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(54) **A FIN FOR A BOILER TUBE ARRANGEMENT AND AN ASSEMBLY COMPRISING SUCH A FIN**

(57) A fin (4, 4a, 4b, 4c, 4d) for a boiler tube arrangement comprising a number of boiler tubes (34, 36, 38, 40) extending along each other, and an assembly (32) comprising such a boiler tube arrangement and such a fin, are provided. A longitudinal center axis (C) of the fin is arranged to extend perpendicular to a length of the boiler tubes, and the fin comprises an inner edge (8) and an outer edge (10). The fin is characterized in that a contour of the inner edge is essentially identical to a contour of the outer edge. Each of the contours of the inner and outer edges definies a number of ridges (16, 18, 20, 26, 28, 30) and a number of valleys (12, 14, 22, 24), which ridges and valleys are alternately arranged and connected to each other at transitions (P, P') being half way between a highest point (H, H') and a lowest point (L, L') of the connected ridge and valley, respectively. The valleys defined by the inner edge are each arranged to receive, and only partly enclose, a respective one of the boiler tubes.

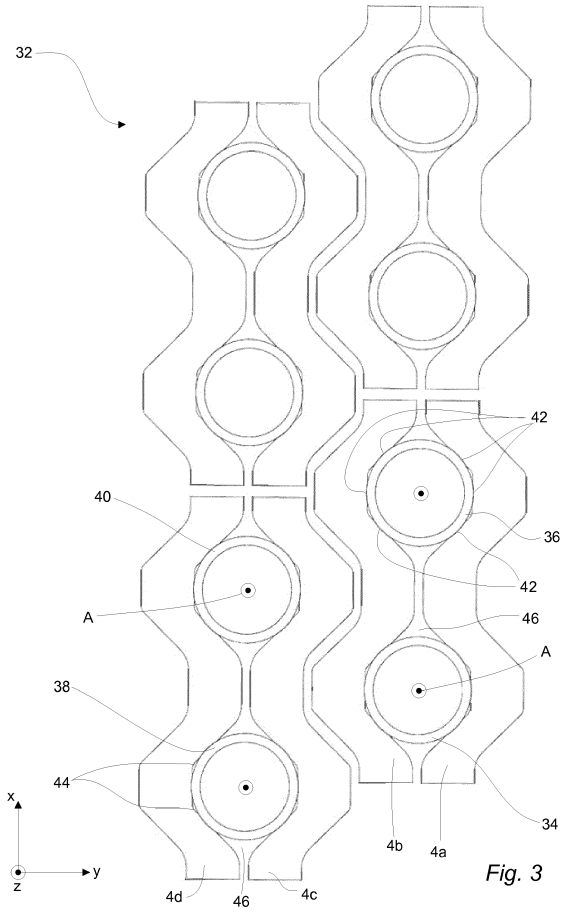

Fig. 3

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Description

Technical field

[0001] The invention relates to a fin for a boiler tube arrangement comprising a number of boiler tubes extending along each other, which fin is arranged to extend perpendicular to a length of the boiler tubes. The invention also relates to an assembly comprising two such fins and a boiler tube arrangement including a first boiler tube.

Background art

[0002] Boilers are well-known and used in many different heat exchange applications, for example in waste heat recovery applications. A known waste heat recovery boiler, used after e.g. a diesel engine to recover heat from the exhaust gases from the diesel engine, comprises a closed vessel and a number of tubes extending along each other inside the vessel. A medium, such as water, is fed through the tubes, and exhaust gas from the diesel engine is fed through the vessel and thus around the tubes, whereby heat is transferred from the exhaust gas to the medium inside the tubes. To increase the heat transfer efficiency of the boiler, the tubes may be provided with surface enlarging elements in the form of fins attached to the tubes. Typically, the fins are formed as rectangular plates provided with voids for receiving the tubes. Even if such fins are widely used and fill their desired purpose, there is still room for improvements.

Summary

[0003] An object of the present invention is to provide a fin for a boiler tube arrangement which is improved as compared to prior art fins. The basic concept of the invention is to provide a fin with a unique, advantageous shape enabling all parts of the fin to contribute considerably to increased heat transfer efficiency, and enabling manufacturing of fins with little waste or scrap. Another object of the present invention is to provide an improved assembly comprising such fins and a boiler tube arrangement. The fin and the assembly for achieving the objects above are defined in the appended claims and discussed below.

[0004] A fin according to the present invention is for a boiler tube arrangement comprising a number of boiler tubes extending along each other. A longitudinal center axis of the fin is arranged to extend perpendicular to a length of the boiler tubes, and the fin comprises an inner edge and an outer edge. The fin is characterized in that a contour of the inner edge is essentially identical to a contour of the outer edge, each of the contours of the inner and outer edges defining a number of ridges and a number of valleys. The ridges and valleys are alternately arranged and connected to each other at transitions being half way between a highest point and a lowest point of the connected ridge and valley, respectively. The valleys defined by the inner edge are each arranged to receive, and only partly enclose, a respective one of the boiler tubes.

[0005] The expressions "ridges" and "valleys" are used herein to specify the shape of the fin with reference to longitudinal axes of the fin extending between the ridges and valleys of the inner and outer edges when the fin has a certain orientation. Naturally, if the fin is turned up-side-down, the valleys are in fact ridges, while the ridges, in fact, are valleys. However, throughout the text, what is defined as a valley and a ridge of the fin when this has said certain orientation will be referred to as a valley and a ridge irrespective of the orientation of the fin.

[0006] The number of boiler tubes of the boiler tube arrangement can be one or more. Further, the number of valleys defined by each of the inner and outer edges can be one or more. Similarly, the number of ridges defined by each of the inner and outer edges can be one or more.

[0007] As mentioned above the fin has an extension perpendicular to a length of the boiler tubes. Naturally, the fin could be arranged to extend obliquely to the length of the boiler tubes, i.e. to have an extension both perpendicular to, and along, the length of the boiler tubes.

[0008] Because of the essentially identical inner and outer fin edges, the ridges defined by the inner fin edge fit into, and fill out, the ridges defined by the outer fin edge, while the valleys defined by the outer fin edge fits into, and fill out, the valleys defined by the inner fin edge. In other words, two similar fins fit into each other when the inner edge of one of the fins faces the outer edge of the other one of the fins. Thus, a plurality of fins according to the present invention can be manufactured in a very material efficient way by being cut out of a sheet, typically a metal sheet, with minimal waste. By essentially identical is meant that the inner and outer edges need not be 100% identical but similar enough such as to enable fin interfitting. Thus, for example, an inner fin edge having a small recess or similar is essentially identical with an outer fin edge lacking such a recess.

[0009] Portions of the fin more distant to the tube will contribute less to the heat transfer than portions of the fin more closer to the tube. Because of the fin according to the invention having a wave shape instead of the conventional shape of a rectangle provided with a tube receiving void, the extension of the fin may be adapted to a distance from the tube such that all portions of the fin may contribute considerably to the heat transfer. Consequently, the fin can be made less material consuming, and thus lighter, and more compact, and it may still contribute considerably to the heat transfer.

[0010] The valleys may be non-uniform with, i.e. have a different shape than, the ridges. In other words, the valleys may be received in, but will not fill out, the ridges, and vice versa. Consequently, two similar fins do not fit into each other when the outer edge of one of the fins faces the outer edge of the other one of the fins, or the inner edge of one of the fins faces the inner edge of the

other one of the fins. Instead, a distance between the two fins will be varying. This may be advantageous as regards heat transfer efficiency, as will be further discussed below.

[0011] Below, the shape of the fin is discussed with reference primarily to the inner fin edge. However, since the contours of the inner and outer fin edges are essentially identical, the below discussion is at least in part applicable also as regards the outer fin edge.

[0012] The fin may be such that a first one of the valleys defined by the contour of the inner edge, which first valley has a bottom, is arranged between two of the ridges defined by the contour of the inner edge. Further, a second one of the ridges defined by the contour of the inner edge, which second ridge has a top, may be arranged between two of the valleys defined by the contour of the inner edge. Such an embodiment means that the number of valleys, just like the number of ridges, defined by the inner fin edge is at least two.

[0013] A contour of the first valley may be shorter than a contour of the second ridge. This is a straight-forward way of achieving the above mentioned nonuniformity between the valleys and the ridges.

[0014] The fin may be such that the first valley has a symmetry axis extending perpendicular to the longitudinal center axis of the fin. Further, also the second ridge may have a symmetry axis extending perpendicular to the longitudinal center axis of the fin. This may facilitate and provide for an optimized fitting of the respective boiler tube in the first valley.

[0015] The fin may be such that the bottom of the first valley and the top of the second ridge are plane and defined by respective straight portions of the inner edge. These straight portions may, or may not, extend parallel to the longitudinal center axis of the fin. Thereby, if the boiler tubes have a circular cross section, as is conventional, areas of no contact between the fin and the boiler tube(s) may be guaranteed. This may be advantageous as regards cleaning and also heat transfer efficiency, as will be further discussed below.

[0016] A flank connecting the bottom of the first valley and the top of the second ridge may be defined by an at least partly straight portion of the inner edge. This flank forms part of both the first valley and the second ridge. Thereby, if the boiler tubes have a circular cross section, as is conventional, areas of no contact between the fin and the boiler tube(s) may be guaranteed. This may be advantageous as regards cleaning and also heat transfer efficiency, as will be further discussed below.

[0017] An assembly according to the present invention comprises a boiler tube arrangement including a first boiler tube and first and second fins of the type described above. The first and second fins extend perpendicular to a longitudinal center axis of the first boiler tube on opposite sides of the first boiler tube. The inner edge of each of the first and second fins faces, and only partly encloses, the first boiler tube. The first boiler tube is received in a respective one of the valleys defined by the inner edges of the first and second fins.

[0018] Naturally, the first fin and/or the second fin could extend obliquely to the longitudinal center axis of the first boiler tube, i.e. they could have an extension both perpendicular to, and along, the length of the first boiler tube.

[0019] Thus, the inner edges of the first and second fins face each other and enclose together, at least partly, the first boiler tube. The outer edge of one or both of the first and second fins may be arranged to face the outer edge of another adjacent fin, as in the below described embodiment.

[0020] The assembly may be such that the boiler tube arrangement further includes a third boiler tube extending along the first boiler tube and third and fourth fins of the types described above. The third and fourth fins may extend perpendicular to a longitudinal center axis of the third boiler tube on opposite sides of the third boiler tube. The inner edge of each of the third and fourth fins may face, and only partly enclose, the third boiler tube, and the third boiler tube may be received in a respective one of the valleys defined by the inner edges of the third and fourth fins. Further, one of the valleys defined by the outer edge of the third fin may be received in one of the ridges defined by the outer edge of the second fin, and one of the valleys defined by the outer edge of the second fin may be received in one of the ridges defined by the outer edge of the third fin.

[0021] Thus, the wave shape of the fins enables a staggered arrangement of the boiler tubes and a compact assembly since adjacent pairs of fins may be received in each other. The conventional rectangular fins do not enable such a compact assembly.

[0022] The assembly may be such that the second fin partly enclosing the first boiler tube and the third fin partly enclosing the third boiler tube are separated from each other. Thereby, a medium flow between the second and third fins, resulting in increased flow turbulence and thus improved heat transfer, is enabled. Further, such a separation may facilitate cleaning of the fins, e.g. removal of soot deposits from the fins originating from exhaust gas.

[0023] Depending on the design of the second and third fins, the distance between them may vary or be constant along their lengths. According to one embodiment of the invention, a distance between the outer edge of the second fin and the outer edge of the third fin is varying along the outer edges of the second and third fins. Such a distance variation may be achieved with second and third fins as described above, i.e. second and third fins the valleys and ridges of which are non-uniform with each other. The distance variation between the second and third fins may result in an increased flow turbulence and thus improved heat transfer.

[0024] The assembly may be such that the first and seconds fins enclosing the first boiler tube are separated from each other by a predetermined distance. Thereby, the first boiler tube is not completely enclosed by the first and second fins. This enables a medium flow between the first and second fins, resulting in increased flow tur-

bulence and thus improved heat transfer. Further, this may facilitate cleaning of the fins and the first boiler tube.

[0025] According to one embodiment of the assembly, an outer contour of the first boiler tube at the first and second fins, and a space for receiving the first boiler tube between the first and second fins, defined by the inner edges of the first and second fins, are non-uniform, i.e. have different shapes. Thereby, areas of no contact between the first and second fins and the first boiler tube may be guaranteed which may result in increased flow turbulence and thus improved heat transfer, and facilitate cleaning. For example, such nonuniformity may be obtained, as mentioned above, by the first boiler tube having a circular outer contour or cross section, and the space for receiving the first boiler tube being at least partly delimited by straight portions of the inner fin edges.

[0026] The first and second fins may engage with the first boiler tube in engagement points which are separated from each other. Thereby, areas of no contact between the first and second fins and the first boiler tube may be guaranteed which may result in increased flow turbulence and thus improved heat transfer, and facilitate cleaning.

[0027] Of course, the advantages associated with the different embodiments of the fins discussed above are advantageous also for an assembly comprising the fins.

[0028] Still other objectives, features, aspects and advantages of the invention will appear from the following detailed description as well as from the drawings.

Brief description of the drawings

[0029] The invention will now be described in more detail with reference to the appended schematic drawings, in which

Fig. 1 is a top view of a metal sheet for producing fins,
Fig. 2 is a top view of a fin, and
Fig. 3 is a top view of an assembly.

Detailed description

[0030] In Fig. 1 a metal sheet 2 is shown from which four identical fins 4 can be obtained by cutting the sheet along lines 6. The fins obtained are wave-shaped, more particularly, they have a wave-shaped inner edge 8 and a wave-shaped outer edge 10, which inner and outer edges have identical contours. One of the fins is shown separately in Fig. 2 from which it is clear that the inner edge 8 of each fin 4 defines a first valley 12, a second valley 14, a first ridge 16, a second ridge 18 and a third ridge 20. The first valley 12 is arranged between the first and second ridges 16 and 18, the second valley 14 is arranged between the second and third ridges 18 and 20 and the second ridge 18 is arranged between the first and second valleys 12 and 14. A transition P between a ridge and an adjacent valley is half way between a highest point H of the ridge and a lowest point L of the valley. The first and second valleys 12 and 14 are identical and the first and third ridges 16 and 20 are identical to a respective part of the second ridge 18.

[0031] Similarly, the outer edge 10 of each fin 4 defines a first valley 22, a second valley 24, a first ridge 26, a second ridge 28 and a third ridge 30. The first valley 22 is arranged between the first and second ridges 26 and 28, the second valley 24 is arranged between the second and third ridges 28 and 30 and the second ridge 28 is arranged between the first and second valleys 22 and 24. A transition P' between a ridge and an adjacent valley is half way between a highest point H' of the ridge and a lowest point L' of the valley. The first and second valleys 22 and 24 are identical and the first and third ridges 26 and 30 are identical to a respective part of the second ridge 28. Accordingly, since the valleys and ridges of the inner and outer fin edges 8 and 10 are equally deep and high, respectively, the transitions P for the inner edge 8 are arranged along an imaginary straight line I and the transitions P' for the outer edge 10 are arranged along an imaginary straight line I'. A longitudinal center axis C of the fin is arranged half way between the imaginary straight lines I and I'.

[0032] The first valleys 12, 22 and the second valleys 14, 24 each has a symmetry axis S extending perpendicular to the longitudinal center axis C of the fin 4. Similarly, the second ridges 18 and 28 each has a symmetry axis R extending perpendicular to the longitudinal center axis C of the fin 4. Further, the first valleys 12, 22 and the second valleys 14, 24 each have a plane bottom B and B', respectively, extending parallel to the longitudinal center axis C of the fin. Similarly, the first ridges 16, 26, the second ridges 18, 28 and the third ridges 20, 30 each has a plane top T and T', respectively, extending parallel to the longitudinal center axis C of the fin. Moreover, flanks F and F' connecting the tops and bottoms of the ridges and valleys of the inner and outer fin edges each comprises a straight portion.

[0033] As is clear from the figures, the shape of the valleys 12, 14, 22 and 24 is different from the shape of the ridges 16, 18, 20, 26, 28 and 30 in that the ridges are less "sharp" or less "acute" than the valleys, and a contour of the ridges is longer than a contour of the valleys. Accordingly, as an example, an area A1 delimited by the imaginary straight line I' and the contour of the first valley 22 is smaller than an area A2 delimited by the imaginary straight line I' and the contour of the second ridge 28.

[0034] With reference to Fig. 1, the lines 6 each defines the inner edge 8 of one fin 4 and the outer edge 10 of an adjacent fin 4. Since the inner and outer edges 8 and 10 have identical contours, the fins 4 fit perfectly into each other when the inner edge 8 of one fin faces the outer edge 10 of an adjacent fin, the valleys 22 and 24 defined by the outer edge of said adjacent fin are received in the valleys 12 and 14, respectively, defined by the inner edge of said one fin, and the ridges 16, 18 and 20 defined by the inner edge of said one fin are received in the ridges 26, 28 and 30, respectively, defined by the outer edge of

said adjacent fin. Thus, the fins 4 can be cut out of the sheet 2 with a minimum of waste material.

[0035] In Fig. 3 an assembly 32 is shown which comprises a boiler tube arrangement of a number of parallel boiler tubes and the same number of fins 4 of the above described type. The assembly 32 is comprised in a waste heat recovery boiler (not illustrated in its entirety) of the initially described type, whereby water is fed inside the boiler tubes and exhaust gas is fed outside the boiler tubes to transfer heat from the exhaust gas to the water. The boiler tubes are pairwise arranged between two opposing ones of the fins. Thus, first and second boiler tubes 34 and 36, which are separated from each other in an x dimension by a certain distance, are arranged between first and second fins 4a and 4b, and third and fourth boiler tubes 38 and 40, which are separated from each other in the x dimension by said certain distance, are arranged between third and fourth fins 4c and 4d.

[0036] The first and second fins 4a and 4b are thus arranged, aligned with each other in dimensions z and y, on opposite sides of the first and second boiler tubes 34 and 36, with their respective longitudinal center axes C (Fig. 2) extending parallel to each other and perpendicular to longitudinal center axes A of the first and second boiler tubes. Further, the first and second fins 4a and 4b are separated from each other by a predetermined distance in a y dimension and so arranged that their inner edges 8 face each other. The first boiler tube 34 is received in a space defined by the first valley 12 of the first fin 4a and the second valley 14 of the second fin 4b, while the second boiler tube 36 is received in a space defined by the second valley 14 of the first fin 4a and the first valley 12 of the second fin 4b. Thus, the first and second boiler tubes 34 and 36 are partly enclosed by the first and second fins 4a and 4b. Arranged like this, the first and second boiler tubes are welded to the inner edges of the first and second fins 4a and 4b in welding points 42, here six per boiler tube, distributed around the first and second boiler tubes.

[0037] Similarly, the third and fourth fins 4c and 4d are arranged, aligned with each other in dimensions z and y, on opposite sides of the third and fourth boiler tubes 38 and 40, with their respective longitudinal center axes C extending parallel to each other and perpendicular to longitudinal center axes A of the third and fourth boiler tubes. Further, the third and fourth fins 4c and 4d are separated from each other by a predetermined distance in the y dimension and so arranged that their inner edges 8 face each other. The third boiler tube 38 is received in a space defined by the first valley 12 of the third fin 4c and the second valley 14 of the fourth fin 4d, while the fourth boiler tube 40 is received in a space defined by the second valley 14 of the third fin 4c and the first valley 12 of the fourth fin 4d. Thus, the third and fourth boiler tubes 38 and 40 are partly enclosed by the third and fourth fins 4c and 4d. Arranged like this, the third and fourth boiler tubes are welded to the inner edges of the third and fourth fins 4c and 4d in welding points 42, here six per boiler tube, distributed around the third and fourth boiler tubes.

[0038] As is clear form Fig. 3, the first, second, third and fourth boiler tubes 34, 36, 38 and 40 all have the same round shape or contour, i.e. the same circular cross section. Further, the spaces formed by the first, second, third and fourth fins 4a, 4b, 4c and 4d for receiving the boiler tubes all have, because of the partly straight portions of the inner edges defining the valleys, the same edgy shape. Because of this difference in shape, the boiler tubes will not contact the respective fins all around their outer surface. Instead, the boiler tubes will be separated from the respective fins in areas 44, 46 between the welding points, wherein each of the areas 44 is formed between one of the fins and one of the boiler tubes while each of the areas 46 is formed between the fins of one of the fin pairs and one of the boiler tubes. This fin-boiler tube separation results in an increased exhaust gas flow turbulence around the boiler tubes and the fins, and thus an increased heat transfer from the exhaust gas to the water fed through the boiler tubes.

[0039] The first, second, third and fourth fins 4a, 4b, 4c and 4d are so arranged that their longitudinal center axes C extend parallel to each other. Further, the fin pairs 4a + 4b and 4c + 4d are aligned with each other in the z dimension and the outer edge 10 of the second fin 4b faces the outer edge 10 of the third fin 4c. The third and fourth boiler tubes 38 and 40 are displaced from the first and second boiler tubes 34 and 36 in the x dimension such that the fourth boiler tube 40 is arranged halfway between the first and second boiler tubes 34 and 36, and the first boiler tube 34 is arranged halfway between the third and fourth boiler tubes 38 and 40. Accordingly, the fin pairs 4a + 4b and 4c + 4d have a staggered arrangement. Herein, by staggered arrangement is meant that the fin pairs are not aligned with each other, but rather displaced, in the y dimension. More particularly, the first valley 22 defined by the outer edge of the third fin 4c is received in the third ridge 30 defined by the outer edge of the second fin 4b, the first valley 24 defined by the outer edge of the second fin 4b is received in the second ridge 28 defined by the outer edge of the third fin 4c, the second valley 24 defined by the outer edge of the third fin 4c is received in the second ridge 28 defined by the outer edge of the second fin 4b and the first valley 22 defined by the outer edge of the second fin 4b is received in the third ridge 30 defined by the outer edge of the third fin 4c.

[0040] Thus, the valleys of the second fin are received in the ridges of the third fin while the valleys of the third fin are received in the ridges of the second fin. The second and third fins 4b and 4c are arranged separated from each other. Since the ridges and valleys have different shapes, the distance between the second and third fins, and more particularly the outer edges thereof, varies along the longitudinal center axis C of the second and third fins. This varying distance results in an increased exhaust gas flow turbulence around the boiler tubes and

fins, and thus an increased heat transfer from the exhaust gas to the water fed through the boiler tubes.

[0041] The rest of the assembly is configured in a way corresponding to the above described why a description thereof is unnecessary.

[0042] The above described embodiment of the present invention should only be seen as an example. A person skilled in the art realizes that the embodiment discussed can be varied and combined in a number of ways without deviating from the inventive conception.

[0043] For example, the fins and the assembly according to the present invention can be used in other types of boilers than waste heat recovery boilers, and for heating, evaporating or superheating other media than water by means of another heat source than exhaust gas. For example, the fins and the assembly according to the present invention can be used in connection with gas turbines or combustion units such as burners.

[0044] The distance between the fins 4b and 4c in Fig. 3 may be in the range of 1-20 mm, but other distances are naturally conceivable. The distance may inter alia be dependent upon the dimensions of the fins and the boiler tubes.

[0045] In the above described embodiment of the inventive assembly, the boilers are attached to the fins by welding. Of course, other attachment methods, such as brazing or gluing are possible. Further, the number of welding points between the fins and the boiler tubes need not be six per boiler tube like above but could be less or more than six. Also, the welding need not be made in points but could be made along lines extending partly or all the way around the boiler tubes. Furthermore, as an alternative, the fins of each pair could be attached to each other and the boiler tubes fixed to the fins by friction only.

[0046] The above described fins are each provided with two valleys and three ridges along each of the inner and other edges. Naturally, the number of ridges and valleys could be less or more than three and two, respectively. As an example, the inner and outer edges of each fin could define two ridges only and one valley arranged between the ridges. A pair of such fins could be arranged to enclose one boiler tube only.

[0047] All the fins of the assembly need not look the same. Not even the fins of one and the same pair need to look the same. Further, the number of fins cooperating to enclose one or more boiler tubes could be more than two. As an example, a fin configured according to the figures, i.e. arranged to partly enclose two boiler tubes, could be arranged to cooperate with two fins arranged to partly enclose a respective one of the two boiler tubes.

[0048] The valleys defined by the inner fin edge need not be identical, just like the valleys defined by the outer fin edge. Further, the inner and outer edges of the fins need not comprise straight portions but could be curved through-out. Also, the boiler tubes could have another cross-section than that illustrated in the figures.

[0049] In the above described embodiment the ridges are less "sharp" than the valleys and a contour of the ridges is longer than the contour of the valleys. Naturally, the fin could be designed in alternative ways, for example with valleys being less "sharp" than the ridges and a contour of the valleys being longer than a contour of the ridges.

[0050] The fins and boiler tubes could be made of any suitable material, such as carbon steel, stainless steel or aluminum. Further, the fins need not be solid but could comprise apertures to further increase the flow turbulence.

[0051] The fins of a pair need not be aligned in the y and z dimensions. As an example, the fins of a pair may be displaced in relation to each other so as to not be aligned in the y dimension and/or the z dimension. The same displacement possibilities as regards the z dimension exist between the pairs of fins.

[0052] In the above described embodiment, each of the boiler tubes is enclosed by the first valley defined by the inner edge of one fin and the second valley defined by the inner edge of another fin. Naturally, depending on how the two fins are oriented, each of the boiler tubes could instead be enclosed by the first valleys defined by the inner edges of the two fins, or the second valleys defined by the inner edges of the two fins.

[0053] It should be stressed that a description of details not relevant to the present invention has been omitted and that the figures are just schematic and not drawn according to scale. It should also be said that some of the figures have been more simplified than others. Therefore, some components may be illustrated in one figure but left out in another figure. Finally, as used herein, when one component is said to be connected to another component, the connection may be direct as well as indirect.

Claims

1. A fin (4, 4a, 4b, 4c, 4d) for a boiler tube arrangement comprising a number of boiler tubes (34, 36, 38, 40) extending along each other, wherein a longitudinal center axis (C) of the fin is arranged to extend perpendicular to a length of the boiler tubes, and wherein the fin comprises an inner edge (8) and an outer edge (10), **characterized in that** a contour of the inner edge is essentially identical to a contour of the outer edge, each of the contours of the inner and outer edges defining a number of ridges (16, 18, 20, 26, 28, 30) and a number of valleys (12, 14, 22, 24), which ridges and valleys are alternately arranged and connected to each other at transitions (P, P') being half way between a highest point (H, H') and a lowest point (L, L') of the connected ridge and valley, respectively, the valleys defined by the inner edge each being arranged to receive, and only partly enclose, a respective one of the boiler tubes.

2. A fin (4, 4a, 4b, 4c, 4d) according to claim 1, wherein the valleys (12, 14, 22, 24) are non-uniform with the

ridges (16, 18, 20, 26, 28, 30).

3. A fin (4, 4a, 4b, 4c, 4d) according to any of the preceding claims, wherein a first one of the valleys (12) defined by the contour of the inner edge (8), and having a bottom (B), is arranged between two of the ridges (16, 18) defined by the contour of the inner edge, and a second one of the ridges (18) defined by the contour of the inner edge, and having a top (T), is arranged between two of the valleys (12, 14) defined by the contour of the inner edge.

4. A fin (4, 4a, 4b, 4c, 4d) according to claim 3, wherein a contour of the first valley (12) is shorter than a contour of the second ridge (18).

5. A fin (4, 4a, 4b, 4c, 4d) according to any of claims 3-4, wherein the first valley (12) has a symmetry axis (S) extending perpendicular to the longitudinal center axis (C) of the fin.

6. A fin (4, 4a, 4b, 4c, 4d) according to any of claims 3-5, wherein the second ridge (18) has a symmetry axis (S) extending perpendicular to the longitudinal center axis (C) of the fin.

7. A fin (4, 4a, 4b, 4c, 4d) according to any of the claims 3-6, wherein the bottom (B) of the first valley (12) and the top (T) of the second ridge (18) are plane and defined by respective straight portions of the inner edge (8).

8. A fin (4, 4a, 4b, 4c, 4d) according to any of claims 3-7, wherein a flank (F) connecting the bottom (B) of the first valley (12) and the top (T) of the second ridge (18) is defined by an at least partly straight portion of the inner edge (8).

9. An assembly (32) comprising a boiler tube arrangement including a first boiler tube (34) and first and second fins (4a, 4b) according to any of the preceding claims, wherein the first and second fins extend perpendicular to a longitudinal center axis (A) of the first boiler tube on opposite sides of the first boiler tube, the inner edge (8) of each of the first and second fins facing, and only partly enclosing, the first boiler tube, the first boiler tube being received in a respective one of the valleys (12, 14) defined by the inner edges of the first and second fins.

10. An assembly (32) according to claim 9, wherein the boiler tube arrangement further includes a third boiler tube (38) extending along the first boiler tube (34) and third and fourth fins (4c, 4d) according to any of claims 1-8, wherein the third and fourth fins and extend perpendicular to a longitudinal center axis (A) of the third boiler tube on opposite sides of the third boiler tube, the inner edge (8) of each of the third and fourth fins facing, and only partly enclosing, the third boiler tube, the third boiler tube being received in a respective one of the valleys (12, 14) defined by the inner edges of the third and fourth fins, wherein one of the valleys (22, 24) defined by the outer edge (10) of the third fin (4c) is received in one of the ridges (26, 28, 30) defined by the outer edge (10) of the second fin (4b), and one of the valleys (22, 24) defined by the outer edge of the second fin is received in one of the ridges (26, 28, 30) defined by the outer edge of the third fin.

11. An assembly (32) according to claim 10, wherein the second and third fins (4b, 4c) are separated from each other.

12. An assembly (32) according to any of claims 10 or 11, wherein a distance between the outer edge (10) of the second fin (4b) and the outer edge (10) of the third fin (4c) is varying along the outer edges of the second and third fins.

13. An assembly (32) according to any of claims 9-12, wherein the first and second fins (4a, 4b) are separated from each other by a predetermined distance.

14. An assembly (32) according to any of claims 9-13, wherein an outer contour of the first boiler tube (34) at the first and second fins (4a, 4b), and a space for receiving the first boiler tube between the first and second fins, are non-uniform.

15. An assembly (32) according to any of claims 9-14, wherein the first and second fins (4a, 4b) engage with the first boiler tube (34) in engagement points (42) which are separated from each other.

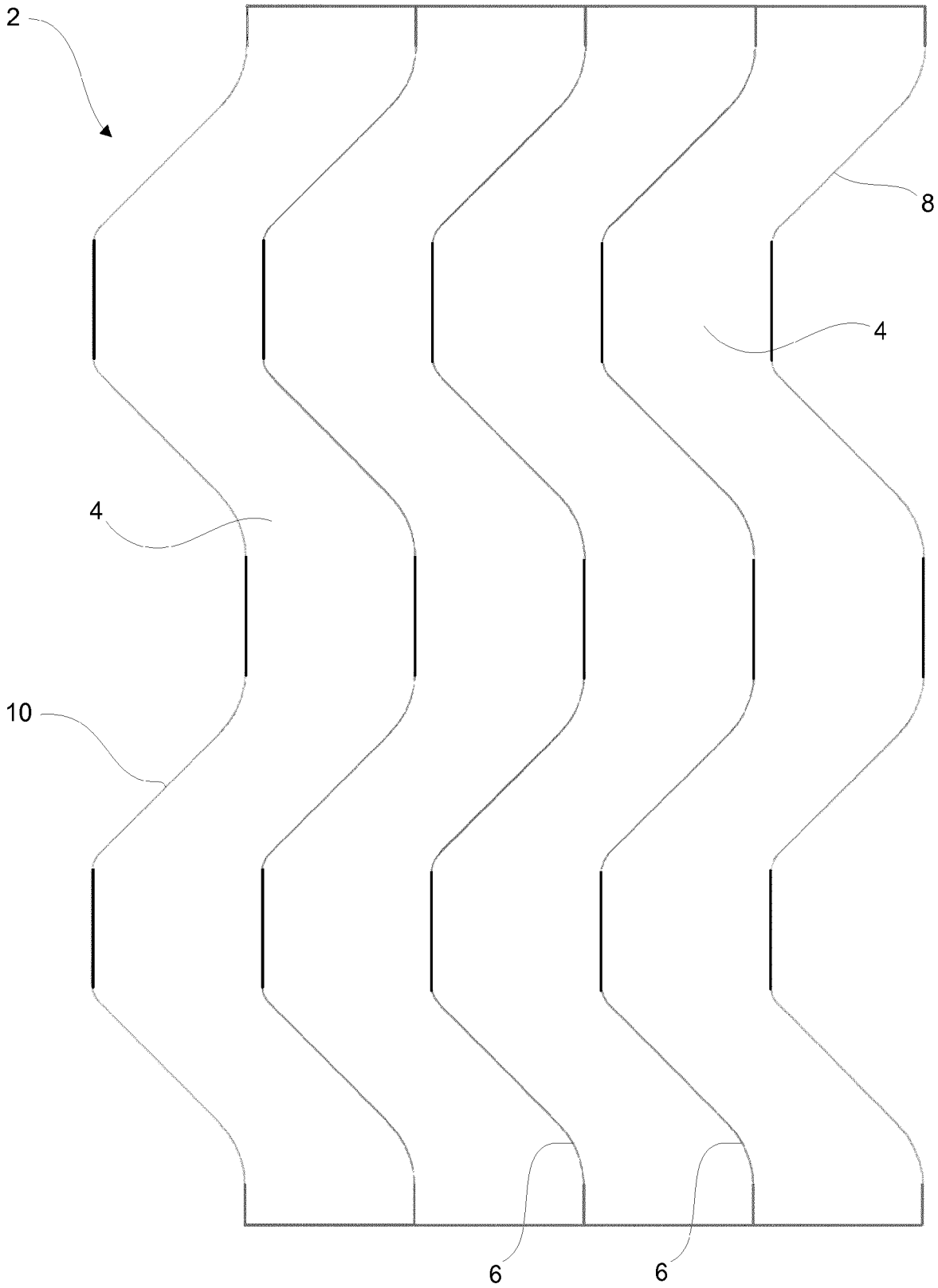

Fig. 1

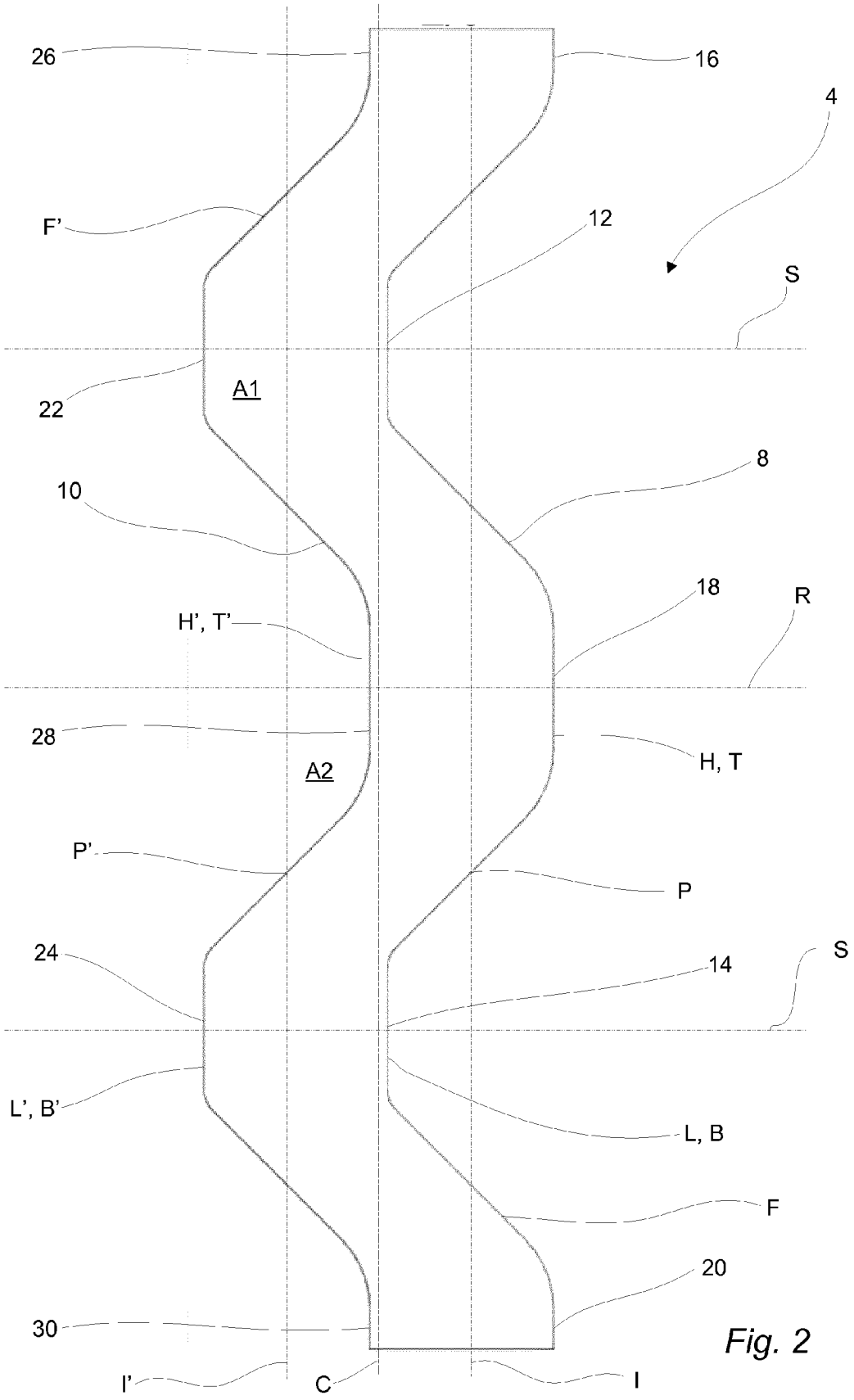

Fig. 2

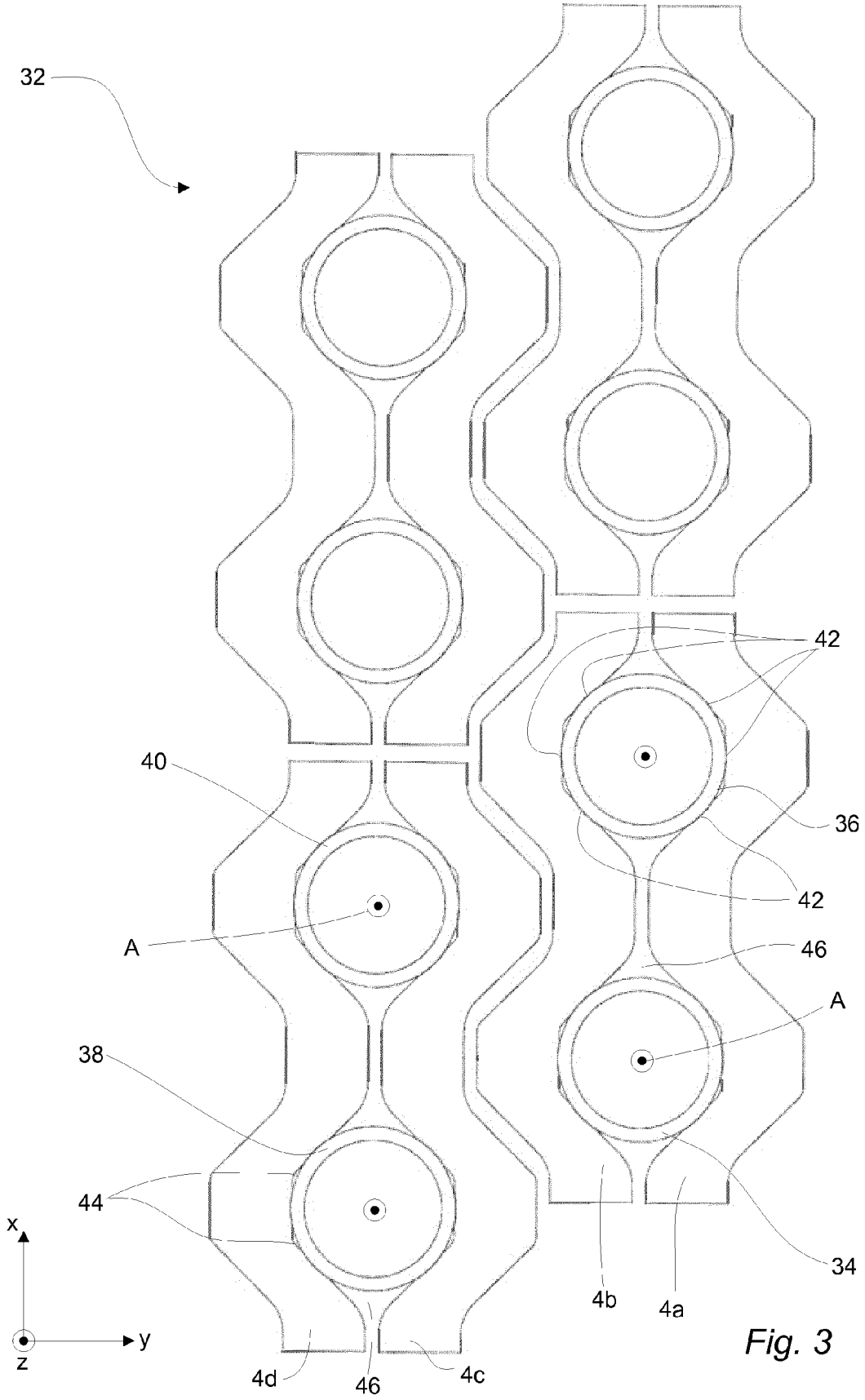

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 16 17 4175

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	SU 1 232 921 A1 (PROIZV OB KRASNYJ KOTELSHCHIK [SU]) 23 May 1986 (1986-05-23) * abstract; figures 1, 2 * * paragraphs [0001] - [0008] *	1-15	INV. F22B37/10 F28F1/10
A	FR 955 196 A (BRAUN, ALEXANDRE) 10 January 1950 (1950-01-10) * abstract; figures 2-7 * * page 1, lines 1-30 * * page 2, line 37 - page 3, line 82 *	1-15	
A	GB 748 644 A (WAAGNER BIRO AG) 9 May 1956 (1956-05-09) * figures 1-4 * * page 1, line 41 - page 2, line 122 *	1-15	
A	GB 757 982 A (ANDRE HUET) 26 September 1956 (1956-09-26) * the whole document *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC) F22B F28F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	5 December 2016	Varelas, Dimitrios

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05-12-2016

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
SU 1232921 A1	23-05-1986	NONE	
FR 955196 A	10-01-1950	NONE	
GB 748644 A	09-05-1956	NONE	
GB 757982 A	26-09-1956	NONE	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82