THE BABCOCK & WILCOX COMPANY
POWER GENERATION GROUP

JAN 15 1980

336-034

ACTION

BDS 963-3

To: J. H. Taylor, Manager, Licensing
E. A. Womack, Manager, Plant Design

W. F. JONES

From: G. E. Rambo, PS&C

CONFIDENTIAL

Cust.: 177 FA and Backlog 205 FA

File No. or Ref.:

Subj.: Proposed B&W Positions Regarding High Point Vents, Water Level Measurements, and Void Fraction Monitoring

Date: December 20, 1979

This letter to cover one customer and one subject only.

GPU
Doft Exh. For ID 33
PW Exh. in Ev
Charles Shapiro CSR
Doyle Reporting Inc. 1/27/81

Attachments: (1) Proposed B&W Positions Regarding High Point Vents

(2) Proposed B&W Positions Regarding Primary Systems Water Level Measurements

(3) Proposed B&W Position Regarding Void Fraction Monitoring

In order to properly respond to NRC Lessons Learned requirements for high point vents and primary system water level measurements, I believe that B&W needs to take a strong position supporting those changes we feel are advantageous and justified by good engineering practice and just as strongly rejecting those suggested changes which are not advantageous and justified by good engineering practice on the B&W plants.

The attached positions were developed from input and comments from the following individuals: E. R. Kane, B. A. Karrasch, E. W. Swanson, J. A. Weimer, G. J. Brazill, H. A. Baker, D. J. Firth and D. B. Fairbrother.

Several of these positions are at variance with recent NRC positions and specific customer, i.e., TVA requests. However, we feel that the B&W plants are unique in both the hot leg "candy cane" design and in the on-going Abnormal Transients Operating Guidelines (ATOG) program. For example, hot leg "candy cane" design provides a means of venting the primary system and monitoring primary system inventory not available on other PWR's. The Inadequate Core Cooling and ATOG programs have been on-going long enough now to provide a good handle on what should be the B&W requirements for primary system venting and RCS inventory monitoring. Thus, some requirements which are generally applicable to other PWR plants may not be specifically necessary or desirable on B&W plants.

Your review and comment would be most appreciated to assist in meeting a mid-January commitment to prepare System Design Criteria for additional instruments.

GER/rw
Attachment

A. E. Rambo /rw

cc: G. J. Brazill, E. W. Swanson, H. A. Baker, D. J. Firth, D. B. Fairbrother, J. A. Weimer, J. D. Carlton, B. A. Karrasch, D. W. LaBelle, S. H. Dunn, E. R. Kane, R. J. Finnin, G. D. Quale, K. E. Suhrke, J. A. Castanes, C. W. Connell, T. G. Wolcott, T. A. Brandsberg, F. J. Levandoski, R. D. Davis

PROPOSED B&W POSITIONS REGARDING HIGH POINT VENTS

CONFIDENTIAL

D3E7 9.5

Purpose of the Vents

The purpose of high point vents is to provide a means for removing non-condensible gases which might otherwise impede natural circulation flow or prevent regaining RCS pressure control in a post-accident condition. According to the NRC the two important safety functions enhanced by this venting capability are core cooling and containment integrity.

NRC Requirements for Reactor Coolant System Venting

Each PWR licensee should provide the capability to vent the reactor vessel head. The reactor vessel head vent should be capable of venting non-condensible gas from the reactor vessel hot legs (to the elevation of the top of the outlet nozzle) and cold legs (through head jets and other leakage paths.) Additional venting capability is required for those portions of each hot leg which can not be vented through the reactor vessel head vent. Venting of the pressurizer is required to assure its availability for system pressure and volume control. These are important considerations especially during natural circulation.

Proposed B&W Vent Position(1)

Single safety grade high point vents should be installed at the top of each hot leg "candy cane". The vent size should be small enough that a stuck open vent valve is covered by the instrument line break analysis, i.e. make-up flow can keep up with the stuck open vent valve. During an emergency the gases should be vented directly to the containment through double valves as shown schematically below. Separate vital busses should power the valves on the two hot legs but all valves on a single hot leg should be powered from the same vital buss.

PROPOSED B&W POSITIONS REGARDING HIGH POINT VENTS

CONFIDENTIAL

D3E 9 6

Purpose of the Vents

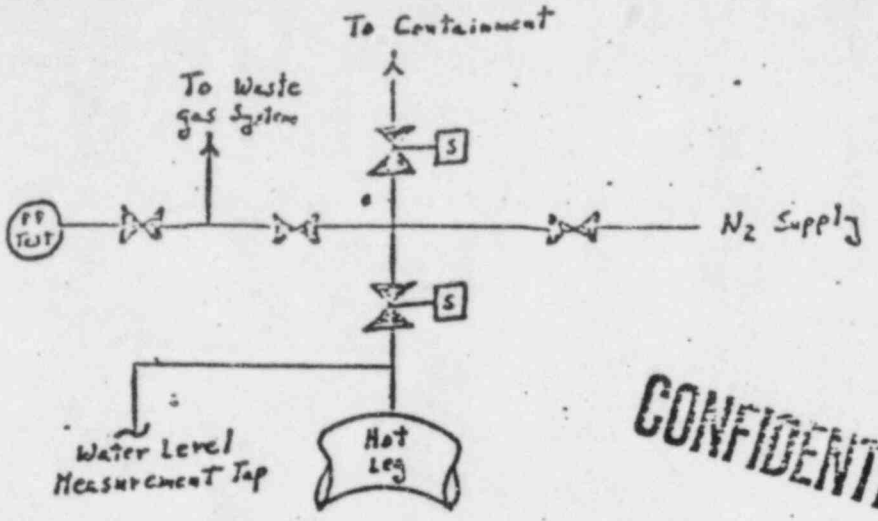
The purpose of high point vents is to provide a means for removing non-condensible gases which might otherwise impede natural circulation flow or prevent regaining RCS pressure control in a post-accident condition. According to the NRC the two important safety functions enhanced by this venting capability are core cooling and containment integrity.

NRC Requirements for Reactor Coolant System Venting

Each PWR licensee should provide the capability to vent the reactor vessel head. The reactor vessel head vent should be capable of venting non-condensible gas from the reactor vessel hot legs (to the elevation of the top of the outlet nozzle) and cold legs (through head jets and other leakage paths.) Additional venting capability is required for those portions of each hot leg which can not be vented through the reactor vessel head vent. Venting of the pressurizer is required to assure its availability for system pressure and volume control. These are important considerations especially during natural circulation.

Proposed B&W Vent Position(1)

Single safety grade high point vents should be installed at the top of each hot leg "candy cane". The vent size should be small enough that a stuck open vent valve is covered by the instrument line break analysis, i.e. make-up flow can keep up with the stuck open vent valve. During an emergency the gases should be vented directly to the containment through double valves as shown schematically below. Separate vital busses should power the valves on the two hot legs but all valves on a single hot leg should be powered from the same vital buss.



CONFIDENTIAL

Justification

Non-condensible gases can accumulate in the hot legs and block natural circulation flow even when the system is sufficiently repressurized to collapse steam bubbles which might have also formed in the top of the hot legs. Thus a means should be provided to vent non-condensible gases which could accumulate in the hot legs. The vents should be double valved and safety grade since they form a primary system boundary.

Proposed B&W Vent Position (2)

The existing pressurizer vent valve should be motorized and made safety grade with provisions for venting directly to the containment under emergency conditions. The vent size should be limited by the instrument line break analysis. The pressurizer vent valve will provide redundant venting capability in conjunction with the PORV on the pressurizer. The PORV and vent valves should be powered from separate vital busses with all valves on the vent line powered from the same busses.

Justification

If the pressurizer were to empty and become refilled with non-condensible gases,

or possibly superheated steam, venting the pressurizer might be necessary in order to obtain a water level above the pressurizer heaters - a necessary step to re-establishing pressurizer control of the RCS. Use of the pressurizer spray in conjunction with the pressurizer heaters is one way to degas the reactor coolant; and venting of the pressurizer is necessary during this process.

CONFIDENTIAL

Proposed B&W Vent Position (3)

At this time B&W does not recommend installation of high point vents on the reactor vessel.

Justification

We recognize that this position is at variance with the NRC requirement. However, we also recognize that the B&W NSS design with its "candy cane" hot legs is different from the other PWR designs. We can find no compelling reason to quickly vent non-condensible gases which could accumulate in the reactor vessel head since there is no danger of achieving a potentially explosive mixture of gases in the RCS and gases trapped in the reactor vessel head will not impede either forced or natural circulation flow. Bubbles which expand out of the top of the reactor vessel will burp into the hot legs and/or pressurizer where they can be vented and will not endanger the core with potential uncovering. If the RCS could be rapidly depressurized, it might be desirable to be able to first vent the RV head but there presently exists no means for rapidly depressurizing the RCS. There are a number of technical reasons including their small size and the increased potential of an ejected rod accident which make utilizing the existing CRDM vent valves for emergency venting at pressure highly undesirable. In any case, the seal gaskets on the control rod drive mechanisms, in all likelihood, will leak any trapped gases to the containment eventually.

PROPOSED B&W POSITIONS REGARDING PRIMARY SYSTEM WATER LEVEL MEASUREMENTS

CONFIDENTIAL

Purpose of Primary System Water Level Measurements

The purpose of RCS water level measurements is to provide:

1. The reactor operator information to follow the course of an accident, so that he will know whether he is losing primary system inventory
2. An indication to the operators on when to operate and secure the primary system vents, and
3. An indication to the reactor operators of RCS inventory during refueling operations to prevent an undetected leak from draining the water level below the suction of the decay heat pumps.

NRC Requirements for Detection of Inadequate Core Cooling

The NRC requires an unambiguous indication of inadequate core cooling which must cover the full range from normal operation to complete core uncovering. The NRC does not specifically require a water level indication, although they do say it should be evaluated.

Proposed B&W Level Measurement Postion (1)

Safety grade water level indication on each of the hot legs with control room read out is necessary to satisfy the purposes stated above. At this time the preferred method is a single channel per hot leg, safety grade, temperature compensated water level measurements utilizing one or more differential pressure sensors. The following goals appear desirable: The range should cover the full range from solid water conditions with the hot leg full to the hot leg completely empty. The instrumentation should give an on-scale reading with four reactor coolant pump forced single phase flow. The indication should be accurate within $\pm$ 6 inches during normal filling and draining and accurate to $\pm$ 18 inches during accident conditions. The level measurements on each hot

leg should be powered from the same vital buss as the vents on that hot leg. A separate manually isolatable, uncompensated dP measurement covering a narrow range near the bottom of one hot leg may be desirable for use during refueling operations to provide control room indication that the water level in the vessel is remaining above the decay heat drop line suction.

Justification

Hot leg water level measurements in conjunction with proper operator instructions satisfy the purposes stated above. Differential pressure sensors appear to be the only commercially available method of water level measurement which can satisfy the need for a reliable, proven, safety grade method with a long life expectancy. Temperature compensation is necessary because of the very wide temperature range over which these measurements need to be fairly accurate.

CONFIDENTIAL

Proposed B&W Level Measurement (2)

B&W does not recommend installation of a water level measurement between the bottom of the hot leg and top of the reactor vessel head.

Justification

Such a measurement would allow monitoring gas or void accumulation in the top of the reactor vessel head and provide an indication as to when to vent the reactor vessel head. However, since bubble formation in the top of the reactor vessel head per se does not endanger adequate core cooling or natural circulation, high point vents on the reactor vessel head are not recommended and water level measurement in the RV head is not necessary. Such instrumentation, if it were installed, increases the potential for small break LOCA's. The small break LOCA potential is amplified by the fact that the RV head is a highly congested area and the pressure sensing line from the RV head would have to be disconnected and later reconnected and vented at each refueling.

Proposed B&W Level Measurement Position (3)

A water level measurement should not be installed across the core region of the reactor between the bottom of the reactor vessel and either the bottom of the hot leg or the top of the RV head.

CONFIDENTIAL

Justification

The hot leg level measurement provides the reactor operator the means to follow loss of inventory down to approximately 18 inches above the core. Once the water level drops to the core region, the incore thermocouples provide a more reliable and accurate measurement of inadequate core cooling and core uncovery than a water level measurement can. A water level measurement cannot be made an accurate and unambiguous indication of core cooling because if the the water level were to fall to the core region, frothing will provide heat transfer over a region not accurately defined by the collapsed water level measured. Also, since the core is a nonuniform heat source, proper temperature compensation of the indicated water level is impossible. This problem appears to negate any value of this measurement as a trending monitor for the reactor operator during an accident. The Inadequate Core Cooling Guidelines specify additional action based upon incore thermocouple readings and we do not anticipate that these criteria would change even if a water level measurement were available across the reactor core. Thus, B&W feels strongly that a water level measurement across the core should not be installed because not only will it not provide interpretable and unambiguous information to the reactor operator during the course of an accident, but it may increase the potential for a small break LOCA, and a small break at the bottom of the reactor vessel is very undesirable.

PROPOSED B&W POSITION REGARDING VOID FRACTION MONITORING

Purpose of Monitoring Void Fraction

Monitoring void fraction during forced flow conditions would provide an indication to the reactor operator or input to an automatic system of changes in reactor coolant inventory in the loops and a basis for tripping reactor coolant pumps before voiding becomes so significant as to inhibit establishment of natural circulation flow.

CONFIDENTIAL

NRC Requirement for Void Fraction Monitoring

There is no explicit NRC requirement for monitoring void fraction except as it impacts the indication of inadequate core cooling which must be unambiguous for all conditions including high void fraction pumped flow.

Proposed B&W Position

One or more methods for determining if a large void fraction exists during forced flow conditions should be developed and implemented. The methods under consideration are:

1. correlation of reactor coolant pump current to void fraction, and
2. correlation of hot leg differential pressure measurement to void fraction.

Justification

Voiding in the primary coolant loops is an indication of a LOCA and measurement of void fraction can help the reactor operator distinguish between an overcooling transient and a small break LOCA. Low RCS pressure concurrent with significant voiding as detemined by reactor coolant pump current measurement is the present criteria for tripping the reactor coolant pumps in an accident situation. While the best method of monitoring void fraction has not yet been determined, this should not delay the plans for implementing a hot leg water level indication.

THE BABCOCK & WILCOX COMPANY
POWER GENERATION GROUP

To: E. J. Bateman - R&D Manager, NSS Systems & Components
J. R. Hamilton - R&D Manager, Advanced NSS Systems
E. E. Dowling - Manager, Plant Protection Equipment

From: R. E. Braumiller - New Idea Coordinator, NPGD (2337)

Cust.

BOS 663.5

File No. or Ref. RBI-13017

Subj. New Idea - Subcooling Margin Indicator; R. M. Ball and E. A. Womack

Date: October 11, 1979

This letter to cover one customer and one subject only.

Attached is a copy of the Invention Disclosure Record which was prepared by the inventors for our Patent Department. This information is forwarded for your use in your R&D Program/NSS design activities.

This new idea is being processed for possible U.S. patent filing. Therefore, please do not disclose this information to the public domain prior to the date on which we intend to file, i.e., estimated at 6 - 12 months from this date.

CONFIDENTIAL

R. E. Braumiller

REB:efc

Attachment

cc: w/o attachment
R. M. Ball
E. A. Womack

GPU

~~Deft.~~ Exh. For ID 34
~~Pll. Exh. in Ev~~
Charles Shapiro CSR 1/27/81
Doyle Reporting Inc.

TD 3560-2

THE BABCOCK & WILCOX COMPANY

(1)

INVENTION DISCLOSURE RECORD

DATE 10/4/79 *

B&W NI - 13017 *

DIVISION FILE NO. 79-5-4 *

This record is an important legal document. Promptness and care in its complete preparation may save you time and inconvenience later. Instructions on back of this sheet should be read carefully before filling in data.

(A) INVENTOR: FULL NAME (S)	(2) YOUR TITLE OR POSITION	(3) COMPANY DIVISION AND LOCATION
Edgar Allen Womack, Jr.	Manager, Plant Design	Nuclear Power Generation
Russell Martin Ball	Manager, Product Development	Babcock & Wilcox Company
		Lynchburg, Virginia

(B) DESCRIPTIVE TITLE OF INVENTION

Subcooling Margin Indicator - A device to detect the loss of subcooling in a hydraulic loop

(C) DESCRIPTION OF INVENTION - Note carefully material suggested for inclusion in this description as set forth in section (C) items (a) through (e) on back of this sheet. See attached sheets 2-5

(D) DATE AND PLACE OF INVENTION:

(1) CONCEPTION BY INVENTOR April 14 1979 AT Lynchburg, Virginia

(2) FIRST SKETCH OR DRAWING April 14 1979 AT Lynchburg, Virginia

FIRST WRITTEN DESCRIPTION May 15 1979 AT Lynchburg, Virginia

(3) DISCLOSED TO (A) NAME Nelson S. Embrey April 23 1979 AT Lynchburg, Virginia

(B) NAME Richard E. Braumiller May 31 1979 AT Lynchburg, Virginia

(4) MODEL OR FULL SIZE DEVICE COMPLETED May 25 1979 AT Lynchburg, Virginia

(5) FIRST TEST OR OPERATION OF INVENTION May 25 1979 AT Lynchburg, Virginia

(E) RESULTS OF TESTS AND EXTENT OF USE OF INVENTION

Invention has been reduced to practice and performed indicated function; demonstrated by Babcock & Wilcox May 31, 1979.

(F) NAMES OF THE OTHER PERSONS HAVING KNOWLEDGE OF FACTS STATED UNDER SECTIONS (D) AND (E)

Paul E. Perrone, James P. Jones, Nelson E. Embrey, Richard E. Braumiller

(G) PERTINENT REPORTS, PATENTS AND COMPANY PATENT APPLICATIONS

Parallel Hybrid Safety System Patent Application by R. Ball and R. Roberts (Case 4281) *

PROJECT OR PROPOSAL DESIGNATION

(H) OTHER CLOSELY RELATED PUBLICATIONS

None

(*) Added by R. E. Braumiller, 10/10/79

INSTRUCTIONS FOR COMPLETING S&W INVENTION DISCLOSURE RECORD

SECTION (A) "INVENTOR(S)"

Give full name, [illegible] title, [illegible] division and location of inventor or inventors.

SECTION (B) "TITLE OF INVENTION"

This should be a description [illegible] as possible the main characteristics of the invention.

SECTION (C) "DESCRIPTION OF INVENTION"

This should state the [illegible] be a sufficiently complete description [illegible] The description [illegible] identified by date and signed and dated by the inventor and [illegible] understands the invention [illegible] Similarly, the inventor and witnesses are to sign and date [illegible] in the same manner they used in signing the disclosure form.

The suggested [illegible]

a. [illegible] the solution of some particular problem [illegible] of the original structure or process [illegible] structure or process, the inventor [illegible]

b. [illegible] A statement [illegible] the purpose and object of the invention, together with [illegible] drawings, when necessary, constituted [illegible] the configuration and relationship of the [illegible] correspondingly designated in the drawings. The [illegible] in which it would be used. When possible, [illegible] to the disadvantages of the [illegible]

c. *New Structure or Arrangement Features* — [illegible] in paragraph (b), particular emphasis [illegible] arrangement features of the invention. For instance, [illegible] elements which make up the total apparatus [illegible] changes. Alternatively, several [illegible] improved result. This aspect should be [illegible]

d. *Advantages* [illegible] improved result, this should be described and [illegible] discussed in terms of the [illegible] structure is an improvement over [illegible] of the description [illegible]

e. *Alternatives* — [illegible] alternative methods, materials or constructions [illegible] should be described.

SECTION (D) "DATE AND PLACE OF INVENTION"

[illegible]

1. Give the earliest [illegible] conceived, even though [illegible]
2. A signed, dated copy of [illegible] should be attached to the disclosure form, and the date and [illegible] on the form.
3. Disclosure, other than to [illegible] names, date and place of disclosure in the appropriate [illegible] provided.
4. If prototype model [illegible] the date and place of completion should be listed. [illegible] "Work in Process," and the place where such work is being done.
5. If test or use [illegible] of invention has been [illegible] give date and place. If no test known, list "None" on the form.

SECTION (E) "RESULTS OF TESTS AND EXTENT OF USE OF INVENTION"

Whenever tests have been made, they should be characterized as either "experimental" or "commercial." The term "experimental" means that the invention was considered to require a test for proof of adequacy before offered for public use. This proof testing may be done by laboratory setup or in an actual field operating setup. The term "commercial" means that the invention has been put to use without any testing or special provisions to observe its performance.

SECTION (F) "NAMES OF ALL OTHER PERSONS HAVING KNOWLEDGE OF FACTS UNDER (D) & (E)"

In this space list the names of any person or persons other than those appearing in Section (D) (3) who have knowledge of the facts stated in Sections (D) and (E).

SECTION (G) "PERTINENT COMPANY PATENT APPLICATIONS AND REPORTS"

List and identify pertinent pending patent applications, Company reports, such as, Research reports, Service reports, etc., which contain information bearing on the problem to be solved by the invention or on the invention itself.

SECTION (H) "OTHER CLOSELY RELATED PUBLICATIONS"

There should be listed, if known, any publications, such as magazine articles, technical bulletins, Engineering Society literature, etc., bearing on the invention.

[illegible] AND METHOD OF RELEASE

This form and all attachments [illegible] the inventor's supervisor [illegible] Department.

PDS-21049-4 (1-79)

Exhibit A

NI-13 017 (2)

79-5-4

MAY 1 1979

NPGD NEW IDEA AND SUGGESTION FORM

DATE MAY 15, 1979

TO: NPGD NEW IDEA COORDINATOR, DEVELOPMENT ENGINEERING

THE FOLLOWING NEW IDEA OR SUGGESTION IS SUBMITTED FOR CONSIDERATION

DESCRIPTIVE TITLE OF NEW IDEA OR SUGGESTION:

Device to detect and measure the loss of subcooling in a hydraulic loop.

BRIEF DESCRIPTION:

A device, as described in the attached sketch to compare measured hydraulic loop temperature and pressure to stored values for saturated conditions of steam and water, and to provide the device user with pressure margin to saturation, temperature margin to saturation, and with an alarm indicating that a preset margin to saturation has been exceeded.

ADVANTAGES OF NEW IDEA OR SUGGESTION:

The device, as sketched, utilizes the parallel hybrid concept of implementation and can, therefore, precisely contain the steam saturation correlation between pressure and temperature as well as any other corrections (including nonlinear behavior) which may be needed for accuracy in the particular system in which it is used. It is rapid in response and will provide the user with direct indication of margins to saturation on a continuous reading basis.

☒ DETAILED INFORMATION AND/OR DRAWINGS ATTACHED

SUBMITTED BY Russell M. Ball
Edward Marchese Jr.

THIS IDEA WAS CONCEIVED AS PART OF:

☐ B&W CONTRACT, R&D, OR PROPOSAL NO. _____

☐ GOVERNMENT OR OTHER CONTRACT NO. _____

☒ OTHER _____

DISCLOSED TO AND UNDERSTOOD BY ME THIS DATE, May 30, 1979

Gabor A. Ember
Signature

DISCLOSED TO AND UNDERSTOOD BY ME THIS DATE, May 31, 1979

Richard P. Braemiller
Signature

THE BABCOCK & WILCOX COMPANY
POWER GENERATION GROUP

INFORMATION

(3)

To: ~~E. A. Womack, Manager, Plant Design~~ R E Braumiller

E A WOMACK 415 OCT 08 1979

From: R. M. Ball, Manager, Product Development (2810)

805 663.5

Cust.

File No. or Ref. NI-13017

Subj. Patent Disclosure

Date October 5, 1979

This letter to cover one customer and one subject only.

I am forwarding this through you to Braumiller. I have not sent anything directly to the New Orleans Patent group.

Under C.a. The only prior art which would apply to this system that I know of would be the use of a book of tables (Keenan and Keyes) or the use of a computer which has a look up table or computes the right answer with some special algorithm.

Under C.c. The distinctive aspect of our invention is the use of a memory with pre-determined or pre-calculated outputs for each state of the input. These inputs are determined and are directly addressed by the analogue-to-digital converter.

R. M. Ball

RMB/ow
Attachment

Disclosed to and understood by
me this OCTOBER 10, 1979
/s/ Richard E. Braumiller

Disclosed to and understood by
me this _____, 19___
/s/ _____

(4)

THE BABCOCK & WILCOX COMPANY
POWER GENERATION GROUP

ACTION

BDS 663-5

To
R.E. BRAUMILLER - R&D

From
E.A. WOMACK - MANAGER, PLANT DESIGN (EXT. 2315)

Cust.

File No. or Ref. NI-13017

Subj.
PATENT DISCLOSURE

Date
OCTOBER 9, 1979

This letter to cover one customer and one subject only.

In response to your note to Russ Ball and myself, dated October 4, 1979, I am responding herewith and returning the package of material related to our invention disclosure record. The material attached to this memorandum is the original. I have not sent anything directly to the New Orleans patent group, except to respond to a specific list of questions related to this item received about three weeks ago.

Under Item C.a., I would agree with Russ Ball's thoughts with the addition of the possible alternate use of an analog device which attempts to simulate the saturation curve in a piece rise manner using one of the function generation formats which can be had with analog equipment.

Under Item C.c., I concur with the informa ion provided in Russ's memo of October 5.

Please let me know if you need additional information.

Thanks.

E. A. Womack/dmb

EAW/dmb

cc: R.M. Ball

Disclosed to and understood by
me this OCTOBER 10, 1979
/s/ Richard E. Braumiller

Disclosed to and understood by
me this _____ 19___
/s/ _____

Babcock & Wilcox

Exhibit A (Cont'd)

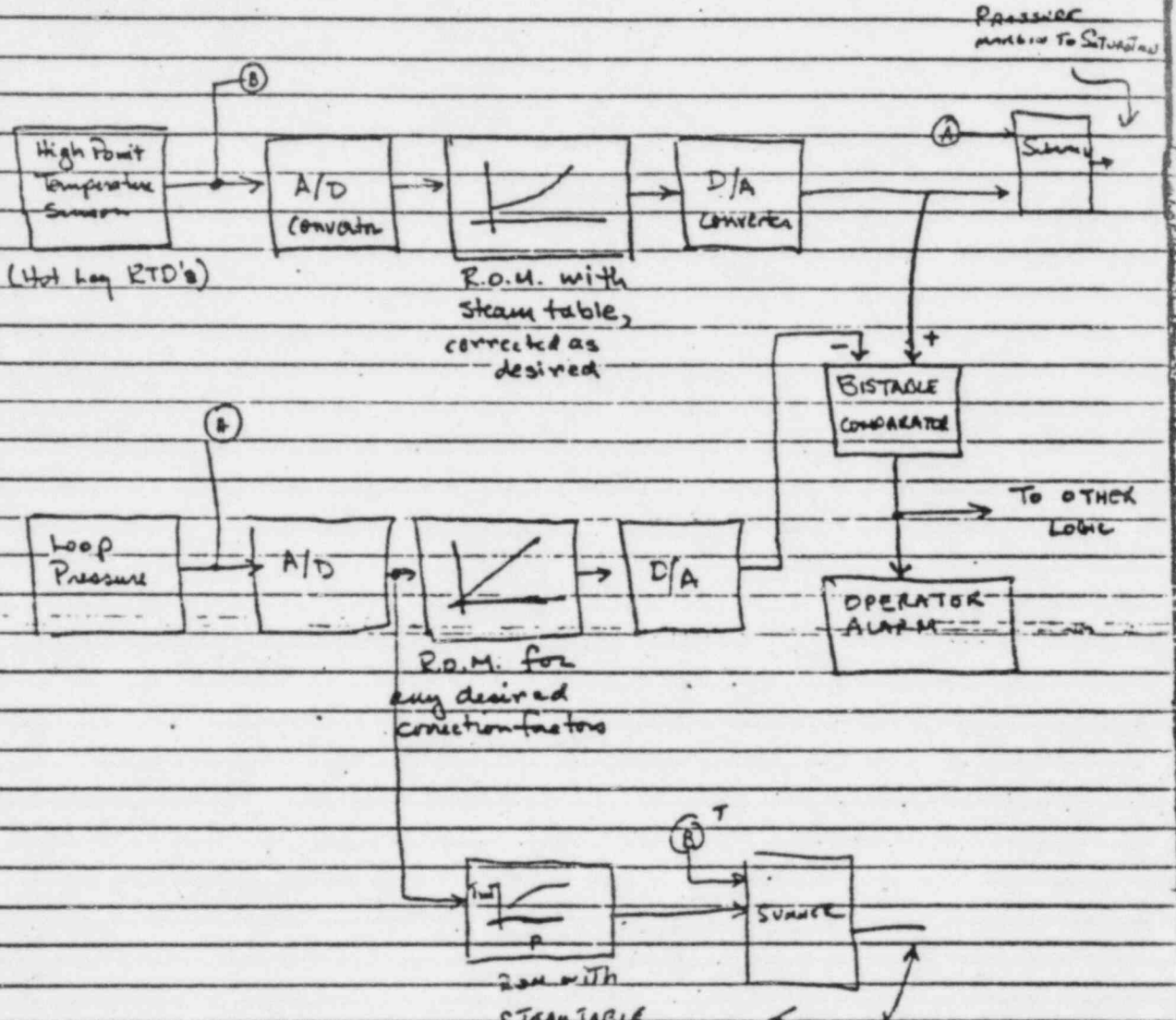
79-5-4

NI-13017

EAW (5)

4/14/79

Device to Detect the Loss of Subcooling in a Hydraulic Loop



Inventors:

Date: April 16 1979

Date: April 17, 1979

Disclosed and understood by me this 23rd day of April, 1979.

Signed:

Disclosed to and understood by me this MAY 31 1979

/s/ Richard E Brumiller

However, the range of the hot leg level indication should be chosen so that forced flow both with and without voiding will give an on-scale indication. This will allow the measurement to be available should efforts to correlate hot leg differential pressure with void fraction be successful.