FIELD EXPERIENCE USING CORIOLIS MASS METERS - 1

by

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FIELD EXPERIENCE USING CORIOLIS METERS

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INTRODUCTION

During the autumn of 1985 Brooks Instruments held an exhibition at an hotel in Aberdeen to demonstrate the range of equipment they produce. On show at the exhibition was the Micromotion mass flow meter, which operates on the Coriolis principle. As an engineer who spends his life having to design orifice and turbine meters into difficult locations the virtual lack of flow conditioning prior to the meter seemed too good to be true. At the time we identified the following potential advantages of the meter over its more established rival types:

1 Relative ease of installation resulting from apparent lack of flow conditioning requirements.

2 Low maintenance costs and hence low "real" cost of ownership.

3 The potential for use on new developments , particularly offshore satellite developments, where additional savings are of obvious importance.

Following an initial appraisal of the meter it was decided to approach the Department of Energy to investigate their acceptance of the meter for Fiscal service. A D150 meter, rated at ANSI 1500, was procured for trial on the Claymore condensate system.

PRE-INSTALLATION WORK

In view of the declared intention to have a meter of this type adopted for Fiscal duty it was decided to check the manufacturers calibration at SIRA before the field test began. This calibration check was carried out during early May 1986.

The meter was tested in the SIRA No2 flow laboratory. The flowmeter was mounted in a straight, horizontal pipeline of 1.5 inch nominal bore, with an upstream straight length of 15D. The Mass was determined by weighing under static conditions, using a gyroscopic force measurement system. A mass of fluid was diverted into a weightank in a measured time. The mass of fluid was corrected for air buoyancy, following which the mass flowrate was calculated.

The flow meter was initially tested on kerosene at 30 ^{o}Celcius, the test was then repeated using a gas oil as the test fluid at 30 ^{o}Celcius. Throughout the test the temperature was maintained to within 0.2 ^{o}Celcius of setpoint.

The fluid densities were determined using a digital density meter operating on the vibrating tube principle. Fluid viscosities were measured using suspended level viscometers, in accordance with BS 188:1977.

All equipment used during the tests was traceable to UK national standards. The flow measurement uncertainty was estimated to be +/- 0.2% of the true conventional value(95% confidence level)

A schematic of the test loop is shown in figure 1.

SIRA Test results

The densities and viscosities of the two test fluids at 30^{o}Celcius were as follows:

KEROSENE	790.9 Kg/m^3	1.41 cSt
GAS OIL	837.9 Kg/m^3	4.81 cSt

The tabulated results of the tests on Kerosene an Gas Oil are given in figures 2 and 3 respectively. A plot of the results is given in figure 4.

The test results indicated that the meter performed within the manufacturers stated accuracy of +/- 0.4 percent.

INSTALLATION

Following the completion of the work at SIRA the meter was then shipped offshore to Claymore for installation on the condensate system, downstream of the existing Fiscal orifice meter run. The meter was installed in the line in June 1986 however, due to the extremely heavy workload with the Scapa development, the meter was not commissioned until early April 1987.

It was realised that the physical installation of the meter was far from perfect. However, this would test the ability of the meter to cope with a lack of flow conditioning. In an effort to eliminate any later criticism of the installation from the manufacturer, representatives of Brooks were invited to visit Claymore and approve the installation for themselves. No strong objections were received following the visit and the test belatedly began on the 1^{st} May 1987. The meter is shown in figure 5 with the installation given in figure 6 and 7.

During the test, the meter was zeroed once and no further adjustments or replacements were made to either the meter or electronics.

FIELD TEST RESULTS

It was decided that the only way to test the meter was to record the daily total registered on both the orifice and the Coriolis meter totalisers. The totals on the orifice meter were taken automatically at midnight by the platform metering supervisory computer whilst the Coriolis meter total was recorded manually at midnight. This is not believed to have affected the results of the test by any significant amount.

Figures 9 and 10 show the variation in the Coriolis meter readings in relation to the orifice measurement. It is important to point out that the error, although depicted as being in the Coriolis meter, may just as likely be in the orifice meter. The comparative test was run at the conditions that prevailed on the platform at the time, no variation of the process conditions other than those required to operate the plant were possible. The relatively large negative peak which occurred in mid August was related to a period of unstable plant operation although, the actual cause of error has not been fully identified. It is very interesting to note that, when comparing the above plot with the plot of measured density the significant positive peaks coincide with positive changes in density. This may well be a function of the flow in the densitometer bypass loop associated with the orifice installation. A comparison of the mass and density plots is shown in figure 11.

Figures 12 and 13 indicate the process conditions throughout the test period.

The plant vibration was measured in the vicinity of the meter to see what vibration was present as the meter was located in the main compressor module. The results of these tests are shown in figure 8. The meter does not appear to be effected by the plant vibration, which was typical of an offshore installation with heavy rotating machinery in the close vicinity.

POST-INSTALLATION WORK

The meter was removed from the condensate system on 1st April 1988. It was then decided to close the evaluation test with a further calibration check, now almost two years since the original test at SIRA. The manufacturer offered to calibrate the meter at their plant in Holland. The tests were carried out at Veenendaal on the 9-10 June 1988, with representatives of the Department of Energy and Occidental in attendance.

The calibration was carried out on water using a load cell to measure the mass. Details of the calibration loop used at Veenendaal are shown on figure 15

On commencement of this calibration the short term repeatability of the meter was extremely poor. The test was halted and a detailed inspection was carried out during which it was discovered the earth connection to the sensor had been severed inside the flexible conduit connection. This damage had been suffered in transit due to the position of entry gland in relation to the lid of the box.

Once the above problem has been corrected the meter again performed within specification, as shown on figure 14.

CONCLUSIONS

The meter tested by Occidental has demonstrated its potential as an accurate, stable and reliable meter suitable for use on Fiscal applications in the future. However, one area which requires further development is the measurement of density within the meter. The accurate measurement of density, together with the mass flow, would allow calculation of volume. Even in a mass measurement multiuser pipeline system the volume of fluids is important as this will always be required for reservoir management and tariffing purposes.

Earlier this year Occidental had selected Coriolis meters to measure the flow of high pressure condensate from the Chanter field. However, due to recent events, this development is under reappraisal. A sketch of the proposed installation arrangement is shown for interest in figure 16. The verification of the meters calibration was to have been carried out off-line with only comparison checks being carried out in service.

ACKNOWLEDGEMENTS

The author would like to thank Union Texas, Texaco Britain, Thomson North Sea, Brooks Instruments and SIRA together with the operations and maintenance staff of Claymore for their assistance during the trials and in the preparation of this paper.

LIST OF FIGURES

SIRA 2500L/MIN HYDROCARBON FLOW FACILITY – SCHEMATIC DIAGRAM

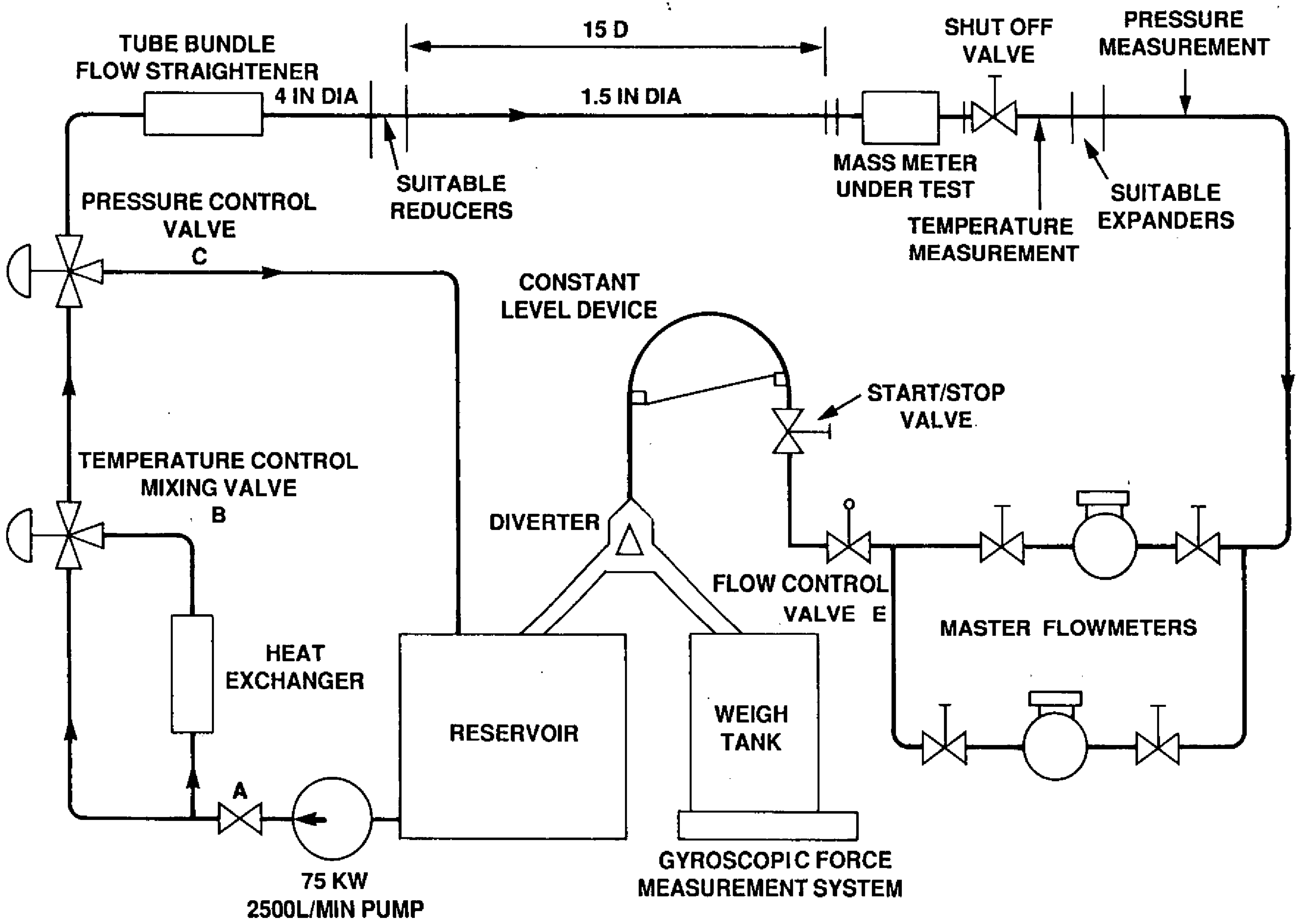

FIGURE 1

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TEST RESULTS
KEROSENE AT 30°C

FLOWRATE t/h	METER FACTOR pulses/t	OUTPUT FREQUENCY Hz
29.38	358999	2930
29.35	359182	2929
29.43	359025	2935
29.42	358756	2931
29.41	358755	2931
27.01	358726	2691
21.04	358087	2093
21.06	358222	2096
24.16	357975	2402
20.54	358176	2044
17.99	358333	1791
24.20	357952	2407
14.81	357764	1472
14.76	358280	1469
14.73	358136	1466
14.83	357980	1475
14.79	358102	1471
11.95	358280	1189
9.000	357561	894
6.003	357525	596
3.090	357867	307
3.083	357663	306
3.083	357997	307
3.079	358003	306
3.083	357488	306

FIGURE 2

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TEST RESULTS
GAS OIL AT 30°C

FLOWRATE t/h	METER FACTOR pulses/t	OUTPUT FREQUENCY Hz
30.51	358309	3037
30.41	357915	3024
30.45	358231	3030
30.00	358036	2983
30.11	357993	2994
27.39	357303	2718
24.13	357223	2394
21.14	356948	2096
11.97	358057	1190
9.071	357570	901
15.31	358083	1523
15.31	357952	1523
15.29	357740	1519
15.28	357263	1516
15.28	358403	1521
15.28	357950	1519
18.35	357144	1820
6.043	358007	601
2.987	357058	296
2.983	356929	296
2.979	357059	295
2.956	357315	295
2.972	356914	295
21.320	356735	2113

FIGURE 3
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MICRO MOTION D150 MASS FLOW METER

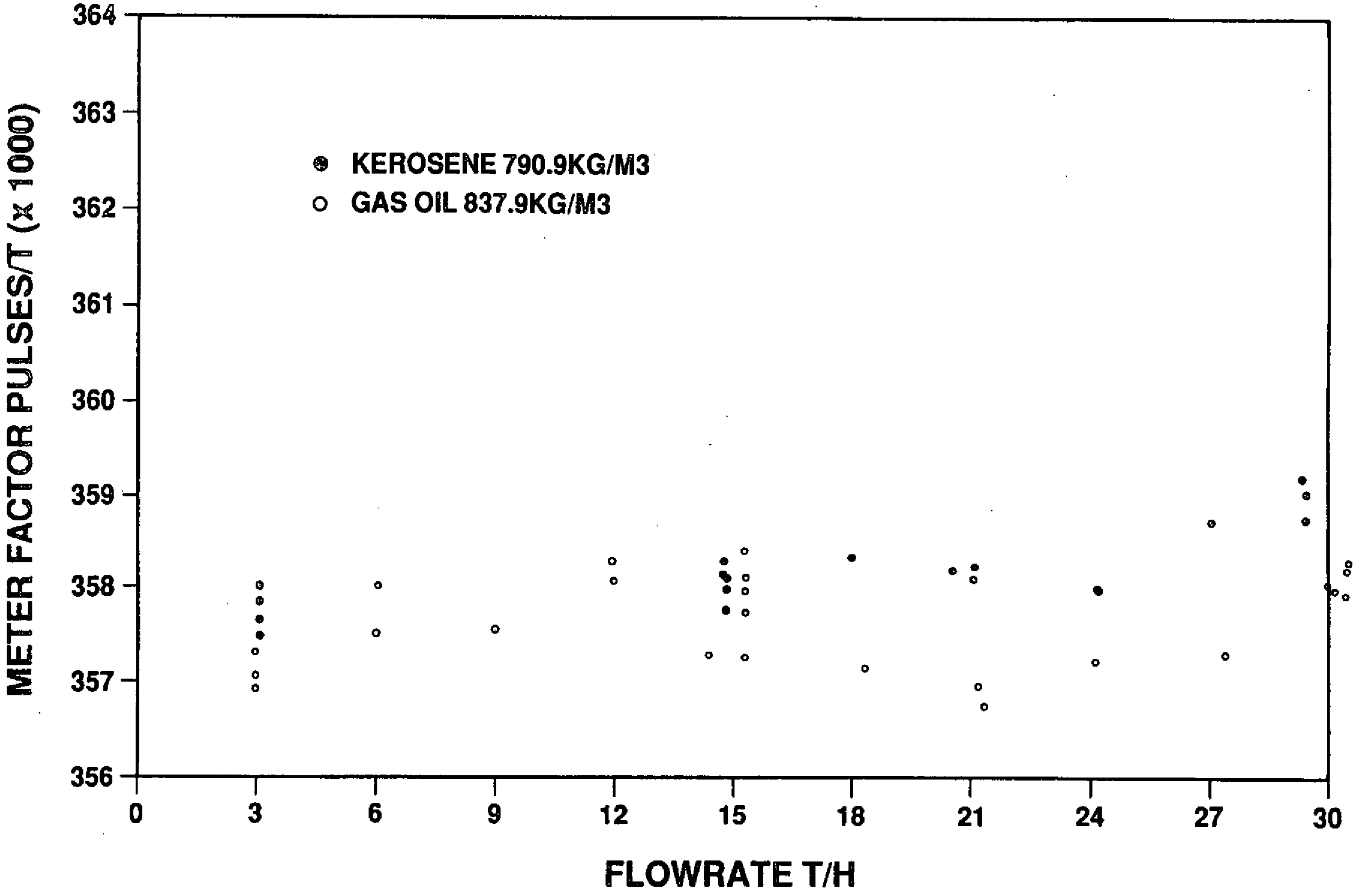

FIGURE 4

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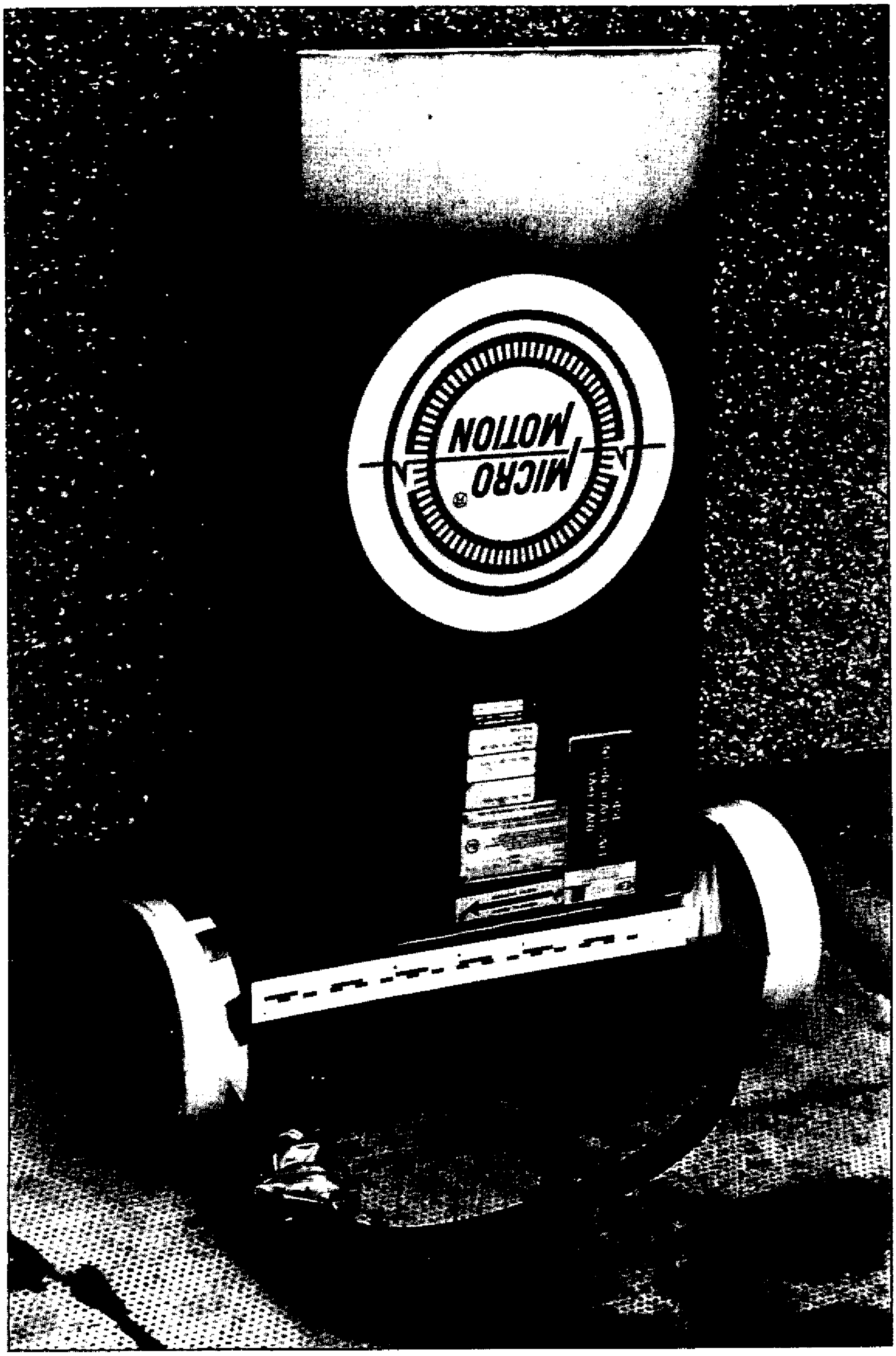


D150 METER
ANSI 1500 PRESSURE RATED

FIGURE 5

CLAYMORE 'A'

PIPEWORK ISOMETRIC FOR CORIOLIS METER INSTALLATION

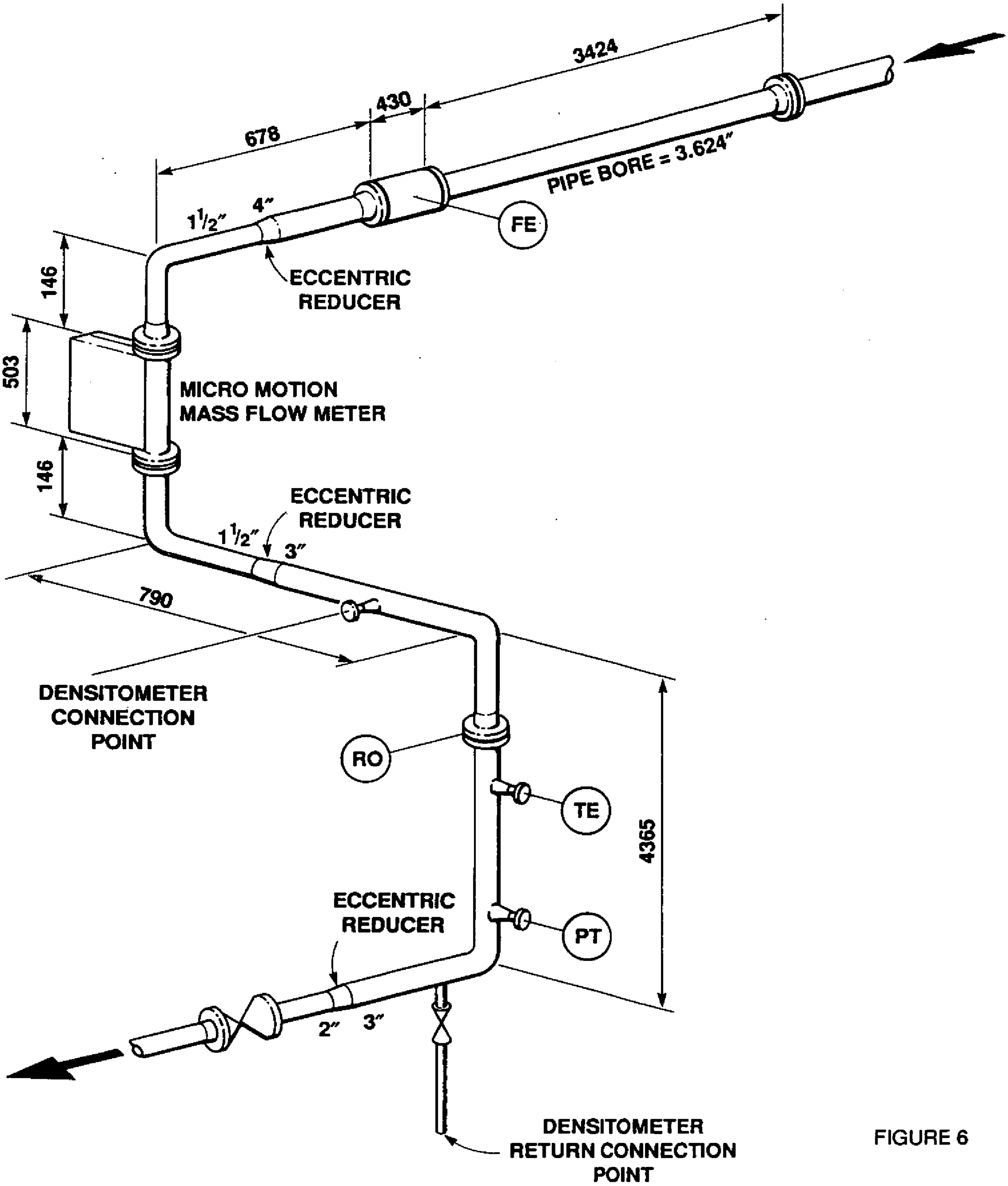
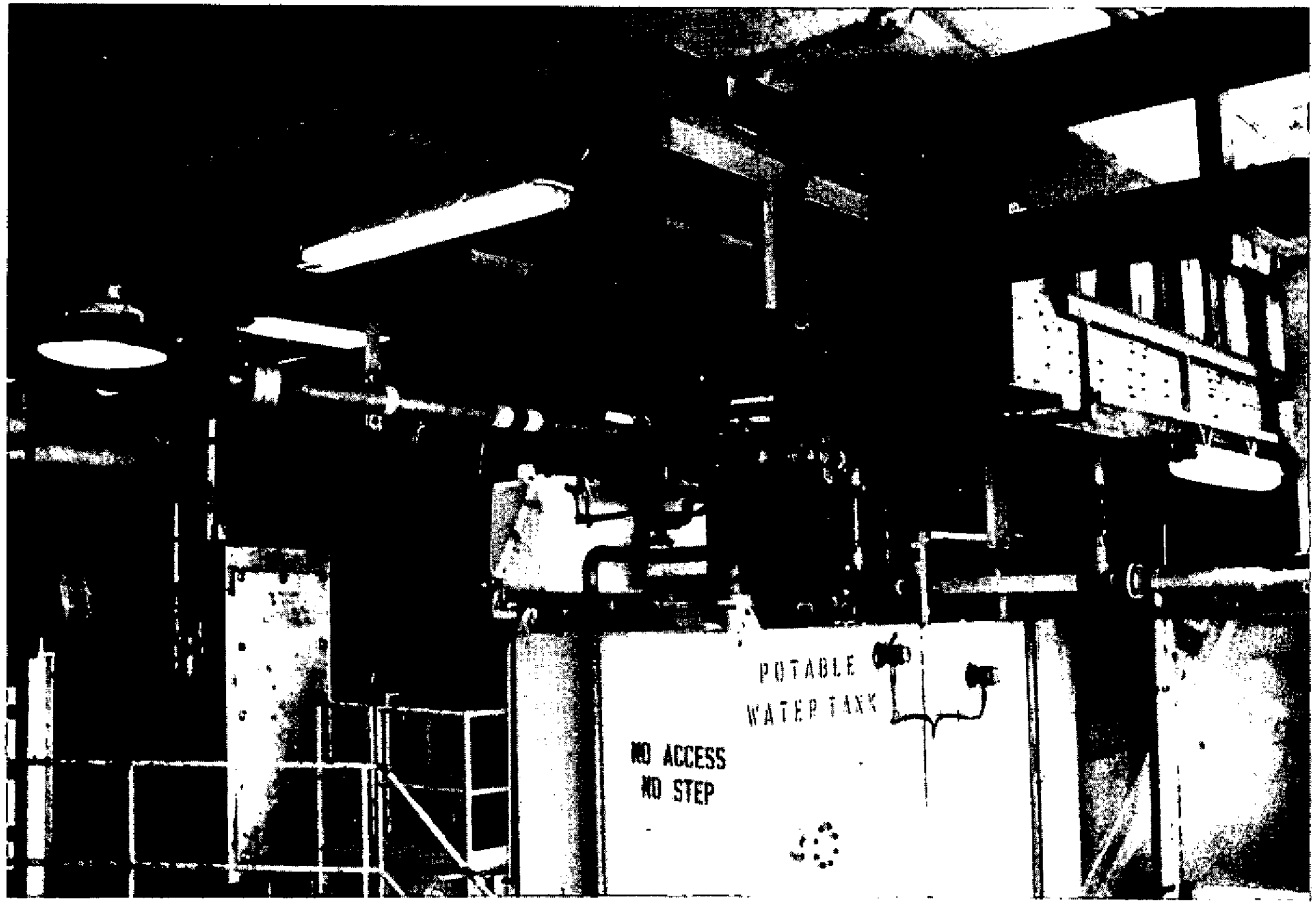
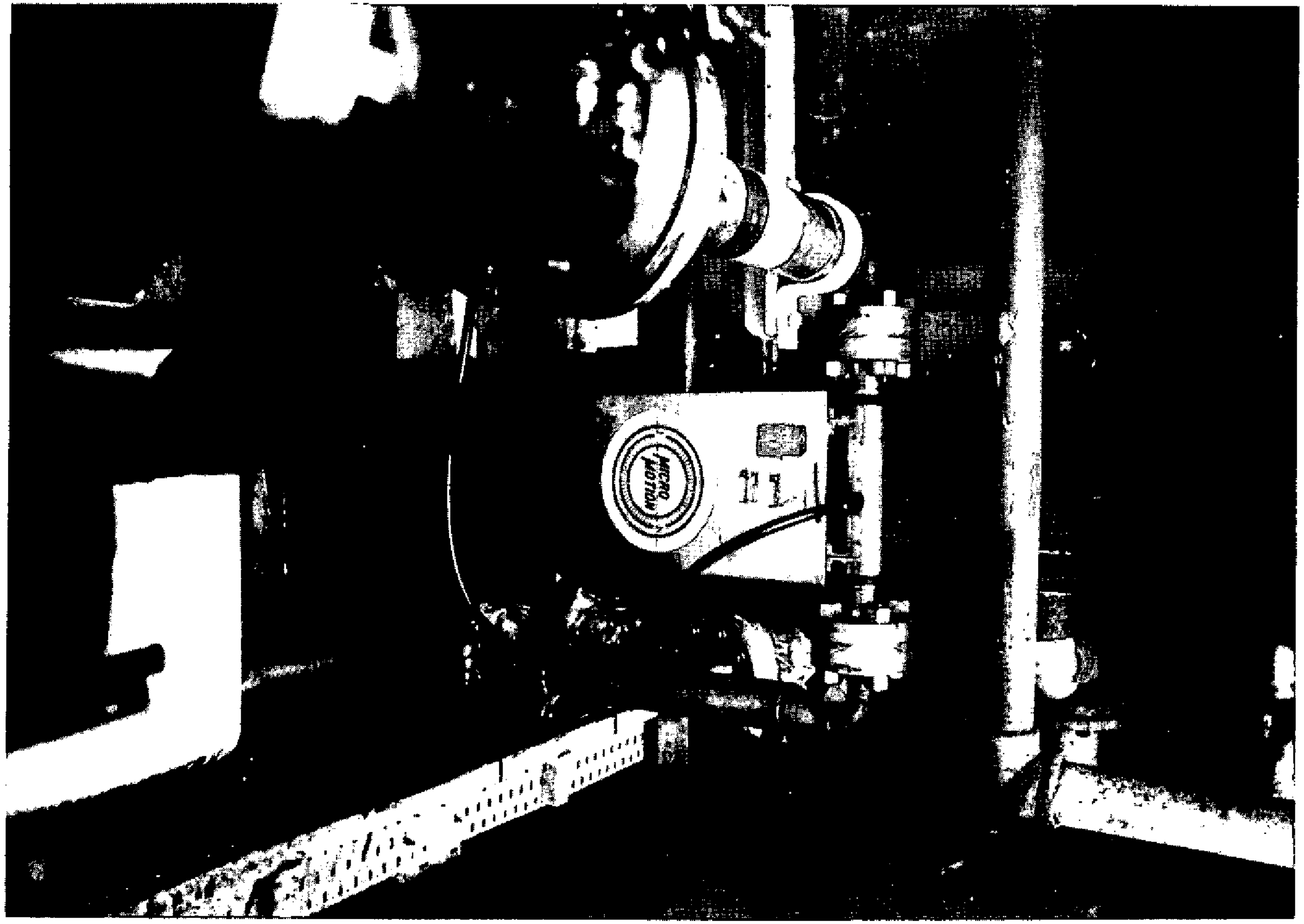


FIGURE 6



CORIOLIS METER INSTALLATION CLAYMORE

FIGURE 7a

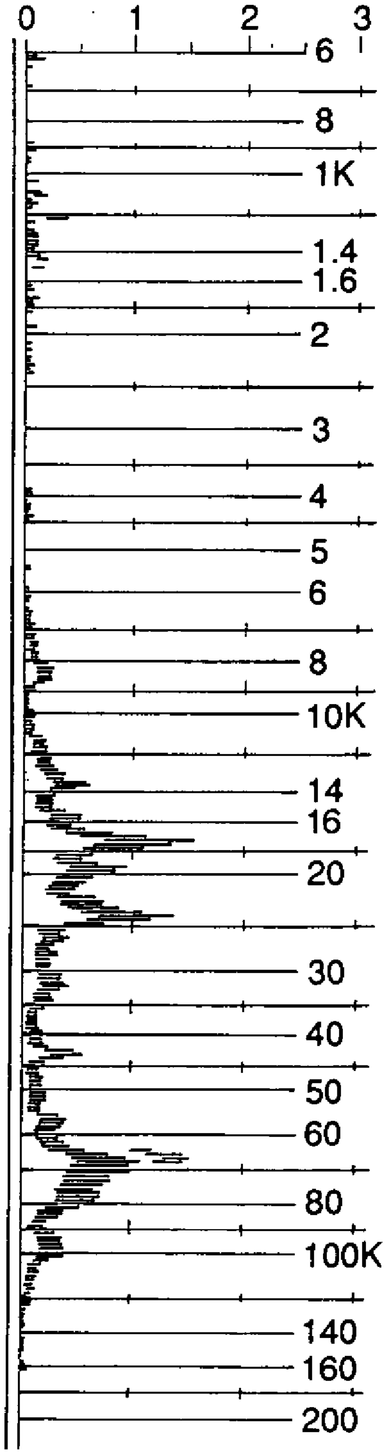


CORIOLIS METER INSTALLATION CLAYMORE

FIGURE 7b

BACKGROUND FREQUENCIES PRESENT ON CLAYMORE MEASURED 1 FOOT FROM OUTLET FLANGE OF CORIOLIS METER

IRD MECHANALYSIS
DATE 19/2/88 OA 4
MACH
POSIT A2 OUTLET IFT
COND
MM/SEC PK 5%BW



INSTRUMENT POWER OFF

IRD MECHANALYSIS
DATE 19/2/88 OA 4
MACH
POSIT A2 OUTLET IFT
COND
MM/SEC PK 5% BW

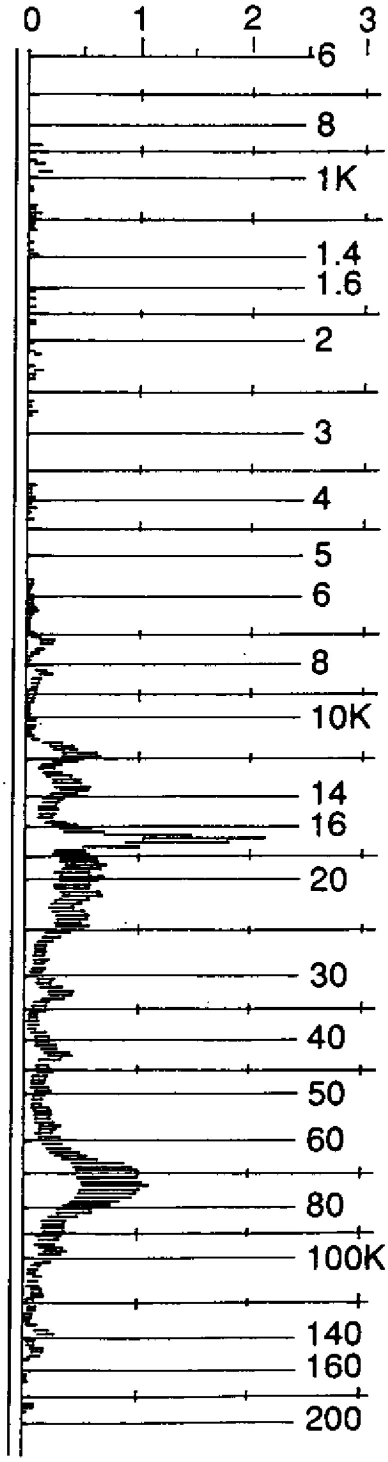


FIGURE 8

CLAYMORE CONDENSATE
COMPARISON OF CORIOLIS METER VS ORIFICE PLATE

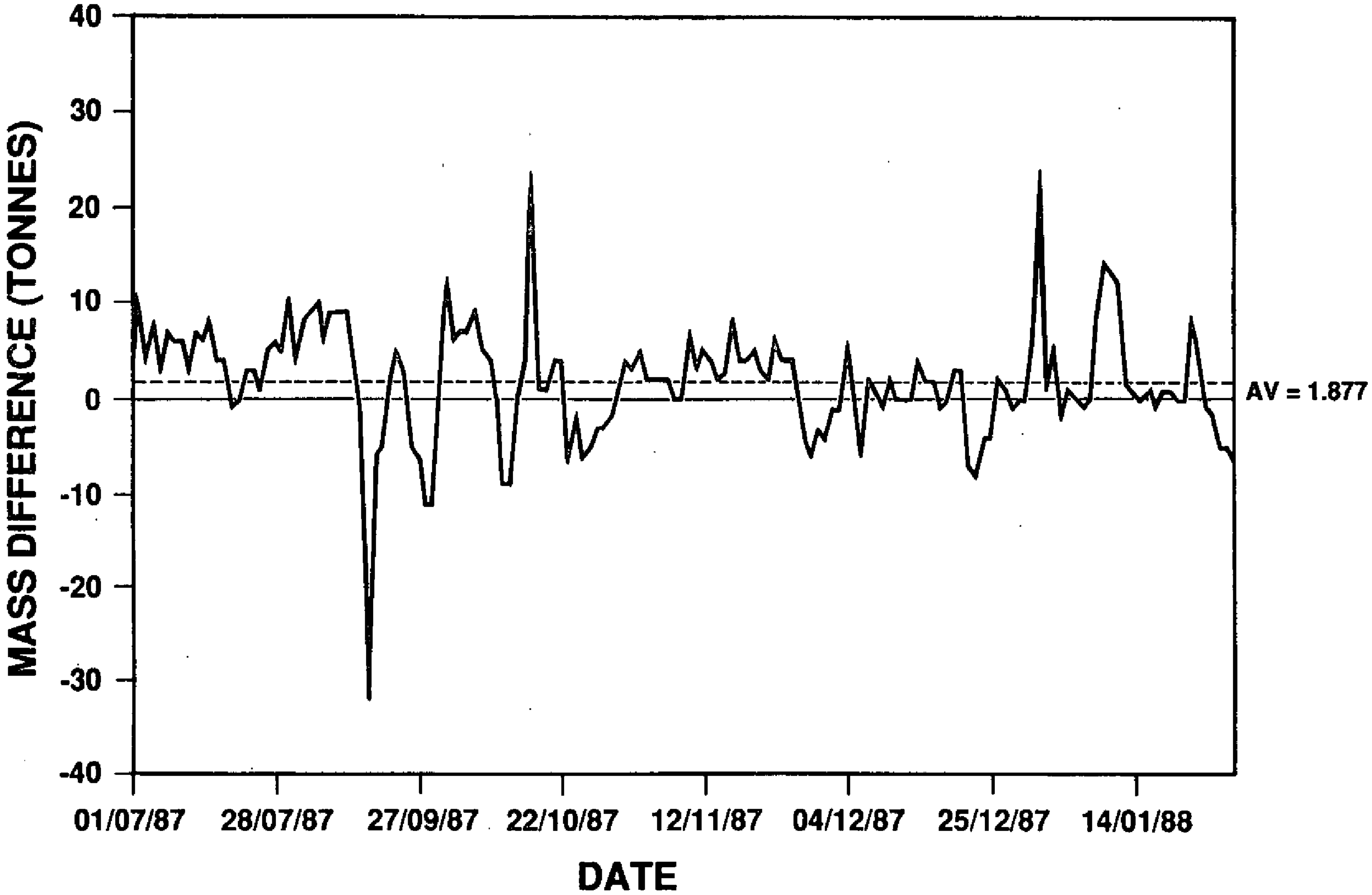


FIGURE 9

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CLAYMORE CONDENSATE
COMPARISON OF CORIOLIS METER VS ORIFICE PLATE

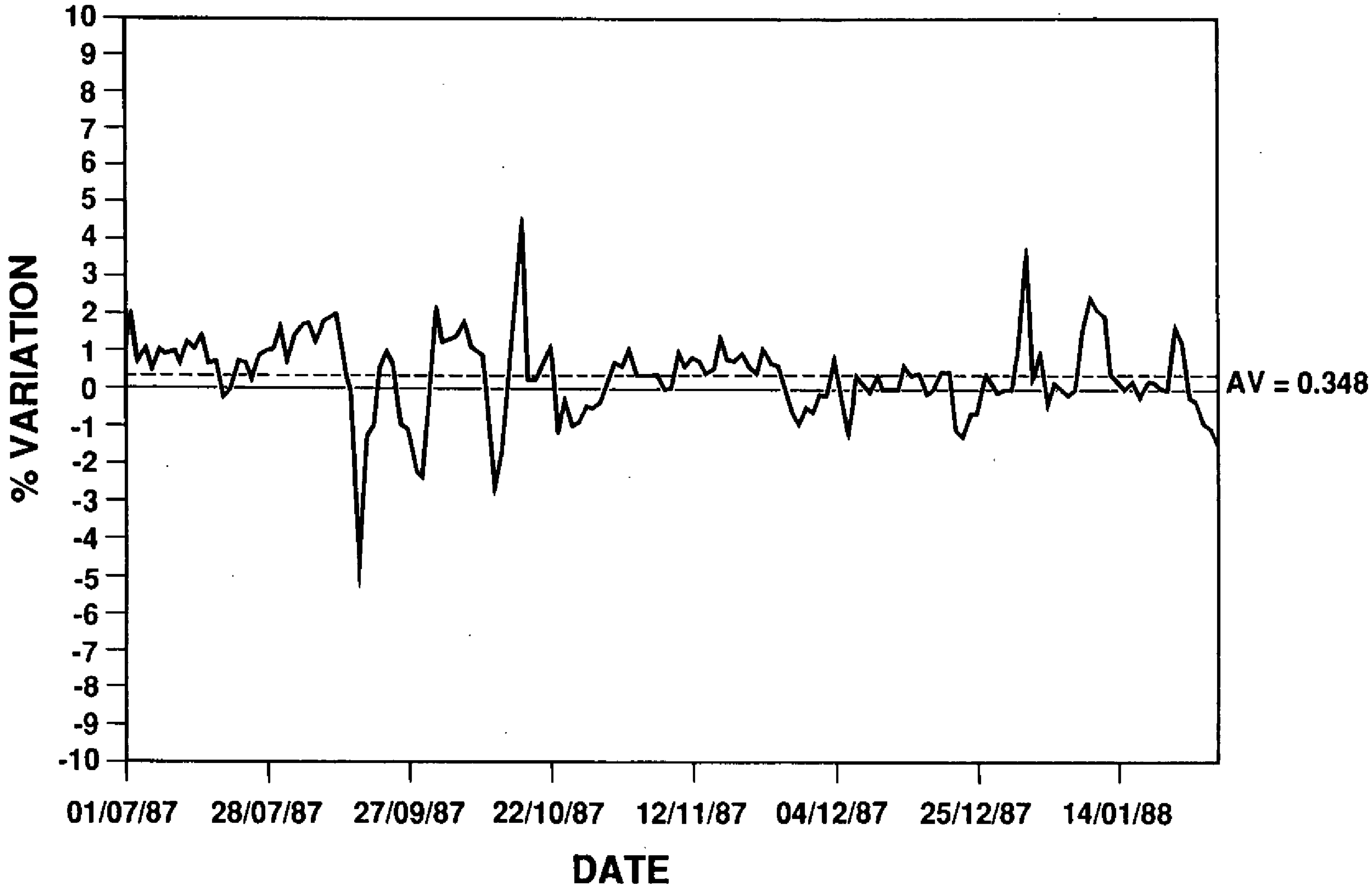

FIGURE 10

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CLAYMORE CONDENSATE
MASS DIFFERENCE Vs OBSERVED DENSITY

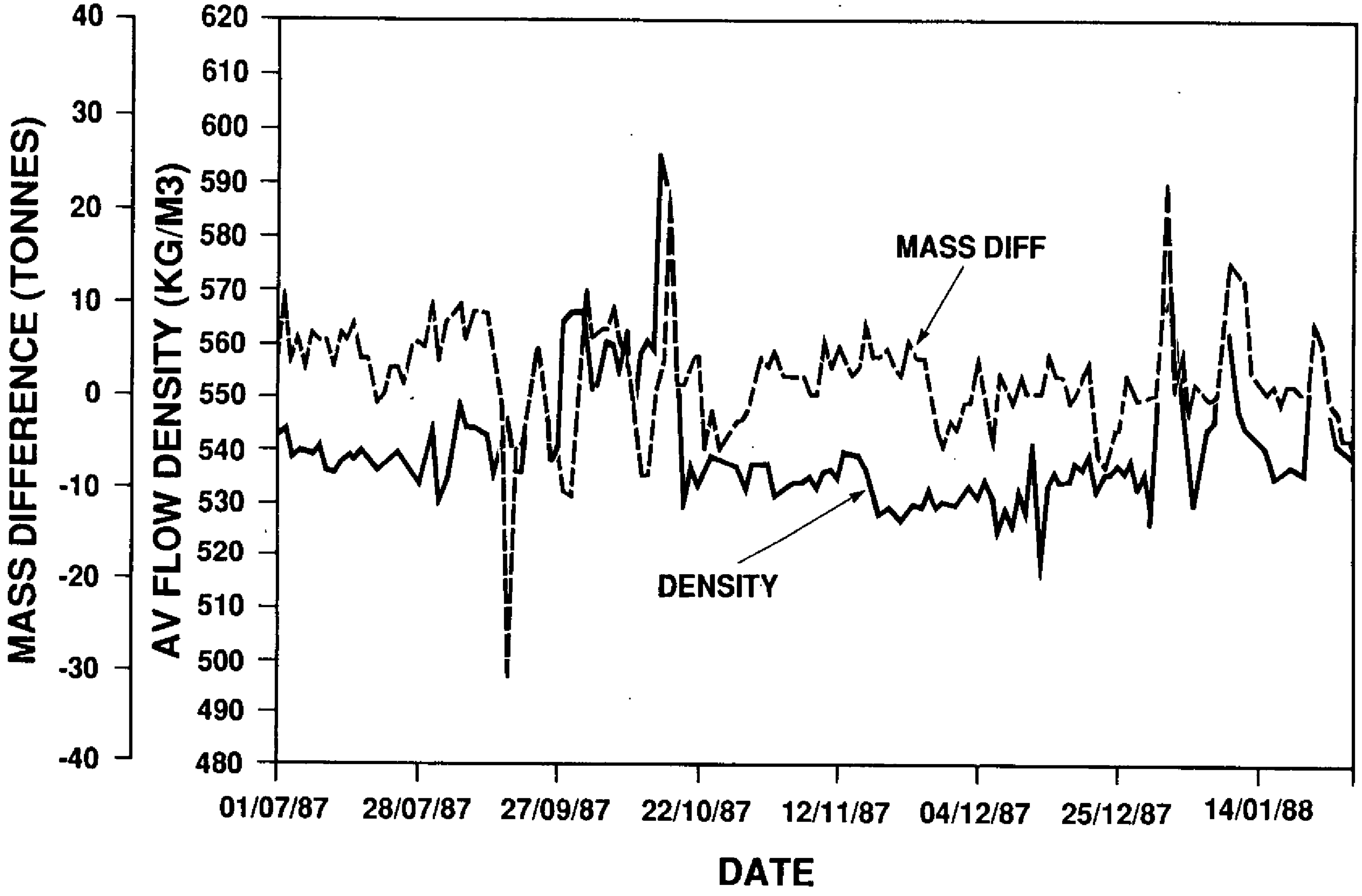

FIGURE 11

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CLAYMORE CONDENSATE
VARIATION OF AVERAGE FLOWING DENSITY

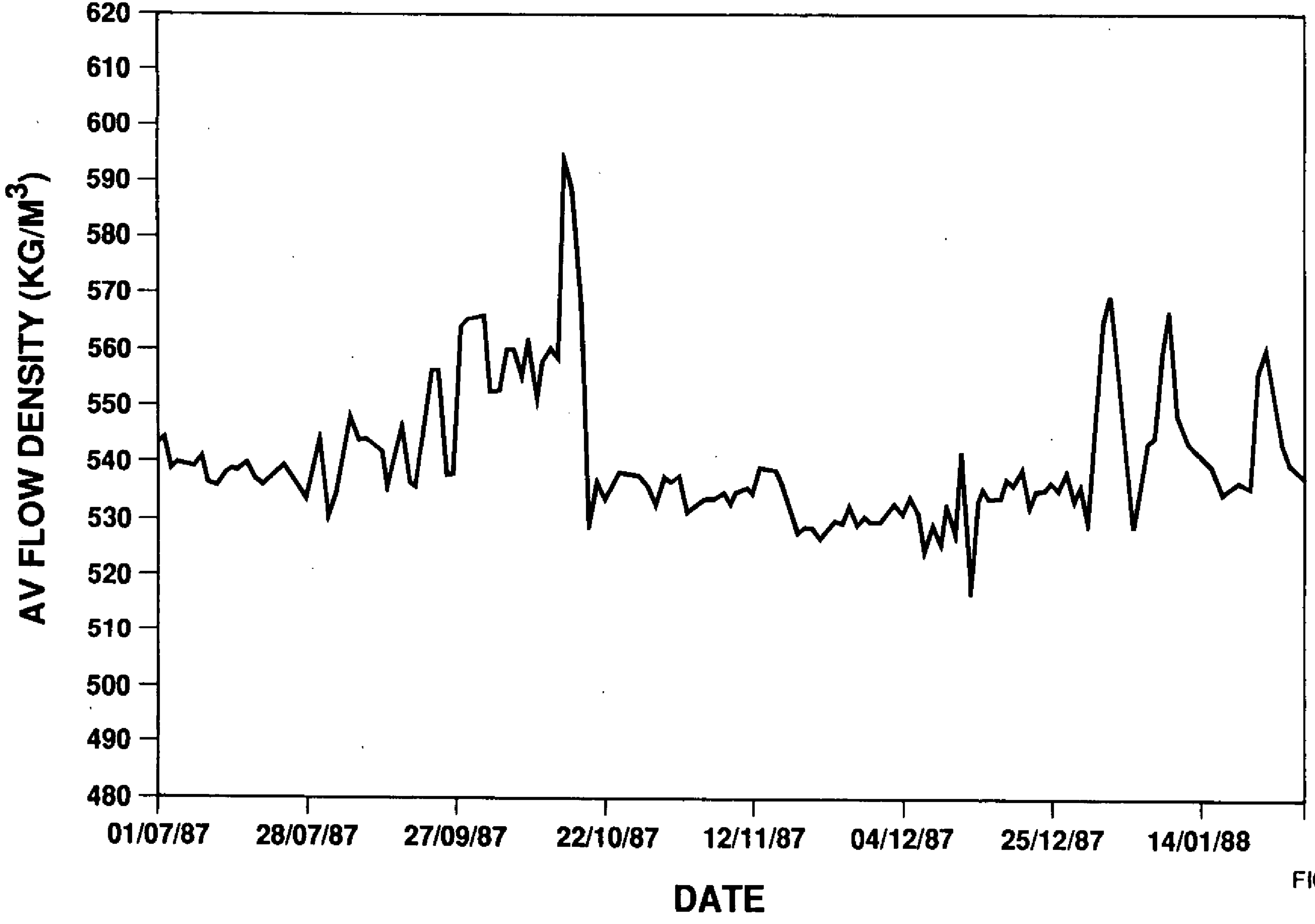

FIGURE 12

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CLAYMORE CONDENSATE
VARIATION OF DAILY FLOW, PRESSURE AND TEMPERATURE

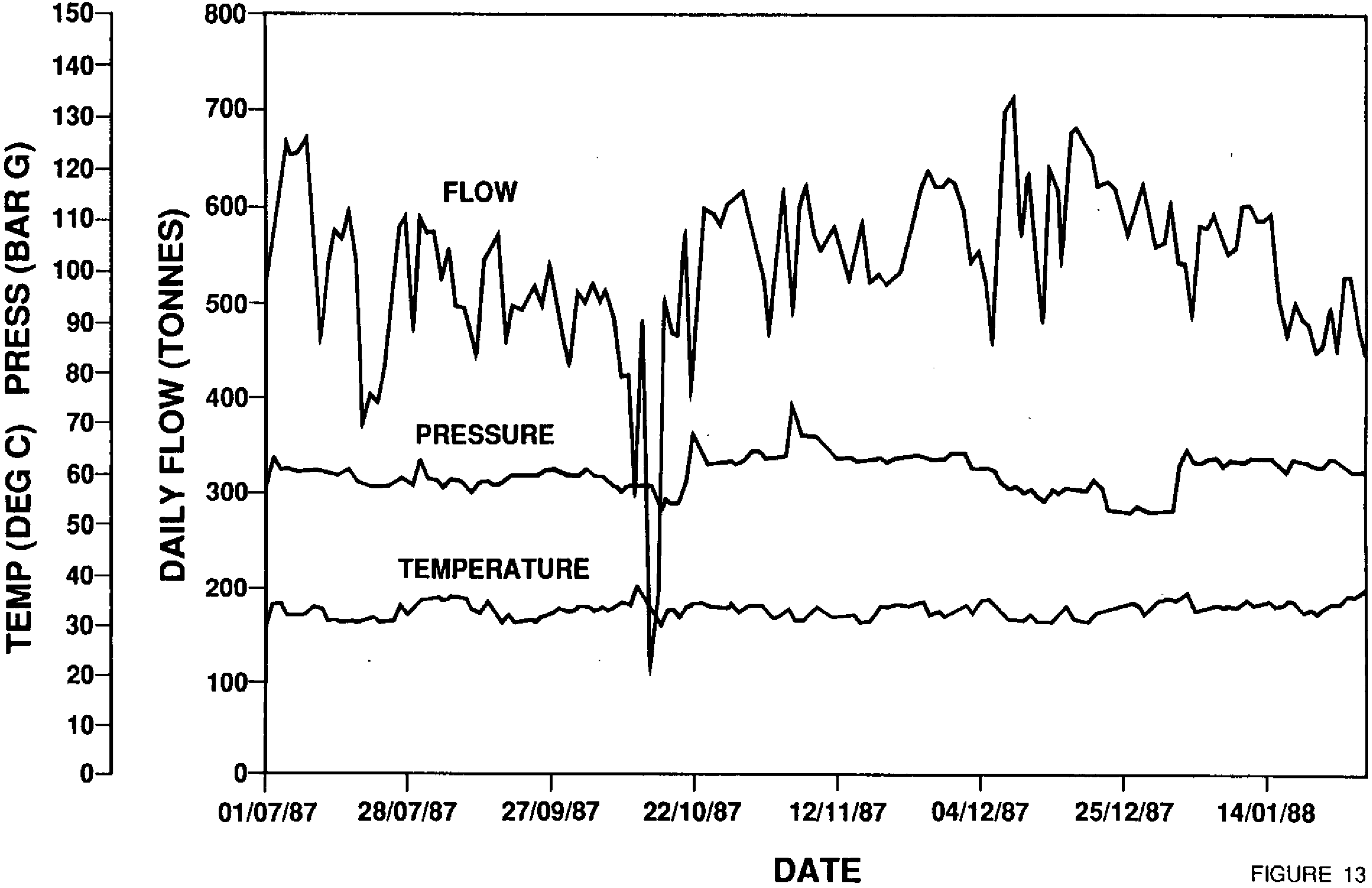

FIGURE 13

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D150 MICROMOTION METER
POST INSTALLATION CALIBRATION
VEENENDAAL JUNE 1988

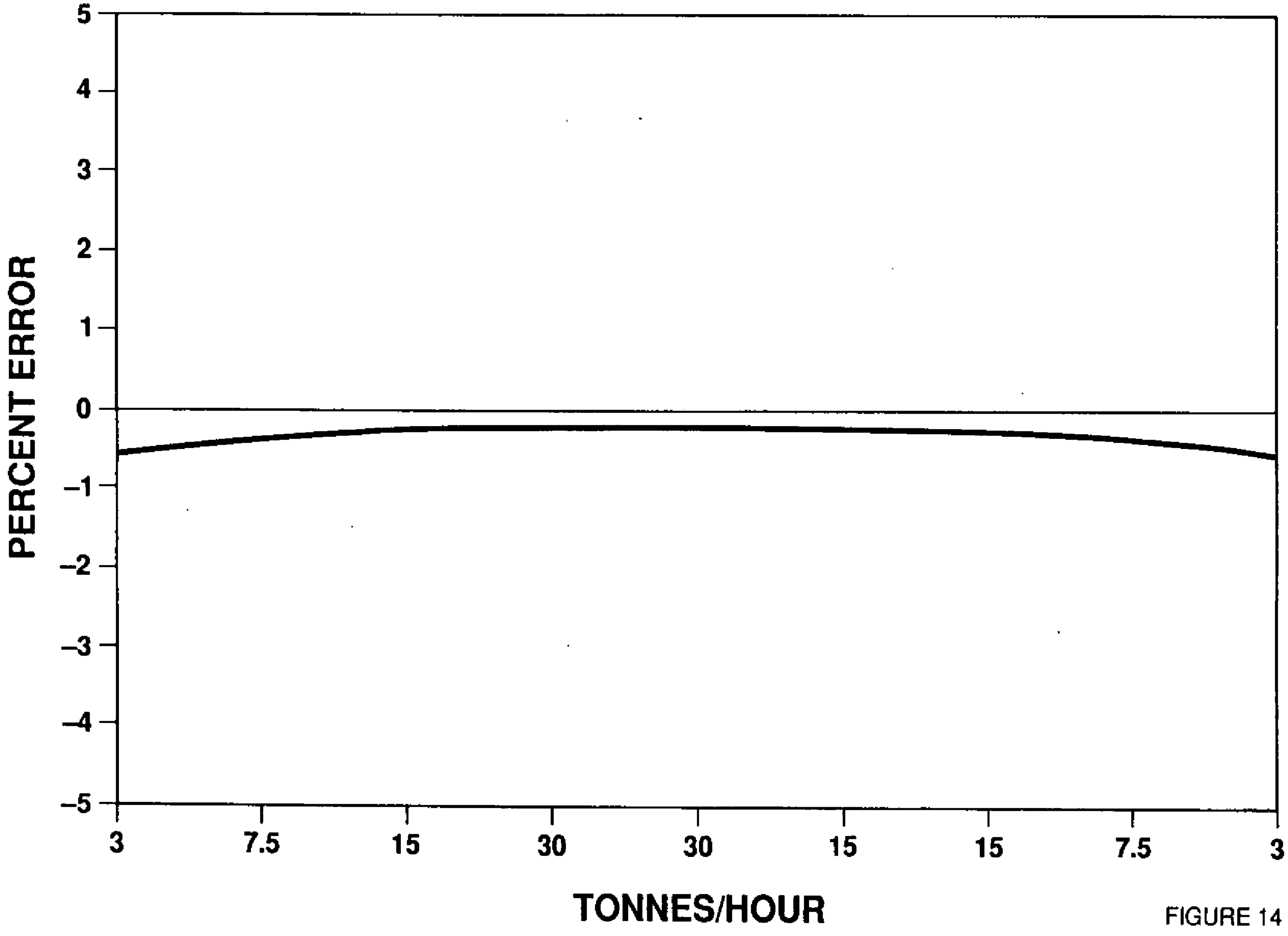

FIGURE 14 0424

DIAGRAM OF CALIBRATION FACILITY AT BROOKS INSTRUMENT PLANT VEENENDAAL HOLLAND

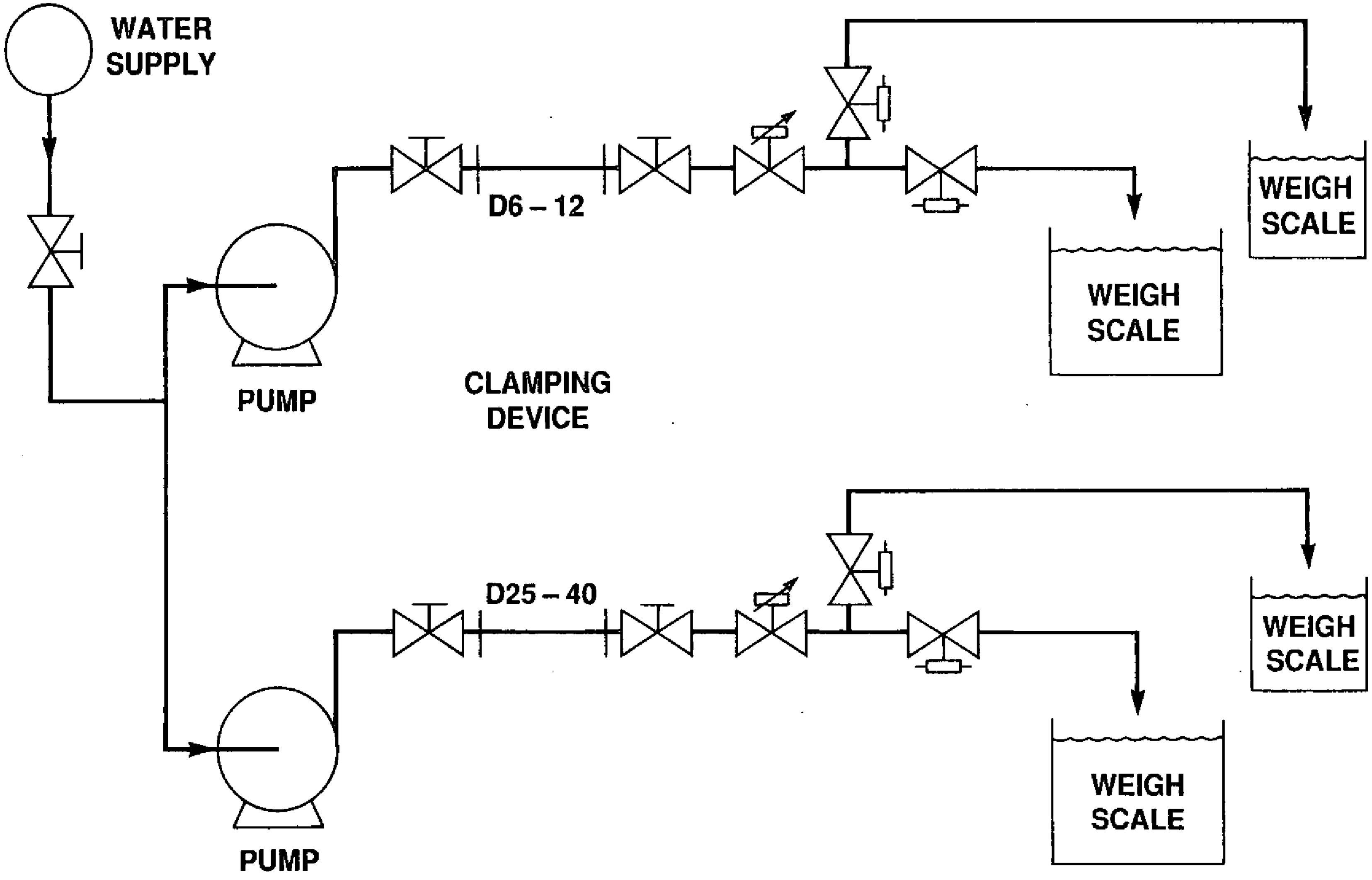

FIGURE 15

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PROPOSED CORIOLIS METER TYPICAL HOOK-UP

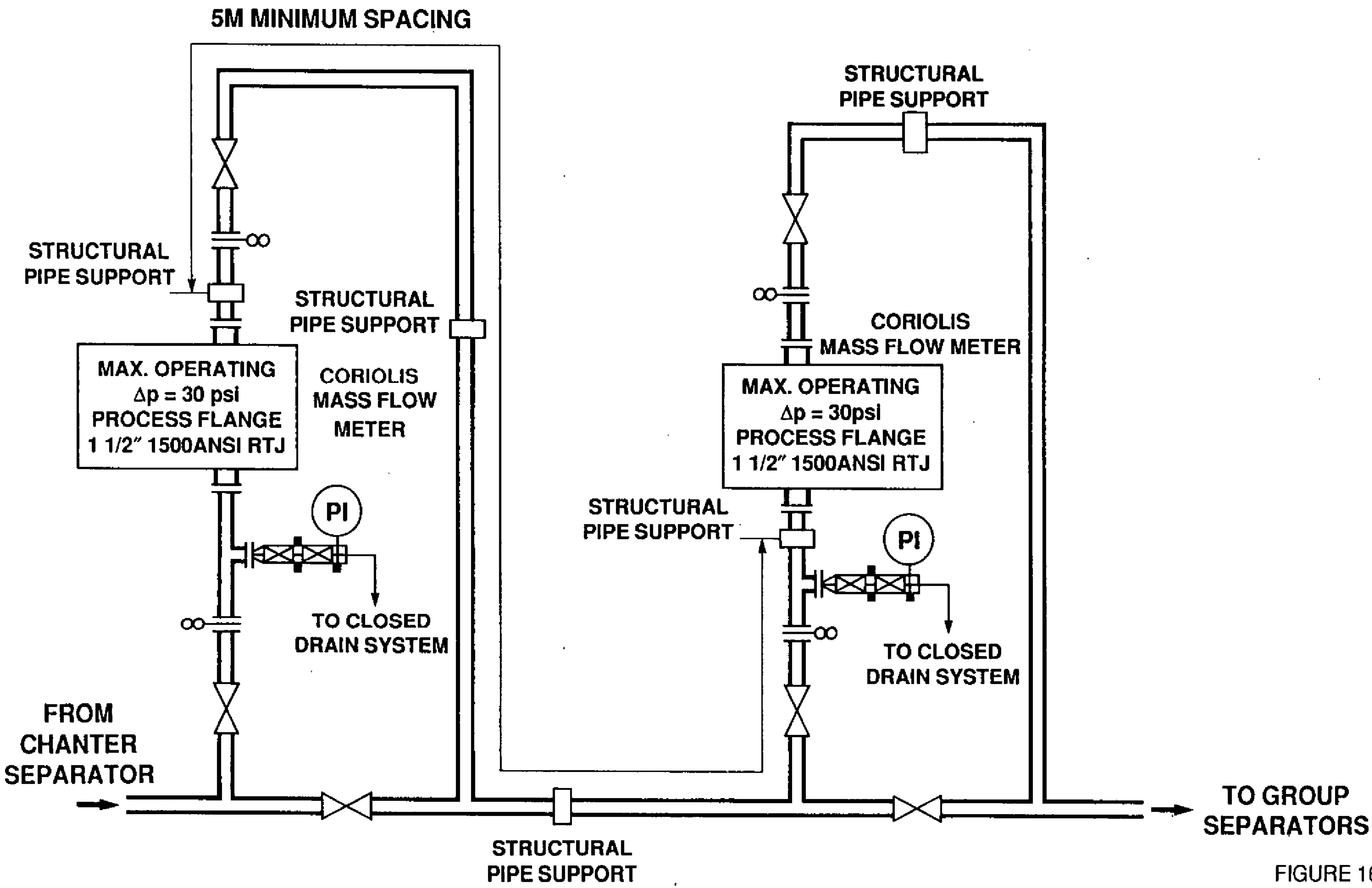

FIGURE 16
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References

[1] Paper presented at the North Sea Flow Measurement Workshop, a workshop arranged by NFOGM & TUV-NEL

Note that this reference was not part of the original paper, but has been added subsequently to make the paper searchable in Google Scholar.