at the one end of the U's, a plate having apertures into which the bends of the U's project, at the opposite ends of the U's, and smaller plates contacting each the bends of one U and resting in said last apertures.

16. The combination in a fluid heater of a plurality of serpentine units arranged for flow of fluid therethru in parallel, each of said units having a series of removable return bends connecting portions of the unit, each of such portions having a plurality of pipes in parallel connected to a single pipe section whose free flow area is less than that of said pipes in parallel.

17. A heater having a plurality of serpentine units connected for parallel flow of fluid there-

through, each of said units having U-loops including pipe runs and return bends for joining said runs, each of said loops comprising throughout the major portion of its length a plurality of tubes in parallel and such tubes united near the ends of the loop into single tube sections having free cross-section not much more than half the total free cross section of the plurality of tubes to which they are joined, removable return bends connecting the unitary tube sections of adjacent ends of different U-loops, polygonal flanges threaded on said unitary tube sections at the ends of the loops, complementary polygonal flanges carried on the ends of said removable return bends and adapted to be bolted to the flanges on said sections, said loops having such dimensions and being so arranged that each of said unitary tube sections is spaced not more than two and a half diameters from the tube section closest to it, the loops of a given unit being all of a given length while those on units on both sides of said given unit are both either longer or shorter than those of the given unit whereby the flanges on the loop of a given unit lie in a different plane from those on the adjacent units to permit the flanges to be threaded into place without interference from those on the other units.

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