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Document details: Country/Office: US

Filing date: 25 Jul 2024 (25.07.2024)

Application number: 18/783,800

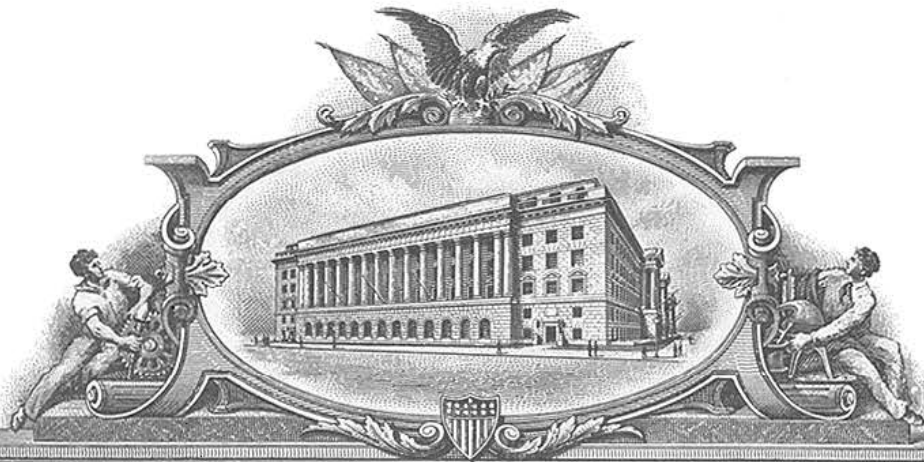
Date of availability of document: 08 Aug 2024 (08.08.2024)

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THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

July 18, 2025

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE UNDER 35 USC 111.

APPLICATION NUMBER: 18/783,800
FILING DATE: *July 25, 2024*

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS *US18/783,800*



Certified by

Coke Moya-Snead

Acting Director of the
United States Patent and Trademark Office

Placeholder Sheet for Supplemental Content

Application Number: 18783800

Document Date: 07/25/2024

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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #
18/783,800

RECEIPT DATE / TIME
07/25/2024 12:43:42 PM Z ET

ATTORNEY DOCKET #
33-10022

Title of Invention

Deep Cleaning Alignment Equipment

Application Information

APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # -

CONFIRMATION # 7043

FILED BY NICHOLAS BECHT

PATENT CENTER # 66517569

FILING DATE -

CUSTOMER # 199904

FIRST NAMED
INVENTOR Keith R. Boye

CORRESPONDENCE
ADDRESS -

AUTHORIZED BY Brad Meyer

Documents

TOTAL DOCUMENTS: 6

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
Transmittal.pdf	1	Transmittal of New Application	164 KB
ADS.pdf	8	Application Data Sheet	2594 KB
Warning: This is not a USPTO supplied ADS fillable form. Data in the form cannot be automatically loaded to other USPTO systems.			
Formal Drawings.pdf	21	Drawings-only black and white line drawings	1489 KB
Declarations.pdf	4	Oath or Declaration filed	2765 KB
Specification-APP.TEXT.docx	35	Application body structured text document	51 KB

Warning: Bookmarks were found and have been removed.

Spec.pdf	35	Auxiliary PDF of Application	296 KB
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Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
Transmittal.pdf	E7E79FA7F056176360CCCD8751E488344C772B62AE4B491D8 18D5BB900EC36228DA12B70CC43BE0D61E46995544FD1EED 041A0FCED316227CCF0D2EF21213081
ADS.pdf	C68A145A8F3BCB8C8C5593C3BBC78919397D7EB39ACF2481 E99BA7206779FF87A5A4A1EEEACF72D6362428936707766EF4 CBE2064EDE2A206DEAE58AEA68AFE4
Formal Drawings.pdf	F144FEDEE0B4B72FC1C60ADFE079A6C2B664916B7646CC93 AA79FA68B931AF7DDE9692E1D47A0E178C67246727B7DDFE7 A3680F1AE1F3BE454B99CCF95B79D5E
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Specification-APP.TEXT.docx	753C644DB242AE935A18FB4300E6260E02242060CC7BB2D4E A3C48B50BDDBB48295EE948E831FAD1C939E50FF8F3865851 383F21CF380F4FD02A9417C7949D9D
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This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

DECLARATION AND ASSIGNMENT
NON-PROVISIONAL PATENT APPLICATION

Title of Invention: Deep Cleaning Alignment Equipment

I. Declaration of Inventor

As the below named inventor, I hereby declare that:

This declaration is directed to the following APPLICATION:

☒ The attached United States non-provisional patent application, or
☐ United States non-provisional patent application or PCT international application number _____, filed on _____

The APPLICATION was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the APPLICATION.

I have reviewed and understand the contents of the APPLICATION, including the claims.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations §1.56.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

II. Assignment of the Invention

In consideration of the sum of One Dollar (\$1.00) and other good and valuable considerations, the receipt of which is hereby acknowledged, I hereby do sell, assign and transfer to Precision Iceblast Corporation (hereinafter referred to as "ASSIGNEE"), a corporation organized under the laws of the state of Wisconsin, and located and doing business at 801 Maple Street, Peshtigo, Wisconsin 54157, its successors and assigns, my entire right, title and interest in said invention in my capacity as an inventor or as otherwise acquired by me, to the above identified invention as set forth in the APPLICATION for United States Letters Patent therefore and any divisions or continuations thereof, and any Letters Patent obtained for the said invention in the United States and foreign countries, or issuing out of said application or any such division or continuation thereof, and any reissues or extensions of any such Letters Patent.

The Commissioner of Patents is hereby authorized and requested to issue Letters Patent for said invention to the ASSIGNEE, as assignee of the entire right, title and interest therein.

I covenant that I have full right to convey my entire title and interest in said invention as an inventor, and that I have not executed and will not execute any agreement in conflict herewith.

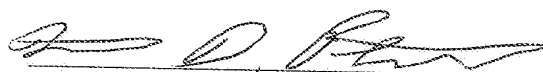
I further covenant that I will, at any time, upon request, execute and deliver any and all papers that may be necessary or desirable to perfect the title in ASSIGNEE to said invention or any Letters Patent that may be granted therefore, and that if ASSIGNEE, or its assignee, desires to make a substitute, divisional or continuation application for said invention, or to secure a reissue or extension of said Letters Patent, to file a disclaimer relating thereto, or an application for a corresponding patent in any foreign country, and that I will, upon request, sign all papers, make all rightful oaths, and do all lawful acts requisite for the said purpose, but at the expense of the ASSIGNEE.

I further covenant and acknowledge that the entire beneficial interest in the invention to which the above referenced application relates is irrevocably vested in the ASSIGNEE including the right to make applications for protection in all countries abroad and to claim priority under the International Convention for such applications and hereby assent to the making of any such applications, with or without priority claim, and of any divisional applications resulting therefrom.

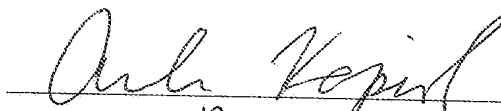
I further covenant that I will at all times, communicate to the ASSIGNEE, its successors, assigns, or legal representatives, all facts relating to said invention and Letters Patent, or the history thereof, known to me, and testify as to the same in administrative actions or other litigation when requested so to do.

I hereby authorize the ASSIGNEE or the attorney of record to insert the filing date and serial number of the APPLICATION in this instrument: App. No. _____; Filed: _____

Executed and delivered this 27th day of July, 2024.



Inventor Name: Matthew D. Peterson



Witness Name: Amber Kopish

DECLARATION AND ASSIGNMENT
NON-PROVISIONAL PATENT APPLICATION

Title of Invention: Deep Cleaning Alignment Equipment

I. Declaration of Inventor

As the below named inventor, I hereby declare that:

This declaration is directed to the following APPLICATION:

☒ The attached United States non-provisional patent application, or
☐ United States non-provisional patent application or PCT international application number _____, filed on _____

The APPLICATION was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the APPLICATION.

I have reviewed and understand the contents of the APPLICATION, including the claims.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations §1.56.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

II. Assignment of the Invention

In consideration of the sum of One Dollar (\$1.00) and other good and valuable considerations, the receipt of which is hereby acknowledged, I hereby do sell, assign and transfer to Precision Iceblast Corporation (hereinafter referred to as "ASSIGNEE"), a corporation organized under the laws of the state of Wisconsin, and located and doing business at 801 Maple Street, Peshtigo, Wisconsin 54157, its successors and assigns, my entire right, title and interest in said invention in my capacity as an inventor or as otherwise acquired by me, to the above identified invention as set forth in the APPLICATION for United States Letters Patent therefore and any divisions or continuations thereof, and any Letters Patent obtained for the said invention in the United States and foreign countries, or issuing out of said application or any such division or continuation thereof, and any reissues or extensions of any such Letters Patent.

The Commissioner of Patents is hereby authorized and requested to issue Letters Patent for said invention to the ASSIGNEE, as assignee of the entire right, title and interest therein.

I covenant that I have full right to convey my entire title and interest in said invention as an inventor, and that I have not executed and will not execute any agreement in conflict herewith.

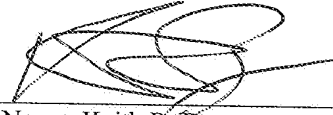
I further covenant that I will, at any time, upon request, execute and deliver any and all papers that may be necessary or desirable to perfect the title in ASSIGNEE to said invention or any Letters Patent that may be granted therefore, and that if ASSIGNEE, or its assignee, desires to make a substitute, divisional or continuation application for said invention, or to secure a reissue or extension of said Letters Patent, to file a disclaimer relating thereto, or an application for a corresponding patent in any foreign country, and that I will, upon request, sign all papers, make all rightful oaths, and do all lawful acts requisite for the said purpose, but at the expense of the ASSIGNEE.

I further covenant and acknowledge that the entire beneficial interest in the invention to which the above referenced application relates is irrevocably vested in the ASSIGNEE including the right to make applications for protection in all countries abroad and to claim priority under the International Convention for such applications and hereby assent to the making of any such applications, with or without priority claim, and of any divisional applications resulting therefrom.

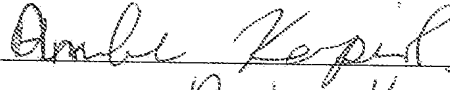
I further covenant that I will at all times, communicate to the ASSIGNEE, its successors, assigns, or legal representatives, all facts relating to said invention and Letters Patent, or the history thereof, known to me, and testify as to the same in administrative actions or other litigation when requested so to do.

I hereby authorize the ASSIGNEE or the attorney of record to insert the filing date and serial number of the APPLICATION in this instrument: App. No. _____; Filed: _____

Executed and delivered this 25 day of July, 2024.



Inventor Name: Keith R. Boye



Witness Name: Amber Kopish

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	33-10022
		Application Number	
Title of Invention	Deep Cleaning Alignment Equipment		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1						Remove	
Legal Name							
Prefix	Given Name	Middle Name	Family Name			Suffix	
	Keith	R.	Boye				
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service							
City	Hobart	State/Province	WI	Country of Residence	US		
Mailing Address of Inventor:							
Address 1		1257 Thayer Trail					
Address 2							
City	Hobart		State/Province		WI		
Postal Code	54155		Country		US		
Inventor 2						Remove	
Legal Name							
Prefix	Given Name	Middle Name	Family Name			Suffix	
	Matthew		Peterson				
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service							
City	Green Bay	State/Province	WI	Country of Residence	US		
Mailing Address of Inventor:							
Address 1		1237 Shepherds Path					
Address 2							
City	Green Bay		State/Province		WI		
Postal Code	54313		Country		US		
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button.						Add	

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	33-10022
		Application Number	
Title of Invention	Deep Cleaning Alignment Equipment		

☐ An Address is being provided for the correspondence information of this application.

Customer Number	199904		
Email Address	docketing@wongmeyer.com	Add Email	Remove Email

Application Information:

Title of the Invention	Deep Cleaning Alignment Equipment		
Attorney Docket Number	33-10022	Small Entity Status Claimed	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	21	Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	☒ Customer Number	☐ US Patent Practitioner	☐ Limited Recognition (37 CFR 11.9)
Customer Number	199904		

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	33-10022
		Application Number	
Title of Invention	Deep Cleaning Alignment Equipment		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78. When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending		Remove		
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
	Continuation in part of	17729133	2022-04-26		
Prior Application Status	Patented		Remove		
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
17729133	Continuation in part of	16204281	2018-11-29	11313632	2022-04-26
Prior Application Status			Remove		
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
16204281	Claims benefit of provisional	62597179	2017-12-11		
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button.					

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX) the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove			
Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ⁱ (if applicable)
Additional Foreign Priority Data may be generated within this form by selecting the Add button.			

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	33-10022
		Application Number	
Title of Invention	Deep Cleaning Alignment Equipment		

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	33-10022
		Application Number	
Title of Invention	Deep Cleaning Alignment Equipment		

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	33-10022
		Application Number	
Title of Invention	Deep Cleaning Alignment Equipment		

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.			
Applicant 1			
If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.			
Clear			
☒ Assignee		☐ Legal Representative under 35 U.S.C. 117	
☐ Person to whom the inventor is obligated to assign.		☐ Person who shows sufficient proprietary interest	
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:			
Name of the Deceased or Legally Incapacitated Inventor:			
If the Applicant is an Organization check here. ☒			
Organization Name	Precision Iceblast Corporation		
Mailing Address Information For Applicant:			
Address 1	801 Maple Street		
Address 2			
City	Peshtigo	State/Province	WI
Country	US	Postal Code	54157
Phone Number		Fax Number	
Email Address			
Additional Applicant Data may be generated within this form by selecting the Add button.			

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	33-10022
		Application Number	
Title of Invention	Deep Cleaning Alignment Equipment		

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	Given Name	Middle Name	Family Name	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		State/Province	
Country ⁱ		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

Signature:

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/brad l. meyer/			Date (YYYY-MM-DD)	2024-07-25
First Name	Brad L.	Last Name	Meyer	Registration Number	71766

Additional Signature may be generated within this form by selecting the Add button.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	33-10022
		Application Number	
Title of Invention	Deep Cleaning Alignment Equipment		

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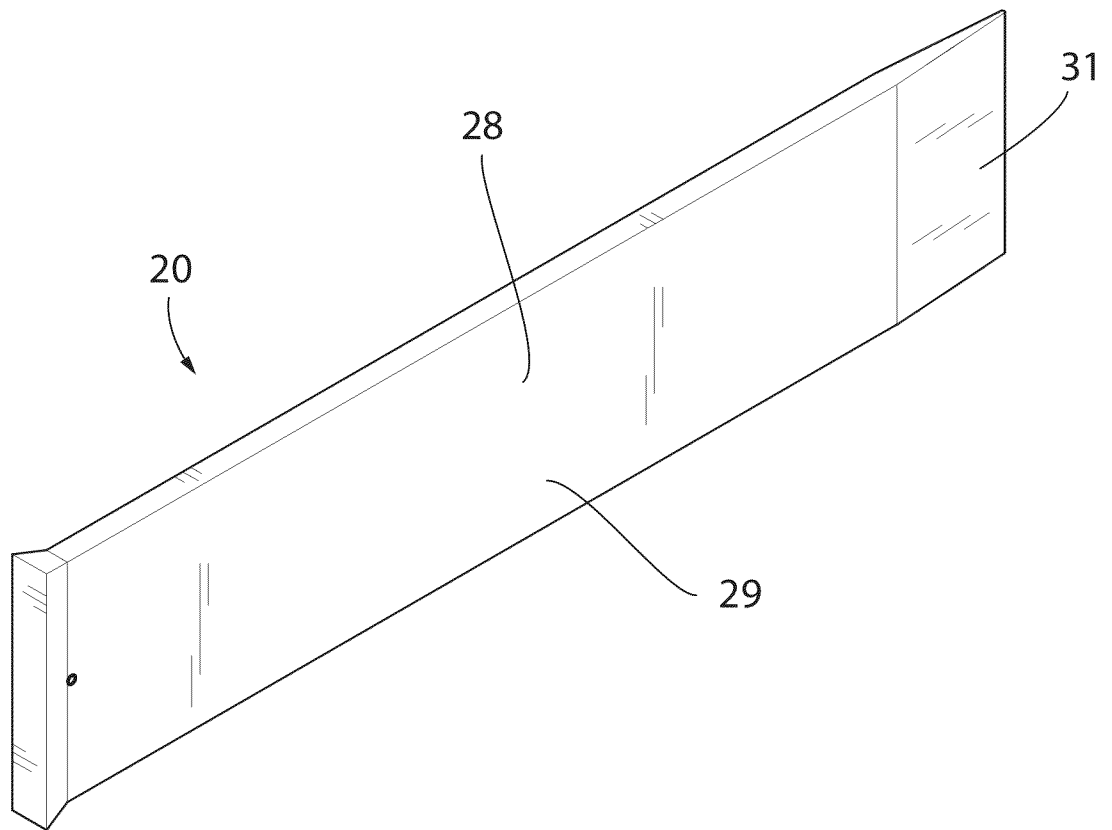


Fig. 1

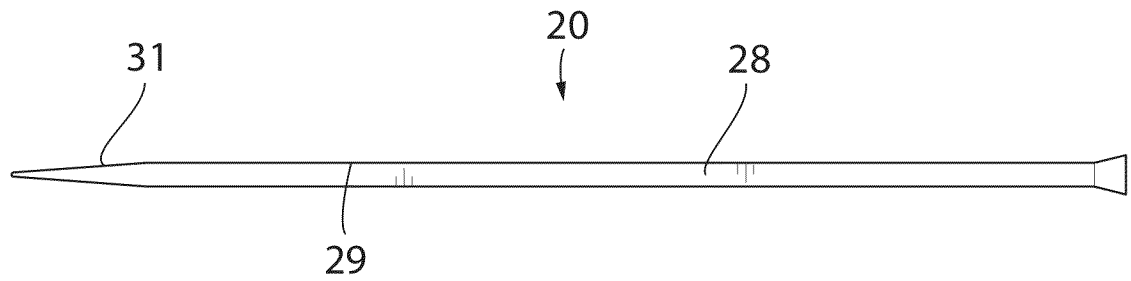


Fig. 2

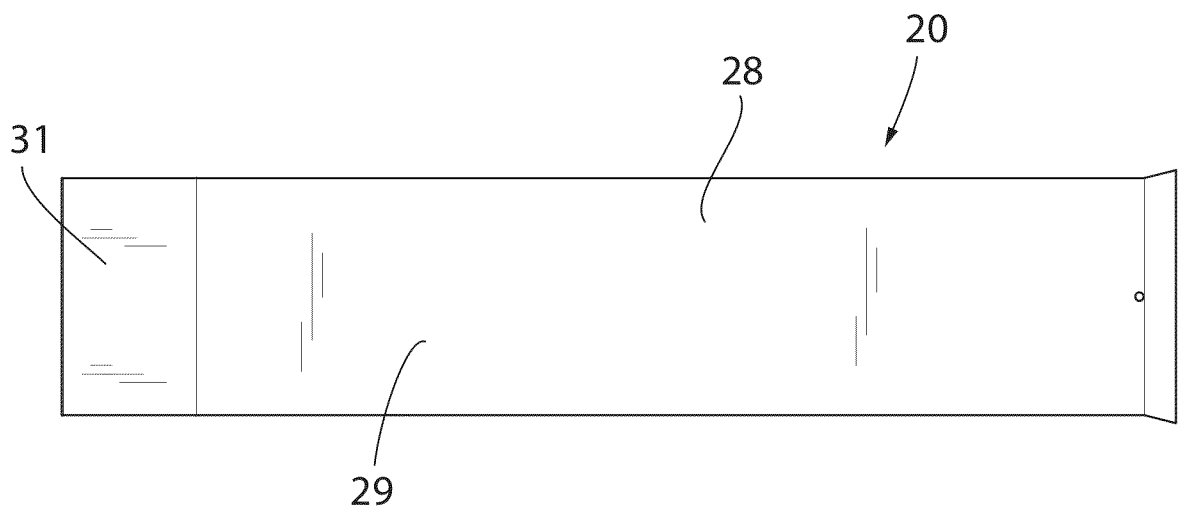


Fig. 3

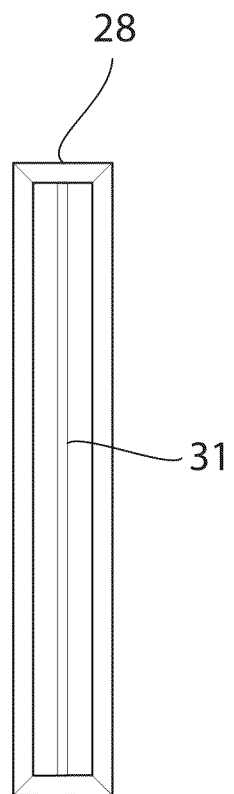


Fig. 4



Fig. 5

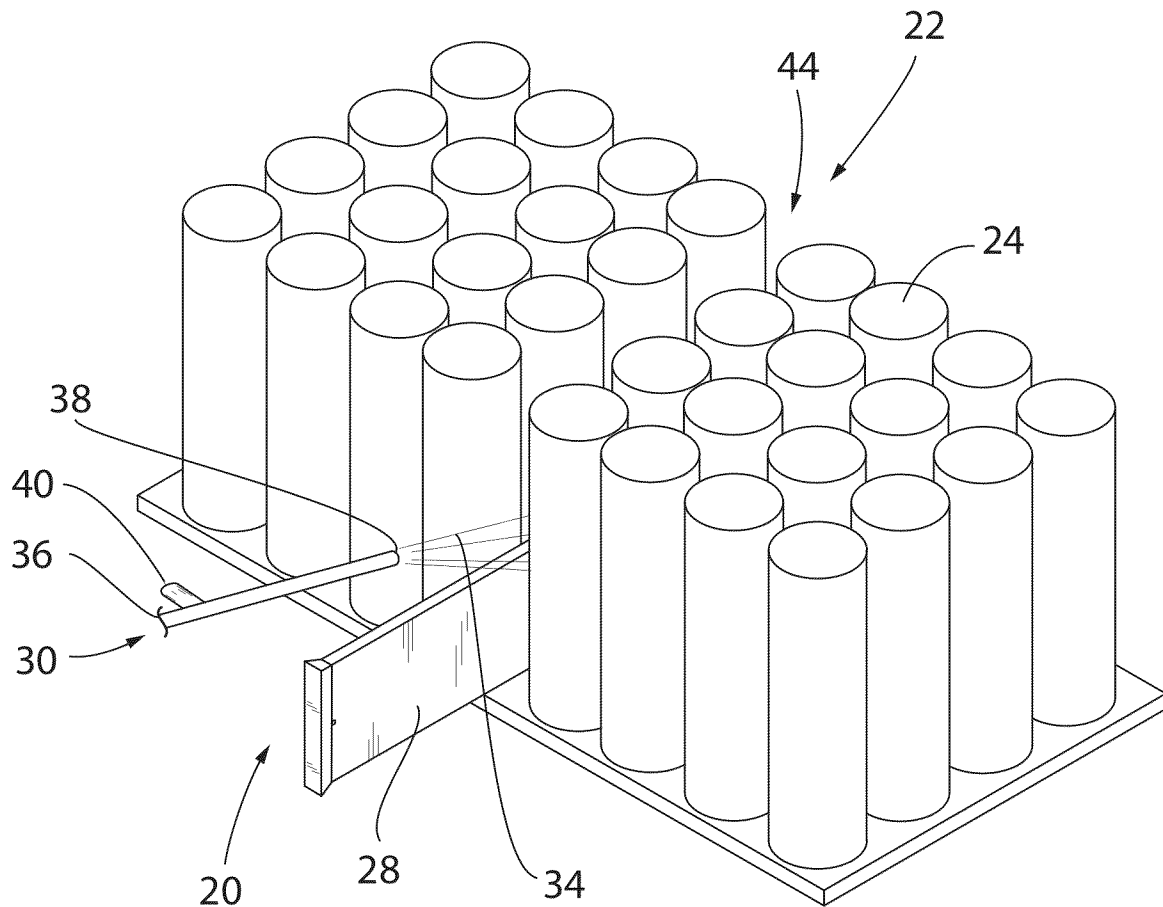


Fig. 6

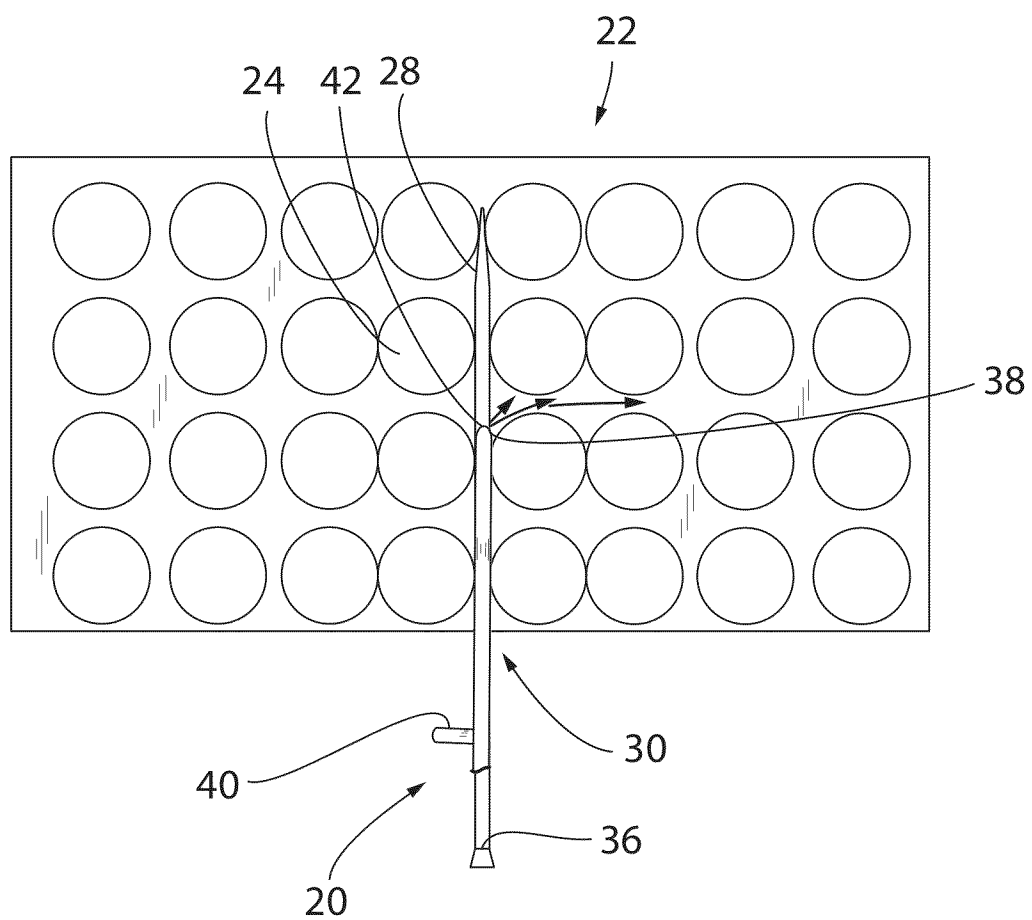


Fig. 7

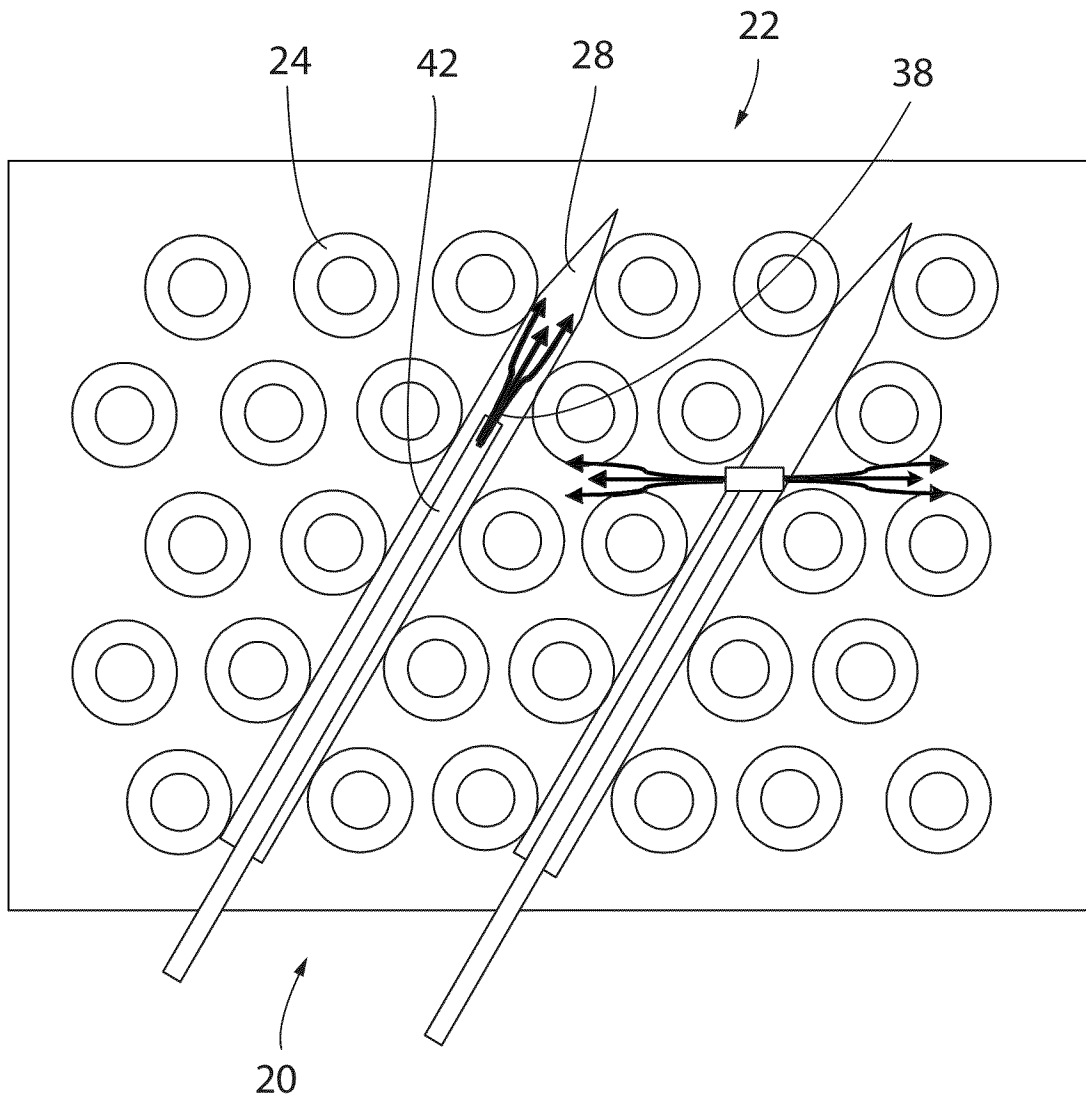


Fig. 8

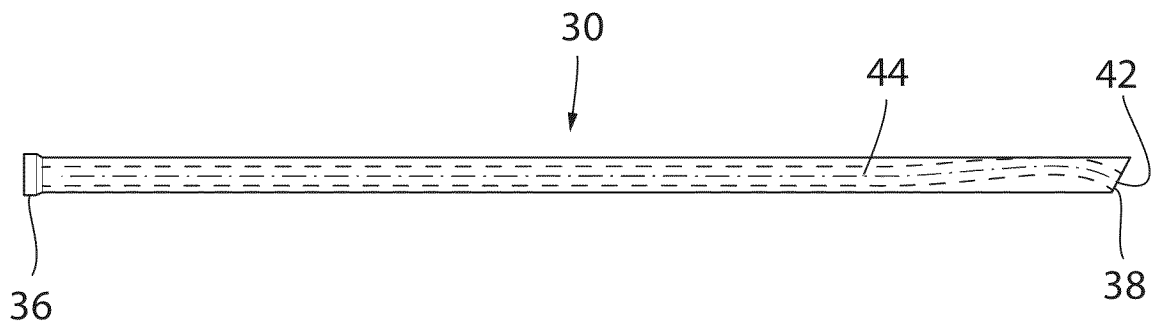


FIG. 9

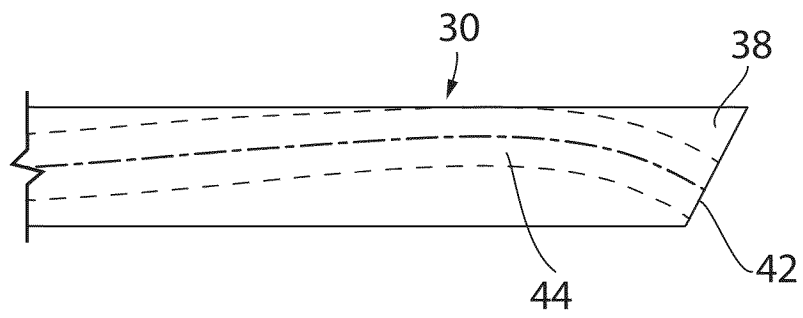


FIG. 10

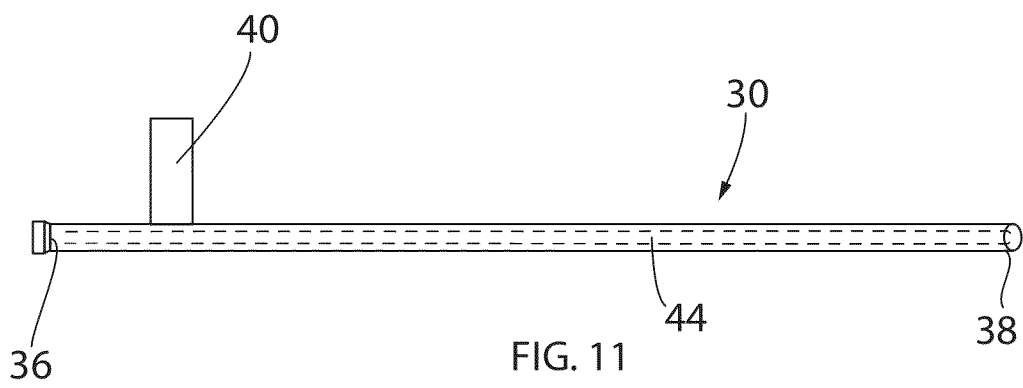


FIG. 11

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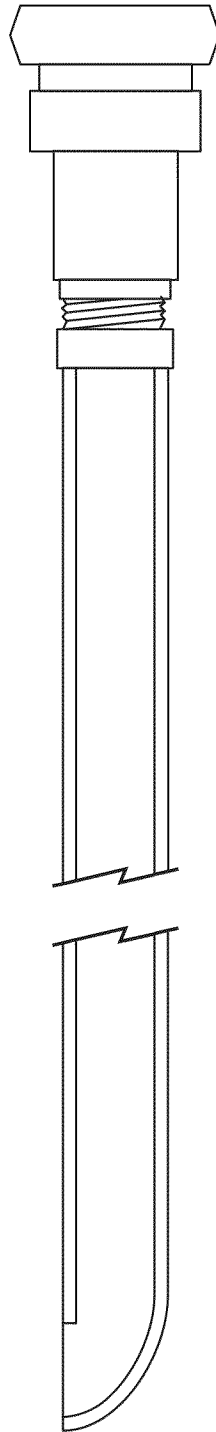


FIG. 12

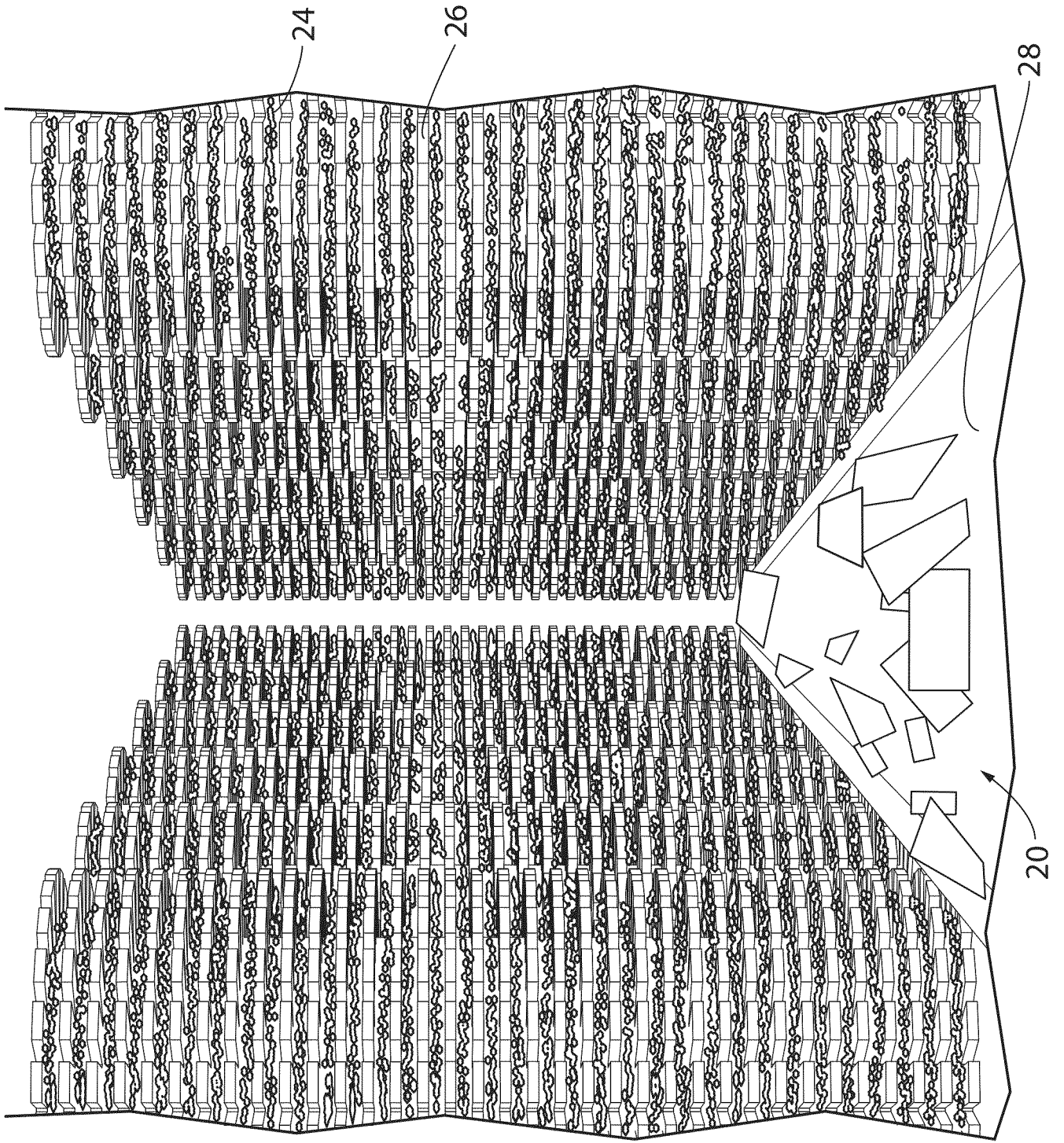


FIG. 13

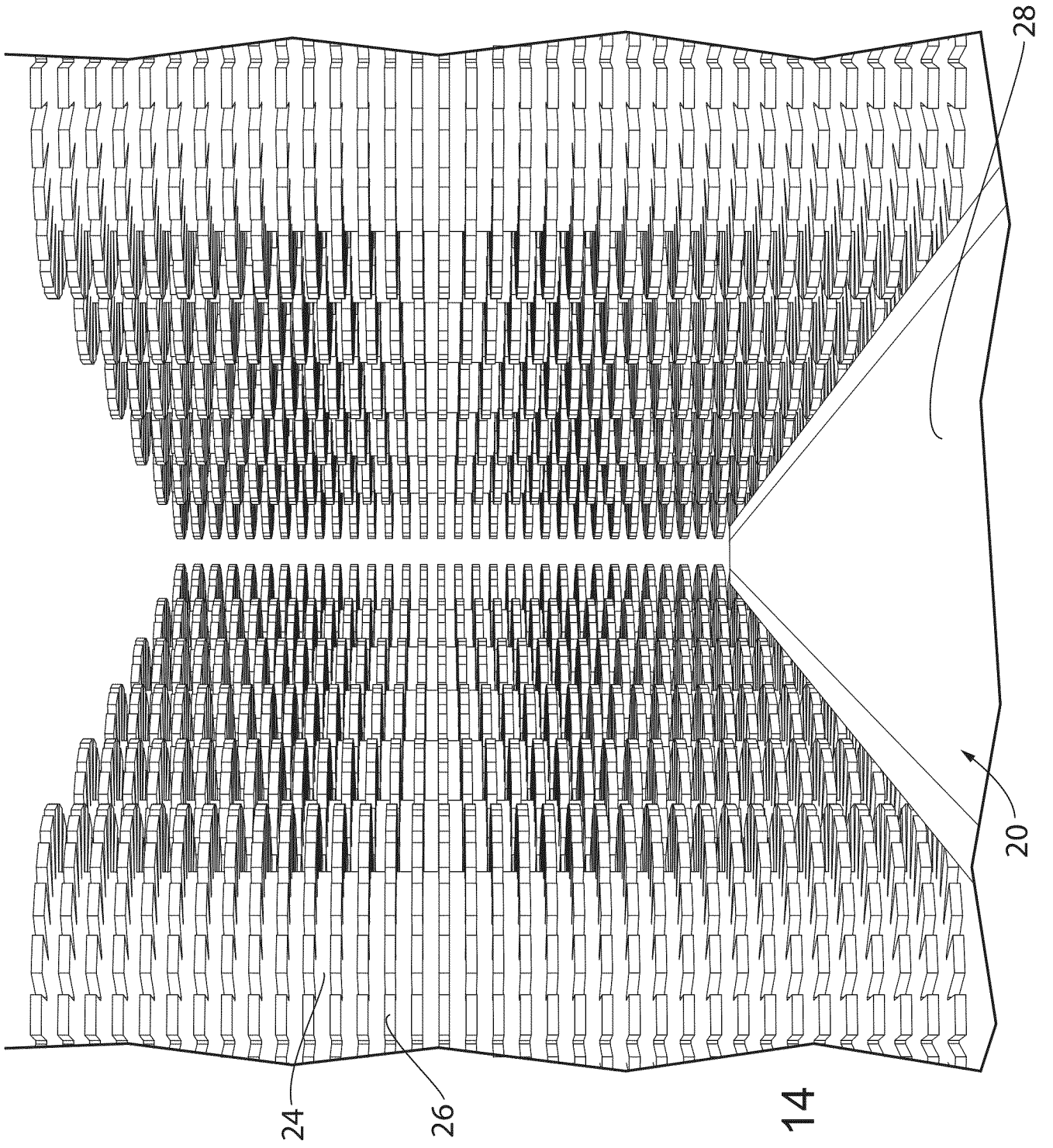


FIG. 14

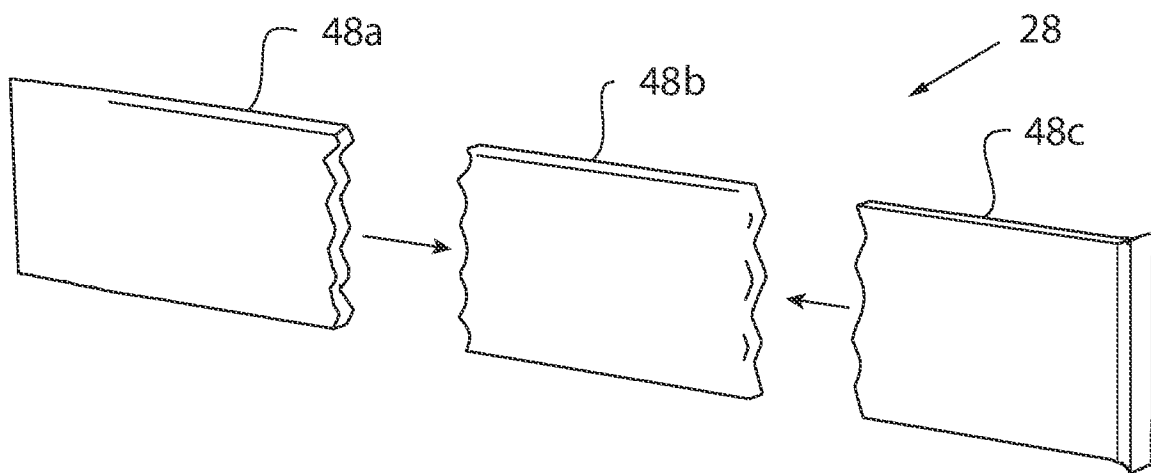


FIG. 15

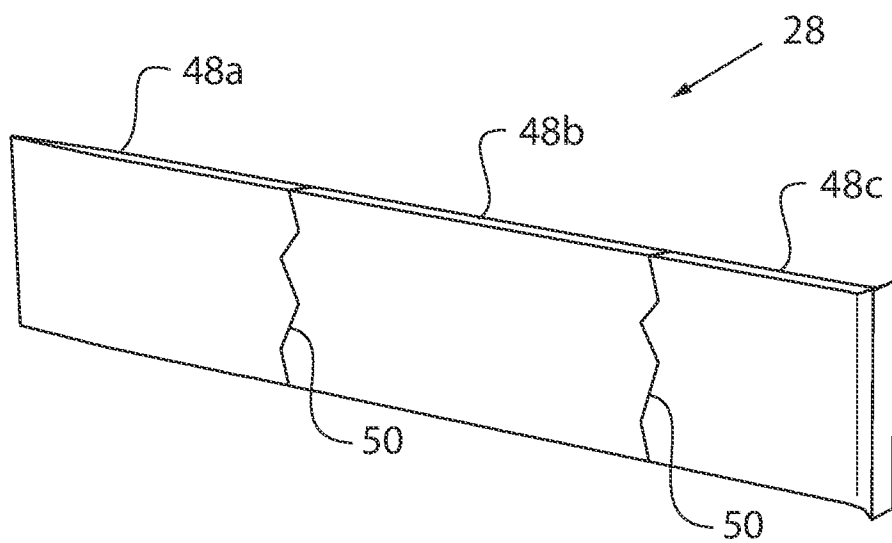


FIG. 16

FIG. 17

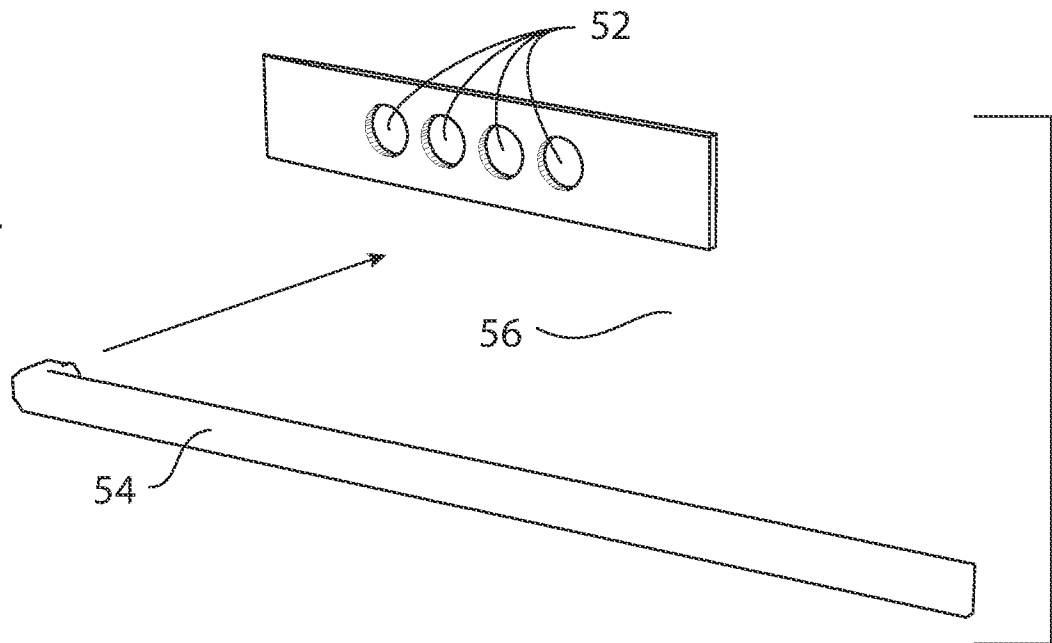


FIG. 18

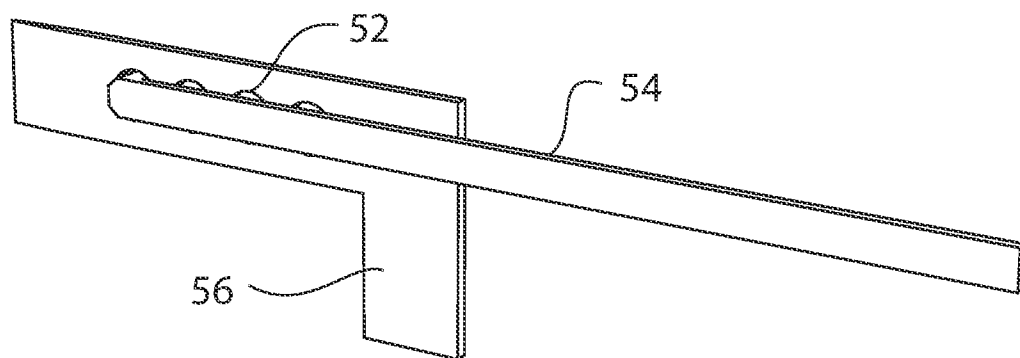
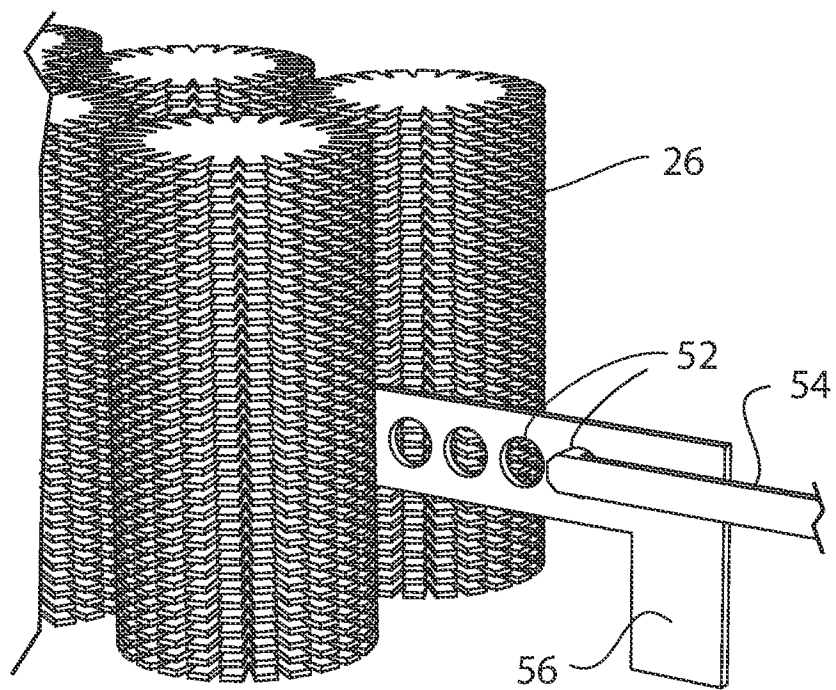


FIG. 19



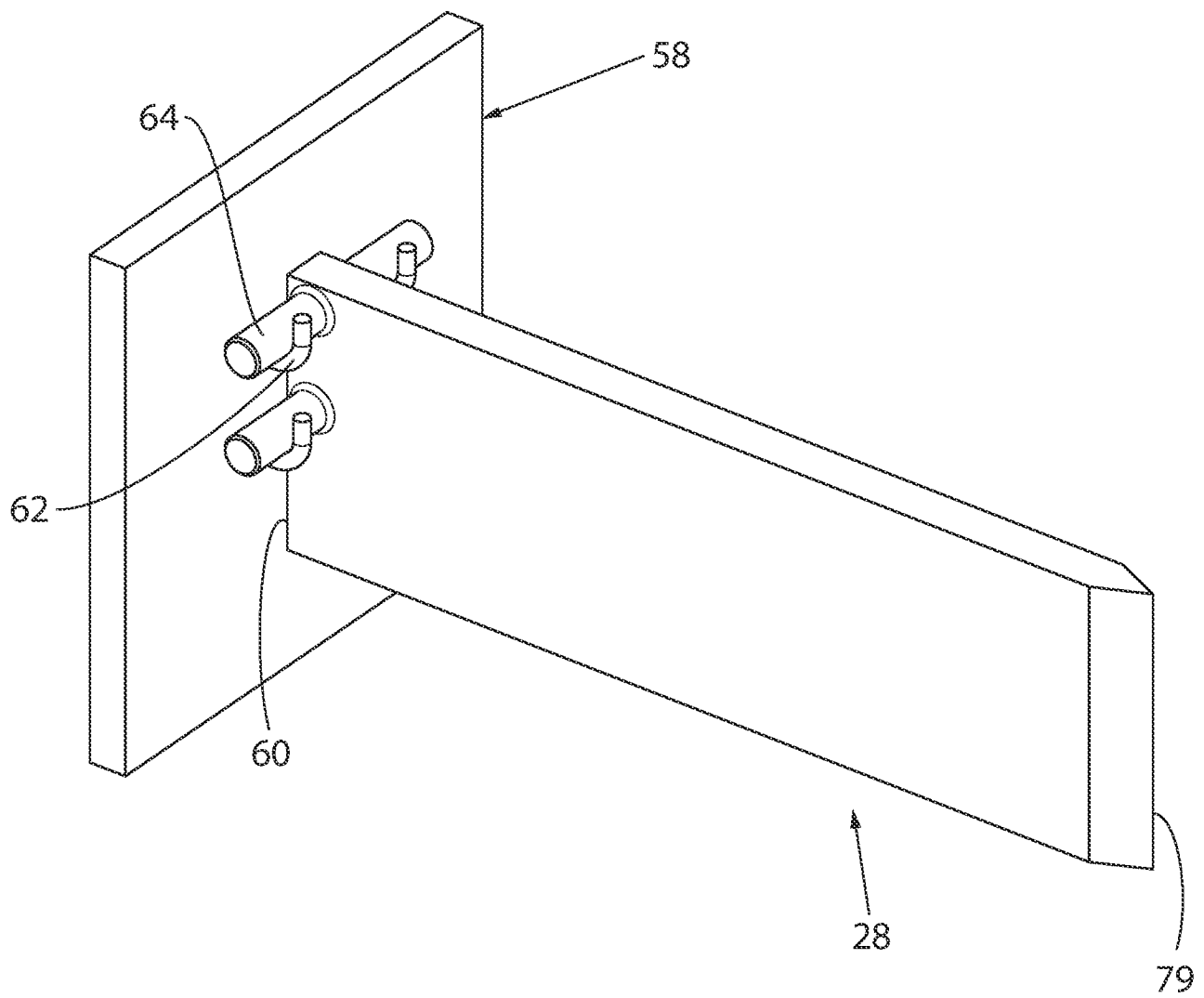


Fig. 20

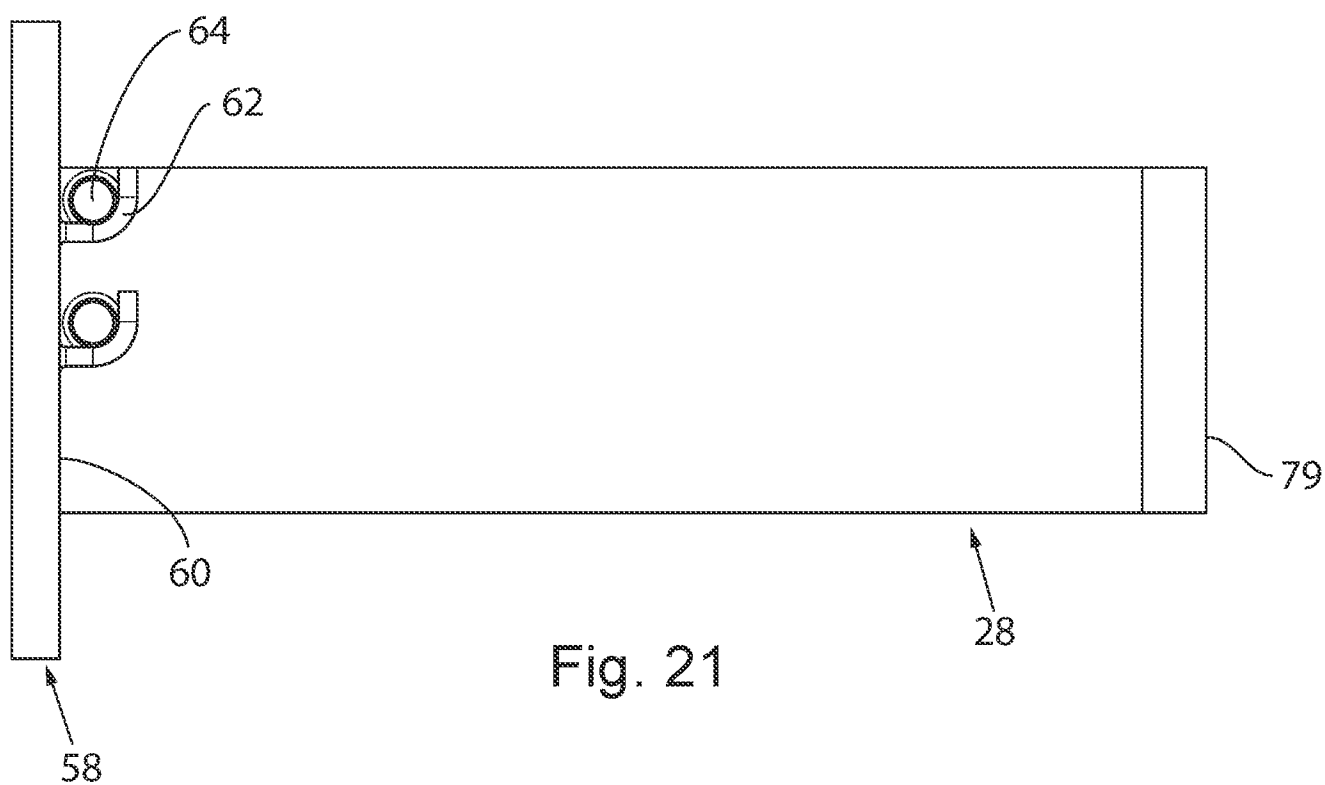


Fig. 21

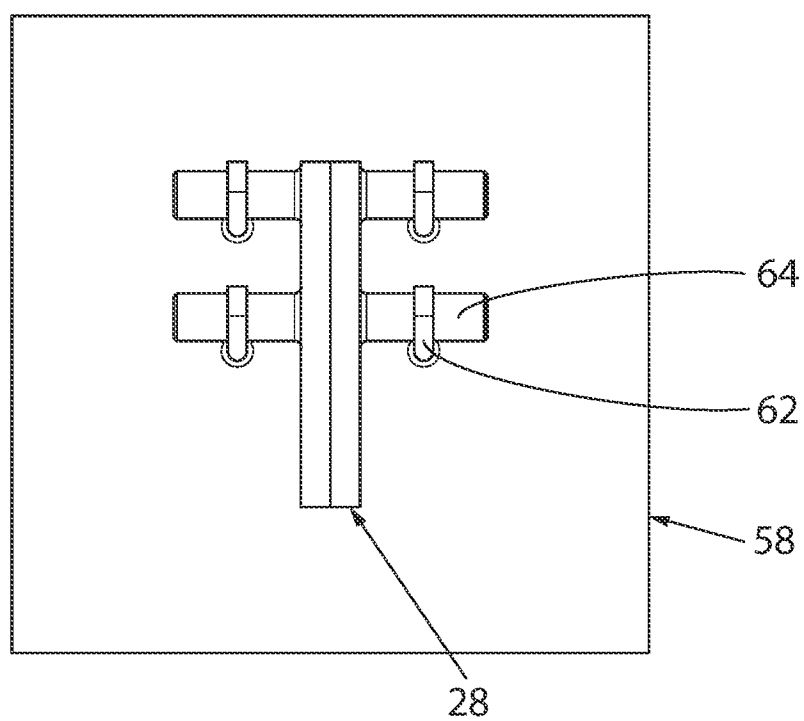


Fig. 22

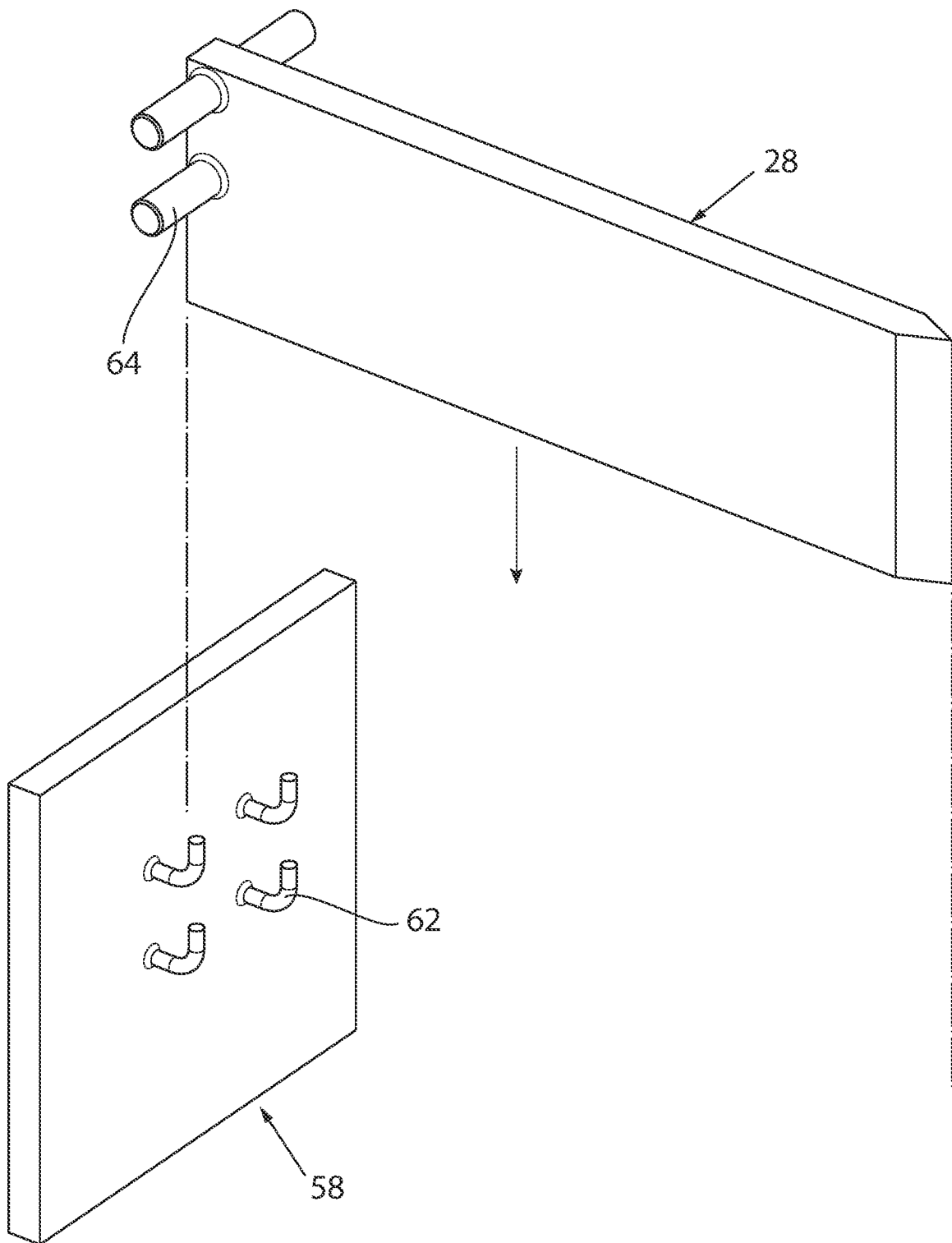


Fig. 23

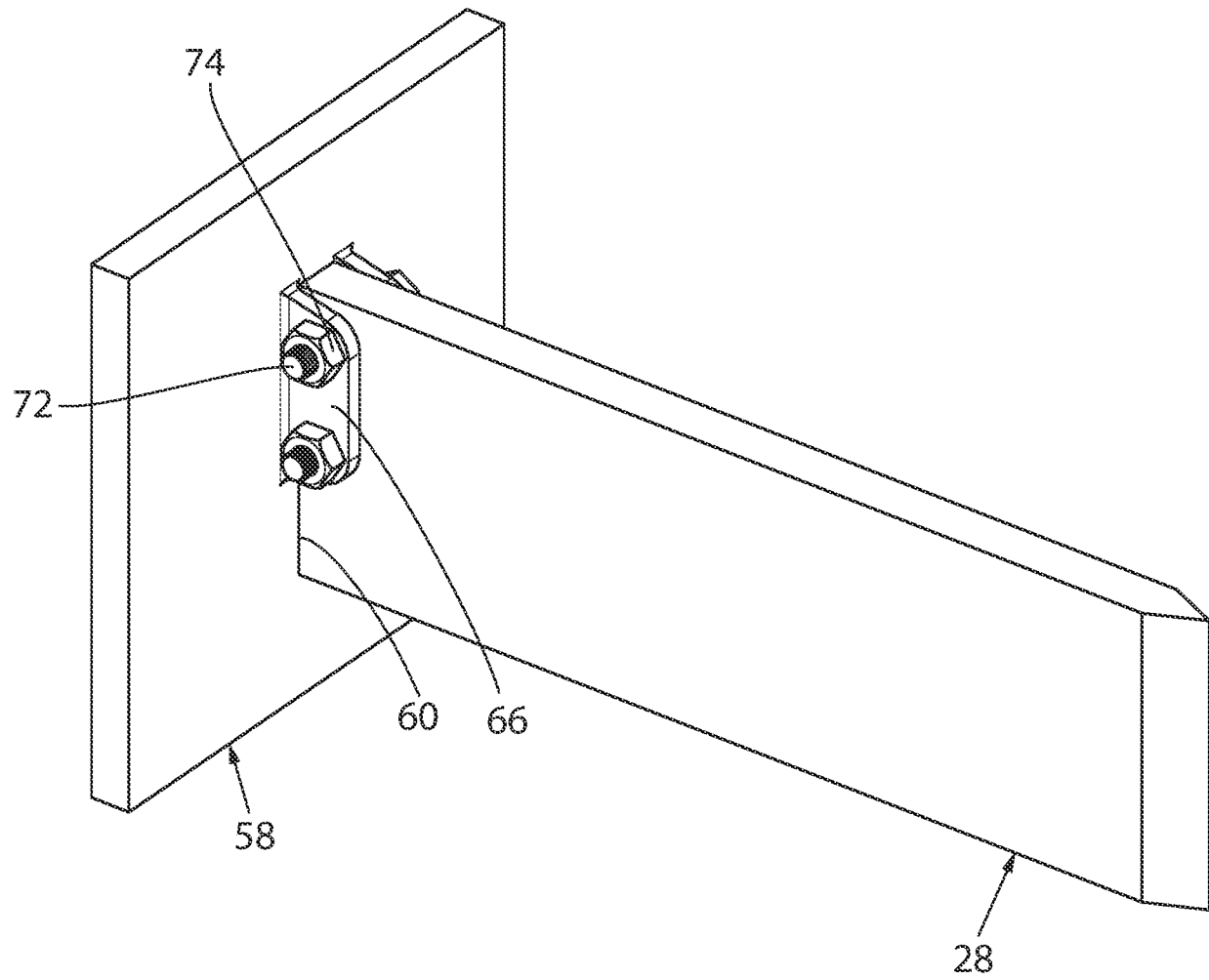


Fig. 24

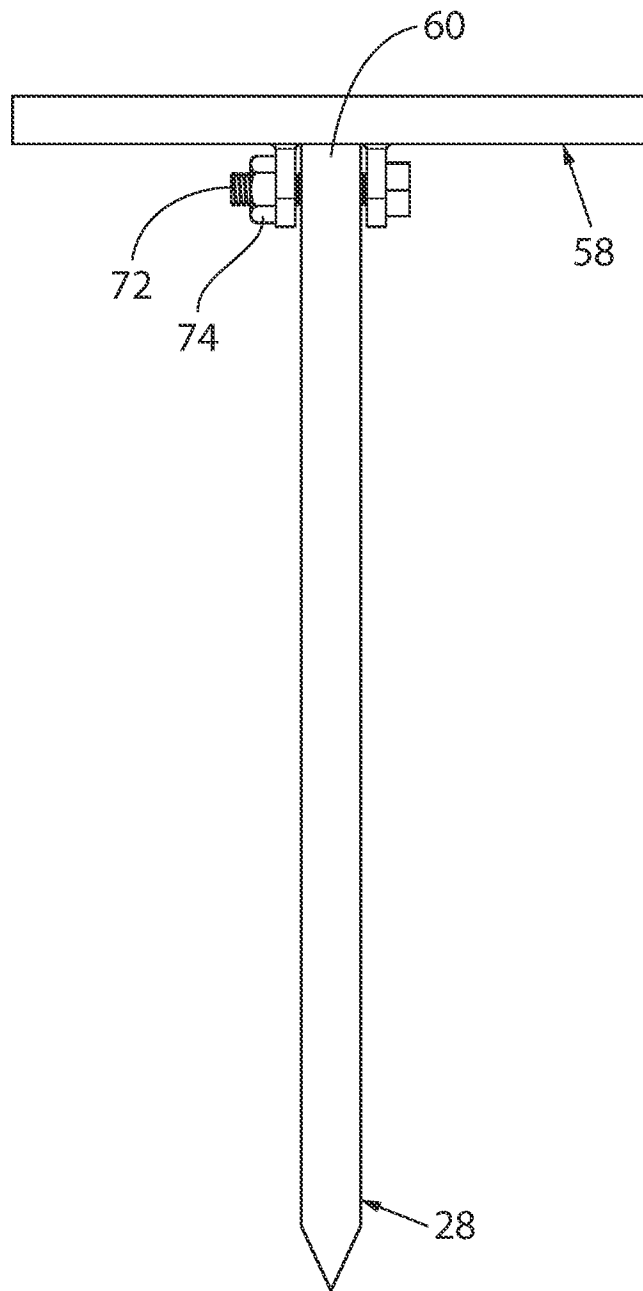


Fig. 25

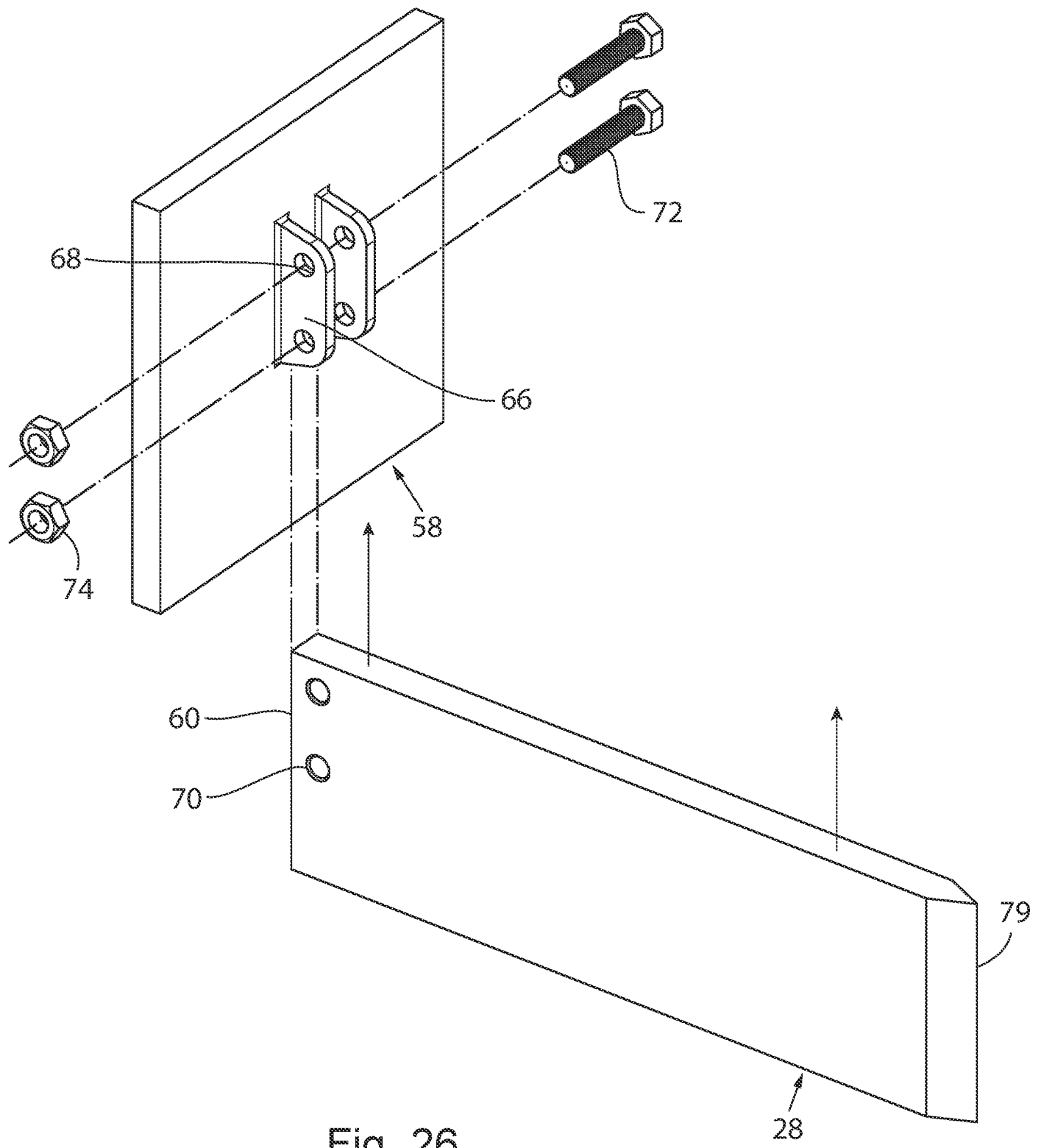


Fig. 26

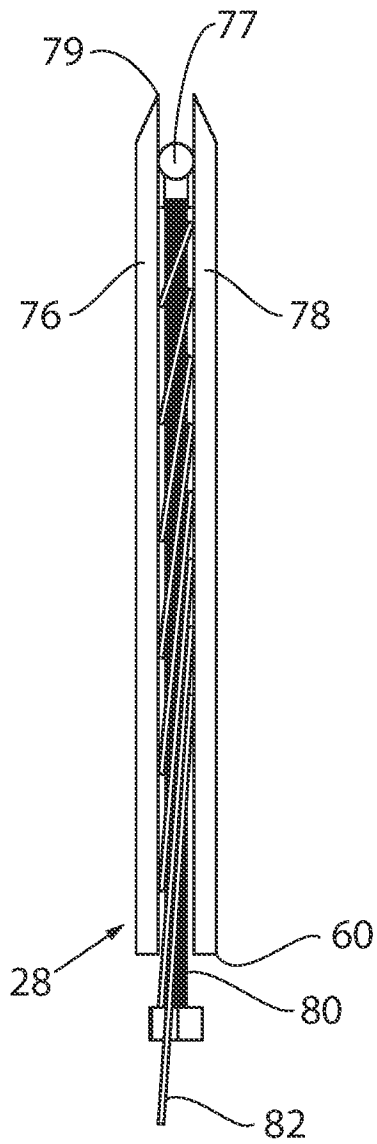


Fig. 27

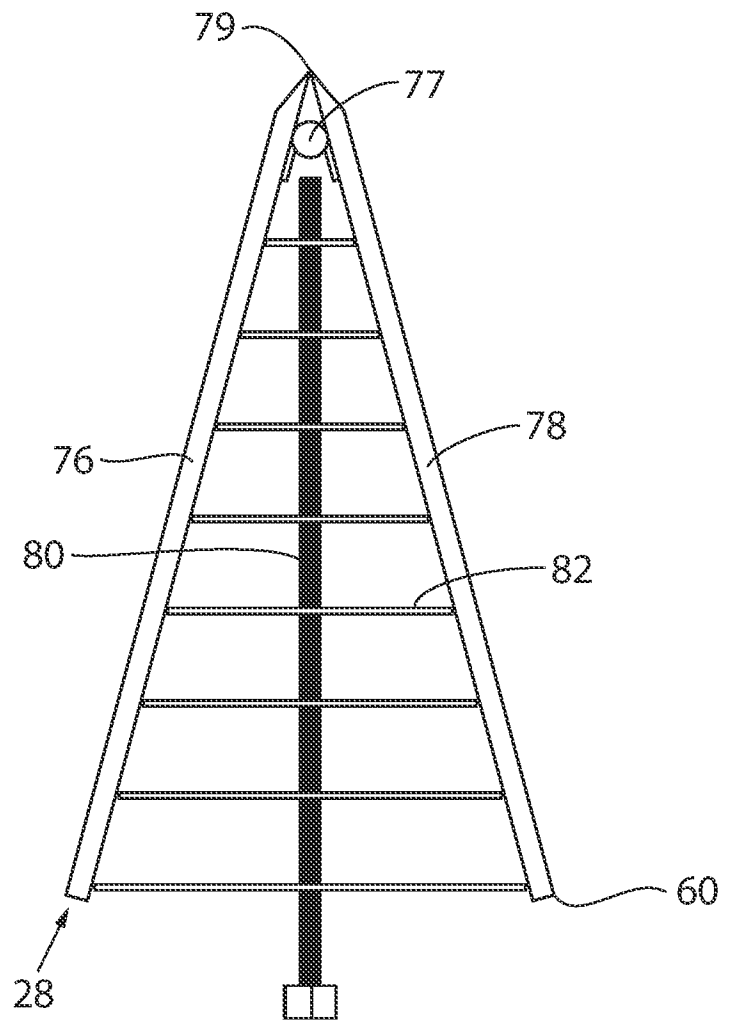
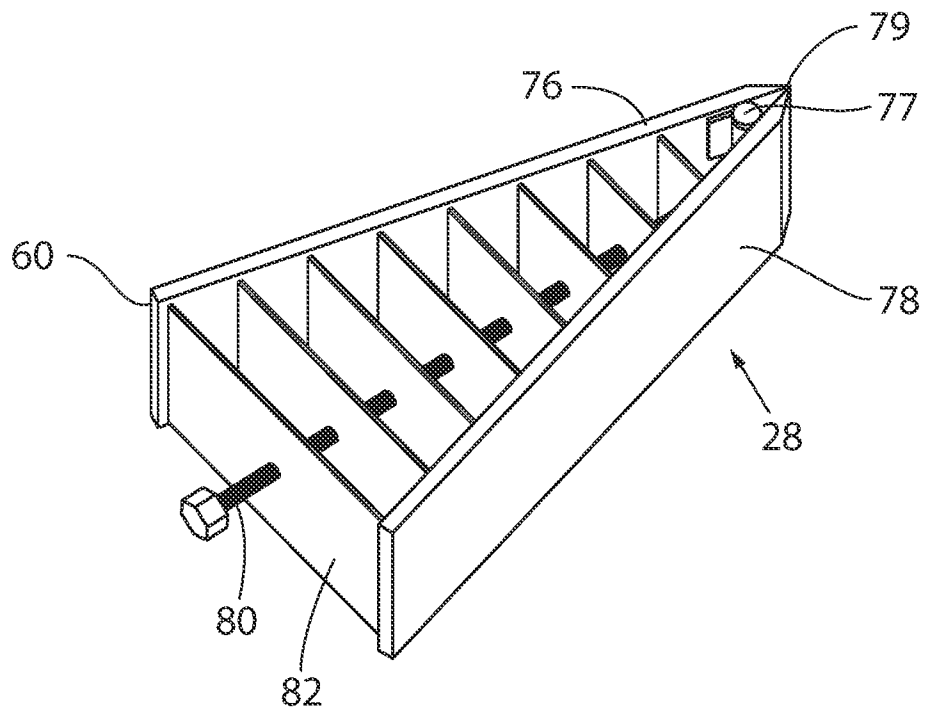
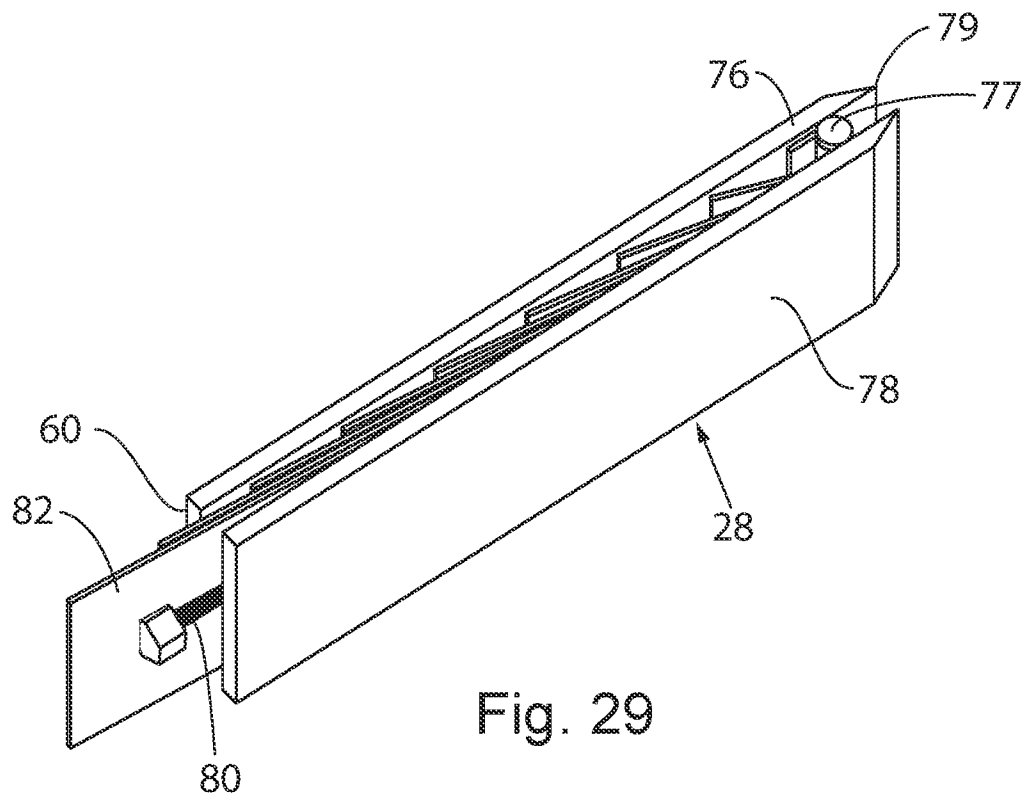
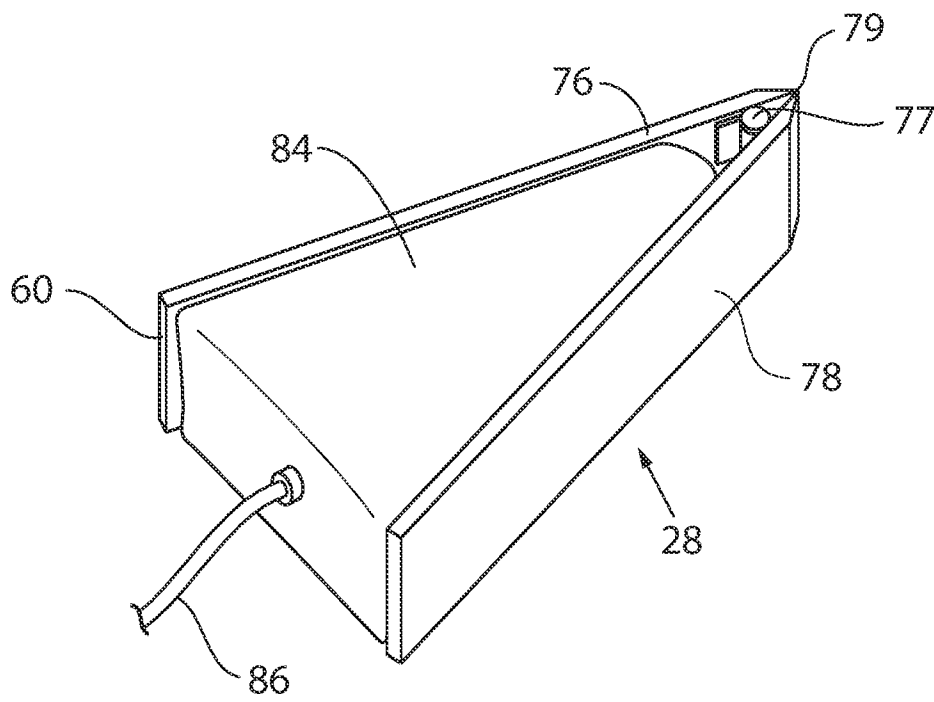
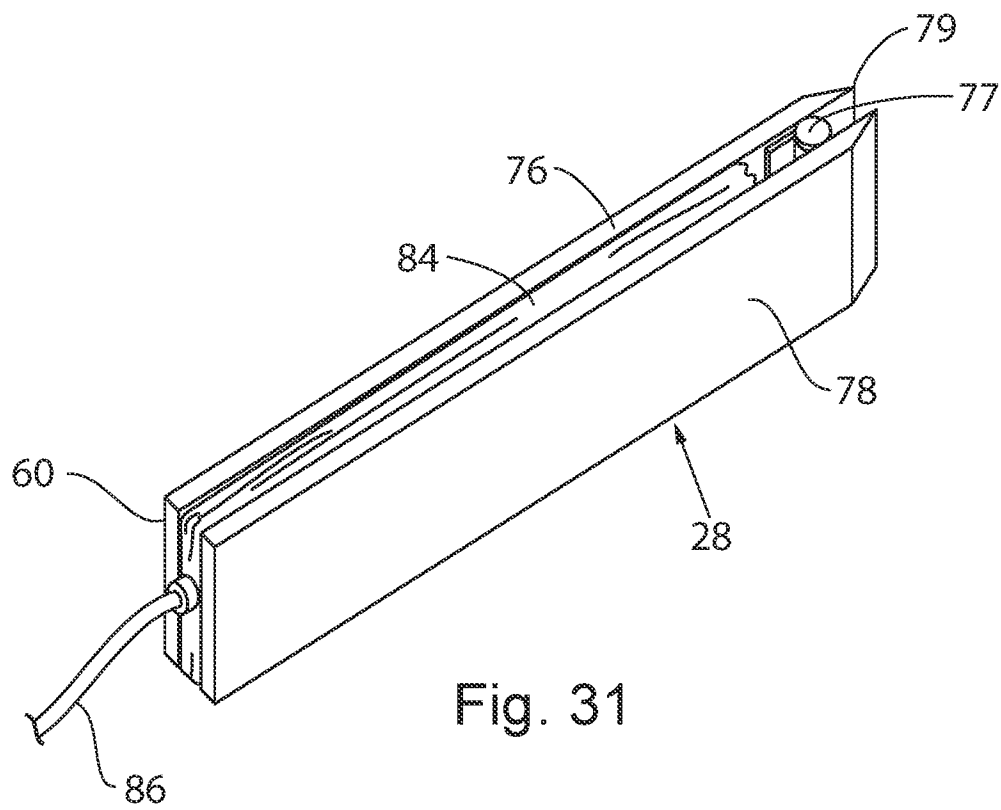


Fig. 28





Non-Provisional U.S. Patent Application

Title: DEEP CLEANING ALIGNMENT EQUIPMENT

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Attorney Docket No.: 33-10022

DEEP CLEANING ALIGNMENT EQUIPMENT
CROSS-REFERENCE(S) TO RELATED APPLICATION(S)

[0001] This present application is a continuation-in-part application that claims priority to U.S. Patent Application Serial No. 17/729,133 filed on April 26, 2022 and entitled *Deep Cleaning Alignment Equipment*, that claims priority to U.S. Patent Application Serial No. 16/204,281 filed on November 29, 2018 and entitled *Deep Cleaning Alignment Equipment*, which issued as U.S. Patent No. 11,313,632 on April 26, 2022, which claims priority on U.S. Provisional Patent Application Serial No. 62/597,179, filed on December 11, 2017 and entitled *Deep Cleaning Alignment Equipment*, the entire contents of both are hereby expressly incorporated by reference into the present application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The invention relates generally to power plants that produce electricity including a heat recovery steam generator (HRSG) with boiler tubes therein and, in particular, to equipment used to improve the ease with which modules housing these boiler tubes can be cleaned.

2. Discussion of the Related Art

[0003] A combined-cycle power plant uses both a gas and a steam turbine together to produce up to 50 percent more electricity from the same fuel than a traditional simple-cycle plant. The waste heat from the gas turbine is routed through a Heat Recovery Steam Generator (HRSG) to the nearby steam turbine, which generates extra power. The boiler tubes within these HRSG's are contained within different sized modules and have varying numbers of tubes within each module. The modules in the HRSG generally consist of some composition of the following modules: Feedwater 1, Feedwater 2, LP Economizer, IP Economizer, HP Economizer, LP Evaporator, IP Evaporator, HP Evaporator, LP

Preheater, IP Preheater, HP Preheater, LP Superheater, IP Superheater, HP Superheater, LP Reheater, IP Reheater, and HP Reheater. When these systems get dirty, the rate of heat transfer can be reduced, which in turn reduces the efficiency of such systems.

[0004] Cleaning inside of the modules can be very difficult. In the past, the methods available were only able to clean the first one to two rows of tubes. By creating an access lane between boiler tubes, enough space can be created between tubes to insert specialized wands that allow all of the boiler tubes in the module to be cleaned. In the past, this space would be created by inserting a metallic pointed wedge-like lance between the tubes. Once the access lane is created, a wand is used to spray a liquid or gas, traditionally air, to clean the tubes and associated components. Oftentimes, these wands are merely configured to spray air directly ahead. As a result, the wand must be inserted into each and every row of tubes in order to clean the entire HRSG.

[0005] Traditionally, such wedge-like bars were made of steel. Similarly, most tubes inside HRSG's are made up of either carbon steel, stainless steel, T22 or T19. Because of the hard material of the wedge, use of these wedges oftentimes presented risk of damage to the tubes or associated fins. Additionally, the wedges are traditionally a pointed lance with a minimal height, which increases the amount of stress caused where the wedge touches the tubes. Furthermore, these wedges are oftentimes heavy and costly to transport. Further still, while air is effective to clean some tube lanes, it can be ineffective to clean hard deposits.

[0006] What is therefore needed is deep cleaning alignment equipment that allows the tubes to be spread to create an access lane that does not damage the tubes or associated fins. What is further needed is a deep cleaning alignment equipment configured to spray various liquids or gases about the tubes and associated fins to clean the HRSG. What is further needed is a cleaning wand capable of

spraying the liquids or gases at a variety of different angles relative to the tube lanes.

SUMMARY AND OBJECTS OF THE INVENTION

[0007] By way of summary, the present invention is directed to a deep cleaning alignment equipment that is used to clean a heat recovery steam generator system and a method associated therewith. The heat recovery steam generator system may include a plurality of metallic tubes. These tubes can be vertically mounted, horizontally mounted, or mounted at various other angles. Each of these tubes may include a base with a plurality of fins extending outwardly from the base.

[0008] In accordance with a first aspect of the invention, the deep cleaning alignment equipment may include an elongate wedge. The elongate wedge includes a width, a length, and a height and may be configured to contact and spread the tubes and fins to form a channel between the tubes. The elongate wedge is configured to contact the tubes and fins about an extended surface area. In turn, this minimizes a stress force between the wedge and the tubes.

[0009] In accordance with another aspect of the invention, the wedge may have a height of at least six inches. The wedge may further have a height of at least eight inches. Further still, the wedge may have a width of at least one half of an inch. Also, the wedge could have a width of one inch. Additionally, the wedge may have a length of at least three-and-a-half feet. Similarly, the wedge may have a length of at least five feet.

[0010] In accordance with a first aspect of the invention, the deep cleaning alignment equipment may include a composite wedge. The composite may be softer than the metallic material of the tubes and associated fins. For instance, the composite could be a high strength carbon nylon. More specifically, the wedge may be made of nylon 12CF. In other embodiments, the wedge may be of a metallic or other hard material. In yet other embodiments, the wedge may

be made of a metallic or other hard material, but covered in a composite or other softer material. The wedge may or may not include a handle for gripping.

[0011] In accordance with another aspect of the invention, the deep cleaning alignment equipment may include a wand. The wand may be configured to spray one of a liquid or a gas about the heat recovery steam generator system. Additionally, the wand may be configured to be removably insertable into the channel formed by the wedge. The wand may have a first end and a second end opposite the first end. At the first end, a handle is mounted to the wand. At a second end, an exit may be formed. For instance, the exit may be configured to spray one of a liquid or a gas at an angle of approximately 30 degrees, 45 degrees, or at other angles relative to the channel.

[0012] In accordance to another aspect of the invention, multiple wands may be provided. More specifically, a first wand may be provided and a second wand may be provided. The first wand may be configured to push debris forward. Additionally, the second wand may be configured to shoot a liquid or a gas. For instance, the second wand may be configured to shoot dry ice. As stated above, either wand may be configured to spray liquid or gas at an angle of approximately 30 degrees, 45 degrees, or any other angle relative to the channel.

[0013] In accordance to another aspect of the invention, a method of using a deep cleaning alignment equipment used to clean a heat recovery steam generator system is described. The method includes the step of inserting an elongate composite wedge having a width, a length, and a height, between the tubes to spread the tubes to form a channel therebetween. The method may also include the steps of inserting a wand into the channel and spraying a liquid or a gas through the wand to clean the tubes and the fins. The method may further include the steps of inserting a first elongate composite wedge having a first width between the tubes, and then inserting a second elongate composite wedge having a second width between the tubes, where the first width is smaller than the second width. Further still, the method may include the step of spraying a

quantity of dry ice through the wand to an exit to clean the tubes and fins, where the exit sprays the quantity of dry ice at an angle of approximately 30 degrees, 45 degrees, or any other angle relative to the channel.

[0014] In accordance with other aspects of the present invention, the various components may be made of a metallic material. In other embodiments, the various components may be made of composite or other materials. In accordance with yet another aspect of the present invention, the wedge may have a handle at an end. In other embodiments, the wedge may not have a handle.

[0015] In accordance with yet another aspect of the present invention, the wedge may be from approximately six inches to approximately nine feet in length, and more preferably between approximately three feet and approximately five feet in length. Additionally, the wedge may have a height of approximately a half of an inch to a height of approximately two feet, and more preferably has a height between approximately two inches and approximately eight inches. Further still, the wedge may have a width of between approximately 1/8th of an inch and approximately four inches, and more preferably between approximately a half of an inch to approximately one and a half inches.

[0016] In accordance with yet another aspect of the present invention, the wedge may have at least one, and more preferably multiple openings formed in the wedge. These openings are configured such that various devices can be inserted into one or more of the openings in order to expedite and simplify the removal of the wedge from the heat recovery steam generator system. For instance, a lever, L bracket, or other device may be inserted into one or more of the openings, in which case the device can be used as a cantilever to help dislodge the wedge from the heat recovery steam generator system. For instance, a user may first use an outermost opening located closest to the end of the wedge that is not inserted into the heat recovery steam generator system. Once the wedge is moved away from the heat recovery steam generator system, the device may be inserted into a second opening that is exposed when the wedge is initially

moved. The device can then move the wedge further from the heat recovery steam generator system. As many openings may be included as needed to incrementally remove the wedge from the heat recovery steam generator system. Additionally, the devices used to engage with the openings and remove the wedge from the heat recovery steam generator system may be a mechanical device where a user uses force to remove the wedge, or a pneumatic device could be used to simplify and expedite the removal of the wedge from the heat recovery steam generator system. These holes or openings may be in any desired size and at any desired spacing, for instance not less than approximately 1/16th between consecutive holes, and not more than approximately three feet between consecutive holes.

[0017] In accordance with yet another aspect of the present invention, the wedge may also be a multi-piece wedge. For instance, the wedge may come in two or more pieces, which could potentially allow for cheaper and/or easier transportation of the wedge from one location to another. By way of example and not limitation, the various pieces of the multi-piece wedge may be secured to one another using threaded openings, interlocking components, jigsaw connections, and the like.

[0018] These, and other aspects and objects of the present invention will be better appreciated and understood when considered in conjunction with the following description and the accompanying drawings. It should be understood, however, that the following description, while indicating preferred embodiments of the present invention, is given by way of illustration and not of limitation. Many changes and modifications may be made within the scope of the present invention without departing from the spirit thereof, and the invention includes all such modifications.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] A clear conception of the advantages and features constituting the present invention, and of the construction and operation of typical mechanisms provided

with the present invention, will become more readily apparent by referring to the exemplary, and therefore non-limiting, embodiments illustrated in the drawings accompanying and forming a part of this specification, wherein like reference numerals designate the same elements in the several views, and in which:

[0020] FIG. 1 illustrates an isometric view of a deep cleaning alignment equipment including a wedge;

[0021] FIG. 2 illustrates a top or bottom plan view of the deep cleaning alignment equipment including the wedge of FIG. 1;

[0022] FIG. 3 is a side elevation view of the deep cleaning alignment equipment including the wedge of FIG. 1;

[0023] FIG. 4 is a front elevation view of the deep cleaning alignment equipment including the elongate wedge of FIG. 1;

[0024] FIG. 5 is a rear elevation view of the deep cleaning alignment equipment including the elongate wedge of FIG. 1;

[0025] FIG. 6 is an isometric view of the deep cleaning alignment equipment of FIG. 1 as the wedge is inserted into a heat recovery steam generator to spread a plurality of tubes to create a channel for a cleaning wand;

[0026] FIG. 7 is a top plan view of the deep cleaning alignment equipment with the wedge spreading the plurality of tubes and the cleaning wand dispensing a cleaning solution to the heat recovery steam generator;

[0027] FIG. 8 is a top plan view of the deep cleaning alignment equipment with the wedge spreading the plurality of tubes and the cleaning wand dispensing a cleaning solution to the heat recovery steam generator where the tubes are in a staggered configuration;

[0028] FIG. 9 is a perspective view of one embodiment of a wand used with the deep cleaning alignment equipment;

[0029] FIG. 10 is a detailed view of an exit of the wand of FIG. 9;

[0030] FIG. 11 is another perspective view of the wand including a handle associated therewith;

[0031] FIG. 12 is a perspective view of one potential nozzle used with the deep cleaning alignment equipment;

[0032] FIG. 13 is a perspective view of the deep cleaning alignment equipment where the wedge has been driven between tubes and fins associated with the heat recovery steam generator before cleaning has commenced;

[0033] FIG. 14 is a perspective view of the deep cleaning alignment equipment where the wedge has been driven between tubes and fins associated with the heat recovery steam generator after cleaning has been completed;

[0034] FIG. 15 is an exploded perspective view of an embodiment of the deep cleaning alignment equipment where the wedge is a multi-piece wedge;

[0035] FIG. 16 is a perspective view of the wedge of FIG. 15 in an assembled view;

[0036] FIG. 17 is a side elevation view of an embodiment of the deep cleaning alignment equipment with a wedge having multiple openings formed therein;

[0037] FIG. 18 is a perspective view of the wedge of FIG. 17 with a removal bracket installed relative to one of the multiple openings;

[0038] FIG. 19 is a perspective view of the wedge of FIGS. 17-18 inserted in a heat recovery steam generator system with the removable bracket inserted therein to remove the wedge from the system;

[0039] FIG. 20 is a perspective view of another embodiment of a wedge in use with a plate;

[0040] FIG. 21 is a side elevation view of the wedge in use with the plate of FIG. 20;

[0041] FIG. 22 is a front elevation view of the wedge in use with the plate of FIGS. 20 and 21;

[0042] FIG. 23 is an exploded view of the wedge and plate of FIGS. 20-22;

[0043] FIG. 24 is a perspective view of another embodiment of a wedge in use with a plate;

[0044] FIG. 25 is a top plan view of the wedge and plate of FIG. 24;

[0045] FIG. 26 is an exploded view of the wedge and plate of FIGS. 24 and 25;

[0046] FIG. 27 is a top plan view of another embodiment of a wedge that is expandable and collapsible in a first configuration;

[0047] FIG. 28 is a top plan view of the wedge of FIG. 27 in a second configuration;

[0048] FIG. 29 is a perspective view of the wedge of FIGS. 27 and 28 in the first configuration;

[0049] FIG. 30 is a perspective view of the wedge of FIGS. 27-29 in the second configuration;

[0050] FIG. 31 is a perspective view of another embodiment of a wedge that is expandable and collapsible in a first configuration; and

[0051] FIG. 32 is a perspective view of the wedge of FIG. 31 in a second configuration;

[0052] In describing the preferred embodiment of the invention which is illustrated in the drawings, specific terminology will be resorted to for the sake of clarity. However, it is not intended that the invention be limited to the specific terms so selected and it is to be understood that each specific term includes all technical equivalents which operate in a similar manner to accomplish a similar purpose. For example, the word connected, attached, or terms similar thereto are often used. They are not limited to direct connection but include connection through other elements where such connection is recognized as being equivalent by those skilled in the art.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0053] The present invention and the various features and advantageous details thereof are explained more fully with reference to the non-limiting embodiments described in detail in the following description.

[0054] A deep cleaning alignment equipment 20 and system for cleaning heat recovery steam generator systems 22 or other types of heat exchangers and associated tubes 24 is generally shown in the figures. While the equipment 20 will be described with relation to a heat recovery steam generator system 22, it should be noted that the equipment 20 could similarly be used in many other

instances where the exterior of various tubes needs to be spread apart for cleaning purposes, such as in other heating, ventilation, and air conditioning applications. As seen in FIGS. 6 and 7, the tubes 24 may be configured to align with one another in an “in line” configuration. Alternatively, as shown in FIG. 8, the tubes 24 may be staggered relative to one another. Of course, other tube 24 configurations could similarly be used.

[0055] The deep cleaning alignment equipment 20 is specifically designed to maximize the efficiency with which the heat recovery steam generator system 22 is cleaned. The heat recovery steam generator system 22 includes a plurality of tubes 24. As shown, these tubes 24 extend vertically about the system 22. However, the tubes 24 could similarly be horizontally mounted, or mounted at other angles as desired. Typically, these tubes 24 are made of steel, although they could similarly be made of other materials. While the figures merely show exemplary cylindrical tubes 24, it should be noted that the tubes 24 may include a plurality of fins 26 that extend outwardly from the tubes 24, as seen in FIGS. 12 and 13. While these fins are 26 not shown in all of the figures, it should be noted that the deep cleaning alignment equipment 20 is configured to be similarly compatible with any fins 26 or tubes 24 associated with a heat recovery steam generator system 22.

[0056] The deep cleaning alignment equipment 20 may include a wedge/alignment bar 28 and at least one wand 30, both of which will further be described below. The wedge 28 is configured to encourage outward movement of the various tubes 24 in order to create a channel 32 between the tubes 24. Once the channel 32 is formed, the at least one wand 30 is used to clean any materials located about the tubes 24. The wedge 28 may have a handle 56 to provide something a user can easily grasp to enhance use and movement of the wedge 28. However, the wedge 28 does not require the inclusion of a handle.

[0057] Next, the wedge/alignment bar 28 as shown in FIGS. 1-5 will be further described. Among other features, the wedge 28 preferably is elongate in shape,

with an extended body 29 coming to a pointed end 31. As such, the wedge 28 could come in a number of different sizes. For instance, a wedge 28 that is longer and taller than other wedges traditionally used in this field could be used. As a result, when the wedge 28 is used, the surface area of the wedge 28 that contacts the tubes 24 can be increased. In turn, this decreases the amount of stress between the wedge 28 and the steel tube 24 about any specific point. This wedge 28 would be approximately eight inches deep in order to spread out the stress point on the about the wedge 28 and the tubes 24. This would also allow for a greater opening along the length of the tubes 24 which would allow better access for the cleaning wands 30. The width and the length of the wedge 28 would vary depending on the type of HRSG 22, width of module, type of arrangement, tube spacing specific to the module being cleaned, and any other factors that would impact the functionality of the deep cleaning alignment equipment 20.

[0058] A few embodiments will now be described, although it should be noted that these are exemplary, such that many other potential dimensioned wedges 28 could similarly be used. In a first embodiment, the wedge 28 could be between three-and-a-half and five feet in length. In this embodiment the wedge 28 could be between approximately one-half inch and one inch in width. The specific size could vary based on the size of the module. For instance, where a boiler module contains twelve rows of tubes 24, a three-and-a-half-foot wedge 28 would be used. For any modules having over twelve rows of tubes 24, the longer five-foot wedge 28 could be used. Where the tubes 24 are located in close proximation to one another, the skinnier one-half inch wide wedge 28 would initially be used. After the one-half inch wedge 28 is inserted, a one-inch wide wedge can be inserted to further space the tubes 24. Alternatively, tubes 24 with a greater initial distance from one another could simply be separated using the one-inch wide wedge 28.

[0059] According to another embodiment, the wedge 28 could be between two and six feet in length. In this embodiment the wedge 28 could be between approximately one-half inch and one-and-a-half inch in width. The wedge 28 could further be between one inch in height and eight inches in height.

[0060] In yet another embodiment, the wedge 28 could be between a quarter inch to two inches wide. Additionally, the wedge 28 could be between a half an inch and two inches wide. Also, the length of the wedge 28 could vary, for instance, between a foot long and ten feet long. Furthermore, the height of the wedge 28 could vary, between a half inch high and twelve inches high, and more preferably between one inch high and eight inches high.

[0061] In yet another embodiment, the wedge 28 may be from approximately six inches to approximately nine feet in length, and more preferably between approximately three feet and approximately five feet in length. Additionally, the wedge 28 may have a height of approximately a half of an inch to a height of approximately two feet, and more preferably has a height between approximately two inches and approximately eight inches. Further still, the wedge 28 may have a width of between approximately $1/8^{\text{th}}$ of an inch and approximately four inches, and more preferably between approximately a half of an inch to approximately one and a half inches.

[0062] Another feature of the wedge 28 is that the wedge 28 may be made of a composite component. This composite component is preferably made up of material that is softer than the steel tubes 24 and fins 26. As a result, when the wedge 28 is inserted into the HRSG 22 and comes into contact with the tubes 24 and/or fins 26, any abrasion from sliding the wedge 28 in would be absorbed by the composite wedge 28 instead of the tubes 24 or fins 26. For instance, the wedge 28 could be made of a high strength carbon fiber nylon. In one embodiment, the wedge 28 is made of nylon 12CF. Nylon 12CF is a lightweight yet durable carbon-fiber reinforced thermoplastic. Thus, the wedge 28 is easily transportable due to its weight, but still durable enough to be used with deep

cleaning alignment equipment 20. Alternatively, the wedge 28 could be made of any other material that is softer than the tubes 24 and fins 26 associated with the tubes 24, which are typically made of steel, for instance, various plastics, composites, and nylon materials. Of course, the wedge 28 could be configured such that it is both elongate and made of the composite component to minimize potential damage to the tubes 24 and fins 26.

[0063] Additionally, the deep cleaning alignment equipment 20 may feature at least one cleaning wand 30, as shown in detail in FIGS. 9-11. The cleaning wand 30 is configured to spray a cleaning solution 34 of liquid or gas about the HRSG 22. More specifically, the cleaning wand 30 may be configured to spray dry ice. This could include high density dry ice (CO₂) pellets. These pellets will be propelled with ultra-high pressure air ranging from 200 – 350 psi. This would be advantageous as it would allow for cleaning of the HRSG 22 with the dry ice eventually evaporating. Of course, other types of media blasting could similarly occur. For instance, the cleaning wand 30 could similarly be configured to spray other liquids or gas, including air, water, cleaning solution, and any other material capable of cleaning the tubes 24 and fins 26.

[0064] As shown, the cleaning wand 30 may have a first end 36 a second end 38. At the first end 36, the cleaning wand 30 may include a handle 40 to allow a user to firmly hold onto the cleaning wand 30 during use. At the second end 38, an exit 42 is formed. A supply channel 44 extends through the wand 30 to deliver the liquid or gas to the exit 42. The exit 42 may direct liquid or gas straight out of the wand 30. Alternatively, the exit 42 may direct liquid or gas out of the wand 30 at various angles. More specifically, FIGS. 7, 9, and 10 show a wand 30 capable of spraying liquid or gas out of the exit at an angle of approximately 45 degrees relative to the wand 30, although the wand 30 could similarly be configured to exit at an angle of approximately 30 degrees or any other desired angle. The wand 30 could also be capable of front blowing and side blowing to clean the tubes 24 and fins 26. Of course, the wands 30 could similarly blow

liquid or gas at any other angle as desired. Additional wands 30 may also be used, such as a first wand to blow air to remove an initial layer of debris, and a second wand to shoot liquid or gas into the HRSG 22. Further still, the wand 30 may have any number of different nozzle assemblies 46 to vary the way the liquid or gas is distributed from the wand 30. For instance, FIG. 12 shows one potential nozzle 46 configuration.

[0065] Furthermore, the wands 30 may be made of steel or composite materials. The use of composite materials could be desired for the same reasons as with the composite wedge 28 to reduce potential damage to the tubes 24 or fins 26 when the wands 30 are quickly and rapidly moved about the tube 24 and fins 26. The wands 30 will be moved up and down the wedged channel 32 in order to clean the tubes 24 from all directions. Cleaning may take place from each side of the module (both upstream and downstream faces) with an overlap of the wedges 28 from each side.

[0066] Operating of the deep cleaning alignment equipment 20 will now be described. Initially, the wedge 28 will be inserted between two adjacent rows of tubes 24. In doing so, the adjacent rows of tubes 24 will be separated apart from one another to form a channel 32. Where the adjacent rows of tubes 24 are narrowly placed relative to one another, multiple wedges 28 may be used. For instance, a first wedge having a narrow width could be used to initially separate the tubes 24, after which a second wedge having a wider width to further separate out the tubes 24 to create a channel 32 through which the wand or wands 30 can be inserted. Once the channel 32 is formed, the wand or wands 30 can be removably inserted into the channel 32 to facilitate cleaning about the HRSG 22.

[0067] Additional features of the system will now be described. Turning initially to FIGS. 15 and 16, the elongate wedge 28 may be a multi-piece elongate wedge 28. These figures show an exemplary multi-piece elongate wedge, but other multi-piece wedges having different proportions could similarly be used. More specifically, the wedge 28 may comprise one or more pieces 48 that can be

releasably connected to one another using a variety of connector interfaces 50. Such a wedge 28 is desirable because it makes it easier, cheaper, more efficient, etc. to ship the wedge 28 from one location to another. As shown, the wedge 28 has three sections 48a, 48b, 48c that can be releasably connected to one another. The various pieces/sections 48 may be releasably connected using any number of different connector interfaces 50. By way of example and not limitation, the connection interface 50 may be a threaded opening, such that adjacent pieces 48 may be rotated relative to one another so that the threaded section engages. In another embodiment, the connection interface 50 may be an interlocking section, with portion of adjacent pieces 48 interlocking with one another at the connection interface. Further still, the connection interface 50 may have a jigsaw or other connection. Regardless of what connection interface 50 is used, the connection interface 50 allows the various pieces 48 to quick and easily be releasably secured to one another with sufficient connection to operate as a wedge as described herein, after which the pieces 48 can be disengaged from one another.

[0068] Turning next to FIGS. 17-19 show another feature associated with the wedge 28. Again, the embodiment shown in these figures are not made to scale, but are shown with exaggerated dimensions, sizes, and proportions in order to demonstrate the underlying features. More specifically, the embodiment shown in these figures are to a wedge that has at least one, and as shown a plurality of holes or openings 52 formed in the side of wedge 28. Various devices, such as brackets, l-brackets, removal brackets, clips, bars, or any other device 54 capable of being inserted into the openings 52 can be used to engage with the wedge 28 in order to facilitate removal of the wedge 28. As known to those in the art, once the wedge 28 is installed, it can be difficult to remove the wedge 28 from a lane of a heat recovery steam generator system or other system. These holes or openings 52 help to facilitate this removal. As shown in FIG. 19, the wedge 28 is installed into a heat recovery steam generator system, with an opening 52 exposed directly next to the handle 56. Again, the wedge 28 does not require a

handle, but for the purposes of description of the location of the opening 52 the handle 56 is used as a point of reference to indicate the end of the wedge 28 that is not inserted into the system. When a user desires to remove the wedge 28 from the system, the device 54 is inserted into the first opening 52. Thereafter, the device 54 is either manually grasped by a user and used as a cantilever, or otherwise connected to another device such as a pneumatic device. The user or pneumatic or other device pull the device 54 away from the system, and in turn pull the wedge 28 at least partially away from the system. When the wedge 28 is securely lodged in the system, it may only incrementally move out of the system. Once a second opening 52 is exposed, the device 54 can be inserted in the second opening 52, after which the process may be repeated. The wedge 28 may include as many openings as desired to facilitate incremental removal of the wedge 28 from the system. The holes or openings 52 may be sized and spaced relative to one another as desired. For instance, in certain embodiments, the holes are between approximately 1/16th of an inch from one another and approximately three feet from one another.

[0069] Turning next to FIGS. 20-23, additional features of the wedge 28 will be described. More specifically, this embodiment includes a wedge 28 in combination with a plate 58 or smash plate. The smash plate 58 is releasably connectable to a near end 60 of the wedge 28. For instance, in the illustrated embodiment, the smash plate 58 may include a plurality of hooks 62, while the wedge 28 may include a plurality of compatible protrusions 64 extending from the near end 60 of wedge 28. As shown, there are four hooks 62 and four protrusions 64. As such, the protrusions 64 can be placed onto the hooks 62 and held in place by the hooks. This allows the wedge 28 and the smash plate 58 are held together during insertion of the wedge 28 into a channel 32.

[0070] In another embodiment shown in FIGS. 24-26, the smash plate 58 may include one or more brackets 66 having openings 68 formed therein. The wedge 28 may complimentary openings 70 that align with the openings 68 formed in

the brackets 66. In this embodiment, bolts 72 are inserted through the openings 68, 70, with nuts 74 being secured to the bolts 72. This is another way to secure the smash plate 58 to the wedge 28. Of course, other fastening and securement mechanisms, including pins, hinges, joints, locks, and the like could similar be used to secure the smash plate 58 and the wedge 28 together.

[0071] The illustrated smash plate 58 is substantially rectangular or square in shape, although it could take any number of different shapes and sizes. The smash plate 58 provides a surface of contact significantly larger than the surface of contact of the near end 60 of the wedge 28. Depending on the specific configuration of wedge 28 and location being cleaned, a variety of different smash plate 58 sizes may be utilized. For instance, in areas having minimal clearance, but where a smash plate 58 having at least some additional surface area is desired, a 3 inch by 3 inch square may be used. In areas having more room, a 20 inch by 20 inch square may be used. Further still, where even more space is available, a 36 inch by 36 inch square may be used. Because of this increased surface area, it is much easier for a user or users to contact the smash plate 58 to drive the wedge 28 further into a channel 32. Typically, these wedges 28 are driven by a sledgehammer or other object using blunt force contact. Thus, the greater surface area of the smash plate 58 is, the easier to contact than the near end 60 of the wedge 28 during insertion. This also increases safety for users in comparison to insertion of the wedge 28 alone having a narrower surface area using a sledgehammer or other blunt force object.

[0072] Turning next to FIGS. 27-30, further additional features of the wedge 28 will be described. This illustrated embodiment includes a wedge 28 that has multiple pieces that can be manipulated relative to one another for improved operational characteristics. As shown, the wedge 28 includes first and second wedge halves 76, 78. By way of example and not limitation, each wedge half 76, 78 may be approximately a quarter inch in width, although narrower or wider wedge halves 76, 78 may be used depending on the desired configuration of the wedge 28.

The first and second wedge halves 76, 78 are manipulatable and movable relative to one another about a hinge 77 located at the far end 79 of the wedge 28. More specifically, the wedge halves 76, 78 may initially be in a collapsed position where they are adjacent or substantially adjacent to one another. See FIGS. 27 and 29. In this configuration, the wedge 28 has a minimum width. Where the wedge 28 includes quarter inch wedge halves 76, 78, the thickness of the wedge 28 in the collapsed configuration is approximately $\frac{1}{2}$ inch. When in this configuration, the wedge 28 can easily be inserted into a channel 32.

[0073] Once properly located, the wedge 28 can be moved into an expanded position in which the two wedge halves 76, 78 are moved away from another about the hinge 77 to a maximum width. For instance, in FIGS. 28 and 30, the wedge 28 includes a rod 80 such as a threaded rod and a plurality of gates 82 and are movable when the threaded rod 80 is rotated. More specifically, when in the collapsed position, the gates 82 are oriented substantially parallel with the threaded rod 80 or at an angle relative to the threaded rod 80. When the wedge 28 is moved to the expanded position, the gates 82 are substantially perpendicular to the threaded rod 80 so that the wedge halves 76, 78 are at a maximum distance from one another. Where the wedge 28 includes quarter inch wedge halves 76, 78, the thickness of the wedge 28 in the expanded configuration is approximately 2 inches. Again, the wedge 28 may have a wider or narrower width depending on desired operating characteristics of the wedge 28 and the channel.

[0074] The wedge halves 76, 78 may also be moved between the collapsed position and the expanded position using other mechanisms than the threaded rod and gate combination. For instance, as shown in FIGS. 31 and 32, another embodiment shows the same wedge halves 76, 78 as those described above, but with the inclusion of an inflatable bag, sack, or other device 84 capable of being quickly and easily expanded or collapsed. The illustrated bag 84 is inflatable in a way similar to an airbag used with a vehicle. More specifically, the bag 84 can be

inflated by an air or other gas supply, or by filling the bag 84 with water or some other liquid. Any of these gases or liquids may be supplied to the bag 84 about a hose 86. Once inflated, the bag 84 holds the wedge halves 76, 78 in the expanded configuration as seen in FIG. 32. After use is completed, the gas, water, or other liquid can be depleted from the bag 84, through the hose 86 at which point the wedge halves 76, 78 return to the collapsed configuration about the hinge 37 as shown in FIG. 31. The wedge 28 can then quickly and easily be removed from the channel .

[0075] Some general background will now be provided relating to the HRSG process, as well as related components will now be provided.

[0076] HRSG Function and Design: As stated in Combine Cycle Theory, the combined cycle setup is a combination of a simple cycle gas turbine (Brayton cycle) and a steam power cycle (Rankine cycle). The Brayton cycle consists of the compressor, combustor, and combustion turbine.

[0077] HRSG Function: The exhaust gas from the combustion turbine becomes the heat source for the Rankine cycle portion of the combined cycle. Steam is generated in the heat recovery steam generator (HRSG). The HRSG recovers the waste heat available in the combustion turbine exhaust gas. The recovered heat is used to generate steam at high pressure and high temperature, and the steam is then used to generate power in the steam turbine/generator.

[0078] The HRSG is basically a heat exchanger composed of a series of preheaters (economizers), evaporator, reheaters, and superheaters. The HRSG also has supplemental firing in the duct that raises gas temperature and mass flow.

[0079] This section is intended to provide turbine operators with a basic understanding of heat recovery steam generator (HRSG) design and operation. The power generation block of the facility produces electrical power in two separate islands:

- The first island within the combined-cycle power block is the combustion turbine (CT) generator set.

- The second island is the HRSG steam turbine generator set.

[0080] The HRSG absorbs heat energy from the exhaust gas stream of the combustion turbine. The absorbed heat energy is converted to thermal energy as high temperature and pressure steam. The high-pressure steam is then used in a steam turbine generator set to produce rotational mechanical energy. The shaft of the steam turbine is connected to an electrical generator that then produces electrical power.

[0081] The waste heat is recovered from the combustion turbine exhaust gas stream through absorption by the HRSG. The exhaust gas stream is a large mass flow with temperature of up to 1,150 degrees Fahrenheit.

[0082] Most large HRSGs can be classified as a double-wide, triple-pressure level with reheat, supplementary fired unit of natural circulation design, installed behind a natural gas fired combustion turbine.

[0083] The steam generated by the HRSG is supplied to the steam turbine that drives the electrical generator system.

[0084] HRSG Design: The function of the combined cycle heat recovery steam generator (HRSG) system is to provide a method to extract sensible heat from the combustion turbine (CT) exhaust gas stream.

[0085] The heat is converted into usable steam by the heat transfer surfaces within the HRSG. The usable steam is generated in three separate and different pressure levels for use in a steam turbine (ST) generator set and for power augmentation of the CT.

[0086] The pressure levels and their associated components are:

- High pressure (HP)
- Intermediate pressure (IP)
- Low pressure (LP)
- Reheat (RH)
- Feedwater preheater (FWPH)

[0087] All generated steam from the HP, RH, and LP systems is supplied to the steam turbine, except for some LP steam used for deaeration. The IP steam is mixed with the cold RH return loop prior to being admitted to the steam turbine.

[0088] Typical heat recovery steam generator circuits have four major components:

- Superheaters
- Evaporators
- Economizers
- Drum

[0089] Since a triple-pressure system may be operated of HP, IP, and LP, these components may be used for each associated pressure. These components (with the exception of the drum) are arranged in series in the gas flow path within the HRSG. Essentially, this means that the heat transfer boiler circuits are not in parallel with one another with respect to CT exhaust gas flow. The gas, after having been used to heat the water/steam in the HRSG is released to the environment through a stack.

[0090] Heat Recovery Steam Generator: The HRSG does not have any moving parts, but it has thermal inertia, and rapid heating may result in high thermal stresses, which would affect the operating life of the HRSG. In a HRSG, the high-pressure drum is most vulnerable to buildup of thermal stresses if heating is done very rapidly. To preclude this possibility, the drum is heated in a controlled manner. The magnitude of the stress depends on the temperature difference which, in turn, depends on the material type thickness, operating pressure of the component, and the fatigue life cycles.

[0091] Controlling the pressure inside the drum can effectively control the temperature difference. If a certain temperature difference is close to the design limit, it can be controlled at that level by holding the pressure constant until the temperature difference decreases because of an increase in the component temperature due to conduction. The constant pressure or saturation temperature line on the drum heating chart indicates this.

[0092] Before an HRSG is put online, it is filled with water, and heat is applied. The cold metal takes some time to get heated, and time is required to soak the HRSG. The HRSG starts producing steam after a soaking period of a few minutes. If the steam is not released, then the pressure starts building up. The amount of steam produced and the increase in the pressure depend on the amount of heat supplied. More heat produces more steam, and pressure increases at a faster rate.

[0093] The drum pressure can be controlled either by relieving the generated steam or by controlling the heat input to the boiler.

[0094] Oftentimes, a combination of both means is used to accomplish the controlled heating of the HRSG. The steam is relieved by venting to the atmosphere or by sending it to a heat sink such as a condenser. Operating the CT at reduced load controls the heat input. A gas-side bypass system, which diverts part of the hot CT gasses to atmosphere, is sometimes used to control the heat input to the boiler. It is not necessary to run the CT at reduced load if a bypass system is provided.

[0095] High-Pressure Evaporator: In the HP EVAP section, the phase change between water and steam occurs. This phase change occurs due to the convective heat transfer or energy exchange between the CT exhaust gas stream and the water in the HP EVAP modules. The HP EVAP modules are all single-pass with no upper and lower header internal baffles. Steam/water mixture flows in upward direction through the tubes and escapes to the steam drum via riser system. Water is fed to the modules from the two downcomer feeder header assemblies. This is referred to as a natural circulation loop.

[0096] High-Pressure Steam Generator: The HPSG is composed of an economizer (HP ECON), evaporator (HP EVAP), and superheater (HP SH). The HPSG flow path is from the economizer to the steam drum/evaporator and finally to the superheater. The sections are located strategically in the exhaust gas stream according to the declining temperature of the exhaust gas and the increasing temperatures of the heated feedwater, thus providing maximum energy recovery

from the CT exhaust. The location of these heat transfer surfaces may be found on the right side setting elevation drawing.

[0097] The HPSG is equipped with a system of three safety relief valves; typically, two are mounted vertically on top of the drum, and one is mounted vertically on the HP main steam header. All PSVs are closed during normal operation; however, in an overpressure situation, the HP superheater PSV will lift first. If the pressure continues to build, the HP drum PSVs will lift (lowest pressure setting first). The three PSVs are designed to relieve 100% of the total HP steam-generating capacity.

[0098] High-Pressure Economizer: Each module is multipass on the water side and single-pass on the gas side. This is accomplished by internal baffles in the upper and lower module headers.

[0099] The HPEC receives feedwater from the feed pumps (provided by others) and absorbs heat from the CT exhaust gas, lowering the CT exhaust gas temperature and raising the water temperature to near saturation prior to entering the high-pressure steam drum.

[0100] High-Pressure Superheater: Steam on the inside of the tubes is received from the high-pressure steam drum at saturated temperature and is heated to final steam temperature.

[0101] The HP superheater is equipped with an interstage attemperator. The attemperator control valve and spray nozzle assembly typically is located between HP SHTR 2 and HP SHTR 3. The attemperator is supplied for final steam temperature control. The spray attemperation process uses water as the cooling media. The spray water is directly fed to the attemperator from the HP feed pumps discharge line. Final steam temperature control is important for protection of the superheater and equipment served by the HRSG. The spray attemperation is designed to limit final steam temperature at HP superheater outlet to final design steam temperature.

[0102]Intermediate Pressure Steam Generator: The IPSG is composed of an economizer (IP ECON), evaporator (IP EVAP), and superheater (IP SH). The IP steam generator economizer forms a tube bank consisting typically of two rows. The IP EVAP consists of many rows and the IP SH consists of typically only two rows. The IPSG flow path is from the economizer to the steam drum/evaporator and finally to the superheater. The sections are located strategically in the exhaust gas stream according to the declining temperature of the exhaust gas and the increasing temperatures of the heated feedwater, thus providing maximum energy recovery from the CT exhaust.

[0103]The IPSG is equipped with a system of three safety relief valves; typically, two are mounted vertically on top of the drum, and one is mounted vertically on the IP main steam header. All PSVs are closed during normal operation; however, in an overpressure situation, the IP superheater PSV will lift first. If the pressure continues to build, the IP drum PSVs will lift (lowest pressure setting first). The three PSVs are designed to relieve 100% of the total IP steam-generating capacity.

[0104]Intermediate Pressure Economizer: Each module is multipass on the water side and single-pass on the gas side. This is accomplished by internal baffles in the upper and lower module headers. The IPEC receives feedwater from the feed pumps (provided by others) and absorbs heat from the CT exhaust gas, lowering the CT exhaust gas temperature and raising the water temperature to near saturation before entering the steam drum.

[0105]Intermediate Pressure Evaporator: In the IP EVAP section, the phase change between water and steam occurs. This phase change occurs due to the convective heat transfer or energy exchange between the CT exhaust gas stream and the water in the IP EVAP modules. The IP EVAP modules are all single-pass with no upper and lower header internal baffles. Steam/water mixture flows in upward direction through the tubes and escapes to the steam drum via riser

system. Water is fed to the modules from the two downcomer feeder header assemblies. This is referred to as a natural circulation loop.

[0106] Intermediate Pressure Superheater: Steam on the inside of the tubes is received from the steam drum at saturated temperature and is heated to final steam temperature.

[0107] Reheater: Steam on the inside of the tubes is received from the cold reheat line at the HP steam turbine discharge. The cold reheat steam is superheated by the reheater to a final hot reheat steam temperature.

[0108] The RH is equipped with an interstage attemperator located prior to the final reheater module. The attemperator is supplied for final steam temperature control. The spray attemperation process uses water as the cooling media. The spray water is directly fed to the attemperator from the IP feed pumps discharge line. Final steam temperature control is important for protection of the reheater and equipment served by the HRSG.

[0109] Low-Pressure Steam Generator: The low-pressure steam generator includes an evaporator (LP EVAP) and a superheater (LPSH). The two are circuit components and are in-series interspersed within the HRSG setting. The LPSG flow path is from the LP ECON, to the steam drum/evaporator, and finally to the superheater. There are no intervening valves between the steam drum and the superheater surface. The location of these heat transfer surfaces may be found on the Vogt-NEM sectional right-side elevation drawing.

[0110] The LPSG is equipped with a system of three safety relief valves; typically, two are mounted vertically on top of the drum, and one is mounted vertically on the LP main steam header. All PSVs are closed during normal operation; however, in an overpressure situation, the LP superheater PSV will lift first. If the pressure continues to build, the LP drum PSVs will lift (lowest pressure setting first). The three PSVs are designed to relieve 100% of the total LP steam-generating capacity, including maximum pegging steam.

[0111] Low-Pressure Evaporator: The LP EVAP modules are all single-pass with no upper and lower header internal baffles. The modules are oriented in this direction to allow steam bubbles generated to escape via the riser tubes to the steam drum. Water is fed to the modules from the downcomer feeder header assemblies. This is referred to as a natural circulation loop.

[0112] In the LP EVAP section, the phase change between water and steam or steam generation occurs. This phase change occurs due to the convective heat transfer or energy exchange between the gas turbine exhaust gas stream and the water in the LP EVAP tubes generating steam.

[0113] Low-Pressure Superheater: Steam on the inside of the tubes is received from the steam drum at saturated temperature and is heated to final steam temperature.

[0114] Feedwater Preheater: The modules have multiple passes on the water side. This is accomplished by internal baffles in the upper and lower headers.

[0115] The FW PHTR receives feedwater from the condensate pump system and absorbs heat from the gas turbine exhaust, lowering the gas temperature and raising the water temperature. The FW PHTR increases HRSG efficiency.

[0116] While the above description provides a number of potential uses of the deep cleaning alignment equipment, it should be noted that there are virtually innumerable uses for the present invention, all of which need not be detailed here. All the disclosed embodiments can be practiced without undue experimentation.

[0117] Although the best mode contemplated by the inventors of carrying out the present invention is disclosed above, practice of the present invention is not limited thereto. It will be manifest that various additions, modifications and rearrangements of the features of the present invention may be made without deviating from the spirit and scope of the underlying inventive concept. In addition, the individual components need not be fabricated from the disclosed materials but could be fabricated from virtually any suitable materials.

[0118] Moreover, the individual components need not be formed in the disclosed

shapes, or assembled in the disclosed configuration, but could be provided in virtually any shape, and assembled in virtually any configuration to improve the efficiency with which the deep cleaning alignment equipment functions and to prevent damage to the HRSG. Furthermore, all the disclosed features of each disclosed embodiment can be combined with, or substituted for, the disclosed features of every other disclosed embodiment except where such features are mutually exclusive.

[0119] It is intended that the appended claims cover all such additions, modifications and rearrangements. Expedient embodiments of the present invention are differentiated by the appended claims.

CLAIMS

What is claimed is:

1. A deep cleaning alignment equipment used to clean a heat recovery steam generator system including a plurality of metallic tubes, wherein each of the plurality of tubes includes a base with a plurality of fins extending outwardly from the base, the deep cleaning alignment equipment comprising:

an elongate wedge having a near end and a far end separated by a length, wherein the wedge is configured to contact and spread the plurality of tubes and the plurality of fins to form a channel therebetween; and

a wand configured to spray one of a liquid or a gas about the heat recovery steam generator system;

wherein the elongate wedge contacts the plurality of tubes and the plurality of fins about an extended surface area to minimize a stress force between the wedge and the plurality tubes and the plurality of fins; and

wherein the wand is removably insertable into the channel.

2. The deep cleaning alignment equipment of claim 1, further comprising a plate configured to be releasably secured to the near end of the elongate wedge.

3. The deep cleaning alignment equipment of claim 2, wherein the plate has a first cross sectional area;

wherein the near end of the elongate wedge has a second cross sectional area;
and

wherein the first cross sectional area is greater than the second cross sectional area.

4. The deep cleaning alignment equipment of claim 3, wherein the plate is substantially rectangular in size; and
wherein the first cross sectional area is approximately nine square inches.
5. The deep cleaning alignment equipment of claim 2, wherein the plate further comprises at least one hook;
wherein the elongate wedge further comprises at least one protrusion extending from the elongate wedge; and
wherein the at least one protrusion is configured to releasably engage with the at least one hook.
6. The deep cleaning alignment equipment of claim 2, wherein the plate further comprises at least one bracket;
wherein the elongate wedge further comprises at least one opening compatible with the at least one bracket; and
wherein one or more bolts, screws, and nuts are configured to secure the plate and the elongate wedge about the at least one bracket and the at least one opening.
7. The deep cleaning alignment equipment of claim 1, wherein the elongate wedge further comprises:
a first wedge half; and
a second wedge half;
wherein the first wedge half and the second wedge half are movable between:
a collapsed configuration having a first width;
an expanded configuration having a second width; and
wherein the second width is wider than the first width.

8. The deep cleaning alignment equipment of claim 7, further comprising:
a rod; and
at least one gate mounted to the rod, the at least one gate in contact with the first wedge half and the second wedge half;
wherein the rod is rotatable to move the at least one gate between:
a first position where the at least one gate is substantially parallel to the rod; and
a second position where the at least one gate is substantially perpendicular to the rod.
9. The deep cleaning alignment equipment of claim 7, further comprising an expandable bag located between the first wedge half and the second wedge half that is configured to move between:
a first configuration where the expandable bag is substantially deflated; and
a second configuration where the expandable bag is substantially inflated and contacts the first wedge half and the second wedge half.
10. A method of using a deep cleaning alignment equipment to clean a heat recovery steam generator system including a plurality of metallic tubes, the method comprising the steps of:
inserting a wedge having a width, a length, and a height, between the plurality of tubes to spread the plurality of tubes to form a channel therebetween;
inserting a wand into the channel;
spraying a liquid or a gas through the wand to clean the plurality of tubes;
and
removing the wedge from the plurality of tubes.

11. The method of claim 10, further comprising the steps of:
releasably securing the wedge to a plate; and
contacting the plate to drive the wedge between the plurality of tubes to spread the plurality of tubes to form a channel therebetween.
12. The method of claim 11, further comprising the step of releasably securing one or more protrusions extending from the wedge to one or more hooks extending from the plate.
13. The method of claim 11, further comprising the steps of:
aligning one or more openings formed in the wedge with one or more openings formed in brackets extending from the plate; and
inserting a fastener into the one or more openings formed in the wedge and the one or more openings formed in the brackets.
14. The method of claim 10, further comprising the steps of:
inserting the wedge between the plurality of tubes when the wedge is at a first width; and
pivoting first and second wedge halves of the wedge about a hinge so that the wedge is at a second width greater than the first width.
15. The method of claim 10, further comprising the steps of:
inserting the wedge between the plurality of tubes when the wedge is at a first width;
rotating a rod located between a first wedge half and a second wedge half in a first direction to move one or more gates located between the first wedge half and the second wedge half;
moving the first wedge half and the second wedge half to a second width greater than the first width.

16. The method of claim 15, further comprising the steps of:
rotating the rod located between the first wedge half and the second wedge half in a second direction opposite the first direction; and
removing the wedge from the plurality of tubes.
17. The method of claim 11, further comprising the steps of:
inserting the wedge between the plurality of tubes when the wedge is at a first width; and
inflating a bag located between a first wedge half and a second wedge half to expand the first wedge half and the second wedge half to a second width greater than the first width.
18. A deep cleaning alignment equipment comprising:
an elongate wedge configured to contact and spread a plurality of tubes and fins to form a channel therebetween and having a first piece and a second piece releasably secured to the first piece; and
a wand configured to spray one of a liquid or a gas about the heat recovery steam generator system; and
wherein the wand is removably insertable into the channel.
19. The deep cleaning alignment equipment of claim 18, further comprising a plate configured to be releasably secured to a near end of the elongate wedge;
wherein the plate has a first cross sectional area;
wherein the near end of the elongate wedge has a second cross sectional area;
and
wherein the first cross sectional area is greater than the second cross sectional area.

20. The deep cleaning alignment equipment of claim 18, wherein the elongate wedge further comprises:

- a first wedge half; and

- a second wedge half;

wherein the first wedge half and the second wedge half are movable between:

- a collapsed configuration having a first width;

- an expanded configuration having a second width; and

wherein the second width is wider than the first width.

ABSTRACT OF THE DISCLOSURE

Systems and methods for cleaning a heat recovery steam generator system including tubes and fins associated therewith using deep cleaning alignment equipment are described. The deep cleaning alignment equipment primarily includes at least one wedge and at least one wand. The wedge may be an elongate wedge configured to maximize the surface area that contacts the tubes and fins, which in turn minimizes the amount of stress about any specific point of the tubes or the fins. Additionally, the wedge may be made of a variety of different materials. The wedge may be releasably secured to a plate to improve ease with which the wedge may be driven into tubes and fins. The wedge may also include wedge halves that are movable between expanded and collapsed positions.

Non-Provisional U.S. Patent Application

Title: DEEP CLEANING ALIGNMENT EQUIPMENT

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DEEP CLEANING ALIGNMENT EQUIPMENT

CROSS-REFERENCE(S) TO RELATED APPLICATION(S)

[0001] This present application is a continuation-in-part application that claims priority to U.S. Patent Application Serial No. 17/729,133 filed on April 26, 2022 and entitled *Deep Cleaning Alignment Equipment*, that claims priority to U.S. Patent Application Serial No. 16/204,281 filed on November 29, 2018 and entitled *Deep Cleaning Alignment Equipment*, which issued as U.S. Patent No. 11,313,632 on April 26, 2022, which claims priority on U.S. Provisional Patent Application Serial No. 62/597,179, filed on December 11, 2017 and entitled *Deep Cleaning Alignment Equipment*, the entire contents of both are hereby expressly incorporated by reference into the present application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The invention relates generally to power plants that produce electricity including a heat recovery steam generator (HRSG) with boiler tubes therein and, in particular, to equipment used to improve the ease with which modules housing these boiler tubes can be cleaned.

2. Discussion of the Related Art

[0003] A combined-cycle power plant uses both a gas and a steam turbine together to produce up to 50 percent more electricity from the same fuel than a traditional simple-cycle plant. The waste heat from the gas turbine is routed through a Heat Recovery Steam Generator (HRSG) to the nearby steam turbine, which generates extra power. The boiler tubes within these HRSG's are contained within different sized modules and have varying numbers of tubes within each module. The modules in the HRSG generally consist of some composition of the following modules: Feedwater 1, Feedwater 2, LP Economizer, IP Economizer, HP Economizer, LP Evaporator, IP Evaporator, HP Evaporator, LP

Preheater, IP Preheater, HP Preheater, LP Superheater, IP Superheater, HP Superheater, LP Reheater, IP Reheater, and HP Reheater. When these systems get dirty, the rate of heat transfer can be reduced, which in turn reduces the efficiency of such systems.

[0004] Cleaning inside of the modules can be very difficult. In the past, the methods available were only able to clean the first one to two rows of tubes. By creating an access lane between boiler tubes, enough space can be created between tubes to insert specialized wands that allow all of the boiler tubes in the module to be cleaned. In the past, this space would be created by inserting a metallic pointed wedge-like lance between the tubes. Once the access lane is created, a wand is used to spray a liquid or gas, traditionally air, to clean the tubes and associated components. Oftentimes, these wands are merely configured to spray air directly ahead. As a result, the wand must be inserted into each and every row of tubes in order to clean the entire HRSG.

[0005] Traditionally, such wedge-like bars were made of steel. Similarly, most tubes inside HRSG's are made up of either carbon steel, stainless steel, T22 or T19. Because of the hard material of the wedge, use of these wedges oftentimes presented risk of damage to the tubes or associated fins. Additionally, the wedges are traditionally a pointed lance with a minimal height, which increases the amount of stress caused where the wedge touches the tubes. Furthermore, these wedges are oftentimes heavy and costly to transport. Further still, while air is effective to clean some tube lanes, it can be ineffective to clean hard deposits.

[0006] What is therefore needed is deep cleaning alignment equipment that allows the tubes to be spread to create an access lane that does not damage the tubes or associated fins. What is further needed is a deep cleaning alignment equipment configured to spray various liquids or gases about the tubes and associated fins to clean the HRSG. What is further needed is a cleaning wand capable of

spraying the liquids or gases at a variety of different angles relative to the tube lanes.

SUMMARY AND OBJECTS OF THE INVENTION

[0007]By way of summary, the present invention is directed to a deep cleaning alignment equipment that is used to clean a heat recovery steam generator system and a method associated therewith. The heat recovery steam generator system may include a plurality of metallic tubes. These tubes can be vertically mounted, horizontally mounted, or mounted at various other angles. Each of these tubes may include a base with a plurality of fins extending outwardly from the base.

[0008]In accordance with a first aspect of the invention, the deep cleaning alignment equipment may include an elongate wedge. The elongate wedge includes a width, a length, and a height and may be configured to contact and spread the tubes and fins to form a channel between the tubes. The elongate wedge is configured to contact the tubes and fins about an extended surface area. In turn, this minimizes a stress force between the wedge and the tubes.

[0009]In accordance with another aspect of the invention, the wedge may have a height of at least six inches. The wedge may further have a height of at least eight inches. Further still, the wedge may have a width of at least one half of an inch. Also, the wedge could have a width of one inch. Additionally, the wedge may have a length of at least three-and-a-half feet. Similarly, the wedge may have a length of at least five feet.

[0010]In accordance with a first aspect of the invention, the deep cleaning alignment equipment may include a composite wedge. The composite may be softer than the metallic material of the tubes and associated fins. For instance, the composite could be a high strength carbon nylon. More specifically, the wedge may be made of nylon 12CF. In other embodiments, the wedge may be of a metallic or other hard material. In yet other embodiments, the wedge may

be made of a metallic or other hard material, but covered in a composite or other softer material. The wedge may or may not include a handle for gripping.

[0011]In accordance with another aspect of the invention, the deep cleaning alignment equipment may include a wand. The wand may be configured to spray one of a liquid or a gas about the heat recovery steam generator system. Additionally, the wand may be configured to be removably insertable into the channel formed by the wedge. The wand may have a first end and a second end opposite the first end. At the first end, a handle is mounted to the wand. At a second end, an exit may be formed. For instance, the exit may be configured to spray one of a liquid or a gas at an angle of approximately 30 degrees, 45 degrees, or at other angles relative to the channel.

[0012]In accordance to another aspect of the invention, multiple wands may be provided. More specifically, a first wand may be provided and a second wand may be provided. The first wand may be configured to push debris forward. Additionally, the second wand may be configured to shoot a liquid or a gas. For instance, the second wand may be configured to shoot dry ice. As stated above, either wand may be configured to spray liquid or gas at an angle of approximately 30 degrees, 45 degrees, or any other angle relative to the channel.

[0013]In accordance to another aspect of the invention, a method of using a deep cleaning alignment equipment used to clean a heat recovery steam generator system is described. The method includes the step of inserting an elongate composite wedge having a width, a length, and a height, between the tubes to spread the tubes to form a channel therebetween. The method may also include the steps of inserting a wand into the channel and spraying a liquid or a gas through the wand to clean the tubes and the fins. The method may further include the steps of inserting a first elongate composite wedge having a first width between the tubes, and then inserting a second elongate composite wedge having a second width between the tubes, where the first width is smaller than the second width. Further still, the method may include the step of spraying a

quantity of dry ice through the wand to an exit to clean the tubes and fins, where the exit sprays the quantity of dry ice at an angle of approximately 30 degrees, 45 degrees, or any other angle relative to the channel.

[0014]In accordance with other aspects of the present invention, the various components may be made of a metallic material. In other embodiments, the various components may be made of composite or other materials. In accordance with yet another aspect of the present invention, the wedge may have a handle at an end. In other embodiments, the wedge may not have a handle.

[0015]In accordance with yet another aspect of the present invention, the wedge may be from approximately six inches to approximately nine feet in length, and more preferably between approximately three feet and approximately five feet in length. Additionally, the wedge may have a height of approximately a half of an inch to a height of approximately two feet, and more preferably has a height between approximately two inches and approximately eight inches. Further still, the wedge may have a width of between approximately 1/8th of an inch and approximately four inches, and more preferably between approximately a half of an inch to approximately one and a half inches.

[0016]In accordance with yet another aspect of the present invention, the wedge may have at least one, and more preferably multiple openings formed in the wedge. These openings are configured such that various devices can be inserted into one or more of the openings in order to expedite and simplify the removal of the wedge from the heat recovery steam generator system. For instance, a lever, L bracket, or other device may be inserted into one or more of the openings, in which case the device can be used as a cantilever to help dislodge the wedge from the heat recovery steam generator system. For instance, a user may first use an outermost opening located closest to the end of the wedge that is not inserted into the heat recovery steam generator system. Once the wedge is moved away from the heat recovery steam generator system, the device may be inserted into a second opening that is exposed when the wedge is initially

moved. The device can then move the wedge further from the heat recovery steam generator system. As many openings may be included as needed to incrementally remove the wedge from the heat recovery steam generator system. Additionally, the devices used to engage with the openings and remove the wedge from the heat recovery steam generator system may be a mechanical device where a user uses force to remove the wedge, or a pneumatic device could be used to simplify and expedite the removal of the wedge from the heat recovery steam generator system. These holes or openings may be in any desired size and at any desired spacing, for instance not less than approximately 1/16th between consecutive holes, and not more than approximately three feet between consecutive holes.

[0017] In accordance with yet another aspect of the present invention, the wedge may also be a multi-piece wedge. For instance, the wedge may come in two or more pieces, which could potentially allow for cheaper and/or easier transportation of the wedge from one location to another. By way of example and not limitation, the various pieces of the multi-piece wedge may be secured to one another using threaded openings, interlocking components, jigsaw connections, and the like.

[0018] These, and other aspects and objects of the present invention will be better appreciated and understood when considered in conjunction with the following description and the accompanying drawings. It should be understood, however, that the following description, while indicating preferred embodiments of the present invention, is given by way of illustration and not of limitation. Many changes and modifications may be made within the scope of the present invention without departing from the spirit thereof, and the invention includes all such modifications.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] A clear conception of the advantages and features constituting the present invention, and of the construction and operation of typical mechanisms provided

with the present invention, will become more readily apparent by referring to the exemplary, and therefore non-limiting, embodiments illustrated in the drawings accompanying and forming a part of this specification, wherein like reference numerals designate the same elements in the several views, and in which:

[0020] FIG. 1 illustrates an isometric view of a deep cleaning alignment equipment including a wedge;

[0021] FIG. 2 illustrates a top or bottom plan view of the deep cleaning alignment equipment including the wedge of FIG. 1;

[0022] FIG. 3 is a side elevation view of the deep cleaning alignment equipment including the wedge of FIG. 1;

[0023] FIG. 4 is a front elevation view of the deep cleaning alignment equipment including the elongate wedge of FIG. 1;

[0024] FIG. 5 is a rear elevation view of the deep cleaning alignment equipment including the elongate wedge of FIG. 1;

[0025] FIG. 6 is an isometric view of the deep cleaning alignment equipment of FIG. 1 as the wedge is inserted into a heat recovery steam generator to spread a plurality of tubes to create a channel for a cleaning wand;

[0026] FIG. 7 is a top plan view of the deep cleaning alignment equipment with the wedge spreading the plurality of tubes and the cleaning wand dispensing a cleaning solution to the heat recovery steam generator;

[0027] FIG. 8 is a top plan view of the deep cleaning alignment equipment with the wedge spreading the plurality of tubes and the cleaning wand dispensing a cleaning solution to the heat recovery steam generator where the tubes are in a staggered configuration;

[0028] FIG. 9 is a perspective view of one embodiment of a wand used with the deep cleaning alignment equipment;

[0029] FIG. 10 is a detailed view of an exit of the wand of FIG. 9;

[0030] FIG. 11 is another perspective view of the wand including a handle associated therewith;

[0031] FIG. 12 is a perspective view of one potential nozzle used with the deep cleaning alignment equipment;

[0032] FIG. 13 is a perspective view of the deep cleaning alignment equipment where the wedge has been driven between tubes and fins associated with the heat recovery steam generator before cleaning has commenced;

[0033] FIG. 14 is a perspective view of the deep cleaning alignment equipment where the wedge has been driven between tubes and fins associated with the heat recovery steam generator after cleaning has been completed;

[0034] FIG. 15 is an exploded perspective view of an embodiment of the deep cleaning alignment equipment where the wedge is a multi-piece wedge;

[0035] FIG. 16 is a perspective view of the wedge of FIG. 15 in an assembled view;

[0036] FIG. 17 is a side elevation view of an embodiment of the deep cleaning alignment equipment with a wedge having multiple openings formed therein;

[0037] FIG. 18 is a perspective view of the wedge of FIG. 17 with a removal bracket installed relative to one of the multiple openings;

[0038] FIG. 19 is a perspective view of the wedge of FIGS. 17-18 inserted in a heat recovery steam generator system with the removable bracket inserted therein to remove the wedge from the system;

[0039] FIG. 20 is a perspective view of another embodiment of a wedge in use with a plate;

[0040] FIG. 21 is a side elevation view of the wedge in use with the plate of FIG. 20;

[0041] FIG. 22 is a front elevation view of the wedge in use with the plate of FIGS. 20 and 21;

[0042] FIG. 23 is an exploded view of the wedge and plate of FIGS. 20-22;

[0043] FIG. 24 is a perspective view of another embodiment of a wedge in use with a plate;

[0044] FIG. 25 is a top plan view of the wedge and plate of FIG. 24;

[0045] FIG. 26 is an exploded view of the wedge and plate of FIGS. 24 and 25;

[0046]FIG. 27 is a top plan view of another embodiment of a wedge that is expandable and collapsible in a first configuration;

[0047]FIG. 28 is a top plan view of the wedge of FIG. 27 in a second configuration;

[0048]FIG. 29 is a perspective view of the wedge of FIGS. 27 and 28 in the first configuration;

[0049]FIG. 30 is a perspective view of the wedge of FIGS. 27-29 in the second configuration;

[0050]FIG. 31 is a perspective view of another embodiment of a wedge that is expandable and collapsible in a first configuration; and

[0051]FIG. 32 is a perspective view of the wedge of FIG. 31 in a second configuration;

[0052]In describing the preferred embodiment of the invention which is illustrated in the drawings, specific terminology will be resorted to for the sake of clarity. However, it is not intended that the invention be limited to the specific terms so selected and it is to be understood that each specific term includes all technical equivalents which operate in a similar manner to accomplish a similar purpose. For example, the word connected, attached, or terms similar thereto are often used. They are not limited to direct connection but include connection through other elements where such connection is recognized as being equivalent by those skilled in the art.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0053]The present invention and the various features and advantageous details thereof are explained more fully with reference to the non-limiting embodiments described in detail in the following description.

[0054]A deep cleaning alignment equipment 20 and system for cleaning heat recovery steam generator systems 22 or other types of heat exchangers and associated tubes 24 is generally shown in the figures. While the equipment 20 will be described with relation to a heat recovery steam generator system 22, it should be noted that the equipment 20 could similarly be used in many other

instances where the exterior of various tubes needs to be spread apart for cleaning purposes, such as in other heating, ventilation, and air conditioning applications. As seen in FIGS. 6 and 7, the tubes 24 may be configured to align with one another in an “in line” configuration. Alternatively, as shown in FIG. 8, the tubes 24 may be staggered relative to one another. Of course, other tube 24 configurations could similarly be used.

[0055]The deep cleaning alignment equipment 20 is specifically designed to maximize the efficiency with which the heat recovery steam generator system 22 is cleaned. The heat recovery steam generator system 22 includes a plurality of tubes 24. As shown, these tubes 24 extend vertically about the system 22. However, the tubes 24 could similarly be horizontally mounted, or mounted at other angles as desired. Typically, these tubes 24 are made of steel, although they could similarly be made of other materials. While the figures merely show exemplary cylindrical tubes 24, it should be noted that the tubes 24 may include a plurality of fins 26 that extend outwardly from the tubes 24, as seen in FIGS. 12 and 13. While these fins are 26 not shown in all of the figures, it should be noted that the deep cleaning alignment equipment 20 is configured to be similarly compatible with any fins 26 or tubes 24 associated with a heat recovery steam generator system 22.

[0056]The deep cleaning alignment equipment 20 may include a wedge/alignment bar 28 and at least one wand 30, both of which will further be described below. The wedge 28 is configured to encourage outward movement of the various tubes 24 in order to create a channel 32 between the tubes 24. Once the channel 32 is formed, the at least one wand 30 is used to clean any materials located about the tubes 24. The wedge 28 may have a handle 56 to provide something a user can easily grasp to enhance use and movement of the wedge 28. However, the wedge 28 does not require the inclusion of a handle.

[0057]Next, the wedge/alignment bar 28 as shown in FIGS. 1-5 will be further described. Among other features, the wedge 28 preferably is elongate in shape,

with an extended body 29 coming to a pointed end 31. As such, the wedge 28 could come in a number of different sizes. For instance, a wedge 28 that is longer and taller than other wedges traditionally used in this field could be used. As a result, when the wedge 28 is used, the surface area of the wedge 28 that contacts the tubes 24 can be increased. In turn, this decreases the amount of stress between the wedge 28 and the steel tube 24 about any specific point. This wedge 28 would be approximately eight inches deep in order to spread out the stress point on the about the wedge 28 and the tubes 24. This would also allow for a greater opening along the length of the tubes 24 which would allow better access for the cleaning wands 30. The width and the length of the wedge 28 would vary depending on the type of HRSG 22, width of module, type of arrangement, tube spacing specific to the module being cleaned, and any other factors that would impact the functionality of the deep cleaning alignment equipment 20.

[0058] A few embodiments will now be described, although it should be noted that these are exemplary, such that many other potential dimensioned wedges 28 could similarly be used. In a first embodiment, the wedge 28 could be between three-and-a-half and five feet in length. In this embodiment the wedge 28 could be between approximately one-half inch and one inch in width. The specific size could vary based on the size of the module. For instance, where a boiler module contains twelve rows of tubes 24, a three-and-a-half-foot wedge 28 would be used. For any modules having over twelve rows of tubes 24, the longer five-foot wedge 28 could be used. Where the tubes 24 are located in close proximation to one another, the skinnier one-half inch wide wedge 28 would initially be used. After the one-half inch wedge 28 is inserted, a one-inch wide wedge can be inserted to further space the tubes 24. Alternatively, tubes 24 with a greater initial distance from one another could simply be separated using the one-inch wide wedge 28.

[0059] According to another embodiment, the wedge 28 could be between two and six feet in length. In this embodiment the wedge 28 could be between approximately one-half inch and one-and-a-half inch in width. The wedge 28 could further be between one inch in height and eight inches in height.

[0060] In yet another embodiment, the wedge 28 could be between a quarter inch to two inches wide. Additionally, the wedge 28 could be between a half an inch and two inches wide. Also, the length of the wedge 28 could vary, for instance, between a foot long and ten feet long. Furthermore, the height of the wedge 28 could vary, between a half inch high and twelve inches high, and more preferably between one inch high and eight inches high.

[0061] In yet another embodiment, the wedge 28 may be from approximately six inches to approximately nine feet in length, and more preferably between approximately three feet and approximately five feet in length. Additionally, the wedge 28 may have a height of approximately a half of an inch to a height of approximately two feet, and more preferably has a height between approximately two inches and approximately eight inches. Further still, the wedge 28 may have a width of between approximately $1/8^{\text{th}}$ of an inch and approximately four inches, and more preferably between approximately a half of an inch to approximately one and a half inches.

[0062] Another feature of the wedge 28 is that the wedge 28 may be made of a composite component. This composite component is preferably made up of material that is softer than the steel tubes 24 and fins 26. As a result, when the wedge 28 is inserted into the HRSG 22 and comes into contact with the tubes 24 and/or fins 26, any abrasion from sliding the wedge 28 in would be absorbed by the composite wedge 28 instead of the tubes 24 or fins 26. For instance, the wedge 28 could be made of a high strength carbon fiber nylon. In one embodiment, the wedge 28 is made of nylon 12CF. Nylon 12CF is a lightweight yet durable carbon-fiber reinforced thermoplastic. Thus, the wedge 28 is easily transportable due to its weight, but still durable enough to be used with deep

cleaning alignment equipment 20. Alternatively, the wedge 28 could be made of any other material that is softer than the tubes 24 and fins 26 associated with the tubes 24, which are typically made of steel, for instance, various plastics, composites, and nylon materials. Of course, the wedge 28 could be configured such that it is both elongate and made of the composite component to minimize potential damage to the tubes 24 and fins 26.

[0063] Additionally, the deep cleaning alignment equipment 20 may feature at least one cleaning wand 30, as shown in detail in FIGS. 9-11. The cleaning wand 30 is configured to spray a cleaning solution 34 of liquid or gas about the HRSG 22. More specifically, the cleaning wand 30 may be configured to spray dry ice. This could include high density dry ice (CO₂) pellets. These pellets will be propelled with ultra-high pressure air ranging from 200 – 350 psi. This would be advantageous as it would allow for cleaning of the HRSG 22 with the dry ice eventually evaporating. Of course, other types of media blasting could similarly occur. For instance, the cleaning wand 30 could similarly be configured to spray other liquids or gas, including air, water, cleaning solution, and any other material capable of cleaning the tubes 24 and fins 26.

[0064] As shown, the cleaning wand 30 may have a first end 36 a second end 38. At the first end 36, the cleaning wand 30 may include a handle 40 to allow a user to firmly hold onto the cleaning wand 30 during use. At the second end 38, an exit 42 is formed. A supply channel 44 extends through the wand 30 to deliver the liquid or gas to the exit 42. The exit 42 may direct liquid or gas straight out of the wand 30. Alternatively, the exit 42 may direct liquid or gas out of the wand 30 at various angles. More specifically, FIGS. 7, 9, and 10 show a wand 30 capable of spraying liquid or gas out of the exit at an angle of approximately 45 degrees relative to the wand 30, although the wand 30 could similarly be configured to exit at an angle of approximately 30 degrees or any other desired angle. The wand 30 could also be capable of front blowing and side blowing to clean the tubes 24 and fins 26. Of course, the wands 30 could similarly blow

liquid or gas at any other angle as desired. Additional wands 30 may also be used, such as a first wand to blow air to remove an initial layer of debris, and a second wand to shoot liquid or gas into the HRSG 22. Further still, the wand 30 may have any number of different nozzle assemblies 46 to vary the way the liquid or gas is distributed from the wand 30. For instance, FIG. 12 shows one potential nozzle 46 configuration.

[0065] Furthermore, the wands 30 may be made of steel or composite materials. The use of composite materials could be desired for the same reasons as with the composite wedge 28 to reduce potential damage to the tubes 24 or fins 26 when the wands 30 are quickly and rapidly moved about the tube 24 and fins 26. The wands 30 will be moved up and down the wedged channel 32 in order to clean the tubes 24 from all directions. Cleaning may take place from each side of the module (both upstream and downstream faces) with an overlap of the wedges 28 from each side.

[0066] Operating of the deep cleaning alignment equipment 20 will now be described. Initially, the wedge 28 will be inserted between two adjacent rows of tubes 24. In doing so, the adjacent rows of tubes 24 will be separated apart from one another to form a channel 32. Where the adjacent rows of tubes 24 are narrowly placed relative to one another, multiple wedges 28 may be used. For instance, a first wedge having a narrow width could be used to initially separate the tubes 24, after which a second wedge having a wider width to further separate out the tubes 24 to create a channel 32 through which the wand or wands 30 can be inserted. Once the channel 32 is formed, the wand or wands 30 can be removably inserted into the channel 32 to facilitate cleaning about the HRSG 22.

[0067] Additional features of the system will now be described. Turning initially to FIGS. 15 and 16, the elongate wedge 28 may be a multi-piece elongate wedge 28. These figures show an exemplary multi-piece elongate wedge, but other multi-piece wedges having different proportions could similarly be used. More specifically, the wedge 28 may comprise one or more pieces 48 that can be

releasably connected to one another using a variety of connector interfaces 50. Such a wedge 28 is desirable because it makes it easier, cheaper, more efficient, etc. to ship the wedge 28 from one location to another. As shown, the wedge 28 has three sections 48a, 48b, 48c that can be releasably connected to one another. The various pieces/sections 48 may be releasably connected using any number of different connector interfaces 50. By way of example and not limitation, the connection interface 50 may be a threaded opening, such that adjacent pieces 48 may be rotated relative to one another so that the threaded section engages. In another embodiment, the connection interface 50 may be an interlocking section, with portion of adjacent pieces 48 interlocking with one another at the connection interface. Further still, the connection interface 50 may have a jigsaw or other connection. Regardless of what connection interface 50 is used, the connection interface 50 allows the various pieces 48 to quick and easily be releasably secured to one another with sufficient connection to operate as a wedge as described herein, after which the pieces 48 can be disengaged from one another.

[0068] Turning next to FIGS. 17-19 show another feature associated with the wedge 28. Again, the embodiment shown in these figures are not made to scale, but are shown with exaggerated dimensions, sizes, and proportions in order to demonstrate the underlying features. More specifically, the embodiment shown in these figures are to a wedge that has at least one, and as shown a plurality of holes or openings 52 formed in the side of wedge 28. Various devices, such as brackets, l-brackets, removal brackets, clips, bars, or any other device 54 capable of being inserted into the openings 52 can be used to engage with the wedge 28 in order to facilitate removal of the wedge 28. As known to those in the art, once the wedge 28 is installed, it can be difficult to remove the wedge 28 from a lane of a heat recovery steam generator system or other system. These holes or openings 52 help to facilitate this removal. As shown in FIG. 19, the wedge 28 is installed into a heat recovery steam generator system, with an opening 52 exposed directly next to the handle 56. Again, the wedge 28 does not require a

handle, but for the purposes of description of the location of the opening 52 the handle 56 is used as a point of reference to indicate the end of the wedge 28 that is not inserted into the system. When a user desires to remove the wedge 28 from the system, the device 54 is inserted into the first opening 52. Thereafter, the device 54 is either manually grasped by a user and used as a cantilever, or otherwise connected to another device such as a pneumatic device. The user or pneumatic or other device pull the device 54 away from the system, and in turn pull the wedge 28 at least partially away from the system. When the wedge 28 is securely lodged in the system, it may only incrementally move out of the system. Once a second opening 52 is exposed, the device 54 can be inserted in the second opening 52, after which the process may be repeated. The wedge 28 may include as many openings as desired to facilitate incremental removal of the wedge 28 from the system. The holes or openings 52 may be sized and spaced relative to one another as desired. For instance, in certain embodiments, the holes are between approximately 1/16th of an inch from one another and approximately three feet from one another.

[0069]Turning next to FIGS. 20-23, additional features of the wedge 28 will be described. More specifically, this embodiment includes a wedge 28 in combination with a plate 58 or smash plate. The smash plate 58 is releasably connectable to a near end 60 of the wedge 28. For instance, in the illustrated embodiment, the smash plate 58 may include a plurality of hooks 62, while the wedge 28 may include a plurality of compatible protrusions 64 extending from the near end 60 of wedge 28. As shown, there are four hooks 62 and four protrusions 64. As such, the protrusions 64 can be placed onto the hooks 62 and held in place by the hooks. This allows the wedge 28 and the smash plate 58 are held together during insertion of the wedge 28 into a channel 32.

[0070]In another embodiment shown in FIGS. 24-26, the smash plate 58 may include one or more brackets 66 having openings 68 formed therein. The wedge 28 may complimentary openings 70 that align with the openings 68 formed in

the brackets 66. In this embodiment, bolts 72 are inserted through the openings 68, 70, with nuts 74 being secured to the bolts 72. This is another way to secure the smash plate 58 to the wedge 28. Of course, other fastening and securement mechanisms, including pins, hinges, joints, locks, and the like could similar be used to secure the smash plate 58 and the wedge 28 together.

[0071] The illustrated smash plate 58 is substantially rectangular or square in shape, although it could take any number of different shapes and sizes. The smash plate 58 provides a surface of contact significantly larger than the surface of contact of the near end 60 of the wedge 28. Depending on the specific configuration of wedge 28 and location being cleaned, a variety of different smash plate 58 sizes may be utilized. For instance, in areas having minimal clearance, but where a smash plate 58 having at least some additional surface area is desired, a 3 inch by 3 inch square may be used. In areas having more room, a 20 inch by 20 inch square may be used. Further still, where even more space is available, a 36 inch by 36 inch square may be used. Because of this increased surface area, it is much easier for a user or users to contact the smash plate 58 to drive the wedge 28 further into a channel 32. Typically, these wedges 28 are driven by a sledgehammer or other object using blunt force contact. Thus, the greater surface area of the smash plate 58 is, the easier to contact than the near end 60 of the wedge 28 during insertion. This also increases safety for users in comparison to insertion of the wedge 28 alone having a narrower surface area using a sledgehammer or other blunt force object.

[0072] Turning next to FIGS. 27-30, further additional features of the wedge 28 will be described. This illustrated embodiment includes a wedge 28 that has multiple pieces that can be manipulated relative to one another for improved operational characteristics. As shown, the wedge 28 includes first and second wedge halves 76, 78. By way of example and not limitation, each wedge half 76, 78 may be approximately a quarter inch in width, although narrower or wider wedge halves 76, 78 may be used depending on the desired configuration of the wedge 28.

The first and second wedge halves 76, 78 are manipulatable and movable relative to one another about a hinge 77 located at the far end 79 of the wedge 28. More specifically, the wedge halves 76, 78 may initially be in a collapsed position where they are adjacent or substantially adjacent to one another. See FIGS. 27 and 29. In this configuration, the wedge 28 has a minimum width. Where the wedge 28 includes quarter inch wedge halves 76, 78, the thickness of the wedge 28 in the collapsed configuration is approximately ½ inch. When in this configuration, the wedge 28 can easily be inserted into a channel 32.

[0073] Once properly located, the wedge 28 can be moved into an expanded position in which the two wedge halves 76, 78 are moved away from another about the hinge 77 to a maximum width. For instance, in FIGS. 28 and 30, the wedge 28 includes a rod 80 such as a threaded rod and a plurality of gates 82 and are movable when the threaded rod 80 is rotated. More specifically, when in the collapsed position, the gates 82 are oriented substantially parallel with the threaded rod 80 or at an angle relative to the threaded rod 80. When the wedge 28 is moved to the expanded position, the gates 82 are substantially perpendicular to the threaded rod 80 so that the wedge halves 76, 78 are at a maximum distance from one another. Where the wedge 28 includes quarter inch wedge halves 76, 78, the thickness of the wedge 28 in the expanded configuration is approximately 2 inches. Again, the wedge 28 may have a wider or narrower width depending on desired operating characteristics of the wedge 28 and the channel.

[0074] The wedge halves 76, 78 may also be moved between the collapsed position and the expanded position using other mechanisms than the threaded rod and gate combination. For instance, as shown in FIGS. 31 and 32, another embodiment shows the same wedge halves 76, 78 as those described above, but with the inclusion of an inflatable bag, sack, or other device 84 capable of being quickly and easily expanded or collapsed. The illustrated bag 84 is inflatable in a way similar to an airbag used with a vehicle. More specifically, the bag 84 can be

inflated by an air or other gas supply, or by filling the bag 84 with water or some other liquid. Any of these gases or liquids may be supplied to the bag 84 about a hose 86. Once inflated, the bag 84 holds the wedge halves 76, 78 in the expanded configuration as seen in FIG. 32. After use is completed, the gas, water, or other liquid can be depleted from the bag 84, through the hose 86 at which point the wedge halves 76, 78 return to the collapsed configuration about the hinge 37 as shown in FIG. 31. The wedge 28 can then quickly and easily be removed from the channel .

[0075]Some general background will now be provided relating to the HRSG process, as well as related components will now be provided.

[0076]HRSG Function and Design: As stated in Combine Cycle Theory, the combined cycle setup is a combination of a simple cycle gas turbine (Brayton cycle) and a steam power cycle (Rankine cycle). The Brayton cycle consists of the compressor, combustor, and combustion turbine.

[0077]HRSG Function: The exhaust gas from the combustion turbine becomes the heat source for the Rankine cycle portion of the combined cycle. Steam is generated in the heat recovery steam generator (HRSG). The HRSG recovers the waste heat available in the combustion turbine exhaust gas. The recovered heat is used to generate steam at high pressure and high temperature, and the steam is then used to generate power in the steam turbine/generator.

[0078]The HRSG is basically a heat exchanger composed of a series of preheaters (economizers), evaporator, reheaters, and superheaters. The HRSG also has supplemental firing in the duct that raises gas temperature and mass flow.

[0079]This section is intended to provide turbine operators with a basic understanding of heat recovery steam generator (HRSG) design and operation. The power generation block of the facility produces electrical power in two separate islands:

- The first island within the combined-cycle power block is the combustion turbine (CT) generator set.

- The second island is the HRSG steam turbine generator set.

[0080]The HRSG absorbs heat energy from the exhaust gas stream of the combustion turbine. The absorbed heat energy is converted to thermal energy as high temperature and pressure steam. The high-pressure steam is then used in a steam turbine generator set to produce rotational mechanical energy. The shaft of the steam turbine is connected to an electrical generator that then produces electrical power.

[0081]The waste heat is recovered from the combustion turbine exhaust gas stream through absorption by the HRSG. The exhaust gas stream is a large mass flow with temperature of up to 1,150 degrees Fahrenheit.

[0082]Most large HRSGs can be classified as a double-wide, triple-pressure level with reheat, supplementary fired unit of natural circulation design, installed behind a natural gas fired combustion turbine.

[0083]The steam generated by the HRSG is supplied to the steam turbine that drives the electrical generator system.

[0084]HRSG Design: The function of the combined cycle heat recovery steam generator (HRSG) system is to provide a method to extract sensible heat from the combustion turbine (CT) exhaust gas stream.

[0085]The heat is converted into usable steam by the heat transfer surfaces within the HRSG. The usable steam is generated in three separate and different pressure levels for use in a steam turbine (ST) generator set and for power augmentation of the CT.

[0086]The pressure levels and their associated components are:

- High pressure (HP)
- Intermediate pressure (IP)
- Low pressure (LP)
- Reheat (RH)
- Feedwater preheater (FWPH)

[0087] All generated steam from the HP, RH, and LP systems is supplied to the steam turbine, except for some LP steam used for deaeration. The IP steam is mixed with the cold RH return loop prior to being admitted to the steam turbine.

[0088] Typical heat recovery steam generator circuits have four major components:

- Superheaters
- Evaporators
- Economizers
- Drum

[0089] Since a triple-pressure system may be operated of HP, IP, and LP, these components may be used for each associated pressure. These components (with the exception of the drum) are arranged in series in the gas flow path within the HRSG. Essentially, this means that the heat transfer boiler circuits are not in parallel with one another with respect to CT exhaust gas flow. The gas, after having been used to heat the water/steam in the HRSG is released to the environment through a stack.

[0090] Heat Recovery Steam Generator: The HRSG does not have any moving parts, but it has thermal inertia, and rapid heating may result in high thermal stresses, which would affect the operating life of the HRSG. In a HRSG, the high-pressure drum is most vulnerable to buildup of thermal stresses if heating is done very rapidly. To preclude this possibility, the drum is heated in a controlled manner. The magnitude of the stress depends on the temperature difference which, in turn, depends on the material type thickness, operating pressure of the component, and the fatigue life cycles.

[0091] Controlling the pressure inside the drum can effectively control the temperature difference. If a certain temperature difference is close to the design limit, it can be controlled at that level by holding the pressure constant until the temperature difference decreases because of an increase in the component temperature due to conduction. The constant pressure or saturation temperature line on the drum heating chart indicates this.

[0092] Before an HRSG is put online, it is filled with water, and heat is applied. The cold metal takes some time to get heated, and time is required to soak the HRSG. The HRSG starts producing steam after a soaking period of a few minutes. If the steam is not released, then the pressure starts building up. The amount of steam produced and the increase in the pressure depend on the amount of heat supplied. More heat produces more steam, and pressure increases at a faster rate.

[0093] The drum pressure can be controlled either by relieving the generated steam or by controlling the heat input to the boiler.

[0094] Oftentimes, a combination of both means is used to accomplish the controlled heating of the HRSG. The steam is relieved by venting to the atmosphere or by sending it to a heat sink such as a condenser. Operating the CT at reduced load controls the heat input. A gas-side bypass system, which diverts part of the hot CT gasses to atmosphere, is sometimes used to control the heat input to the boiler. It is not necessary to run the CT at reduced load if a bypass system is provided.

[0095] High-Pressure Evaporator: In the HP EVAP section, the phase change between water and steam occurs. This phase change occurs due to the convective heat transfer or energy exchange between the CT exhaust gas stream and the water in the HP EVAP modules. The HP EVAP modules are all single-pass with no upper and lower header internal baffles. Steam/water mixture flows in upward direction through the tubes and escapes to the steam drum via riser system. Water is fed to the modules from the two downcomer feeder header assemblies. This is referred to as a natural circulation loop.

[0096] High-Pressure Steam Generator: The HPSG is composed of an economizer (HP ECON), evaporator (HP EVAP), and superheater (HP SH). The HPSG flow path is from the economizer to the steam drum/evaporator and finally to the superheater. The sections are located strategically in the exhaust gas stream according to the declining temperature of the exhaust gas and the increasing temperatures of the heated feedwater, thus providing maximum energy recovery

from the CT exhaust. The location of these heat transfer surfaces may be found on the right side setting elevation drawing.

[0097] The HPSG is equipped with a system of three safety relief valves; typically, two are mounted vertically on top of the drum, and one is mounted vertically on the HP main steam header. All PSVs are closed during normal operation; however, in an overpressure situation, the HP superheater PSV will lift first. If the pressure continues to build, the HP drum PSVs will lift (lowest pressure setting first). The three PSVs are designed to relieve 100% of the total HP steam-generating capacity.

[0098] High-Pressure Economizer: Each module is multipass on the water side and single-pass on the gas side. This is accomplished by internal baffles in the upper and lower module headers.

[0099] The HPEC receives feedwater from the feed pumps (provided by others) and absorbs heat from the CT exhaust gas, lowering the CT exhaust gas temperature and raising the water temperature to near saturation prior to entering the high-pressure steam drum.

[0100] High-Pressure Superheater: Steam on the inside of the tubes is received from the high-pressure steam drum at saturated temperature and is heated to final steam temperature.

[0101] The HP superheater is equipped with an interstage attemperator. The attemperator control valve and spray nozzle assembly typically is located between HP SHTR 2 and HP SHTR 3. The attemperator is supplied for final steam temperature control. The spray attemperation process uses water as the cooling media. The spray water is directly fed to the attemperator from the HP feed pumps discharge line. Final steam temperature control is important for protection of the superheater and equipment served by the HRSG. The spray attemperation is designed to limit final steam temperature at HP superheater outlet to final design steam temperature.

[0102]Intermediate Pressure Steam Generator: The IPSG is composed of an economizer (IP ECON), evaporator (IP EVAP), and superheater (IP SH). The IP steam generator economizer forms a tube bank consisting typically of two rows. The IP EVAP consists of many rows and the IP SH consists of typically only two rows. The IPSG flow path is from the economizer to the steam drum/evaporator and finally to the superheater. The sections are located strategically in the exhaust gas stream according to the declining temperature of the exhaust gas and the increasing temperatures of the heated feedwater, thus providing maximum energy recovery from the CT exhaust.

[0103]The IPSG is equipped with a system of three safety relief valves; typically, two are mounted vertically on top of the drum, and one is mounted vertically on the IP main steam header. All PSVs are closed during normal operation; however, in an overpressure situation, the IP superheater PSV will lift first. If the pressure continues to build, the IP drum PSVs will lift (lowest pressure setting first). The three PSVs are designed to relieve 100% of the total IP steam-generating capacity.

[0104]Intermediate Pressure Economizer: Each module is multipass on the water side and single-pass on the gas side. This is accomplished by internal baffles in the upper and lower module headers. The IPEC receives feedwater from the feed pumps (provided by others) and absorbs heat from the CT exhaust gas, lowering the CT exhaust gas temperature and raising the water temperature to near saturation before entering the steam drum.

[0105]Intermediate Pressure Evaporator: In the IP EVAP section, the phase change between water and steam occurs. This phase change occurs due to the convective heat transfer or energy exchange between the CT exhaust gas stream and the water in the IP EVAP modules. The IP EVAP modules are all single-pass with no upper and lower header internal baffles. Steam/water mixture flows in upward direction through the tubes and escapes to the steam drum via riser

system. Water is fed to the modules from the two downcomer feeder header assemblies. This is referred to as a natural circulation loop.

[0106]Intermediate Pressure Superheater: Steam on the inside of the tubes is received from the steam drum at saturated temperature and is heated to final steam temperature.

[0107]Reheater: Steam on the inside of the tubes is received from the cold reheat line at the HP steam turbine discharge. The cold reheat steam is superheated by the reheater to a final hot reheat steam temperature.

[0108]The RH is equipped with an interstage attemperator located prior to the final reheater module. The attemperator is supplied for final steam temperature control. The spray attemperation process uses water as the cooling media. The spray water is directly fed to the attemperator from the IP feed pumps discharge line. Final steam temperature control is important for protection of the reheater and equipment served by the HRSG.

[0109]Low-Pressure Steam Generator: The low-pressure steam generator includes an evaporator (LP EVAP) and a superheater (LPSH). The two are circuit components and are in-series interspersed within the HRSG setting. The LPSG flow path is from the LP ECON, to the steam drum/evaporator, and finally to the superheater. There are no intervening valves between the steam drum and the superheater surface. The location of these heat transfer surfaces may be found on the Vogt-NEM sectional right-side elevation drawing.

[0110]The LPSG is equipped with a system of three safety relief valves; typically, two are mounted vertically on top of the drum, and one is mounted vertically on the LP main steam header. All PSVs are closed during normal operation; however, in an overpressure situation, the LP superheater PSV will lift first. If the pressure continues to build, the LP drum PSVs will lift (lowest pressure setting first). The three PSVs are designed to relieve 100% of the total LP steam-generating capacity, including maximum pegging steam.

[0111]Low-Pressure Evaporator: The LP EVAP modules are all single-pass with no upper and lower header internal baffles. The modules are oriented in this direction to allow steam bubbles generated to escape via the riser tubes to the steam drum. Water is fed to the modules from the downcomer feeder header assemblies. This is referred to as a natural circulation loop.

[0112]In the LP EVAP section, the phase change between water and steam or steam generation occurs. This phase change occurs due to the convective heat transfer or energy exchange between the gas turbine exhaust gas stream and the water in the LP EVAP tubes generating steam.

[0113]Low-Pressure Superheater: Steam on the inside of the tubes is received from the steam drum at saturated temperature and is heated to final steam temperature.

[0114]Feedwater Preheater: The modules have multiple passes on the water side. This is accomplished by internal baffles in the upper and lower headers.

[0115]The FW PHTR receives feedwater from the condensate pump system and absorbs heat from the gas turbine exhaust, lowering the gas temperature and raising the water temperature. The FW PHTR increases HRSG efficiency.

[0116]While the above description provides a number of potential uses of the deep cleaning alignment equipment, it should be noted that there are virtually innumerable uses for the present invention, all of which need not be detailed here. All the disclosed embodiments can be practiced without undue experimentation.

[0117]Although the best mode contemplated by the inventors of carrying out the present invention is disclosed above, practice of the present invention is not limited thereto. It will be manifest that various additions, modifications and rearrangements of the features of the present invention may be made without deviating from the spirit and scope of the underlying inventive concept. In addition, the individual components need not be fabricated from the disclosed materials but could be fabricated from virtually any suitable materials.

[0118]Moreover, the individual components need not be formed in the disclosed

shapes, or assembled in the disclosed configuration, but could be provided in virtually any shape, and assembled in virtually any configuration to improve the efficiency with which the deep cleaning alignment equipment functions and to prevent damage to the HRSG. Furthermore, all the disclosed features of each disclosed embodiment can be combined with, or substituted for, the disclosed features of every other disclosed embodiment except where such features are mutually exclusive.

[0119] It is intended that the appended claims cover all such additions, modifications and rearrangements. Expedient embodiments of the present invention are differentiated by the appended claims.

CLAIMS

What is claimed is:

1. A deep cleaning alignment equipment used to clean a heat recovery steam generator system including a plurality of metallic tubes, wherein each of the plurality of tubes includes a base with a plurality of fins extending outwardly from the base, the deep cleaning alignment equipment comprising:

an elongate wedge having a near end and a far end separated by a length, wherein the wedge is configured to contact and spread the plurality of tubes and the plurality of fins to form a channel therebetween; and

a wand configured to spray one of a liquid or a gas about the heat recovery steam generator system;

wherein the elongate wedge contacts the plurality of tubes and the plurality of fins about an extended surface area to minimize a stress force between the wedge and the plurality tubes and the plurality of fins; and

wherein the wand is removably insertable into the channel.

2. The deep cleaning alignment equipment of claim 1, further comprising a plate configured to be releasably secured to the near end of the elongate wedge.

3. The deep cleaning alignment equipment of claim 2, wherein the plate has a first cross sectional area;

wherein the near end of the elongate wedge has a second cross sectional area;
and

wherein the first cross sectional area is greater than the second cross sectional area.

4. The deep cleaning alignment equipment of claim 3, wherein the plate is substantially rectangular in size; and
wherein the first cross sectional area is approximately nine square inches.
5. The deep cleaning alignment equipment of claim 2, wherein the plate further comprises at least one hook;
wherein the elongate wedge further comprises at least one protrusion extending from the elongate wedge; and
wherein the at least one protrusion is configured to releasably engage with the at least one hook.
6. The deep cleaning alignment equipment of claim 2, wherein the plate further comprises at least one bracket;
wherein the elongate wedge further comprises at least one opening compatible with the at least one bracket; and
wherein one or more bolts, screws, and nuts are configured to secure the plate and the elongate wedge about the at least one bracket and the at least one opening.
7. The deep cleaning alignment equipment of claim 1, wherein the elongate wedge further comprises:
a first wedge half; and
a second wedge half;
wherein the first wedge half and the second wedge half are movable between:
a collapsed configuration having a first width;
an expanded configuration having a second width; and
wherein the second width is wider than the first width.

8. The deep cleaning alignment equipment of claim 7, further comprising:
a rod; and
at least one gate mounted to the rod, the at least one gate in contact with the first wedge half and the second wedge half;
wherein the rod is rotatable to move the at least one gate between:
a first position where the at least one gate is substantially parallel to the rod; and
a second position where the at least one gate is substantially perpendicular to the rod.
9. The deep cleaning alignment equipment of claim 7, further comprising an expandable bag located between the first wedge half and the second wedge half that is configured to move between:
a first configuration where the expandable bag is substantially deflated; and
a second configuration where the expandable bag is substantially inflated and contacts the first wedge half and the second wedge half.
10. A method of using a deep cleaning alignment equipment to clean a heat recovery steam generator system including a plurality of metallic tubes, the method comprising the steps of:
inserting a wedge having a width, a length, and a height, between the plurality of tubes to spread the plurality of tubes to form a channel therebetween;
inserting a wand into the channel;
spraying a liquid or a gas through the wand to clean the plurality of tubes;
and
removing the wedge from the plurality of tubes.

11. The method of claim 10, further comprising the steps of:
releasably securing the wedge to a plate; and
contacting the plate to drive the wedge between the plurality of tubes to spread the plurality of tubes to form a channel therebetween.
12. The method of claim 11, further comprising the step of releasably securing one or more protrusions extending from the wedge to one or more hooks extending from the plate.
13. The method of claim 11, further comprising the steps of:
aligning one or more openings formed in the wedge with one or more openings formed in brackets extending from the plate; and
inserting a fastener into the one or more openings formed in the wedge and the one or more openings formed in the brackets.
14. The method of claim 10, further comprising the steps of:
inserting the wedge between the plurality of tubes when the wedge is at a first width; and
pivoting first and second wedge halves of the wedge about a hinge so that the wedge is at a second width greater than the first width.
15. The method of claim 10, further comprising the steps of:
inserting the wedge between the plurality of tubes when the wedge is at a first width;
rotating a rod located between a first wedge half and a second wedge half in a first direction to move one or more gates located between the first wedge half and the second wedge half;
moving the first wedge half and the second wedge half to a second width greater than the first width.

16. The method of claim 15, further comprising the steps of:
rotating the rod located between the first wedge half and the second wedge half in a second direction opposite the first direction; and
removing the wedge from the plurality of tubes.
17. The method of claim 11, further comprising the steps of:
inserting the wedge between the plurality of tubes when the wedge is at a first width; and
inflating a bag located between a first wedge half and a second wedge half to expand the first wedge half and the second wedge half to a second width greater than the first width.
18. A deep cleaning alignment equipment comprising:
an elongate wedge configured to contact and spread a plurality of tubes and fins to form a channel therebetween and having a first piece and a second piece releasably secured to the first piece; and
a wand configured to spray one of a liquid or a gas about the heat recovery steam generator system; and
wherein the wand is removably insertable into the channel.
19. The deep cleaning alignment equipment of claim 18, further comprising a plate configured to be releasably secured to a near end of the elongate wedge;
wherein the plate has a first cross sectional area;
wherein the near end of the elongate wedge has a second cross sectional area;
and
wherein the first cross sectional area is greater than the second cross sectional area.

20. The deep cleaning alignment equipment of claim 18, wherein the elongate wedge further comprises:

- a first wedge half; and

- a second wedge half;

wherein the first wedge half and the second wedge half are movable between:

- a collapsed configuration having a first width;

- an expanded configuration having a second width; and

wherein the second width is wider than the first width.

ABSTRACT OF THE DISCLOSURE

Systems and methods for cleaning a heat recovery steam generator system including tubes and fins associated therewith using deep cleaning alignment equipment are described. The deep cleaning alignment equipment primarily includes at least one wedge and at least one wand. The wedge may be an elongate wedge configured to maximize the surface area that contacts the tubes and fins, which in turn minimizes the amount of stress about any specific point of the tubes or the fins. Additionally, the wedge may be made of a variety of different materials. The wedge may be releasably secured to a plate to improve ease with which the wedge may be driven into tubes and fins. The wedge may also include wedge halves that are movable between expanded and collapsed positions.

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UTILITY PATENT APPLICATION TRANSMITTAL <i>(Only for new nonprovisional applications under 37 CFR 1.53(b))</i>	Attorney Docket No.	33-10022
	First Named Inventor	Keith R. Boye
	Title	Deep Cleaning Alignment Equipment
	Priority Mail Express® Label No.	

APPLICATION ELEMENTS <i>See MPEP chapter 600 concerning utility patent application contents.</i>	Commissioner for Patents P.O. Box 1450 Alexandria, VA 22313-1450
1. ☐ Fee Transmittal Form (PTO/SB/17 or equivalent) 2. ☒ Applicant asserts small entity status. See 37 CFR 1.27 3. ☐ Applicant certifies micro entity status. See 37 CFR 1.29. Applicant must attach form PTO/SB/15A or B or equivalent. 4. ☒ Specification [Total Pages <u>35</u>] Both the claims and abstract must start on a new page. (See MPEP § 608.01(a) for information on the preferred arrangement) 5. ☒ Drawing(s) (35 U.S.C. 113) [Total Sheets <u>21</u>] 6. Inventor's Oath or Declaration [Total Pages <u>2</u>] (including substitute statements under 37 CFR 1.64 and assignments serving as an oath or declaration under 37 CFR 1.63(e)) a. ☒ Newly executed (original or copy) b. ☐ A copy from a prior application (37 CFR 1.63(d)) 7. ☒ Application Data Sheet * See note below. See 37 CFR 1.76 (PTO/AIA/14 or equivalent) 8. CD-ROM or CD-R in duplicate, large table, or Computer Program (Appendix) ☐ Landscape Table on CD 9. Nucleotide and/or Amino Acid Sequence Submission (if applicable, items a. – c. are required) a. ☐ Computer Readable Form (CRF) b. ☐ Specification Sequence Listing on: i. ☐ CD-ROM or CD-R (2 copies); or ii. ☐ Paper c. ☐ Statements verifying identity of above copies	ACCOMPANYING APPLICATION PAPERS 10. ☐ Assignment Papers (cover sheet & document(s)) Name of Assignee _____ 11. ☐ 37 CFR 3.73(c) Statement ☐ Power of Attorney (when there is an assignee) 12. ☐ English Translation Document (if applicable) 13. ☐ Information Disclosure Statement (PTO/SB/08 or PTO-1449) ☐ Copies of citations attached 14. ☐ Preliminary Amendment 15. ☐ Return Receipt Postcard (MPEP § 503) (Should be specifically itemized) 16. ☐ Certified Copy of Priority Document(s) (if foreign priority is claimed) 17. ☐ Nonpublication Request Under 35 U.S.C. 122(b)(2)(B)(i). Applicant must attach form PTO/SB/35 or equivalent. 18. ☐ Other: _____ _____ _____ _____ _____

***Note:** (1) Benefit claims under 37 CFR 1.78 and foreign priority claims under 1.55 **must** be included in an Application Data Sheet (ADS).
(2) For applications filed under 35 U.S.C. 111, the application must contain an ADS specifying the applicant if the applicant is an assignee, person to whom the inventor is under an obligation to assign, or person who otherwise shows sufficient proprietary interest in the matter. See 37 CFR 1.46(b).

19. CORRESPONDENCE ADDRESS

☒ The address associated with Customer Number: 199904 OR ☐ Correspondence address below

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