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METHOD OF MAKING A HEAT REGENERATOR

Filed Aug. 23, 1956

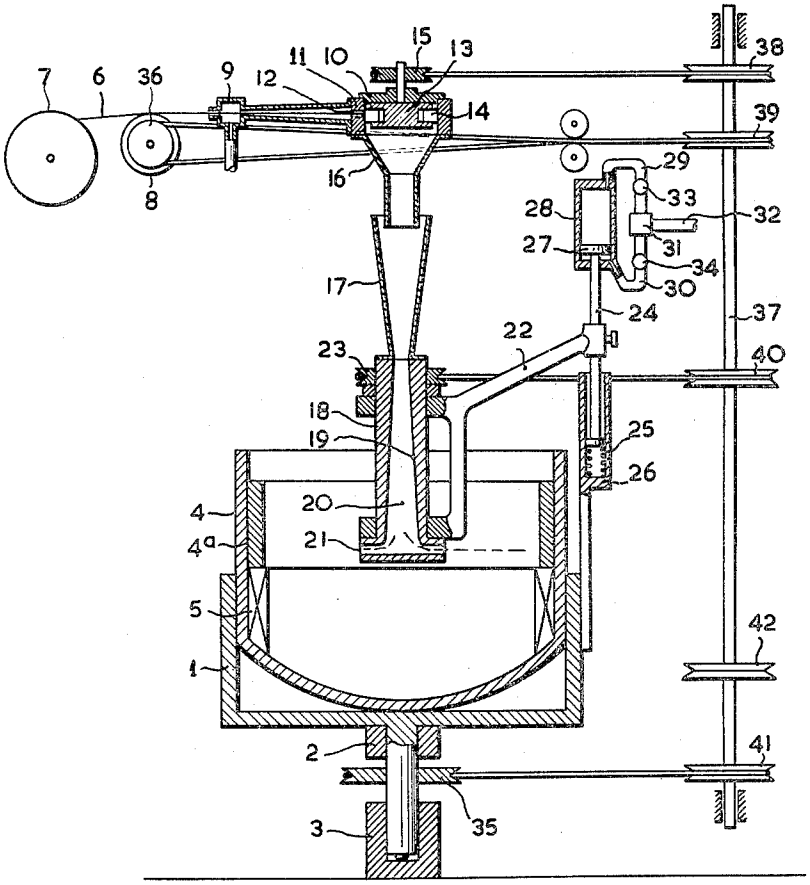


FIG.1

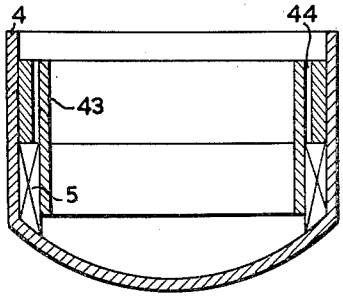


FIG.2

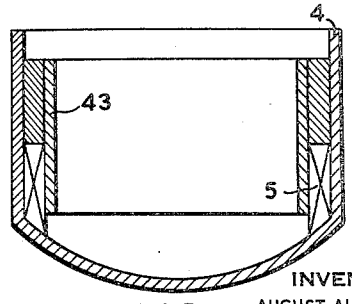


FIG.3

INVENTOR
AUGUST ALBERT LIEBE
BY
AGENT

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METHOD OF MAKING A HEAT REGENERATOR

August Albert Liebe, Eindhoven, Netherlands, assignor to Hartford National Bank and Trust Company, Hartford, Conn., as trustee

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3 Claims. (Cl. 29—157.3)

The invention relates to a method of making a heat regenerator which may be successfully employed particularly in hot-gas reciprocating machines. The term "hot-gas reciprocating machine" is to be understood to mean herein a hot-gas engine, a refrigerator and a heat pump, the latter two operating on the reversed hot-gas engine principle.

It is known that these regenerators can be manufactured in various ways. In one method that has been employed these few years a wire bent along zigzag lines is wound helically.

Afterwards it has been found, however, that the homogeneity of the regenerator must fulfil very severe requirements. Regenerators having a very satisfactory homogeneity may be manufactured by supplying tape or wire material, having a hydraulic diameter of less than 50μ, to a space, for example by spraying it in pieces into the space. Thus a chaotic wire mass is formed on the bottom of the space, this mass being found to have a very high degree of homogeneity, the regenerators thus manufactured have a high useful effect.

The invention now has for its object to manufacture a regenerator which also has a very satisfactory homogeneity by a different method. In accordance with the invention the wall of the space rotates during the spraying operation, the space being rotated during or after the supply of wire with such a speed that the layer formed during the supply on the wall attains the desired filling factor. In this case a large number of short wire pieces may be supplied to the space or, as an alternative, a comparatively small number of long wire pieces, for example of a few meters or more, may be supplied.

With the method according to the invention in contradistinction to the known method, the layer formed does not lie on the bottom, but it engages the rotating side wall, whilst, owing to the centrifugal force, the layer is compressed against the wall. Particularly for the manufacture of a regenerator having a height of more 1 cm. it will at any rate be desirable for the position where the tape or wire material is supplied to the space to be moved, in accordance with a further aspect of the invention, in the direction of the axis of rotation of the wall relatively to this wall. In this case the supply position may be displaced or the wall itself may be displaced in the direction of the axis of rotation.

With one embodiment of the invention the speed of rotation during or after the supply of the material is so high that the layer attains a filling factor which is at least equal to the filling factor required for the regenerator. This filling factor lies, as a rule, between 3 and 30%. As a rule, the layer obtained in this embodiment does therefore not require a subsequent compression by means of special tools to obtain the desired filling factor, which is required in the known method.

According to a further method the wire material is supplied to the space which is to contain finally the regenerator.

Although the space into which the wire material is introduced may have various shapes, it will, as a rule, be desirable to have a cylindrical wall. Especially in this case a further method may be carried out. In this embodiment of the invention the wall is rotated, during

or after the introduction of the wire material, at a higher speed than is required for the desirable filling factor of the regenerator: during this rotation a second wall is introduced inside the first one, so that an annular space is formed between the two walls, which space is employed as the regenerator space, the quantity of the material supplied being such that, when the rotation is stopped, the regenerator has the desired filling factor.

The device for carrying out the aforesaid method has the feature that it is provided with means to form the space, into which the wire or tape material is to be introduced and with means to rotate this space with such a high speed that the wire or tape material supplied bears on the wall of the space, means being furthermore provided to supply wire or tape material to the interior of the drum.

According to a further aspect of the invention the means for supplying the wire material can be displaced in the drum in the direction of the axis of rotation of this drum.

The invention will be described more fully with reference to one embodiment.

FIG. 1 shows diagrammatically a system by means of which a regenerator as described above can be manufactured and

FIGS. 2 and 3 show the housing of a regenerator, in which an inner wall is provided subsequent to the supply of the wire or tape material.

FIG. 2 shows the condition of the regenerator filler during the rotation and

FIG. 3 shows the condition after the rotation has been stopped.

The system shown in FIG. 1 has a cylindrical container 1, which is adapted to rotate in a journal 2 and which is supported in a thrust bearing 3. The container 1 may accommodate the head 4 of a hot-gas reciprocating machine, for example a cold-gas refrigerator, this head having an inner wall 4A and having already, if desired, vanes 5 for the freezer. This head constitutes at the same time the outer wall of the regenerator housing. This regenerator consists of a large quantity of wire material, for example, copper wire having a hydraulic diameter of less than 50μ. This copper wire 6 is stored on a reel 7 and is fed by means of a roller 8 and a spraying device 9 to a cutting device 10, where small pieces are cut from the wire. The length of these pieces is, as a rule, preferably smaller than 10 cms. and larger than 2 mms. The cutting device 10 consists of a housing 11 with an aperture 12 for the supply of the wire 6 and of a knife holder 13, having a plurality of knives 14. The knife holder 13 is rotatable by means of a pulley 15. The cutting device 10 furthermore comprises a funnel-shaped outlet duct 16, which is arranged over a funnel-shaped duct 17, which communicates with the supply device 18 for the supply of the wire pieces to the housing of the regenerator. This supply device consist of a duct 19, having a channel 20 tapering upwards and merging at the lower end in a plurality of axial channels 21. With the aid of a pulley 23 the device is adapted to rotate in a frame 22, whilst the device and the frame are adapted to move up and down. To this end the frame 22 is secured to a rod 24, the lower end of which bears on a spring 25 secured in a holder 26. The holder 26 is secured to the container 1. At the top end the rod 24 has a piston 27, which is adapted to move up and down in a cylinder 28. The cylinder 28 has supply channels 29 and 30 at the top and the bottom respectively for the supply of medium subjected to pressure. Via a three-way cock 31 these supply channels communicate with a common supply

duct 32. The channels 29 and 30 include reducing devices 33 and 34 respectively.

The container 1 is adapted to be rotated with the aid of a pulley 35. The roller 8 also has a pulley 36 to rotate this roller. The pulleys 15, 23, 35, and 36 are adapted to be driven from a shaft 37, which is provided to this end with pulleys 38, 39, 40 and 41; this shaft has furthermore a pulley 42, by means of which it can be driven by a motor (not shown).

The system operates as follows. The container 1 with the head 4 and the supply device 18 are rotated; by a suitable choice of the sizes of the pulleys 35, 41 and 23, 40 there is a difference in speed between the container 1 and the supply device 18 for the wire material. The wire 6, provided on the reel 7, is fed by the rotation of the roller 8 and the air supply of the spraying device 9 through the aperture 12 of the cutting device 10. During the rotation of the holder 13 the knives 14 cut off pieces of wire, which enter the supply device 18 through the funnels 16 and 17. Since the supply device 18 rotates, the pieces of wire could be accumulated on the inner wall of the duct 20. However, this inner wall is slightly conical, so that the wire pieces are yet transported downwardly. Via the axial channels 21 the wire pieces emerge from the device and are swung against the wall 4A of the housing 4: owing to the centrifugal force they bear on the wall.

Owing to an alternate supply of a compressed medium, for example a liquid or a gas over and below the piston 27, the supply device 18 is moved up and down regularly in the direction of the axis of rotation of the wall 4A, so that on the wall 4A of the housing 4 a uniform layer is formed. The speed of the piston 28 can be controlled by the adjustment of the reducing devices 33 and 34.

The filling factor of the regenerator may be determined by the speed of rotation of the container 1. If the regenerator housing is to be provided with an inner wall, this may, for example, be performed during the rotation. In this case, of course, the supply device for the wire pieces must be removed temporarily.

FIG. 2 shows the housing of the regenerator, in which an inner wall 43 is provided. Owing to the rapid rotation of the housing there is a certain amount of opening 44 between the wall 43 and the regenerator filler. When the speed of rotation is reduced, the regenerator filler expands and fills out the complete space between the inner wall and the outer wall, as is shown in FIG. 3. Instead of using short pieces of wire, use may be made of a plurality of long pieces of wire for the regenerator. In this case the cutting device 10 may be omitted and the spraying device 9 is capable of feeding the wire directly to the supply device 18.

The wire or the wire pieces are supplied from the supply device 18 to the wall 4A, in the embodiment shown, by means of the centrifugal force produced by the rotation of the supply device. However, as an alternative, the wire or the wire pieces may be blown from the supply device to the wall 4A: in this case the spraying device 9 can provide the required compressed air. In this case, it is of course, desirable to provide a closure between the funnels 16 and 17.

In the embodiment shown the piston 25 is displaced with the aid of a medium subjected to pressure: as an alternative, however, the displacement may be obtained by purely mechanical agency, for example with the use of a heart-shaped cam disc, on which bears the rod 24.

The desired filling factor of the regenerator may be attained by rotating the housing during the supply of the wire material with such a speed that the filler is compressed by the centrifugal force until this factor is obtained. As a matter of course the speed of rotation may be compartively low during the supply, so that in this period the required filling factor is not attained, the speed of rotation being increased after the supply of the wire material until the required filling factor is attained: the speed of rotation may even be increased beyond this value, as is described above, the filling factor of the wire material being attained after the speed of rotation has been reduced.

What is claimed is:

1. A method of manufacturing a heat regenerator provided with regenerator material constituted of metal wire or tape comprising filling the wall of the heat regenerator housing with a layer of resilient wire particles by simultaneously rotating the resilient wire particle supply device at a rate of speed sufficient to deposit a layer of resilient wire particles on said wall of said heat regenerator housing and rotating said housing at such a speed of rotation that the required centrifugal force is developed to provide not only the desired filling factor of the resilient wire particles but to insure the compression thereof, furnishing regenerator material in strip form, cutting said regenerator material into relatively small pieces and supplying the same to said supply device, inserting an annulus member within said compressed resilient wire particles while said housing is being rotated, and thereafter terminating the rotation of said housing whereby said resilient wire particles will expand and secure said annulus member within said housing.

2. A method of manufacturing a heat regenerator provided with regenerator material constituted of metal wire or tape comprising filling the wall of the heat exchanger housing with a layer of resilient wire particles by simultaneously rotating the resilient wire particle supply device at a rate of speed sufficient to deposit a layer of resilient wire particles on said wall of said heat regenerator housing and rotating said housing at a rate of speed sufficient to develop the required centrifugal force not only to provide the desired filling factor of the resilient wire particles but to insure the compression thereof, inserting an annulus member within said compressed resilient wire particles while said housing is being rotated, and thereafter terminating the rotation of said housing whereby said resilient wire particles will expand and secure said annulus member within said housing.

3. A method of manufacturing a heat regenerator as claimed in claim 2 comprising further translating said supply device while said supply device is being rotated at least partly within said heat regenerator housing whereby a layer of regenerator material is deposited on said regenerator housing by means of centrifugal force.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,015,153 January 2, 1962

August Albert Liebe

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the grant, lines 2 and 3, for "assignor to Hartford National Bank and Trust Company, of Hartford, Connecticut, as trustee," read -- assignor, by mesne assignments, to North American Philips Company, Inc., of New York, N. Y., a corporation of Delaware, --; lines 12 and 13, for "Hartford National Bank and Trust Company, as trustee, its successors" read -- North American Philips Company, Inc., its successors --; in the heading to the printed specification, lines 3 to 5, for "assignor to Hartford National Bank and Trust Company, Hartford, Conn., as trustee" read -- assignor, by mesne assignments, to North American Philips Company, Inc., New York, N. Y., a corporation of Delaware --.

Signed and sealed this 14th day of August 1962.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents