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(19)

(54) APPARATUS FOR CARRYING OUT ULTRASONIC INSPECTION OF PRESSURE VESSELS

(71) We, UNITED KINGDOM ATOMIC ENERGY AUTHORITY, London, a British Authority, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to apparatus for carrying out ultrasonic inspection of coolant nozzles of nuclear reactor pressure vessels.

According to the invention a manipulator for supporting an ultrasonic scanning transducer within a coolant nozzle of a nuclear reactor pressure vessel and arranged for carriage by a support member disposed within the vessel comprises a pair of legs pivotable in caliper manner to span the bore of the nozzle, the pair of legs being arranged for carrying the ultrasonic transducer and being rotatable about a manipulator axis extending between the legs and normal to the pivoting axis of the legs, means for pivoting the legs together to enable free entry of the manipulator anl ultrasonic scanning transducer into the nozzle and for pivoting the legs apart to span the bore of the nozzle to bring the transducer into an operable position adjacent the wall of the nozzle.

The invention provides a manipulator for taking an ultrasonic scanning transducer into the inlet or outlet nozzle of a reactor pressure vessel, the manipulator being rotatable whilst in the nozzle to enable the transducer to scan the interior surface of the nozzle. The manipulator is radially contractable to enable the manipulator to be easily inserted in the nozzle and is radially expansible to enable it to span the bore of the nozzle (thereby urging the transducer into an operable position for scanning the interior surface of the nozzle) without passing back significant reaction forces to the manipulator rotating or support means.

A construction of apparatus for carrying out ultrasonic inspection of a nuclear reactor pressure vessel and including a manipulator according to the invention will now be described by way of example, with reference to the accompanying drawings wherein:

Figure 1 is a diagrammatic view of the apparatus in position for inspecting a pressure vessel,

Figure 2 is a side view of the manipulator, and

Figure 3 is a fragmentary end view of the manipulator as seen in the direction of arrow III on Figure 2.

In Figure 1 a reactor pressure vessel designated 1, (such as a vessel for a reactor known as a presurised water reactor) is shown located within a massive shielding structure 2 and the top face 3 of the structure provides an operating floor from which operations can be conducted on the reactor. The vessel is shown with the cover removed and the apparatus comprises a bridge 4 movable along rails 5 which span the opening of the vesel. The bridge has a slewing ring 6 (or turntable) located on it and the turntable carries a beam 7 which can be orientated in any direction in a plane parallel to the plane of the opening of the vessel by rotation of the slewing ring.

A carriage 8 (hereinafter called the "mast carriage") is provided on the beam 7 and is movable linearly along the beam. Depending from the carriage there is a mast 9 extending downwardly into the pressure vesel. The mast also has a carriage 10 (hereinafter called the "manipulator carriage") movable linearly up and down the mast. The manipulator carriage 10 is adapted to support a mechanism selected from a range of mechanisms for carrying out ultrasonic scanning inspection operations but for the inspection of coolant nozzles the carriage 10 supports a manipulator in accordance with the invention. The manipulator is shown in Figures 2 and 3 and is designated 11. The manipulator is carried such

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that it extends normal to the mast. The manipulator can be entered into a nozzle of the vessel by performing four operations:

1. locate the axis of the slewing ring 6 on or approximately on the axis of the vessel by locating the brindge 4:

2. locate the beam 7 at the slewing ring 6 so that it extends in a direction parallel or approximately parallel to the axis of the nozzle.

3. move the manipulator carriage 10 on the mast 9 so that the axis of the manipulator is on, or approximately on, the axis of the nozzle; and

4. move the mast carriage 8 on the beam 7 so that the mast moves towards the nozzle to feed the manipulator into the nozzle.

The manipulator 11 is basically of two-leg caliper form, the legs of the calipers being closed to allow the manipulator to enter a nozzle and opened (that is, radially expanded) to permit the manipulator to span the bore of the nozzle. The manipulator is rotatable about an axis 12 extending between the legs and normal to the pivoting axis 17 of the legs by a motor driven spindle 12a on the manipulator carriage.

One leg 13 of the manipulator 11 terminates at a wheel 14 for rolling around the interior surface 5 of the nozzle and the other leg 15 of the manipulator terminates at a pivotable frame 18 (shown in broken line) for carrying an ultrasonic transmit/receive transducer (not shown). The frame 18 has a pivotable mounting 20 for the transducer, the mounting being pivotable on a frame first axis 21 which is in the plane of the manipulator axis 12. The frame 18 is itself pivotable from the leg 15 on a frame second axis 19 which is parallel to the pivoting axis 17 of the legs. The frame 18 has four wheels 22 disposed one adjacent each corner of the frame for rolling around the interior surface of the nozzle. The legs 13 and 15 have between them a pair of pneumatic rams 25 so that they can be contracted together or expanded apart. There is also provided an arrest bar 23 which serves to limit contraction of the legs. It is also provided that the second pivoted part of the gimbal is drawn towards a stop 26 such as by a spring 24, as the legs are contracted together. Thus the manipulator is compact and rigid when the legs are contracted so that it can be moved into a nozzle with a good clearance. As the legs are opened apart the parts of the manipulator have a high freedom of movement. When the legs are opened so that all wheels (four wheels 22 on the frame 18 and the wheel 14 on the leg 13 of the manipulator) contact the interior surface of the nozzle, the manipulator takes on a high degree of rigidity in any one position but is flexible to adapt to changed conditions as it is rotated without applying significant reactive loads to the mast or to the motor drive spindle for rotating the manipulator. In fact, the principal axis of the manipulator does not need to lie exactly on the axis of the nozzle. The manipulator axis can be slightly displaced and parallel to the nozzle axis or skewed relative to the nozzle axis without affecting the abiilty of the scanner mechanism to keep the scanning ultrasonic transmit/receive head accurately spaced from the interior surface of the nozzle as the manipulator is rotated and a scan takes place. Displacement of axis may cause some errors in interpreting the precise location of faults detected by the scanner but with modest displacements these errors may not be too significant and may be insignificant if the only problem is to identify the presence or absence of faults regardless of their location. The manipulator therefore acepts errors in its alignment in the nozzle and also accepts deviations from true cylindrical conditions in the nozzle as the manipulator is rotated.

WHAT WE CLAIM IS:—

1. A manipulator for supporting an ultrasonic scanning transducer within a coolant nozzle of a nuclear reactor pressure vessel, the manipulator being arranged for carriage by a support member disposed within the vessel and comprising a pair of legs pivotable in caliper manner to span the bore of the nozzle, the pair of legs being arranged for carrying the ultrasonic transducer and being rotatable about a manipulator axis extending between the legs and normal to the pivoting axis of the legs, means for pivoting the legs together to enable free entry of the manipulator and ultrasonic scanning transducer into the nozzle and for pivoting the legs apart to span the bore of the nozzle to bring the transducer into an operable position adjacent the wall of the nozzle.

2. A manipulator according to claim 1 wherein the free end of one leg has a guide wheel for rolling around the interior surface of the nozzle and the free end of the other leg has a pivotable frame for carrying the transducer.

3. A manipulator according to claim 2 wherein the frame has a pivotable mounting for the transducer, the mounting being pivotable on a frame first axis which is in the piane of and parallel to the manipulator axis and the frame being pivotably supported from the other leg on a frame second axis which is parallel to the pivoting axis of the legs, the frame having wheels for rolling around the interior surface of the nozzle and thereby spacing the transducer from the interior surface of the nozzle.

4. A manipulator according to claim 3

wherein the means for pivoting the legs together comprises a pneumatic ram.

5. A manipulator substantially as hereinbefore described with reference to the accompanying drawings.

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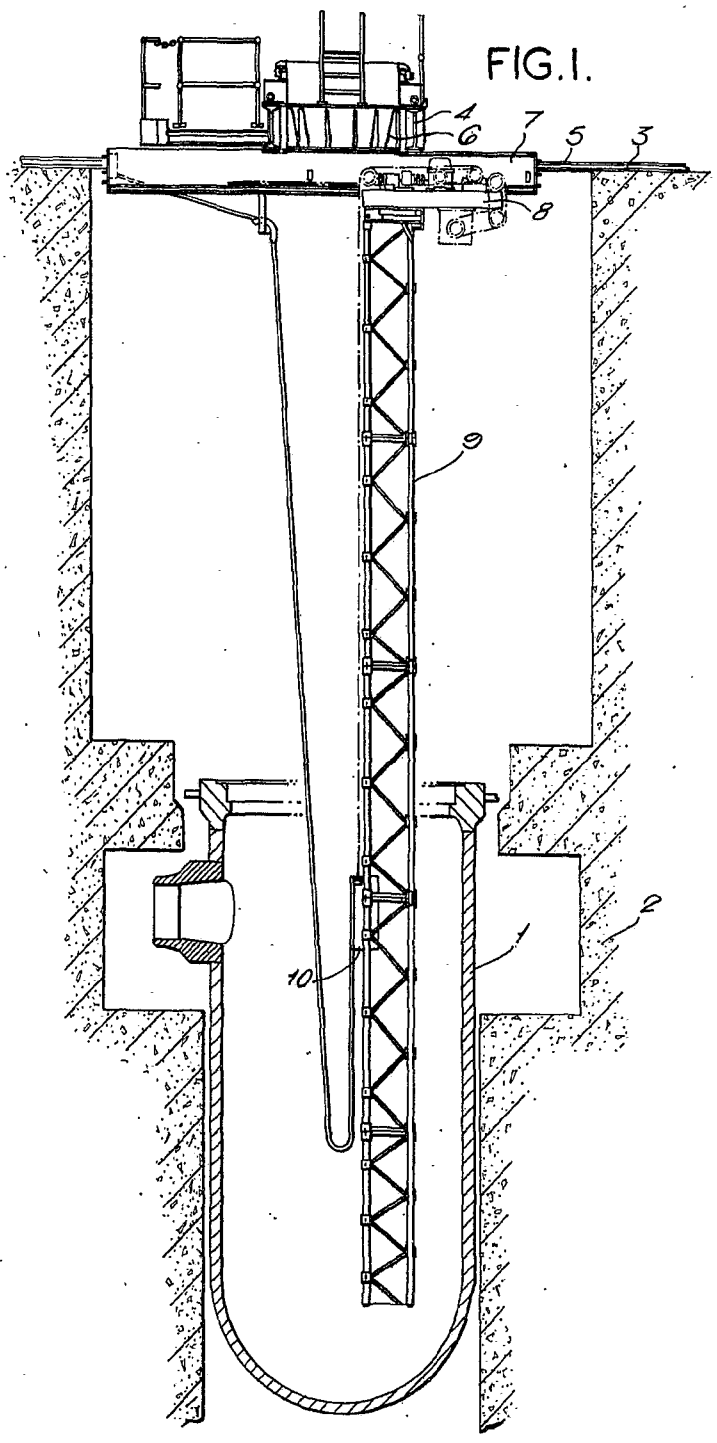
FIG.1.



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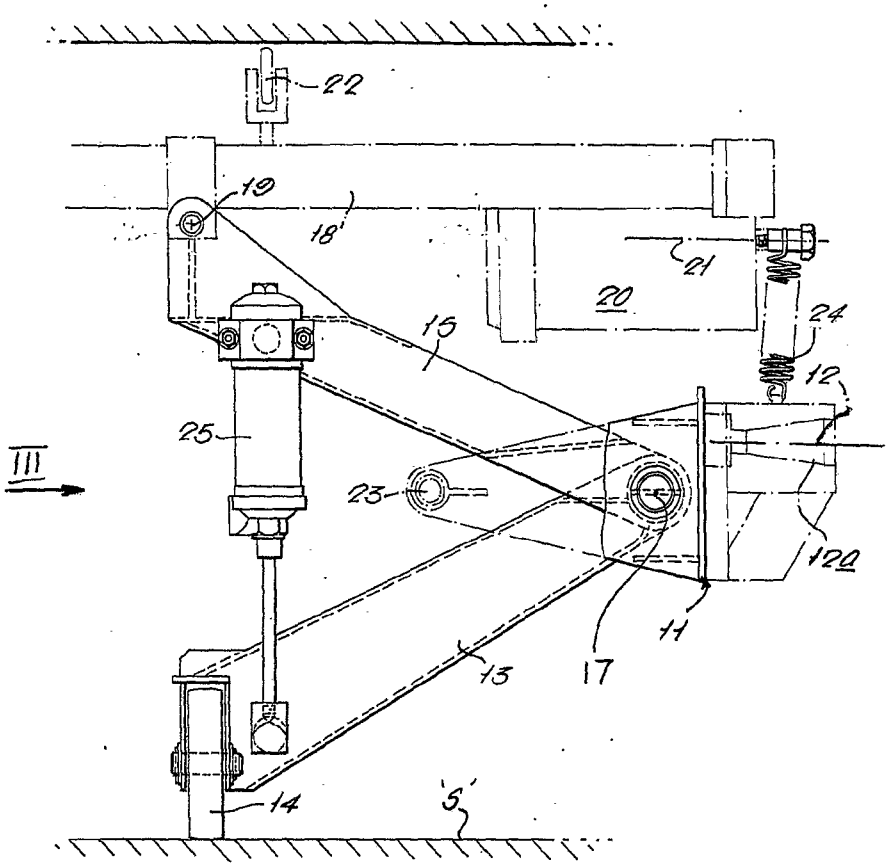
Sheet 2

FIG.2.



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Sheet 3

FIG. 3.