Dec. 25, 1951 C. CONE 2,580,283

COIL ANNEALING APPARATUS

Filed Dec. 23, 1947 2 SHEETS—SHEET 1

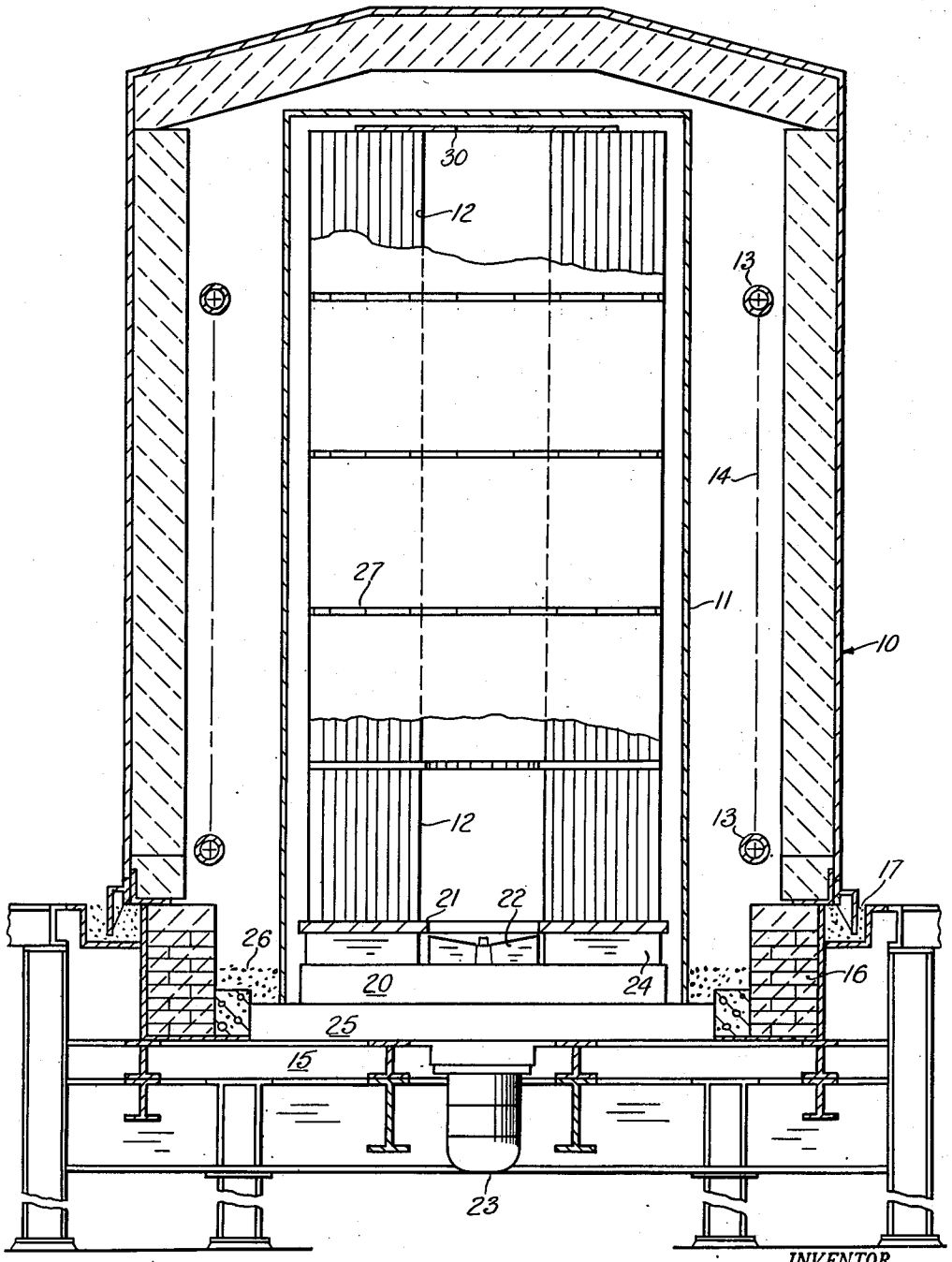


Fig. 1.

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Fig. 2.

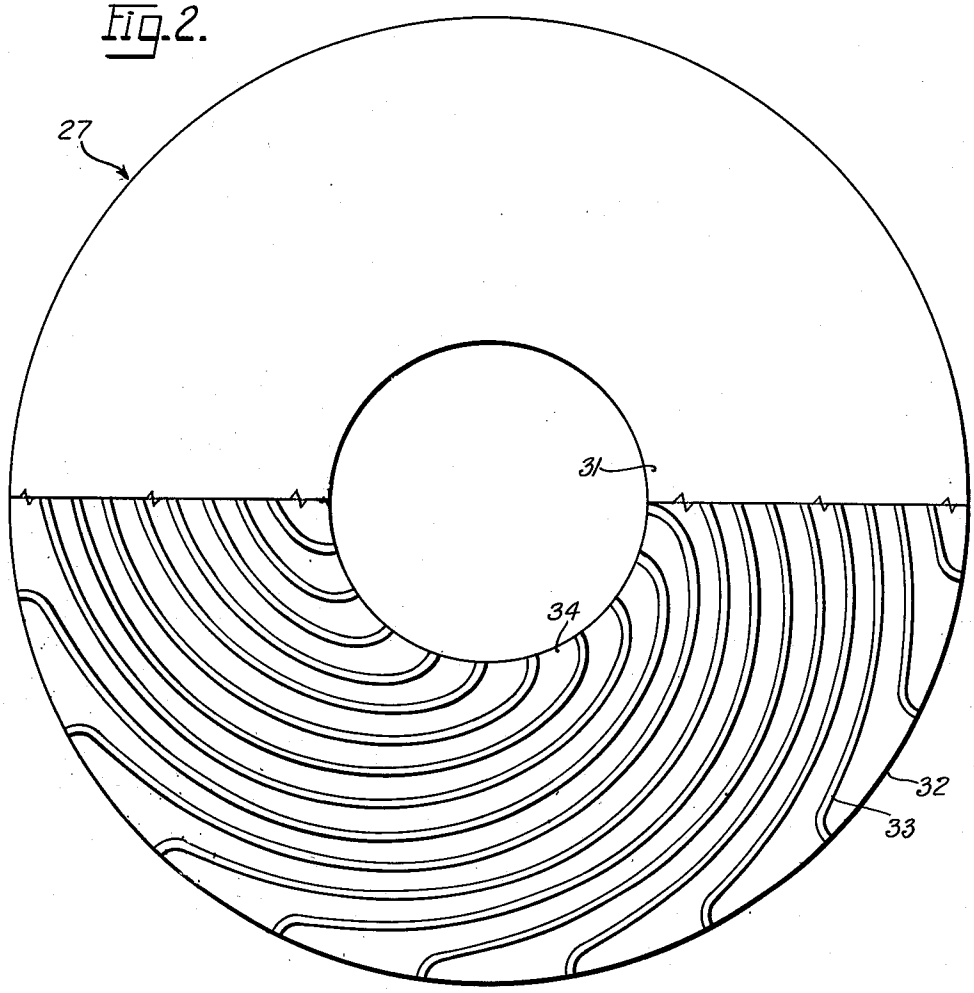
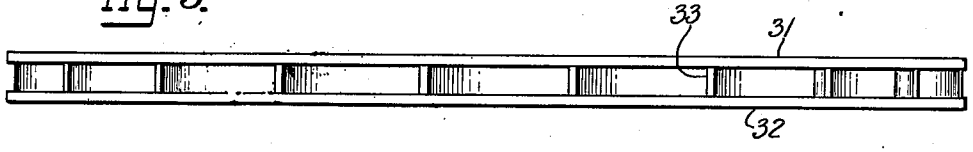


Fig. 3.



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COIL ANNEALING APPARATUS

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4 Claims. (Cl. 263—47)

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This invention relates to apparatus for annealing a stack of cylindrical coils of flat material such as steel strip. It has long been recognized that radial heat flow through the lamination of a strip coil is relatively slow as compared to the heat flow parallel to the laminations heated from the edges and it has been proposed to provide channelled separators between the coils to permit heat to be applied to the edges of the laminations by heat carried by gases flowing through the channels of said separators.

Experimental work to date has indicated that the results secured with coil separators may vary considerably with the design of the multiple passages through the separator and various improvements have been suggested to secure both maximum ultilization of available fan circulation and optimum uniformity of heat distribution between the inside and outside of the coil by control of the shape and cross section of the gas flow passages.

The simplest possible separator consists of two plates spaced apart by radial supporting ribs. Gas circulates in the space between the ribs. At constant temperature, the velocity of the circulating gas obviously varies inversely as the radius from the center, and the heat transfer area added by the separating ribs also contributes more to the inside than to the outside of the separator unit. It follows that with a given volume and pressure differential available in fan circulation, most of the heat transfer effect is utilized towards the inside diameter of the coil.

The ideal separator design would be one which would bring all portions of the coil end to final temperature at the same time. In an effort to obtain this effect, an attempt was made to maintain a uniform cross section for gas flow from the inside to the outside of the separator unit, so that for a given gas temperature both the convection heat transfer per square inch of exposed surface and the heat transfer area per square inch of coil end surface would be constant regardless of diameter. Separators of this type actually show improved results as compared with the simple radial rib design and are being currently used in coil annealing practice.

With a uniform sectional area of flow passage from inside to outside, separators could be used equally well with either inward or outward gas flow. Both types of flow have been utilized in practice. However, the type of annealing furnace ordinarily used is one in which the gases are drawn through the separators from outside to inside and exhausted from the center of the stack by a centrifugal fan in the supporting base or

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stand under the coils. In furnaces of this type it is customary to cover the coil stack with a bell type muffle and to surround the muffle with a heating hood. With such equipment part of the heat is transmitted to the load by direct radiation from the muffle. There is thus some tendency for the external wraps of the coils to come to temperature first, regardless of the uniformity of the heating effect from the ends of the coils. With circulation through the separators from outside to inside, there is a decrease in the effective temperature difference between gas and work in the direction of circulation which also tends to concentrate the heat transfer effect toward the outside of the coils. To compensate for these combined effects, it has been found desirable to modify the uniform cross section of the gas channels in the separators and to adopt a more or less tapering cross section. With the latter design, the cross section of the gas passages decreases more or less continuously from the outside to the inside diameter, increasing both velocity and concentration of heat transfer surface to compensate for decreasing temperature differential and for absorption of radiant heat through the outer wraps of the coil.

With the development of more powerful and more efficient circulating fans, the heating effect of the convection circulation inside the coil stack becomes appreciable. It follows that with tapering gas passages and with the direction of gas circulation from outside to inside through the separator passages, there will be a tendency for the extreme inside wraps to be heated or cooled appreciably faster than the intermediate area of the coil ends. It, therefore, becomes desirable to compensate for this effect, as well as for the tendency to overheat outside wraps as described above, and it is one of the objects of the present invention to accomplish this objective in a relatively simple and practical manner.

Considering coil separators as heat exchanger units, it is desirable for maximum overall heat transfer effect to obtain the highest velocity possible with a given volume of circulation and with the available pressure differential as developed by the circulating fan. To this end, it is desirable to minimize entrance and exit losses in the separator passages; the present invention accomplishes this in a simple and practical manner. Also, to compensate for effects tending to produce non-uniform temperatures as described above, the maximum velocity should be obtained at the points least favorably situated for heating and cooling

by other means; the present invention accomplishes this in a simple and practical manner.

For a consideration of what I consider to be novel and my invention, attention is directed to the following specification and the claims appended thereto.

In the accompanying drawings forming part of this specification;

Fig. 1 is a vertical section of a typical annealing furnace for annealing a cylindrical column of coils of sheet or strip steel.

Fig. 2 is a plan view of the improved coil separator with one-half of the top plate of the separator broken away to show the gas passages between the top and bottom plates of the separator.

Fig. 3 is an edge view of the separator shown in Fig. 2.

The annealing furnace shown in Fig. 1 comprises a portable heating hood 10 for heating a bell-type muffle 11 disposed over a cylindrical column of coils 12 of sheet steel which is to be annealed. (It will be understood that the thickness of the laminations of the coils have been greatly exaggerated for illustrative purposes.) The source of heat carried by the heating hood will ordinarily comprise internally-fired radiant tubes 13 distributed along the side walls of the hood. For simplicity of illustration only the upper and lower tubes are shown, but as indicated by the vertical connecting line 14 there will be additional tube therebetween.

The base of the furnace is generally indicated at 15 and comprises an upstanding peripheral wall 16 on which the heating hood is seated, the seat being surrounded by a conventional sand seal 17. The furnace base also comprises a stand 20 for supporting the column of coils 12, the stand being shown in elevation except for the top plate 21 which is in section. This top plate has a central aperture coaxial with a circulating fan 22 which is driven by a motor 23 carried by the underside of the coil stand. The top plate 21 is spaced from the lower portion of the coil stand by radial spacers 24 whereby to provide radial gas passages below said plate for the gas circulated by the fan 22. The muffle 11 is shown as supported on a ledge 25 which surrounds the coil stand and the foot of the muffle is shown as surrounded by a layer of granular sealing material 26 to prevent objectional leakage of gas from the muffle, it being understood that some seepage of gas from the muffle is not objectionable but rather desirable. A non-oxidizing gas is supplied to the muffle by a supply pipe not shown but which extends through the coil stand 20 from below.

From the foregoing it will be readily understood that unless the coils are spaced apart to provide gas passages therebetween all of the gases circulated by the fan 22 must enter at the top of the coil stack for downward flow therein. In Fig. 1, the coils are spaced apart by channelled separators 27 and an orifice plate 30 is placed on top of the coil stack. The purpose of the orifice plate 30 is, of course, to restrict the entry of circulated gas to the inside of the stack by way of the top thereof whereby to cause part of the circulated gases to flow laterally inward through the gas passages in the coil separators.

Referring now more particularly to Figs. 2 and 3, the improved coil separator comprises a pair of identical annular plates 31 and 32 separated by a multiplicity of vanes or ribs 33. The ribs are curved between their ends so that the gas passage 34 between adjacent ribs is relatively long compared to the radial distance between the inner and outer diameters of the plates 31 and 32. I have discovered that for maximum heating effect and maximum temperature uniformity the gas velocity should be at a minimum at the entering and exit ends of each passage and should be at a maximum toward the halfway length of the passage for a substantial portion of the total length of the passage. To this end each gas passage has a uniform width throughout most of its length intermediate its ends. This uniform width will ordinarily be of the order of 1.50 inches. At its inner end the passage smoothly tapers to a terminal width of about 2.64 inches and at its outer end the passage is tapered to a rounded entrance. The parallelism of the ribs or vanes 33 intermediate their ends results from causing them to follow involute curves extending from a circle coaxial with but of smaller radius than the central aperture of the separator plate (31 or 32); the gradual divergence of said vanes 33 as they approach the central aperture of the separator plates results from causing them to follow curves of greater curvature than said involute curves, and the gradual divergence of said vanes as they approach the outer rim of said plates results from causing them to follow curves of lesser curvature than said involute curves. The gas passage between adjacent vanes 33 therefore corresponds to a venturi having an extended throat portion of uniform cross section.

It will be obvious that by suitably modifying the spiral curves used for intermediate supporting ribs, the sectional areas at the inside, center and outside of the separator can be made in any desired proportions. It will also be apparent that as long as the entering and exit areas are larger than the minimum area at the center, and the contracting and expanding passages are smoothly tapered, the pressure drop corresponding to a given gas velocity at the center of the passage will be substantially less than that for any of the designs discussed above and the power consumption required to circulate the gases at the given velocity is substantially reduced.

What I claim is:

1. A gas circulating separator for insertion between the individual coils of a vertical pile of coils which are to be heat treated in a forcibly circulated atmosphere, the separator comprising a centrally apertured plate, a plurality of curved vanes secured to and disposed along one side of the plate, the vanes extending in a generally radial direction between the inner and outer rims of the plate and being spaced apart to define a plurality of curved gas circulating passages between said vanes, the distance between adjacent vanes being substantially uniform between two points which are relatively remote from each other and which are between the opposite ends of the vanes and which are a substantial distance from said ends, and the distance between said vanes from said points to the next adjacent ends of said passage gradually increasing so that the general shape of the passage between adjacent vanes is that of a venturi having an extended throat portion of uniform cross section.

2. A gas circulating separator for insertion between the individual coils of a vertical pile of coils which are to be heat treated in a forcibly circulated atmosphere, the separator comprising a centrally apertured plate, a plurality of vanes secured to and disposed along one side of the plate, the vanes extending in a generally radial direction between the inner and outer rims of the plate and being spaced apart to define a plu-

rality of curved gas circulating passages between said vanes, the distance between adjacent vanes being substantially uniform for a major portion of said passages intermediate the ends thereof, and the distance between said vanes at one end of said passages gradually increasing as said passages approach said one end whereby to flare said one end of said passages.

3. A gas circulating separator according to claim 2 wherein said one end of said passages which is so flared is the end thereof next adjacent the inner rim of said plate.

4. A gas circulating separator according to claim 2 wherein said one end of said passages which is so flared is the end thereof next adjacent the outer rim of said plate.

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