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PATENT SPECIFICATION (11) 1 368 837

(21) Application No. 27046/72 (22) Filed 9 June 1972
(44) Complete Specification published 2 Oct. 1974
(51) International Classification G05D 3/04; F15B 9/16; G21C 19/20//F16L 55/00
(52) Index at acceptance
G3P 1G 24X
F2G 8
G6C 220 22Y 240 24Y
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(19)

(54) MECHANISM AND METHOD FOR POSITIONING A MACHINE NOZZLE

(71) We, CANADIAN GENERAL ELECTRIC COMPANY LIMITED, a Company organized under the laws of Canada, of 214 King Street West, Toronto, Ontario, Canada, 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 is directed to a mechanism and method for positioning a machine nozzle and more particularly, but not exclusively, to an attitude sensing mechanism and a method of controlling the homing of a fuelling machine on to a fuel channel of a nuclear reactor.

In the operation of nuclear reactors of the Candu type, a type well known to those skilled in the art, the economically satisfactory functioning of such a reactor is predicated upon carrying out refuelling operations while the reactor is in the on-load condition. This art entails the homing of the snout or nozzle of a refuelling machine into precise mating relation with the outer end of a selected fuel channel end fitting, for latching of the nozzle thereto in a sealed condition, and to preclude jamming of fuel or the ram of the machine in the fuel channel. The problems of positioning the refuelling machine into aligned relation with the end of a specified fuel channel are complicated by the fact that the fuel channel pressure tubes, to which the fuelling machine must be hermetically sealed, have their ends protruding from a supporting shield structure, and deviation of the tube ends from a truly horizontal axis can readily occur due to construction tolerances. In view of the need to latch the refuelling machine snout in pressure sealed relation with a respective tube end, it will be understood that the capability of precise alignment and coincidence of the ends of the tube and the snout in a common plane and on a common axis is required in order to achieve the requisite extent of sealing tightness.

A measure of the problems involved can be gauged from the fact that the fluid to be contained at the seal interface is deuterium, at about 1500 psi. and 500° F. (and costing about $30. per pound) while the refuelling machine includes a barrel portion some eleven feet long weighing in the order of 7000 pounds. Furthermore, the snout securing operation, including homing of the snout in precise relation to a selected channel and attachment of the snout in sealed relation with the channel tube end, must all occur within a hazardous irradiated environment, and must be effected by remote control from outside the reactor compartment.

The present invention provides a method of precisely positioning the nozzle of a fuelling machine in oriented relation with a tube end of a nuclear reactor, including the steps of positioning the nozzle adjacent the tube end in sensible axial alignment therewith; contacting the tube end face; controlling the discharge of air from a pressurized source in response to the contact with the tube end face; and varying the orientation of the fuelling machine in response to variation in pressure consequent upon the air discharge to align the nozzle end face substantially parallel with the tube end face, whereby the machine may be secured in accurate alignment to the tube end.

In order to carry out the method there is provided a positioning mechanism adapted to be mounted on a machine, such as a nuclear fuelling machine having a snout, and operable when so mounted to provide parallelism between the machine snout and the end face of a tube to which the machine snout is to be coupled in aligned axially extending relation, comprising a plurality of sensors adapted to be mounted on the machine snout for movement therewith,

contact means adapted to be mounted on the machine snout so as to engage the end face of the tube upon approach of the snout to the tube, a plurality of control means connected one to each of the sensors, a plurality of position controlling servo motors adapted to be mounted in position controlling relation connecting the fuelling machine with a machine support carriage, and means connecting each control means to a related servo motor in controlling relation therewith, whereby when the mechanism is mounted on a machine and brought into general alignment with a tube, the contact means are moved to activate one or more of the sensors upon approach of the machine snout to the said tube to engage the contact means with the end face thereof, the extent of activation of respective sensors by the contact means contacting the end face of the tube determining the actuation of respective servo motors via the control means, so that the snout may be precisely positioned in a predetermined attitude with reference to the end face of the tube.

Certain embodiments of the invention are described, reference being made to the accompanying drawings, wherein;

FIGURE 1 is a general view in part section of a portion of a fuelling machine nozzle in locked engagement with a fuel channel end;

FIGURE 2 is a diametrical vertical section of the arrangement of Figure 1;

FIGURE 3 is an enlarged detail showing an adjustable resilient mounting for a sensing plate;

FIGURE 4 is a diametrical section view showing the fuelling machine head approaching a selected fuel channel tube end; and

FIGURES 5 and 6 are views corresponding to Figure 4 showing a possible sequence of operation in completing homing interconnection.

Referring primarily to Figures 1 and 2, a fuel channel tube outer end 12 is shown in homed and latched relation with the outer snout or nozzle end 10 of a fuelling machine (not shown). The homing head 14 is attached by a pair of actuators 16 to the front end of the fuelling machine, for forward extension into an operative position as shown, or for rearward retraction to an inoperative position, as required.

A homing head support ring 18 or mounting plate is attached to the actuators 16, having a reference plate 20 resiliently attached thereto by interposed Belleville washers. Four sensors, shown in Figures 1, 2, 4 and 5, mounted on plate 20 in mutual quadrature relation, comprise upper and lower sensors 21 and 23, side sensor 22 and a fourth sensor (not shown) having respective air supplies 31, 33 and 32 connected thereto (Fig. 1).

Each sensor 21, 22, 23 or 24 comprises an air valve having a forwardly projecting valve stem 28 which permits normal outward passage of air from the valve until rearward deflection of the stem 28 causes throttling.

Actuation of the respective air valves is effected by a sensing plate 34 resiliently supported at 36 by a plurality of spaced adjustable mounts, shown in more detail in Figure 3. The contact pads 35 against which the valve stems 28 make contact are individually threadedly adjustable relative to plate 34.

The snout 40 of the fuelling machine has a replaceable sealing ring providing sealing engagement between the inner lip 41 of the snout and a like inner lip 13 of the tube end 12, when brought into accurate register therewith.

A guide ring 50 assists the entry of the homing head 14 over the tube end 12 (see also Figures 4, 5 and 6). The end face 15 of the tube 12 contacts an interposed contact means illustrated as a contact ring 52, as the fuelling machine is advanced bodily in the axial or Z direction of forward drive. Canting of the contact ring 52, due to eccentric contact thereof with the tube end face 15 causes corresponding canting of the sensing plate 34, bringing one or more pads 35 thereof into pressing contact with the respective valve stem 28. Depression of the respective stem 28, shown in Figure 5 as being the valve 21 located at the 12 o'clock position, reduces the release of air through the valve somewhat proportionately to the amount of valve stem displacement. The respective air supplies 31, 32, 33 etc. shown in Figure 1 experience proportional pressure build-ups which activate the related portion of pressure sensitive limit switch 30. Each limit switch portion has a high and a low pressure setting and is in turn connected in energization controlling relation with one of the four positioning servos, by means of which the "X" and "Y" axis inclination of the fuelling machine is controlled.

By maintaining Z motion of the snout towards the tube end, while making automatic X and Y attitude corrections in response to the functioning of the servo limit switches as a result of back pressure variation in the respective limit switches caused by sensor plate contacts therewith, the fuelling machine snout may be brought into correct mating relation with the tube end, at which time the homing head 14 is retracted and the latching members 60, shown in phantom in Figure 2 may be engaged. At this time the sealing ring 42 is in metal-to-metal sealing relation both with

the snout and the tube end.

Owing to the use of such an air exhaling system at the snout, adjacent the reactor face, excellent reliability and inherent self cooling is achieved, with a marked absence of contamination. The arrangement permits the location of the electrical switching components on the fuelling machine at a position remote from the reactor face, where incident radiation is much reduced and thermal changes are less. A further advantage is the self damping characteristic that may be readily achieved, to avoid hunting and undue oscillation.

WHAT WE CLAIM IS:—

1. A positioning mechanism adapted to be mounted on a machine, such as a nuclear fuelling machine having a snout, and operable when so mounted to provide parallelism between the machine snout and the end face of a tube to which the machine snout is to be coupled in aligned axially extending relation, comprising a plurality of sensors adapted to be mounted on the machine snout for movement therewith, contact means adapted to be mounted on the machine snout so as to engage the end face of the tube upon approach of the snout to the tube, a plurality of control means connected one to each of the sensors, a plurality of position controlling servo motors adapted to be mounted in position controlling relation connecting the fuelling machine with a machine support carriage, and means connecting each control means to a related servo motor in controlling relation therewith, whereby when the mechanism is mounted on a machine and brought into general alignment with a tube, the contact means are moved to activate one or more of the sensors upon approach of the machine snout to the said tube to engage the contact means with the end face thereof, the extent of activation of respective sensors by the contact means contacting the end face of the tube determining the actuation of respective servo motors via the control means, so that the snout may be precisely positioned in a predetermined attitude with reference to the end face of the tube.

2. A positioning mechanism as claimed in claim 1 wherein the said sensors include two pairs of contactors in mutual quadrature arrangement, said contact means including a resiliently mountable contact ring adapted to be positioned between the contactors and the tube end face for movement relative to a said contactor in actuating relation therewith on being contacted by said tube end-face.

3. A positioning mechanism as claimed in claim 2, wherein each sensor comprises a variable discharge air valve responsive to actuation of the contactor by the contact means and a control switch responsive to back-pressure of air supplied to the valve such that when the mechanism is assembled on a machine, a respective servo motor is controlled to position the snout of the machine within predetermined distance limits of the tube end face.

4. A positioning mechanism as claimed in Claim 3, wherein when assembled to a machine, each contactor provides flow control from a respective air valve in air throttling relation, to progressively limit air outflow therethrough on approach of the snout contact ring to a predetermined relationship with the end face of a tube.

5. A method of precisely positioning the nozzle of a machine such as a nuclear fuelling machine in oriented relation with the tube end of a nuclear reactor, including the steps of positioning the nozzle adjacent the tube end in sensible axial alignment therewith; contacting the end face of the tube; controlling the discharge of air from a pressurized source in response to the contact with the tube end face; and varying the orientation of the machine in response to variation in pressure consequent upon the air discharge to align the nozzle end face substantially parallel with the tube end face, whereby the machine may be secured in accurate alignment to the tube end.

6. A method as claimed in claim 5 wherein the air discharge is diminished as the distance to the tube end face is diminished.

7. A method as claimed in claim 5 or claim 6 including the step of sensing the pressure of air supplied to a plurality of index points in spaced relation with the tube end face, and energizing a plurality of servo motors in response to the sensed pressures to orientate the machine as required.

8. A positioning mechanism substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

9. A method of precisely positioning the nozzle of a machine substantially as hereinbefore described with reference to the accompanying drawings.

10. A nuclear refuelling machine incorporating a positioning mechanism as claimed in any of Claims 1 to 4, or 8.

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Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1974.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

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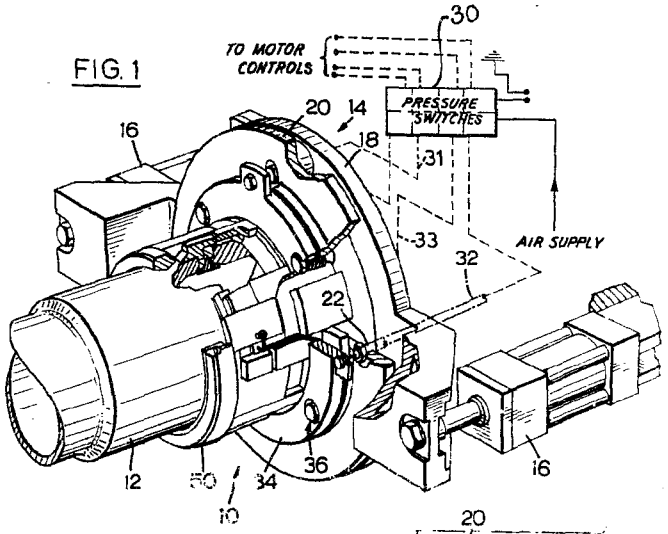
Sheet 1

FIG. 1



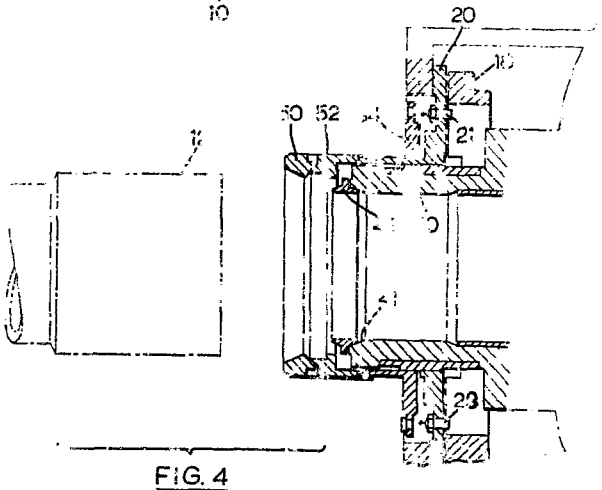


FIG. 4

FIG. 2

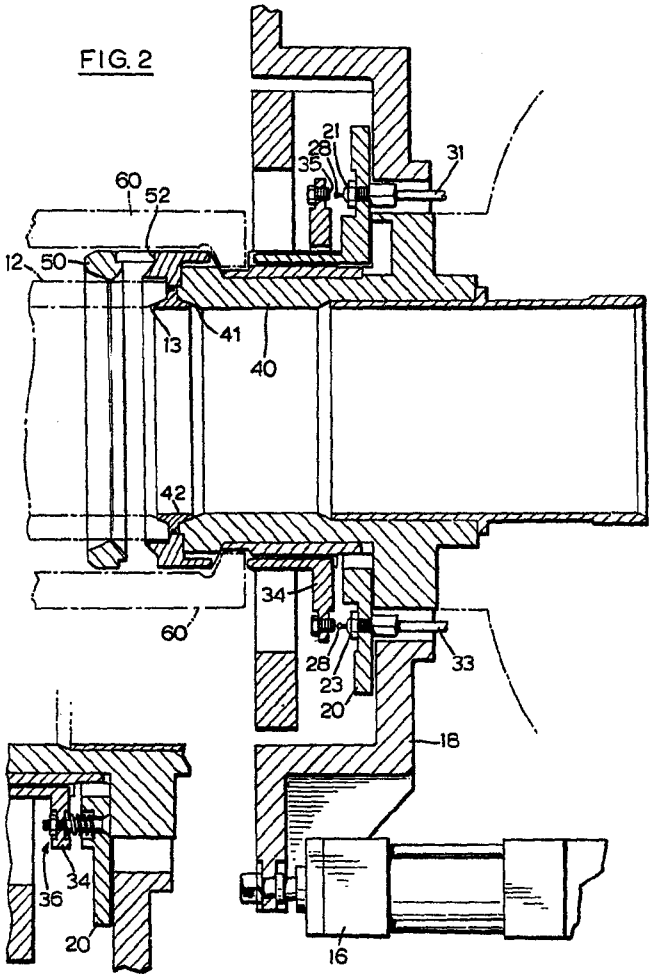


FIG. 3

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Sheet 3

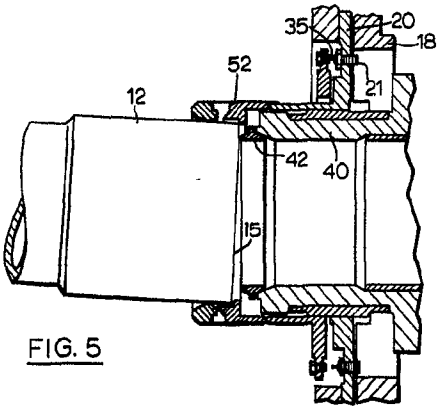

FIG. 5

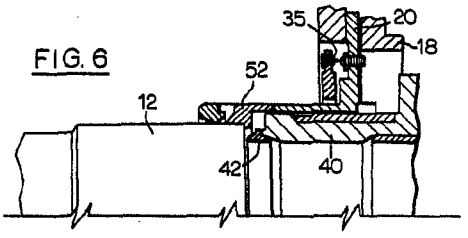

FIG. 6