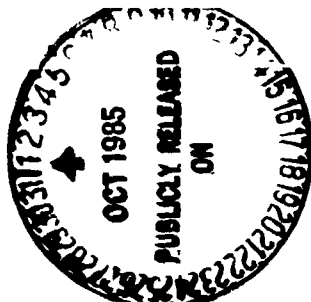
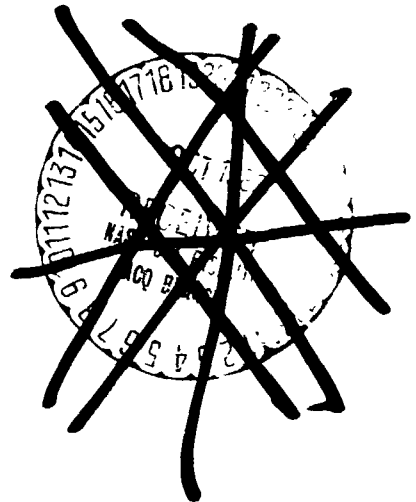


SBT



(NASA-CR-170888) RESULTS OF TESTS OF THE
SRB AFT SKIRT HEAT SHIELD CURTAIN IN THE
MSPC HOT GAS FACILITY (Lockheed Missiles and
Space Co.) 64 p HC AG4/MF A01 CSCL 21H

N85-35223

Unclas
16044

Date of general release

33/20



 **Lockheed**
Missiles & Space Company, Inc
Huntsville Research & Engineering Center

Cummings Research Park
4800 Bradford Drive
Huntsville, AL 35807

RESULTS OF TESTS OF THE SRB
AFT SKIRT HEAT SHIELD
CURTAIN IN THE MSFC HOT
GAS FACILITY

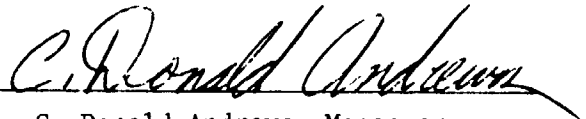
February 1982

Contract NAS8-32982

Prepared for National Aeronautics and Space Administration
Marshall Space Flight Center, AL 35812

by
W. G. Dean

APPROVED



C. Donald Andrews, Manager
Systems Engineering Section

FOREWORD

This work was performed by personnel in the Systems Engineering Section of Lockheed's Huntsville Research & Engineering Center for NASA-Marshall Space Flight Center under Contract NAS8-32982.

The MSFC technical monitor for this study is Mr. W. P. Baker, EP44.

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1. INTRODUCTION

During the first two Space Shuttle flights the aft skirt heat shield curtain performed well during ascent but failed during reentry. This exposed the inside of the skirt and its subsystems to reentry heating. The resulting exposure damaged various expensive systems items and therefore a curtain reassessment is required. As a part of this reassessment, tests were conducted in the MSFC Hot Gas Facility (HGF). The purposes of these tests were to determine if the curtain would fail in a manner similar to that in flight and to demonstrate that meaningful tests of the curtain can be conducted in the HGF.

2. TECHNICAL DISCUSSION

Two curtain specimens were made up by the MSFC Fabric Shop. These were "single segment curtains" and were designated SSC-1 and SSC-2. Both specimens were instrumented with thermocouples and accelerometers. They were mounted in a steel frame approximately 30 in. by 22 in. by 3½ in. deep. The "drape" of the curtain was in the flow direction. Figure 1 shows the curtain installed in Position 1 of the HGF. Figure 2 shows the mounting details of the curtain in the steel frame. Figure 3 shows the thermocouple locations. Figure 4 shows the accelerometer locations for both curtains. Figure 5 shows the pretest specimen SSC-2. (No pretest photograph is available for SSC-1).

2.1 DESCRIPTION OF TESTS

Specimen SSC-1 was run in the HGF only while SSC-2 was run in a radiant test rig and then in the HGF. This radiant test was designed to simulate ascent heating of the curtain.

Table 1 shows a summary of the HGF runs on both curtains. SSC-1 was run for two separate cold flow tests of 60 sec and 10 sec. Then it was run for 60 sec of hot flow and then again for 10 sec of cold flow. Specimen SSC-2 was run for 60 sec of hot flow. Tables 2 and 3 show the approximate cold flow and hot flow run conditions to which the curtain was exposed in the HGF test. For comparison, Table 4 shows a set of values for SRB flight at the beginning of reentry.

The radiant tests were conducted in a special buildup heating facility consisting of three modular heating units (MHUs).

The total size of this radiant lamp bank was about 40 in. by 40 in. These were set up in test cell 300 at MSFC.

2.2 TEST RESULTS

2.2.1 SSC-1 Results

The temperature values from the first curtain hot flow test (SSC-1) are shown in Figs. 6 through 23. These results are difficult to interpret because most of the thermocouples were destroyed during the test. However, all are presented for the sake of completeness.

Accelerometer data are shown in Figs. 24 through 29. These g-levels ranged up to approximately 300 g, showing that very severe motion of the curtain occurred. Post-test inspection of the curtain showed that all layers of the blanket burned through. A review of the test movies showed that the curtain outer layers shredded early in the test, indicating severe flutter and flapping of the curtain resulting in the complete shredding by this action. A post-test photograph of the curtain is shown in Figure 30.

2.2.2 SSC-2 Results

The temperature values from the radiant test of the second curtain (SSC-2) are shown in Figure 31. The total test time was approximately 220 sec due to some problems in getting the lamps to respond correctly without kicking off the controller. However, this is not considered to be a major problem because the objective was to get the surface to a maximum temperature rather than to achieve any particular heat load value. The outer layer temperature reached approximately 1880 F and was held there for approximately 50 sec. The rest of the plot (from 220 sec to 400 sec) shows the cooldown period.

Figures 32 through 49 show the temperature-time plots for the 18 thermocouples of curtain SSC-2 during the HGF test. The outer surface temperatures are very erratic as expected due to the severe flapping of the curtain. The inner blanket temperatures are somewhat more steady. No comparison with analysis was made due to the unsteady nature of the heating rate on a flapping curtain.

Figures 50 through 53 show accelerometer data from these tests. The peak g-levels exceeded 300 g.

Review of the test movies showed a violent motion and tearing of the curtain similar to that of SSC-1.

Post-test examination of this curtain showed that SSC-2 was in better condition than SSC-1. However, all layers burned through except the very last one. This better end condition was probably due to the difference in the total test time - when cold flow time is included. Also, this was probably due to part of the cold flow test on SSC-1 being performed after the hot flow test in the HGF. A post-test photograph of SSC-2 is shown in Fig. 54. From this photograph it is obvious that SSC-2 was in better condition after the test than was SSC-1.

Movie films of these tests are available from W. P. Baker, EP44.

3. CONCLUSIONS

From these tests it was concluded that:

- The HFG can be successfully used to conduct tests of the SRB Aft Skirt Heat Shield Curtain.
- The curtain segments both failed in these tests leaving a post-test condition somewhat similar in appearance to the flight curtain.
- Very severe acceleration levels can be attained in the HGF curtain tests.
- More study is needed to compare these test conditions to the predicted flight values, especially structural loads.
- Future HGF testing should be very useful in testing of any new curtains/redesigns.

REFERENCE

1. Engel, Karl, R. C. Lewis and J. V. McAnnally, "SRB Thermal Environment Data Book," RTR-028-1, REMTEC, Inc., Huntsville, Ala., July 1977.

Table 1
 RUN SUMMARY

<u>Curtain Specimen</u>	<u>Run No.</u>	<u>Run Time (sec)</u>	<u>Date (Dec 81)</u>	<u>Description</u>
SSC-1	1030	60	10	Cold Flow
SSC-1	1031	10	10	Cold Flow
SSC-1	1032	60	10	Hot Flow
SSC-1	1033	10	11	Cold Flow
SSC-2	1052	60	23	Hot Flow

Table 2
 SINGLE SEGMENT CURTAIN COLD FLOW TEST
 (MSFC HOT GAS FACILITY)

<u>Test Conditions</u>	<u>Value</u>
Static Pressure	13.9 psia
Total Pressure	52. psia
Mach Number	1.51
Dynamic Pressure	22.3 psia
Static Temperature	-160 F
Velocity	1283 ft/sec
Total Temperature	23 F

Table 3

SINGLE SEGMENT CURTAIN HOT FLOW TEST
(MSFC HOT GAS FACILITY)

<u>Test Conditions</u>	<u>Value</u>
Static Pressure	1.3 psia
Total Pressure	142 psia
Mach Number	3.75
Dyanmic Pressure	12.9 psia
Static Temp.	100 F
Total Temp.	1700 F
Velocity	4377 ft/sec

Table 4

TYPICAL SRB FLIGHT CONDITIONS
AT THE END OF ASCENT*
(Approximately 130 sec)

<u>Flight Condition</u>	<u>Value</u>
Total Temperature	1770 F
Mach Number	4.19
Velocity	4566 ft/sec

*Data from Ref. 1.

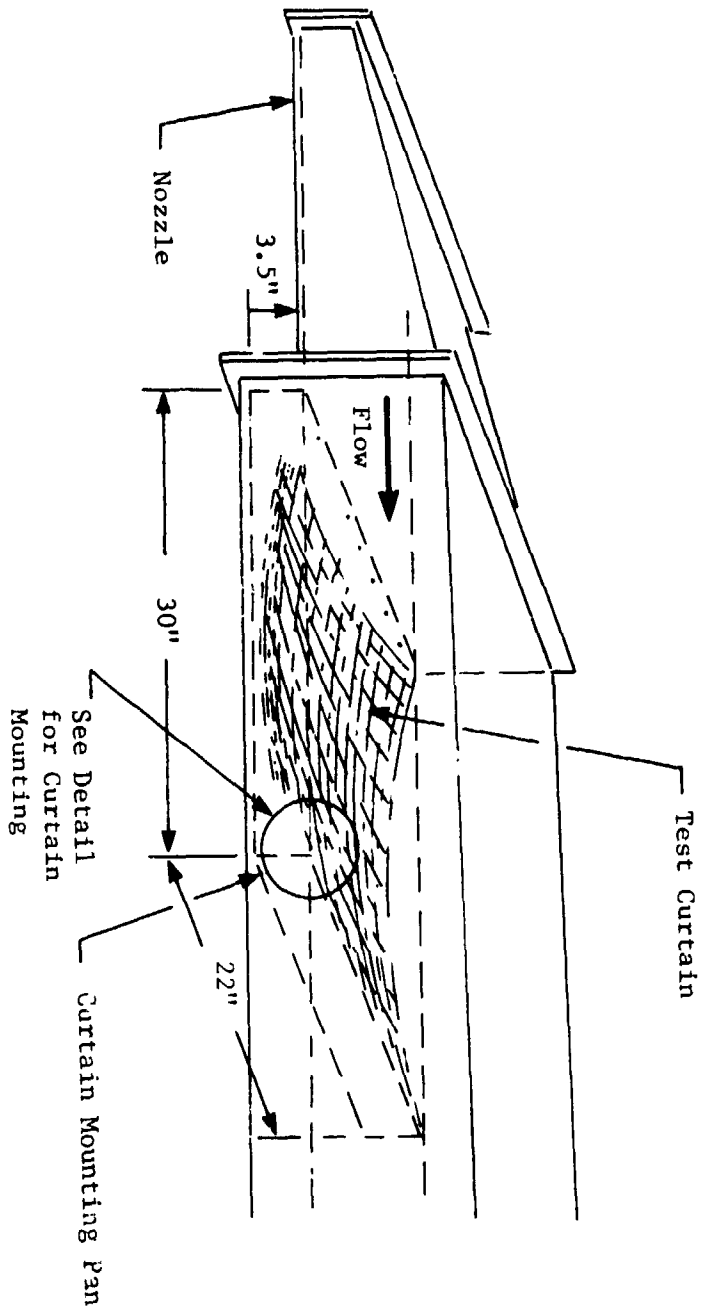


Fig. 1 - Thermal Curtain Installed in MSFC Hot Gas Facility

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ORIGINAL PHOTO
OF POOR QUALITY

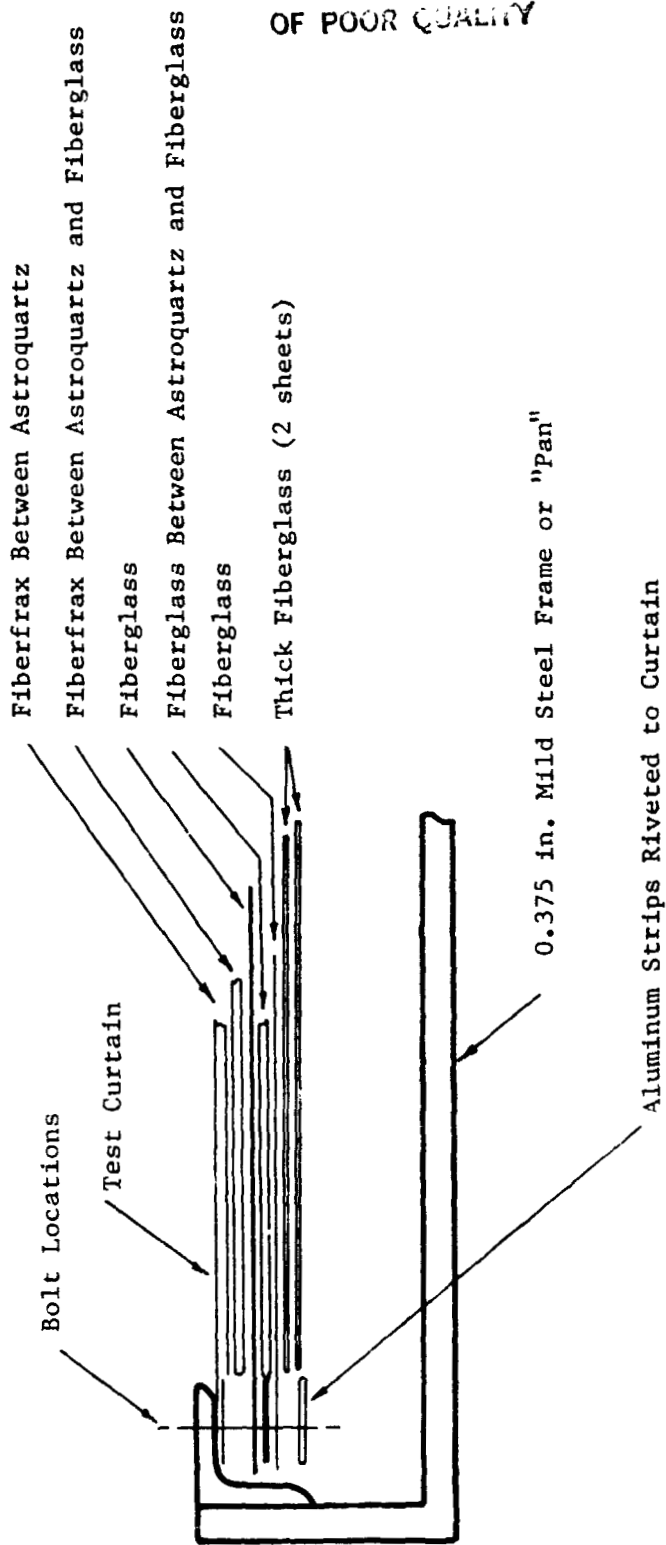


Fig. 2 - Thermal Curtain Mounting Details
(View Looking into Flow)

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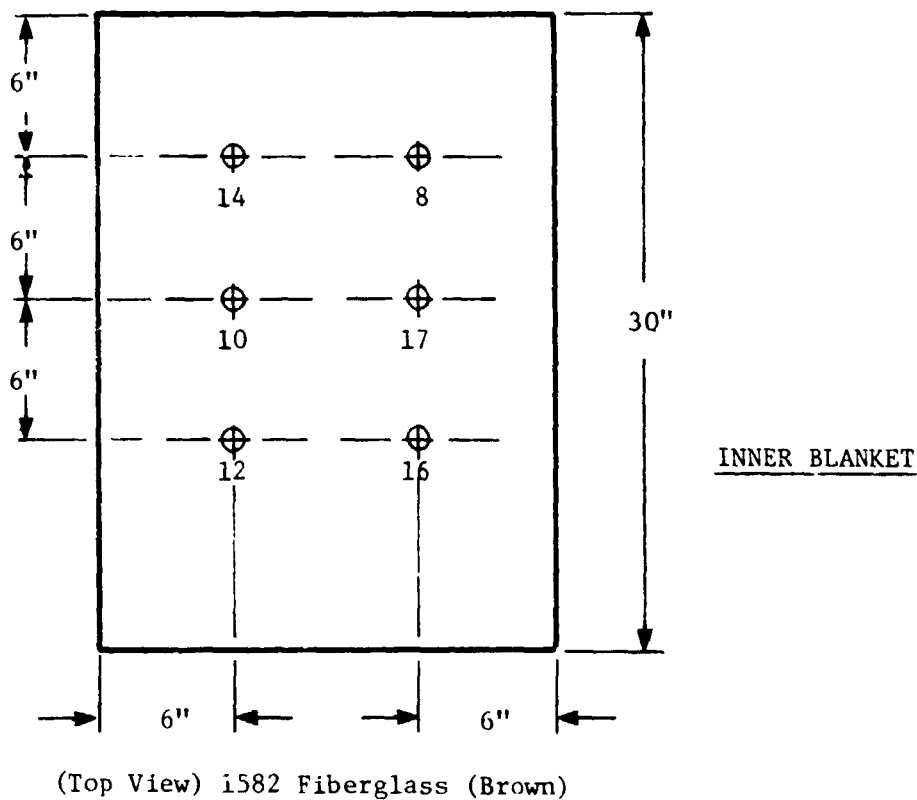
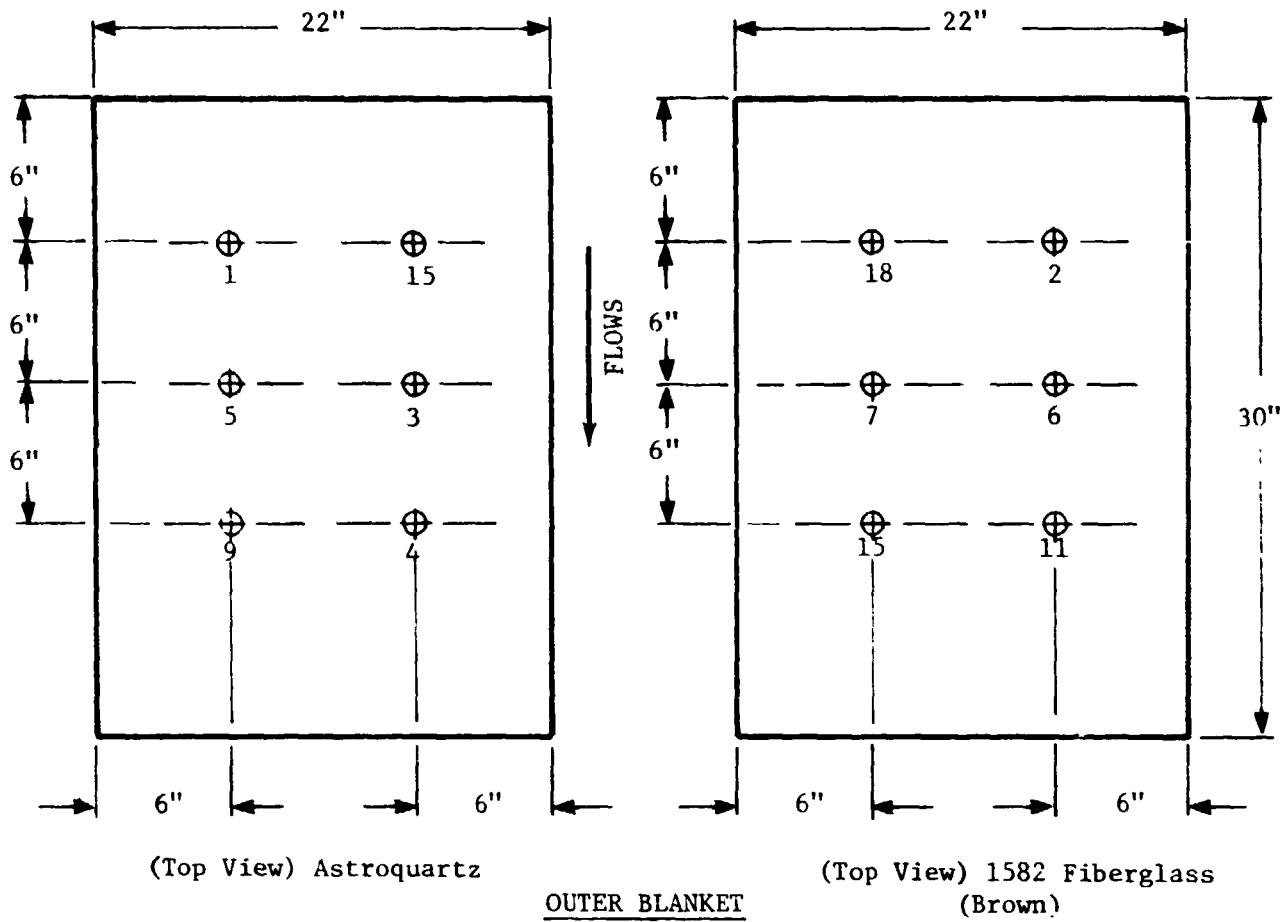


Fig. 3 - Approximate Thermocouple Locations

CRUISE TESTS
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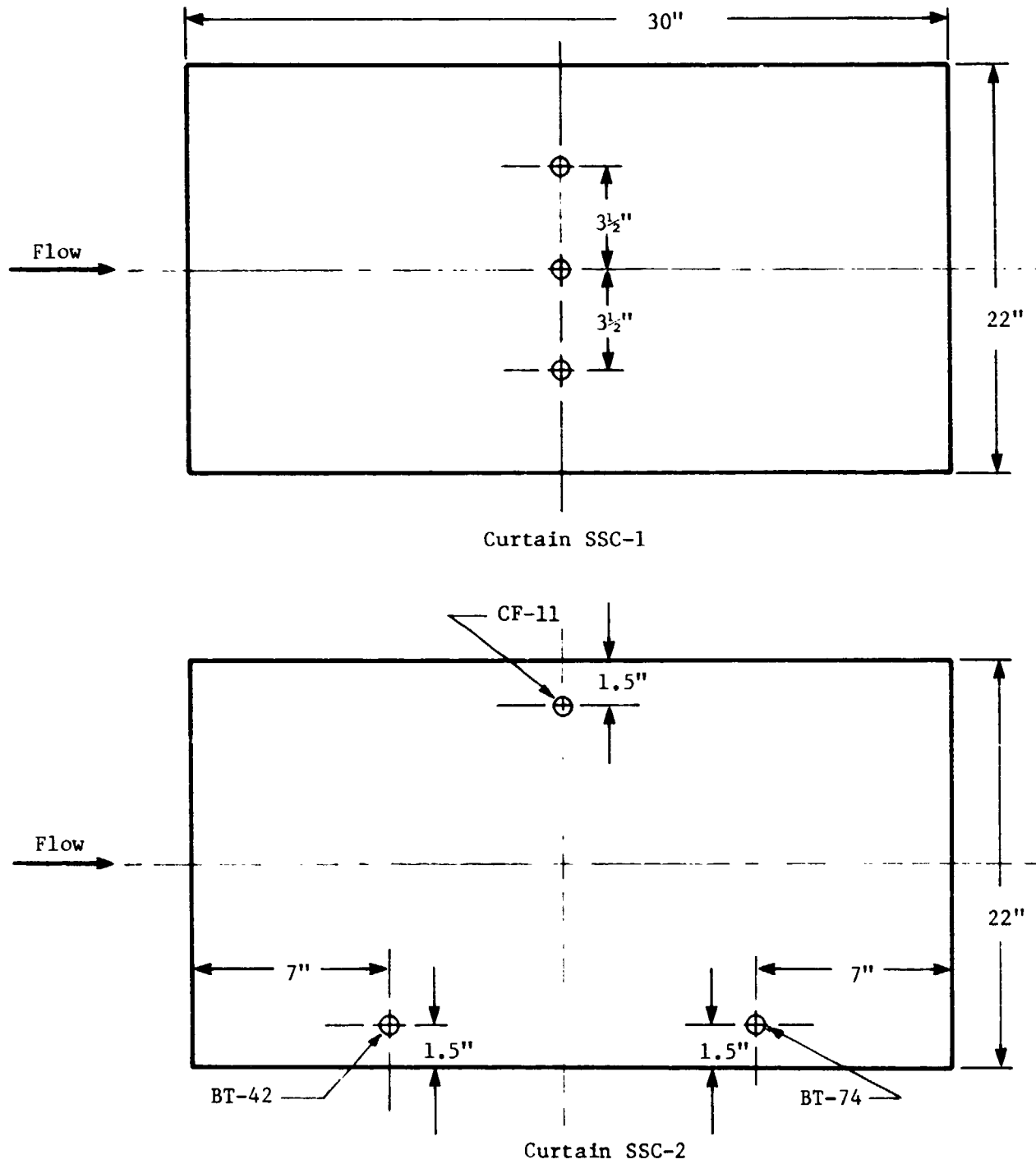


Fig. 4 - Approximate Accelerometer Locations

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Fig. 5 - Pretest Photo of Curtain Specimen - SSC-2

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CURTAIN TEMP .1

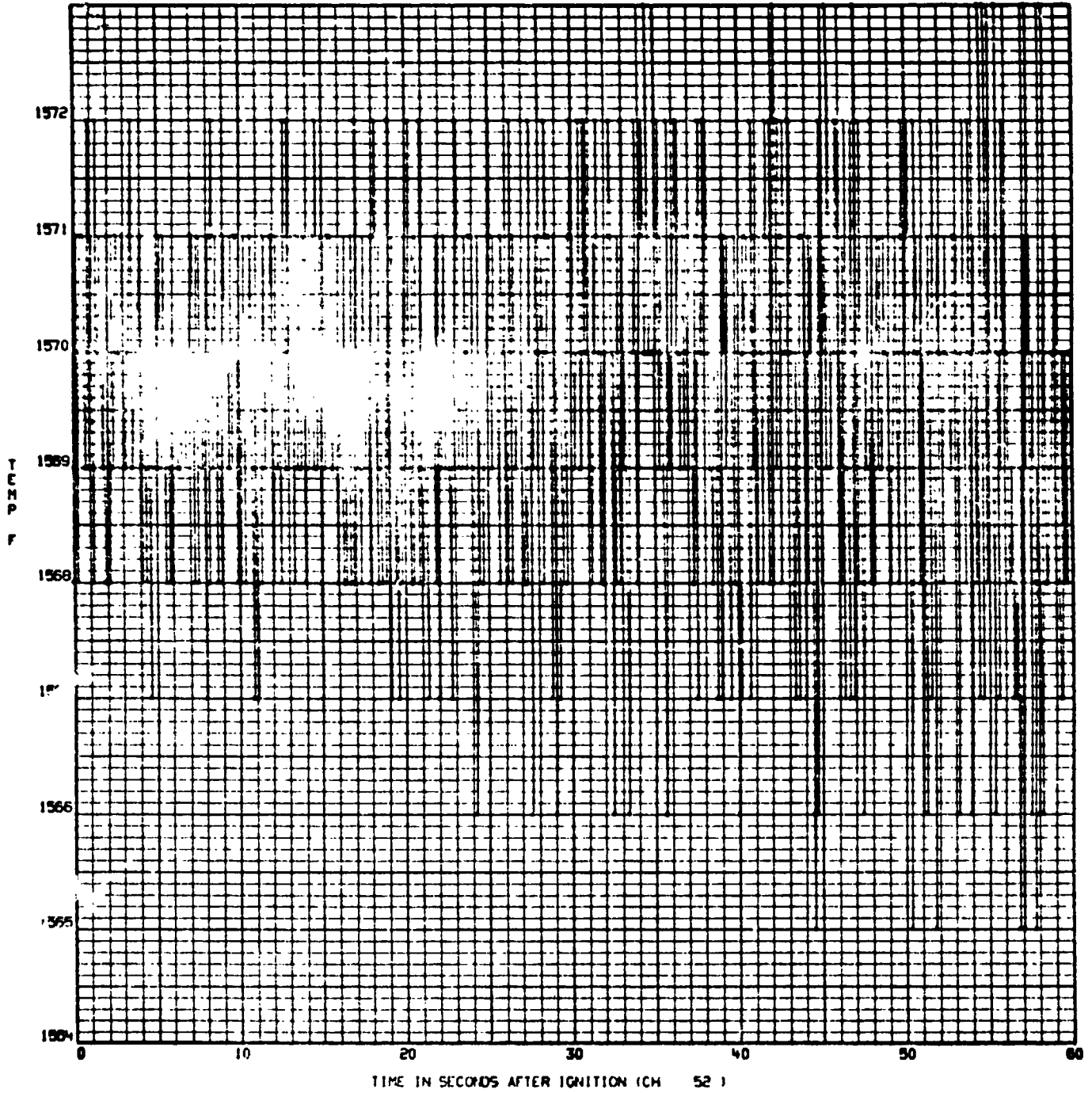


Fig. 6 - Temperature vs Time for Thermocouple 1 on SSC-1

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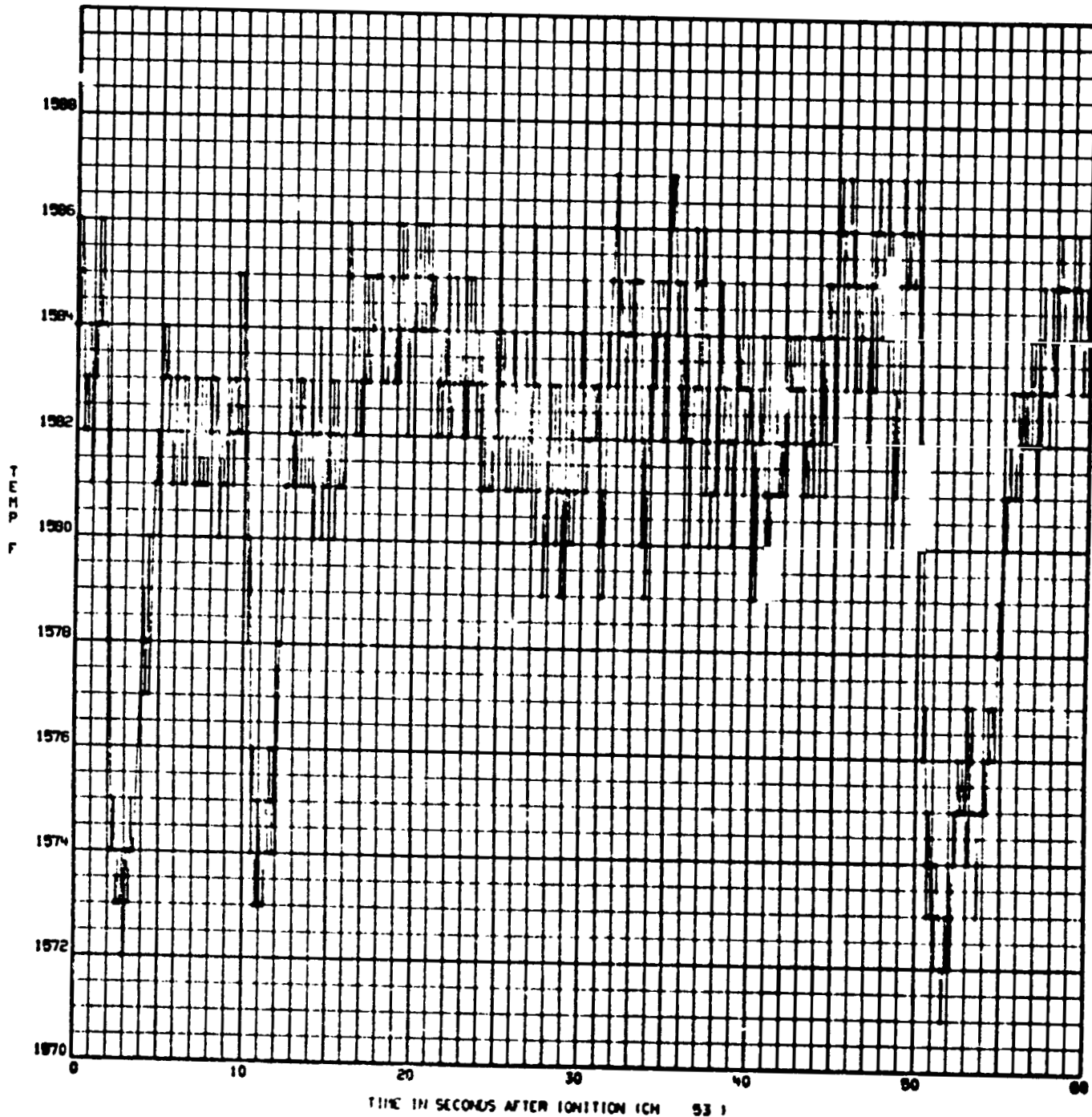


Fig. 7 - Temperature vs Time for Thermocouple 2 on SSC-1

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CURTAIN TEMP .3

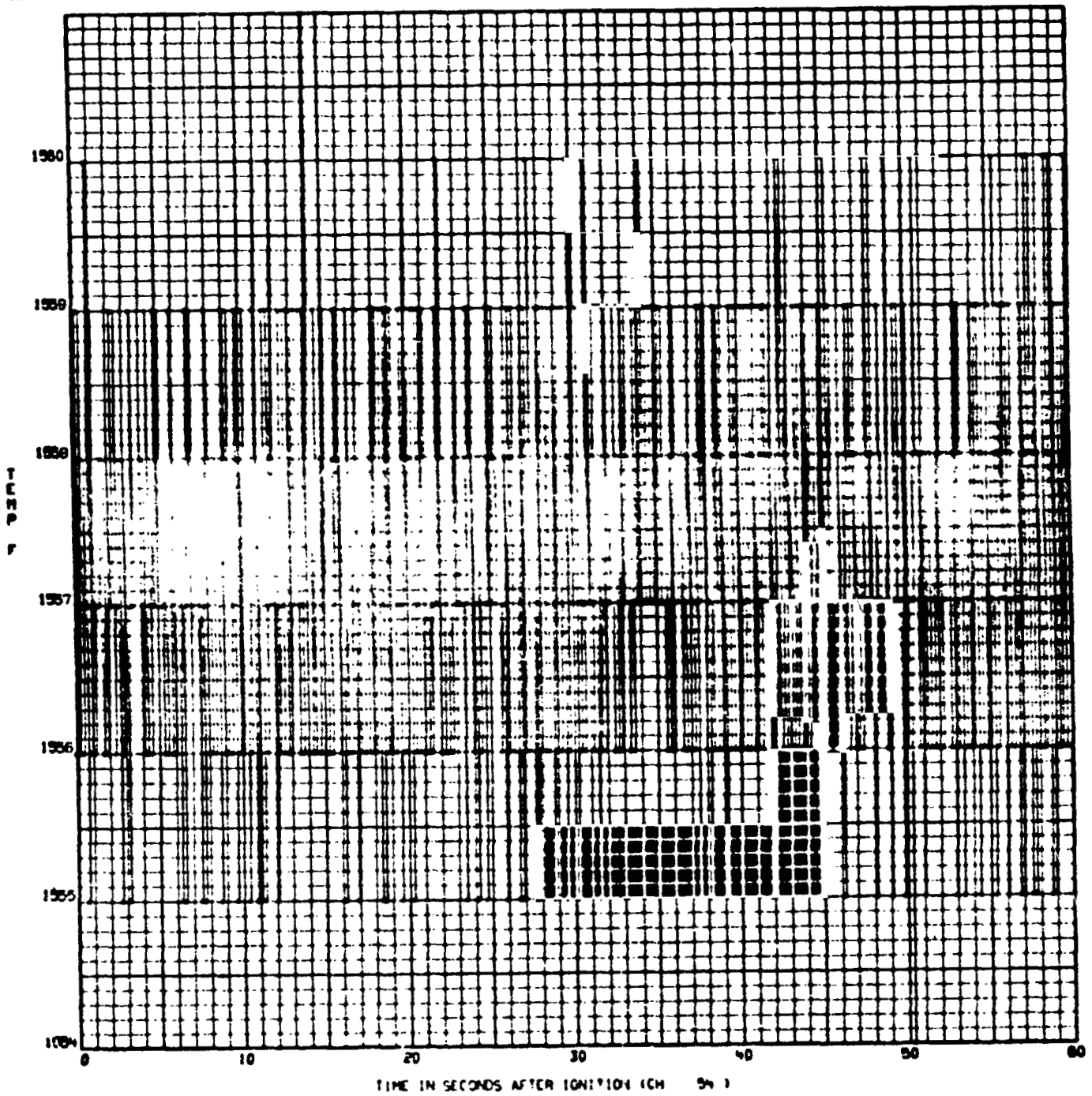


Fig. 8 - Temperature vs Time for Thermocouple 3 on SSC-1

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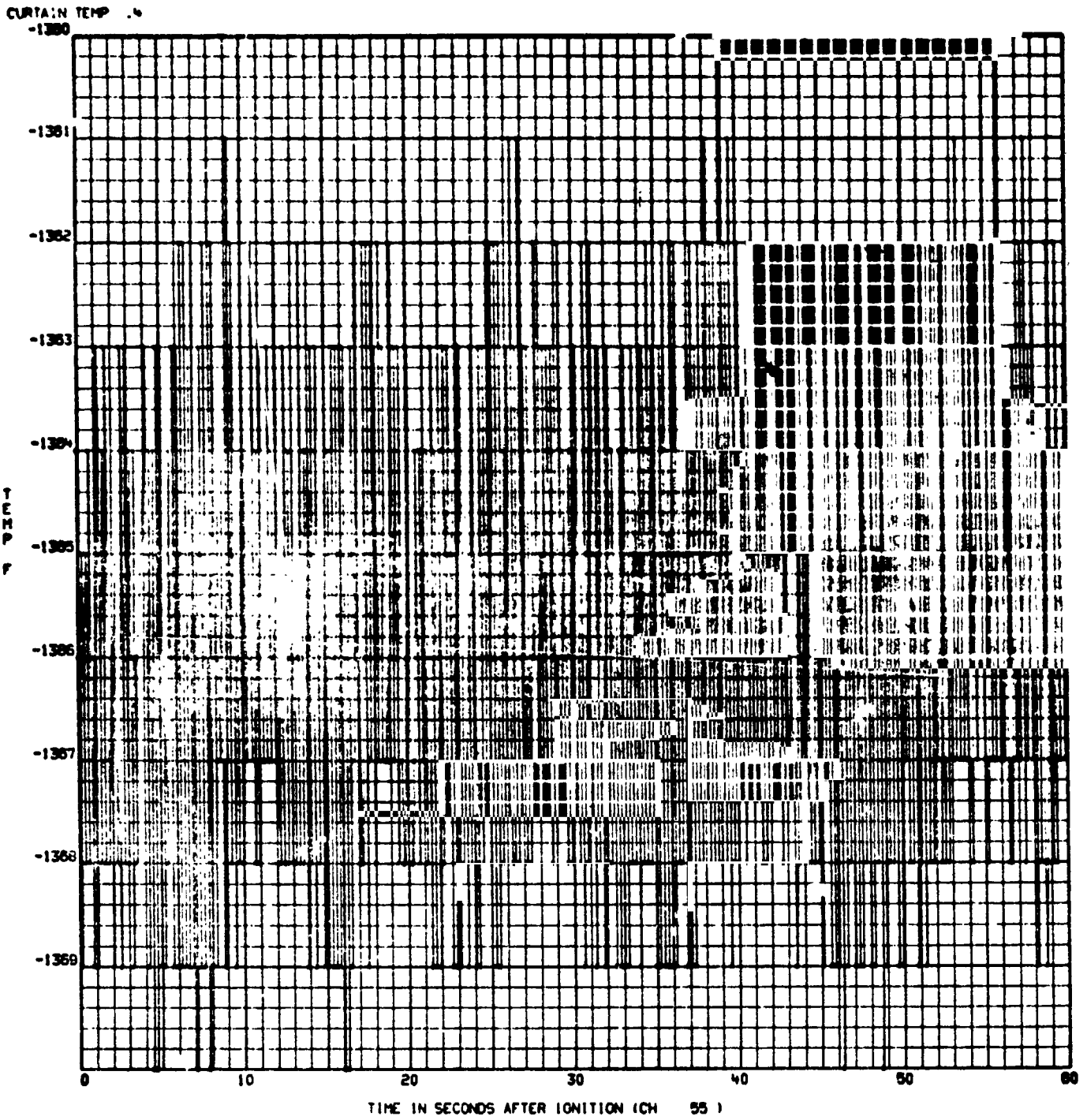


Fig. 9 - Temperature vs Time for Thermocouple 4 on SSC-1

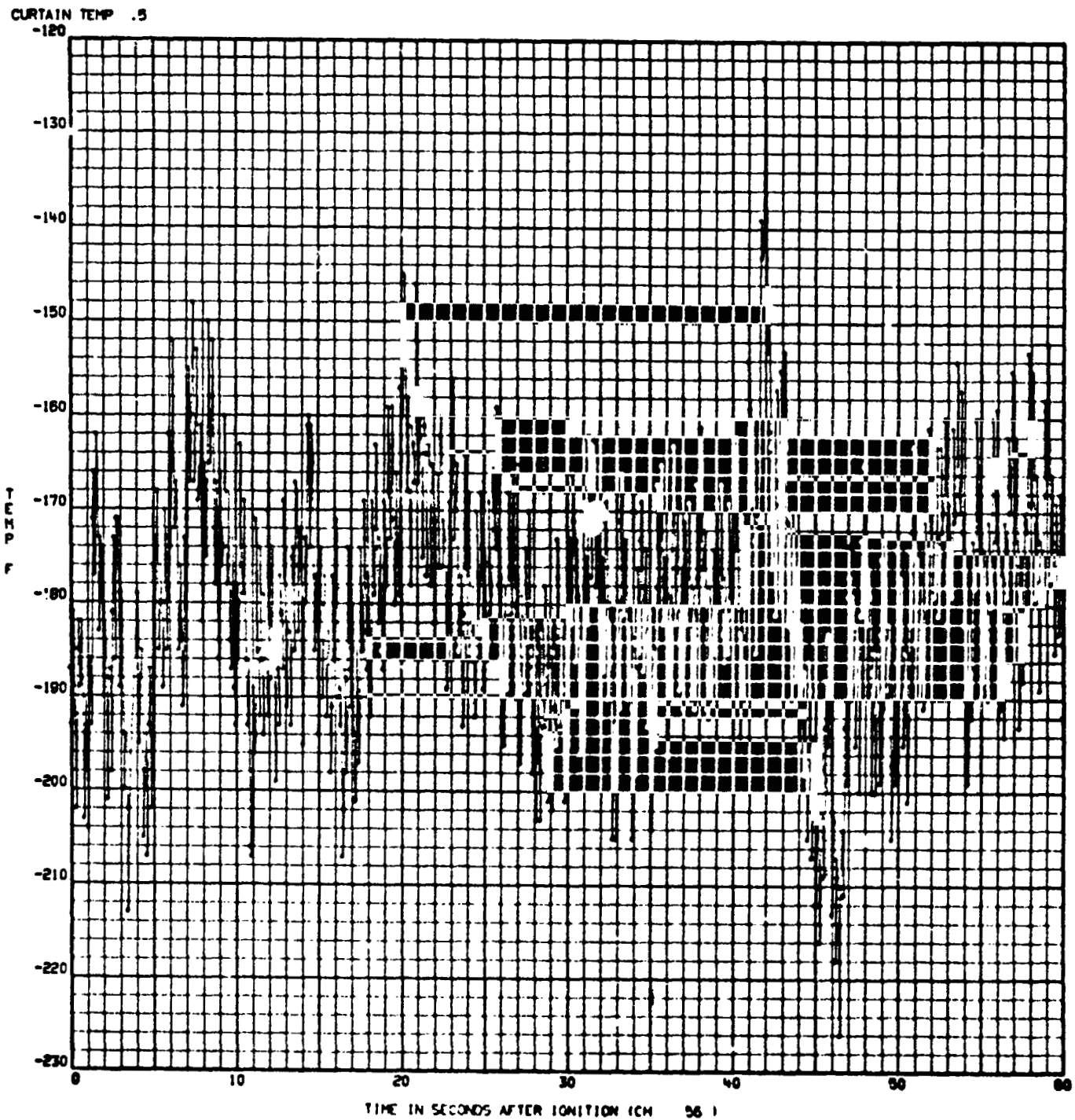


Fig. 10 - Temperature vs Time for Thermocouple 5 on SSC-1

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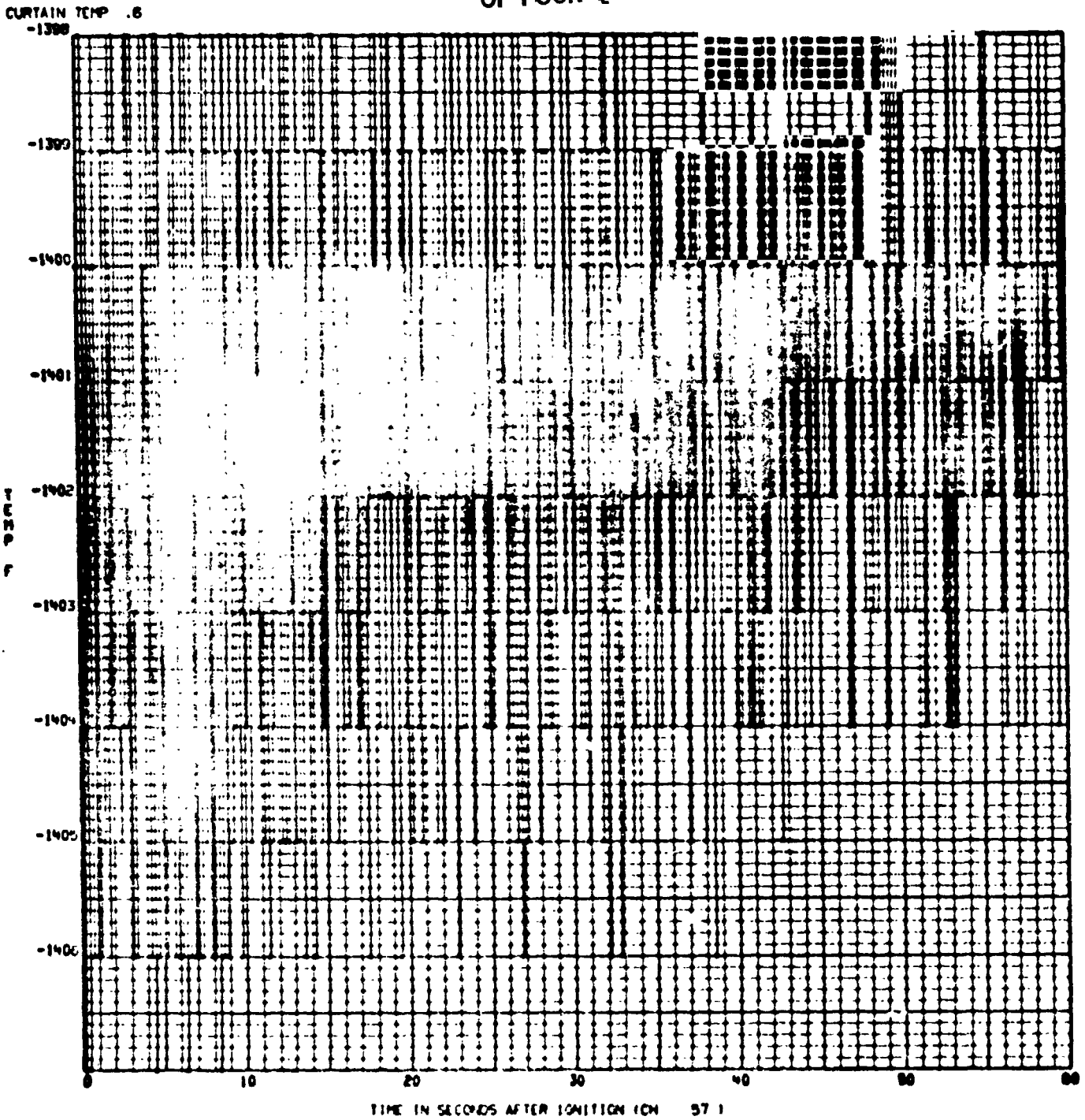


Fig. 11 - Temperature vs Time for Thermocouple 6 on SSC-1

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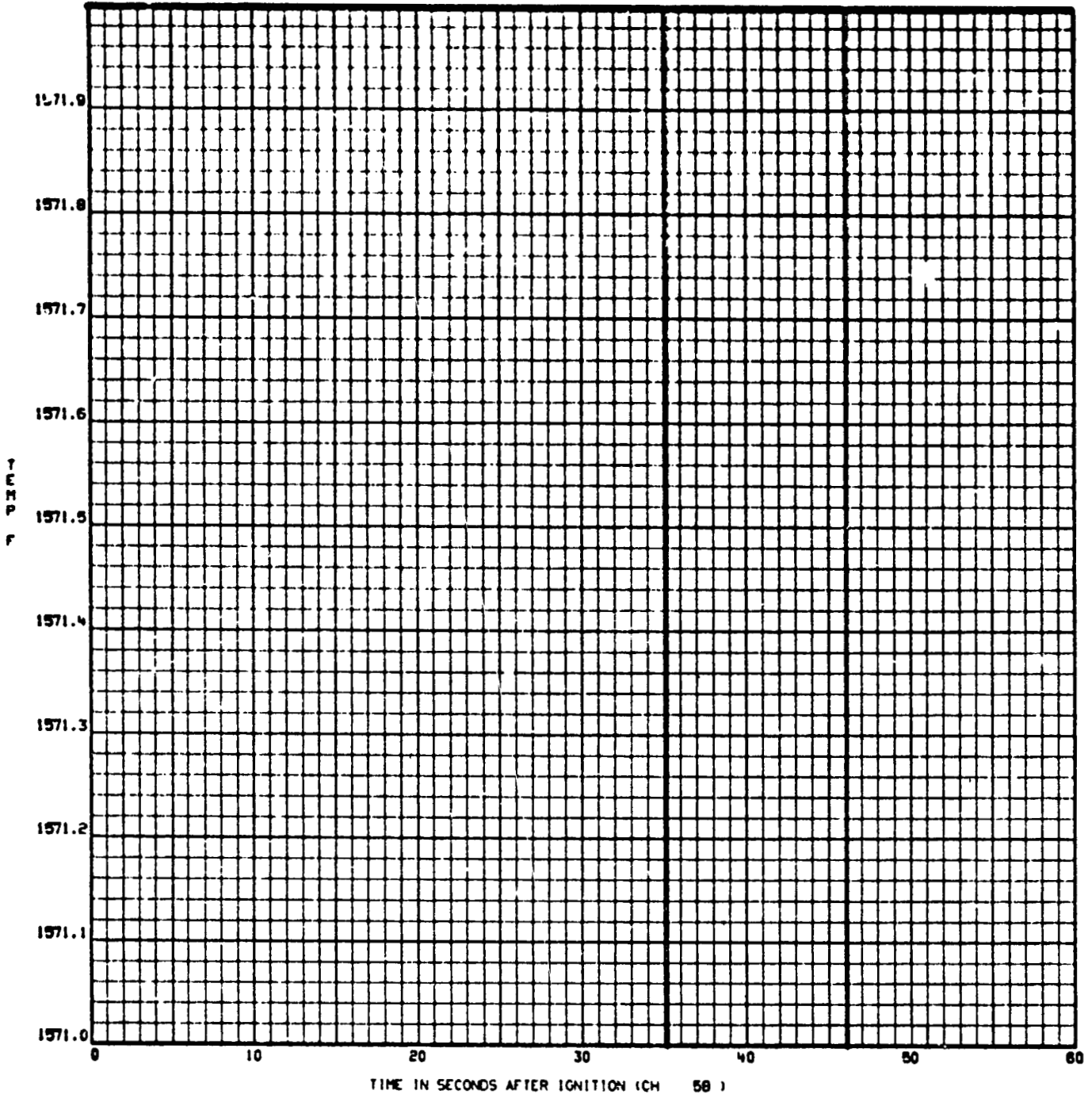


Fig. 12 - Temperature vs Time for Thermocouple 7 on SSC-1

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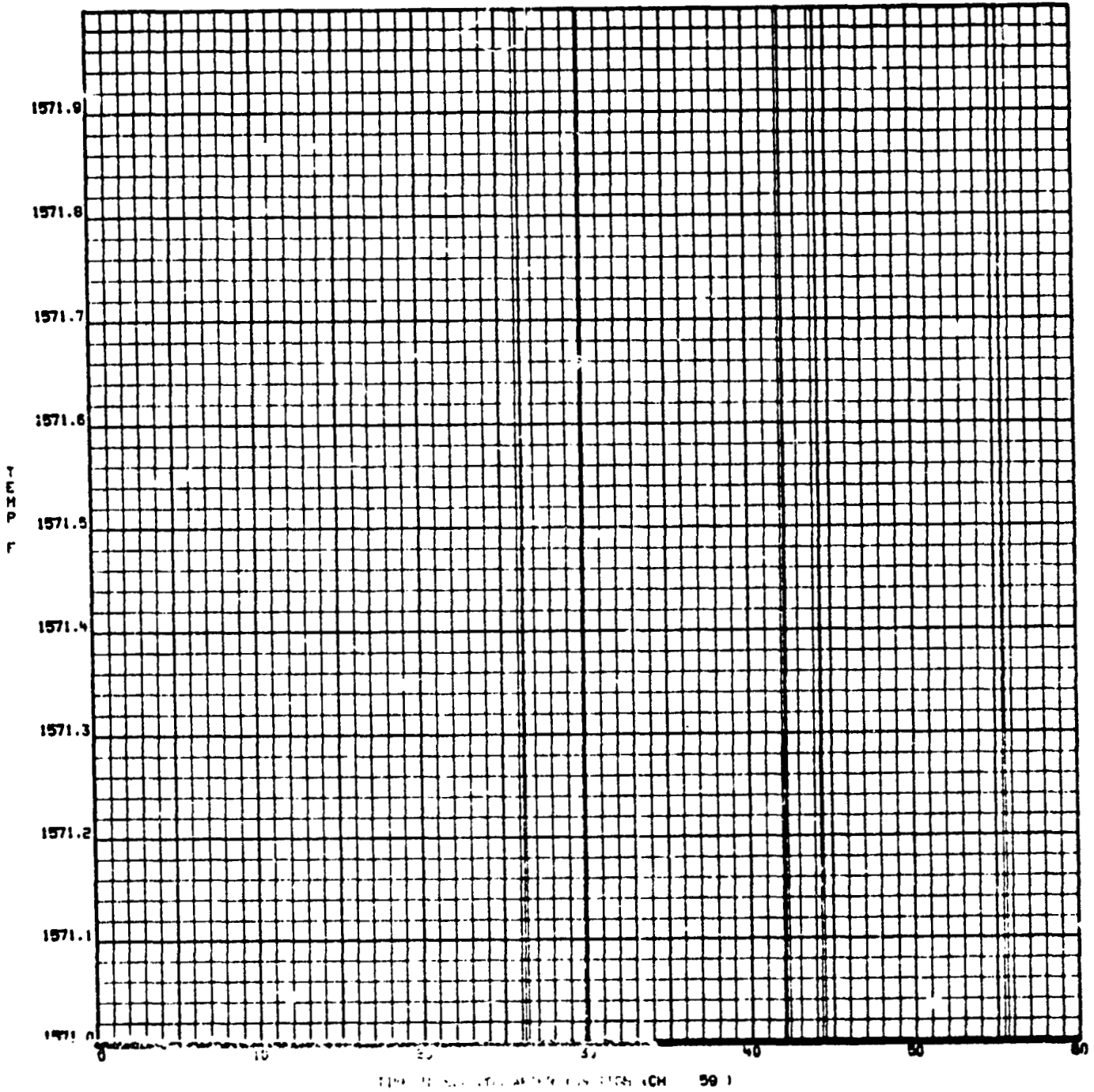


Fig. 13 - Temperature vs Time for Thermocouple 8 on SSC-1

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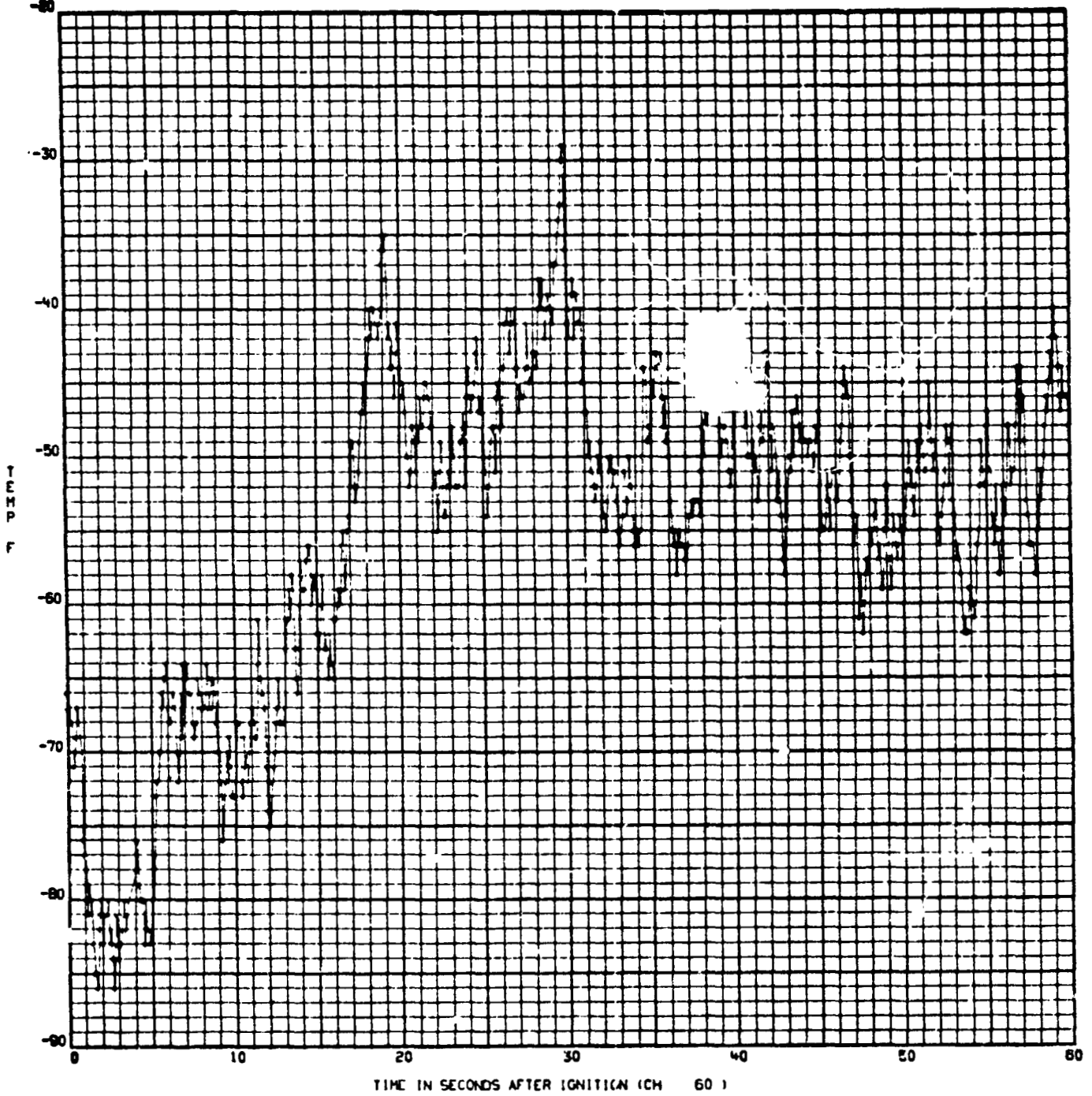


Fig. 14 - Temperature vs Time for Thermocouple 9 on SSC-1

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CURTAIN TEMP 10

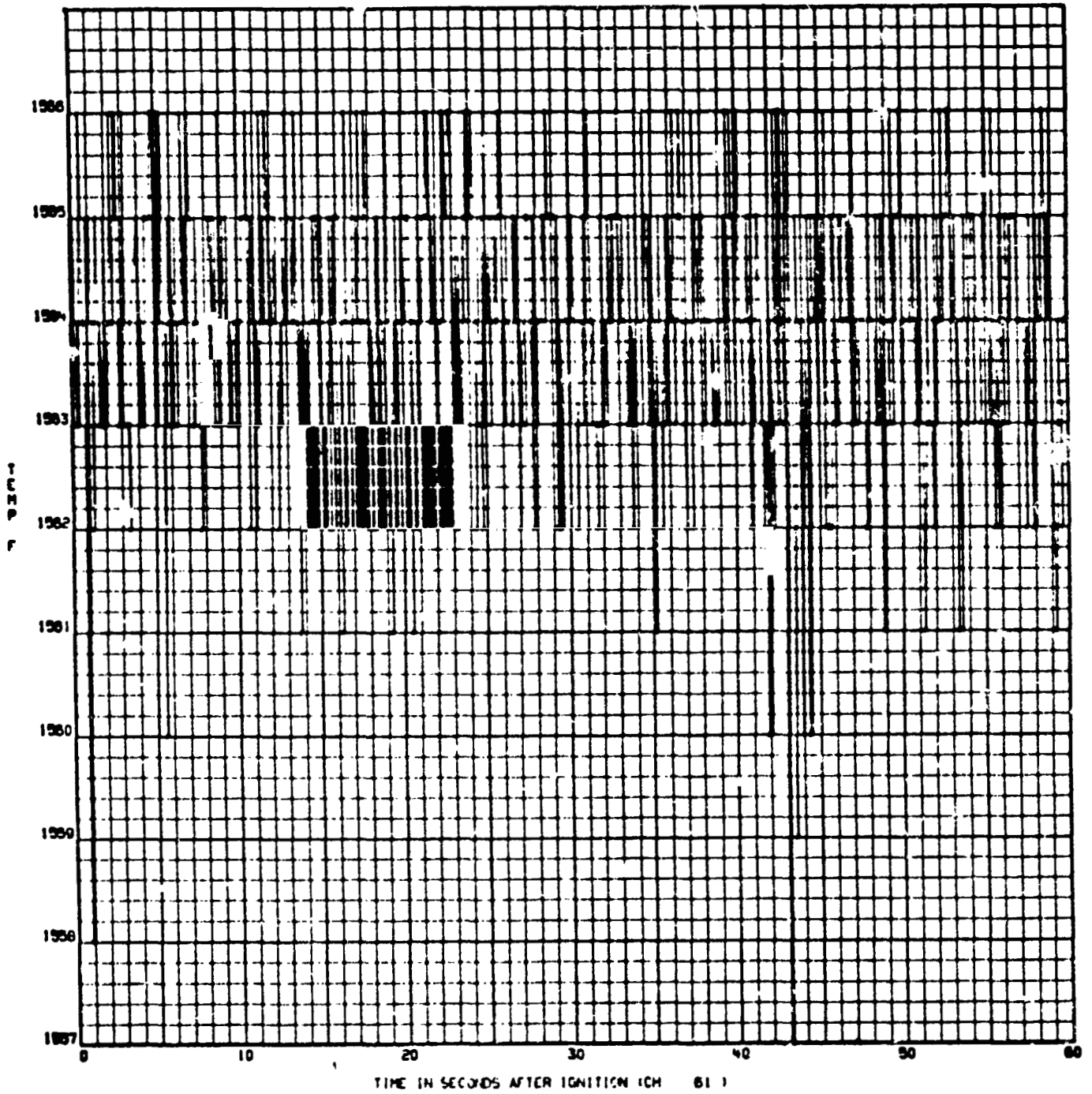


Fig. 15 - Temperature vs Time for Thermocouple 10 on SSC-1

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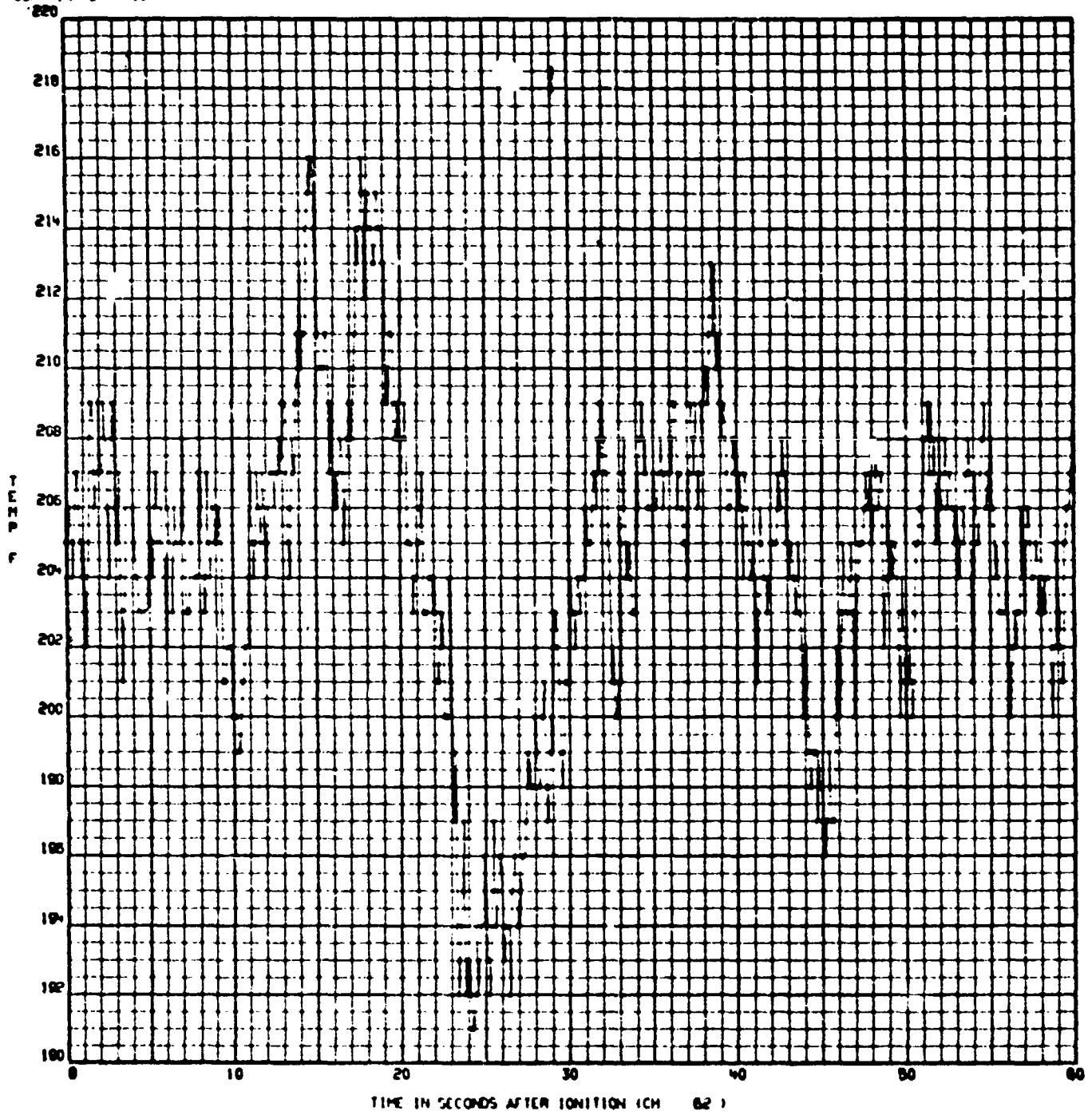


Fig. 16 - Temperature vs Time for Thermocouple 11 on SSC-1

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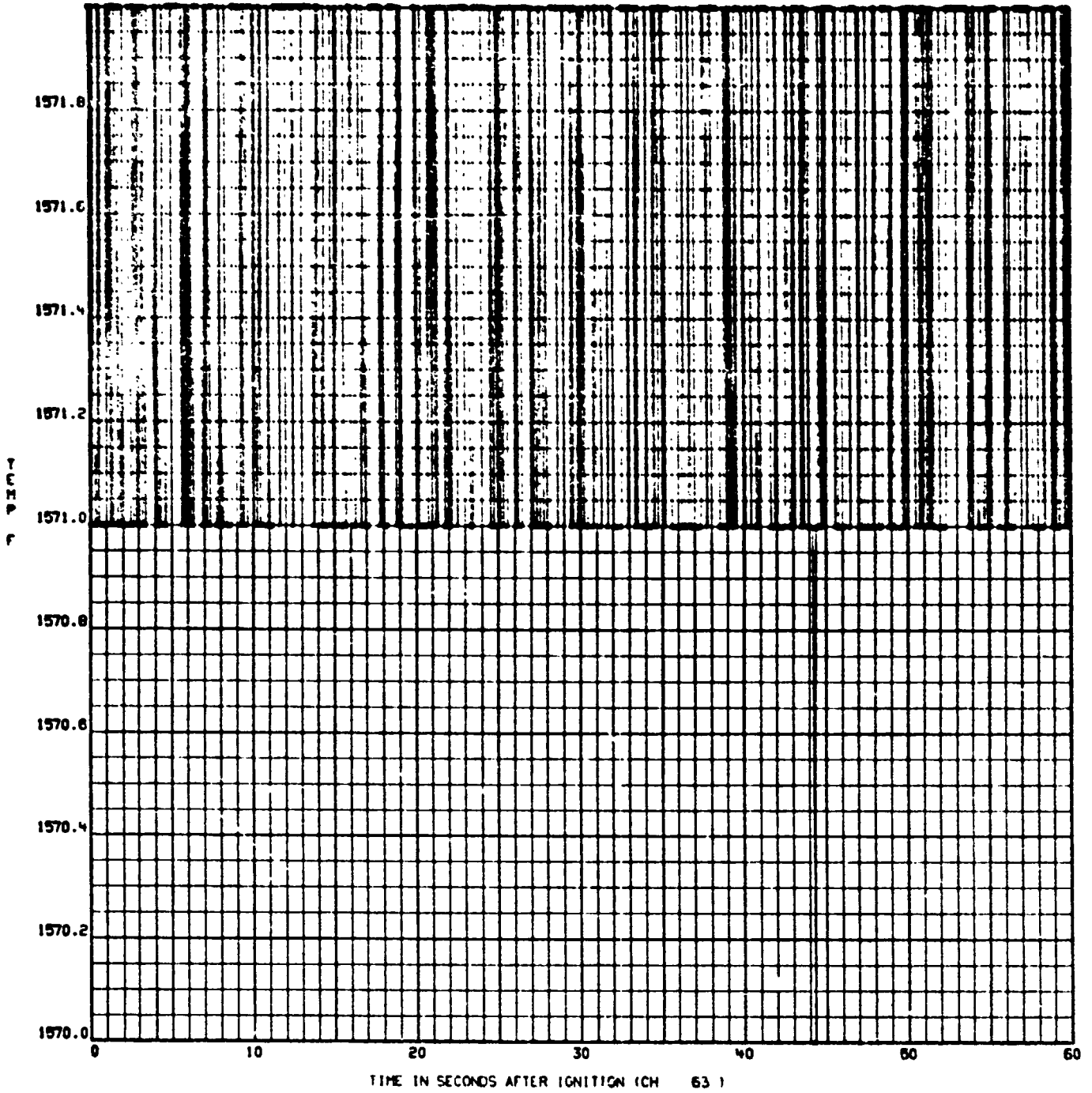


Fig. 17 - Temperature vs Time for Thermocouple 12 on SSC-1

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CURTAIN TEMP 13

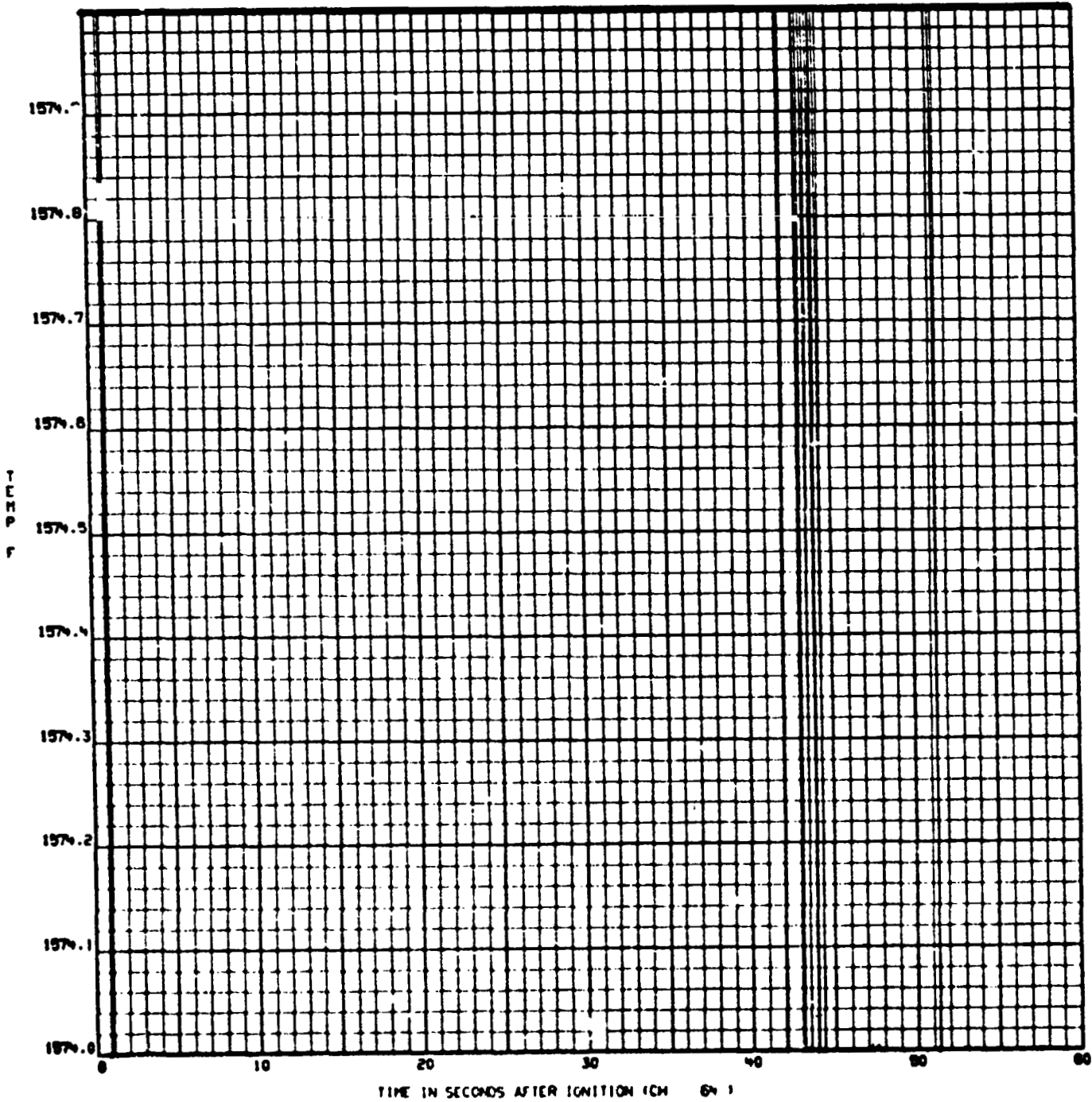


Fig. 18 - Temperature vs Time for Thermocouple 13 on SSC-1

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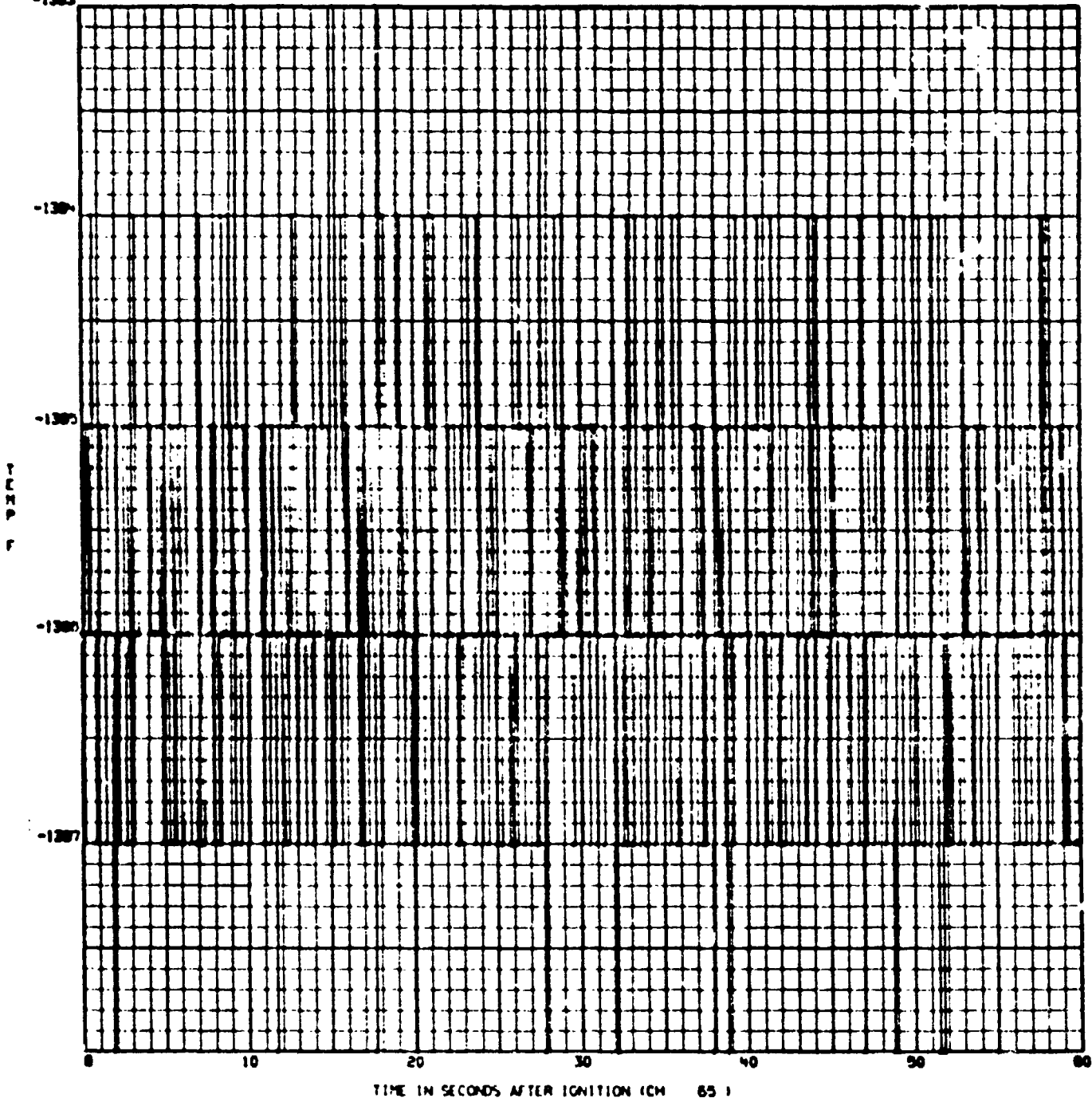


Fig. 19 - Temperature vs Time for Thermocouple 14 on SSC-1

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TEMP

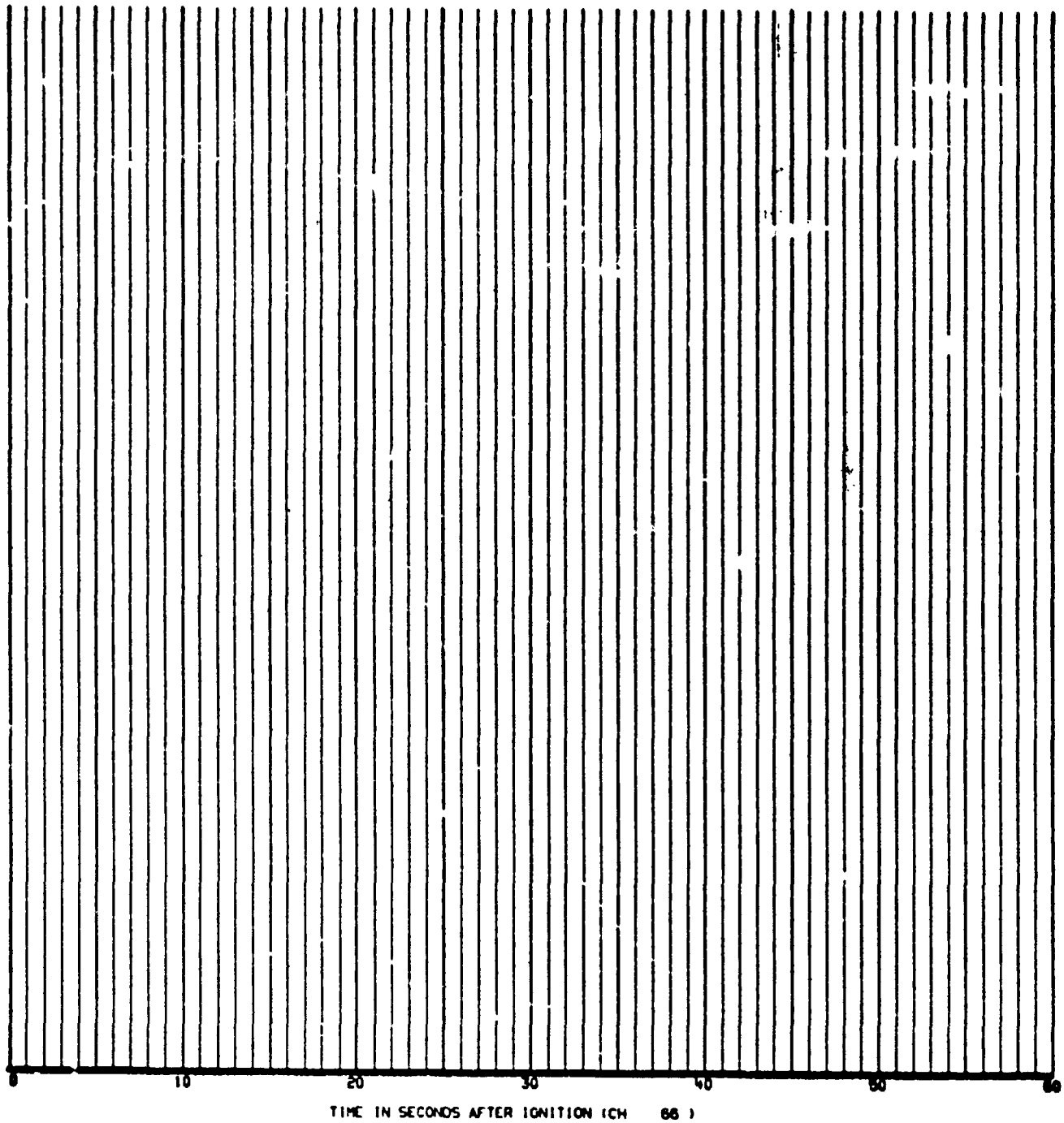


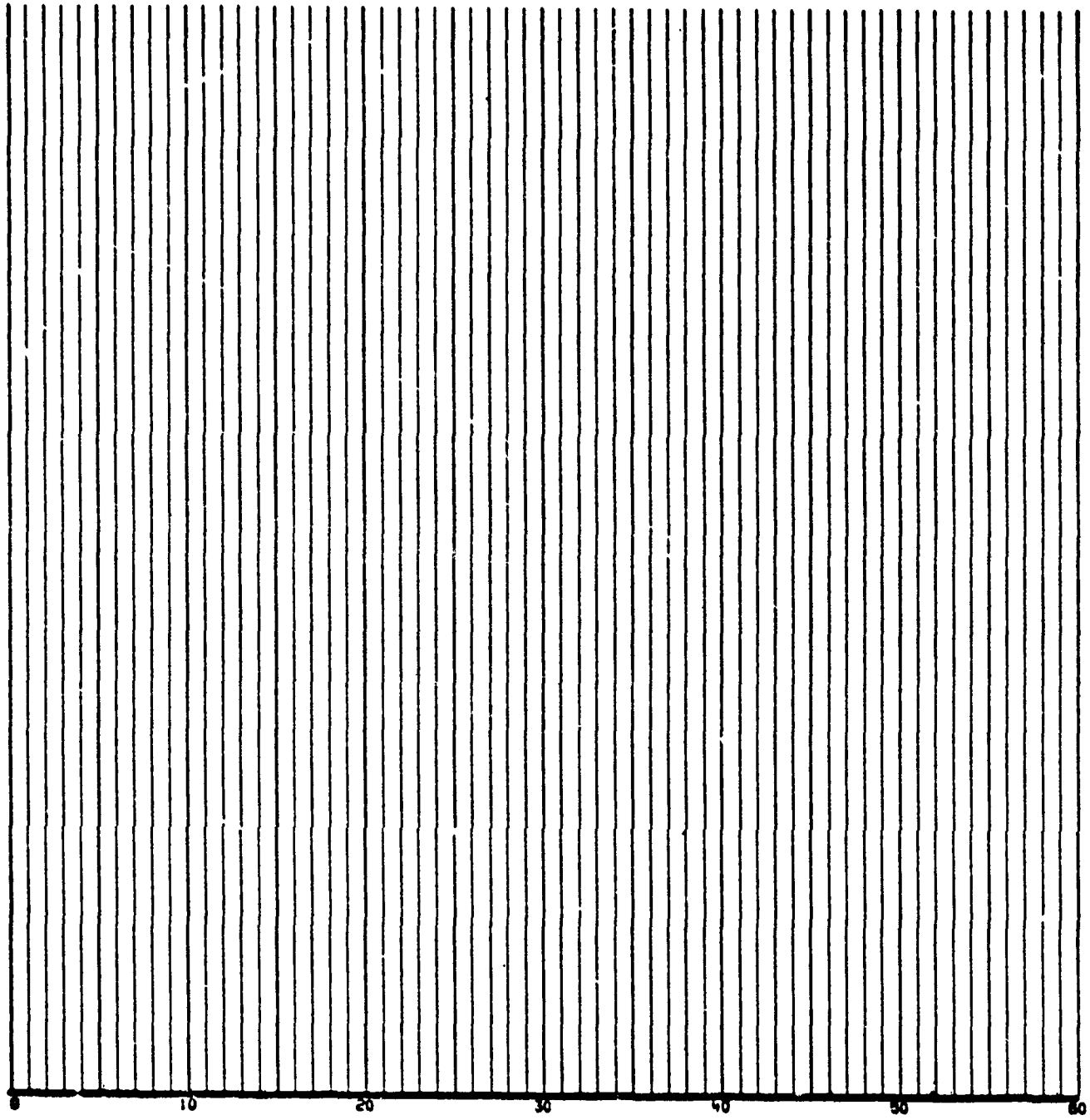
Fig. 20 - Temperature vs Time for Thermocouple 15 on SSC-1

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TEMP



TIME IN SECONDS AFTER IGNITION (CH 67)

Fig. 21 - Temperature vs Time for Thermocouple 16 on SSC-1

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CURTAIN TEMP 17

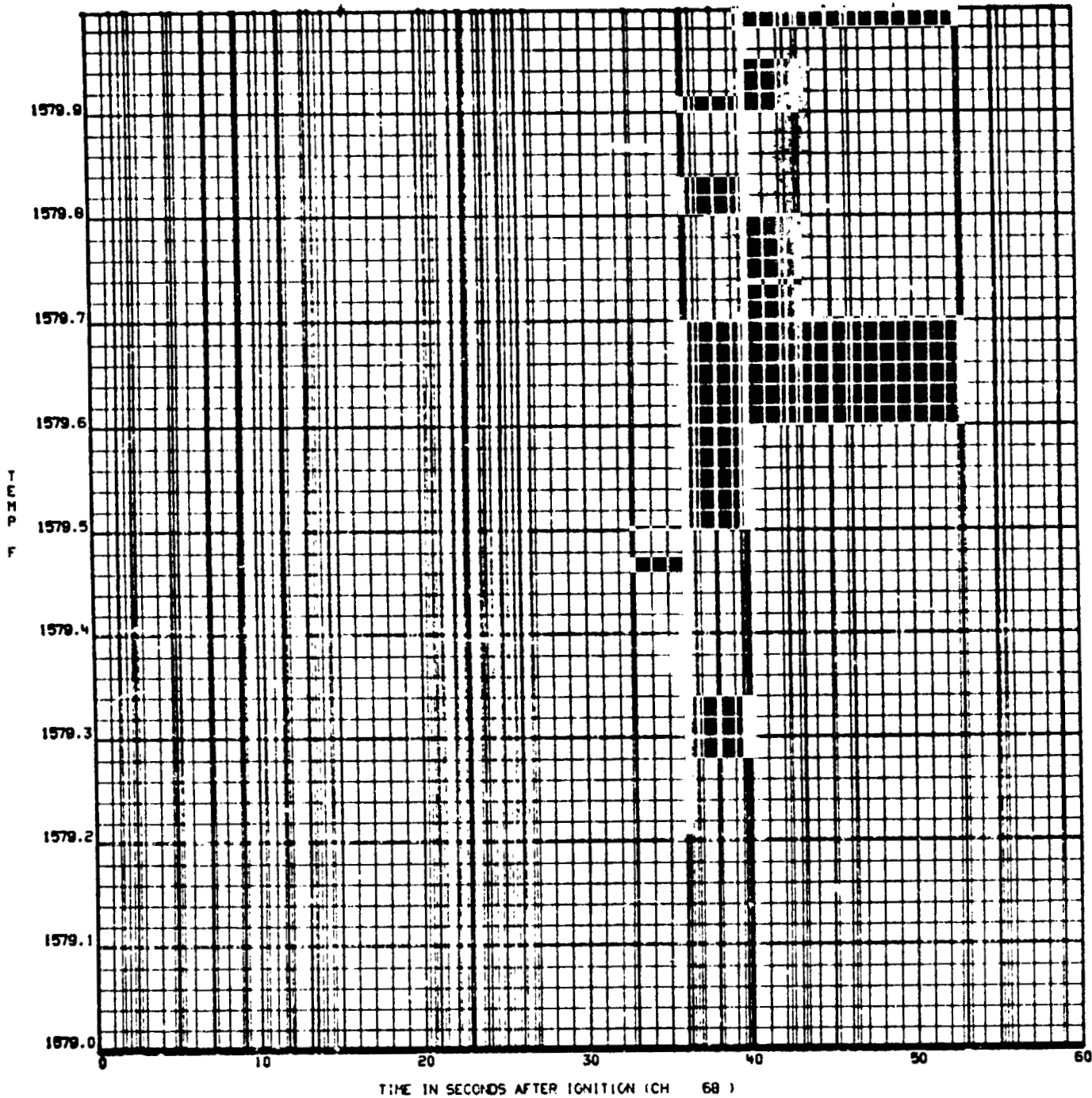


Fig. 22 - Temperature vs Time for Thermocouple 17 on SSC-1

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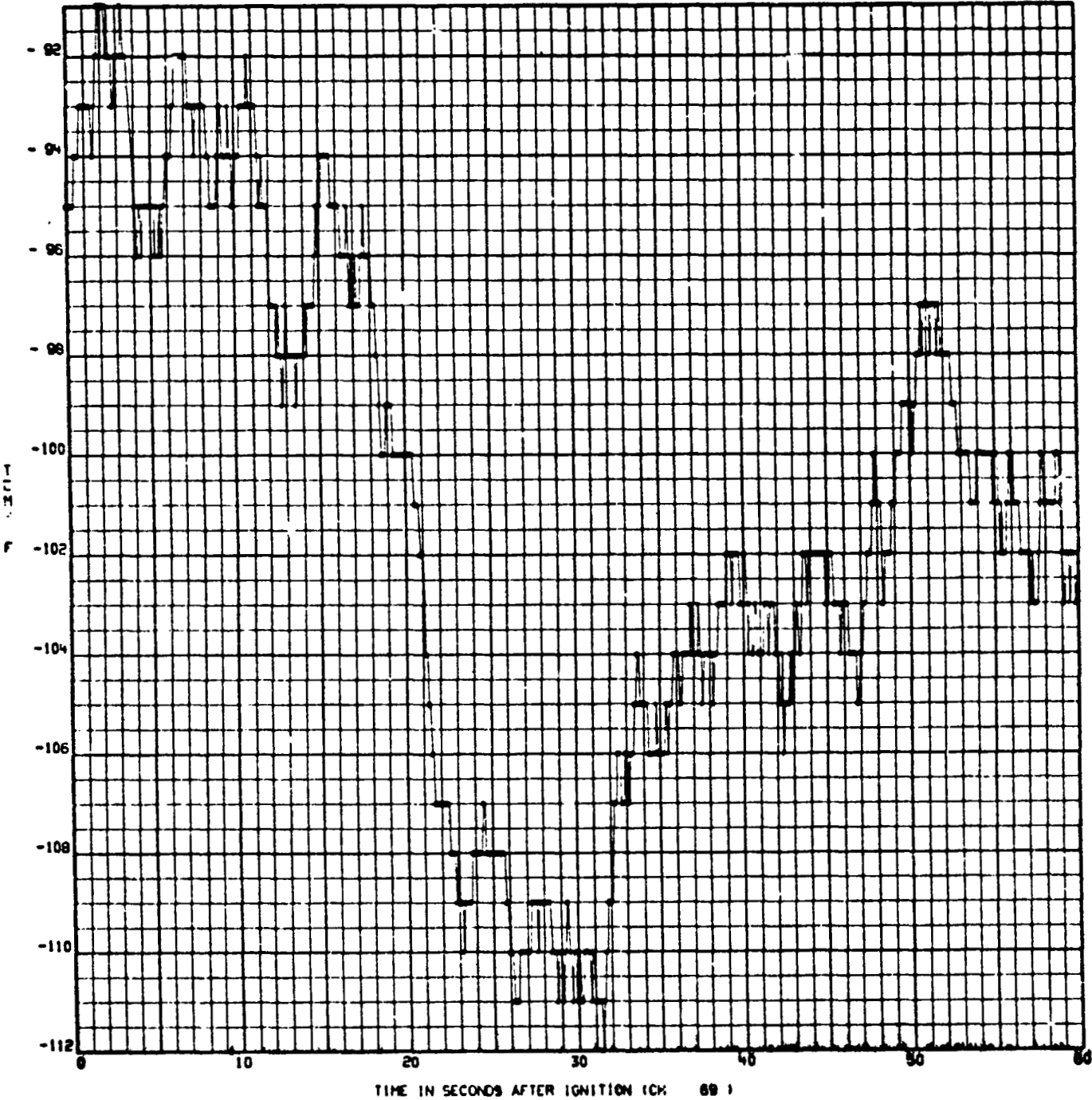


Fig. 23 - Temperature vs Time for Thermocouple 18 on SSC-1

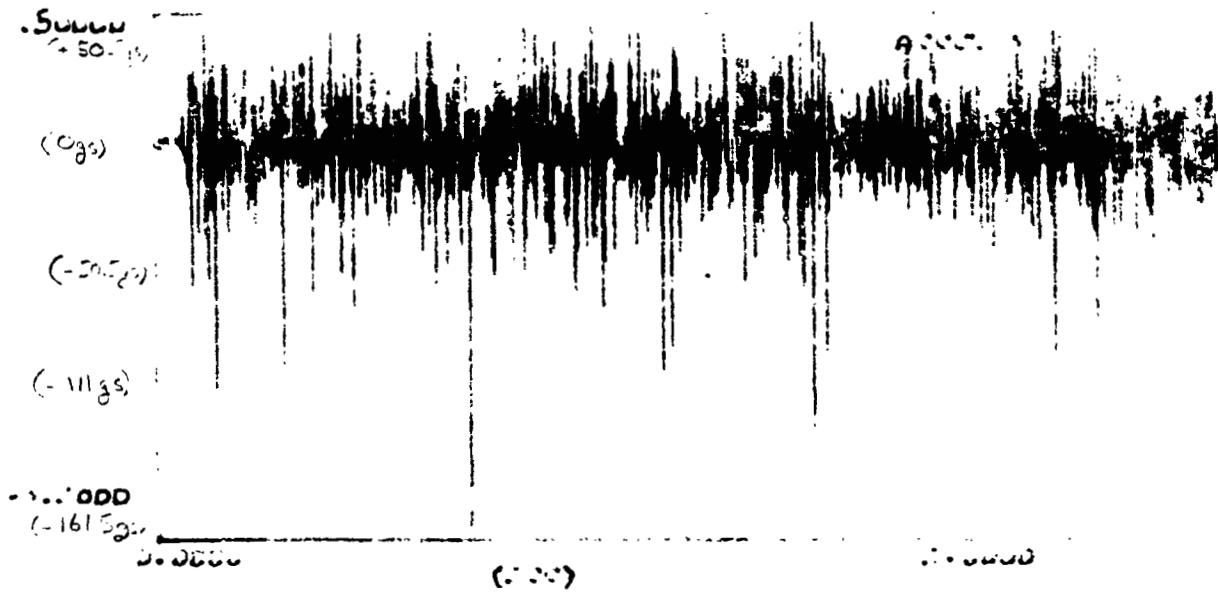


Fig. 24 - Data from Accelerometer A1
for Run 1031 - Cold Flow

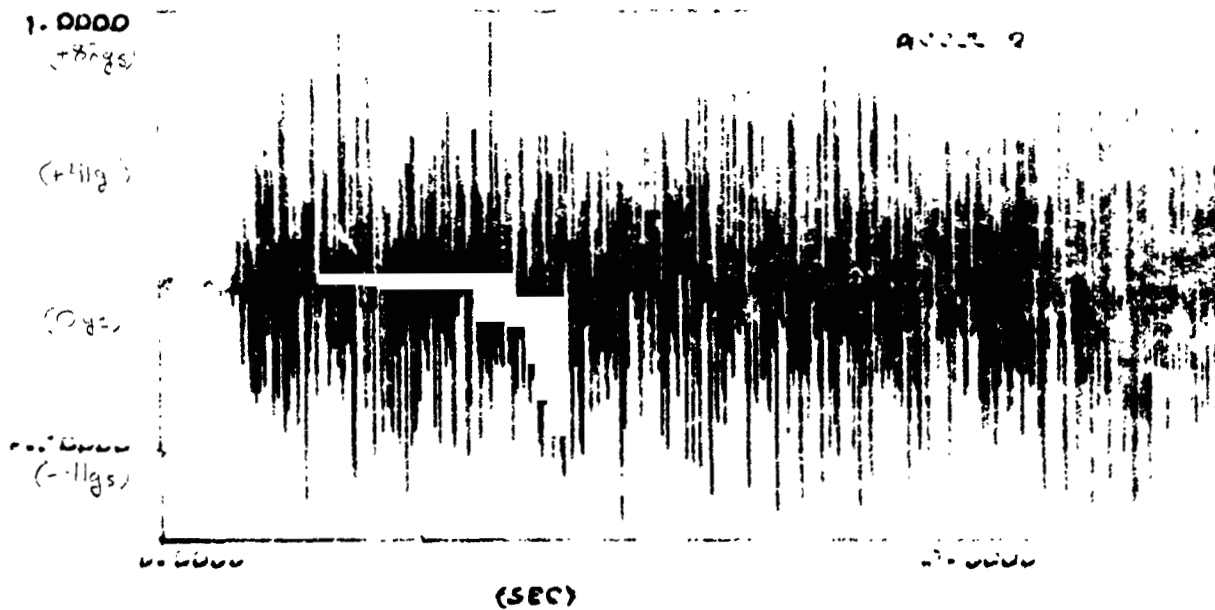


Fig. 25 - Data from Accelerometer A2
for Run 1031 - Cold Flow

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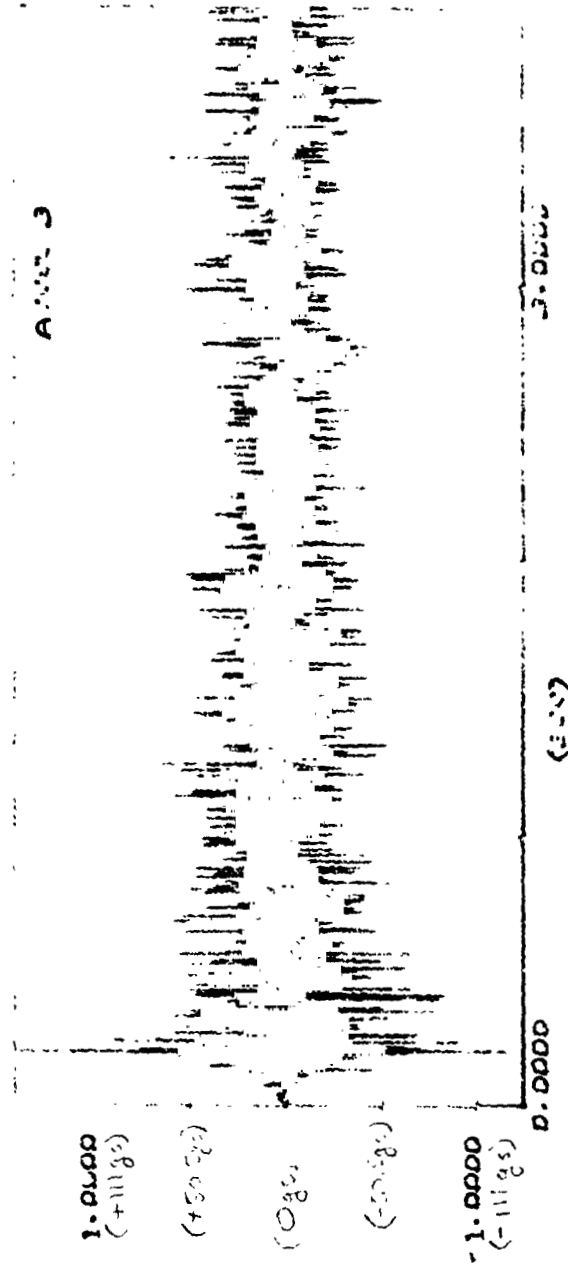


Fig. 26 - Accelerometer Data from Accelerometer A3,
from Run 1031, Cold Flow

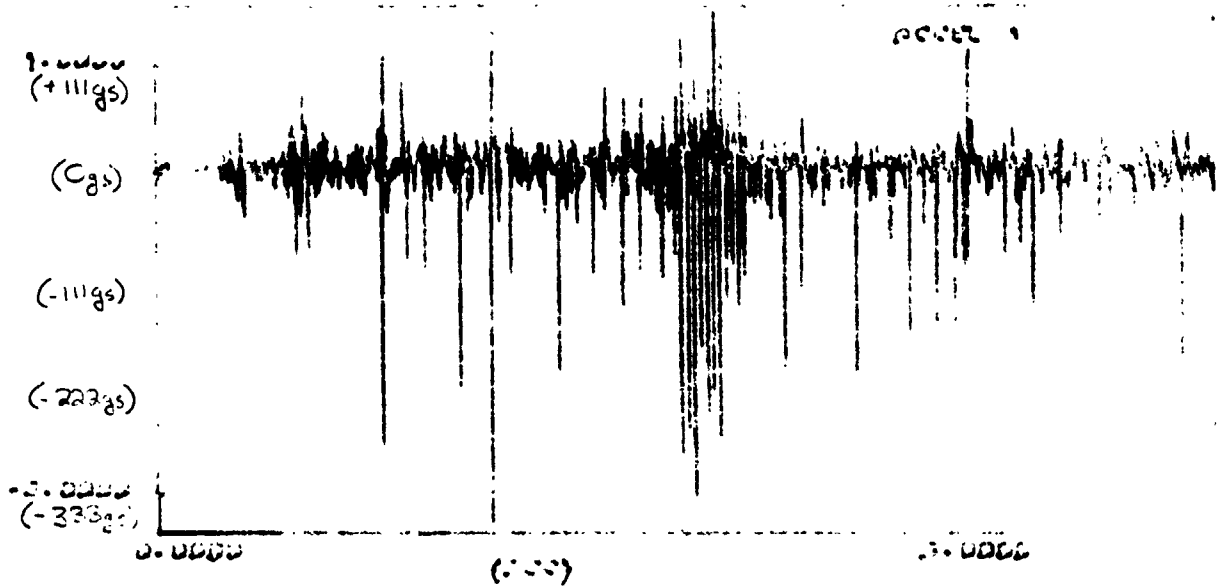


Fig. 27 - Data from Accelerometer A1
for Run 1032 - Hot Flow

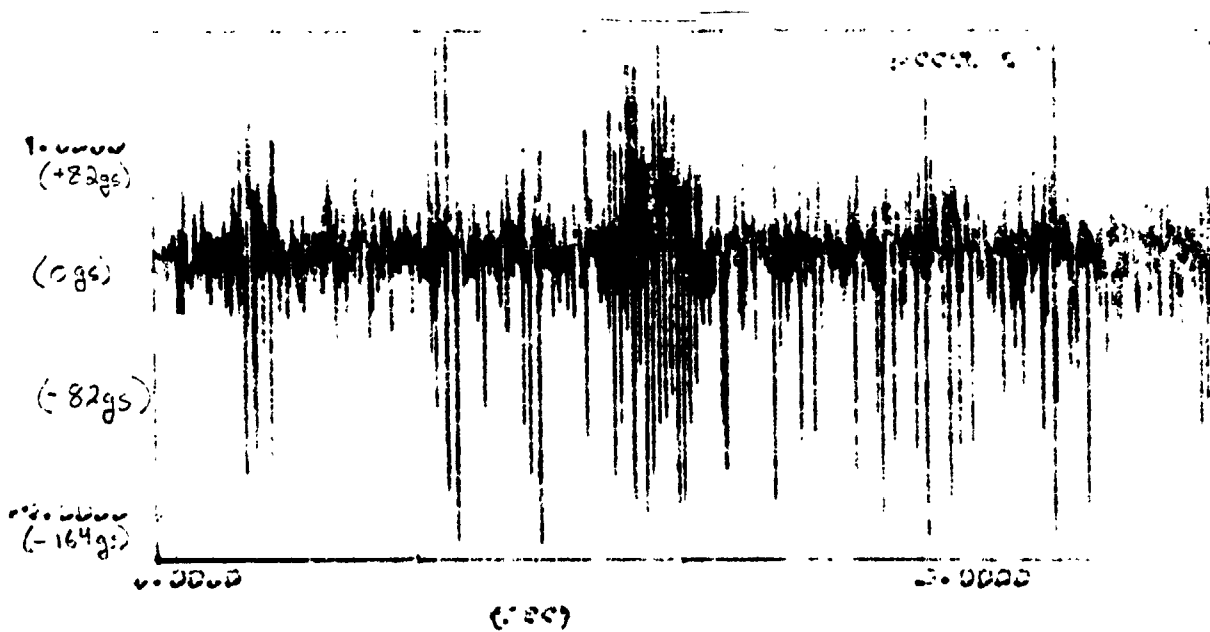


Fig. 28 - Data from Accelerometer A2
for Run 1032 - Hot Flow

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Fig. 29 - Data from Accelerometer A3
for Run 1032 - Hot Flow



Fig. 30 - Post Test photo of Curtain SSC-1

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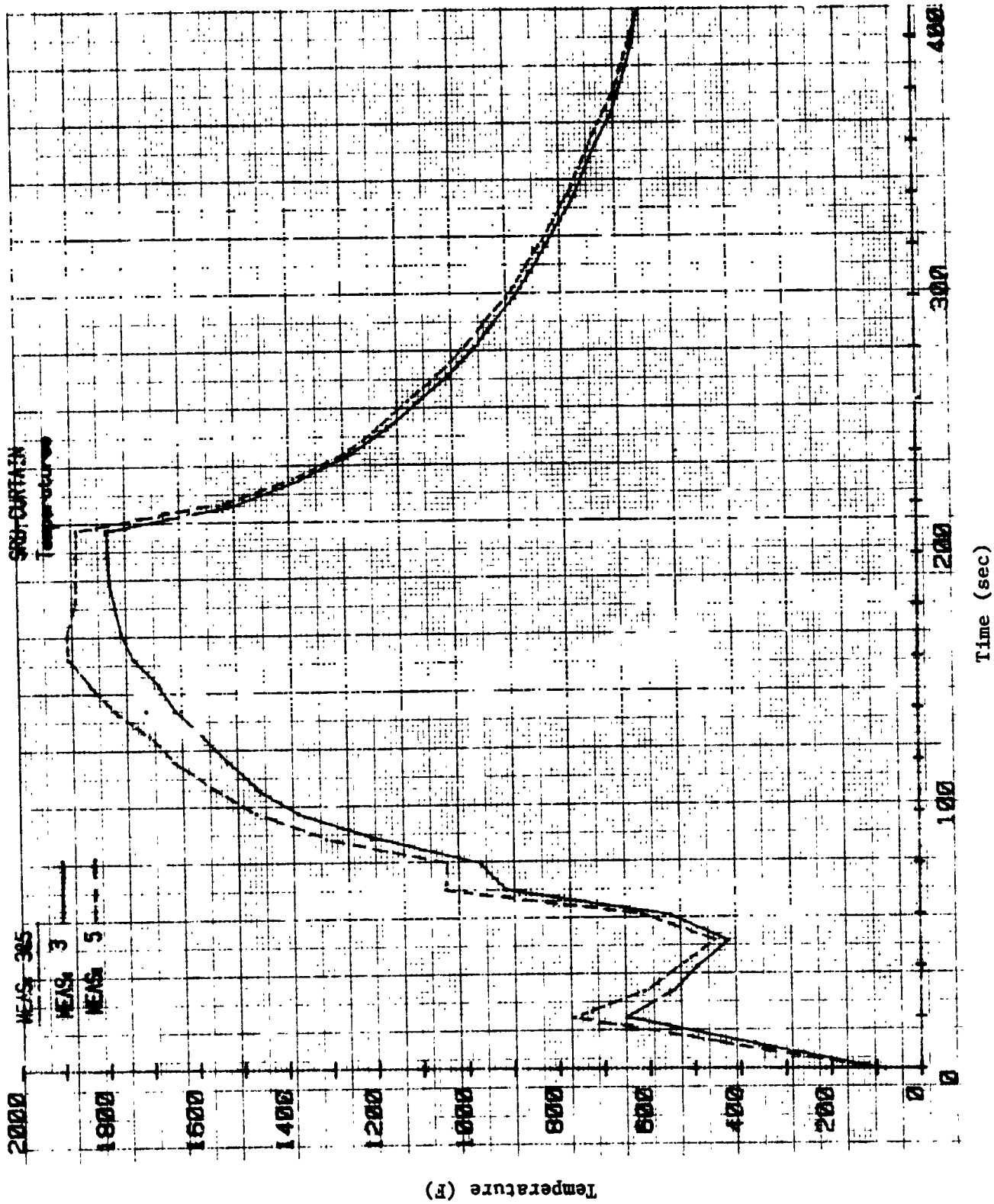


Fig. 31 - Temperature vs Time Results for the Radiant Test of Curtain SSC-2.

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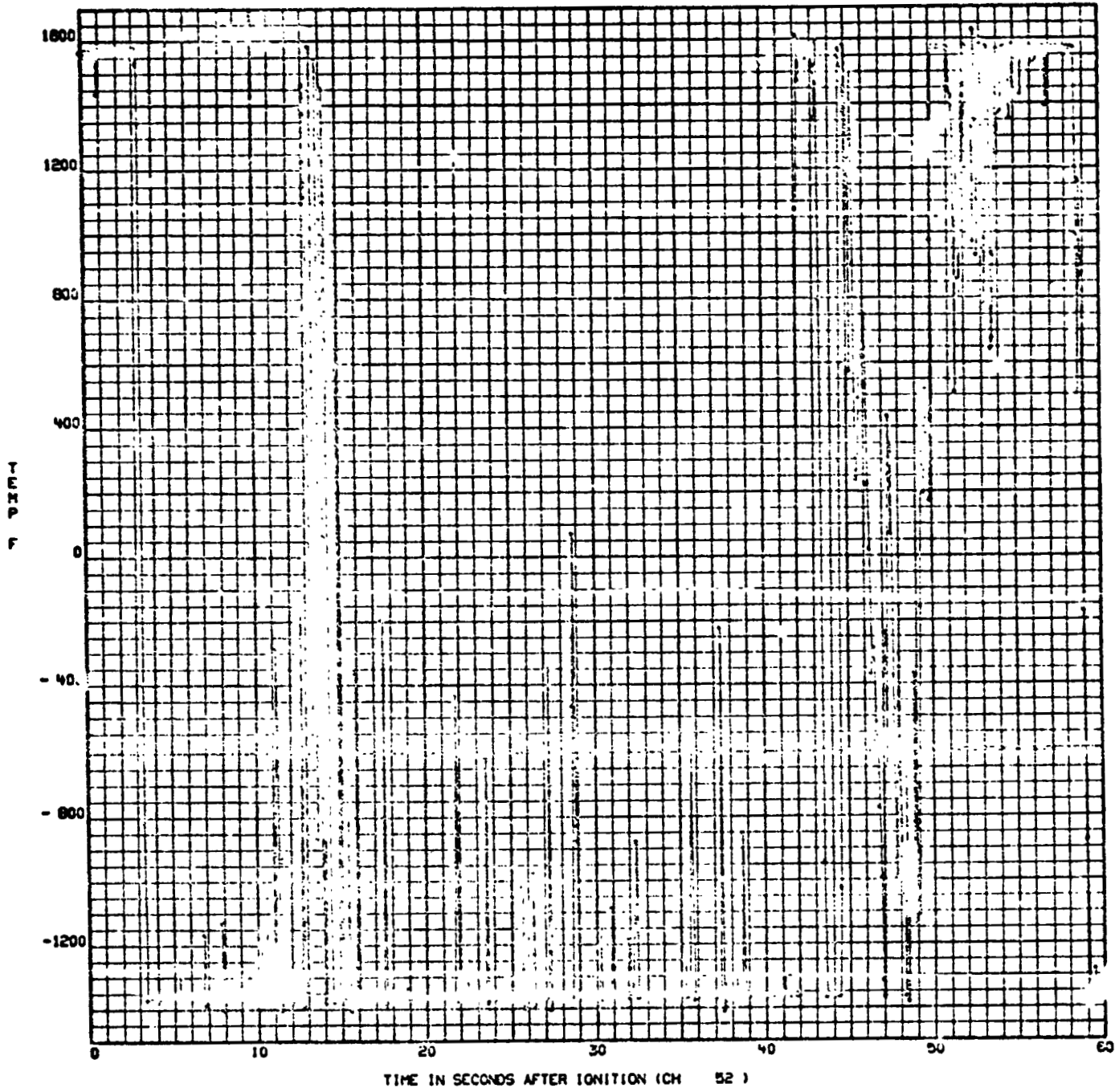


Fig. 32 - Temperature vs Time for Thermocouple 1 on SSC-2

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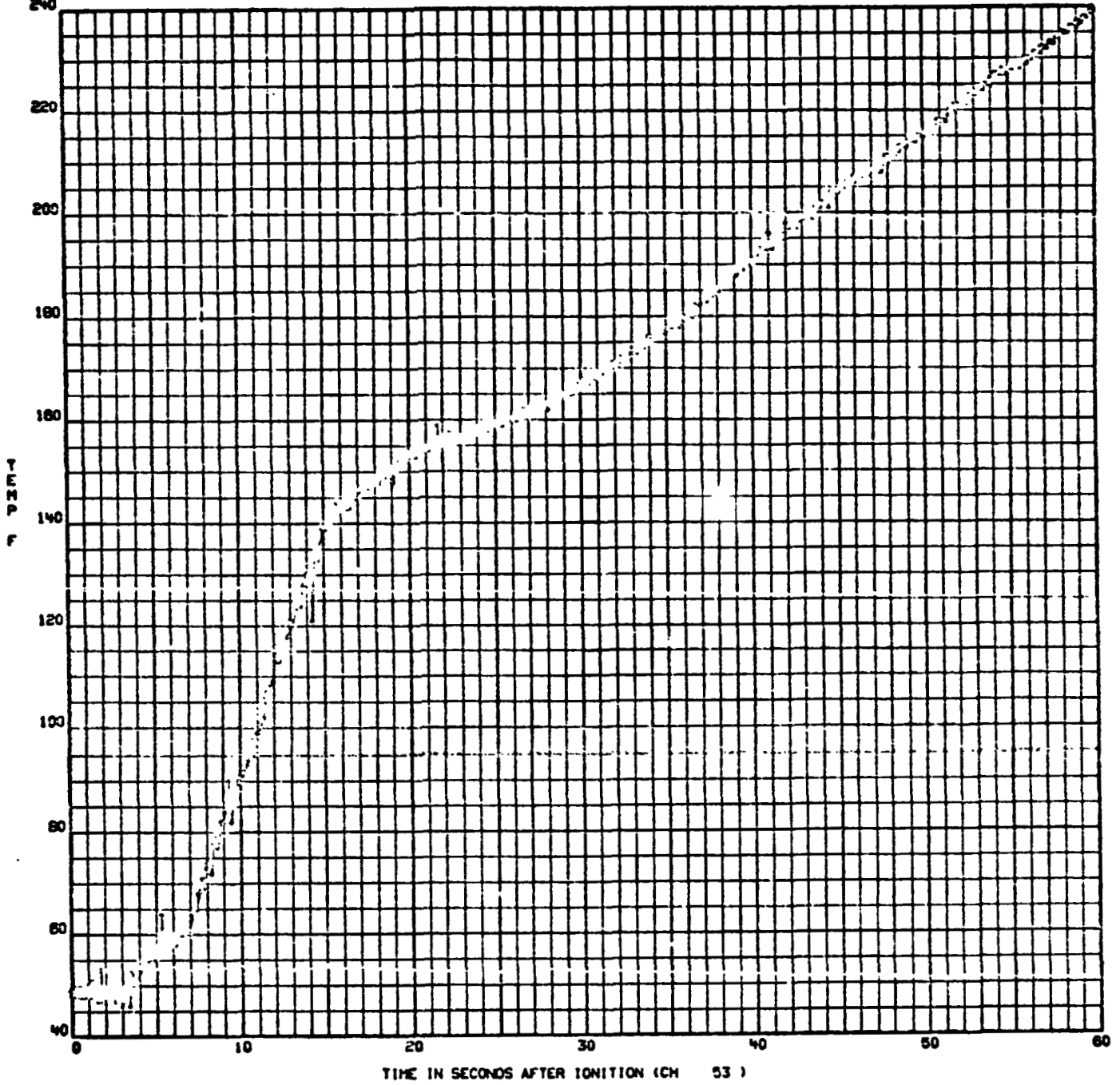


Fig. 33 - Temperature vs Time for Thermocouple 2 on SSC-2

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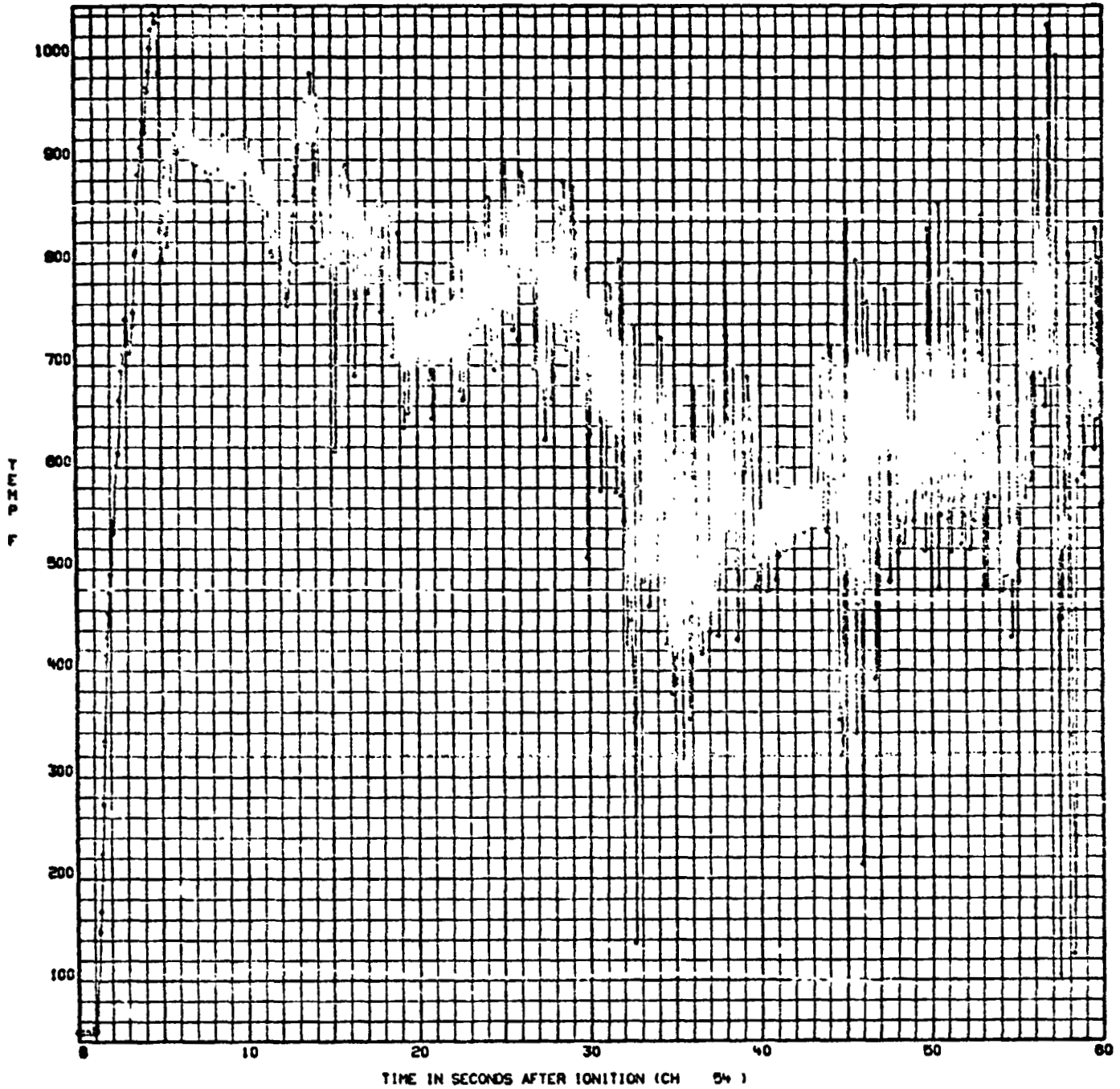


Fig. 34 - Temperature vs Time for Thermocouple 3 on SSC-2

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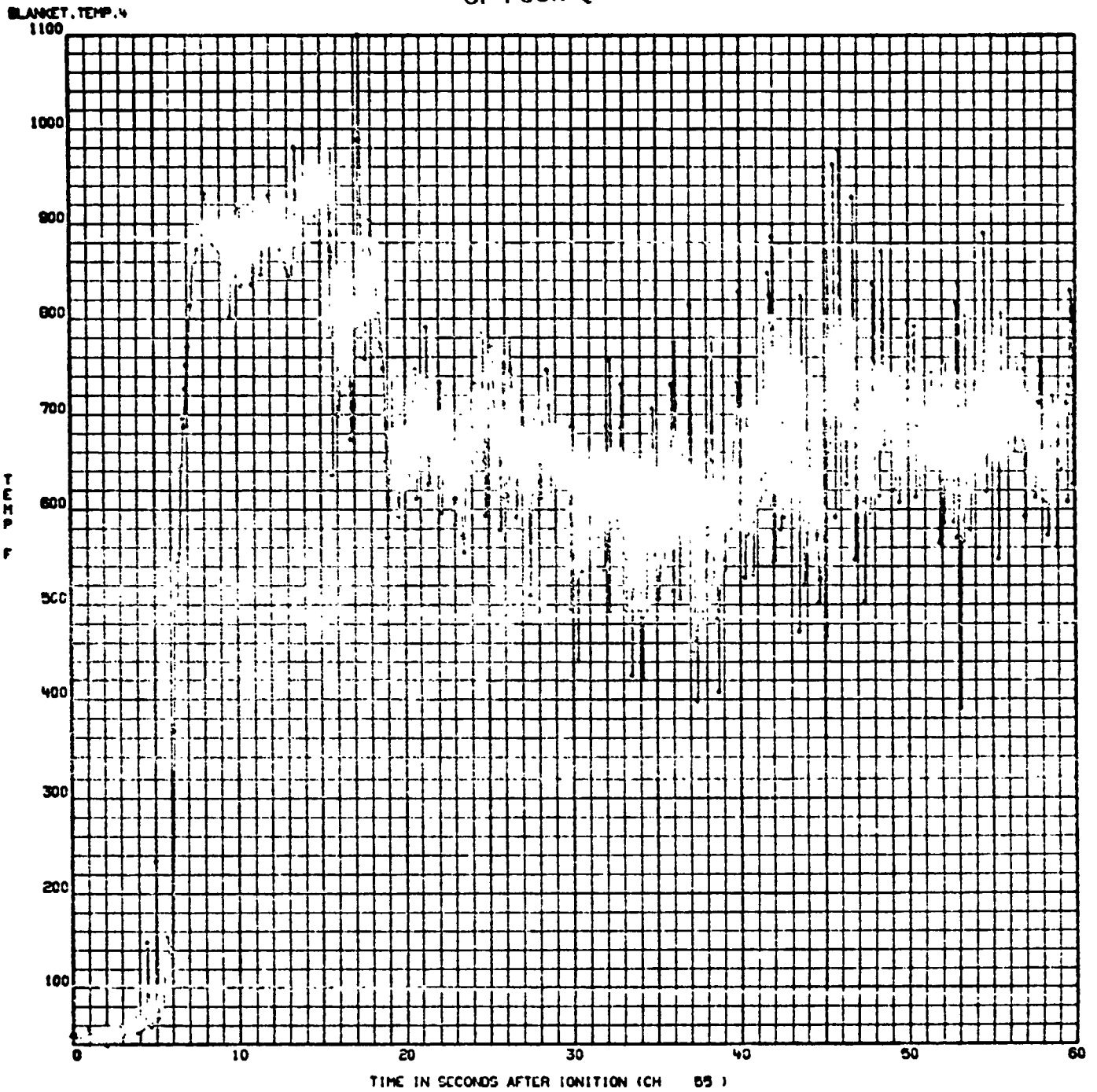


Fig. 35 - Temperature vs Time for Thermocouple 4 on SSC-2

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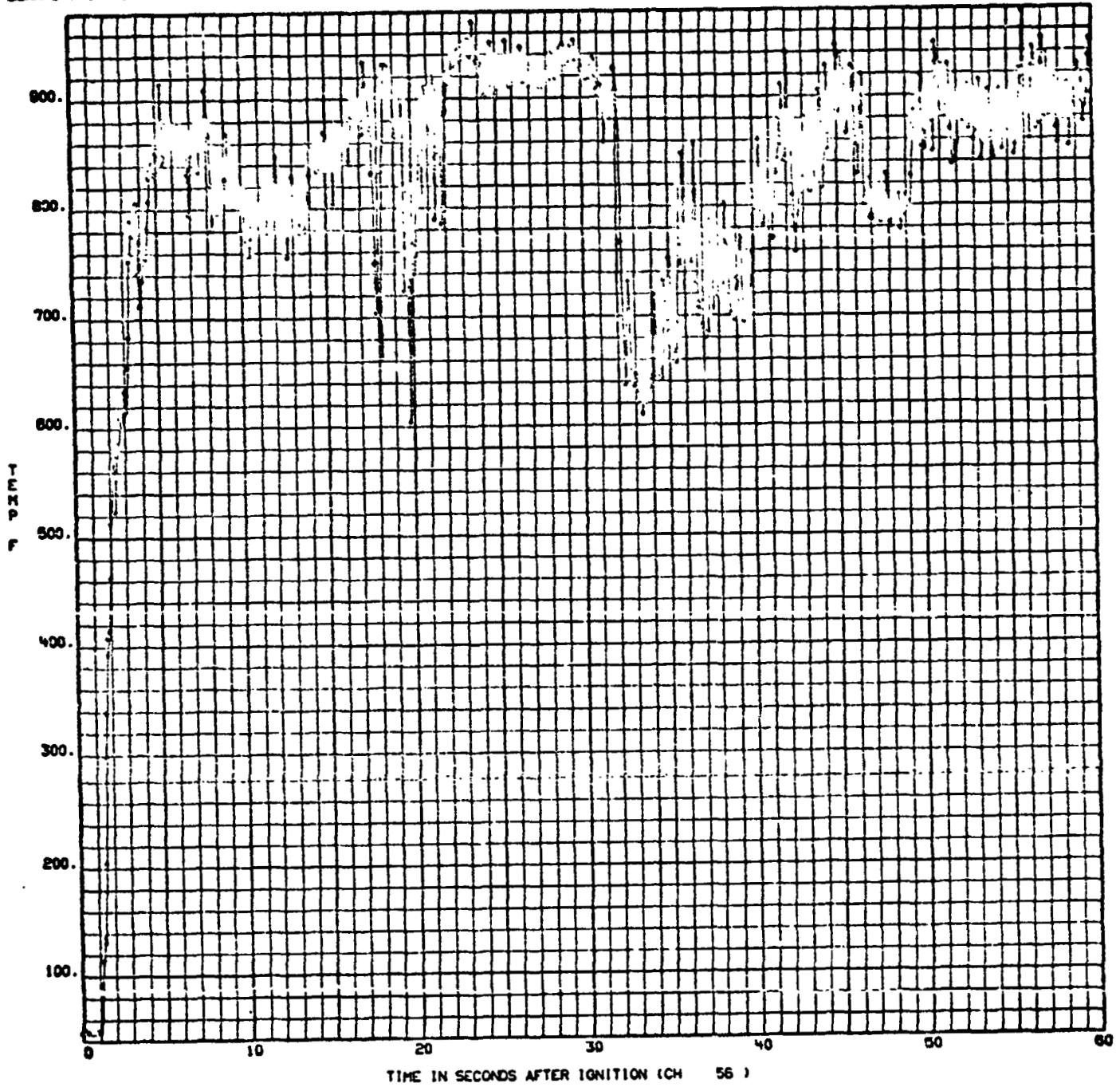


Fig. 36 - Temperature vs Time for Thermocouple 5 on SSC-2

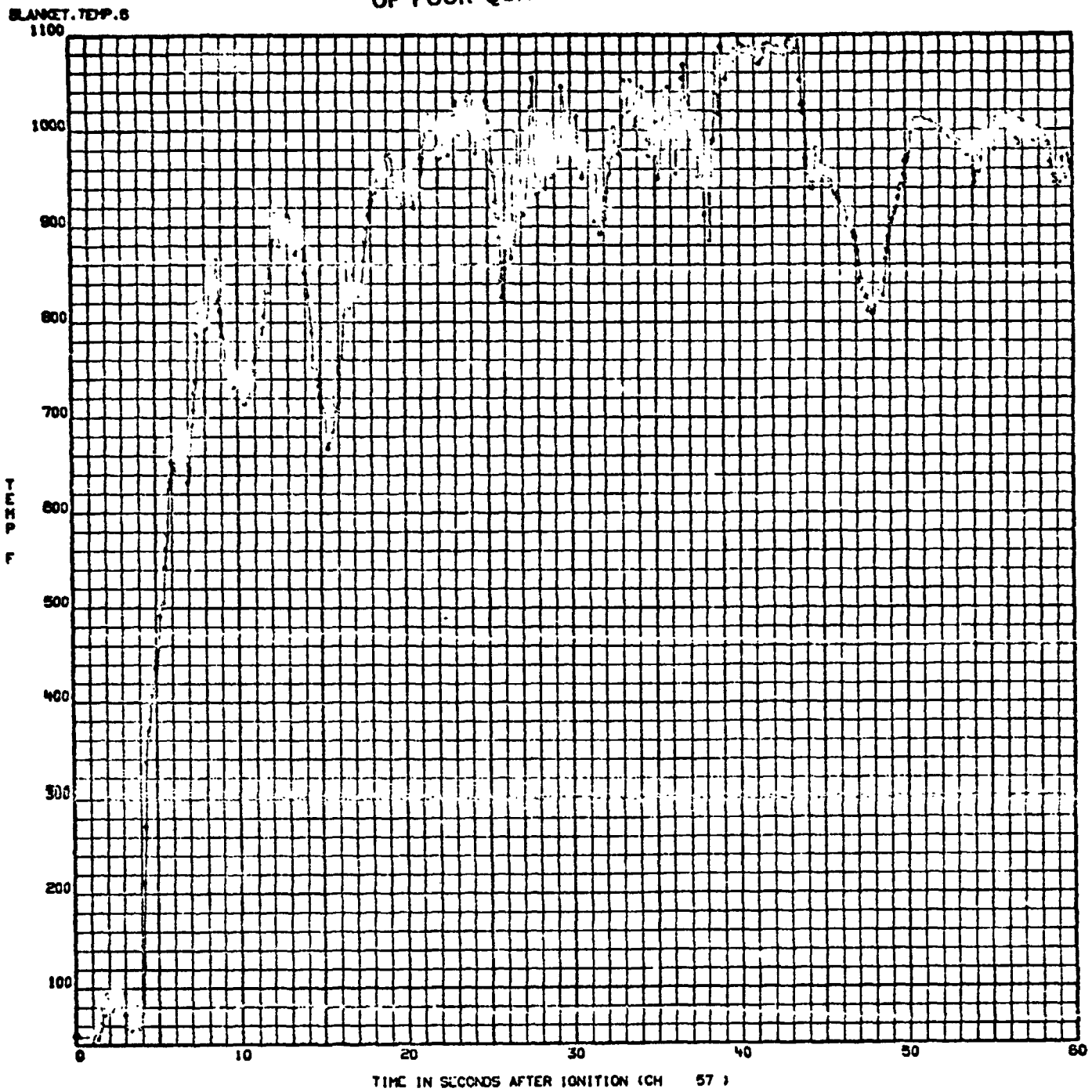


Fig. 37 - Temperature vs Time for Thermocouple 6 on SSC-2

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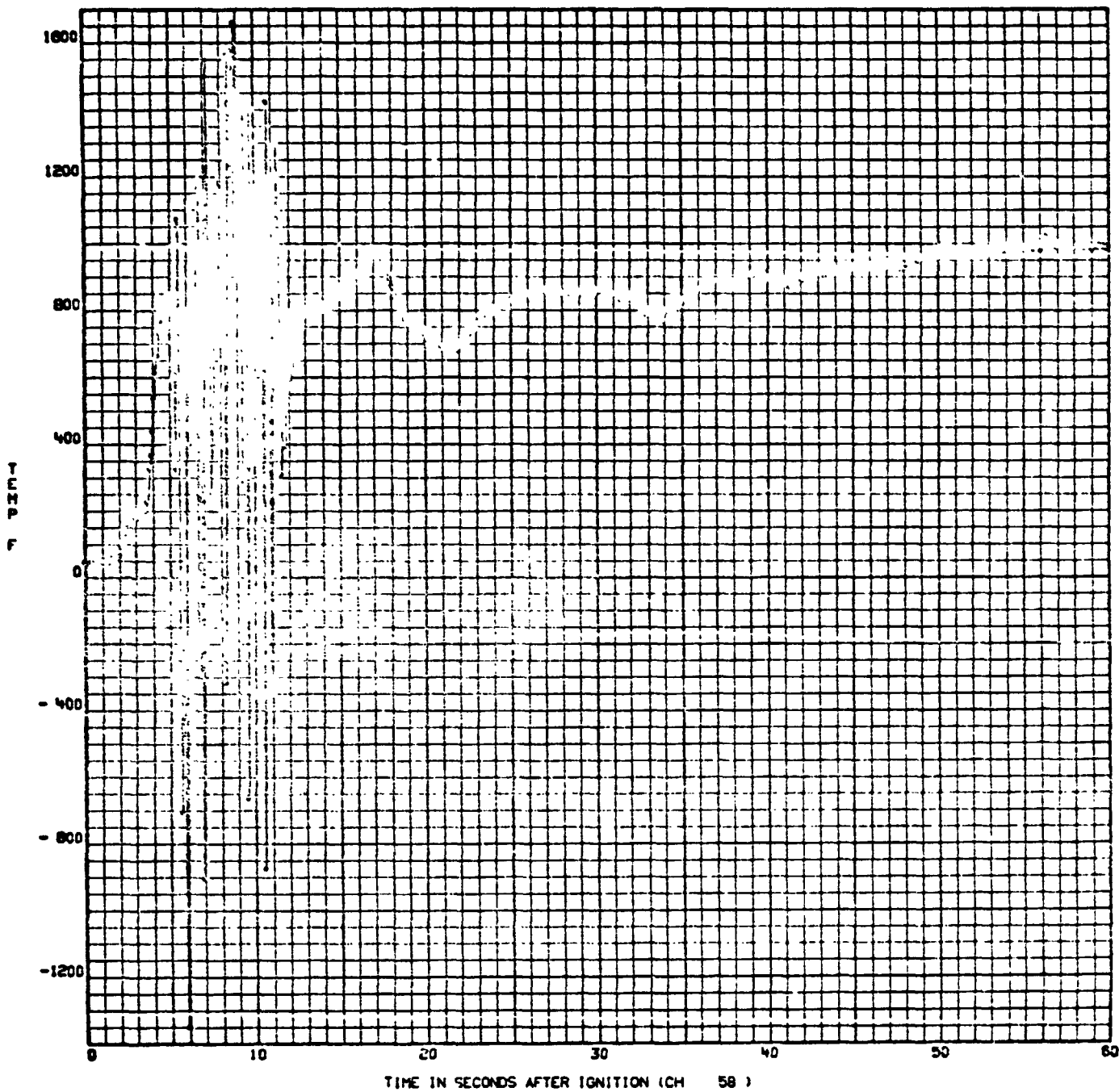


Fig. 38 - Temperature vs Time for Thermocouple 7 on SSC-2

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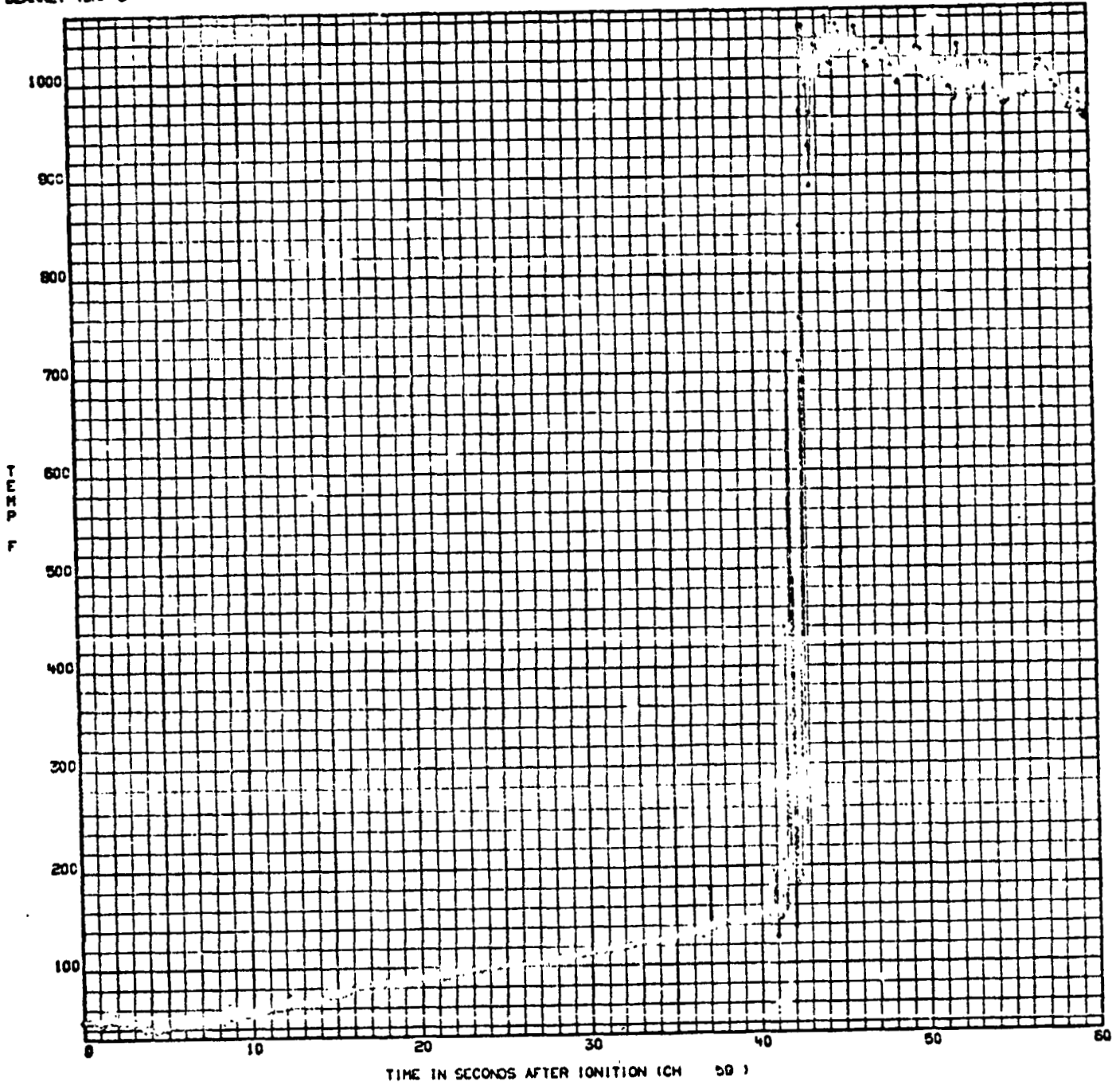


Fig. 39 - Temperature vs Time for Thermocouple 8 on SSC-2

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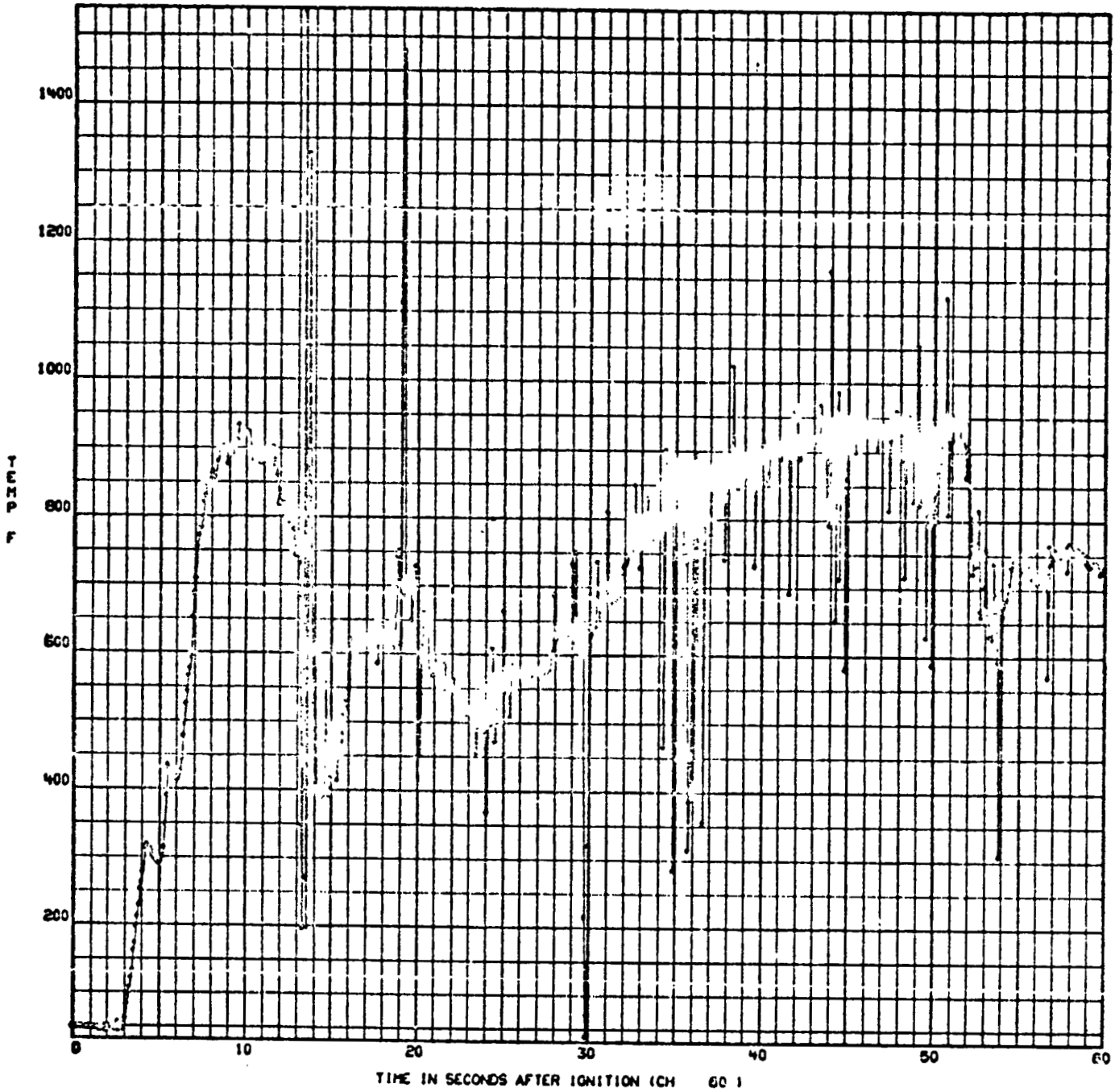


Fig. 40 - Temperature vs Time for Thermocouple 9 on SSC-2

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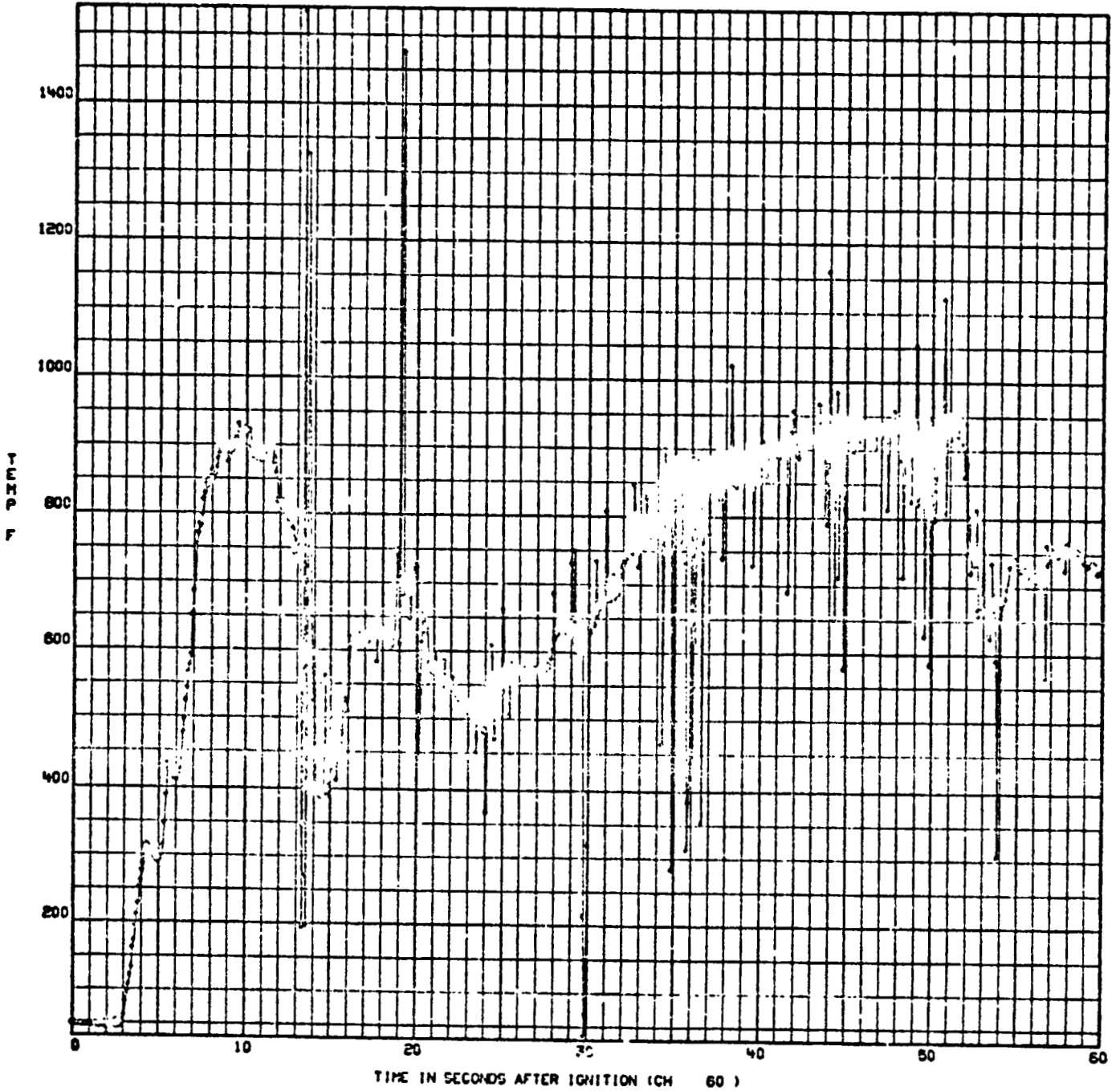


Fig. 41 - Temperature vs Time for Thermocouple 10 on SSC-2

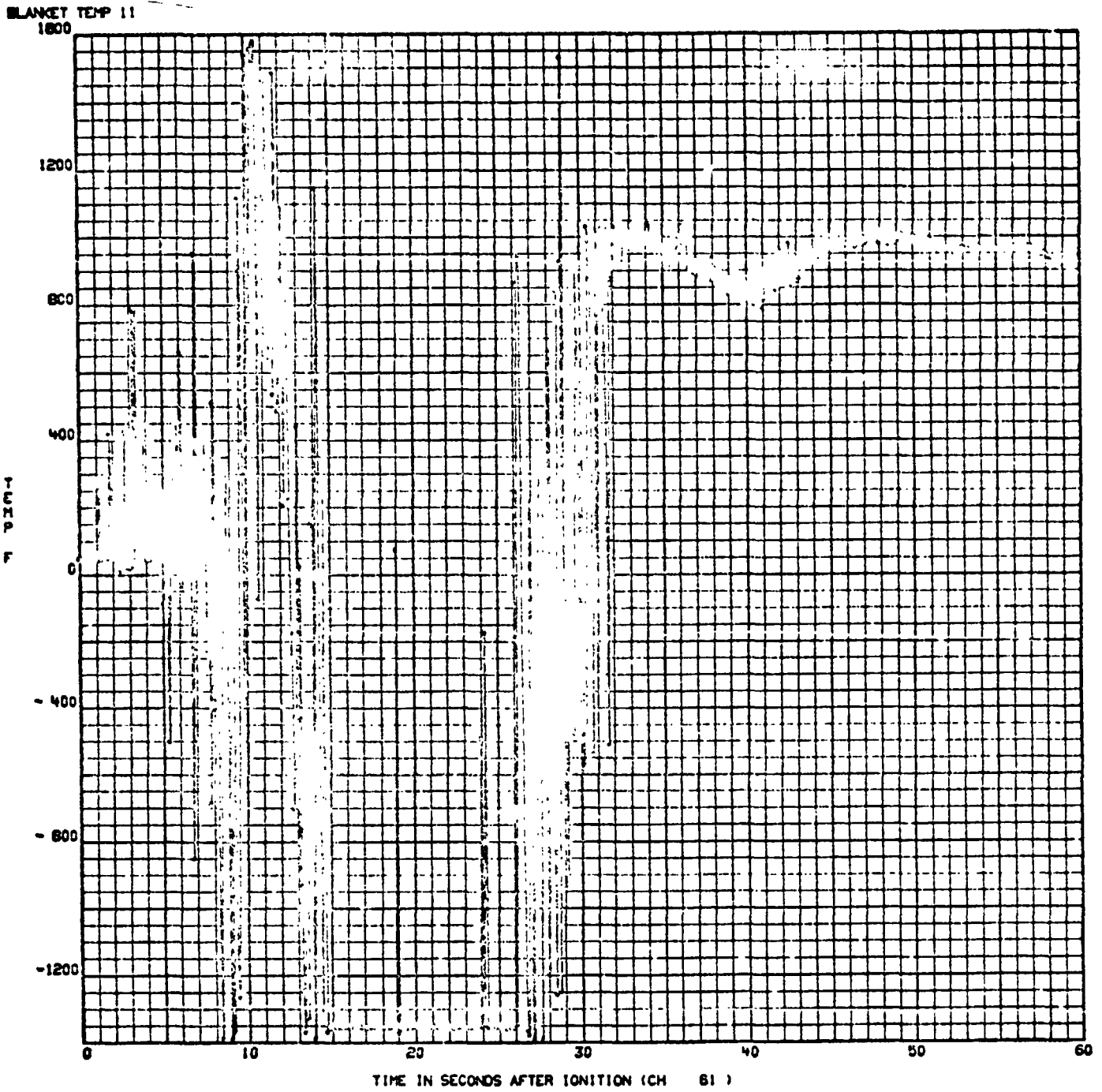


Fig. 42 - Temperature vs Time for Thermocouple 11 on SSC-2

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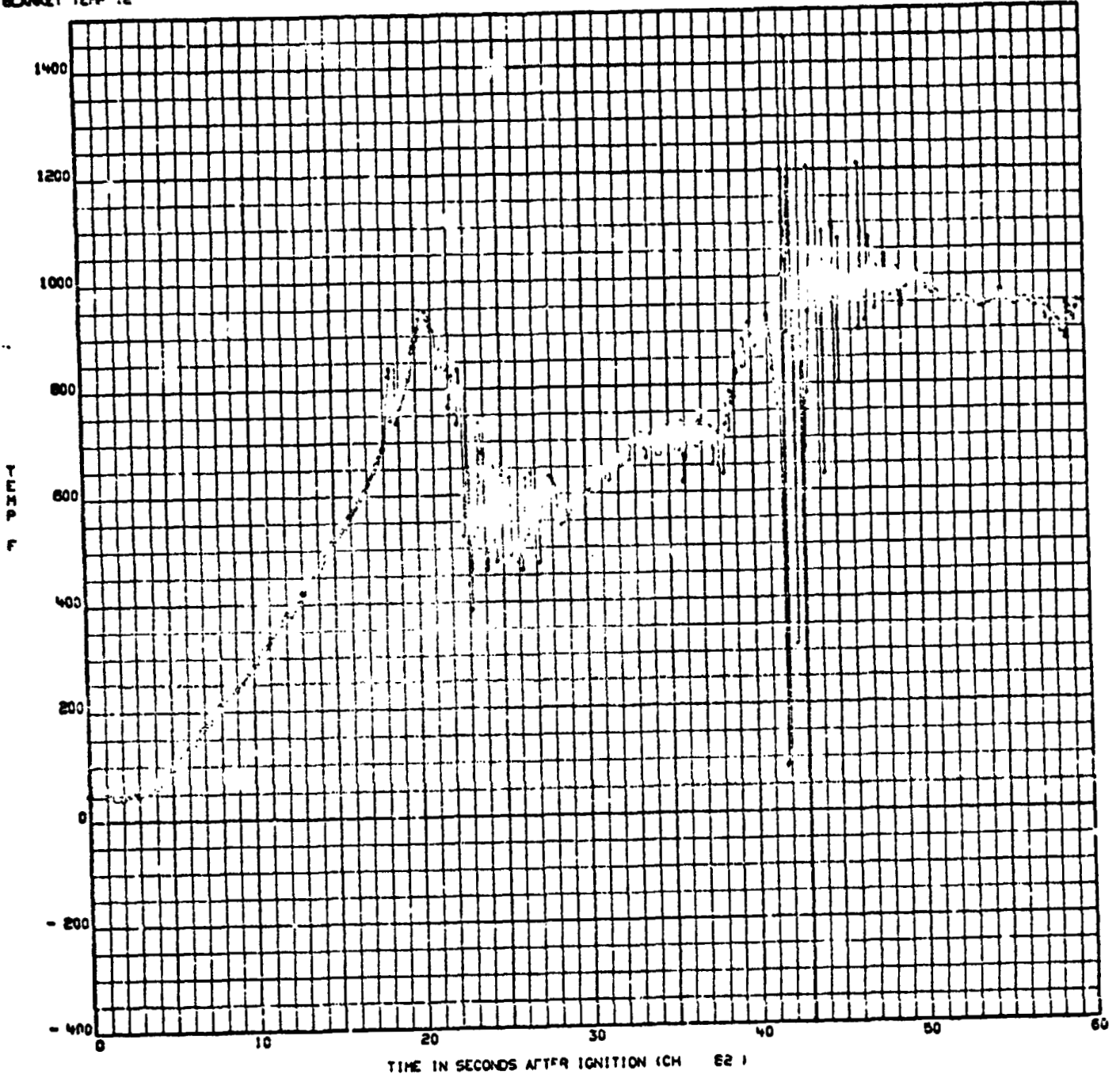


Fig. 43 - Temperature vs Time for Thermocouple 12 on SSC-2

CURTAIN TEMP 13

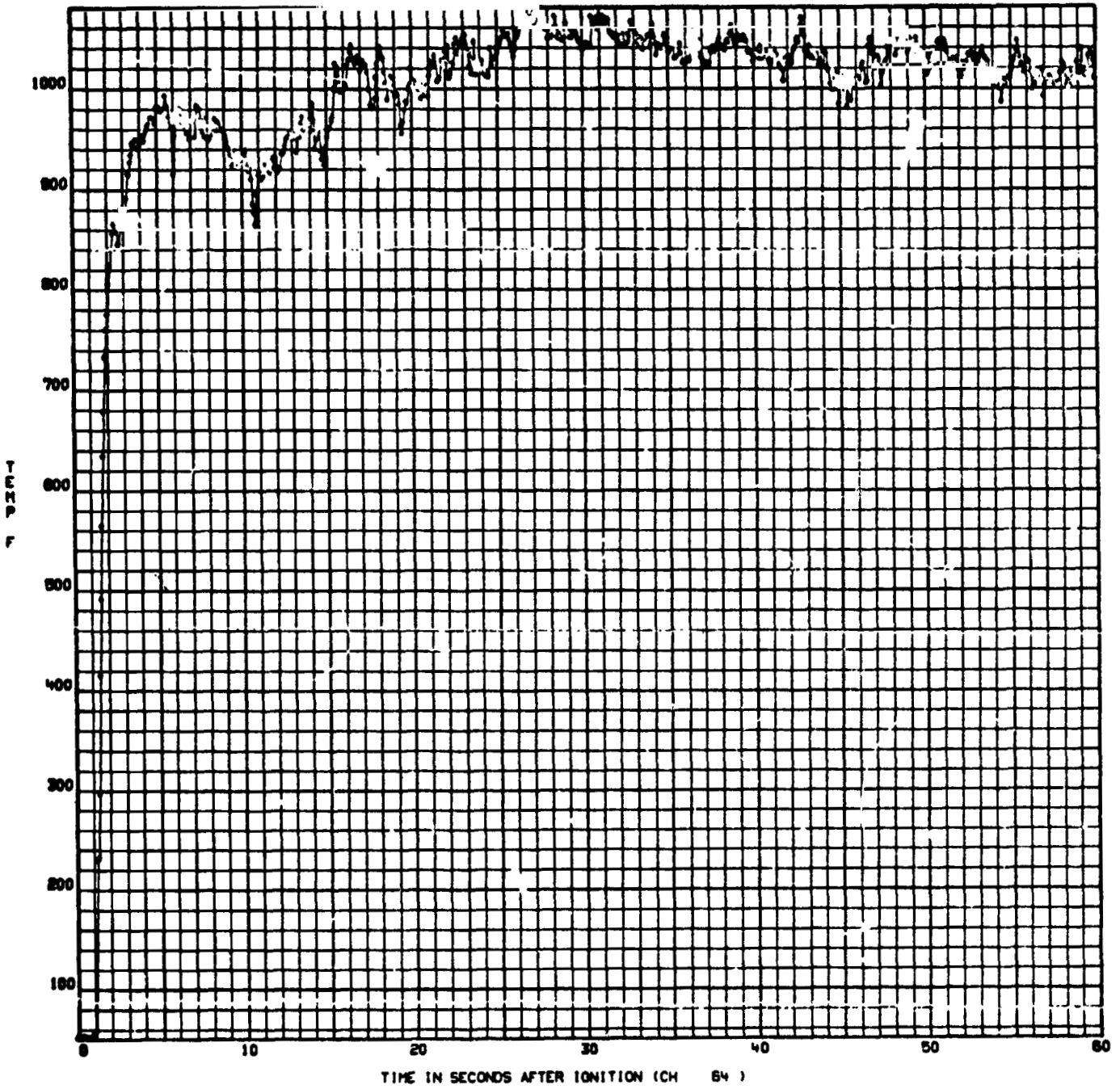


Fig. 44 - Temperature vs Time for Thermocouple 13 on SSC-2

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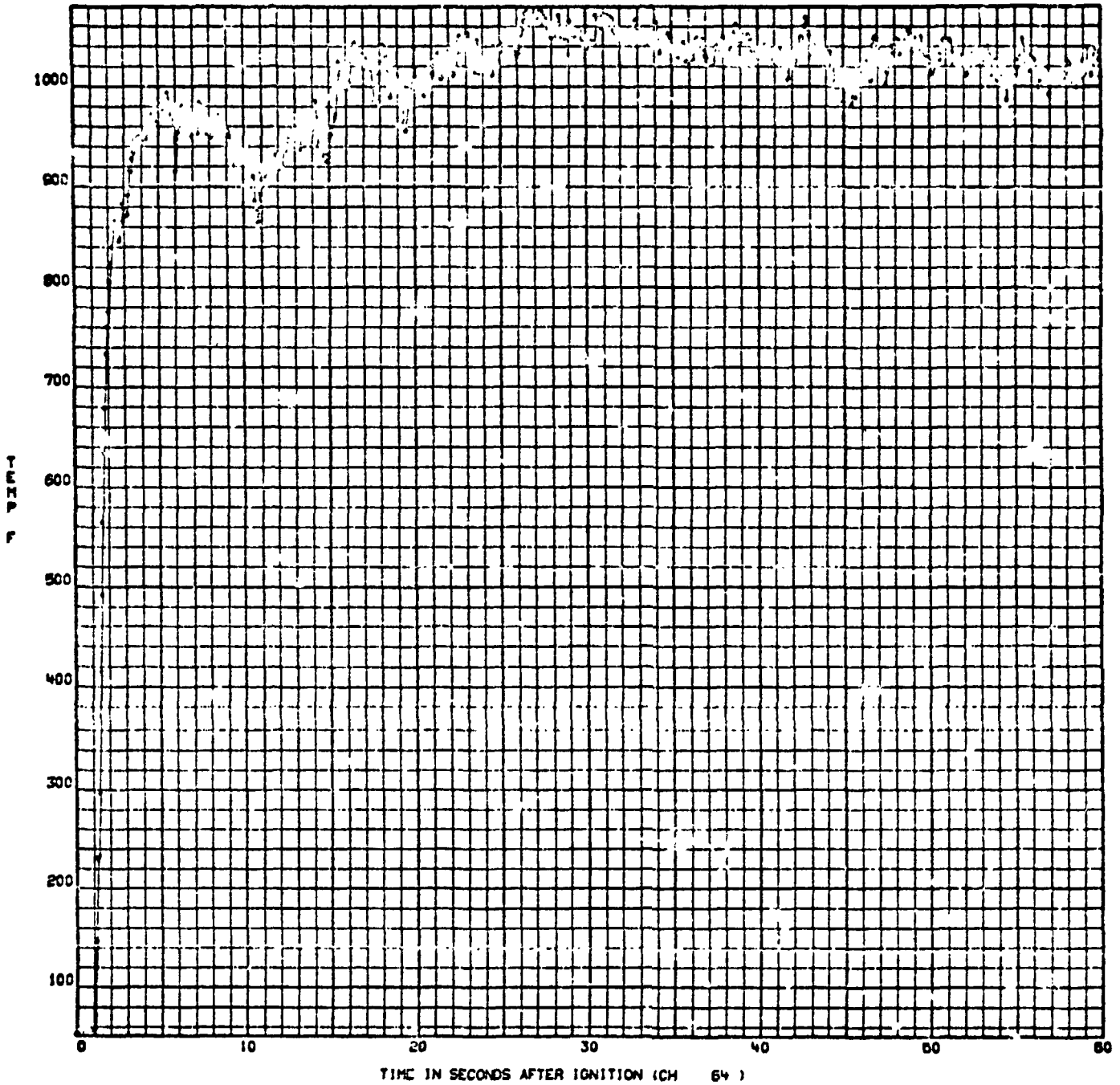


Fig. 45 - Temperature vs Time for Thermocouple 14 on SSC-2

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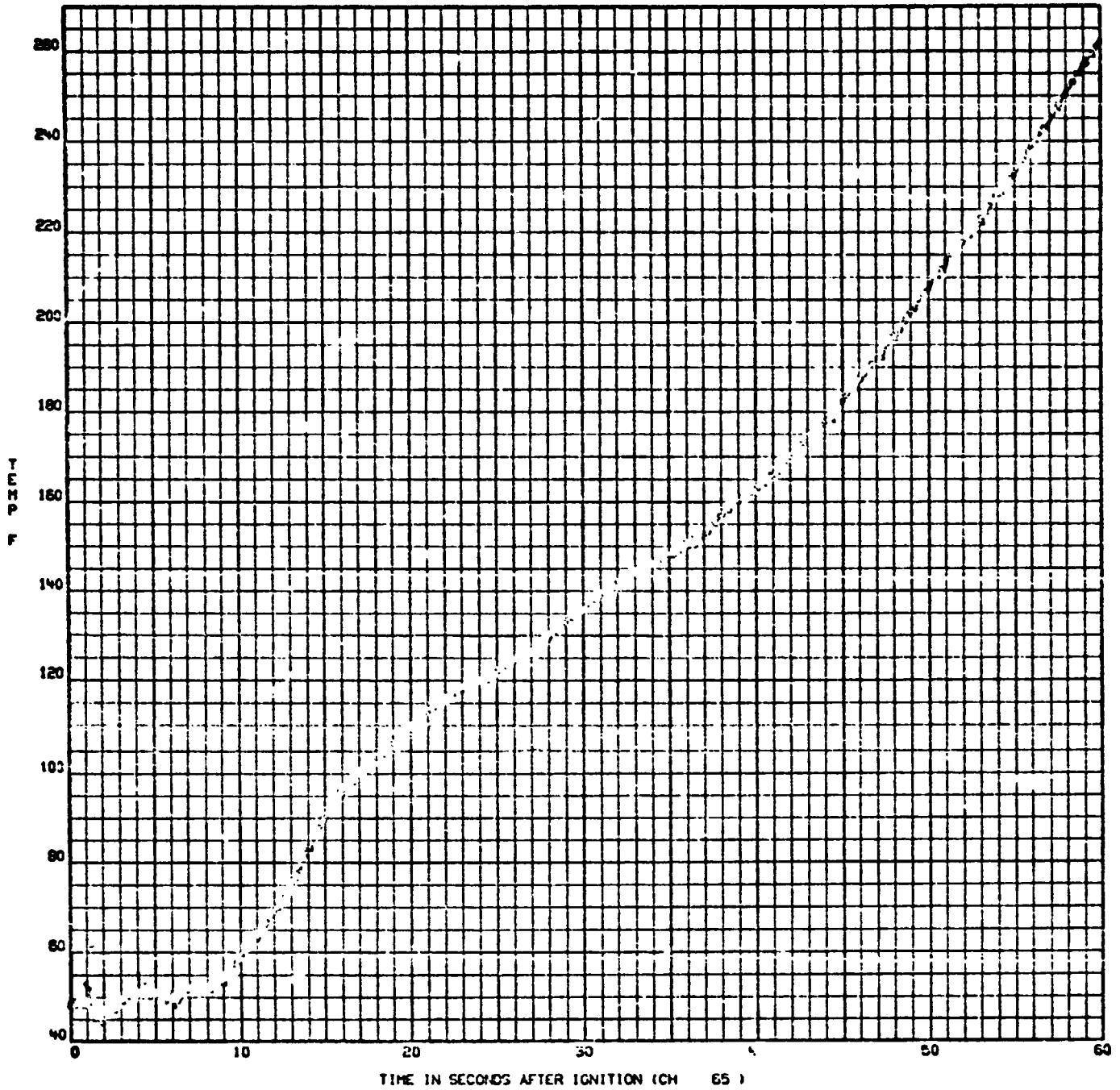


Fig. 46 - Temperature vs Time for Thermocouple 15 on SSC-2

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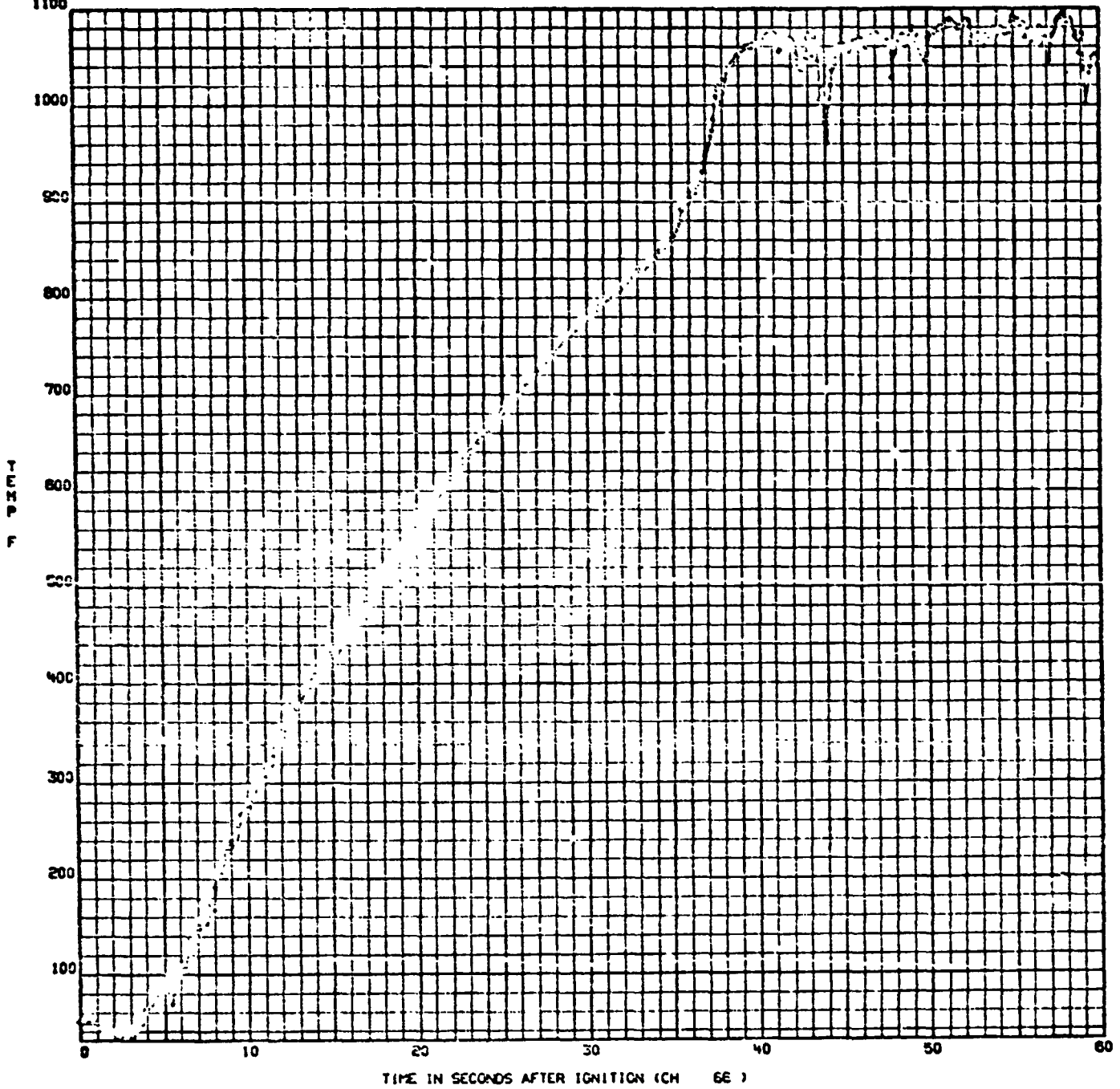


Fig. 47 - Temperature vs Time for Thermocouple 16 on SSC-2

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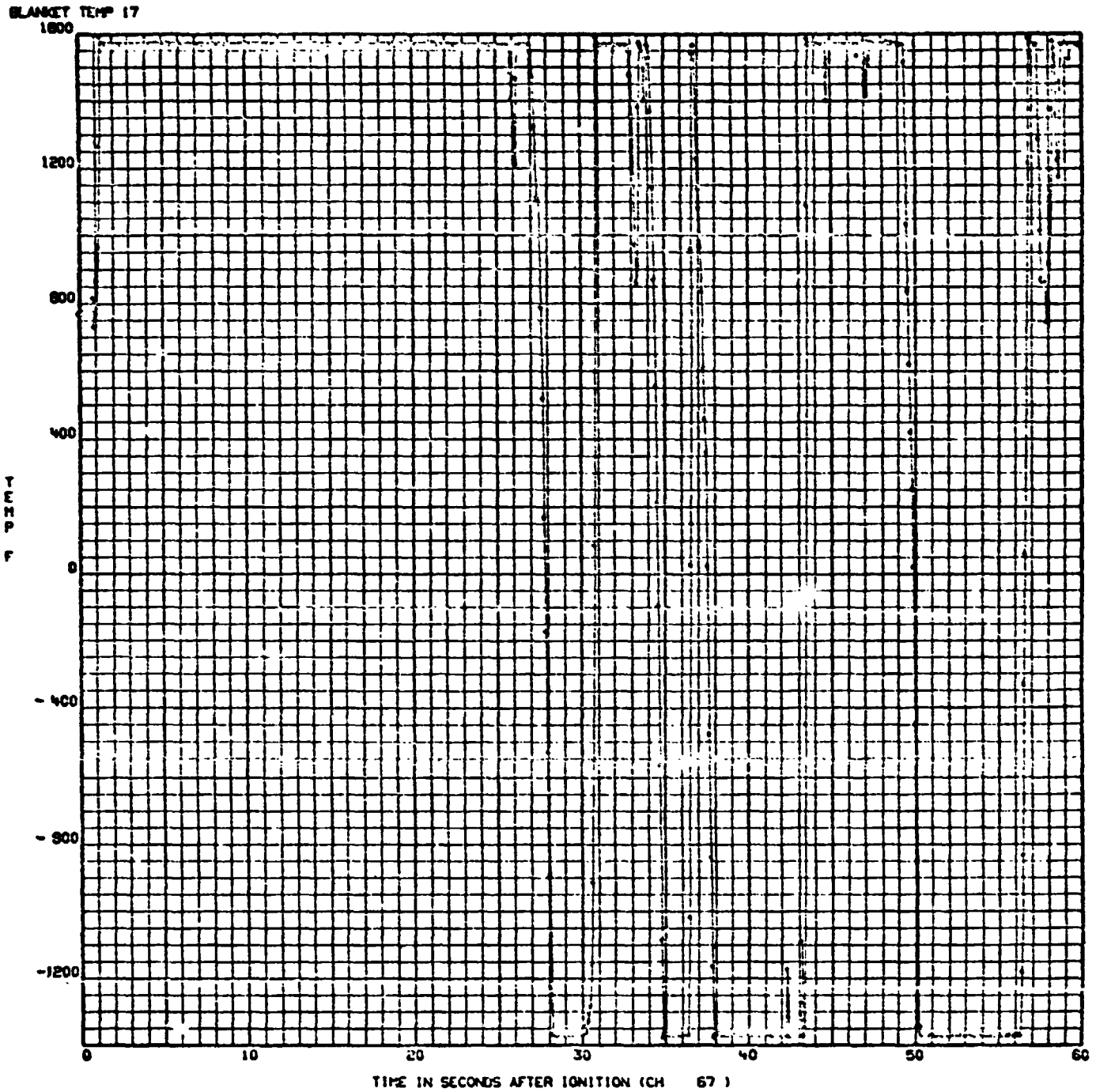


Fig. 48 - Temperature vs Time for Thermocouple 17 on SSC-2

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BLANKET TEMP 18

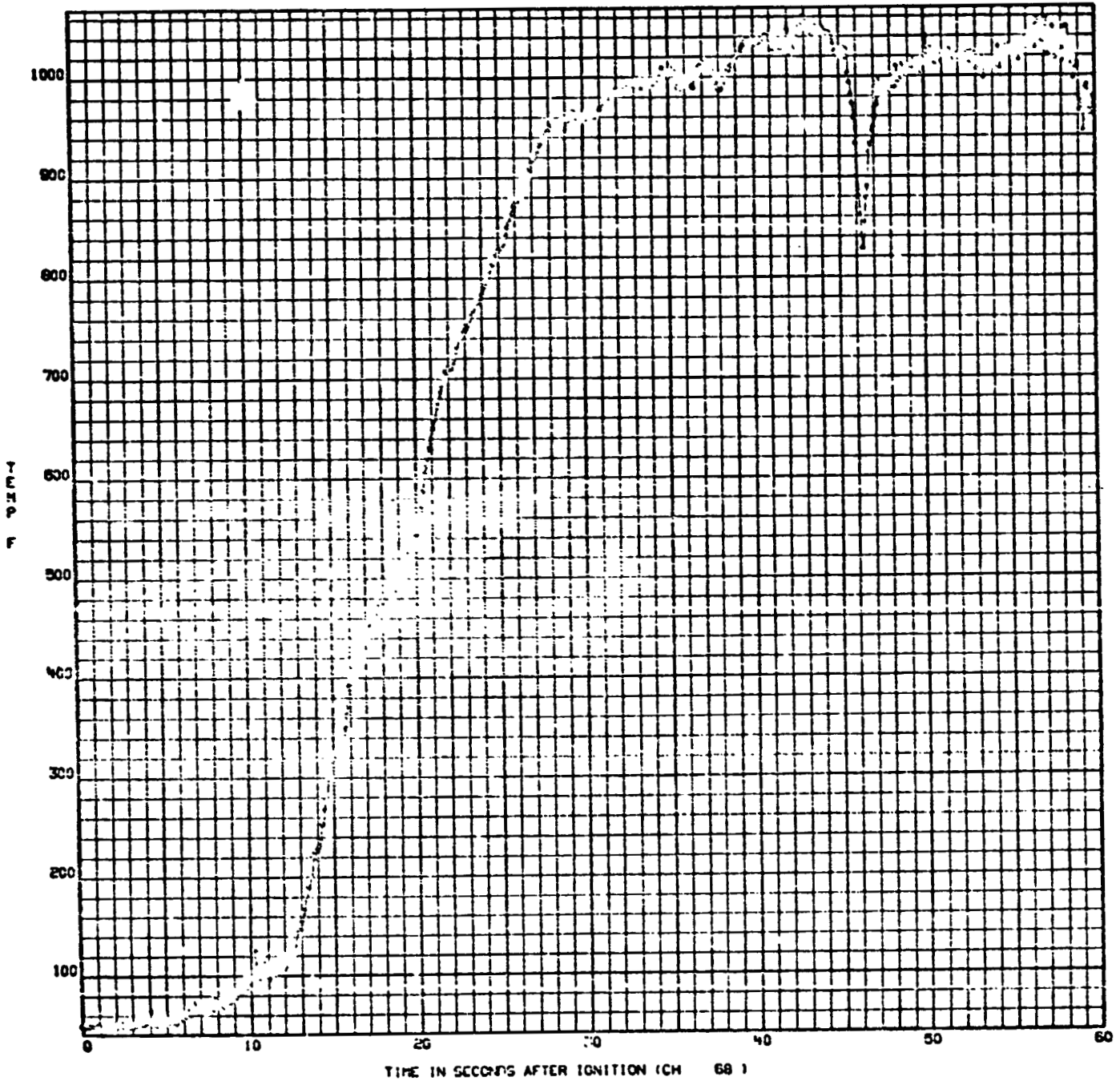
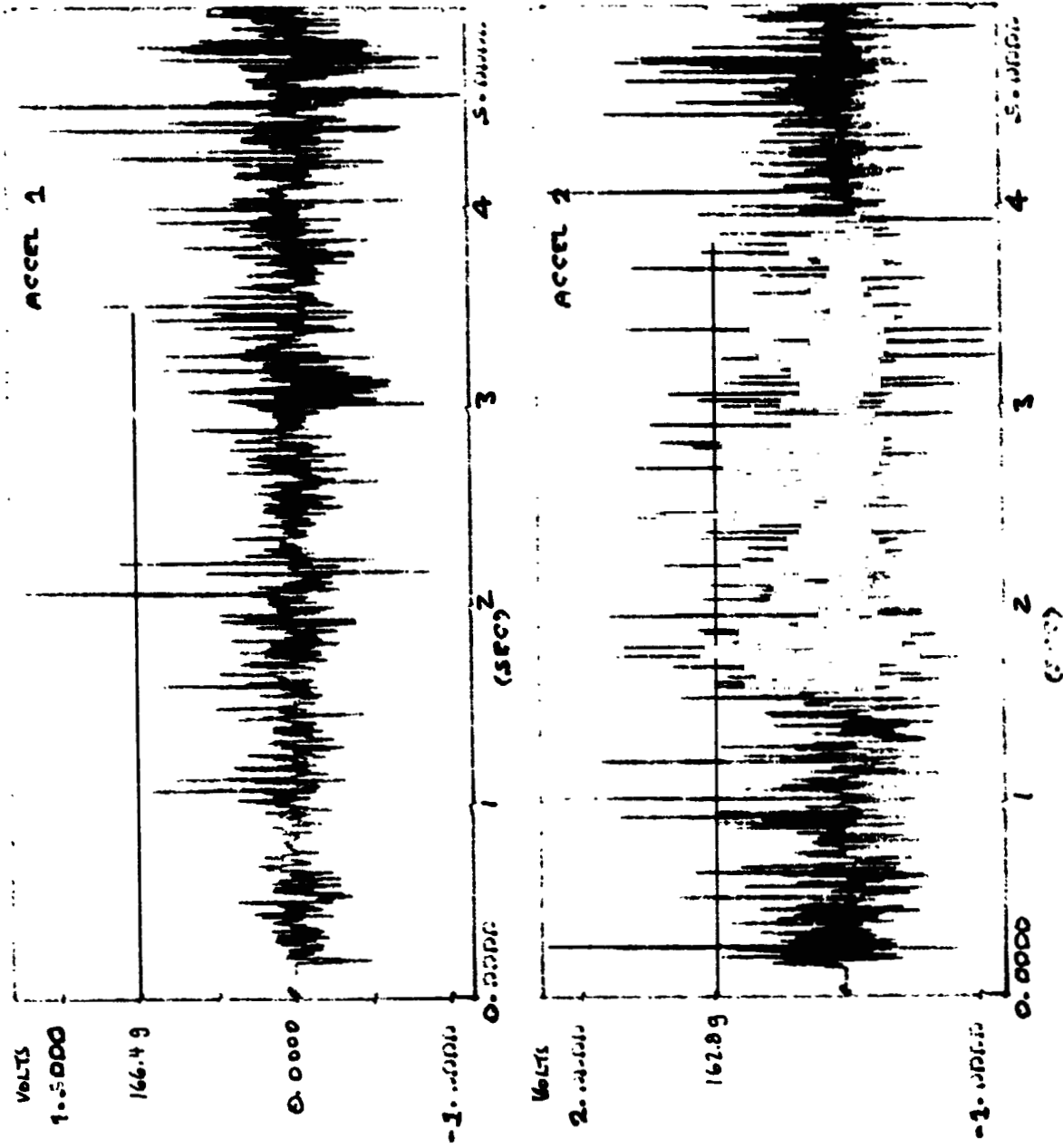


Fig. 49 - Temperature vs Time for Thermocouple 18 on SSC-2

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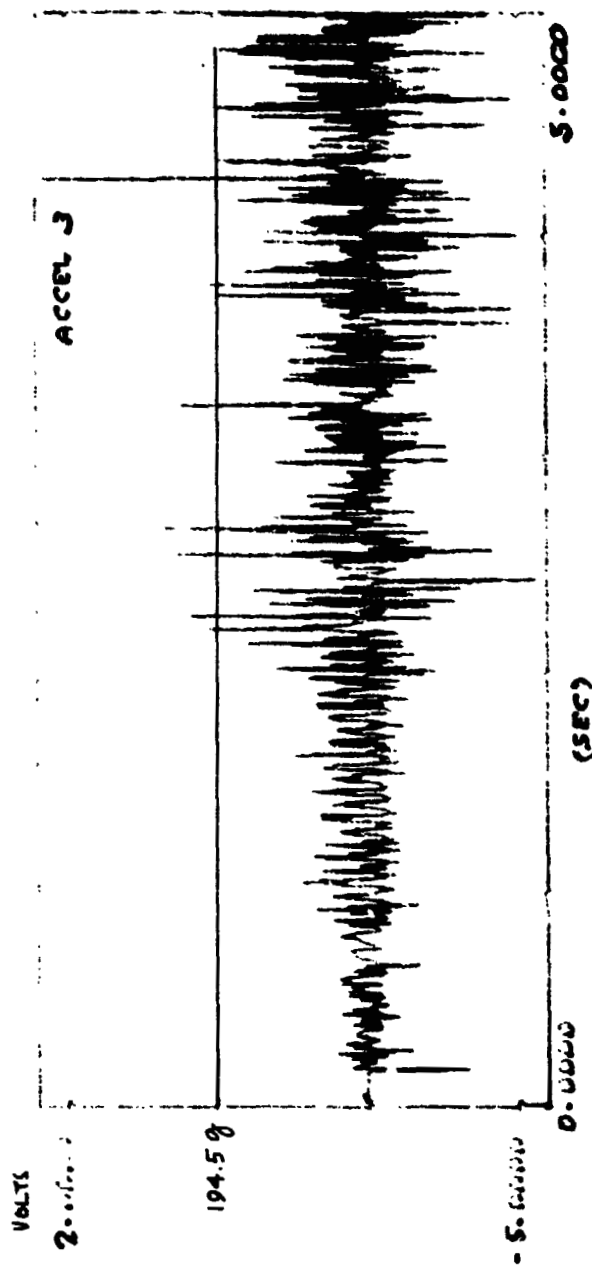


Hot Gas
 12/23/81
 Test 1052
 5 msec sample rate

BT-74
 SEN 25.7 mv/g
 166.4 g/v

BT-42
 SEN: 24.6 mv/g
 162.8 g/v

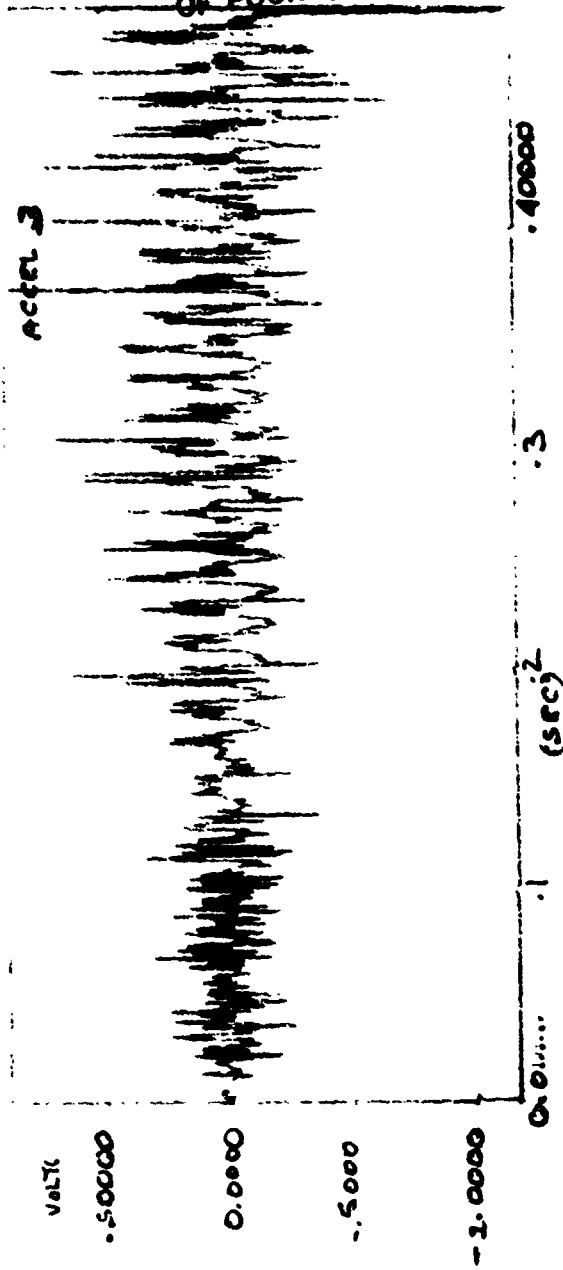
Fig. 50 - Accelerometer Data for First 5.0 sec of Test Run 1052
 (Instruments BT-74, BT-42)



5msec Sample Rate
Test 1052
12/23/81
CF11
SEN: 25.7 mv/g
194.5 g/v

Fig. 51 - Accelerometer Data for First 5.0 sec of Test Run 1052
(Instrument CF11)

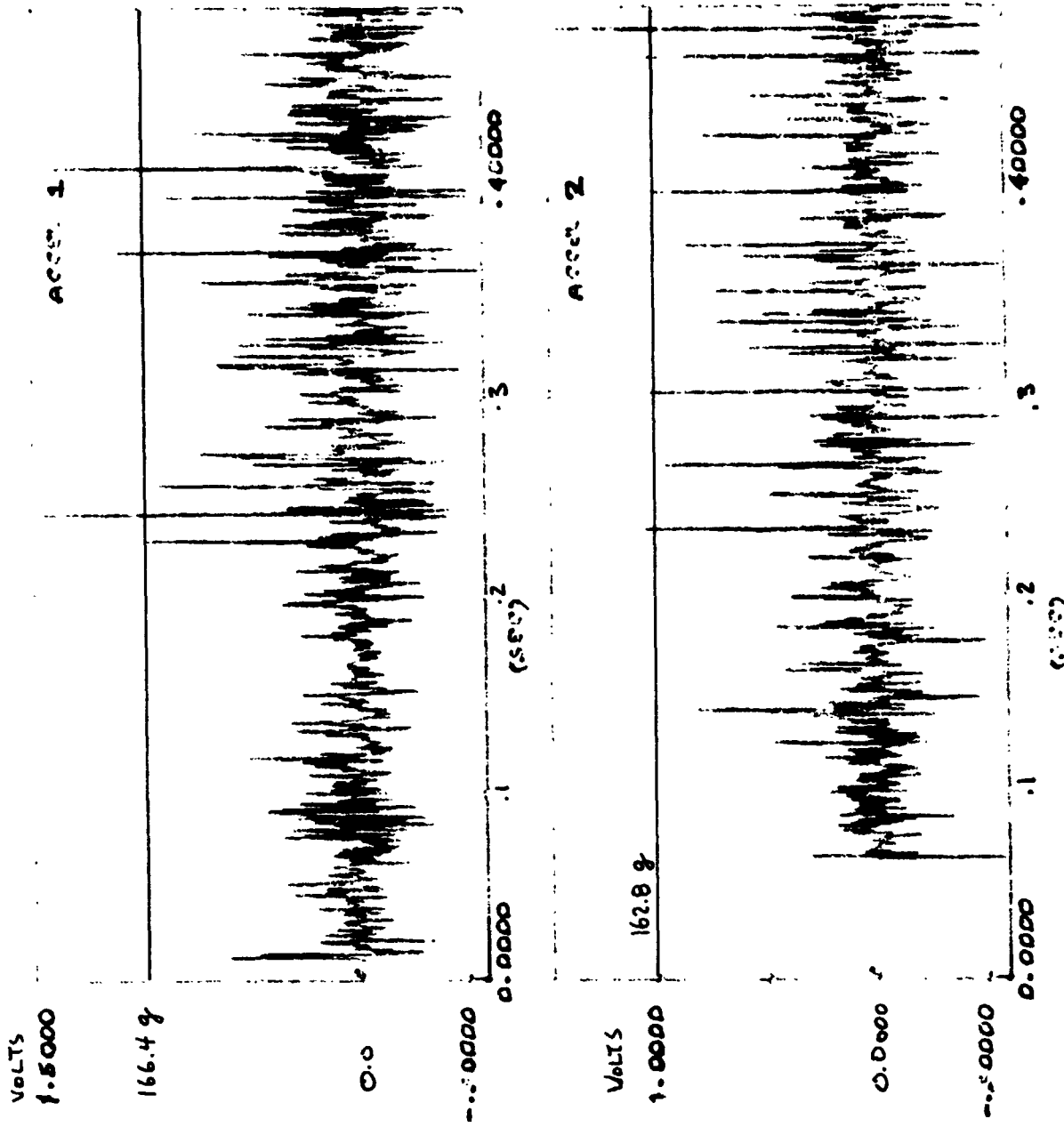
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500 μ sec Sample Rate
Hot Gas Test 1052
12/23/81

CF11
SEN: 25.7 mv/g
194.5 g/v

Fig. 52 - Accelerometer Data for First 0.5 sec of Test Run 1052
(Instrument CF11)



Hot Gas
12/23/81
Test 1052
500 /sec sample rate

BT-74
SEN: 25.7 mv/g
166.4 g/v

BT-42
SEN: 24.6 mv/g
(162.8 g/v)

Fig. 53 - Accelerometer Data for First 0.5 sec of Test Run 1052
(Instruments BT 74, BT 42)

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Fig. 54 - Post Test Photo of Curtain SSC-2