THE FORT ST. VRAIN
INITIAL APPROACH TO
POWER TESTS (B-SERIES)

INTERIM REPORT 8

Report for Period Ending August 22, 1978

7811270156

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INITIAL APPROACH TO POWER TESTS

(B SERIES STARTUP TESTS)

The initial approach to power is accomplished in a series of discrete power level stages. At each power level, tests are made to measure the characteristics of the plant and to ensure that the plant is within its design limits and the power can be safely increased to the next stage.

The initial phase of the approach to power program will increase the reactor power and steam conditions in stages until approximately 28% power when rated steam conditions are achieved. From this level to full power the reactor power is increased in stages maintaining rated steam conditions. The sequence for the performance of these tests is given in Figure 1 together with the corresponding approximate reactor power levels. The reactor power levels, helium flow rates, feedwater flow rates, steam temperatures, and steam pressure given in the following description of the initial approach to power may differ somewhat from those in the actual approach to power due to change in test requirements or improvements in operating methods identified during other tests.

In general, the initial approach to power will be accomplished in the following order:

1. Feedwater flow will first be established through both steam generator loops and the bypass flash tank system using a boiler feed pump. Helium flow through the core will be provided using one circulator in each loop.

2. The reactor power will be increased to approximately 2%.

3. The reactor power, feedwater flow, and helium flow rate will be simultaneously increased to 5% power, 20% helium flow, and 25% feedwater flow using reactor generated steam from the bypass flash tank supplemented by the auxiliary boiler to power the circulator turbines, turbine driven boiler feed pump, and other plant steam requirements.

4. The reactor power will then be increased to approximately 8% concurrent with an increase in feedwater flow to about 30%. The helium flow will be maintained at about 20% during this power increase. At this condition the second circulator in each loop will be started, maintaining constant helium flow and the main steam pressure will be increased to 2,400 psig.

5. The reactor power will be increased to about 11% and feedwater will be reduced to 25% to initiate boiling.

6. The reactor power will be increased to about 18% simultaneously with an increase in helium flow to about 33%, maintaining a 25% feedwater flow, followed by an increase in reactor power to about 26% with a helium flow of 49%. At this condition the main steam temperature will be about 800°F.

7. The helium flow will then be reduced to about 40% concurrent with a slight adjustment of the reactor power to about 28%.

8. The reactor power will be increased in stages to about 40%, 50%, 60%, 80%, and finally to 100% of full power. During these power level increases, the helium flow rate through the core will be increased to maintain full steam conditions.

This report covers tests performed at approximately 70%.

Each power level was maintained for a period of time to perform one or more of the following tests. Preliminary analysis of these measurements as specified in the overall controlling test document was completed prior to increasing the reactor power to the next stage.

Steam System Performance Tests (B-1). Just prior to steaming and at subsequent power levels during the initial rise to power, data will be accumulated and analyzed on the performance of the steam generators, the turbine and the steam plant auxiliaries. Measurements of the turbine performance will be made at the lower power levels and the turbine will be loaded at about 28% reactor power.

Analysis of Chemical Impurities in the Primary Coolant (B-2). As the reactor power level is increased to about 11% of rated, the core and reactor internals will experience temperatures in excess of those reached during the core heatup for reactivity coefficient measurements. At these temperatures, additional impurities will be degassed. Data on the performance of the helium purification system in removing these chemical impurities from the primary coolant will be taken and analyzed.

PCRV Performance Tests (B-3). As the reactor power level is increased to 28% power, the helium pressure and temperatures approach their quarter load values which results in a system heat load of approximately 80%. At each power level stage up to 28% power and at selected stages up to full power, data will be taken and analyzed on the performance of the PCRV and its cooling system on the structural response of the PCRV to increased internal pressure and on the primary system helium use rate.

Primary Coolant System Performance Tests (B-4). At each power level data on the performance of the helium circulators and their auxiliaries will be taken and analyzed. Measurements of the radial power distribution (region peaking factors) will be made at approximately 2%, 5%, and 8% reactor power. Data on the performance and calibration of the core helium flow orifice valve will be obtained at approximately 28%, 50%, and 100% reactor power.

Plant Instrumentation Performance Tests (B-5). In these tests the performance of the portions of the plant instrumentation which could not be tested prior to power operation will be checked. The nuclear instrumentation will be calibrated by means of heat balance measurements and analyses. The calibration of the condensate and feedwater flow instrumentation and the core region outlet thermocouples will be checked. The core region outlet thermocouple test will be performed just prior to the first adjustment of the helium flow orifices at approximately 8% power and again at approximately 100% power.

Plant Transient Performance Tests (B-6). In these tests, the transient performance of the plant will be tested and analyzed. The testing will include: a scram and turbine trip from approximately 28% reactor power with rated steam conditions, a turbine trip from approximately 40% reactor power, a main turbine generator load rejection from approximately 60% reactor power to house load, sequential tripping of the two circulators in a loop from approximately 80% reactor power and resultant loop shutdown, and boiler feed pump start and stop transients.

Plant Automatic Control System Performance Tests (B-7). The components of the automatic control system will be placed into service and tested as the controlled variables come into their controllable range. Dynamic verification tests of the control system will be performed at selected power levels during the power level increase of the initial approach to full power. A demonstration of full load change from approximately 100% to approximately 25% turbine load will be made under full automatic control.

Reactor Coefficient Measurements (B-8). Measurements of changes in reactivity will be made during the approach to full power by measuring the change in control rod positions required to produce a core temperature and reactor power level change.

Differential Control Rod Worth Measurements (B-9). The reactivity worth of control rods which are moved during the initial rise to power will be measured using a reactivity computer to obtain the instantaneous reactivity change produced by a control rod motion.

Xenon Buildup and Decay Measurements (B-10). The reactivity change produced by buildup, burnout, or decay of xenon poison following a power level change will be measured by recording the change in the critical control rod positions following a change.

Xenon Stability Test (B-11). In this test the absence of any sustained xenon oscillations is demonstrated. At 100% power a perturbation is produced from equilibrium xenon by inserting a control rod in one region and withdrawing a control rod in another position. The indicated power level and

Xenon Stability Test (B-11) (continued). region outlet temperatures are recorded as a function of time and analyzed for the presence of any oscillation produced by xenon.

Shielding Surveys (B-12). At approximately 28% reactor power and approximately 100% reactor power surveys of the radiation levels within the plant are performed. An additional survey is taken during and following any regeneration of the helium purification system. These measured data are recorded and analyzed to demonstrate the adequacy of the shielding design.

Radiochemical Analysis of the Primary Coolant (B-13). In this test the radioactive gaseous fission products in the primary coolant will be sampled and analyzed. These tests are used in the initial startup phase to define fuel fission product release-to-birth ratio at zero burnup and will yield information on the fraction of failed fuel particle coatings. This test is performed at each major power level of the initial rise to power.

FIGURE 1

REACTOR POWER (% OF RATED)	2%	5%	8%	11%	18%	26%	28%	40%	50%	60%	80%	100%
STEAM SYSTEM PERFORMANCE			●	●	●	●	●	●	●	●	●	●
ANALYSIS OF CHEMICAL IMPURITIES	●	●	●	●	●	●	●	●	●	●	●	●
PCRV PERFORMANCE	●	●	●	●		●	●	●	●	●	●	●
PRIMARY SYSTEM PERFORMANCE	●	●	●	●	●	●	●	●	●	●	●	●
PLANT INSTRUMENTATION	●	●	●	●	●	●	●	●	●	●	●	●
PLANT TRANSIENT PERFORMANCE							●		●	●	●	
AUTO CONTROL SYSTEM	●	●	●	●		●	●	●	●	●	●	●
REACTIVITY COEFFICIENTS	●	●	●	●	●	●	●	●	●	●	●	●
DIFFERENTIAL ROD WORTHS	●	●	●	●	●	●	●	●	●	●	●	●
XENON BUILDUP AND DECAY			●			●			●			●
XENON STABILITY												●
SHIELDING SURVEYS							●					●
RADIO CHEMICAL ANALYSIS	●	●	●	●	●	●	●	●	●	●	●	●

Rise to Power Testing Sequence

ACKNOWLEDGEMENT

The contents of this report on the results of B Series Startup testing at Fort St. Vrain, Unit No. 1, have been taken from unpublished, internal reports of General Atomic Company and Public Service Company of Colorado.

This is an interim report based on preliminary data and therefore both data and results are subject to change. This report will be supplemented periodically as further testing is completed.

HISTORICAL SUMMARY OF PLANT OPERATION

At the beginning of the report period, the plant was operating at approximately 65% power.

On May 24, 1978, an unplanned automatic Loop 1 shutdown occurred due to a failure of the feedwater flow controller. Operation on one loop at about 30% reactor power continued until May 26, 1978, when the main turbine generator was shutdown to recover the shutdown loop. The main turbine was re-synchronized on May 28, 1978, about 32 hours after it was taken off.

A test was initiated on June 2, 1978, to investigate the primary system temperature fluctuations. This test consisted of partial insertion of a number of control rods to flatten the core power distribution and adjustment of the region helium flow orifice valves to minimize inter-regional variations in differential pressure. On June 3, 1978, while making these adjustments at 50% reactor power, temperature fluctuations appeared. Reactor power was reduced to 35%, stopping the fluctuations and the remainder of the orifice adjustments completed on June 4, 1978. The test then called for an increase from 40% to 45% reactor power at a rate of 5% per minute in an attempt to initiate fluctuations. Fluctuations were observed which required a reactor power reduction to 34% to terminate. The test demonstrated that a reduction in inter-regional differential pressure did not prevent temperature fluctuations. It is planned to repeat this test with a different orifice valve adjustment pattern to further evaluate the effect of minimizing inter-regional differential pressure.

The plant operated normally at about 65% reactor power (203 MWe) except as described above, until June 6, 1978, when an unplanned automatic shutdown of Loop 2 occurred during surveillance testing. The plant was shutdown at this time and remained shutdown until June 10, 1978, for operator licensing examinations.

The plant returned to power operation and the main turbine-generator synchronized to the system at 28% reactor power on June 12, 1978. Plant output was then increased to 65%.

On June 14, 1978, an unplanned trip of the 1D circulator occurred during surveillance testing. The shutdown circulator was restarted and the plant returned to 65% power within three hours.

A test of the redesigned cold reheat attemperator nozzles was performed, with acceptable results. Resolution of attemperator flow control system problems is continuing.

Slightly higher than acceptable primary system moisture and total oxidant levels were experienced during this period, and have been traced to leakage past the buffer helium dryer, air operated, bypass valve. A modification is planned to provide manual isolation valves and a bypass around the air operated valve to facilitate repair during operation. During the installation of the modification, the leaking valve will be repaired.

The plant operated at 57% (170 MWe) to 67% (212 MWe) reactor power until June 29, 1978. During this period the plant load was limited by condenser vacuum because one of the circulating water pumps was out of service to repair the motor.

On June 29, 1978, power was lost to non-interruptable instrument bus two. This event resulted in a perturbation of the helium circulator auxiliaries, an automatic isolation and steam water dump of the Loop 2 steam generator, and a reactor scram. Two blown fuses were found in the inverter for the failed instrument bus. The loop shutdown and steam water dump were caused by high moisture in Loop 2 primary coolant, resulting from the circulator auxiliary system upset.

The reactor was taken critical June 30, 1978, and returned to power as rapidly as the moisture concentration in the primary coolant permitted.

The turbine generator was resynchronized with the system on July 4, 1978, at a reactor power of 28%. Plant operation was restricted by the availability of only one helium circulator in each loop. Helium circulator 1A was out of service due to an inoperable operator on the inlet steam isolation valve, and circulator 1C in Loop 2 was indicating high buffer-mid-buffer differential pressure with the main drain controller in automatic.

The buffer-mid-buffer problem on 1C circulator was cleared by increasing the circulator speed. Helium circulator 1A inlet steam isolation valve was manually opened and the circulator returned to service on July 6, 1978. The reactor power level was increased to 40% (110 MWe) on July 6, 1978, and to 52% (162 MWe) on July 8, 1978.

On July 7, 1978, a localized fire occurred in the turbine building at a hydraulic valve operator that leaked hydraulic fluid on the hot reheat steam piping. The fire was readily extinguished using hand held fire extinguishers. No permanent damage was done by the fire.

The reactor power was increased to 58% (175 MWe) on July 10, 1978, and operated at this level until July 14, 1978, when an unplanned trip of circulator 1D occurred during surveillance testing of the Plant Protective System. Failure of an integrated circuit chip caused this trip. While trouble shooting to determine the cause of the 1D circulator trip, circulator 1C tripped causing loss of primary coolant flow throught the Loop 2 steam generators. The reactor was manually scrammed following this occurrence.

The plant was returned to power, the turbine generator resynchronized and power increased to 58% (175 MWe) on July 17, 1978.

Two trips of instrument bus inverter 1C occurred during this period, (July 13, 1978, and July 14, 1978) caused by failed silicon controlled rectifiers.

The plant operated between 45% (133 MWe) and 65% (195 MWe) until July 31, 1978. Beginning on July 26, 1978, during the evenings, with lower system power demands, the power level was decreased to 45% to reduce the core outlet temperature below 1,200°F. This mode of operation reduces the total time of operation above the 1,200°F, which is the threshold for the 10 ppm total oxidants conditional limit on primary coolant impurity levels.

On July 31, 1978, a winding failure and insulation fire occurred in 480 volt transformer 1A and the plant was manually scrammed. The loss of the 480 volt transformer caused an upset in the buffer helium system for Loop 1, resulting in ingress of an unknown amount of moisture into the primary system.

The reactor was taken critical on August 5, 1978, and operated between 2% and 6% of rated power. Further increase in power was restricted by high levels of moisture in the primary coolant.

The moisture level in the primary coolant was between 230 ppm and 800 ppm.

Approximately 60 gallons of water were removed from the primary system during August, 1978. Operations pursued to increased the rate of cleanup of the primary system moisture included:

a) Operation at low power levels to increase the cold gas temperature within the PCRV.

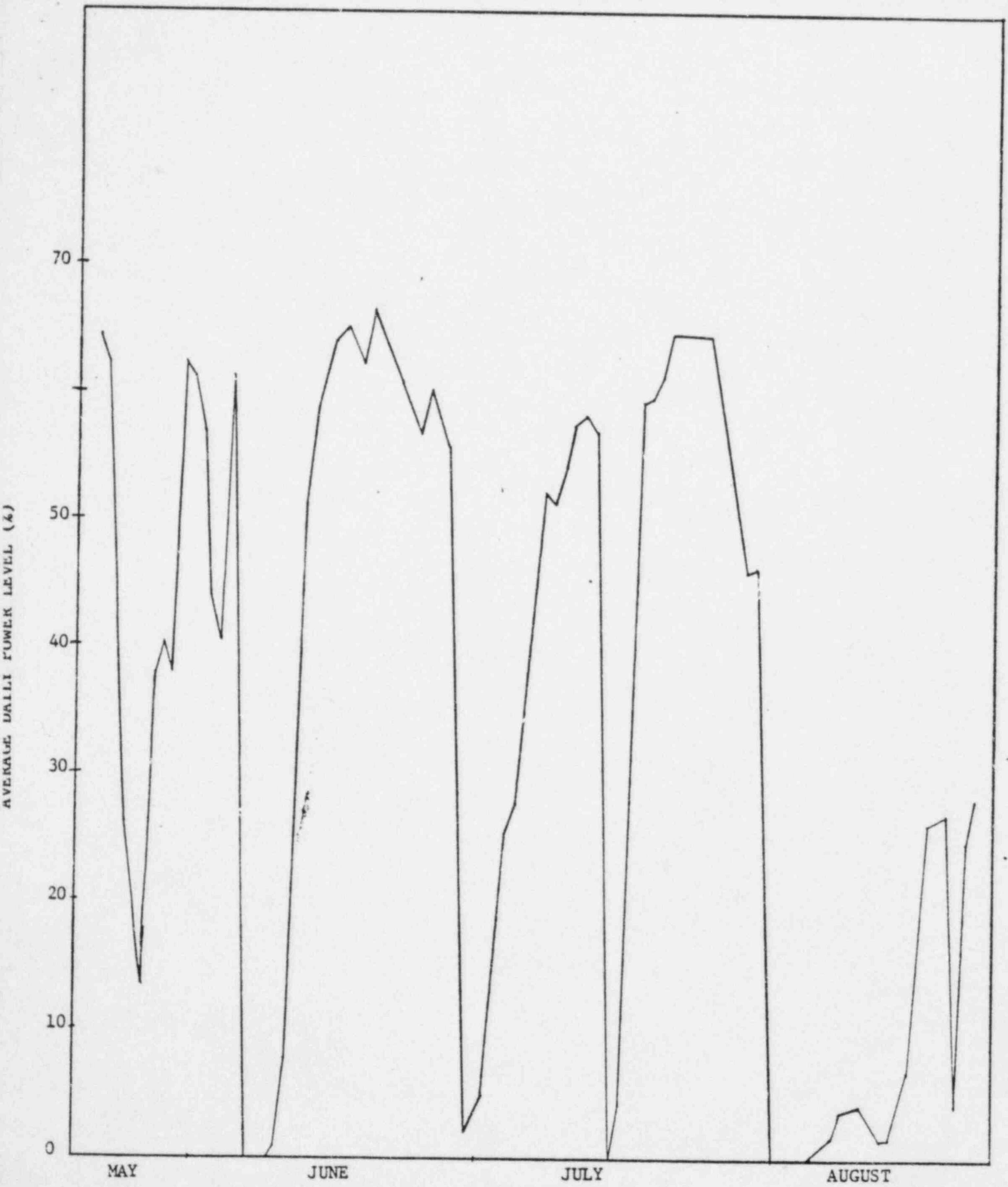
b) Cycling of the reactor pressure.

c) Operation with various combinations of circulators. (operation of the 1A circulator increased the primary system moisture level).

d) Increasing the temperature of the PCRV Liner Cooling System.

The reactor power was increased to 25% of rated on August 16, 1978, resulting in an increase in primary system moisture level from 130 ppm to 190 ppm. The primary system moisture level subsequently decreased to 80 ppm. Reactor power was increased to 29% and the main turbine generator was synchronized on August 17, 1978. The turbine was taken off line two hours later and the reactor power was reduced to 26% of rated due to increased primary system moisture.

The main turbine generator was re-synchronized and loaded to 45 MWe on August 18, 1978. On August 20, 1978, an automatic reactor scram and steam water dump of the Loop 2 steam generator occurred due to a noise spike on a high level moisture monitor with the low level monitors previously tripped. The reactor was returned to 28% power and the main turbine generator reloaded to 45 MWe on August 21, 1978. On August 22, 1978, a turbine trip occurred due to an upset in the turbine first stage pressure and the main steam temperature following a system frequency spike. The main turbine generator was back on line about one hour later.


AVERAGE DAILY POWER LEVEL (%)
70
50
40
30
20
10
0
MAY
JUNE
JULY
AUGUST

TESTING SUMMARY

SUT B-7, Feedwater Flow Control

Both feedwater flow control loops responded adequately to transient step changes on FC-2205 and FC-2206. Some noise was experienced while testing Loop 2. However, the noise was determined not to be due to the controller gain.

SUT B-7, Deaerator Level Control

The deaerator level tuning consisted of tuning LIC-3175 first then tuning FIC-3175 with both controllers (LIC-3175, FIC-3175) in operation. In each case the system response appears adequate and less than 1/4 amplitude damping.

SUT B-7, Feedwater Valve ΔP Control

The action from the feedwater valve ΔP controllers PDC-22127 and HC-31207 due to the transient testing appears to be adequate. The PDC-22127 action is somewhat slow due to its being tuned for loop trips.

SUT B-7, Circulator Speed Control

The circulator steam turbine speed control system response meets the 1/4 amplitude damping criteria. Very rapid control from the speed controllers was sacrificed to prevent small oscillations of the speed valves, and thus increased wear.

SUT B-7, Cold Reheat Pressure Ratio Control

The previous settings on the two cold reheat bypass ratio controllers PC-2243 and PC-2244 were left unchanged due to the satisfactory control system response during this transient testing series. The step change in the pressure ratio on Loop 1 did not cause any changes in circulator speed on Loop 2 and vice versa. This indicated excellent decoupling of pressure ratio from circulator speed.

SUT B-7, Reheat Steam Desuperheaters

Reheat steam bypass to the condenser temperature control could only be achieved for this test when the reheat steam bypass desuperheater controller was adjusted so that its output signal would close the spray valve more than the minimum of 15%. Temperature setpoint changes were made with a stable response. However, to insure an adequate spray condition in the reheat steam desuperheaters the spray valves have a minimum open position of 15%. (The spray valves will never fully close when the reheat bypass valves are open.) Because of this minimum open position, temperature control of this system will probably never occur--due to overspray. Only one of the reheat steam desuperheater controllers was tuned, and the other controller settings were changed to match the one that was tested. The primary purpose of the reheat steam desuperheaters is to protect the condenser, and the results of this test indicate that the system operates satisfactorily to perform this function.

SUT B-7, Main Steam Desuperheaters

The main steam desuperheater control system exhibits satisfactory response to transient step changes. Prior to performing this test, and because of previously noted control instability at low steam flow, the valve positions of TCV-5208 and TCV-5207 were changed from a linear characteristic to a square characteristic by FCN-4139. When the steam flow through desuperheaters was reduced, no undamped oscillations were seen.

SUT B-7, Main Steam Temperature Control

The main steam temperature control system was tuned by making changes in the setpoint of the main steam temperature controllers (TC-2225, TC-2226) one loop at a time. The response of both loops was satisfactory and exhibits less than 1/4 amplitude damping.

SUT B-7, Reheat Steam Temperature Test

The response of the reheat steam temperature control system to step changes appears satisfactory. However, quarter amplitude damping response cannot be verified because the second step change was made prior to the first step change stabilizing. Both the reheat steam temperature controller and the flux controller have a small deadband which prevents excessive control rod movement. Thus due to the deadband the 1/4 amplitude damping criteria is not really applicable to this test. This item is considered closed.

SUT B-7, Load Change Response

In this test a load change was made (at approximately 1% per minute) from 69% power to 30% power. The plant remained at the 30% power level for one hour to stabilize, then the power was increased at 1% per minute to the previous power level of 68%. All the following plant limits as called out by B-7, Part 20F were acceptable: main steam temperature limits, reheat steam temperature limits, main-to-reheat steam temperature limit and turbine inlet steam pressure and temperature limits.

On Both the load decrease and the load increase, feedwater flow exhibited some small oscillations.

The main steam and reheat steam appeared to droop the correct amount during the load change, but did not follow the ramp function. The cause for this appears to be the inherent thermal lag of the plant during a load increase or decrease.

The output of the main steam temperature controllers TC-2225 and TC-2226 showed a high response during this thermal lag to increase the mainsteam temperature, but their action on circulator speed is very small, as most of the action is from feedwater flow.

SUT B-9, Control Rod Calibration

Additional measurements of the reactivity worth for control rod Group 4A were performed at positions between 145" to 176" withdrawn. These measurements were consistent with previous measurements performed on this control rod group. The total integral worth of control rod Group 4A was measured.

STEAM SYSTEM PERFORMANCE VERIFICATION (B-1)

This test was not scheduled during the report period.

CHEMICAL IMPURITIES IN THE PRIMARY COOLANT (B-2)

This test was not scheduled during the report period.

PCRV PERFORMANCE TESTS (B-3)

This test was not scheduled during the report period.

PRIMARY SYSTEM PERFORMANCE (B-4)

This test was not scheduled during the report period.

PLANT INSTRUMENT PERFORMED (B-5)

This test was not scheduled during the report period.

PLANT TRANSIENT PERFORMED (B-6)

This test was not scheduled during the report period.

Startup Test B-7 Plant Automatic Control System Performance Tests

Part 2D - Data Feedwater Flow Control

Data collected furing the performance of Part 2D is shown in Figures B-7.2D.1 through D-7.2D.3.

Part 3D - Deareator Level Control

Data collected during the performance of Part 3D is shown in Figures B-7.3D.1 and D-7.3D.2.

Part 7D - Feedwater Valve Differential Pressure Control

Data collected during the performance of Part 7D is shown in Figures B-7.7D.1 through B-7.7D.4.

Part 8D - Circulator Speed Control

Data collected during the performance of Part 8D is shown in Figures B-7.8D.1 through B-7.8D.4.

Part 10D - Circulator Pressure Ratio Control

Data collected during the performance of Part 10D is shown in Figures B-7.10D.1 through B-7.10D.4.

Part 12C - Reheat Steam Desuperheat Control

Data collected furing performance of Part 12C is shown on Figure B-7.12C.1.

Part 13A - Main Steam Desuperheater Temperature Control

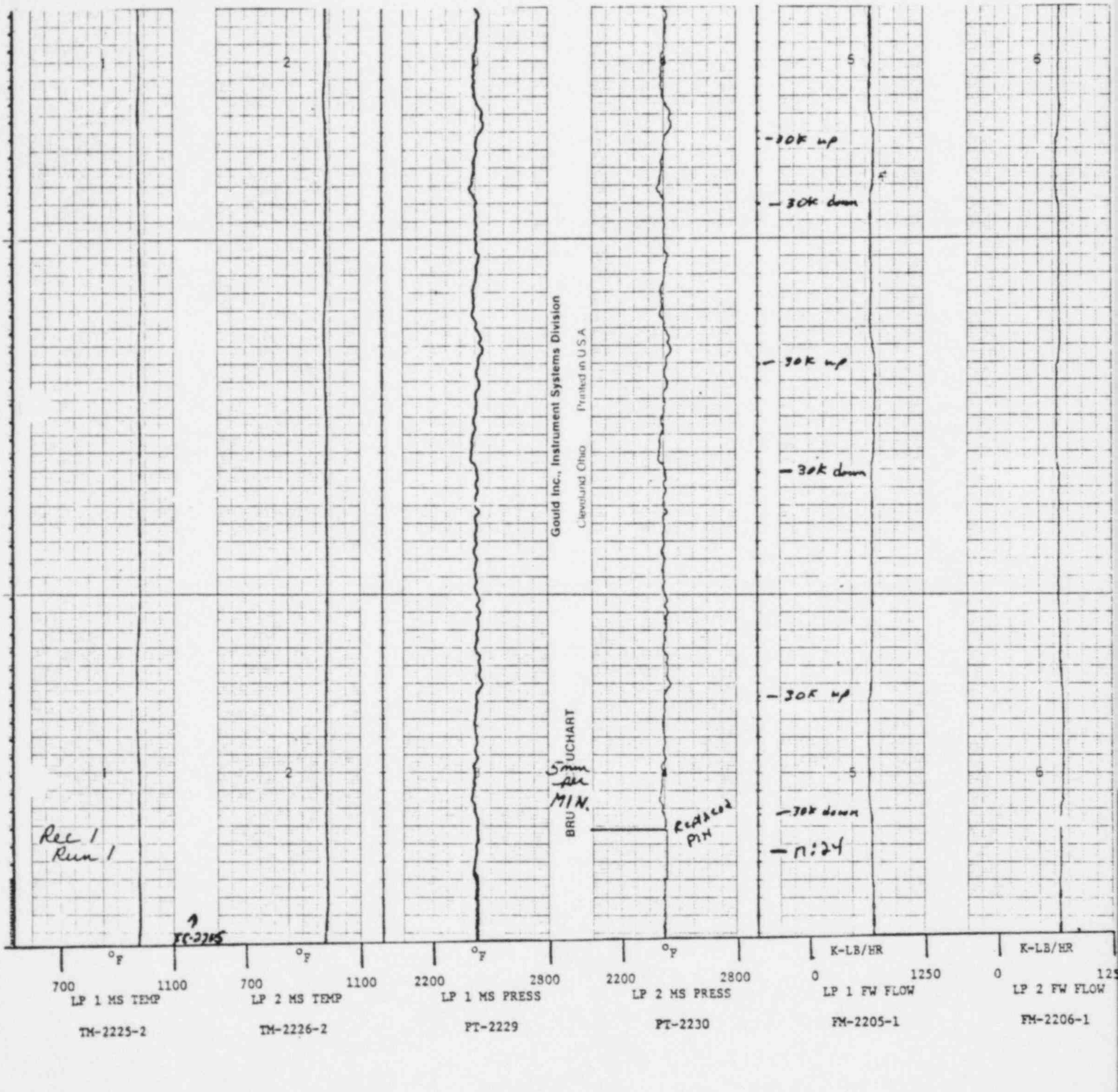
Data collected during performance of Part 13A is shown on Figures B-7.12A.1 through B-7.13A.4.

Part 14E - Main Steam Temperature Control

Data collected during performance of Part 14E is shown on Figures B-7.14E.1 through B-7.14E.8.

Part 15E - Reheat Steam Temperature Control

Data collected during performance of Part 15E is shown on Figures B-7.15E.1 through B-7.15E.5.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5
6
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-30K down
-30K up
-30K down
-30K up
-30K down
-11:24
Gould Inc., Instrument Systems Division
Cleveland Ohio Printed in U.S.A.
BRUSH UCHART
5mm per MIN.
Replaced PIN
Rec 1
Run 1
TC-2245
°F
700
1100
LP 1 MS TEMP
TM-2225-2
°F
700
1100
LP 2 MS TEMP
TM-2226-2
°F
2200
2800
LP 1 MS PRESS
PT-2229
°F
2200
2800
LP 2 MS PRESS
PT-2230
K-LB/HR
0
1250
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FM-2205-1
K-LB/HR
0
125
LP 2 FW FLOW
FM-2206-1

Fig. B-7.2D.1

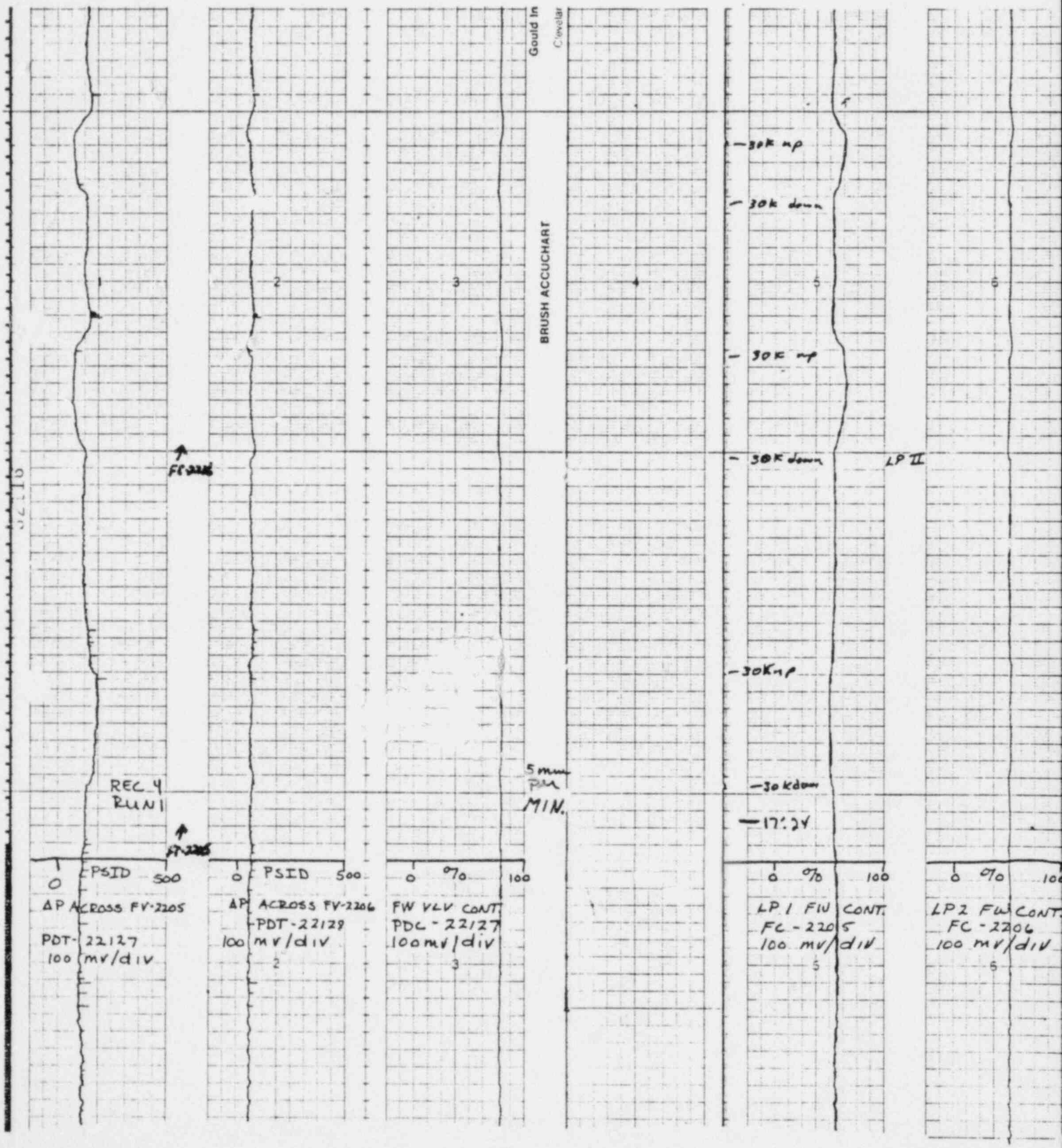

Gould Inc
Cleveland
BRUSH ACCUCHART
1
2
3
4
5
6
–30K up
–30K down
–30K up
–30K down
LP II
–30K up
–30K down
–17:24
FC-2206
FT-2205
REC 4
RUN 1
5 mm
PM
MIN.
0
PSID
500
0
PSID
500
0
%
100
0
%
100
0
%
100
ΔP ACROSS FV-2205
PDT-22127
100 mv/div
ΔP ACROSS FV-2206
PDT-22128
100 mv/div
FW VLV CONT.
PDC-22127
100 mv/div
LP 1 FW CONT.
FC-2205
100 mv/div
LP 2 FW CONT.
FC-2206
100 mv/div

Fig. B-7.2D.2

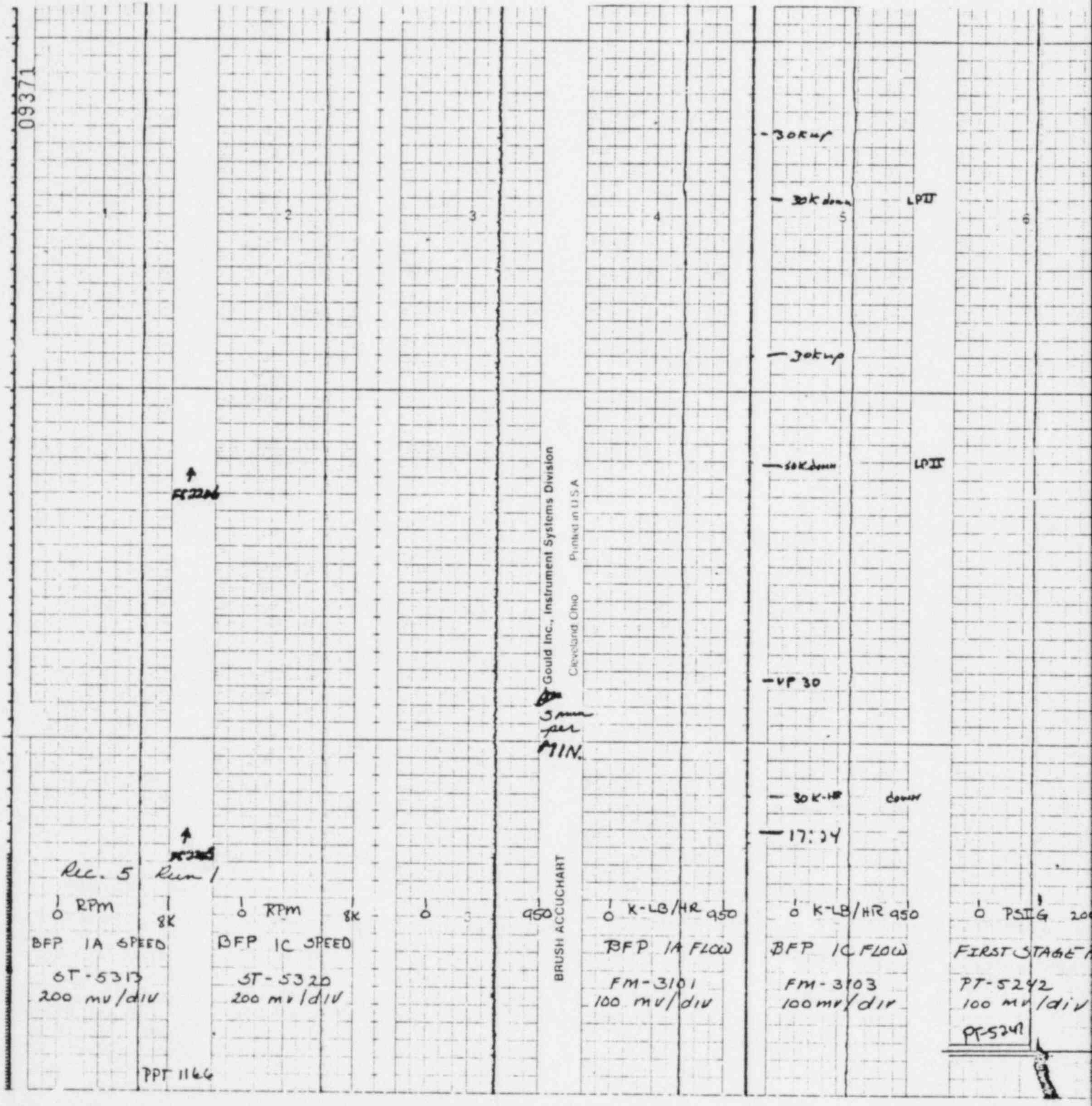
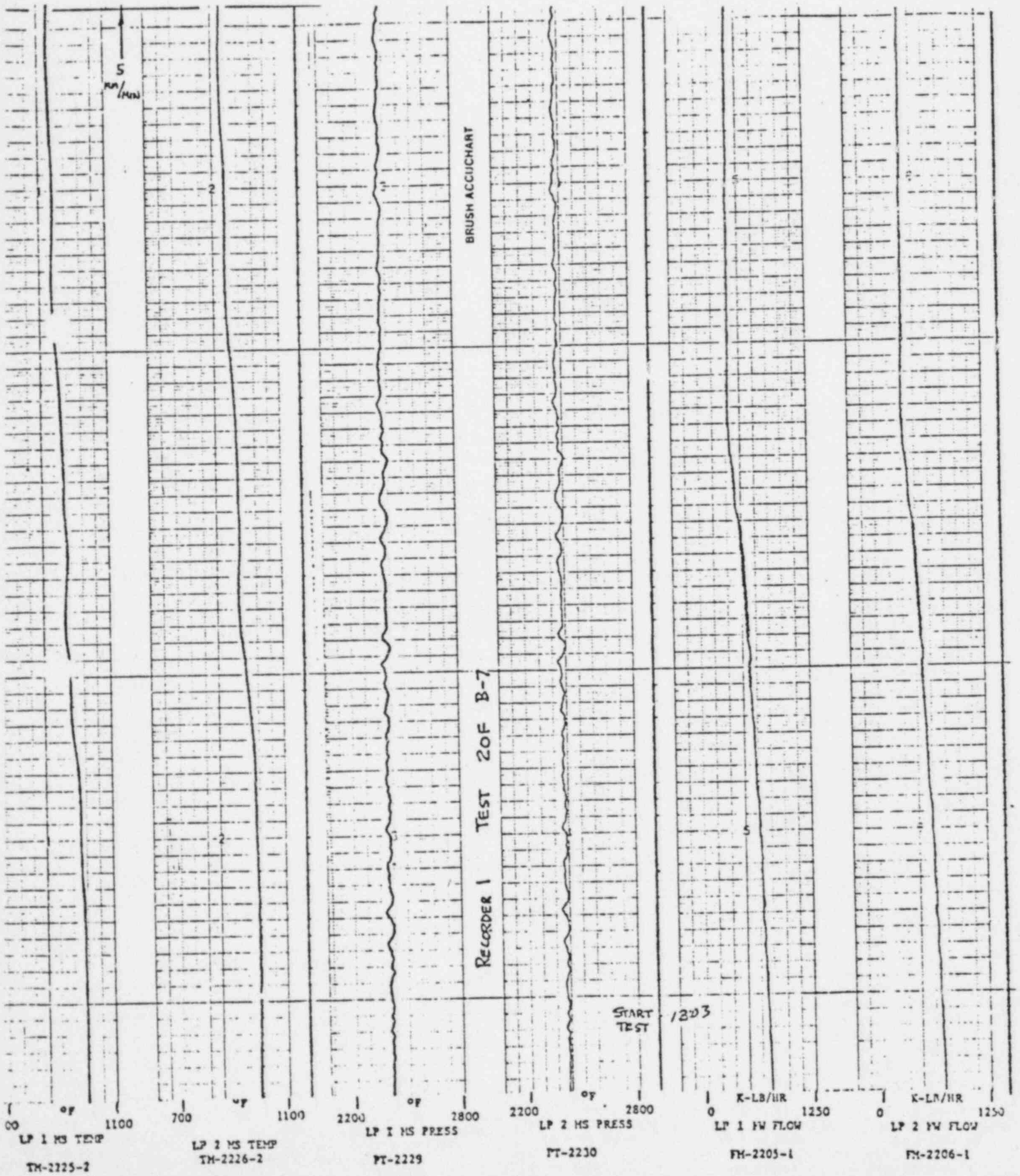

09371
1
2
3
4
5
6
- 30K up
- 30K down
LPII
- 30K up
- 50K down
LPII
- VP 30
- 30 K-HR
down
- 17:24
FE2206
FE2206
Gould Inc., Instrument Systems Division
Cleveland Ohio
Printed in U.S.A.
3mm per MIN.
BRUSH ACCUCHART
Rec. 5 Run 1
0 RPM 8K
BFP 1A SPEED
ST-5313
200 mv/div
0 RPM 8K
BFP 1C SPEED
ST-5320
200 mv/div
0 3 950
0 K-LB/HR 950
BFP 1A FLOW
FM-3101
100 mv/div
0 K-LB/HR 950
BFP 1C FLOW
FM-3103
100 mv/div
0 PSIG 20
FIRST STAGE
PT-5242
100 mv/div
PT-5242
PPT 1166

Fig. B-7.2D.3


5 mm/min
BRUSH ACCUCHART
RECORDER 1 TEST 20F B-7
START TEST 1203
°F
00
1100
LP 1 MS TEMP
TM-2225-2
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°F
1100
LP 2 MS TEMP
TM-2226-2
2200
°F
2800
LP 1 MS PRESS
PT-2229
2200
°F
2800
LP 2 MS PRESS
PT-2230
0
K-LB/HR
1250
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FM-2205-1
0
K-LB/HR
1250
LP 2 FW FLOW
FM-2206-1

Fig. B-7.20F.1

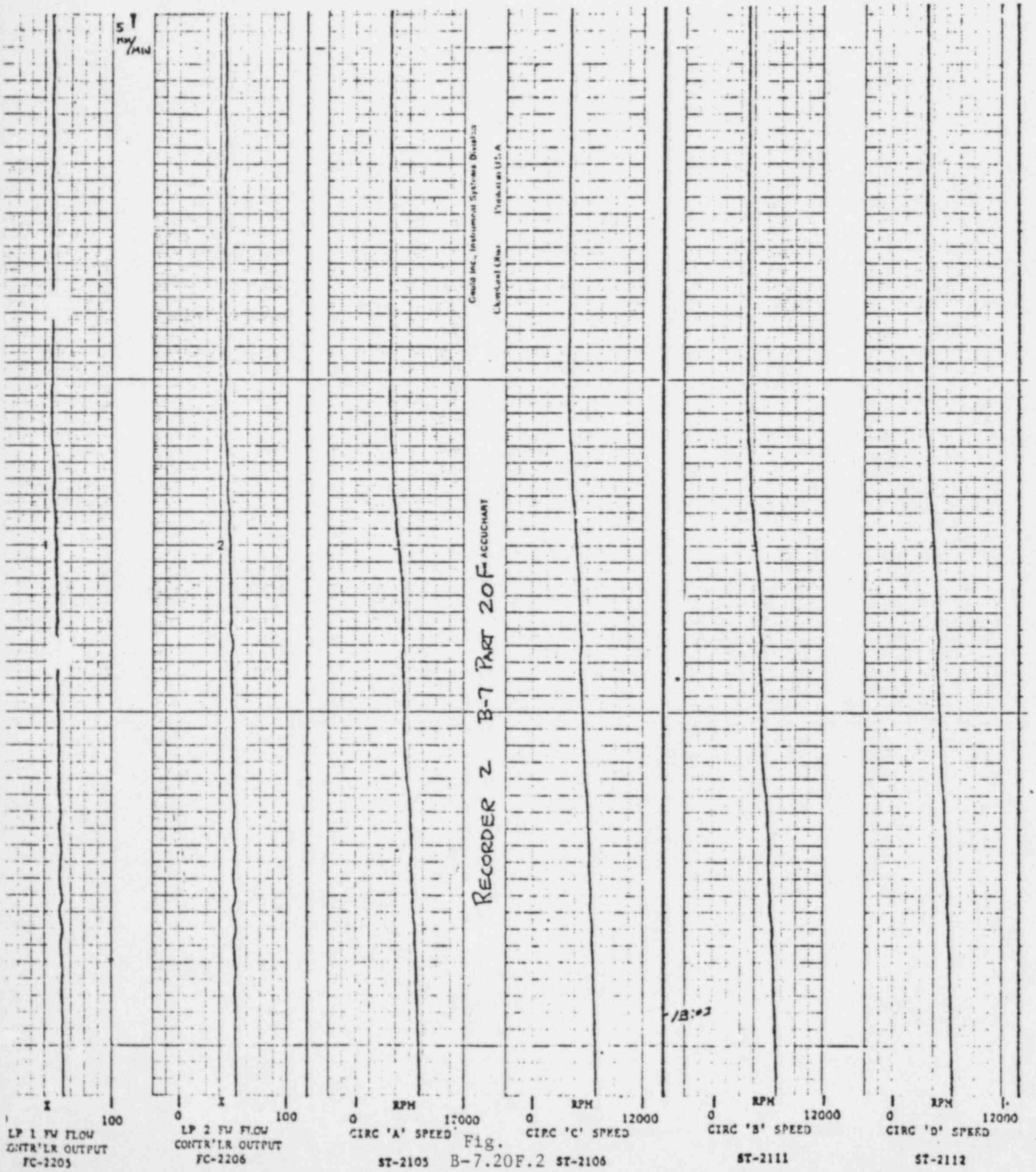
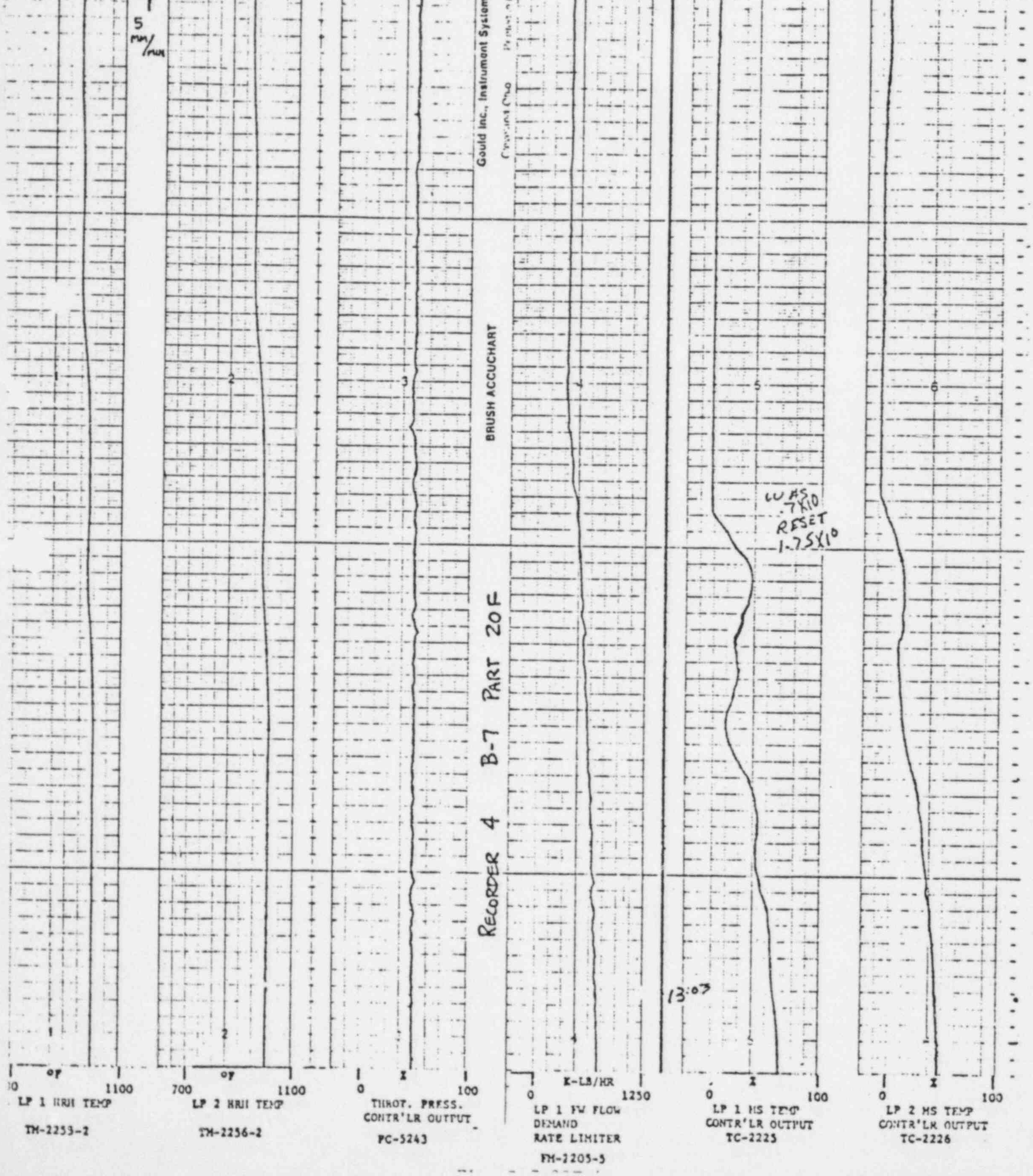
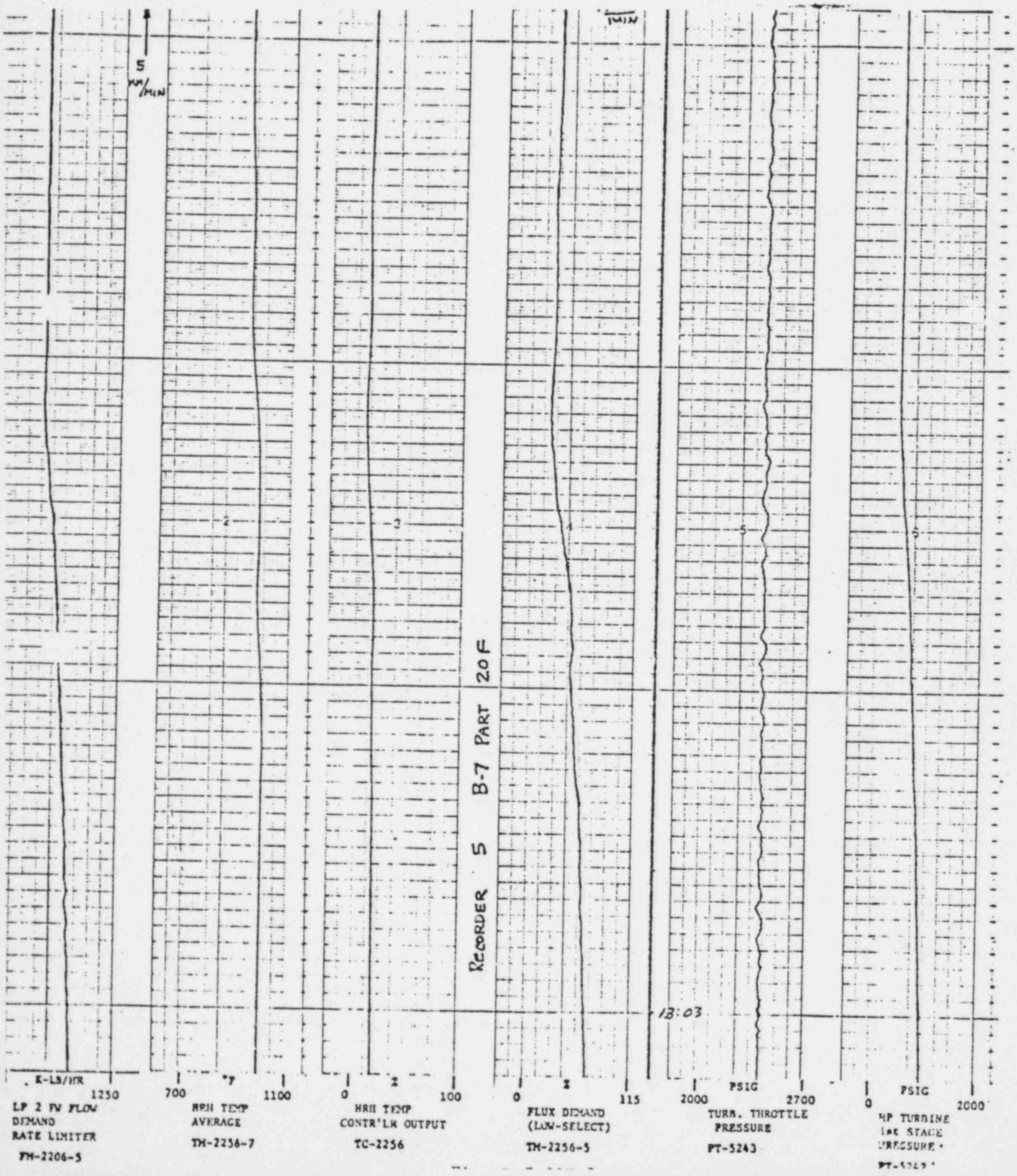

5 mm/MIN
Gould Inc., Instrument Systems Division
Cleveland, Ohio Printed in U.S.A.
RECORDER 2 B-7 PART 20F
ACCUCHART
1
2
18:03
%
100
LP 1 FW FLOW
CNTR'LR OUTPUT
FC-2205
0
%
100
LP 2 FW FLOW
CONTR'LR OUTPUT
FC-2206
0
RPM
12000
CIRC 'A' SPEED
ST-2105
0
RPM
12000
CIRC 'C' SPEED
ST-2106
0
RPM
12000
CIRC 'B' SPEED
ST-2111
0
RPM
12000
CIRC 'D' SPEED
ST-2112

Fig. B-7.20F.2


5 mm/min
1
2
3
4
5
6
BRUSH ACCUCHART
Gould Inc., Instrument Systems Division
Cleveland, Ohio U.S.A.
RECORDER 3 B-7 PART 2OF
B:03
RPM
12000
LP 1 CIRC SPEED DEMAND
TH-2225-5
0
RPM
12000
LP 2 CIRC SPEED DEMAND
TH-2226-5
0
PSID
500
LP 1 FW VLV ΔP
PDT-22127
CHANNEL OFF
0
PSID
500
LP 2 FW VLV ΔP
PDT-22128
0
%
100
FW VLV ΔP CONTR'LR OUTPUT
PDC-22127

Fig. B-7 2OF 3


5 mm/min
Gould Inc., Instrument Systems
BRUSH ACCUCHART
RECORDER 4 B-7 PART 20F
WAS .7X10 RESET 1.75X10
13:03
1
2
3
4
5
6
°F
0
1100
LP 1 HRH TEMP
TM-2253-2
°F
700
1100
LP 2 HRH TEMP
TM-2256-2
%
0
100
THROT. PRESS. CONTR'LR OUTPUT
PC-5243
K-LB/HR
0
1250
LP 1 FW FLOW DEMAND RATE LIMITER
FM-2205-5
%
0
100
LP 1 HS TEMP CONTR'LR OUTPUT
TC-2225
%
0
100
LP 2 HS TEMP CONTR'LR OUTPUT
TC-2226


1MIN
5 MM/MIN
Recorder 5 B-7 Part 20F
13:03
K-LB/HR
1250
LP 2 FW FLOW
DEMAND
RATE LIMITER
FM-2206-5
700
°F
1100
HRH TEMP
AVERAGE
TM-2256-7
0
%
100
HRH TEMP
CONTR'LR OUTPUT
TC-2256
0
%
115
FLUX DEMAND
(LOW-SELECT)
TM-2256-5
2000
PSIG
2700
TURB. THROTTLE
PRESSURE
PT-5243
0
PSIG
2000
HP TURBINE
1st STAGE
PRESSURE
2
3
4
5
6

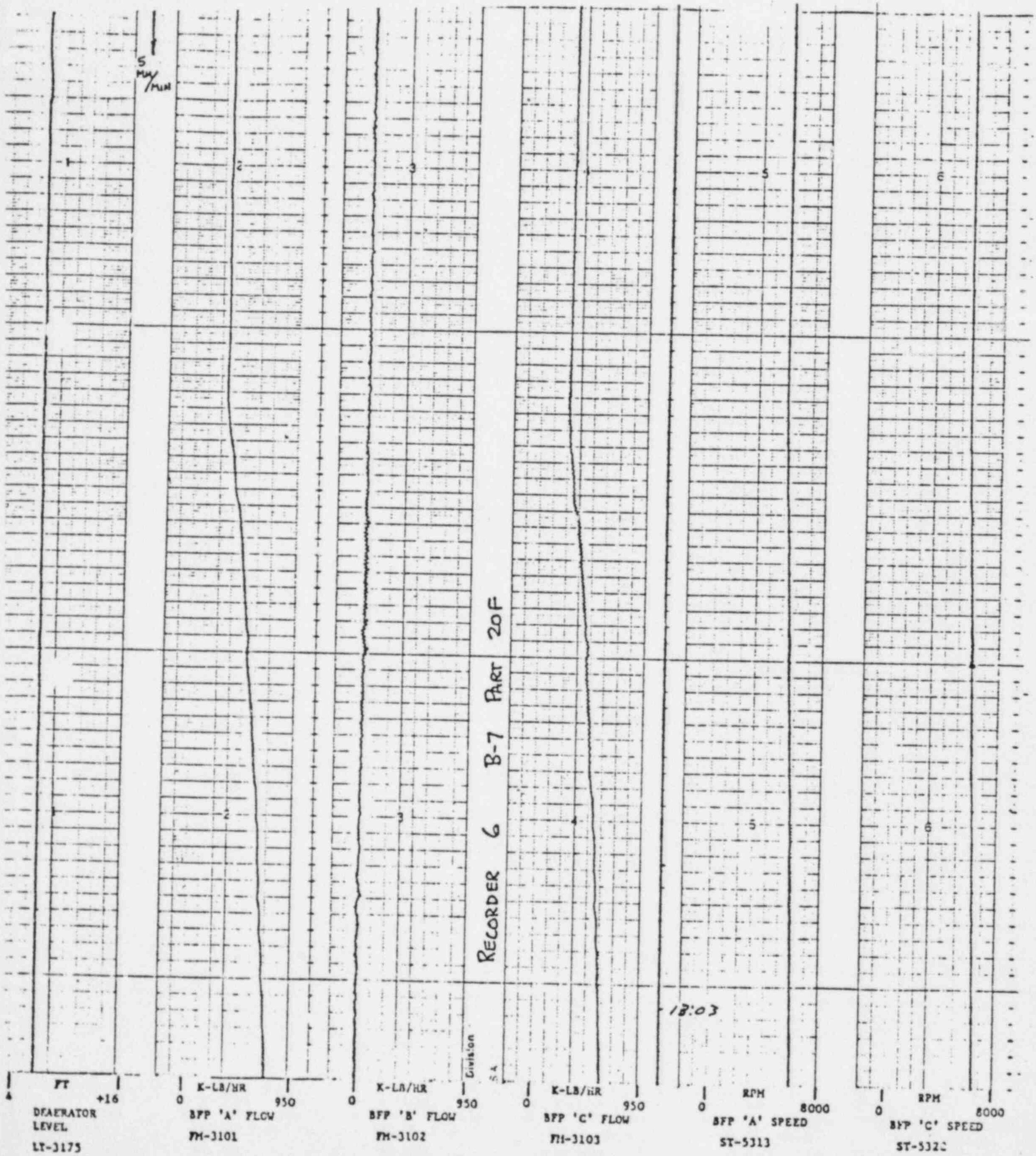

5 MM/MIN
RECORDER 6 B-7 PART 20F
13:03
Division
SA
4
FT
+16
DEAERATOR LEVEL
LT-3175
0
K-LB/HR
950
BFP 'A' FLOW
FM-3101
0
K-LB/HR
950
BFP 'B' FLOW
FM-3102
0
K-LB/HR
950
BFP 'C' FLOW
FM-3103
0
RPM
8000
BFP 'A' SPEED
ST-5313
0
RPM
8000
BFP 'C' SPEED
ST-532?
1
2
3
4
5
6

Fig. B-7.20F.6

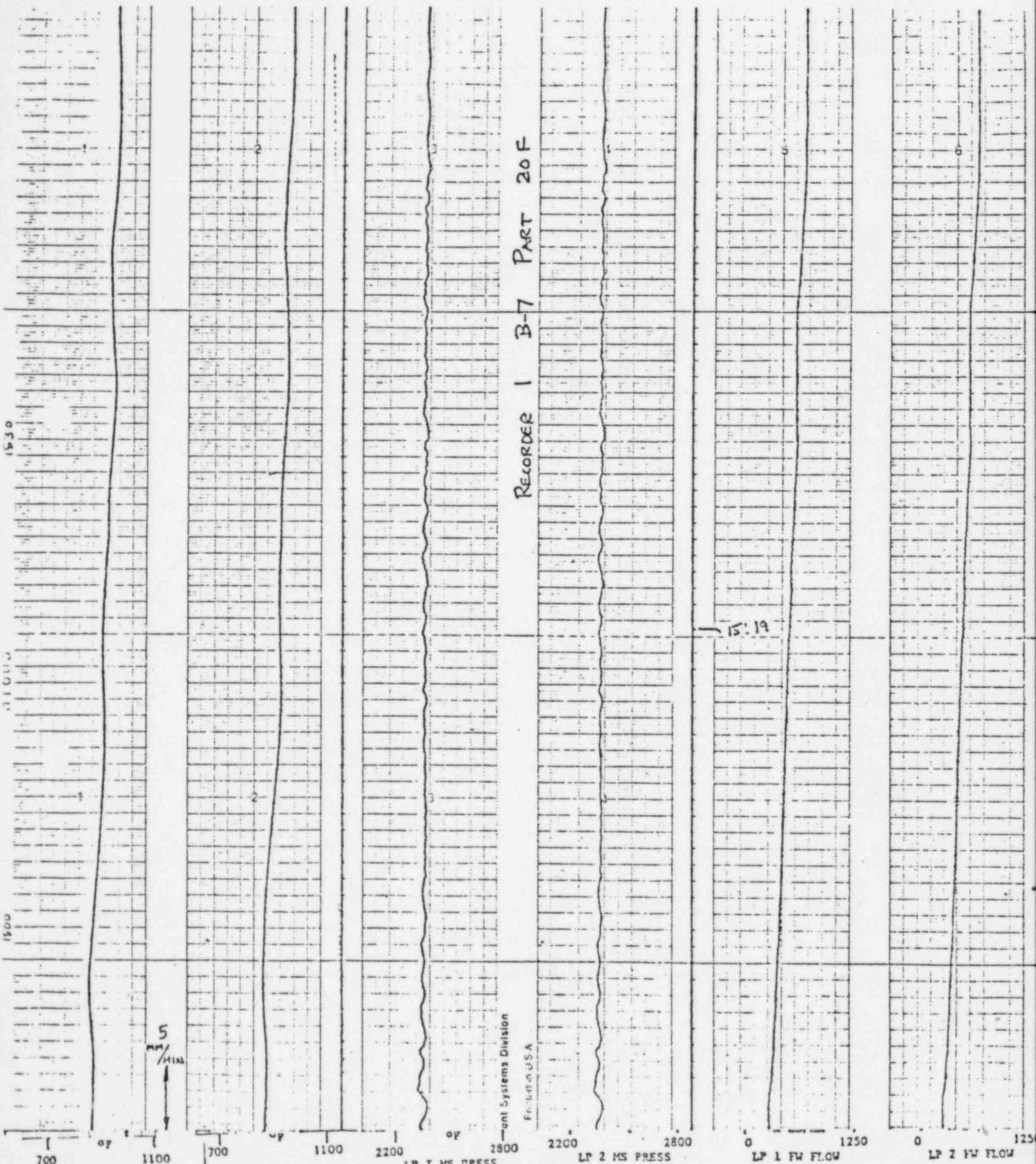

RECORDER 1 B-7 PART 20F
1530
1500
15:19
5 MM/MIN
1
2
3
4
5
6
°F
700
1100
LP 1 MS TEMP
TM-2225-2
700
1100
LP 2 MS TEMP
TM-2226-2
2200
2800
LP 1 MS PRESS
PT-2229
2200
2800
LP 2 MS PRESS
PT-2230
0
1250
LP 1 FW FLOW
FM-2205-1
0
1250
LP 2 FW FLOW
FM-2206-1
Systems Division
USA

Fig. B-7.20F.7

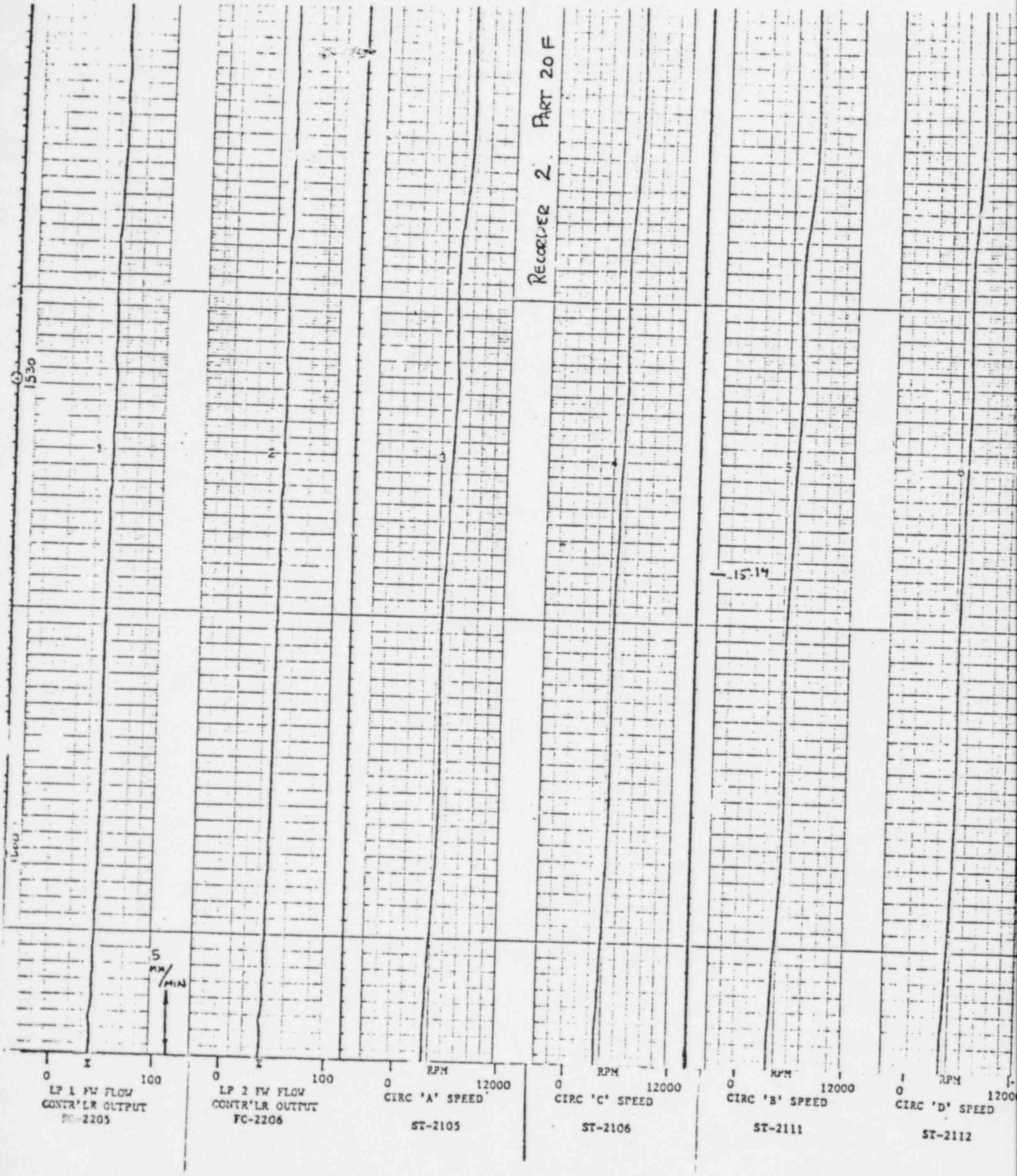

RECORDER 2 PART 20F
1530
1500
15:14
1
2
3
4
5
6
5 MM/MIN
0
I
100
LP 1 FW FLOW CONTR'LR OUTPUT
FC-2205
0
I
100
LP 2 FW FLOW CONTR'LR OUTPUT
FC-2206
0
RPM
12000
CIRC 'A' SPEED
ST-2105
0
RPM
12000
CIRC 'C' SPEED
ST-2106
0
RPM
12000
CIRC 'B' SPEED
ST-2111
0
RPM
CIRC 'D' SPEED
ST-2112

Fig. B-7.20F.8

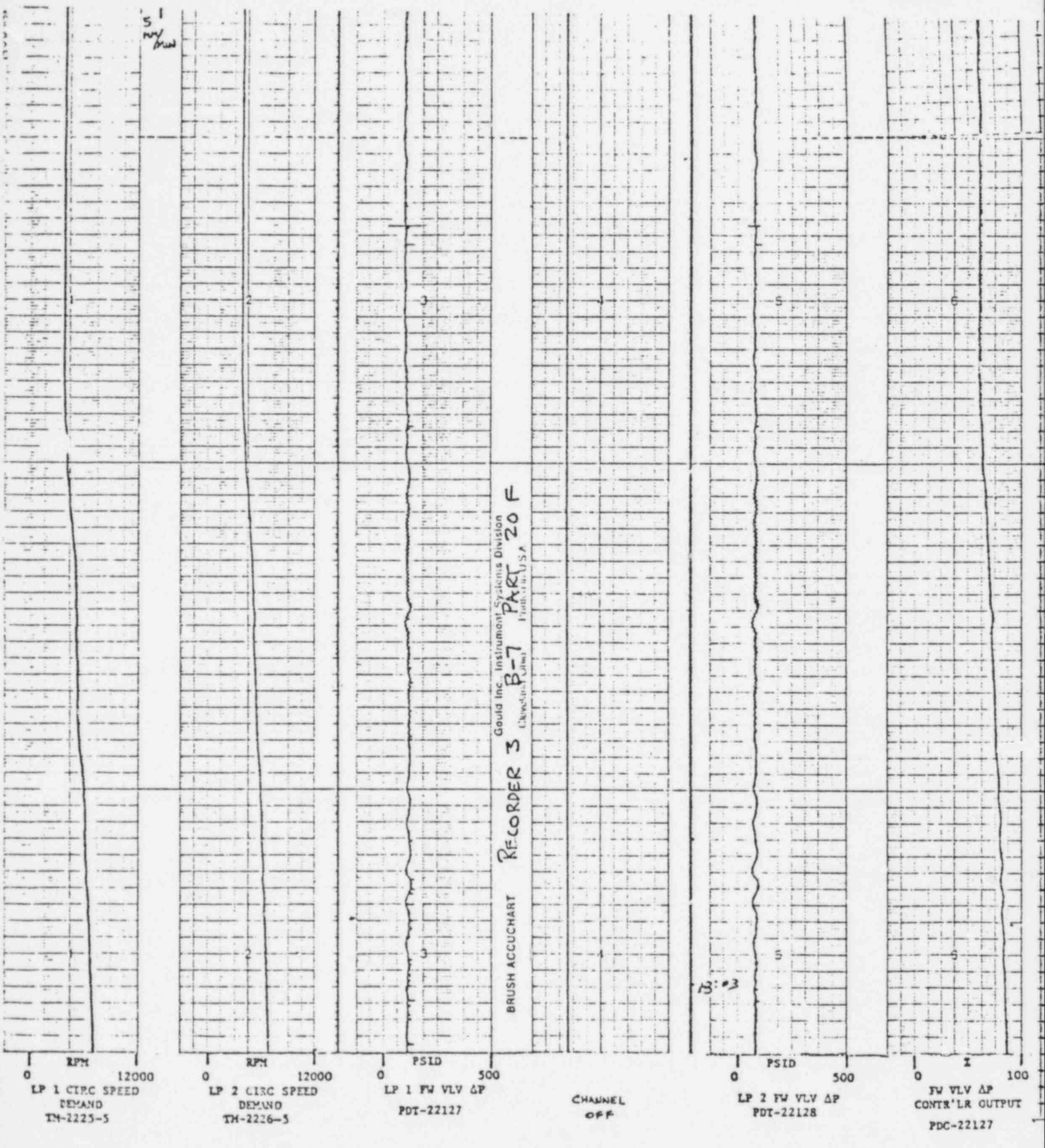

5 mm/min
2
3
4
5
6
Gould Inc. Instrument Systems Division
Cleveland, Ohio U.S.A.
BRUSH ACCUCHART
RECORDER 3 B-7 PART 20 F
B:03
0
RPM
12000
LP 1 CIRC SPEED DEMAND
TM-2225-5
0
RPM
12000
LP 2 CIRC SPEED DEMAND
TM-2226-5
0
PSID
500
LP 1 FW VLV ΔP
PDT-22127
CHANNEL OFF
0
PSID
500
LP 2 FW VLV ΔP
PDT-22128
0
%
100
FW VLV ΔP CONTR'LR OUTPUT
PDC-22127

Fig. B-7.20F.9

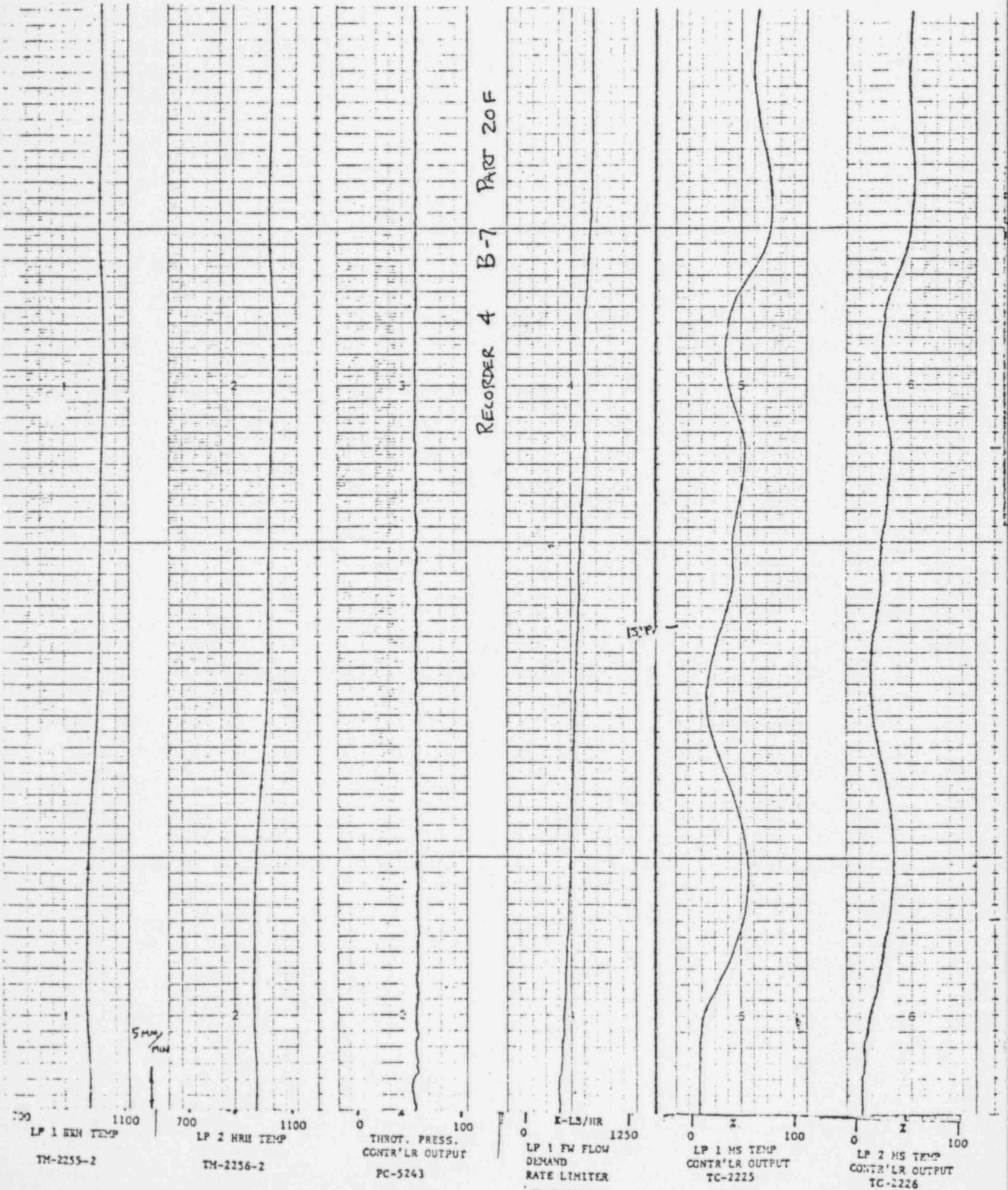

RECORDER 4 B-7 PART 2 OF
1
2
3
4
5
6
15:P/
5MM/MIN
700
1100
LP 1 HRH TEMP
TM-2255-2
700
1100
LP 2 HRH TEMP
TM-2256-2
0
100
THROT. PRESS.
CONTR'LR OUTPUT
PC-5243
K-LB/HR
0
1250
LP 1 FW FLOW
DEMAND
RATE LIMITER
FM-2205-5
0
%
100
LP 1 MS TEMP
CONTR'LR OUTPUT
TC-2225
0
%
100
LP 2 MS TEMP
CONTR'LR OUTPUT
TC-2226

Fig. B-7.20F.10

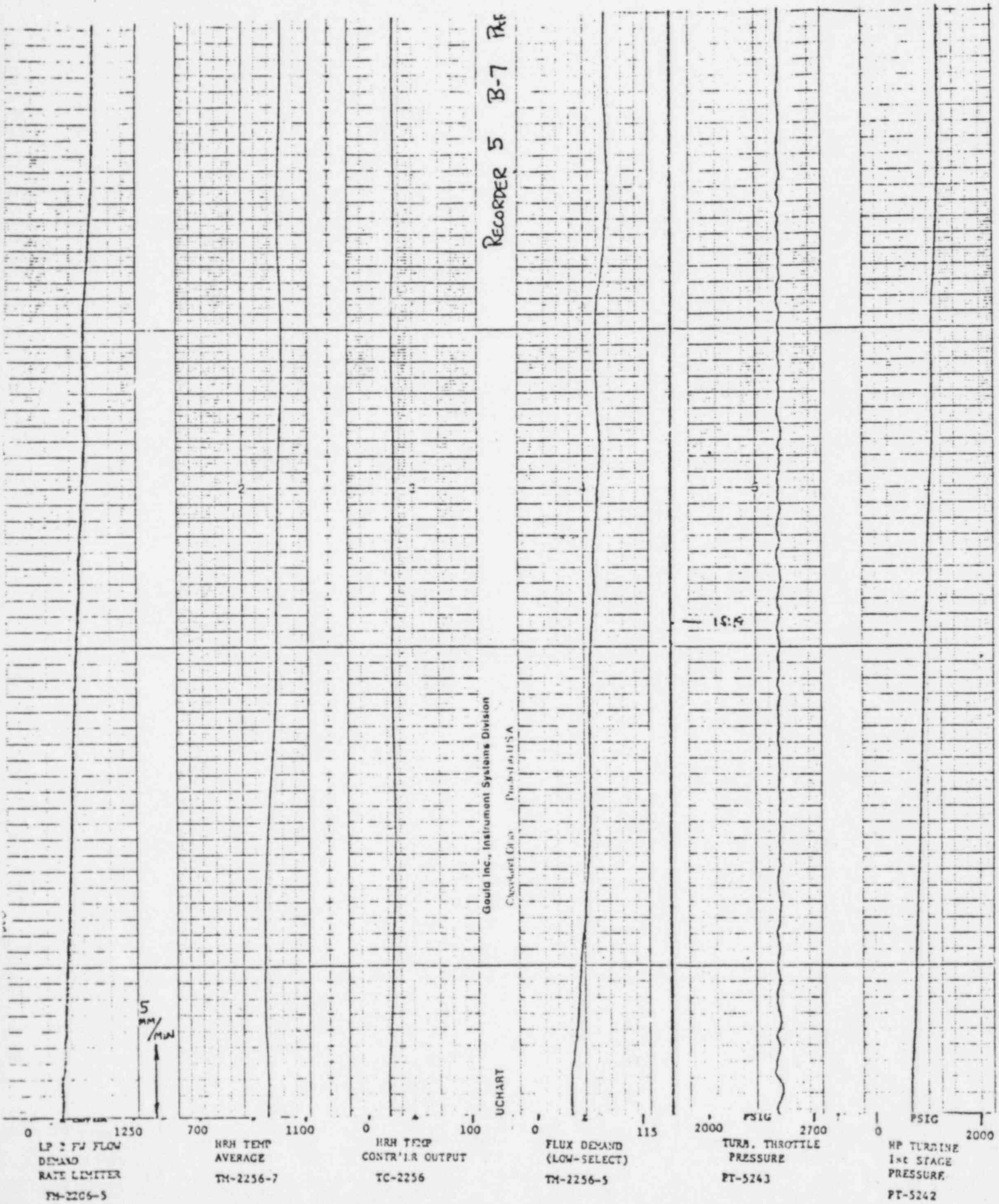

RECORDER 5 B-7 Ref
1
2
3
4
5
— 15:4
Gould Inc., Instrument Systems Division
Cleveland Ohio Printed in USA
UCHART
5 MM/MIN
PSIG
PSIG
0
1250
LP 2 FW FLOW DEMAND RATE LIMITER
FM-2206-5
700
1100
HRH TEMP AVERAGE
TM-2256-7
0
100
HRH TEMP CONTR'LR OUTPUT
TC-2256
0
115
FLUX DEMAND (LOW-SELECT)
TM-2256-5
2000
2700
TURB. THROTTLE PRESSURE
PT-5243
0
2000
HP TURBINE 1st STAGE PRESSURE
PT-5242

Fig. B-7.20F.11

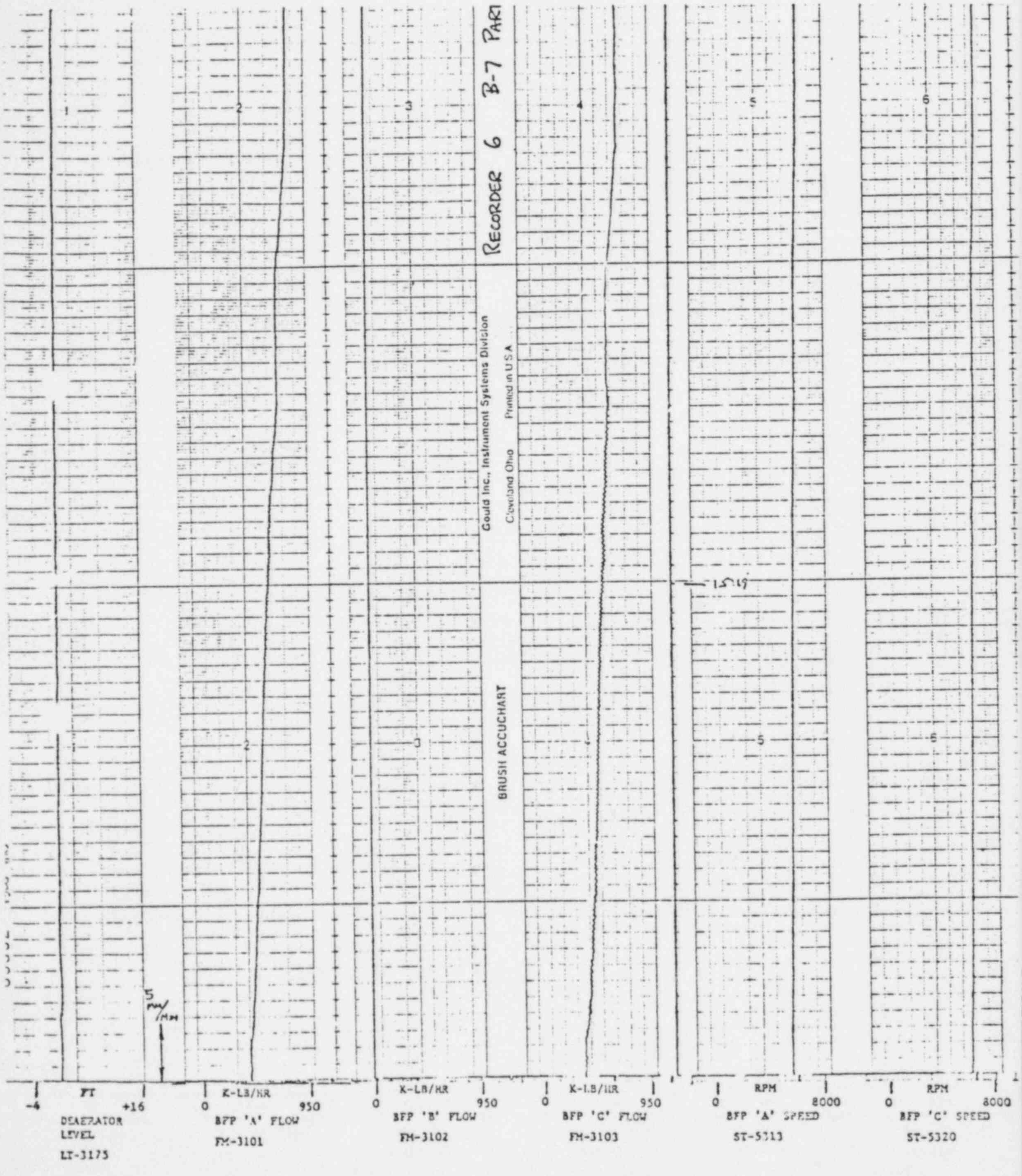

RECORDER 6 B-7 PART
Gould Inc., Instrument Systems Division
Cleveland Ohio Printed in USA
BRUSH ACCUCHART
1 2 3 4 5 6
15:19
5 mm/MIN
-4 FT +16
DEAERATOR LEVEL
LT-3175
0 K-LB/HR 950
BFP 'A' FLOW
FM-3101
0 K-LB/HR 950
BFP 'B' FLOW
FM-3102
0 K-LB/HR 950
BFP 'C' FLOW
FM-3103
0 RPM 8000
BFP 'A' SPEED
ST-5313
0 RPM 8000
BFP 'C' SPEED
ST-5320

Fig. B-7.20F.12

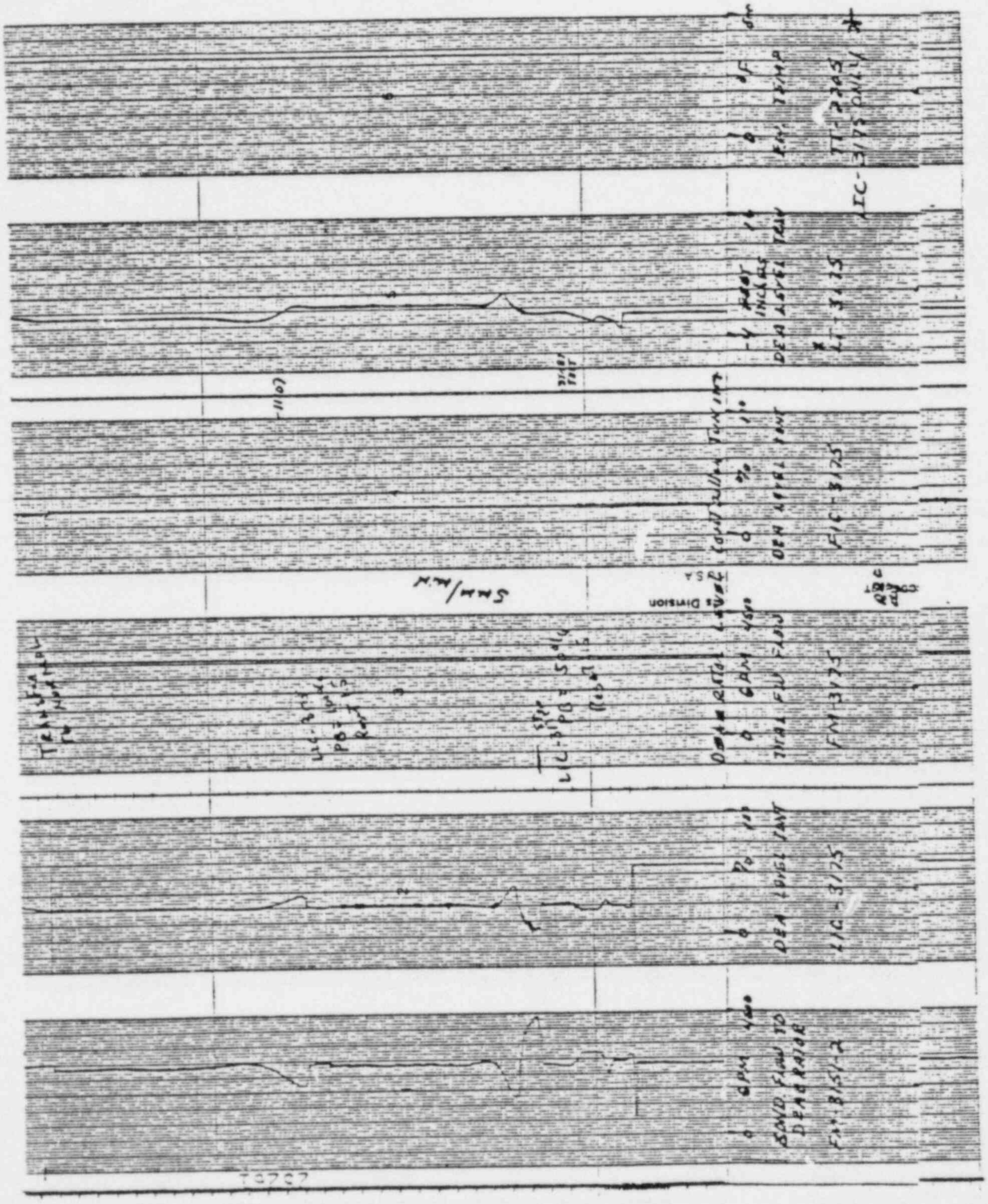

0 GPM 4000
COND. FLOW TO DEAERATOR
FT-3151-2
0 % 100
DEA LEVEL INPUT
LIC-3175
DEAERATOR LEVEL
0 GPM 4500
TOTAL FW FLOW
FM-3175
CONTROLLER TUN INT
0 % 100
DEA LEVEL INPUT
FIC-3175
-4 FOOT INCHES 4
DEA LEVEL TRAN
LT-3175
0 °F 600
FW TEMP
TT-2205
LIC-3175 ONLY
TRANSFER TO NORMAL
LIC-3175 PB = 100% Reset 1.5
STEP LIC-3175 PB = 50% Reset 1.5
5mm/min
1107
TS727
Division
TSA

Fig. B-7.3D.1

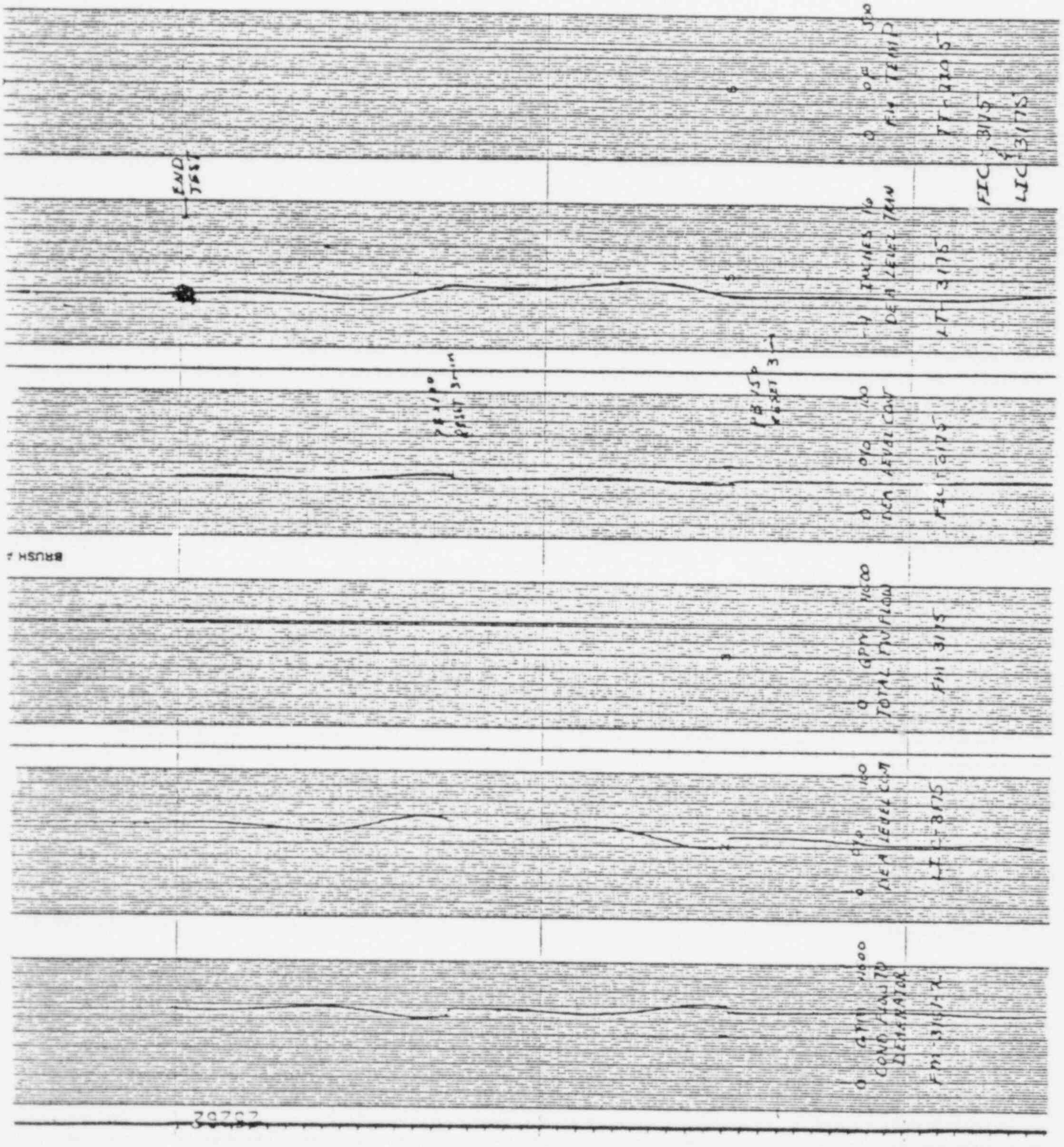

END TEST
0 °F 500
FW TEMP
TT 3105
FIC 3105
LIC 3175
4 INCHES 16
DEA LEVEL TRAN
LT 3175
PB 120
RESET 3-min
PB 45P
RESET 3
0 0/0 100
DEA LEVEL CONT
FIC 3175
BRUSH
0 GPM 1600
TOTAL FW FLOW
FM 3175
0 0/0 100
DEA LEVEL CONT
LIC 3175
0 GPM 1600
COND FLOW TO
DEAERATOR
FM 3104

Fig. B-7.3D.2

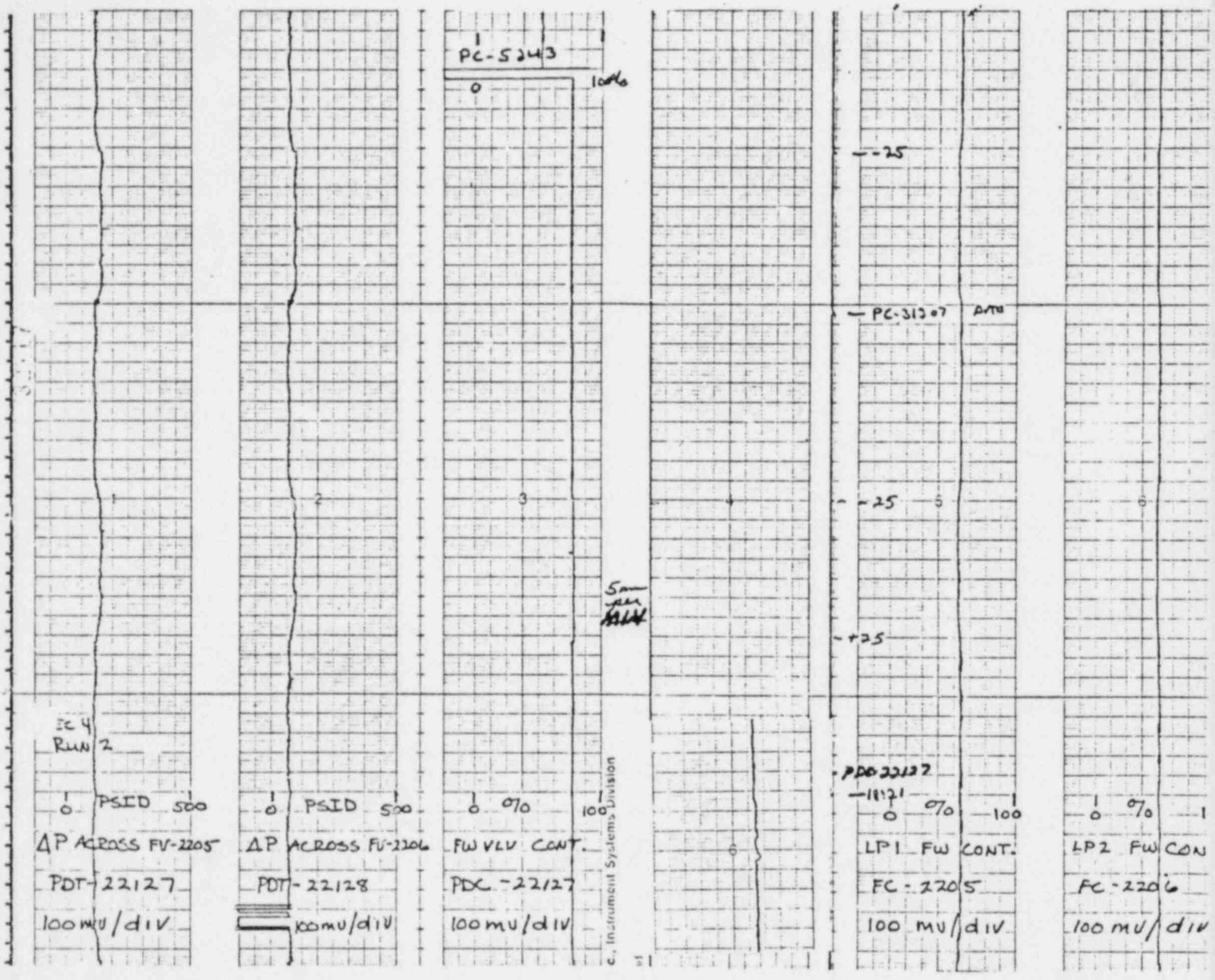

PC-5243
0
100%
--25
-PC-31207 AUTO
--25
5mm per MIN
-+25
IC 4
RUN 2
0 PSID 500
ΔP ACROSS FV-2205
PDT-22127
100mV/dIV
0 PSID 500
ΔP ACROSS FV-2206
PDT-22128
100mV/dIV
0 % 100
FW VLV CONT.
PDC-22127
100mV/dIV
Instrument Systems Division
PDC 22127
-18:21
0 % 100
LP1 FW CONT.
FC-2205
100 mV/div
0 % 1
LP2 FW CON
FC-2206
100 mV/div
1
2
3
4
5
6

Fig. B-7.7D.1

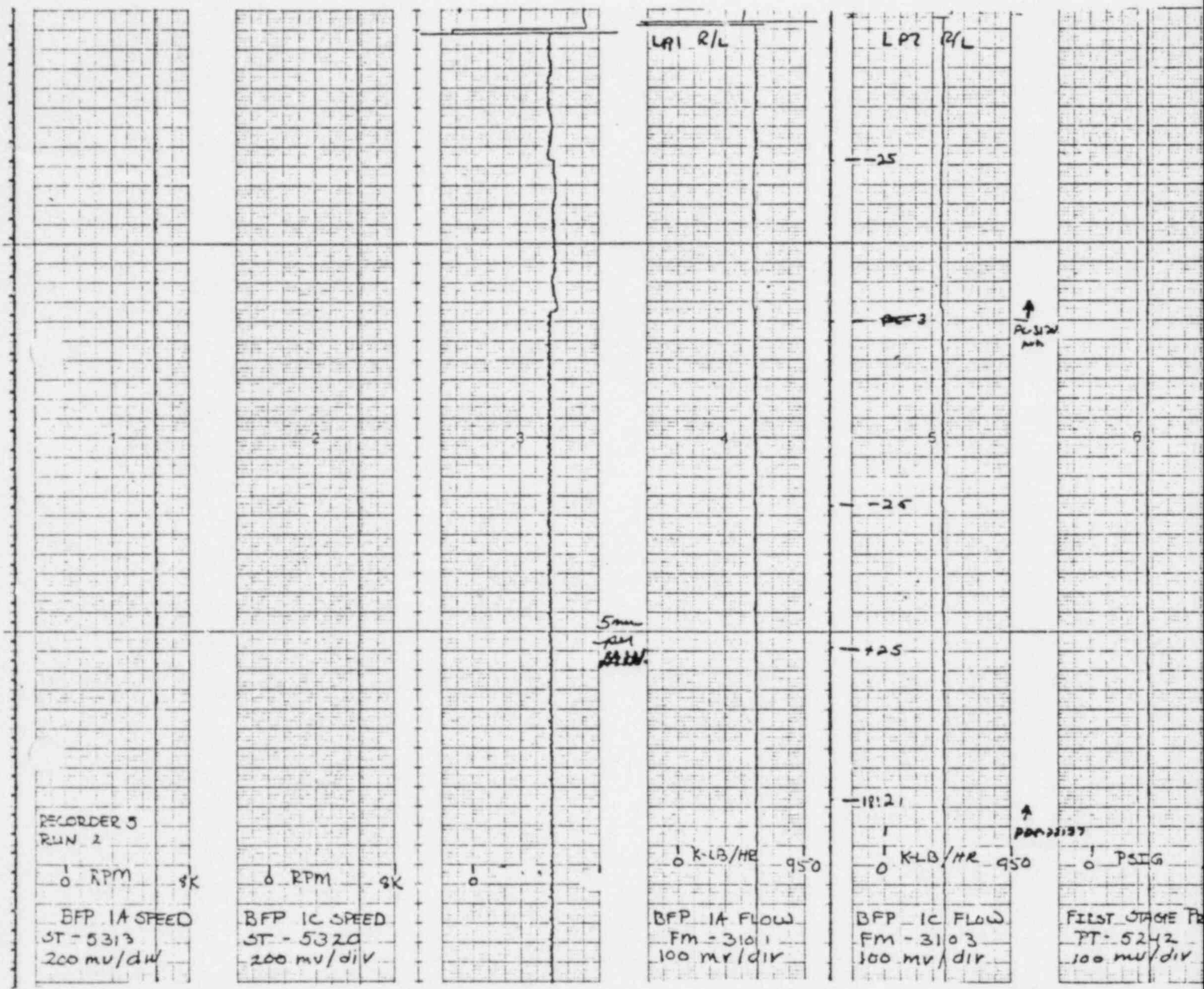

LP1 R/L
LP2 R/L
-25
-25
+25
18:21
1
2
3
4
5
6
5mm
RECORDER 5
RUN 2
0 RPM 8K
0 RPM 8K
0
0 K-LB/HR 950
0 K-LB/HR 950
0 PSIG
BFP 1A SPEED
ST-5313
200 mv/div
BFP 1C SPEED
ST-5320
200 mv/div
BFP 1A FLOW
Fm-3101
100 mv/div
BFP 1C FLOW
Fm-3103
100 mv/div
FIRST STAGE P
PT-5242
100 mv/div

Fig. B-7.7D.2

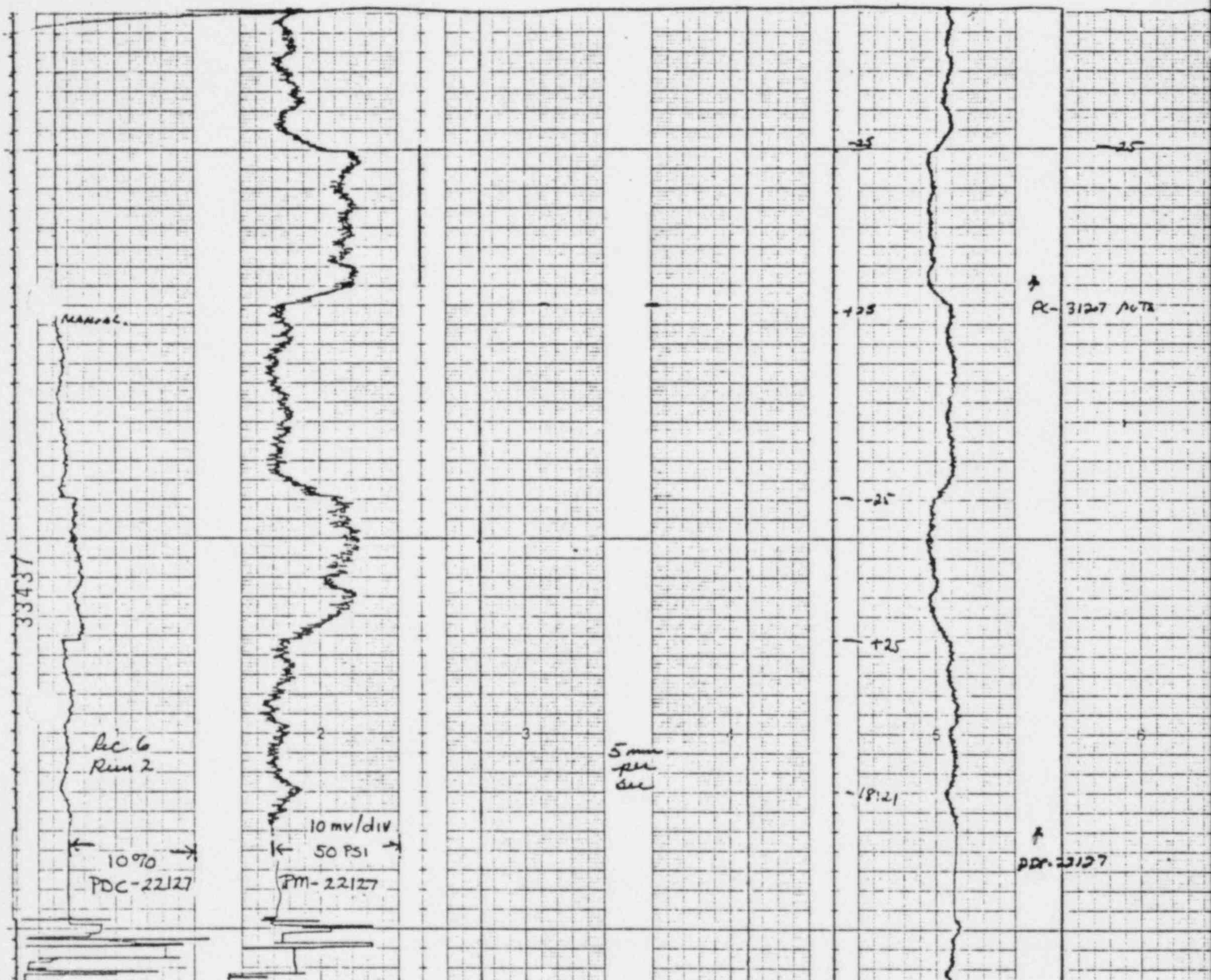

33437
MANUAL
Rec 6
Run 2
10%
PDC-22127
10 mv/div
50 PSI
PM-22127
2
3
5 mm per sec
4
-25
+25
-25
+25
-18:21
5
6
-25
PC-31207 AUTO
PDC-22127
Division
SA

Fig. B-7.7D.3

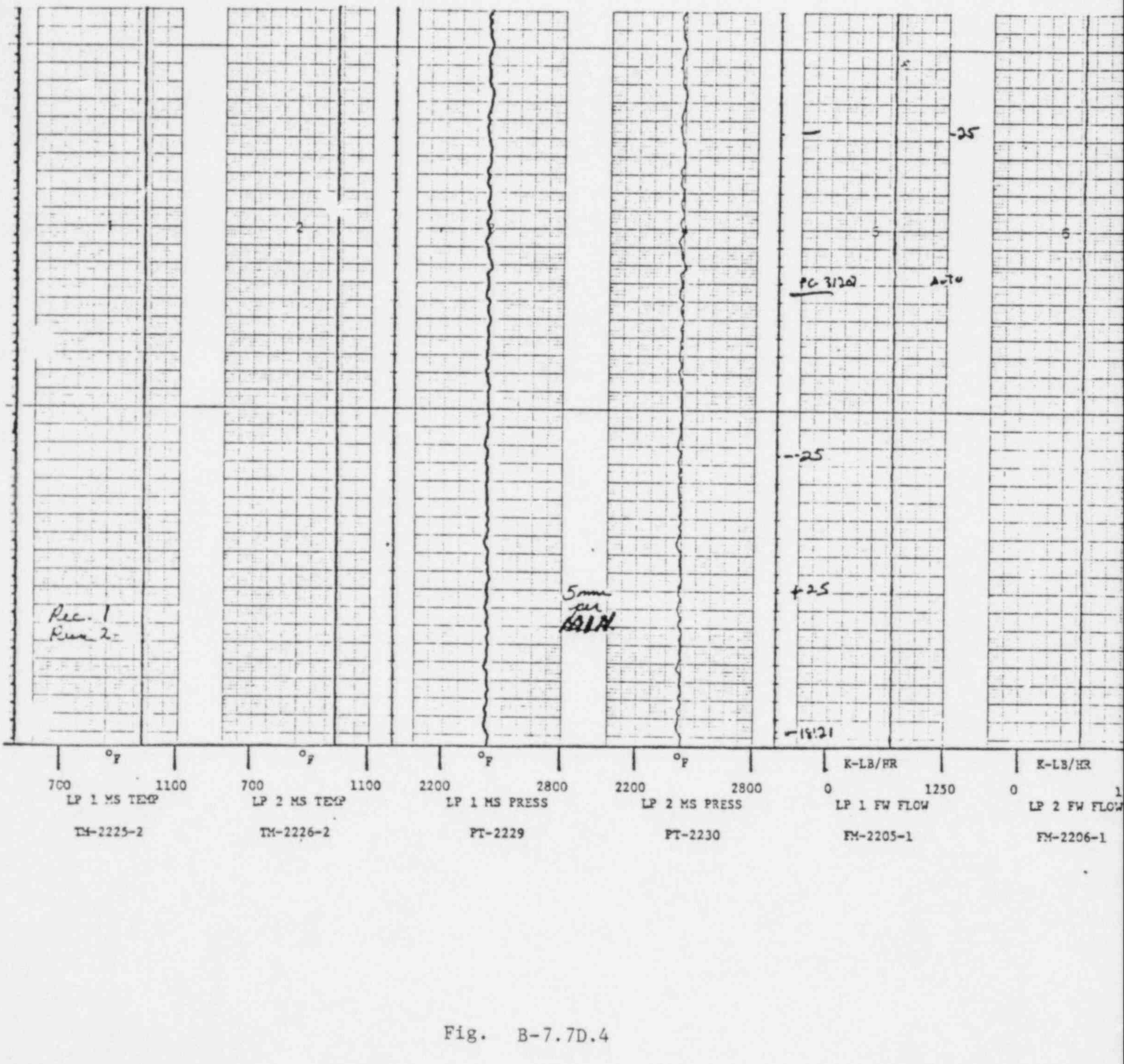

1
2
5
6
-25
PC 3120
Auto
--25
+25
-18:21
Rec. 1
Run 2
5mm per
°F
700
1100
LP 1 MS TEMP
TM-2225-2
°F
700
1100
LP 2 MS TEMP
TM-2226-2
°F
2200
2800
LP 1 MS PRESS
PT-2229
°F
2200
2800
LP 2 MS PRESS
PT-2230
K-LB/HR
0
1250
LP 1 FW FLOW
FM-2205-1
K-LB/HR
0
LP 2 FW FLOW
FM-2206-1

Fig. B-7.7D.4

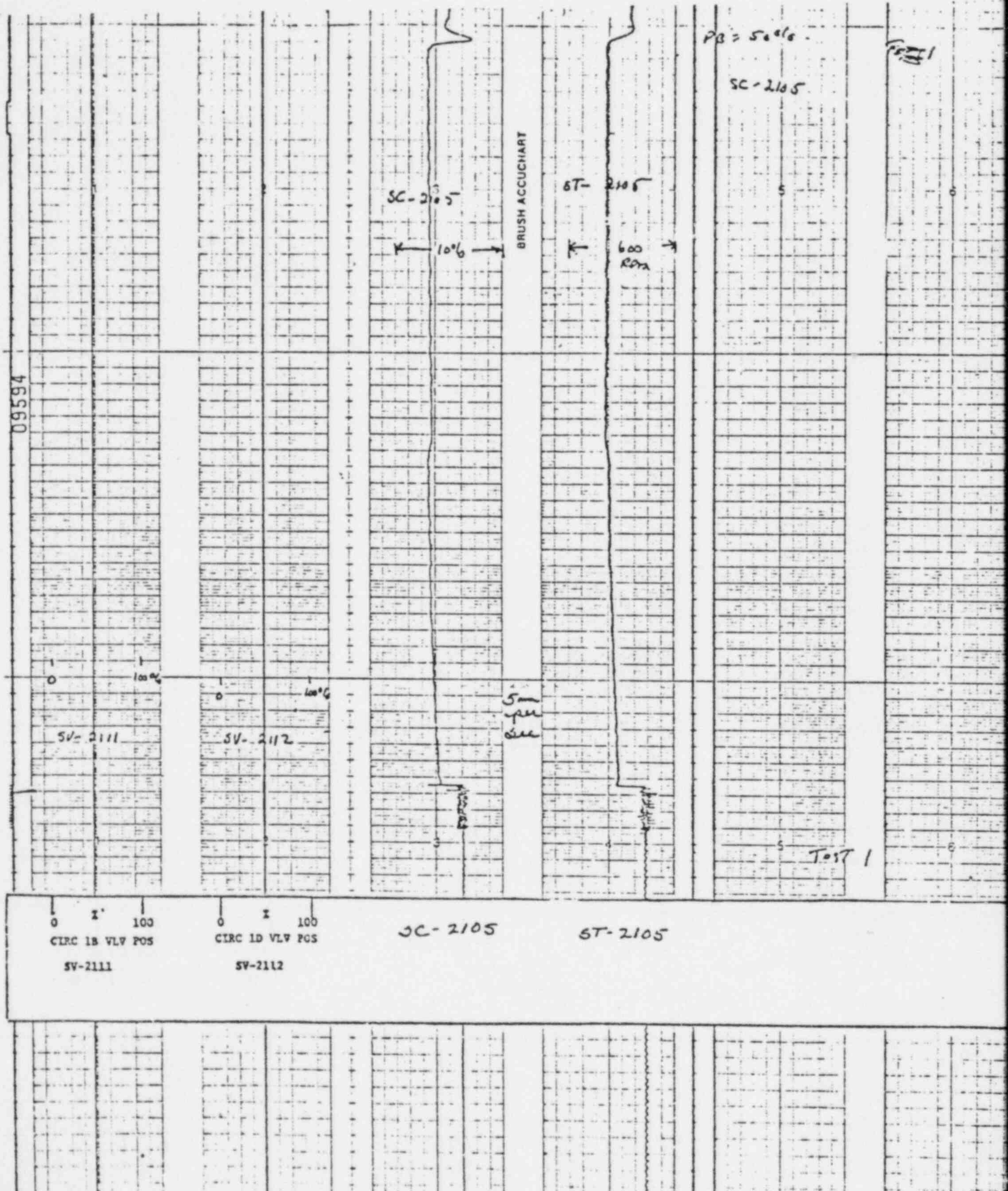

PB = 50%
SC-2105
SC-2105
10%
BRUSH ACCUCHART
ST-2105
600 Rpm
09594
0
100%
0
100%
SV-2111
SV-2112
5mm per sec
Test 1
0
I
100
CIRC 1B VLV POS
SV-2111
0
I
100
CIRC 1D VLV POS
SV-2112
SC-2105
ST-2105

Fig. B-7.8D.1

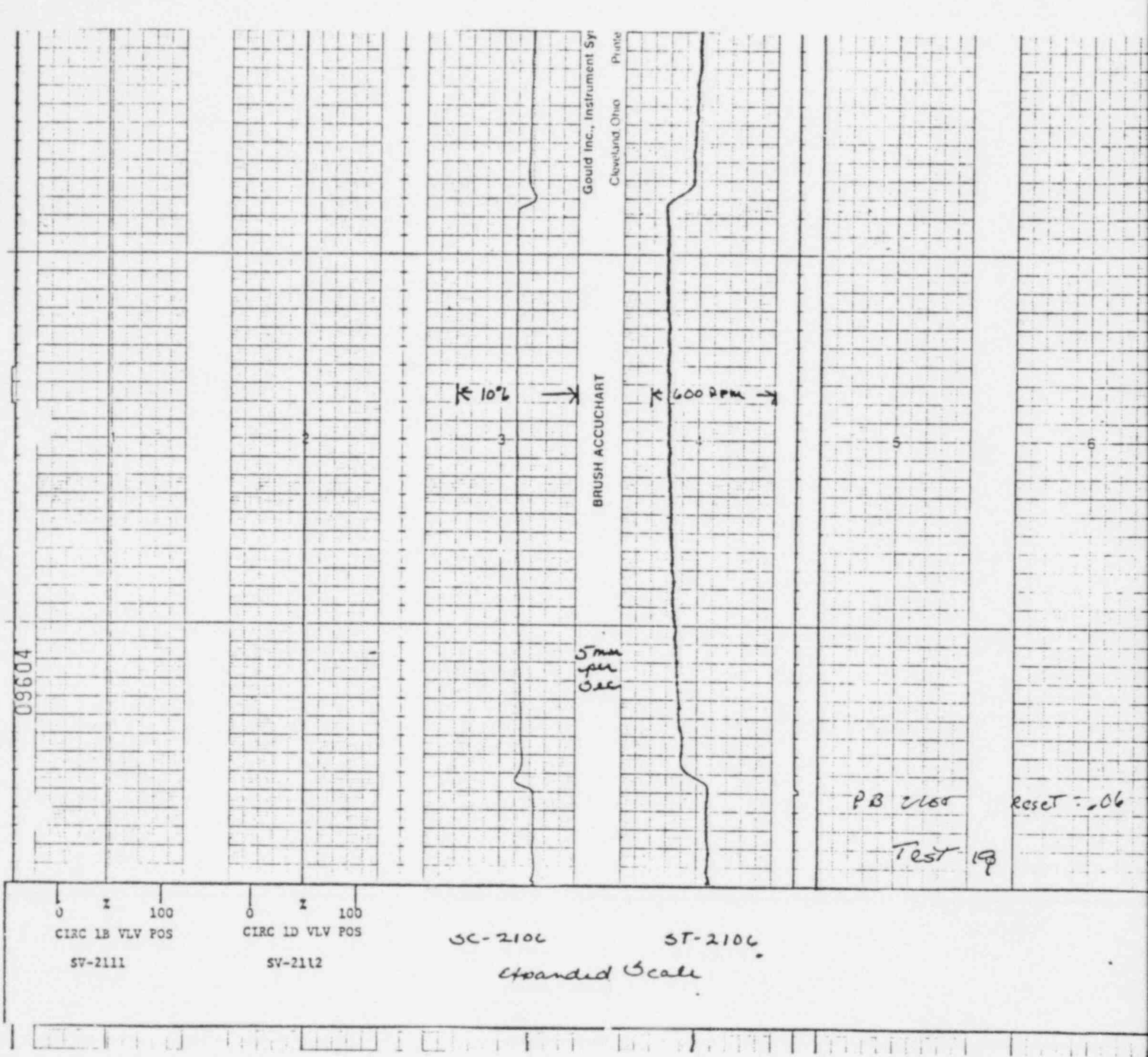

Gould Inc., Instrument Sy
Cleveland Ohio
Printe
BRUSH ACCUCHART
09604
1
2
3
4
5
6
← 10% →
← 600 RPM →
5mm per sec
PB 2100
Reset = .06
Test 1B
0
%
100
CIRC 1B VLV POS
SV-2111
0
%
100
CIRC 1D VLV POS
SV-2112
SC-2106
ST-2106
Expanded Scale

Fig. B-7.8D.2

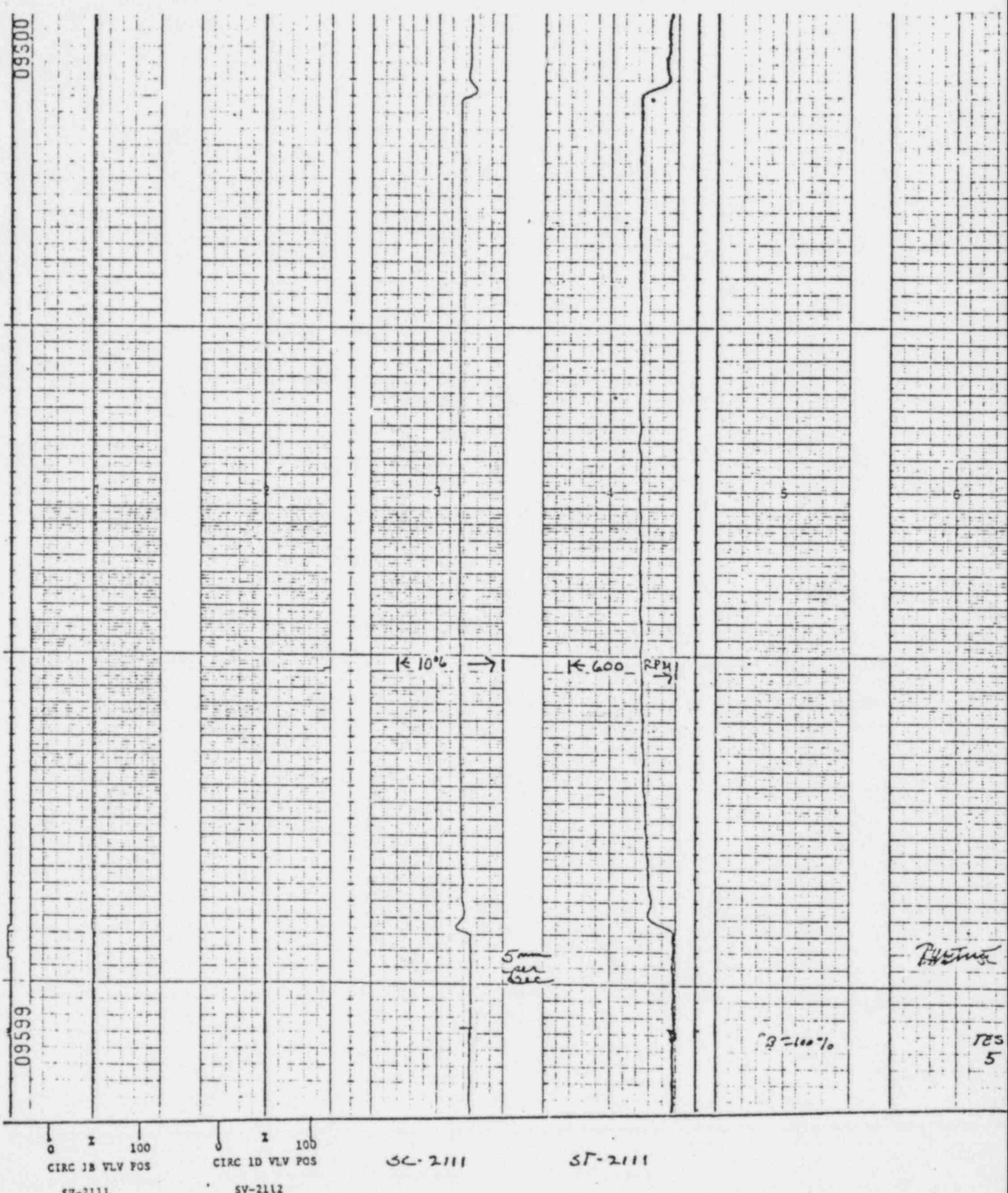

09500
09599
2
3
4
5
6
|← 10% →|
|← 600 RPM →|
5 mm per sec
B = 100%
TES 5
0 % 100
CIRC 1B VLV POS
SV-2111
0 % 100
CIRC 1D VLV POS
SV-2112
SC-2111
ST-2111

Fig. B-7.8D.3

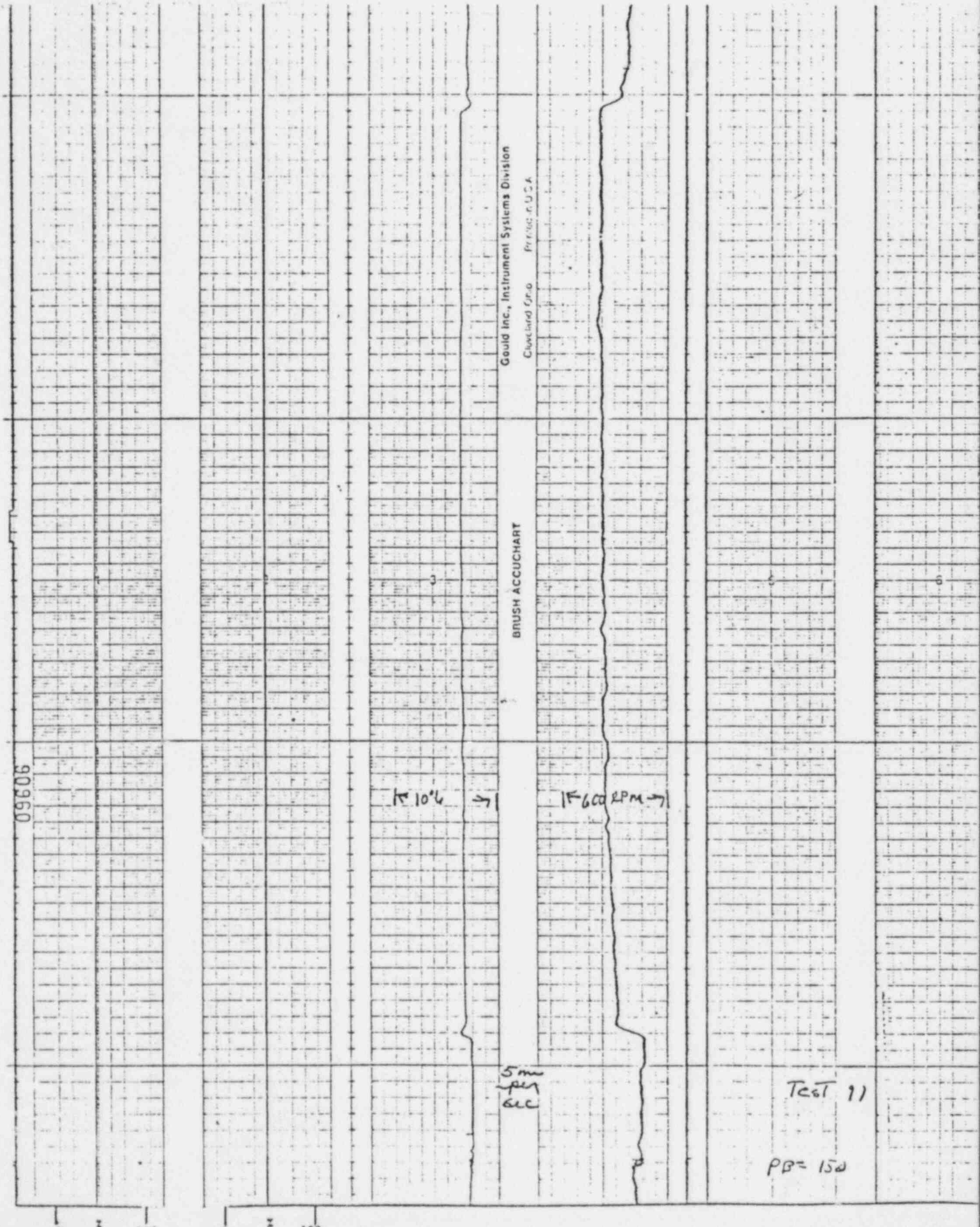

Gould Inc., Instrument Systems Division
Cleveland Ohio Printed in U.S.A.
BRUSH ACCUCHART
09606
1F 10% →|
1F 600 RPM →|
5 mm per sec
Test 11
PB= 150
0 % 100
CIRC 1B VLV POS
SV-2111
0 % 100
CIRC 1D VLV POS
SV-2112
SC-2112
ST-2112

Fig. B-7.8D.4

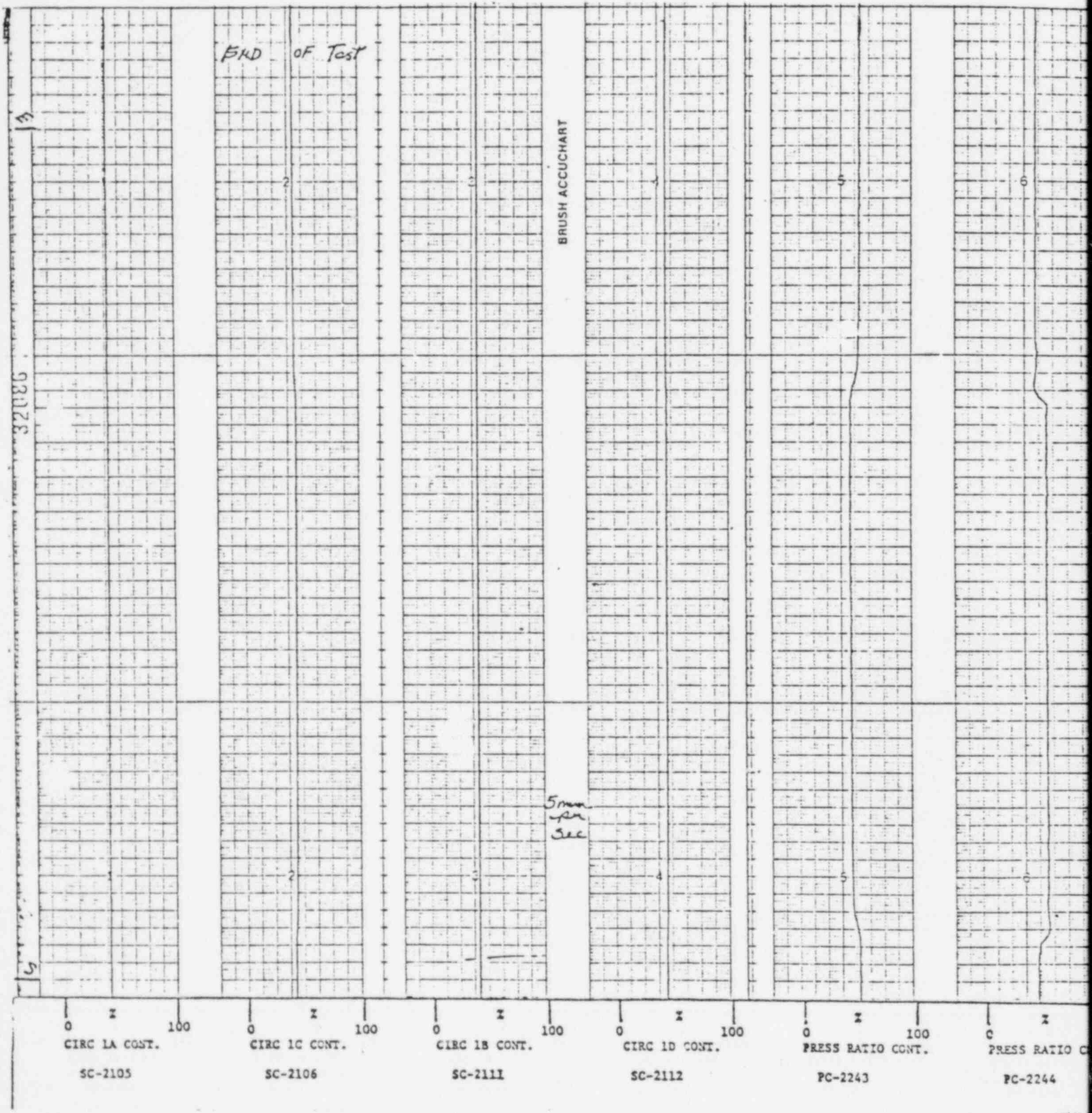

End of Test
BRUSH ACCUCHART
5mm per sec
3
5
1
2
3
4
5
6
0
%
100
CIRC 1A CONT.
SC-2105
0
%
100
CIRC 1C CONT.
SC-2106
0
%
100
CIRC 1B CONT.
SC-2111
0
%
100
CIRC 1D CONT.
SC-2112
0
%
100
PRESS RATIO CONT.
PC-2243
0
%
PRESS RATIO C
PC-2244

Fig. B-7.10D.1

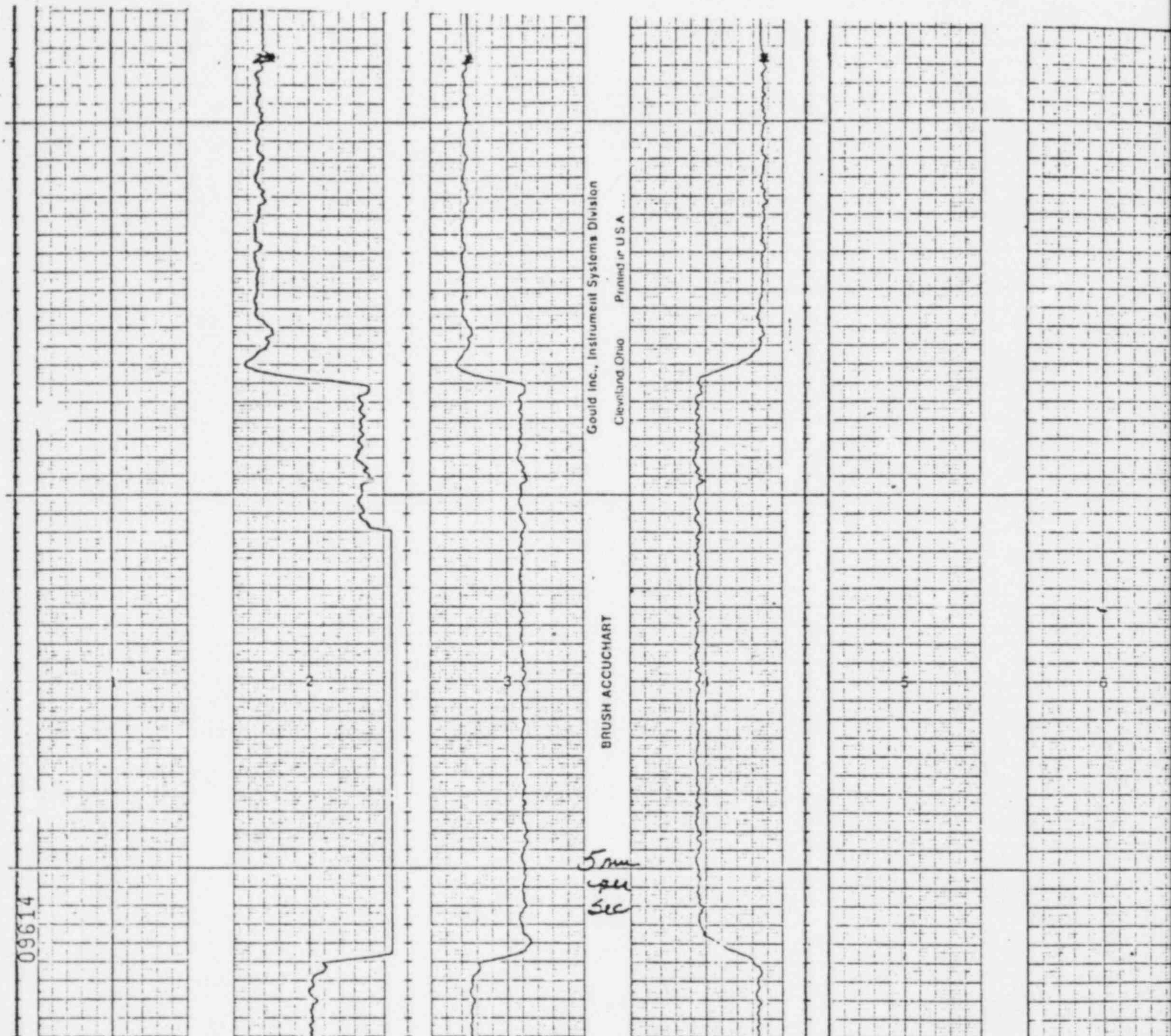

Gould Inc., Instrument Systems Division
Cleveland Ohio
Printed in USA
BRUSH ACCUCHART
2
3
4
5
6
09614
5 mm per sec
← 10% →
← .1 →
PY-2244
PC-22-44
pm-2244
REC6 Run

Fig. B-7.10D.2

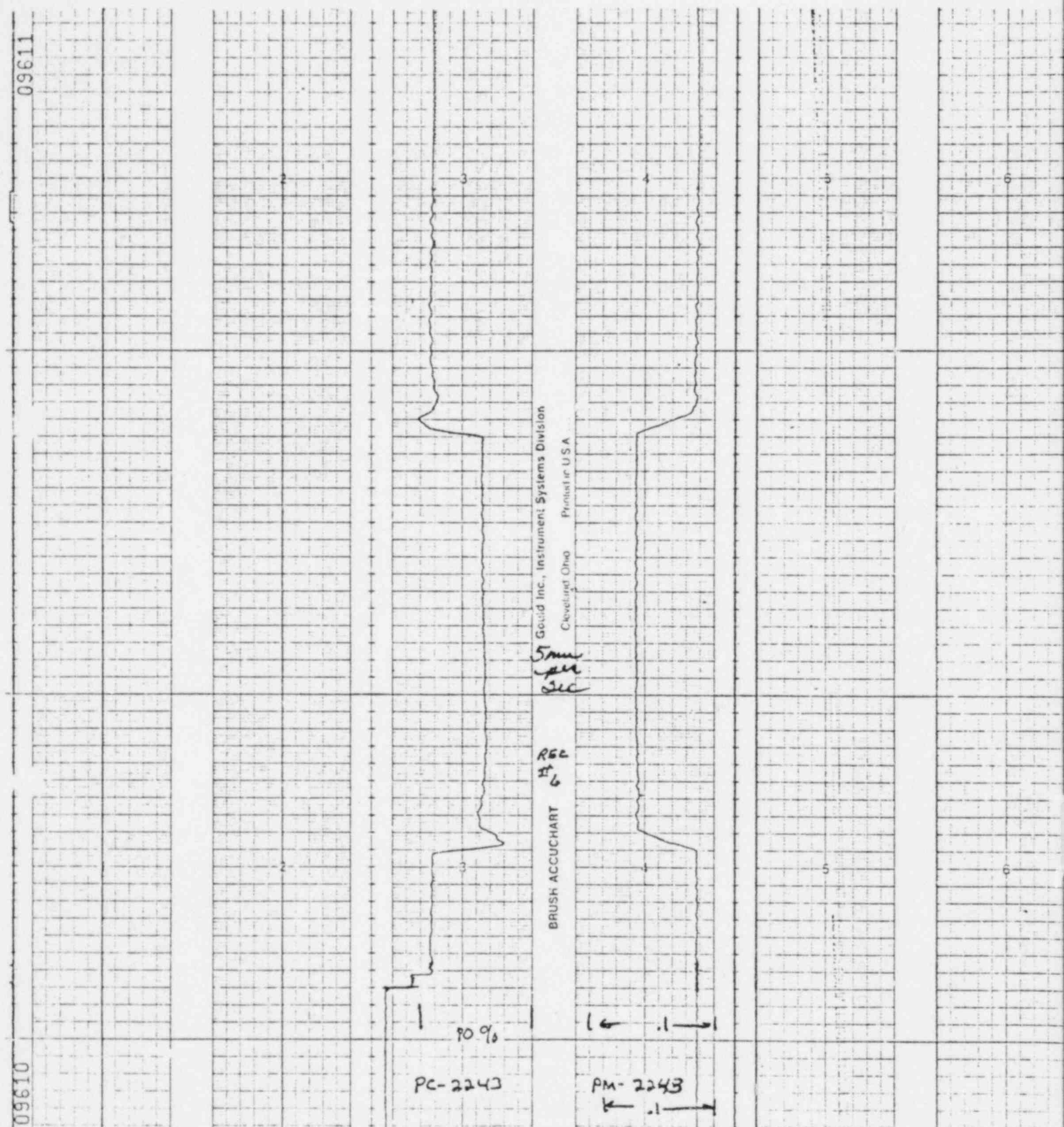

09611
2
3
4
5
6
Gould Inc., Instrument Systems Division
Cleveland Ohio
Printed in U.S.A.
5mm per sec
REC #6
BRUSH ACCUCHART
2
3
4
5
6
90%
|← .1 →|
PC-2243
PM-2243
|← .1 →|
09610
REC 6 Run 1 PC-2243

Fig. B-7.10D.3

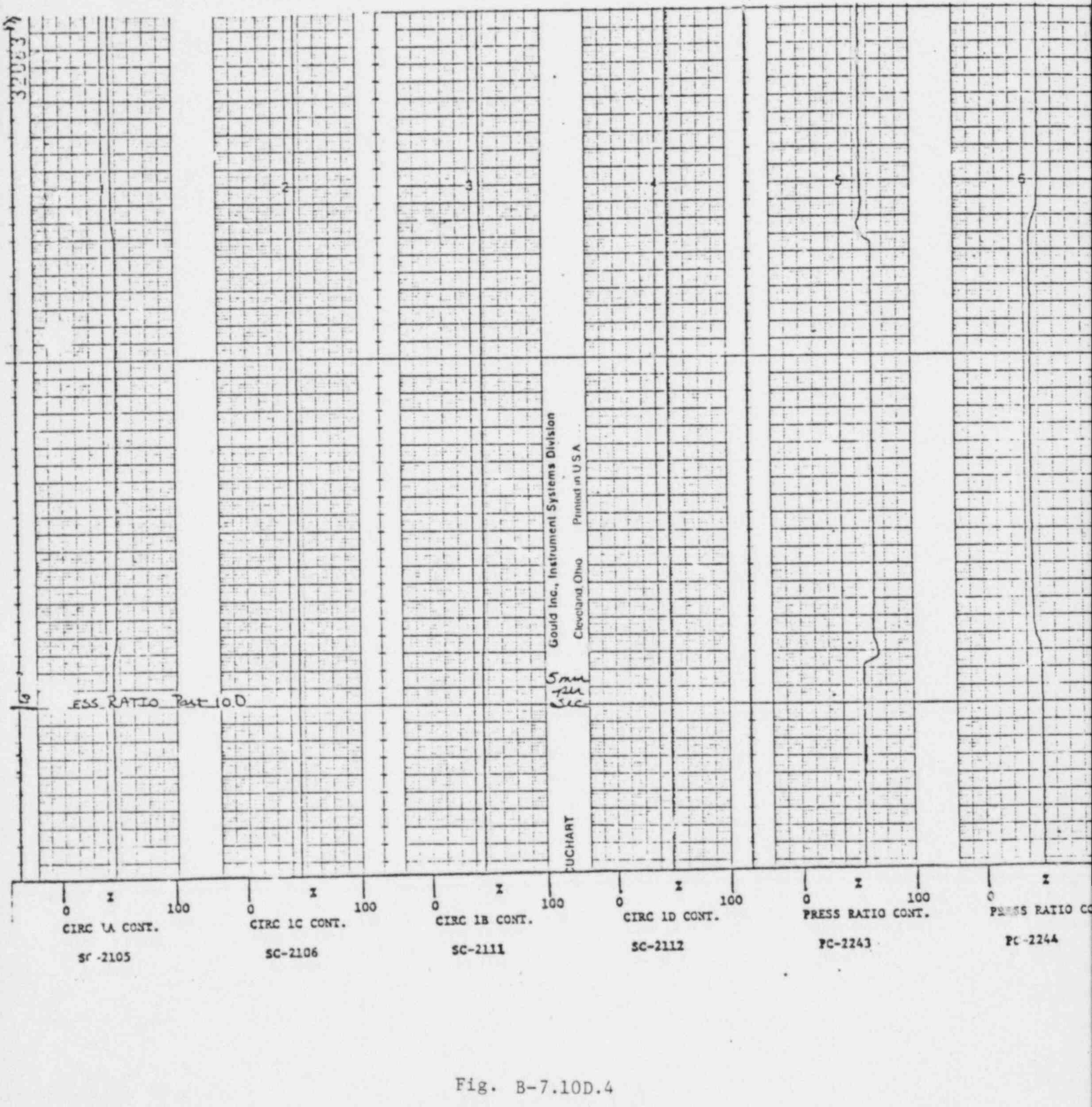

32063
1
2
3
4
5
6
ESS RATIO Past 10.D
Gould Inc., Instrument Systems Division
Cleveland Ohio Printed in U.S.A.
5mm per sec
UCHART
0 % 100
CIRC 1A CONT.
SC-2105
0 % 100
CIRC 1C CONT.
SC-2106
0 % 100
CIRC 1B CONT.
SC-2111
0 % 100
CIRC 1D CONT.
SC-2112
0 % 100
PRESS RATIO CONT.
PC-2243
0 %
PRESS RATIO CO
PC-2244

Fig. B-7.10D.4


Gould Inc., Instrument Systems Division
Cleveland Ohio Printed in USA
BRUSH ACCUCHART
2
3
4
5
6
100 175 250 325 400
0 100%
HC5207
0 100%
HC5208
400 °F 800
TT 5216
Cold Reheat
Temperature
0 100%
TIC 5226-1
-09:32
Reheat
bypass
Desuperheater
Temperature
Controller
100 400
TT 5226-1
Reheat
bypass
Temp.

Fig. B-7. .2C.1

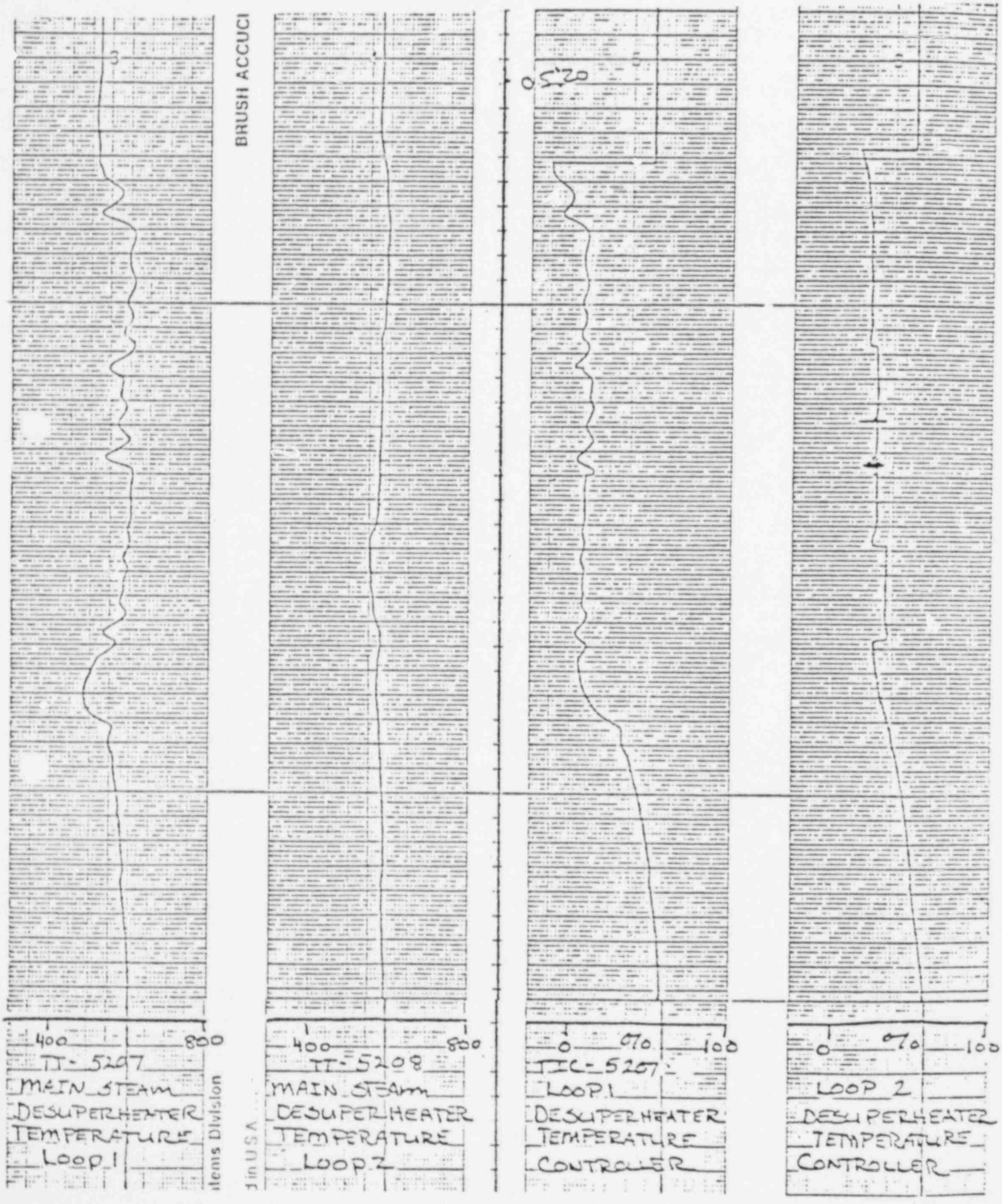

BRUSH ACCUCI
05:20
400
800
TT-5207
MAIN STEAM
DESUPERHEATER
TEMPERATURE
LOOP 1
tems Division
d in U S A
400
800
TT-5208
MAIN STEAM
DESUPERHEATER
TEMPERATURE
LOOP 2
0
%
100
TIC-5207
LOOP 1
DESUPERHEATER
TEMPERATURE
CONTROLLER
0
%
100
LOOP 2
DESUPERHEATER
TEMPERATURE
CONTROLLER

Fig. B-7.13A.1

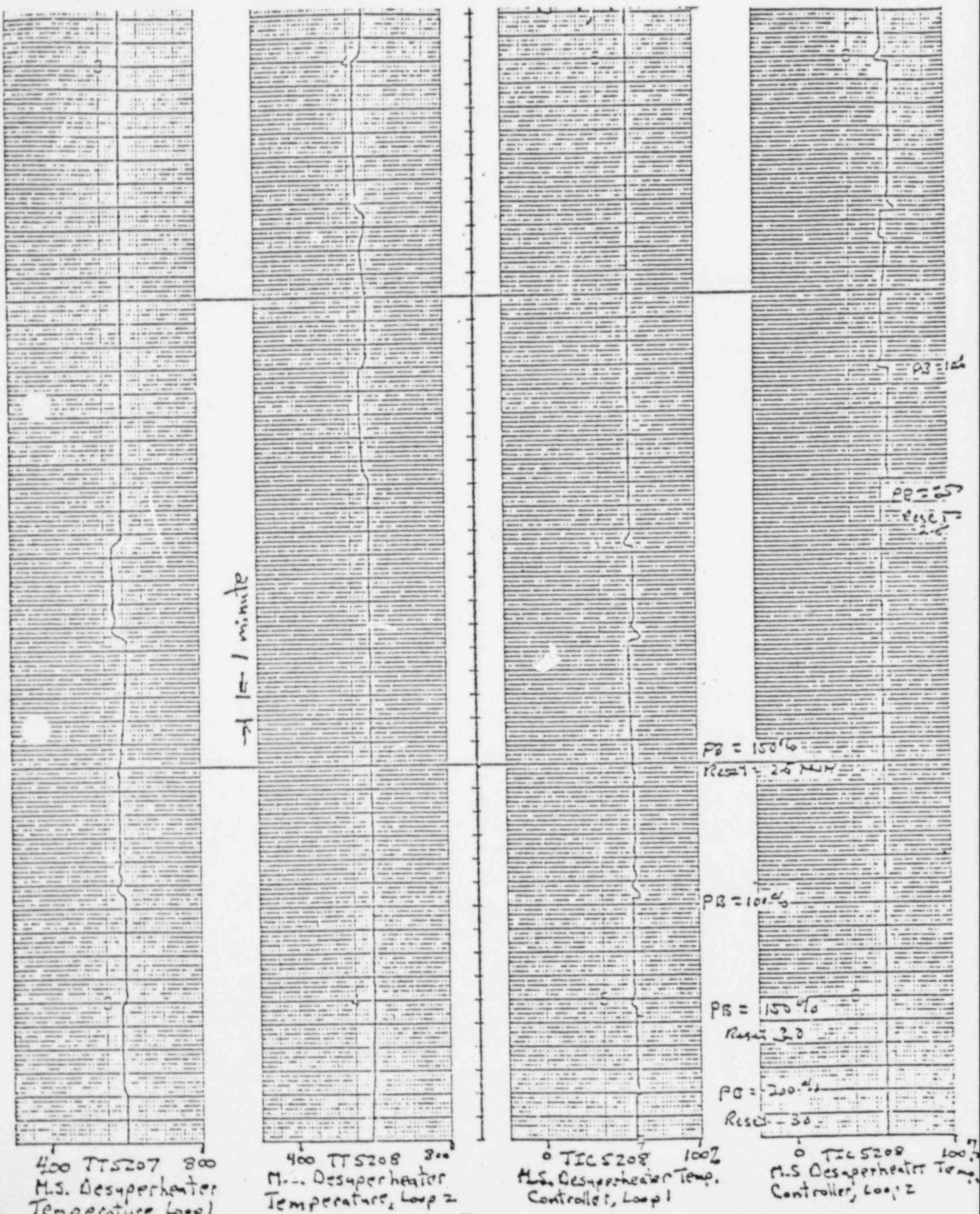

1 = 1 minute
PB = 100
PB = 75
Reset = 2.6
PB = 150%
Reset = 25 MIN
PB = 100%
PB = 150%
Reset 3.0
PB = 200%
Reset - 30
400 TT5207 800
M.S. Desuperheater Temperature, Loop 1
400 TT5208 800
M.S. Desuperheater Temperature, Loop 2
0 TIC5208 100%
M.S. Desuperheater Temp. Controller, Loop 1
0 TIC5208 100%
M.S Desuperheater Temp. Controller, Loop 2

Fig. B-7.13A-2

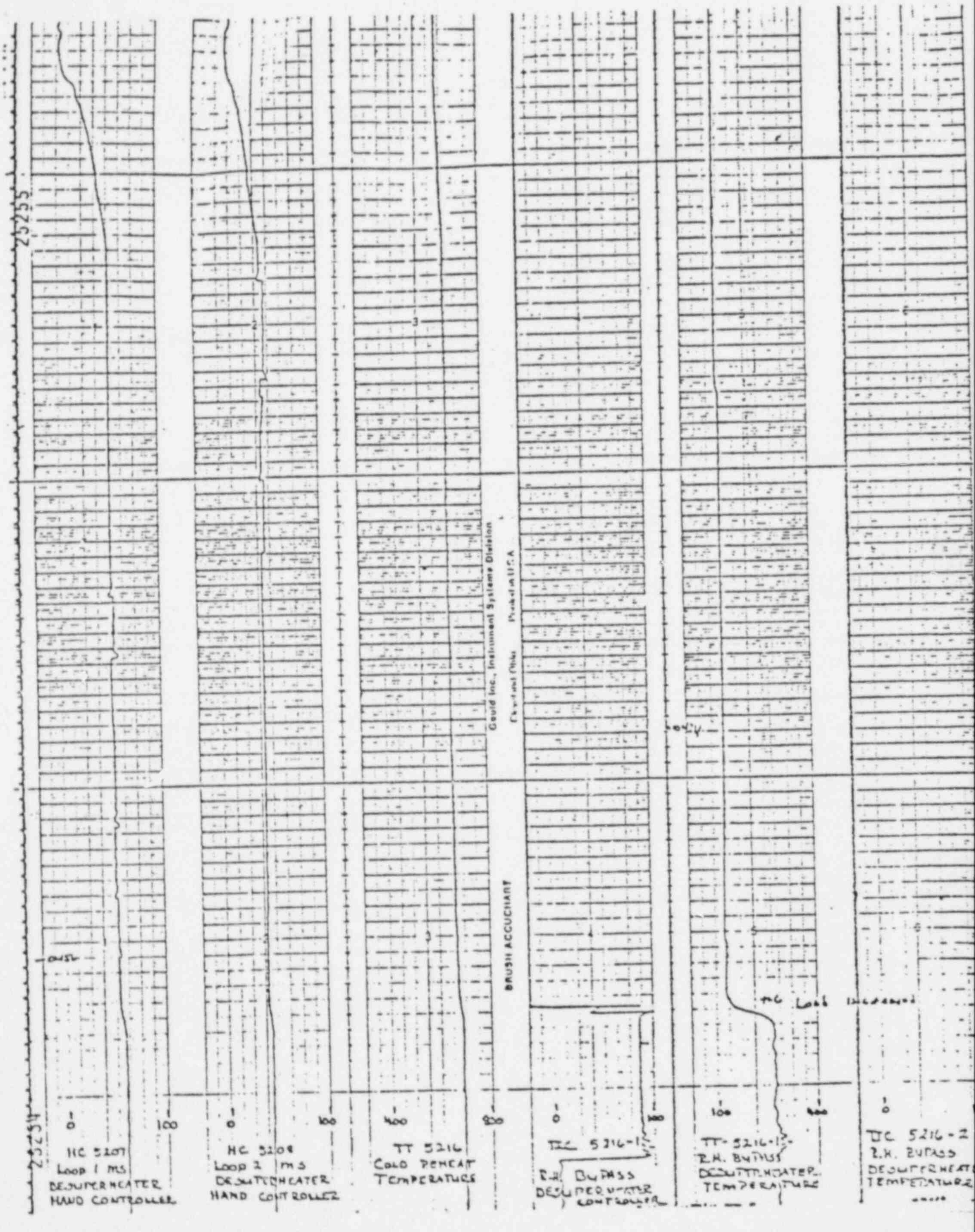

25255
25254
ONSL
TIC Load increased
0
100
HC 5207
Loop 1 MS
DESUPERHEATER
HAND CONTROLLER
0
100
HC 5208
Loop 2 MS
DESUPERHEATER
HAND CONTROLLER
400
800
TT 5216
COLD REHEAT
TEMPERATURE
Gould Inc., Instrument Systems Division
Cleveland Ohio Printed in USA
BRUSH ACCUCHART
0
100
TIC 5216-1
R.H. BYPASS
DESUPERHEATER
CONTROLLER
100
400
TT-5216-1
R.H. BYPASS
DESUPERHEATER
TEMPERATURE
0
TIC 5216-2
R.H. BYPASS
DESUPERHEATER
TEMPERATURE

Fig. B-7.13A.3

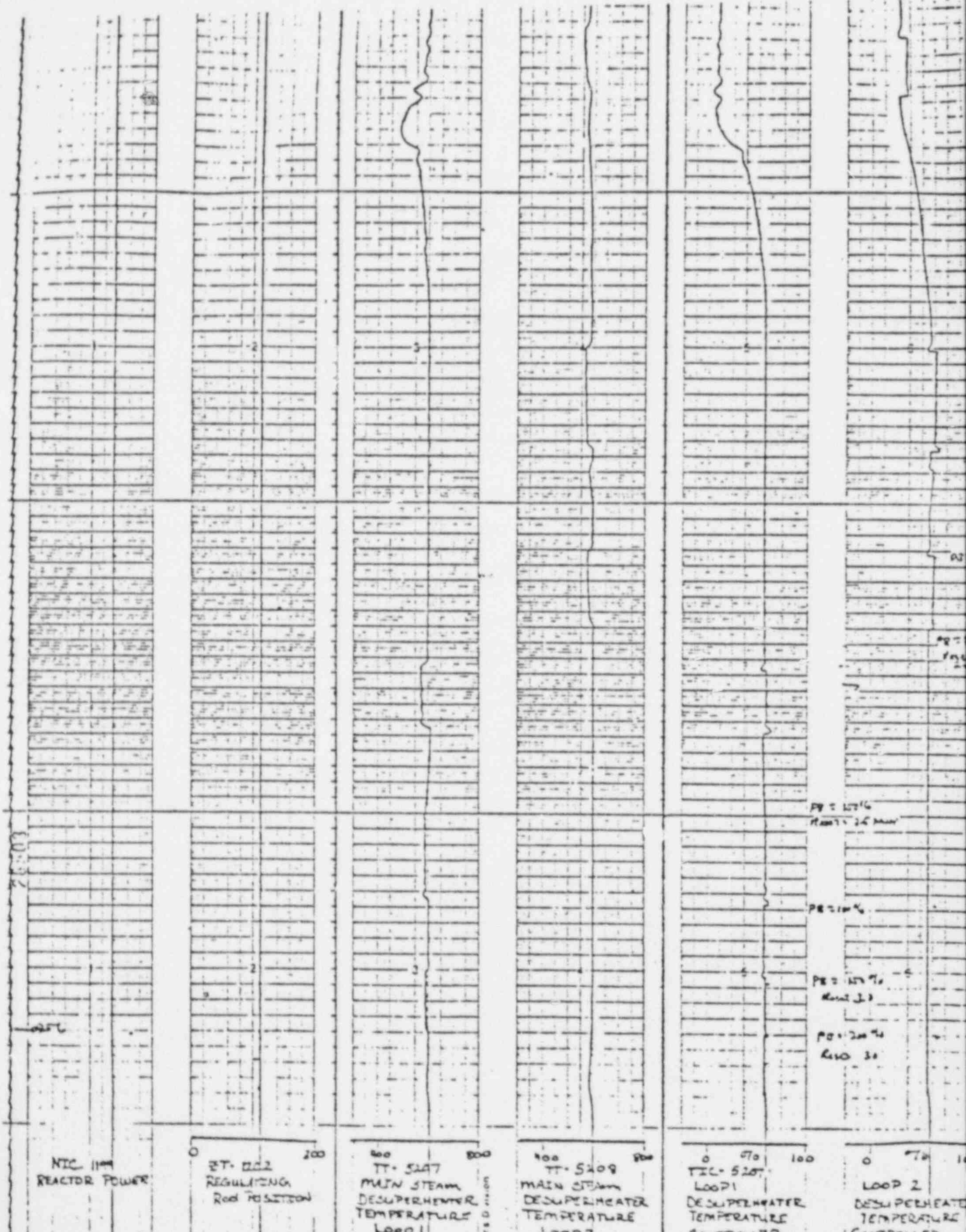

NIC 1199
REACTOR POWER
0
200
ZT-1202
REGULATING
ROD POSITION
400
800
TT-5207
MAIN STEAM
DESUPERHEATER
TEMPERATURE
LOOP 1
400
800
TT-5208
MAIN STEAM
DESUPERHEATER
TEMPERATURE
LOOP 2
0
70
100
TIC-5207
LOOP 1
DESUPERHEATER
TEMPERATURE
CONTROLLER
0
70
LOOP 2
DESUPERHEATER
TEMPERATURE
CONTROLLER

Fig. B-7.13A.4

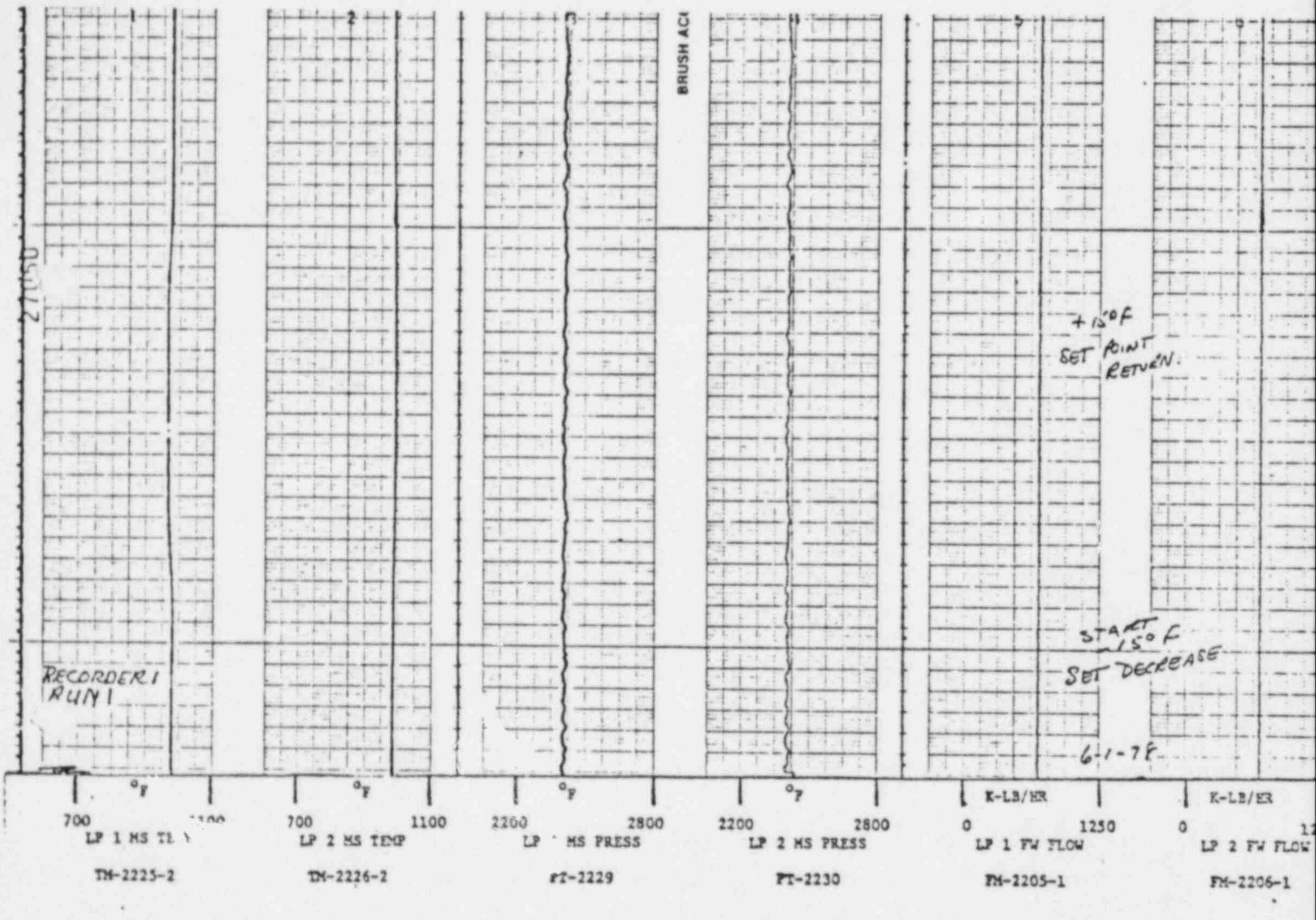

BRUSH ACI
2
3
5
6
2750
RECORDER 1
RUN 1
+15°F
SET POINT
RETURN.
START
-15°F
SET DECREASE
6-1-78
°F
700
LP 1 MS TE
TM-2225-2
°F
700
1100
LP 2 MS TEMP
TM-2226-2
°F
2200
2800
LP MS PRESS
PT-2229
°F
2200
2800
LP 2 MS PRESS
PT-2230
K-LB/HR
0
1250
LP 1 FW FLOW
FM-2205-1
K-LB/HR
0
LP 2 FW FLOW
FM-2206-1

Fig. B- E.1

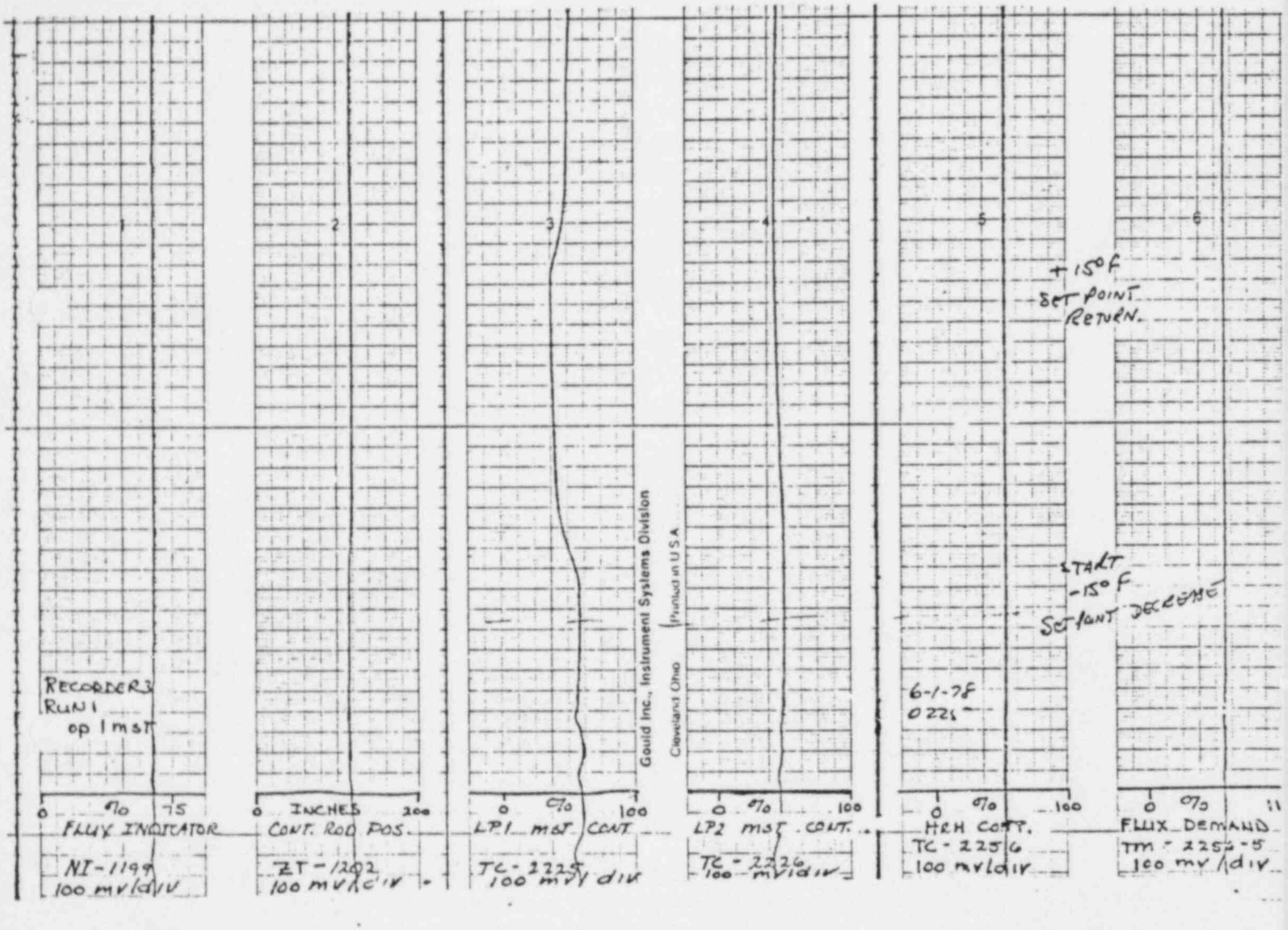

1
2
3
4
5
6
+15°F
SET POINT
RETURN.
START
-15°F
SET POINT DECREASE
Gould Inc., Instrument Systems Division
Cleveland Ohio
Printed in USA
RECORDER 3
RUN 1
op 1 mst
6-1-78
0225
0 % 75
FLUX INDICATOR
NI-1199
100 mv/div
0 INCHES 200
CONT. ROD POS.
ZT-1202
100 mv/div
0 % 100
LP1 mst CONT
TC-2225
100 mv/div
0 % 100
LP2 mst. CONT.
TC-2226
100 mv/div
0 % 100
HRH CONT.
TC-2256
100 mv/div
0 % 11
FLUX DEMAND
TM-2255-5
100 mv/div

Fig. B-7.14E.2

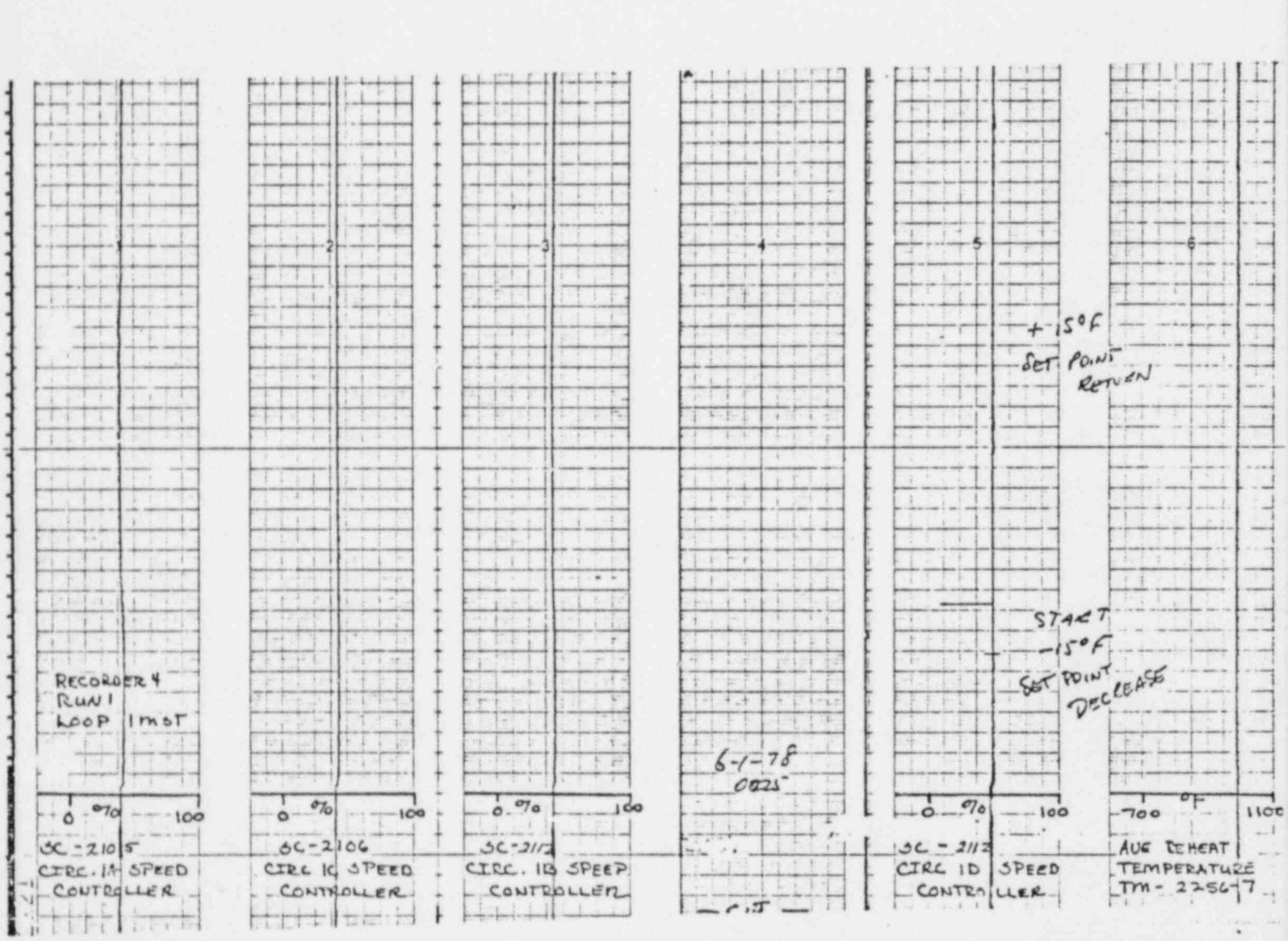

1
2
3
4
5
6
+15°F
SET POINT
RETURN
START
-15°F
SET POINT
DECREASE
RECORDER 4
RUN 1
LOOP 1 MST
6-1-78
0025
0 % 100
SC-2105
CIRC. 1A SPEED CONTROLLER
0 % 100
SC-2106
CIRC 1C SPEED CONTROLLER
0 % 100
SC-2112
CIRC. 1B SPEED CONTROLLER
0 % 100
SC-2113
CIRC 1D SPEED CONTROLLER
700 °F 1100
AVG REHEAT TEMPERATURE
TM-2256-7

Fig.B-7.14E.3

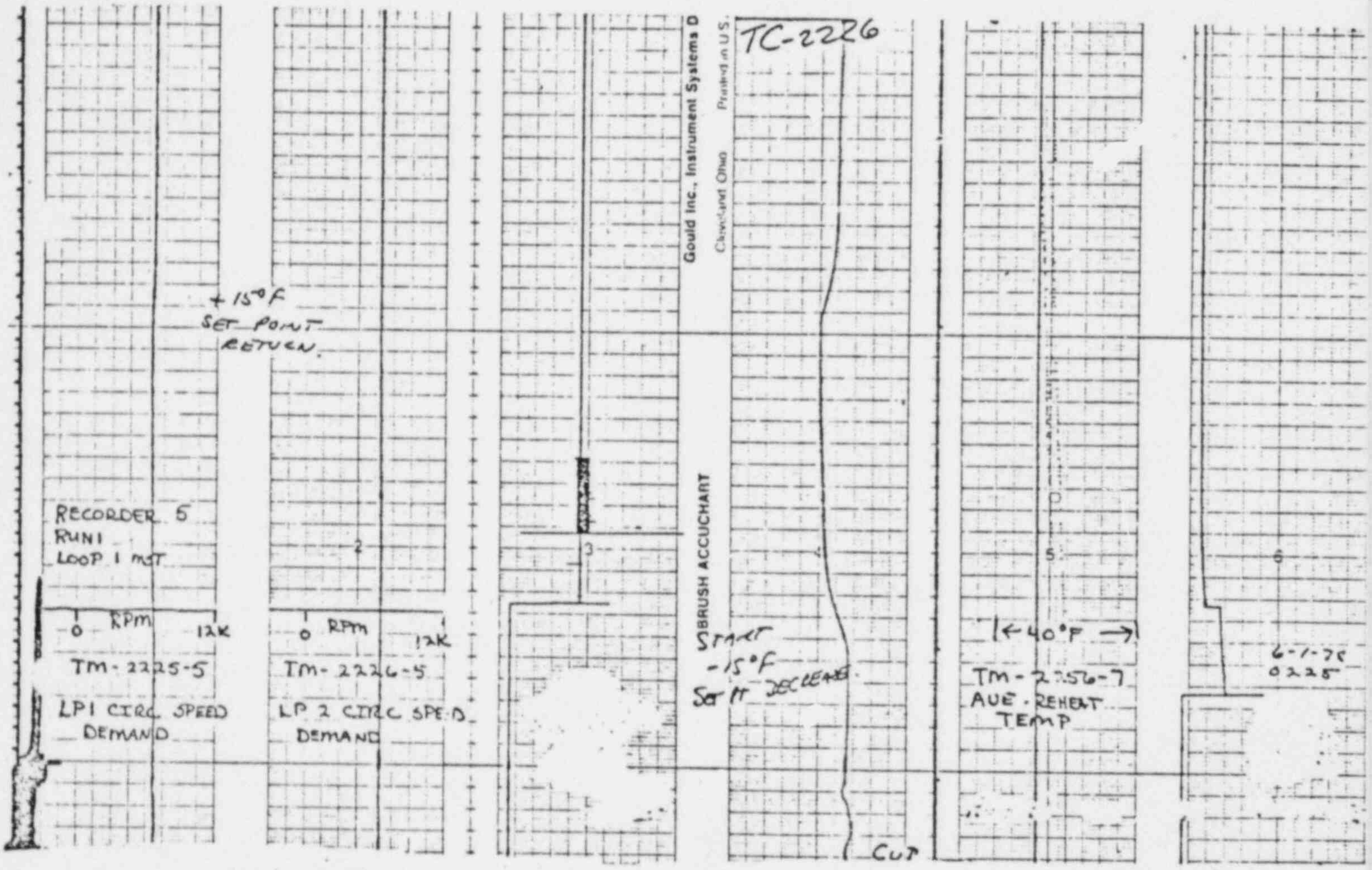

+15°F
SET POINT
RETURN.
RECORDER 5
RUN1
LOOP 1 MST
0 RPm 12K
TM-2225-5
LP1 CIRC SPEED
DEMAND
0 RPm 12K
TM-2226-5
LP 2 CIRC SPEED
DEMAND
2
3
4
5
6
Gould Inc., Instrument Systems D
Cleveland Ohio Printed in U.S.
BRUSH ACCUCHART
TC-2226
START
-15°F
SET PT DECREASE.
CUT
|←40°F →|
TM-2256-7
AVE. REHEAT
TEMP
6-1-78
0225

Fig. B-7.14E.4

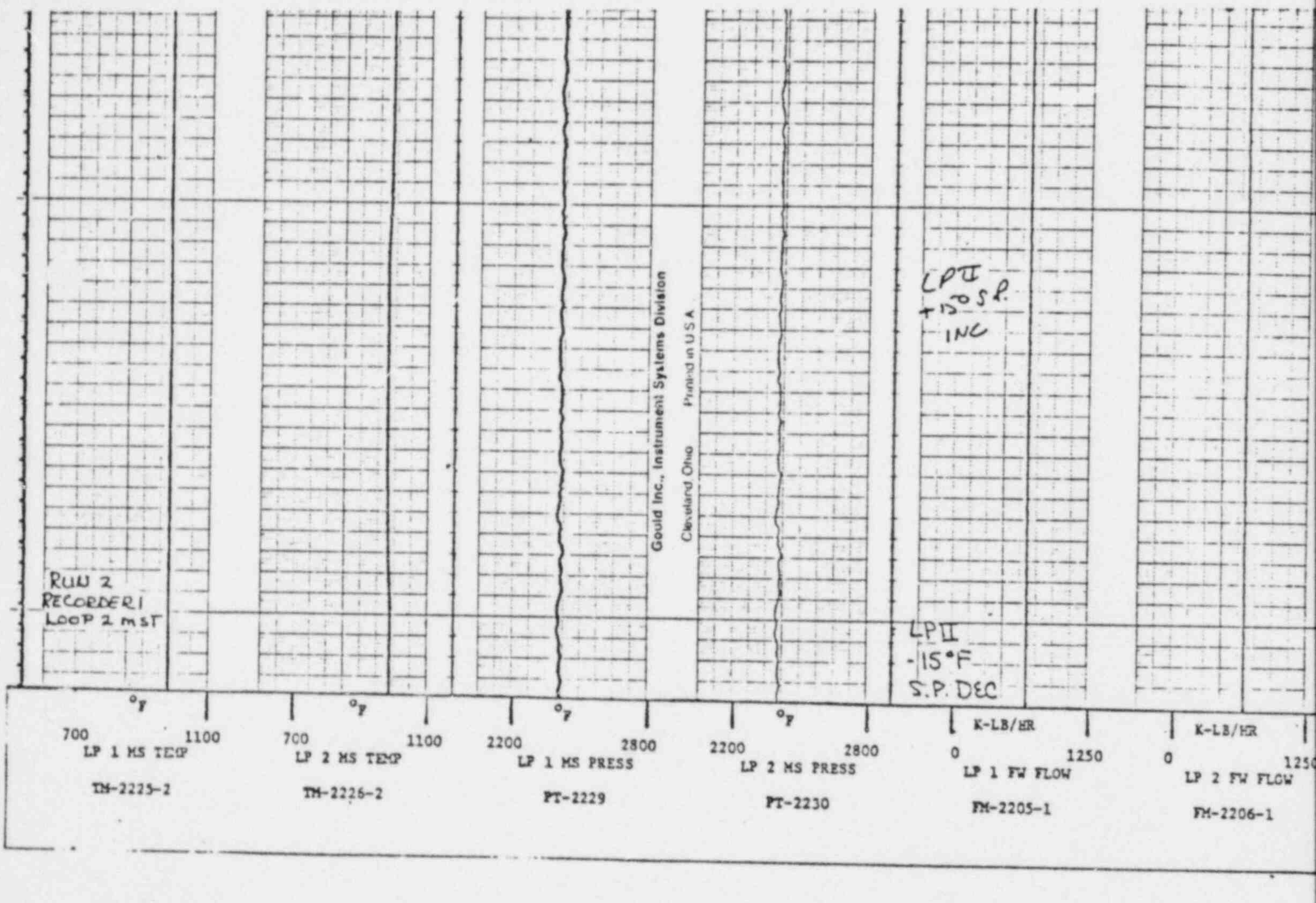

RUN 2
RECORDER 1
LOOP 2 MST
Gould Inc., Instrument Systems Division
Cleveland Ohio Printed in U.S.A.
LPII
+15°S.P.
INC
LPII
-15°F
S.P. DEC
°F
700
1100
LP 1 MS TEMP
TM-2225-2
°F
700
1100
LP 2 MS TEMP
TM-2226-2
°F
2200
2800
LP 1 MS PRESS
PT-2229
°F
2200
2800
LP 2 MS PRESS
PT-2230
K-LB/HR
0
1250
LP 1 FW FLOW
FM-2205-1
K-LB/HR
0
1250
LP 2 FW FLOW
FM-2206-1

Fig.B-7.14E.5

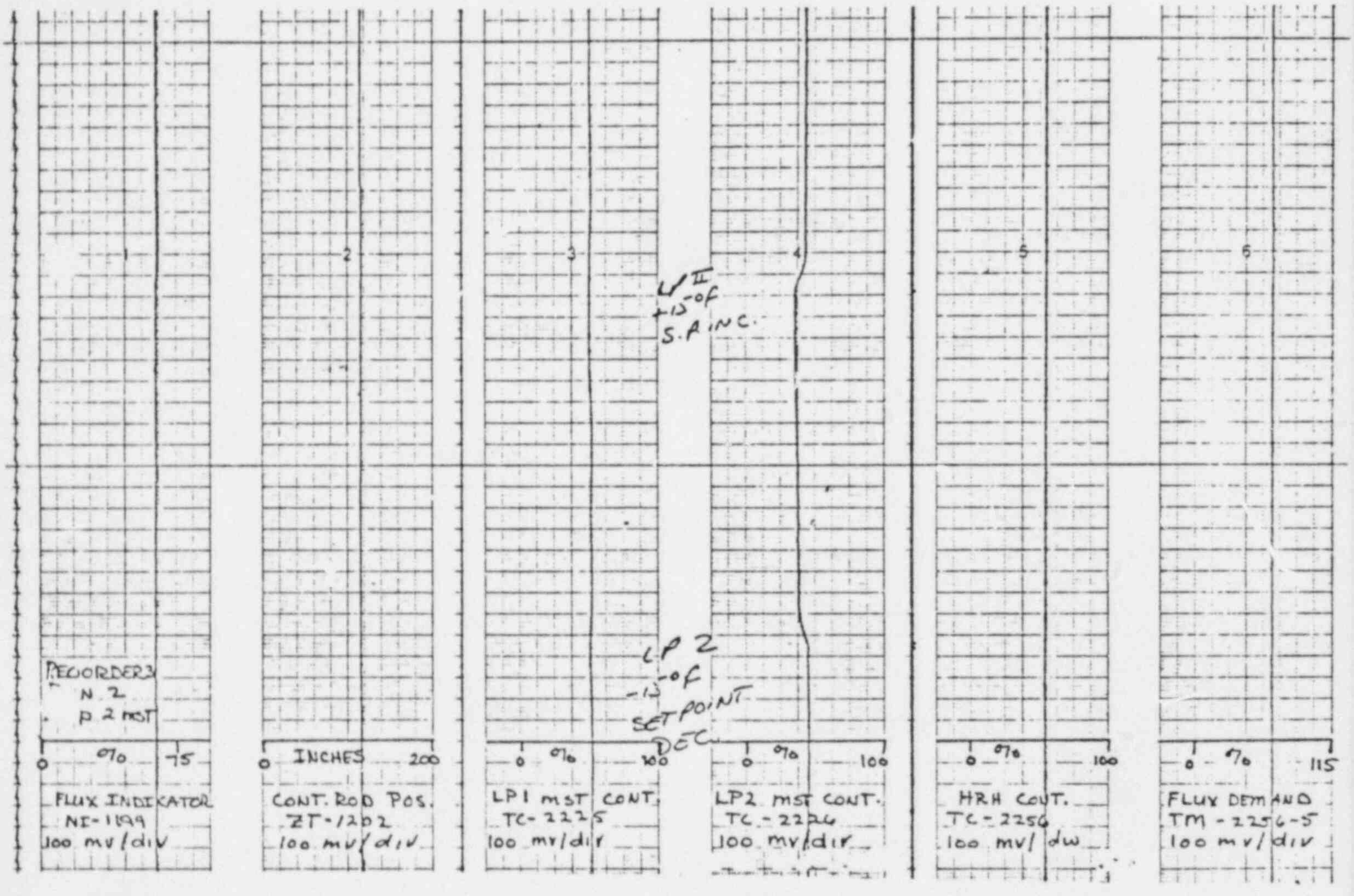

1
2
3
4
5
6
LP II
+15°F
S.P. INC.
LP 2
-15°F
SET POINT
DEC.
RECORDER 3
N. 2
p 2 mst
0 % 75
FLUX INDICATOR
NI-1199
100 mv/div
0 INCHES 200
CONT. ROD POS.
ZT-1202
100 mv/div
0 % 100
LP1 mst CONT.
TC-2225
100 mv/div
0 % 100
LP2 mst CONT.
TC-2226
100 mv/div
0 % 100
HRH CONT.
TC-2256
100 mv/div
0 % 115
FLUX DEMAND
TM-2256-5
100 mv/div

Fig. B-7.14E.6


BRUSH ACCUCHART
1
2
3
4
5
6
LP II
+15°F
S.P. INC
3C122
RECORDER 4
RUN 2
Loop 2 mbr
LP II
-15°F
S.P. DEC
LP II
% 100
SC-2105
CIRC 1A SPEED
CONTROLLER
0 % 100
SC-2106
CIRC 1C SPEED
CONTROLLER
0 % 100
SC-2112
CIRC 1B SPEED
CONTROLLER
0 % 100
SC-2112
CIRC 1D SPEED
CONTROLLER
700 °F 1100
AVE REHEAT
TEMPERATURE
TM-2256-7

Fig. B-7.14E.7

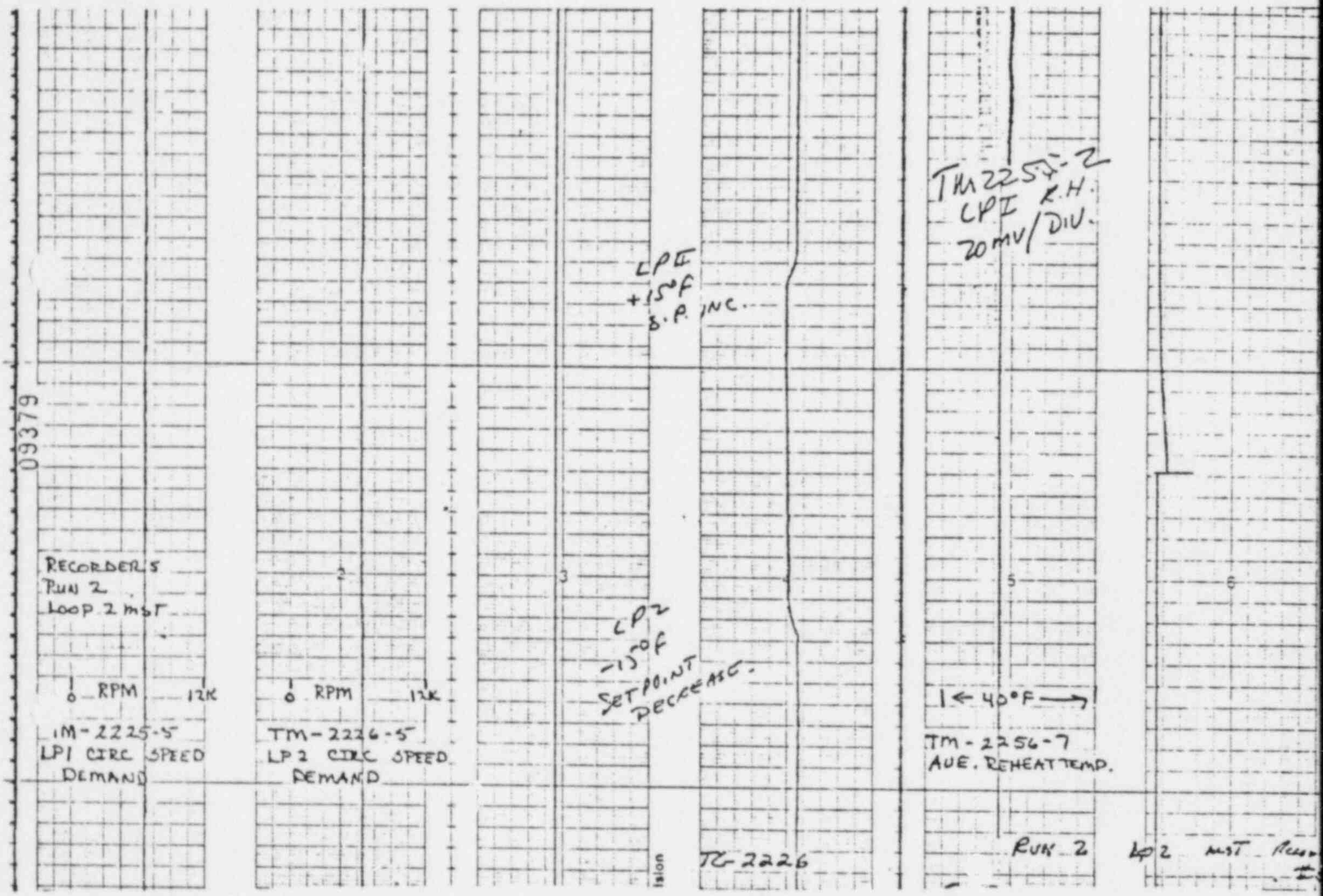

09379
RECORDER 5
RUN 2
LOOP 2 MST
0 RPM 12K
IM-2225-5
LP1 CIRC SPEED
DEMAND
0 RPM 12K
TM-2226-5
LP2 CIRC SPEED
DEMAND
2
3
LP II
+15°F
S.P. INC.
LP2
-15°F
SETPOINT
DECREASE
TC-2226
4
TM 2257-2
LP I R.H.
20mv/DIV.
5
|← 40°F →|
TM-2256-7
AVE. REHEAT TEMP.
RUN 2
LP2
MST
6

Fig. B-7.14E.8

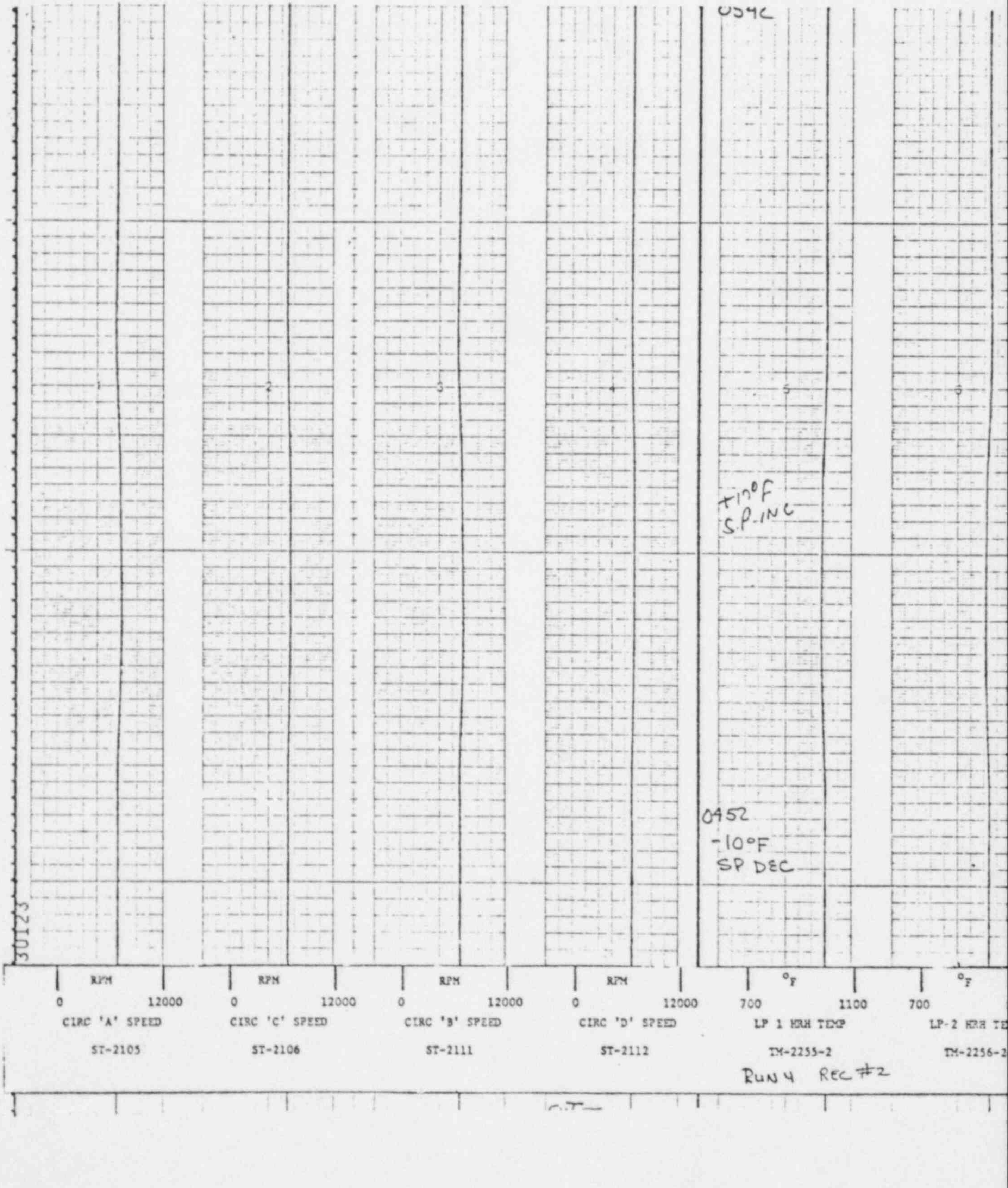

0542
+10°F
S.P.INC
0452
-10°F
SP DEC
30123
1
2
3
4
5
6
RPM
0
12000
CIRC 'A' SPEED
ST-2105
RPM
0
12000
CIRC 'C' SPEED
ST-2106
RPM
0
12000
CIRC 'B' SPEED
ST-2111
RPM
0
12000
CIRC 'D' SPEED
ST-2112
°F
700
1100
LP 1 HRH TEMP
TM-2255-2
°F
700
LP-2 HRH TE
TM-2256-2
RUN 4 REC #2

Fig. B-7.15E.1

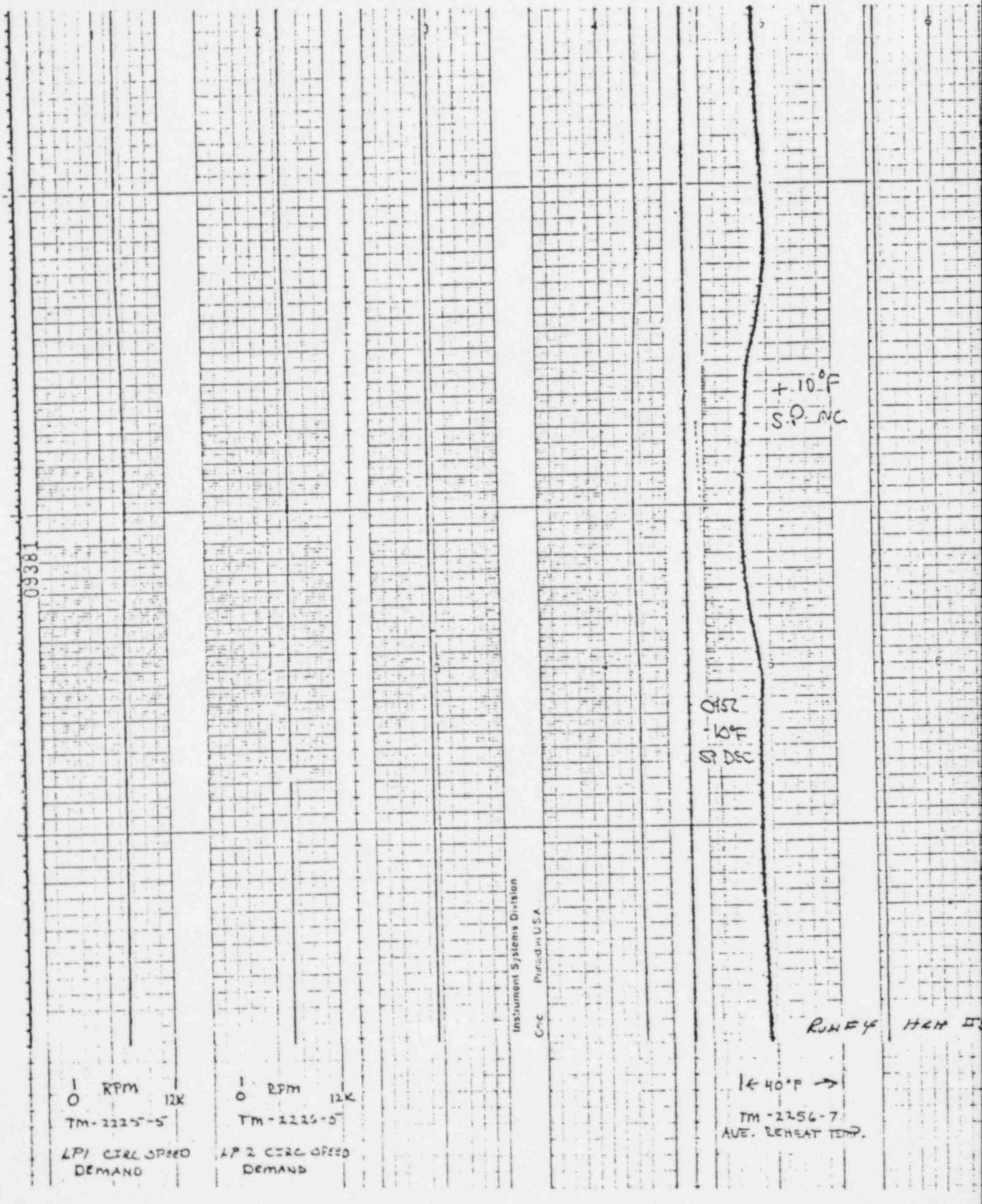

09381
+10°F
S.P. INC
0952
-10°F
SP DEC
RUN F4
HCH
Instrument Systems Division
GE Printed in USA
0 RPM 12K
TM-2225-5
LP1 CIRC SPEED DEMAND
0 RPM 12K
TM-2226-5
LP 2 CIRC SPEED DEMAND
← 40°F →
TM-2256-7
AVE. REHEAT TEMP.

Fig. B-7.15E.2

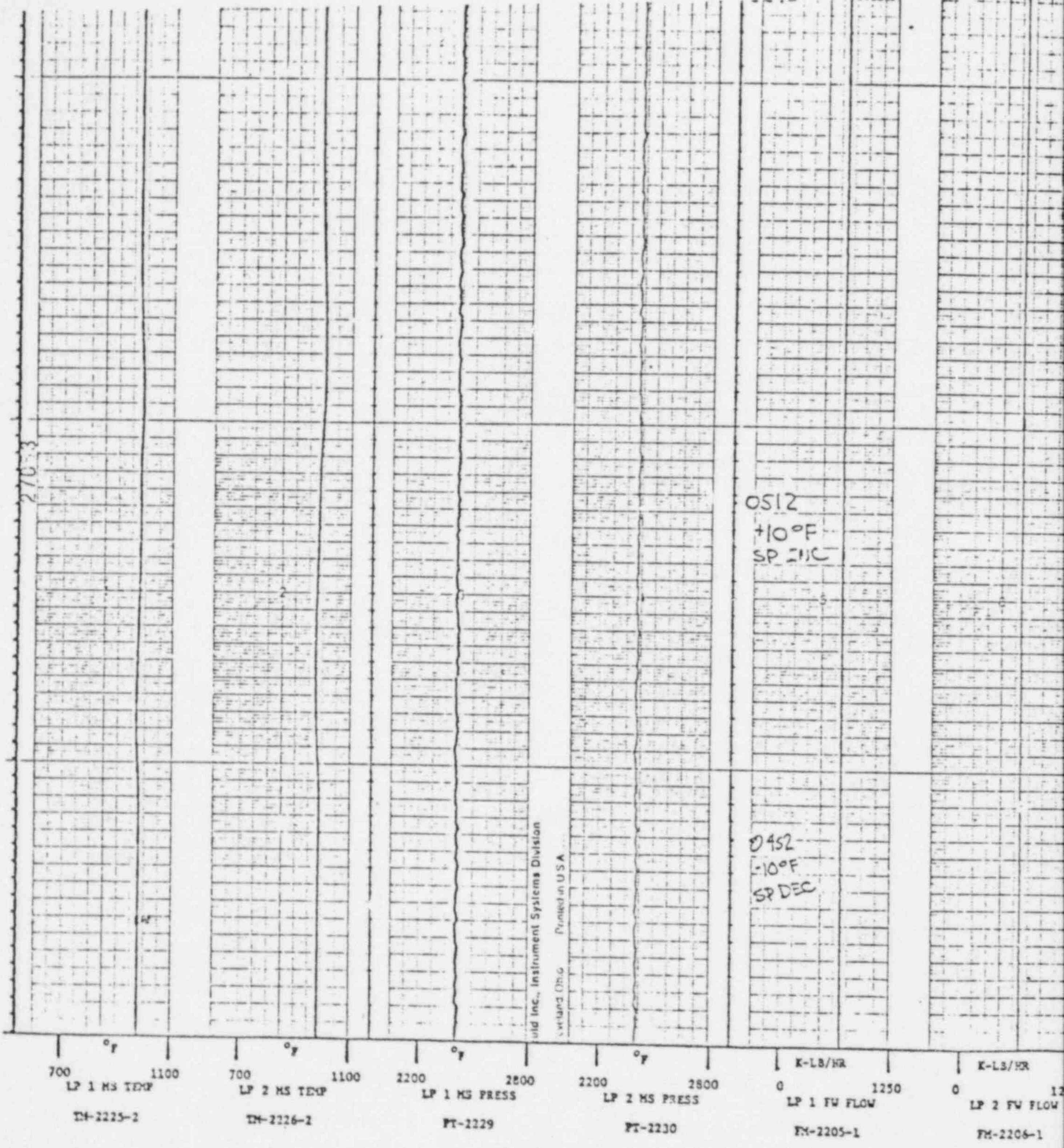

27C-3
0512
+10°F
SP INC
0452
-10°F
SP DEC
uld Inc., Instrument Systems Division
Printed in U.S.A.
Cleveland Ohio
°F
700
1100
LP 1 MS TEMP
TM-2225-2
°F
700
1100
LP 2 MS TEMP
TM-2226-2
°F
2200
2800
LP 1 MS PRESS
PT-2229
°F
2200
2800
LP 2 MS PRESS
PT-2230
K-LB/HR
0
1250
LP 1 FW FLOW
FM-2205-1
K-LB/HR
0
LP 2 FW FLOW
FM-2206-1

Fig. B-7.15E.3

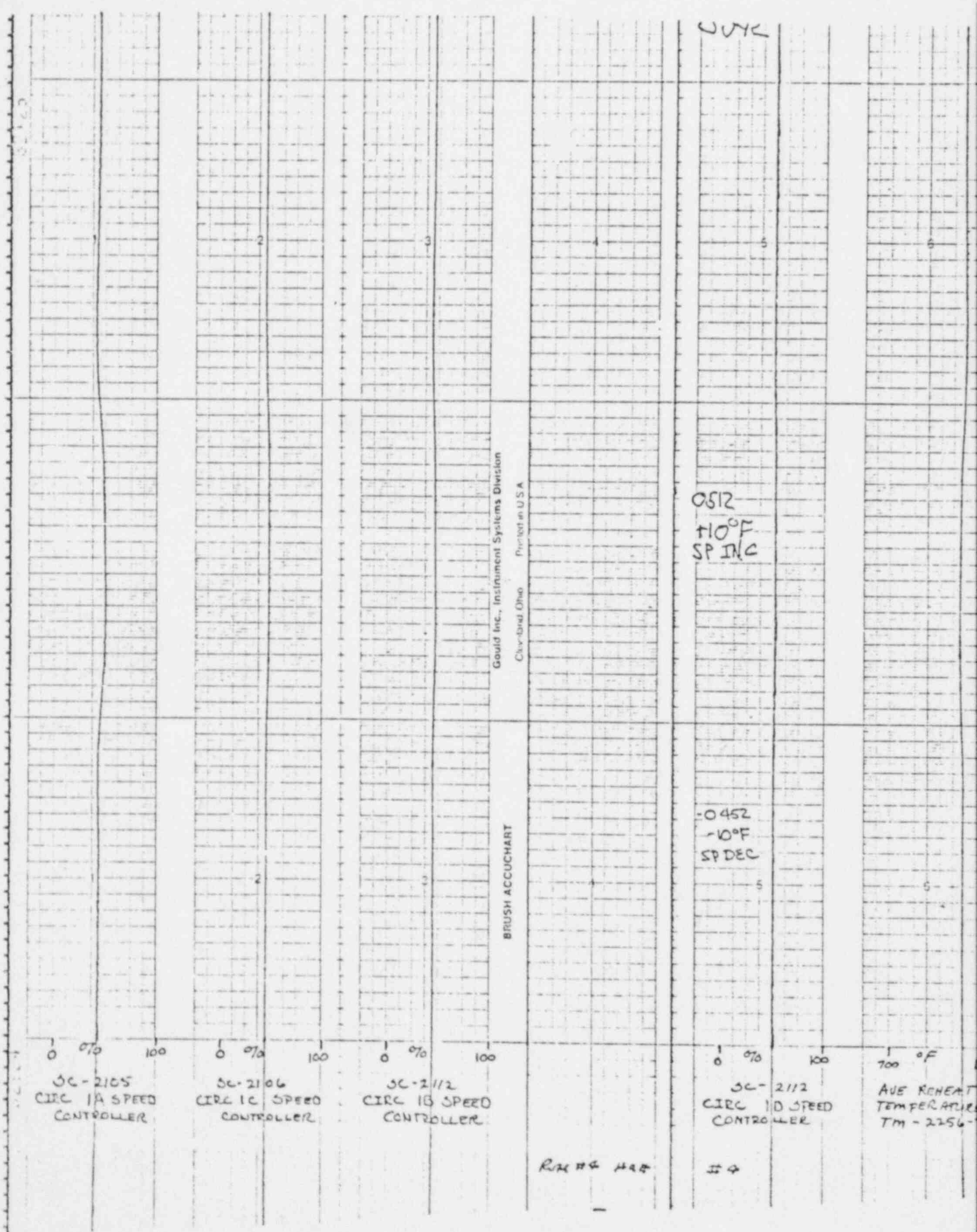

0512
+10°F
SP INC
-0452
-10°F
SP DEC
Gould Inc., Instrument Systems Division
Cleveland Ohio Printed in U.S.A.
BRUSH ACCUCHART
0 % 100
SC-2105
CIRC 1A SPEED
CONTROLLER
0 % 100
SC-2106
CIRC 1C SPEED
CONTROLLER
0 % 100
SC-2112
CIRC 1B SPEED
CONTROLLER
0 % 100
SC-2112
CIRC 1D SPEED
CONTROLLER
700 °F
AVE REHEAT
TEMPERATURE
TM-2256-
RM #4 H&B
#4

Fig. B-7.15E.4


0542
BRUSH ACCUCHART
+10°F
SP INC
0952
-10°F
SP DEC
0 % 75
FLUX INDICATOR
NI - 1199
100 mv/div
0 INCHES 200
CONT. Rod POS.
ZT - 1202
100 mv/div
0 % 100
LP1 MST CONT
TC - 2225
100 mv/div
0 % 100
LP2 MST CONT.
TC - 2226
100 mv/div
RUN #4 HRH #3
0 % 100
HRH CONT.
TC - 2256
100 mv/div.
0 %
FLUX DEM
TM - 2256
100 mv/div

Fig. B-7.15E.5

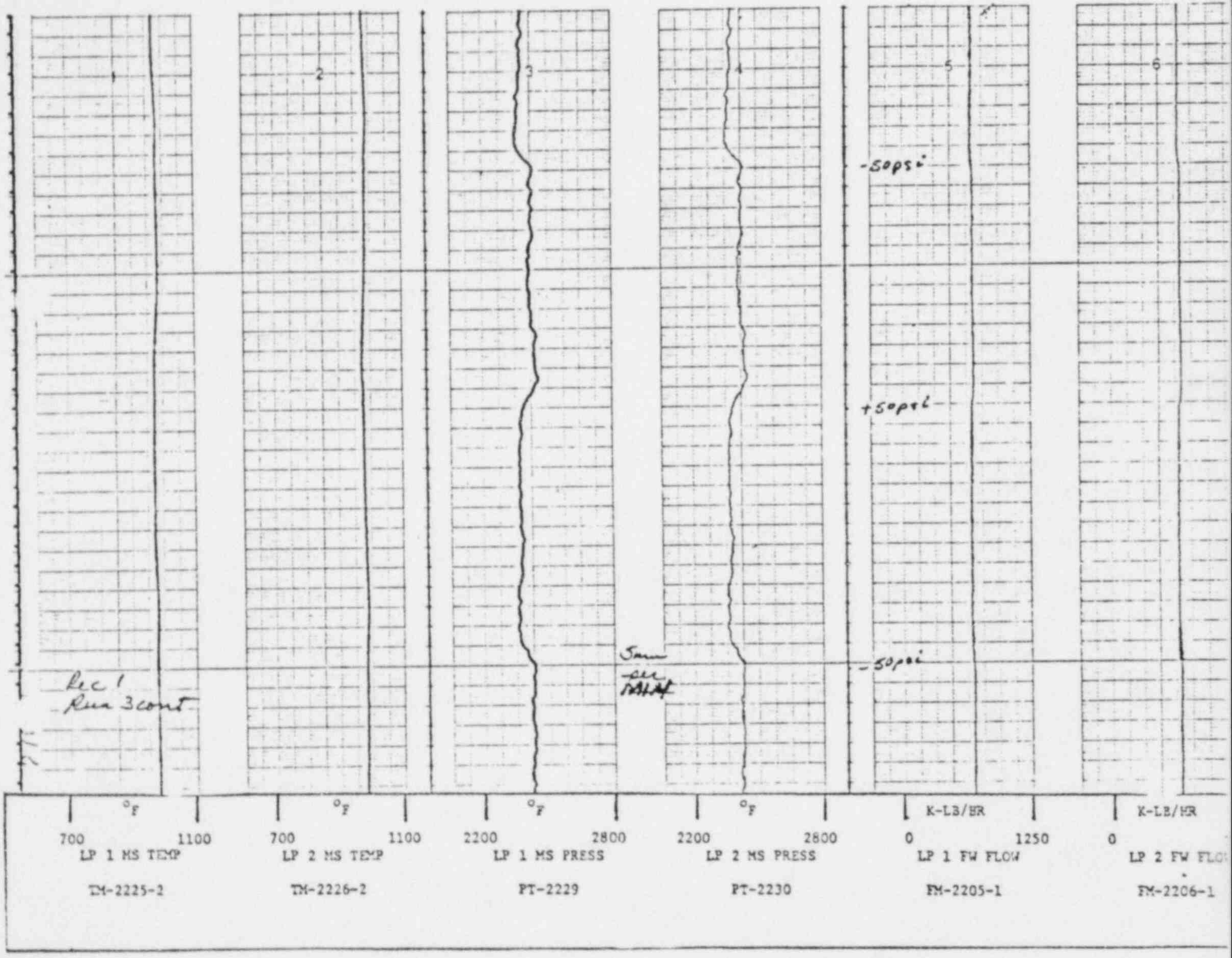

1
2
3
4
5
6
-50psi
+50psi
-50psi
Rec 1
Run 3 cont
5mm
sec
°F
700
1100
LP 1 MS TEMP
TM-2225-2
°F
700
1100
LP 2 MS TEMP
TM-2226-2
°F
2200
2800
LP 1 MS PRESS
PT-2229
°F
2200
2800
LP 2 MS PRESS
PT-2230
K-LB/HR
0
1250
LP 1 FW FLOW
FM-2205-1
K-LB/HR
0
LP 2 FW FLO
FM-2206-1

Fig. B-7.16D.1

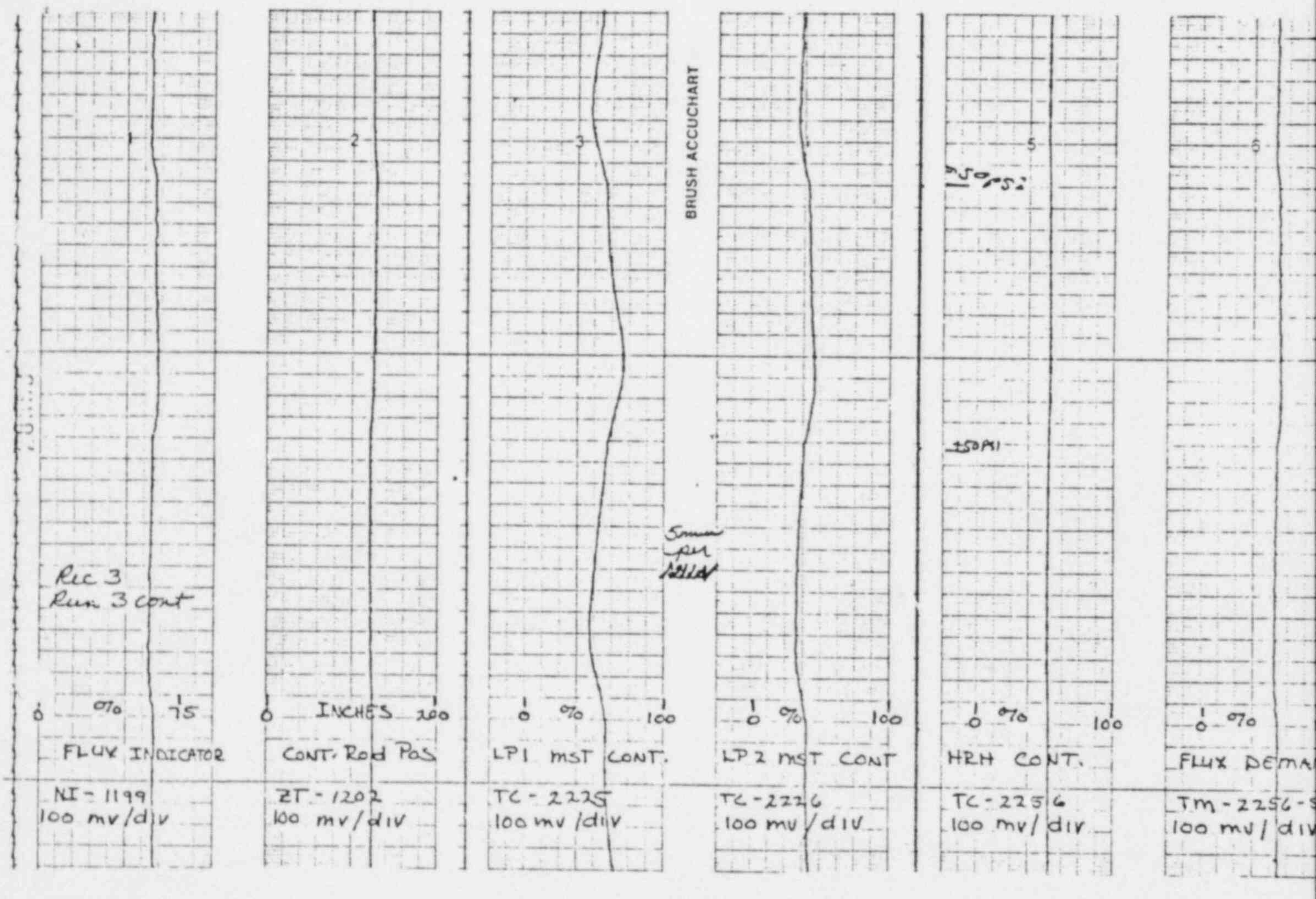

1
2
3
BRUSH ACCUCHART
5
6
50PSI
±50PSI
5mm per min
Rec 3
Run 3 cont
0 % 75
FLUX INDICATOR
NI - 1199
100 mv/div
0 INCHES 200
CONT. Rod Pos
ZT - 1202
100 mv/div
0 % 100
LP1 MST CONT.
TC - 2225
100 mv/div
0 % 100
LP2 MST CONT
TC - 2226
100 mv/div
0 % 100
HRH CONT.
TC - 2256
100 mv/div
0 %
FLUX DEMA
TM - 2256-
100 mv/div

Fig. B-7.16D.2


1
2
3
4
5
6
SMIN
MIN
- -50psi
+50psi
- -50psi
REC 4
RUN3cont
0 PSID 500
ΔP ACROSS FV-2205
PDT -22127
100 mv/div
0 PSID 500
ΔP ACROSS FV2206
PDT -22128
100 mv/div
0 % 100
FW VLV CONT
PDC -22127
100 mv/div
Gould Inc., Instrument Systems Division
U.S.A.
0 % 100
LP1 FW CONT
FC-2205
100 mv/div
0 %
LP2 FW CON
FC-2206
100 mv/di

Fig. B-7.16D.3

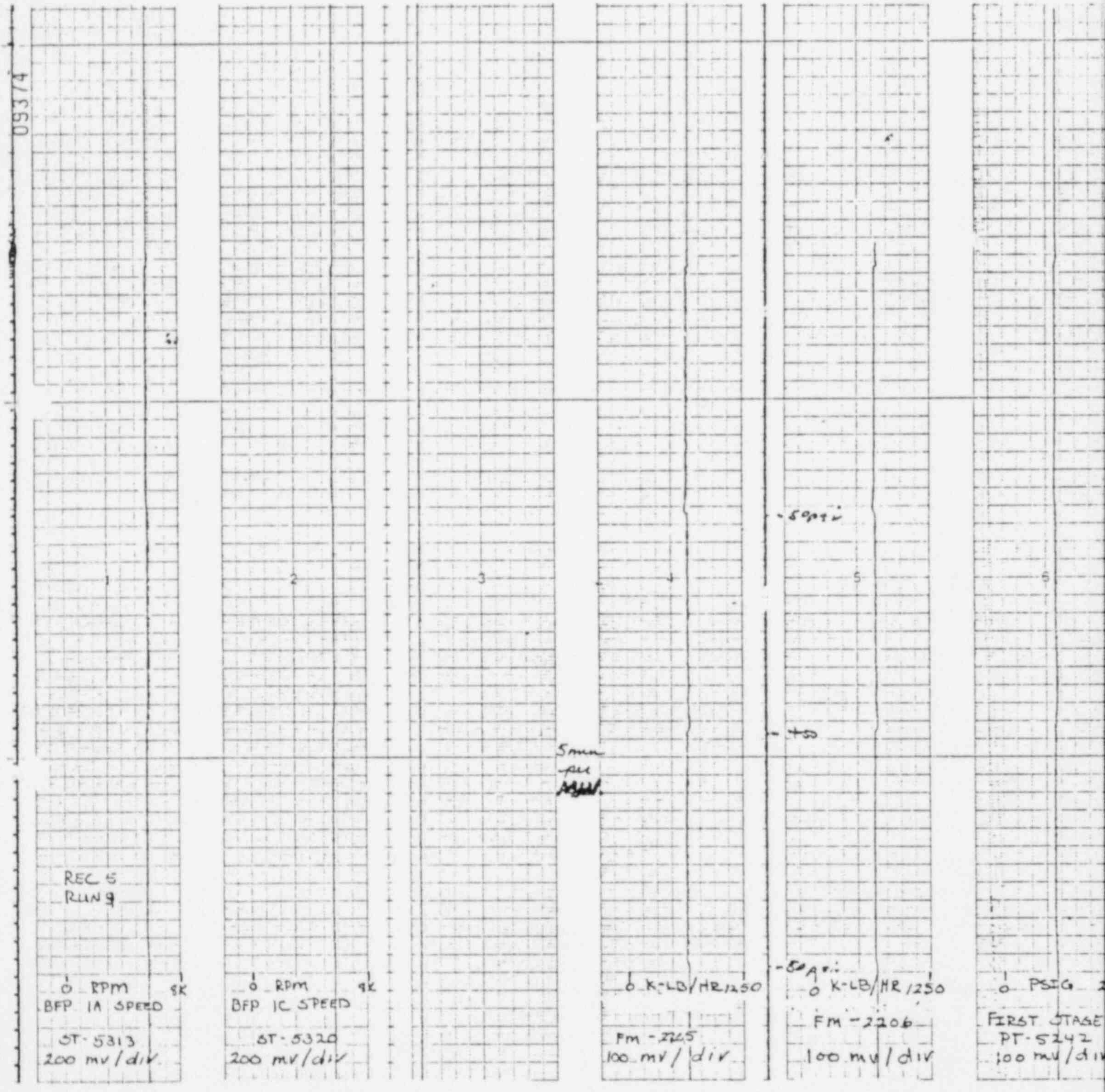

09374
1
2
3
4
5
6
-50mv
+50
5mm per MW.
-50mv
REC 5
RUN 9
0 RPM 8K
BFP 1A SPEED
ST-5313
200 mv/div.
0 RPM 8K
BFP 1C SPEED
ST-5320
200 mv/div
0 K-LB/HR 1250
FM-2205
100 mv/div
0 K-LB/HR 1250
FM-2206
100 mv/div
0 PSIG
FIRST STAGE
PT-5242
100 mv/di

Fig. B-7.16D.4

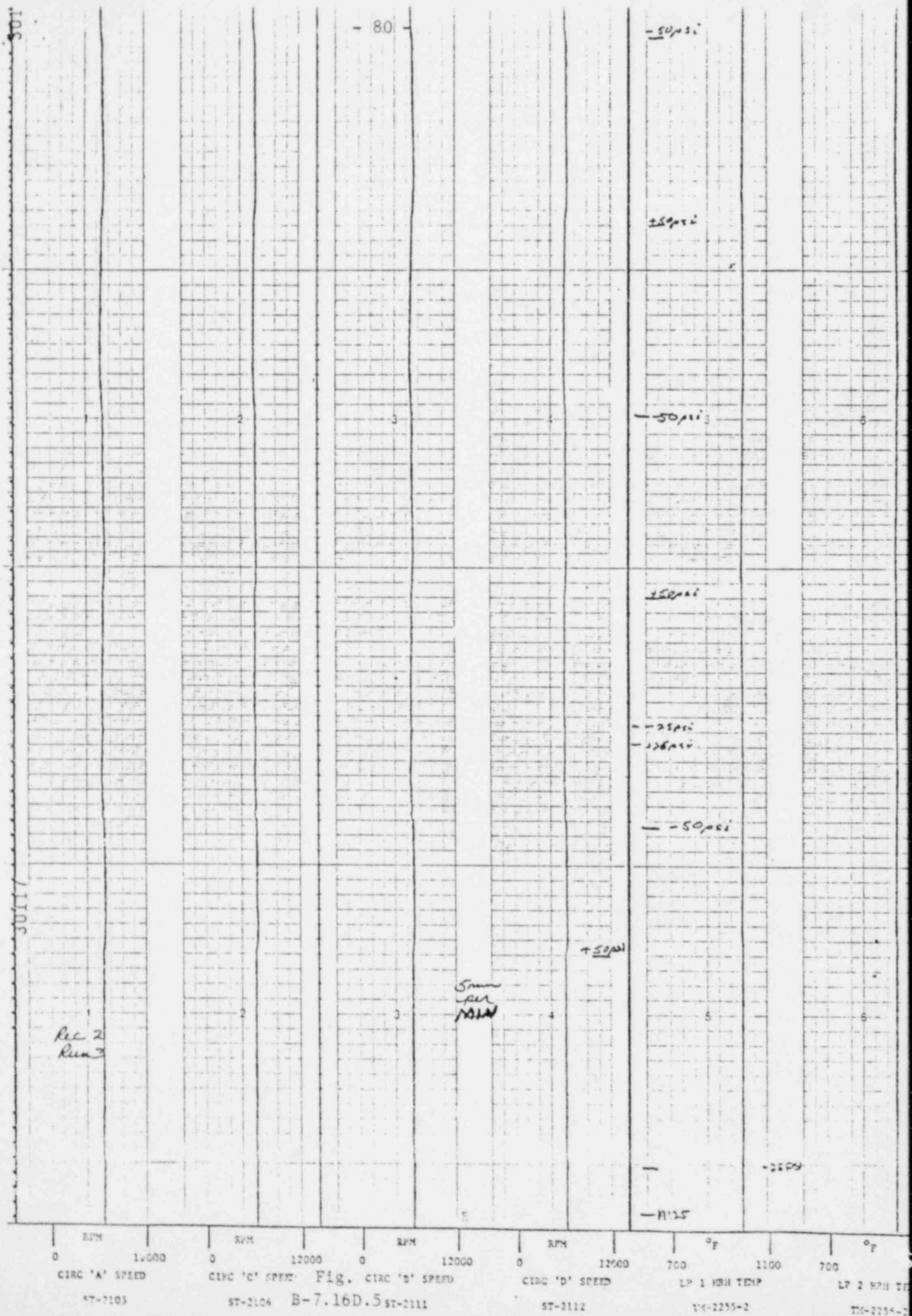

301
-50psi
±50psi
1
2
3
4
5
6
-50psi
+50psi
-25psi
+25psi
-50psi
+50psi
5mm per MIN
Rec 2 Run 3
2
3
4
5
6
-25psi
RPM
0
12000
CIRC 'A' SPEED
ST-2103
RPM
0
12000
CIRC 'C' SPEED
ST-2106
RPM
0
12000
CIRC 'B' SPEED
ST-2111
RPM
0
12000
CIRC 'D' SPEED
ST-2112
°F
700
1100
LP 1 HRH TEMP
TM-2255-2
°F
700
LP 2 HRH TE
TM-2254-2

Fig. B-7.16D.5

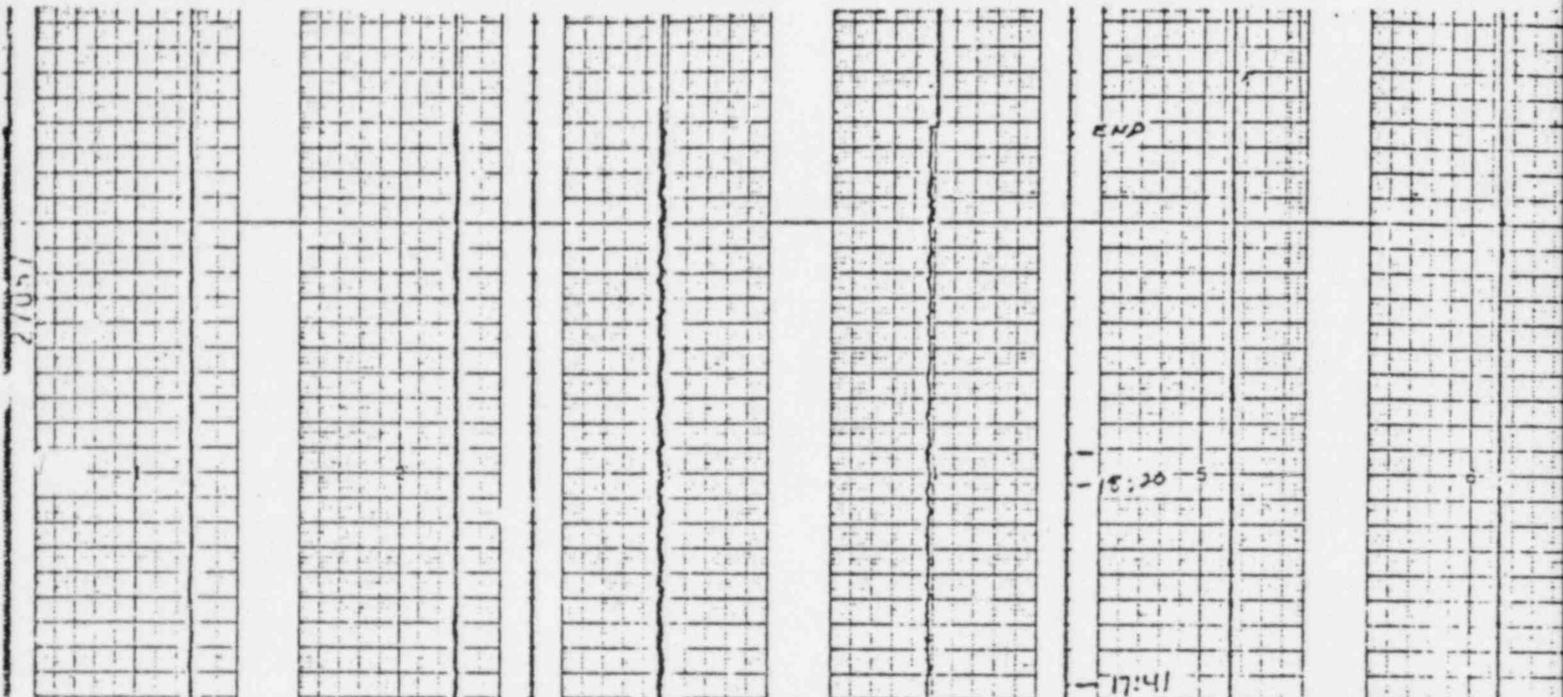

2705?
END
15:20
17:41
RECORDER 1
1mm/min
REC #1
Gould Inc. Instrument Systems Division
Cleveland Ohio
Printed in USA
°F
700
1100
LP 1 MS TEMP
TM-2225-2
°F
700
1100
LP 2 MS TEMP
TM-2226-2
°F
2200
2800
LP 1 MS PRESS
PT-2229
°F
2200
2800
LP 2 MS PRESS
PT-2230
K-LB/HR
0
1250
LP 1 FW FLOW
FM-2205-1
K-LB/HR
0
LP 2 FW FLOW
FM-2206-1

Fig. B-7.17D.1

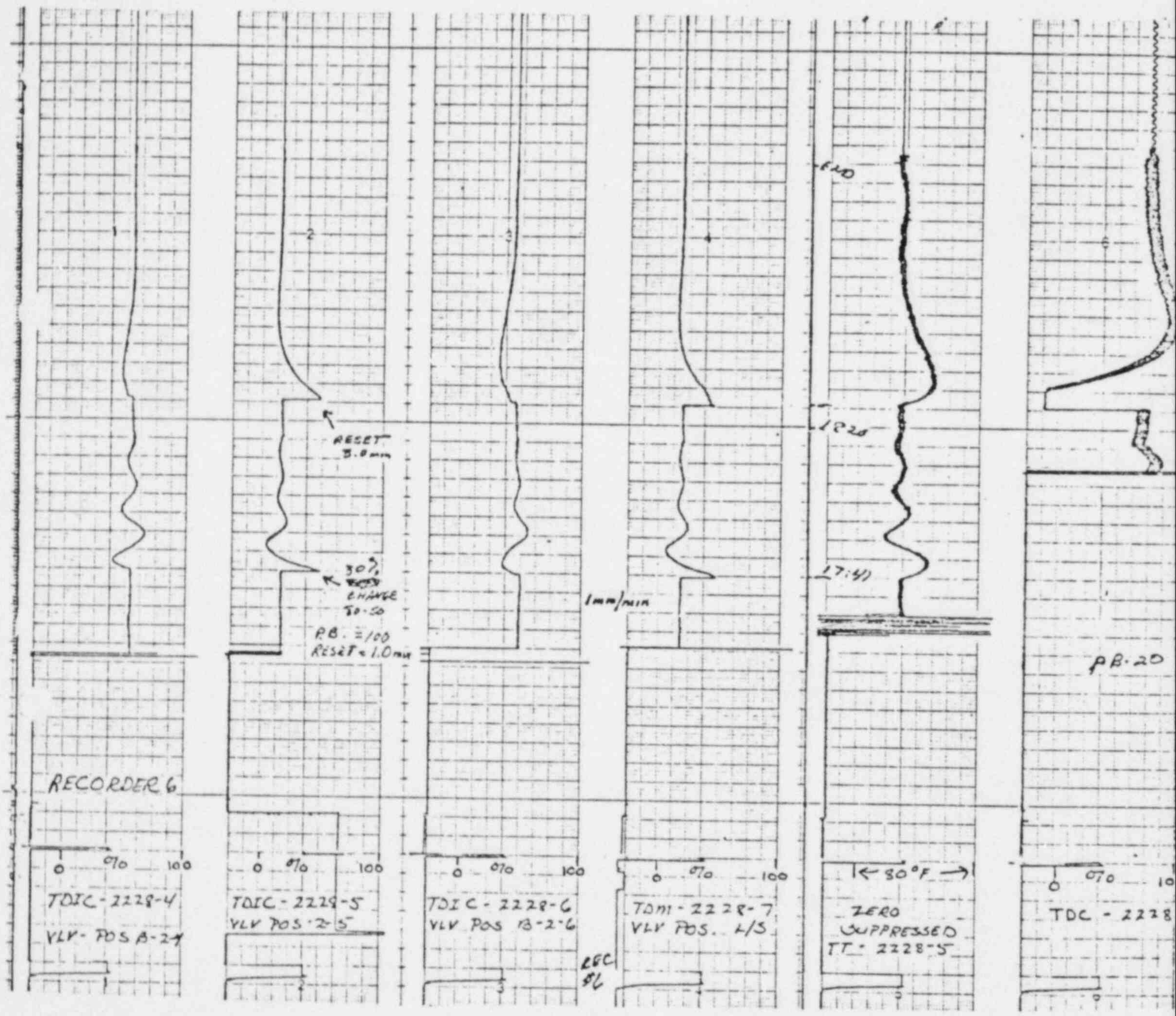

1
2
3
4
6
RESET 3.0 min
30% ~~RESET~~ CHANGE 50-50
P.B. = 100
RESET = 1.0 min
1 mm/min
620
1820
17:41
P.B. 20
RECORDER 6
0 % 100
TDIC - 2228-4
VLV - POS B-24
0 % 100
TDIC - 2229-5
VLV POS 2-5
0 % 100
TDIC - 2228-6
VLV POS B-2-6
REC
56
0 % 100
TDM - 2228-7
VLV POS. L/S
← 80°F →
ZERO
SUPPRESSED
TT - 2228-5
0 % 10
TDC - 2228

Fig. B-7.17D.2

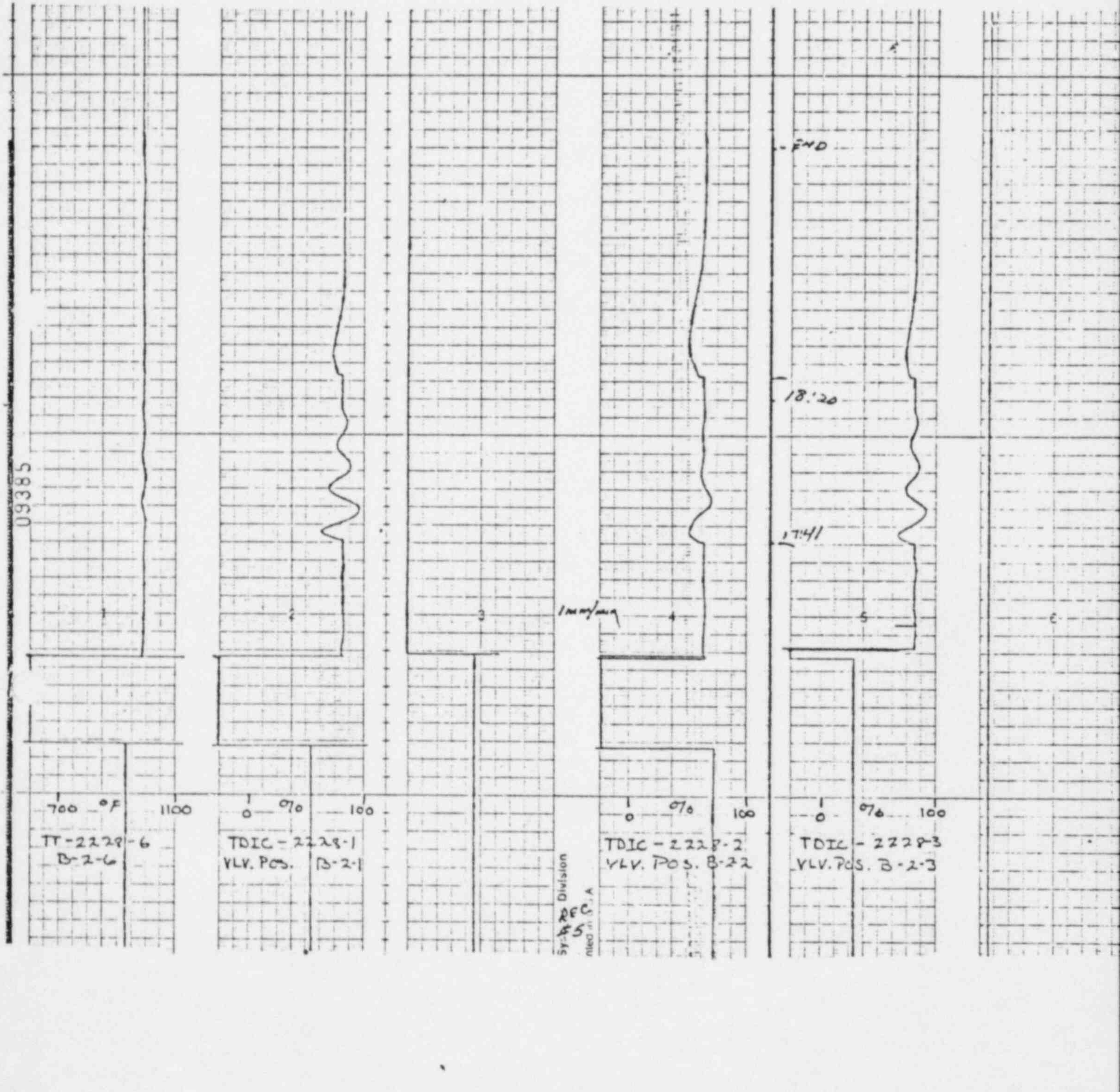

09385
END
18:20
17:41
1mm/min
1
2
3
4
5
6
700 °F 1100
TT-2228-6
B-2-6
0 % 100
TDIC-2228-1
VLV. POS. B-2-1
REC
#5
0 % 100
TDIC-2228-2
VLV. POS. B-22
0 % 100
TDIC-2228-3
VLV. POS. B-2-3

Fig. B-7.17D.3

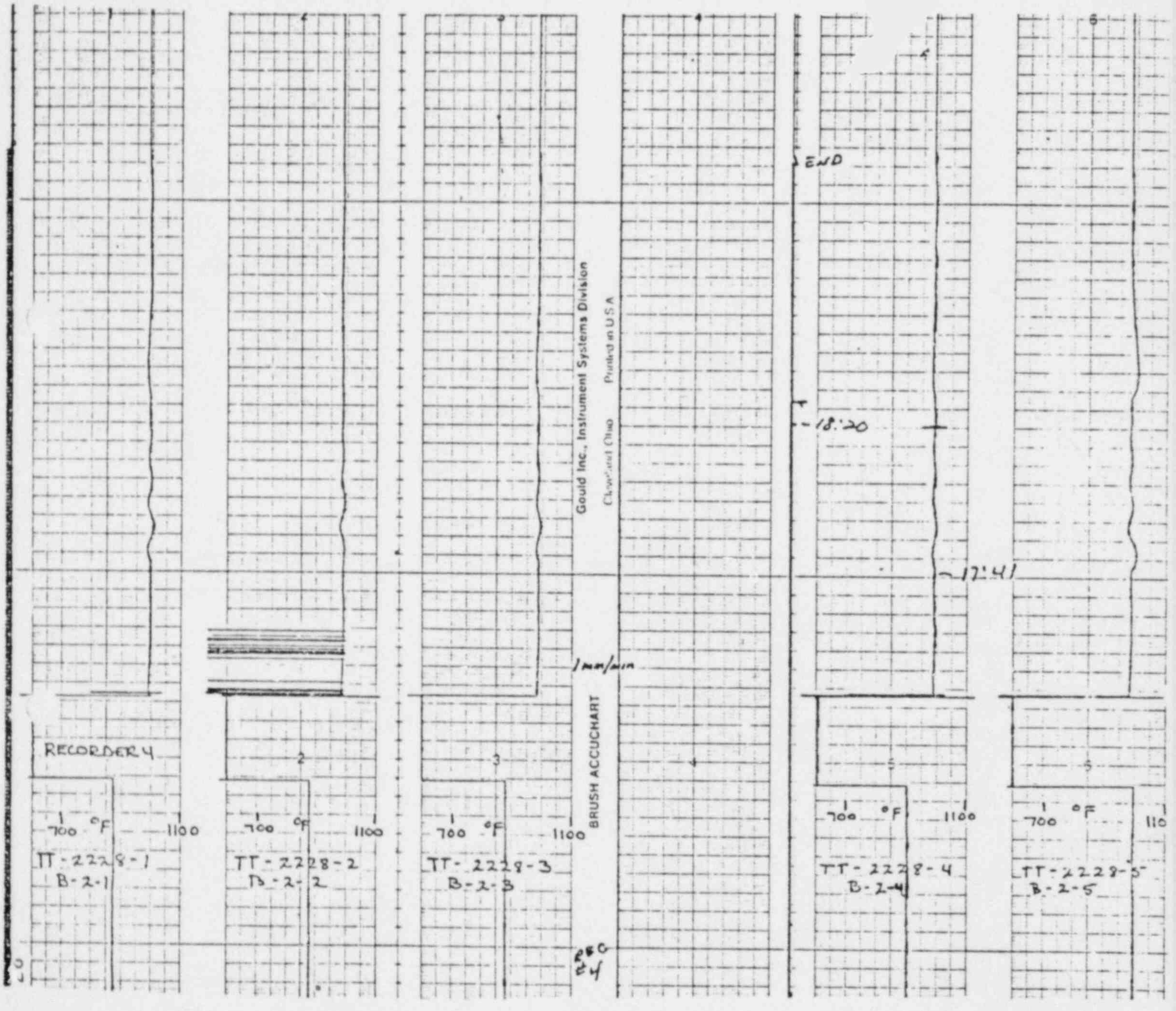

END
18:20
17:41
1mm/min
Gould Inc., Instrument Systems Division
Cleveland Ohio Printed in USA
BRUSH ACCUCHART
RECORDER 4
2
3
4
5
6
700 °F 1100
TT-2228-1
B-2-1
TT-2228-2
B-2-2
TT-2228-3
B-2-3
TT-2228-4
B-2-4
TT-2228-5
B-2-5
REC #4

Fig. B-7.17D.4


BRUSH
END
18:20
1741
3
4
5
6
0 % 75
0 INCHES 200
0 % 100
1mm/min
0 % 100
0 % 100
0 % 11
FLUX INDICATOR
NI-1199
100 mv/div
CONT. ROD POS.
ZT-1202
100 mv/div
LP1 MST CONT.
TC-2225
100 mv/div
LP2 MST CONT
TC-2226
100 mv/div
HRH CONT.
TC-2256
100 mv/div
FLUX DEMAND
TM-2250-5
100 mv/div

Fig. B-7.17D.5

Startup Test B-7, Plant Automatic Control System Performance Tests

Comparison of Predicated and Measured Data

Part 2D - Feedwater Flow Control

Tuning of the high range feedwater controllers consisted of making 30K lb/hr step changes in setpoint. Loop II proportional band required adjustment to meet quarter amplitude damping. Loop I was left unchanged.

Final gain settings are, proportional band (PB) 200% and reset of 0.25 minutes for FC-2205 , PB 150% and reset of 0.25 minutes for FC-2206. The differential pressure across FV-2205 and FV-2206 is sent through a low select which is then used as the demand input to the feedpump controls. Since Loop 2 is the low loop this causes a coupling with the feed pump control and is the reason for the higher gain requirements in Loop 2.

Part 3D - Deaerator Level Control

The deaerator level tuning consisted of tuning LIC-2175 and FIC-3175, LIC-3175 was tuned first with FIC-3175 bypassed. Then FIC-3175 was tuned with both controllers in operation. Quarter amplitude damping was achieved.

The level controller LIC-3175 was tuned first, even though it was not the inner loop controller, because it can be used to control the deaerator level with FIC-3175 bypassed.

Figure B-7.3D.1 shows the response of deaerator level (LT-3175) and condensate flow (FM-3151-2) to an increase of 2 inches in LIC-3175 setpoint , with the gains as found, PB of 50% and reset of 1.5 minutes. Figure B-7.3D. also shows the response to a decrease of 2 inches in setpoint with the PB of LIC-3175 changed to 100%.

FIC-3175 was switched into operation. The reset of FIC-3175 was changed to 3.0 minutes which is maximum without changing the controller wiring. This change was made because two controllers with reset in series controlling the deaerator level tend to be unstable. Figure B-7.3D.2 shows the response to a setpoint increase of 2 inches (LIC-3175) with a PB of 150% for FIC-3175 and a decrease of 2 inches (LIC-3175) with a PB of 100% for FIC-3175.

The final gains for LIC-3175 are PB of 100% and reset of 1.5 minutes. Also the gains for FIC-3175 are PB of 100% and a reset of 3.0 minutes.

Part 7D - Feedwater Valve Differential Pressure Control

With PDC-31207 in manual PDC-22127 setpoint was increased and then decreased by 25 psi. Gains were found to be adequate to meet the quarter amplitude damping and therefore were not changed. The same procedure was used for PDC-31207 with PDC-22127 in manual. Here again gains were found adequate and not changed.

Final gains are PB of 300% and reset of 0.75 minute for PDC-22127; and PB of 50% and reset of 0.75 minute for PDC-31207. Even though PDC-31207 tuning was not required, this data was acquired and approved. Original gain setting were made for PDC-22127 to satisfy the loop trip transient.

Part 8D - Circulator Speed Control

Tuning of the circulator speed controllers consisted of successively placing each controller in "Local Automatic" and making a 200 RPM setpoint change. Controller gains were adjusted to meet quarter amplitude damping and to reduce valve oscillation.

The circulator speed controller tuning indicated that even with quarter amplitude damping the circulators speed valves were oscillatory . To reduce wear on the speed valves the controller gains were decreased. Indications are that the circulator speed controls are still fast enough to handle normal control and plant transients.

Part 10D - Circulator Pressure Ratio Control

The pressure ratio controller tuning consisted of making a .05 setpoint change and then back to the original setting. Both controllers indicated less than quarter amplitude damping and therefore did not require any gain adjustments.

Each controller setpoint was changed decreasing and then increasing by 0.05. PC-2243 setpoint was at 1.48 while PC-2244 was set to 1.54 at start and end of test. Final gain settings remained at PB of 35% and reset of .015 minutes for PC-2243, and PB of 50% and reset of .015 minutes for PC-2244.

Part 12C - Reheat Steam Desuperheat Control

The purpose of the hot reheat desuperheaters is to cool the hot reheat steam bypassing the turbine before it enters the condenser. This cooling is accomplished by spraying condensate into the six bypass lines. Initial attempts to operate the system at low power resulted in temperature controller oscillations. The oscillations were caused by the inability of the spray nozzles to atomize the small amount of condensate flow required at the low power levels. The control system was modified so that the minimum flow at which good atomization occurs was always maintained during reheat steam bypass. This was done by setting the batch limit on the desuperheater temperature controller, TIC-5226, so that the control valve could not close to less than a 15% open position in automatic operation.

The hot reheat desuperheater controller tuning test was conducted at 60% power, feedwater flow was 656,000 lb/hr per loop, main steam temperature was 970°F and reheat steam temperature was 1000°F. Steam flow through the #1 reheat bypass line was established by opening the #1 reheat bypass valve with a jumper in the valve test circuit. This caused a steam flow through the desuperheater of 1/7 of the reheat steam flow or ~187,000 lb/hr.

Part 12C - (continued)

When the system stabilized, the desuperheater temperature controller, TIC 5526-1, output was at the batch limit (control valve 15% open) and the desuperheater outlet temperature was at saturation. The controller was then placed in manual and the output reduced to about 12%. The outlet temperature of the desuperheater increased above saturation temperature. The batch limit of the controller was then adjusted to allow the control valve to close farther than 15% in automatic operation. When the controller was placed in automatic, the desuperheater outlet temperature and controller output oscillated. The controller gain was changed from 100% proportional band to 200%. When a setpoint change was made, oscillations were still seen in the response, so the proportional band was increased to 300%. With this setting, satisfactory response was obtained.

The reheat desuperheater temperature controllers will never control temperature to setpoint. During most operation, the outlet temperature of the desuperheaters will be saturation temperature, caused by excessive spray. The condenser will therefore always be protected. Reheat bypass steam flow above 25% is expected for only short periods of time following turbine trips. Immediately following a turbine trip the spray flow is at maximum and is reduced only if the measured temperature at the outlet of the desuperheater is less than setpoint.

Part 13A - Main Steam Desuperheater Temperature Control

The main steam desuperheater tuning test required a significant amount of main steam bypass flow. This was accomplished by placing the feedwater flow and reactor power controller in local automatic and reducing the turbine load. During the desuperheater tuning, approximately half of the main steam flow was being bypassed.

The Loop 1 desuperheater temperature controller, TIC 5207, was tuned first. The proportional band was increased to 150% and the reset time decreased to 2.5 minutes. A setpoint change was made with good temperature response.

Part 13A - (continued)

Several setpoint steps to the Loop 2 desuperheater controller, TIC-5208, wer made. Good temperature response was obtained with a proportional band of 100% and reset time of 2.5 minutes. The recommended desuperheater temperature control settings are therefore:

	Proportional Bank, %	Reset, Minutes
TIC 5207	150	2.5
TIC 5208	100	2.5

After the previous main steam desuperheater controller tuning test, when the flow through the desuperheaters was reduced, the desuperheater control system oscillated. To prevent the oscillations at low steam flow, the valve positions of TCV-5208 and TCV-5207 were changed from a linear characteristic to a square characteristic. When the steam flow through the desuperheaters was reduced during this test, no undamped oscillations were seen.

Part 14E - Main Steam Temperature Control

The main steam temperature controller tuning consisted of making a controller setpoint changes of -15°F followed by a setpoint change of +15°F. These setpoint changes were made in one loop at a time with the setpoint rate limiters set for 10°F per minute.

The response of Loop 1 and Loop 2 are not the same, but the difference is believed to be caused by the controllers and they will be checked during the next plant shutdown. Both loops meet quarter amplitude damping and are therefore acceptable.

The helium flow in Loop 1 was reduced when the Loop 1 main steam temperature setpoint was reduced 15°F. The Loop 1 main steam temperature decreased and reheat steam temperature decreased for a while then increased. The Loop 2 main steam and reheat steam temperature increased. The reactor power changed and the Regulating Rod moved out when the Loop 1 setpoint was decreased and the reactor power changed

Part 14E - (continued)

and the Regulating Rod moved in when the Loop 1 setpoint was increased. These power changes and Regulating Rod movements are believed to be effects of reactivity changes caused by core temperature changes resulting from helium flow changes.

Part 15E - Reheat Steam Temperature Control

The reheat controller setpoint rate limiter was increased to 10°F per minute. A -10°F setpoint change was made to TC-2256. The reduction in reactor power caused the main steam temperatures to decrease along with the reheat steam temperatures. The main steam temperature controllers increased the circulator speeds to maintain main steam temperature at setpoint.

The 10°F increase in setpoint was made before the transient from the -10°F setpoint had settled out and the quarter amplitude damping cannot be determined.

The reheat steam temperature controller has a ± 5°F deadband and the flux controller has a ± 1.0 percent deadband. The expanded trace of the control rod position indicates that the control rod had stopped moving after both the -10°F and +10°F setpoint changes. The fact that the control rod had stopped moving means that linear analyses and quarter amplitude damping doesn't apply anymore. The reheat steam temperature will tend to move around as the two controllers go in and out of their deadband.

The controller is very responsive, but stable operation has been experienced during large plant transient, therefore the reheat steam controller tuning is considered acceptable. The controller tuning will be observed to determine if it is causing excessive control rod jogs.

Part 16D - Throttle Pressure Control

This tuning consisted of placing PC-5243 in manual and making ± 50 psi steps in setpoint. Gains did require changing. Quarter amplitude damping was achieved.

Part 17D - Module Main Steam Temperature Trim Control

The module main steam temperature trim control system was tuned by transferring controller TDIC-2228-5 to manual and ramping its output to 50% and then transferring the controller to automatic.

Controllers TDC-2227 and TDC-2228 have proportional band only plus a manually set output bias. The bias was set to give a controller output of 50% with a zero deviation. This required a PB of 20% and a setpoint of 85% to maintain the most open valve at 90% open.

The first run showed that the TDIC-2228-1 thru -6 controller gains of PB - 100% and reset of 1.0 minute was to high. The reset gain dial was increased to 3.0 minutes (this is a reduction in reset gain). The second run satisfied quarter amplitude damping. The gains of TDIC-2227-1 thru -6 were also set to PB of 100% and reset of 3.0 minutes. Loop 1 was not tested because of problems with patching the signals to the Brush recorders and the Time Data computer.

The proportional gain for TDC-2227 and TDC-2228 was not changed from 20%.

Part 20F - Load Change Response

The load change ramp was to be 1% per minute down and back up. The down ramp is accomplished by the operator reducing the turbine-generator load manually. The down ramp rate started at .6% per minute and increased to 1.3% near the end of the down ramp. The up ramp is controlled by the turbine-generator control system. The up ramp was .6% per minute. The up ramp was stopped at about 50% for about 10 minutes for operator shift change.

The load change required operator action on the shim rods to maintain control of reactor power with the Regulating Rod. On the down ramp, the Regulating Rod was allowed to move in to about 75 inches before the shim rods were moved. The Regulating Rod was maintained at 100 inches during the load increase. The reactor power followed power demand very well even with shim rod movement.

Reactivity Coefficient Measurements (B-8)

This test was not scheduled during the report period.

Part 20F- (continued)

The reheat steam temperature was about 1000°F at the start of the load change and decreased to 940°F at 30% load. The main steam temperature was about 990°F at the start of the load change and decreased to about 890°F at 30% load. The steam temperatures drooped the right amount but they did not follow a ramp function down. The main steam temperature started to droop first and then reheat steam temperature started to droop. This reheat steam temperature droop caused the main steam temperature to droop even more. It is possible that the main steam and reheat steam temperature control systems were interacting to cause the resulting steam temperature droops. The hold portion of the up ramp caused a larger perturbation in the steam temperature than the load change itself.

Both main steam temperature controls went to zero during the main steam temperature droop and the reheat steam temperature control decreased to 30% during the reheat steam temperature droop. If this condition exists during steady state operations, the circulator speed and reactor power characterizers could be reprogrammed to better match the steady state circulator speed and reactor power requirements. This will be monitored during future automatic operation at low power.

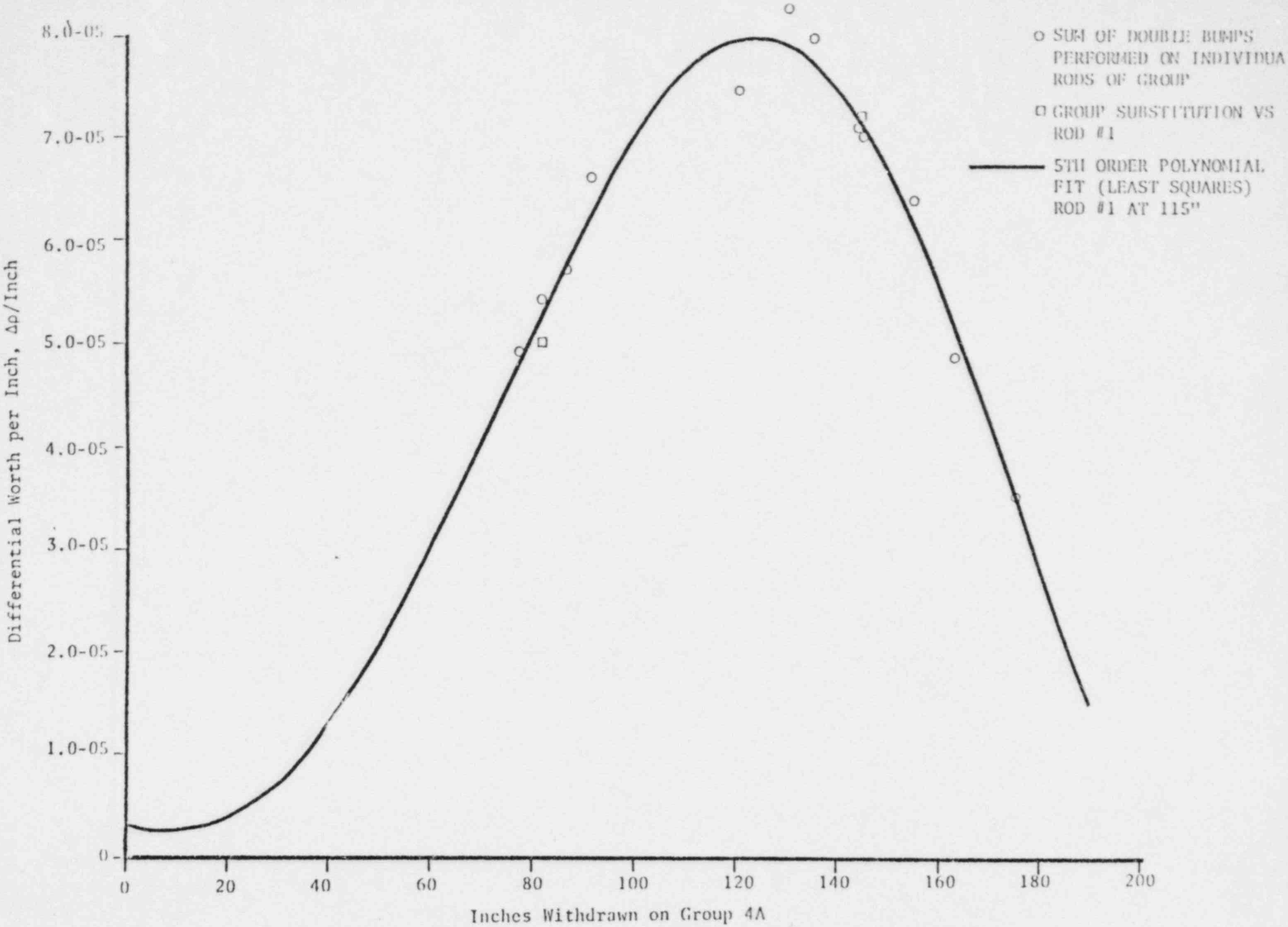
The feedwater flow experienced some oscillations on the down ramp and up ramp. The feedwater flow oscillations appear to be caused by the oscillation on the extraction steam pressure to 'BFP-1A' and 'BFP-1C'.

CONTROL ROD CALIBRATION (B- 9)

DATA

The measured differential rod worth data for rod group 4A is given in Table B-9.1. These data are plotted in Figure B-9.1.

Figure B-9.1



Differential worth, rod group 4A (rods #20, 26, 32)

TABLE 8-9.1 (continued)

Rod #	Avg. Pos.	Δp/Inch
32	131.0	0.285×10^{-4}
32	120.8	0.259×10^{-4}
20+26+32	145.0	0.714×10^{-4}
20	176.2	0.076×10^{-4}
20	164.2	0.103×10^{-4}
26	176.0	0.153×10^{-4}
26	164.0	0.216×10^{-4}
32	176.1	0.121×10^{-4}
32	163.4	0.167×10^{-4}
20	157.0	0.140×10^{-4}
20	146.2	0.165×10^{-4}
26	156.0	0.288×10^{-4}
26	146.0	0.289×10^{-4}
32	155.8	0.214×10^{-4}
32	146.0	0.248×10^{-4}

TABLE B-9.1

SUMMARY OF ROD GROUP 4A DIFFERENTIAL WORTH MEASUREMENTS

Rod #	Avg. Pos.	Δp/Inch
20	87.0	$0.161x10^{-4}$
20	79.0	$0.150x10^{-4}$
26	86.9	$0.259x10^{-4}$
26	77.0	$0.206x10^{-4}$
32	87.1	$0.153x10^{-4}$
32	77.0	$0.136x10^{-4}$
20+26+32	81.6	$0.501x10^{-4}$
20	92.2	$0.180x10^{-4}$
20	81.6	$0.146x10^{-4}$
26	91.4	$0.291x10^{-4}$
26	81.6	$0.239x10^{-4}$
32	91.8	$0.189x10^{-4}$
32	81.5	$0.156x10^{-4}$
20	145.0	$0.167x10^{-4}$
20	136.0	$0.184x10^{-4}$
26	145.0	$0.298x10^{-4}$
26	135.0	$0.334x10^{-4}$
32	145.1	$0.244x10^{-4}$
32	135.0	$0.282x10^{-4}$
20	131.1	$0.205x10^{-4}$
20	121.0	$0.185x10^{-4}$
26	131.0	$0.335x10^{-4}$
26	121.0	$0.302x10^{-4}$

COMPARISON OF ACTUAL AND PREDICTED PERFORMANCE

Table B-9.2 shows a comparison of the measured and predicted integral rod worths for the rod groups measured through the startup test program so far. The acceptance criteria limits are also shown.

Figure B-9.2 shows the measured differential rod worth points and the least squares fitted curves from which the integral worth is obtained for rod group 4A. The integral worth curve for this rod group is shown in Figure B-9.2.

TABLE B-9.2

COMPARISON OF PREDICTED AND MEASURED ROD GROUP WORTHS

Group	Predicted Group Worth Δρ	Measured Group Worth Δρ	Deviation Measured-Predicted %ρ	Acceptance Criteria Limits %ρ	Predicted Cumulative Worth Δρ	Measured Cumulative Worth Δρ
All groups in sequence prior to group 2B*	0.1016	0.103*	--	--	0.1016	0.103*
2B	0.0416	0.0406	-2.4%	±20%	0.1432	0.1436
3A	0.0163	0.0188	+15%	±20%	0.1595	0.1624
4D	0.0026	0.0025	-4%	+100% -50%	0.1621	0.1649
3B	0.0232	0.0205	-12%	±20%	0.1853	0.1854
4E	0.0082	0.0082	0	±20%	0.1935	0.1936
4A	0.0083	0.0082	-1%	+100% -50%	0.2018	0.2018

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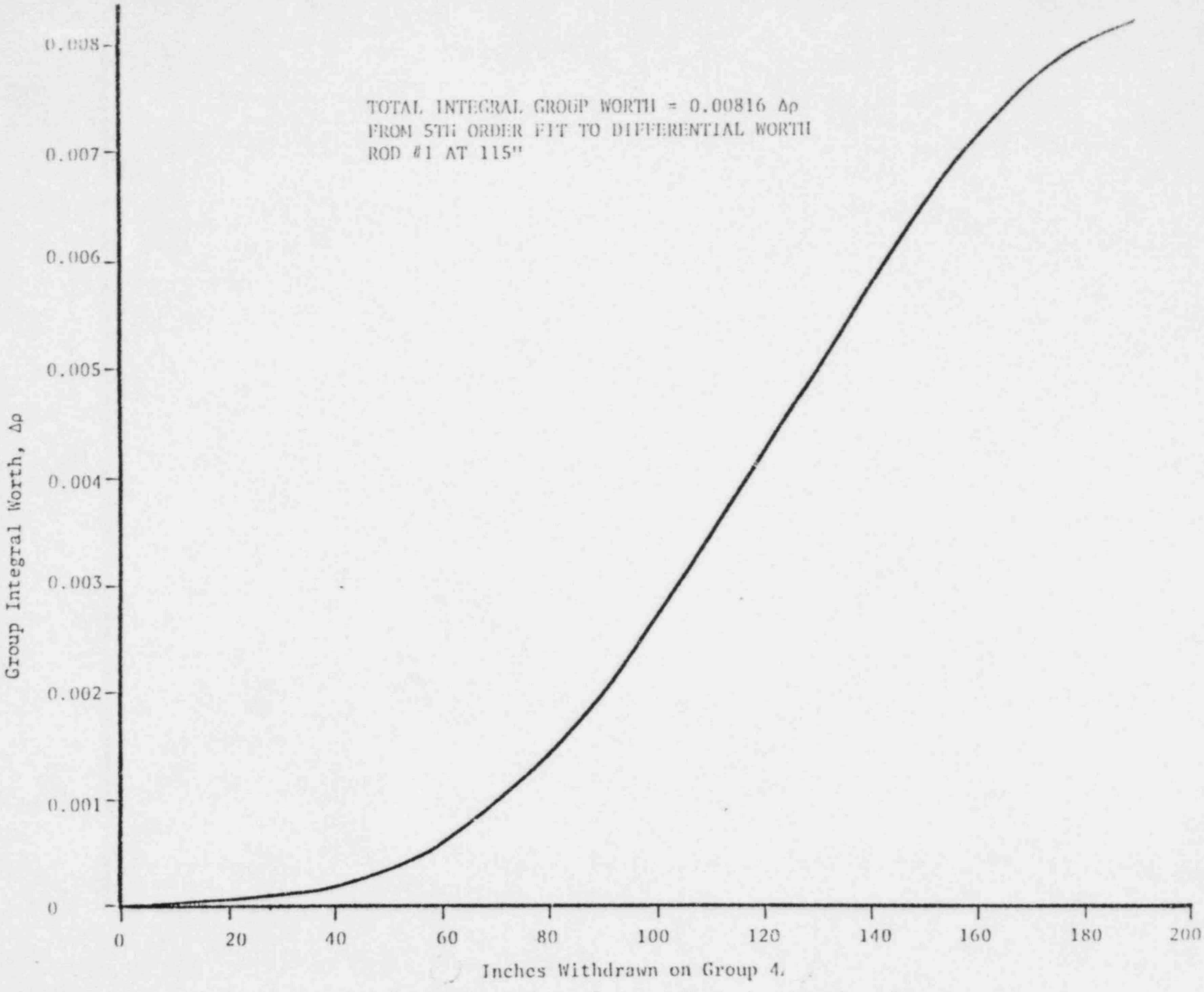
[*] Measured in SUT A-3



Integral worth, rod group 4A (rods #20, 26, 32)

Figure B-9.2

XENON BUILDUP AND DECAY MEASUREMENTS (B-10)

This test was not scheduled during the report period.

XENON STABILITY TESTS (B-11)

This test was not scheduled during the report period.

SHIELDING SURVEYS (B-12)

This test was not scheduled during the report period.

RADIOCHEMICAL ANALYSIS OF THE PRIMARY COOLANT (B-13)

This test was not scheduled during the report period.