

Feb. 21, 1950

J. W. SAWYER
MEANS FOR FORMING NEGATIVE SURFACE
REPLICAS OF TUBE INTERIORS

2,497,914

Filed April 5, 1949

3 Sheets-Sheet 1

FIG. 1.

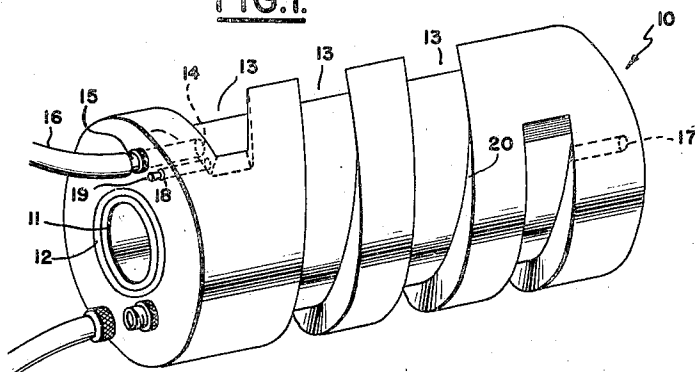


FIG. 2.

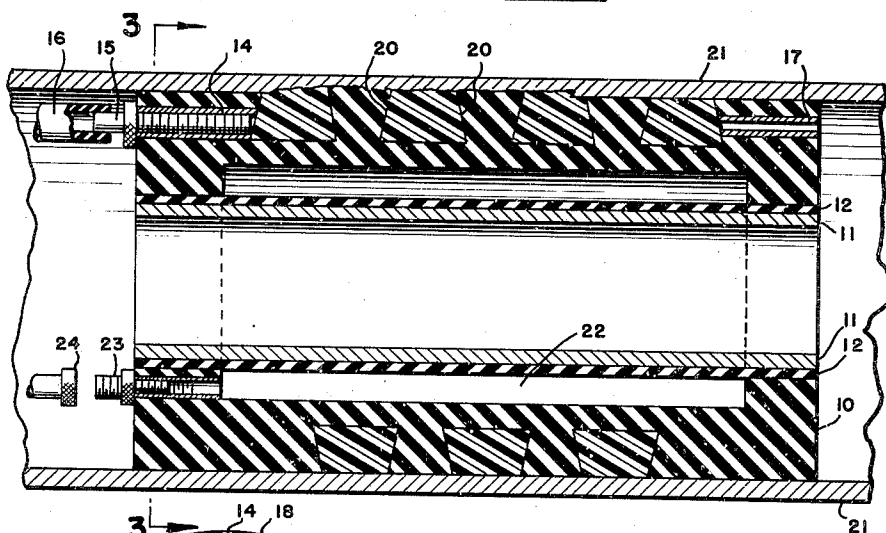
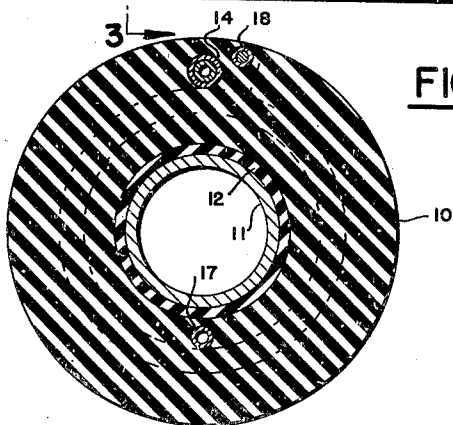


FIG. 3.



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FIG. 4.

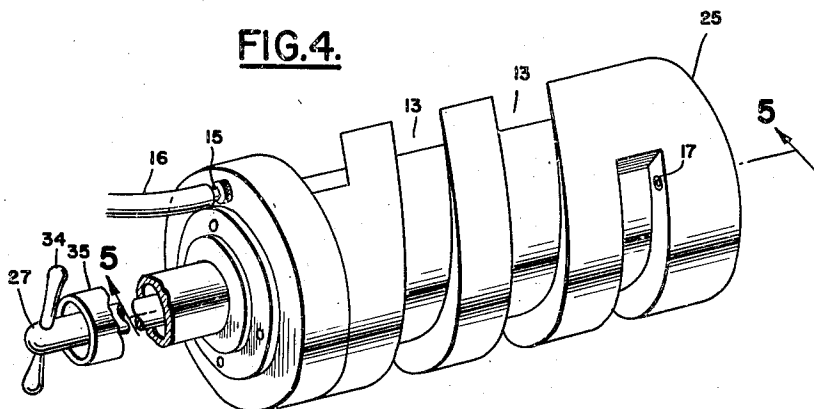


FIG. 5.

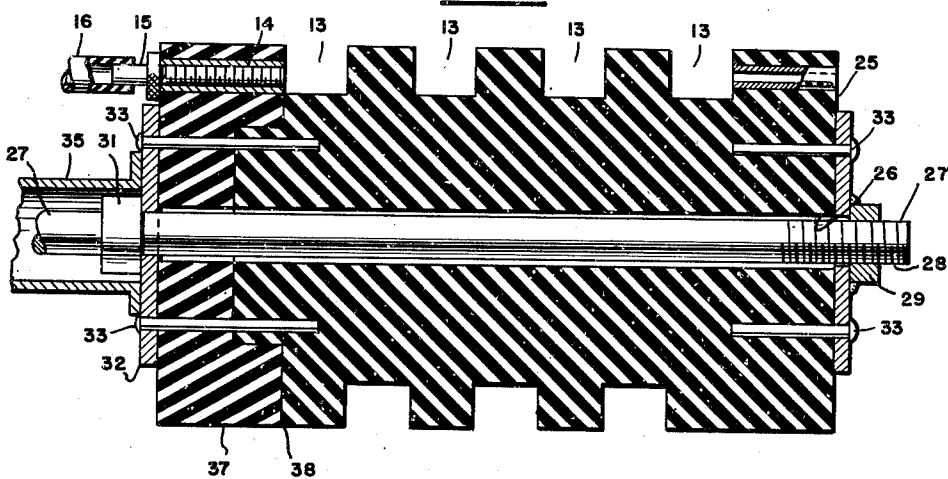
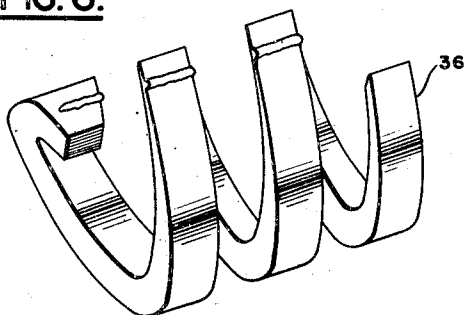


FIG. 6.



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FIG. 7.

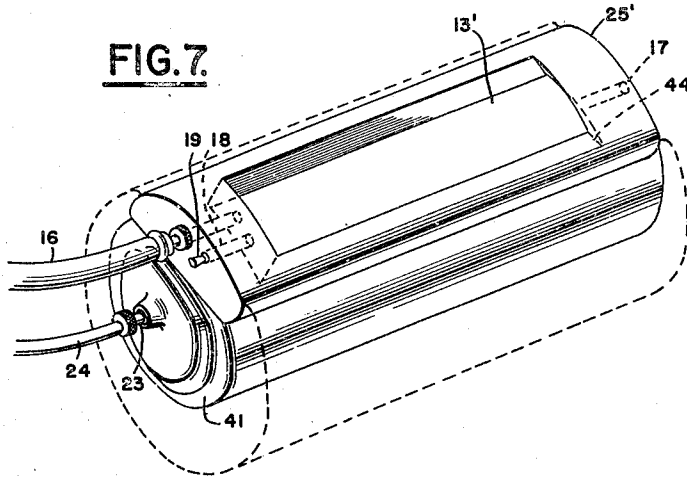


FIG. 8.

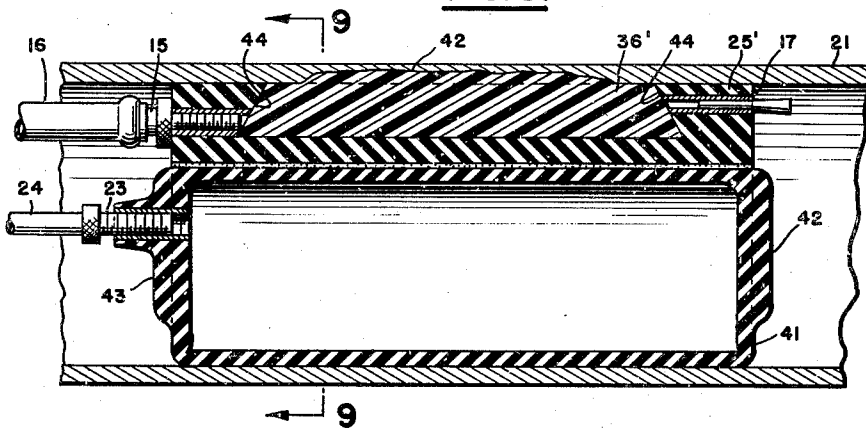


FIG. 9.

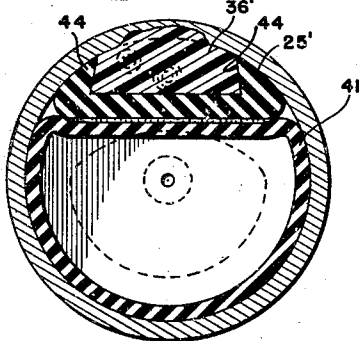
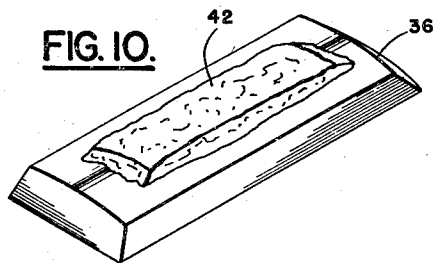


FIG. 10.



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UNITED STATES PATENT OFFICE

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MEANS FOR FORMING NEGATIVE SURFACE
REPLICAS OF TUBE INTERIORS

John W. Sawyer, Arlington, Va.

Application April 5, 1949, Serial No. 85,701

11 Claims. (Cl. 18—42)

(Granted under the act of March 3, 1883, as
amended April 30, 1928; 370 O. G. 757)

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This invention relates generally to the art of testing tubular structures while the tubes thereof are in place in an installation, and more particularly for casting negative surface replicas of tube interiors and removing the casting from the tube.

In the operation of boilers of the water tube or fire tube varieties there is a problem of internal surface pitting due to erosion, electrolysis, corrosion and oxidation which results in progressive failure of the tube structure. It is important in large installations for public service use, industrial uses and in Navy vessels to inspect periodically the condition of the tube interiors, and to determine the state of surface deterioration to detect the approach of ultimate failure of the tube structure. A similar problem and consequent need for periodic inspection occurs in underground sewage and water systems and in numerous other systems in which the failure of the tube structure arises from inside surface deterioration.

The difficulty of inspection of tube interiors by previously known methods has effectively prevented proper inspection, so that the eventual failure has generally not been predictable until actual failure has occurred. This results in failure of power aboard ship, in power plants and other installations, at highly inconvenient times with large economic losses of previously unavoidable type.

It is accordingly an object of this invention to provide a method of examining and testing interiors of tubular structures to determine the degree of deterioration of the tubes.

It is another object of this invention to provide means and method of casting a surface replica of any desired section of a tube interior and removing the casting for eventual testing by visual means or for quantitative measurement of the degree of deterioration at spaced or regular intervals.

A further object is to provide suitable apparatus for casting different types of negative surface replicas under various tube conditions.

A still further object is to provide the necessary means for removing surface castings from inner portions of long tubes of irregular or non-linear shape.

The exact nature of this invention as well as other objects and advantages thereof will be readily apparent from a consideration of the following specification relating to the annexed drawings in which:

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Fig. 1 is a perspective view of an inflatable mold employed in this invention;

Fig. 2 is a longitudinal section through a mold according to Fig. 1 having a plastic casting therein in place within a tube;

Fig. 3 is a cross sectional view of the assembly of Fig. 2 taken along the line 3—3;

Fig. 4 is a perspective view of an alternative form of the mold structure;

Fig. 5 is a longitudinal section taken along line 5—5 of Fig. 4;

Fig. 6 is a perspective view of a negative surface replica casting from the mold of Fig. 1 or Fig. 4, showing a typical longitudinal surface defect;

Fig. 7 is a perspective view of an uninflated mold of an alternative type for taking a plastic impression of a longitudinal defect in a tube;

Fig. 8 is a longitudinal section through a mold according to Fig. 7 after inflation in a tube and showing a casting in place in the tube;

Fig. 9 is a sectional view taken along the line 9—9 of Fig. 8;

Fig. 10 illustrates a typical molded impression of a tube interior surface from the mold of Fig. 7.

Referring now to the drawings in which like numerals refer to like or corresponding parts throughout the several views, there is shown in Fig. 1 an expansible mold 10 for the formation of a casting within the tube structure 21 to be tested, according to a preferred manner wherein a substantially linear tube is accessible from one end thereof, and where no severe constrictions are present to prevent insertion and withdrawal of the mold and casting. The material of the mold is of flexible material such as rubber or a plastic which will not react with the liquid plastic filler for the mold cavity. The flexible mold is preferably formed over a metallic cylinder 11 which reinforces the inner wall 12 of the hollow mold structure. The mold cavity 13 is illustrated as a spiral groove about the periphery of the outer mold wall which comes in contact with the inner surface of the tube under test. By forming the casting in this shape a flexibility is given to the set plastic permitting withdrawal thereof from the tube past minor obstructions. The spiral groove illustrated has the filling opening 14 at one end thereof fitted with a suitable hose connector 15 to which may be attached the hose 16.

Vent holes are provided at either end of the spiral cavity as at 17 and 18, each being fitted with stopper means. One such stopper is normally in place as at 19 while the other is removed during

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filling of the mold. The vent holes are arranged to permit fully filling the mold cavity with the axis thereof horizontal, the excess air leaving by way of outlet 17, and in filling the mold with the filling end uppermost, by opening the outlet 18 and closing 17, the excess air leaving by the uppermost vent hole.

The mold is made with a hollow region 22 extending substantially the full length of the mold, and at least to the region under the ends of the cavity 13. This hollow region is inflatable by means of an air connection 23 leading into the hollow region 22 and threaded for connection to an air line 24. When the mold has been inserted in the tube to the distance desired, lines 16 and 24 being connected, air pressure in line 24 expands the mold into firm engagement with the walls of the tube 21, whereupon the mold cavity is sealed and can be filled via hose 16. When the casting has hardened the air pressure is released and the mold contracts to normal size, disengaging the casting from the walls of the tube.

As shown in Figs. 1 and 2 the mold cavity is broader at the innermost face than at the face contacting the tube. The sides of the mold cavity are formed convergent outwardly as at 20. By this construction the contracting rubberlike material of the mold grasps the cast spiral by the several lateral faces to pull it from the walls of the tube 21. In order to increase the force with which the spiral casting is grasped for separation thereof from the tube walls the mold diameter is normally made substantially less than the tube diameter, inflation of the mold being necessary to effect a tight fit of the mold in the tube. Thus the mold may be readily withdrawn from the tube by the lines 16 and 24, at the same time removing the spiral casting, and preserving the casting for study of the section of tube surface to be examined.

The inner wall of the mold 12 is conveniently formed separately from the remainder of the mold 10, after which the sleeve 12 may be cemented or vulcanized in place to complete the mold assembly. The metal sleeve or tube 11 is thereafter inserted to strengthen the sleeve 12, if desired.

The type of material used in filling the mold for casting a negative surface replica of the desired type is more fully disclosed in co-pending patent application Serial Number 79,264, filed March 1949, by John W. Sawyer for Method and apparatus for testing surface defects. The molding materials used are preferably of the chemical setting type in which the filler, if any, is of fine texture to preserve minute details of surface structure. Methods of injecting liquid plastic in molds are also disclosed in the same co-pending application, as are also various types of apparatus employed for the purpose of measuring surface defects accurately reproduced in negative replica by the method and apparatus of this invention.

In Fig. 4 is shown an alternate form of mold, generally similar to mold 10, except that inflation of the mold after insertion in the tube is not required. The mold 25 is of similar external shape, but lacks the sleeve 11 and hollow region 22 and the inflating means 23 and 24. The spiral groove may be the same as in Fig. 1 or may be of the straight-sided type illustrated. In place of the hollow region 22 and the internal sleeve 11 the mold is formed with a smaller central hole such as 26 of size to receive a tension member 27, threaded one end as at 28, to engage the threaded collar 29, which engages one end of the mold 25. At the other end of the mold there is attached

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the collar 31 or member 27 which rotatively engages washer 32 to compress the mold longitudinally as the threaded portion 28 is screwed into the collar 29, the collar 31 being rigidly fixed to the member 27. Pins 33 key the collar 29 and washer 32 to the mold to prevent rotation thereof as the member 27 is screwed into the collar 29.

An extension of member 27, of sufficient length to extend beyond the tube being examined, is furnished and has a turning handle 34. A tubular member 35, of similar length and surrounding the extension of member 27, is conveniently provided for inserting the mold into the tube under examination. The operator, by grasping the member 35 and turning member 27, can compress or release the pressure on the mold member 25 as desired. When the mold is inserted the desired distance into a tube it may be expanded in diameter as much as required to produce a tight fit within the tube. In this manner a 50% expansion of diameter is found to be practicable.

For ease in removing a molded impression of the spiral type, as shown at 36 of Fig. 6, the mold 25 may be provided at one end with a separable endpiece 37 joined to the mold at a snug fitting junction 38. When the mold has been filled, the molded impression hardened, and the assembly withdrawn from the tube, the piece 37 is removed and the piece 35 unscrewed from the mold 25, after which the mold may be reassembled for the next casting.

Another form of mold suitable for casting a negative surface replica of a tube interior is illustrated in Figs. 7, 8 and 9. The mold cavity, according to this modification, may be of the shape illustrated for taking an elongated impression at one side of the tube, or it may be of any other desired shape. The modification shown embodies a means of securing the mold cavity to the interior face of the tube, and consists essentially of an inflatable rubberlike tube having reinforced ends and secured to a mold 25' by cementing, vulcanizing, or the like, the means for inflating the rubberlike tube being generally similar to that of Fig. 1.

The mold 25' is functionally similar to mold 25 and has a mold cavity 13' of any desirable shape. Air vents and filling tube structures may be as illustrated in Fig. 1 and as described. The inflatable tube 41 is shown largely deflated in Fig. 7 and inflated in Figs. 8 and 9 thereby to fill the tube 21 and firmly press the mold 25' against the interior of the tube.

An air connection 23 and hose 24 secured to the inflatable tube or bladder 41 provides means of securing the mold to any section of pipe or tube in which it is placed. The flexible and deflatable nature of the bladder permits inserting the mold into the interior regions of pipes and tubes having constrictions which would prevent the insertion of molds of the type shown in Figs. 1 and 4. By the use of a flexible shaft or spring thrusting member the mold may be passed around right angle bends or turns in a pipe or tube, and the mold may be employed for casting impressions of remote and inaccessible sections of pipe.

The tube or bladder 41 is preferably provided with end reinforcing members 42 and 43 to prevent excessive endwise dilation of the bladder as it is inflated. The reinforcing member 43 may be provided with a thickened portion for supporting the air connection 23. As the bladder is inflated pressure is applied laterally against the sides of the tube 21, forcing the mold 25' against

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the tube. The lateral pressure caused by confining the sides of the bladder is adequate to secure the mold in the region of the tube selected and to force the surface of mold 25' into intimate contact therewith even though shaped for a pipe of different diameter. The embodiment of Figs. 7-9 is therefore suitable for use in a wide range of tube sizes, such for example, as two to six inches or like ratio of diameters.

The sectional view of Figs. 8 and 9 and the perspective view of Fig. 10 show overhanging lips 44 of the mold 25' for the purpose of casting a generally trapezoidal edged replica such that the mold 25' grips the casting 36' after hardening thereof and deflation of the bladder 41. This construction facilitates removal of the replica from inaccessible regions of a tube or pipe. It is merely necessary to place, inflate and fill the mold, await hardening of the plastic, deflate the mold by releasing air pressure therefrom, and to withdraw the mold and casting by pulling on the tubes 16 and 24.

As described in the co-pending application referred to hereinbefore, the cast replica may be taken from the surface on which cast and examined microscopically, visually or by laboratory methods at engineering headquarters remote from the location of the structure examined. Progressive failure is logged by repeated or periodic tests of surface deterioration as revealed in the structure of the negative replicas thereof. Failures of tubes and pipes are predictable to an extent heretofore not possible, a suitable surface sampling procedure being provided by the structure and methods herein described. Quantitative measurements of tube corrosion by laboratory instruments such as profilometers and profilographs provide an improved technique of inspection for pipes and tubes which are themselves inaccessible for test or inspection.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood, that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

Having thus described the invention, what is claimed is:

1. In a mold for the construction of a negative replica of a tube interior surface, the combination of, an elongated mold member of diameter substantially less than the diameter of said tube, a mold cavity channel formed within the periphery of said mold member and adapted when pressed against the interior surface of the tube to form a complete closed mold cavity, means extending beyond the end of the tube for expanding said mold member into contact with said surface, means extending beyond the end of the tube and into said mold cavity for filling the cavity with a liquid molding material, means venting the cavity to permit complete filling thereof, and means for removing the mold and negative replica therein when the molding material has set.

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2. The combination of claim 1 in which the mold cavity channel has overhanging sides for engaging the sides of the negative replica to facilitate removal thereof.

3. The combination of claim 1 in which said mold cavity channel is spirally formed about the periphery of said mold member for forming a negative replica extending at least throughout the circumference of a section of the tube.

4. The combination of claim 3 in which said spirally formed mold channel has overhanging lips for engaging sides of the negative replica after hardening thereof, thereby retaining the spiral replica in the channel.

5. The combination of claim 1 in which said means for expanding the mold member comprises an air-tight hollow flexible container and means for inflating said container.

6. The combination of claim 5 wherein said flexible container is reinforced with a rigid cylindrical tube arranged concentrically within the mold member.

7. In a mold structure for casting an impression of an internal tube surface, a generally cylindrical mold structure of resilient rubber-like material substantially smaller in diameter than said tube, a mold cavity extending substantially around the circumference of said mold structure, said cavity being open adjacent to said surface, a pair of collars at the ends respectively of the mold structure, at least one being threaded, arranged for compressing the mold structure longitudinally, a rigid screw member arranged within the structure and threadedly engaging the collars for adjustment of the spacing therebetween, and rigid turning means extending beyond said tube and engaging said screw member, whereby the spacing between the collars is adjustable from outside the tube to expand the mould structure into peripheral contact with the tube surface.

8. The mold structure of claim 7 wherein the mold cavity is a spiral groove in the outer face of the cylindrical mold.

9. The mold structure of claim 7 having a mold positioning and holding member concentrically arranged with said rigid turning means.

10. The mold structure of claim 9 having a flexible tube connection to said mold cavity and vent means for venting the air from the cavity as the casting material is forced through said flexible tube connection.

11. A mold for use within a rigid tube interior comprising; a flexible walled structure shaped for general conformity to a section of tube surface and defining an open-sided cavity; means for forcing said flexible structure into tube surface conformity comprising, an inflatable bladder of rubber-like material, reinforcing means at the ends of said bladder, the bladder being secured along one side of said flexible walled structure; means including an air connection and air tube extending beyond said rigid tube for inflating the bladder; and flexible filling tube means connected to said cavity for filling the cavity after inflation of the bladder.

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No references cited.