

[54] **ASSEMBLY FOR PLUGGING HEAT EXCHANGER TUBES**

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[22] Filed: **June 25, 1969**

[21] Appl. No.: **836,297**

[30] **Foreign Application Priority Data**

July 1, 1968 Austria.....A 6294/68

[52] **U.S. Cl.** .....228/15, 228/4, 29/470.5, 220/24.5, 138/89

[51] **Int. Cl.** .....**B23k 1/20**

[58] **Field of Search** .....228/15, 16, 3, 4; 29/470.5, 29/157.3; 220/24.5; 138/89

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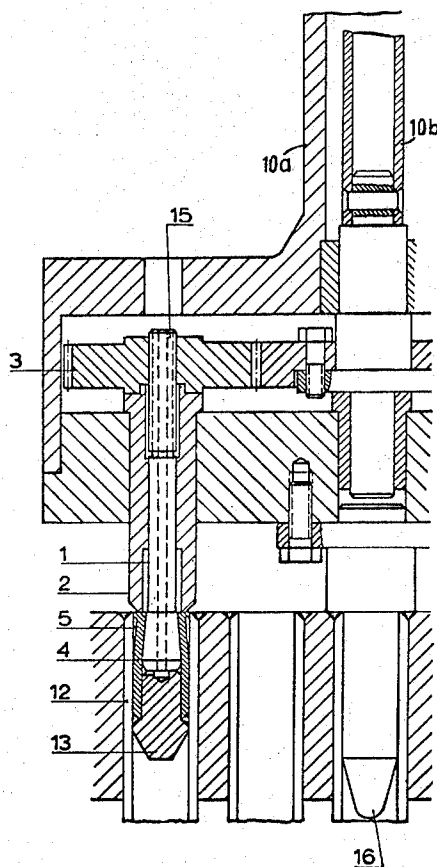
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[57] **ABSTRACT**

An assembly for plugging defective heat exchanger tubes. A plug which has a closed end and a deformable tubular wall extending therefrom surrounds with its tubular wall a deforming member which spreads the wall of the plug against an inner surface of a defective heat exchanger tube during withdrawal of the deforming member from the interior of the plug. A holding element holds the plug in position during withdrawal of the deforming member, and the latter is withdrawn by a pulling structure actuated through a transmission which is remotely operable from the exterior of the heat exchanger so that by guiding the assembly into the heat exchanger and positioning the plug in a defective tube it is possible to carry out the exterior of the heat exchanger operations which will fix the plug to the defective tube.

**10 Claims, 2 Drawing Figures**



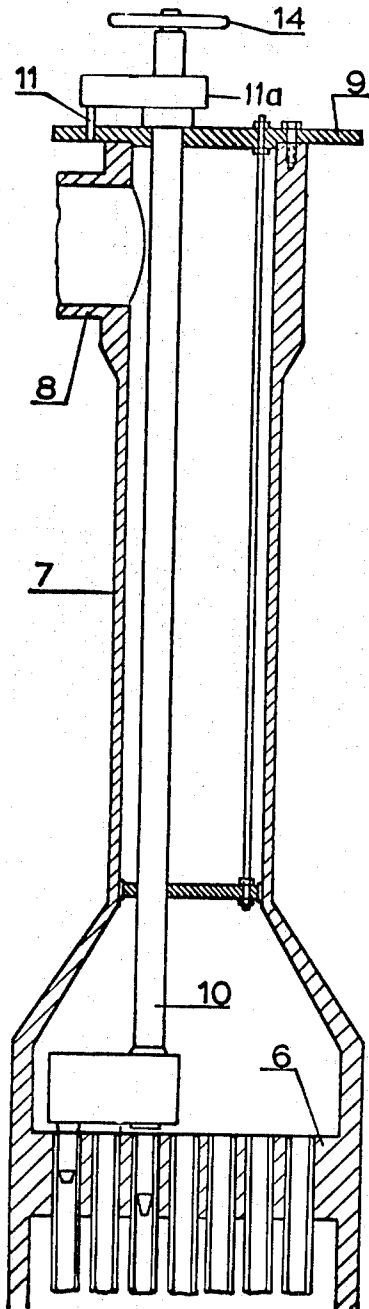


FIG. 1

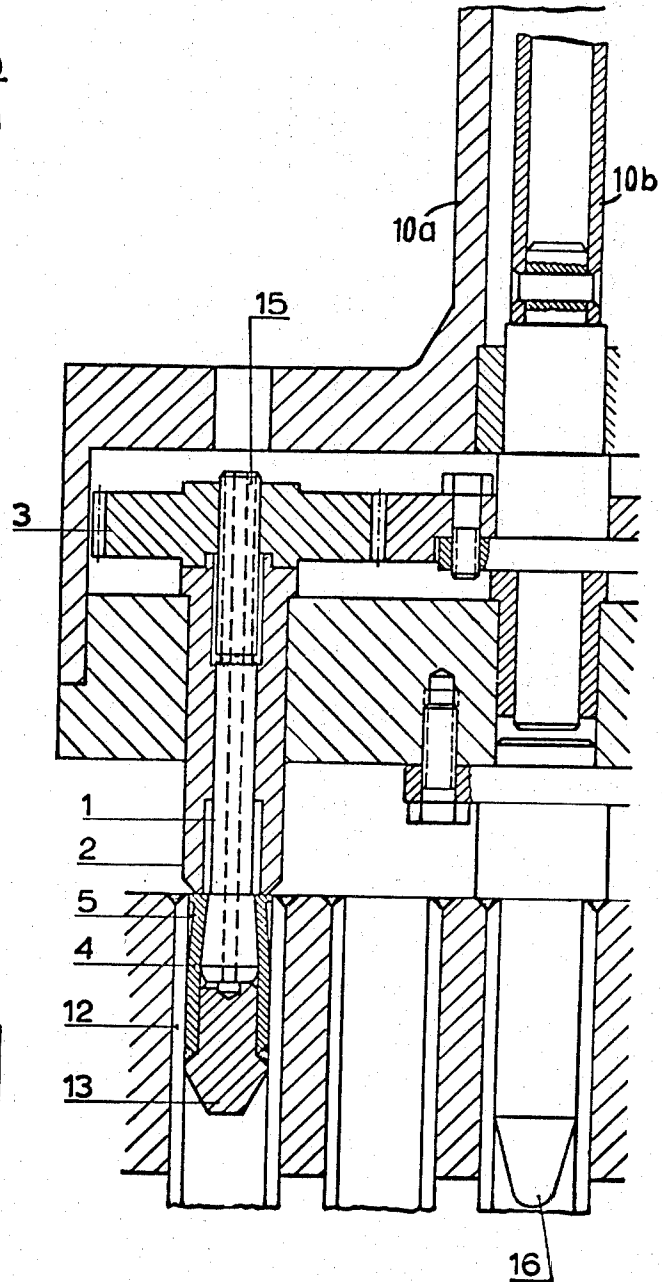


FIG. 2

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## ASSEMBLY FOR PLUGGING HEAT EXCHANGER TUBES

### BACKGROUND OF THE INVENTION

The present invention relates to the repair of heat exchangers.

In particular, the present invention relates to an assembly for plugging an end of the defective tube in the interior of a heat exchanger.

The invention is particularly applicable to remotely operable assemblies of this type which are especially useful with heat exchangers used in nuclear installations.

As is well known, when a heat exchanger tube becomes defective as by failing to maintain a proper sealed connection with the elements which carry the tube, particularly in the case of a heat exchanger tube of a nuclear installation, it becomes essential to prevent the defective tube from participating further in the operation of the heat exchanger. This elimination of such defective tube from the operations is carried out by plugging the ends of the defective tube where these ends communicate with a supply chamber where fluid is supplied to the tube and a discharge chamber where fluid discharge is from the tube. For this purpose suitable plugs and plugging machines are provided.

However, while such devices may be used with conventional heat exchangers where the tube sheets are freely accessible from the exterior as by removing an end cover of the heat exchanger, in the case of nuclear installations it is not possible to have ready access to the tube sheet. As a result considerable difficulties are encountered in installations of this latter type because the tube sheets are located at a considerable distance from the accessible exterior of the heat exchanger and there are no readily removable elements which can give free access to the tube sheet.

### SUMMARY OF THE INVENTION

It is accordingly a primary object of the invention to provide an assembly which will render it possible to close off defective interior tubes of heat exchangers in which the tubes are situated so that ready access cannot be had to the tube sheets from which the tubes extend.

In particular, it is an object of the invention to provide an assembly of this type which can be readily used with heat exchangers of nuclear installations.

Another object of the invention is to provide an assembly of the above type which can be remotely operated at the exterior of the heat exchanger to bring about introduction and fixing of a plug into an end of a defective tube which is situated at a considerable distance from the exterior of the heat exchanger in a relatively inaccessible interior portion thereof.

Another object of the present invention is to provide for an assembly of this type a construction which will reliably indicate at the exterior of the heat exchanger the precise location of the plug in the interior of the heat exchanger.

In accordance with the invention the assembly includes a plug which has a closed end and a tubular wall extending therefrom. This tubular wall is deformable and receives in its interior a deforming means which when axially displaced out of the tubular wall deforms the latter against an inner surface of a defective tube of

a heat exchanger. A holding means holds the plug while the deforming means is withdrawn therefrom and a pulling means coacts with the deforming means to pull the latter out of the plug so as to fix the latter to the defective tube. An operating means is located distant from the pulling means so that it can conveniently be situated at the exterior of the heat exchanger, and a transmission means extends between the operating means and the pulling means to transmit movement of the operating means to the pulling means. In this way by actuating the operating means at a location distant from the defective tube at the exterior of the heat exchanger it is possible to transmit to the deforming means through the pulling means a pull which will withdraw the deforming means out of the plug while the latter is held by the holding means so that in this way the plug can be deformed against the inner surface of a defective tube which will thus be reliably plugged and prevented from further participating in the operations.

### BRIEF DESCRIPTION OF DRAWINGS

The invention is illustrated by way of example in the accompanying drawings which form part of this application and in which:

FIG. 1 is a simplified fragmentary sectional elevation of one embodiment of an assembly of the invention shown schematically in its position of use during insertion of a closure plug into the end of a defective tube; and

FIG. 2 is an enlarged fragmentary sectional illustration of the structure of FIG. 1 at the region where a plug is located in an end of a tube, FIG. 2 showing details of the structure which are not apparent from FIG. 1.

### DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to the drawings, FIG. 1 illustrates the special assembly of the invention which includes a plugging device and a plug which is acted upon by the device. This assembly of the invention is shown used in connection with a defective tube which extends from an interior tube sheet 6 which extends transversely across and is connected to the interior of an elongated collecting pipe 7 in which fluid is collected. This collecting pipe 7 may be either the pipe in which water is supplied to be converted into steam in the heat exchanger or the collecting pipe 7 may be a steam pipe in which steam into which the water is converted collects. The conduit 8 which is fragmentarily illustrated extending perpendicularly from and communicating with the interior of pipe 7 may be either a supply conduit through which water is supplied or a steam conduit through which steam discharges.

As apparent from FIG. 1, the collecting pipe 7 has a top open end which is freely accessible at the exterior of the heat exchanger. This open end is normally closed by a suitable cover. However, when the structure of the invention is to be used the cover is removed and replaced by a different cover plate 9 which serves as a template, as will be apparent from the description below.

The cover plate 9 is releasably fixed to the top end of the pipe 7 in a predetermined manner which orients the plate 9 so that openings of the plate 9 will be precisely

positioned in alignment with the several heat exchanger tubes which extend from the tube sheet 6. Therefore these openings of the template 9 will precisely indicate the arrangement and layout of the several tubes extending from the tube sheet 6.

The assembly of the invention includes a rotary elongated straight rod 10, which may be hollow, as is apparent from FIG. 2, and this rod 10 forms part of a transmission means of the structure of the invention. The rod 10 is freely turnable within an opening of the plate 9 as well as within an opening of a lower plate which is parallel to the plate 9 and which is fixed thereto by tie rods one of which is illustrated in FIG. 1 at the right part of pipe 7. This lower plate has a periphery corresponding to the inner diameter of the pipe 7 at the portion thereof which extends upwardly from the outwardly flaring lower part which receives the lower portion of the apparatus of the invention. Thus, the plate 9 together with the lower plate shown in FIG. 1 in the interior of the tube 7 form a positioning and guide means for guiding and positioning the assembly of the invention in the collecting pipe 7.

The rod assembly 10 includes an outer rod 10a (FIG. 2) forming part of an outer housing of the entire assembly and an inner rotary rod 10b connected to an exterior handwheel 14 so that when the latter is turned the inner rod 10b will turn. On the other hand, the outer tubular rod 10a, which is freely turnable within the openings of the positioning and guiding means, carries a crank arm 11a from which a locating pin 11 extends. This pin is placed in a selected one of the openings of the template 9 for the purpose referred to below.

The housing which is shown in FIG. 2 connected with and extending from the outer hollow rod 10a carries a hollow tubular holding means 2 in which an elongated pulling means 1 is accommodated for vertical movement. Any suitable keys or the like coact on the one hand between the housing and the holding means 2 and on the other hand between the holding means 2 and the pulling means 1 to prevent rotary movement of the latter while freeing the pulling means 1 for axial movement.

The lower end of the pulling means 1 is tapered, as is clear from FIG. 2. This tapered portion of the pulling means 1 extends into the interior of an elongated tubular wall of a plug 4. This tubular wall of the plug is made of a deformable weldable material and is fixed by suitable welding to a closed end 13 of the plug. This closed end 13 is in the form of a body which has a lower tapered end facilitating entry of the plug into the defective tube 12. The welding of the hollow tubular wall of the plug 4 to the closed end body 13 thereof makes the entire plug 4 exceedingly simple to manufacture. This wall of the plug 4 is initially tapered to conform to the tapered configuration of the lower end portion of the pulling means 1. At its exterior surface the tubular wall of the plug 4 is formed with cutouts 5, so as to facilitate outward expansion and deformation of the wall of the plug during withdrawal of the deforming means 1 from the interior thereof. Thus, as may be seen from FIG. 2, while the bottom end of the holding means 2 engages the top end of the plug 4 to prevent the latter from moving out of the defective tube 12, the deforming means 1 can move upwardly so as to spread the wall of

the plug outwardly and into tight engagement with the inner surface of the defective tube 12.

The deforming means 1 and the plug carried thereby are at all times coaxially aligned with the locating pin 11. The operator will know which of the tubes is defective and which of the openings of the template 9 correspond with the defective tube so that the operator can locate the pin 11 in the proper opening of the template. The result is that the plug and pulling means 1 will be aligned with the proper tube 12. The crank arm 11a will cause the outer hollow rod 10a to swing together with the entire housing about the axis of the rod assembly 10 so as to locate the pulling means 1 and plug 4 in alignment with the proper tube 12.

It will be noted that the bottom wall of the housing carries, coaxially with the rod assembly 10, a guide pin 16 having a tapered bottom end facilitating entry of this pin into a tube which is in the region of the defective tube. Therefore, it is possible to support the entire assembly for rotary movement about the axis of the rod portion 10 thereof during introduction of the locating pin 11 into a proper opening of the template 9 with simultaneous introduction of the plug into the defective tube 12.

The interior hollow rod member 10b which is connected to the operating means 14 for rotary movement therewith forms part of the transmission means which includes the gear train 3 situated within the housing of the machine. This gear train terminates coaxially with the deforming means 1 and holding means 2 in an internally threaded rotary gear which is in threaded engagement with an exterior threaded portion 15 of the deforming means 1. Therefore, when the parts are in the position shown in FIG. 2 the operator need only turn the handwheel 14 so that through the transmission the left rotary gear 3 which is shown in FIG. 2 will turn with respect to the elongated pulling means 1. The threads 15 are such that this pulling means will be pulled up out of the plug which is held by the holding means 2, with result that the plug is expanded into tight engagement with the inner surface of the tube 12 through these operations.

The material used particularly for the tubular wall of the plug 4 is such that it will remain permanently deformed with plastic deformation taking place during withdrawal of the deforming means 1. Of course, the outer recesses or cutouts 5 in the exterior surface of the wall of the plug facilitate the expansion and deformation thereof.

As is apparent from FIG. 2, the entire elongated deforming means 1 is formed with an axial bore passing completely therethrough from one to the other end thereof. The purpose of this bore is to test a plug before it is introduced into the defective tube 12. Thus, the plug will initially be situated on the enlarged tapered lower end of the deforming means 1 as illustrated in FIG. 2. At this time the welded connection between the end body 13 and tubular wall of the plug is tested. This test is carried out by way of a wet helium spectrometer which in a well-known manner will check that there is absolute tightness between the welded components of the plug. For this purpose it is necessary that the interior of the plug be evacuated to a high degree so that very little pressure remains therein, and this evacuation of the interior of the plug is facilitated by way of the axial bore formed through the deforming means 1.

After the plug has been fixed in the interior of the defective tube 12 at an end thereof by outward expansion and permanent deforming of the wall of the plug tightly against the inner surface of the tube, it is desirable in many cases to provide an even tighter closure at the location where the repair has been made. For this purpose the illustrated structure, or a part thereof, may be replaced by a welding assembly which is interchangeable with the structure of the invention in the interior of the collecting pipe 7 and which makes it possible to weld the plug 4 to the defective tube 12 so that an extremely tight permanent closure of the defective tube 12 is achieved. The welding operations also are carried out from the exterior of the heat exchanger through a suitable operating means for the welding structure after the latter has been introduced into the heat exchanger by way of the same positioning and guiding means which is used for the plug-deforming assembly.

What is claimed is:

1. In an assembly for plugging a defective heat exchanger tube, a plug having a closed end and a deformable tubular wall fixed to and extending from said closed end to be expanded and deformed against an inner surface of a defective heat exchanger tube, deforming means situated within and surrounded by said wall of said plug for expanding and deforming said plug wall against an inner surface of a defective tube during complete withdrawal of said deforming means from the interior of said tubular plug wall, holding means coacting with said plug for holding the latter in a defective heat exchanger tube during withdrawal of said deforming means from the plug, operating means distant from said plug, deforming means, and holding means, pulling means coacting with said deforming means for pulling the latter completely out of a plug held by said holding means, and transmission means extending between and operatively connected with said pulling means and operating means for transmitting movement of said operating means to said pulling means to actuate the latter, whereby when said pulling means, deforming means, holding means, and a plug carried by said deforming means are situated in the interior of a heat exchanger with the plug introduced into an end of a defective tube and with said operating means accessible at the exterior, it is possible upon operation of said operating means to weld or otherwise fix the plug to the interior of the defective tube.

2. The combination of claim 1 and wherein a positioning and guide means coacts with said transmission means extending between said operating means and pulling means for guiding said transmission means along the interior of a fluid-collecting pipe which carries a transverse tube sheet from which said defective tube extends, said positioning and guide means guiding the remainder of assembly into the collecting pipe to a location where said plug carried by said deforming means will be precisely situated with respect to the de-

fective tube for entering into the latter.

3. The combination of claim 2 and wherein said positioning and guide means includes at an exterior end of said collecting pipe a template covering the open end of the collecting pipe and formed with a series of openings corresponding to the location of the tubes which extend from the tube sheet, and a locating pin interconnected with the plug and deforming means for indicating the location thereof at the exterior of the template so that by introducing said pin into a selected one of the template openings the plug will be introduced into the corresponding tube.

4. The combination of claim 1 and wherein said operating means, deforming means, holding means, transmission means, and pulling means are replaceable by a welding means which can be operated to act on said plug differently from said deforming means to weld the plug to the tube after the plug has been inserted into and deformed against the inner surface of the tube upon withdrawal of the deforming means.

5. The combination of claim 1 and wherein said deforming means has a tapered configuration and said wall of said plug being correspondingly tapered so as to be expanded upon withdrawal of the tapered portion of said deforming mean.

6. The combination of claim 4 and wherein said wall of said plug is made of an easily deformable and weldable material.

7. The combination of claim 5 and wherein said plug is provided at the exterior surface of its tubular wall with cutouts to facilitate deformation of said wall.

8. The combination of claim 5 and wherein said closed end of said plug is formed by a body which is welded to said tubular wall.

9. The combination of claim 2 and wherein said transmission means includes an elongated straight rod which extends axially along the interior of said collecting pipe and which is guided for rotary movement by said positioning and guide means, a positioning pin coaxial with said rod and extending into a tube which is adjacent the defective tube for positioning the rod in the interior of the collecting pipe, and said locating pin being connected by a crank arm to said rod so that the latter will turn during location of the locating pin in a selected template opening, turning the plug and deforming means also around the rod axis to properly situate the plug in the defective tube.

10. The combination of claim 9 and wherein said operating means is a rotary handwheel, said rod forming part of said transmission means and the latter including a gear train transmitting rotary movement of said rod to said pulling means, said pulling means including a threaded portion of said deforming means and a rotary threaded member surrounding an engaging said threaded portion and turned by said transmission means for displacing said deforming means out of said plug while the latter is held by said holding means.

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