

The present invention concerns equipment for indirectly heating fluids in accordance with a pre-characterizing clause of claim 1.

Such equipment is needed, in particular, for carrying out high-temperature processes, as these frequently occur in processing mineral oil and in petrochemistry. Fluid to be heated, fluid or gaseous hydrocarbons or a hydrocarbon/steam mixture for example is normally guided through heat-exchanger pipes and is thereby heated through walls of these pipes without coming into contact with a heating medium concerned. Heat transfer to a pipe wall concerned mostly occurs by means of heat-radiation coming from a naked flame or a fuel burned in an oven or boiler heating-zone and to a lesser extent by means of hot combustion gases by convection. Heat-exchange pipes meander through heating zones concerned.

A great disadvantage of naked flames is that a required geometric form of flames and a greatest possible uniformity of temperature distribution can only be set with great difficulty. Amongst varying operating conditions, in particular, uniform heating can barely be realized. In practical terms, limits for sufficiently controlled operation are very narrowly set. Variations in geometry of a flame are in accordance with variations in separation of a heat-exchanging pipe from a flame surface. This means that heat-flow through a heat exchanging pipe does not only constantly vary considerably along a pipe length. Non-uniform heat-flow can also be observed over a periphery of a heat-exchanger pipe, as separate sections of a pipe surface necessarily have

a varying orientation in relation to a flame concerned and must partly face away from such a flame and therefore such a pipe section must show a variation in heat radiation. This can lead to over-heating of individual points on heat-exchange pipes and, simultaneously, a considerable underheating below a required pipe wall temperature at other points. In this way, firstly, heat damages to heat-exchanging pipes can occur from outside and, secondly, unwanted effects concerning a fluid to be heated can occur (eg. coking of inner surfaces of pipes). In traditional ovens for high-temperature processes, differences are often so great that a ratio of maximum to average heat-flow in a wall of a heat-exchanging pipe is from 3:1 to 4:1.

It is known for gaseous fuels (gases or vaporized liquid fuels) to be burned, in practice, without formation of a flame in a burner with a heat-radiation surface, with a gaseous fuel mixed with gas containing acids (eg. air) being passed through a porous radiation-member and ignited and burned on an outer surface of such a member. Ignition here occurs by means of incandescence of this outer surface (heat radiation surface). Corresponding to a geometrical form of a radiation body concerned, a heat radiation surface concerned is likewise uniform in a shape which, unlike an open flame, does not vary with a change in fuel supply. Furthermore, temperature distribution with a heat radiation surface concerned is very uniform.

Such a burner with a heat-radiation surface (heat-radiator) is known, for example, from US 4 722 681. Its radiation member is formed from a ceramic fibre matrix and is, by comparison with depth of a burner concerned, very long and wide, such that a large heat-radiation surface results. This burner is provided for heat-treating long webs of paper or fabrics.

It is also known from US 4 865 543 for a burner with a heat-radiation surface to be used to heat a unit through a heating zone of which a laminar pipe as a heat-exchanger is directed. A fluid to be treated flows in a side pipe and is indirectly heated as a result of heat-radiation. A heat radiator concerned, which is developed as a fibre burner and which is disposed on a base of a heating-zone, releases hot combustion gases through burning, which rise and are removed above from a said heating zone.

A pipe of a heat-exchanger concerned lies in a vertical plane, whereby pipes of separate windings of piping are essentially horizontally arranged.

Finally, a heating unit is known, from EP 0 385 963 A1, which is formed from a cylindrical housing in which a likewise cylindrical ceramic hollow body with porous walling is disposed. Furthermore, there is a heat-exchanger, in a said housing, with a separation from a cylindrical surface of a ceramic body, which is again cylindrical and which is built in and through which a heat-loaded medium passes. A mixture of a gaseous fuel and a gas containing acid, under excess pressure, can be introduced into an intermediate space between a housing casing concerned and an outer surface of a said ceramic body. This gaseous fuel and gas containing acid flows through a ceramic body concerned and is burned on an inner surface of a said ceramic body. Hot fumes occurring as a result of combustion can enter a casing surface of a cylindrical heat-exchanger concerned through relevant openings, giving off heat into a hollow zone surrounding this heat-exchanger, and from there can be removed. This heating unit, in which a large part of heat taken up by a heat-exchanger is transferred by convection, is above all conceived for use as a heating boiler for heating building-

interiors and is not suited to implementation of high-temperature processes.

A fluid to be heated is fed into a heat-exchanger from above and is removed again below, such that a 'direction of conveyance' in piping is opposed to a flow of combustion gases in an upwards direction. Use of vaporized liquid fuels such as kerosine, diesel, naphtha, or alcohols is foreseen for combustion.

In this known unit, lower parts of heat-exchanger piping are set out for strong heat radiation, while upper parts can no longer be reached by heat-radiation from a burner and are essentially heated by convection. However, even with a lowest heat-exchange pipe, heat radiation can only act on part of a pipe surface concerned.

While side areas of horizontal pipes are greatly less radiated than a lowest heat-exchange pipe, upper sides of heat-exchange pipes are not directly radiated at all. This means that there are enormous heat variations in a heat-flow both in a peripheral direction of heat-exchange pipes and also in a direction of conveyance of a heat-exchanger.

Equipment for indirect heating of fluids is also known from EP 0 233 030 A2, in which several rows of flat radiation burners disposed over each other with a separation from each other are mounted parallel to each other. In intermediate spaces of these rows of burners there is, in each case, a pipe heat-exchanger with a number of pipe meanders which run essentially horizontally, which are disposed in two essentially vertical planes in relation to radiating burners. Intermediate spaces between two directly adjacent pipe meanders are in each case free. Both separations from effective radiation surfaces of radiation burners and an

angle of heat radiation vary over a pipe periphery concerned, such that a temperature of a pipe wall is not uniform over this periphery.

The purpose of the present invention is to herald equipment for indirect heating of liquids of a type in which essentially uniform heat-flow is ensured in a heat-exchanger.

This aim is realized by characteristics of patent claim 1. Favourable further developments of the present invention are stated in subsidiary claims 2 to 14.

A present invention provides for pipes in heat-exchanging piping, through which a fluid to be heated passes, which are each radiated by two heat-radiating means which are positioned on opposite sides in relation to an axis of a pipe concerned and in relation to a surface in which piping concerned extends. Each length of piping is therefore disposed between two heat-radiating means which are disposed facing each other with their heat radiation, such that there is no longer an unradiated part of a pipe periphery. As heat-radiation surfaces of a heat-radiator concerned each have a form which corresponds to a surface extension of heat-exchanging piping concerned, uniform radiation can also occur in a direction of conveyance of a heat-exchanger concerned.

There is however a problem in that heat-exchanger piping generally presents a closed surface, nevertheless there is a free intermediate space remaining between separate meanders. This means that heat-radiation of two opposite heat-radiators can be directed through these intermediate spaces and can lead to unwanted temperature increases in corresponding areas of both heat-radiation surfaces. In this way, not only uniformity of temperature distribution of heat-radiation

surfaces is adversely affected, there can also be damages to a radiation member of a heat-radiating means concerned.

A present invention therefore provides for arrangement of two diametrically opposite longitudinal ribs, on an outer side of heat-exchanger pipes, which extend over a whole or nearly a whole length of a pipe concerned and in each case extend into intermediate spaces of piping. These lengthwise ribs therefore represent an obstacle to passage of heat-radiation through intermediate spaces of piping. It is useful for covering of as much as possible of these intermediate spaces to be ensured.

Together with this covering effect, another important aim is pursued with lengthwise ribs within range and scope of a present invention. As lengthwise ribs concerned can take up enormous amounts of radiated heat, a heat-flow concerned can be intensified through areas of pipe walls lying laterally in relation to a direction of radiation from heat-radiation means, that is, through less strongly radiated pipe wall areas, in that additional heat flows into these lateral areas through heat conduction from said lengthwise ribs. Lengthwise ribs should therefore have contact with a pipe surface concerned (eg. welding) which is as good as possible. It can also be appropriate for a material with higher heat-conductivity than pipe material to be used for lengthwise ribs.

As heat flow is directly dependent on a cross-sectional area in a direction of flow, a thickness of lengthwise ribs concerned should, as far as is possible, be such that heat conduction from lengthwise ribs nearly balances reduction of heat intake into lateral areas of pipes as a result of low direct heat-radiation. A minimum thickness of lengthwise ribs which is necessary for this can be determined by calculation

in a known way. In some cases it can be appropriate, instead of having lengthwise ribs with uniform thickness, to use lengthwise ribs which have an approximately trapezium-shaped cross-section, whereby a thickness of longitudinal ribs increases in a direction towards a pipe surface. In this way, with reduced overall weight and reduced cost of material, heat conduction which is as good as in a case of lengthwise ribs which have a constant thickness, which corresponds to a thickest point of a trapezium-shaped lengthwise rib, over their whole height, can be realized.

Piping of a heat-exchanger concerned through which a fluid concerned is directed, will suitably extend in a plane, that is, meanderings of a said piping lie in one plane. In principle, a heat-exchanger concerned can also extend in curved surfaces, as a heat-radiation surface can be adapted to a said surface by corresponding formation of a radiating member. For reasons of ease of production, a cylindrical surface is suitable in such a case, whereby heat-exchanger pipes can for example be disposed in a helical shape. 'Piping' should also include here this form of implementation. Alternatively, pipes can also run parallel to cylindrical casing lines, for example. Naturally, it is also possible for several lines of piping to be provided as heat-exchangers in a heating zone concerned. A principle of invention concerned remains unchanged when each piping surface is associated with opposite heat-radiating means. With this, it is possible for heat-radiating means positioned between adjacent piping lengths to be combined in each case into a single burner housing with two heat-radiating surfaces which radiate in opposite directions. In order to achieve approximately constant heating conditions over a whole length of piping concerned, it is recommendable for lengths of piping to be disposed in their vertical plane such that parallel pipe sections of piping are vertically aligned. This

means that a fluid to be heated in counter-running pipe-sections of separate windings of piping is in each case directed alternatively downwards and then upwards and is carried in an overall horizontal direction in relation to a lengthwise extension of piping.

In this way, an interfering influence of hot fumes rising upwards, possible leading to different heat conditions in a case of essentially horizontal alignment of pipe sections, is largely prevented. If several parallel heat-exchangers are provided it is possible to connect supply and removal of fluids to separate heat-exchangers to a collecting pipe, ie. to a supply collector and a removal collector. It is also possible to dispose several heat-exchangers in one same plane, whereby meanders of heat-exchangers interlock one in another. In such a case, covering of intermediate spaces between heat-exchanger pipes is in each case realized by a combined effect of lengthwise ribs of several heat-exchangers.

As heating conditions of a heat-exchanger, because of association of heat-radiating means in a design in accordance with a present invention, are practically completely independent from heat conditions of other heat-exchangers in other parallel planes, it is directly possible, in contrast to preceding state of the art, to operate individual heat-exchangers at different temperatures within a same heating zone. Furthermore one same heat-exchanger, in relation to its direction of conveyance, can for example be divided up into two or three zones with specified different heating, by correspondingly dividing up an associated heat-radiating surface and feeding this different quantities of fuel. This is like having a corresponding series arrangement of smaller heat-exchangers, which can be operated independently, separate heat-radiation surfaces of which complement each

other to form a total heat radiation surface corresponding to a surface of a heat-exchanger.

A traditional design does not enable such targeted differential heating as rising waste-gases of combustion of burners disposed below in a heating room unavoidably influence an effect of burners disposed above, while a present invention allows for controlled variation of temperature gradients of a fluid concerned on its course through piping.

Although a present invention can be implemented with any surface-type heat-radiation means (eg. electrically-heated radiating elements) burners with porous radiating bodies, on a candescent surface of which gaseous fuels can be burnt, with a gas containing acids, with a flame, are, for economic reasons, particularly suitable. Ceramic-fibre burners are particularly favoured.

This type of heat-radiation source not only recommends itself through simple operation by hand, low pressure losses, quick response to variation in load and low noise levels, they also, in particular, show exceptionally low levels of oxides of nitrogen (less than 20 ppm), carbon monoxide and unburnt fuel in a combustion waste-gas concerned. Through a possibility of adapting physical form of a heat-radiation surface to a physical form of a heat-exchanger and by preventing irregularities in a naked flame as a heat source, heat-radiation means and heat-exchangers can be brought very close together, without there being a danger of uncontrolled excess heating at some points. In this way, heat-exchange can be kept at an unusually efficient level even if equipment concerned is to be operated with a low level of power. Heat-radiating means with a vertically disposed heat-radiating

surface are favoured. A present invention can nevertheless be implemented with horizontal heat-radiation surfaces.

Below, a present invention is described in detail in connection with figures 1 to 7 in which parts having identical functions are given identical reference numbers. These figures are as follows:

Figure 1 a diagrammatic cross-section through equipment in accordance with a present invention,

figures 2a a cross- or longitudinal section  
and 2b through a traditional oven for  
pyrolysis of acetic acid,

figures 3a a cross- or longitudinal section  
and 3b through an oven in accordance with a  
present invention for pyrolysis of  
acetic acid,

figure 4 a cross-section through a heat-  
exchanger pipe with trapezium-shaped  
lengthwise ribs,

figure 5 a cross-section through a meander in  
heat-exchanger piping with overlapping  
of lengthwise ribs,

figure 6 a part of a cross-section through  
equipment in accordance with a present  
invention with heat-exchanger piping developed  
in a form of a cylindrical casing, and

figure 7 a section through a traditional oven for pre-

heating and vaporization of a liquid.

Figure 1 shows a cross-section of piping 4, placed in a vertical plane of a heating zone 14, which has heat-radiation applied to two heat-exchangers 1. Pipes of piping 4 have diametrically opposite and vertically projecting lengthwise ribs 5, on their upper and lower side, which are welded to an outside of a pipe concerned.

Heat-exchangers 1 have a radiating member 15 made of a porous material (eg. ceramic-fibre material), which is bedded in a housing of a burner, which is open on a side facing piping concerned 4. A mixture of a gaseous fuel and a gas containing acid can enter a housing of a burner through a gas intake 2 and flows through a radiation member 15, a surface 3 of which is candescent and causes ignition and combustion of a supplied gas mixture, with uniform surface distribution. This combustion occurs immediately next to a radiation surface 3, such that there is practically no flame.

Heat-radiation of a heat-radiation surface 3 is applied to pipes of piping 4 and their lengthwise ribs 5 and heats these. As lengthwise ribs 5 of immediately superposed pipe sections of piping 4 lie close to each other, and even meet, with their outer, front faces, an intermediate space between pipes of piping 4 is practically fully covered against direct passage of heat-radiation of one heat-radiation means 1 to another heat-exchanger 1, such that these cannot negatively effect each other. Heat taken up by lengthwise ribs 5 is in each case taken into a wall of a pipe in piping 4 by heat conduction and from there is transmitted to a fluid passing through this pipe. Thickness of lengthwise ribs 5 is designed such that, taking heat-conductivity of such ribs into consideration, heat-flow which can be conducted through such ribs is sufficient to approximately balance otherwise

occurring lower (in relation to 3 o' clock and 9 o' clock positions) heat uptake in upper and lower surface areas (in an area of 12 o' clock and 6 o' clock positions), or to at least greatly reduce differences. This means that liquid directed through piping 4 is applied to approximately identical heat conditions in relation to an overall inner surface of a heat-exchanger. This is not so with traditional units for high-temperature processes.

To clarify this, a reaction oven for pyrolysis of acetic acid for producing ketenes for example, is shown in figures 2a and 2b. A heating zone 14 is surrounded by a heat-insulated housing 7. Piping, of two heat-exchangers disposed in parallel, vertical planes, marked 6, through which acetic acid concerned is directed, are supported on a hanging device 10 in a heating zone 14.

As can be deduced from figure 2b, lowest heat-exchanger pipes of piping lengths 6 are connected to supply pipes 8 and uppermost heat-exchanger pipes are connected to removal pipes 9, such that a direction of conveyance of acetic acids concerned through a heat-exchanger is in principle directed upwards from below, although piping lengths 6 run essentially horizontally. Burners 11 (shown by dot-dashed lines), naked flames of which are directed onto heat-exchanger pipes, are disposed on either side of piping lengths 6, in a housing wall 7. Combustion gases occurring as a result for burning are directed upwards out of a heating zone 14 through a fume-vent 12. Clearly, separate surface areas of pipes of piping lengths 6 are, as already explained above, radiated with heat at different intensities. This applies both to longitudinal extensions of pipes and also around their periphery, as heat-radiation means (burners 11) are not developed with large

surface-areas and there are no lengthwise ribs on pipes concerned which could produce intensification of heat-flow in less strongly radiated areas.

Significantly uniform heat transfer into heat-exchanger pipes in accordance with a present invention means that heat-exchangers concerned can be operated with overall higher efficiency. This means that either, with an equal heat-exchanging surface of piping, a greater amount of heat can be transmitted, or that, with an equal maximum permissible pipe wall temperature, an equal amount of heat can be transmitted with a smaller heat-exchanging surface.

With each heat-exchanger heated by means of heat-radiation means, heat transfer capacity is constantly at approximately a middle value between a maximum and a minimum heat-flow in areas of heat-exchanger pipes which are most strongly and most weakly radiated. In a most favourable case, with traditional heat-exchangers, a ratio of an average to a maximum heat-flow is approximately 1:1.2. Whereas a design in accordance with a present invention enables this ratio to be brought to nearly 1:1, as a total surface of heat-exchanger pipes shows an almost equal temperature level.

Significance of equalization of a heat-flow concerned is also shown in that a maximum permissible pipe wall temperature is not only dependent on temperature stability of pipe material concerned, it is also essentially determined by heat properties of a fluid concerned that is heated. Accordingly, dissociation reactions for example can occur above certain critical temperatures (eg. development of coke), which lead to deposits on an inner surface concerned of heat-exchanger pipes thereby causing increasingly worsening heat-transfer properties of a heat-exchanger concerned. A present invention makes a mode of operation possible whereby

narrowly limited excesses of a critical temperature limit at certain points are surely prevented without an average temperature concerned having, simultaneously, to be lowered distinctly below this critical limit. By equalization of heat-flow on a periphery of heat-exchanger pipes, a pipe wall temperature can practically be kept at a maximum permissible value over a whole periphery.

Figures 3a and 3b show an oven in accordance with figures 2a and 2b and in accordance with a present invention, in a vertical or longitudinal cross-section. Four lengths of piping 4 are disposed in a heating-zone, which is enclosed by a housing 7, as heat-exchanger pipes disposed parallel to each other in vertical planes. Supply 8 of fluid to be heated to piping lengths 4 occurs through a common pipe (feed collector 13). Correspondingly, a removal collector (which is not shown) is provided for removal 9 of a heated fluid. In contrast to a traditional design in accordance with figures 2a and 2b, heat-exchanger pipes of piping 4, which are attached to hanging means 10 on a housing 7, within a vertical plane (in parallel pipe sections), run vertically instead of running essentially horizontally. A general direction of conveyance of fluids concerned through a heat-exchanger is therefore horizontal. A heat-radiating means 1 is in each case disposed on both flat sides of each piping length 4 parallel to these sides. Areas of heat radiation surfaces 3 of said radiating means correspond to surface extension of piping 4. A gas intake 2 for supplying a heat-radiating means 1, which is implemented as a fibre burner, is developed as a common collector pipe. Hot combustion gases occurring are removed through a waste-gas outlet 12 above. Excepting heat-radiating means 1 disposed on outer sides, other heat-radiating means 1 are in each case provided with two heat-radiating surfaces 3 acting in opposite directions and therefore act like two separated heat-radiating means 1.

As can be deduced from figure 3b, lengthwise ribs 5 attached to heat-exchanger pipes of piping lengths 4 exclude unwanted mutual influence of heat-radiating means 1 directed towards each other, by complete covering of intermediate space between individual counter-running pipes.

Furthermore, lengthwise ribs 5 ensure intensification of heat-flow as described above, in areas of heat-exchanger pipe walls which are less strongly affected by direct heat-radiation.

As no naked flames are used for heating in a design implementation in accordance with a present invention, heat-radiation surfaces 3 concerned need to be brought relatively close up against piping lengths 4. This enables an unusually compact construction of equipment concerned. With a conventional construction, such closeness of a burner with a naked flame would unavoidably lead to excess heating at particular point on heat-exchanger pipes. For this reason, a traditional oven, with an equal heat-transfer capacity has a substantially larger heating zone. For design in accordance with a present invention, requirement for space is reduced to a third of a former value, as is roughly shown by comparison of figures 2b and 3b. In addition, heat-radiation losses outwards are also reduced by a smaller volume. This, together with a rise in efficiency of heat-transfer as a result of nearness of heat-radiation surfaces 3 to a surface concerned of heat-exchanger pipes, leads to an overall clear economy in use of fuel.

A separate heat-exchanger pipe of piping 4, is shown in figure 4, with lengthwise ribs 5a which are trapezium-shaped in cross-section, whereby a cross-section concerned widens towards a pipe surface concerned. This shape takes into account that heat removal must only occur in a direction

towards a heat-exchanger pipe, and a quantity of heat to be removed towards a pipe surface increases continuously over a height of a lengthwise rib concerned. Thickness of lengthwise ribs is therefore designed according to separation from a pipe surface, such that a minimum necessary cross-section for a relevant amount of heat is ensured.

This type of design leads, in relation to a layout in accordance with a maximum necessary cross-section (constant over a whole height of lengthwise ribs) to savings in material and weight, without reducing heat-conductivity of lengthwise ribs 5a.

While, in figure 1 and figure 3a, lengthwise ribs 5 of two directly adjacent pipe stretches of piping 4 abut against each other on their outer front faces and are aligned with each other, a variation is shown in fig. 5, in which lengthwise ribs 5b mutually overlap over an extension of their height (from a pipe surface concerned). With this there is an advantage that complete covering of intermediate spaces between stretches of piping 4 can always be ensured. This would also be possible by having a single metal plate as a common lengthwise rib for two counter-running pipe stretches) instead of two lengthwise ribs. This would however lead to considerable problems as a result of thermal tensions to be expected in a construction concerned. Whereas a solution in accordance with figure 5 allows for a free extension of pipes and lengthwise ribs 5b, without there being a gap in an intermediate space concerned through which heat-radiation could directly pass through. Figure 6 shows a sectional representation of a design implementation of a present invention, in which piping 4, like heat-exchanger surfaces 3 of a radiation member 15 of heat radiating means 1, has a curved form, namely a cylindrical casing form. Piping 4 can in this way be implemented as parallel rings or in a helical

form. A basic principle concerned nevertheless fully corresponds to that of representations of figures 1, 3a and 3b.

Effectiveness of a design in accordance with a present invention is particularly clear if it is used on an oven for pre-heating and vaporizing crude oil which is to then undergo an atmospheric distillation. A traditional design is shown in figure 7. Below in a heating-zone 14 of a said oven, burners 11 (only one burner is shown) are disposed which produce naked flames directed upwards which cause heating of piping lengths 6 concerned. Crude oil is conveyed through supply pipes 8 close to a waste-gas outlet 12 in two piping lengths 6 and, after heating and partial vaporization, is removed below from a heating zone 14 through removal pipes 9 and is conveyed to a distillation unit (not shown). As piping lengths 6 are disposed on walls of a heating zone 14, they only receive radiated heat from burner flames on one side. For this reason enormous temperature differences inevitably occur around a periphery of heat-exchanger pipes concerned. Moreover, large temperature differences also result in a vertical direction along piping 6, through different separation of separate pipe surface areas from a centre of burner flames. Considerable advantages of an oven in accordance with a present invention in which lengthiest ribs are applied to heat-exchanger pipes and piping lengths are supplied with heat-radiation from two sides, in relation to an oven in accordance with figure 7, can be concluded in detail from a following table:

|                        | traditional<br>oven | oven<br>in accordance<br>with invention |
|------------------------|---------------------|-----------------------------------------|
| heat taken up (kCal/h) | 49,168,000          | 49,168,000                              |

| burner type                                    | naked flame<br>naturally drawn | with heat-<br>radiation surface |
|------------------------------------------------|--------------------------------|---------------------------------|
| number of burners                              | 36                             | 35                              |
| fuel consumption (kCal/h)                      | 83,103,000                     | 52,680,000                      |
| average heat-flow (kCal/h)                     | 30,100                         | 42,140                          |
| piping surface area (m <sup>2</sup> )          | 1,652                          | 1,169                           |
| implementation of piping                       | horizontal                     | vertical                        |
| heating zone volume (m <sup>3</sup> )          | 1,813                          | 616                             |
| heating zone surface area<br>(m <sup>2</sup> ) | 967                            | 442                             |
| NO <sub>x</sub> emissions (kg/h)               | 13.7                           | 2.3                             |

For an equal heat transfer, fuel consumption of an oven in accordance with a present invention is 37% lower and giving off of oxides of nitrogen is 60% less than for a traditional oven concerned. In addition there is a greatly more compact construction which is shown in that surface area of piping lengths are approximately 30% less, a volume of a heating zone concerned is 66% lower and a surface area of a heating zone concerned is 54% lower.



### Patent claims

1. Equipment for indirect heating of fluids, for high-temperature processes in particular, with a heating zone, in which at least one laminar, meandering pipe is disposed, through which fluid to be heated can flow and which can have radiated heat applied to it from outside, wherein  
a pair of heat-radiation members (1), which have a heat-radiation surface (3) formed corresponding to the laminar extension of a meandering pipe (4), is in each case associated with a meandering pipe (4), whereby said heat-radiation members (1) are in each case disposed on opposite sides of a said meandering pipe (4) and piping of a said meandering pipe (4) is in each case provided with longitudinal fins (5, 5a, 5b) on two, in relation to the cross-section of said piping, opposing sides on its outer side, whereby said longitudinal fins extend over the whole or nearly the whole length of a said meandering pipe (4) into an intermediate space between windings of a said meandering pipe (4).
2. Equipment in accordance with claim 1, wherein  
longitudinal fins (5, 5a, 5b) have a height which ensures complete or nearly complete covering of an intermediate space between windings of a meandering pipe (4).
3. Equipment in accordance with claim 1 or 2, wherein  
thickness of longitudinal fins (5, 5a, 5b), taking heat-conductivity of material said longitudinal fins are made



of and the height of said longitudinal fins (5, 5a, 5b) into account, is designed such that heat-flow occurs via said longitudinal fins (5, 5a, 5b) into a wall of piping of a meandering pipe (4), which largely compensates self-adjusting reduced heat-supply into surface zones of piping of a said meandering pipe (4) inclined in relation to a heat-radiation surface (3) of a heat-radiation member (1) resulting from irregular direct heat-radiation over the periphery of said piping.

4. Equipment in accordance with claim 3,  
wherein  
longitudinal fins (5a) have an approximately rectangular cross-section, whereby their thickness in each case increases in a direction towards piping of a meandering pipe (4).
5. Equipment in accordance with any one claims 1 to 4,  
wherein  
a meandering pipe (4) and a heat-radiation member (1) in each case extend in a level surface.
6. Equipment in accordance with any one of claims 1 to 4,  
wherein  
a meandering pipe (4) and a heat-radiation member (1) in each case extend in a curved surface, a cylindrical, casing-like surface in particular.
7. Equipment in accordance with any one of claims 1 to 6,  
wherein  
several meandering pipes (4) and several pairs of heat-radiation members (1) are disposed in a heating-zone (14).
8. Equipment in accordance with claim 7,  
wherein



a meandering pipe (4) and a heat-radiation body (1) extend, in every case, parallel to each other in a vertical plane.

9. Equipment in accordance with any one of claims 1 to 8, wherein  
piping of a meandering pipe (4) in every case mainly runs vertically.
10. Equipment in accordance with claim 7, wherein  
a feed-collector (13) and an outlet collector are provided, with which fluid to be heated can be guided to or extracted from a meandering pipe (4).
11. Equipment in accordance with claim 7, wherein  
a pair of heat-radiation bodies (1) which is associated in every case with a meandering pipe (4) can be regulated, concerning its heating capacity, independently of heat-radiation bodies (1) of other meandering pipes (4).
12. Equipment in accordance with claim 1, wherein  
a pair of heat-radiation members (1), which is associated in every case with a meandering pipe (4), is divided (as seen in the direction of flow of a said meandering pipe (4)) into sections of a heat-radiation surface (3), which are regulated, concerning heating capacities, independently of each other.
13. Equipment in accordance with any one of claims 1 to 12, wherein  
a heat-radiation member (1) is in each case developed with a burner with a porous radiation-body (15), through which



a mixture of gaseous or vaporized fuel and a gas containing oxygen can be guided and be ignited by means of incandescence of a surface of a said radiation-body (15).

14. Equipment in accordance with claim 13,  
wherein  
a heat-radiation body (1) is developed as a ceramic fibre burner.