GENERAL ELECTRIC

KKL IN-SERVICE EXPERIENCE WITH

EPG - BALL VALVES

(NIAGARA MOHAWK TASK NO. GE-1)

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Purpose

The purpose of this report is to document the in-service experience provided to GE by KKL on EPG designed ball valves used at Leibstadt. This report is in support of the Niagara Mohawk Power Corporation task force efforts regarding the current concerns associated with the Main Steam Isolation Valves (MSIVs).

Background

On October 5, 1986, Mr. J. Boseman (Valve Design Engineering) and Mr. G. Hanson (Materials Engineering) from General Electric Nuclear Engineering Business Operations were dispatched to meet with KKL personnel to obtain the Leibstadt experience with EPG designed ball valves. GE and KKL personnel met on the 6th and 7th of October, 1986 for this purpose. The following KKL personnel were in attendance:

(*) Mr. Ulrich Frick; Mechanical Engineering Department Head
Mr. Peter Buhlmann; Mechanical Engineering Group Leader
Mr. Walter JAK; Mechanical Engineer
Mr. Arthur Oberle, Consultant to KKL (retired BBC engineer - previously acquainted with Leibstadt ball valve efforts)

(*) - Part Time

The following information was provided by KKL regarding their experience(s) on this type of ball valve design.

1.0 LEIBSTADT BALL VALVE SYSTEM APPLICATION(S)

KKL uses large ball valves in two system applications as noted on Figure #1, attached. A 20-inch size ball valve was originally used as a shutoff valve in each of the two feedwater lines located in the auxiliary building. A 26-inch size ball valve is used as a turbine building shutoff valve on each of the four mainsteam lines. These valves are also located in the auxiliary building.

2.0 BALL VALVE MANUFACTURER AND REFERENCE INFORMATION

Manufacturer: Gulf & Western Energy Products Group (EPG)
Warwick, Rhode Island

Typical Drawing: E20-1500-1 (Feedwater Valve)

Actuator Type: Efcomatic Assembly Series 600
(same size used on both feedwater and mainsteam shutoff valves)

Installed Ball Valve Stem/Bonnet Orientation:

Feedwater valve - mounted in the horizontal axis
Mainsteam valve - mounted in the vertical axis

3.0 BALL VALVE REQUIREMENTS

3.1 Feedwater Shutoff Valves

The feedwater shutoff valves are required to close automatically within 30 seconds after receipt of an RHR initiating signal. The valves are required to open within 60 minutes after receiving an open signal. The maximum valve leakage criteria is to be consistent with proper RHR system operation. The actual maximum criteria was not available during the meeting. The original criteria used for the production units was identified as being 2cc per inch of valve size diameter.

3.2 Mainsteam Shutoff Valves

KKL identified that the original opening, closing and leakage requirements imposed on this valve for procurement purposes was the same as those imposed for the inboard and outboard mainsteam isolation valves.

In actual practice however the valve need only be capable of being manually closed either mechanically or electrically within 30 minutes after the inboard and outboard MSIV's have closed. The leakage criteria applied need only be consistent with safe and prudent maintenance practice when servicing the turbine building equipment.

4.0 INSTALLATION AND OPERATING HISTORY

4.1 History of Feedwater Shutoff Valves

1978-1980 - Design and manufacture of valves by EPG and subsequent storage at the site (approximately two years of storage).

1981-1982 Installation

May-October 1982 - Pressure Test of Feedwater Lines - During the hydrotest of the feedwater system it was found that these valves leaked so badly that they could not build up sufficient pressure to complete the test.

November-December 1982 - Disassembly of Valves - The major leakage was due to the spool/seals being frozen into the spool bore due to corrosion of the carbon steel spool bore and the subsequent buildup of corrosion product. This probably resulted in low seat to ball pressure. It was believed that leakage through the packing area also contributed. KKL designed a special tool to apply enough pressure to remove the spool/seals which were "frozen" in place from the corrosion. The pitting of the carbon steel in the packing area was approximately 10-20 mils deep. There was also some scoring and removal of carbide from the surface of the ball in the same area as the scoring of the Nine Mile balls. KKL contacted Union Carbide regarding the damage to the carbide. Union Carbide stated that the Tungsten Carbide would stabilize. KKL locally ground the edge when the carbide was spalled. KKL cleaned up the corroded areas by grinding and reassembled the valves. They changed packing from Chesterton 1500 to Chesterton 1000 which was lower in chloride. The Chesterton 1500 had 16-46 ppm chloride. The subsequent January, 1983, Pressure Test at 169 bars for 30 minutes was successful. KKL did not cycle the valves under pressure. KKL initiated a study of packing materials to determine the effects on room temperature corrosion of carbon steel. They found that some packing performed better than others. One of the better performing ones was Graflex 6501, a graphite coated asbestos. A Swiss packing (Titan) was ultimately chosen which also gave low corrosion.

February 1983 - Hydraulic actuator pump motor bus was found broken. The hydraulic cylinder was not properly centered resulting in seizure. The cylinder was replaced with a spare of the same size and properly aligned.

July to November 1983 - Feedwater valve 52 was disassembled because of high leakage. The spool/seal seating surface, on the pressure side, was found to have 52 radial cracks in the stellite overlay. The other seats were not cracked. New seats were installed.

All of the small springs in the seats plus every fourth large spring was removed to reduce the spring load on the ball seating surface.

The corrosion was ground out on the spool/seals and the spool/seals were electroless Nickel plated to maintain the proper gap between the spool/-seal and the spool bore (body).

The bonnets were modified on both valves to overcome a leakage problem and to resolve binding and scoring of the bonnet to valve body surfaces on disassembly. The original design required retensioning of bolts after the first pressurization. This was not practical so the bonnet and seal was redesigned to assure that the bolt preload was adequate to remain sealed without retorquing after pressurization.

Scored areas on the balls were locally blended by grinding.

On one valve actuator, the hydraulic fluid drained from the hydraulic cylinder to the reservoir due to elevation of the reservoir being lower than the cylinder. This resulted in a shock loading of the valve and actuator structure and probably caused the bracket fracture previously observed. KKL relocated the fluid reservoir to prevent the draining potential.

The roller bearings were found to have more clearance than the packing lantern rings (0.5mm for bearings versus 0.3 for lantern rings). KKL increased the clearance in the lantern ring to assure that the bearing would take the load.

<u>November 1983 - Modifications Complete, Testing Resumed</u> - Problems were encountered with the latch mechanism. The problem was scoring and ing of the trip solenoid. KKL modified all solenoids by removing the e (Seal Ring No. 28) which caused the binding.

<u>February 1984 - Problems with FW52</u> - Trip solenoid defective, needle valve damaged, filter replaced, pump coupling rubbing on sides. Misalignment of hydraulic cylinder bearings caused seizure of the cylinder and would not open the valve.

<u>May 1984 - Plant Startup</u> - Could not trip or close FW51 valve due to jammed solenoid. Could not open FW52 because of pump seals. KKL replaced the seals and freed the solenoid.

<u>June 1984 - Plant Shutdown</u> - Could not trip FW51. Latch mechanism had to be readjusted again.

October 1984 - External leakace through the packing. Pesolved by tightening the packing.

Summer 1985 - Feedwater valves were removed and replaced with check valve plus a motor operated gate valve in each line.

4.2 History of Main Steam Shutoff Valves

July 1983 - All inner spool/seals springs were removed. The modified designed bonnets were installed. Weld overlayed the bonnet sealing area with $13C_r$ 4Ni weld deposit. Restellited spool/seal seating surface(s).

Steam valves were exposed to steam and temperature from an auxiliary boiler.

Spool/seal bores were cleaned and ground to remove pitting. Spool/seals were Kanigen Nickel plated to provide for proper clearance (packing).

November 1983 - MSIV 22 - Wouldn't close during functional test due to failure of the solenoid trip.

Pressure test at 1.1 bars. All valves leaked greater than 50 liters per minute. They couldn't tell how much higher. MSIV 22 was dismantled and lapped. This reduced the leakage on this one valve to 30 liters per hour (0.9 cu ft per hour).

1985 Overhaul and Test - New manual mechanical trip levers were supplied by BBC and installed for ease in tripping the valves. If the trip solenoid does not operate electrically when actuated, then the manual mechanical trip lever assures tripping.

MS21 hatch roller bearing was found to have a crack.

Valves were tested for closing with no pressure with the following results:

MS21 - Closed within 2 days (not sure when)
MS22 - Closed after 2 hours, would not close on hand trip (prior to insalling the new mechanical manual trip).
MS23 - Closed properly (less than two minutes)
MS24 - Closed only after manually tripping via the solenoid.

August 1986 - Valves were actuated with no pressure and only MS22 failed to close. The trip solenoid was frozen in place due to the lubricant which had hardened.

Valve was disassembled and examined.

Some scoring and carbide was missing on the ball in high pressure surface areas. Also some upstream edge corrosion/spalling. Ball and seat relapped and valve reassembled with new packing.

5.0 MAINSTEAM SHUTOFF VALVE MODIFICATIONS

The KKL mainsteam ball valve design was modified as described below:

5.1 All of the small inner springs were removed from the nested springs located in the spool/seal assembly. Removal of these springs was recommended by the manufacturer to minimize scoring and thereby the leakage potential by reducing the imposed spring load from 600 lbs to approximately 400 lbs or approximately 40%.

5.2 The ball is coated with Nickel NEVER-SEEZ after maintenance and relapping in order to minimize friction and thus the potential for ball scoring. The vendor recommended this practice to enhance operability.

5.3 The bonnet pressure seal was redesigned/modified to minimize the potential for scoring the bonnet sealing surface during bonnet removal. This modification was recommended by BBC.

5.4 The body and bonnet guide surfaces were hardfaced with a 13 Cr 4Ni alloy to minimize corrosion between those surfaces and thus the scoring potential of the sealing surfaces for use with the pressure seal. This modification was a BBC recommendation.

5.5 The originally supplied Chesterton Packing 1500 was replaced with a 3/8 inch square Titan (Swiss supplier) packing set. This modification was incorporated due to the concern for corrosion of the bore surfaces and the quality control of the original type packing for chlorides, flourides and contaminants which could act as a catalyst for corrosion.

5.6 The spring retainer bore diameter was increased in order to assure that the spring(s) would not bind-up when compressed.

5.7 The lantern ring diameter was changed to assure that the roller bearing would be the effective load bearing member and to minimize eccentric rotation.

5.8 All trip solenoids were modified by removing the sleeve (PC #28) which had been the cause for malfunction on the feedwater valve.

5.9 The manual operator (actuator) trip lever was modified to permit manual mechanical tripping from the above flooring. In addition, the modified trip lever design incorporated a greater mechanical advantage to assure mechanical tripping of the actuator.

5.10 In addition to the above, KKL uses a specially (BBC) designed pre-load fixture for bolting up the body to bonnet closure. This fixture was designed to minimize the potential for leakage through that joint and to minimize axial movement of the ball due to stud relaxation after the valve is pressurized.

5.11 Attachment 1 identifies the originally provided materials list for the various spare parts items which can be used to compare to the NMP-2 MSIV ball valves.

5.12 KKL noted that after finding the radial cracks on the feedwater valve the spool/seal on all of the valves were re-hardfaced with stellite to assure a quality spool/seal seat.

6.0 LEIBSTADT EPG-BALL VALVE(S) OPERATING STATUS

6.1 KKL identified that the two feedwater stop valves were removed from the system and replaced with a third swing check valve (inside the auxiliary building) and a motor-operated gate valve in the turbine building. The decision to remove these valves was based primarily upon the inability of the valve to close reliably within the 30 second requirement for compatibility with operation of the RHR system.

6.2 With regard to the main steam shutoff ball valves, KKL identified that the modified valves are still installed in the system. Since the valves are not required to perform a safety-related function, there are no immediate plans to replace those steam valves.

7.0 OTHER ITEMS DISCUSSED/NOTED

7.1 KKL identified that numerous problems were experienced with the EFCOMATIC Series 600 actuator. The problem areas experience are highlighted on the attached figures 2 and 3. The types of problems ranged from leaking seals, broken bracket, cracked roller bearing to misalignment of parts. Due to the short time schedule for the visit, specific details were not discussed for each problem area. Essentially, KKL replaced or repaired parts or re-aligned features depending upon the cause. Modification efforts were limited to beefing up the bracket and changing the mechanical manual trip lever.

7.2 KKL indicated that they have not specifically noted chattering of the ball valve(s) per se.

7.3 With regard to scoring of the thrust washers, KKL did not observe any evidence of contact of the thrust washer on the feedwater shutoff valves but did note some light scoring on the main steam shutoff valves.

7.4 KKL identified that should Niagara Mohawk Power Corporation have need for an engineering test valve, that the removed feedwater valves are available for their use. KKL also identified that Sultzer Y-pattern MSIV's are available from the Swentendorf cancelled power plant should Niagara Mohawk be interested. If interested, KKL suggested contacting the U.S. based KSB agent, Mr. Bradford H. Robinson, who is located at the (KSB Inc.) Commerce Center, 175 Commerce Drive, Hauppauge, N.Y. #11788 (Tel: 516-231-0303, Extension 06).

7.5 Since Dr. Varga from BBC was on vacation and not available, Mr. A. Oberle (retired) formally from the BBC Engineering Department and a consultant to KKL, was asked to meet with us since he was knowledgeable with some of the history and problem areas concerning this ball type valve design. During the discussion, it was noted that some informal seat load calculations (not available at the meeting) had been performed and that high seating stresses were noted when a static differential pressure was applied across the ball to seat contacting surfaces. Recollection by Mr.

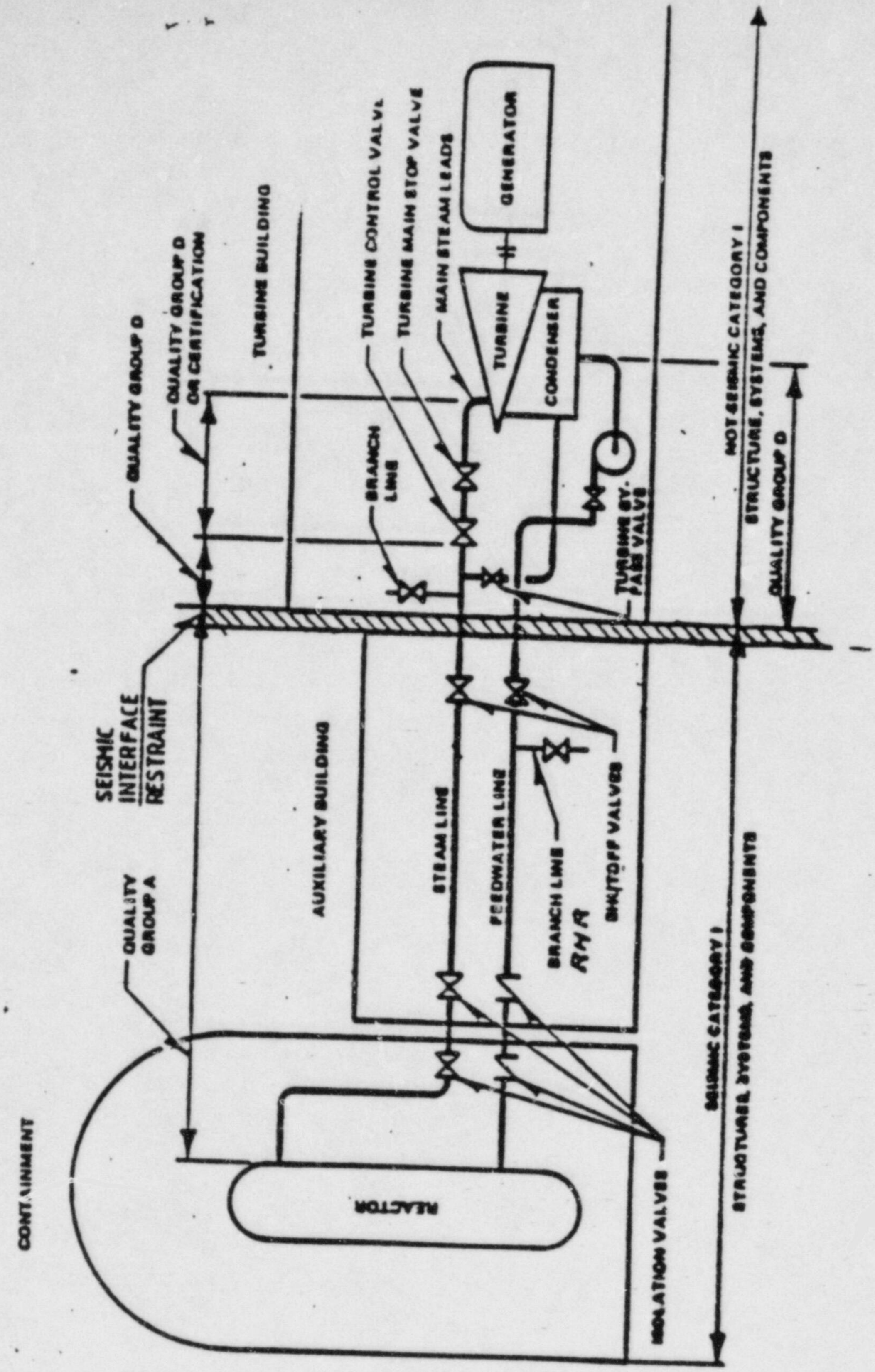
Oberle, indicated that the highest stress condition occurred just prior to valve closure assuming concentric valve rotation. High contact stress could also be expected when closing the valve should eccentric ball rotation occur which was evidenced by the ball scoring locations.

7.6 During the meeting it was noted that alignment and tolerance stack-ups of the ball to spool/seal is considered important to improve valve operation/performance.

7.7 Both of the balls from the feedwater valves were visually examined. Both of the balls were covered with a high temperature red oxide on the inside diameter of the ball. One of them was also coated with red oxide on the outside surface of the ball indicating that some water had been present on the outside surface of this ball. There were heavy burnish marks on the Tungsten Carbide starting from the bore and eminating 8 or 10 inches toward the seat. These burnish marks were present in a band approximately 8 inches wide. There were only small amounts of carbide removed)less than ¼ inch diameter spots) inthe same high stress area as the Nine Mile Point valves.

Visual examination of the photographs of the balls from the steam valves showed similar wear marks and spalling on the carbide surfaces except that the wear pattern was not as wide as the wear pattern on the feedwater valves. Another difference noted was the steam valve had what appeared to be corrosion of the carbide coating at the leading edge of the hole in the ball on the upstream side of the valve (pressure side). All of the Leibstadt balls (both steam and feedwater valves) showed much less spalling of the carbide than the Nine Mile balls examined by GE.

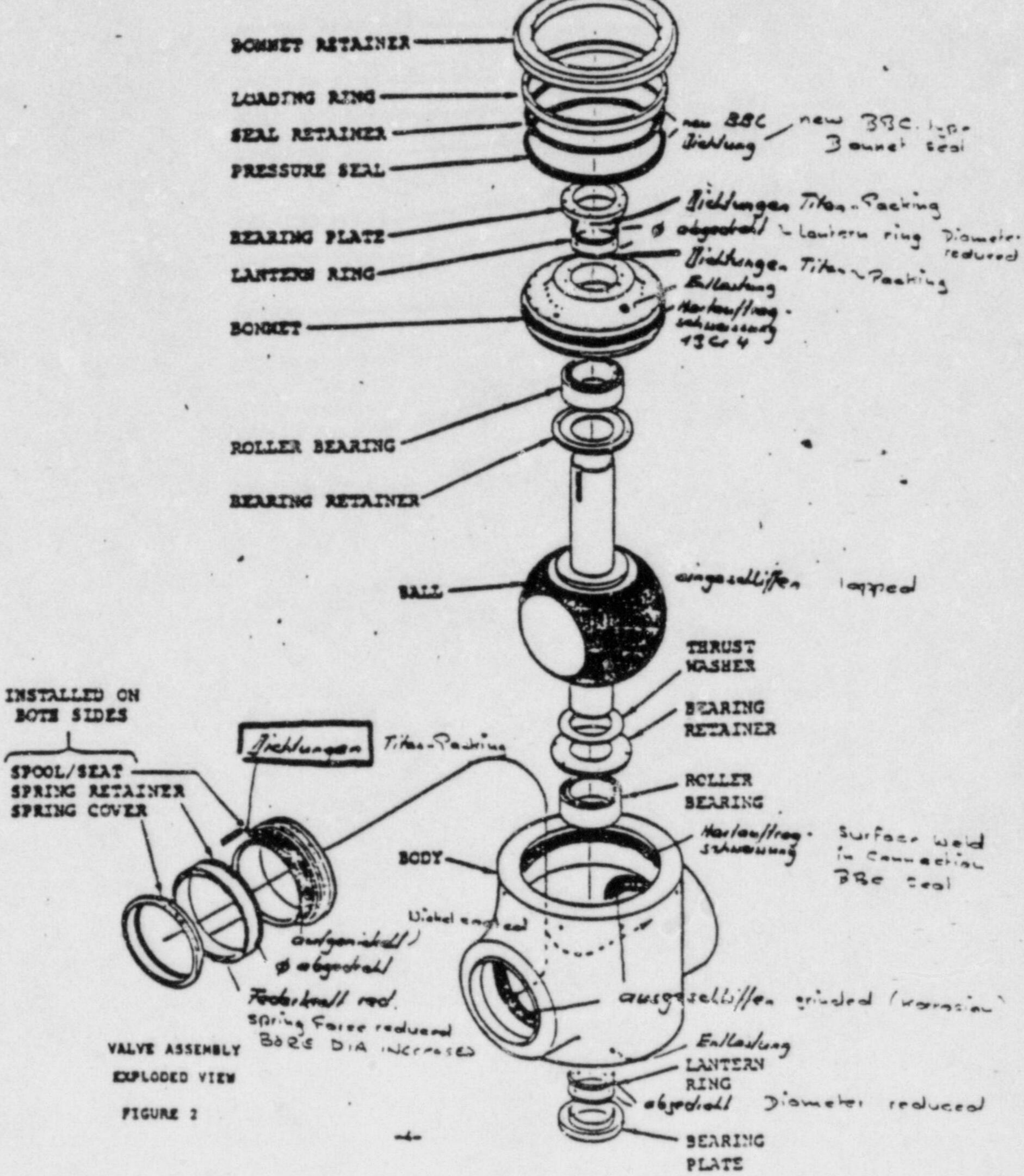
General Electric, on behalf of Niagara Mohawk Corporation, thanked the KKL personnel and Mr. Oberle for their time and cooperation in assisting us, on such a short meeting notice, with their experiences and information.



KKL KERNKRAFTWERK LEIBSTADT AG

QG and SC Classification Applicable to Power Conversion System Components in BWR/6 Plants

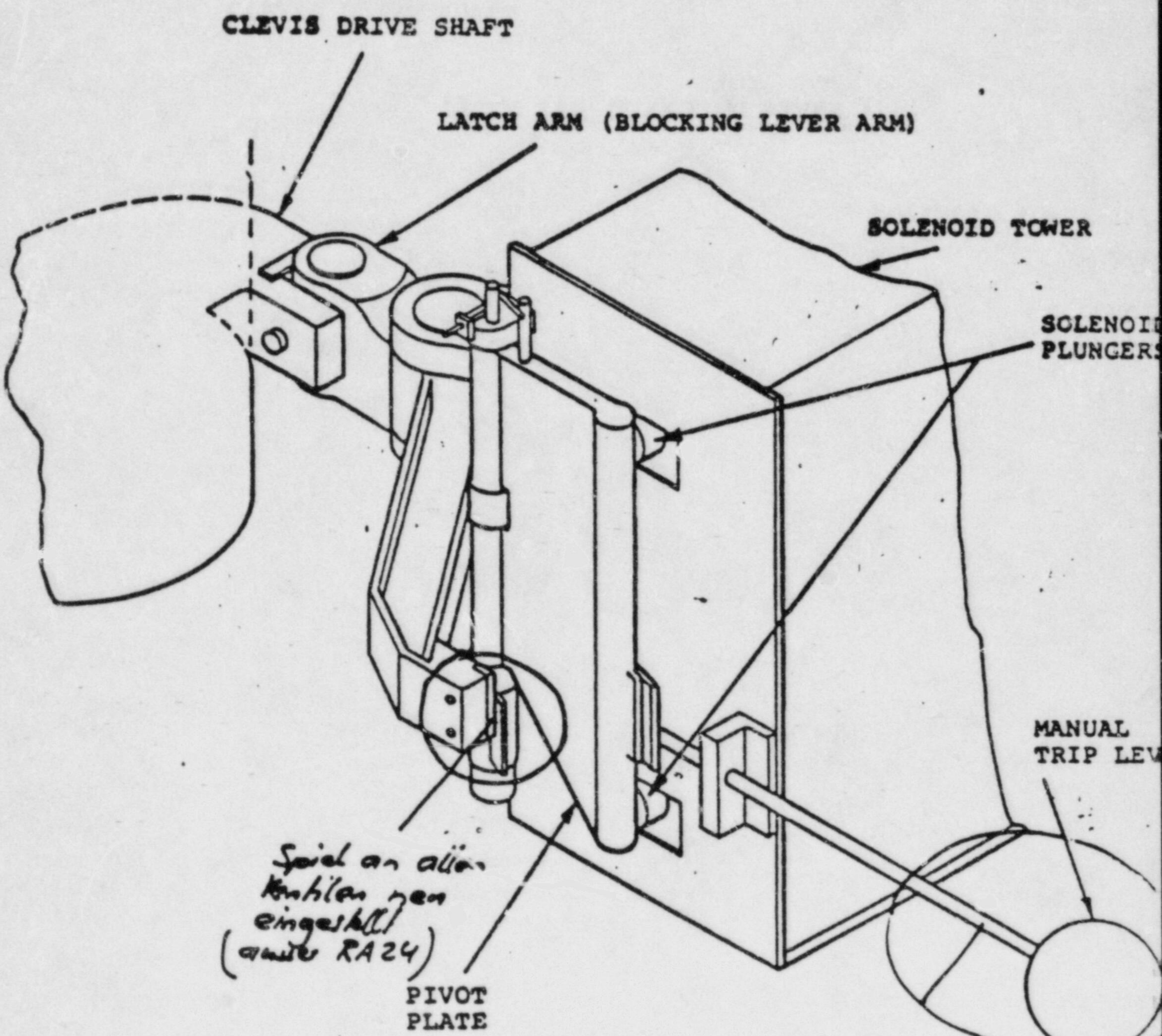
SAR Fig. 1



VALVE ASSEMBLY

EXPLODED VIEW

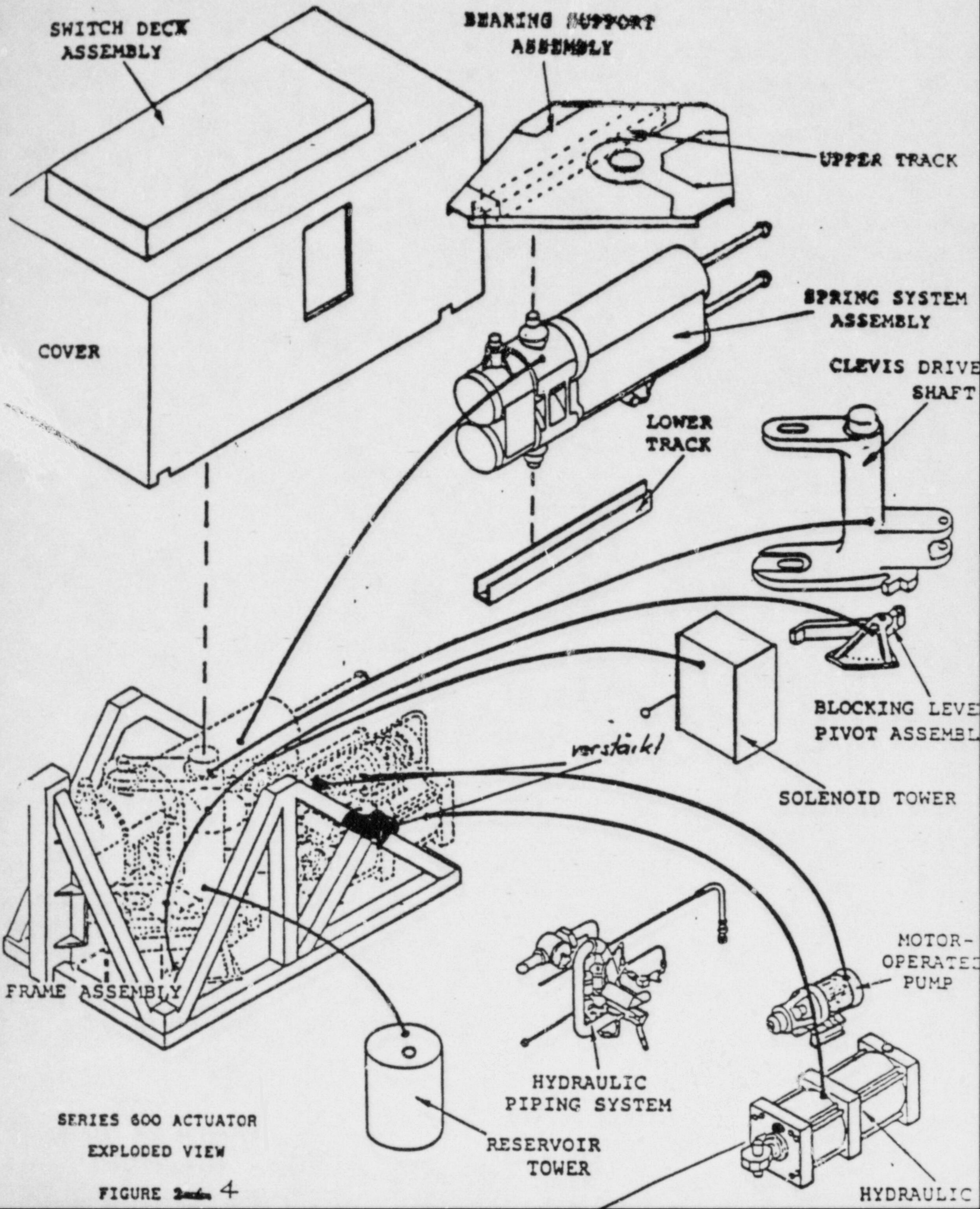
FIGURE 2



Alle RA Ventile mit neuem Trip-Hebel versehen

LATCH ARM AND SOLENOID TOWER

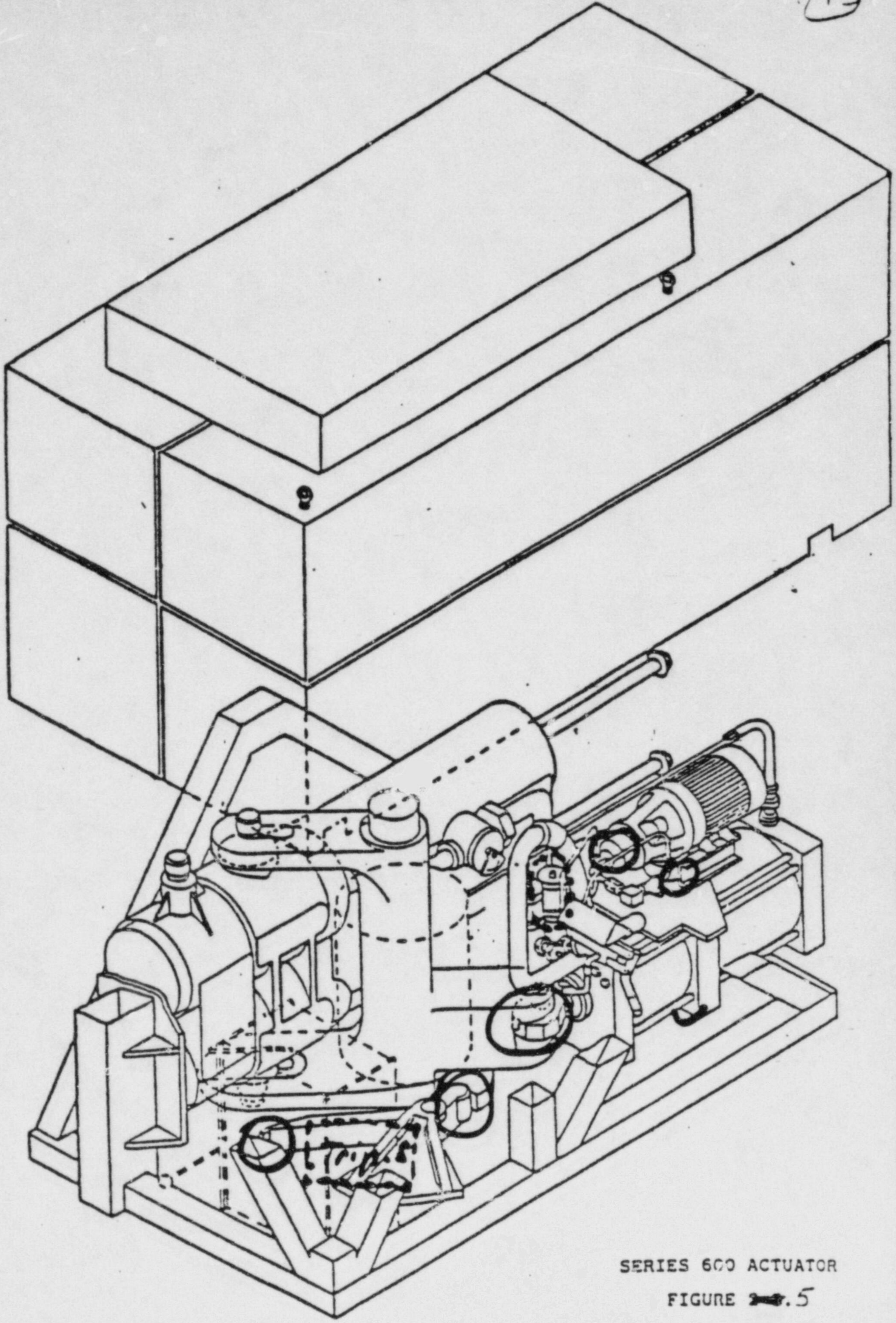
FIGURE 9-7.3



SERIES 600 ACTUATOR
EXPLODED VIEW

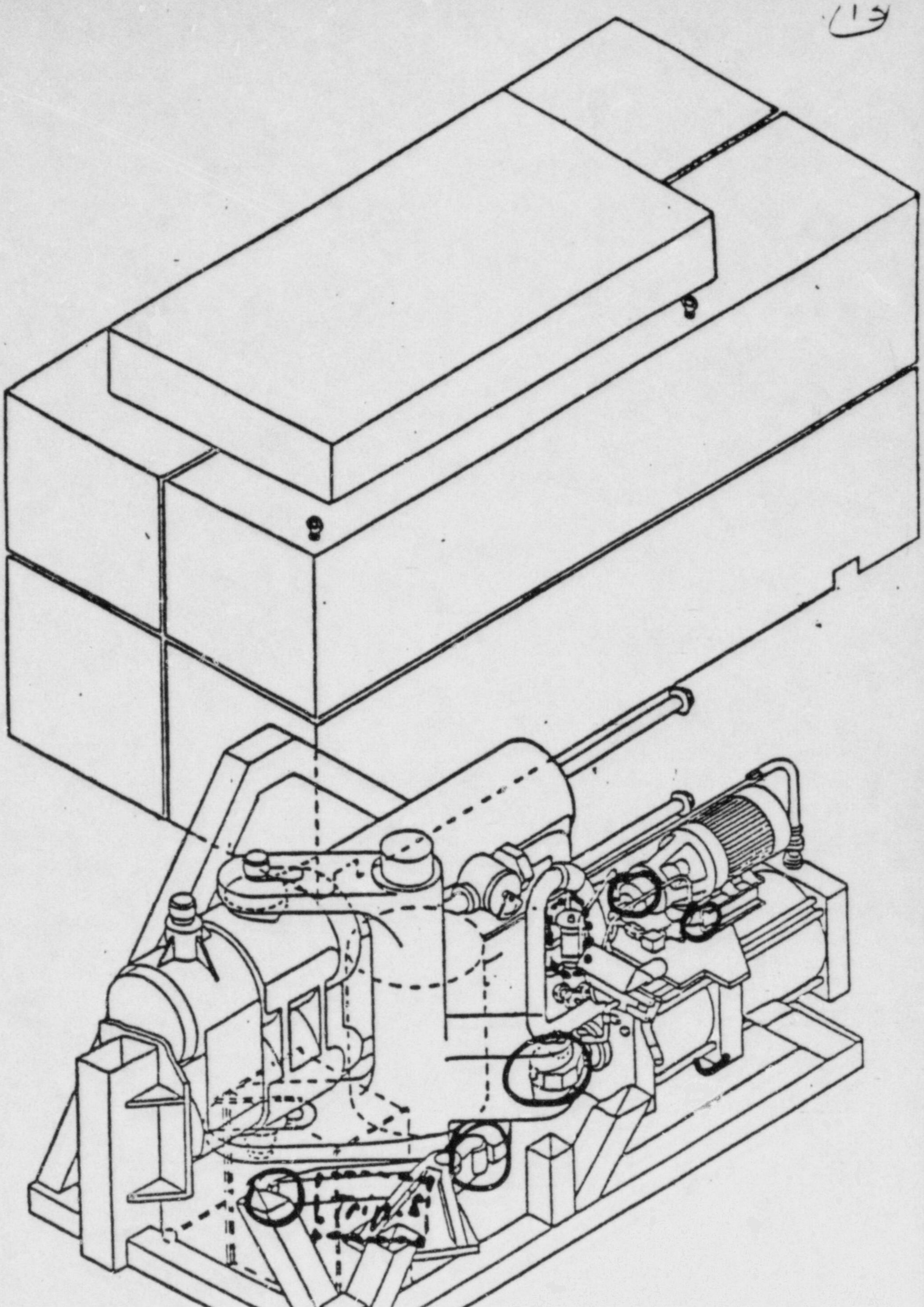
FIGURE 4

(13)



SERIES 600 ACTUATOR

FIGURE ~~2-~~.5



SERIES 600 ACTUATOR

FIGURE ~~2-7~~. 5