United States Patent [19]

English

[11] **3,891,845**

[45] **June 24, 1975**

[54] **WET ENVIRONMENT RADIOGRAPHY APPARATUS**

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[22] Filed: **Dec. 18, 1972**

[21] Appl. No.: **315,914**

[52] **U.S. Cl.** **250/321;** 250/358; 250/508

[51] **Int. Cl.** **G03b 41/16**

[58] **Field of Search** ..... 250/65 R, 83.3 D

[56] **References Cited**

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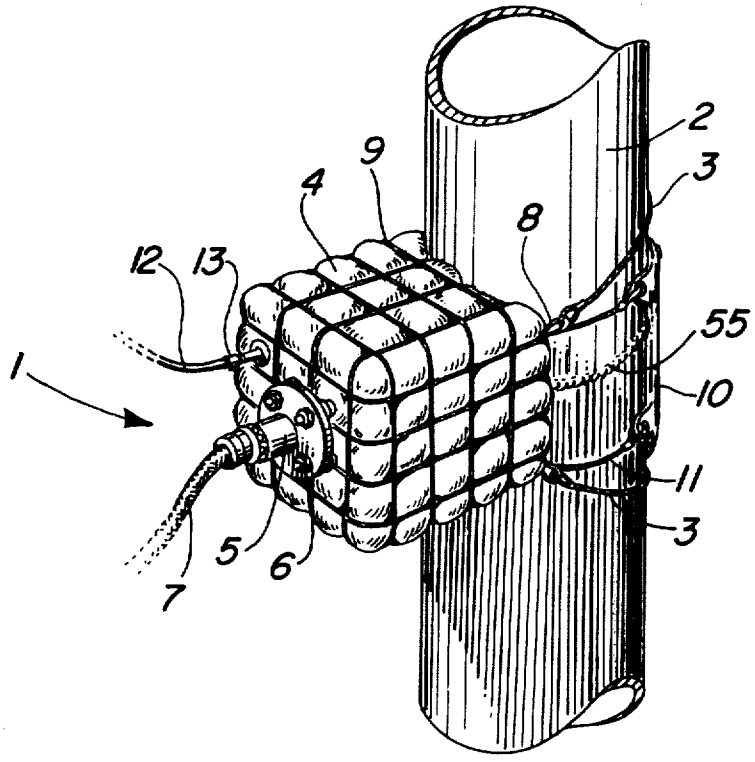
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Primary Examiner—James W. Lawrence
Assistant Examiner—C. E. Church
Attorney, Agent, or Firm—George F. Helfrich

[57] **ABSTRACT**

A wet environment radiography apparatus attachable to the exterior surface of an object which is to be radiographed where the exterior surface is in a wet environment.

5 Claims, 9 Drawing Figures



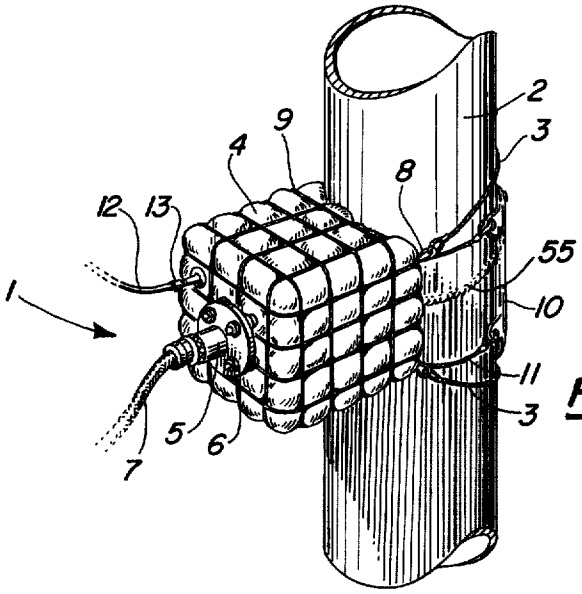


FIG. 1.

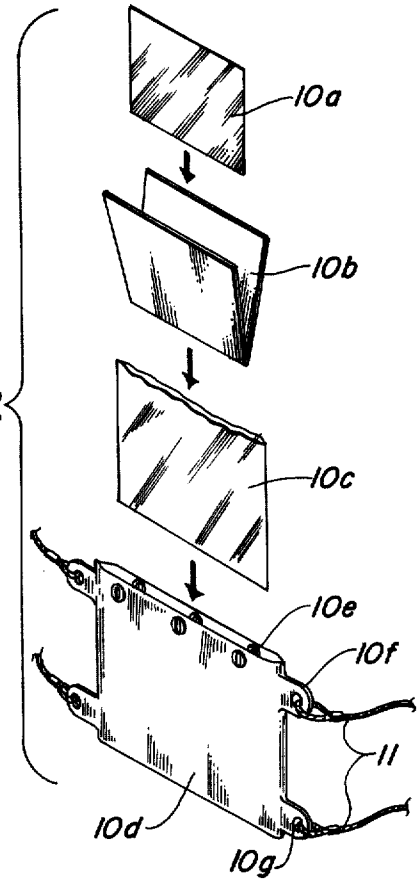


FIG. 2.

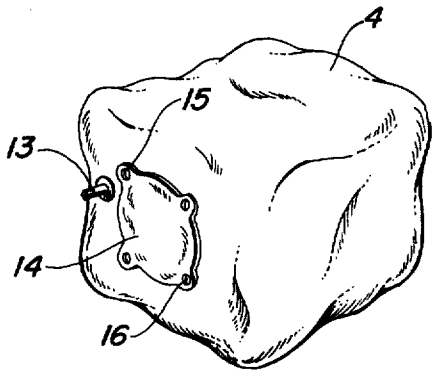


FIG. 3.

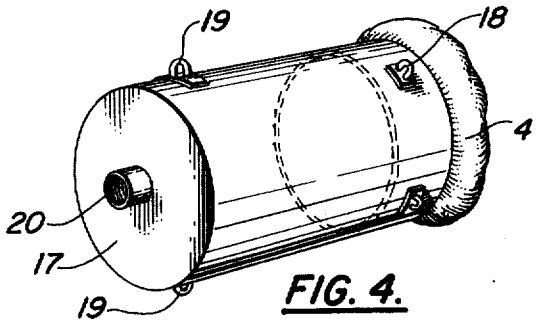


FIG. 4.

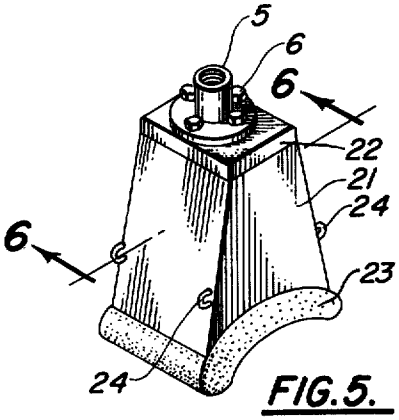


FIG. 5.

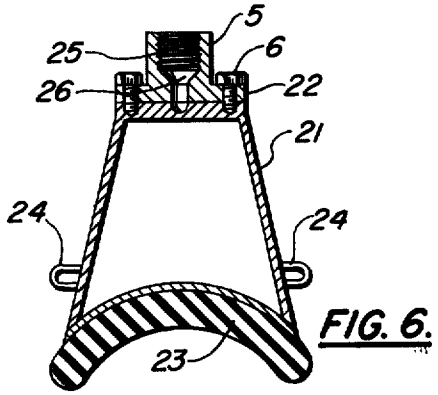


FIG. 6.

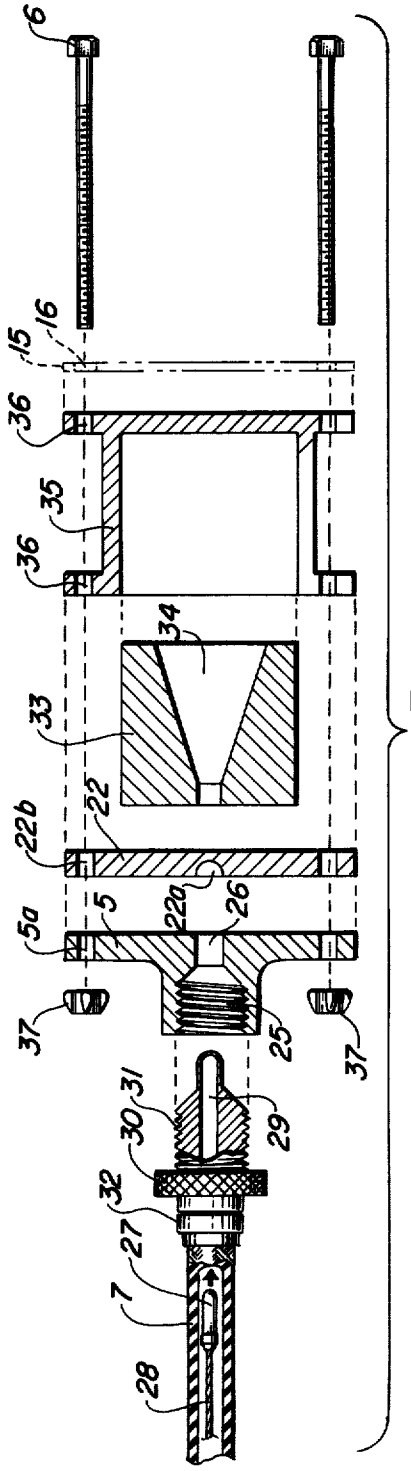


FIG. 7.

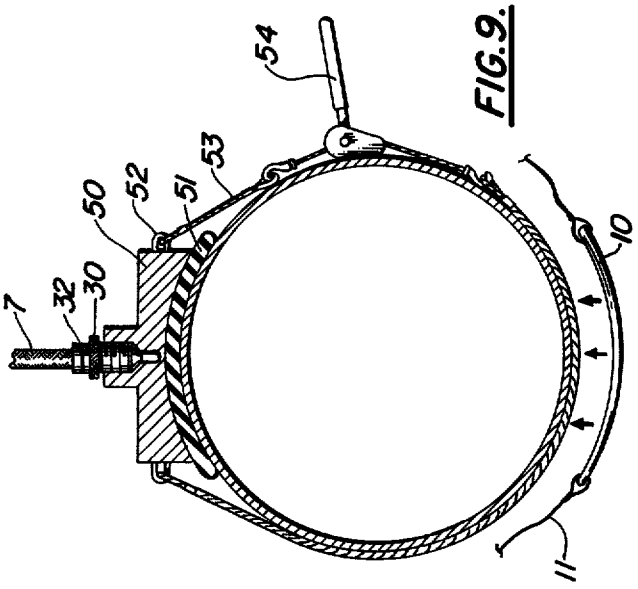


FIG. 9.

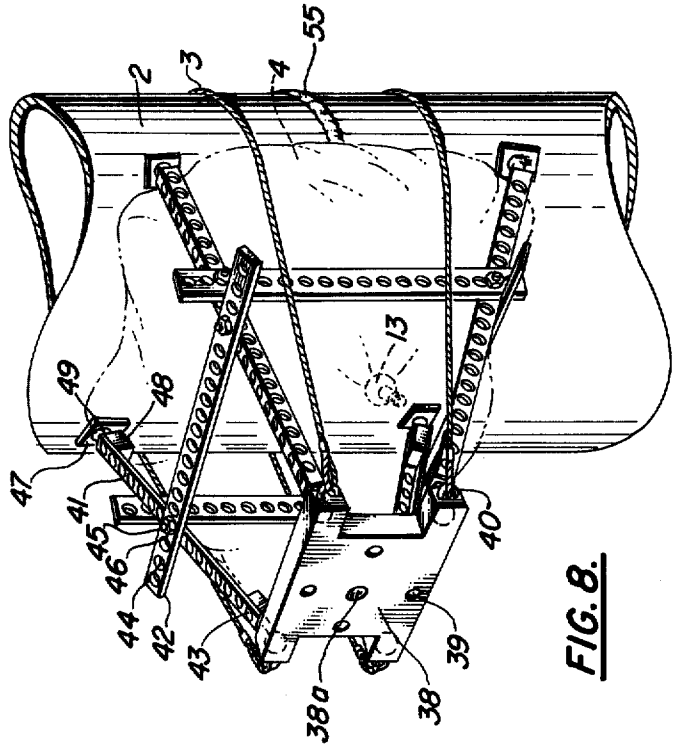


FIG. 8.

WET ENVIRONMENT RADIOGRAPHY APPARATUS

BACKGROUND OF THE INVENTION

a. Field of the Invention

This invention relates broadly to radiant energy and particularly to radiant energy photography, and more particularly to wet environment radiography apparatus and procedures.

b. Prior Art

During the past thirty years radiant energy photography (i.e., radiography) has become the accepted quality control testing procedure for many industrial purposes. Because of radiography's ability to make 360° photographs of solid material density, it has been used extensively in examination of rough surfaces, cracks, poor welding joints, etc. in steel or other flat metal plates, hollow metal bodies, girders and other metal objects. Illustratious of the prior art techniques and apparatus used in radiographing these types of objects can be seen in U.S. Pat. No. 2,340,923, entitled "Method and Apparatus for Making Radiographs" filed Dec. 1, 1942 by C. E. Boucher; U.S. Pat. No. 2,412,174 entitled "Radiographic Inspection Method" filed June 24, 1946 by R. G. Rhoades; U.S. Pat. No. 2,532,536 entitled "Method and Apparatus for Locating Welds in Hot Hollow, Metal Bodies" filed June 9, 1948 by C. E. Boucher; U.S. Pat. No. 2,719,926 entitled "Method and Apparatus for Radiographic Examination of Hollow Articles" filed Aug. 15, 1972 by C. G. Proctor, et al; U.S. Pat. No. 2,905,824 entitled "Filmholder for Radiographic Examination of Pipe Welds" Oct. 8, 1956 by J. J. Thielsch; U.S. Pat. No. 3,087,058 entitled "Method and Apparatus for Radiographic Inspection" filed Sept. 15, 1958 by K. Arvanetakis; U.S. Pat. No. 3,445,655 entitled "Apparatus for the Support and Movement of Radiographic Equipment on an Elongated Pipe" filed Aug. 18, 1966 by L. O. Curry; U.S. Pat. No. 3,492,477 entitled "Method and Apparatus for Examining Hollow Bodies" filed Feb. 28, 1966 by T. Arnesen; and U.S. Pat. No. 3,547,040 entitled "Flaw Detector Carriage for Introducing Radioactive Source into Pipelines" filed May 23, 1967 by Miroslav Daran.

While the industrial uses of radiography are numerous, present techniques have proved unsatisfactory for radiographing in a wet environment. This problem is especially acute in the oil and gas industry which has over the past 35 years laid thousands of miles of pipelines on the ocean bottoms. At present there is no known technique or apparatus which can be used to determine the structural soundness of these pipelines in situ. At present it is necessary to remove these pipelines from the ocean bottoms and transport them to the surface where they can be examined. Such procedures have proved extremely time consuming and expensive. Therefore, in view of the age of some of the pipelines that are now existing on the ocean bottoms there is a critical need in the industry for apparatus and procedures to examine the structural integrity of these pipelines quickly and in situ on the ocean bottoms.

One of the primary difficulties in wet environment radiography is designing an apparatus which not only is able to remove the attentuating fluid media in the area being radiographed, but also, designing of an apparatus which can be easily manuevered in an underwater environment by a diver. The only known wet environment radiography apparatus is disclosed in U.S.

Pat. No. 3,214,586 entitled "Underwater Radiographic Exposure Device" filed Oct. 29, 1962 by G. T. Graham. While the apparatus disclosed in this patent does provide a means for removing the fluid media from about the area to be radiographed, it still requires that heavy, difficult-to-handle shielding be inserted and positioned within the object being radiographed. This leads to problems of equipment hangup and lodgment within the object which can lead to serious radiation pollution if the radioactive source within the apparatus cannot be extracted. Furthermore, positioning of the shielding within the object is difficult and can result in the penetrating ray source not being positioned directly opposite the area to be radiographed. Also, in many cases access to interior portion of the object being radiographed is not available nor desirable. This is particularly true in those hollow objects having internal webbing or rigid arm support members or in pipelines where severing or gaining entrance to the interior may cause pollution or other undesired problems.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a wet environment radiography apparatus which overcomes the prior art difficulties.

It is an object of this invention to provide a wet environment apparatus capable of radiographing any structural member, solid plates, solid braces, etc.

It is a further object of this invention to provide a wet environment radiography apparatus which is safe to handle, yet does not require insertion of heavy, difficult-to-handle shielding into the object to be radiographed.

It is another object of this invention to provide a wet environment radiography apparatus which can be used in radiographing both vertical and horizontal pipes and other objects.

It is still another object of this invention to provide a wet environment radiography apparatus which can be simply and accurately attached to the exterior surface of the object to be radiographed.

These and other advantages for in situ radiographing of either a solid or hollow object located in a wet environment is provided which comprises a penetrating ray source holding means, a fluid dispersal means having a low penetrating ray absorption and scattering characteristics which is attached to the holding means and secured to the exterior surface of the object being radiographed, and a penetrating ray source positioned within the holding means.

In another embodiment of this invention the apparatus will also comprise retaining members which attach to the penetrating source holding means in position about the object to be radiographed. More particularly, the retaining means may comprise a flexible open webbing, or an open or solid rigid arm structure. Furthermore, the fluid dispersal means may comprise an inflatable fluid tight container, a rigid enclosed hollow structure, or a combination thereof.

In still another embodiment of this invention the apparatus will also comprise a collimating means which attaches also to the penetrating ray source holding means. More particularly the collimating means will comprise a fluid tight container attached to the source holding means and a block of material having high penetrating ray absorption characteristics inserted within the fluid tight container, wherein the block has a hol-

low passageway running through about its center portion wherein one end of the passageway is narrower than the other end and wherein the narrower end is positioned closer to the source located in the source holding means.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of one embodiment of the invention employing an inflatable fluid dispersal means to a hollow pipeline.

FIG. 2 is an exploded view of the film package used in this invention.

FIG. 3 illustrates a perspective view of an inflatable fluid dispersal means.

FIG. 4 illustrates a fluid dispersal means having an inflatable or flexible portion in conjunction with a rigid section.

FIG. 5 illustrates a fluid dispersal means having a less flexible portion in conjunction with a hollow rigid section.

FIG. 6 is a cross-section of FIG. 5.

FIG. 7 is an exploded view of the penetrating ray source holding means having an attaching collimating means.

FIG. 8 is a perspective view of one embodiment of the retaining means which employs adjustable rigid arms.

FIG. 9 is a cross-sectional view illustrating another embodiment of the apparatus of this invention which is particularly suitable to hollow objects having larger diameters.

PREFERRED EMBODIMENTS OF THE INVENTION

While the apparatus of this invention may be used in radiographing almost any object located in a wet environment, it is particularly suitable for radiographing objects such as pipelines, metal plates, metal girdes, ship hulls and other like objects. Therefore, for the purpose of describing preferred embodiments of this invention, its use in radiographing offshore pipeline is illustrated. However, it is not the intention of applicant to limit his invention only to the use in such pipeline.

In general, the radiographic apparatus of this invention will comprise a fluid dispersal means secured adjacent to the area of the object being radiographed, a penetrating ray source holding means attached to the fluid dispersal means and being designed to hold a penetrating ray source in a position for radiographing. Many factors, some of which are inter-related, need to be taken into consideration when developing preferred embodiments of the radiographic apparatus of this invention. Such things as the shape of the fluid dispersal means, the material from which the fluid dispersal means is constructed, the type of penetrating ray source used, the penetrating ray source intensity, the thickness of the object being radiographed, the geometry of the area from which the fluid has been dispersed, the location of the penetrating ray source, the location of the radiographic film, as well as other characteristics disclosed herein more fully.

In selecting the shape of the fluid dispersal means primary considerations must be given to scattering and absorption cross-section characteristics of the fluid displaced, as well as, that of the dispersal means material. First, of course, is to displace as much water fluid from the area to be radiographed as possible and replace it with a material (such as air) which has low scatter and absorption cross-section characteristics for the penetrating ray. This will reduce the attenuation of the penetrating ray beam and result in high resolution radiographs. Since there will be some scattering of the penetrating rays regardless of the material used in the dispersal means, it is preferable that the scattering be as uniform as possible. Therefore, it is preferred that the dispersal means symmetrically displace the fluid from about the area being radiographed. This is achieved by conforming the front face of the fluid dispersal means to the exterior surface of the object being radiographed. It is preferred that the fluid be displaced from the area a distance at least equal to the maximum diagonal of the area being radiographed.

As disclosed hereinafter more fully the fluid dispersal means may be constructed of many types of materials. The chief considerations, of course, are that the materials used should be fluid tight and possess low scattering and absorption cross-section characteristics for the particular penetrating ray source used. In a preferred embodiment that portion of the fluid dispersal means adjacent to the area being radiographed should not only be constructed of the material having the lowest possible scattering and absorption characteristics, but also, should be uniformly dense. In this manner, distortions in the radiographic images will be minimized.

While most any penetrating ray source can be utilized, the most common sources would include neutrons, alpha particles, beta particles, the gamma particles with the latter being particularly preferred because of its ready accessibility in the form of certain isotopes of sufficient intensity to minimize the exposure time needed in making the radiographs. Examples of suitable gamma isotope sources would include iridium 192 or cobalt 60 with cobalt 60 being the most preferred because it will minimize back scatter problems due to the fact that the gamma particle emitted is more energetic.

It is also preferred that the penetrating ray source be maintained as far from the area being radiographed as permissible by the intensity of the source and the amount of fluid being displaced. In this manner the penetrating rays will pass through the object being radiographed in a more parallel fashion resulting in better resolution in the radiographs.

It is preferred that the penetrating ray source be maintained at a distance from the area being radiographed greater than or equal to the maximum diagonal across the area being radiographed. This will insure relatively parallel radiation paths passing through the object being radiographed.

It is preferred that the radiographic film or imaging means be placed on the opposite side of the object being radiographed from where the penetrating ray source is located. In positioning the radiographing film it is important that there be a minimum amount of water or other fluids between the film and the object being radiographed in order to avoid distortions of the images produced.

Considering now the specific embodiments shown in FIG. 1, it is seen that the radiographic apparatus 1 is attached to the pipeline 2 by some securing means 3, such as ropes or cables. In this particular embodiment, the fluid dispersal means 4 is an inflatable bag which is shown in more detail in FIG. 3.

Such an inflatable bag may be constructed of any water-tight material such as rubber, leather, various plastics or a combination of these materials. More particularly, the fluid dispersal means has an attaching disk **14** secured to bag **4** which disk is provided with tabs **15** having opening **16** through them. Bag **4** is, or course, provided with a valve **13** for permitting the insertion of some gas, such as air, in order to inflate bag **4.** Returning to FIG. **1** this fluid dispersal means is attached to a penetrating ray source holding means **5** by passing bolt and nut arrangement **6** through opening **16** and adjacent openings provided in source holder **5.** In a more preferred embodiment, a retaining means **9** is provided about the fluid dispersal means **4** which serves not only to maintain bag **4** in a desirous shape, but also is provided with attaching tabs **8** by which securing means **3** can be attached to hold bag **4** in position about the area to be radiographed (shown here as weld **55**).

In practice, inflatable bag **4** is positioned over weld **55** and held firmly in position by ropes **3** attached to tabs **8** of the webbed restraining means **9.** In this particular embodiment the restraining means consist of open webbing made either from ropes, synthetic fibers, or rubber which encompass the inflatable bag. Air or other gases having low absorption and scattering cross-section are inserted from line **12** past valve **13** into bag **4.** The bag is inflated until it conforms to the shape of the restraining means **9.** More preferably, the bag is centered over weld **55** in order to symetrically displace the water about pipe **2.** In this manner the resolution of the radiographs is improved because scattering of the penetrating rays is minimized and what scattering does take place is uniform.

Next, film package **10** is placed on the opposite side of pipeline **2** and secured into position by ropes **11** which may extend around pipeline **2** and preferably also attach to tabs **8.** Once the film package and fluid dispersal means have been secured to the pipeline the penetrating ray source is removed from its shield container and passed through source line **7** until it is positioned in source holding means **5.** As is seen there is no need to position and secure heavy shielding about the pipeline. This means greater ease and quicker assembly of the apparatus about the pipeline. This feature is very important since the time a diver can remain underwater is limited.

If the pipeline being radiographed contains water or other fluids, then it is preferable that these be removed from the area being radiographed. These can be done, for example, by procedures shown in copending application entitled "Wet Environment Radiography Procedures" filed Dec. 18, 1972, Ser. No. 315,915, by Paul Nelson English, or by insertion of an apparatus shown in copending application entitled "Wet Environment Radiography Apparatus" filed Dec. 18, 1972, Ser. No. 315,912, by Paul Nelson English.

As is seen in FIG. **2** the film package consists of film **10*a*** which is placed within supporting plates **10*b*** which is sealed in a fluid tight container **10*c***. In a preferred embodiment supporting plates **10*b*** are lead lined to reduce backscatter of the penetrating rays thus improving the resolution of the radiographs. Container **10*c*** is then placed within a flexible canvas or rubber container **10*d*** which is closed by sealing means **10*e***. Flexible container **10*d*** has tabs **10*f*** through which attaching lines **11** are connected and extended about pipeline **2** or attach to tabs **8** securing the film package to the pipeline.

In FIG. **4** an alternate embodiment of the fluid dispersal means is shown. In this embodiment the fluid dispersal means comprises the rigid container **17** to which an inflatable or flexible member **4** is attached. Member **4** is positioned adjacent to the area being radiographed. Because it is flexible it will fit flush with the object thus displacing all the water and not leaving any pockets of the water adjacent to the area being radiographed which could distort the resolution of the radiographs taken. The rigid container **17** which also acts as a fluid dispersal means is provided with attaching tab **18** and **19** by which the radiographic apparatus can be secured to the object being radiographed. The rigid container **17** is provided with a source holding means **20** to which source pipeline **7** can be attached.

An embodiment particularly adaptable to objects having convex surfaces, e.g. pipelines, is shown in FIG. **5.** In this embodiment an enclosed rigid fluid dispersal means **21** is provided with a non-cellular, deformable flexible material **23** (e.g., rubbers, rubber polymers and other similar materials) which fits flush against the exterior contours of the pipeline even if there are small irregularities on the pipeline's surface. Attached to the top surface of means **21** by bolts **6** is penetrating ray source holder **5** which is provided with a threaded receiving section described in more detail hereinafter. Also attached to means **21** are tabs **24** which securing means **3** (not shown) connect to hold means **21** secure to the pipeline.

Examining FIG. **6,** a cross-section of the FIG. **5** embodiment is shown. The bottom section of means **21** is curved, preferably of the same curvature of the pipeline being examined. In this manner, a more water-tight seal can be achieved between the pipeline and the flexible piece **23** that is attached to the bottom section of means **21.** Source holder **5** is provided with a center cavity **26** which will hold the penetrating ray source during radiographing. At the top portion of cavity **26** is a threaded section **25** for receiving and securing hollow source line **7.** In FIG. **7** the source line **7** comprises a threading knob **30** attached to a hollow threaded body **31** having a hollow chamber **29** for receiving source **28** which is positioned in chamber **29** by positioning means **28.** Source line **7** is connected to the source holding means **5** and secured in position by turning threading knob **30** into the threaded section **25.** In order to insure source line **7** is not broken by twisting, threading knob **30** is attached to a swivel joing **32** which insures source line **7** will not be twisted while screwing into section **25.** FIG. **7** also illustrates another preferred embodiment of the invention wherein a collimating means **33** is positioned next to source **27.** In this embodiment the source holding means comprises a solid portion labeled as **5** having holes **5*a*** through which bolt **6** may be inserted and secured by nuts **37.** There is also provided a plate **22** having holes **22*b*** and a hollow portion **22*a*** wherein source **27** will be positioned when radiographing the object. It is obvious that plate **22** could be part of source holding means **5.** The collimating means **33** is held in position by fluid tight container **35** which has openings **36** for bolt **6** to pass through. Collimating means **33** is provided with a hollow passageway **34** which is narrower at that end next to plate **22.** While passageway **34** may be of various shapes best collimation and image resolution is ob-

tained by utilizing a conically-shaped passageway wherein the narrower portion of the cone is next to plate cavity 22*a* as shown.

If an inflatable bag is to be used as the fluid dispersal means, an alternate embodiment for retaining fluid dispersal means 4 is shown in FIG. 8 wherein a rigid arm structure is utilized. In this embodiment a source holding plate 38 is provided with a source receiving cavity 38*a* and bolt openings 39 with which to attach the source holding means 5. Attached to plate 38 is rigid arms 41 which extend to and contact pipeline 2, and are separated at the desired distance by members 42 which attached by bolt and nut means 45 and 46. In a preferred embodiment both arms 41 and 42 are adjustable by providing holes 43 and 44, respectively, in legs 41 and means 42. In a still further preferred embodiment, legs 41 are provided with gripping means 47 which are attached by a ball and swivel joint 49 connected to a solid portion 48 of arm 41. This retaining means is secured to pipeline 2 by cables 3 attached to attaching tabs 40.

In FIG. 9 another embodiment of the invention is shown whereby the fluid dispersal means 51 comprises only a thin flexible piece attached directly to source holding means 50 which is secured to pipeline 2 by ropes or cables 53 and a tightening means such as a come-along device 54. In this particular embodiment a "pipeliner" radiographic camera can be easily adapted as a penetrating ray source adaptable to other types.

It is obvious that there are many variances and modifications of the disclosed apparatus which could be used and these are intended to be included in this invention. For example, the source holder shown in FIGS. 1 through 8 could be adapted to secure various types of radiographic cameras to the fluid displacement means.

What I claim is:

1. In an apparatus for making a radiograph of an object submerged in a liquid, the improvement therein which comprises the combination of:

a. means for providing a beam of penetrating radiation;

b. means for supporting the radiation-providing means;

c. means for securely positioning the means for supporting the radiation-providing means in proximity to, but spaced from the object to be radiographed, so the radiation will impinge upon a chosen section of a surface of the object;

d. means for displacing the liquid from the intervening space between the radiation-providing means and said chosen section so that significant attenuation and scattering of the beam of radiation impinging upon said chosen section will not result, the radiation-providing means and support means being otherwise surrounded by the liquid;

e. imaging means positioned on a surface of the object so that said chosen section is between the radiation-providing means and the imaging means; and

f. means for securing the imaging means to the object.

2. The apparatus according to claim 1, wherein the liquid displacing means is a container enclosing a gas, the container having a wall, which contacts the entire surface of the chosen section of the object upon which the radiation impinges, and conforms thereto.

3. The apparatus of claim 2, wherein the wall which contacts the surface of the chosen section of the object is flexible.

4. The appparatus of claim 3, wherein the container is an inflatable bag.

5. The apparatus of claim 4, which comprises additionally a penetrating radiation collimating means, which is positioned between the liquid displacement means and the radiation providing means, and from which liquid is excluded.

* * * * *