FOUR POINT MODIFIED ISOCHRONAL TESTING OF EAST MEREENIE NO. 10

by

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SEPT, 1984

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SUMMARY

A four point modified isochronal flow test of East Mereenie No. 10 has revealed the following :

(a) The absolute open flow potential (AOF) of the well is 810 MCF/D.

(b) The 64 ft. of perforated interval has an average permeability of 3 md.

(c) There is a large rate-dependent pseudoskin associated with the well which significantly limits the flow capacity of the well. The indicated flow potential of the sands in the absence of the skin is approximately 6.5 MMCF/D.

(d) Since this pseudo-skin is probably caused by liquid build-up around the well it won't be removed by well stimulation techniques.

(e) There is evidence of a gas-oil contact about 144 ft. down dip or 7 vertical feet from the well at about -2400 ft. MSL.

INTRODUCTION

East Mereenie No. 10 was completed in the lower Stairway sandstone on the far eastern nose of the Mereenie anticline, after encountering only water in the Pacoota reservoirs. The perforated interval in the straight hole is 64 ft. of 2 shots per foot from 4618 to 4682 ft. KB.

Since the Stairway gas may become important in the future, in order to make contributions to either the Yulara or Darwin pipelines, it was decided to conduct a four point isochronal test in order to assess the production capacity of the well and to attempt to detect any limits to the reservoir.

PROCEDURE

The well was flowed at four different rates using three different chokes. The flowrates and times are shown in Table 1.

Table 1.

Test	Rate MCF/D	Flow Time (hrs)	Build-up time (hrs)
1	814.9	72	72
2	437.9	8	16
3	750.4	8	16
4	781.0	48	72

Further data on the tests are shown in Table 2.

The highest flowrate was done first in order to get some early information on the productive capacity of the well. The drawdown from this test indicated that the flowrate was not being controlled by the choke but by back pressure from the separator which was operating at 260 psig. The second flow on a 10/64" choke gave a reasonable drawdown and rate for the first 3 hours but then the lines behind the choke started to freeze up and further choked the flow. The third flow was on a 14/64" choke for 8 hours and for the fourth flow the 18/64" choke was selected again but with a separator pressure of only 80 psig. The fourth flow was maintained for 48 hours but produced a slightly lower gas rate than the first flow. This was probably due to the increase in the apparent skin caused by further liquid build-up around the well.

RESULTS

The linear drawdown plots of pressure versus time are shown in Figures 1-4. These show that in flows 1, 3 and 4 the bottom hole pressure reached a steady value rather than a pseudo steady drawdown. In case 2 the drawdown shows the effects of the line freezing up. Hence no analysis of the drawdown could be attempted. The reasons for this drawdown behaviour are unclear, however the projections from the drawdown pressures indicates that the absolute open flow potential (AOF) of the well is 810 MCF/day.

The Horner build-up plots of linear pressure versus log $\left(\frac{tp + \Delta t}{\Delta t}\right)$ are shown in Figures 5-8. These show the high damage present in the wells. However to properly analyse the build-up data one must plot either the real gas pseudo function or pressure squared versus the Horner time function.

In this case since μz remains constant during the straight line portion of the semi log plots, the p^2 function was plotted and analysed. For each build-up plot the value of tp, the total producing time, was the total of the previous flow times. Hence for the fourth build-up plot, tp = 136 hours. The p^2 plots for cases 1, 2 and 4 are shown in Figures 9, 10 and 11.

Each of these plots shows a break in the slope of the linear portion of the build-up which is indicative of multiple flow barriers or a fluid contact nearby. The ratio of the two slopes is of the order 6.5:1, hence there is something other than a linear fault causing this phenomena. A linear fault would cause a simple doubling of the slope. The most likely cause of this

slope change is the presence nearby of the gas-oil contact. Further evidence of this is the high fluid content associated with the gas, about 20 bbls/MMCF, and the nature of the associated fluid: honey coloured oil.

The intersection of the two straight line portions can be used to determine the distance from the well to the contact using Greys' equation. This gives a value of 144 ft. Since the formation dip in the area is about 2.8° the vertical distance to the GOC is 7 ft. Hence the GOC in the lower Stairway is at approximately -2400 ft. MSL.

The results of the Horner analysis on the build-up is shown in Table 3. This shows that average permeability over the 64 ft. of perforations is 3 md. It also shows high skin factors which are markedly rate dependent. Projecting these skins back to zero rate shows that there is no real formation damage in the well but the high apparent skins present are probably due to the liquid build-up around the well. The liquid would come from the nearby oil column and would also be dropping out of the gas, as the pressure is drawn down.

This high pseudoskin that exists at maximum flowrates does prevent the well from producing at higher rates.

The damage ratios of 7-9 that are a result of the apparent skin mean that if the skin could be removed the potential flowrate for the well is 6-7 MMCF/D. However since it is not a real skin conventional well stimulation techniques will not appreciably affect the flowrates. Even if the sands are acidized

or fractured or the perforation shot density is increased one would still be left with liquid dropping out of the gas and impeding the flow to the well bore.

NOMENCLATURE

C_t = total compressibility, psi^{-1}

DR = damage ratio

h = net sand thickness, ft

k = permeability md

L = distance to flow barrier in reservoir, ft.

m = slope of p^2 versus Horner time function plot in psi^2/cycle

p = pressure in bottom of hole, psia

p_{wf} = bottom hole flowing pressure, psia

p* = extrapolated build-up pressure, psia

p_{1hr} = pressure at 1 hour point on semi log straight line of build-up

Q_g = gas flow rate, MCF/D

Q_o = oil flow rate, STB/D

r_w = radius of wellbore, ft.

s = skin factor

T = Fluid Temperature, °R

t_p = total production time, hrs

Δt = build-up time, hours

z = real gas law deviation factor

μ = viscosity, cp

ϕ = formation porosity

APPENDIX 1

Equations used in the Analysis :

Horner Analysis of Gas Wells

$$k = \frac{1637 Q \mu z T}{mh}$$

$$s = 1.1513 \left[\frac{p^2_{1hr} - p^2_{wf}}{m} - \log \left(\frac{k}{\phi \mu c_t r^2_w} \right) + 3.23 \right]$$

$$DR = \frac{p^{*2} - p^2_{wf}}{p^{*2} - p^2_{wf} - 0.868ms}$$

Gray's equation for distance to flow Barrier.

$$L = \frac{0.0002637 t_p k}{4 \phi \mu c_t \left[t_D r^2_w / 2L \right]}$$

APPENDIX 2

Calculation of Absolute Open Flow Potential

The drawdown data for the four tests is as follows :

Test No.	$\bar{p}$ psia	p_{wf} psia	Q_g MCF/D	$\log (\bar{p}^2 - p_{wf}^2)$
1	2117.62	507.1	814.9	6.62605
2	2109.69	1819.0	437.9	6.05768
3	2097.26	664.58	750.4	6.59735
4	2090.46	509.17	781.0	6.61392

Assuming a productivity relationship given by; $Q = J (\bar{p}^2 - p_{wf}^2)^n$

A plot of log Q V log $(\bar{p}^2 - p_{wf}^2)$ will give a value for n and J. This plot is shown in Figure 12 and gives; n = 0.4533 ; J = 0.7822 MCF/D $psia^{2n}$.

This productivity relationship gives an AOF of 810.5 MCF/D. Note that this figure is lower than the flowrate achieved in test 1, but is consistent with the flowrate and drawdown achieved in test 4.

This dichotomy is a reflection of the rate dependent pseudoskin associated with the well.

TABLE 2

WELL TEST SUMMARY DATA SHEET FOR EM 10

TEST NO.	DATE	INTERVAL TESTED		SAND NAME	RECORDER DEPTH FT. KB	WELL ELEVATION	RECORDER SUB SEA DEPTH	
		TOP	BOTTOM				FT. MSL	CHOKE SIZE INS
1	11/8/84	4618	4682	L. STAIR	4600	2291	-2309	18/64
2	17/8/84	4618	4682	L. STAIR	4600	2291	-2309	10/64
3	18/8/84	4618	4682	L. STAIR	4600	2291	-2309	14/64
4	19/8/84	4618	4682	L. STAIR	4600	2291	-2309	18/64

TABLE 3

WELL TEST RESULTS FOR EM 10

TEST NO.	SEMI LOG SLOPE m psi^2/cycle $X10^{-6}$	NET SAND h ft.	OIL RATE Q_o STB/D	GAS RATE Q_g MCF/D	PERMEABILITY k md	SKIN FACTOR S	DAMAGE RATIO	EXTRAPOLATED PRESSURE p* psia
1	0.05091	64	15	814.9	3.1	84.7	7.76	2134.33
2	0.027	64	-	437.9	3.15	38.1	4.44	2112.20
3	0.080733	64	3	750.4	1.8	48.6	6.83	2105.03
4	0.0417	64	11.8	781.0	3.63	104.3	9.28	2119.0

FIG. 1

PRESSURE vs TIME - (LINEAR)

COMPANY : OILMIN N.L.
WELL : EAST MEREENIE #10
Comments : #1 Flow test (Draw down 18/64

Eq. Type
Gauge No

From : 09:00:56 11/08/84
To : 09:00:20 14/08/84

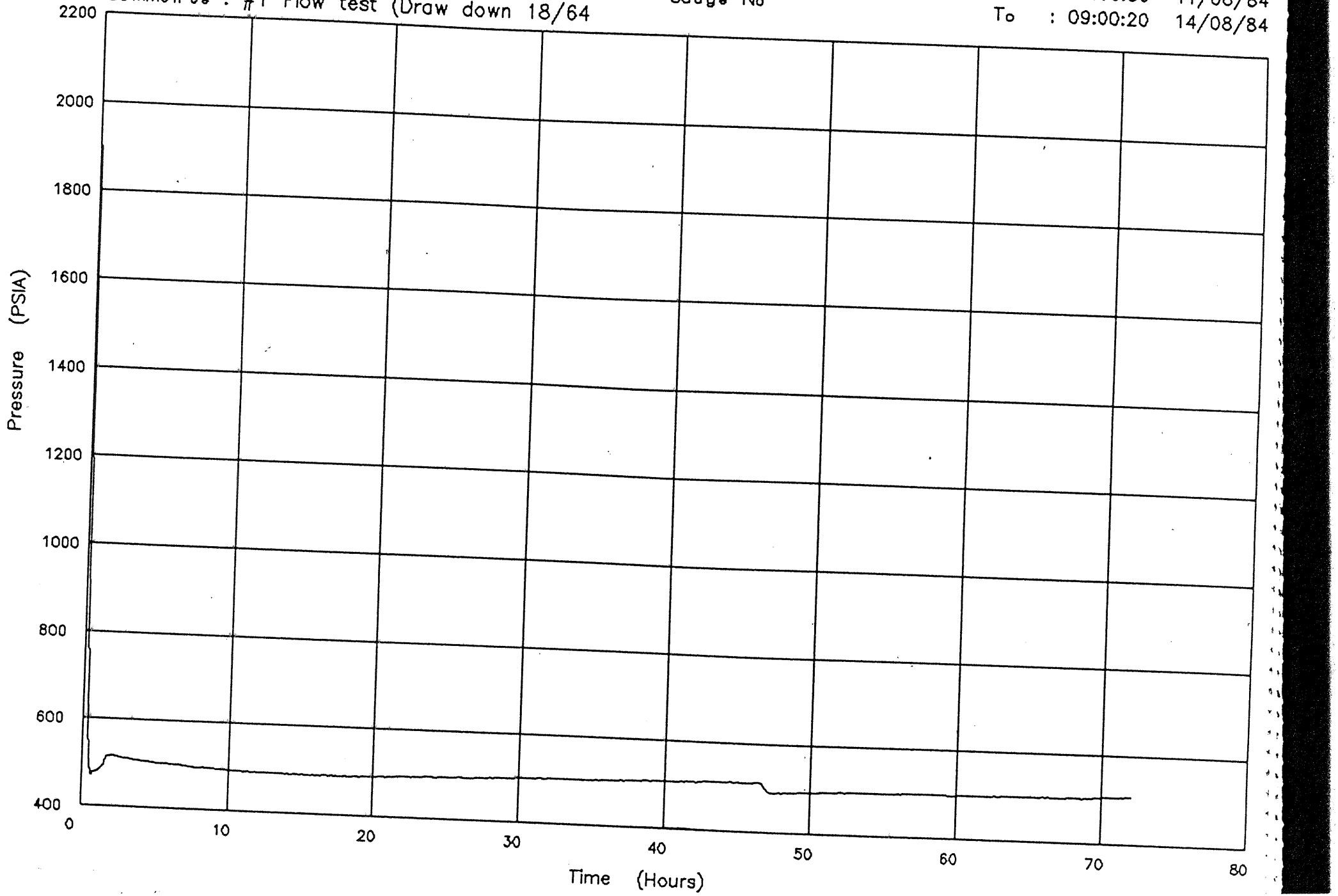
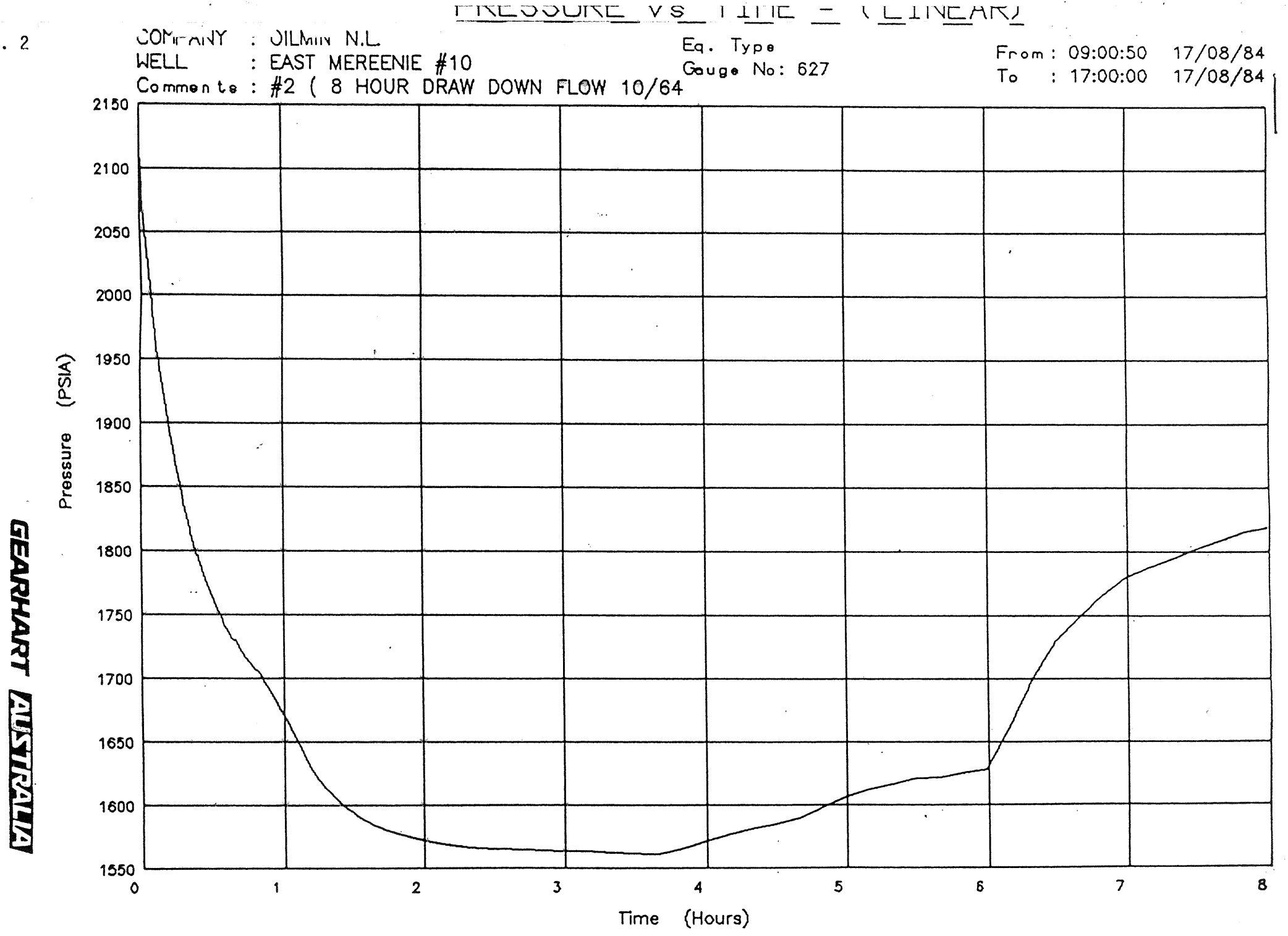


FIG. 2



GEARHART AUSTRALIA

FIG. 3

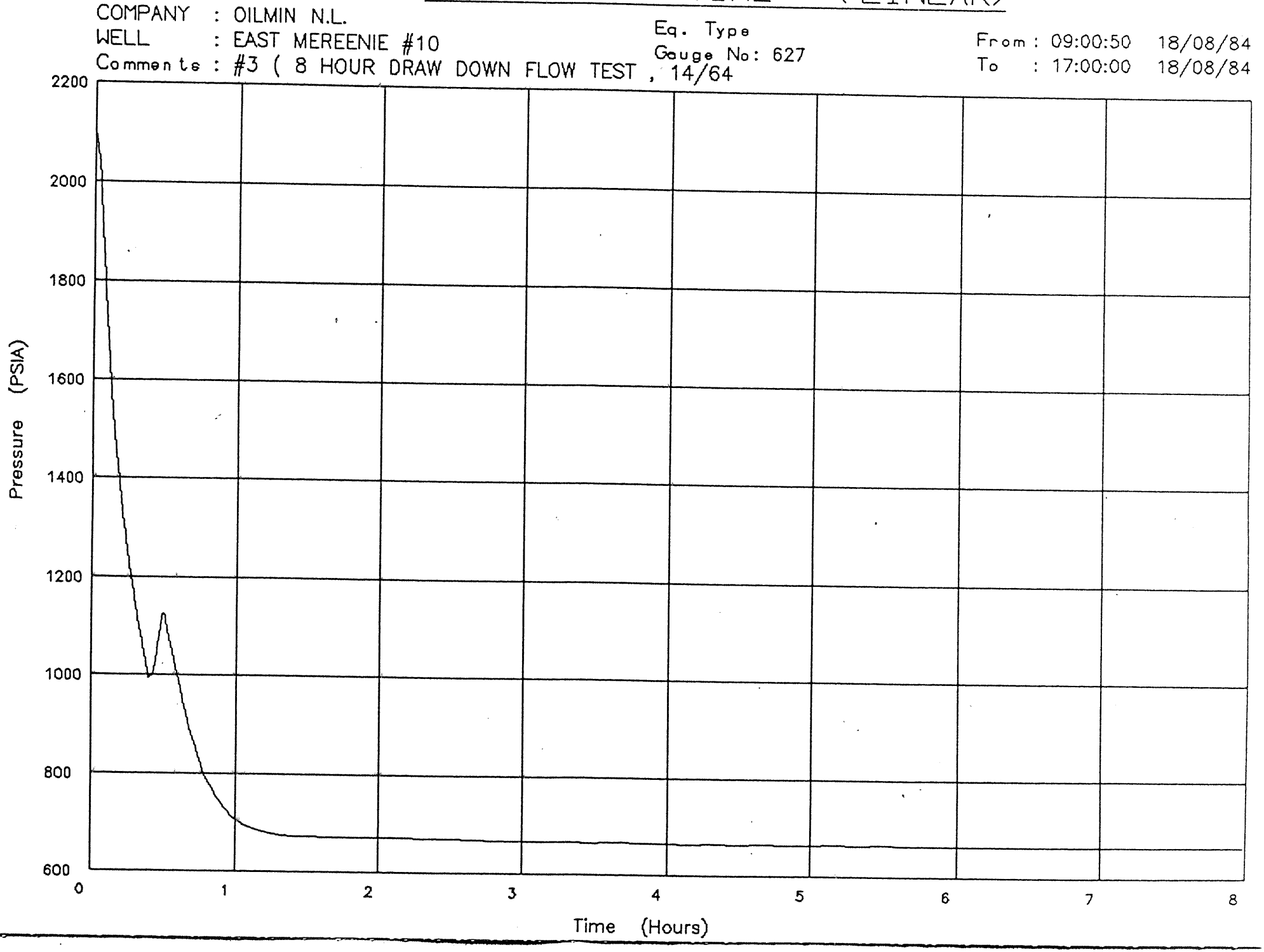

PRESSURE vs TIME - (LINEAR)
COMPANY : OILMIN N.L.
WELL : EAST MEREENIE #10
Comments : #3 (8 HOUR DRAW DOWN FLOW TEST , 14/64
Eq. Type
Gauge No: 627
From : 09:00:50 18/08/84
To : 17:00:00 18/08/84
Pressure (PSIA)
2200
2000
1800
1600
1400
1200
1000
800
600
0
1
2
3
4
5
6
7
8
Time (Hours)

FIG. 4

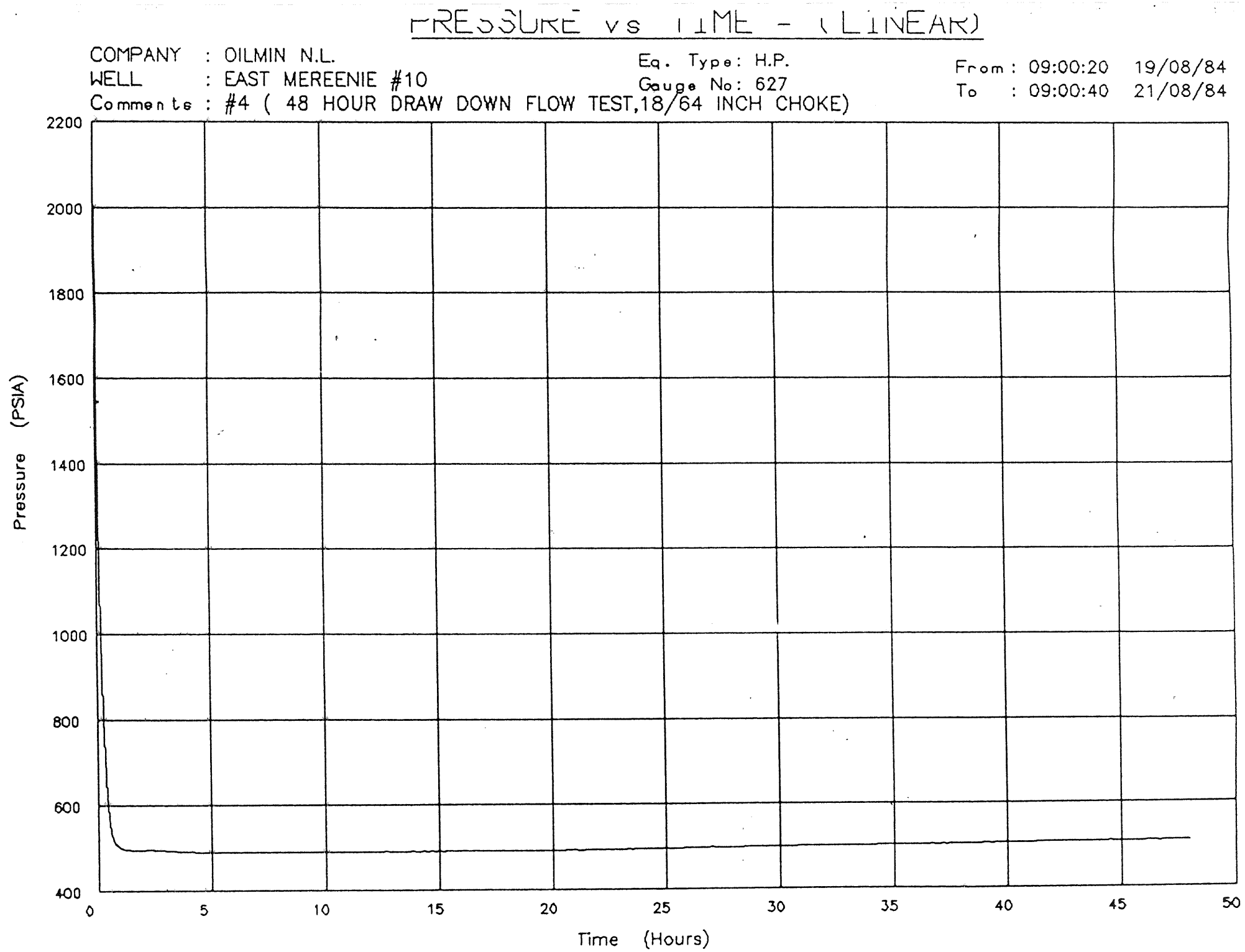

PRESSURE vs TIME - (LINEAR)
COMPANY : OILMIN N.L.
WELL : EAST MEREENIE #10
Comments : #4 (48 HOUR DRAW DOWN FLOW TEST,18/64 INCH CHOKE)
Eq. Type: H.P.
Gauge No: 627
From : 09:00:20 19/08/84
To : 09:00:40 21/08/84
Pressure (PSIA)
2200
2000
1800
1600
1400
1200
1000
800
600
400
0
5
10
15
20
25
30
35
40
45
50
Time (Hours)

FIG. 5

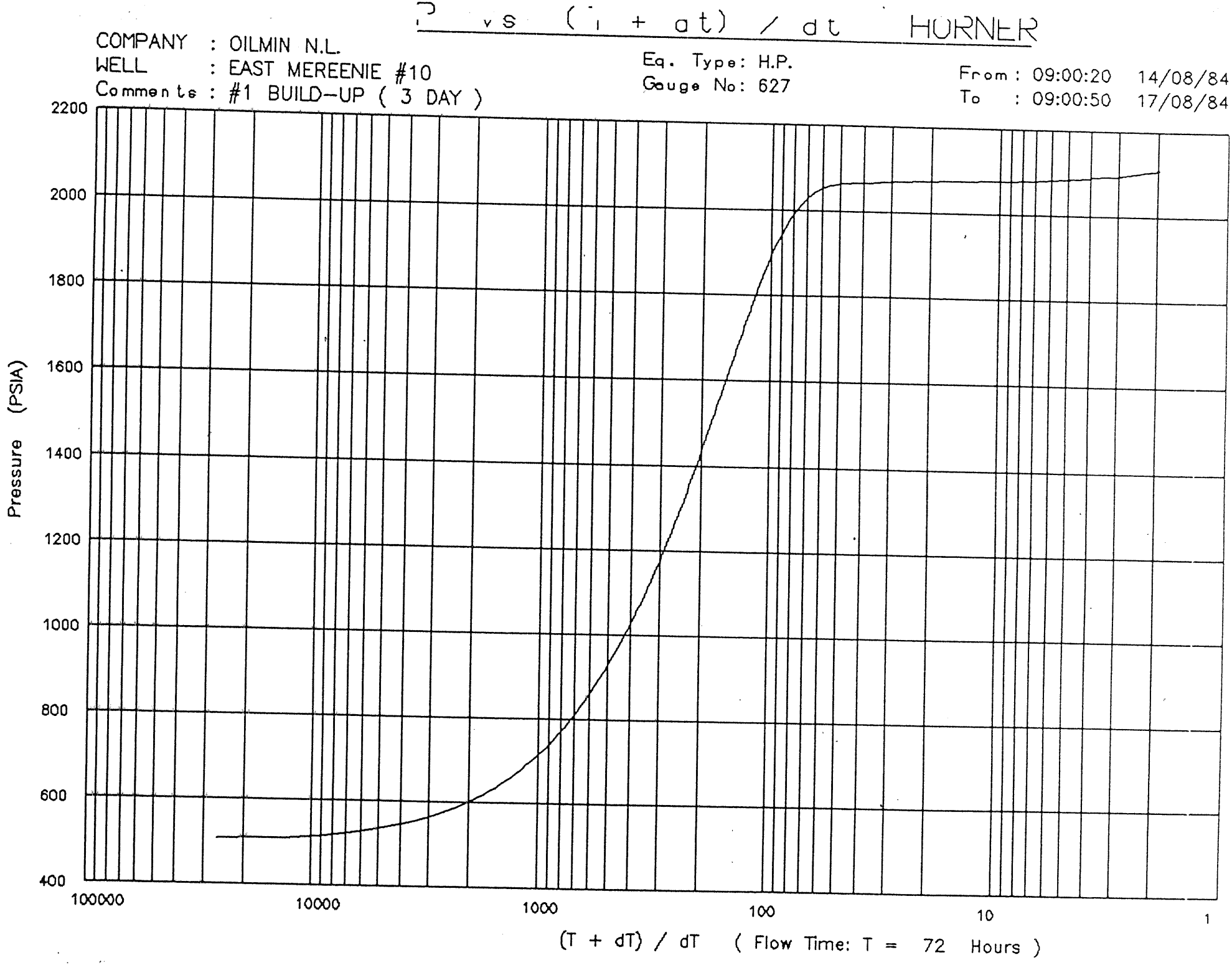

P vs (T + dT) / dt HORNER
COMPANY : OILMIN N.L.
WELL : EAST MEREENIE #10
Comments : #1 BUILD-UP (3 DAY)
Eq. Type: H.P.
Gauge No: 627
From : 09:00:20 14/08/84
To : 09:00:50 17/08/84
Pressure (PSIA)
2200
2000
1800
1600
1400
1200
1000
800
600
400
100000
10000
1000
100
10
1
(T + dT) / dT (Flow Time: T = 72 Hours)

FIG. 6

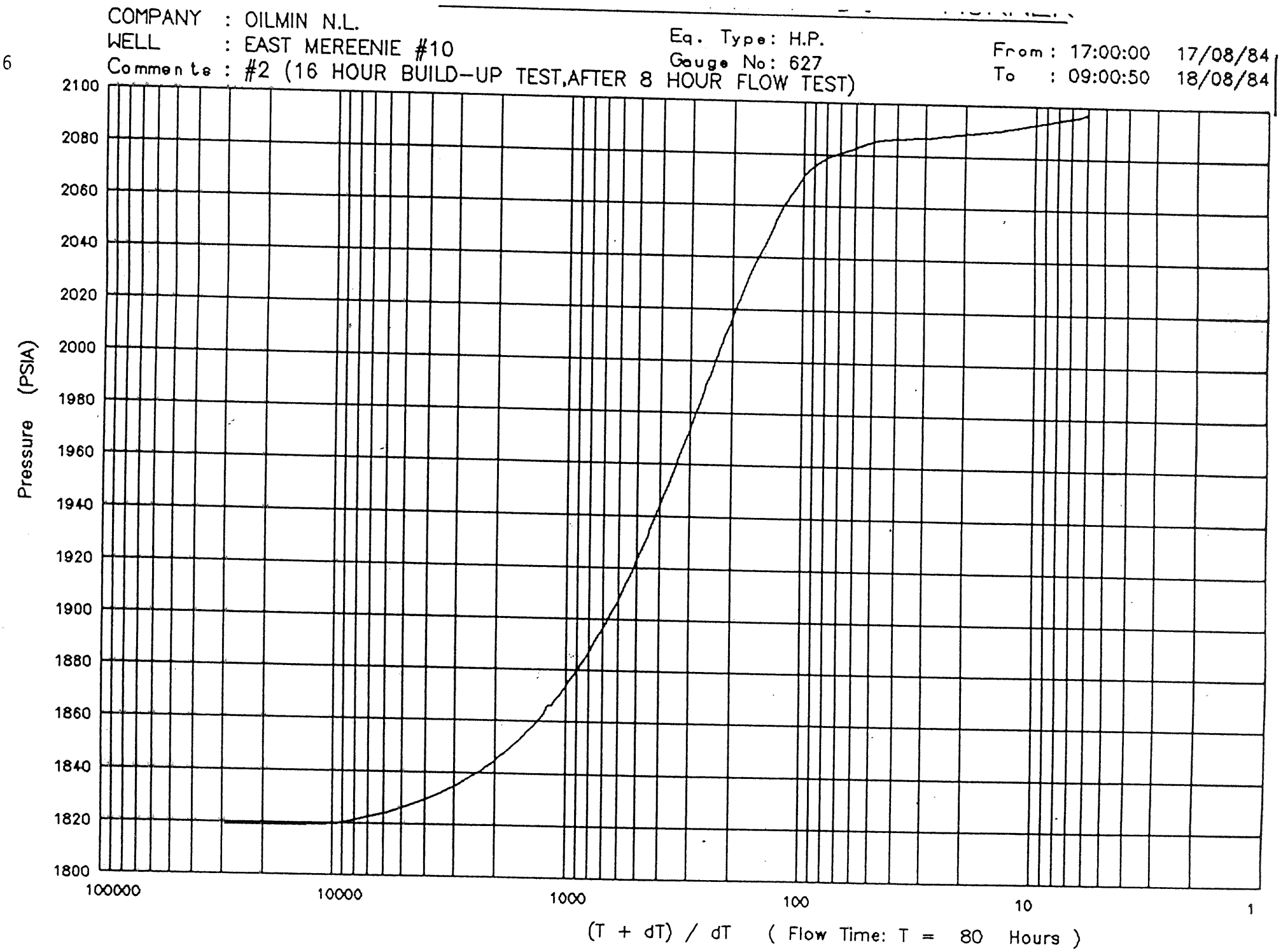

COMPANY : OILMIN N.L.
WELL : EAST MEREENIE #10
Comments : #2 (16 HOUR BUILD-UP TEST,AFTER 8 HOUR FLOW TEST)
Eq. Type: H.P.
Gauge No: 627
From : 17:00:00 17/08/84
To : 09:00:50 18/08/84
Pressure (PSIA)
2100
2080
2060
2040
2020
2000
1980
1960
1940
1920
1900
1880
1860
1840
1820
1800
100000
10000
1000
100
10
1
(T + dT) / dT (Flow Time: T = 80 Hours)

FIG. 7

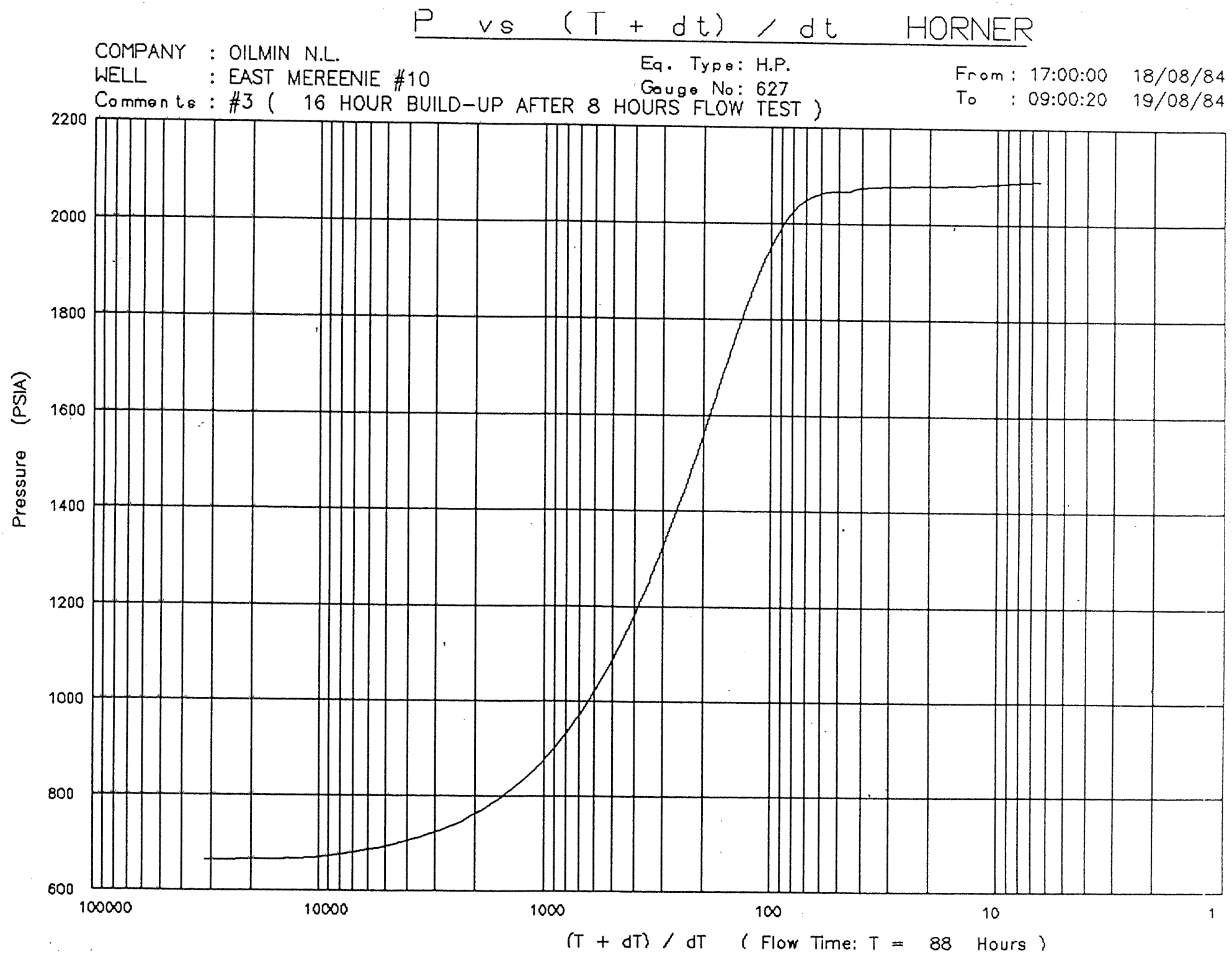
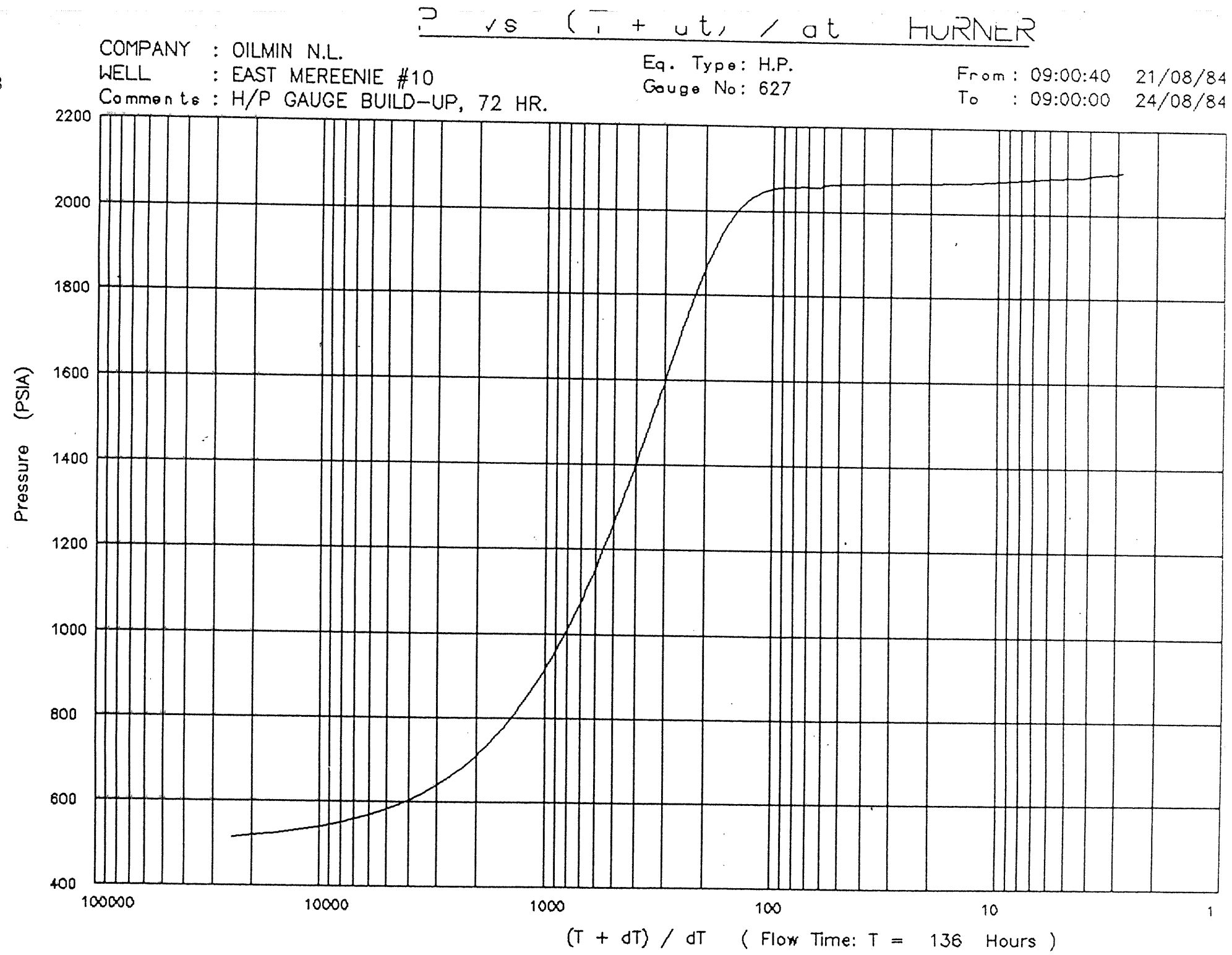

P vs (T + dt) / dt HORNER
COMPANY : OILMIN N.L.
WELL : EAST MEREENIE #10
Comments : #3 (16 HOUR BUILD-UP AFTER 8 HOURS FLOW TEST)
Eq. Type: H.P.
Gauge No: 627
From : 17:00:00 18/08/84
To : 09:00:20 19/08/84
Pressure (PSIA)
2200
2000
1800
1600
1400
1200
1000
800
600
100000
10000
1000
100
10
1
(T + dT) / dT (Flow Time: T = 88 Hours)

FIG. 8


P vs (T + ut) / at HORNER
COMPANY : OILMIN N.L.
WELL : EAST MEREENIE #10
Comments : H/P GAUGE BUILD-UP, 72 HR.
Eq. Type: H.P.
Gauge No: 627
From : 09:00:40 21/08/84
To : 09:00:00 24/08/84
Pressure (PSIA)
2200
2000
1800
1600
1400
1200
1000
800
600
400
100000
10000
1000
100
10
1
(T + dT) / dT (Flow Time: T = 136 Hours)

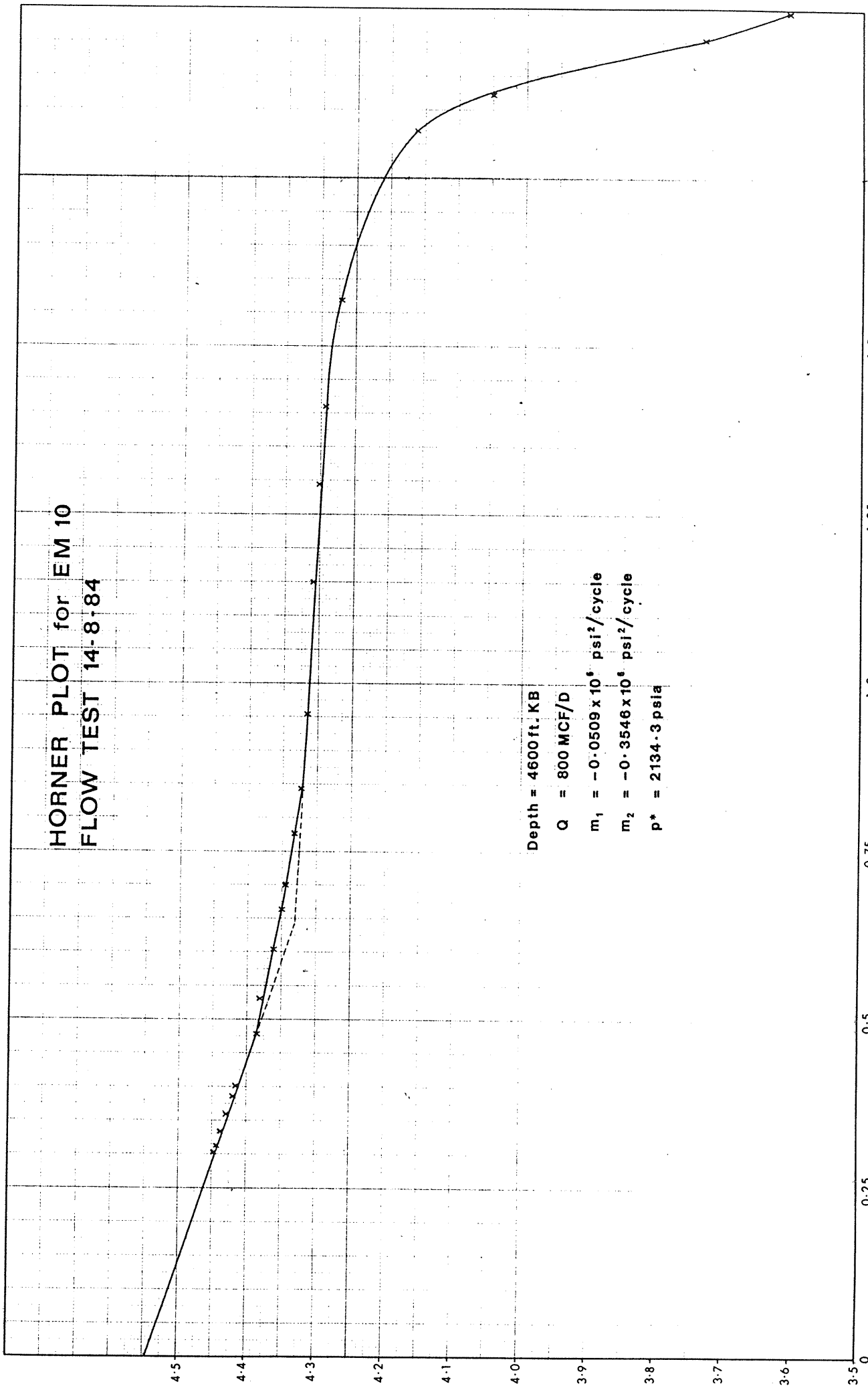

HORNER PLOT for EM 10
FLOW TEST 14-8-84
Depth = 4600ft. KB
Q = 800 MCF/D
m_1 = −0·0509 x 10^6 psi²/cycle
m_2 = −0·3546 x 10^6 psi²/cycle
p* = 2134·3 psia
$p^2 \times 10^{-6}$ (psia²)
$\log\left(\frac{t_p+\Delta t}{\Delta t}\right)$

Fig 9

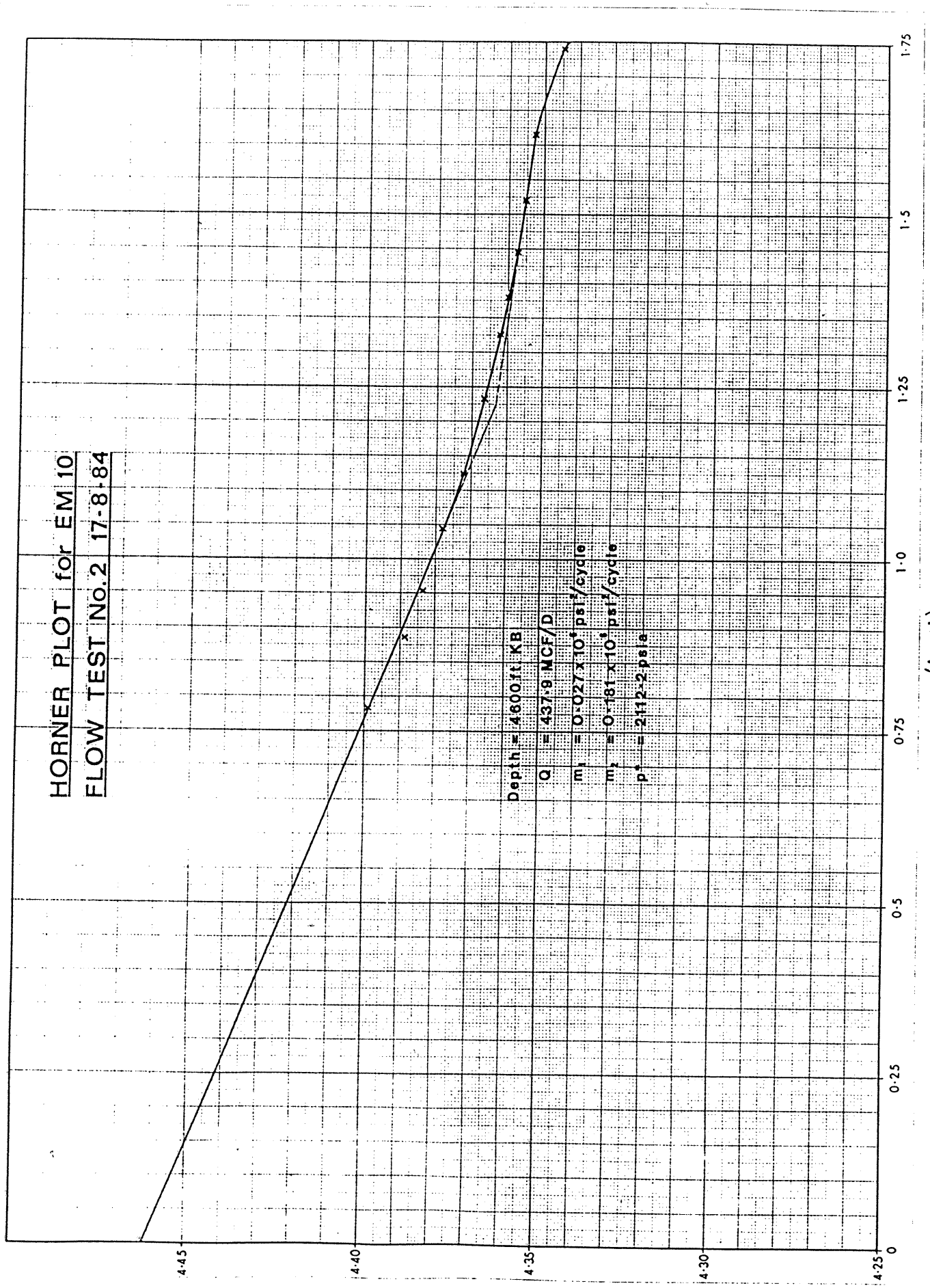

HORNER PLOT for EM 10
FLOW TEST No.2 17-8-84
Depth = 4600 ft. KB
Q = 437·9 MCF/D
m1 = 0·027 x 10⁻⁶ psi²/cycle
m2 = 0·181 x 10⁻⁶ psi²/cycle
p* = 2112·2 psia
p² x 10⁻⁶ (psia²)
4·45
4·40
4·35
4·30
4·25
0
0·25
0·5
0·75
1·0
1·25
1·5
1·75
log ((tp+Δt)/Δt)

FIG 10

FIG. 11

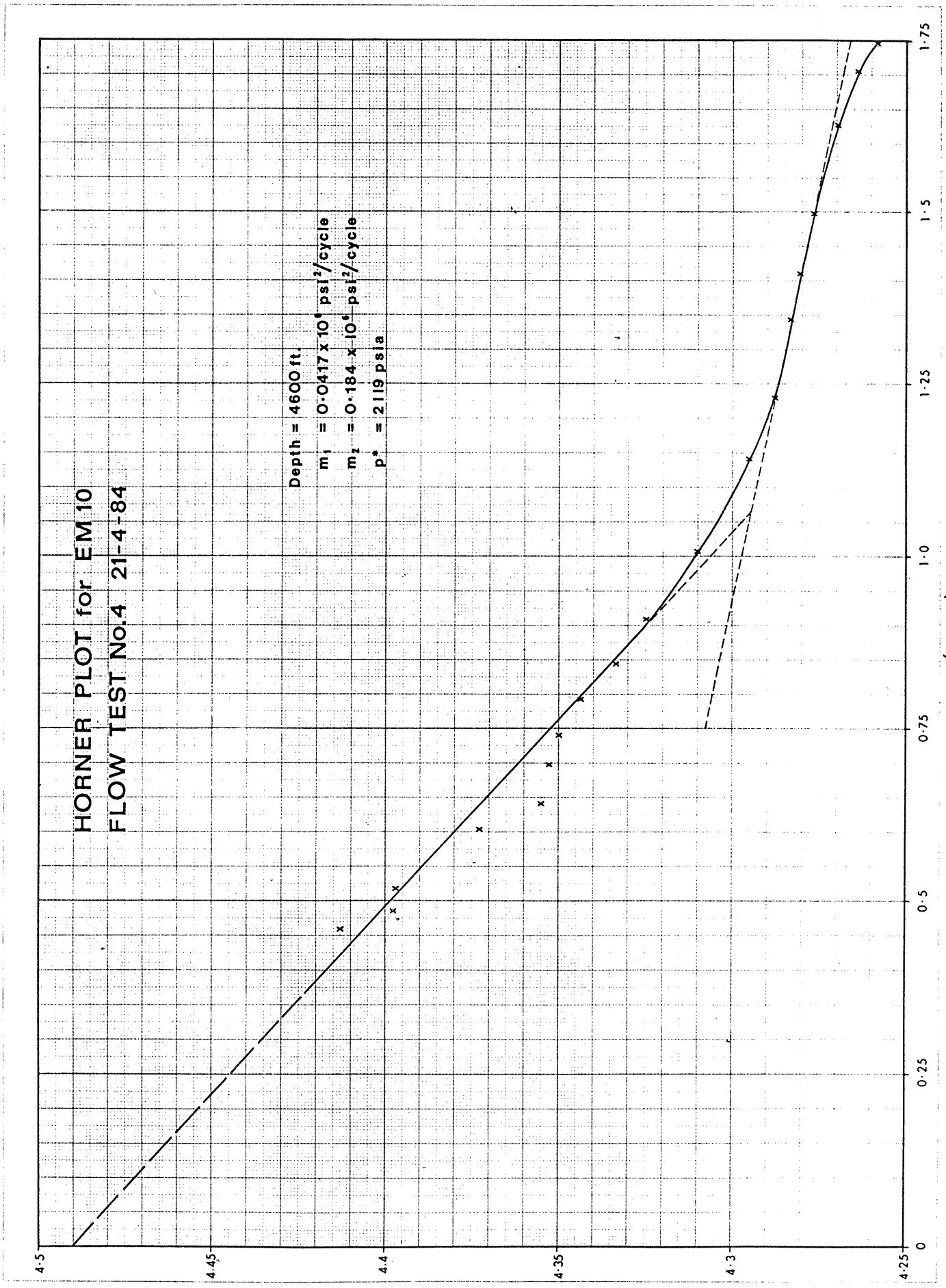
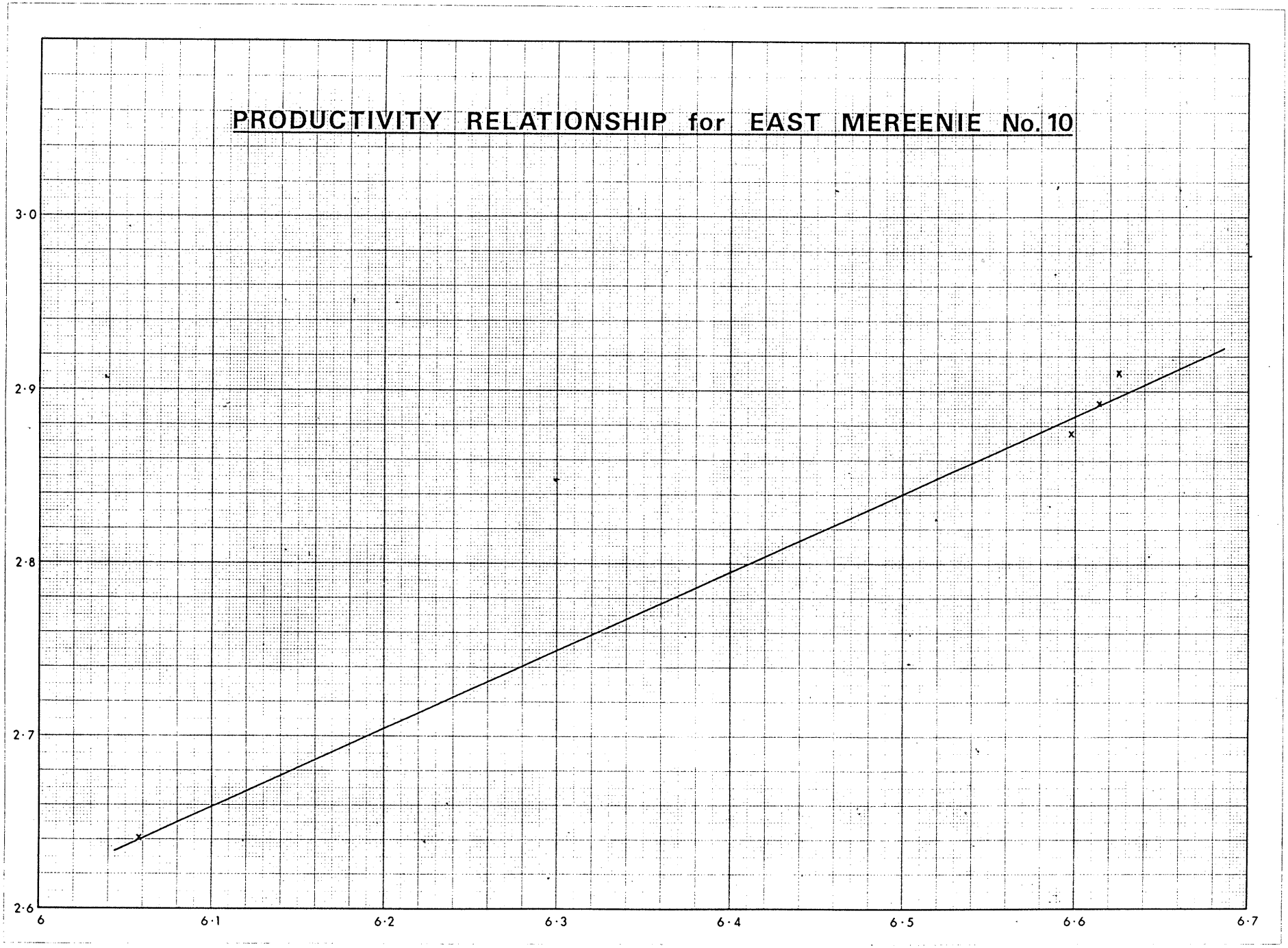

HORNER PLOT for EM 10
FLOW TEST No.4 21-4-84
Depth = 4600 ft.
m1 = 0·0417 x 10⁶ psi²/cycle
m2 = 0·184 x 10⁶ psi²/cycle
p* = 2119 psia
p² (psia²)
log ((tp+Δt)/Δt)
4·5
4·45
4·4
4·35
4·3
4·25
0
0·25
0·5
0·75
1·0
1·25
1·5
1·75

FIG. 12


PRODUCTIVITY RELATIONSHIP for EAST MEREENIE No. 10
log (Q_g, MCF/D)
3·0
2·9
2·8
2·7
2·6
6
6·1
6·2
6·3
6·4
6·5
6·6
6·7
log ($(\bar{p}^2 - p_{wf}^2)$, psia^2)