TASK CLOSE OUT DOCUMENT

Task Scope Natural Circulation - Prediction of Temperature

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Task No. 30

Date Complete 4/23/79

Reason felt task is complete:

Some estimate of thermocouple behavior have been made based upon past performance

Members of Committee

S. Levy
Signed
Committee Leader

PRELIMINARY PREDICTION OF CORE THERMOCOUPLE BEHAVIOR DURING NATURAL CIRCULATION

SUMMARY

Past core thermocouple behavior has been reviewed to establish how the thermocouples may behave during natural circulation. It is expected that the highest rate of core thermocouple increase will be below 30°F/hr and that at most 12 thermocouples may reach saturation temperature or above. Most thermocouples will remain wetted and will show temperatures below 250°F to 300°F.

DISCUSSION

There have been many reports written about the core thermocouples and the basis for some of the readings in excess of the reactor outlet temperature. The most accepted picture is that of fuel particulates being in proximity to the thermocouples. The presence of fuel particles near the thermocouples coupled with water flow having trouble reaching the thermocouples would explain the thermocouple history observed since the loss of feedwater accident. It is postulated that during the early phases of cooldown, the fuel heat generation was high enough and the flow to some thermocouples low enough to produce superheated steam at some of the thermocouples. As the reactor power decayed, some of the thermocouples were rewetted and this behavior is illustrated in Figures 1a and 1b where thermocouples at position G-11, F-7, G-9, E-11 and E-9 and H-8 are all seen to exhibit a temperature drop of over 200°F/hr while falling below the saturation temperature. The final temperature reached by the thermocouples probably depended upon the flow reaching the thermocouple after it was rewetted. The behavior of thermocouples K-11 and D-10 is particularly interesting as they may exhibit rewetting and redryout as the saturation temperature was lowered. It is also suspected that during this early phase of the decay, some fuel particles redistribution was taking place.

One of the ways to ascertain that some of the thermocouples were dry during the early part of the accident is to look at their behavior as system pressure is modified. If the thermocouples are blanketed with steam, a pressure increase should lower the temperature and a pressure decrease should do the opposite. This behavior is especially noticeable in Figure 2a where thermocouple H8 behavior is opposite to that of T_{sat} on 4/8/79. A similar pattern of thermocouple rising while T_{sat} is decreasing is observed in Figure 2b. A plot was made of the coverage of the five hottest thermocouples minus hot leg temperature as a function of time and it was compared to pressure swings. The results are shown in Figure 3. It is observed that they generally correspond though the change in the hottest thermocouples is small indicating that steam or dry areas are very small at this stage of the decay heat. This is shown in Figure 4 where the five hottest temperatures are plotted versus time versus outlet leg temperature. The consistent behavior of all these thermocouples indicates that all core thermocouples are now practically wetted.

Of particular interest during the natural circulation run is the behavior of the core thermocouples. The highest rate of decrease or increase was that already noted in Figures 1a and 1b. Making allowance for decay heat decrease, this maximum rate of temperature change would be 60 to 70°F/hr. If we assume that rewetting and dryout are reversible temperature increases of 60 to 70°F may be indicative of local core thermocouple dryout. A more reasonable expectation of the temperature rise that might result is to look at Figure 5 when the pump trip took place. In this case, thermocouple H-8 which was primarily wetted started to rise sharply due to particulate and flow redistribution. The rate of temperature rise is about 70°F/hr and allowing for decay heat reduction, this would correspond to about a 30°F/hr temperature rise in late April. It is suspected that during the switch to natural circulation, hottest core thermocouples can be expected to rise at the most at this rate.

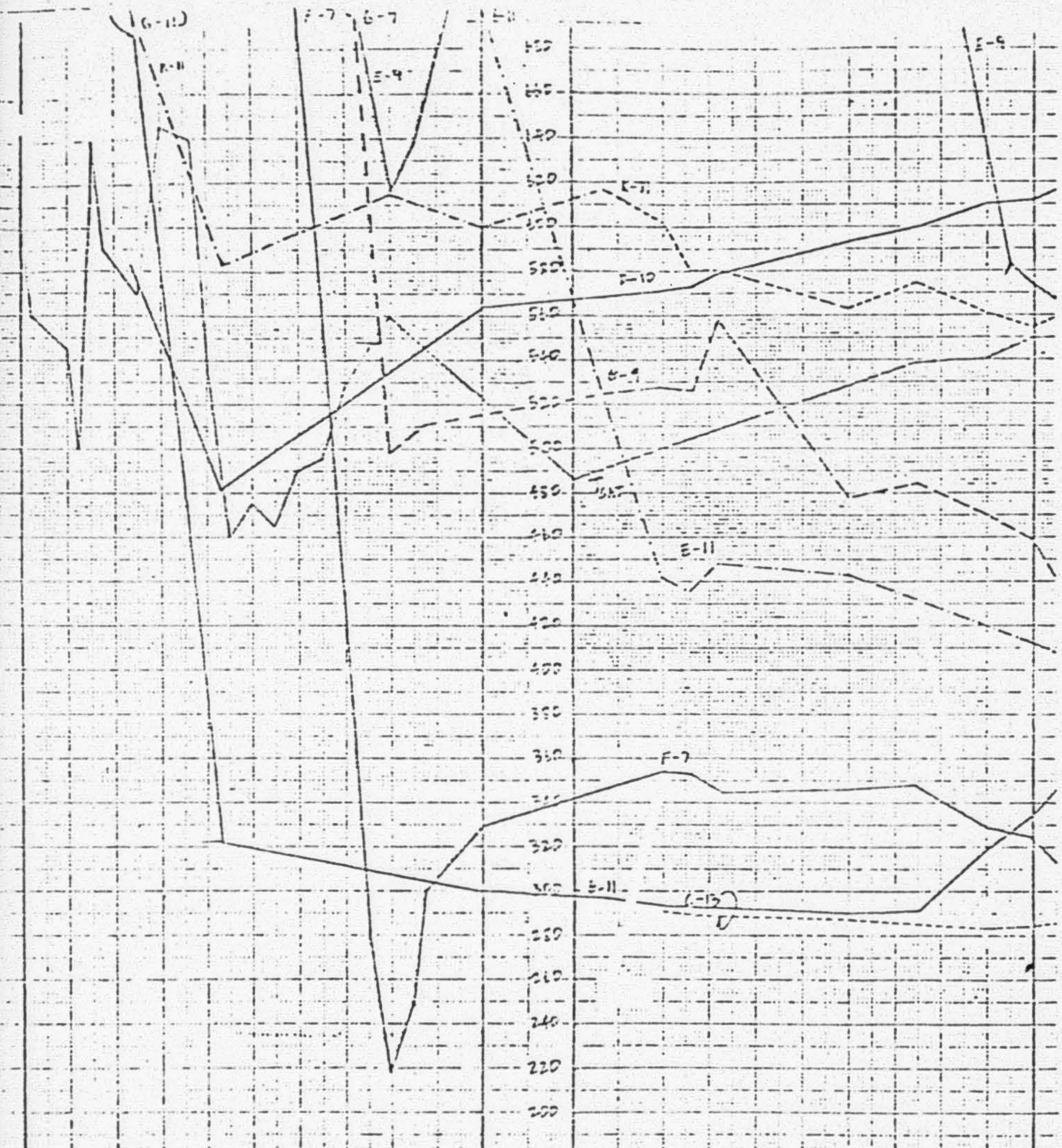
During natural circulation, there are two periods of very great interest. During the transient after the pump is tripped, the flow falls below the natural circulation value (see for example Figure 6). This flow could produce stagnation flow at some of the thermocouples and dryout of the fuel particulates around the thermocouple. This period of zero to 800 seconds is especially critical. Thermocouples should rise at 30°F/hr and as high as 70°F/hr if they become blanketed.

The next period of interest is the behavior of the thermocouples at the much lower flow rate of natural circulation. The total flow will decrease by a factor of about 20 and if we assume that the thermocouple temperature will rise accordingly, it is found that at most 12 thermocouples may reach saturation temperature. This rate of rise will take place slowly as water flow drops through the particulates. It is expected that some redistribution will take place during this period of time, but that in general, the same number of high thermocouples will continue to exist.

CONCLUSION

1. Most core thermocouples will rise gradually during the transfer to natural circulation and they should stop at 200 to 250°F.
2. A few thermocouples may be subject to redistribution of flow and fuel particulates. Their temperature rise may be at most 30°F/hr.
3. Due to the reduced flow rate associated with natural circulation, a few thermocouples may reach saturation temperatures. This number is not expected to exceed 12.
4. During the initial stage of the transient close to stagnation flow may set in. Even under stagnation flow, the thermocouple temperature rise will be below 70°F/hr and may be terminated as natural circulation sets in.

S. Levy
4/23/79



-160 175

Figure 1a

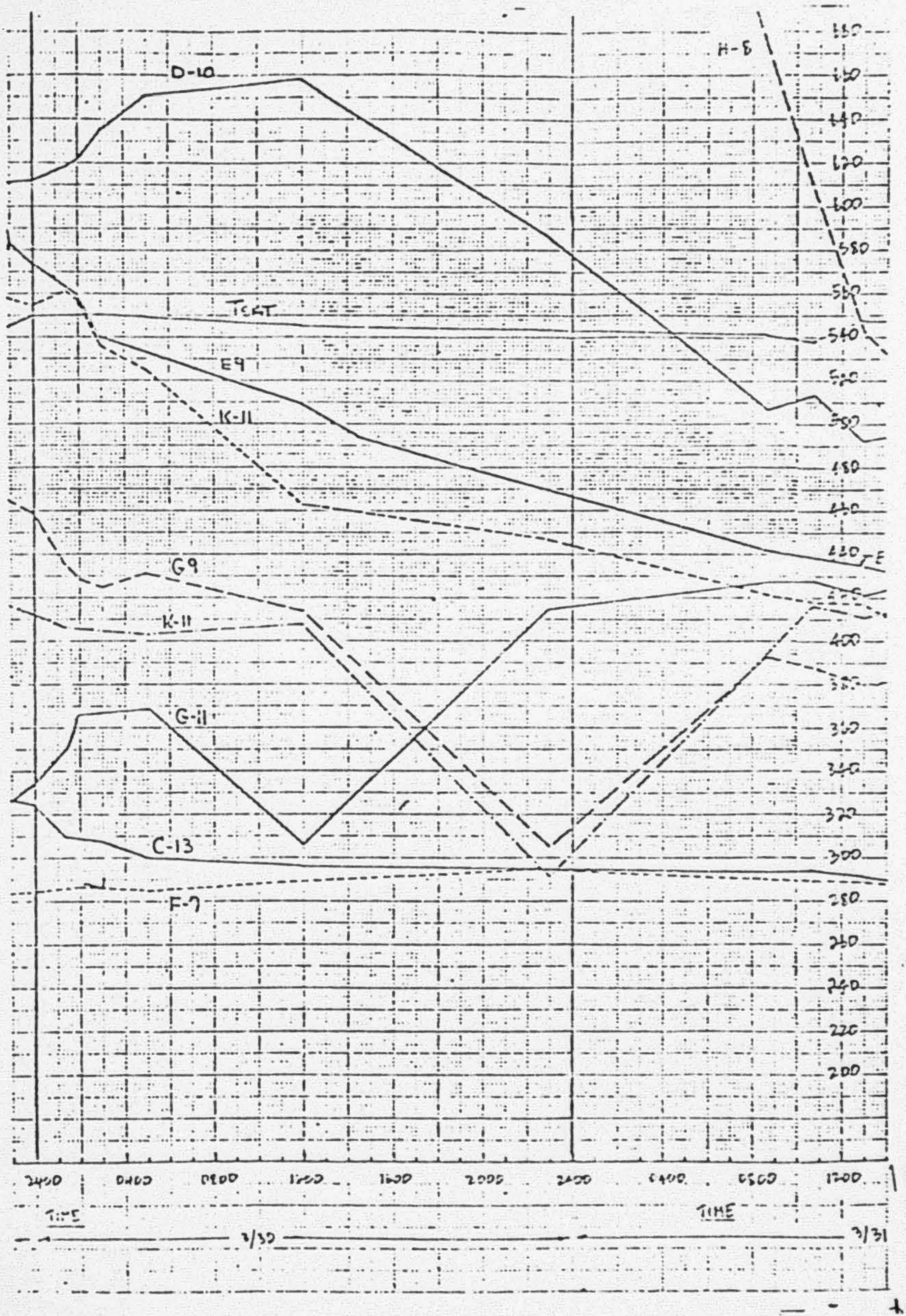


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Figure 1b

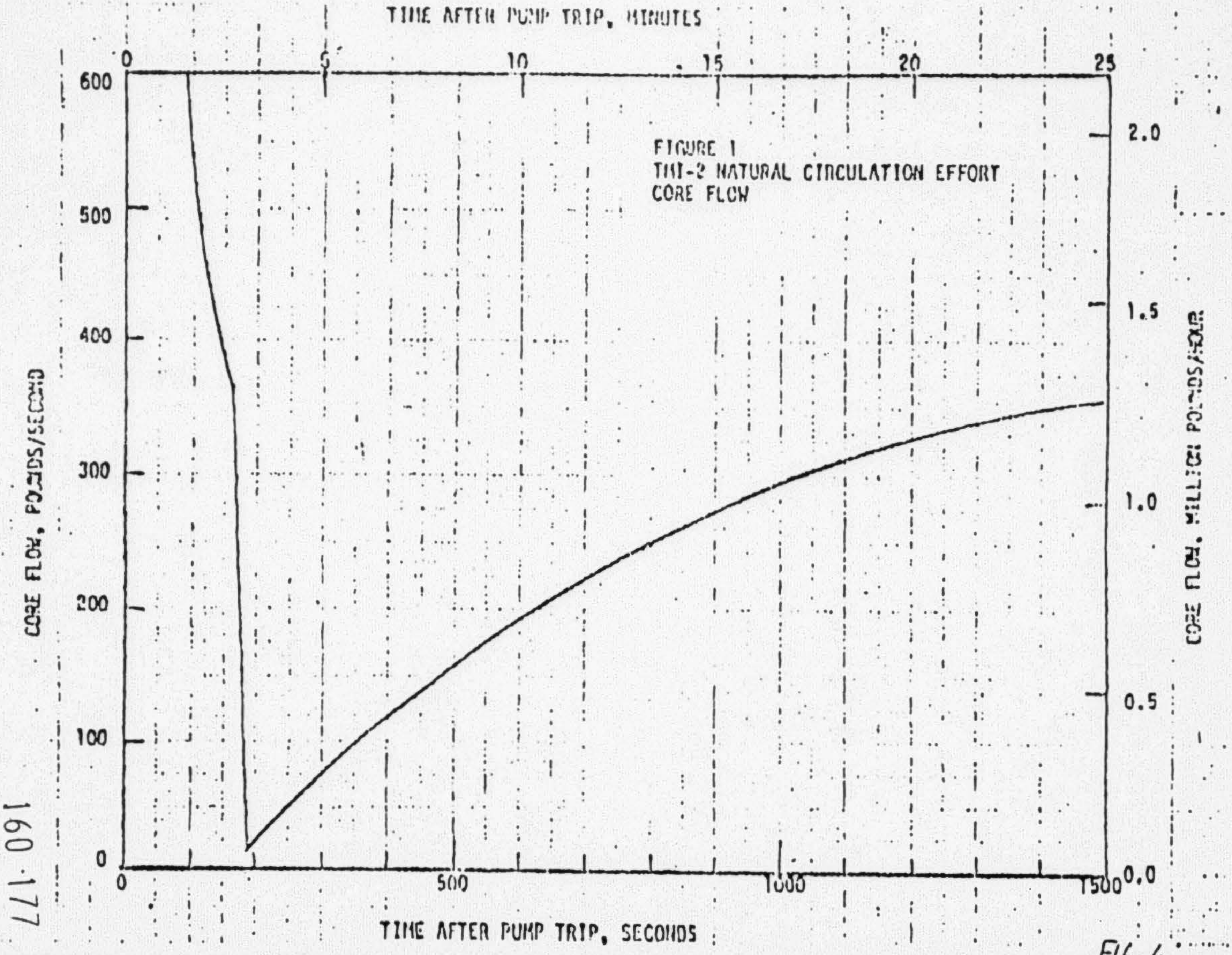
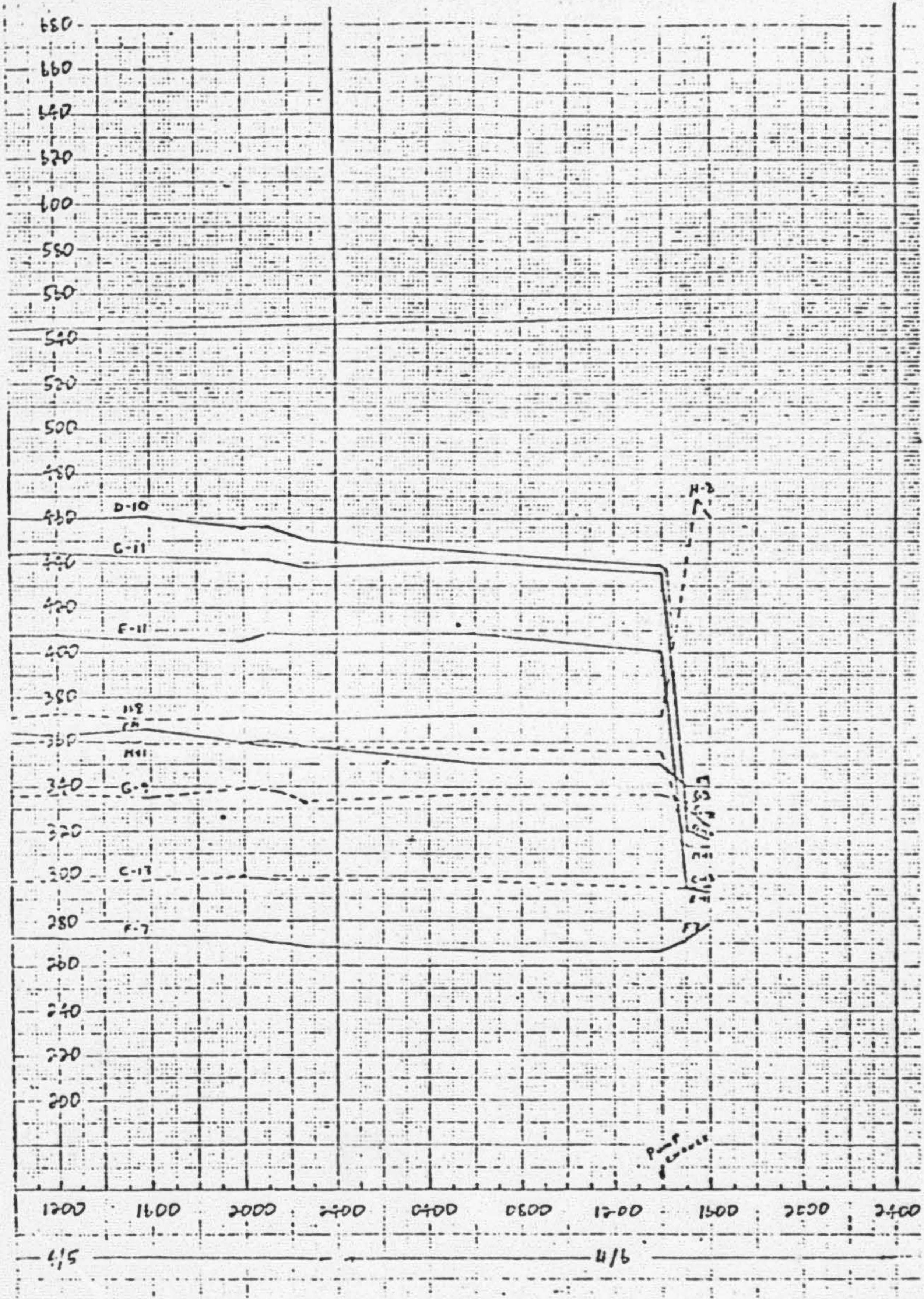


FIGURE 1
TMI-2 NATURAL CIRCULATION EFFORT
CORE FLOW

FIG. 6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D-10
C-11
F-11
118
M41
G-9
C-13
F-7
H-2
Pump change
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1600
2000
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0400
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1200
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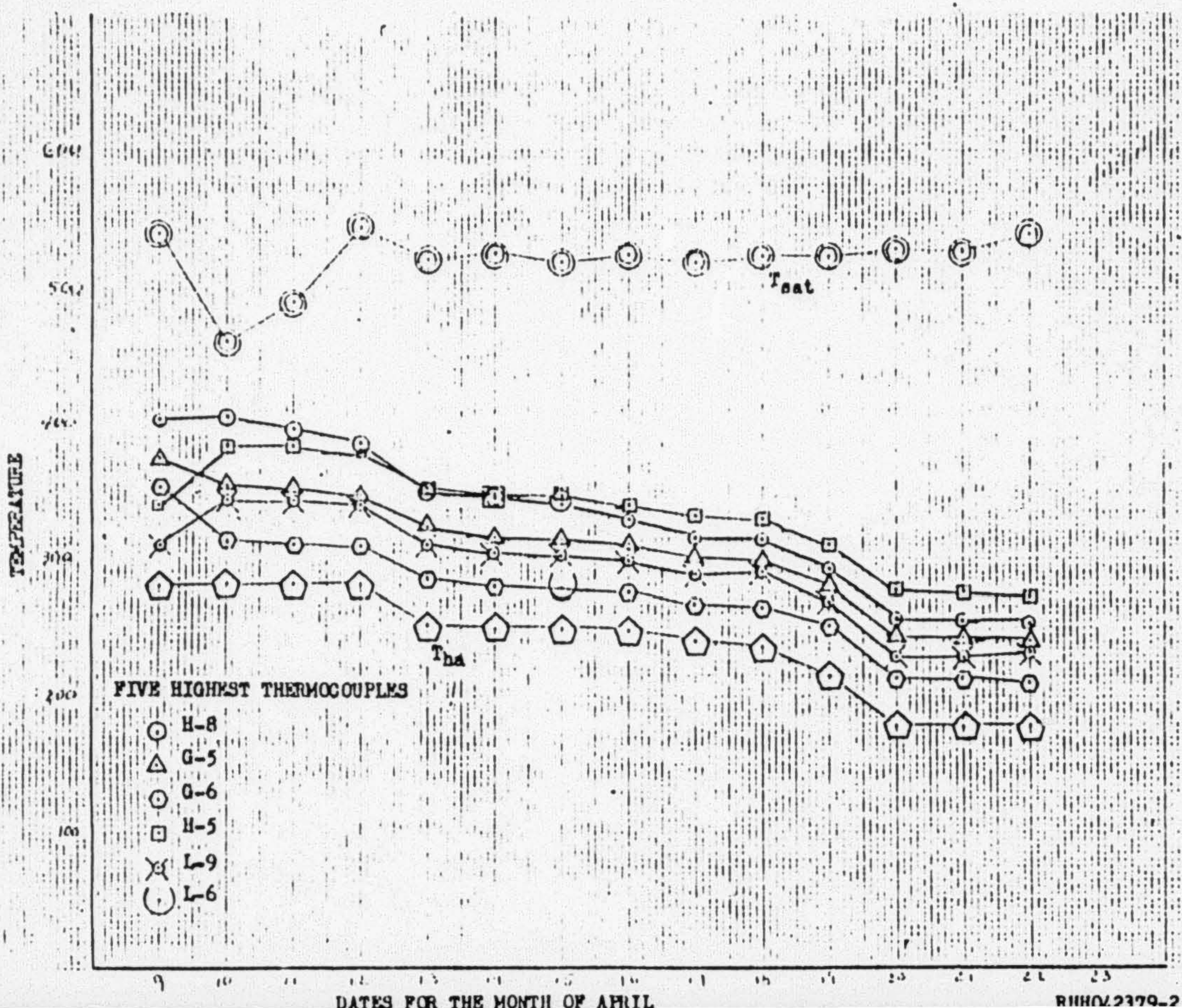
4/5
4/6

Figure 5

Fig. 4


TEMPERATURE
600
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200
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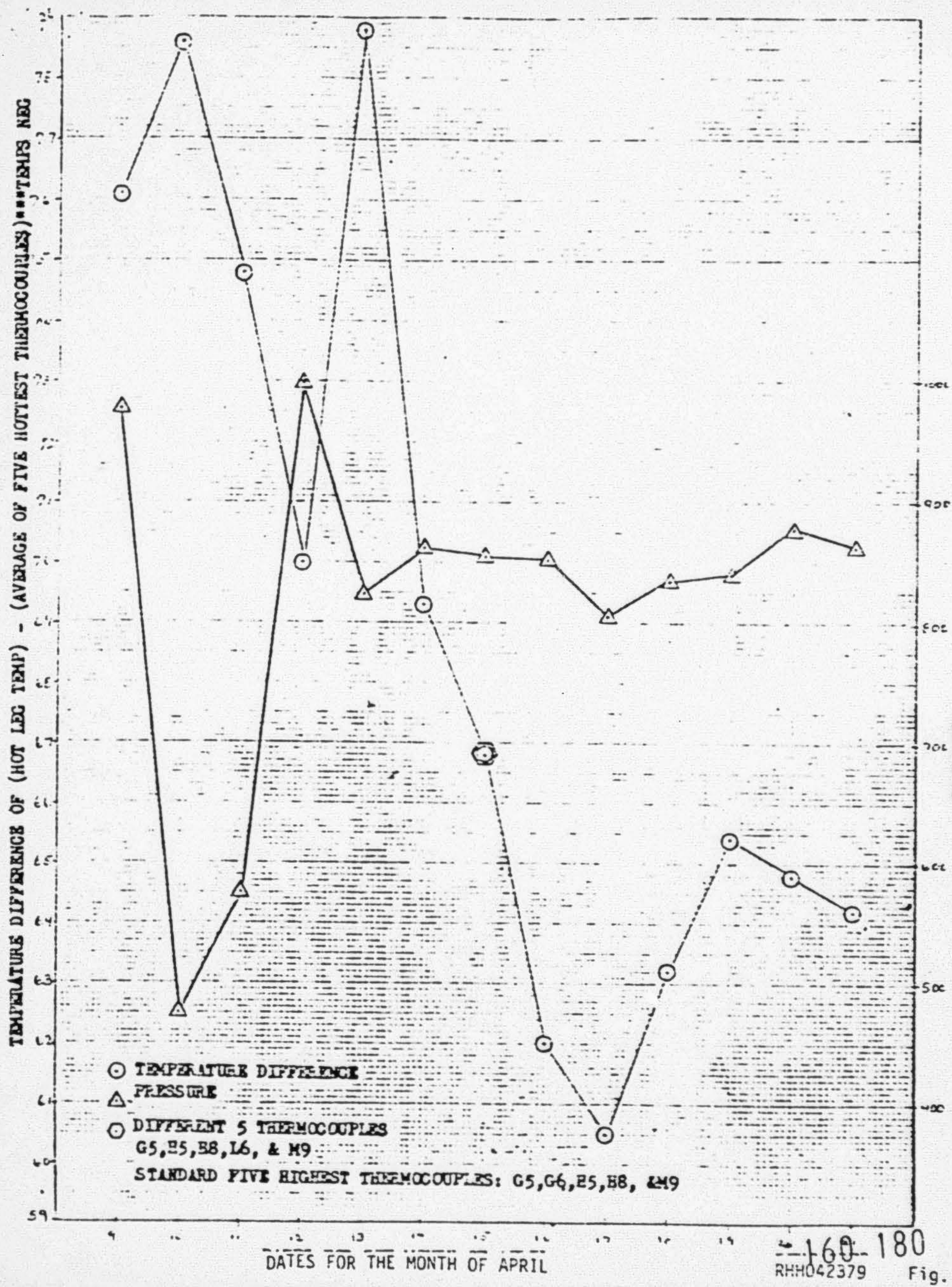
T_{sat}
T_{ba}
FIVE HIGHEST THERMOCOUPLES
H-8
G-5
G-6
H-5
L-9
L-6
9
10
11
12
13
23
DATES FOR THE MONTH OF APRIL
RUHO42379-2

160 179


TEMPERATURE DIFFERENCE OF (HOT LEG TEMP) - (AVERAGE OF FIVE HOTTEST THERMOCOUPLES)***TEMPS DEG
PRESSURE
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75
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600
700
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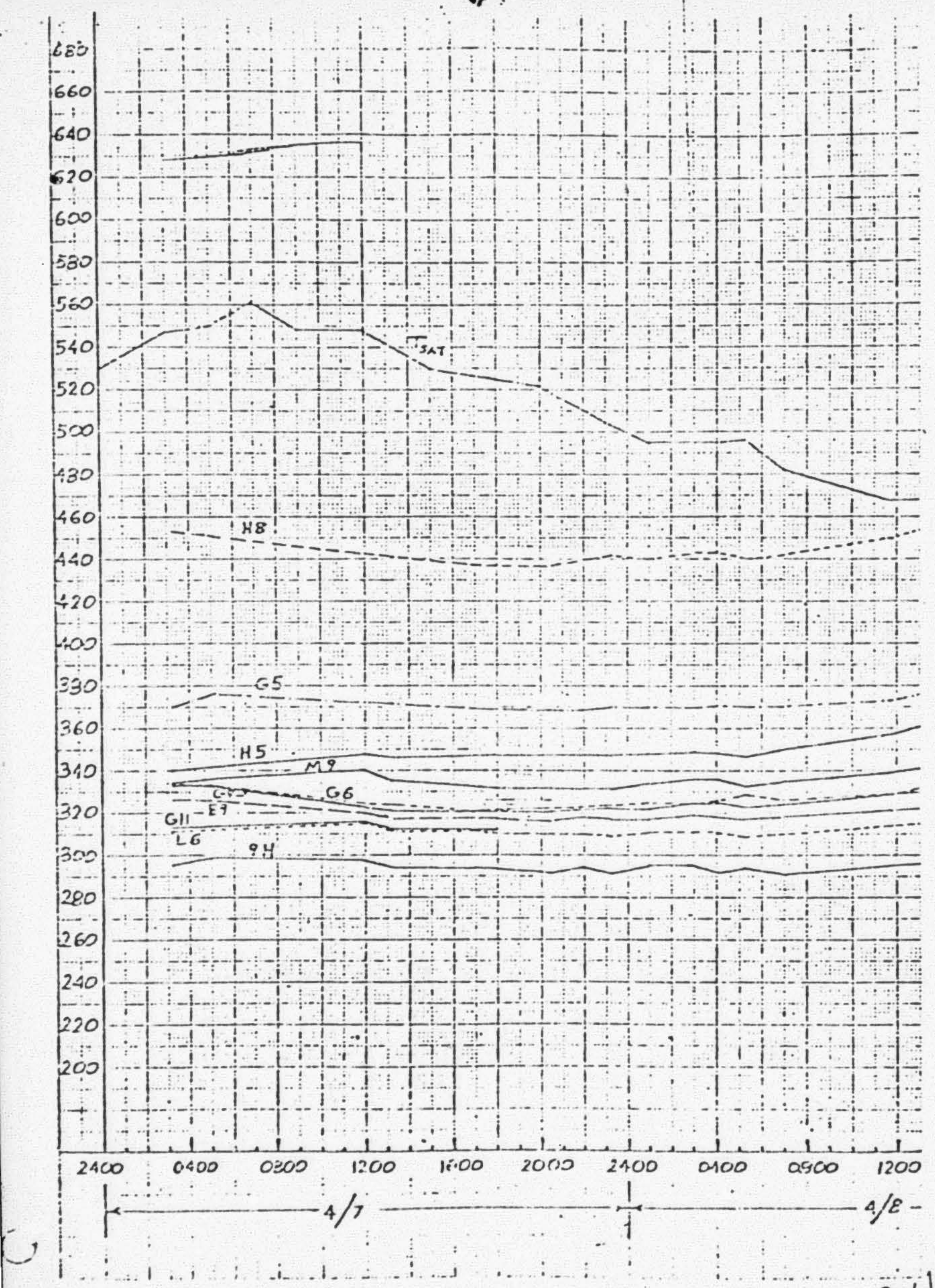
900
1000
9
12
13
DATES FOR THE MONTH OF APRIL
⊙ TEMPERATURE DIFFERENCE
△ PRESSURE
⊙ DIFFERENT 5 THERMOCOUPLES
G5,E5,E8,L6, & M9
STANDARD FIVE HIGHEST THERMOCOUPLES: G5,G6,E5,E8, &M9

Fig. 3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M9
G13
G6
G11
E7
L6
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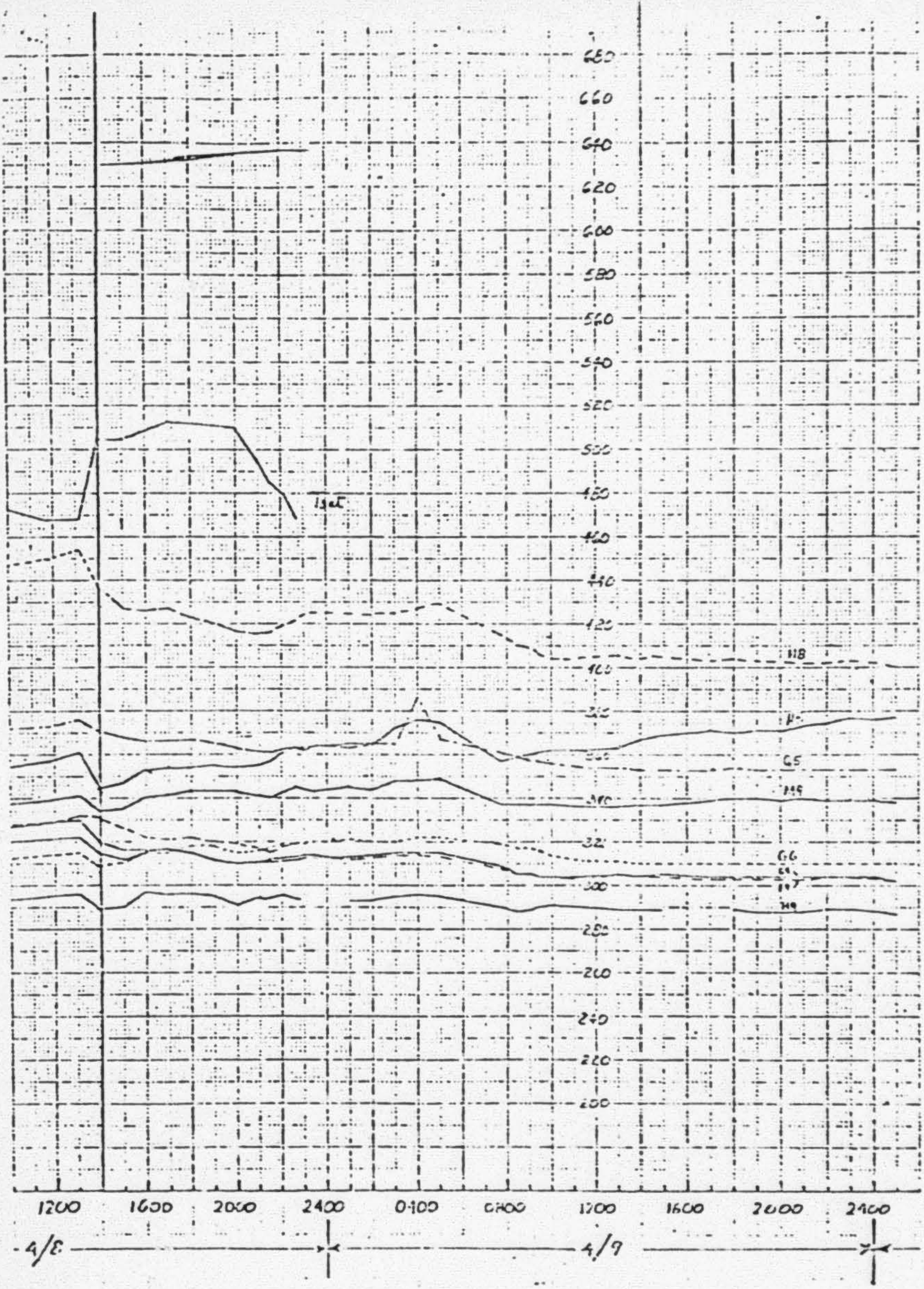
0800
1200
4/7
4/8

Figure 3b.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1200
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2400
4/8
4/9
Tset
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149
66
69
147
149

Figure 5d