

Aug. 31, 1943.

T. C. TOOMEY ET AL

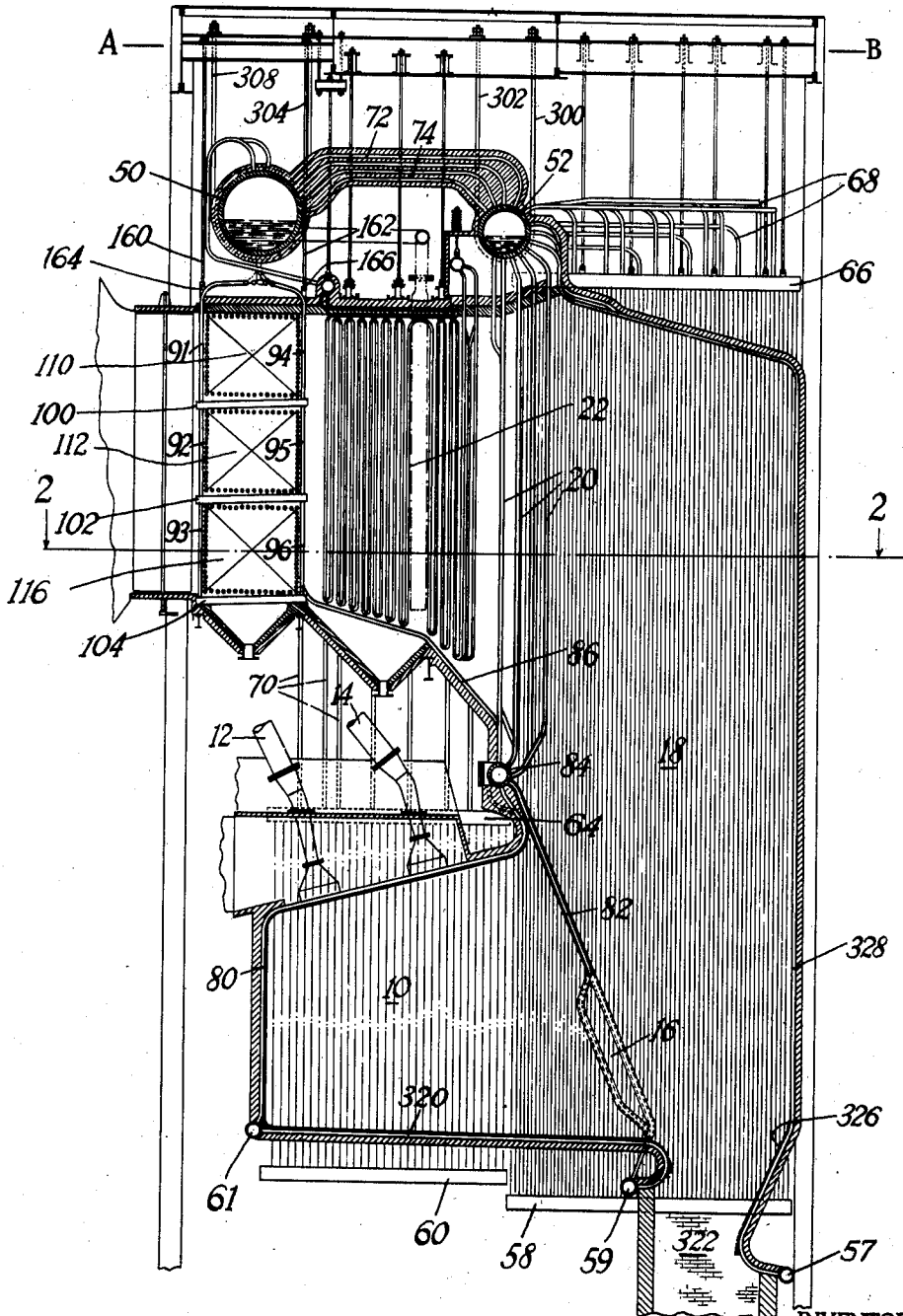
2,328,039

STEAM GENERATOR

Filed April 30, 1938

7 Sheets-Sheet 1

Fig. 1



INVENTORS
Thomas C. Toomey &
Joseph G. Brandt
BY *Benj. R. Hancock*
ATTORNEY.

Aug. 31, 1943.

T. C. TOOMEY ET AL

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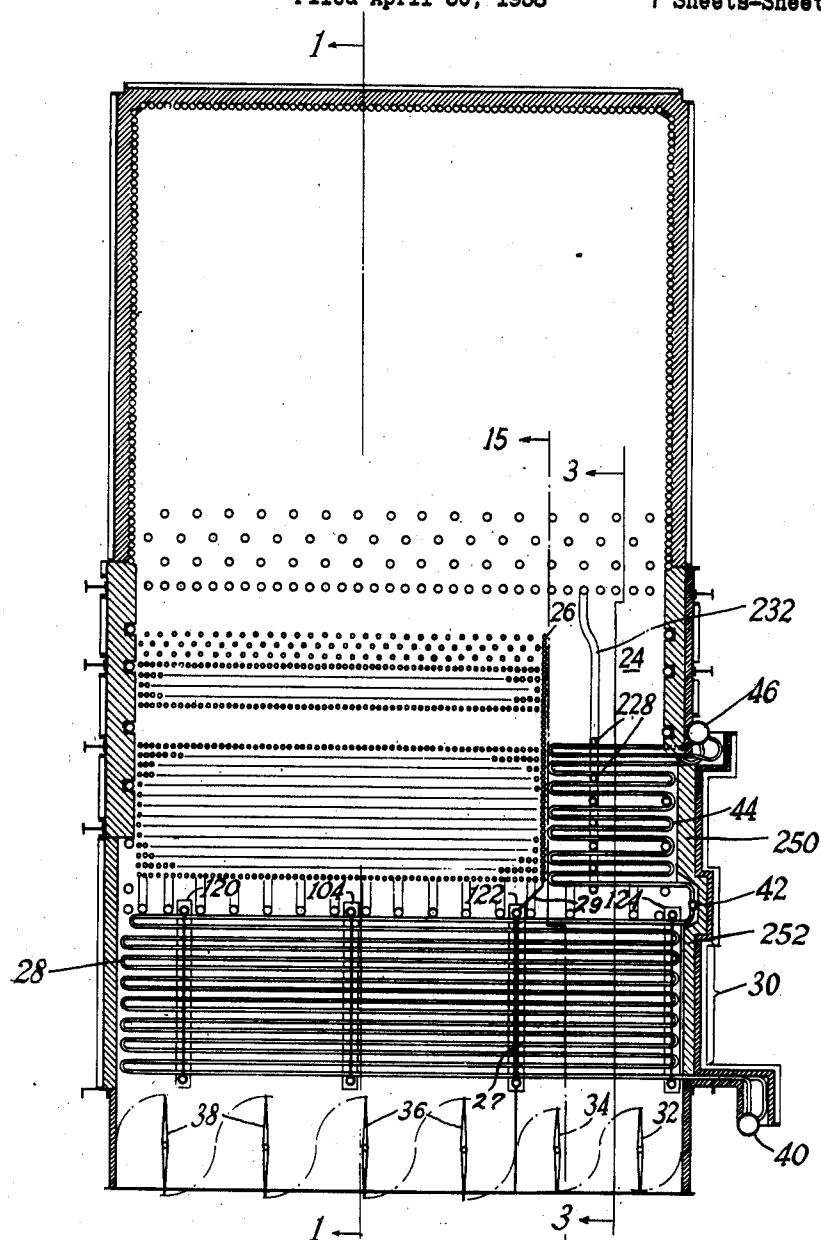


Fig. 2

INVENTORS
Thomas C. Toomey &
Joseph G. Brandt
BY *R. R. Kautz*
ATTORNEY.

Aug. 31, 1943.

T. C. TOOMEY ET AL

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Fig. 4

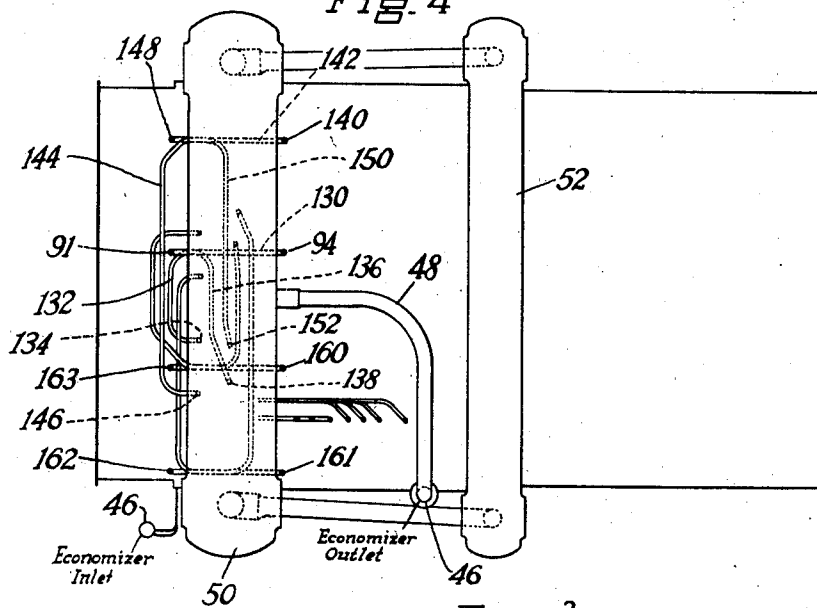
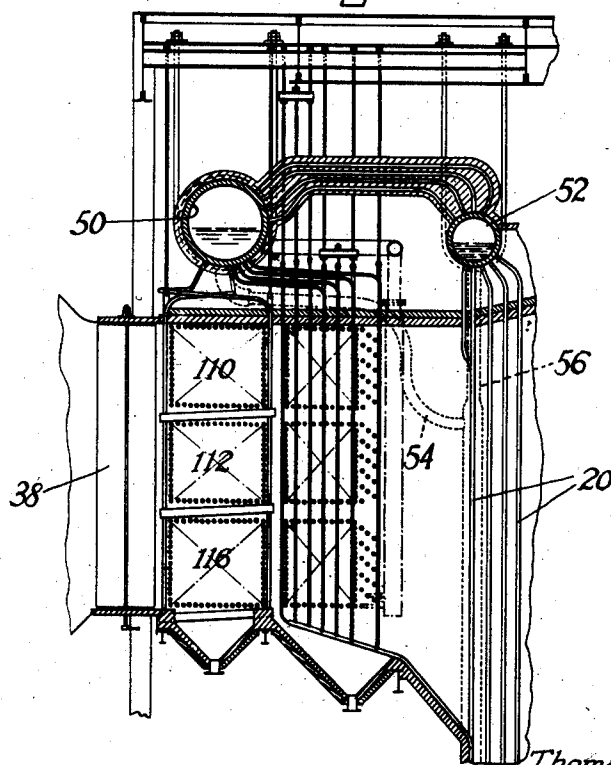


Fig. 3



INVENTORS
Thomas C. Toomey &
Joseph G. Brandt
BY *Paul R. Hancock*
ATTORNEY.

Aug. 31, 1943.

T. C. TOOMEY ET AL

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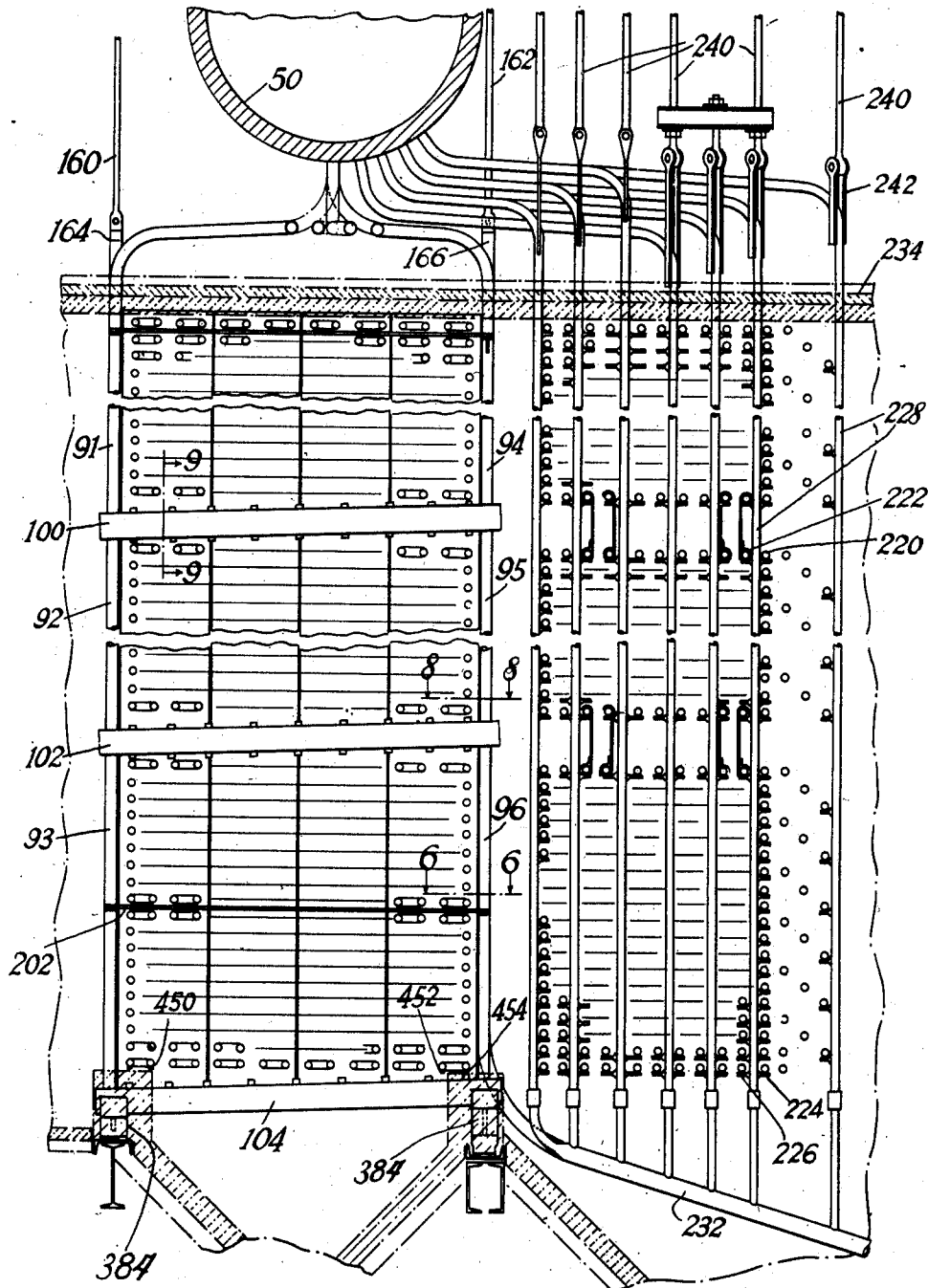


Fig. 5

INVENTORS
Thomas C. Toomey &
Joseph G. Brandt
BY *Barry R. Skacel*
ATTORNEY.

Aug 31, 1943.

T. C. TOOMEY ET AL

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Fig. 9

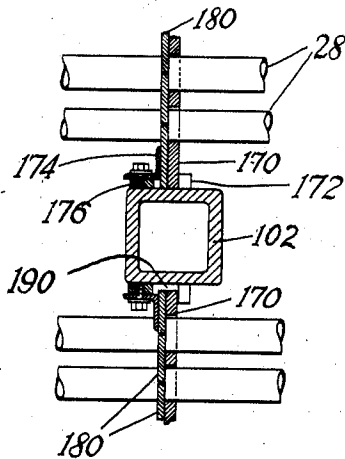


Fig. 8

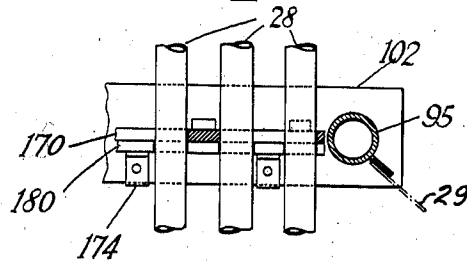


Fig. 6

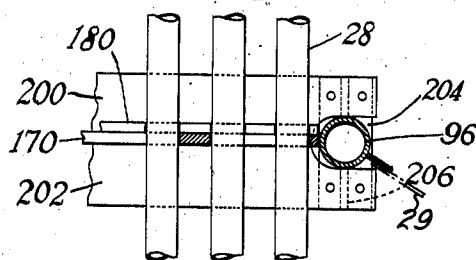


Fig. 11

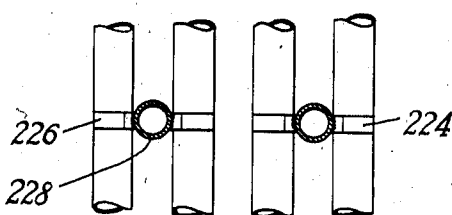


Fig. 10

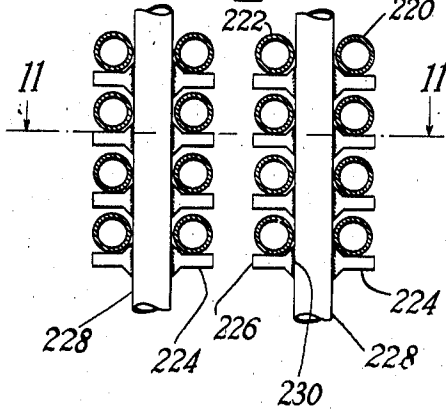
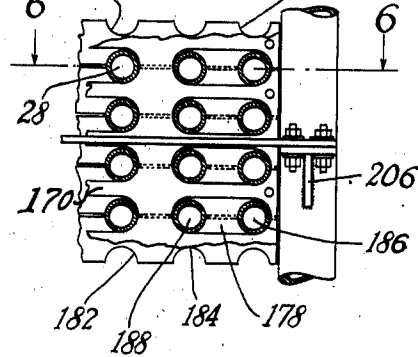


Fig. 7



INVENTORS
Thomas C. Toomey &
Joseph G. Brandt
BY *Paul R. Hancock*
ATTORNEY.

Aug. 31, 1943.

T. C. TOOMEY ET AL

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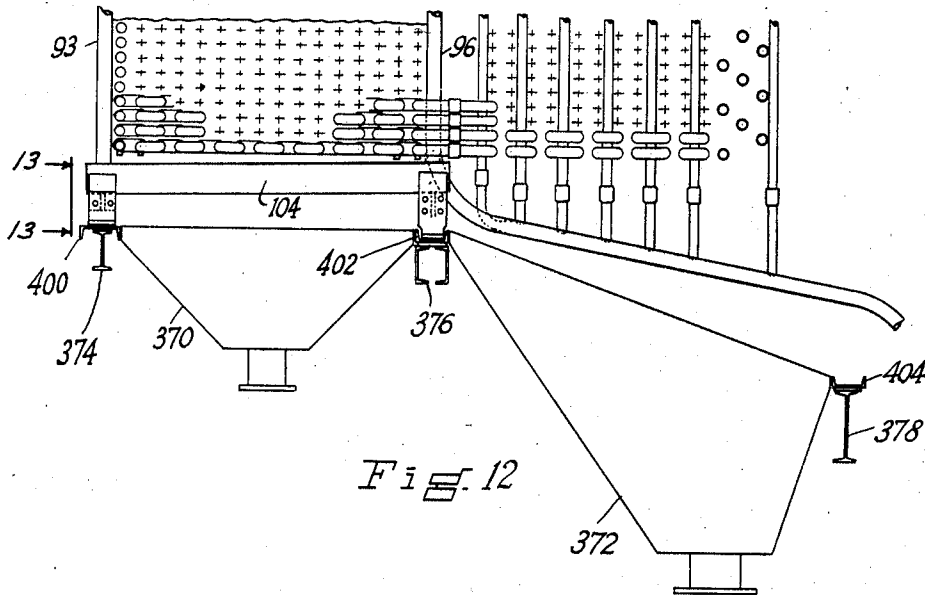


Fig. 12

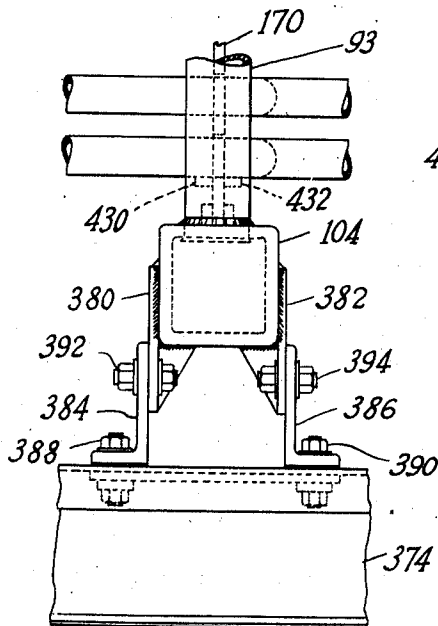


Fig. 13

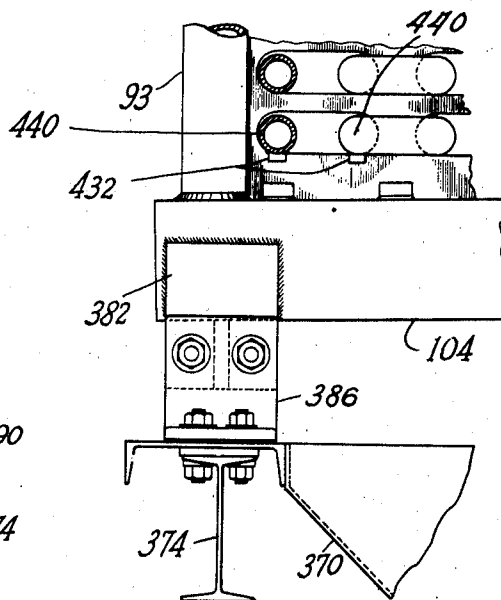


Fig. 14

INVENTORS
Thomas C. Toomey &
Joseph G. Brandt
BY *Ray. R. K. K. K.*
ATTORNEY.

Aug. 31, 1943.

T. C. TOOMEY ET AL

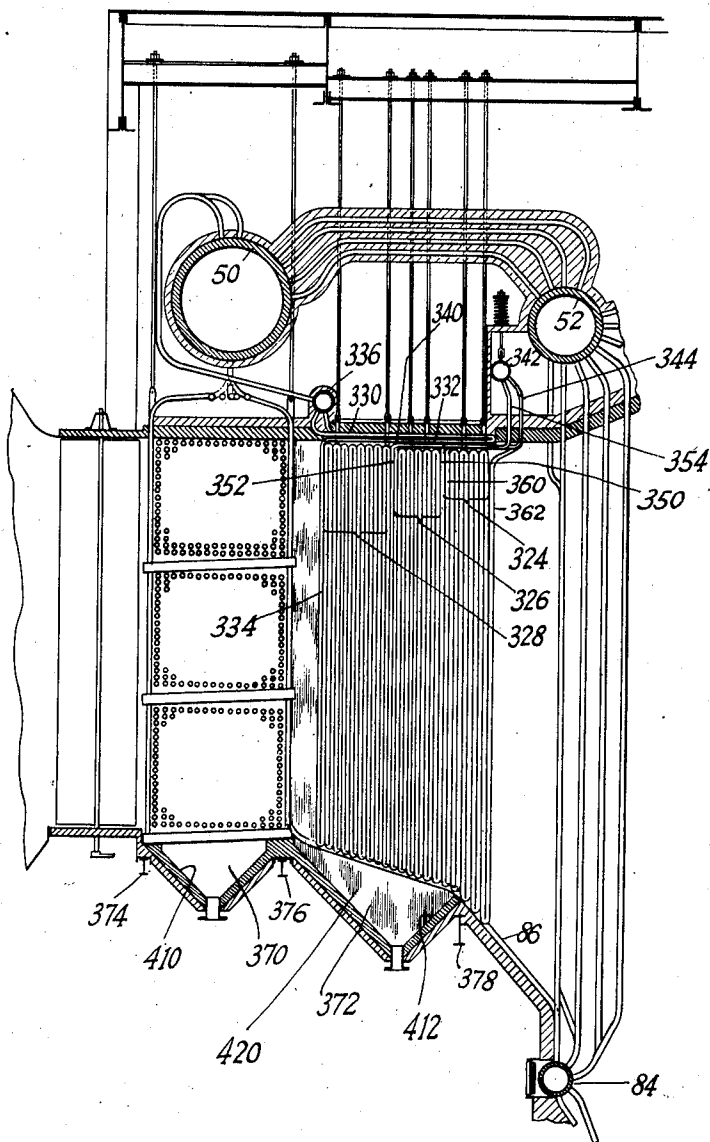
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STEAM GENERATOR

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Fig. 15



INVENTORS
Thomas C. Toomey &
Joseph G. Brandt
BY *Ray R. Kautz*
ATTORNEY.

UNITED STATES PATENT OFFICE

2,328,039

STEAM GENERATOR

Thomas C. Toomey, West New Brighton, Staten Island, N. Y., and Joseph G. Brandt, Westfield, N. J., assignors to The Babcock & Wilcox Company, Newark, N. J., a corporation of New Jersey

Application April 30, 1938, Serial No. 205,156

4 Claims. (Cl. 257-230)

This invention relates to cross flow economizers, and it is more particularly concerned with such an economizer associated with, and acting as an integral part of, a high pressure steam generating installation.

The illustrative cross flow economizer involves a bank of spaced tubes some of which are connected for series flow of water therethrough in counter-flow relation to the flow of a heating medium passing over the tubes. These series connected tubes preferably form flat coils which are horizontally arranged. Effective heat transfer is thereby attained, rapidly and facility of erection is promoted, and the cost of maintenance is decreased.

The invention also relates particularly to fluid heat exchange apparatus involving a novel manner of supporting an economizer heat absorbing unit and a novel casing construction for such a unit. The invention provides for such a wide range of expansion as occurs in high pressure steam boilers and it does this while providing a type of enclosure which is particularly effective in so far as gas tightness is concerned. This is of particular advantage because of the high draft conditions existing in the economizer zones of such apparatus.

The invention is also particularly directed to a new type of support for a high pressure economizer which includes flat coils with the water entering the coils at one side of the economizer and flowing horizontally through the coils. The temperature and expansion conditions of such an economizer result in problems which are quite distinct from economizer constructions of other types.

The invention will be described with reference to the accompanying drawings which illustrate an embodiment of the invention.

In the drawings:

Fig. 1 is a vertical side view section of a high capacity radiant boiler having the illustrative economizer co-ordinated therewith.

Fig. 2 is a horizontal section on the line 2-2 of Fig. 1, particularly illustrating the arrangement of the economizer coils with reference to the superheater which is also part of the steam generating installation.

Fig. 3 is a view in the nature of a vertical section taken on the line 3-3 of Fig. 2 and showing the relationship of the main economizer section to the auxiliary section which is disposed within the superheater bypass.

Fig. 4 is a diagrammatic view in the nature of a plan looking down upon the top of the installa-

tion and indicating the relative positions of water connections to the rear drum.

Fig. 5 is a vertical section of a part of the installation indicated in Fig. 3 of the drawings, on an enlarged scale.

Fig. 6 is a detail view in the nature of a sectional plan along the line 6-6 of Figs. 5 and 7. This view shows the relationship of adjacent tubes of a single horizontal economizer coil to the upright fluid cooled economizer supports, and the interposed spacers which maintain the economizer tubes in their operative relationships.

Fig. 7 is a detail view in the nature of a vertical section showing other relationships of the components of the structure indicated in Fig. 6 of the drawings.

Fig. 8 is a detail view somewhat similar to Fig. 6 but showing a modified construction for locating and fixing the spacers for the economizer tubes.

Fig. 9 is a detail view mainly in the nature of a vertical section showing one of the fluid cooled beams for supporting the economizer and indicating more clearly the relationship of the supports shown in Fig. 8 of the drawings.

Fig. 10 is a detail view in the nature of a vertical section showing the manner of sustaining the tubes or coils of the auxiliary economizer section by means of fluid cooled supports.

Fig. 11 is a detail section in the nature of a horizontal section taken on the plane of the line 11-11 of Fig. 10.

Fig. 12 is a partial view in the nature of a side elevation showing the arrangement of dust hoppers below the economizer and indicating the arrangement of the economizer coils. This view is intended to illustrate the manner in which the dust hoppers are suspended by the economizer supports and arranged beneath the economizer coils.

Fig. 13 is a partial side elevation of a part of the combination shown in Fig. 12, this view being taken in the direction of the arrow 13 in Fig. 12 and showing particularly the manner in which the dust hopper supporting beam is secured to the lower cross headers of the economizer.

Fig. 14 is a detail view of the elements shown in Fig. 13. This figure is in the nature of a side elevation taken at right angles to Fig. 13.

Fig. 15 is a view in the nature of a vertical section taken at the position indicated by the line 15-15 of Fig. 2 and looking in the direction of the arrows. This view is intended to show more particularly the arrangement of the superheater

coils which form the "tube-to-tube" wall between the superheater and the gas passage 24 by which the furnace gases may be by-passed around the superheater.

The particular steam generating installation of which the illustrative economizer is a co-ordinated component is one which has a maximum continuous capacity of over 600,000 lbs. of steam per hour. Its operative steam pressure is in excess of 1400 pounds per square inch and total steam temperature is in excess of 900° F. This installation is the radiant boiler indicated in Fig. 1 of the drawings. It involves a primary furnace stage of which the high temperature furnace section 10 operates at temperatures in the range of 2200 to 3000° F. This primary furnace stage is a combustion chamber with which the fuel burners 12 and 14 are associated.

The furnace gases pass from the primary furnace stage of the radiant boiler, through the gas outlet 16, and into the secondary furnace stage which is illustrated as including a large volume gas cooling chamber 18 having fluid cooled walls formed by upright tubes connected into the boiler circulation. The second stage of the furnace action takes place in the chamber 18 and the furnace gases flow horizontally from the upper portion of the second furnace stage across the upright slag screen tubes 20 and thence into contact with the upright tubes of the high temperature superheater 22.

At one side of the superheater 22 there is a gas by-pass 24 separated by a baffle or partition wall 26 from the gas chamber in which the superheater is located. As indicated in Fig. 2 of the drawings, this baffle preferably extends rearwardly of the superheater and across the tubes 28 to the main section 30 of the economizer. At the position of the economizer tubes 28 the baffle is formed by spacers and flame plates between the spaced headers 122 arranged in an upright row. Thus, two flow paths for the furnace gases are provided, and, by the operation of the flow regulators 32 and 34 at the outlet of the by-pass 24, gas flow over the superheater and parts of the economizer is regulated in the interest of temperature control. Other flow regulators 36 and 38 are provided at the outlet of the main gas flow across the superheater tubes and the major portions of the tubes of the main economizer section. This arrangement of elements is particularly illustrated in Fig. 2 of the drawings.

The flow of the furnace gases in the illustrative installation (including superheater and economizer surface) is largely horizontal, the gases passing in a generally horizontal direction between the pendant superheater loops and over and around the tube sections of the horizontal and flat economizer coils indicated in Figs. 1, 2, and 5 of the drawings.

Feed water is supplied to the upright header 40 (see Fig. 2) from which it passes in parallel through a plurality of superposed horizontal coils 28 of the main economizer section and flows generally in counter-current relation to the flow of the furnace gases over the tubes of the coils. From the main economizer section the coils 28 discharge at successive levels into the short coils 44 of the auxiliary economizer section. The latter coils discharge at successive levels into the upright economizer outlet header 46 which is connected by the tube section 48 (see Fig. 4) to the water space of the main steam and water drum 50. Each coil 28 is preferably

welded to one of the coils 44 and this operation is done in the field, one of the welded junctions being shown at 42.

Communication between the water space of the drum 50 and the auxiliary drum 52 is maintained by the downtake connections 54 and 56, shown in Fig. 3. Water from the two drums 50 and 52 passes through the downtake 54 and 56 to the water wall inlet headers at the lower part of the installation. Some of these headers are indicated at 57-61, inclusive, in Fig. 1 of the drawings. They are in communication with upright water wall tubes which define the primary and secondary furnace stages. Water, together with steam formed in these tubes rises therethrough and passes to the auxiliary drum 52 through upper headers somewhat corresponding in number to the number of the lower headers. Some of these headers are indicated at 64 and 66 in Fig. 1. The headers 66 are connected to the drum 52 by the risers 68, and wall suspending circulators 70 direct steam and water from the headers 64 upwardly to one of the drums. Steam discharging into the drum 52 is separated from the accompanying water to some extent in that drum and then passes through the horizontal circulators 72 and 74 to the steam space of the drum 50.

Water, mixed with steam which is formed in the furnace wall tubes 80 and 82 passes upwardly therethrough to the suspension header 84, and thence through the upright slag screen tubes 20 to the water space of the drum 52. The circulating tubes 35, connected to the drum 50, are arranged at positions adjacent the lower ends of the loops of the tubes of the superheater 22 and may be provided with welded lugs connected to said loops in order to maintain the latter in their operative relationships.

The economizer shown in the drawings, disposed rearwardly of the superheater 22, may be said to be of the type having stacks of horizontally extending flat coils disposed one above the other. These coils are held in their operative positions by upright support tubes 91-96, inclusive (Fig. 1), and they are connected by the cross headers 100, 102, and 104. They are also in communication with the water space of the drum 50 in order that a cooling circulation may be maintained through the headers 100-104 which act as fluid cooled beams supporting the groups of economizer coils 110, 112, and 116. Circulation through these headers and the connected tubes 91-96 is promoted by positioning the headers 100-104 at slight inclinations. They are shown in Fig. 1 as being inclined upwardly toward the support tubes 94-96.

It is to be understood that there are a plurality of such economizer supporting structures at spaced intervals lengthwise of the economizer coils 28. This is indicated in Fig. 2 of the drawings, in which lower headers 120, 122, and 124, similar to the header 104, are shown.

Fig. 4 of the drawings indicates the manner in which the upper sections of the economizer supporting tubes are connected with the drum 50. The upright portion of the circulator 94 is bent so that it extends transversely of the drum and underneath the latter, as indicated by the dotted lines 120. Extending to the opposite side of the drum, this circulator is again bent so as to form the longitudinally extending section 132 which is connected to the drum at 134. The vertical portion of the circulator section 91 is bent so that it extends underneath the drum and longitudi-

nally thereof as indicated by the dotted lines 136. This portion extends to the position indicated at 138 where the circulator is connected to the water space of the drum. Similarly, the upright circulator section 140 is bent transversely of the drum and underneath the latter, as indicated by the dotted lines 142. It extends longitudinally of the drum, as indicated at 144, to a position at 146 at which it is connected to the drum. The opposite upright circulator section 148 has the longitudinal portion 150 extending to the position indicated at 152 wherein it is connected to the water space of the drum. Such connections have advantages in connection with the erection of the boiler and they prevent relative expansions and contractions caused by various temperature differences from loosening tube seats. They also provide the desired flexibility necessary to permit operation without undue strains on tubes or joints.

When the steam generator is operating at a pressure of 1400 lbs. per square inch, the saturated temperature is 588° F. Considering room temperature as being 80° F., then the change from room temperature to saturated temperature is 508° F. With such a temperature range, and taking the linear coefficient of expansion of the metal of the tubes as 0.0464' per ft., the expansion of a 32 foot length of the tubes or tube sections would be approximately 1.48'. This illustrates the degree of expansion to be provided for in the construction when the water in the economizer goes to steaming temperature.

The remaining tubular support sections indicated in Fig. 4 at 160-163, inclusive, have connections with the water space of the drum 50 similar to those above described. They are oppositely arranged with reference to the ends of the drum 50, but, in other respects, they are connections of the same type, and have similar advantages.

The circulator sections 91 and 94 are, as shown in Figs. 1 and 5 of the drawings, pendantly supported by hangers such as those indicated at 160 and 162. These hangers are fixed at their upper ends to steelwork along which there is a common datum line support for all of the pressure parts of the installation. The hangers are attached at their lower ends to lugs 164 and 166 welded to the sections 91 and 94 at the ends of their vertical portions. Similar arrangements are provided for pendantly supporting all of the circulator sections, and the entire economizer including all of the fluid cooled cross headers and the various stacks of horizontal flat coils, are thus pendantly supported so that the entire structure is free to expand downwardly. Temperature created stresses are thus maintained at a minimum.

The structures for maintaining the economizer coils 28 in their operative relationships are more clearly indicated in Figs. 5-9, inclusive, of the drawings. They include heavy vertically arranged support plates one of which is indicated at 170 in Fig. 9. This plate is generally of rectangular outline and is seated upon the upper surface of the header 102. It is arranged longitudinally of the header and held in its operative relation to the header by a row of spaced lugs 172 and an angle 174 fixed to the header 102 by the studs 176. Each plate 170 is provided with openings such as those indicated at 178 in Fig. 7. These are of such shape and size that they will readily receive the loops of the economizer coils in order that the latter may be freely moved into

their operative positions from one side of the installation.

Secured to the plates 170, constituting a part of the baffle 26, are tube seal strips 180, the upper and lower edges of which are provided with semi-circular recesses such as those indicated at 182 and 184 in Fig. 7. The individual tube sections 186 and 188 of the economizer coils are received in these recesses in such a way that they are adequately maintained in their predetermined spaced relationships and, in such a way that the bypass 24 is adequately separated from the superheater gas pass. Along the upper surface of the header 102 (see Fig. 9), one of the strips 180 is shown as being interposed relative to the angle 174 and the plate 170, there being a similar relationship of elements along the lower surface of the header for maintaining the lower plate 170 and its associated seal strips 180 in their operative relationships, the only difference being that the top of the plate 170 is spaced from the lower surface of the header, as indicated at 190, to provide for expansion.

The economizer part 27 of the baffle 26 is formed by the plates 170 and strips 180 just described, and this baffle part or section is joined with the remainder of the baffle 26 by the oblique plate 29.

Approximately halfway between such superposed headers as those indicated at 102 and 104 in Fig. 5, there are parallel re-inforcing plates 200 and 202. They fit closely against the opposite sides of the vertical plates 170 and are rigidly secured in such positions by means of brackets, such as those indicated at 204 and 206 in Figs. 6 and 7 of the drawings. These brackets are preferably welded to the upright circulator sections, such as the section 96.

The manner in which the coils 44 of the auxiliary economizer section are supported is clearly indicated in Figs. 5, 10, and 11 of the drawings. Referring to the latter figure, the individual tube sections, such as those indicated at 220 and 222, rest upon metallic lugs 224 and 226 which are arranged upon opposite sides of the upright circulators 228. These lugs preferably have enlarged portions at their circulator ends, as indicated at 230, and these portions are welded to the circulators.

Several of the circulators 228 are indicated in Fig. 5 as being connected at their lower ends to a large diameter tube 232 which is inclined upwardly and preferably connected at its lower end to the header 84. The upper ends of the circulators 228 extend through the casing top 234 and are individually connected to the water space of the drum 50. The load of these circulators and the economizer coils supported thereby is taken by hangers 240 secured to the common datum line steelwork at their upper ends and having their lower ends attached to hanger straps 242. The latter are welded to the circulators at the uppermost parts of their vertical portions, as clearly shown in Fig. 5.

The circulators 228 are so arranged with reference to the economizer coils 44 that the latter may be moved endwise into their operative relationships and the removable section of the casing 250 thereafter placed in position, this mode of procedure being reversed when it is desired to remove one of the coils from the installation for the purpose of repair or replacement. The same mode of procedure holds true for the main economizer coils 28, any one of which may be removed independently of the other coils after being dis-

connected from its header 40 and junction 42, the removal of the contacting spacer strips 180, and after the removal of the casing section 252.

It will appear from the above description that the installation involves horizontal flat economizer coils extending across a horizontal gas pass as a bank of tubes. In installations of such high capacity and high pressure as the present one, the economizer coils are of considerable length and weight, and special attention must be given to their support in order that there may be adequate strength and safety factors. The supports must also allow adequate freedom of expansion and they must facilitate removal of the flat coils and the replacement thereof during the life of the installation. The economizer supports must also have certain flexibility characteristics as to their connections with the steam and water drum disposed above the economizer and for connection with inlet and outlet headers.

The economizer cross headers 100-104, supported by the hanger circulators 91-96, illustrate the method of constructing the economizer in gas zones in which the temperature is not excessively high. These cross headers are arranged transversely of the horizontal economizer tubes and are located at spaced positions under the bottom of each tube bank provided by the economizer tubes. The hanger circulators are supported by tie rods from structural steel at high levels, preferably the same steel that carries the drum suspension rods 304-308. Water circulates through the cross headers to and from the circulatory system of the boiler to limit the stressed metal temperatures to safe values in spite of the high temperatures of the gases, and when it is considered that the economizer has a total weight in excess of 100 tons, it will be appreciated that the fluid cooled beams formed by the cross headers must have adequate strength characteristics and that those characteristics must be maintained at the high temperatures involved.

Each of the horizontally arranged flat coils of the economizer is formed of straight tube sections connected in series by multiple return bends, and each coil is independently supported by vertically disposed plates transversely arranged with reference to the straight tubes of the economizer coils and supported by the water cooled beams or cross headers. These plates have spaced slots formed therein so that one return bend may pass through each slot for endwise removal or insertion of the economizer coils. These vertically extending plates may be sectioned to facilitate manufacture and erection.

When tubes of the flat economizer coils are positioned in gas zones of temperatures so high as to impose the possibility of overheating the water cooled beams formed by cross headers, or to cause leaks at the tube seats in those headers by unequal metal expansion, or where the gases are at temperatures too high for the use of the vertical plates above referred to, I employ the construction illustrated at the right-hand part of Fig. 5 of the drawings. The economizer coils are here supported by the vertical circulators or hanger tubes 228 provided with the short bracket lugs 224. The latter are welded to the water cooled suspension tubes, preferably one of the lugs being provided for each straight tube section of the horizontal economizer coils. By making these bracket lugs short and thick enough, their temperature will be kept to a safe low value by the transfer of heat to the water tubes to

which they are welded. In the arrangement shown, a large number of the suspension tubes 228 are used, the tubes being preferably arranged in rows, in the direction of gas flow.

The illustrative manner of supporting the economizer tubes individually on vertically suspended water tubes, or as a bank with cross beams provided beneath the economizer coils, makes the economizer as an entirety independent of the casing of the horizontal gas pass, so far as relative expansion and supports are concerned, and any desired form of casing may be used.

To eliminate objectionable stresses and excessive loads, the predominant portion of all of the fluid heat exchange surfaces of the installation indicated in Fig. 1 of the drawings, or substantially all of the elements providing the heating surfaces, are preferably pendantly supported from the steelwork of the boiler setting at substantially a common level which may be considered as indicated by the common datum line AB, appearing in Fig. 1 of the drawings. This entire arrangement permits the fluid circulating parts of the installation to freely expand downwardly from positions substantially at a single level as the temperatures of the different components of the system change.

The floor of the combustion chamber of the primary furnace stage 10 is defined by floor tubes 320 connected at their opposite ends to the headers 59 and 61. This floor, as well as the remaining walls of this stage, may be of refractory and stud tube construction, and the division wall defined by the tubes 82 may be of the same construction. Above the gas outlet 16, this division wall is preferably closed, and the parts of the tubes 82 extending across the outlet 16 preferably have ceramic refractory material mechanically and thermally maintained thereon by metallic studs welded to the tubes.

The floor of the primary stage 10 preferably has a continuous slope or inclination toward an ash pit or hopper 322. With this construction, and under the high temperatures involved in the operation of the illustrated installation, molten slag deposited on the furnace floor as a result of the burning of pulverized fuel in the furnace, will be maintained in such a state that it flows toward the hopper 322.

The tubes 22 may be provided with a ceramic refractory and stud tube construction along their sides facing the primary furnace stage while the opposite sides of the division wall defined by these tubes may present bare metal surfaces of the tubes to the heat of the furnace gases in the second stage 18. Alternatively, metallic blocks secured in good heat exchange relationship with the tubes 82 may form the surface of the division wall presented toward the secondary stage 18. Preferably the upright tubes defining the walls of the secondary furnace stage 18 present bare metal tube surfaces toward the furnace gases with the exception of the zone at the lower part of the second stage 18 in which the wall surfaces of this stage may be provided by metallic blocks such as those which are indicated at 326 along the lower parts of the tubes 328.

That part of the baffle construction separating the superheater bypass 24 from the superheater is shown in Fig. 5 as consisting of vertically extending superheater coils. The upright tubular elements of these coils are substantially in contact so as to form a substantially complete baffle. Furthermore, the baffle formed by the super-

heater tubes consists of three separate coils. These are indicated at 324, 326, and 328 in Fig. 15. Steam flows from the superheater inlet header 336 through the horizontal tube sections 330 and 332 and then downwardly through the first upright tube section 334 of the superheater coil 328 and then through the succeeding vertical tubes of this coil to the outlet tube 340. This tube is connected to the superheater outlet header 342 by an upright tube section 344. Thus, the flow of steam through the coil 328 is counter-flow with respect to the furnace gases.

In the intermediate superheater coil 326 the flow of steam is, in general, parallel with respect to gas flow, the steam entering this coil through the tube 350 which is connected with the inlet header 336, and passing from this coil through the tube 352 which has an upright portion 354 connected to the outlet header 342.

Steam enters the superheater coil 324 through the tube 360 and is discharged from that coil through the tube 362 which is directly connected to the outlet header 342. Thus, the flow of steam through this superheater coil is, in general, counter-flow with respect to gas flow.

Under some conditions of operation, the superheater tubes forming part of the baffle 26 are subjected to heat transfer rates much greater than the tubes 22 of the remainder of the superheater, and, where the tubes form such a "tube-to-tube" baffle as shown in Fig. 15, the tubes of this baffle would be apt to be damaged as a result of overheating if all of the baffle-forming tubes were presented by one coil. One reason for such damage would be the low velocity of the steam through such a coil and the lack of uniformity of steam distribution from the superheater inlet header to this coil and the other superheater coils. By using the three separate coils 324, 326, and 328 to form the superheater part of the baffle 26, a greater steam velocity is maintained in each of these coils and these tubes are thereby prevented from being damaged. The velocity of steam in these coils may be even greater than the velocity in the main superheater coils 22 if the three baffle coils are each constructed and arranged so that its total length is less than one of the main superheater coils 22.

The lower return bends, or loops of the superheater baffle coils 324, 326, and 328 may be secured to one of the circulators 86, and at spaced positions throughout the height of these coils the tubes may be provided with inter-engaging lugs for maintaining the tubes in their baffle-forming alignment.

Fig. 15 also indicates dust hoppers 370 and 372 beneath the economizer and the superheater bypass respectively. A row of the hoppers 370 are carried by the beams 374 and 376 beneath the economizer and, similarly, a row of the hoppers 372 may be carried by the beams 376 and 378 beneath the superheater. All of these hoppers are preferably suspended with the described pressure parts, in the manner indicated in Figs. 12, 13, and 14.

The beams 374 and 376 extend beneath, and transversely of, the lower economizer cross headers, one of which is shown in Fig. 12 at 104. These beams are secured to the cross headers by means of lugs 380 and 382 which are illustrated in Fig. 13 as welded to the opposite sides of the header 104. Beneath the lugs, brackets 384 and 386 are arranged. They are secured to the beam 374 by bolts 388 and 390, and, at their upper ends, they are similarly secured to the downwardly

projecting lugs 380 and 382. For structural purposes, and for facilitating erection, slots may be provided in the lower ends of the lugs 380 and 382 or in the upper ends of the brackets 384 and 386 to receive the connecting bolts 392 and 394. The beam 376 is similarly secured at the opposite ends of the lower economizer headers, and between the channels 400 and 402, forming parts of the beams 374 and 376 respectively, the hoppers 370 are secured.

The hoppers 372 are similarly secured to the opposite side of the channel 402 and to the flange of a channel 404 constituting a part of the beam 378.

The hoppers 370 and 372 may be lined with refractory material as indicated at 410 and 412, and one of the hoppers 372 may have an upright baffle wall 420 arranged therein to form an extension of the wall or baffle construction separating the superheater bypass 24 from the main superheater pass.

Figs. 5, 13, and 14 also indicate metal lugs 430 and 432 arranged on opposite sides of the plates 170 and welded to the outer tube sections 440 of the lower economizer coils. These lugs are provided so that the plates 170 and the supporting headers may be maintained in their proper operating relationship during temperature changes incident to the normal use of the installation. Other economizer coil tube sections 450, 452, and 454 (see Fig. 5) are similarly provided with similarly arranged lugs.

Subject matter relating to the economizer construction and arrangement relative to gas flow, shown herein but not claimed, is being claimed in our divisional application #464,606, filed November 5, 1942.

What is claimed is:

1. In an economizer, spaced straight economizer tubes arranged in horizontal rows disposed at successively higher levels, the tubes of each row being serially connected so as to constitute a flat coil, and means including fluid cooled suspension tubes supporting said coils at points intermediate the ends of the straight tubes, the suspension tubes being disposed exteriorly of the removal path of each coil and having secured thereto coil engaging supports so that each coil is supported independently of other coils for the independent withdrawal thereof horizontally endwise.

2. In an economizer, spaced straight economizer tubes arranged in horizontal rows disposed at successively higher levels, the tubes of each row being serially connected by multiple return bends so as to constitute a separate horizontally arranged flat coil, means including fluid cooled suspension tubes carrying coil supports taking the load of said coils at points intermediate the ends of the straight tubes, each coil being supported independently of other coils for the independent withdrawal thereof horizontally endwise, the suspension tubes being disposed exteriorly of the removal paths of the coils, and a casing including a section which is independently removable so as to permit said independent withdrawal, said casing section being located at the side of the economizer adjacent the inlet and outlet ends of the flat coils.

3. In an economizer, spaced tubes serially connected to form U-tube sections and extending transversely of the path of furnace gases, said spaced tubes being arranged in a plurality of banks, substantially horizontally arranged headers extending beneath said banks so as to act

as load-carrying supports therefor, upright circulating connectors whereby the said headers are connected into boiler circulation, vertically arranged and fixed plates supported by said headers and having slots of such shape that the economizer U-tube sections may be moved therethrough into or from their operative positions, and economizer tube spacer strips provided with spaced recesses for receiving the economizer U-tube sections, said spacer strips being removably secured in operative relation to said plates so as to co-act with the slots in the plates to maintain the economizer tubes in their operative positions while permitting withdrawal of individual groups of said tubes by the removal of the spacer strips contacting with the tubes of the group or groups to be removed.

4. In an economizer, spaced tubes serially connected and extending transversely of the path of furnace gases, adjacent tubes being connected by

return bends, load-carrying supports for said tubes, said supports including fixed plates disposed normally to the longitudinal axes of said tubes and having slots therein through which the economizer tubes with their return bends may be moved into or withdrawn from their operative positions, and economizer tube spacer strips provided with spaced tube fitting recesses between which there are slot closing parts, said recesses receiving the economizer tubes, said spacer strips being removably secured in operative relation to said plates so as to co-act with the slots in the plates to maintain the economizer tubes in their operative positions while permitting withdrawal of individual groups of said tubes by the removal of the spacer strips contacting with the tubes of the group or groups to be removed.

THOMAS C. TOOMEY,
JOSEPH G. BRANDT.