UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION REPORT BY THE OFFICE OF NUCLEAR REACTOR REGULATION CONCERNING THE CONTROL ROD DRIVE TRIP BREAKERS AT ARKANSAS NUCLEAR ONE, UNIT NO. 1 DOCKET NO. 50-313

I. BACKGROUND

In response to NRC Bulletin 83-04 "Failure of the Undervoltage Trip Function of Reactor Trip Breakers", all the reactor trip breakers were tested successfully on March 14, 1983. The licensee's written response to this bulletin is provided by his letter of March 21, 1983 to J. T. Collins, NRC Regional Administrator. On March 23, 1983, with plant in cold shutdown and routine testing of the control rod drive system in progress, the undervoltage trip device of one reactor trip breaker was unable to trip that breaker upon demand from the manual scram switch on the main control board. The failed breaker was the "A" a.c. main feed breaker. All other reactor trip breakers performed and the control rods were all fully inserted into the reactor core.

After discussing the situation with the licensee, the NRC issued a Confirmatory Action Letter on March 25, 1983. This letter requires that the reactor not be operated until certain actions were completed and the safety concerns were resolved. One of these actions involved a plant modification that would add the shunt trip, in addition to the present undervoltage trip, as a safety-related mechanism to operate the reactor trip breakers.

On March 31, 1983, a meeting was held in Bethesda, MD during which the licensee presented the results of the investigation of the cause of the breaker failure, proposed corrective actions, and his basis for continued safe operation of the plant. We have reviewed the information presented by the licensee, as discussed below.

As an Attachment 1 to this report, we have prepared a summary description of the reactor protection system and reactor trip breakers at this plant. The description covers the redundancy and the diversity, which in this design are substantial. It depicts pictorially the spring adjustment used to set the pickup voltage of the undervoltage trip attachment to the breaker. Also it depicts and discusses the trip shaft bearings and the trip latch precision bearing in the breaker that require periodic lubrication.

As Attachment 2 to this report, we have reviewed the prior experience of trip breakers failures at this plant. As a result of this experience, we conclude that there is indication that the failure rate of reactor trip breakers at this plant may be higher than the average.

II. Identification of Cause of Breaker Failure to Trip

On March 23, 1983, the plant was preparing to return to operation after a refueling. The control rod drive systems were being tested. One of the last steps is to remove power from the drive system via the manual reactor scram switch on the main control board. Following this operation, the operators determined that the "A" main A.C. feed reactor trip breaker had failed to operate. The breaker was manually tripped by the local mechanical trip mechanism and then placed in a "quarantined" status by the plant Operations Superintendent pending a full investigation with assistance from the manufacturer's design engineering staff.

The licensee's letter to J. T. Collins, NRC Regional Administrator, dated March 25, 1983; discussions and copies of slides presented during meetings on March 31, 1983; and additional discussions with the licensee's and vendor's representatives form the basis for the following evaluation and staff judgement.

A. Description of Investigative Tests - The licensee performed investigative tests based on a work plan developed in consultation with the vendor, General Electric (GE). Tests involved measuring of breaker shaft torque requirement and response time. Response time was measured both prior to and after lubrication of the breaker bearings. The pickup voltage setting of the undervoltage coil was set at 84 volts. The response time for trip through the undervoltage coil was measured at 84 volts, the original set point, and at 102 volts (85% of 120 VAC). This latter value is recommended by the vendor in his Service Advice Letter in 1979 (i.e., NRC Bulletin 79-09).

B. Results of Tests - The measured response times were presented as follows:

Trip Time In Seconds

	PRE-Lube		POST-Lube	
	84V	102V	84V	102V
Trip #1	0.042	0.0249	0.025	0.027
Trip #2	0.542	0.027	0.033	0.02
Trip #3	0.034	0.0236	0.028	0.017
Trip #4	1.76	0.021	0.029	0.021

The torque measurement prior to lubrication was approximately 26 inch ounces and less than 24 inch ounces post-lubrication. Based on information obtained from the vendor and other sources, the maximum torque available from the under voltage coil with a pickup setting of 102 volts is in the range of 27 to 30 inch-ounces. Thus, the measured torque values observed during the investigative tests correlate with the trend from the measured response time.

C. Conclusions - During discussions with the licensee and through a visual examination of the breaker bearings it was observed that some bearings are protected by a dust shield. It is now hypothesized by the licensee that the dust shields may have been thought to be sealed bearings, and may not have been serviced during routine service and maintenance. A comparison of the response time pre and post lube strongly supports the hypothesis.

Comparison of the pre-lub response time between the 84 volts and 102 volts settings on the UV device is also significant. With the higher voltage setting, which is recommended by the vendor, the response time is reduced significantly tending towards the post-lube values.

The licensee also described how breakers were purchased to the quality assurance requirements for safety-related components, and was able to verify that the original purchase order identified the breakers as being safety-related. The licensee also reviewed the maintenance history, and confirmed that the maintenance is indeed performed by "Q" job order, i.e., maintenance performed on safety-related equipment. However, because of the dust cover on the bearings it cannot be confirmed how frequently they have been lubricated.

Based on the above, the staff concludes that the most likely causes of the failure to trip are (a) lack of lubrication of the breaker trip shaft bearings and the precision trip latch bearing, and (b) the undervoltage coil pickup voltage setting being less than that recommended by the vendor.

The staff has requested and the licensee has agreed to provide on the docket the complete results of the investigative tests and revised maintenance procedures that assure proper lubrication and undervoltage coil pickup voltage settings. Records of procurement of the breakers and replacement parts including records of maintenance and surveillance performed on the breakers are maintained by the licensee and are available to the NRC for inspection.

III. Maintenance and Testing Procedure for Reactor Trip Breakers (RTB)

The licensee's letter to J. T. Collins, NRC Regional Administarator dated March 25, 1983; and discussions during a meeting with the staff on March 31, 1983; were reviewed and form the basis for the following evaluation.

A. Control of RTB Vendor Information

The licensee discussed the procedure for control and dissemination of vendor information. All incoming vendor information goes through the document control procedure and is reviewed by the Operations Experience Assessment Group and the Responsible Discipline/Section Manager. Also, controlled copies are issued and updated. Changes and revisions to relevant procedures are made when and to the extent that the licensee's review indicates that a change is necessary based on the incoming information. The staff finds the procedure is responsible and adequate. The licensee agrees that all records related to the disposition of the GE service advice letter of 1979 on RTB's are available for NRC inspection.

B. Control of RTB Configuration

The breaker maintenance program is consistent with the criteria for safety-related components, and are initiated by "Q" job order. Therefore, the maintenance history is retrievable. However, the previous procedure did not call for recording the breaker identification number, and it is not possible to trace the path of a specific breaker in various locations. The licensee has proposed and the staff agrees that the revised procedure will include the breaker identification number in future maintenance records.

C. RTB Maintenance Programs

The licensee's maintenance program for RTB's is performed in accordance with a formal procedure, Procedure #1405.17 consistent with safety-related quality assurance criteria, with well defined frequency and established maintenance records. The staff, however, has not completed a detailed review of the licensees procedure, and additional long term and short term requirments are defined later.

The licensee reported all failures related to the RTB's that had not been previously reported in the letter to J. T. Collins, NRC Regional Administrator dated March 25, 1983.

Staff review of the licensee's maintenance programs as presented to the staff during the meeting of March 31, 1983, in Bethesda, MD with respect to quality assurance requirments, maintenance records and reporting of failures shows good faith on the part of the licensee.

D. Compliance with NRC Bulletins and Circulars
The licensee has indicated compliance with IEB 79-09, IEC 81-12, IEB 83-04 with respect to procedures and informing operators regarding failure to scram scenarios. We have reviewed the licensee's actions in response to NRC IEB 79-09 and the associated GE 1979 Service Advice Letter. Based upon information presented on March 31, 1983, we draw the tentative conclusion that the licensee did not fully comply with the vendor's Service Advice letter in three areas. these are: (1) the pickup voltage setting of the undervoltage trip device, (2) lubrication of the precision trip latch bearing in the main mechanism of the breaker, and (3) the frequency of inspection and maintenance of the trip breakers. Although the licensee appears not to have been in full compliance with IEB 79-09, we conclude, based on our review, that the upgraded procedures now conform to IEB 79-09.

E. Proposed Revisions

The licensee has proposed to revise his maintenance procedure. The revised procedure is subject to detailed staff review and approval. In order to ensure that all RTB's are rendered operational and maintained in an operable and reliable condition, the staff requires that the following short term and long term conditions be met. The licensee has committed to these conditions in a letter dated April 4, 1983.

Short Term Conditions:

Prior to criticality the licensee has agreed that:

a) All RTB's have been lubricated per vendor recommendation including the lubricant type and lubrication points and torque and response time test results are within acceptable values.

b) All RTB's will have been cycled by the undervoltage trip at least ten times without any intervening adjustment or maintenance with a minimum of five minutes between each cycle. Visual confirmation of break in contact at each breaker location, in all ten of the above tests must occur to consider a specific breaker to be operable. Failure should be promptly reported to the NRC.

Long Term conditions:

The licensee has agreed to provide maintenance procedures for RTBs and control rod drive scram system that address the following before the next six month maintenance period:

a) When out of tolerance conditions are found, procedures should clearly state what actions are to be taken by the maintenance personnel. A review of the conditions of failure by the quality assurance and engineering staff should also be included.

b) Procedure documents must include figures to show exact lubrication points. No deleterious effects will be caused by the lubricants with respect to corrosion or hardening of the lubricant.

IV. Periodic Surveillance Testing

A. Procedures

The licensee has surveillance procedures documented as Reactor Protection System Channel D test, 1304.40, Revision 8. This procedure is to be used in the monthly surveillance tests. We have reviewed the procedure and determined it to be acceptable.

V. Proposed Shunt Trip Modifications

Prior to the breaker failure on March 23, 1983, the licensee had been developing a design change that would add the shunt trip coil (STC) of each reactor trip breaker to the safety-related reactor trip system. The licensee has proposed to install this modification prior to plant restart. The purpose of the modification is to provide a diverse mechanism independent of the UV trip device in each breaker in order to increase the reliability of the reactor trip breakers.

Conceptually, this modification involves the addition of an undervoltage relay in parallel with the UV trip coil. When the protection system removes voltage from the UV trip coil, the undervoltage relay would also "de-energize." The output contacts of the undervoltage relay would apply a separate d.c. voltage to the STC and thereby also cause it to trip the breaker. Associated with the modification are switches to permit independent testing of the UV and STC trip mechanisms, loss-of-voltage monitoring relays (which would operate a trouble alarm in the plant main annunciator system), and locally mounted indicating lights.

In our review, we identified a concern that the independence of the two safety-related redundant electric power divisions may be put in jeoparity by the design as presently proposed. The undervoltage relay is not a simple coil-contact device. Rather, it is solid-state circuitry for which separate d.c. power is provided for its operation. In the case of the 4 d.c. breakers, the d.c. power being used for the undervoltage relay and the a.c. power being used for the UV trip devide are from the two different redundant electrical divisions. If failures internal to the solid-state circuitry could result in d.c. from one division being applied to the a.c. of the redundant division, the vital bus's inverter could be lost and cause interactions with other systems that may be unacceptable. The d.c. system might also be compromised.

The electrical independence concern remains unresolved. Furthermore, additional questions have arisen. These matters will not permit staff approval at this time. Accordingly, our evaluation for the restart of ANO-1 is proceeding based on the upgraded maintenance, surveillance and pick up voltage settings on the existing design using only the UV trip coil.

Installation of the proposed modification has been initiated. Because safety concerns about the design remain unresolved, the licensee has agreed not to terminate the electrical connections to the proposed design, and also agreed to perform appropriate testing to assure that operability of the reactor protection system has not been compromised. These actions will be completed prior to any plant activities that depend upon the operation of the reactor trip breakers. The NRC will monitor these actions at the plant site.

We believe that the addition of the shunt trip, if designed and installed properly, can provide an increase in the reliability of the reactor trip breakers that is worthwhile and desirable. The licensee has invested a considerable effort into this modification. It should not be abandoned or unnecessarily postponed. We also believe that any change to the protection system should not be rushed, but rather be reviewed comprehensively and thoroughly at all licensee organizational levels before submittiong the design modification for NRC review.

VI. Human Factors Considerations

Because the proposed design modification will not be installed at this time, we have determined that it is not necessary to complete our review of the human factors considerations related to the modification.

VII. CONCLUSIONS

In consideration of the foregoing evaluation, we conclude that subject to the conditions noted herein, it is acceptable for the ANO-1 plant to return to criticality and power operation. Prior to any plant activities that depend upon proper operation of the reactor trip breakers to assure that the ability to shutdown is maintained, the licensee has agreed to complete the following:

1. All CRDTBs have been inspected and maintenance performed to remove the cause of the failure.

2. Verify the operability of each reactor trip breaker by 10-cycle testing.

3. Assure that the electrical connections for the proposed shunt trip coil modifications have not been made and related electrical wiring is secured.

4. Complete appropriate testing to assure the operability of the reactor protection system.

In addition, the licensee has agreed to provide upgraded maintenance procedures as noted under long term conditions in Section III.E herein.

Our conclusions are based upon several considerations which are: (a) the design configuration of devices to interrupt power to the control rods incorporates a considerable degree of both redundancy and diversity, (b) simultaneous failre of two power interrupting devices have never occurred at this plant, (c) the causes of the March 23, 1983 single breaker failure have been identified, and (d) corrective actions will have been completed to return all trip breakers to an operable status and to maintain that status.

DESCRIPTION OF REACTOR PROTECTION SYSTEM AND REACTOR TRIP BREAKERS

The reactor protection system (RPS) is designed by the Babcock and Wilcox Company to sense several plant variables and to actuate a trip of the reactor (emergency shutdown) in the event that any plant variable reaches an abnormal value (setpoint). The RPS consists of multiple instrument channels and logic units to cause the holding power to the control rods to be interrupted. When this power is interrupted, either by ac or dc circuit breakers or by solid-state silicon controlled rectifiers, the control rods fall into the reactor core and thereby terminate the nuclear reaction process.

The RPS is designed to comply with the NRC General Design Criteria (GDC) in Appendix A to 10 CFR 50. The most germane of these criteria to the reactor trip breaker issue is GDC-23 which requires that, for conditions such as loss of electric power, the RPS must fail to a safe state. Traditionally, this criterion has been applied as requiring the RPS design to be such that it intrinsically causes an automatic reactor trip upon loss of power to the RPS. Therefore, RPS designs include undervoltage (UV) trip mechanisms as part of the reactor trip breakers. The UV trip is energized during normal plant operation and will trip the breaker either when power is lost or when power to the UV trip is interrupted by automatic or manual protective signals.

In addition to the GDC's, NRC regulations (10 CFR 50.55a) require that the protection system meet the requirements of IEEE Standard 279 "Criteria for Protection Systems for Nuclear Power Generating Stations." This standard defines twenty-two criteria.

The present design of the RPS and the reactor trip actuation devices at ANO-1 is summarized below. The RPS detects nine different plant parameters, such as RCS pressure low. For each plant variable, four instrument channels are provided. When a measured variable reaches its predetermined setpoint, a trip signal is generated by that instrument channel and is sent to its corresponding reactor trip logic module. If any 2-out-of-4 instrument channels are tripped, the logic modules will generate trip signals and send them to the final actuating devices to effect an automatic reactor trip.

Equipment-wise, one of the instrument channels for each plant variable and a reactor trip logic module are combined to form what is called at ANO-1 a "Protection Channel." There are four such automatic protection channels. The output signal of each automatic protection channel is fed through a section of the manual reactor trip switch to one or more reactor trip breakers. Protection Channel "A" operates ac feed breaker "A"; Protection Channel "B" operates ac feed breaker "B". Protection Channel "C" operates both dc dual breakers "C", and the "main" SCR's. Protection Channel "D" operates both dc dual breakers "D", and the "secondary" SCR's.

The configuration of the trip breakers and other devices used at ANO-1 to interrupt power to the control rods is shown in Figure 1. This configuration is a (1-out-of-2) X 2 logical arrangement. The combination of the Protection Channels and the breaker/contactor configuration provides an overall logic of (1-out-of-2) X 2 for reactor trip.

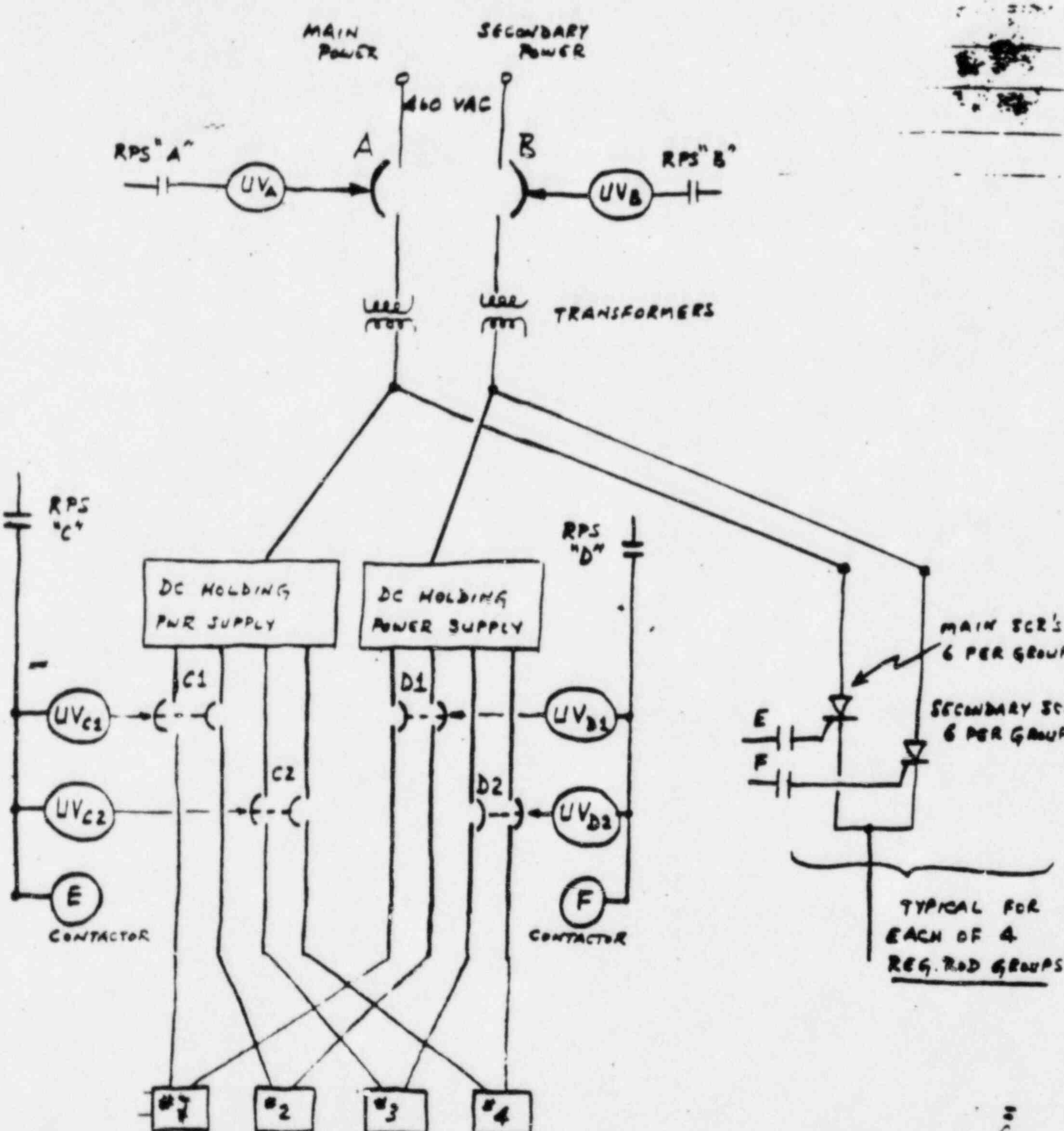
The motive power through an SCR is controlled by turning control power off or on at the gate of the device. When all 12 SCR's for a group are gated off, there is no power for the regulating rods in that group and they fall into the reactor core.

When a reactor trip occurs, three distinct power interruptions take place as shown in Figure 1. First, the two ac feed breakers (that provide power to all rods) are opened. Second, the dc breaker to each group of safety rods is tripped. Third, the contactors open which are indirectly in the gate circuits of the SCR's, causing the SCR's to stop conducting.

The design includes a feature to automatically trip the turbine when the reactor is tripped. This turbine trip signal is derived from a series-parallel combination of the reactor trip breaker position switches and the SCR contactor contacts. Since these are all "output signals", this automatic turbine trip circuit is highly dependent upon successful trip operation of the breakers and contactors. If all breakers should fail but the SCR contactors tripped successfully, the reactor would trip but the automatic turbine trip signal would not be generated.

The ac feed breakers are the 3-pole, stored-energy type equipped with instantaneous UV trip devices. The ac breakers are General Electric type AK-2A-25. There are four GE breakers used to interrupt the dc holding power to the rods. Each breaker is tripped by a UV trip device. Additionally, a shunt trip coil (STC) is installed in each breaker. The STC is operated by an overvoltage sensor to protect the equipment in the control rod drive system from potentially harmful overvoltage conditions, which is not considered to be a nuclear safety related function. Figure 2 is a schematic representation of the GE AK-2 breaker. It illustrates the three mechanisms provided to trip the breaker: the UV trip, the STC, and the manual mechanical trip. It is noted that all these trip mechanisms operate (rotate) the trip shaft, which in turn operates (with the two trip shaft bearings) the trip latch against the latch bearing. The trip latch bearing is a precision bearing provided with dust covers and is not a sealed bearing. All these bearings require periodic maintenance to prevent the torque required to trip the breaker from becoming excessive.

Figure 3 is a detail representation of the UV trip device. It shows various adjustments including the spring tension used to set the device pickup voltage. This figure also shows the trip shaft bearings and the precision latch bearing.



SAFETY ROD GROUPS

(ONE "C" BREAKER AND ONE "D" BREAKER MUST OPEN TO TRIP EACH ROD GROUP)

G.T. Baird
3/30/83

FIGURE 1

GE AK-2 TYPE

Reactor Trip Breaker

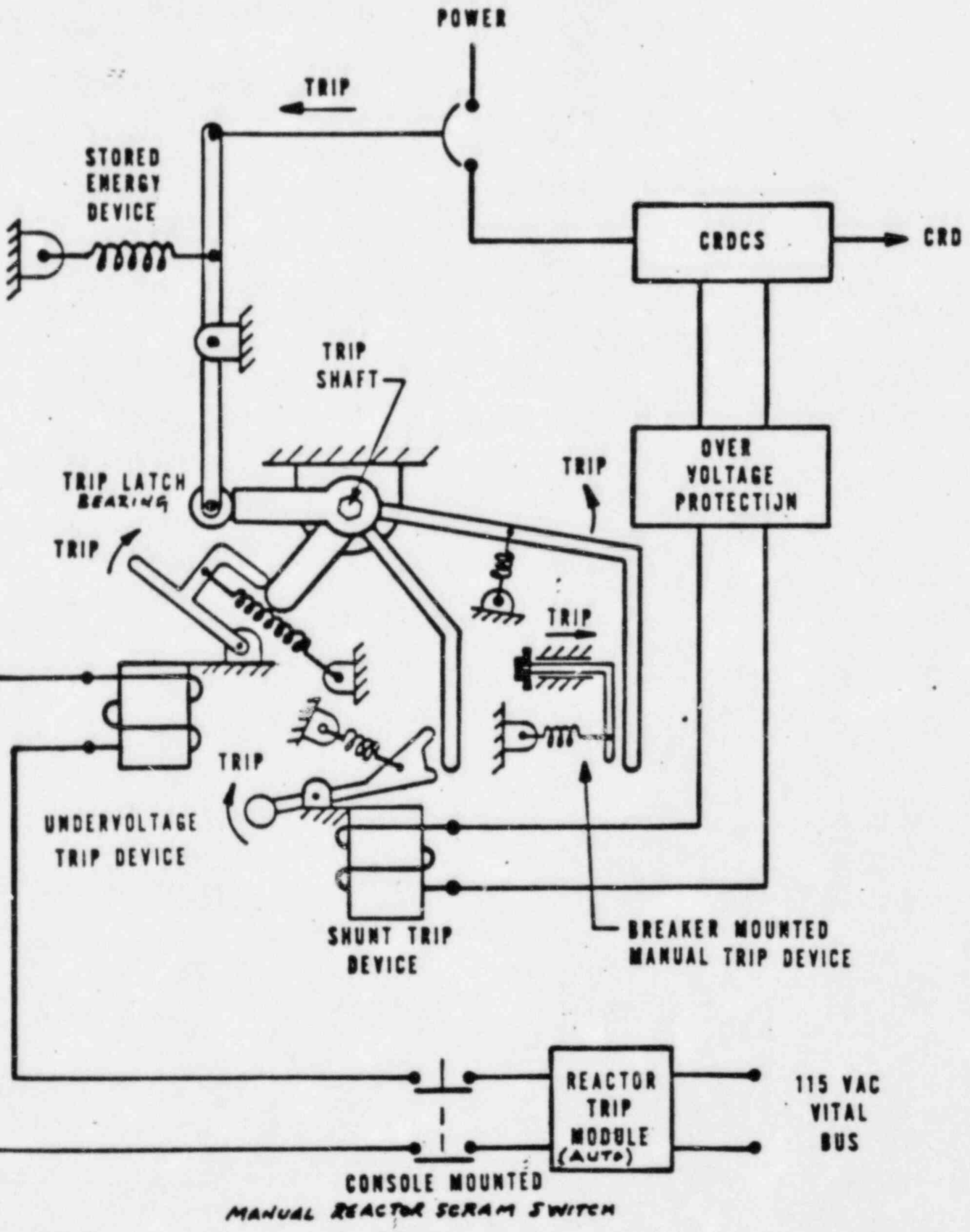


FIGURE 2

GE AK-2 UV TRIP DEVICE

(ENERGIZED)

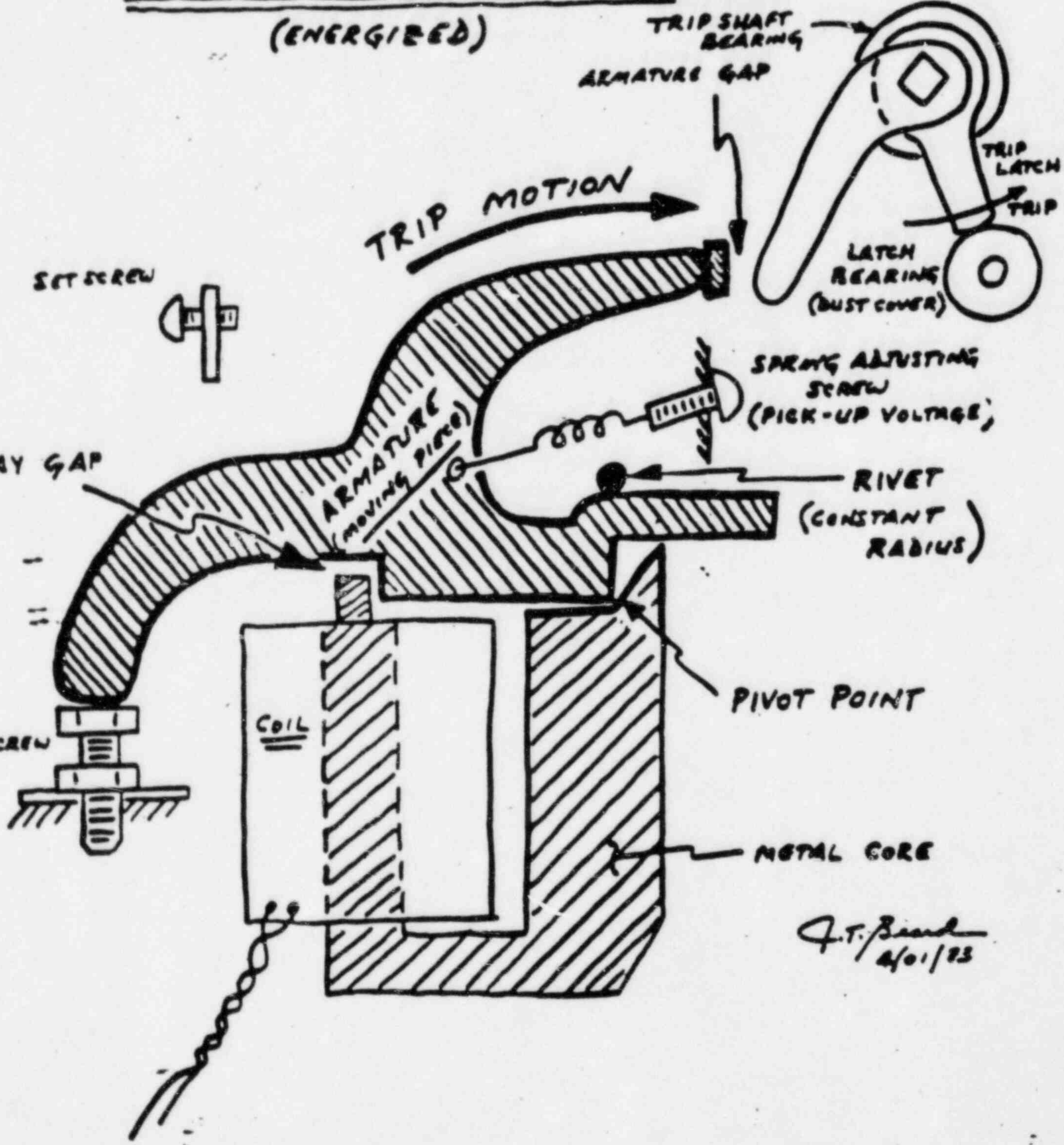


FIGURE 3

Attachment 2

PREVIOUS TRIP BREAKERS FAILURES

Prior to March 23, 1983, here had been a total of 8 reactor trip failures at this plant. The plant went into commerical power operation nine years ago, in April 1974. About five years later in the later part of 1978 and early 1979, the plant experienced a series of 4 breaker failures. All these failures involved the same "A" a.c. main feed breaker repeatedly, and in each case the undervoltage trip device was unable to trip the breaker when voltage to the device was interrupted. In early 1979, this breaker was replaced with a new breaker. About 4 years later in the later part of 1982, the plant experienced a second series of breaker failures. Again, the UV device was not able to trip the device. During this series, special surveillance of the breakers was progressively increased and finally was being conducted on a daily basis. In November 1982, a new replacement breaker was installed for the "B" a.c. main feed breaker. The March 23, 1983 failure is the first breaker failure to occur since the two series of failures. All the failures at this plant have been single breaker failures; there has never arisen a case of two breakers failing simultaneously or concurrently.