MASTER

LOFT TECHNICAL REPORT LTR 1310-26

JULY 24, 1978

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PSMG SETS A AND B PROTECTIVE RELAYING

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DEPARTMENT OF ENERGY

IDAHO OPERATIONS OFFICE UNDER CONTRACT EY-76-C-07-1570

DISCLAIMER

LOFT TECHNICAL REPORT

EG&G Idaho, Inc.

TITLE PSMG SETS A AND B PROTECTIVE RELAYING	REPORT NO. 1310-26
AUTHOR J. E. Burnett	GWA NO. / ACCOUNT NO.
SECTION INSTRUMENT AND ELECTRICAL DESIGN	
BRANCH	DATE July 24, 1978

CPS Suprv. LI&ED Suprv. P&CSB Mgr. C&BSS Suprv.

RSB Mgr.

ABSTRACT

The "TAN/LOFT 13.8 KV, 2.4 KV and 480V Relay and Circuit Breaker Coordination Study" presented an analysis to determine overcurrent settings for the LOFT Power System protective relays including those for the drive motors of the PSMG sets. This LTR is written to form the basis of the relay settings entered in Specification ES-60238 Rev. B, for protection of the PSMG generator, primary coolant pump motor and interconnecting power cable.

A momentary commercial power voltage dip occurred on January 10, 1978 which caused a trip of the PSMG field breakers. A corrective design to prevent reoccurrence is discussed and recommendations are presented below.

RECOMMENDATIONS

1. (Temporary Correction) Lower the dropout of the underspeed protection (Acromag, devices no. 14-1 and 14-2) power supply voltage relays (G.E. 12NGV13A11A, devices 27-1/14-1 and 27-2/14-2) from 100 volts to 70 volts.

2. (Final Correction) Remove the undervoltage relay monitoring the vital AC voltage powering the PSMG underspeed relaying. Remove the existing vital AC powering the underspeed relay. Place a DC to AC inverter across the 250 VDC Vital battery and place the 115 VAC output across the underspeed relay and the auxiliary relay.

   Change the underspeed relay contacts from normally closed to normally open, and change the auxiliary relay contacts from normally open to normally closed.

3. Reliability of the PSMG generator field would be further increased by removing the disabled field undervoltage relays (devices number 40 and 40X).

   Responsibility for implementing the recommended changes is placed with the LOFT Instrument and Electrical Design Section, to be accomplished prior to Nuclear Power Range Testing.

PSMG SETS A AND B PROTECTIVE RELAYING

I. INTRODUCTION

Momentary commercial power voltage dips which occurred on January 10, 1978 and March 12, 1978, resulted in trips of the LOFT PSMG field breakers. The consequence of these trips is that the primary coolant pump stops almost immediately with no "spindown" (ordinarily provided by the M-G set flywheel). The seriousness of the consequence (identified in FSAR 15.2.6.1 as most severe credible loss of flow incident), led the LOFT Instrument and Electrical Design Section to examine the probable cause and recommend a solution. In the course of the examination, it became apparent that documentation and control of relay settings was lacking. This LTR is written in response to those needs.

II. DESCRIPTION OF UNDERSPEED PROTECTION SYSTEM

A schematic diagram of the system is shown on drawings 650-E-900 sheets 1 and 2 and G.E. 0105C4139 sheet #3.

Underspeed protection is provided by DC undervoltage relays (Acromag, devices No. 14-1 and 14-2) monitoring the output of the DC tachometer generators. When the output of the tachs falls below a certain threshold (corresponding to low speed), the undervoltage relay trips a lockout which trips the field breaker(s).

The Vital AV Power supplied to the Acromag is monitored by an AC undervoltage relay (G.E. 12NGV13A11A, devices No. 27-1/14-1 and 27-2/14-2).

If the vital AC voltage falls below the dropout setting of the NGV, a lockout is tripped which trips the field breaker. Such an event occurred on January 10, 1978 and March 12, 1978 when a commercial power momentary voltage dip caused the vital AC voltage to fall below 100 volts The NGV tripped the field breakers, even though 120 vac remained available at the vital buses after the transient period. The incident highlighted the vulnerability of the PSMG sets to momentary transients on the commercial power system.

The vital batteries are not susceptible to such transients. Consequently the use of the Vital batteries to power the underspeed relays through a DC to AC inverter, is a more reliable alternative. Using an auxiliary relay (device 14-1) which would also monitor the inverted power to the underspeed relay would further increase reliability (See the reliability analysis in Appendix A, and figures 1 and 2).

III. PSMG PROTECTIVE RELAYING

Protective relaying is furnished for the synchronous generator. In order to provide maximum opportunity to utilize the flywheel stored energy for powering the coolant pump motor, the generator protective relaying (differential current, generator ground fault), is set up to either trip the prime mover breaker or to activate the annunciator. Should the prime mover be tripped, the flywheel generator will coast down, supplying stored energy to the coolant pump.

The primary coolant pump motor protective relaying (underspeed, generator overcurrent and phase unbalance), opens the PSMG field breakers causing the PCP motor to stop almost immediately. This is done to protect the PCP motor from possible further damage (see figure 3).

Manufacturer's recommended relay settings based upon the following Primary Coolant Pump Motor data:

	PSMG		CURRENT (Amps)					
Motor	Field Current	Inrush (35HZ)	15HZ	25HZ	35HZ	45HZ	55HZ	62HZ
PCP-1	30A	1480	200	235	300	400	550	680
PCP-2	28A	1500	190	220	290	385	435	475

Relay 12IJC51B7A-T (Devices No. 46-1 and 46-2)

Application - Phase Unbalance

Factory Settings:

Relay rating, 5 amps
Pickup setting, 1 amp
Corresponds to 200 amps primary, CT ratio 1000:5
Time Dial Set at 10
For a plot of pickup versus frequency, refer to the calibration curve, Figure 4.
Slope -125% (25% phase unbalance)

NOTE: Relays are not recommended with less slope because of interraction.

Relay 12PJC11AV3A - C20 (Device No. 87G)

Application - Generator Differential
Relay Setting:
Adjustment range 2-8 amps
Set pickup at 4 amps, corresponding to 80 amps differential with a CT ratio of 100:5.

Relay 12PJC11AV4A - C20 (Device No. 50-1 and 50-2)

Application - Stator Overcurrent
Relay Settings:
Adjustment range 4-16 amps
Set pickup at 9 amps, corresponding to 1800 amps primary with a CT ratio of 1000:5

NOTE: The nine amp setting was arrived at by increasing the pickup until spurious trips upon starting were eliminated.

For a plot of pickup vs. frequency for type PJC relays, refer to the calibration curve, Figure 5. For time - current curves of PJC relays, refer to Figure 6.

Relay 12PJV11W6A (Device No. 64)

Application - Generator Ground

Relay Setting:

Adjustment range, 70-160 volts

Set for 70 volts

Ground current sensitivity - 70 volts/43.4 - 1.6 amps

Rated amps - 750

Relay is rectified and provides same pickup accuracy over range of 25-Hz - 5000-Hz

Relay 12NGV13A1A (Device No. $\frac{27\ 1}{14\ 1}$ and $\frac{27\ 2}{14\ 2}$)

Application - 120 volts, AC under voltage

Relay Setting:

Adjustment range 70-100 volts

Set for 70 volts (Temporary recommended setting prior to modification of acromag relay as recommended.)

Relay 12PJV11AE2A (Device No. 40 - Disabled)

Application - DC Field Undervoltage

Set for 240 VDC p.u.
210 VDC d.o.

Relay 373 (Acromag) (Device No. 14-1 and 14-2)

Application - Generator Underspeed

Relay Setting:

> 18 Volts dc corresponds to 12 Hz at a tachometer generator output of 1.5 volts/Hz.

Figure 3 shows how the above relays affect the PSMG field breaker trip coil.

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CALCULATION WORK SHEET

Page 4a of ______ Pages

Subject SIMPLIFIED DIAGRAM UNDERSPEED PROTECTION SYSTEM Date 3-15-78

Prepared By J. E. BURNETT Checked ______ Work Request ______

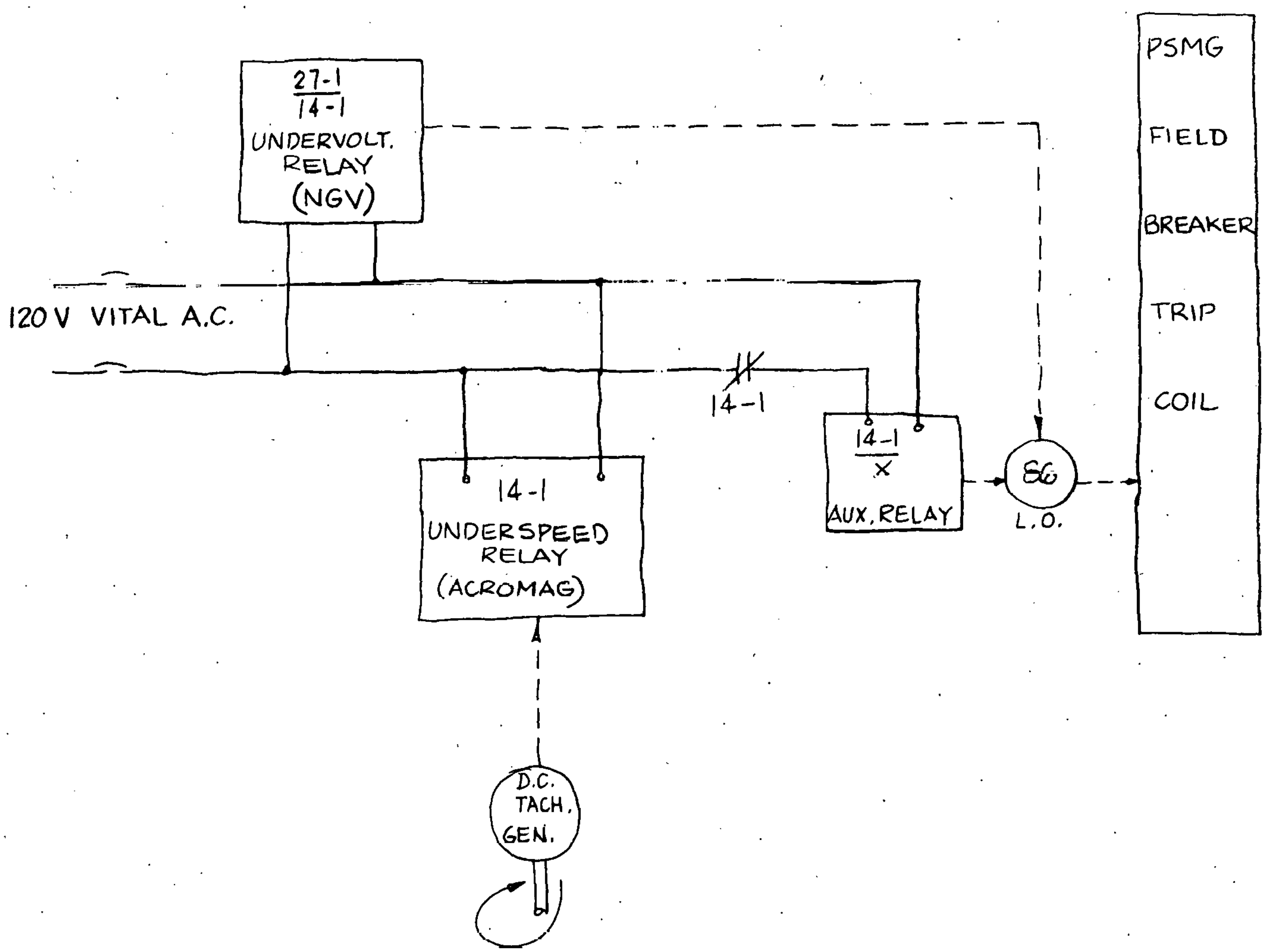

FIG. 1

SIMPLIFIED DIAGRAM - EXISTING PSMG UNDERSPEED PROTECTION SYSTEM (TYPICAL - 2 PER PSMG SET) REFERENCE DWGS. 650-E-900 & G.E. 0105C4139

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CALCULATION WORK SHEET

Page 5 of ____ Pages

Subject SIMPLIFIED DIAGRAM UNDERSPEED PROTECTION SYSTEM Date 3-15-78

Prepared By J.E. BURNETT Checked ____ Work Request ____

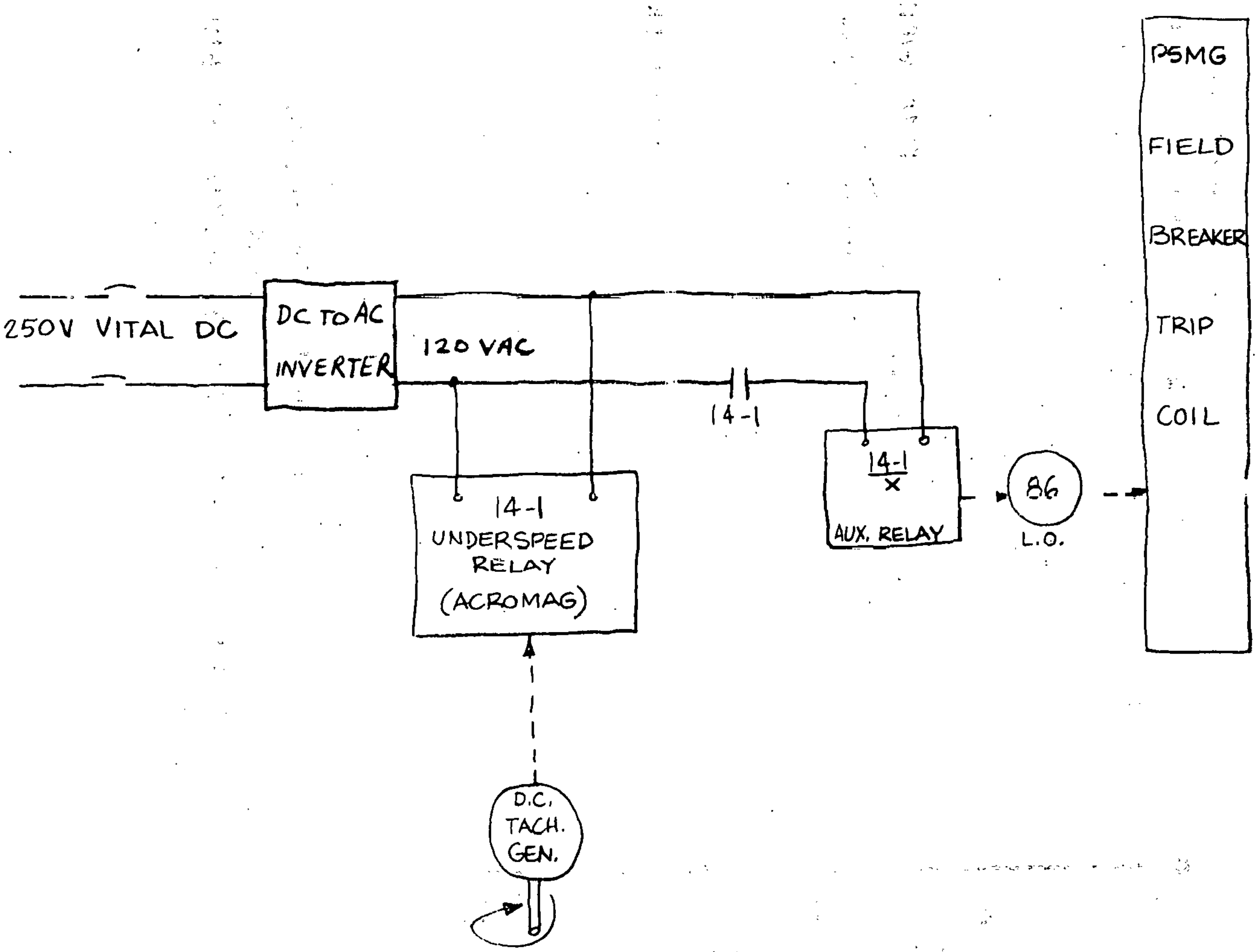

FIG. 2

SIMPLIFIED DIAGRAM - RECOMMENDED PSMG UNDERSPEED PROTECTION SYSTEM (TYPICAL - 2 PER PSMG SET)

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Page 6 of ____ Pages

Subject PSMG FIELD BREAKER TRIP MODES Date 3-16-78

Prepared By J.E. BURNETT Checked ____ Work Request ____

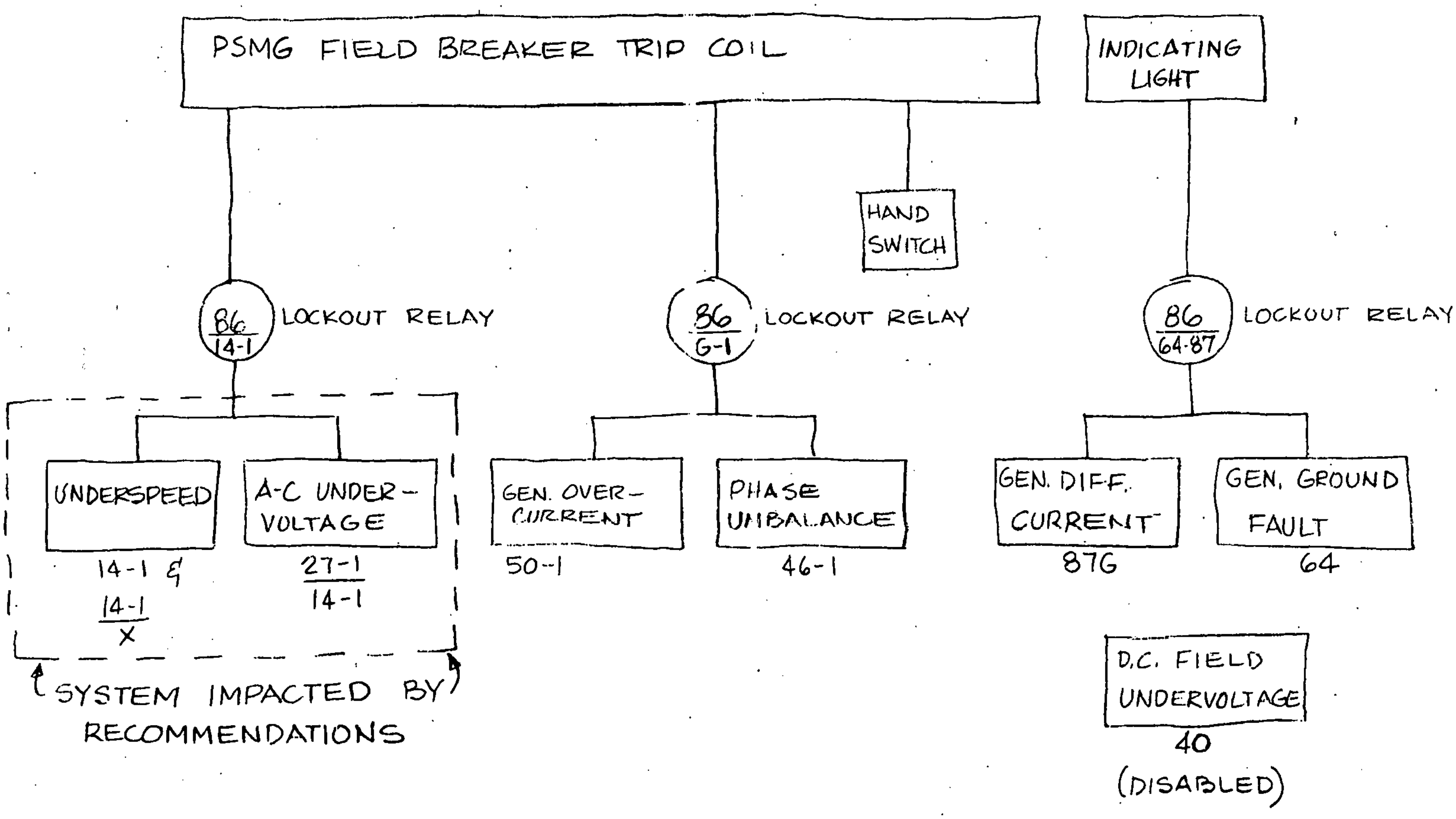

FIG. 3

PSMG FIELD BREAKER TRIP MODES SHOWING UNDERSPEED RELAYING IMPACTED BY RECOMMENDATIONS

CALIBRATION CURVE PICKUP vs FREQUENCY
FOR
IJC-51B7A RELAY

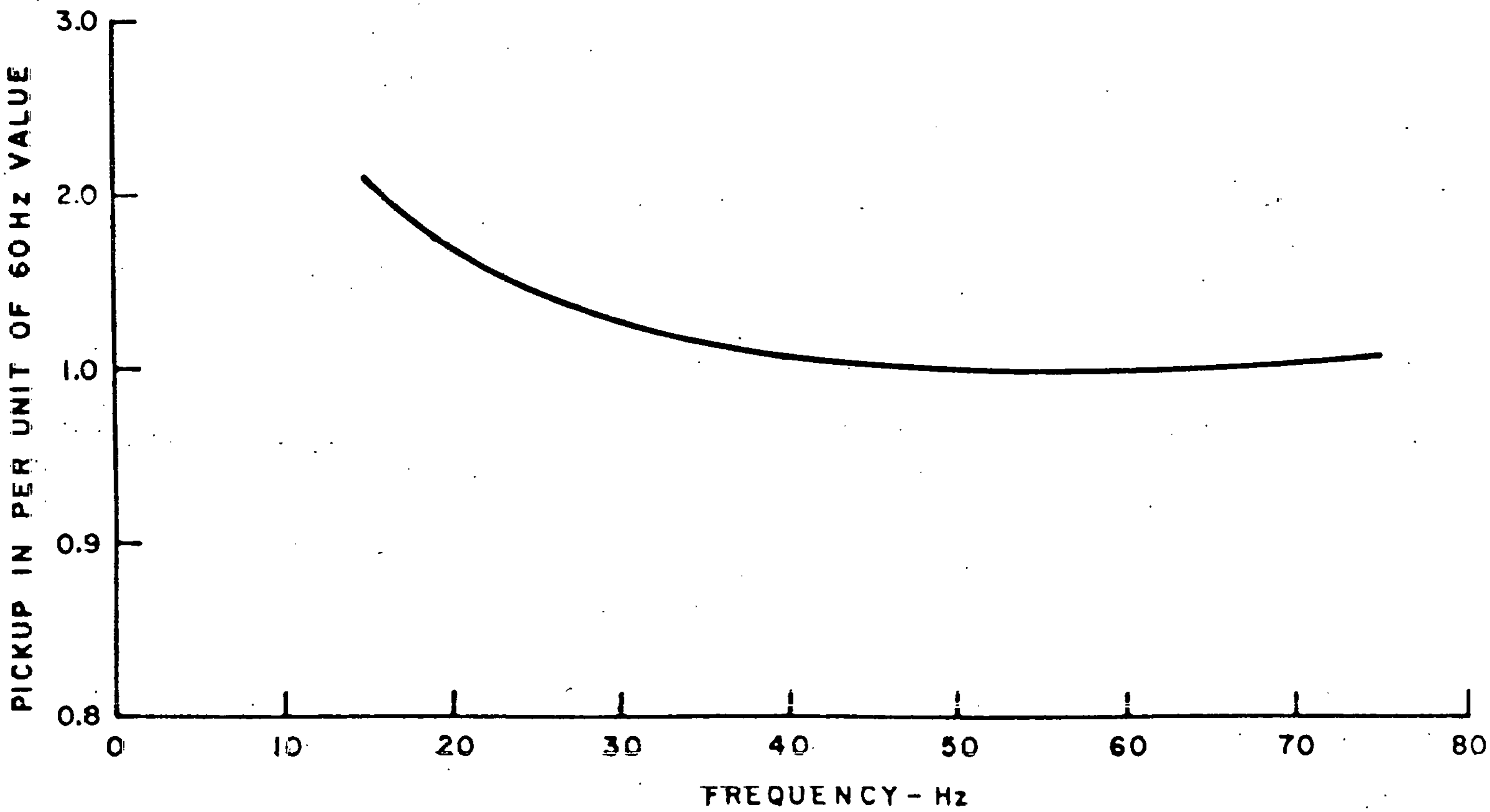

Fig. 4. Calibration Curve for 12IJC51B7A-T Relay

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CALIBRATION CURVES PICKUP vs FREQUENCY
FOR
PJC 11AV RELAY

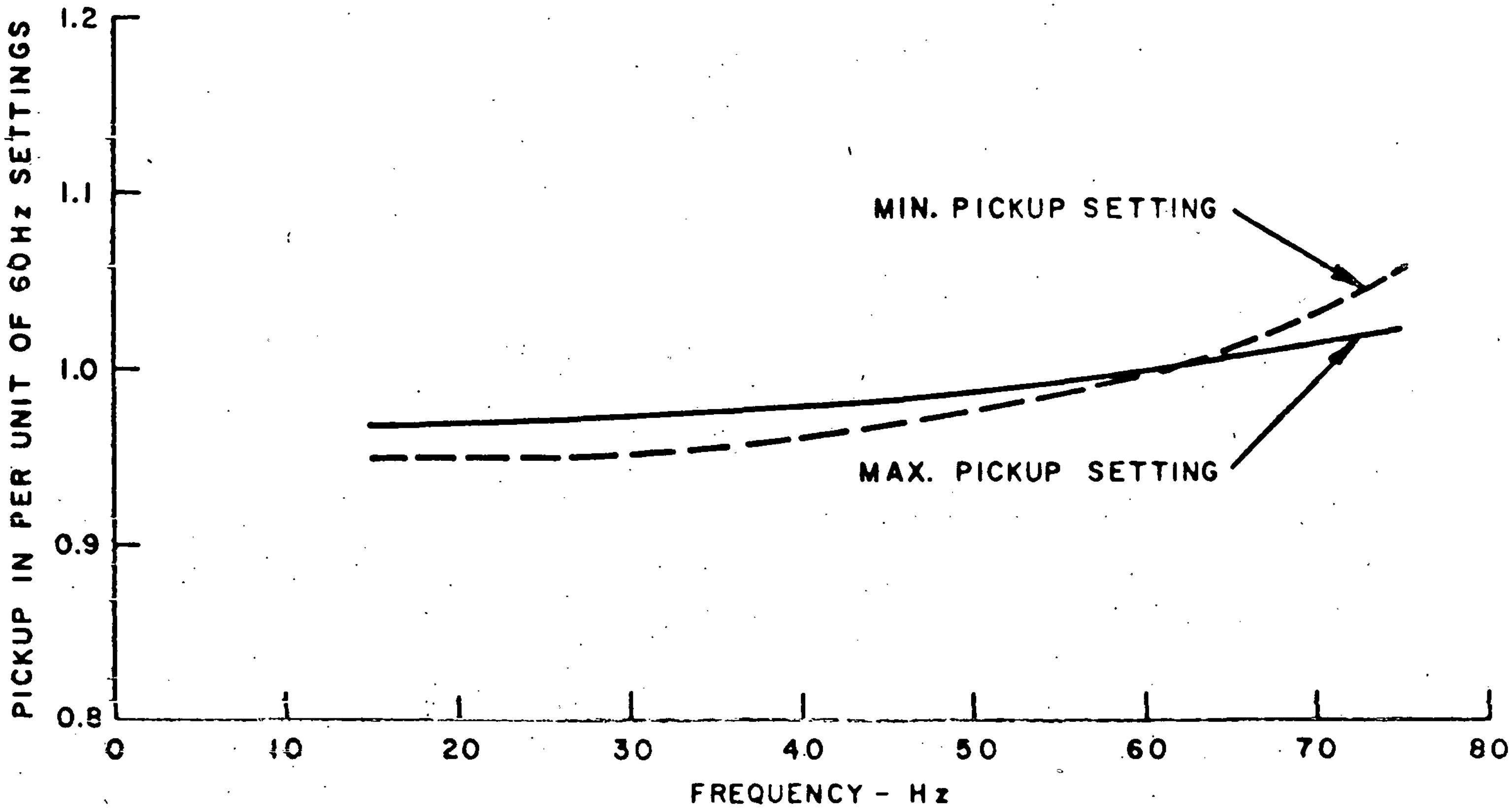

Fig. 5 Calibration Curve for 12PJC11AV3A-C20 Relay

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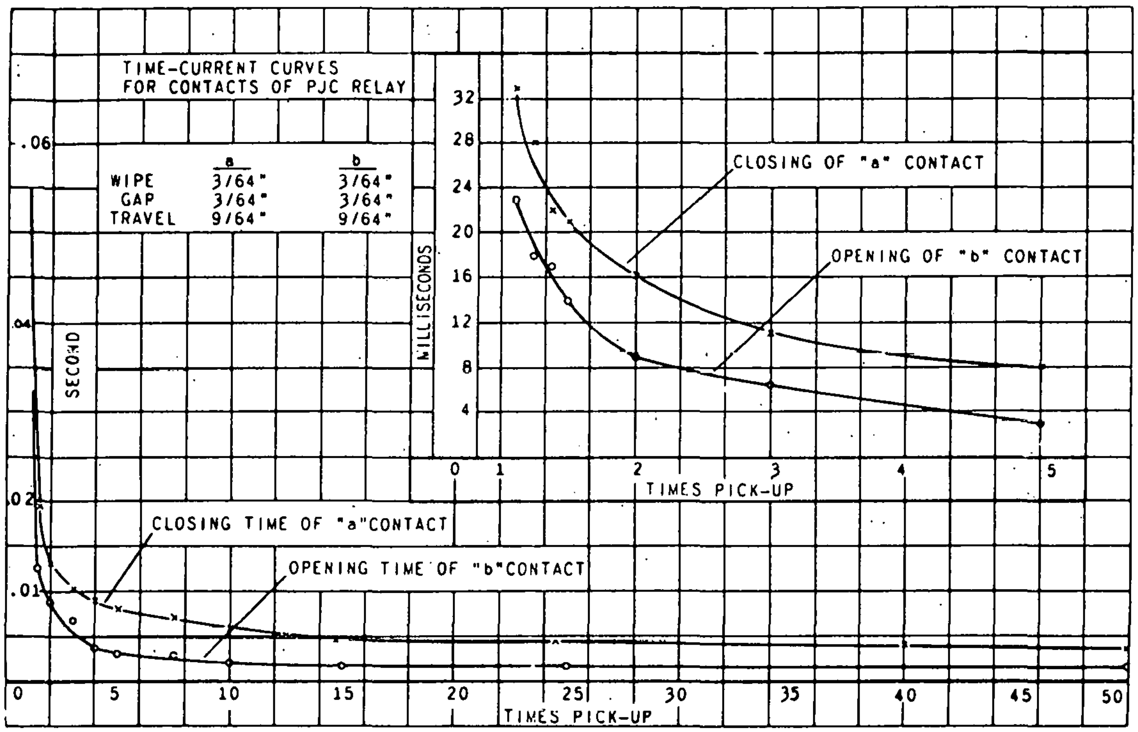

Fig. 6 Typical Time-Current Curves For The Contacts Of Type PJC Relays

APPENDIX A - SINGLE FAILURE ANALYSIS

FAILURE	FAILURE MODE	RELATIVE PROBABILITY	CONSEQUENCE
Present Installation			
NGV Undervoltage	Open (Energized)	C	No breaker trip for power failure.
	Closed (De-Energized)	A	One Field Breaker Trips.
Acromag	Open (Energized)	C	No breaker trip for underspeed.
	Closed (De-Energized)	A	One Field breaker trips.
Aux. Relay	Closed (Energized)	C	One Field breaker trips.
	Open (De-Energized)	A	No breaker trip for underspeed.
Commercial Power	Voltage Dip	A	Both field breakers trip, resulting in loss of PSMG Field.
Recommended Installation			
Acromag	Closed (Energized)	C	No breaker trip for underspeed
	Open (De-Energized)	A	One field breaker trips.
Aux. Relay	Open (Energized)	C	No breaker trip for underspeed.
	Closed (De-Energized)	A	One field breaker trips.
DC to AC inverter	Loss of 120 VAC	A	One field breaker trips

Probability

A - Most likely

N - Less likely

C - Least Likely

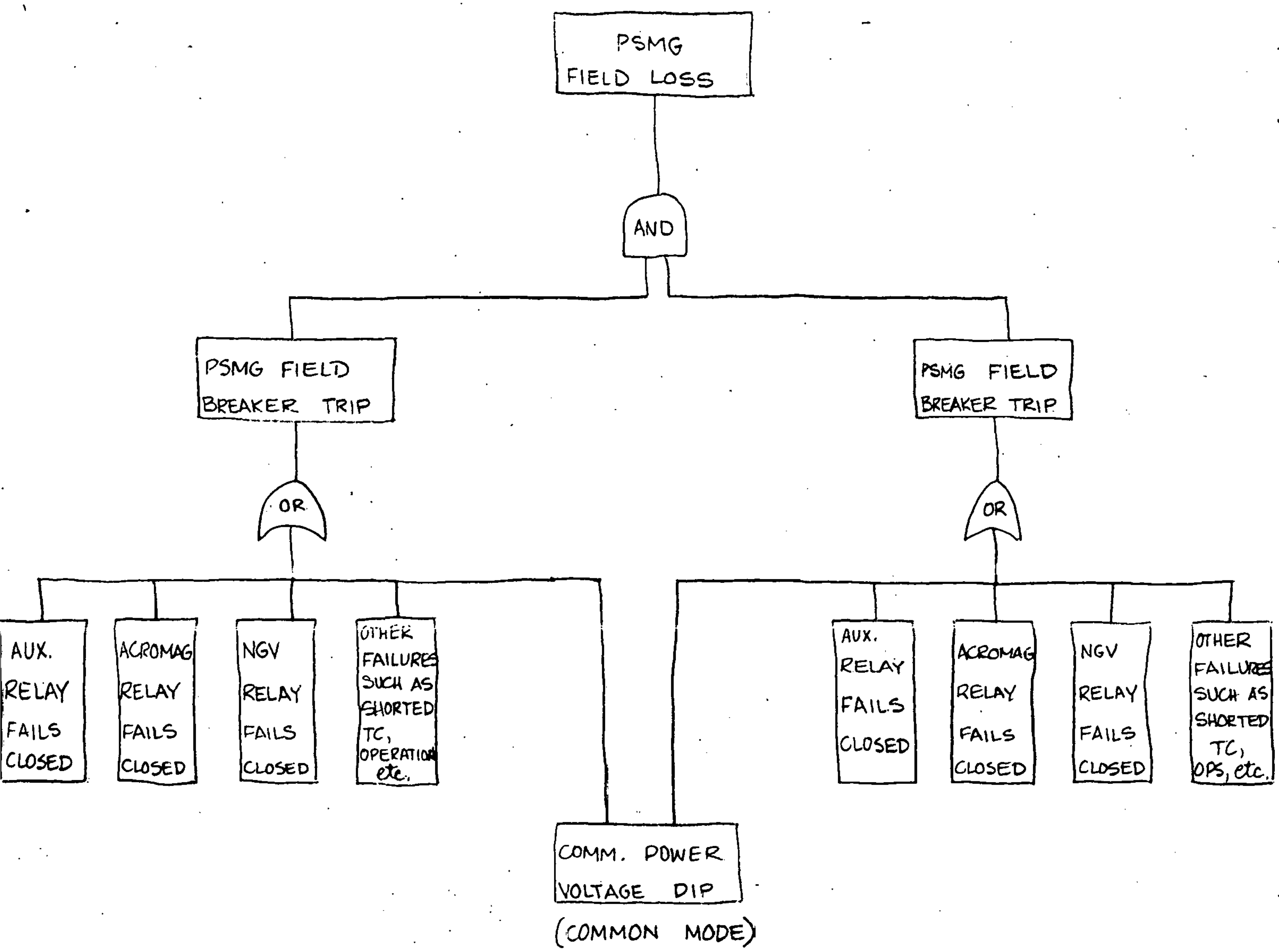

FIG. A1

SINGLE FAILURES RESULTING IN LOSS OF PSMG FIELD - EXISTING UNDERSPEED SYSTEM.

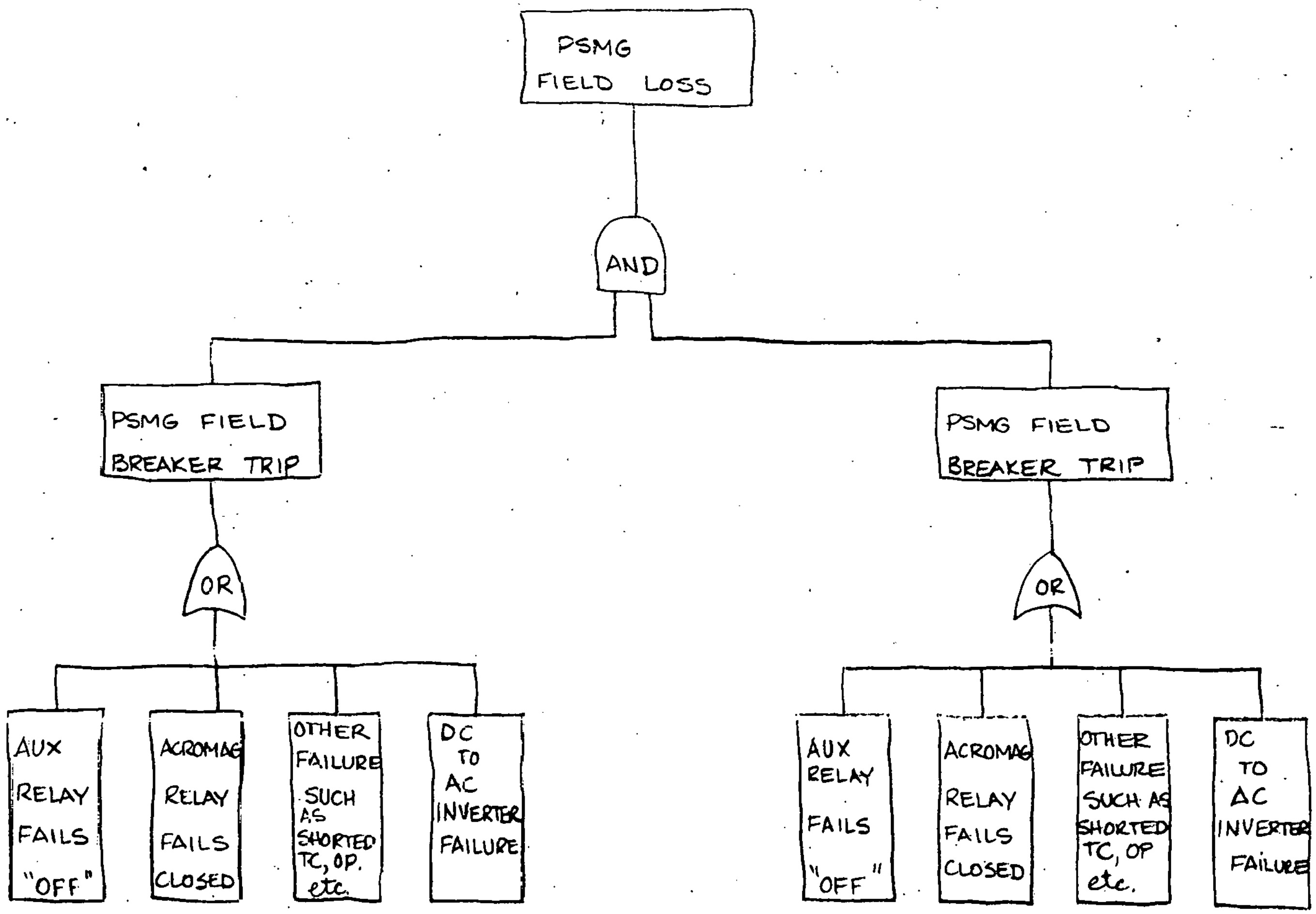

FIG. A2

SINGLE FAILURES RESULTING IN LOSS OF FIELD - RECOMMENDED UNDERSPEED SYSTEM