United States Patent

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[54] **ROTARY KILN CHAIN**
14 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **263/33; 34/142**
[51] **Int. Cl.** **F27b 7/00**
[50] **Field of Search** ..... 263/33, 33(C); 34/142; 159/9, 9(A)

[56] **References Cited**
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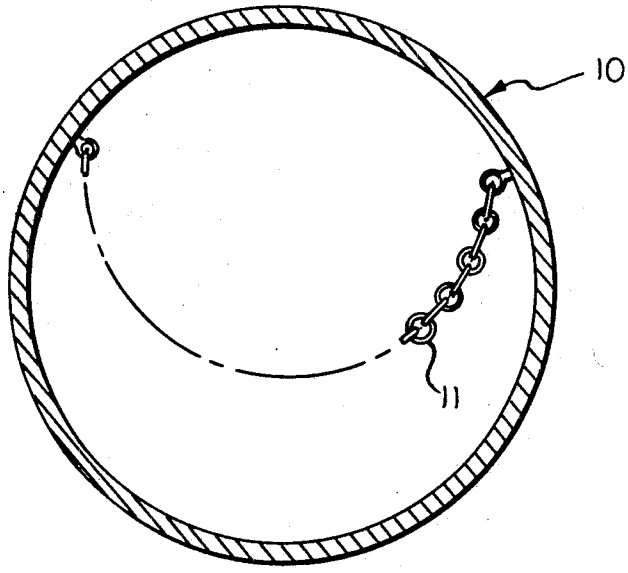
ABSTRACT: Rotary kiln chain for use as a heat transfer element in a rotary kiln used in the manufacture of cement, and like products, including connected circular links formed with a uniform cross-sectional shape that is substantially greater in dimension in one of the axial or radial directions than the other of the axial or radial directions, and provided with inner engaging surfaces having a form that minimizes material buildup to provide more efficient heat transfer action.



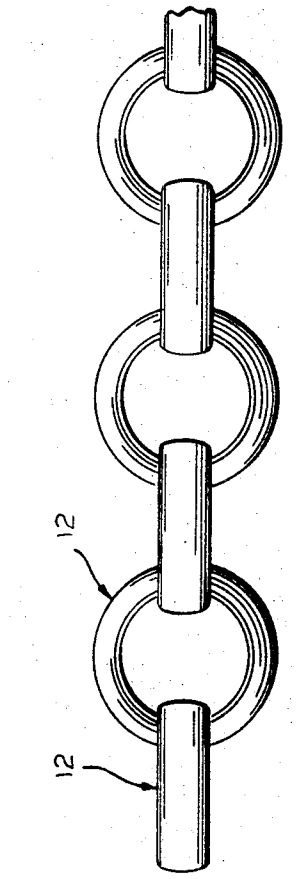


FIG. 2

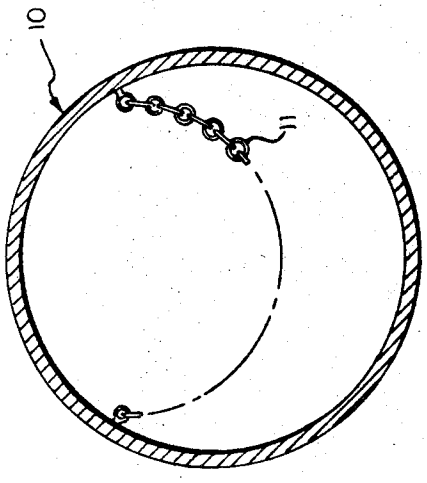


FIG. 1

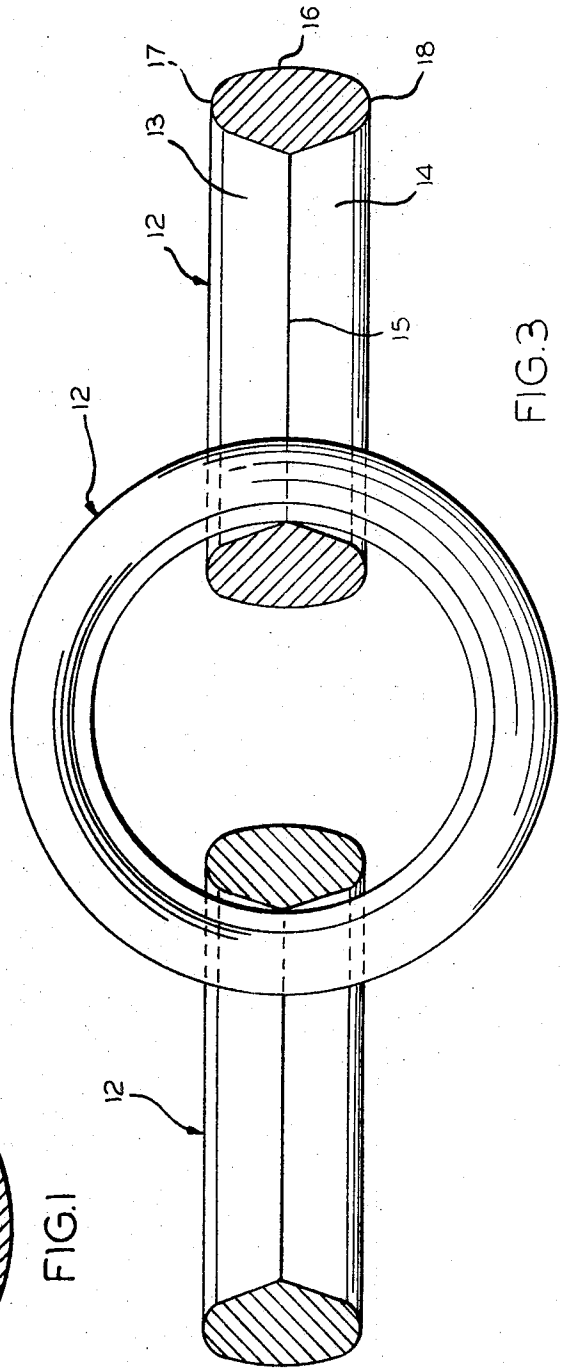


FIG. 3

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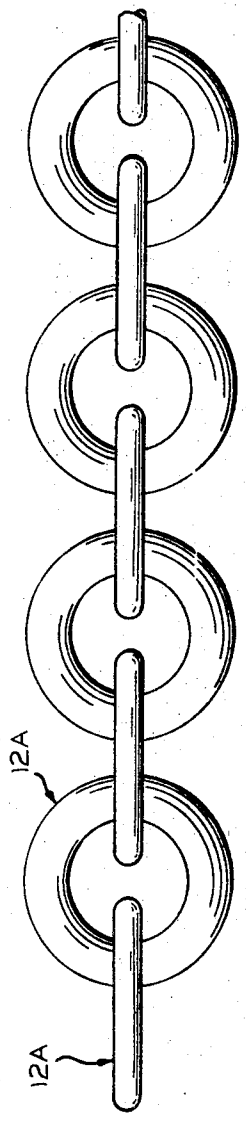

FIG. 4

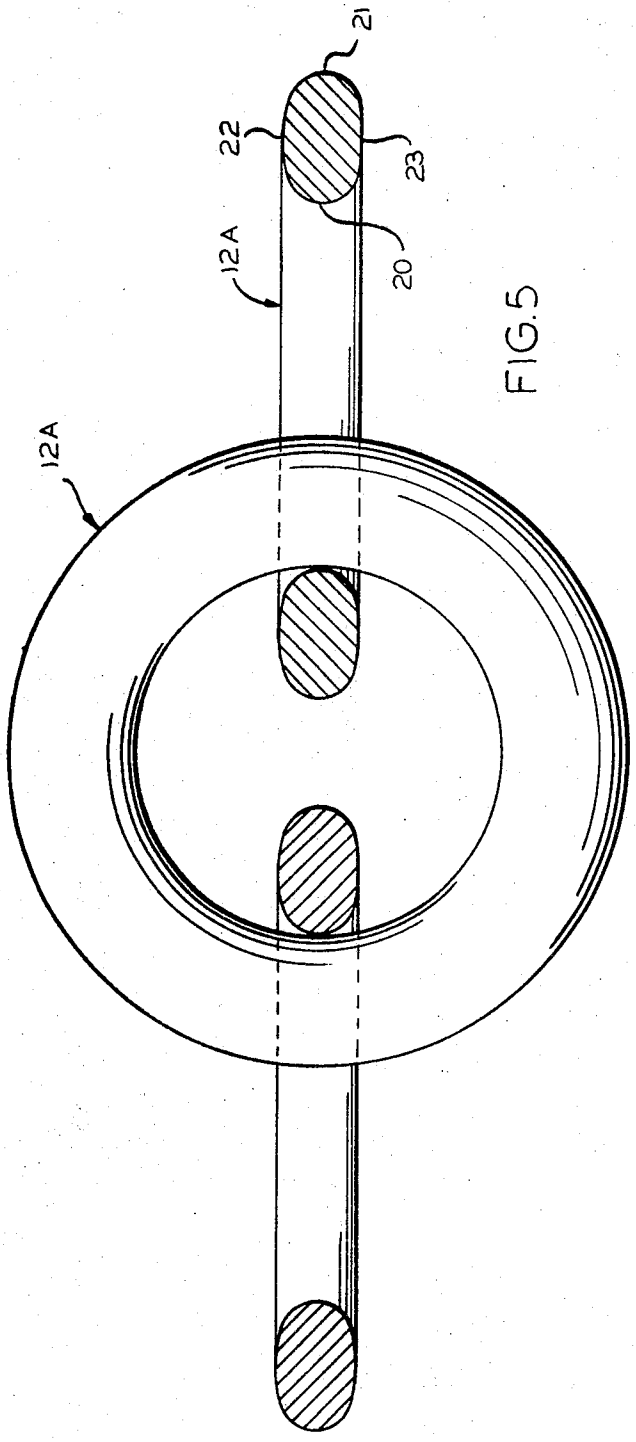

FIG. 5

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ROTARY KILN CHAIN

This invention relates in general to a rotary kiln, and more particularly to chain employed as a heat transfer means in a rotary kiln, and still more particularly to rotary kiln chain having a cross-sectional shape that minimizes material buildup and maintains continued, efficient heat transfer capability.

The chain of the present invention is employed in rotary kilns used in the manufacture of cement and like products, and for the purpose of transferring heat to the material being treated. For example, a wet, raw material may be fed into the inlet end of a rotary kiln that is rotated slowly about its axis, and which is disposed at a slight incline downwardly toward the delivery end. The chain is suspended within the kiln in any desired manner, and heated gases are directed into the delivery end of the kiln to transfer heat to the chain, which, in turn, during rotation of the kiln, comes into contact with the wet, raw material and transfers heat to the material.

Many different shapes of chain links have heretofore been used as heat transfer elements in rotary kilns. For example, one such form is found in U.S. Letters Pat. No. 3,281,134, granted Oct. 25, 1966, wherein the cross-sectional shape of the link is such that the axial width is greater than the radial width. This shape is important and advantageous over the conventional rod or wire stock of comparable size, because of the reduction in weight will still maintaining nearly the same heat transfer surface area. Weight reduction is important from the standpoint of kiln construction and the reduction of power needed to operate the kiln. Thus, it is desirable to reduce weight without materially reducing the exterior heat transfer area of the chain links. Moreover, the inner engaging surface of each link is somewhat flat and is formed to provide nearly complete contact along its axial dimension with another link for the stated purpose being to minimize wear caused by interengagement of adjacent links. This structure has been objectionable in that undesirable material buildup is experienced, and which is detrimental to efficient kiln operation. The buildup is such that the links become partially or fully plugged, thereby impeding gas flow through the chain section, and ultimately causing production problems. Material buildup also reduced the heat transfer capability of the links due to the insulating properties of links covered with material.

The chain of the present invention obviates the above difficulties by providing a structure that eliminates or substantially eliminates material buildup by enabling better cleaning action between links, thereby maintaining effective and efficient gas flow through the chain section. Further, by maintaining the links substantially clean, because of the more efficient cleaning action established, the heat transfer properties of the links are utilized to their fullest.

The chain of the present invention includes connected links, wherein each link is provided with a uniform cross-sectional shape throughout the circumference thereof. One of the axial or radial thicknesses of the link cross-sectional shape is substantially greater than the other of the axial or radial thicknesses. More efficient cleaning action is obtained by forming the inner surface of the link to define minimal engaging contact with another link, thereby enhancing self-cleaning as the links move relative each other minimizing material buildup between links. In one embodiment, the axial thickness is greater than the radial thickness and the inner surface is V-shaped, so that a relatively knife edge contact is established between adjacent links. In another embodiment, the radial thickness of the link cross-sectional shape is substantially greater than the axial thickness, thereby automatically minimizing the relative engaging contact between links. In this latter embodiment, it has also been found that the pull strength is materially increased.

Accordingly, it is an object of the present invention to provide an improved rotary kiln chain that enhances self-cleaning and eliminates or substantially eliminates material buildup between links.

Another object of this invention is in the provision of chain for rotary kiln having a more efficient cleaning action between links, thereby maintaining the heat transfer ability throughout its life, and throughout its operation in a kiln, and to enable efficient gas flow through the chain section.

A further object of this invention resides in the provision of rotary kiln chain having the inner, engaging surface formed to facilitate cleaning action and to provide minimal, engaging contact between links.

Other objects, features and advantages of the invention will be apparent from the following detailed disclosure, taken in conjunction with the accompanying sheets of drawings, wherein like reference numerals refer to like parts, in which:

FIG. 1 is a vertical, sectional view taken through a rotary kiln and illustrating one section of chain suspended within the kiln;

FIG. 2 is a plan view of several links of chain constructed in accordance with the present invention;

FIG. 3 is a view of several links of chain, illustrating some of the links in section and one link in plant to illustrate the interaction between links;

FIG. 4 is a plan view of several links of chain illustrating modifications of the invention; and

FIG. 5 is a view of the chain of FIG. 4, illustrating some links in section and one link in plan to show the interconnection and engagement of the links.

An exemplary kiln within which the kiln chain of the present invention would be employed as a heat-exchanging element is illustrated in FIG. 1, and is generally indicated by the numeral 10. This kiln is of the rotary type that would have a large diameter and an extremely long length, depending upon the particular installation. The kiln would be suitably supported for rotary movement about its axis, and be powered to rotate at a slow speed. Moreover, the kiln would be inclined downwardly from the inlet end to the discharge end. The material to be treated would be introduced at the inlet end, treated during its travel to the kiln, and discharged at the outlet end.

A section of chain 11 is illustrated in suspended relation within the kiln by being secured at opposite ends to the inner kiln wall. Any number of chain sections will be provided throughout the kiln or in the areas where the material is to be treated. And the chain sections may be secured in any other fashion, such as solely from one end of the section.

The present invention relates primarily to the cross-sectional shape of chain which enhances the efficiency during its use in a kiln, so that it can maintain a high and desired production output, as well as enhancing its life to reduce the chain costs involved in a kiln. While the embodiments illustrated show links of particular construction, it should be appreciated that the present invention could also be applied to links of other configurations.

It has been accepted in the industry that circular link design is most preferable on the basis that it is self-cleaning, and wears evenly, because it can rotate, and has the least tendency to entangle. However, some circular link chain, such as that shown in the aforesaid U.S. Pat. No. 3,281,134 , has been objectionable because of material buildup, which interferes with the efficiency of kiln operation. In particular, material buildup can result in plugged chain that interferes with th heated gas flow through the chain section, thereby causing production problems. For example, interfering of gas flow through any section might result in overheating of chain in another section, which would have a detrimental effect on chain life. Further, material buildup interferes with the heat transferability of the chain inasmuch as it effectively applies a heat insulating layer on the chain. Such would reduce production of a kiln. The contact between links of the chain of the aforesaid patent is substantial and complete relative to the axial width of the links. The material buildup problem has been overcome in the present invention by providing chain having minimum interengaging contact.

In the first embodiment of the present invention, FIGS. 2 and 3, circular links 12 are sized so that with respect to the cross-sectional shape the axial width of each link is substan-

tially greater than the radial width, just as the chain link in the aforesaid patent. The inner surface of each link is formed to produce point or knife edge engagement between successive links, which engagement provides a cleaning action that substantially if not completely eliminates material buildup between links. In this respect, the cross-sectional shape of the inner surface of each link is substantially V-shaped and includes flat surfaces **13** and **14**, which define at the junction a relatively sharp or knife edge **15**, that is located along a central plane extending through each link. The flat surfaces are continuous relative to the circumferential character of each link, and, therefore, annular. From this central plane, and considering the cross-sectional shape, the cross section is symmetrical. The outer surface **16** is arcuate and smooth, and formed by an arc having a radius about equal to the radius of the inner diameter of the link. This outer surface is connected at each of its ends by arcuate end faces **17** and **18** to the flat faces **13** and **14**.

During use in a kiln, the links **12** will change position, as the chain condition transforms from slack to tight or suspended condition, so that bearing contact with an adjacent link will vary along the knife edge **15**. As seen in FIG. **3**, the knife edge of one link will engage the knife edge of an adjacent link. This relatively sharp edge contact and the normal movement of the links relative to each other will produce an effecient cleaning action, so as to substantially, if not completely eliminate material buildup on the chain. Buildup will be efficiently eliminated between chain links at the bearing contact engaging faces, and will also be eliminated at the outer surfaces of the links by virtue of when the chain goes slack, the inner surfaces of some links will engage the outer surfaces of other links. This efficient cleaning action will, by preventing material buildup, maintain the chain links open and unplugged, thereby utilizing the gas flow in the chain section. Moreover, the maintaining of the links in substantially clean condition will enable substantially complete use of the heat transfer surface on the links. Overall, the chain of the present invention will facilitate efficient operation of a kiln, and enhances chain life.

While the chain of the embodiment of FIGS. **2** and **3** may have any desired size and weight, and may be constructed in any desirable manner, it is preferably cast of an alloy steel having the following approximate dimensions. Each link would have an outside diameter of 45/16 inches and an inside diameter of 3 inches and have a radial width of twenty one -thirty two seconds inch and an axial width of 1 9/32 inches. This would produce a link that would have an estimated weight of 2.12 pounds. The chain weight per foot would be about 8.48 pounds, while the surface area per link would equal 34.46 square inches.

Another embodiment of the invention is shown in FIGS. **4** and **5** that is constructed to perform the same efficient cleaning action on a chain as the embodiment of FIGS. **2** and **3**. The link of this embodiment is generally identified as **12A**. Each link **12A** is circular and includes an inner surface **20** of arcuate shape for bearing engagement with the inner surfaces of adjacent links defined by a radius that is substantially smaller than the inner radius of the link, an outer surface **21** of arcuate shape and of the same shape as the inner surface **20**, and arcuate interconnecting end faces **22** and **23**. The interconnecting end faces **22** and **23** are substantially flat and the cross-sectional shape is such that the radial width is substantially greater than the axial width. Moreover, the cross-sectional shape is symmetrical in form.

The inner surface **20** is formed so that it defines with an adjacent link minimal engaging contact as shown in FIG. **5**. In this respect, it is operable just like the embodiment of FIGS. **2** and **3** in that efficient self-cleaning action is obtained by the links during operation in a kiln

The size and weight of the chain of this embodiment maybe according to the needs of the kiln, but a size and weight that is comparable to that of the embodiment of FIGS. **2** and **3** will provide substantially the same weight per link and substantially the same heat transfer surface. The outer diameter of each link would be 5 ⅛ inches while the inner diameter would be 3 inches. The axial width of a cross section would be .670 inches while the radial width would be about 1 1/16 inches. A link of this size would have an estimated weight of 2.02 pounds, while a chain with links of this type would weight about 8.08 pounds per foot. The surface area of each link would be about 35.61 square inches.

An added advantage for a chain of this configuration would be to have the same area and weight with greater strength. The pull strength for a chain of this link structure is about five to six times the pull strength of the chain in FIGS. **2** and **3**.

Essentially, the cross-sectional shape of this embodiment is turned 90° relative to the cross-sectional shape of the embodiment of FIGS. **2** and **3**. As in the first embodiment this chain may be made in any suitable manner, such as by casting from alloy steel.

From the foregoing, it can be appreciated that the chain of the present invention will enable efficient and long-life operation of a kiln by minimizing material buildup, while providing maximum heat transfer with minimum weight.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention, but it is understood that this application is to be limited only by the scope of the appended claims.

I claim:

1. Rotary kiln chain comprising, connected links, each link having a uniform, cross-sectional shape throughout, said link cross-sectional shape throughout, said link cross-sectional shape having an axial thickness and a radial thickness as taken relative the link center and a medial plane extending therethrough, one of said thicknesses being substantially greater than the other, and the inner surface of said link cross-sectional shape being formed to provide substantially single point and minimal engaging contact with an adjacent link, thereby enhancing the cleaning action between links and minimizing material buildup.

2. Rotary kiln chain comprising, connected links, each link having a uniform cross-sectional shape throughout, said link cross-sectional shape having an axial thickness and a radial thickness as taken relative the link center and a medial plane extending therethrough, said axial thickness being substantially greater than said radial thickness, and the inner surface of said link cross-sectional shape being formed to provide minimal engaging contact with an adjacent link thereby enhancing the cleaning action between links and minimizing material buildup.

3. Rotary kiln chain as defined in claim **2**, wherein the inner surface of each link is V-shaped to provide substantially knife edge contact between links.

4. Rotary kiln chain as defined in claim **3**, wherein the links are circular.

5. Rotary kiln chain as defined in claim **4**, wherein the outer surface of each link is particircular on a radius substantially equal to the inner radius of each link.

6. Rotary kiln chain as defined in claim **1**, wherein the radial thickness is substantially greater than the axial thickness.

7. Rotary kiln chain as defined in claim **6**, wherein the inner surface is particular.

8. Rotary kiln chain comprising connected, substantially circular links having a uniform cross-sectional shape throughout the circumference thereof and a dimension in a direction transverse the planes of the links substantially greater than the thickness thereof within said planes, and the inner bearing surface of said links being formed to provide substantially point contact therebetween, whereby the bearing contact substantially eliminates material buildup at the inner surfaces.

9. Rotary kiln chain as defined in claim **8**, wherein said inner surface if V-shaped to provide a substantial knife bearing surface.

10. Rotary kiln chain as defined in claim 8, wherein said outer surface is particircular on a radius substantially equal to the inner radius of each link.

11. Rotary kiln chain comprising connected substantially circular links having a uniform cross sectional shape through the circumference thereof with arcuate inner and outer surfaces, said cross-sectional shape having a dimension in a direction transverse to the planes of the links substantially more narrow than the thickness thereof with in said planes thereof, and the inner surface being formed with a radius substantially smaller than the plane radius of the links to define substantially point contact therebetween.

12. Rotary kiln chain as defined in claim 11, wherein the outer arcuate surface is defined by a radius substantially smaller than the plane radius of the link.

13. Rotary kiln chain as defined in claim 12, wherein said cross-sectional shape is symmetrical.

14. Rotary kiln chain as defined in claim 13, wherein relatively flat and radially extending opposed end faces are provided interconnecting the inner and outer arcuate faces.