Dec. 26, 1961 J. H. NICKLAS 3,014,856

LOCKING DEVICE FOR REACTOR FUEL ELEMENTS CONTAINING AN INTERLOCKING FEATURE

Filed Oct. 22, 1957 2 Sheets-Sheet 1

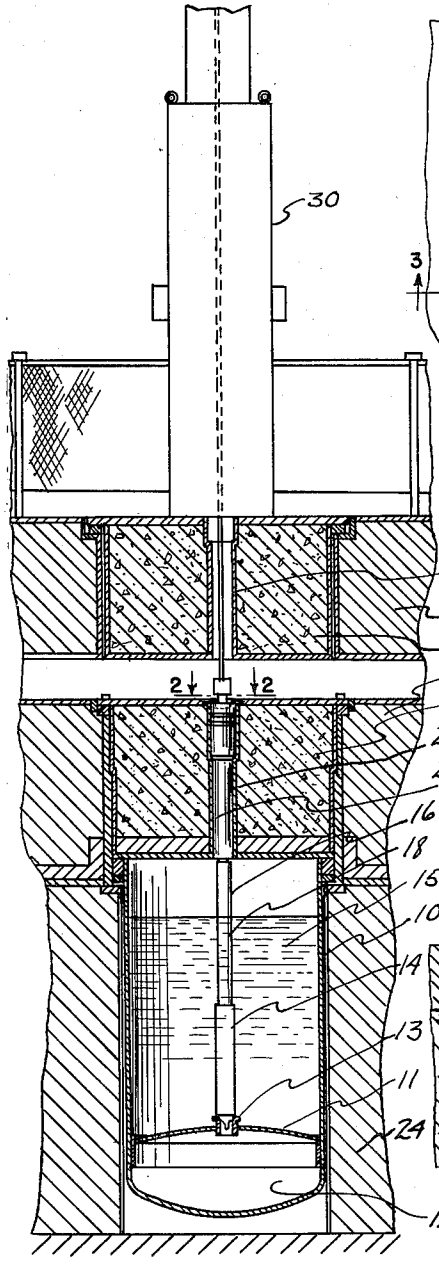


Fig. 1

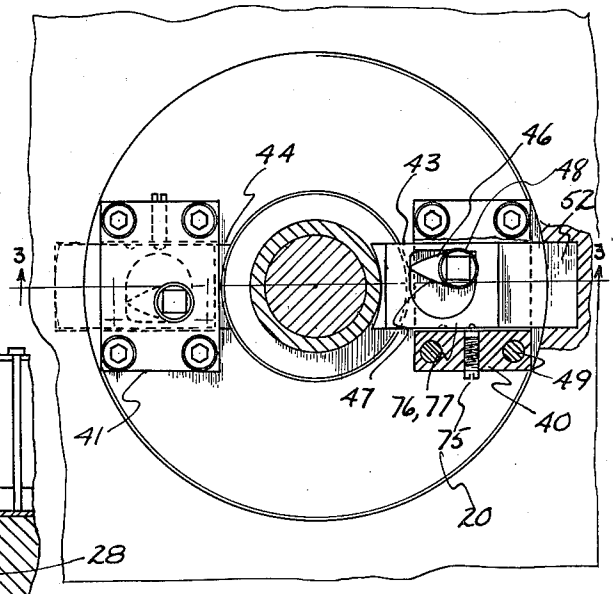


Fig. 2

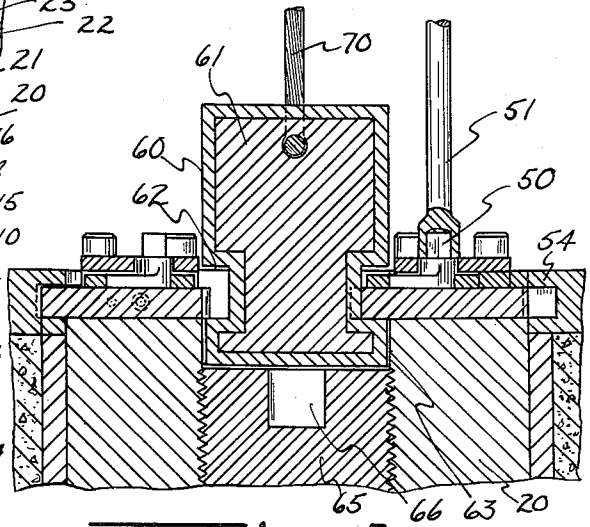


Fig. 3

INVENTOR

JOHN H. NICKLAS

BY Laurence M. Goodridge

ATTORNEY

Dec. 26, 1961 J. H. NICKLAS 3,014,856

LOCKING DEVICE FOR REACTOR FUEL ELEMENTS CONTAINING AN INTERLOCKING FEATURE

Filed Oct. 22, 1957 2 Sheets-Sheet 2

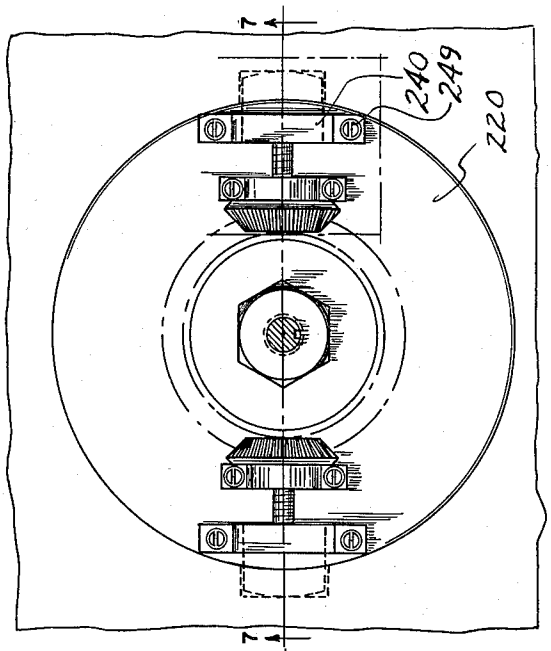


Fig. 6

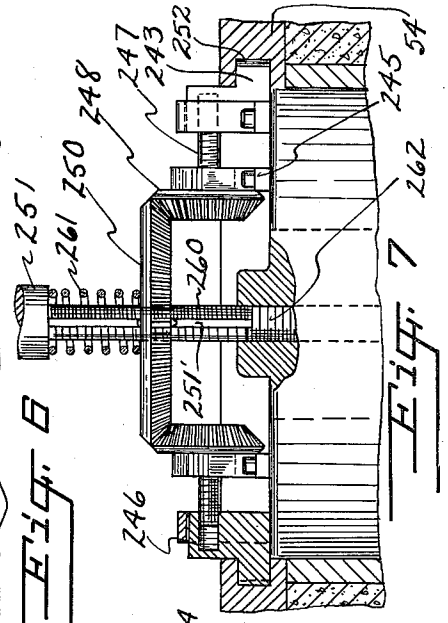


Fig. 7

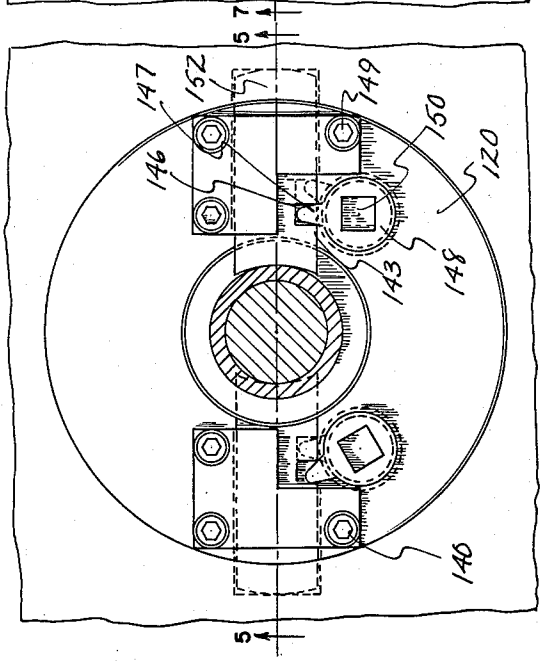


Fig. 4

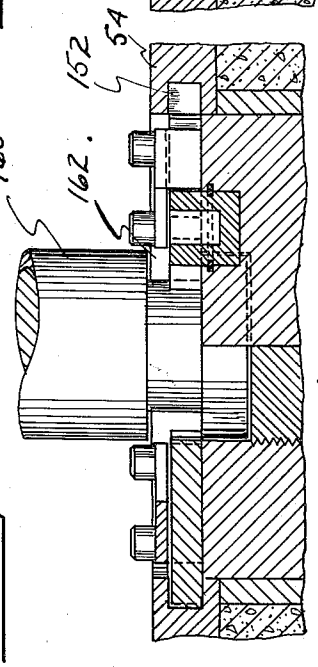


Fig. 5

INVENTOR

JOHN H. NICKLAS

BY Laurence M. Goodridge

ATTORNEY

United States Patent Office 3,014,856 Patented Dec. 26, 1961

3,014,856

LOCKING DEVICE FOR REACTOR FUEL ELEMENTS CONTAINING AN INTERLOCKING FEATURE

John H. Nicklas, Hyattsville, Md., assignor, by mesne assignments, to Allis-Chalmers Manufacturing Company, a corporation of Delaware

Filed Oct. 22, 1957, Ser. No. 691,572
5 Claims. (Cl. 204—193.2)

This invention relates to safety devices for nuclear power plants and more specifically to safety interlocking devices requiring the proper sequential operation for securing or releasing removable parts of the shielding of nuclear reactors and the like.

Because of the dangerous radiation generated by power plants and reactors using nuclear fuel, it is necessary to take every conceivable precaution against accidental exposure of persons operating the equipment. It is customary, for example, to equip the operating parts of nuclear reactors with safety devices which prevent operation unless the proper sequence of steps are followed. These safety features anticipate failure of operating personnel to follow proper operational procedure. Where proper interlocks are provided which compel sequential operation according to proper procedures, the chance of exposure for the operating personnel is materially reduced. The possibility of human error is then more or less removed from the risk involved in close association. The reduced risk, in turn, will certainly enhance the interest of insurance companies in accepting substantial financial responsibility for personnel operating a nuclear plant which is properly equipped in this respect.

This invention is particularly concerned with the application of safety devices to the removable fuel assembles forming the core of a reactor for research or power purposes but, as will be clear to those skilled in the art, the same safety devices have a more general use or application in this particular art.

According to this invention the fuel assemblies which carry the fuel elements are constructed so that they may be separately removed and replaced in the reactor, but preferably only by a tool specially adapted to this purpose. This tool is attached to the hoist line of the usual crane provided for the purpose, and is adapted to be removably secured to the exposed end of the shielding plug of a fuel assembly; for example, as a safety feature the shielding plug carries a latch which is engageable with, and disengageable from, suitable cooperating structure in the inner center shield of the reactor. In the process of releasing the tool from the plug after the fuel assembly is placed in the reactor, the latch is engaged with the shield structure and disengaged from the tool. When the tool is secured to the plug, the latch is disengaged from the shield structure and engaged with the tool, so that the fuel assembly may be removed from the reactor. Latch operation is remotely controlled by an operator located above the outer top shield of the reactor where he is protected from radiation during each of the operational steps.

One of the objects of this invention is to provide a shield plug with a mechanism to prevent accidental unlatching of the plug.

It is another object of this invention to provide a shield plug with a mechanism to insure that it is securely latched after being placed in the shield.

It is also an object of this invention to provide a plug with a mechanism arranged to accept a pulling tool which cannot be operated successfully without unlatching the plug from the shield.

It is another object of the invention to provide the plug with a mechanism for latching the plug in place

and for latching the plug to a pulling tool, which mechanism requires proper sequential operation of the parts thereof.

Further objects of the invention will become apparent from the following description taken in connection with the accompanying drawings, in which:

FIG. 1 is an environmental view schematically illustrating in vertical section the conventional parts of a nuclear reactor and a single fuel element for this reactor, together with the tool and flask utilized in its placement and replacement.

FIG. 2 is a transverse top view, partly in section, taken on the line 2—2 of FIG. 1.

FIG. 3 is an elevational view in section showing the engagement between the pulling tool and the shield plug of the fuel assembly.

FIG. 4 is a view similar to FIG. 2 showing a modification of the invention.

FIG. 5 is a view similar to FIG. 3 showing a transverse elevational section of the structure shown above in FIG. 4.

FIG. 6 is a view similar to FIG. 2 showing a second modification of the invention.

FIG. 7 is an elevational section through the modification shown in FIG. 6.

In the following description of the invention, so much of the nuclear reactor itself will be described as to enable one skilled in that art to understand the instant invention.

FIG. 1 illustrates such a nuclear reactor more or less schematically. In this view a tank **10**, usually of aluminum, is divided at **11** to form a plenum chamber **12** supplied with heavy water (D_2O) which acts as a moderator for the reactor. Suitable connections (not shown) with the plenum chamber **12** pressurize the chamber so that the moderator flows through the grid opening **13** into the fuel elements **14** (only one shown) which contain spaced plates carrying the uranium or other nuclear fuel charge. The moderator indicated as **15** is discharged through suitable openings in the fuel assembly **16** which carries the fuel element **14** and the moderator is maintained at a certain level as indicated at **18** by means well understood in the art. For example, reference is made to "Research Reactors," U.S.A.E.C.

Fuel assembly **16** is affixed to a shielding plug **20** removably supported within the hole **21** in the inner center shield **22**. The inner center shield or plug is in turn removably mounted within the inner annular shielding which surrounds the reactor indicated as **23**. All portions of the tank **10** are also suitably shielded as indicated at **24**.

Above the inner shield **23** is an outer annular shield **26** with a removable center shield or outer top plug **27**. The hole **28** in the outer center shield is adapted to receive a suitable lead plug of shielding material, but as here illustrated this plug has been removed so as to allow access to the inner center shield **22**.

Positioned on the outer center shield **27** is a flask **30** in which the fuel assembly **16** may be transported. The flask, of course, is suitably shielded by lead and contains proper mechanism for enclosing and transporting the fuel element.

Safety latching and unlatching mechanism

FIG. 2 and FIG. 3 illustrate in detail the construction of the latching means for holding the plug **20** locked in place within the inner center shield or, alternatively, locked to the tool means shown as tool **60** for removing or replacing the plug within the reactor. The top surface of the plug **20** carries two pairs of guides **40** and **41** which slidably mount the latch members **43** and **44**. Since each

guide and latch is of the same construction, only one will be described in detail.

The latch member 43 has a D-shaped cam socket 46 and a cooperating cam 47 supported by a spindle 48 journaled in the parallel guides 40. The guides are suitably secured to the plug by screws or bolts 49. The upper end of the spindle 48 projects through the top surface of the guide 40, and has a nut end 50 for operation by a suitable tool 51 which, in this case, is a socket-type wrench. Operation of the cam 47 by the wrench 51 in a clockwise direction moves the latch 43 inwardly, and retracts the latch from the cavity 52 formed in the upper cover plate provided on the inner center shield 54.

The tool for removing and replacing the fuel element 16 has a cylindrical body 60 forming a casing for ballast such as lead 61 within the cylindrical body 60 of the tool. The tool is provided with means for receiving the latch member and defines a peripheral circumferentially extending groove 62 into which the latch 43 is moved when the cam 47 is rotated in a clockwise direction. Counterclockwise rotation of the cam 47 forces the latch 43 into the socket 52, thus locking the plug 20 in place. In other words, the end portions of the slidable latch 43 are telescopically receivable respectively by cavity 52 and groove 62. The plug 20 has a central bore 63 for receiving the lower end of the tool 60. The bore 63 may be closed by a suitable plug 65 providing access to a radiation chamber for receiving samples to be tested. The socket 66 is shaped to be engaged by a wrench for removing the plug 65. Tool 60 is supported from the crane by a cable 70.

Operation

The utilization of the above described equipment for placing a fuel assembly 16 within the reactor is as follows: After the plug has been removed from the bore 28 in the outer center shield 27, the flask 30 is positioned in alignment with the bore. The tool 60 supported by the cable 70 from the crane is then fastened to the plug 20 by inserting the tool 60 within the bore 63 of the plug 20 and rotating the cams 47 in a clockwise direction. The gates of the flask 30 (not shown) are then opened, and the fuel assembly 16 lowered into the position shown in FIG. 1 by the crane. In this position, the wrench 51 is inserted through the hole 28, and each of the cams 47 rotated in a counter-clockwise direction, thus releasing the tool 60 and at the same time forcing the latches 43 into the sockets 52 to secure the fuel assembly against accidental removal or displacement due to fluid pressures generated within the reactor. The tool 60 cannot be released from the plug 20 unless the latches 43 are in the proper latched position in the sockets 52. Likewise, the plug 20 cannot be secured to the tool 60 unless the latches 43 are fully removed from the sockets 52 into engagement with the circumferential groove 62 in the tool. This insures that once the tool 60 has been released, the plug 20 is secured. The cams 47 are so shaped that when rotated to the full extent in either direction, they actually are in a dead-center position, resisting any force on the latches 43 tending to move the latch in either direction. As an added safety precaution a spring pressed detent 75 with cooperating notches 76 and 77 is provided to hold the latch 43 in its extreme positions.

It is contemplated that spindles 48 could be interconnected for simultaneous operation.

First modified form of the invention

FIGS. 4 and 5 illustrate a modification of the latch structure above described. Similar parts will be given the same reference characters, preceded by 100.

FIG. 4 shows a pair of guides 140 secured to the top of a plug 120 of a fuel element by suitable screws 149. Since both latches are the same, only one will be described here. The guide 140 slidably supports and retains a latch 143. In one edge of the latch 143 is a socket 146 receiving the tooth or cam 147 which is mounted on a spindle 148 suitable journaled in the top of the plug 120. The spindle 148 has a socket 150 for receiving a wrench for rotating the tooth or cam 147. Rotation of the spindle 150 in a clockwise direction projects the latch 143 into a socket 152 located in the cover plate 54 of the inner center shield. Rotation of the spindle 150 in a counterclockwise direction projects the latch 143 into engagement with a peripheral groove 162 in the casing of the tool 160, which casing may contain suitable ballast material and be adapted for support by a cable 70 from the hoist in the same manner as heretofore described.

Operation of first modified form

The operation of this embodiment is similar to that above described, except that the spindles 148 are rotated in opposite directions to engage and disengage the latches with the shield cavities 152 and the tool 160, respectively. Regardless of this feature, the same characteristics insuring safe operation are provided—that is, in order to engage the tool with the latches, the latches must be unlocked from the sockets 152, and, in order to disengage the tool 160 from the plug 120, the latches must be engaged with the sockets 152. There is no possibility that the plug could be placed in the center shield and the tool 160 removed without also effectively latching plug 120 in place; nor is there a possibility that the tool could be engaged with the plug without disengaging the latches from the center shield.

Construction of second modification

In the modification shown in FIGS. 6 and 7, similar parts are indicated by the same reference characters, preceded by 200.

The plug 220 carried by the top of the fuel assembly mounts a pair of latches which are similar in construction, and so only one will be described. Latch 243 is slidably guided in and out of a socket 252 in the cover of the inner center shield by a guide 240 held on the plug by screws 249. A threaded recess 246 in the latch 243 is engaged by the threads 247 of a screw mounted in the stationary journal 245 on top of the plug 220. Screw 247 carries a beveled pinion 248 operated by the beveled gear wheel 250. The gear 250 can be rotated by tool 251, to which the gear 250 is slidably keyed. The lower end of the tool 251 is threaded to engage with corresponding threads 262 in the plug 220. A spring 261 is biased between a shoulder on the tool 251 and the top of the gear wheel 250. Suitable provision may be made for limiting the downward movement of the gear wheel 250 on the threaded portion 260 of the tool 251. Keyway 251' extends only part-way to the end of the threaded portion 260 for this purpose.

Operation of second embodiment

The operation or utilization of the tool 251 is very similar to those heretofore described. The tool 251 is suspended from the cable 70 by a swivel joint, if desired, so that it can be rotated in either direction. When so constructed, the threads 260 can be screwed into the threads 262 of the plug 220. During this engaging operation, bevel gear 250 is urged into mesh with pinions 248 to rotate bevel pinions 248 in a direction to cause the threads 247 to withdraw the latches 243. When the threads 260 are fully engaged in the plug 220, the latches 243 are completely withdrawn. The spring 261 maintains the gears in mesh.

The fuel assembly can now be lowered into the reactor to the position shown in FIG. 7, and rotation of the tool 251 in the opposite direction projects the latches 243 into the sockets 252, locking the fuel element in place in the center inner shield while disengaging the threads 260 from the threads 262.

The reverse operation involved in removing the fuel assembly is performed in the same manner. With this arrangement of parts, rotation of the tool 251 to engage

the threads **260** insures the withdrawal of the latches **243**. It is accordingly impossible for the operator to attempt to withdraw the plug **220** without first disengaging the latches **243**.

Several embodiments of this invention have been described which will fulfill all of the objects of the present invention, but it will be readily recognized that other modifications will occur to those skilled in the art which come within the terms of the appended claims.

I claim:

1. In a nuclear reactor having a stationary shield structure and a plug of shielding material removably disposed in said shield, a mechanism for automatically performing a plurality of operations in a sequential manner in accordance with a predetermined safe procedure for removing and replacing said plug of shielding material in said stationary shield structure comprising a tool member telescopically engageable with said plug, latching means associated with said plug including a latch member mounted on said plug for back and forth movement alternatively between a plug locking position and a tool locking position, said latch member and said shield structure having portions respectively cooperating with each other when said latch member is disposed in said plug locking position to prevent removal of said plug from said shield structure, and said latch member and said tool member having portions respectively cooperating with each other in load transmitting relationship for removal of said plug from said shield structure when said latch member is disposed in said tool locking position, and operating means for said latch member adapted for actuation from a remote position.

2. The combination as defined in claim 1 in which said latching means for locking and unlocking said plug in the shield structure of said reactor includes a latch slidable on said plug, and in which said means for operating said latching means includes a screw having threads meshing with mating threads of said latch and a beveled pinion for operating said screw, and in which said plug removal means includes a threaded spindle engaging mating threads in said plug and a bevel gear on said spindle for driving said pinion.

3. The combination as defined in claim 1 in which said latching means associated with said plug includes a pair of diametrically opposed latch guides mounted on the outer end of said plug, said latch members being slidable in said guides.

4. The combination as defined in claim 1 in which said mechanism includes said movably mounted latch member having opposite end portions thereof, said shield structure having a cavity defined therein for receiving one end portion of said latch member to lock said plug to said shield structure, and said tool member having a peripheral circumferentially extending groove defined therein for receiving the other end of said latch member in load transmitting relationship therewith to lock said tool member to said plug.

5. The combination as defined in claim 4 in which said mechanism includes a latch member having a cam socket and a cam rotatably mounted on said plug and operating in said socket to alternatively project said end portions respectively into said shield cavity and into said tool member groove.

References Cited in the file of this patent

UNITED STATES PATENTS

1,929,701	McCalister	Oct. 10, 1933
2,514,909	Strickland	July 11, 1950
2,725,993	Smith	Dec. 6, 1955
2,848,404	Treshow	Apr. 19, 1958
2,851,410	Vernon et al.	Sept. 9, 1958