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ACCESSION NBR:8803080276 DOC.DATE: 88/02/25 NOTARIZED: NO DOCKET #
FACIL:STN-50-528 Palo Verde Nuclear Station, Unit 1, Arizona Publi 05000528
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SUBJECT: Forwards response to RJ Pate request for justification for continued operation of Unit 1 & inability of Control Element Assembly 56 to reliably drop during testing.Addl info solicited by C-E & followed.

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February 25, 1988
161-00826-EEVB/JRP

Mr. John B. Martin, Regional Administrator
Office of Inspection and Enforcement
U.S. Nuclear Regulatory Commission, Region V
1450 Maria Lane, Suite 210
Walnut Creek, CA 94596-5368

Dear Mr. Martin:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Unit 1
Justification for Continued Operation - Inability of CEA 56 to Drop
File: 88-A-056-026

This letter is in response to a request from Mr. R. J. Pate, of your staff, to provide Justification for Continued Operation of Unit 1 in light of the recent inability of Control Element Assembly (CEA) Number 56 to reliably drop during testing prior to initial criticality after the first refueling outage. Since then, ANPP has been gathering and analyzing information pertaining to this event. In addition to the formation of an in-house review group, Combustion Engineering (CE) was included in the investigation and their recommendations were solicited and followed.

Attachment A will provide the following information for your review: I. Event Description, II. Event Investigation, III. Event Evaluation and IV. Conclusion/Corrective Action. Attachment B provides the list of figures.

Based on the information and material presented herewith, the continued operation of PVNGS Unit 1 presents no undue risk to the public health and safety.

Very truly yours,

E. E. Van Brunt

E. E. Van Brunt, Jr.
Executive Vice President
Project Director

EEVB/JRP
Attachments
cc: O. M. De Michele (all w/attachments)
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T. J. Polich
R. J. Pate

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ATTACHMENT A

I. EVENT DESCRIPTION

On January 22, 1988, Unit 1 was in Mode 3 at normal operating pressure and temperature. The CEA Drop-Time test was in progress. During the testing of CEA 56, the CEA did not drop when its individual power supply breaker was opened. The Reactor Trip Switch Gear (RTSG) was then opened to assure power was removed to the CEA and that it was not an individual breaker fault. The CEA still did not drop into the core. After moving the CEA up and down through several cycles (referred to as CEA-"exercising"), the operators were able to insert the CEA to the bottom of the core using the normal Control Element Drive Mechanism (CEDM). CEA-exercising was continued until the CEA would drop freely to the bottom of the core. The CEA drop time was within the acceptance criteria established by Technical Specifications and was consistent with the other CEAs. The CEA was then left at the bottom of the core in order to allow completion of drop-time testing on other CEAs. All other CEAs passed the surveillance test.

The following day testing was resumed on CEA 56 since the cause of the initial binding had not been determined. Electrical testing of the CEDM coils indicated that there was either a binding problem somewhere along the CEA, or the CEA extension shaft, or the CEDM grippers failed in such a way as to "lock" the grippers on to the extension shaft creating a rachet effect (the CEA could be withdrawn but not reliably inserted). Coincident with this event it became necessary to cool the plant down to Mode 5 in order to repair a leak in an RCS auxiliary piping system. It was decided that further testing would be performed after entering Mode 5.

II. EVENT INVESTIGATION

After discovery of the problem with CEA 56, plant management after consultation with ANPP Senior Project Management, formed an on-site task force review group. This group was made up of Engineering Evaluations Department personnel, Unit 1 Plant Manager, Unit 1 Work Control and CE. They were tasked with being the focal point for organizing, coordinating, evaluating and directing the trouble shooting and inspection regarding CEA 56. CE provided inspection, evaluation, direction and assistance during the investigation and recovery.

Subsequent testing of CEA 56 while in Mode 5 consisted of pulling it up 10 inches and then inserting back into the core.

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The CEA moved freely up 10 inches, but could not be inserted nor dropped to the bottom of the core. The CEA was then pulled to 30 inches in a stepwise fashion. The CEA moved freely out of the core but could not be returned to the bottom of the core. The CEA was left at the 30 inch level until further evaluations could be made.

Following the cooldown, further testing of the CEDM coil traces verified that the CEDM was performing, electrically, as designed. The decision was then made to proceed with removal of the CEDM Upper Pressure Housing in order to determine if there was mechanical interference between the extension shaft and the motor guide tube. Upon completion of this effort no indication of mechanical interference was found. The CEDM was removed with no evidence of binding. A boroscope examination was performed on the accessible portions of CEA 56 in the Upper Guide Structure (UGS) through the opening of the pulled CEDM. The boroscope examination allowed inspection of the extension shaft down to the top of the UGS upper support plate, the spider, and the extension shaft spider joint. No evidence of mechanical interference or CEA damage was found using this technique.

Subsequent to the boroscope examination, an attempt to exercise the CEA was made (with the CEDM removed). This was done utilizing an overhead hoist with a dynometer installed to measure the lift resistance. The CEA was initially lifted at a tensile load of approximately 480 lb_f, then moved freely upward with the dynometer indicating only the hanging weight of the CEA (approximately 280lbs). The lifting force was removed and the CEA did not move downward under its own weight. An additional 75 lb_f load was added to the CEA per CE's recommendation. This effort was not successful and the CEA remained at 32 inches withdrawn.

To continue the investigation, it was necessary to remove the reactor vessel head to gain access to the inner portions of the UGS. The reactor vessel head was removed and stored on its support stand. A preliminary inspection was then performed using binoculars to determine if CEA 56 was in any way oriented differently than the other CEAs. It appeared to be oriented correctly with respect to the others.

Through the use of special cameras, an inspection of CEA 56 was performed looking at the extension shaft, the extension shaft/spider coupling, the CEA finger nuts, the arms of the spider, and the first weld zone of each of the CEA fingers. This examination determined that the visible portion of the CEA showed no damage or deformation that would be related to excessive downward thrust loading. The inspection continued down the finger to the UGS support plate where it was then noted

that it's CEA fingers were oriented to the east in the UGS guide tubes. This led to the assumption that the binding was located below the UGS, and was in one of the west most fingers.

To more fully inspect the full length of the CEA fingers, the UGS was removed from the vessel and placed in its storage location within the refueling pool. At the same time this allowed the top of the fuel assemblies to be inspected. A camera inspection of the top portions of the nine fuel assemblies centered by CEA 56 was performed, resulting in the finding of an indication of damage in the flare of the southeast guide post of fuel assembly P2C117.

CE had provided for a method to check each of the twelve fuel assembly guide tubes with a ball-check gauge to verify the diameter clearance within the tube, and to ensure the bottom of the guide tubes were free from debris that could prohibit the full travel of a CEA finger. This inspection led to the discovery of a ball bearing in the bottom of the southeast guide tube post of fuel assembly P2C117. This was removed by vacuuming the guide tube. No other debris was found that could have affected CEA 56. Caliper measurements of the ball gave a diameter of 0.153 inches.

In parallel with the ball gauge inspection, a full-length finger inspection of the affected CEA was performed. The camera inspection of the CEA fingers revealed several marks along the twelfth finger (this finger would reside in the southeast guide tube of fuel assembly P2C117). It should be noted that CE System 80 utilizes a twelve finger CEA which has four fingers in the center fuel assembly and two fingers in each of four adjacent fuel assemblies (Fig. 8). The location of the affected CEA finger is shown in Figure 8. These marks were located in the same orientation as the marks found on the flare of the fuel guide post in question. A comparison of the mark on the CEA finger and the finger diameter, as measured on a video screen showed the mark to be approximately 1/8" across.

III. EVENT EVALUATION

As a result of these investigations, it was determined that the binding was due to the ball bearing lodging between the CEA finger and the fuel assembly guide post flare (Fig. 12). <u>The occurrence of this phenomena is only possible if the ball bearing enters from the UGS support plate, travels down the UGS guide tube to the fuel assembly guide post flare area.</u> This was further proven by taking a similar sized ball bearing, a dummy fuel assembly, and a dummy CEA finger (all dimensionally correct) and assembling them together in the same orientation as would have existed for CEA 56. The finger was free to move in the outward direction but it was discovered that the finger became lodged by the ball bearing when moved inward and further insertion of the finger was prohibited.

The CEA finger O.D. coupled with the guide tube I.D. would prohibit the ball bearing from traveling down the tube with a CEA finger in the guide tube. The diametrical clearance between the guide tube post and the CEA finger is 0.1575 inches at the top of the guide post flare but the clearance narrows to 0.126 inches at the bottom of the guide post flare.

A review of the operating equipment in or around the UGS was performed, and it was determined that the ball bearing originated from the MST which is used to tension and detension the reactor vessel head studs. The ball bearing recovered from the guide tube, plus ball bearings from the Multi-stud Tensioner (MST) were sent to an independent laboratory for metallurgical analysis. The MST ball bearings and the one removed from the guide tube were confirmed to be metallurgically equivalent using standard industry comparison techniques. The ball bearing that was removed from the guide tube was found to be contaminated and not activated. Therefore, the ball bearing was not in the reactor coolant system during the first cycle and must have been introduced during the refueling outage.

The most probable course of travel for the ball bearing is summarized below:

a. The MST was removed from the reactor vessel head to the storage location with the studs stored in the MST (Fig. 1).

b. The MST was being utilized for stud cleaning in the storage location (Fig. 1).

c. While the stud cleaning was in progress, the reactor vessel head was removed to its storage location (Fig. 1).

d. The UGS was then removed to the UGS storage pit (Figs. 1&2).

e. The ball bearing was released from the MST (Fig. 1).

f. During the course of work activities, the ball bearing fell into the UGS Storage Pit and onto the top of the UGS upper support plate (Figs. 1&2).

g. The UGS was reinstalled in the reactor vessel (Figs. 1&2).

h. The reactor vessel head was reinstalled.

i. During the course of heating up and running the RCPs, the ball bearing dropped between the UGS guide tube and the CEA finger (Figs. 3-12).

j. The ball bearing became lodged between the CEA finger and the fuel assembly guide post (Fig. 12).

k. The CEA drop time testing resulted in the discovery of CEA mechanical binding.

Other pathways were reviewed and found not to be as probable because of Q.A. inspections prior to lifting off the reactor vessel head.

Had a bearing assembly failed while the MST was positioned on the reactor vessel flange (during stud detensioning), the ball bearing could have fallen on to the floor of the refueling canal. As the level in the refueling pool was raised and lowered during the refueling evolution, it would be conceivable that the ball bearing could have been swept into the UGS while it was in the reactor vessel. This scenario is highly unlikely since a ball bearing traveling from the fuel transfer canal floor would fall into a gap between the reactor vessel and the flange (Fig. 2A).

As previously discussed, damage was found on the southeast guide post of fuel assembly P2C117. It can be characterized as a uneven contact mark on the flare region of the guide post with a minor amount of raised metal on the mid-height portion of the flare (Fig. 16).

The function of the guide post flare region is to provide a smooth surface for entry of CEA fingers into the fuel assembly. CEA alignment is such that no contact is made with the post flare region following reactor reassembly, even with the CEA fully withdrawn.

A review of the indications on the guide post confirmed that observed damage is confined to the guide post flare region of the guide tube (Fig. 12). No damage that could interfere with CEA travel was evident in the lower portion of the guide tube since the ball gauge traversed the full length of the guide tube without binding. In addition, there was no indication that the ball bearing traveled below the guide post flare region. Since no CEA guide post flare area contact is made during operation and no material which could become loose was observed in the damaged area the guide post is considered acceptable for unrestricted continued operation.

CEA 56 is a twelve finger CEA. It was inspected for damage caused by interaction with the ball bearing. The initial observation made of this CEA immediately after the reactor vessel head was removed was that the CEA was leaning slightly toward the east axis of the reactor. All the CEA fingers were in contact with the east side of their respective UGS guide tubes. This suggested that the particular finger which was stuck was toward the west axis. All the CEA fingers were inspected at the point which corresponds to approximately 30 inches withdrawn. Although wear marks were observed on the east side of the fingers of the CEA, none were evaluated to be

excessive or requiring further examination. These marks were made either by normal contact with the guide tube during reactor trips or by contact with the guide tube/end fitting while the CEA was stuck. The CEA finger which did interact with the ball bearing was examined over its entire length. Evidence of scratches normally occurring due to metal-to-metal contact between CEAs and guide tubes were evident and evaluated as acceptable. Scratches and occasional indentations were observed at several elevations on the CEA finger and generally within a small area of the circumference of the finger. The most severe indication was located on the CEA approximately 147 inches from the bottom of the CEA. Thus, when the CEA is 30 inches withdrawn, the damaged area of the CEA would be adjacent to the damaged area of the fuel assembly guide post. It could be characterized as a depression approximately 1/8 inch wide at the surface of the CEA and approximately 3 inches long in the axial direction. This corresponds to the region of the top of the B_4C pellet stack in the upper portion of the CEA (Fig. 21). It was visually determined that the CEA cladding was not breached.

Based on the above evaluation the CEA remains acceptable for continued operation because:

- All indications of contact with the ball bearing are above the region where swelling of the boron carbide pellets will occur in amounts large enough to close the diametrical gap with the cladding.
- All indications of contact with the ball bearing were in an area above the length of the CEA which enters the tight clearance buffer region of the guide tube at the bottom of the fuel assembly.
- Sharp edges were not involved in the creation of damage.
- The loads exerted on the CEA finger were within the original design basis axial loads.
- The spider joints and upper nuts were examined and found to be satisfactory. The entire length of the CEA was found to be free of any abnormal bowing.

Although the inspection supports the conclusion that the CEA cladding retains its structural integrity, the consequences of a cladding breach in the damage area have been reviewed. Control rods supplied by various vendors have been operated with cladding cracks. These cracks were near the rod tips, and were induced by a combination of corrosion and high tensile stress created by absorber swelling. Even with this outward stress, the associated cladding deformation has not interfered with control rod drop. In the Palo Verde case, there will be no outward strain of the cladding due to swelling, at the location of the indication.

A breach in the cladding would result in exposure of the boron carbide pellets to reactor coolant. Based on limited BWR data, the washout of boron carbide is minimal unless the rod is heavily irradiated (Boron-10 depletion of greater than 50%). Exposures required to cause these levels of depletion would only occur near the lower tip of the rods.

An evaluation was performed to determine the impact of a ball bearing in the RCS on core performance. It was concluded that the following three items were the only significant concerns with respect to continued operation:

1) The effects of a ball bearing on core operation (potential for blockage and reduction of safety margin);

2) The potential for the ball bearing to become lodged in a fuel assembly causing fretting damage that may impact cladding integrity.

3) The potential that a ball bearing, within a fuel assembly could travel from its location in the RCS to the point where the mechanical interference would prevent insertion of the CEA. The effects of a stuck CEA is addressed in the safety analysis.

1) Potential for flow channel blockage:

There is a very low probability that a 0.153" nominal ball bearing could fall or otherwise be transported downward past the top fuel spacer grid into the fuel assembly or be transported upward past the bottom fuel spacer grid into the fuel assembly. There are 14 cross-sectional flow areas (two per guide tube and at the four corners) that would just allow the passage of the 0.156" ball bearing (See Fig. 20); this constitutes 1.1% of the cross sectional flow area of the fuel assembly. The axial location of the fuel pins (within the fuel assemblies) do not extend to the edges of the top or the bottom spacer grids.

ANPP Safety Analysis Section and CE have performed an evaluation of the effects of the ball bearing within the fuel assemblies. Their analysis demonstrated that a ball bearing trapped in the fuel assembly could not reduce the margin to DNBR during transient events.

2) Potential for fuel pin damage:

Another effect considered is that of a ball bearing trapped between a fuel pin and a spacer grid. This could result in a limited amount of fretting. In the event that this occurs it would be bounded by the allowed 1% failed fuel limit currently used as the design basis.

3) Potential for debris immobilizing a CEA:

This concern can be broken down into two possible scenarios:

a) The ball bearing falls into a fuel assembly guide tube;
b) The ball bearing rests in the fuel or on top of the fuel, and is picked up by RCS through the flow holes to the upper plate of the UGS.

a) The ball bearing at the bottom of a fuel assembly guide tube will present no adverse consequences. In order to move a ball bearing that is seated at the bottom of the guide tube it would have to be subjected to a hydraulic force such as RCS flow. In this scenario, the flow holes of the guide tube are above the elevation of the seated ball bearing. Therefore insufficient flow exists to suspend or lift the ball bearing and it would remain seated at the bottom of the guide tube.

During a CEA trip, the CEA will fall no closer than 0.2 inches from the bottom of the guide tube. If the turbulent flow within the guide tube, during a CEA trip, does cause the ball bearing to lift, the height that it could be lifted to is limited by the elevation of the guide tube bleed hole (less than 1.5 inches above the bottom of the guide tube). At that elevation the CEA is approximately 99 percent inserted. The geometries of the components involved make it highly unlikely that the ball bearing would wedge between the CEA finger and the guide tube.

b) If it is assumed that there may be a ball bearing in the core which cannot be identified or recovered. This ball bearing may have been in the UGS and may have fallen into the core during reactor vessel reassembly. When the RCPs are placed into service it can be postulated that hydraulic forces could result in the ball bearing being lodged in the same location which produced the mechanical interference of the CEA.

There is only one credible pathway which the ball bearing can follow that can produce an interference of the type observed in this event. It would be necessary for the ball bearing to travel from its location in the core up into the upper plenum (Fig. 10), via flow holes in the UGS support plate and then down through the UGS guide tube, between the CEA finger and the UGS guide tube (Fig. 14). An evaluation (documented on an Engineering Evaluation Report) shows that there is less than a 0.5% probability that this event could occur when full RCS flow is established. The probability of the event is reduced even further during one - RCP and two - RCP combinations. This will contribute to a

reduction of the probability of this event occurring by increasing the likelihood that a ball bearing, it if exists in the core, will be swept down the hot leg prior to Mode 2 operation.

An evaluation was also performed to determine the impact of a ball bearing on individual Reactor Coolant System Interfaces. It was concluded that the following items were the only concerns with respect to continued operation.

(1) Reactor Coolant Pump
(2) Control Element Drive Mechanism
(3) Reactor Internals
(4) Chemical and Volume Control System
(5) Safety Injection/Containment Spray System
(6) Sampling and Instrument Sensing Lines

1) Reactor Coolant Pump

In the event that a 0.153 inch diameter ball bearing is sucked up into the Reactor Coolant Pump, it should pass through the impeller and diffuser and out of the pump through the discharge nozzles. It is unlikely that hydraulic performance would be affected.

The radial clearance between the impeller O.D. and diffuser I.D. is 6 mm (0.236 inch) so it is possible that the ball bearing could pass through this gap and become lodged on the top of the impeller, particularly if there is reverse flow through the pumps as will occur with less than four pumps operating. The ball bearing would not pass further up into the bearing or shaft seal area because the radial clearance between the impeller hub and bearing sleeve bore is 0.0275 inch; (Fig. 27). If the ball bearing size is reduced through wear, it is still unlikely that it would enter the pump bearing because the downward flow of seal injection water would prevent this.

The radial clearance between the impeller lower shroud O.D. and mating suction pipe I.D. is 1-2mm (0.04-0.08 inch), so the ball bearing will not jam or pass through this area.

2) Control Element Drive Mechanism

The PVNGS Control Element Drive Mechanisms are located at the top of the Reactor Vessel head vertically in a no flow area.

An analysis was performed on the components of the CEDM to determine if sufficient clearance was available to allow for the passage of foreign material in the size of a 0.153 inch diameter ball bearing.

The area between the drive shaft and the latch guide tube is the only area which would provide sufficient clearance for the

object to enter the CEDM motor. Foreign material of this size and shape in this location would not cause or prevent a scram. In the event the object could travel against gravity within a no flow area, sufficient clearance exists above and below the latch in the window area of the CEDM where the object would be trapped with no detrimental effect to the CEDM operations.

3) Reactor Internals

Various paths of a ball bearing were evaluated with the possibility of the ball bearing coming to rest at different locations in the internals other than what has already been discovered.

The first path considered with the Reactor Vessel Head removed was a ball bearing falling between the UGS upper flange and the core support barrel flange possibly continuing into the lower head region of the Reactor Vessel where the ball bearing, during operation, could be carried from the lower RV Head into the lower end of the fuel assemblies. Ball bearing with a .153 diameter would not cause a detrimental effect on the internals.

A slight possibility is that the bearing could fall into a Surveillance Capsule Holder. This is very unlikely since the Holder is shadowed by the thick walled section of the Reactor Vessel. However, if a ball bearing were to fall here, it is unlikely that it would interfere with the operation of the Surveillance Capsule Retrieval tool during an outage.

Finally, the ball bearing being captured in the Heated Junction Thermocouple guide tube, is an extremely torturous path and highly unlikely.

4) Chemical and Volume Control System

A. <u>Potential Paths to the CVCS</u>

1. Letdown line from RCP Loop 2B.
2. RCS loop drains to Reactor Drain Tank (RDT).
3. Miscellaneous reliefs, drains, vents, leakoff, etc. to RDT.
4. Miscellaneous reliefs, drains, vents, etc. to Equipment Drain Tank (EDT).
5. Shutdown cooling to Letdown Purification line.
6. RCP controlled bleedoff to Volume Control Tank (VCT).
7. Safety injection mini flow to Refueling Water Tank (RWT).

Note: Any lines with flow into RCS (charging, aux. spray, seal injection, etc) with check valves to prevent reverse flow are not considered as potential sources.

B. Possible Scenarios for Ball Bearing

1. Lodge in pipe or component with no effect.

2. Lodge in pipe or component with subsequent failure of pipe or component causing loss of letdown or charging, or possibly a reactor trip/shutdown in worst case.

3. Breakup of ball bearing due to impact or mechanical force (pump, valve, etc.).

4. Chemical reaction of carbon steel ball bearing with Boric Acid with subsequent plateout of by-products or removal by purification.

5. Removal from system through filters, ion exchanger, strainers in CVCS.

6. Cause reduced flow, blockage of flow and/or pressure oscillations.

C. Impact of Ball Bearing in Path listed in Part A

1. A ball bearing entering the CVCS letdown line would be stopped by the Letdown Flow Control Valves (LCV's) and/or the Letdown Bypass Orifice. The cage on the LCV's provides a strainer type effect preventing further travel. The cage flow holes are tapered from 0.094 inches (outside) to 0.051 inches (inside). The presence of the ball bearing in the inlet of the LCV's would probably cause pressure oscillations in the Letdown line due to continual blockage of one of the flow holes followed by subsequent unblockage as the cage rotates from the flow unbalance created by the blocked hole. Similar pressure oscillations were experienced when weld slag was found at the valve inlet.

   The ball bearing could break up over time due to repeated impact and pass through the valve. There's a possibility that a small piece could then stick in one of the flow holes either reducing flow, causing unstable control or causing the valve to hang-up or stick. The pieces that pass through the valve would flow to the purification filters and subsequently be removed either during draining of the filter or replacement of the filter element.

   Bypass of the filters is possible through CH-355 which would allow the bearing to flow in the Letdown Ion Exchangers, Pre-Holdup Ion Exchanger, EDT, Pre-Holdup Strainer, Letdown Strainer, Gas Stripper, Holdup Tank, Boric Acid Concentrator, or VCT depending on valve

lineup. The pieces would only reach the VCT if the purification filters were bypassed at the same time that the Purification Ion Exchangers were bypassed due to high letdown temperature (not a likely scenario). Even if the pieces did reach the VCT, they would then go to the charging pumps and be pumped back into either the RCS or seal injection filters. These small pieces would not impact charging pump operation.

A ball bearing in the Letdown Orifice Bypass line would remain upstream of the orifice with no loss in system performance. The orifice is much to small to pass the ball bearing, flow (0.5gpm) in this line is infrequent, used only during recovery from loss of letdown when flow has been lost for greater than 30 minutes and when at normal operating pressure and temperature.

2. If the ball bearing made its way to the low points in the RCS loops, it would eventually make it to the RDT for processing when the loops are drained at which time the ball bearing would remain in the RDT or be pumped to the Reactor Drain Filter.

3. As mentioned in item 2 above, any input to the RDT is processed and the ball bearing and/or pieces of the ball bearing would be removed.

4. Any input to the EDT is processed as is the contents of the RDT.

5. Any particle (ball bearing) introduced to the letdown purification system from the shutdown cooling system would be removed (2 microns) as in normal purification mode mentioned in item 1. This flow enters downstream of the LCV's and Letdown Bypass Orifice.

6. Its very unlikely that any ball bearing or part of a ball bearing would pass by the first RCP seal since seal injection pressure should be greater than RCS pressure causing flow into RCS. The clearances are much too small even if seal injection was lost or stopped assuming the seal is not grossly failed.

7. Mini flow return from the Safety Injection System to the RWT is a potential flow path but very unlikely to be the source for the ball bearing because of the piping configuration. If it did, the ball bearing would end up on the RWT bottom; the suction strainer for the Low Pressure Safety Injection/High Pressure Safety Injection (LPSI/HPSI) pumps has a 0.09 inch screen particle retention capability.

Entry into the CVCS is the most desirable place for the ball bearing to go in order to remove it from the RCS. However, the size is large enough that it may not pass the LCV's to the purification system. This is acceptable because if the ball bearing did not make it to the LCV's, it is anticipated that the Back Pressure Control Valves (BPCV's) will experience oscillations in conjunction with pressure oscillations and be easily detected. At that time the parallel LCV could be placed into service and the LCV experiencing oscillations could be isolated for removal of the bearing. There is a possibility that presence of a ball bearing will not cause noticeable pressure oscillations and remain undetected. In this case, long term degradation of the cage could occur due to impact velocities of the ball bearing. The carbon steel ball bearing would probably deteriorate before the 17-4PH cage. Based on the above it is determined that operation of the CVCS with a ball bearing in the system will not compromise safety of the plant or personnel.

5) Safety Injection/Containment Spray System

An evaluation of the effect of the presence of a ball bearing in the Safety Injection System (SIS)/Containment Spray System (CSS)/Shutdown Cooling System (SDCS) indicates the following conclusions:

1) During the unlikely event of an Engineered Safety Feature actuation, the screens in the RWT and containment sump would not allow the bearings to pass (the screen size is designed to filter a maximum particle size of 0.09 inch). As a result, the bearing will not enter the system during post accident operation. The sump and RWT are the only suction sources for the HPSI.

   During operation of the SDCS, it could be assumed that a bearing in the RCS would make it to the hot leg suction lines. However, due to the size of the SDCS, it would be anticipated that a bearing would pass through the system and either return to the RCS or be drawn into the purification system of the CVCS. No damage would be expected to the major components, such as the SDC heat exchangers and LPSI (or Spray) pumps.

   A bearing, lingering in the system from previous SDC operation, is not expected to prevent SIS/CSS operation. Due to the flow under the seat orientation of the systems' header isolation valves, a bearing will not prevent their opening. The LPSI mini-flow orifices would pass the bearing to the RWT. The spray nozzles would also pass the bearing.

6) Sampling and Instrument Sensing Lines

The PVNGS sampling and instrument sensing lines are located such that the migration of a ball bearing is all but excluded from entering the lines (not located at the bottom of piping).

In a sampling line there is no flow until a sample is drawn. At this time the flows are very low and a ball bearing would have to be resting directly at the entrance of the flow path (suspended) in order to enter the line.

There is no flow through the instrumentation sensing lines attached to the reactor coolant system. This combined with the small diameter of the sensing line, assures that the probability of a ball bearing blocking a sensing line is extremly low. Safety class instrumentation is comprised of four channels which would reduce the likelihood that safety systems would not perform their design function.

The preceding analysis of the ball bearing within the reactor coolant system has provided assurance that the impact of a ball bearing would be minimal. Nevertheless, extensive visual inspections of all accessible areas of the UGS upper support plate were performed using a drop camera and light to provide assurance that there is no debris in the UGS that could interfere with CEA movement. The camera was lowered into each CEA shroud area and around the shroud itself to provide a detailed inspection. The UGS upper support plate was subsequently vacuumed and all vacuumed debris was collected. The inspection and vacuuming did not provide evidence of any ball bearings. After reassembly of the reactor vessel internals the reactor cavity was drained and a piece of debris was found and removed from the flange area of the UGS, outside of the guide tube shrouds. This debris was confirmed by the inspection videotapes to be on the UGS flange during the UGS and CEA inspections. This debris was identified as a 7/8" x 3/16" roll pin from a tool that had been used to uncouple the CEAs from their extension shafts (to prepare CEA 56 for camera inspection) while the UGS was in the laydown area. This was confirmed by matching the two sheared ends. A sighting which later proved to be a carbon steel roll pin was noted on the inital viewing of the video tape, however, it was not identified as foreign material. A corrosion layer from the carbon steel roll pin obscured any sharp edges or observable depth of the object. When the roll pin was recovered the video tape was reviewed again and the faint edges of the pin were observed with dimensions matching that of the recovered pin. A corrosion resistant 52100 type bearing steel ball bearing would not have been obscured by it's corrosion layer.

IV CONCLUSION/CORRECTIVE ACTIONS

The evaluation of the minor damage done to the guide post indicates it will not prohibit full power operation. An evaluation has also determined that the damage to the CEA finger will not prevent the CEA from performing its design function, providing a negative reactivity insertion when called upon by the Plant Protection System. This will be verified by the performance of the normal post-outage CEA drop-time test.

CE evaluated the damage documented by the video inspection of the CEA and has concluded that it could be used for continued operation based upon the locations and extent of the damage. The fuel assembly guide tube post was also video inspected and evaluated by CE to be acceptable for continued operation based upon the limited amount of damage.

In order to ensure that all accessible debris was removed, the UGS top plate, UGS flange, and UGS lift rig were extensively inspected and the top plate was also vacuumed.

Following the evaluation of this event, and an analysis of the potential consequence of debris in the RCS, the following remedial actions are being implemented.

1. During the RCS fill and vent a variety of Reactor Coolant Pump combinations will be run. This will provide flushing of the fuel assemblies as previously discussed.

2. All CEAs will be exercised following the filling and venting, in Mode 5, to provide assurance that no debris is in a location that can interfere with the CEA movement. In the event that debris is evident in the UGS, it will be detected immediately during testing.

3. The CEA exercising and the CEA drop-time test will be performed at normal operating temperature and normal operating pressure to assure CEA operability and conformance to Technical Specifications.

4. The pre-criticality run time for RCP combinations will be approximately four days.

5. The MST design for Units 1 and 2 have been modified and Unit 3 will be modified prior to use to eliminate the possibility that a bearing will be released during operation. The design change of the bearing assembly will be verified prior to its use.

6. Prior to Mode 2 entry, operators will be instructed to review Procedure 41EP-1ZZ01 "Emergency Operations" and Technical Specification Section 3/4.1.3.1 "CEA Position".

Investigations into the occurrence of this event identified areas of concern with the foreign material exclusion program in that it was not designed or intended to exclude material from component failure, e.g., MST bearing failure. The following actions are being taken to enhance the foreign material exclusion program.

1. A specific procedure dealing with foreign material exclusion will be developed to assure the controls are adequate to eliminate the introduction of foreign material into plant systems or components specifically associated with safety-related systems.

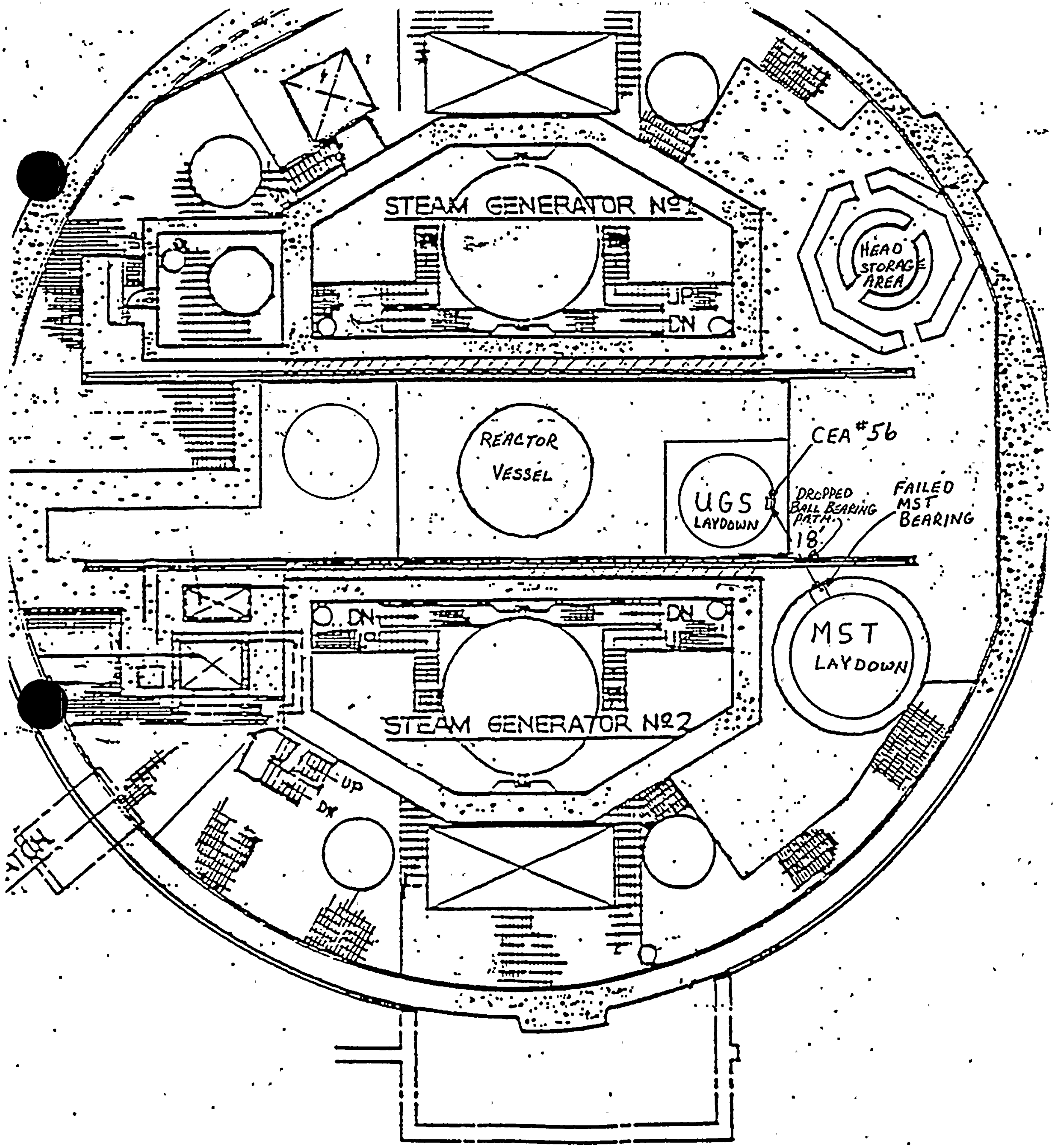
2. A specific training program will be developed and presented to all appropriate personnel when the foreign material exclusion procedure is issued and thereafter as part of annual retraining.

3. Appropriate supervision and management personnel including Q.A. and ISEG will be trained in their responsibilities for foreign material exclusion.

4. Implementation of the action items listed in 1 through 3 will be completed by August 31, 1988.

ATTACHMENT B FIGURES

The following list of figures are available for reference:



MST / UGS FLOOR LAYOUT

FIG 1

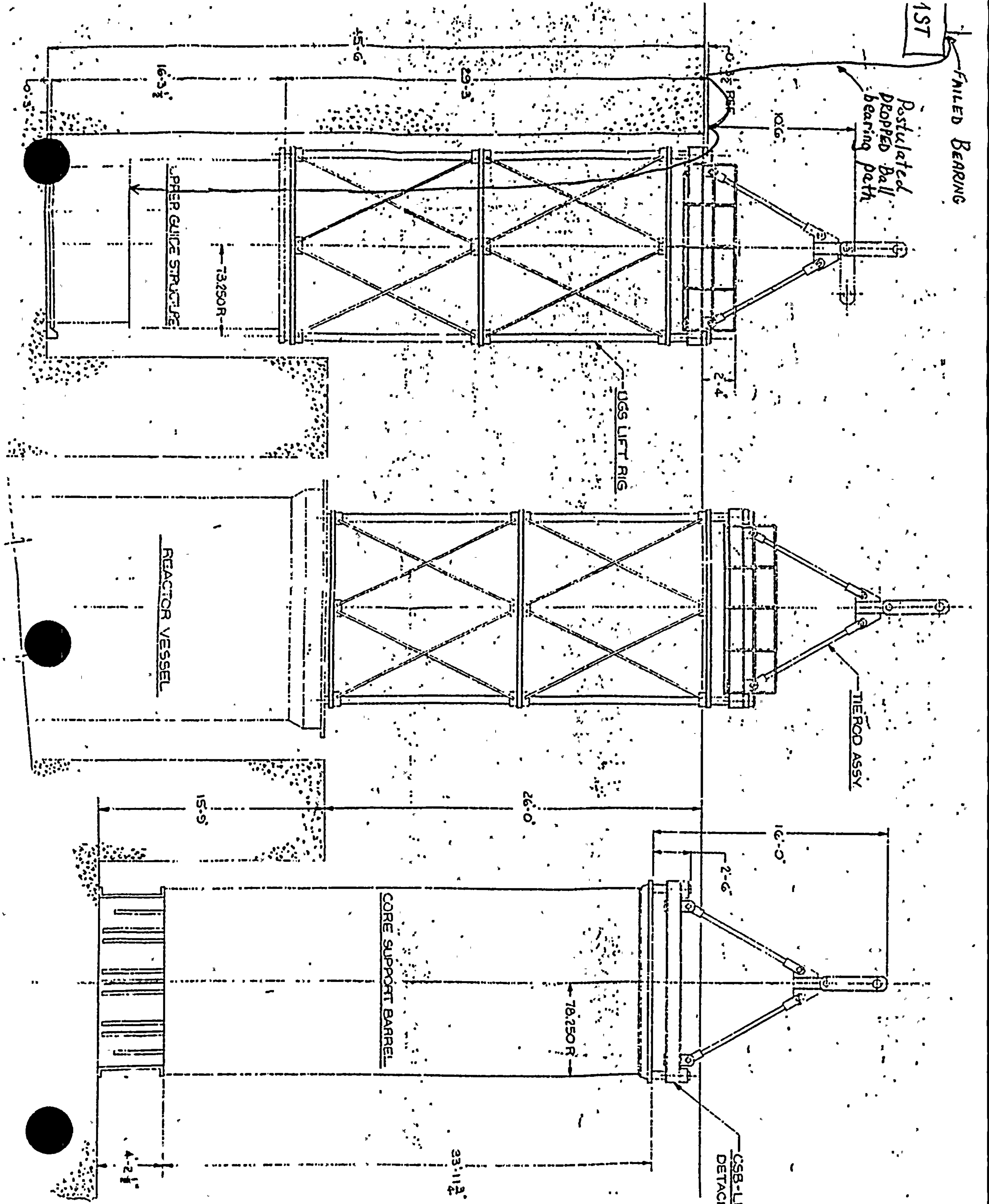
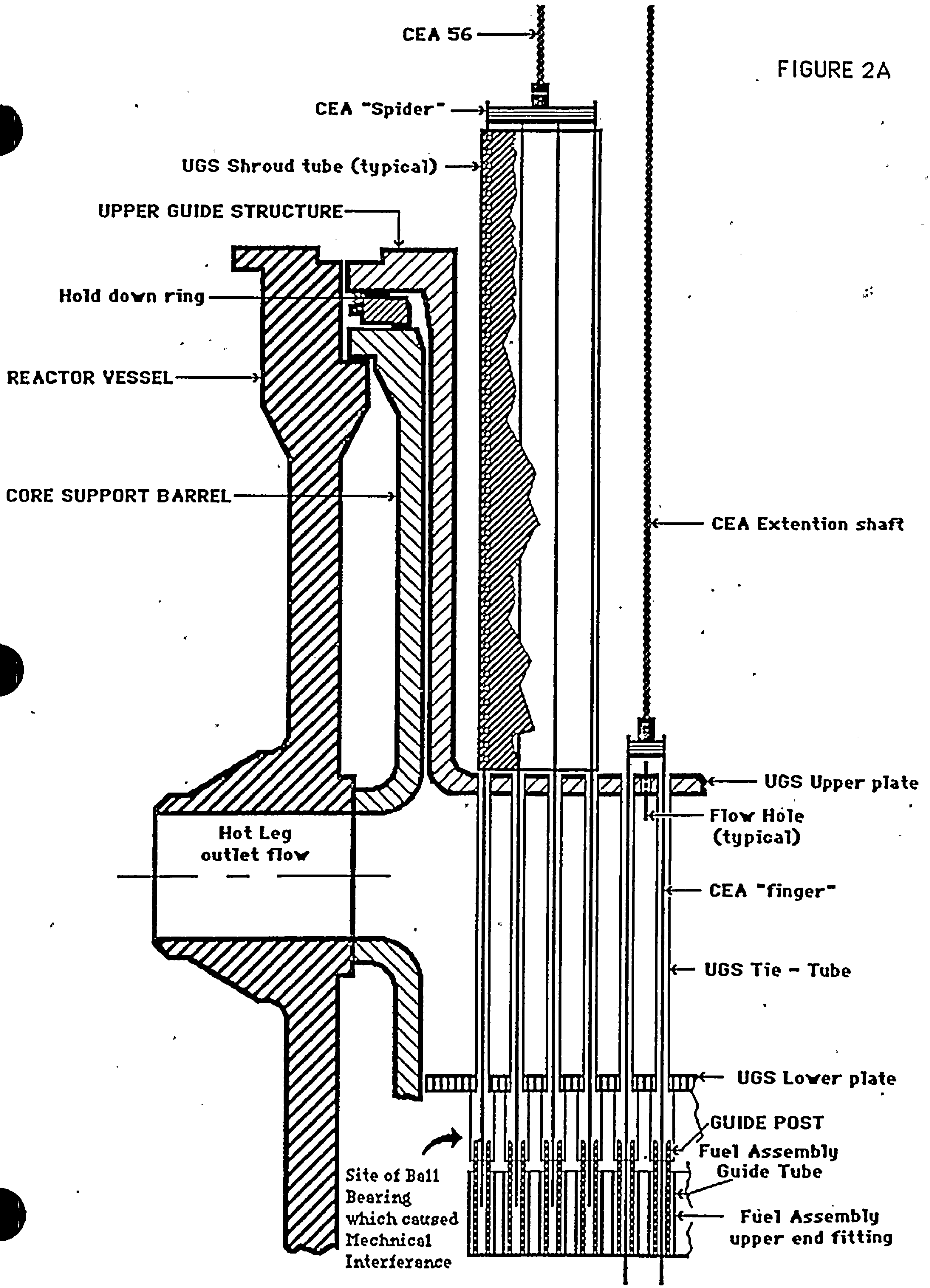
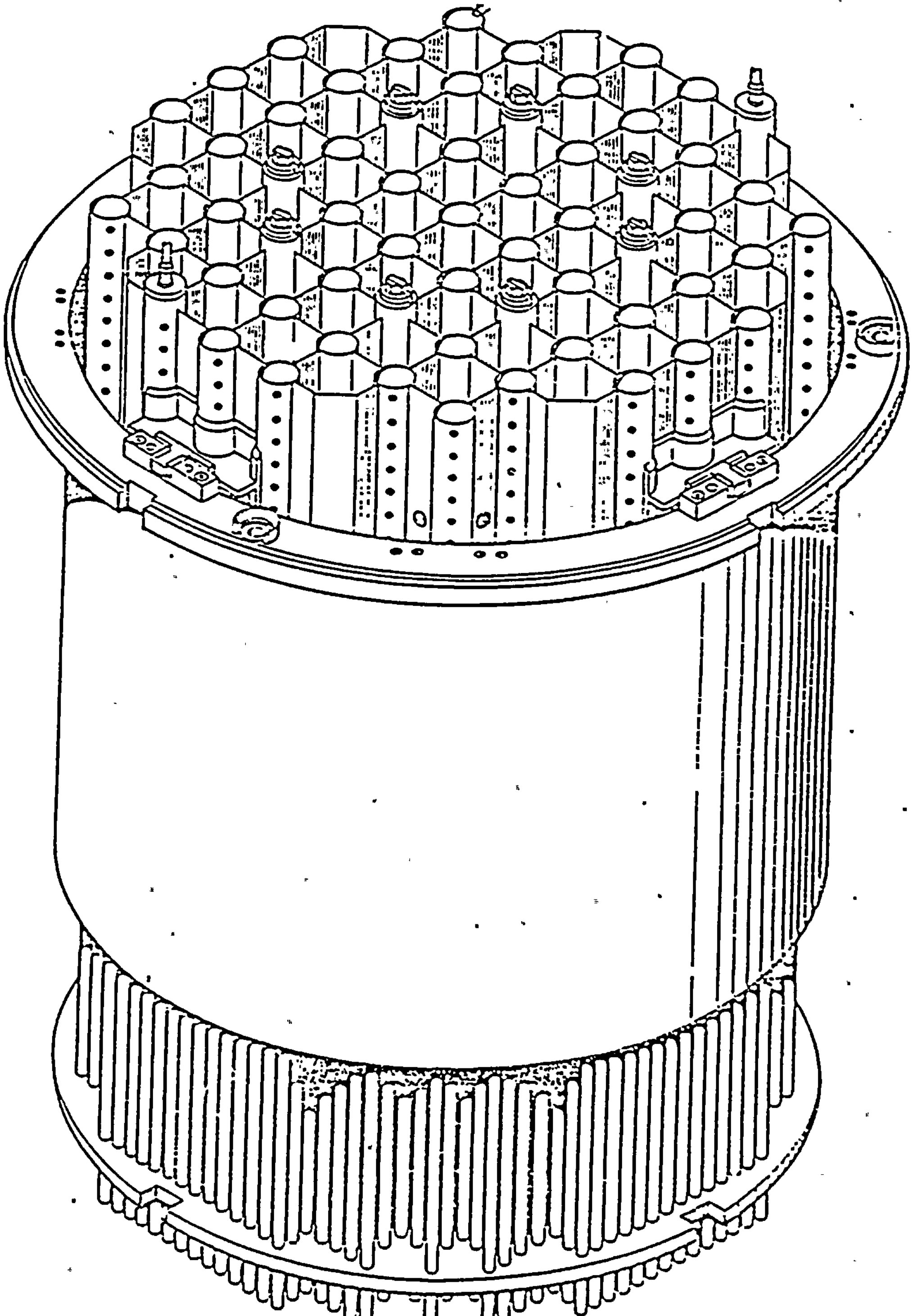

FAILED BEARING
Postulated DROPPED Ball bearing path
1ST
UPPER GUIDE STRUCTURE
73.250R
UGS LIFT RIG
REACTOR VESSEL
TIE ROD ASSY.
CORE SUPPORT BARREL
78.250R
CSB-LIFT R. DETACHABLE
45'-6"
29'-3"
10'-6"
2'-4"
15'-9"
26'-0"
16'-0"
2'-6"
23'-11 3/4"

FIG. 2

FIGURE 2A

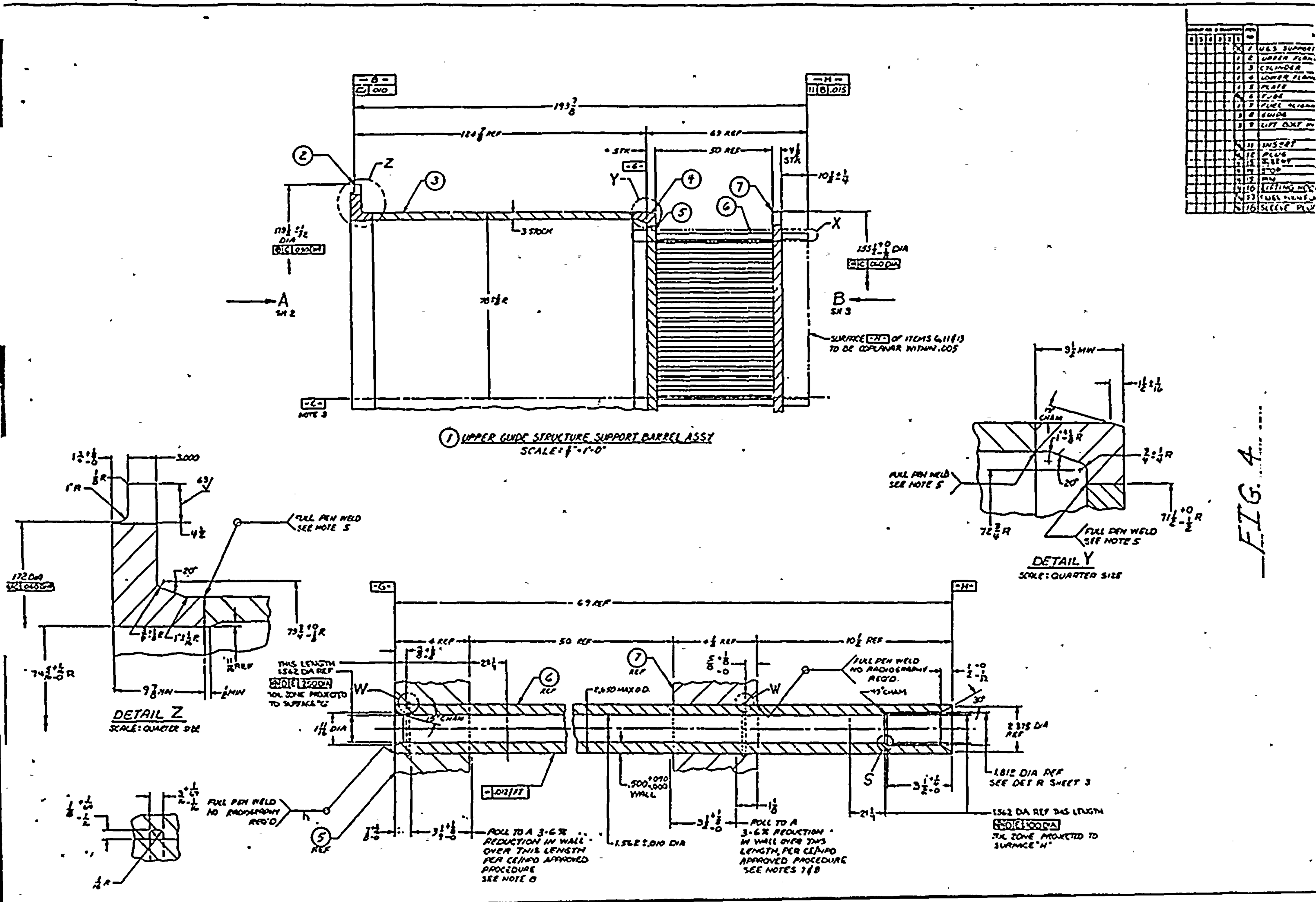


CEA 56
CEA "Spider"
UGS Shroud tube (typical)
UPPER GUIDE STRUCTURE
Hold down ring
REACTOR VESSEL
CORE SUPPORT BARREL
CEA Extention shaft
Hot Leg
outlet flow
UGS Upper plate
Flow Hole
(typical)
CEA "finger"
UGS Tie - Tube
UGS Lower plate
GUIDE POST
Fuel Assembly
Guide Tube
Site of Ball
Bearing
which caused
Mechanical
Interference
Fuel Assembly
upper end fitting



MODIFIED
UPPER GUIDE STRUCTURE
ASSEMBLY

FIG. 3

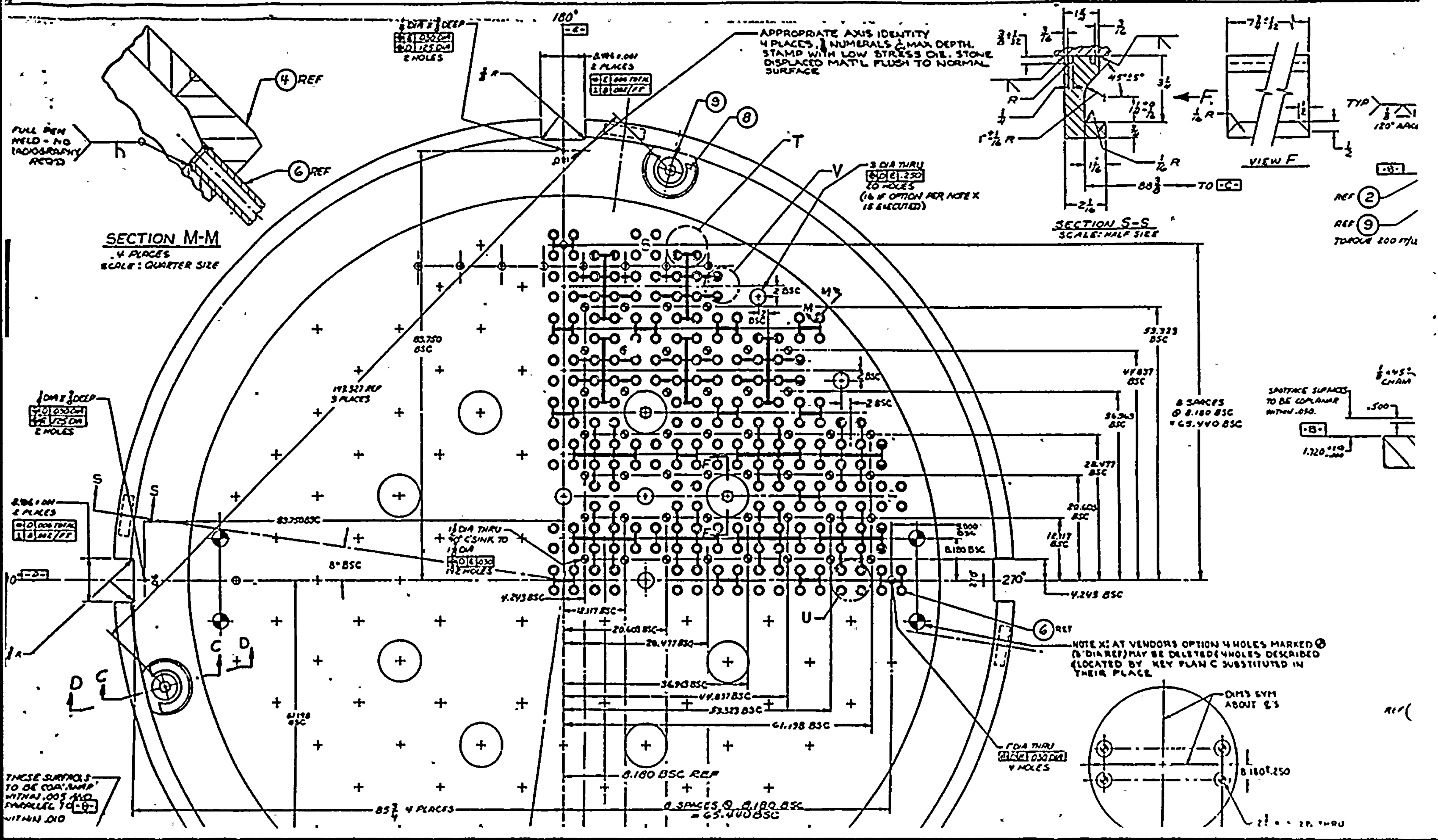


1 UPPER GUIDE STRUCTURE SUPPORT BARREL ASSY
SCALE: 1/8"=1'-0"
193 7/8
124 7/8 REF
69 REF
50 REF
A SH 2
B SH 3
SURFACE -H- OF ITEMS 6, 11 & 13 TO BE COPLANAR WITHIN .005
DETAIL Y
SCALE: QUARTER SIZE
FULL PEN WELD SEE NOTE 5
DETAIL Z
SCALE: QUARTER SIZE
FULL PEN WELD NO RADIOGRAPHY REQ'D.
ROLL TO A 3-6% REDUCTION IN WALL OVER THIS LENGTH PER CE/NPO APPROVED PROCEDURE SEE NOTE 8
ROLL TO A 3-6% REDUCTION IN WALL OVER THIS LENGTH, PER CE/NPO APPROVED PROCEDURE SEE NOTES 7 & 8
1.812 DIA REF SEE DET R SHEET 3

FIG. 4

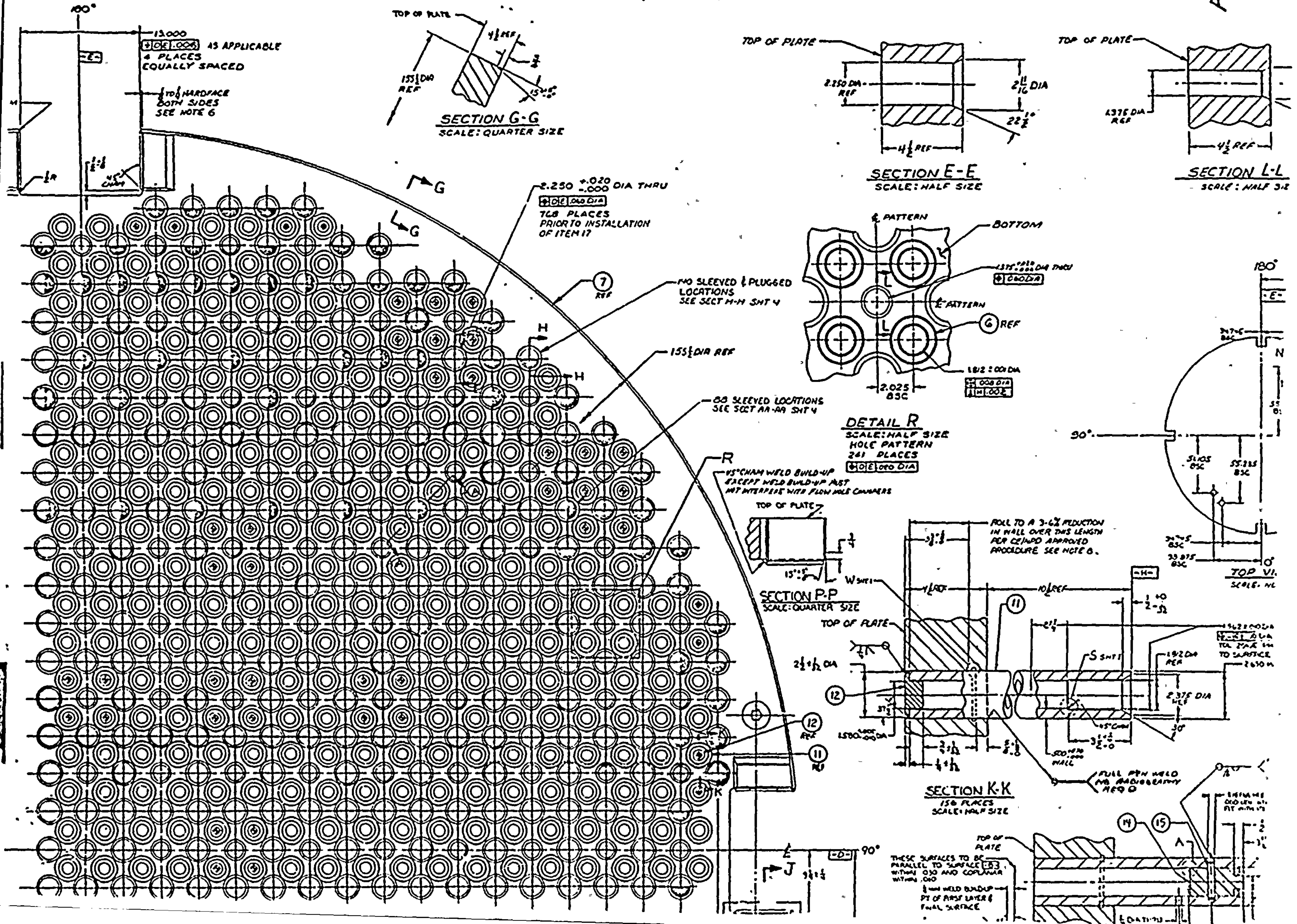
FIG 5

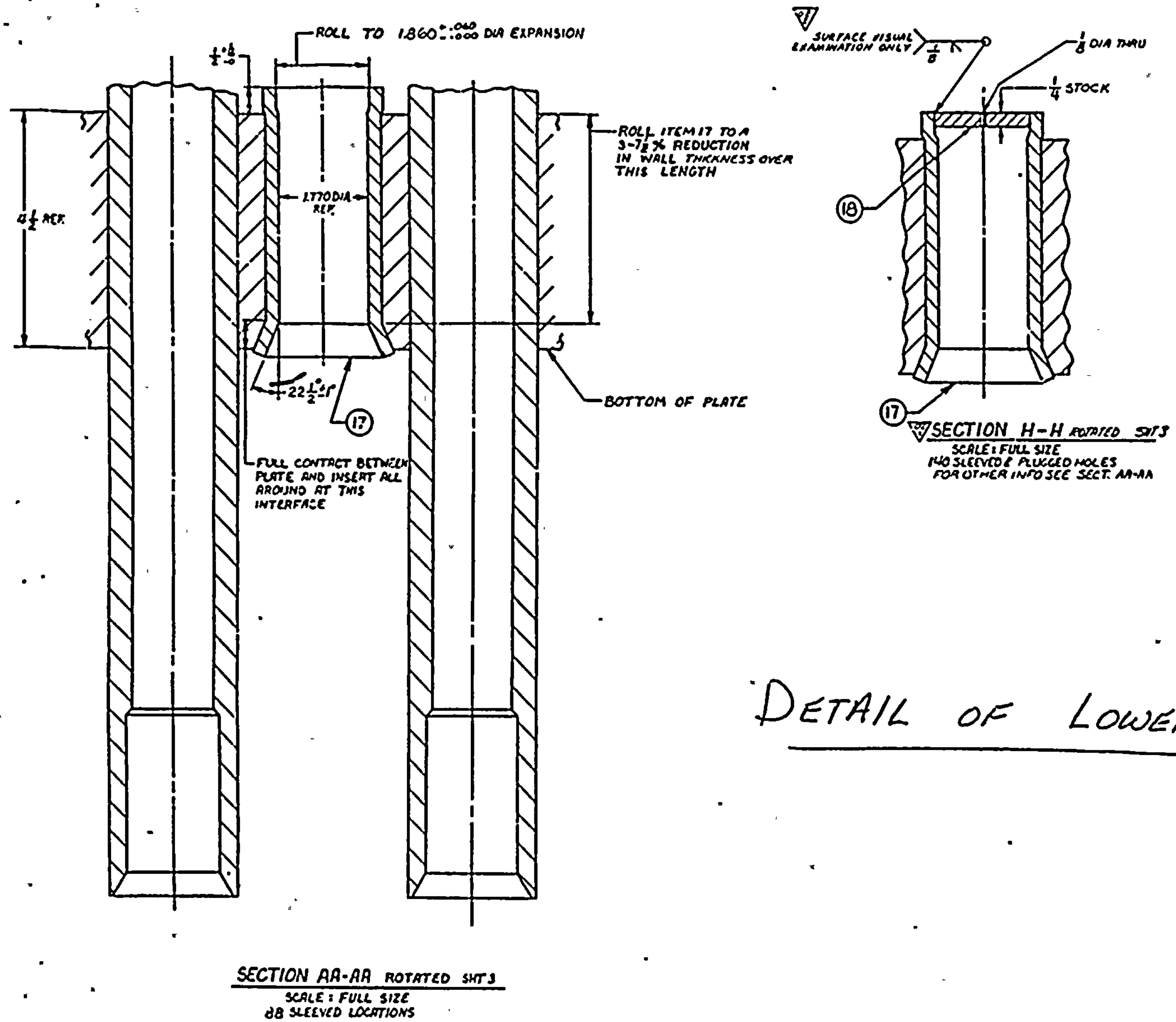
UPPER PLATE



LOWER PLATE

FIG. 6

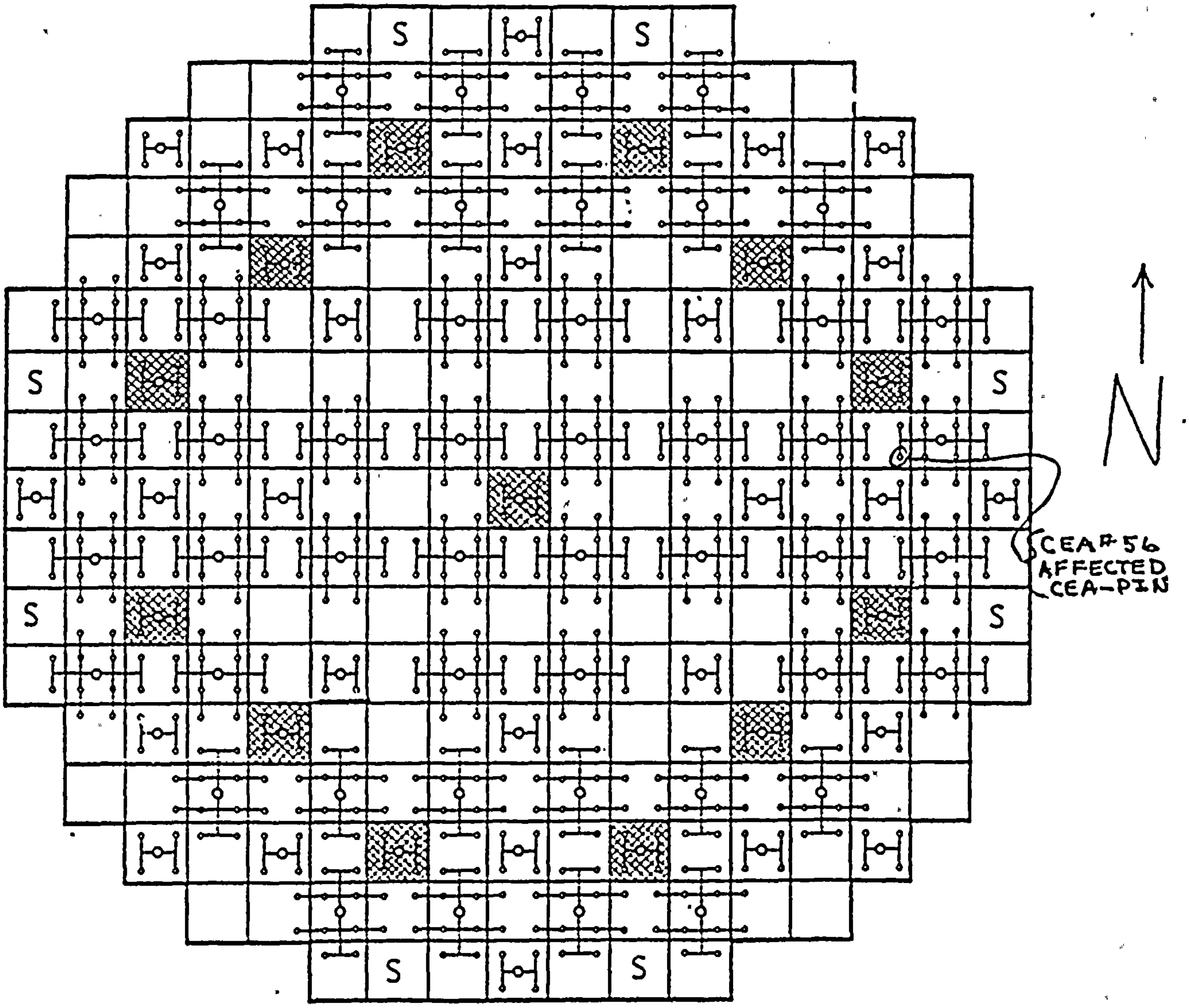




DETAIL OF LOWER PLATE

FIG. 7

241 FUEL ASSEMBLYS

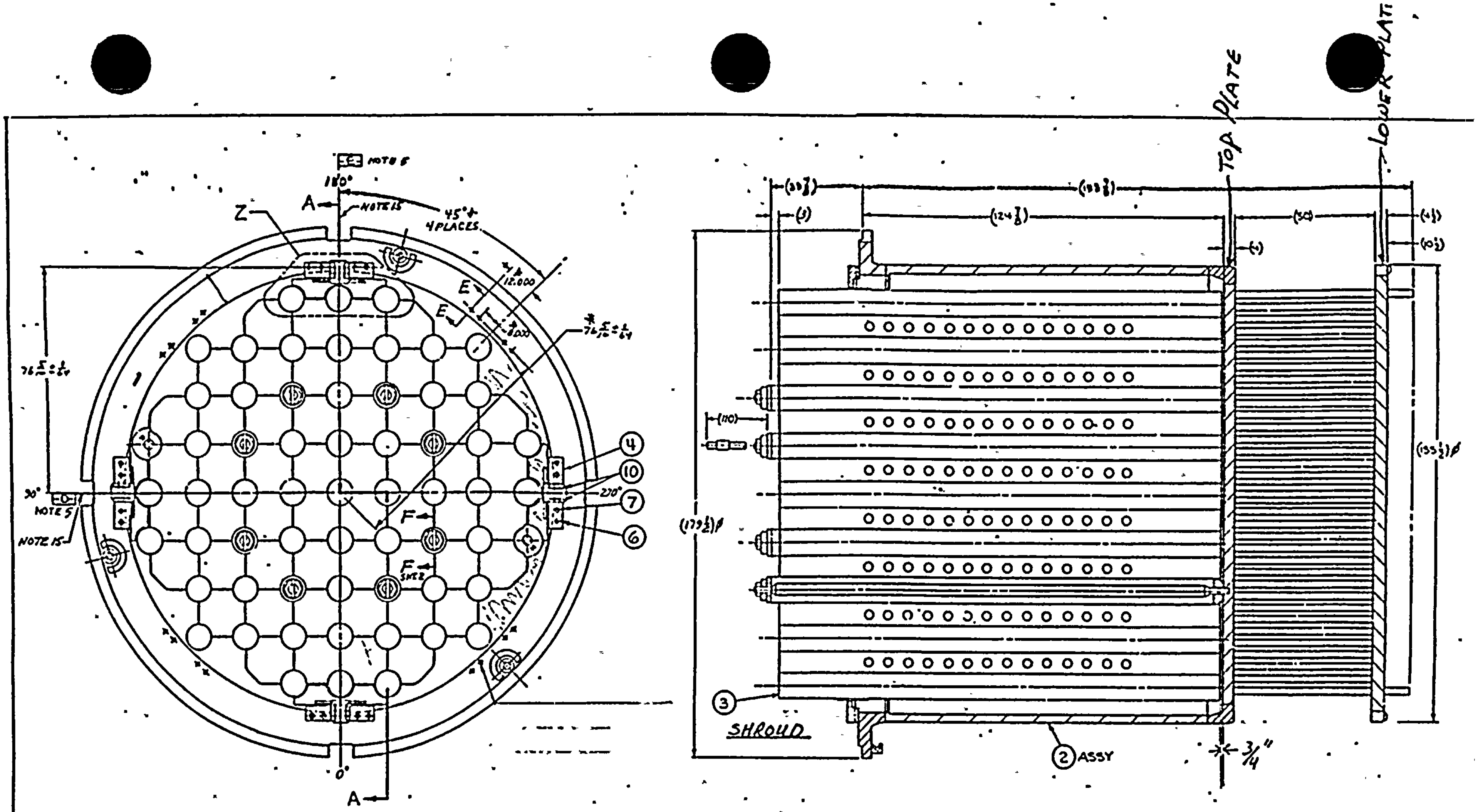


12 ELEMENT FULL LENGTH CEA's		48
4 ELEMENT FULL LENGTH CEA's		28
4 ELEMENT PART LENGTH CEA's	13	
TOTAL	89 CEA's	

S DENOTES SPARE CEA LOCATIONS 8

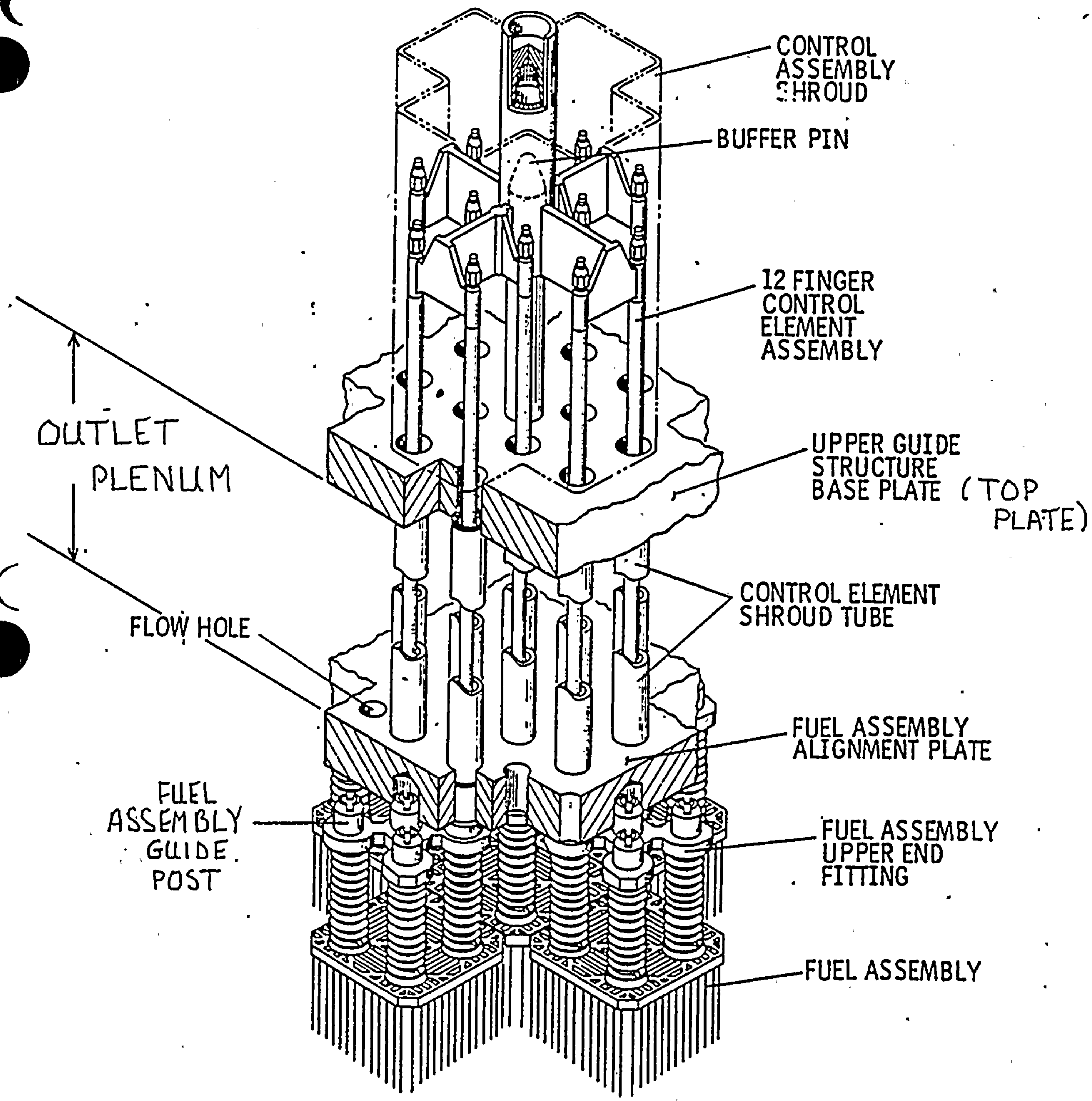
CONTROL ELEMENT ASSEMBLY LOCATIONS

FIG. 8



1 MODIFIED UPPER GUIDE STRUCTURE ASSY

FIG. 9



Fuel/control element/upper guide structure interface

FIG. 10

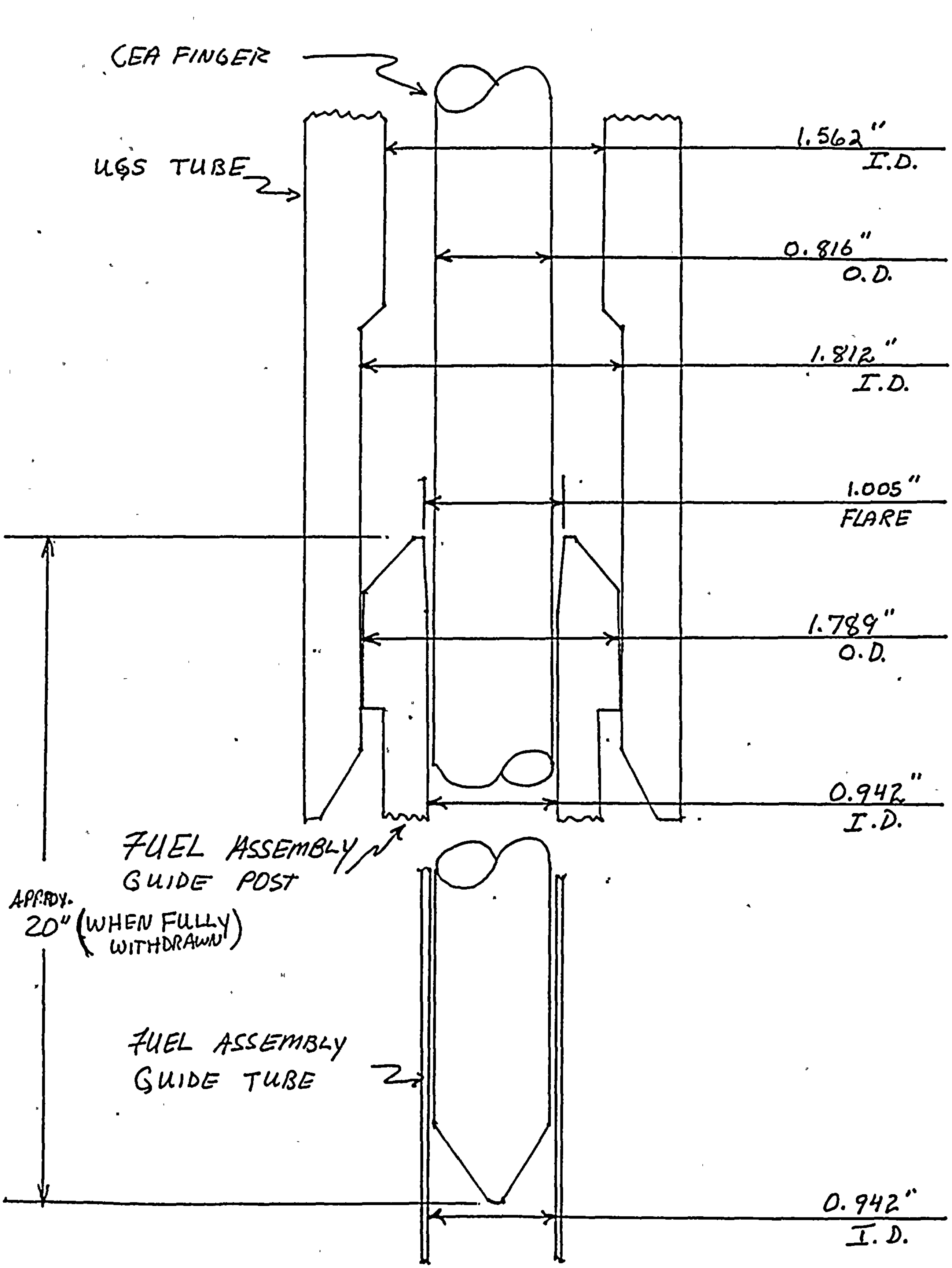

CEA FINGER
UGS TUBE
1.562"
I.D.
0.816"
O.D.
1.812"
I.D.
1.005"
FLARE
1.789"
O.D.
0.942"
I.D.
FUEL ASSEMBLY
GUIDE POST
APPROX.
20" (WHEN FULLY WITHDRAWN)
FUEL ASSEMBLY
GUIDE TUBE
0.942"
I.D.

FIG. 11

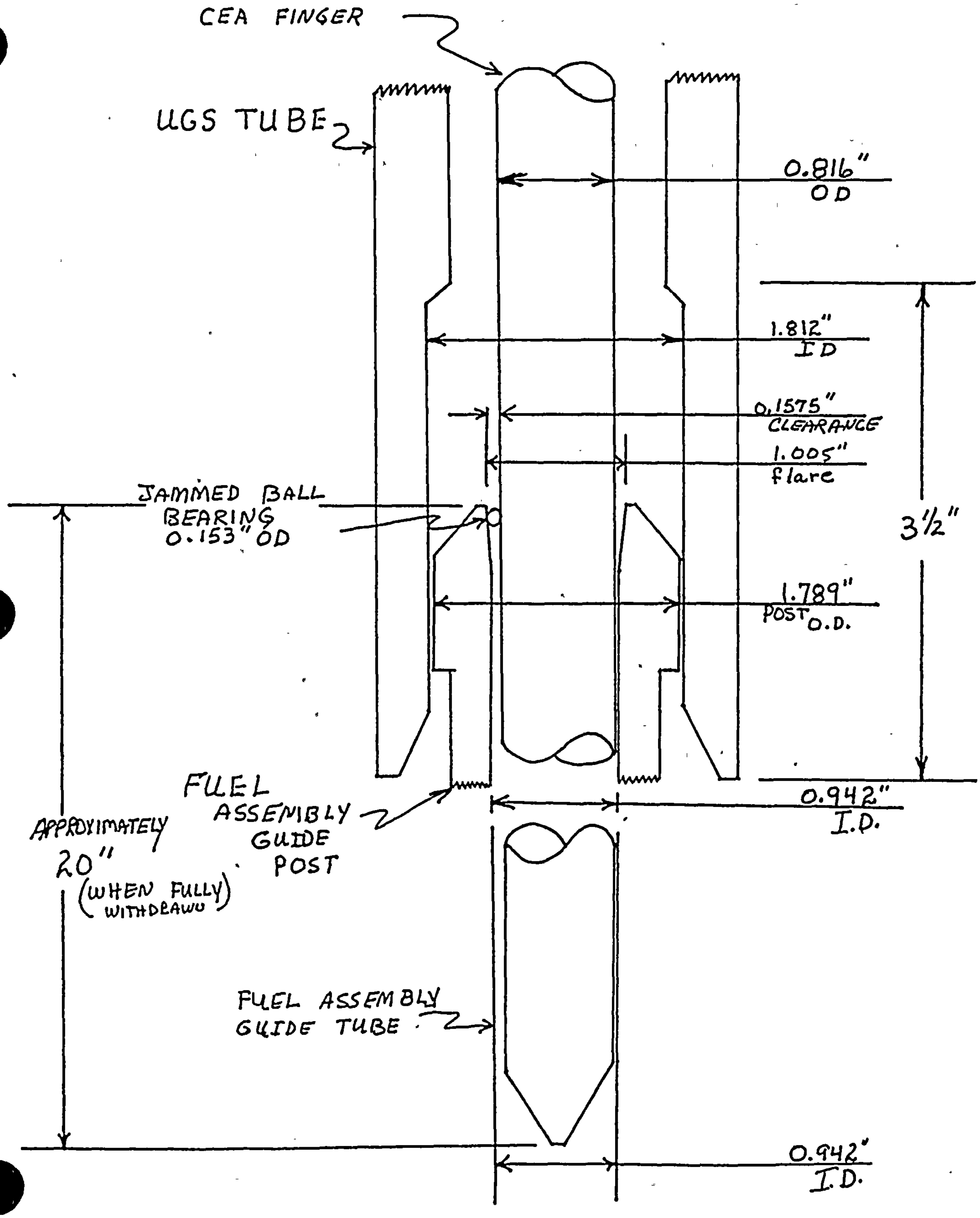
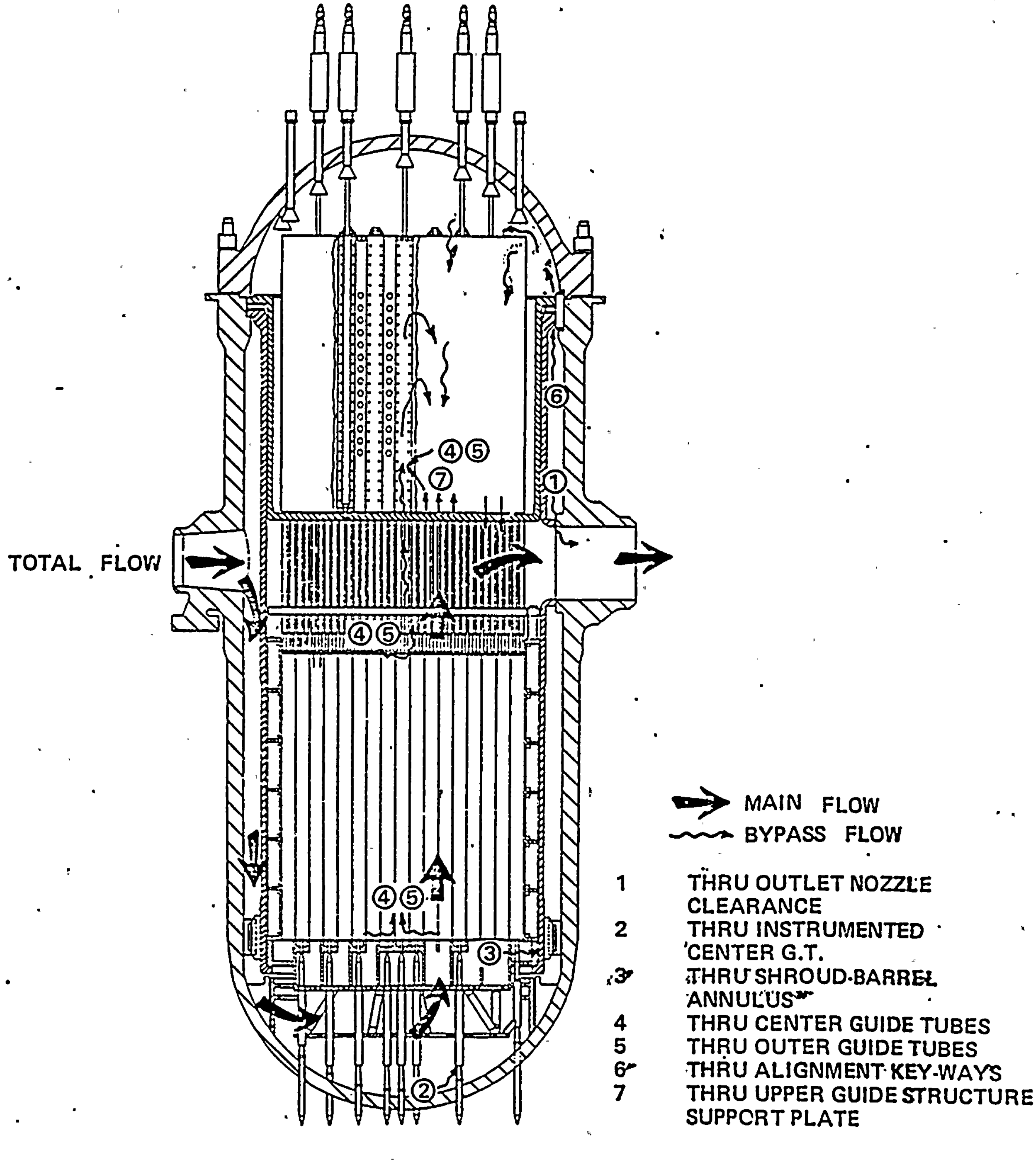
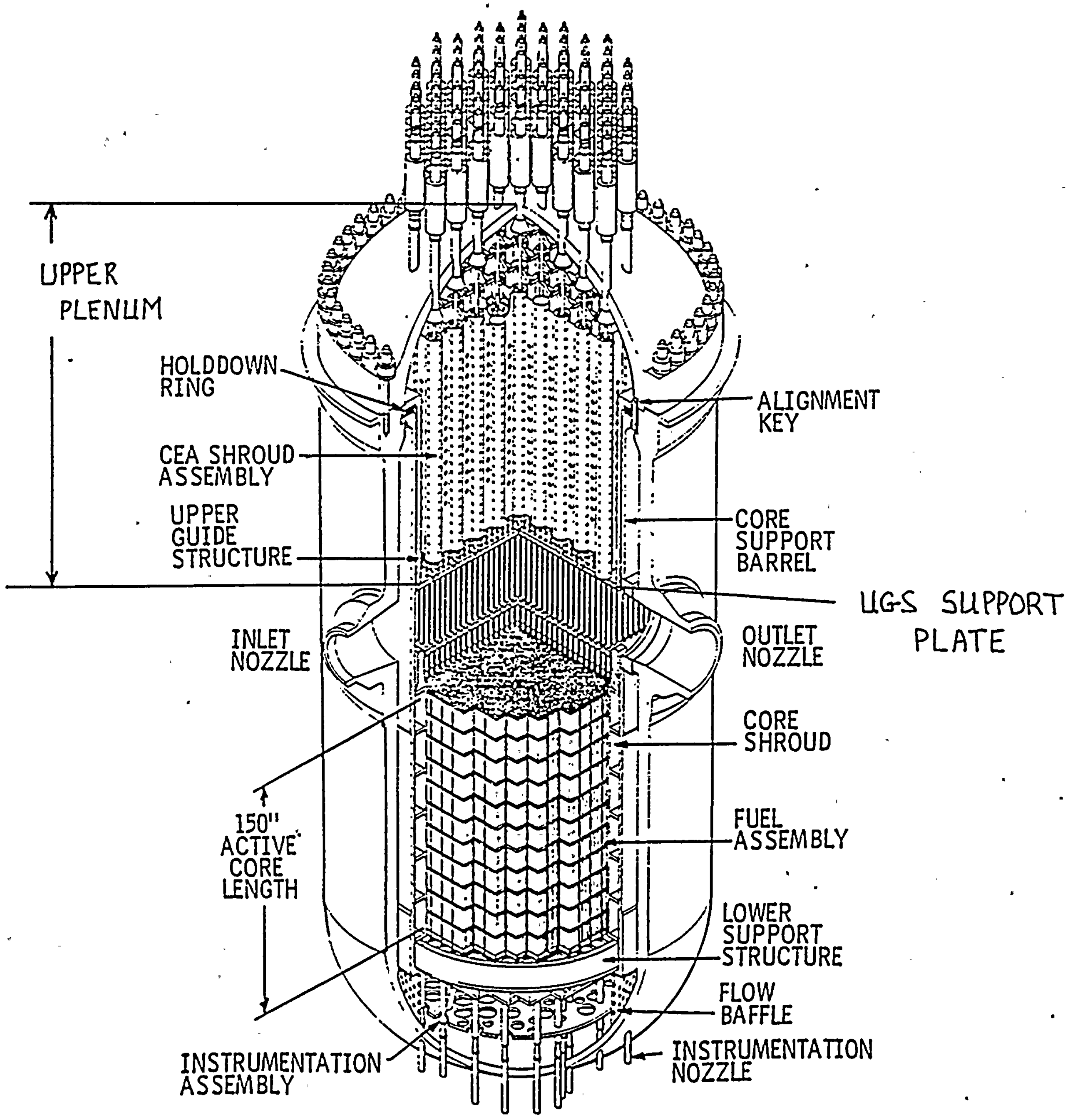

CEA FINGER
UGS TUBE
0.816" OD
1.812" ID
0.1575" CLEARANCE
1.005" flare
3½"
JAMMED BALL BEARING 0.153" OD
1.789" POST O.D.
FUEL ASSEMBLY GUIDE POST
APPROXIMATELY 20" (WHEN FULLY WITHDRAWN)
0.942" I.D.
FUEL ASSEMBLY GUIDE TUBE
0.942" I.D.

FIG. 12



REACTOR FLOW PATHS

FIG. 13



REACTOR VESSEL ARRANGEMENT

FIG. 14

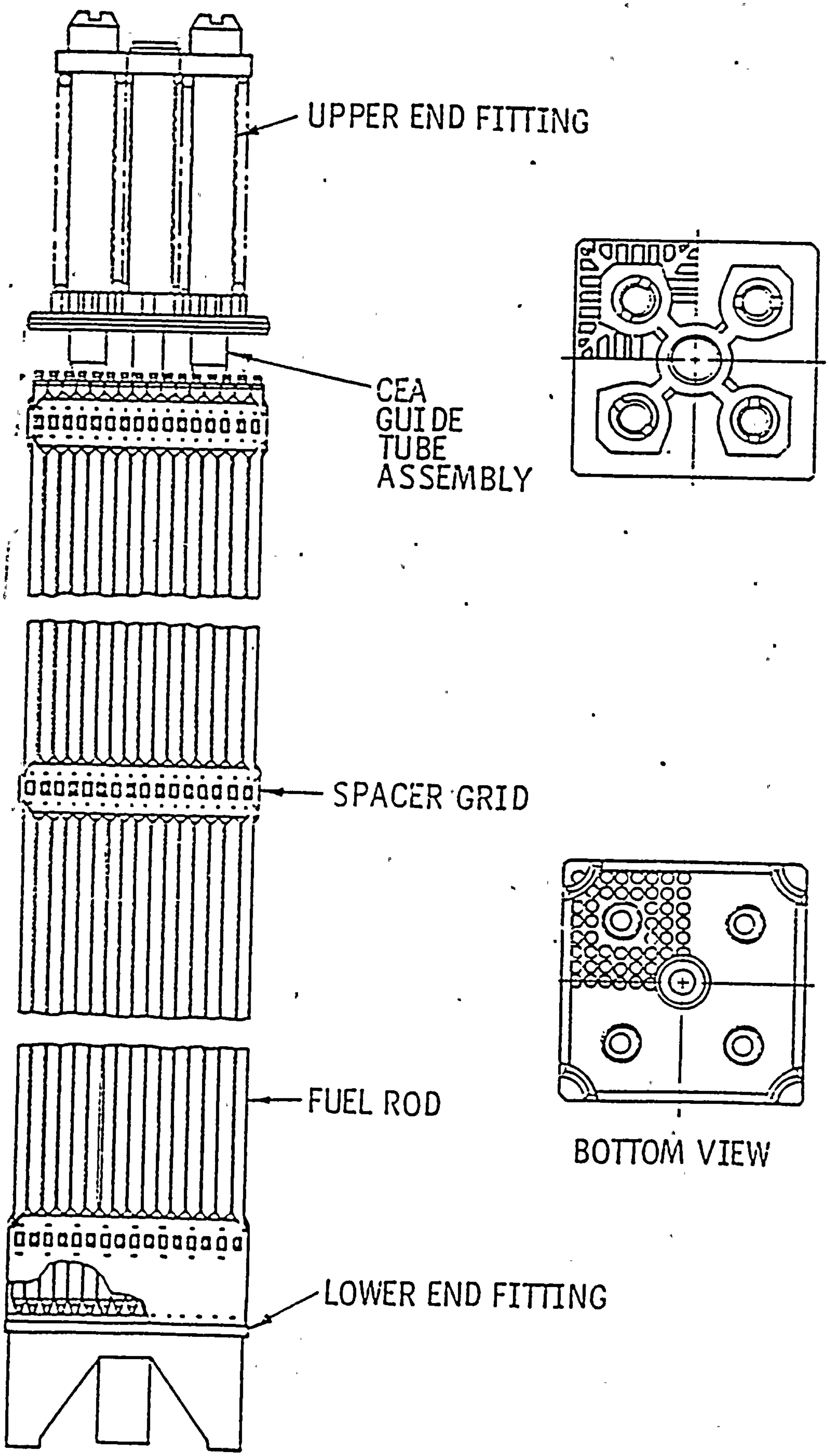
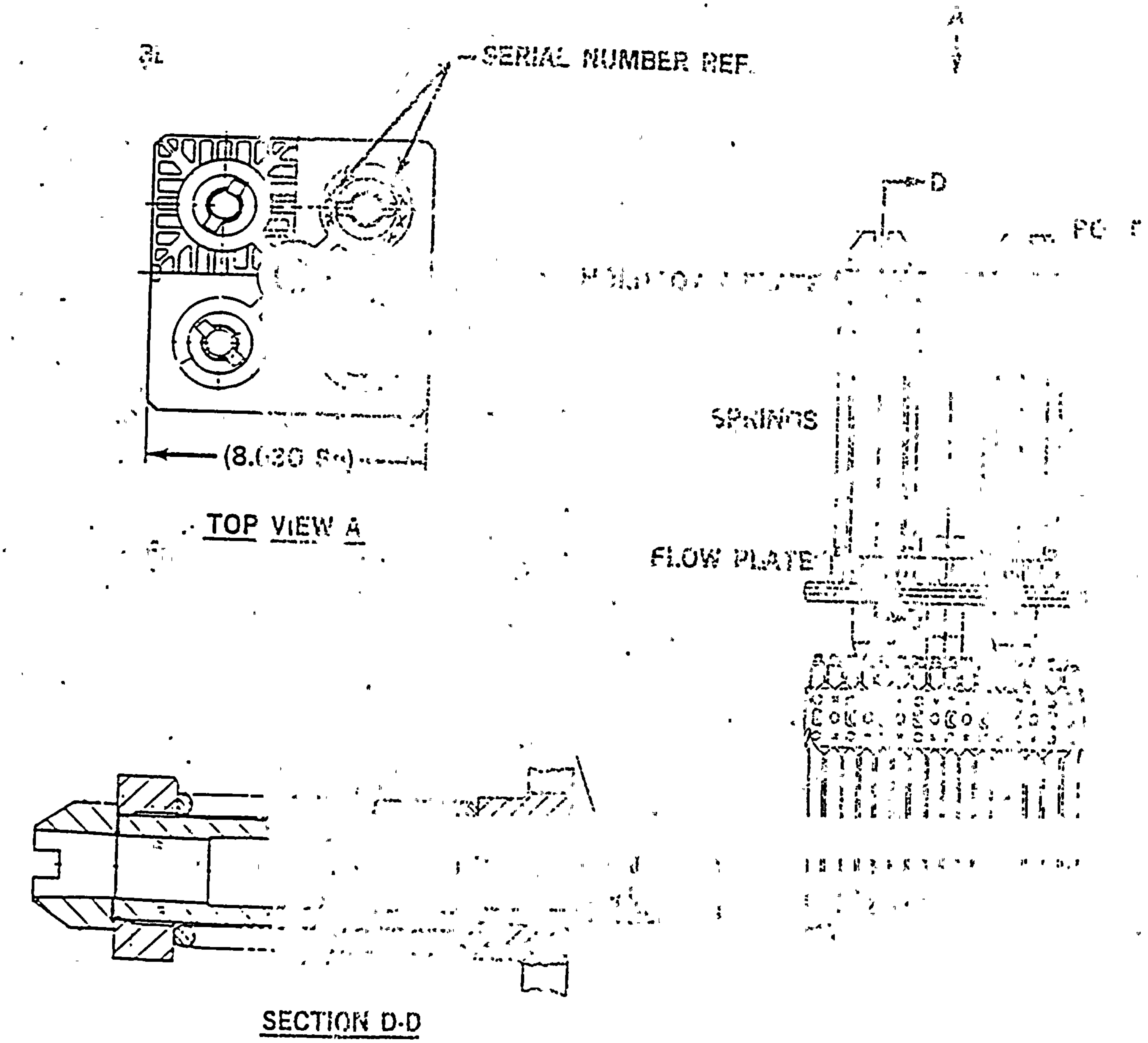
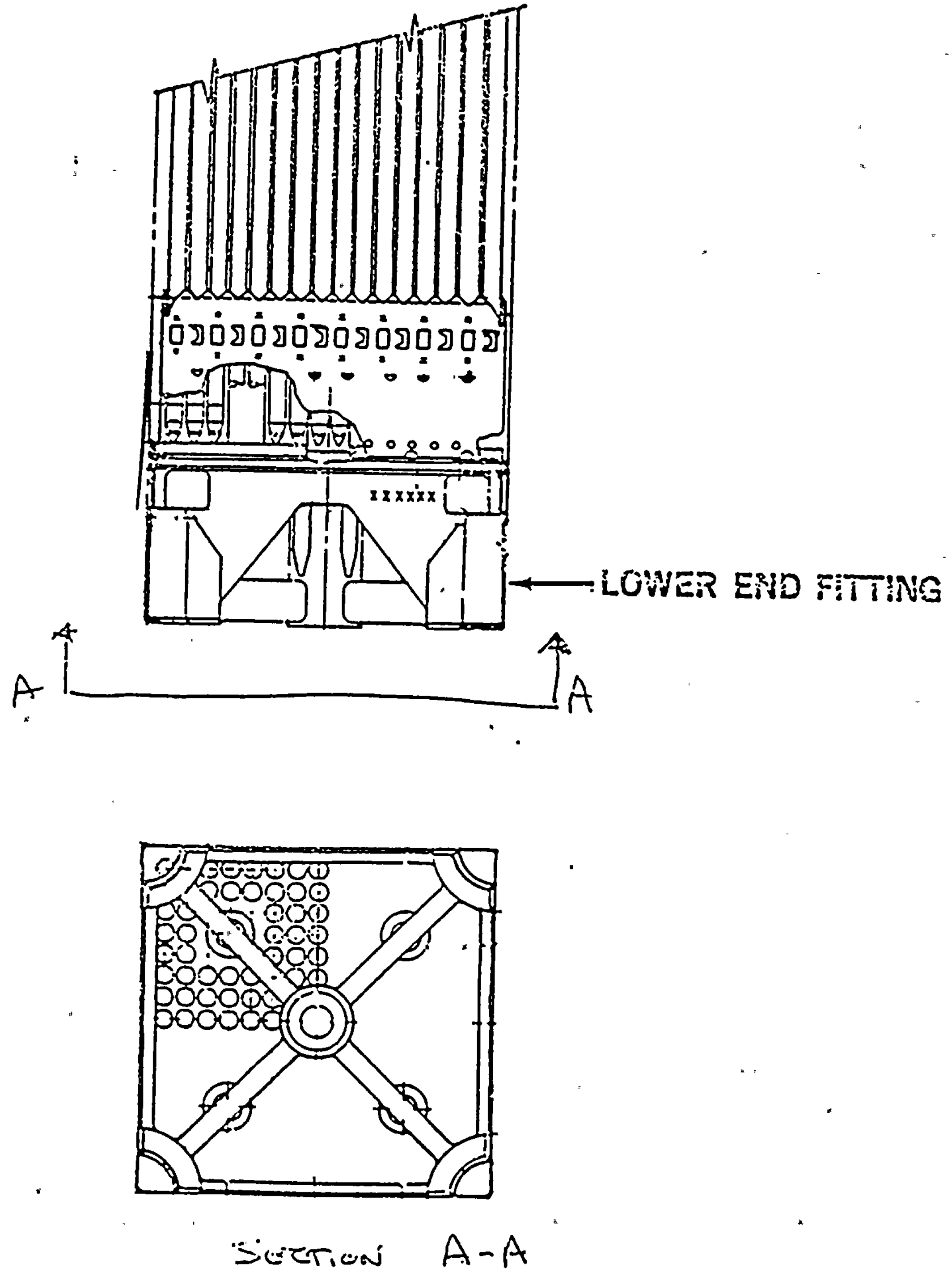


FIG. 15

FUEL ASSEMBLY



UPPER END FITTING



LOWER END FITTING

FIG. 17

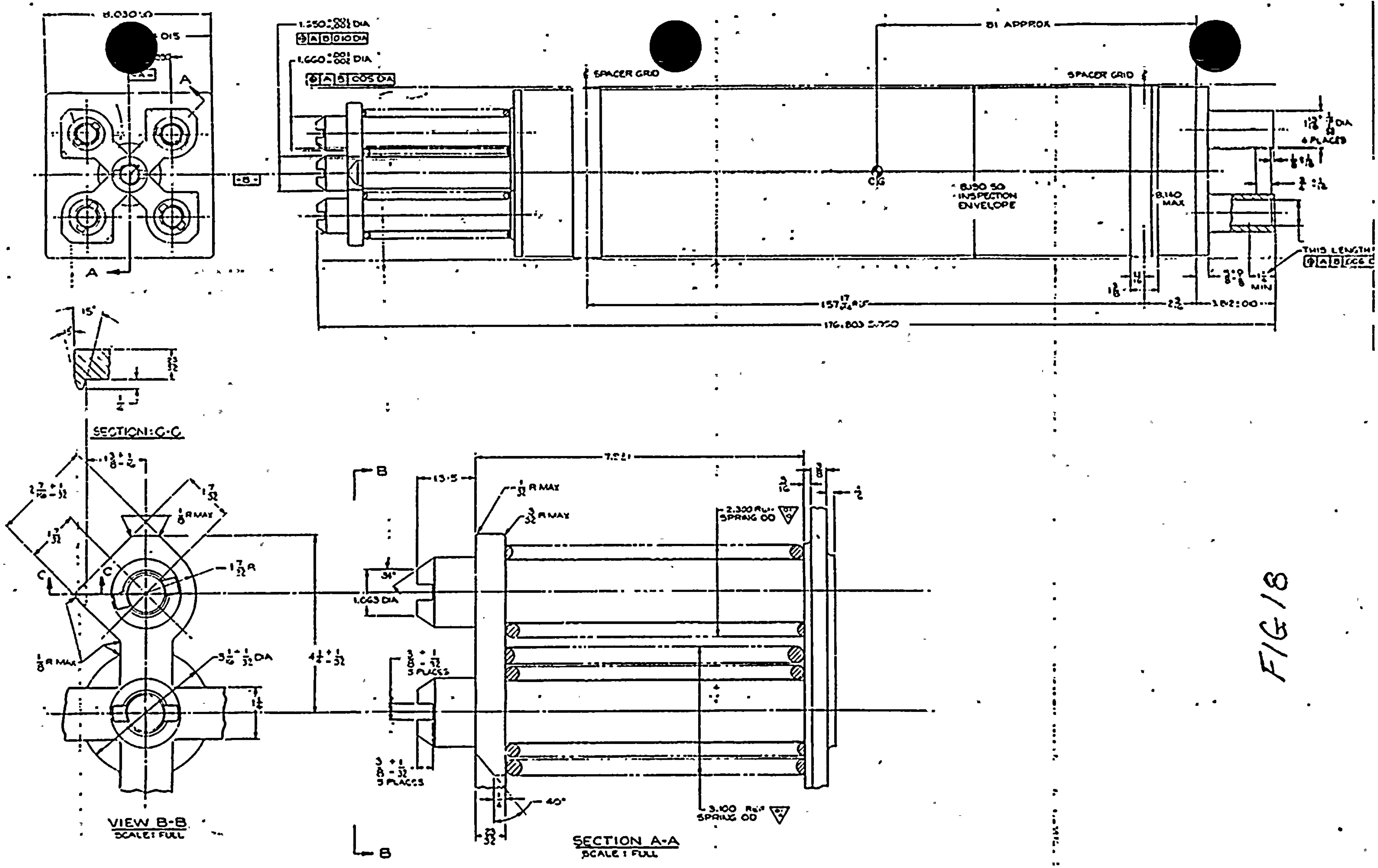
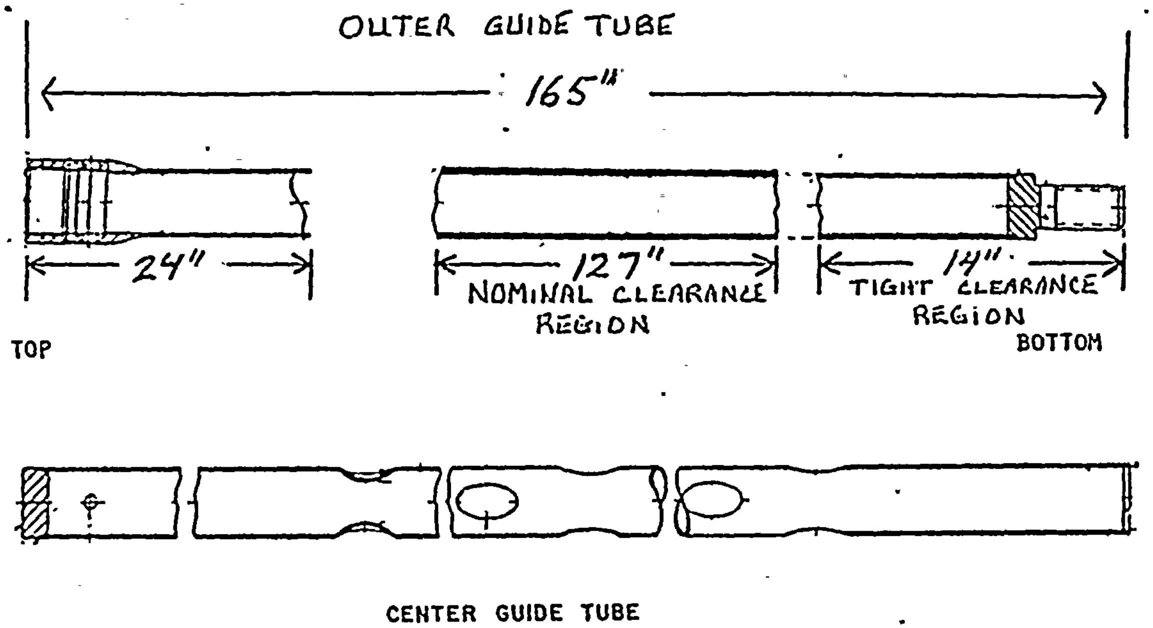
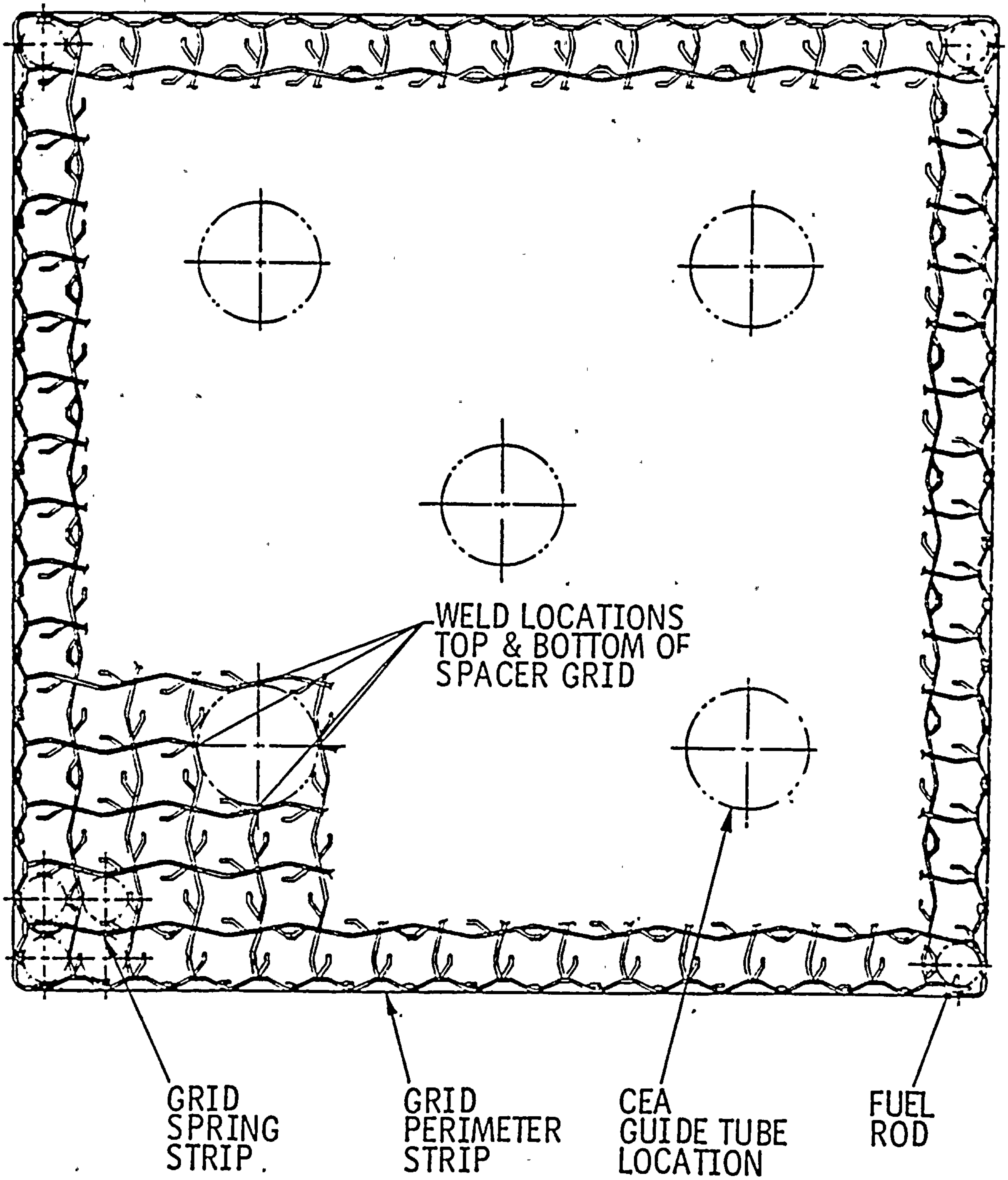

SPACER GRID
SPACER GRID
81 APPROX
CG
8.130 SQ INSPECTION ENVELOPE
8.140 MAX
THIS LENGTH
SECTION: C-C
VIEW B-B
SCALE: FULL
SECTION A-A
SCALE: FULL
2.300 REF SPRING OD
3.100 REF SPRING OD
1.063 DIA
5 PLACES
4 PLACES

FIG 18

FIGURE 19



FUEL ASSEMBLY: CEA GUIDE TUBES



FUEL SPACER GRID

FIG. 20

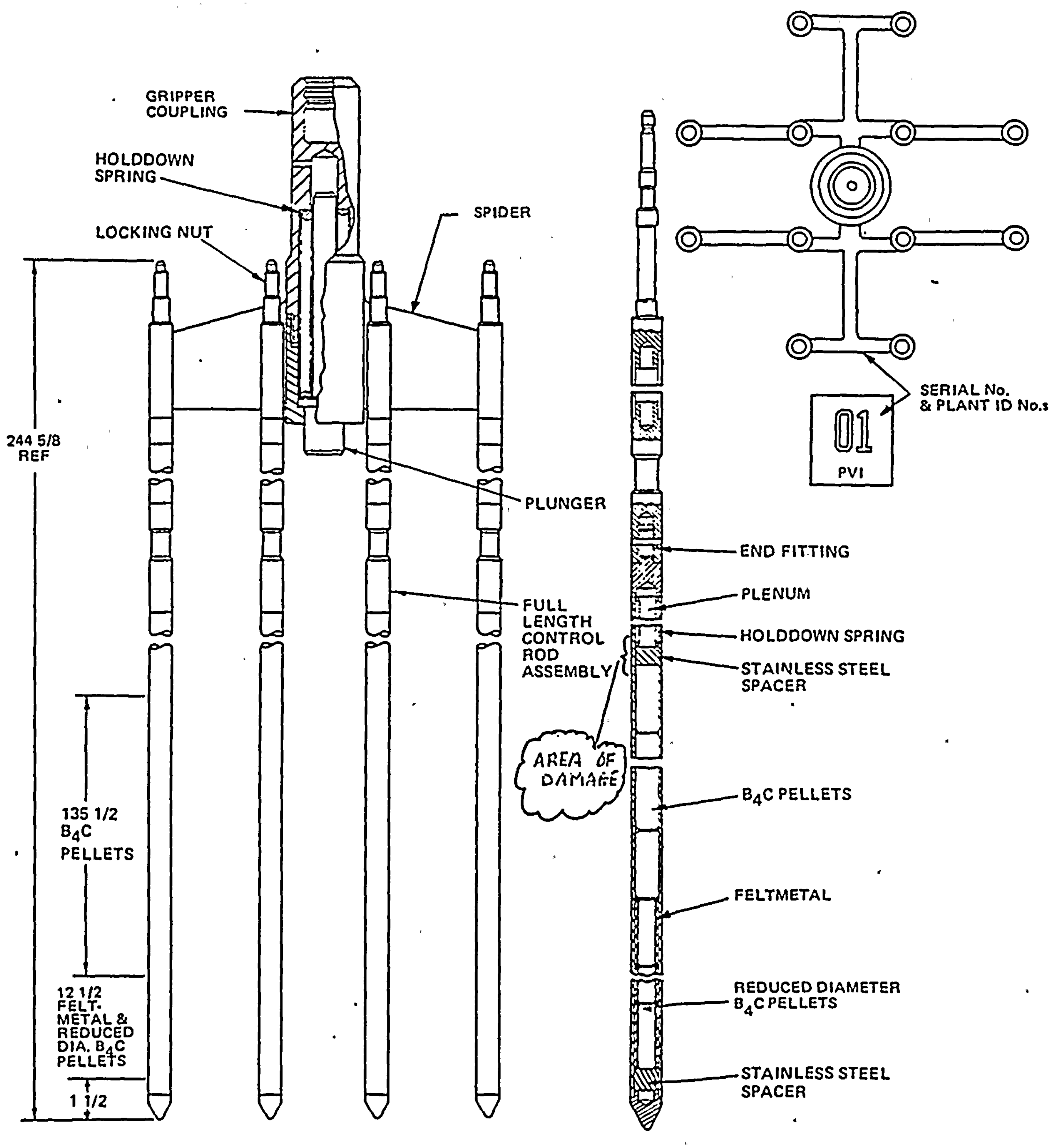
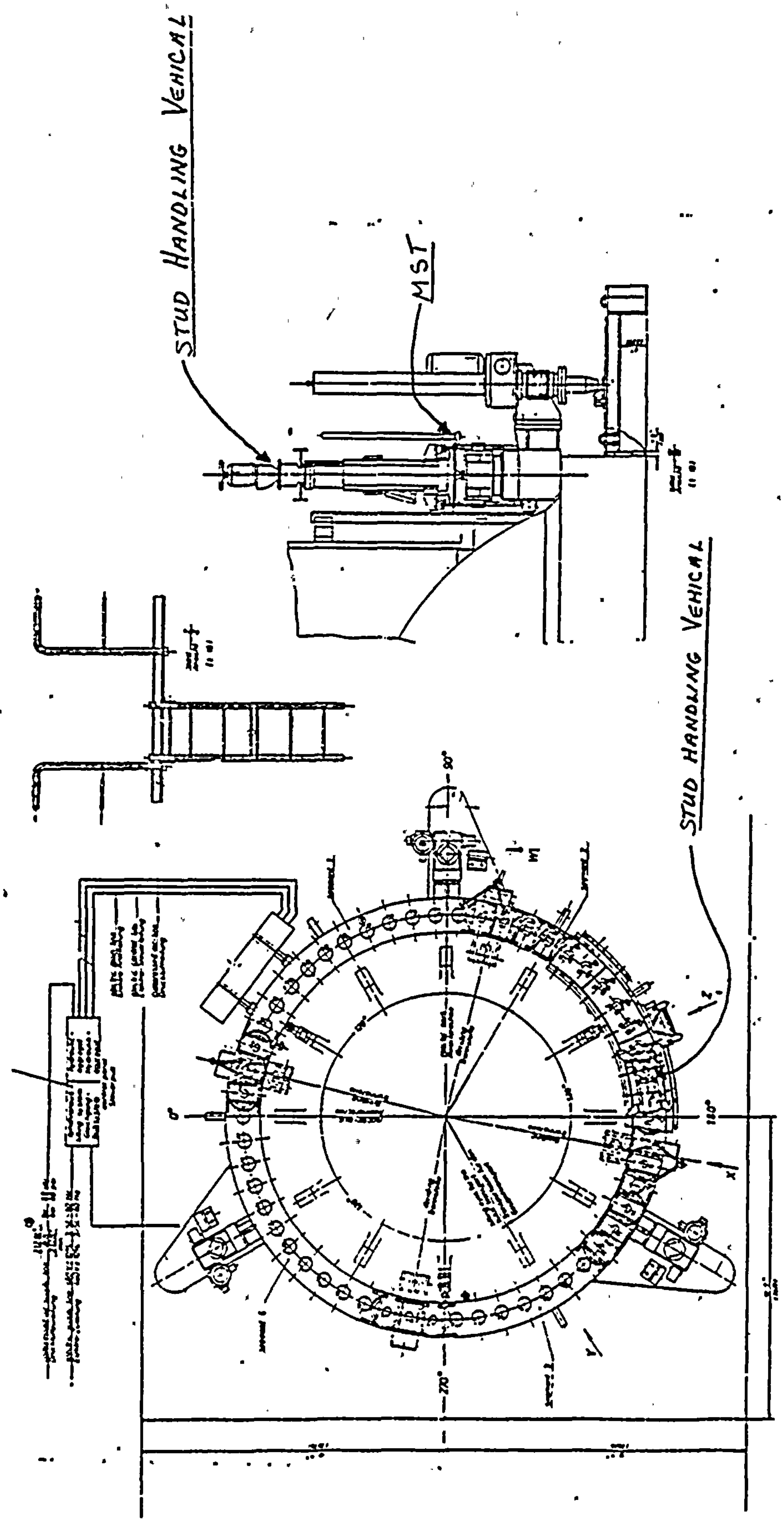


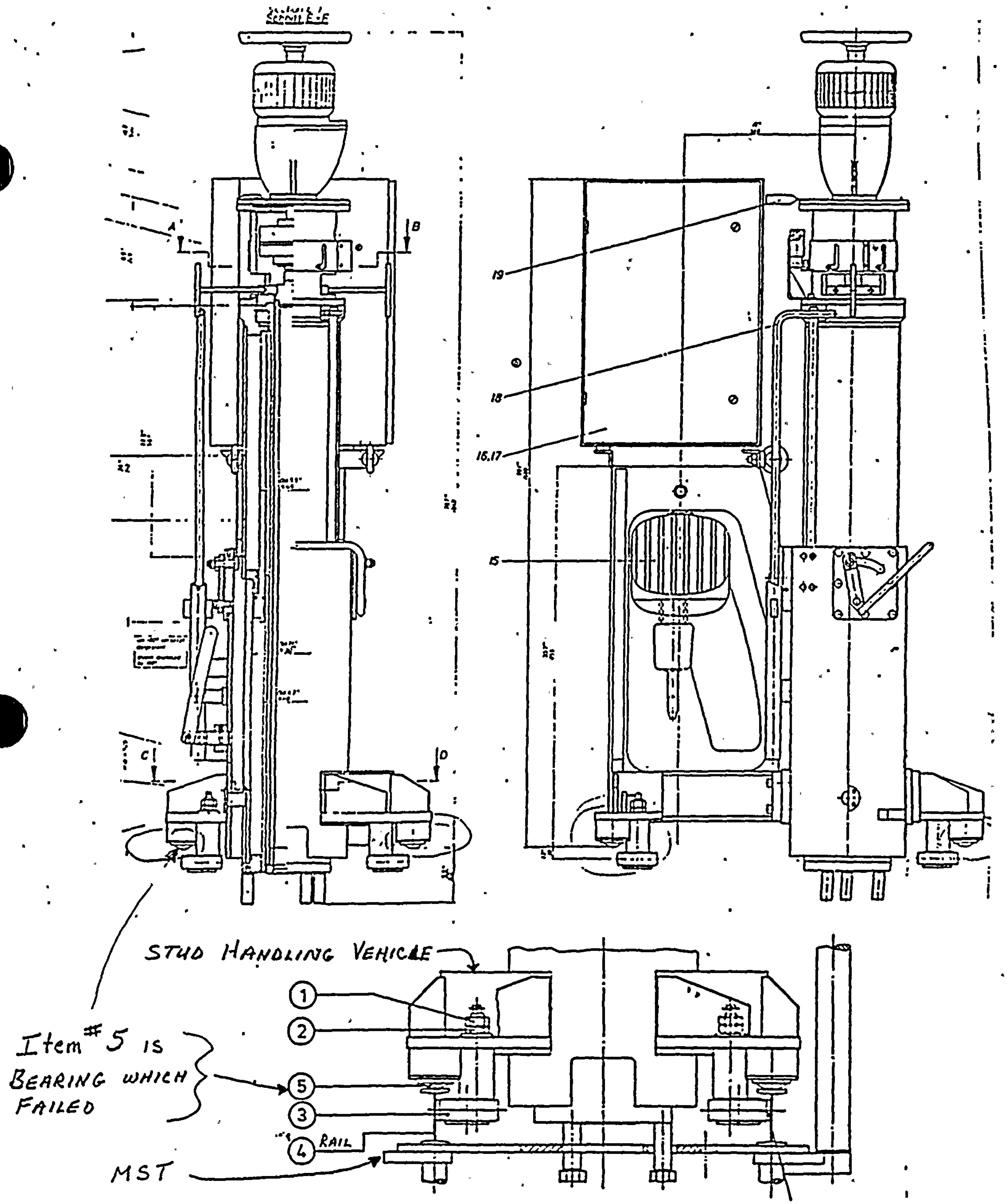
FIG. 21

C-E SYSTEM 80	FULL LENGTH CONTROL ELEMENT ASSEMBLY (12 - ELEMENT)



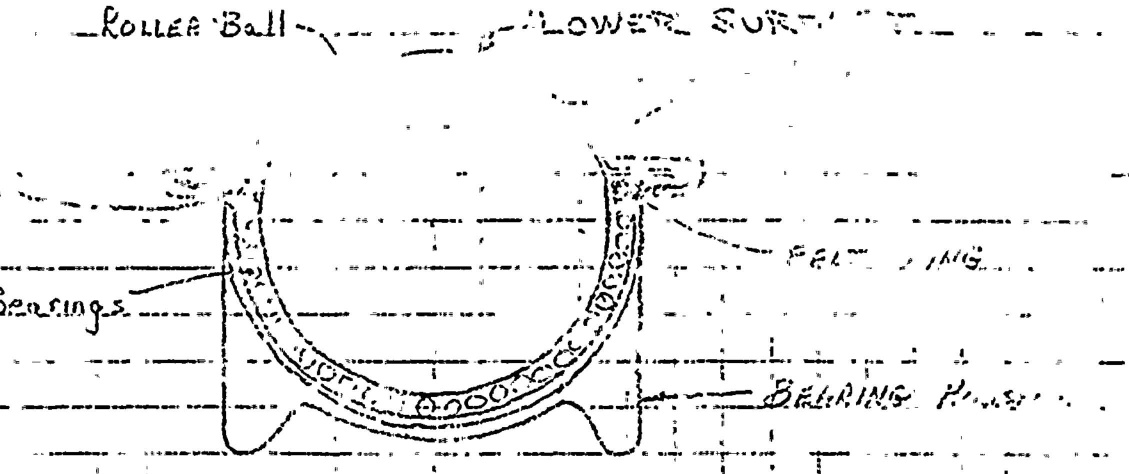
MULTIPLE STUD TENSIONER

FIG. 22

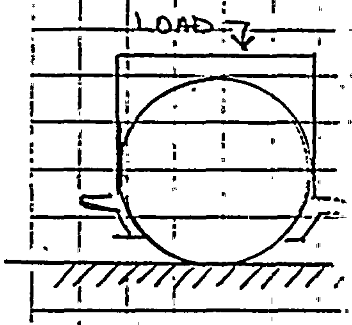


MST - STUD HANDLING VEHICLE

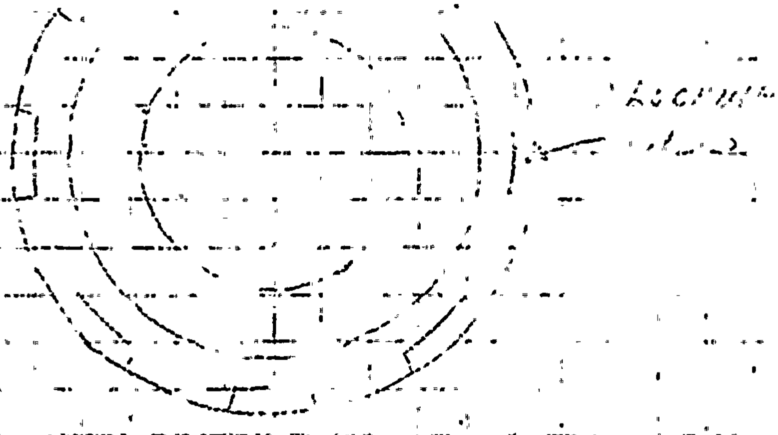
FIG. 2.3



BEARING ASSEMBLY



BEARING ORIENTATI



BOTTOM VIEW OF

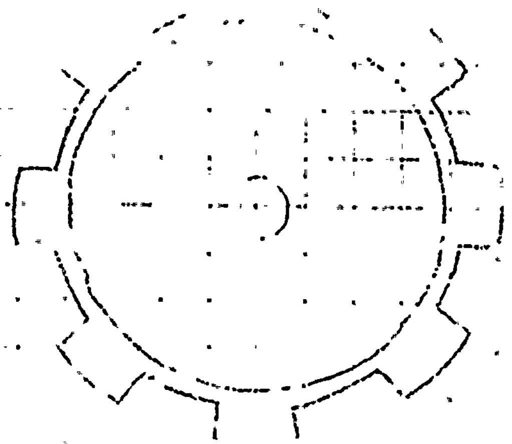
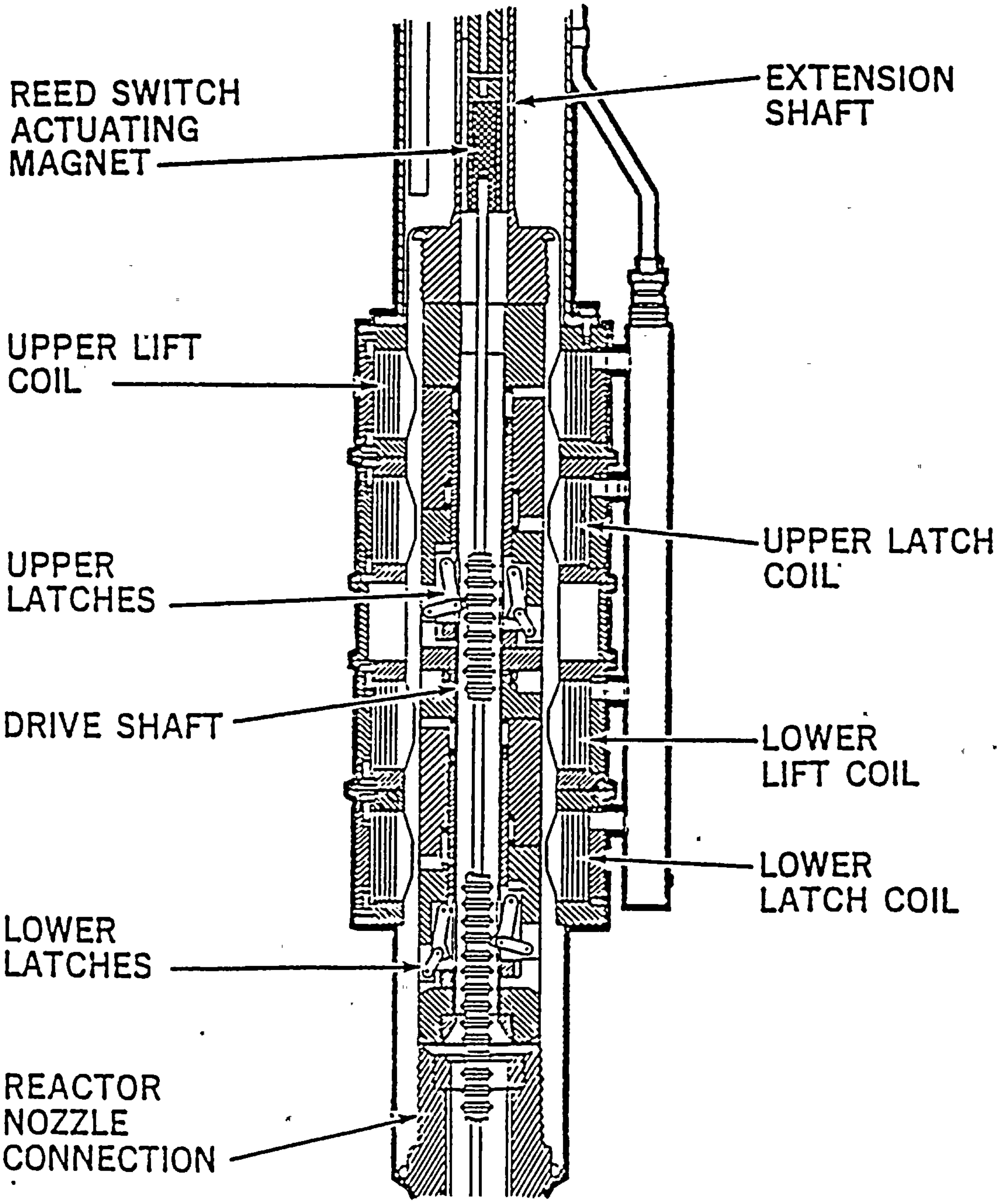
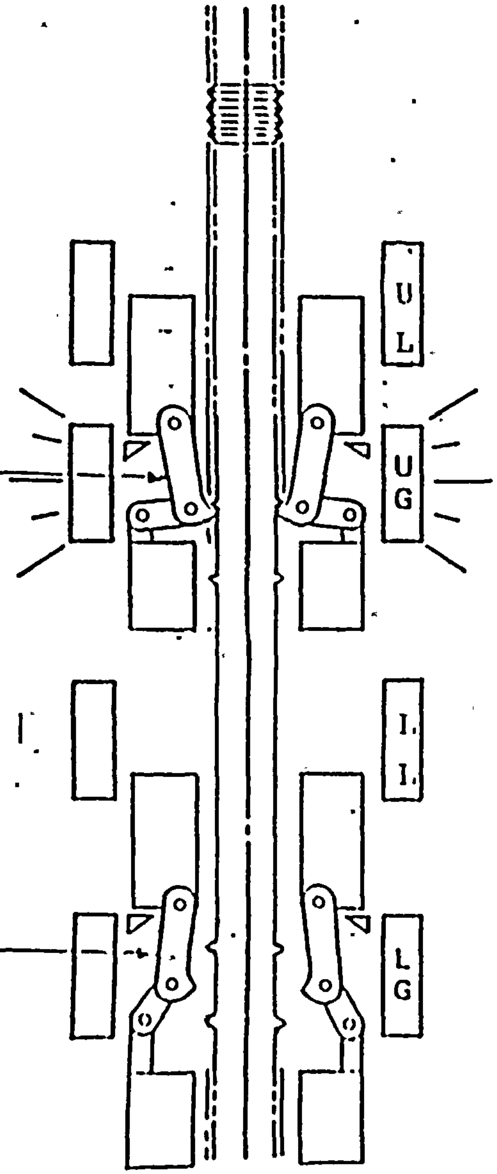


FIG. 24 MST- Bearing



CEDM OPERATIONAL CHARACTERISTICS

FIG. 25

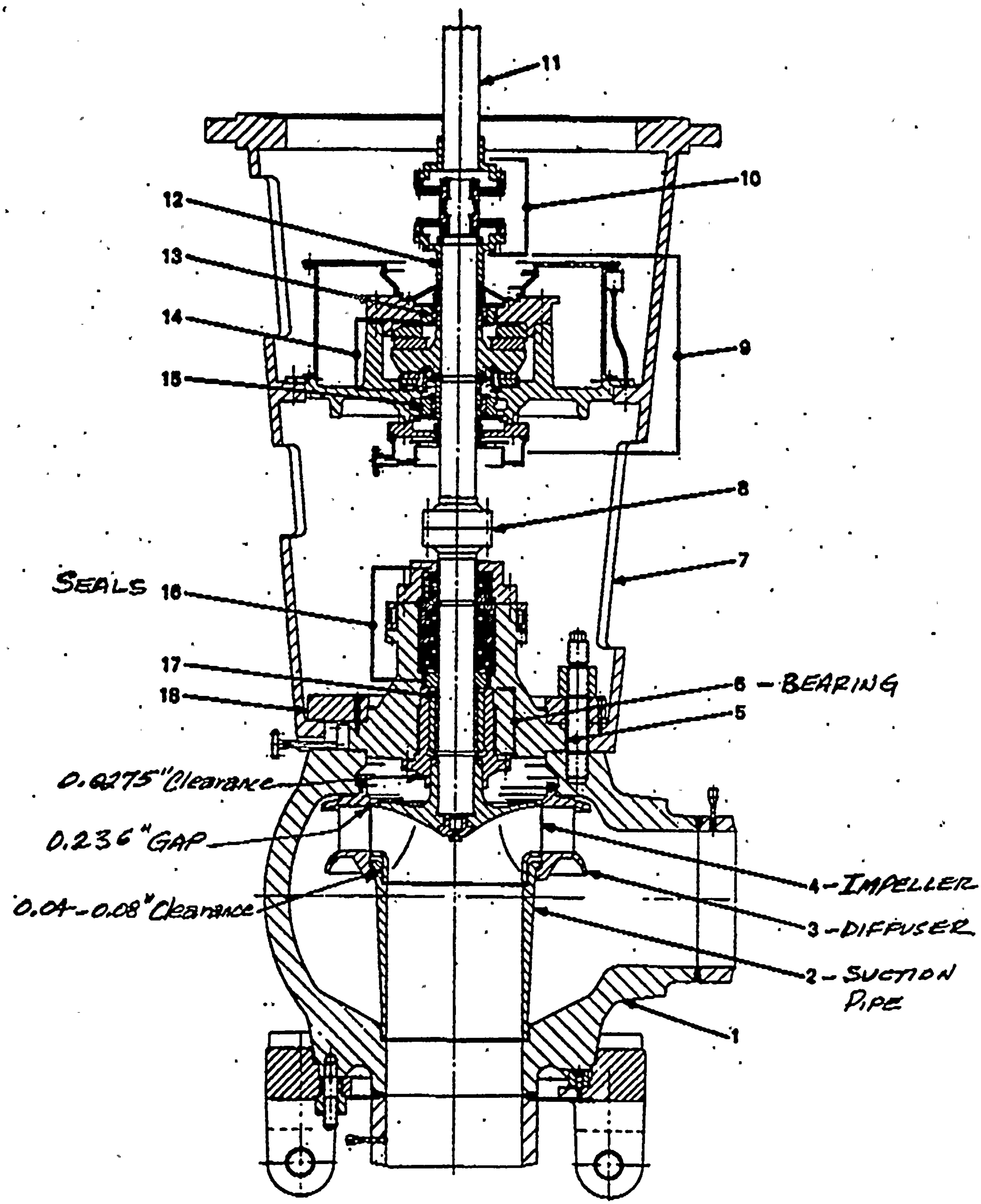


WITHDRAWAL SEQUENCE

1 OF 7

HOLDING MODE

FIG. 26



Reactor Coolant Pump Component Locations.

FIGURE- 27