

June 10, 1930.

F. LJUNGSTRÖM

1,762,446

REGENERATIVE AIR PREHEATER

Filed Aug. 17, 1923

3 Sheets-Sheet 1

Fig. 1.

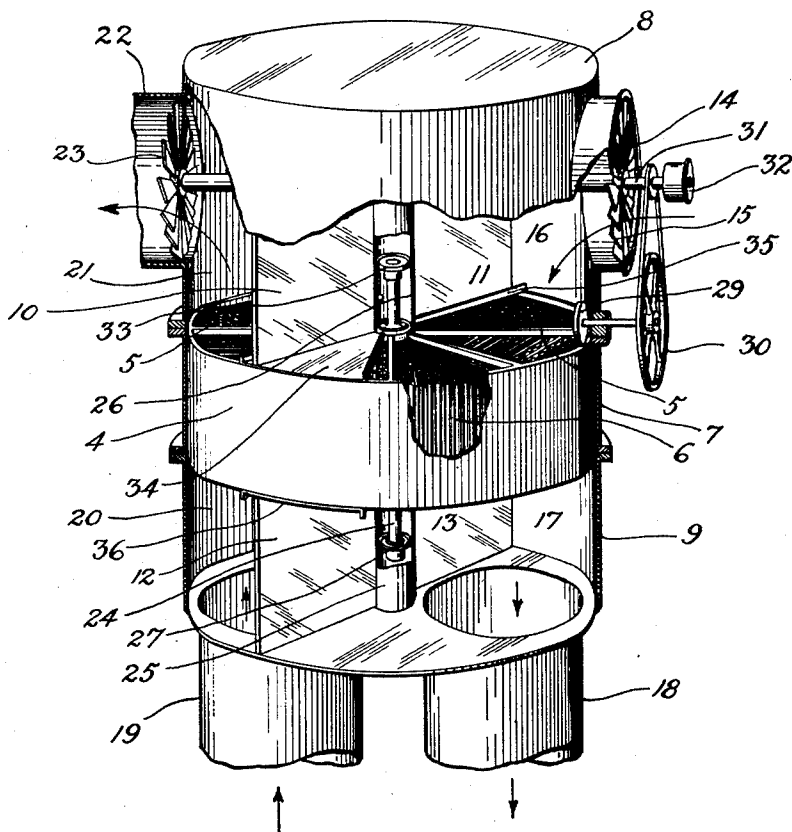


Fig. 2.

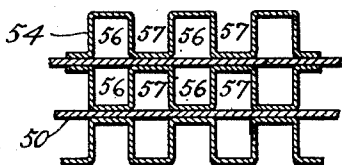
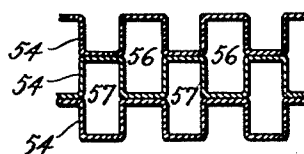


Fig. 3.



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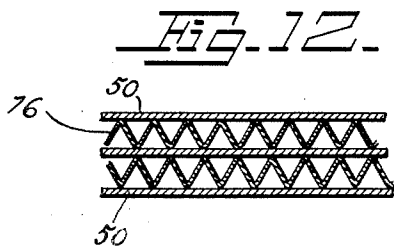
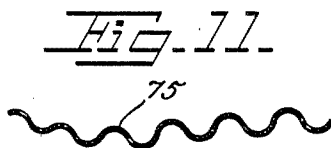
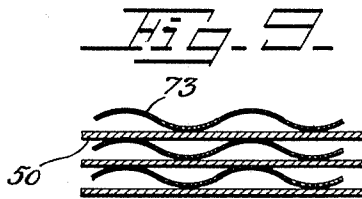
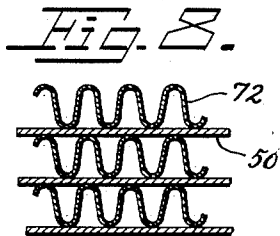
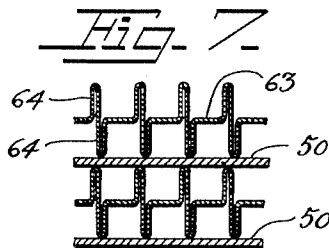
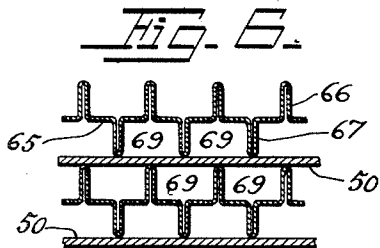
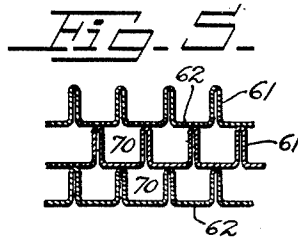
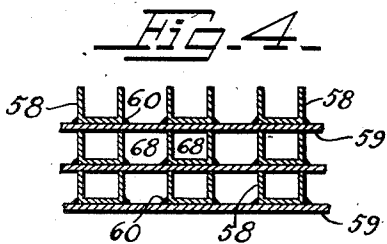
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3 Sheets-Sheet 2



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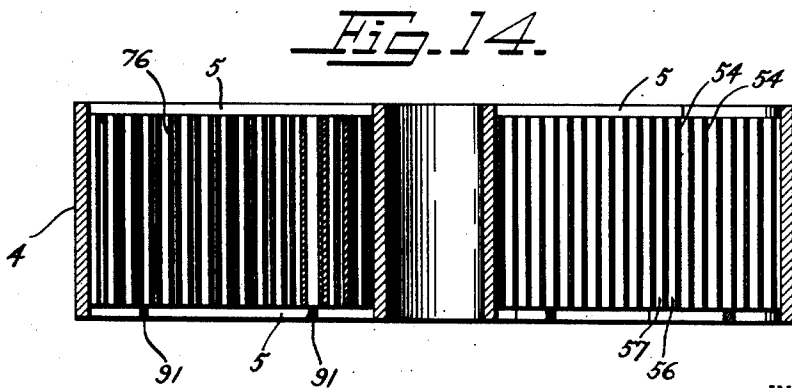
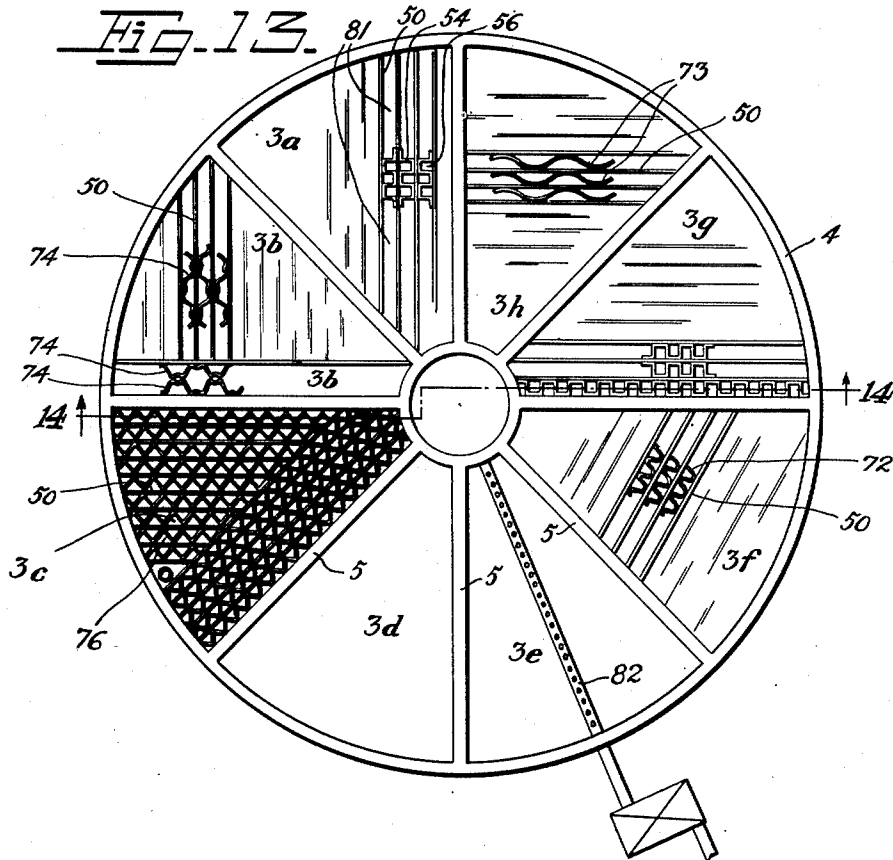
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REGENERATIVE AIR PREHEATER

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3 Sheets-Sheet 3



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REGENERATIVE AIR PREHEATER

Application filed August 17, 1923, Serial No. 657,991, and in Sweden August 23, 1922.

My invention relates to heat exchange devices of the so-called "regenerative" type wherein one fluid passes in contact with the surface of a substance and gives off heat to the same, whereafter another fluid passes into contact with the same surface and is heated.

My invention relates generally to heat exchange apparatus of the regenerative type and more specifically to the particular kind wherein the regenerative material is rotated. It is to be understood however that my invention is not limited to this particular form of device.

My invention is particularly directed to the form of regenerative material and has for its object to provide a maximum heat absorbing and heat rejecting surface with a minimum of flow resistance whereby a maximum of efficiency is obtained. This is accomplished, in the preferred form, by arranging the regenerative material to form a multiplicity of extremely narrow channels extending in the general direction of flow of gases through the regenerative material.

Further objects and the nature of the invention will be readily apparent from the following description, taken in connection with the accompanying drawings, which sets out various forms of the invention applied to one type of regenerative heater.

In the accompanying drawings: Fig. 1 shows a complete regenerative heating device assembled including a rotor divided into compartments in each of which is placed regenerative material; Fig. 2 shows one form of regenerative material consisting of alternately disposed flat and bent plates; Fig. 3 shows a second form of regenerative material comprising bent plates alone; Fig. 4 shows a regenerative material comprising flat plates and angle irons; Fig. 5 shows a regenerative material consisting of plates bent to form ribs; Fig. 6 shows alternately disposed flat and double ribbed bent plates; Fig. 7 shows alternately disposed flat and bent plates somewhat different from that shown in Fig. 6; Fig. 8 shows alternately disposed flat and corrugated plates, the corrugations of the corrugated plates being dis-

posed relatively close to each other; Fig. 9 shows a different form of alternately disposed flat and corrugated plates, the corrugated plates having shallow corrugations; Fig. 10 shows a type of plate bent to form a spring action when interposed as regenerative material together with flat plates; Fig. 11 shows a different type of corrugated plate adapted to be held in position by its spring-like character; Fig. 12 shows alternately disposed flat and corrugated plates, wherein the corrugated plates have sharp edges forming angles; Fig. 13 is a plan view of the rotor showing the different forms of regenerative material set into the compartments thereof; and Fig. 14 is a vertical sectional view taken on the line 14—14 of Fig. 13.

In Figs. 1, 13 and 14 reference character 4 designates a rotor which is of cylindrical outer form and is divided by radial walls into a series of radially disposed chambers (Fig. 13) each of which contains metal regenerative material as indicated by reference character 6 in Fig. 1. The rotor together with the radial walls 5 constitute a framework for supporting the regenerative material. The rotor is disposed in an intermediate rotor section 7 of the heating device as a whole. The rotor section is interposed between an upper section 8 and a lower section 9. The upper section and the lower section are divided by radially extending walls 10, 11, 12 and 13 into separate chambers respectively which form supply and discharge conduits for a fluid to be heated and a fluid giving off heat. The fluid to be heated enters through fan opening 14 in which is disposed a forced draft fan 15 and passes downwardly through chamber 16 which is a supply conduit for the fluid to be heated and into the passages formed within the regenerative material between members thereof. The rotor is open at either end and the regenerative material is arranged perpendicularly to the open ends of the rotor so that the passages for the flow of fluid through the regenerative material are in the general line of flow through the regenerative heating device. It is to be noted

that an important feature of the present invention is having the passages in the general line of flow through the regenerative heating device. After passing through the regenerative material which is in communication with chamber 16, the fluid passes into chamber 17 which is on the same side of the partition formed by plates 10, 11, 12 and 13 as the chamber 16. Chamber 17 constitutes an outlet channel for the fluid to be heated. This chamber 17 is connected with a conduit 18 which carries the heated fluid to its point of use.

The heating fluid passes through conduit 19 and into chamber 20 which is on the opposite side of the partition 12, 13 to the chamber 17. Thence the heating fluid passes upwardly through the regenerative material which is in communication with chamber 20 and passes into chamber 21 which is opposite chamber 16 with respect to partition 10, 11. At this point the heating fluid has been cooled by the regenerative material and it passes away through conduit 22 in which is disposed an induced draft fan 23.

The rotor rotates about a shaft 24 which is situated within tubular members 25, 26 and is supported in bearings within the tubular members of which the lower bearing is indicated at 27 and the upper bearing is indicated at 33. The rotor is rotated by means of a roller 29 driven by a wheel 30 which is interconnected to fan shaft 31 on which both fans 15 and 23 are mounted. A pulley 32 is arranged on shaft 31 to receive a belt actuated by any suitable prime mover. The rotor and the fans are thus operated together in the manner set out and described in Patent No. 1,586,816, granted to me on June 1, 1926.

In order to prevent leakage of fluid from one side of partition 10, 11, 12, 13 to the other, sector plates 34, 35 are employed at the lower edges of plates 10 and 11 and corresponding sector plates are employed at the top edges of plates 12 and 13 of which the sector plate at the top edge of plate 12 is indicated by reference character 36. These sector plates are of such size as to completely cover each chamber 3 in its rotation as it passes from one channel to the other. The edges of the sector plates bear against the upper and lower edges of the partitions 5. One form of this arrangement is described and claimed in my co-pending application Serial No. 460,600 filed April 11, 1921.

Fig. 2 shows one form of regenerative material suitable for accomplishing the purpose of the present invention. The regenerative material comprises straight or plane plates 50 between which are interposed plates 54 which are bent along mutually parallel lines so as to form together with the flat plates substantially square passages

56 and 57. This arrangement gives a large heat absorbing and heat rejecting surface for a small volume of regenerative material. By means of the bent plates, each of the relatively long passages between the parallel plates 50 is subdivided into a multiplicity of small narrow passages. The regenerative material is placed so that the passages 56 and 57 are in the general line of flow of fluid through the heater. All the passages 56 and 57 are parallel to each other. When applied to the type of heater shown in Fig. 1 the plates are arranged so that every portion of the same is parallel to the axis of rotation. This gives a minimum resistance so that very little power is required to drive the fans while an enormous surface is obtained and the cleaning of the passages is made relatively simple.

Fig. 3 shows an arrangement similar to that shown in Fig. 2 except that the flat plates 50 are omitted. By this arrangement the U-shaped channels 56 and 57 of adjacent plates 4 form double channels. Instead of separating the bent plates 54 by flat plates they may be separated by strips. This would prevent the possibility of the recesses in the plates setting into each other.

In Fig. 4 the regenerative material is made up by welding, as indicated by reference character 60, a series of channels 58 to flat plates 59. The channels are arranged on the flat plates so that intermediate passages 68 are formed which are of uniform cross-section and parallel. The elements formed in this way are inserted into the rotor in such manner that the flat plate 59 of the element is directed towards the open channels of the adjacent element. The arrangement may be altered by welding channels to opposite sides of a plate and placing such elements between flat plates.

The regenerative material in Fig. 5 is formed by bending a flat plate to provide ribs 61 on the same. By this means both the spaces between the flat plates and the cross-subdivisions are obtained by a series of like plates. The elements are inserted in the same way into the rotor of Fig. 1 so that all the portions of the plates are parallel to the axis of rotation so that the intermediate passages 70 are in the straight line of flow through the regenerative material.

In the embodiment shown in Fig. 6, plates 65 are bent to form ribs 66 and 67 on opposite sides of the same. These plates are interposed between flat plates 50 and form straight parallel channels 69.

In Fig. 7 the plates 63 which correspond to plates 65 of Fig. 6 are bent somewhat differently. The general result will be the same as obtained by the arrangement of Fig. 6. In this case one side of any fin

64 is a continuation of one side of an oppositely disposed in.

Figs. 8 and 9 show alternately disposed straight and corrugated plates of different formations, the corrugated plates 72 of Fig. 8 having the corrugations disposed closer to each other so that there is a less number of corrugations per unit of length than in the corrugated plate 73 of Fig. 9. The corrugated plates are preferably introduced alternately with plane plates and arranged as previously set out.

In Figs. 10 and 11, multifariously corrugated plates 74 and 75 are shown which are adapted to be placed into the rotor together with intermediate flat plates and which, because of their elastic action, exert a strain of the elements against the walls of the rotor whereby an increased stiffness is obtained.

In the embodiment shown in Fig. 12 corrugated plates 76 with sharp corrugations are interposed between flat plates 50. This arrangement makes a series of parallel triangular passages extending in the general line of flow of fluid through the regenerative heater.

In the rotor shown in Fig. 13 the compartment designated by reference character 3^a is filled with regenerative material as shown in Fig. 2. Viewing the rotor as shown in this figure the eye can look straight down through the passages 56. It is clearly seen from this view how the flat plates 54 form what might be termed relatively long passages between them as indicated by reference character 81. These passages 81 are subdivided by the transverse portions of the bent plates 54 into a multitude of very small passages.

The compartment marked 3^b has a series of plates in the same of the type shown in Fig. 10 with flat plates 50 interposed therebetween and another series of corrugated plates 74 abutting each other.

While the majority of the compartments are diagrammatically shown as filled with regenerative material, the compartment marked 3^c has been filled in with regenerative material of the type shown in Fig. 12 consisting of triangularly corrugated plates 76 with flat plates 50 interposed between the same. It will be noticed that the plates may be placed at any angle with respect to the walls 5 of the rotor. Compartments 3^d and 3^e are left open and any of the forms of regenerative material may be placed in these compartments. While different types of regenerative material are used in different compartments, it would be most common in practice to use the same type of material in all compartments.

82 designates a stationary soot blower of the type shown in Patent No. 1,558,445, granted to me on October 20, 1925.

In compartment 3^f regenerative material

is shown of the type previously shown in Fig. 8 and consisting of corrugated plates 72 interposed between flat plates 50. In compartment 3^g the same type of material has been inserted as in compartment 3^e. Fig. 14 clearly shows how the passages 56 and 57 run.

Compartment 3^h shows regenerative material of the type shown in Fig. 9 with corrugated elements 73 interposed between flat plates 50.

The plates do not extend the full height of the rotor and are retained in the rotor by means of transverse supports 91.

While I have described the invention as applied to one form of regenerating heating device, it is to be understood that this is merely for sake of description and that the invention is not to be limited to the type of regenerative heater or the modifications herein described. It will be obvious that the invention can be applied to the radial and other types of regenerative heaters.

It will be understood that the word "corrugated" as employed in the appended claims is not specific to any particular manner of corrugation but is used as applied to any plate or member which is bent so as to form alternate ridges and furrows.

Having thus described my invention, what I claim is:

1. In a heat exchange apparatus, the combination with a cylindrical frame-work, means including inlet and outlet conduits for causing a body of heating fluid to flow through said frame-work, means including inlet and outlet conduits for causing a body of fluid to be heated to flow through said frame-work, and means for causing relative movement between said conduits and said frame-work, of regenerative material mounted in said frame-work comprising flat plates arranged axially in the general line of flow through said frame-work forming a series of passages therebetween through said regenerative material and bent plates between said flat plates arranged to subdivide each of the passages between proximate flat plates into a multitude of passages extending axially in the general line of flow through the frame-work.

2. A regenerative heating device for fluids wherein heat is abstracted from one fluid passing through the same and is given off to another fluid passing through the same, said device comprising supply and discharge conduits for the fluid to be heated and the fluid giving off heat, a frame-work, said frame-work having open ends, said open ends determining planes, regenerative material in said frame-work comprising members arranged perpendicularly to the planes of the open ends of said frame-work and of such form as to provide a series of continuous passages through said frame-work in the gen-

eral line of flow therethrough, other members separating the before mentioned members and serving to form a series of passages between each of the first mentioned members also in the general line of flow through the frame-work, and means for effecting relative movement between said frame-work on the one hand and said supply and discharge conduits on the other hand so that said fluids pass alternately through the same passages.

3. A rotor for use in regenerative heaters comprising a cylindrical frame-work having an axis of rotation, a plurality of chambers in said frame-work, each comprising a series of bent members arranged axially and a series of straight members interposed between said bent members whereby a multiplicity of channels for flow of fluid is formed axially.

4. A regenerative heating device in which heat is transmitted from one fluid to another fluid comprising a rotor, supply and discharge conduits for the fluid to be heated and for the fluid giving off heat, means for rotating said rotor and alternately effecting communication between said conduits and different portions of said frame-work, a series of walls in said frame-work dividing the same into a series of chambers, a series of bent metal plates arranged in said chambers in the general line of flow therethrough and a series of flat plates separating said bent plates.

5. In a heat exchange apparatus, the combination with a frame-work, means including inlet and outlet conduits for causing a body of heating fluid to flow through said frame-work, means including inlet and outlet conduits for causing a body of fluid to be heated to flow through said frame-work, and means for causing relative movement between said conduits and said frame-work, of regenerative material mounted in said frame-work comprising bent members arranged to form a series of parallel passages between them of substantially triangular cross-section and in the general line of flow of fluid from the inlet conduits through the regenerative material and to the outlet conduits respectively.

6. In a heat exchange apparatus, the combination with a frame-work, means including inlet and outlet conduits for causing a body of fluid to be heated to flow through said frame-work, and means for causing relative movement between said conduits and said frame-work, of regenerative material mounted in said frame-work comprising flat plates arranged in the general line of flow through said frame-work from the inlet conduits to the outlet conduits and forming a series of parallel passages therebetween through said regenerative material and bent plates disposed between said flat plates to

divide the passages formed between proximate flat plates into a multitude of passages also extending in the general line of flow through the regenerative material from the inlet conduits to the outlet conduits.

7. A regenerative heat exchange device comprising regenerative material consisting of alternately disposed flat and corrugated plates forming a multitude of passages, channels for a fluid to be heated and a fluid giving off heat, and continuously moving means controlling communication between said passages and different channels to simultaneously cause certain of the passages to form part of the path of the fluid to be heated and other passages to form part of the path of the heating fluid without intermixture of the two fluids, said plates being arranged so that said passages extend in the general line of flow through the device.

8. A regenerative heat exchange device comprising regenerative material consisting of alternately disposed flat and corrugated plates forming a multitude of passages, channels for a fluid to be heated and a fluid giving off heat, said channels and said regenerative material being relatively movable, and means controlling communication between said channels and said passages for simultaneously causing certain of the passages to form part of the path of the fluid to be heated and other passages to form part of the path of the fluid giving off heat.

9. In a heat exchange apparatus, the combination with a frame work, means including inlet and outlet conduits for causing a body of heating fluid to flow through said frame work, means including inlet and outlet conduits for causing a body of fluid to be heated to flow through said frame work, and means for causing relative movement between said conduits and said frame work, of regenerative material mounted in said frame work comprising a plurality of plates arranged in the general line of flow through said frame work and contacting at spaced intervals to form a series of separated passages extending in the general line of flow through the frame work.

10. A rotor for use in regenerative heaters comprising a cylindrical frame work having an axis of rotation, a plurality of chambers in said frame work each comprising a plurality of plates arranged axially and contacting at spaced intervals to form a multiplicity of separated channels for flow of fluid axially through said frame work.

11. A regenerative heat exchange device comprising regenerative material consisting of plates contacting at spaced intervals to form a multitude of passages, channels for a fluid to be heated and a fluid giving off heat, said channels and said regenerative material being relatively movable, and

means controlling communication between said channels and said passages for simultaneously causing certain of the passages to form part of the path of the fluid to be heated and other passages to form part of the path of the fluid giving off heat.

12. A regenerative heat exchange device comprising regenerative material consisting of plates contacting at spaced intervals to form a multitude of passages, channels for a fluid to be heated and a fluid giving off heat, said channels and said regenerative material being relatively movable, and means for relatively moving said channels and said regenerative material to simultaneously cause selected passages to form part of the path of the fluid to be heated and other passages to form part of the path of the fluid giving off heat, said passages extending in the general line of flow through the device.

In testimony whereof I affix my signature.

FREDRIK LJUNGSTRÖM.

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