

WHAT IS CLAIMED IS:

1. A method for repairing a cooling stave in situ wherein, the cooling stave having a stave inlet outlet pipe attached to a cooling pipe in the cooling stave, the method comprising:
inserting a pipe into the stave inlet outlet pipe to form a first annulus;
inflating a bladder disposed inside the pipe and cooling stave;
injecting a first uncured epoxy material into the first annulus;
permitting the first uncured epoxy to cure; and
removing the bladder.
2. The repair method of claim 1 wherein a first end of the pipe distal to the cooling stave further comprises a means for introduction of the first uncured epoxy to the first annulus, and a second end of the pipe proximal to the stave further comprises means for venting air displaced during injecting of a first uncured epoxy into the first annulus.
3. The repair method of claim 1 further comprising the steps of:
applying an outer pipe external to the stave inlet outlet pipe to form a second annulus;
injecting a second uncured epoxy material into the second annulus; and
permitting the second uncured epoxy material to cure.
4. The repair method of claim 3 wherein the first and second uncured epoxies are cured concurrently.
5. The repair method of claim 3 wherein the first uncured epoxy is cured before the second uncured epoxy is cured.
6. The repair method of claim 3 wherein a first end of the outer pipe distal to the cooling stave further comprises a means for introduction of the second uncured epoxy to the second annulus, and a second end of the outer pipe proximal to the cooling stave further comprises a boot adapted to form seals with the outer pipe and the cooling stave, and the second end having an aperture in open communication with the second annulus.
7. A method for repairing a cooling stave in site, comprising:
rethreading an aperture in the cooling stave formed after removal of a compromised stave inlet outlet pipe;

installing a new inlet outlet pipe;
inserting an inner pipe into the new stave inlet outlet pipe to form an annulus;
inflating a bladder inside the inner pipe and the cooling stave;
injecting an uncured epoxy material into the annulus;
permitting the uncured epoxy to cure; and
removing the bladder.

8. A repair system kit for a cooling stave utilized in a blast furnace, the cooling stave having a stave inlet outlet pipe comprised of:
 - an inflatable bladder;
 - an inner rigid pipe;
 - a grout inlet; and
 - a vent tube.
9. The repair system kit of claim 8 further comprising a concentric outer pipe; and a flexible rubber seal.

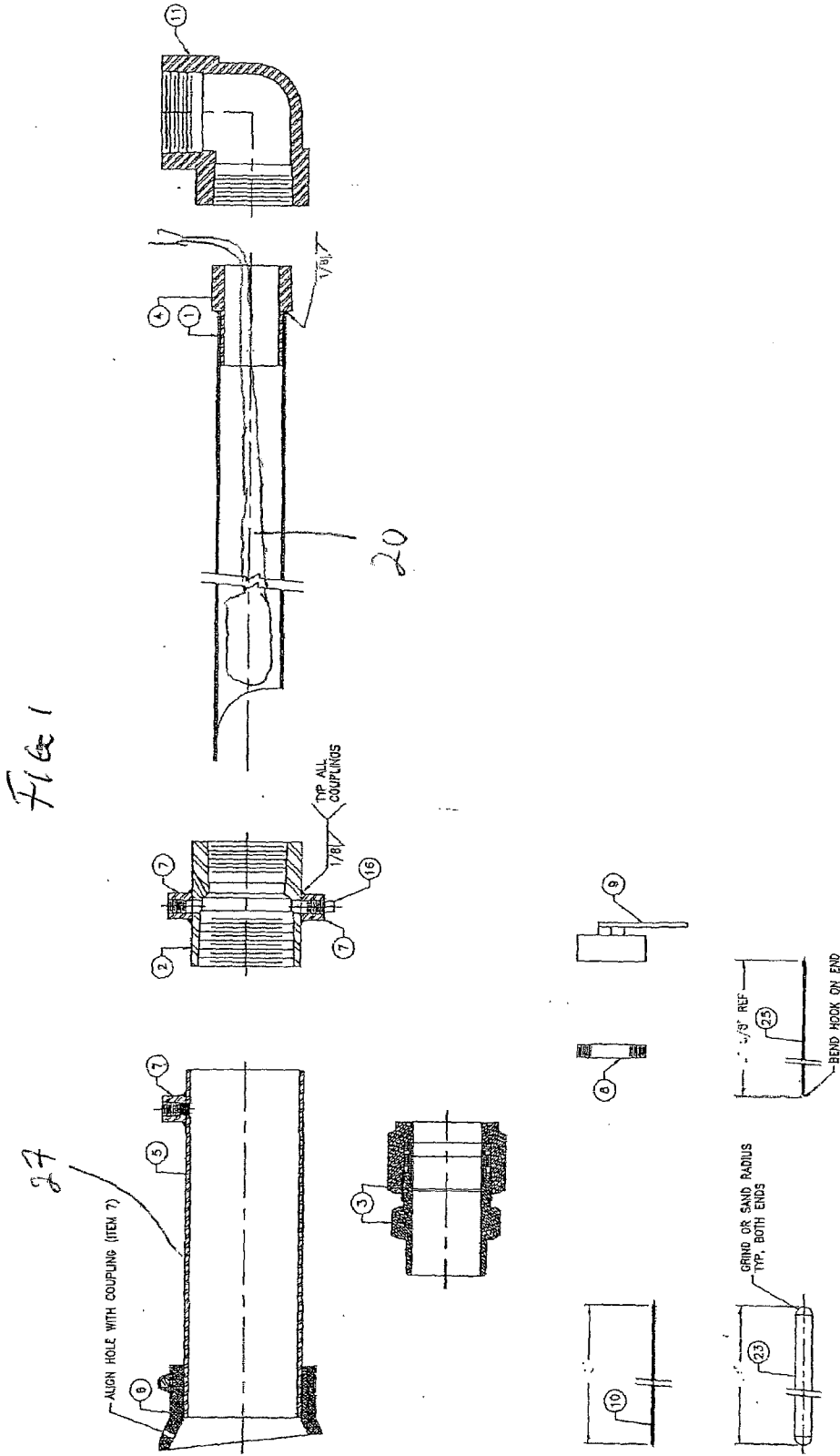


FIG 2

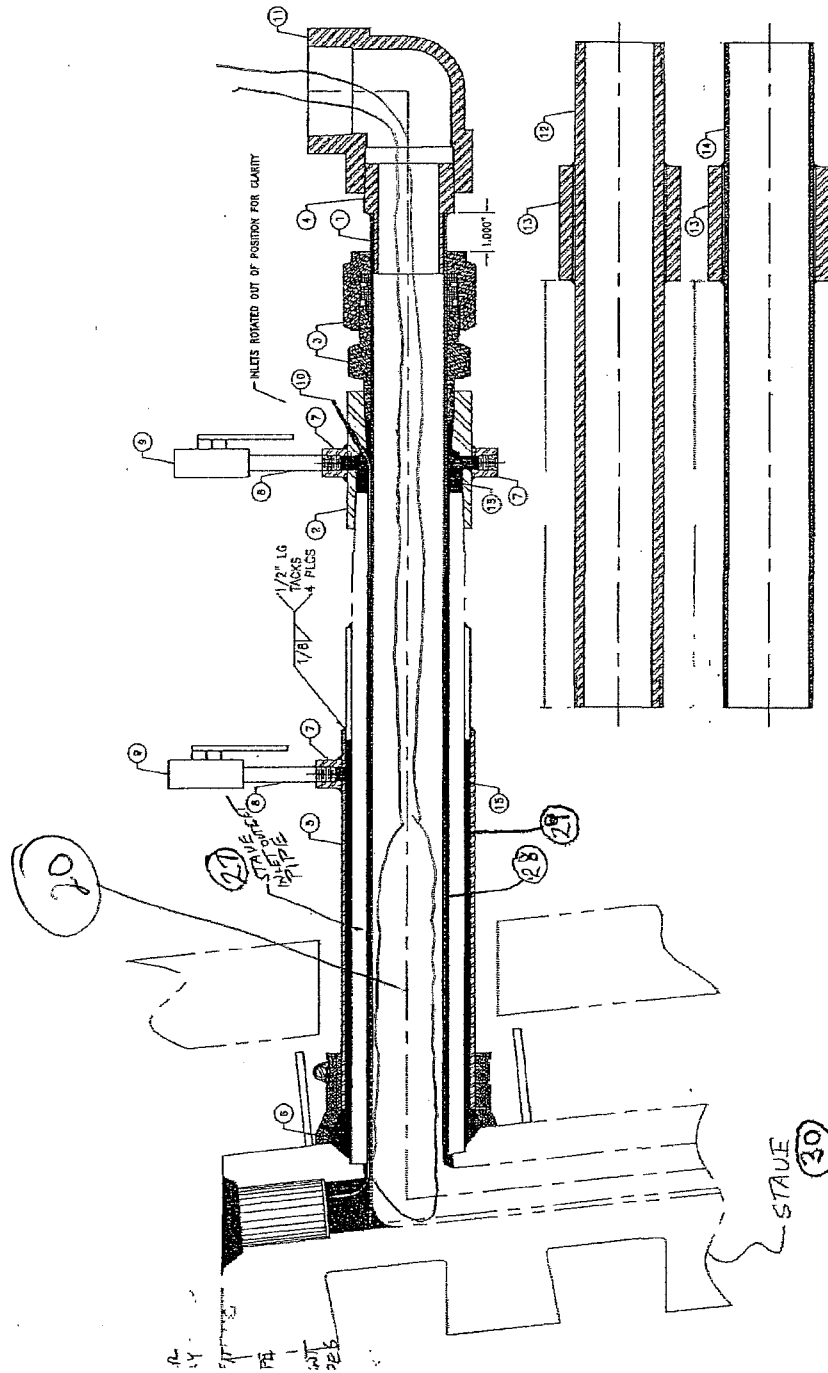
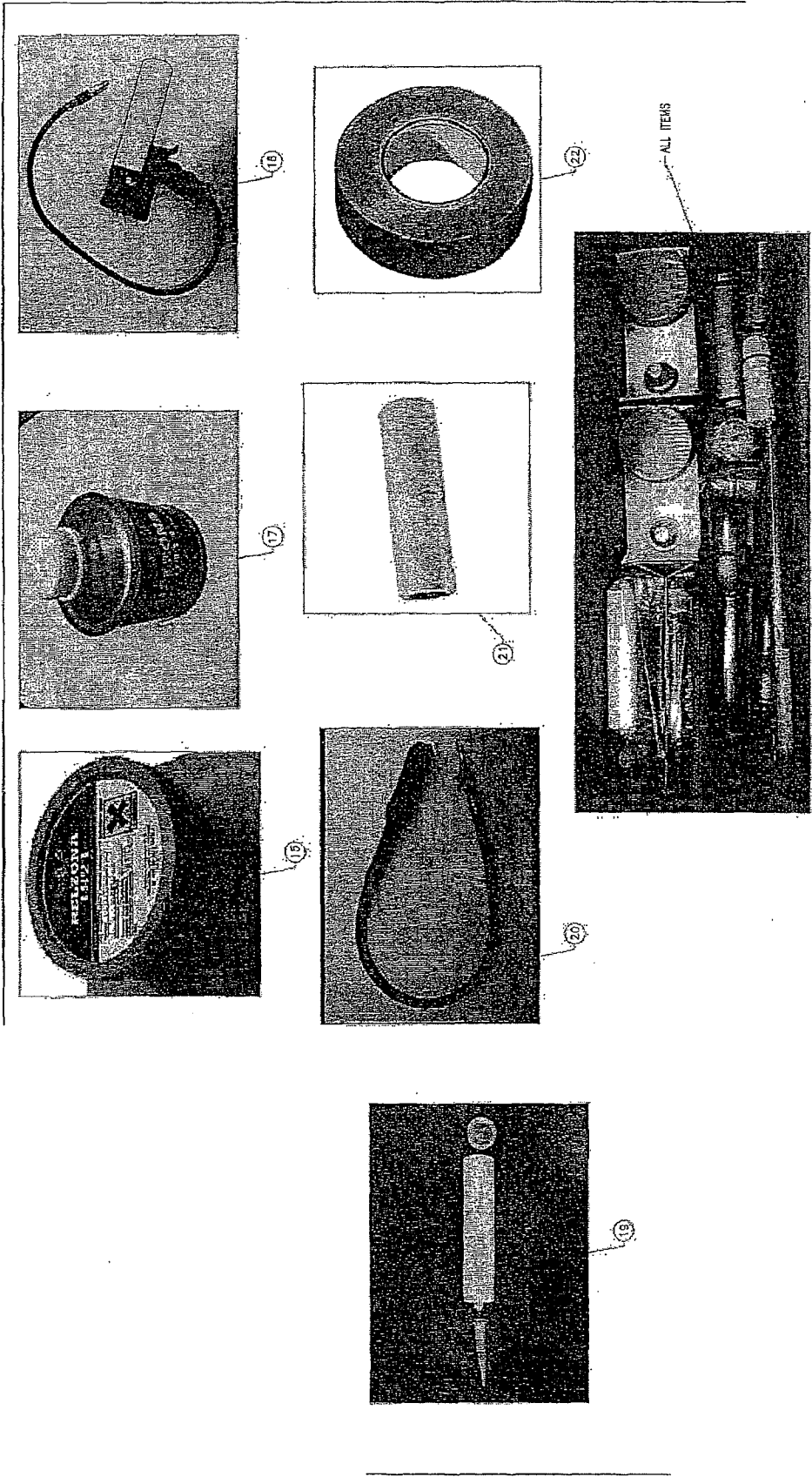


Fig 3



Existing Stave Failure Mechanisms – Pipe Weld Cracks Due to Thermal Expansion

- Cyclic stresses from rapid heat up and cool down
- Stave deflection
- Non uniform flow
- Longer staves more susceptible
- Water leak

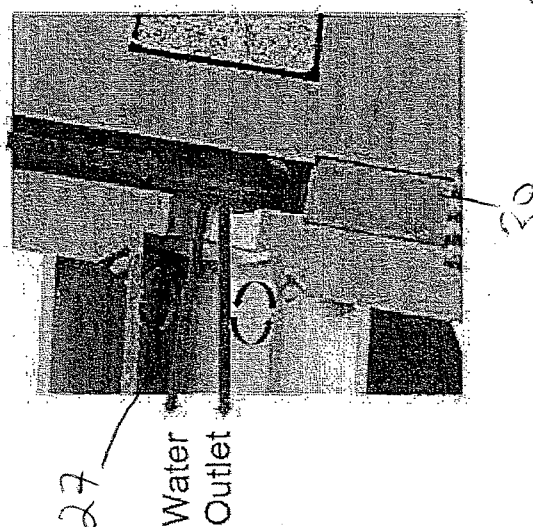
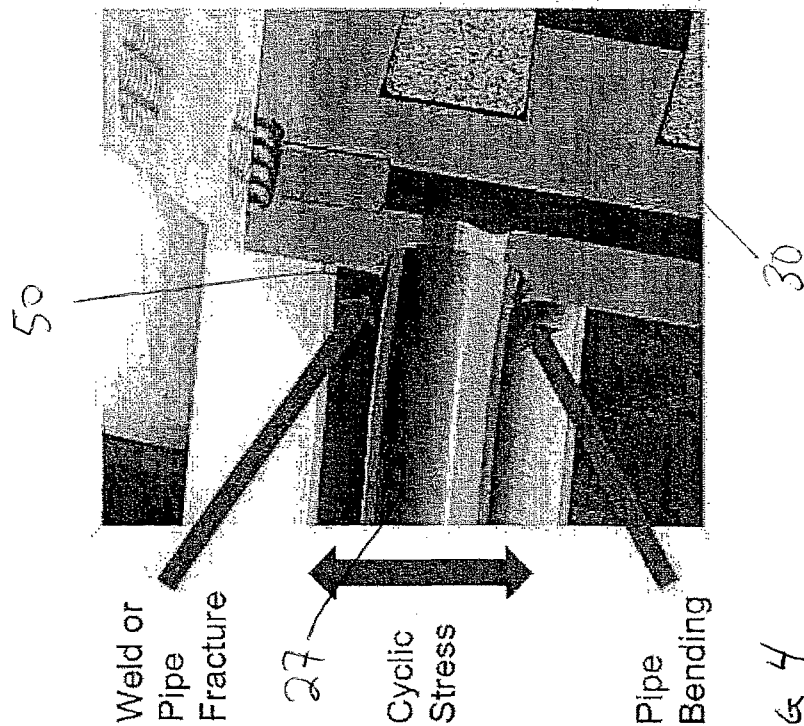
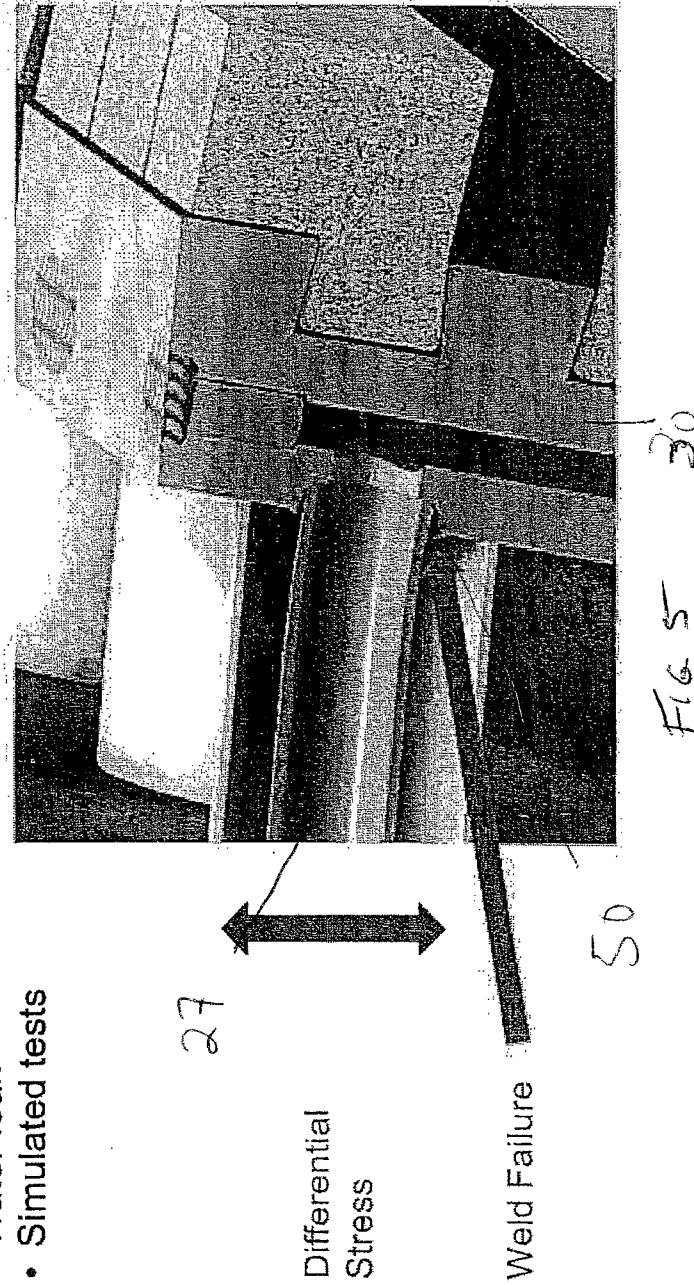


Fig 4

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Existing Stave Failure Mechanisms – Pipe Weld Cracks Due to Flow Disruptions

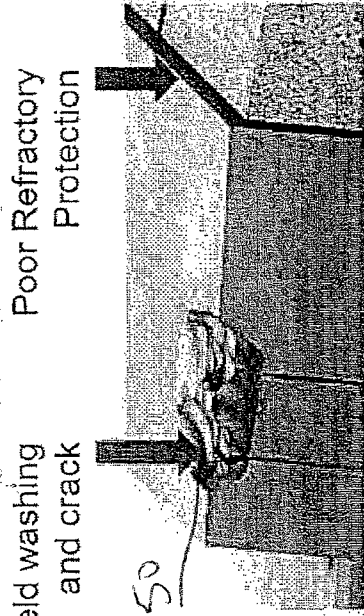
- Flow interruptions rapid heat up
- Heat input area vs. removal area
- Differential thermal expansion
- Water leak
- Simulated tests



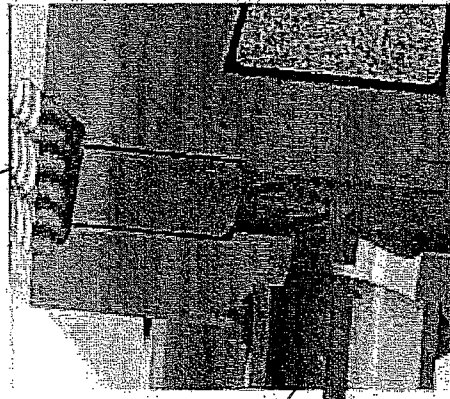
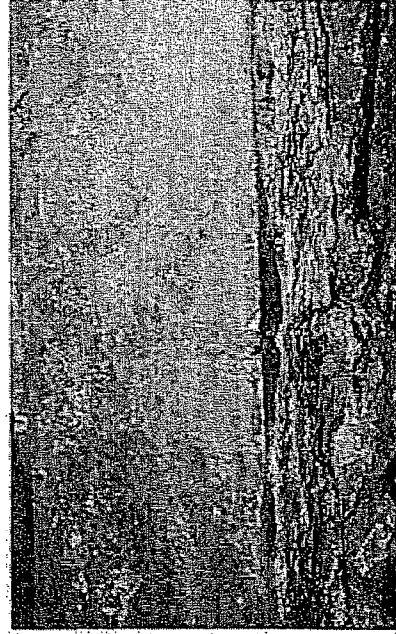
Existing Stave Failure Mechanisms – Plug Washing

- Non uniform flow
- Weld wire conductivity
- Cyclic stresses
- Limited protection top of stave
- Weld washing
- Water leaks

Weld washing
and crack



Plug Washing 3 Years Service



Water
Inlet

30 Fig 6

Property of the inventor, not to be used without his consent.

METHOD TO REPAIR COMPROMISED INLET OUTLET PIPING

RELATED APPLICATION

[0001] This application claims priority benefit under 35 U.S.C. § 119(e) of U.S. Provisional Application No. 61/567,395, filed December 6, 2011, the contents of which are herein incorporated by reference.

BACKGROUND

[0002] The cooling stave of the blast furnace body is used to protect the furnace shell, provide cooling, support brick lining refractory material and maintain a proper furnace shape. In operation, the heat of refractory material is transferred to the cooling stave base, and the base transfers heat to a pipe carrying cooling water. The cooling water takes heat out of the furnace. One failure mode occurs when the pipeline fractures in the heat load.

[0003] As pipe fractures are common, several existing methods were developed to reestablish cooling to the stave. These methods include blowing nitrogen through the stave, inserting a corrugated metal hose through the entire stave circuit and grouting around it with a lower conductivity grout, drilling through the blast furnace shell and stave to install cigar coolers, or grouting the inlet without cooling. The methods do not provide an effective means of cooling. The high stresses in the stave using these existing methods over time cause further damage to the stave. Damage includes the inlet outlet piping completely tearing from the stave, stave face washing, stave cupping or curving, and anchor bolts pulling from the stave.

SUMMARY

[0004] A first aspect of the application describes a repair method for a cooling stave utilized in a blast furnace, the cooling stave having a stave inlet outlet pipe attached to the cooling pipe in the cooling stave, the method comprising of the steps of: inserting a rigid pipe into the compromised stave inlet outlet pipe to form a first annulus; inflating a bladder disposed inside the inner pipe and cooling stave; injecting a first uncured epoxy material into the first annulus; permitting the first uncured epoxy to cure; and removing the bladder. In a preferred embodiment a first end of the inner tube distal to the stave further comprises a means for introduction of the first uncured epoxy to the first annulus, and a second end of the inner tube proximal to the stave further comprises means for venting air displaced during injecting of a first uncured epoxy into the first annulus. In a preferred embodiment the repair method further comprises the steps of: applying an outer pipe external to the compromised stave inlet outlet pipe to form a second annulus; injecting a second uncured epoxy material into the second annulus; and permitting the second uncured epoxy material to cure. In a preferred embodiment the first and second uncured epoxies are cured concurrently. In a preferred embodiment the first uncured epoxy is cured before the second

uncured epoxy is cured. In a preferred embodiment a first end of the outer tube distal to the stave further comprises a means for introduction of the second uncured epoxy to the second annulus, and a second end of the outer tube proximal to the stave further comprises a boot adapted to form seals with the outer tube and the stave, and the second end having an aperture in open communication with the second annulus.

[0005] A second aspect of the application describes a repair method for a cooling stave utilized in a blast furnace, the method comprised of the steps of: rethreading an aperture in the cooling stave formed after removal of a compromised stave inlet outlet pipe; installing a new inlet outlet pipe; inserting an inner rigid pipe into the new stave inlet outlet pipe to form an annulus; inflating a bladder inside the inner rigid pipe and the cooling stave; injecting an uncured epoxy material into the annulus; permitting the uncured epoxy to cure; and removing the bladder.

[0006] A third aspect of the application describes a repair system kit for a cooling stave utilized in a blast furnace, the cooling stave having a stave inlet outlet pipe comprised of: an inflatable bladder; an inner rigid pipe; a grout inlet; and a vent tube. In a preferred embodiment the repair system further comprises a concentric outer pipe; and a flexible rubber seal.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 illustrates embodiments of elements of one aspect of the application.

FIGURE 2 illustrates further embodiments of elements of the application.

FIGURE 3 illustrates another aspect of the application.

FIGURE 4 illustrates existing stave failure mechanisms.

FIGURE 5 illustrates existing stave failure mechanisms.

FIGURE 6 illustrates existing stave failure mechanisms.

DETAILED DESCRIPTION

[0007] In the following detailed description, reference is made to the accompanying examples and figures that form a part hereof, and in which is shown, by way of illustration, specific embodiments in which the inventive subject matter may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice them, and it is to be understood that other embodiments may be utilized and that structural or logical changes may be made without departing from the scope of the inventive subject matter. Such embodiments of the inventive subject matter may be referred to, individually and/or collectively, herein by the term "invention" merely for convenience and without intending to voluntarily limit the scope of this application to any single invention or inventive concept if more than one is in fact disclosed. The following description is, therefore, not to be taken in a limited

sense, and the scope of the inventive subject matter is defined by the appended claims and their equivalents.

[0008] Improved, more effective methods to reestablish cooling to the stave are necessary. Referring to **FIGURES 1-3**, the repair system utilizes an inflatable bladder **20**, a concentric inner rigid pipe **1**, a custom machined grout inlet **7**, vent tube **8**, and compression fitting **3**. In a preferred embodiment of the first aspect, inner rigid pipe **1** is inserted into the compromised stave pipe **27**. Inflatable bladder **20** is inserted into the inner rigid pipe **1** as far as stave **30**. The bladder **20** is inflated to a specified pressure and epoxy **15** is injected into the compromised stave inlet outlet pipe **27** and around the inner rigid pipe **1** via the grout inlet **7** in fitting **2**. The epoxy **15** is injected until the entire first annular gap **28** between the compromised stave inlet outlet pipe **27** and the inner rigid pipe **1** is filled. An optional vent tube **10** is positioned in the first annular gap **28** extending beyond the length of the first annular gap **28** allows for displaced air to escape. After the epoxy **15** is injected it is cured. When the curing is finished the bladder **20** is deflated and removed. In preferred embodiments, the inner rigid pipe **1** is an epoxy pipe.

[0009] In a second embodiment of the first aspect, an outer rigid pipe **5** may be positioned around the compromised stave pipe **27**. A grout inlet **7** is formed or attached through the outer rigid pipe **5**. A flexible seal **6** is fitted to an end of the outer rigid pipe **5**. The flexible seal **6** has an optional aperture **31** to allow for escape of displaced air. Epoxy **15** is injected until the entire second annular gap **29** between the compromised stave inlet outlet pipe **27** and the outer rigid pipe **5** is filled. After the epoxy **15** is injected it is cured. In preferred embodiments, the outer rigid pipe **5** is an epoxy pipe.

[00010] In a third embodiment, the compromised stave inlet outlet pipe **27** may first be removed from the stave **30** to give a resulting aperture. The resulting aperture is rethreaded and a new inlet outlet pipe is installed in the resulting aperture. The method steps of the first and second embodiments may then follow.

[00011] The repair being complete, stave inlet hoses may be reattached to the epoxy pipe **1**, in a preferred embodiment through an attached connector **4** and elbow **11** and the water circuit tested per plant procedures.

[00012] In some embodiments, a dowel rod **23** and pull rod **25** are used to assist in the insertion and removal of the bladder **20**.

[00013] In still another aspect of the invention, a repair system kit for a cooling stave utilized in a blast furnace, the cooling stave having a compromised stave inlet outlet pipe comprised of an inflatable bladder **20**, a rigid inner pipe **1**; a grout inlet **7**; and a vent tube **8**. The repair system kit may further comprise rigid outer pipe **5** and flexible seal **6**.

[00014] **FIGURES 4-6**, illustrate example staves **30** and stave inlet/outlet pipes **27** that may be repaired with the repair system and repair kit of the present application. Specifically **FIGURE 4**

illustrates a weld or pipe fracture 50 caused by heating and cooling cycles; FIGURE 5 illustrates a pipe or weld fracture 50 caused by flow disruptions; and FIGURE 6 illustrates a pipe or weld fracture 50 caused by plug washing.

[00015] This method of repair allows the customer to reestablish water to a compromised water pipe without losing the cooling effects of the water in contact with the stave.

[00016] The epoxy system offers the following advantages over conventional repair methods:

- Improved cooling compared to other methods
- Can be installed in short outages
- Can be installed when the leak is found
- Able to use existing cooling circuits
- Lower stresses on staves
- Can repair both upper and lower inlets or washed plug welds
- Increased strength to the stave inlet outlet piping

[00017] In the foregoing Detailed Description, various features are grouped together in a single embodiment to streamline the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments of the invention require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus, the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate embodiment.

[00018] It should be understood that while this invention has been described herein in terms of specific embodiments set forth in detail, such embodiments are presented by way of illustration of the general principles of the invention, and the invention is not necessarily limited thereto. Certain modifications and variations in any given material, process step or chemical formula will be readily apparent to those skilled in the art without departing from the true spirit and scope of the present invention, and all such modifications and variations should be considered within the scope of the claims that follow.