



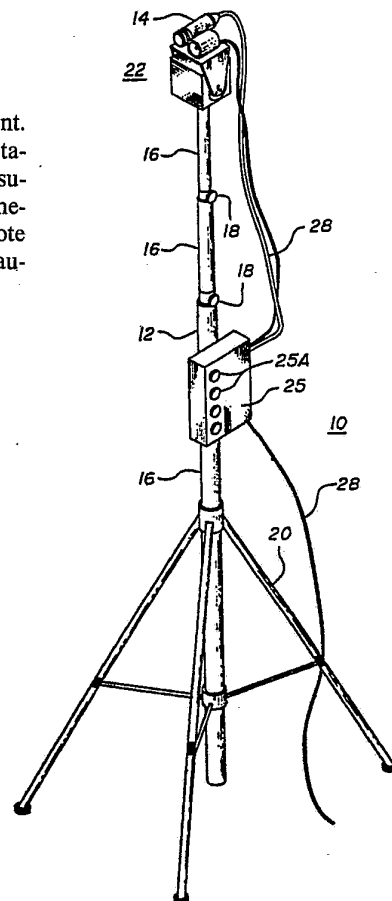
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: PCT/US93/04561 (22) International Filing Date: 13 May 1993 (13.05.93) (30) Priority data: 07/882,847 14 May 1992 (14.05.92) US (60) Parent Application or Grant (63) Related by Continuation US 07/882,847 (CON) Filed on 14 May 1992 (14.05.92) (71) Applicant (for all designated States except US): BROOKS SUPPORT SYSTEMS, INC. [US/US]; 6546 Pound Road, Williamson, NY 14519 (US).</p>	<p>(72) Inventors; and (75) Inventors/Applicants (for US only) : BROOKS, Raymond, J. [US/US]; 7211 Furnace Road, Ontario, NY 14519 (US). GAY, John, M. [US/US]; 364 French Road, Pittsford, NY 14534 (US). WEIR, Bruce, A. [US/US]; 420 Haley Road, Ontario, NY 14519 (US). McENTEE, Paul, E. [US/US]; 61 Bell Mawr Drive, Rochester, NY 14624 (US). BLOOD, Lauren [US/US]; 3832 Center Street, Livonia Center, NY 14488 (US). (74) Agent: NAVON, Jeffrey, M.; Synnestvedt & Lechner, 2600 One Reading Center, 1101 Market Street, Philadelphia, PA 19107-2960 (US). (81) Designated States: AT, AU, BB, BG, BR, CA, CH, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, KZ, LK, LU, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UA, US, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>	

(54) Title: INSPECTION DEVICE

(57) Abstract

A device (10) suited for inspecting selected positions of a nuclear power plant. The invention comprises a boom (12) for extending to a position in a nuclear power station to be inspected, and a video camera (14) affixed to the boom for permitting the visual inspection of the position to be inspected. In preferred embodiments, the video camera (14) is affixed to a pan and tilt mechanism which may be adjusted by a remote joystick or by a control box (25) situated on the boom. The video camera includes an auto-focus feature.



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INSPECTION DEVICE

Field of the Invention

The present invention is directed to the field of inspection devices and methods. In particular, the present invention is directed to nuclear power plant inspection devices.

Background of the Invention

Nuclear power plants typically contain three major components as shown in Figure 1: a reactor which produces superheated water which is transported to one or more steam generators; the one or more steam generators which generate steam; and a power turbine, driven by the generated steam, which produces electrical power. Nuclear power plants may have miles of pipes and ducts which must be inspected and examined for corrosion, leakage and damage. These regions include the reactor bowl, the tube sheet, support plates and the tubing within the steam generator.

It is particularly difficult to inspect all areas of the plant including the primary bowl and steam generator. These areas are often highly radioactive and may leak contaminated liquids. Typically, direct human inspection of the key areas of the steam generator and reactor bowl is limited to several minutes per six-month period.

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There are a number of issued patents which disclose devices for nuclear power plant inspection and repair. U.S. Patent No. 4,673,027 discloses a device for inspecting and repairing the tubes of a nuclear reactor steam generator. The
5 device includes a manipulator which is insertible in the chamber and which may be locked onto the tube sheet for supporting remotely controlled and monitored inspection instruments and tools. The manipulator includes a support leg which is adjustable in length in an axial direction, a main
10 arm connected to and movable relative to the support leg and an equipment carrier which is connected to the main arm.

U. S. Patent No. 4,653,971 discloses a device for selectively positioning a tool carried by a vehicle which moves on a perforated plate, while the device utilizes an
15 elbow which swings a telescoping arm into position.

Similarly, U. S. Patent No. 4,945,979 discloses an improved robotic arm for effecting a tube plugging operation. The system also includes an elbow control mechanism.

U. S. Patent No. 4,205,939 discloses an apparatus
20 for remotely repairing the tubes in a steam generator. The device includes a boom pivotally mounted on a column and a system for rotating the column and the boom therewith. The disclosed device further includes a tool which is operable on the tubes.

25 U. S. Patent No. 4,231,419 discloses a manipulator for inspecting and repairing the tubes of heat exchangers. An inspection arm is inserted and removed through a lead-in nozzle and a swivel arm carries an extendable and retractable mouthpiece carrier with a mouthpiece which can be aligned into
30 the tube openings. U. S. Patent No. 4,919,194 discloses a method of positioning a robot for inspecting and maintaining the steam generator within a nuclear plant.

U. S. Patent No. 4,302,772 discloses a device for television inspection of an inner surface of a closed
35 cylindrical vessel having vertical access and an access hole in the vessel's upper part. The device includes a television camera and at least one flood light for lighting an area to be

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inspected. The camera is suspended from a flexible tube which is held rigid under torsion and through which pass electricity supply cables for the camera and floodlight.

U. S. Patent No. 4,424,531 discloses an inspection device for inspecting internal spaces in nuclear reactor installations. The device includes a camera arranged on an adjustable tube. U.S. Patent No. 4,967,092 discloses an apparatus for optically checking the inner profile of a tube. The apparatus includes a probe which is positioned in, and movable longitudinally within, the tube.

Finally, U.S. Patent No. 4,702,878 discloses a device for searching and retrieving objects on a tube sheet of a steam generator. The device includes a sled having a probe and a gripper which is connected to a flexible tube having control means.

While each of the above mechanisms have been utilized to inspect and/or repair of nuclear power plants and include the use of robotic manipulators or arms, none have been successfully utilized to facilitate the easy hand inspection of the primary bowl of the reactor by an operator or the inspection of the steam generator and associated tubing. Most of the above devices require the use of complex mechanical systems which must be controlled from a remote position.

There has been a long felt need for a versatile and all purpose nuclear power plant inspection device which can be used to inspect the reactor bowl, steam generator areas, tubing and ducts, and other areas within the nuclear power plant. There has also been a long felt need for an inspection device which is hand held and portable, which can be used to inspect large portions of the nuclear power plant, and which can be utilized for a variety of non-nuclear power plant applications.

Summary of the Invention

In accordance with this long felt need, an inspection device and method are disclosed. In a most

preferred embodiment, the invention comprises boom means for extending to a position to be inspected, and video camera means affixed to an end of said boom means for permitting the visual inspection of said position to be inspected.

5 In a second embodiment, the invention is directed to a nuclear power plant inspection device comprising boom means for extending to a position in a nuclear power plant to be inspected, and video camera means affixed to an end of said boom means for permitting the visual inspection of said
10 position in said nuclear power plant to be inspected.

In another embodiment, the present invention comprises a device for inspecting the primary bowl of a nuclear reactor. The invention further comprises boom means for extending into the primary bowl of a nuclear reactor, and
15 CCD video camera means affixed to the end of said boom means for visually inspecting said primary bowl.

The present invention is also directed to a method for inspecting portions of a nuclear power station. The method comprises the steps of extending a boom to a section of
20 a power station to be inspected, said boom having a CCD camera attached thereto for permitting the visual inspection of said section to be inspected.

The device of the present invention can be utilized to inspect the primary bowl of the reactor, the steam
25 generator, and other difficult to reach portions of a plant. The present invention is designed to be hand held and manipulated. It is further expandable by means of a plurality of telescoping members and can extend up to 32 feet.

The inspection device of the present invention, in a
30 preferred embodiment, utilizes a charge-coupled video camera which facilitates the inspection of selected portions of the plant. In yet other embodiments, the inspection device includes means for maintaining the inspection device in a vertical position.

35 While a preferred embodiment and application of the present invention is directed toward nuclear power plant inspection, it is to be appreciated that the inspection device of

the present invention may be utilized for a large number of non-nuclear related applications, including inspection of chemical plants, oil refineries, waste treatment plants and facilities, fossil fuel burning electric power generation plants and other applications. These and other advantages of the present invention will become apparent from the detailed description and claims which follow.

Brief Description of the Drawings

Figure 1 is a representation of the components of a nuclear power plant.

Figure 2 is a perspective view of the hand-held inspection system of the present invention.

Figure 3 is a prospective view of the pan and tilt mechanism utilized with the hand-held inspection system of the present invention.

Figure 4 is a perspective view of the hand-held inspection system of the present invention.

Detailed Description of the Present Invention

The present invention is described with reference to the enclosed Figures wherein the same numbers are utilized where applicable. The present invention, in preferred embodiments, is directed to a device for inspecting portions of a nuclear power plant. However, it will be immediately apparent to those skilled in the art that the inspection device of the present invention is in no way limited to nuclear power plant inspection and may be utilized for a large number of non-nuclear related applications. Nonexclusive examples of potential alternative uses include the inspection of chemical plants, oil refineries, waste treatment plants, and coal and fossil fuel burning electric generation plants.

Referring to Figure 2, the inspection device of the present invention, in a most preferred embodiment, comprises a boom means for extending to a position to be inspected. The boom means is designed to be hand held and is affixed at a distal end to video camera means.

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In a preferred embodiment, the boom means 12 comprises a plurality of telescoping members 16 which can be adjusted manually and mechanically locked to a fixed length by means of a plurality of locking means or clamps 18. In this
5 manner, the length of the boom means 12 can be selectively adjusted. In a preferred embodiment, the boom means 12 should comprise enough telescoping members 16 to facilitate the expansion of the boom means a total length of about 32 feet. This length is sufficient to facilitate the full vertical
10 examination of a nuclear steam generator and other difficult to reach positions of the plant.

As shown in Figure 2, the device 10 of the present invention can be supported in a vertical position by means of a stand such as a tripod stand 20. Stand 20 permits the
15 device to be retained in a selected position while, for example, the operator views a remote TV monitor to which the camera means is electrically interfaced so that images can be relayed to the remote TV monitor.

As noted above, the distal end of the boom means 12
20 has affixed thereto a video camera means 14 attached to a pan and tilt mechanism 22. As shown in Figure 3, the pan and tilt mechanism 22 comprises a box 24 with a tiltable pivoting member 26. The pivoting member 26 facilitates the approximate 180° vertical tilt of the video camera means 14. In a
25 preferred embodiment, the video camera also should be able to pan 359°. In this manner, the video camera 14 can completely inspect a selected position or section of the plant.

The video camera means 14 preferably transmits video images to a TV monitor situated at a remote location. In a
30 preferred embodiment, the video camera will incorporate CCD ("charge-coupled device") technology. The advent of CCD image transducers has permitted television cameras to be fabricated in very small sizes. The CCD detector assembly is positioned to receive optical images from the camera lens so that it can
35 convert the components of the received image to corresponding electrical signals. Electrical circuitry associated with the detectors converts the image component signals to standard

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video signals for use by television receiver/monitors. In the present invention, the CCD circuitry may, for example, comprise Sony Model A-7560-026A, which functions to convert optical images received from a lens assembly into electrical video signals. The lens assembly of the preferred embodiment, may, for example, comprise Sony Model VCL08SBYA.

In an alternative embodiment, a small video receiver can be interfaced along the boom means 12 or on one of the telescoping members 16 and electrically interfaced to the camera means 14 so that a video image of the inspected area can be directly viewed by the user of the inspection device as he or she is inspecting the area. In a preferred embodiment, a small video receiver is, for example, a Sony WALKMAN which is clipped or otherwise mounted to a telescoping member 16 or the boom means 12. In the case when the small video receiver is directly attached to the inspection device, it may not be necessary to run electrical lines back to a remote location so that another individual can view the inspected area on a remote terminal. However, it would be possible to run additional lines back to a remote area so that both the person at a remote terminal and the individual actually performing the inspecting can simultaneously view the inspected area.

The video camera means 14 will also preferably incorporate an auto focus mechanism which, along with the pan and tilt means 24, may be controlled by a remote operator with a joy stick (not shown) at a remote location. As shown in Figure 2, both the pan and tilt mechanism 22 and autofocus may alternatively be controlled by the operator of the inspection device by means of a control box 25 with activation buttons 25a attached to the boom means 12. A joystick may also be provided to control box 25 for easier manipulation of the camera means and pan and tilt by the operator of the inspection device. Furthermore, the control box may include controls to electromechanically extend the boom means 12 and telescoping members 16 to the desired length.

Figures 2 and 4 illustrate connecting cables 28 which facilitate the remote operation of the auto focus and

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pan and tilt mechanism 28. The cables 28 from the video camera lead to the closed circuit TV monitor situated at a remote location.

In operation of the inspection device provided in accordance with the present invention, the length of the boom is initially adjusted by fixing the position of the telescoping members 16 with locking means 18 or alternatively extending the boom means with electromechanical controls. The boom means 12 with attached CCD video camera 14 is then extended to a position in the plant to be inspected. The CCD camera transmits an image via the cables 28 to a remote TV monitor, or to the video receiver attached to the boom means 12 or telescoping members 16. In another case, the position of the CCD camera can be changed by adjusting the pan and tilt mechanism 22 either remotely or by the activation of buttons situated on a hand control box 25 attached to the boom means 12. As shown in Figure 4, the operator 30 may utilize a headset 32 where he can be directed into an appropriate position by a remote operator viewing the TV monitor at a remote location.

The device of the present invention can be utilized for a large number of applications in a nuclear power plant. For example, the device may be utilized to inspect the primary bowl of the reactor. In this case, the boom containing the CCD camera is lowered into the primary bowl of the reactor via a manhole. The CCD video camera attached to the end thereof is then adjusted via pan and tilt mechanism 22 to inspect various portions of the reactor bowl which is to be viewed and inspected. As shown in Figure 4, the device of the present invention can also be utilized to inspect overhead piping and ductwork 34.

The present invention has been described with reference to the enclosed Figures. It is to be appreciated that other embodiments fulfill the spirit and scope of the present invention and that the true nature and scope of the present invention is to be determined with reference to the claims appended hereto.

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ClaimsWhat is claimed is:

1. An inspection device comprising:
boom means for extending to a position to be
5 inspected; and
video camera means affixed to an end of said
boom means for permitting the visual inspection of said
position to be inspected.
2. The device of Claim 1 wherein said video camera
10 means is affixed to pan and tilt means attached to the end of
said boom means.
3. The device of Claim 1 wherein said video camera
means is a charge-coupled device.
4. The device of Claim 1 wherein said boom means
15 comprises a plurality of telescoping members.
5. The device of claim 1 further comprising means
for supporting said device in a vertical position.
6. The device of claim 1 further comprising a
video receiver attached to the boom means for receiving video
20 images of the inspected position.
7. A nuclear power plant inspection device
comprising:
boom means for extending to a position in a nuclear
power plant to be inspected; and
25 video camera means affixed to an end of said boom
means for permitting the visual inspection of said position in
said nuclear power plant to be to be inspected.
8. The device of claim 7 wherein said boom means
comprises a plurality of telescoping members.

9. The device of claim 7 wherein said video camera is affixed to a pan and tilt mechanism attached to the end of said boom means.

5 10. The device of claim 7 wherein said video camera is a charge-coupled device.

11. The device of claim 7 wherein said boom means comprises a plurality telescoping members.

12. The device of claim 9 wherein said pan and tilt
10 means is controlled by a control box affixed to said boom means.

13. The device of claim 12 further comprising a video receiver attached to the boom means for viewing the inspected position by an operator of the inspection device.

15 14. A method for inspecting difficult to reach portions of a nuclear power station comprising:

extending a hand held boom to a position in a power station to be inspected, said boom having a CCD camera attached to an end thereof for permitting the visual
20 inspection of said position to be inspected.

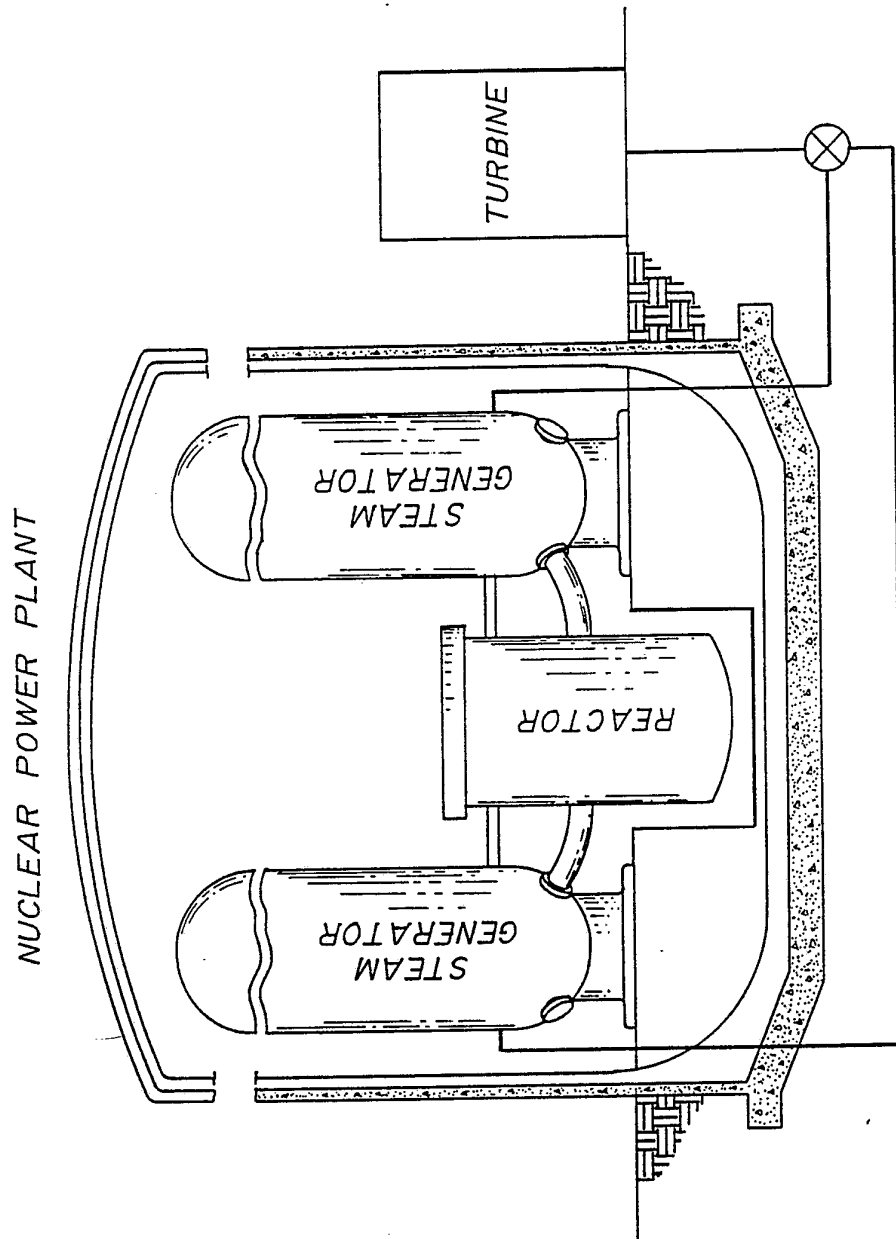


FIG. 1

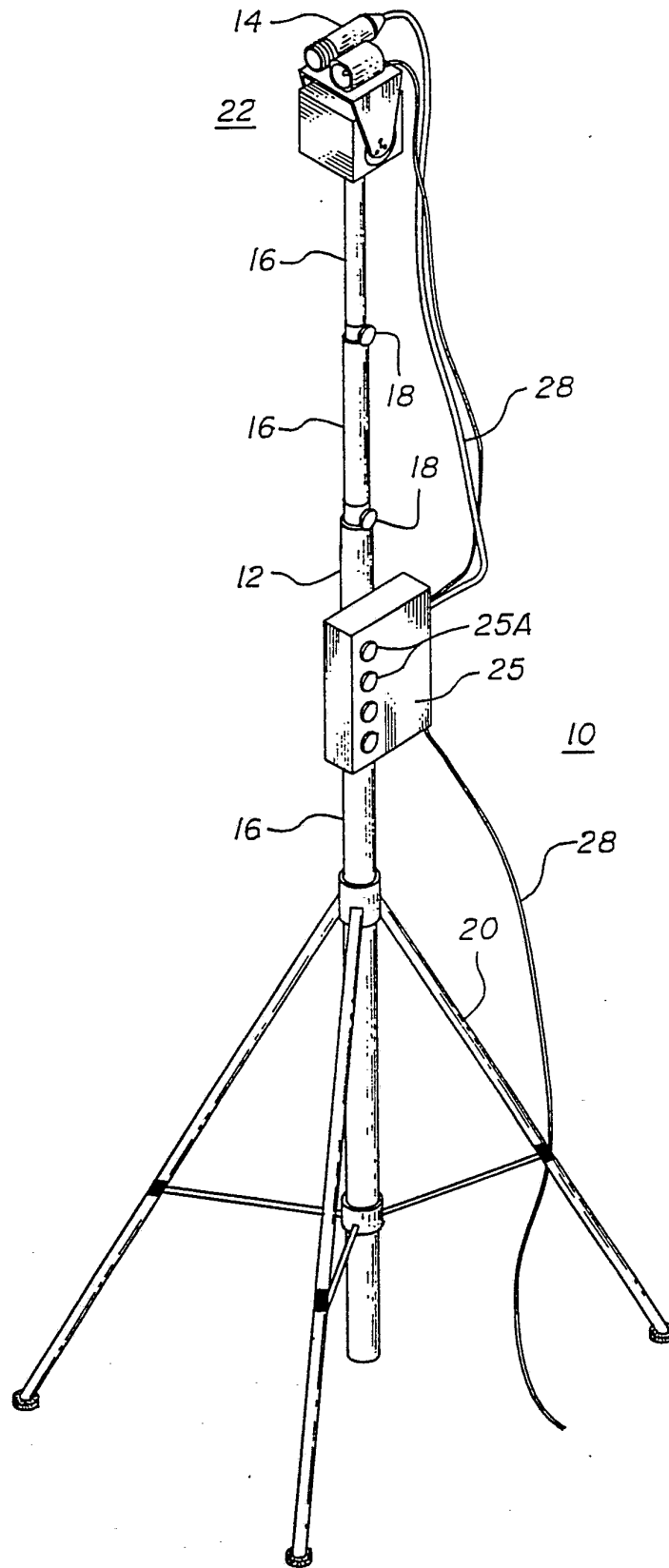


FIG. 2

SUBSTITUTE SHEET

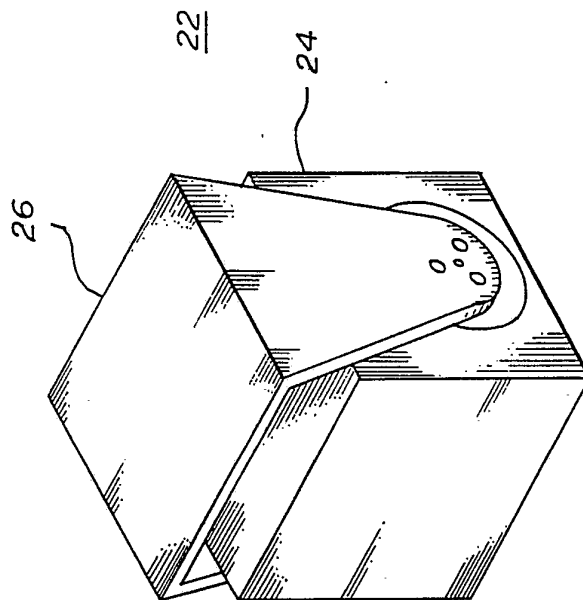


FIG. 3

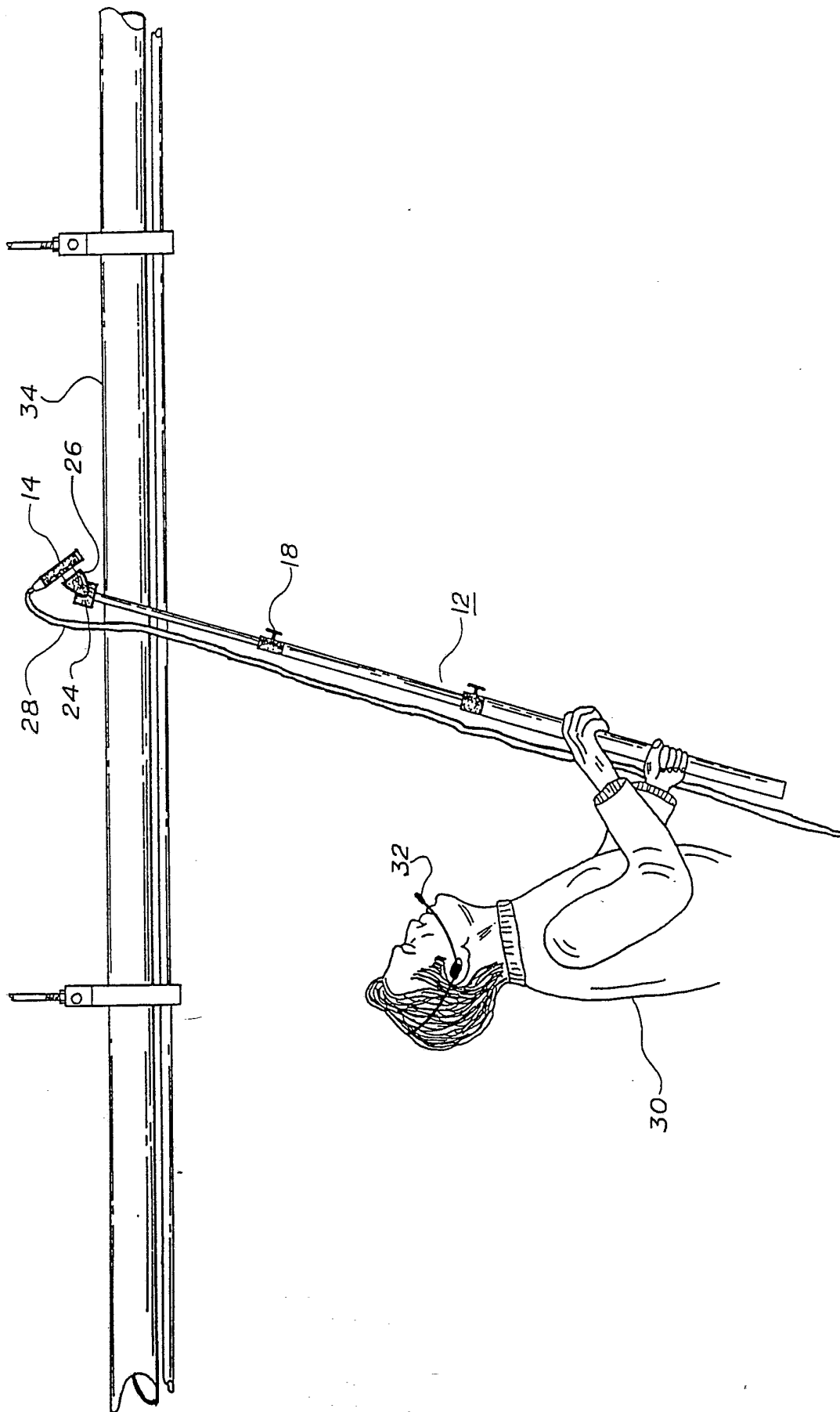


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/04561

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :G21C 17/00
US CL :376/249

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 376/248; 976/DIG. 210, DIG. 213; 364/513,527,525.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ----- Y	US, A, 5,065,249 (HORN ET AL) 12 November 1991. See Fig. 1, 2, 3 Col. 1 lines (1-3,29-45), col. 2, lines (1-16), col. 3 lines (1-31+).	1-6 ----- 7-14
X ----- Y	US, A, 3,780,571 (WIESENER) 25 December 1973, See entire document. See Fig. 1, 6, 8, col. 2, lines (49-56), col. 3, lines (14-24). Col. 4, lines (52-57), col. 11, lines 34-44+).	7-14

Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be part of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
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"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 24 August 1993	Date of mailing of the international search report 16 SEP 1993
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Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. NOT APPLICABLE	Authorized officer Meena Chelliah <i>Richard Carver</i> Telephone No. (703) 308-0514
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INTERNATIONAL SEARCH REPORTInternational Application No.
PCT/US93/04561**Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)**

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Group I, Claims 1-6 are broadly claimed inspection device used anywhere to inspect a position.

Group II, claims 7-14 are device and method to inspect a difficult to reach portions of a nuclear power plant.

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

The additional search fees were accompanied by the applicant's protest.

No protest accompanied the payment of additional search fees.