

March 18, 1969

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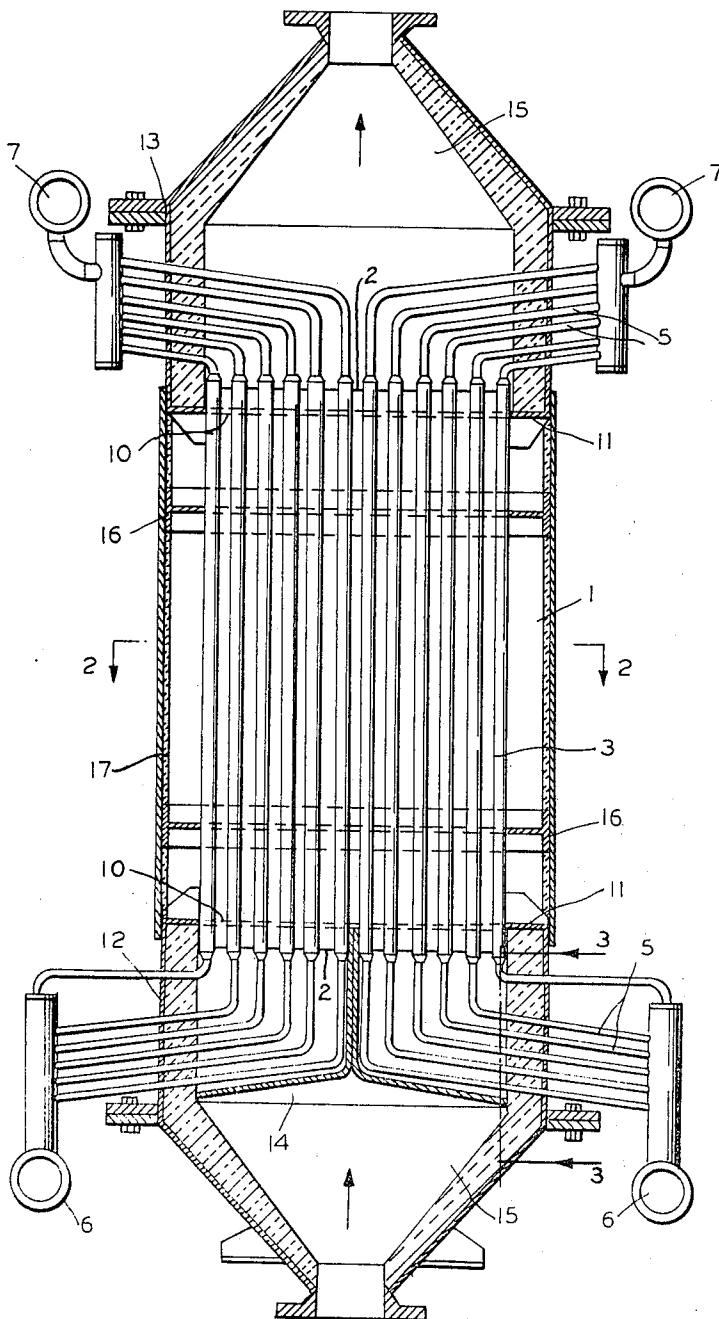
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HEAT EXCHANGER ESPECIALLY FOR THE COOLING OF HOT GASES

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FIG. 1



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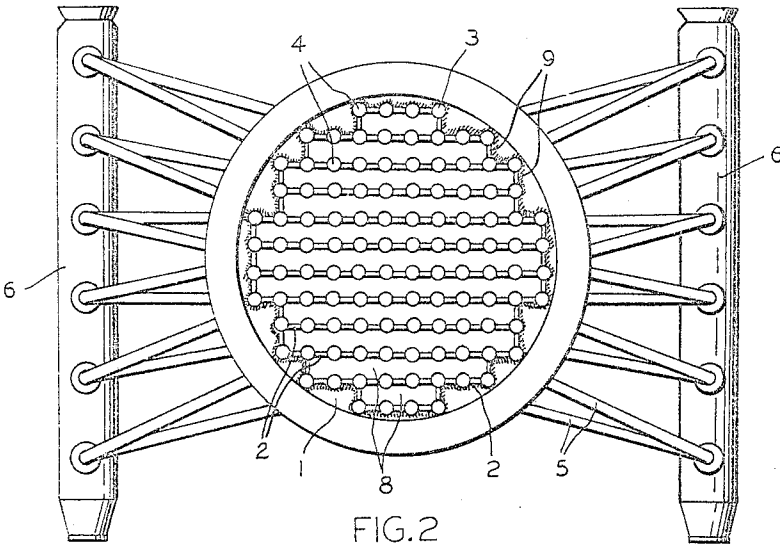


FIG. 2

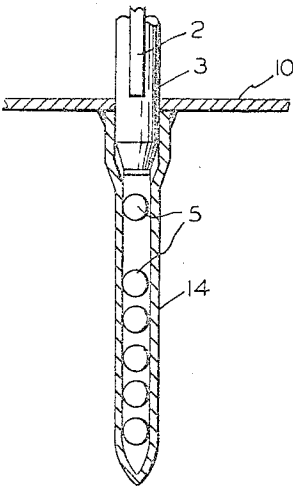


FIG. 3

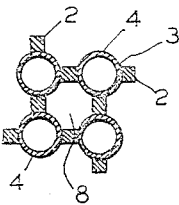


FIG. 4

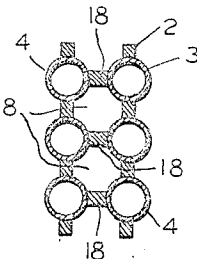


FIG. 5

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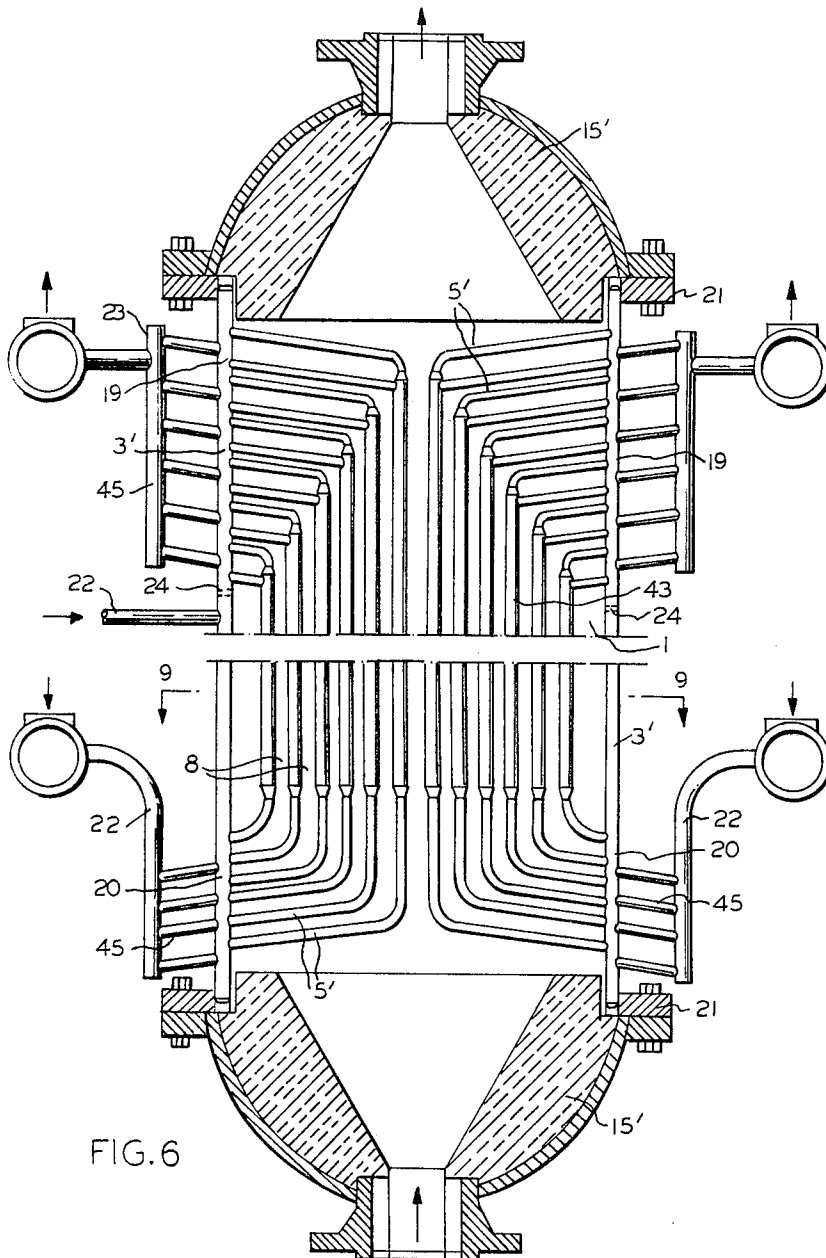


FIG. 6

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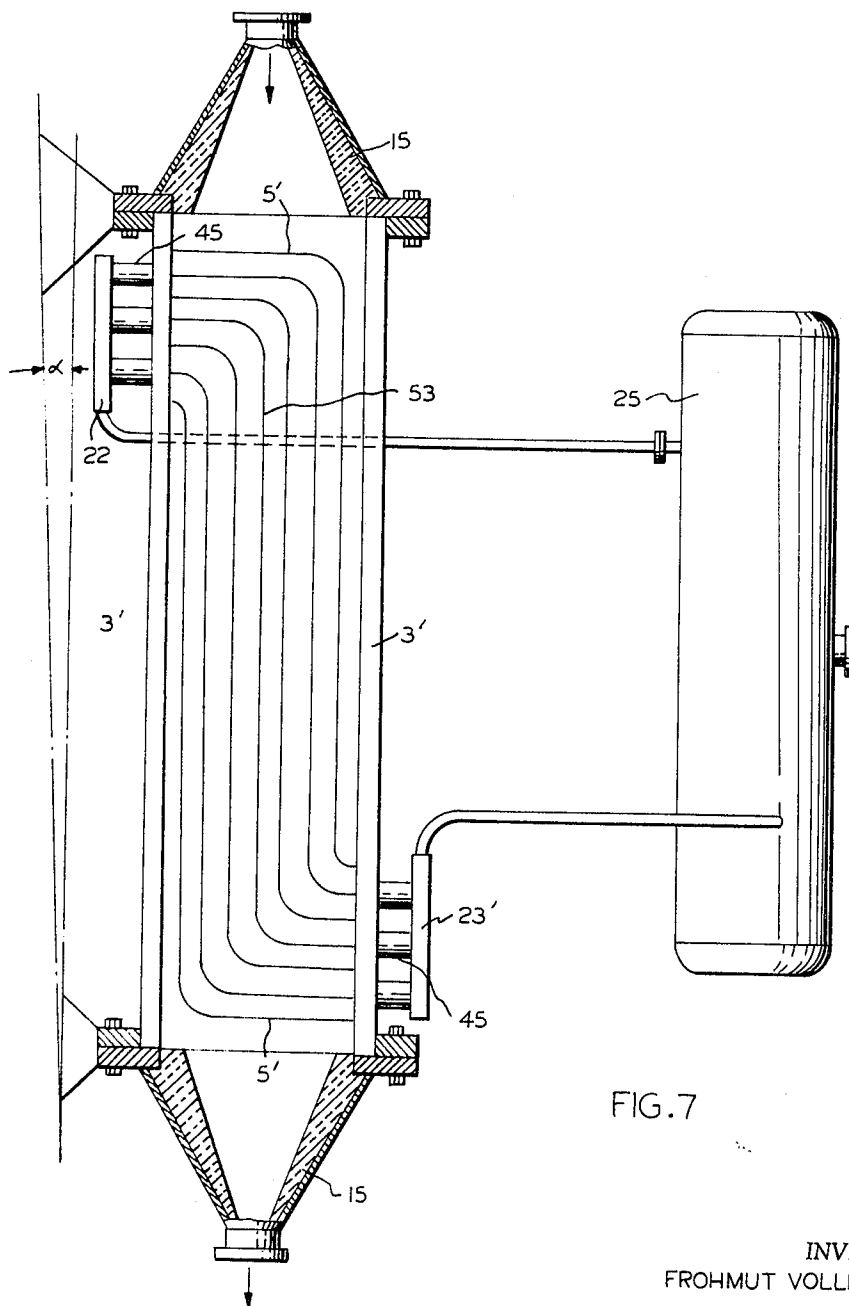
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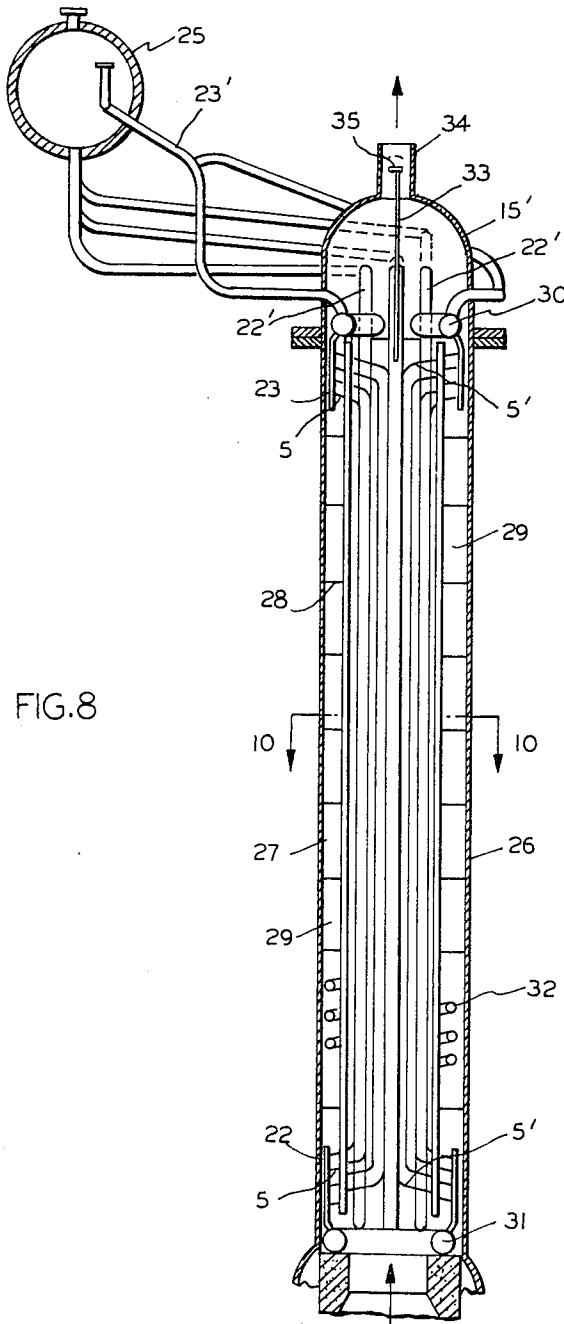


FIG. 8

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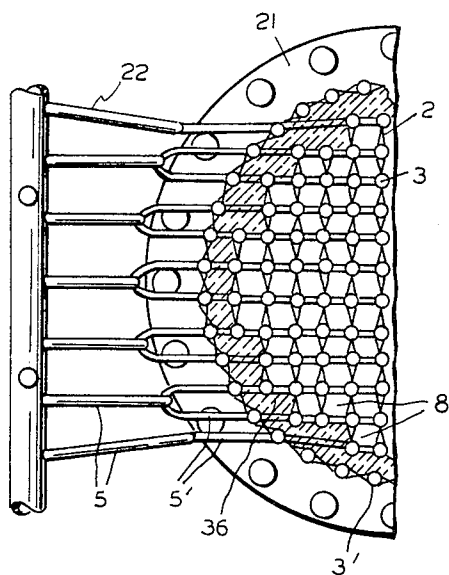


FIG. 9

FIG. 10

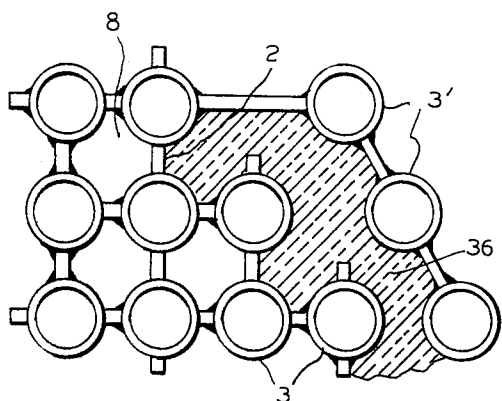
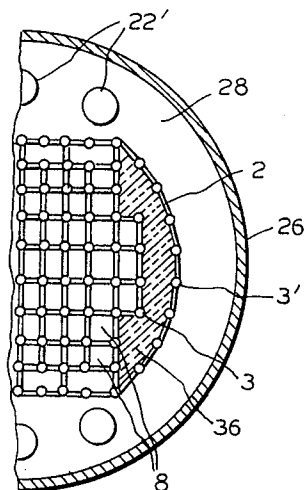


FIG. 11

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HEAT EXCHANGER ESPECIALLY FOR THE COOLING OF HOT GASES

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12 Claims

Int. Cl. F28f 1/32, 1/34; F28d 7/10

ABSTRACT OF THE DISCLOSURE

The heat exchanger has a plurality of substantially straight pipes with longitudinally extending fins thereon for the cooling medium. The fins on the pipes are used to form parallel pipe walls for the medium to be cooled. The exterior pipes are secured together by welding longitudinal fins on the pipes to adjacent and neighboring pipes. The construction permits the formation of passages for the gas to be cooled and at the same time forms at the exterior a casing which is resistant to pressure. The passages between the walls are closed laterally by ribs on the pipes.

The invention relates to a heat exchanger especially for cooling freshly cracked gases and/or synthesis gases at high pressure, consisting essentially of straight water pipe provided with longitudinal fins to form walls of the pipes with parallel passages for the gas at predetermined distances from one another by connecting the longitudinal edges of the longitudinal fins to the water pipes and the ends of the pipes are connected by mains with distributors and collectors for the feed and discharge of the cooling medium.

Heat exchangers especially adapted for the cooling of freshly cracked gases and/or synthesis gases under high pressure necessitate a special construction. It is necessary to take into consideration for the constructional form of such heat exchangers, their pressure and the high temperature under which the gases to be cooled are produced in considerable amounts, but also their tendency during cooling for re-formation whereby an undesired coke precipitation is produced in the cooler, and in addition to a premature contamination and the resulting inoperation for cleaning the cooling surfaces there is also produced a decreased yield of the desired final product. An object of the invention is to avoid such disadvantages.

Coolers which are suitable for the cooling of such gases have to be designed in such a way that the thermal cracking of the gases is terminated by a sufficient cooling soon after their exit from the cracking furnace or reactor. The flow of the gas in all parts of the cooler including the gas inlet and gas outlet compartments has to be well defined and besides such inflow and outflow should be non-rotational as much as possible. Also, a contamination of the cooling surface by a deposit of condensate and coking shall be avoided. A secure control of high thermal stresses of the cooling surface has to be provided and if possible the yielded heat from the gases by the cooling medium should be utilized via a waste heat boiler for the production of energy. A further object of the invention is to provide a heat exchanger having the above advantages.

Fire tube coolers are known consisting of a pressure casing surrounding a water compartment with pipe bottoms at both ends and fire tubes extending through the water compartment. This kind of cooler is not very suitable for the mentioned purpose, since the pipe bottoms

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as well as the casing because of the temperatures to be maintained for the cooling walls have to withstand a high pressure of the cooling medium of about 80 to 200 atmospheric pressure and therefore necessitate a strong walled casing and thick pipe bottoms which make them very expensive in regard to their construction and material. Besides, a metallic connection of the fire tubes with such strong bottoms because of the necessary pipe spacing is possible only to a limited degree and the pipe parts which contract the bottom non-metallic material are subject to an accumulation of heat and excessively high temperatures, so that within a short period of operation a corrosion of the pipes occurs at these parts. Also, high temperature corrosion by H_2S occurs here. An object of the invention is to avoid the above disadvantages.

Heat exchangers are known also, in which a casing is closed at both its ends by bottoms and pipes with longitudinal fins combined in a bundle are arranged to convey the cooling medium. Hereby the inlet or outlet of the cooling medium to the individual fin pipes is accomplished by distributors and collectors arranged within the interior space of the casing from which pipes lead to the individual fin pipes. The feed and discharge of the cooling medium to the distributor and the collector is accomplished by inlet and outlet pipes extending through the bottoms and fixed in the same.

A heat exchanger constructed in such a way also is not suitable for the cooling of the mentioned gases. As has been mentioned, such gases are produced in large amounts and under high temperatures. Since the upper interior space of the inlet part of such a cooler does not have a sufficient cooling, because of the inevitable heat accumulation the upper bottoms and the casing within its upper range would soon be destroyed. Furthermore, such a cooler is not suitable for the cooling of the mentioned gases, since such gases have an inclination towards reformation and it is necessary therefore to eliminate occurring undesired coke separations which on one hand lead to a fast contamination of the cooler and on the other hand result in a diminished yield of the desired final product. Such a coke precipitation can be counteracted only, it has been found, by a shortened duration of time of the gases flowing into the cooler head, i.e. by a flowing out of the gases as fast as possible into the effective range of the cooling surfaces. But, for this purpose, the known cooler because of the installations provided in its upper range of inflow is unsuited, since these installations represent an increased resistance to flow and bring about an extension of the duration of time. A cleaning also is difficult. A further object is to eliminate the above disadvantages.

A further object of the present invention is to provide a construction for the formation of a uniform compression resistant cooling surface which is formed by passages and pipe walls parallel to one another or groups of pipes supporting each other as well as a lateral gas-tight closure of the passages by longitudinal fins whose longitudinal edges are welded to the pipe walls of the respective water pipes at the exterior as well as to the neighboring pipe walls of the water pipes located opposite.

A further object is to provide a heat exchanger which does not necessitate an exterior casing and in which the inflowing cooling medium soon after its entry into the cooling head flows off into the cooling range between the pipe walls without encountering any resistance, so that an exceptionally short duration of time within the cooler head is obtained.

A further object is to provide a cooler wherein the cooling medium is applied to pressures nearly to the critical pressure when only a natural circulation is used.

Because of the elimination of the casing and the bottom, besides, a harmful heat accumulation by a material aggregation does not have to be feared anywhere.

A further object is to provide an arrangement of the gas inlet or gas outlet sockets with the correlated gas guide caps on both ends of the cooling surface part with a circular disk which cooperates with the water pipes in the outermost limitation of the cooling surface part, and the inside edge of which is welded to the water pipes, while the edge of the disc protruding towards the outside forms the supporting flange for the gas inlet and gas outlet sockets. Because of this advantageous cooler construction the otherwise necessary arrangement of the heat expansion compensator is superfluous, since the water pipes and thereby the entire heat exchanger can expand freely.

A further object is to prevent a heat transfer between the water pipes forming the exterior casing of the cooling body and the water pipes making up the interior part of the cooling body and serving for the heat exchange. This space between the exterior water pipes and the water pipes fitted in the interior part of the cooling body is filled with a heat insulation material.

A still further object is to provide a heat exchanger wherein the cooling body is advantageously hung in a casing resistant to compression which surrounds and is spaced from the exterior water pipes. The annulus formed between the casing of the water pipes of the cooling body and the interior wall of the casing is especially in high heat exchanges subdivided by cross partitions into which an inert gas, for instance nitrogen is led under pressure, in order to obtain a pressure compensation between the water pipe casing of the cooling body and the interior wall of the casing.

A further object is to construct a heat exchanger which is not only suitable for the cooling of cracked and synthesis gases, but also is very suitable as a waste heat boiler for H_2S - or S-combustion, especially in view of the easy dismantling properties and the elimination of the usually necessary brick lining.

With the above and other objects in view which will become apparent from the detailed description below, some preferred modifications of the invention are shown in the drawings in which:

FIG. 1 illustrates a heat exchanger in a center cross section with parts in elevation;

FIG. 2 is a cross section taken along line 2—2 in FIG. 1;

FIG. 3 is a cross section through a cap taken along line 3—3 in FIG. 1;

FIG. 4 is a partial cross section through a group of water pipes having staggered fins;

FIG. 5 is a partial cross section through a group of water pipes with finned and plane pipes alternating and spacing sheets between two pipes;

FIG. 6 is a modified heat exchanger wherein the casing pipes in the center cross section are distributed in the steam collector and falling water distributor sections;

FIG. 7 illustrates diagrammatically in cross section a further modification wherein a heat exchanger is in a horizontal position;

FIG. 8 is a diagrammatic view in central cross section of a further modification wherein a heat exchanger hung into a compression casing;

FIG. 9 illustrates a partial cross section through the heat exchanger of FIG. 6 along section line 9—9;

FIG. 10 is a partial cross section through the heat exchanger of FIG. 8 along section line 10—10 on an enlarged scale; and

FIG. 11 is an enlarged section of a portion of FIG. 10.

The heat exchanger 1 consists of essentially straight water pipes 3 which are provided with longitudinal fins 2. The water pipes 3 are combined by welding or fastening of the longitudinal edges of the longitudinal fins 2 to the pipe walls 4. The pipe ends of each water pipe 3 are con-

nected by mains 5 with distributors 6 or collectors 7 for the inlet and outlet of the cooling medium.

The pipe walls 4 are arranged parallel and spaced from one another and neighboring pipe walls 4 form passages 8 between them. For the construction of a uniform cooling surface resistant to compression as well as a lateral gas-tight termination of the passages 8, longitudinal fins 9 are provided whose longitudinal edges are welded to the exteriorly positioned water pipes 3 to each pipe wall 4 as well as to the neighboring pipe wall 4 of the water pipes 3 positioned opposite to such water pipes 3. The number of water pipes 3 correlated to each pipe wall 4 and the number of pipe walls 4 to be arranged next to each other depends on the necessary size of the cooling surface. By a corresponding variation of the width of the pipe wall any desired form of design of the cooling surface part, perhaps necessitated by the place to be constructed, may be chosen.

In both ends of the water pipes 3 a circular disc 10 is arranged, the inside edge of which is welded to the water pipes 3 which are positioned in the outer limitation of the cooling surface part formed by the pipe walls 4 and passages 8. The disc 10 is provided at the outside with a supporting edge 11. Onto this supporting edge 11 gas inlet sockets 12 and gas outlet sockets 13 are superimposed. The gas inlet and gas outlet sockets 12 and 13 are provided with a gas guide cap 15 extending towards the gas inlet and the gas outlet side.

The mains 5 lead from the ends of the water pipes 3 at the gas inlet side to the distributors 6 arranged superimposed in the plane of the pertaining pipe wall 4 within the range of the interior space of the gas inlet socket 12 and are led laterally through the wall of the gas inlet socket 12 towards the exterior and are covered in such a way by caps 14 (see FIG. 3) so that the exterior walls of the cap of neighboring pipe walls 4 form guide surfaces for the inflowing gas into the passage 8.

For improving the flowing out of the gases entering into the gas inlet sockets to be cooled in the cooling surface part, i.e. in the passages, in an advantageous way, the mains are guided by the ends of the water pipes and each pipe wall at the gas inlet side towards the distributors, and the mains are in the plane of the pertaining pipe wall arranged superposed and led laterally by the wall of the gas inlet socket towards the outside. The mains are covered in such a way by caps 14, that their exterior walls form guide surfaces for the medium flowing into the passages.

A further advantageous object of a heat exchanger according to the present invention is that the exterior water pipes forming the lateral casing-like termination of the cooling body entirely or a part of the same in their upper termination are connected by mains with the upper ends of the water pipes making up the interior part of the cooling body as well as also the lower termination of the exterior water pipes with the lower ends of the water pipes making up the interior part of the cooling body, so that these water pipes are divided into an upper steam collector section and a lower falling water distributor section from which corresponding rising mains and distributor mains originate.

By this measure there is obtained a gas-tight and pressure-tight cooling body having a completely uniform construction in which, when necessary, each individual pipe rib by itself after removing of the superimposed gas guiding caps at the side of the gas inlet and gas outlet by a simple separation of the mains connecting the pipe rib with the pertaining exterior water pipe can be disassembled. The assembly of a corresponding new pipe rib is just as simple.

By using a bleed which is provided with a perforation, the upper termination of the exterior water pipes can be separated from the lower termination. In the upper termination which serves as a steam collector, the water which precipitates from the outflowing steam-water mixture may then flow to the lower part of the water pipe

to the gravity water distributor section, while on the other hand a clear separation of the pipe parts, different in their mode of operation, is obtained.

For cooling surface parts of an especially long shape, locking rings 16 may be distributed for increasing the resistance to compression throughout the length of the cooling surface parts.

By the arrangement of the staggered fins 2 and the water pipes 3 (FIG. 4) which form groups, or by spacing sheets 18 between parallel pipe walls 4 (FIG. 5) a support of the water pipes 3 among themselves can be obtained, whereby the locking rings 16 then receive the force of reaction and a bending out is avoided. Of course, the groups of pipes may be also so combined that only each second water pipe 3 is provided with fins (FIG. 5).

For a better heat insulation the cooling surface part between the gas inlet and gas outlet sockets 12, 13 may be covered with a heat insulating material 17.

The water pipes 3' (see FIG. 6) which are united to a gas-tight casing of the cooling body which is resistant to compression are in their upper final section connected with the upper ends of water pipes 43 which make up the interior part of the cooling body, as well as in their lower end section 20 with the lower ends of water pipes 43 by mains 5'. The cooling body which is formed is resistant to compression and gas-tight, resembling a uniform construction part, and is supported at each end by a flange 21 onto which the gas inlet or gas outlet caps 15' are placed, through which the medium to be cooled is fed to the cooling body or is led out of the same.

The cooling medium is supplied to the cooling body via gravity tubes 22 and mains 45. The latter empty into the final sections 20 of water pipes 3'. From the final sections 20 the cooling medium distributes via mains 5' to water pipes 3. The mixture of water vapor forming in these pipes is led at the upper end of water pipes 43 via mains 5' to the terminal sections 19 of water pipes 3' and from the same via mains 45 to the rising mains 23 which empty into a steam drum (not shown) (FIG. 6).

An aperture 24 is installed in the water pipes 3' and separates the upper terminal section 19 from the lower terminal section 20 so that a water pre-separation from the outflowing steam mixture can take place.

For the purposes of heat insulation between the water pipes 3' and the interior water pipes 43 the intermediate space is filled with a heat insulating material 36 (FIGS. 9 to 11).

The horizontal heat exchanger according to FIG. 7 corresponds essentially to that of FIG. 6. In order that the formed steam mixture in water pipes 53 does not become stagnant but may rise via the rising main 23' to the steam drum 25, the heat exchanger is erected at an angle to the horizontal. Such a heat exchanger may also be constructed with multi-flues by the installation of known separation walls and the arrangement of corresponding turning chambers at the inlet and outlet ends. It is also possible, of course, to operate such a heat exchanger in forced rotation if necessary with water distribution through nozzles.

In the heat exchanger according to FIG. 8, the cooling body consists of water pipes 3 and 3', the mains 5 and 5', the gravity tubes 22 and the rising mains 23. This cooling body is hung in a casing 26 resistant to compression. The circular space 27 so formed is divided by cross partitions 28 into sections 29. Into these sections 29 as a pressure compensating means an inert gas is fed under pressure. The rising mains 23 lead to collectors 30 from which the rising mains 23' lead to the steam drum 25. The gravity tubes 22 are connected to the circular distributor 31 which is in connection with the steam drum 25 via the gravity tubes 22'. The gravity tubes 22' extending the length of the cooling body are provided with known expansion coils 32. The gas outlet cap 15' is placed on the upper end of the casing 26.

Separation wall 33 may separate the outlet part of the cooling body and the gas outlet cap 15' into two sections. Because of a swivel flap 35 arranged in the gas outlet socket 34 a cleaning effect on the cooling surfaces of the corresponding half of the cooling body by a rise in draft of the heating medium may be secured in a simple way.

Advantageously, the distance of neighboring water pipes of a pipe wall and the distance of neighboring pipe walls is so chosen that the hydraulic diameter between four oppositely positioned water pipes corresponds to the diameter of one of these water pipes or is even smaller.

Hereby, not only a passage of the cooling gases is obtained as free as possible from resistance, but, if necessary, an effective cleaning of the passages by flushing by means of high pressure water jets may be done.

A heat exchanger according to the present invention may be constructed in any conceivable cross sectional form, for instance round, quadrangular, rectangular or in any other desired form.

It is thought that the invention and its advantages will be understood from the foregoing description and it is apparent that various changes may be made in the form, construction and arrangement of the parts without departing from the spirit and scope of the invention or sacrificing its material advantages, the forms hereinbefore described and illustrated in the drawings being merely preferred embodiments thereof.

I claim:

1. Heat exchanger especially for the cooling of fresh cracked gases and/or synthesis gases produced at high pressure comprising an inlet and an outlet for the gas to be cooled, a plurality of substantially straight pipes having longitudinally extending fins to form parallel pipe walls located between said inlet and outlet, said pipe walls being spaced from one another to form passages for said gas communicating with said inlet and outlet, the said longitudinally extending fins having their longitudinal edges welded to adjacent pipes, mains connected to the ends of said pipes, distributors and collectors for the input and output of the cooling medium connected to said mains, said passages formed by said parallel pipe walls supporting one another forming a uniform cooling surface resistant to compression and additional longitudinally extending fins on the exterior pipes of said pipe walls for the lateral gas-tight closure of said passages, said additional fins having their longitudinal edges welded to the exterior pipes of each pipe wall and also to the pipes of an opposite neighboring pipe wall.

2. Heat exchanger as claimed in claim 1 wherein the distance of the pipes forming a pipe wall from a neighboring pipe wall is so dimensioned that the hydraulic diameter between four oppositely located pipes corresponds to about the diameter of one of said pipes.

3. Heat exchanger as claimed in claim 1 wherein a circular disc is provided adjacent the ends of said pipes having its inner edge welded to the exterior pipes and having a supporting edge protruding towards the outside on which said gas inlet and outlet are supported.

4. Heat exchanger as set forth in claim 3 wherein said inlet and outlet have a gas guiding cap.

5. Heat exchanger as claimed in claim 1 wherein said mains lead from the ends of said pipes of each pipe wall at the gas inlet side towards said distributors and are arranged superposed at the level of the associated pipe wall and lead laterally through said gas inlet towards the outside.

6. Heat exchanger as set forth in claim 5 wherein said mains are covered by caps so that the exterior walls of the caps of neighboring pipe walls form guiding surfaces for the medium flowing through said pipes.

7. Heat exchanger as claimed in claim 1 wherein the exterior pipes forming the lateral casing-like closure of the cooling body have their upper ends connected with

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each other by mains with the upper ends of said pipes filling the interior part of the cooling body as well as the lower ends of said pipes filling the interior part of the cooling body and said exterior pipes are divided into an upper steam collecting section and a lower gravity water distributor section from which corresponding rising mains and gravity mains originate.

8. Heat exchanger as claimed in claim 7 wherein said upper section is separated from said lower section of said exterior pipes by a bleed device.

9. Heat exchanger as claimed in claim 1 wherein the space between said exterior pipes forming the casing and said pipes filling the interior are provided with a heat insulating material.

10. Heat exchanger as claimed in claim 1 wherein said exchanger is mounted in a casing resistant to compression surrounding said exterior pipe casing and spaced therefrom to form a circular space.

11. Heat exchanger as claimed in claim 10 wherein said circular space is divided by cross partitions into sections.

12. Heat exchanger as claimed in claim 11 wherein

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said sections of said circular space are kept under high pressure by means of a gas which does not react with the cooling medium.

References Cited

UNITED STATES PATENTS

2,146,261	2/1939	Krug	122—235
2,195,274	3/1940	Ferguson	122—7
2,590,465	3/1952	Ris	165—134 X
3,033,535	5/1962	Schaap	122—235 X

FOREIGN PATENTS

518,290	9/1953	Belgium.
1,106,016	7/1955	France.
835,612	4/1952	Germany.

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