July 4, 1967 D. BEGGS ETAL 3,328,997

STABILIZING SYSTEM FOR STRIP WORK

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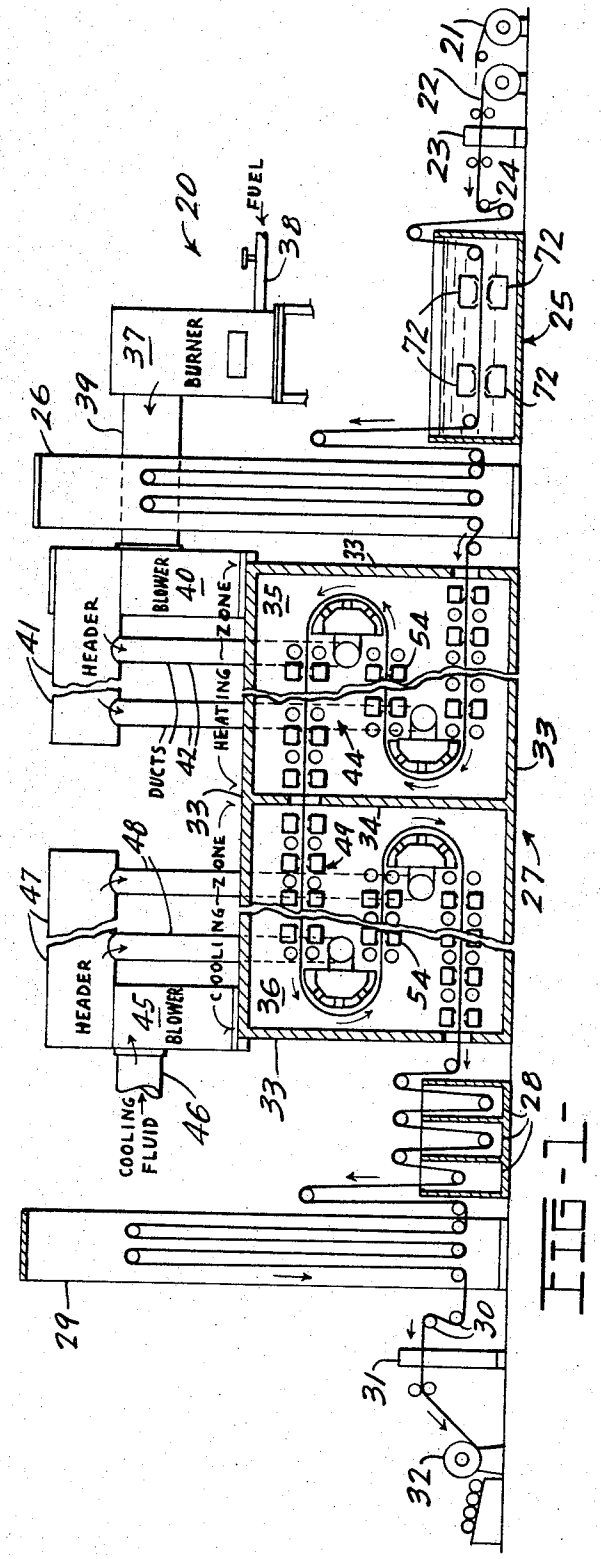


FIG-1-

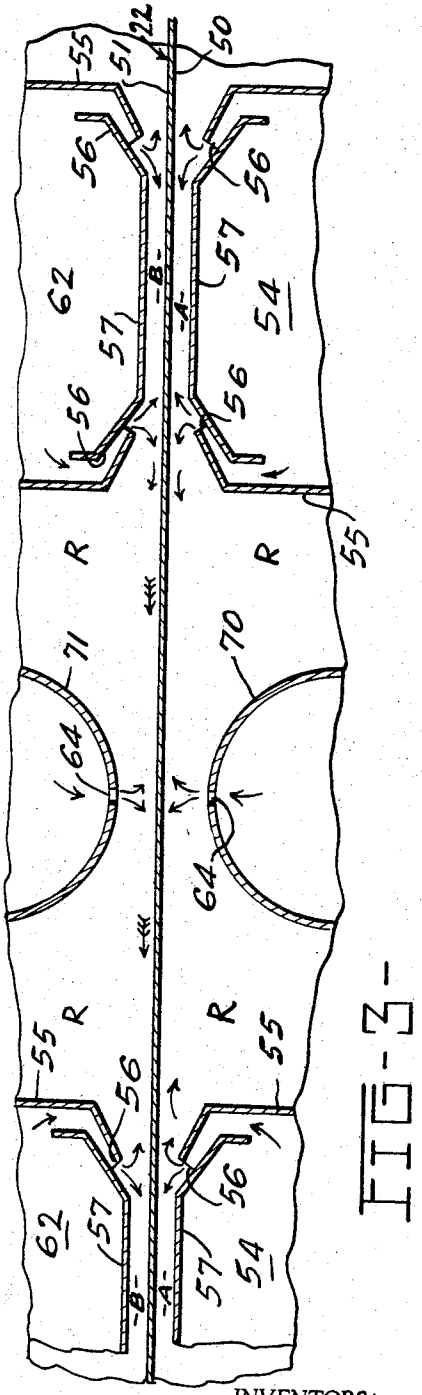


FIG-2-

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STABILIZING SYSTEM FOR STRIP WORK

Filed Sept. 2, 1964 8 Sheets-Sheet 2

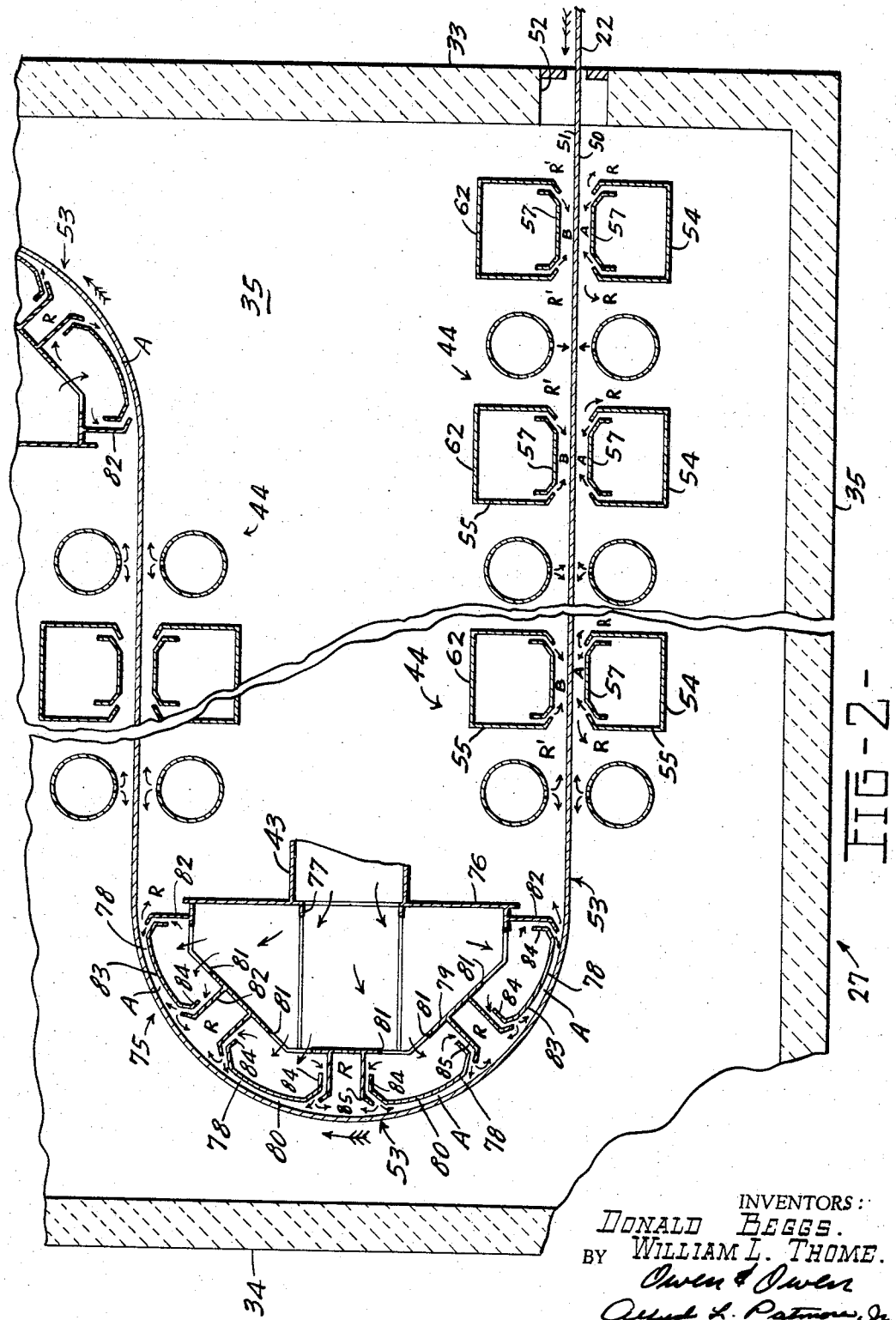


FIG-2-

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July 4, 1967 D. BEGGS ETAL 3,328,997

STABILIZING SYSTEM FOR STRIP WORK

Filed Sept. 2, 1964 8 Sheets-Sheet 3

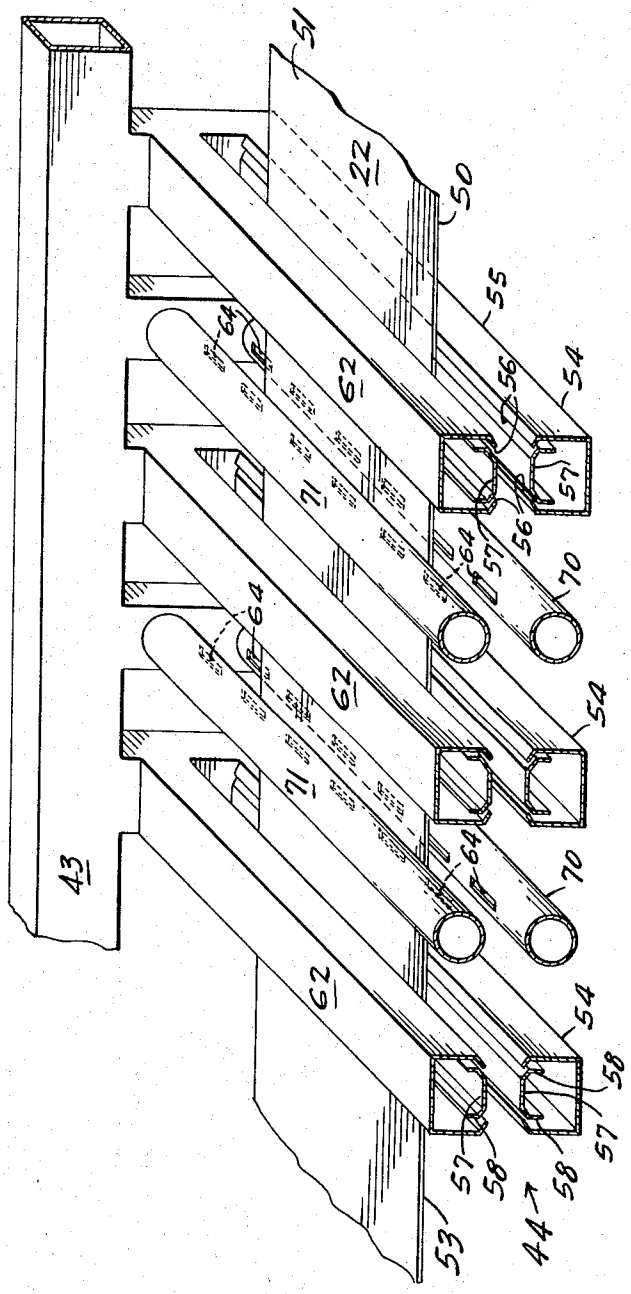


FIG - 4 -

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STABILIZING SYSTEM FOR STRIP WORK

Filed Sept. 2, 1964 8 Sheets-Sheet 4

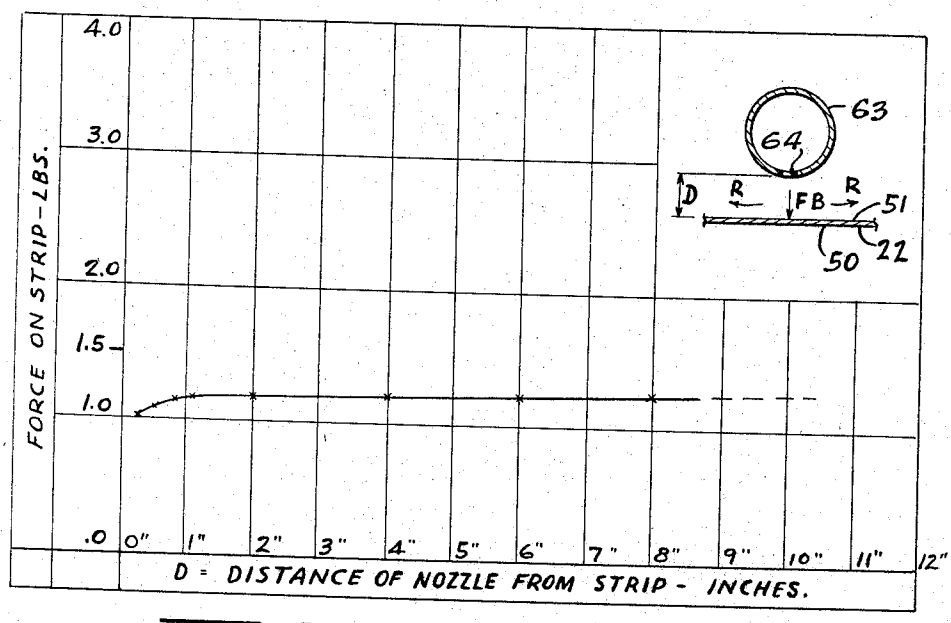


FIG-5 -

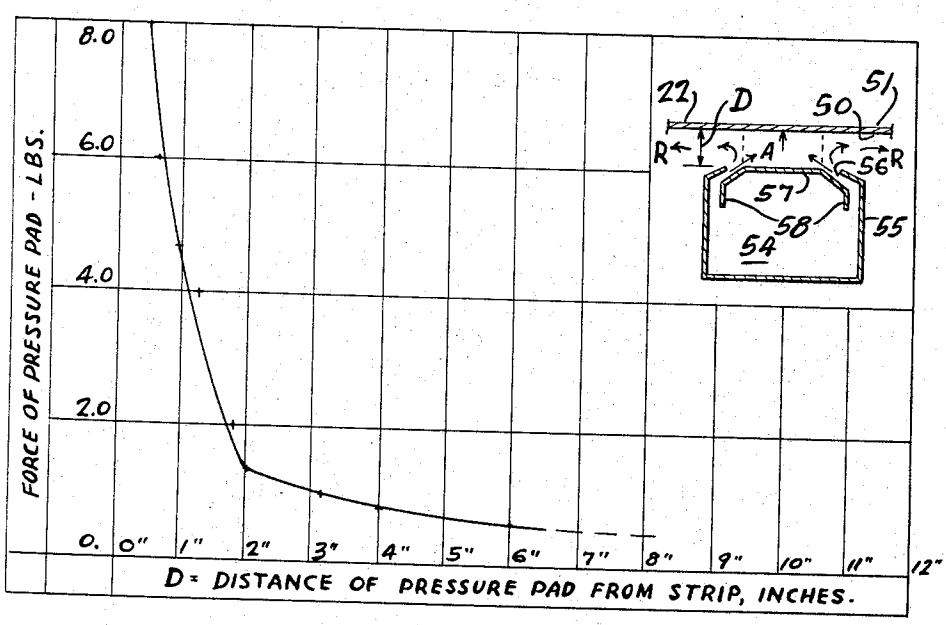


FIG-6 -

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STABILIZING SYSTEM FOR STRIP WORK

Filed Sept. 2, 1964 8 Sheets-Sheet 5

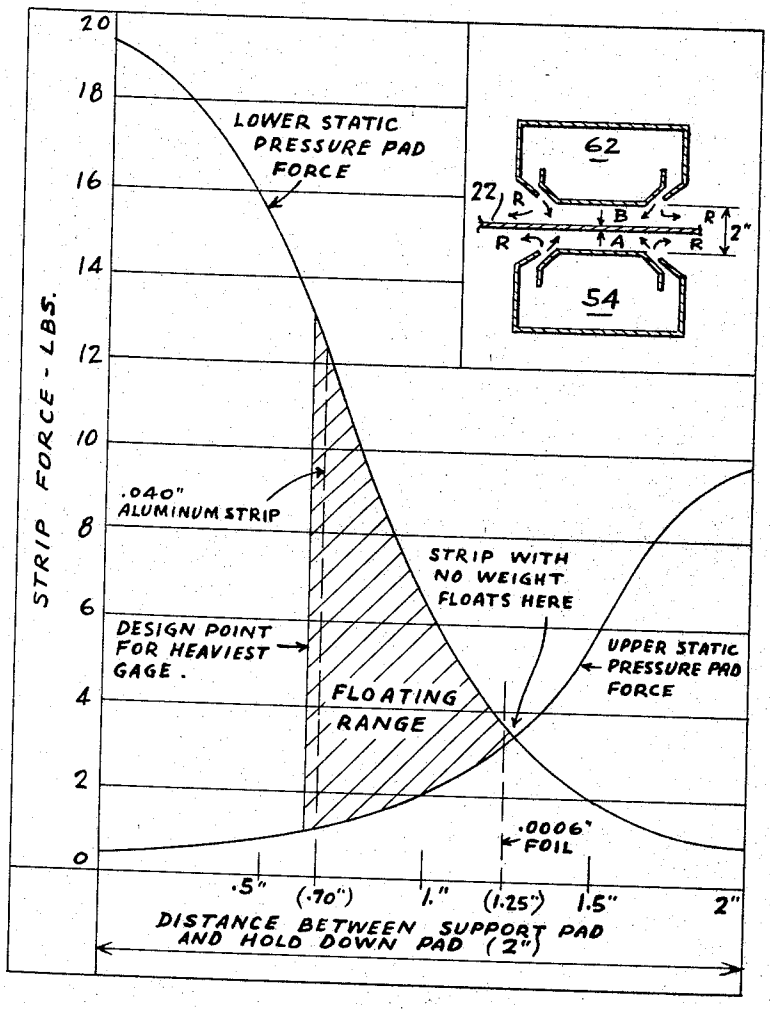


FIG-7-

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STABILIZING SYSTEM FOR STRIP WORK

Filed Sept. 2, 1964 8 Sheets-Sheet 6

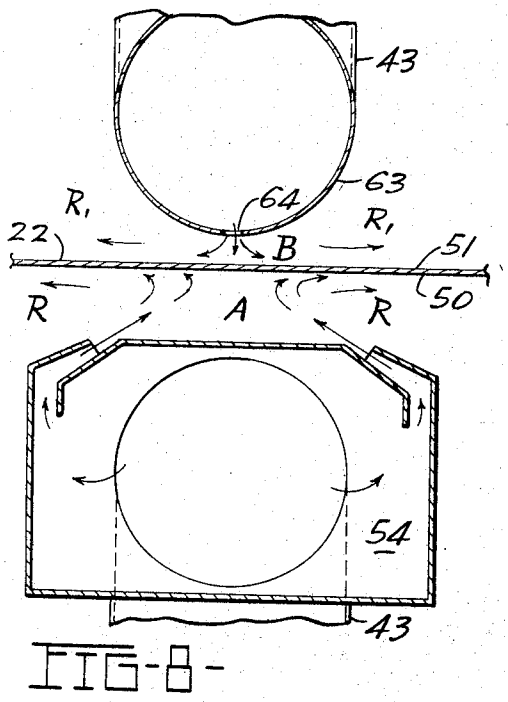


FIG-8-

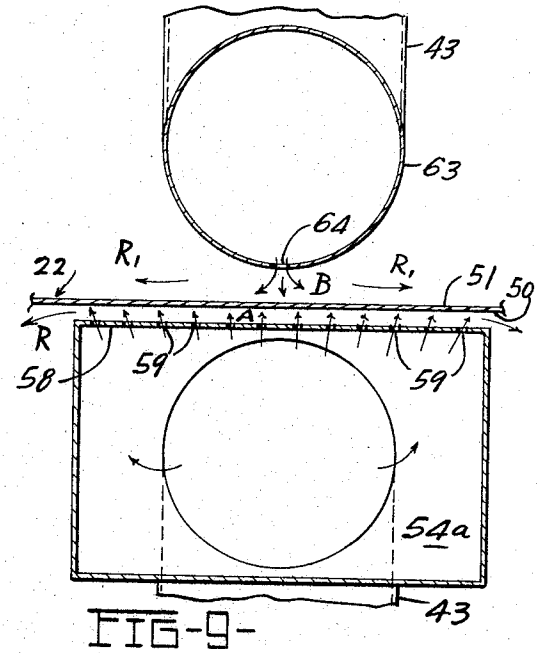


FIG-9-

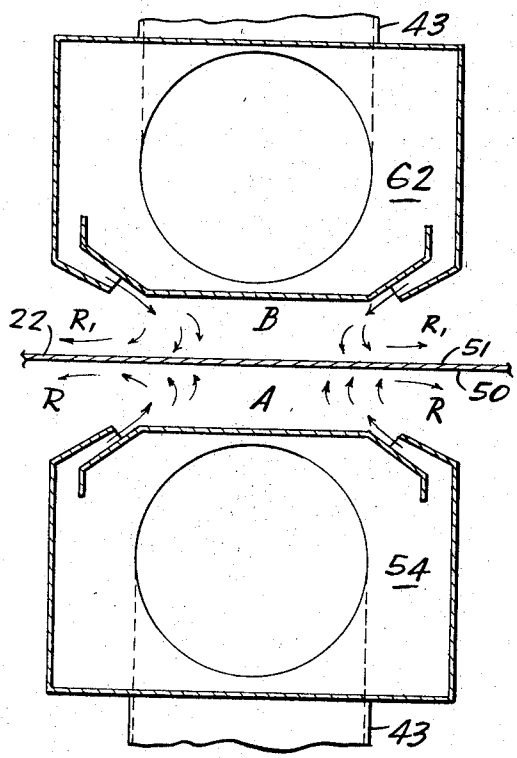


FIG-10-

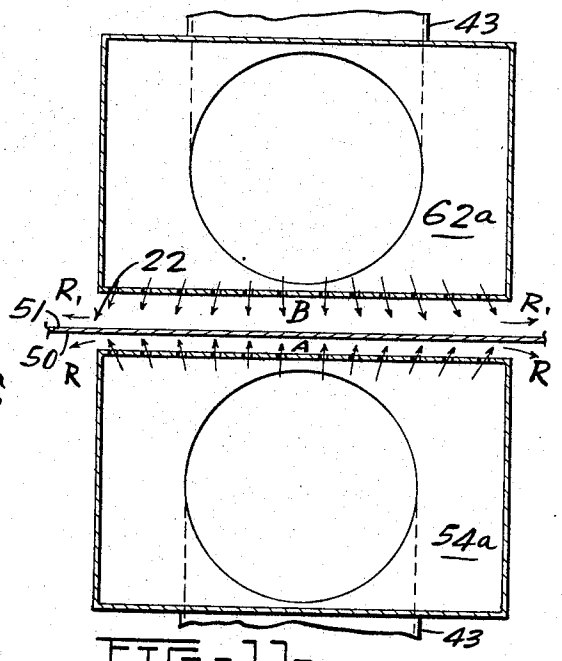


FIG-11-

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STABILIZING SYSTEM FOR STRIP WORK

Filed Sept. 2, 1964 8 Sheets-Sheet 7

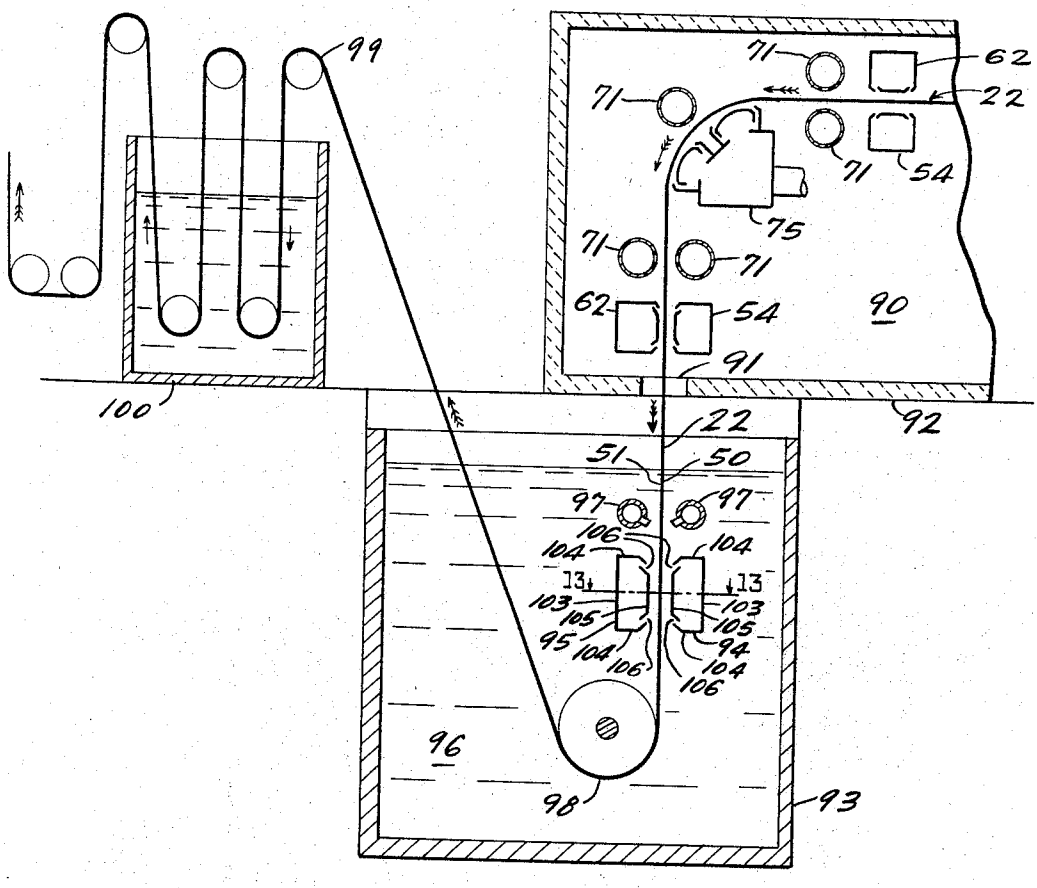


FIG-12-

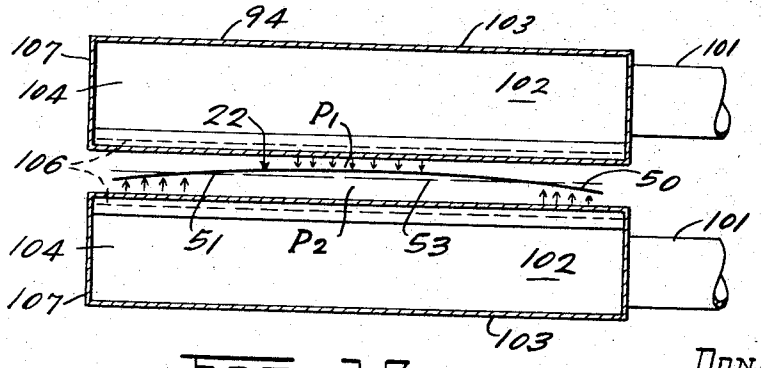


FIG-13-

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STABILIZING SYSTEM FOR STRIP WORK

Filed Sept. 2, 1964 8 Sheets-Sheet 8

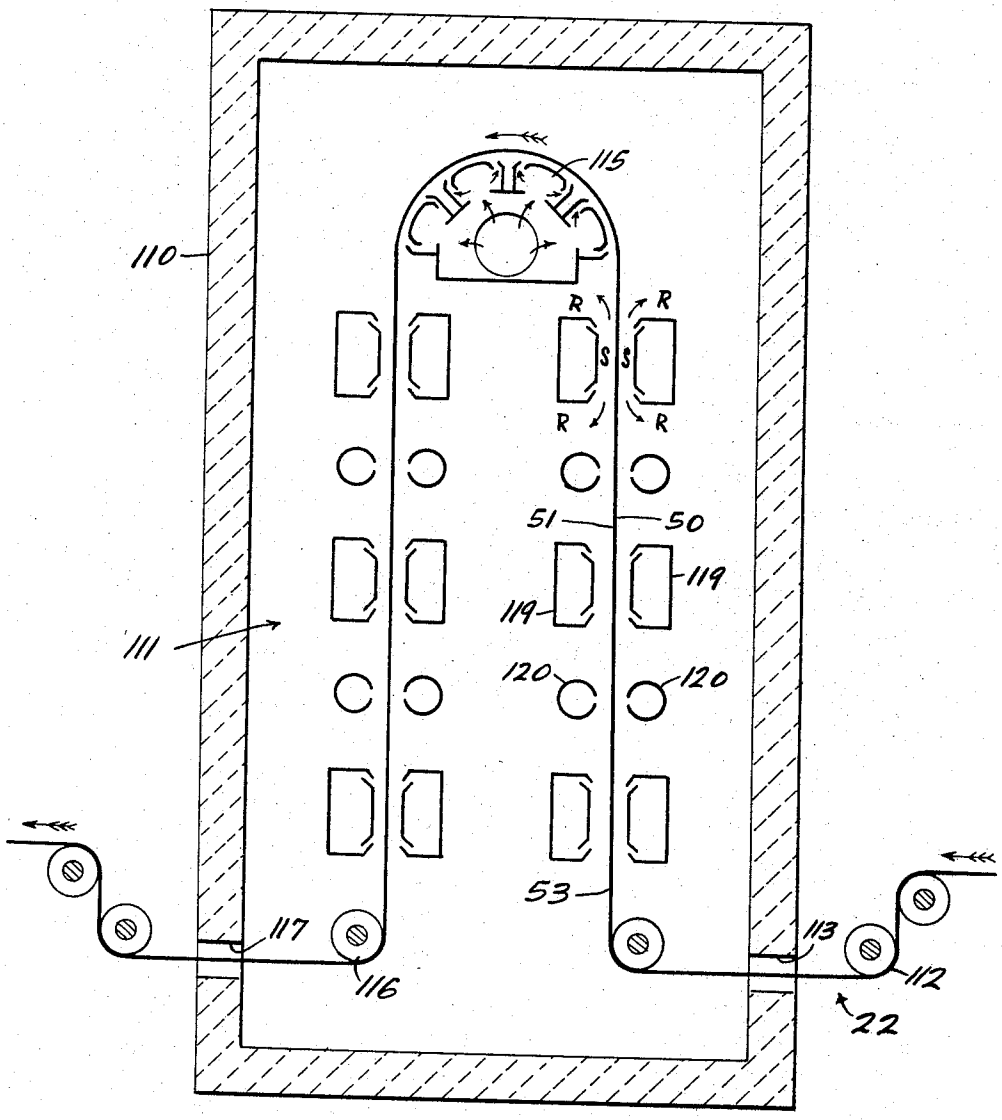


FIG-14-

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3,328,997

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3,328,997

STABILIZING SYSTEM FOR STRIP WORK

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Filed Sept. 2, 1964, Ser. No. 394,080
16 Claims. (Cl. 72—342)

ABSTRACT OF THE DISCLOSURE

This invention relates to a method and an apparatus for stabilizing a flat body, and, more particularly, to an improved method and apparatus for stabilizing a continuous flat body having first and second opposed major surfaces in a predetermined path while simultaneously heat treating the flat body. At least one stream of a fluid, which stream extends transversely on the strip work, is directed against the first major surface of the strip work at each of a plurality of stabilizing regions which are spaced from one another longitudinally of the strip work. Escape of a fluid from each of the stabilizing regions is prevented in a direction normal to the predetermined path of the work, to establish a pressure within each stabilizing region by virtue of the confined fluid flow therein. Fluid is withdrawn from regions which are transverse of the strip work and adjacent the stabilizing regions, thereby preventing appreciably pressure variation, lateral of the strip work, in the general stabilizing regions. Fluid flows from the stabilizing regions in the direction longitudinal of the work to the respective relief regions. The strip work is balanced within the chamber by directing at least one stream of a fluid against the second major surface of the strip work at each of the plurality of balance regions which are operatively opposed to the stabilizing regions.

The uniform heat treating of a continuous flat body, for example strip work, has presented several serious problems to the art. In the heat treatment of cold worked brass strips of an indefinite length, it is known to be extremely difficult to achieve uniform grain size by high thermal-head furnacing. Nonuniform heating of such brass strip work contributes to nonuniform grain size in the treated strip. Various attempts have been made to use low thermal-head processes to heat treat brass and other strip work to achieve uniform grain size. However, high velocity, low thermal-head heat transfer fluid flow generally longitudinal of the strip work gives rise to problems of strip work flutter, and high velocity, low thermal-head heat transfer fluid flow generally normal to the strip work has heretofore given rise to work scratching problems.

In the heat treatment of non-ferrous strip work, for example, brass or aluminum alloys, the strip is damaged by passing over conveyor rolls when such strip is at an elevated temperature. At such elevated temperatures zinc or aluminum oxide tends to deposit upon the conveyor roll surfaces. Such deposits, after a short period of operation, cause permanent damage to a strip passing over the rolls by marking the strip. To prevent such marking, prior art furnaces have been designed having an extremely high vertical height, usually in excess of 75 feet, whereby the strip can pass over an upper roll at a temperature under a critical elevated temperature; pass downwardly through a high temperature treatment zone; downwardly through a cooling zone; and finally around a lower roll at a temperature again below the critical elevated temperature. However, prior art furnaces of this type are unsatisfactory to many customers because their extreme heights often require constructions of special buildings, and have not completely solved the problems of low thermal-head processing. Problems have also arisen because

stress relief in the work or aerodynamic forces, or both, have caused bowing or corrugating of the work. Work which is bowed or corrugated in such processing is permanently damaged in passing over a roll in such condition.

Among the numerous prior art attempts which have been made to accomplish low thermal-head processing are various designs for floating systems for strip work wherein fluid is directed upwardly from a hearth to support a portion of the weight of the strip. For examples, see U.S. Patents 1,948,173 and 3,048,383 and an article at pages 3–5 of the February 1963 (vol. 14; No. 1) issue of Heat Treat Review. In U.S. Patent 3,048,383 it has also been proposed to pass strip work between distribution systems located both above and below the strip for directing fluid against both sides of the strip. However, no system has heretofore been suggested for eliminating bowing or corrugating, if it occurs, whether caused by stress relief, aerodynamic force, or both. Furthermore, if the total floating force on the underside of the strip does not equal the weight of the strip, it has been contemplated that some of the weight of the strip would be supported by strip tension, for example, between spaced rolls, and only such tensioning techniques were available to prevent corrugating or bowing.

There are basically two types of fluid force effects which can be used in strip floating, namely, "velocity pressure" force and "static or confined pressure" force. Velocity pressure force, as the term is used in this specification, is the force that acts upon the strip due to fluid flowing out of a nozzle which is directed at the strip in an unconfined environment, wherein the fluid is free to disengage from the strip in any direction. Velocity pressure force is dependent only upon the jet momentum and is not dependent upon the distance from the jet nozzle to the strip. This phenomenon results from conservation of momentum and is readily observed by directing a wind nozzle at a platform scale. The force acting upon the scale is not affected as the nozzle is moved to different distances from the scale platform.

It is a further characteristic of velocity pressure systems that a comparatively high convective heat transfer rate can be achieved between a heat transfer fluid and the strip work.

Static or confined pressure force, as the term is used in this specification, is the force that acts upon the strip where the environment is such that the strip and a spaced, generally parallel member act to confine fluid flow over a limited region. As applied to strip floating, the static pressure force is an inverse function of the distance of the strip from the confining environment. This phenomenon is observed by feeding fluid to an open bottom box and moving the box up and down relatively close to the platform of a platform scale. The closer the box is to the platform, the greater the force acting upon the scale.

The static pressure systems known in the art have relied on the disengagement of fluid from the strip work predominantly at the edges of the strip to an extent sufficient to cause strip instability. This disengagement technique results in the establishment of a longitudinal ridge of pressure down the longitudinal center line of the strip work which is an inherently unstable way to support the strip work. This technique of supporting strip work results in a "bowing" or "canoeing" of the strip work because a greater force is exerted along the longitudinal center line than along the edges of the strip. Because of the differential pressures, the strip work has a tendency to move laterally to one side because unequal disengagement of the fluid from the edges of the strip quickly develops with any distortion in the strip; and if the strip work comes into contact with the nozzle structure it becomes marked and must be rejected. The prior art attempts to overcome this tendency by applying tension to

the strip work. However, in the length of furnaces contemplated in the instant invention, the floating system does not rely upon a large amount of strip tension to overcome the tendency to shift or track to one side.

It is also important that any floating system be capable of supporting and processing a relatively wide range of strip gauges without wind flow adjustment so as to maintain high heat transfer.

It is the primary object of the instant invention to provide an improved method and apparatus for stabilizing a moving flat body, for example, strip work.

It is another object of the invention to provide an improved method and apparatus for stabilizing such a flat body moving in a vertical path.

It is a further object to provide such method and apparatus for stabilizing and supporting such a flat body moving in a horizontal path.

It is still another object of the invention to provide a method and apparatus for floating flat bodies, wherein the flat bodies are self-centering in a direction normal to the strip path and are uniformly heat treated.

It is still another object of the instant invention to provide a method and apparatus for directing floating flat bodies along an arcuate path without the necessity of supporting rollers.

It is a further object of the invention to provide a method and apparatus for floating flat bodies in a wider range of unit weights than could be accommodated by prior art floating systems.

It is still a further object of the invention to provide a method and apparatus for flattening a flat body, for example, strip work.

Further objects of this invention will become apparent from the following specification and drawings, in which:

FIG. 1 is a fragmentary, diagrammatic representation of a continuous strip heat treating line including a floating system according to the invention;

FIG. 2 is a fragmentary, expanded diagrammatic view, of a portion of the floating system shown in FIG. 1, and showing in detail apparatus for changing the direction of travel of the strip work;

FIG. 3 is a fragmentary, enlarged scale, vertical sectional view of a portion of the floating system shown in FIG. 1;

FIG. 4 is a fragmentary, perspective view of a portion of the heat treating and floating system shown in FIG. 1;

FIG. 5 is a diagram showing the relationship between fluid force and the distance of a velocity pressure nozzle from strip work;

FIG. 6 is a diagram, similar to FIG. 5, having a reduced ordinate scale, and showing the relationship between fluid force and the distance of a static pressure pad from strip work;

FIG. 7 is a diagram showing the floating range of strip work in apparatus constituting a preferred embodiment of the instant invention;

FIG. 8 is a diagrammatic view showing an embodiment of the instant invention, wherein a static pressure force apparatus is positioned on a first side of the strip work and a velocity pressure apparatus is positioned on the second side of the strip work;

FIG. 9 is a view, similar to FIG. 8, wherein another embodiment of a static pressure force apparatus is positioned on one side of the strip work;

FIG. 10 is a view similar to FIG. 8 wherein static pressure force apparatus according to the instant invention is disposed on opposed sides of the strip work;

FIG. 11 is a view, similar to FIG. 10, wherein another embodiment of static pressure force apparatus is disposed on opposed sides of the strip work;

FIG. 12 is a fragmentary, diagrammatic view, showing another embodiment of the instant invention which incorporates a flattening apparatus according to the invention;

FIG. 13 is a fragmentary, sectional view, taken along the line **13—13** of FIG. 12 and showing the flattening forces acting upon the strip work; and

FIG. 14 is a fragmentary, diagrammatic view similar to FIG. 1, but showing a system according to the invention wherein strip work travels mainly in a vertical path.

Briefly, the invention relates to a method and apparatus: (1) for stabilizing or for stabilizing and supporting strip work of indefinite length in a chamber, (2) for causing the strip work to move through the chamber in a predetermined arcuate path, and (3) for flattening the strip work. In one embodiment of the invention strip work, having first and second opposed major surfaces is directed through the chamber along a predetermined path and is stabilized within at least one part of the chamber by directing at least one stream of a fluid, which stream extends transversely of the strip work, against the first major surface of the strip work at each of a plurality of stabilizing regions which are spaced from one another longitudinally of the strip work. Escape of the fluid from each of the stabilizing regions is prevented in a direction normal to the predetermined path of the work, to establish a pressure within each stabilizing region by virtue of the confined fluid flow therein. Fluid is withdrawn from relief regions which are transverse of the strip work atnd adjacent the stabilizing regions, thereby preventing appreciable pressure variation, lateral of the strip work, in the general stabilizing regions. Fluid flows from the stabilizing regions in a direction longitudinal of the work into the respective relief regions. The strip work is balanced within the chamber by directing at least one stream of a fluid against the second major surface of the strip work at each of a plurality of balance regions which are operatively opposed to the stabilizing regions. Fluid is withdrawn from relief regions adjacent balance regions.

As the strip work moves through a predetermined arcuate path the work is supported by directing at least one stream of a fluid, which stream extends transversely of the work, against the first major surface of the work at each of a plurality of support regions. The support regions are spaced from one another longitudinally of the strip work and are located along a path parallel to the predetermined arcuate path. Fluid is prevented from escaping from each of the support regions in a direction normal to the predetermined arcuate path, while at the same time fluid is withdrawn from relief regions intermediate adjacent support regions. The fluid forces acting on the strip work are balanced by applying tension to the strip work.

Flattening of the strip work is accomplished by a method which includes moving the work through the predetermined path. At least one stream of a fluid is directed transversely of the strip work against the first major surface of the strip work at a first pressure region. Fluid is prevented from escaping from the first pressure region in a direction normal to the predetermined path of the work while fluid is withdrawn from relief regions which are transverse of the strip work and adjacent the first pressure region. At least one stream of a fluid is directed transversely of the strip work against the second major surface at a second pressure region which is opposed to the first pressure region. Fluid is prevented from escaping at the second pressure region in a direction normal to the predetermined path of the work while fluid is withdrawn from relief regions which are transverse of the strip work and are adjacent the second pressure region.

Referring to FIG. 1 of the drawings, a generally horizontal continuous strip processing line is generally indicated at **20**. The line **20** comprises a pair of pay-off reels **21** which supply strip work **22** of an indefinite length, a stitching unit **23**, bridle rollers **24**, a pretreatment tank generally indicated at **25**, a looping tower **26**, a heat treatment furnace generally indicated at **27**, a series of cleans-

ing chambers **28**, a looping tower **29**, bridle rolls **30**, a shear **31** and a rewind reel **32**.

The heat treatment furnace **27** includes walls **33** and an intermediate wall **34** which divides the furnace into two compartments; a heating zone compartment **35** and a cooling zone compartment **36**.

Fuel for heating the furnace **27** is supplied to a burner **37** through a conduit **38**. The products of combustion of the burner **37** are utilized as a heat exchange fluid and are discharged through a conduit **39** to a blower **40**. The blower **40** discharges the heat exchange fluid through a header **41** into a plurality of supply ducts **42**, which carry the heat exchange fluid into the heating compartment **35**. The supply ducts **42** are in communication with a manifold **43** (see FIG. 4) which leads to a plurality of distributing means generally indicated at **44** (see FIG. 1).

Preferably, the disengaged heating fluid is recirculated through the blower **40** and combined with the products of combustion of the burner **37** and then reintroduced into the heating compartment **35** through the ducts **42**, the manifold system **43**, and the distributing means **44**.

Similarly, a cooling fluid, for example, ambient air, enters a blower **45** through a conduit **46**. The cooling fluid is then discharged through a header **47**, through ducts **48**, through a manifold system (not shown) to a distributing means **49** located in the cooling compartment **36**.

The disengaged cooling fluid is exhausted to the atmosphere from the cooling compartment **36** and is not recirculated unless a controlled, e.g., non-oxidizing, atmosphere is used, in which case recirculation is preferred.

Referring to FIGS. 2 and 4, the strip **22** having a first major surface **50** and a second major surface **51** enters the chamber **35** through an entrance port **52**. The strip work **22** moves through the furnace **27** in a predetermined path indicated by the reference numeral **53**. The strip work **22** is supported by the distributing means **44** and **49** which comprise a first plurality of opposed pairs of spaced apart, elongate static pressure pads, the lower ones of which are designated **54**, disposed generally transversely of the strip work **22** and the predetermined path **53**.

In the preferred embodiment, each of the lower static pressure pads **54** consists of a longitudinally extending hollow body **55**, the interior of which is in fluid communication with the manifold system **43**. The hollow body **55** defines a pair of ports **56** (see FIG. 4) in its upper surface which direct heat exchange fluid toward the strip work at a converging angle with respect to one another. A substantially impervious plate **57** extends between the ports **56**, defining one side of each of the ports **56**, and has downwardly extending wings **58** which direct the flow of heat exchange fluid through the ports **56**.

The heat exchange fluid is directed outwardly from the static pressure pads **54** against the first major surface **50**, of the strip work **22** in each of a plurality of support regions A (see FIG. 3) which are spaced from one another longitudinally of the strip work **22**. The support regions A are regions of static pressure force and support the strip work **22** in the predetermined path **53**.

Referring to FIG. 6, the static pressure force in the support region A increases if the strip work **22** moves from the predetermined path **53** toward the static pressure pad **54**. This increased static pressure force urges the strip work **22** back into the predetermined path **53**. A very important feature of the instant invention is that the fluid is prevented by the plate **57** from escaping or disengaging from each of the support regions A in a direction normal to the strip work **22**, but flows generally longitudinally thereof, and is withdrawn or disengaged to relief regions R which extend transversely of the strip work **22** and are adjacent the support regions A. Such disengagement of fluid through the relief regions R greatly reduces the tendency of the strip **22** to "canoe" or "bow" as in the case of prior art floating systems wherein the longitudinal center line was an area of high pressure as compared to the edges of the strip where the fluid was forced to escape. Therefore, the support system according to the invention makes it possible to construct long furnaces using a floating system because it is not necessary to compensate for this canoeing effect by placing a high degree of tension in the strip work.

In the preferred embodiment (see, in particular, FIG. 3) an upper static pressure pad **62** is provided in opposition to each of the lower static pressure pads **54**. The static pressure pads **62** are substantially identical structurally with the static pressure pads **54**, and are in fluid communication with the manifold system **43**; their discharge ports direct fluid upon the second major surface **51** of the strip work **22**. The static pressure pads **62** direct a downward balancing stream of fluid against the second major surface **51** at a plurality of balance regions B, each of which is opposed to one of the support regions A. The disengaged fluid from the static pressure pads **62** is withdrawn through relief regions R which are intermediate adjacent balance regions B and extend transversely of the strip work **22**.

An embodiment of the instant invention shown in FIG. 8 utilizes a velocity pressure device **63** to establish the balancing region B acting against the second major surface **51** of the strip work **22**. The velocity pressure device **63** defines a series of longitudinally spaced velocity nozzles **64** in its periphery adjacent the strip work **22**. The nozzles **64** are elongate in cross section; however, the instant invention is not limited to velocity nozzles of this shape. The velocity pressure device **63** does not prevent the unrestrained escape or disengagement of fluid from the balancing regions B in a direction normal to the strip work. On the contrary, the unrestrained escape of fluid is inherent in a velocity pressure nozzle system.

Referring to FIG. 5, the force acting upon the second major surface **51** of the strip work **22** is not appreciably affected or increased as the strip **22** moves toward the velocity jet or velocity nozzle **64**. As will be observed by referring to FIG. 5, the force of the jet on the strip work **22** even increases slightly as the strip work **22** moves away from the jet or nozzle **64**.

The force characteristics of a velocity nozzle have created an inherent difficulty or problem in prior art floating systems which utilize velocity nozzles on both sides of the strip work. As the strip work moved closer to the upper velocity nozzle, the fluid therefrom did not increase the force upon the strip to urge the strip back towards its centered position, but the force exerted by the lower velocity nozzle was slightly increased and, therefore, there was a tendency for the strip to move farther away from its desired position rather than to return thereto. Therefore, in prior art velocity nozzle systems, excessive tension is applied to the strip work in an attempt to retain the strip work in a desired position. However, in a long furnace, or when there is a great distance between the supporting rolls, this method of tensioning is not practical because strip weight would inherently cause the strip to take a catenary shape.

When the forces on the opposed major surfaces of the strip are independent of floating height or in other words independent of the distance from the nozzles to the strip work, the upper force plus the weight of the strip must be exactly balanced by the force exerted on the bottom of the strip. If a strip having a different unit weight is introduced into a furnace utilizing such a floating system, the fluid pressures must be precisely adjusted to compensate for the difference in the weight of the new strip.

The static pressure pad **54** according to the instant invention exerts at all times upon the first major surface **50** of the strip work **22** a force which varies as an inverse function of distance. As a consequence, strip work varying substantially in unit weight can be successfully "floated" through the furnace **27** at a given fluid velocity. This point is a very important feature of the instant invention. If the work **22** is the furnace **27** were floated

only on the pressure pad **54**, it has been found that, for any given fluid pressure in the pad **54**, the strip work unit weight should preferably vary not more than about threefold to achieve a desirable floating range. According to the invention, however, it is possible to achieve the desirable floating range with strip having actual unit weights which vary far in excess of the 3:1 ratio. This is accomplished by applying a preload pressure force upon the second major surface **51** of the strip work **22**.

This phenomenon is illustrated for the embodiment of FIG. 8 in the following table:

TABLE 1

	Actual Strip Size	Actual Ratio	Preload Force Equivalent Strip Size, Inch	Effective Strip Size	Effective Ratio
(I)	0.10" (Min.) 0.30" (Max.)	3:1	0	0.10" (Min.) 0.30" (Max.)	3:1
(II)	0.10" (Min.) 1.10" (Max.)	11:1	0.40	0.50" (Min.) 1.50" (Max.)	3:1

Therefore, if the embodiment shown in FIG. 8 is utilized and a preload force equivalent in strip size to 0.40" is supplied by the velocity pressure nozzles **64** strip having an actual ratio of strip thicknesses of 11:1 can be floated in the system and still achieve the desirable floating range. Therefore, the embodiment shown in FIG. 8 can handle strip having size variances from 11:1 without the necessity for adjusting the pressures within the opposed pressure devices. As has been previously pointed out, when the embodiment of FIG. 8 is utilized, the velocity pressure nozzle **64** produces a force in the balance region B which is essentially constant (see FIG. 5).

When the preferred embodiment of the instant invention is utilized, namely when static pressure pads **54** and **62** are placed on opposed sides of the strip work **22**, as shown in FIG. 10, it is possible to float strip work having an extremely high ratio of thicknesses without adjusting the fluid pressures introduced into the static pressure pads **54** and **62**. As an example, the diagram shown in FIG. 7 illustrates the allowable floating range when opposed static pressure pads **54** and **62** are placed a distance of two inches from one another. In this embodiment, it is possible to float .0006" foil at a distance of 0.75" from the near surface of the static pressure pad **62** and under the same fluid supply conditions to float .040" aluminum strip at a distance of .70" from the near surface of the opposed static pressure pad **54** during another run of the strip processing line **20**. The thickness ratio between these two materials is in excess of 65:1. The reason for this marked increase in the actual thickness ratio of the materials which can be handled is readily observed in FIG. 7. As the strip work **22** approaches the static pressure pad **54**, the force acting in the support region A upon the first major surface **50** is increased. The preload force exerted by the static pressure pad **62** is not a uniform force as in the case of a velocity pressure nozzle, but rather is an inverse function of the distance of the pad from the strip work. Therefore, the preload force increases as the strip **22** approaches the pressure pad **62**. This phenomenon of a static pressure pad, constructed according to the instant invention, makes it possible for the furnace operator to treat strip material of widely different unit weights, without manipulative adjustments to the fluid pressure controls and still achieve the desirable floating range.

In the preferred embodiment of the invention, as shown in FIG. 4, first spaced apart, elongate, velocity pressure conduits **70** are disposed transversely of the predetermined path **53** in a position adjacent the first major surface **50** of the strip work **22**. Likewise, second spaced apart, elongate, velocity pressure conduits **71** are aligned transversely of the predtermined path **53** and are positioned adjacent the second major surface **51** of the strip work **22**. Both the conduits **70** and the conduits **71** are in fluid communication with the manifold system **43** and define in their peripheries a plurality of elongate velocity pressure nozzles **64**. The velocity pressure nozzles **64** direct heat exchange fluid upon the opposed major surfaces of the strip work **22**. As has previously been noted, velocity pressure devices have superior convective heat transfer rates. The conduits **70** and **71** are utilized in the preferred embodiment of the instant invention because of their heat transfer properties, and not for support of the strip **22**.

It will be apparent from the foregoing detailed discussion that a preferred embodiment of the instant invention involves the use of the pressure pad **54** acting on one side of the strip work and the use of either a pressure pad **62** (FIG. 10) or a velocity nozzle **64** (FIG. 8) operatively opposed thereto. This is an inherently stable support system because the force exerted by the pad **54** varies as an inverse function of distance of the strip **22** therefrom and does not couse "canoeing" or "bowing" of the strip work because fluid discharged from the pad **54** flows generally longitudinally of the strip **22** and into the relief region R, thus preventing a pressure ridge extending generally longitudinally of the work. In addition, the converging streams of the pad **54** "float" the strip work **22** a substantial distance from the pad, thereby minimizing the chance of strip scratching due to incidental shape variations, for example, incident to stress relief. This feature is important when the strip work travel is generally horizontal as previously discussed, and also when such travel is vertical, as subsequently discussed, or in any other direction.

Embodiments of the invention shown in FIGS. 9 and 11 have many of the advantages over the prior art that make the embodiments of FIGS. 8 and 10 important. The apparatus of FIGS. 9 and 11 includes a pressure pad **54*a*** which has an elongate hollow body **55*a*** and an upper plate member **58** with a multiplicity of perforations **59** therein. In service, heat exchange fluid is supplied to the elongate body **55*a*** from the manifold system **43**, and flows upwardly therefrom through the perforations **59** into contact with the lower surface **50** of the strip work. The fluid flows, as indicated by arrows, generally longitudinally of the work to prevent a pressure ridge and "canoeing" or "bowing" of the work. Furthermore, because the fluid is confined between the work **22** and the plate **58**, the upward force exerted on the work is an inverse function of the distance between the work **22** and the plate **58**. Consequently, when the pressure pad **54*a*** is used in cooperation with a velocity nozzle **64** (FIG. 9) or a pressure pad **62*a*** (FIG. 11) which is substantially identical with the pad **54*a***, an inherently stable system is provided for the reasons set forth above in the discussion of FIGS. 8 and 10. The pad **54*a***, however, does not have the important feature of "floating" the strip a substantial distance thereabove, as can be seen from the following table which shows the approximate force in pounds per foot of strip width exerted under certain

conditions by the pads **54** and **54***a* on strip **22** at various distances therefrom:

TABLE 2

	Force in pounds per inch of strip width	
	Pad 54	Pad 54a
Distance in inches from pad to strip:		
1½	5.4	2.78
1¼	7.2	2.86
1	12.0	3.01
¾	19.8	3.32
½	33.1	4.22
¼	46.8	9.1
⅛	81.0	26.6

The pad **54**, therefore, is unexpectedly more advantageous than the pad **54***a*, and shares therewith important unexpected advantages over prior art structures.

The instant invention is not limited to using products of combustion or conditioned air as a heat exchange fluid. Referring to FIG. 1, the pretreatment tank **25** contains a cleaning liquid, for example a detergent solution. Static pressure pads **72**, which are structurally similar to the static pressure pads **54**, are spaced apart and traversely positioned with respect to the strip work **22**. The static pressure pads **72** are placed in opposed pairs, with the lower pads acting upon the first major surface **50** of the strip work **22** and the upper pads acting upon the second major surface **51** of the strip work **22**. Liquid is supplied to the static pressure pads **72** from a pump supply system (not shown) which utilizes the detergent solution as a fluid. The fluid escapes to relief regions R as previously discussed, and is then recirculated through the pump system. It should be noted that the pretreatment tank **25** may contain other liquids which are utilized as heat transfer media for heat treatment purposes. For examples, heated liquid metal, heated salt solutions, or heated silicone fluids may be used as the treatment fluids. The heating system and the stabilizing systems may be separated, with the stabilizing or support system being served by an independent fluid supply system. In this type of construction, heating may be accomplished by an independent heat treatment fluid system utilizing either a gas or a liquid as a heat transfer medium, and the necessary heat can be supplied thereto in any suitable manner, for example, by burners as previously described, or by electrical heating elements.

Referring to FIG. 2, a fluid pulley is generally indicated at **75**. The fluid pulley **75** comprises a distributor chamber **76** having an opening **77** which is in fluid communication with the manifold system **43**. A plurality of static pressure pads **78** are secured to a wall **79** of the distributor chamber **76**. The outer surfaces **80** of the static pressure pads **78** are located in a path parallel to the predetermined path **53**, which in this case is arcuate in shape. The wall **79** of the distributor chamber **76** has a plurality of openings **81** which are in fluid communication with the interiors of the static pressure pads **78**. The static pressure pads **78** have toed-in walls **82** and a substantially impervious top plate **83**. Wings **84** which extend downwardly from the top plate **83** and the upper portion of the toed-in walls **82** define opposed fluid discharge ports **85**.

In a typical operation, fluid travels through the manifold system **43**, to the distributor chamber **76**, into the static pressure pads **78**, and a stream of fluid is projected outwardly through each of the discharge ports **85** which extend transversely of the strip work **22**. As has previously been disclosed, the static pressure pad fluid establishes a plurality of support regions A which are spaced from one another longitudinally of the strip work and, in the instant embodiment, are located along an arcuate path parallel to the predetermined arcuate path **53**. Escape of the fluid from each of the support regions A in a direction normal to the predetermined arcuate path **53** is prevented by the top plates **83**. Fluid flows from the support regions A in a path which is longitudinal of the strip work **22**. The fluid is withdrawn from relief regions R which are located intermediate adjacent support regions A and, in the instant embodiment, are defined between adjacent walls **82** of the static pressure pads **78**. These relief regions R extend transversely of the predetermined path **53** and prevent the buildup of a longitudinal pressure ridge along the center of the strip work. Longitudinal pressure ridges are established when the fluid is forced to escape only adjacent the edges of the strip. The strip work **22** is balanced in the arcuate path by tension applied thereto by the remainder of the support system in the compartment **35**. The fluid pulley **75**, for reasons not fully understood, only performs satisfactorily if the tension in the strip work **22**, as it travels around the pulley **75**, is relatively low in magnitude. Accordingly, when strip work to be heat treated must be under substantial tension for any reason, the air pulley **75** is not suitable, and the strip work must pass through the apparatus according to the invention in a straight line as distinguished from an arcuate path.

Considerable difficulty has been experienced in the processing of light gauge strip materials, for examples, aluminum, brass and steel. While proceeding through the treatment chambers, the materials are sometimes corrugated. If the strip work passes over, for example, a seal tank roll when in this condition the strip work is permanently wrinkled and must be rejected. Referring to FIG. 12, another embodiment of the instant invention is shown which incorporates a flattening apparatus.

The strip work **22** passes through a final treatment compartment **90** downwardly through an opening **91** in a bottom wall **92** and into a flattening tank **93**. Flattener pads **94** and **95** are mounted in the tank **93** transversely of the strip work **22** with the flattener pad **94** disposed adjacent the first major surface **50** of the strip work **32** and with the flattener pad **95** directly opposed to the flattener pad **94** adjacent the second major surface **51**.

The flattening tank **93** is filled with a liquid **96**, for example, water. Buffer jet nozzles **97** are preferably mounted above the flattener pads **94** and **95**, and are utilized to prevent excessive turbulence in the tank **93**.

A roll **98** is mounted below the pads **94** and **95**. The strip work **22** passes around the roll **98** and over a roll **99** into a cleansing chamber **100** and then to the end of the strip processing line.

The buffer jet nozzles **97** and the flattener pads **94** and **95** are in fluid communication with a pumping system (not shown) which preferably circulates the fluid **96**.

Referring to FIG. 13, the fluid enters the pads **94** and **95** through entrance conduits **101** which are connected to the pumping system. The flattener pads **94** and **95** operate on a static pressure principle and are similar in construction, in the preferred embodiment, to the static pressure pads **54** and **62**. Each of the flattener pads **94** and **95** comprises a hollow body **102** having a bottom plate **103**, toed-in walls **104** (see FIG. 12) extending outwardly from the bottom plate **103** and defining, with a top plate **105** a pair of ports **106** which are disposed transversely of the strip work **22**. The body **102** is closed by end plates **107** (see FIG. 13).

In operation the strip work moves in the predetermined path **53**, which is indicated by the dashed line in FIG. 13. The pressurized fluid passes outwardly through the ports **106** of the flattener pad **94** and the streams of fluid established at static pressure region P1 acting against the first major surface **50** of the strip work **22**. Escape of the fluid from the pressure region P1, in a direction normal to the predetermined path **53**, is prevented by the top plate **105** of the flattener pad **94**. The fluid is withdrawn from relief regions which are transverse of the strip work **22** and adjacent the pressure region.

The flattening fluid is discharged through the ports **106** of the flattener pad **95** against the second major surface **51** of the strip work **22**. This establishes a second static pressure region P2 which is opposed to the first pressure region P1. The fluid is prevented from escaping from the pressure region P2 in a direction normal to the predetermined path **53** by the top plate **105** of the flattener pad **95**. Fluid is likewise withdrawn from the pressure region P2 to relief regions which are transverse of the strip work **22** and adjacent the pressure region P2.

In FIG. 13, the strip work **22** is shown in a bowed or slightly corrugated condition. The force exerted on the strip work **22** by the static pressure pads **94** and **95** varies as an inverse function of distance therefrom. In FIG. 13, the center of the strip is nearer the flattening pad **94**. Therefore, the pressure region P1 exerts an increased force (indicated by the small arrows) on the center of the strip work **22** and urges such strip work toward the predetermined path **53**. Similarly, the edges of the strip work **22** are closer to the flattening pad **95** and the static pressure region P2 exerts a greater force (indicated by the small arrows) on such edges and urges the edges toward the predetermined path **53**. These opposed forces flatten the strip work **22** prior to its passage over the roll **98**.

The instant invention is not limited to use solely in a horizontal strip processing line. For example, FIG. 14 shows a furnace **110** having a vertical processing line generally indicated at **111**. The strip work **22**, passes over entrance bridle rolls **112**, through an entrance port **113** and around a roller **114**. The strip work travels upwardly over a fluid pulley **115**, constructed according to the instant invention, downwardly around an exit roller **116**, through a discharge port **117** and over discharge bridle rolls **118**.

A plurality of opposed static pressure pads **119**, which are substantially identical with the pads **54** and **62**, are disposed on opposite sides of the predetermined path **53**. The opposed pairs of pads are spaced apart longitudinally of the strip work **22**.

Similarly a plurality of velocity pressure nozzles **120** which are structurally identical with the nozzles **64**, are disposed on opposite sides of the strip work **22**. The velocity pressure nozzles **120** direct heat exchange fluid upon the opposed major surfaces of the strip work **22**.

In a typical operation, fluid is directed outwardly from each of the opposed static pressure pads **119** against the major surfaces **50** and **51**, respectively, of the strip work **22** into a pair of opposed stabilizing regions S. Opposed pairs of stabilizing regions S are spaced from one another longitudinally of the strip work **22** and are regions of static pressure force. As the strip work **22** moves from the predetermined path **53** toward a pressure pad **119** the static pressure force in the respective stabilizing regions S increases and urges the strip work **22** back into the predetermined path **53**.

Fluid is prevented from escaping or disengaging from each of the stabilizing regions S in a direction normal to the strip work **22**. Fluid is withdrawn or disengaged after flow generally longitudinal of the work **22**, to relief regions R which extend transversely of the strip work **22** and are adjacent respective ones of the stabilizing regions S.

The difference between a stabilizing region S and a support region A is that in a substantially vertical processing line the weight of the strip work **22** is supported by means other than the stabilizing regions S, for example, by the fluid pulley **115**. The function of the stabilizing regions S is to center and "stabilize" the strip work **22** during its vertical travel. The support regions A also perform this centering and stabilizing function and in addition "support" at least a part of the weight of the strip work.

While the pressure pads **54**, **62**, **72**, **94**, **95** and **119** are substantially identical in structure, they may vary both geometrically and dimensionally. For example, the pads **54**, when used in a substantially horizontal strip processing system, must perform both a support and stabilizing function, as mentioned above. In such a system, the pads **62** which perform stabilizing and "preload" functions will often vary dimensionally with respect to the pads **54**. The pads **62** may also vary geometrically, for example, the walls defining the ports **56** may be altered to change the angle of convergence of the fluid flow. Variations in effective nozzle areas are also contemplated to insure that desired fluid flow forces act upon the opposed major surfaces of the strip work.

Preferably, the longitudinal spacing of any of the pressure pads, for examples, pressure pads **54** and **62**, varies. The variation in longitudinal spacing of the pads dampens any tendency for the strip work to vibrate in a longitudinal direction. It has been found that if the pads are uniformly spaced, the pads serve as nodes and the strip work vibrates in a natural frequency with the wave length extending between two alternately spaced pads. As the amplitude of vibration of the strip work is increased the danger of marking of the strip work increases. Varying the spacing of the pressure pads dampens this tendency to vibrate.

The opposed pressure pads **54** and **62** which act upon the opposed major surfaces **50** and **51** of the strip work **22** are not necessarily geometrically opposed (as shown in FIG. 4) but need only be *operatively* opposed. In other words, the longitudinal centerlines of two operatively opposed pads **54** and **62** do not necessarily fall in a common plane which is normal to the predetermined planar path **53**, but may be longitudinally spaced apart with respect to the strip work **22**. Similarly, the velocity jets **64** and the pads **54***a* and **62***a* need be only operatively opposed.

Reference has heretofore been made to flow of fluid, generally longitudinal of strip work **22** to relief regions R and R1 (see, for example, FIG. 10) to prevent a pressure ridge generally longitudinal of the work and consequent "bowing" or "canoeing." In general, the pressure pads **54**, because of the converging upward fluid flow, inherently provide such flow. However, such flow would be prevented if the pads were excessively wide (longitudinally of the strip **22**), for example, wider than about the width of the strip work **22** being processed, which can conveniently be designated *a*. Such flow does not occur with the pads **54***a*, however, if such pads are wider than about one-half *a*, and it is usually preferred that the pads **54** be not wider than about one-half *a* to eliminate any chance of a pressure ridge. In general, it is only necessary, with any pressure pad used according to the invention to prevent escape of the fluid from the stabilizing region associated therewith in a direction normal to the work path, to establish a pressure within the stabilizing region by virtue of the confined fluid flow therein and to withdraw fluid from relief regions which are transverse of the strip work and adjacent the stabilizing region to prevent appreciable pressure variation, lateral of the strip work, in the stabilizing region.

While the present invention has been disclosed in connection with a specific arrangement of parts, it should be expressly understood that numerous modifications and changes can be made without departing from the spirit and scope of the invention as defined in the appended claims.

We claim:

1. In a method for stabilizing strip work of indefinite length, and having first and second opposed major surfaces, in a chamber, which method includes directing the work through the chamber along a predetermined path, the improvement of stabilizing the strip work within at least a part of the chamber by directing at least one stream of a fluid, which stream extends transversely of the strip work, against the first major surface of the strip work at each of a plurality of stabilizing regions which are spaced from one another longitudinally of the strip work, preventing escape of the fluid from each of the stabilizing

regions in a direction normal to the predetermined path, to establish a pressure within each stabilizing region by virtue of the confined fluid flow therein while withdrawing fluid from relief regions which are transverse of the strip work and adjacent the stabilizing regions to prevent appreciable pressure variation, lateral of the strip work, in the several stabilizing regions, balancing the strip work within the chamber by directing at least one stream of a fluid against the second major surface of the strip work at each of a plurality of balance regions which are operatively opposed to the stabilizing regions, and withdrawing fluid from relief regions adjacent balance regions.

2. In a method for stabilizing strip work of indefinite length, and having first and second opposed major surfaces, in a chamber, which method includes directing the work through the chamber along a predetermined path, the improvement of stabilizing the strip work within at least a part of the chamber by directing a plurality of streams of a fluid, which streams extend transversely of the strip work, against the first major surface of the strip work at each of a plurality of stabilizing regions which are spaced from one another longitudinally of the strip work, preventing escape of the fluid from each of the stabilizing regions in a direction normal to the predetermined path, to establish a pressure within each stabilizing region by virtue of the confined fluid flow therein while withdrawing fluid from relief regions which are transverse of the strip work and adjacent the stabilizing regions to prevent appreciable pressure variation, lateral of the strip work, in the several stabilizing regions, balancing the strip work within the chamber by directing at least one stream of a fluid against the second major surface of the strip work at each of a plurality of balance regions which are operatively opposed to the stabilizing regions, and withdrawing fluid from relief regions adjacent balance regions.

3. In a method for stabilizing strip work of indefinite length, and having first and second opposed major surfaces, in a chamber, which method includes directing the work through the chamber along a predetermined path, the improvement of stabilizing the strip work within a least a part of the chamber by directing operatively opposed pairs of converging streams of a fluid, which streams extend transversely of the strip work, against the opposed major surfaces of the strip work at each of a plurality of operatively opposed stabilizing regions which are spaced from one another longitudinally of the strip work, and preventing escape of the fluid from each of the stabilizing regions in a direction normal to the predetermined path, to establish a pressure within each stabilizing region by virtue of the confined fluid flow therein while withdrawing fluid from relief regions which are transverse of the strip work and adjacent the stabilizing regions to prevent appreciable pressure variation, lateral of the strip work, in the several stabilizing regions.

4. In a method for treating strip work of indefinite length, and having first and second opposed major surfaces, in a chamber, which method includes directing the work through the chamber along a predetermined path, the improvement of stabilizing the strip work within at least a part of the chamber by directing operatively opposed pairs of converging streams of a fluid, which streams extend transversely of the strip work, against the opposed major surfaces of the strip work at each of a plurality of operatively opposed stabilizing regions which are spaced from one another longitudinally of the strip work, preventing escape of the fluid from each of the stabilizing regions in a direction normal to the predetermined path, to establish a pressure within each stabilizing region by virtue of the confined fluid flow therein while withdrawing fluid from relief regions which are transverse of the strip work and adjacent the stabilizing regions to prevent appreciable pressure variation, lateral of the strip work, in the several stabilizing regions, and directing a heat exchange fluid against the opposed major surfaces of the strip work at locations intermediate adjacent stabilizing regions.

5. In a method as claimed in claim 4, the improvement wherein the spacing, longitudinally of the strip work, between adjacent ones of the several stabilizing regions varies.

6. In a method for treating strip work of indefinite length, and having first and second opposed major surfaces, in a chamber, which method includes directing the work through the chamber along a predetermined path, the improvement of stabilizing the strip work within at least a part of the chamber by directing operatively opposed pairs of converging streams of a fluid, which streams extend transversely of the strip work, against the opposed major surfaces of the strip work at each of a plurality of operatively opposed stabilizing regions which are spaced from one another longitudinally of the strip work, preventing escape of the fluid from each of the stabilizing regions in a direction normal to the predetermined path, to establish a pressure within each stabilizing region by virtue of the confined fluid flow therein while withdrawing fluid from relief regions which are transverse of the strip work and adjacent the stabilizing regions to prevent appreciable pressure variation, lateral of the strip work, in the several stabilizing regions, and directing jet momentum streams of a heat exchange fluid against the opposed major surfaces of the strip work at locations intermediate adjacent stabilizing regions.

7. In a method for stabilizing strip work of indefinite length, having first and second opposed major surfaces and having a width of at least *a*, in a chamber, which method includes directing the work through the chamber along a predetermined path, the improvement of stabilizing the strip work within at least a part of the chamber by directing operatively opposed pairs of converging streams of a fluid, which streams extend transversely of the strip work, against the opposed major surfaces of the strip work at each of a plurality of operatively opposed stabilizing regions which have a width, longitudinally of the strip work, not greater than one-half *a*, and are spaced from one another longitudinally of the strip work, and preventing escape of the fluid from each of the stabilizing regions in a direction normal to the predetermined path, to establish a pressure within each stabilizing region by virtue of the confined fluid flow therein while withdrawing fluid from relief regions which are transverse of the strip work and adjacent the stabilizing regions to prevent appreciable pressure variation, lateral of the strip work, in the several stabilizing regions.

8. In a method for stabilizing strip work of indefinite length, and having first and second opposed major surfaces, in a chamber, which method includes directing the work through the chamber along a predetermined and generally vertical path, the improvement of stabilizing the strip work within at least a part of the chamber by directing operatively opposed pairs of converging streams of a fluid, which streams extend transversely of the strip work, against the opposed major surfaces of the strip work at each of a plurality of operatively opposed stabilizing regions which are spaced from one another longitudinally of the strip work, and preventing escape of the fluid from each of the stabilizing regions in a direction normal to the predetermined path, to establish a pressure within each stabilizing region by virtue of the confined fluid flow therein while withdrawing fluid from relief regions which are transverse of the strip work and adjacent the stabilizing regions to prevent appreciable pressure variation, lateral of the strip work, in the several stabilizing regions.

9. In a method for supporting and stabilizing strip work of indefinite length, and having first and second opposed major surfaces, in a chamber, which method includes directing the work through the chamber along a predetermined and generally horizontal path with the

first surface facing generally downwardly, the improvement of supporting and stabilizing the strip work within at least a part of the chamber by directing converging streams of a fluid, which streams extend transversely of the strip work, upwardly against the first major surface of the strip work at each of a plurality of support regions which are spaced from one another longitudinally of the strip work, preventing escape of the fluid from each of the support regions in a direction normal to the predetermined path, to establish a pressure within each support region by virtue of the confined fluid flow therein while withdrawing fluid from relief regions which are transverse of the strip work adjacent the support regions to prevent appreciable pressure variation, lateral of the strip work, in the several support regions, balancing the strip work within the chamber by directing converging streams of a fluid downwardly against the second major surface of the strip work at each of a plurality of balance regions which are operatively opposed to the support regions, and preventing escape of the fluid from each of the balance regions in a direction normal to the predetermined path, to establish a pressure within each balance region by virtue of the confined fluid flow therein while withdrawing fluid from relief regions which are transverse of the strip work and adjacent the balance regions to prevent appreciable pressure variation, lateral of the strip work, in the several balance regions.

10. Apparatus for supporting strip work of indefinite length, and having first and second major surfaces, in a chamber, said apparatus comprising, in combination, means for moving such strip work through such chamber in a predetermined path, and support means for such strip work comprising static pressure pad means positioned within such chamber for directing at least one stream of a fluid, transversely of such strip work, against the first major surface of such strip work, means for supplying a pressurized fluid to said static pressure pad, means on said static pad to prevent escape of such fluid in a direction normal to the predetermined path, balancing pad means spaced from and opposed to said static pressure pad means for directing at least one stream of such fluid against the second major surface of such strip work in opposition to a stream of such fluid from said static pressure pad means, and means for supplying such fluid to said balancing pad means.

11. Apparatus for supporting and effecting heat treatment of strip work of an indefinite length, and having first and second major surfaces, said apparatus comprising, in combination, a chamber, means for moving such strip work through said chamber in a predetermined path, circulating means for introducing and removing a heat exchange fluid into and out of said chamber, first distributing means in fluid communication with said circulating means for directing such heat exchange fluid toward such strip work, said first distributing means comprising a first plurality of spaced apart elongate static pressure pads disposed generally transversely of such predetermined path, and positioned adjacent the first major surface of such strip work and a second plurality of spaced apart elongate static pressure pads opposed to said first plurality of static pressure pads and positioned adjacent the second major surface of such strip work, each of said static pressure pads comprising a pair of port means disposed transversely of such predetermined path for directing heat exchange fluid toward such strip work at a converging angle, and substantially impervious means extending between said port means for preventing the flow of heat exchange fluid in a direction normal to such strip work, a second distributing means in fluid communication with said circulating means for directing such heat exchange fluid toward such strip work, said second distributing means comprising a first plurality of spaced apart elongate velocity pressure conduits disposed generally transversely of such predetermined path and positioned adjacent the first major surface of such strip work, and a second plurality of spaced apart elongate velocity conduits disposed generally transversely of such predetermined path and positioned adjacent the second major surface of such work, said velocity pressure conduits defining therein a plurality of velocity pressure nozzles.

12. In a method for supporting strip work of indefinite length, and having first and second major surfaces, through a predetermined arcuate path, the improvement comprising, moving the strip through the predetermined arcuate path, supporting the strip work by directing at least one stream of a fluid, which stream extends transversely of the strip work, against the first major surface of the strip work at each of a plurality of support regions which are spaced from one another longitudinally of the strip work and are located along a path parallel to the predetermined arcuate path, preventing escape of the fluid from each of the support regions in a direction normal to the predetermined arcuate path, to establish a pressure within each support region by virtue of the confined fluid flow therein while withdrawing fluid from relief regions which are transverse of the strip work and adjacent the support regions to prevent appreciable pressure variation, lateral of the strip work, in the several support regions, and balancing the strip work in the arcuate path by tension applied thereto.

13. In a method of straightening strip work of indefinite length, and having first and second major surfaces, which method includes moving the work through a predetermined path, the improvement comprising, directing at least one stream of a fluid transversely of the strip work against the first major surface of the strip work at a first pressure region, preventing escape of the fluid from the first pressure region in a direction normal to the predetermined path of the work while withdrawing fluid from the first pressure region from relief regions which are transverse of the strip work and adjacent the first pressure region, directing at least one stream of a fluid transversely of the strip work against the second major surface at a second pressure region which is opposed to the first pressure region, preventing escape of the fluid from the second pressure region in a direction normal to the predetermined path of the work while withdrawing fluid from the second pressure region from relief regions which are transverse of the strip work and adjacent the second pressure region.

14. In a method of straightening strip work of indefinite length and having first and second major surfaces, which method includes moving the work through a predetermined path, the improvement comprising, directing a plurality of streams of a liquid transversely of the strip work against the first major surface of the strip work at a first pressure region, preventing escape of the liquid from the first pressure region in a direction normal to the predetermined path of the work while withdrawing liquid from the first pressure region from relief regions which extend transversely of the strip work and adjacent the first pressure region, directing a plurality of streams of a liquid transversely of the strip work against the second major surface at a second pressure region which is opposed to the first pressure region, preventing escape of the liquid from the second pressure region in a direction normal to the predetermined path of the work while withdrawing liquid from the second pressure region from relief regions which extend transversely of the strip work and adjacent the second pressure region.

15. In a method for stabilizing strip work of indefinite length, and having first and second opposed major surfaces, in a chamber, which method includes directing the work through the chamber along a predetermined path, the improvement of stabilizing the strip work within at least a part of the chamber by directing at least one stream of a fluid, which stream extends transversely of the strip work, against the first major surface of the

strip work at at least one stabilizing region preventing escape of the fluid from the stabilizing region in a direction normal to the predetermined path, to establish a pressure within the stabilizing region by virtue of the confined fluid flow therein while withdrawing fluid from relief regions which are transverse of the strip work and adjacent the stabilizing region to prevent appreciable pressure variation, lateral of the strip work, in the stabilizing region, balancing the strip work within the chamber by directing at least one stream of a fluid against the second major surface of the strip work at at least one balance region which is operatively opposed to the stabilizing region, and withdrawing fluid from relief regions adjacent the balance region.

16. Apparatus for supporting and effecting heat treatment of strip work of an indefinite length, and having first and second major surfaces, said apparatus comprising, in combination, a chamber, means for moving such strip work through said chamber in a predetermined path, circulating means for introducing and removing a heat exchange fluid into and out of said chamber, first distributing means in fluid communication with said circulating means for directing such heat exchange fluid toward such strip work, said first distributing means comprising a first plurality of spaced apart elongate static pressure pads disposed generally transversely of such predetermined path, and positioned adjacent the first major surface of such strip work, balancing pad means spaced from and opposed to said static pressure pad means for directing at least one stream of such fluid against the second major surface of such strip work in opposition to a stream of

such fluid from said static pressure pad means, each of said static pressure pads comprising a pair of port means disposed transversely of such predetermined path for directing heat exchange fluid toward such strip work at a converging angle, and substantially impervious means extending between said port means for preventing the flow of heat exchange fluid in a direction normal to such strip work, a second distributing means in fluid communication with said circulating means for directing such heat exchange fluid toward such strip work, said second distributing means comprising a first plurality of spaced apart elongate velocity pressure conduits disposed generally transversely of such predetermined path and positioned adjacent the first major surface of such strip work, and a second plurality of spaced apart elongated velocity conduits disposed generally transversely of such predetermined path and positioned adjacent the second major surface of such work, said velocity pressure conduits defining therein a plurality of velocity pressure nozzles.

References Cited

UNITED STATES PATENTS

3,048,383	8/1912	Champlin	263—3
3,262,688	7/1966	Beggs	266—2

FOREIGN PATENTS

1,354,189	1/1964	France.

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