

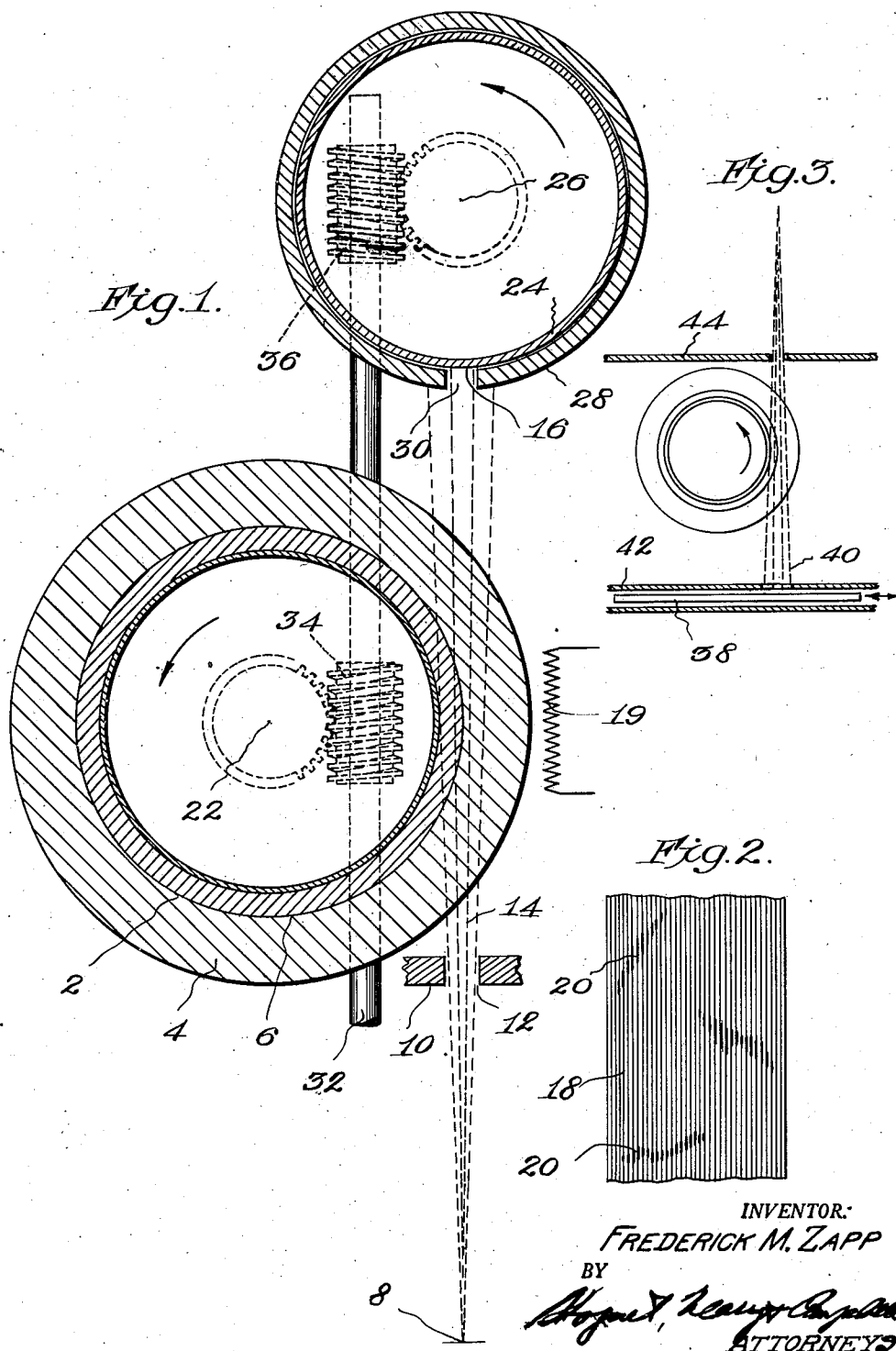
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X-RAY INSPECTION OF BODIES

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X-RAY INSPECTION OF BODIES

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This invention relates to methods and means for the examination of bodies to determine the presence and location of flaws therein, and relates particularly to the X-ray examination of bodies formed of dissimilar materials.

It is frequently of great importance in the manufacture of engines, bearings, and other machine parts or manufactured products wherein there is a bond between dissimilar materials, to inspect the bond to determine whether it is complete and sound or is standing up under the conditions of use. Thus, for example, when manufacturing aeroplane motors having a steel sleeve or cylinder barrel on which an aluminum muff has been cast for the machining of cooling fins of the engine, it is important to insure the formation and preservation of a complete and adequate bond between the different metals.

Flaws or cracks in the bond between the aluminum muff and steel sleeve not only weaken the structure but greatly decrease the heat transfer from the cylinder to the cooling fins. Moreover, if such flaws exist, the effect thereof is increased on heating and expansion of the metals, since the aluminum has a greater coefficient of expansion than the steel and tends to enlarge any cracks or non-conducting areas.

No satisfactory method or means has existed heretofore for the inspection of bonds or areas of this character.

In accordance with the present invention, the desired inspection is effected by means of X-rays and the operation is carried out by methods and means which not only indicate the presence of an imperfect bond between the materials, but also indicate the location and extent of the imperfection. Furthermore, the present invention renders it possible to locate flaws and cracks or imperfections which are so minute or latent as to be incapable of detection by prior means of inspection as well as any sponginess in the aluminum muff or other imperfections in the metals under inspection.

These results are preferably attained by passing a beam of X-rays through the bond while the materials are heated or subjected to differences in temperature which tend to open up any cracks or weak bonds between the materials. When the bond is concentric with an axis of the body to be examined, the beam of X-rays may be passed tangentially through the bond onto an X-ray sensitive film or screen and if desired, the body and screen may be moved in a coordinated manner to associate the exposure of different portions of the screen with particular portions of the

object under inspection so as to definitely locate the position and extent of any imperfection in the product.

One of the objects of the invention is to provide novel methods and means for the X-ray examination of bodies.

Another object of the invention is to provide methods and means for examination of bonds between materials having different coefficients of expansion.

A further object of the invention is to provide improved methods and means for the examination of areas of a body which are concentric with an axis of the body.

A specific object of the invention is to simplify the examination of concentric cylinders of different metals to determine the character and action of the bond therebetween.

These and other objects and features of the invention will appear from the following description thereof in which reference is made to the figures of the accompanying drawing.

In the drawing:

Fig. 1 is a diagrammatic plan view of one form of mechanism embodying the present invention; Fig. 2 illustrates a typical exposed film produced with the mechanism of Fig. 1; and

Fig. 3 is a diagrammatic illustration of an alternative embodiment of the present invention.

In that form of the invention illustrated in Fig. 1, the article to be examined is shown as an engine cylinder having a steel sleeve 2 with an aluminum muff 4 bonded to the sleeve. The bond between the steel and aluminum is shown at 6 and represents the area to be examined. A suitable source of X-rays is indicated at 8 and a shield 10 having a slot 12 therein is positioned so that a beam of X-rays 14 will pass through the slot 12 and through the engine cylinder tangential to the bond 6 between the sleeve 2 and the aluminum muff 4.

An X-ray sensitive film or screen 16 is located in position to receive X-rays after they have passed the bond 6 so as to record the condition of the bond. If the bond between the aluminum and steel is faulty, there will be a crack through which the X-rays will pass more readily than they pass through the metals and as a result, the film or screen will be exposed to a greater extent in those areas than in portions which are completely shielded by the steel and aluminum. The nature, location and size of the crack can then be determined from inspection of the screen. Similarly if there are spongy areas in the alumi-

num or other flaws in either metal they will be shown up by the X-rays.

Since any cracks in the bond may be very small and therefore difficult to identify or observe, the whole body may be heated or heat may be applied only to the aluminum muff on the exterior of the sleeve so as to cause the aluminum to expand to a greater extent than the steel sleeve. The crack will then be opened up appreciably or cracks may be produced in weakened areas which would not withstand the conditions under which the engine will be used. The enlarged cracks pass a greater portion of the X-rays than smaller, hair-line cracks, or a weakened bond, and thus insure sufficient exposure of the screen or film to render small or latent imperfections more easily observable.

The whole body may be heated by any suitable means, such as the heating element 19, or, if desired, a difference in expansion of the metals or materials may be established by heating or cooling one metal to a greater extent than the other. The metals may be readily cooled by means of a cooling medium such as Dry Ice, or the like. When examining a bearing or other object in which the metal having the greater coefficient of expansion is located on the interior of a metal of lower expansion Dry Ice or a cooling medium may be located in the center of the body. The manner in which the object is heated or cooled should in any case be such as to cause the bond or joint between the materials to open up and thus offer less resistance to the passage of X-rays therethrough.

In order to examine a complete cylinder or other object having a bond concentric with an axis of the body, it is necessary to rotate or otherwise move the body and screen so that the full extent of the bond may be inspected. This may be accomplished by mounting the cylinder on a suitable support and rotating it about its axis 22 while keeping the area to be examined in the beam of X-rays and between the source of X-rays and the screen. The location and extent of the crack or imperfection in the bond or other flaws in the product can be determined by moving the film or screen relative to the cylinder so as to obtain a continuous or intermittent series of exposures which serve to record the condition of each or a plurality of sections of the bond under inspection.

By moving the cylinder and film 16 in a coordinated manner with respect to the beam of X-rays 14 successive and predetermined portions of the film may be exposed to show the condition of successive and predetermined areas of the bond. A typical exposed film produced in this manner is illustrated in Fig. 2 wherein the area 18 corresponds to a perfect section of the bond and the areas 20 indicate over-exposures corresponding to cracks in the bond.

As shown in Fig. 1, the film 16 is mounted on a cylindrical support 24 rotatable about an axis 26 parallel to the axis 22 about which the article to be examined is rotated. The film is shielded by a stationary lead sheath 28 having a sight opening 30 through which it is exposed to the beam of X-rays. The support 24 may itself be formed of lead or shielded to prevent the X-rays passing through the sight opening 30 from exposing the film a second time as it passes the side of the cylinder opposite the sight opening.

The movement of the object to be examined and the film 16 are preferably coordinated by suitable means such as the shaft 32 and worms

34 and 36, so that the speed of movement of the bond 6 and that of the film are equal or related. The location of any dark or over-exposed areas on the film will then correspond to the location of any cracks between the sleeve and muff or other imperfections in the piece being examined.

Instead of rotating the film it may be supported in a cassette 38 as shown in Fig. 3 and moved in a vertical plane past the sight opening 40 in the lead shielding tracks 42. A further lead shield 44 also may be provided to aid in limiting the X-ray radiation passing toward the film and thereby reduce fogging of the film by stray X-rays. Movement of the film and cassette may be coordinated so as to advance the film only one half as rapidly as the bond rotates so that the area of any flaws in the bond will be concentrated and brought out more distinctly on the film.

In either form of the invention the exposure of the film and the movement of the cylinder may be continuous or in successive steps. Continuous movement of the cylinder and film speeds up the inspection operation whereas step by step inspection can be carried out with simpler equipment.

The constructions described not only indicate the location and character of flaws in the bond but they also indicate the presence and location of imperfections such as spongy areas in the aluminum muff. The latter will pass X-rays more readily than sound metal and the record on the film will show two areas corresponding to the increase in radiation permitted when the spongy area intercepts the beam of X-rays at the front and again at the rear of the arc through which it travels past the X-ray beam.

It is usually preferable also to use X-ray sensitive film instead of a fluorescent screen or other means giving a transient record of the piece since the record can then be attached to the piece as it passes through the plant or is returned for repair or further inspection. Moreover, the contrast in areas of the film can be made more pronounced by prolonged exposure so as to increase the density of the areas of the film showing the location of imperfection.

While the forms of the invention shown in the drawing include a cylindrical support and a cassette for the film, any other form of support may be used and the elements employed for moving the object and film or for coordinating their movement may be varied as desired without departing from the spirit and scope of the invention.

I claim:

1. A method for the examination of curved bonds between materials having different coefficients of expansion which comprises the steps of subjecting the materials to temperature conditions which tend to separate the materials at the bond, passing X-rays through the bond tangential thereto, and registering the condition of the joint on an X-ray reactive screen.

2. A method for the examination of curved bonds between materials having different coefficients of expansion which comprises the steps of heating the materials until they tend to separate at the bond, passing X-rays through the bond tangential thereto, and registering the condition of the bond on an X-ray reactive screen.

3. A method for the examination of curved bonds between materials having different coefficients of expansion which comprises the steps of heating the material having a higher coefficient

of expansion until it tends to separate from the other material at the bond, passing X-rays through the bond tangential thereto, and registering the condition of the bond on an X-ray reactive screen.

4. A method for the detection of flaws in a curved bond between metals having different coefficients of expansion which comprises the step of passing X-rays through the bond tangential thereto while said metals are at different temperatures tending to cause separation at the bond and registering the condition of the bond on an X-ray sensitive screen.

5. A method for the examination of a body having a bond therein between materials having different coefficients of expansion and located in an area concentric with an axis of the body, which comprises the steps of rotating said body about said axis, subjecting said materials to temperature conditions which tend to separate said materials, and passing X-rays through said body tangential to the path of movement of the bond and onto an X-ray sensitive surface.

6. A method for the examination of a body having a bond between dissimilar materials located concentric with an axis of the body which comprises the steps of heating said body until said materials tend to separate at said bond, rotating said body about said axis, passing a beam of X-rays tangentially through said bond, moving an X-ray sensitive screen with respect to said beam at a speed corresponding to the speed of movement of said bond, and shielding said screen from X-rays except at a narrow zone in alignment with said bond, whereby the position of differently exposed portions of the screen will bear a predetermined relation to the position of definite portions of said bond.

7. Apparatus for the inspection of bonds between dissimilar portions of a body having the form of a surface of revolution, comprising means for rotating said body about its axis, means for generating X-rays, means for moving an X-ray sensitive means in a manner coordinated with the movement of the body, and shielding means interposed between said rotating means and said X-ray sensitive means, having a narrow X-ray pervious portion permitting substantially only

those X-rays passing through said bond to impinge upon said X-ray sensitive means.

8. Apparatus for the inspection of bonds between dissimilar portions of a body having the form of a surface of revolution, comprising means for rotating said body about its axis, means for generating X-rays, a film holder rotatable about an axis parallel to the axis of said body, means for coordinating the speed of rotation of said body and holder, and shielding means interposed between said holder and said rotating means having a narrow X-ray pervious portion in alignment with said X-ray generating means and said bond.

9. Apparatus for the examination of a bond between metals having different coefficients of expansion and located in an area concentric with an axis of a body comprising means for subjecting said body to temperatures which tend to separate said metals at the bond, means for rotating said body about its axis, means for passing X-rays through said body tangential to said bond, movable X-ray sensitive means positioned to receive X-rays after they have passed through said bond, means for coordinating the movement of said X-ray sensitive means and said body rotating means, and shielding means interposed between said X-ray sensitive means and said body rotating means, said shielding means having a narrow X-ray pervious portion in alignment with said bond.

10. Apparatus for the examination of a bond between metals having different coefficients of expansion and located in an area concentric with an axis of a body comprising means for subjecting said body to temperatures which tend to separate said metals at the bond, means for rotating said body about its axis, means for passing X-rays through said body tangential to said bond, X-ray sensitive means positioned to receive X-rays after they have passed through said bond, means for moving said X-ray sensitive means in a manner coordinate with the movement of said body, and shielding means interposed between said X-ray sensitive means and said body rotating means having a narrow X-ray pervious portion substantially in alignment with said bond and the source of X-rays.

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