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Reference P.T.- 165 1st August, 1947.

Cousland No. 4 Well

Report on formation tests carried out whilst this well was drilling

Rotary Table Elevation 631'

Review of results obtained

Cousland No. 4 well, sited about two miles from Cousland No. 1 well, encountered quite a different sandstone development from that obtained in No. 1 well. In particular the sands were very much thinner, yielding only very small gas shows.

Practically all the sands penetrated to the well's final depth of 1995' were tested satisfactorily. This involved 24 tests, and in general water free gas shows were obtained, the gas production only being accompanied by definite reservoir water productions in the case of five sands. When two sands were tested simultaneously, the true interpretation of formation test results was a matter of conjecture, but it appears that roughly twelve sands were capable of water free gas production, although the sum of their production capacities, excluding the 1480' - 1490' sand, did not exceed 15,000 cubic feet per day.

When first tested, the 1480' - 1490' had only been penetrated to the extent of 5', the production capacity then increasing to over 70,000 cubic feet per day. After drilling through the sand it was re-tested, but it was mostly mudded off initially as the production rate had declined to 2000 cubic feet per day and fell off during the test to 350 cubic feet per day. The production rate then increased steadily, and after the final production test, had reached a rate of over 100,000 cubic feet per day.

The pressure build-up was recorded after the final production test, and it was found that the well could still produce at a rate of 100,000 cubic feet per day at a flowhead pressure of 250 lbs. gauge. The second test lasted over 18 hours so that it was not practicable to continue it for a still longer period to determine what the production rate would have risen to from this thin sand. However, it seems unlikely that it would have exceeded 200,000 cubic feet per day. The reservoir pressure was determined to be 592 p.s.i.g. at the 9148' contour. The only other gas show of any consequence was derived from the 1038'-1056' sandstone, which improved to 12,000 cubic feet per day during its formation test, calculated from the pressure rise in the drill pipe at an average flowhead pressure of 67 p.s.i.g.

An oil sand was encountered in the well from 1400'-1411', and was first tested when only 2 feet of it were exposed. A little gas and oil were produced during the test, the oil production rate only amounting to some 30 gallons per day. After drilling through the sand it was re-tested but no production was obtained. Further indications of oiliness were obtained in the 1593'-1615' sand which was oily and gassy at the top, but only a small gas show was obtained in the subsequent test carried out.

In general gas samples were collected after reproducing the volume of the drill pipe, in all five samples being collected. Analyses showed these to consist of essentially Methane - about 90%, with a small quantity of Ethane - about 2%, and less than 1% Propane and heavier, the remainder of the gas consisting of Nitrogen. Similar gas analyses were obtained at Cousland No. 1 well.

Scope of detailed report.

The detailed report of the tests has been arranged as follows:

A. Tabulation of sandstones drilled through with brief remarks.

B. Details of bailing test after cementing surface string of casing.

C. Details of formation tests subdivided as follows:

   a. Diaries of tests.
   b. Details of production tests of particular interest supplementing the Tabular Summary, including pressure build-up data.
   c. Reservoir Pressure Measurements.
   d. Collation of analyses of gas samples.
   e. Collation of analyses of reservoir water samples.

The following graphs and charts are included with the report:

(1) Schematic diagram showing in general the results of the tests.
(2) Graph of results obtained on 1480-1490 sandstone as follows:

   i Production test results (2 graphs)
   ii Drill stem pressure build-up records.
   iii F.H.P. Production graph based on final pressure build-up record.

(3) Tabular summary of tests.
(4) Amerada charts obtained.

COUSLAND NO. 4 WELL

DETAILED REPORT

A. TABULATION OF SANDSTONES DRILLED THROUGH IN THE CALCIFEROUS SANDSTONE SERIES

Depth Interval	U.G.C.	Remarks
297' - 350'	10334 - 10281	Bailing tests. Water production.
400' - 450'	10231 - 10181	Could not test. Probably water bearing.
498' - 540'	10133 - 10091	Dunnet sst. ?Gas & water production.
735' - 760'	9896 - 9871	Gas & reservoir water production.
915' - 947'	9716 - 9684	Gas show only.
964' - 975'	9667'- 9656	Gas show only.
996' - 1008'	9635 - 9623	Not tested.
1038' - 1056'	9593 - 9575	Gas show. ?Reservoir water.
1089' - 1098'	9542 - 9533	Gas show only.
1152' - 1159'	9479 - 9472	Gas show only.
1234' - 1272'	9397 - 9359	Gas show. ?Reservoir water.
1282' - 1293'	9349 - 9338	Reservoir water. ?Gas show.
1350' - 1375'	9281 - 9256	Not productive
1393' - 1411'	9238 - 9220	Small oil and gas show.
1463' - 1470'	9168 - 9161	Probably not productive.
1480' - 1490'	9151 - 9141	Main gas sand.
1522' - 1523'	9109 - 9108	Not productive.
1532' - 1544'	9099 - 9087	Not productive.
1593' - 1615'	9038 - 9016	Oily sand producing a little gas.
1617' - 1632'	9014 - 8999	?Gas show!
1651' - 1654'	8980 - 8977	?Gas show.
1710' - 1713'	8921'- 8918	Not productive.
1733' - 1750'	8898 - 8881	Not productive. Interbedded ssts. & lmsts.
1827' - 1832'	8804 - 8799	Gas & reservoir water production.
1854' - 1858'	8777 - 8773	?Gas show.
1868' - 1871'	8763 - 8760	?Gas show.
1880' - 1896'	8751 - 8735	?Gas show.
1924' - 1931'	8707 - 8700	Not productive.
1972' - 1990'	8659 - 8641	Gas & reservoir water production.

B. BAILING TEST - 16th April, 1947.

	Depth	U.G.C.
11.3/4" casing to	280'	10351
11.3/4" hole to	284'	10347
8.5/8" " "	299'	10332
7.3/4" " "	319'	10312
Top of sandstone	297'	10334

(N.B. Total Sandstone interval 297'-350')

1. Well left standing 12 hours - fluid level rose to 160 feet.
2. Bailed well down to 280' - after standing 1.1/4 hours level rose to 170' Thus the rise is 110' equivalent to 434 gallons, or 8300 g.p.d.
3. This procedure was repeated three times.

Water Samples

Particulars	S.G. @ 60°F	Salinity 10^5 Cl	Indicator 10^6 dye
Before bailing	1.0016	14	24
From 200' during second bailing down	1.0016	20	12
From bottom after third bailing down v	1.0009	10	1½

C. FORMATION TESTS

a. DIARIES OF TESTS

(1) In April

Test 1 18th April - Interval 390' - 450'

(1st attempt)

2.35 p.m. Running in drill pipe. Halliburton tester & rat hole rubber.
3.15 p.m. "Set" packer rubber.
3.29 p.m. Opened tester valve. A.S. mud level fell. Tried re-seating packer, opening & shutting tester valve, etc. unsuccessfully.
3.50 p.m. Pulling out of hole.
6.00 p.m. Ran in with 8.5/8" bit & reamed 3' off pilot hole.

(2nd attempt)

8.20 p.m. Running in drill pipe. Found top of pilot hole bridged. Pulled out.
8.50 p.m. Ran in with 5.3/8" bit and cleaned out pilot hole.
11.30 p.m. Running in drill pipe.
11.50 p.m. "Set" packer rubber.
12.18 a.m. Opened tester valve. A.S. mud level held, and then fell away. Shut tester valve.
12.25 a.m. Pulled packer free.

N.B. There was evidently insufficient weight to seat the rubber satisfactorily.

Test 2 22nd April Interval 490' - 540' (Dunnet Sandstone)

9.00 p.m. Running in drill pipe. Halliburton tester & rat hole rubber.
9.45 p.m. Set packer rubber.
10.06 p.m. Opened tester valve.
11.09 p.m. Shut tester valve.
11.11 p.m. Pulled packer free.

Test 3	26th April	Interval 750'-760'
	1.00 p.m.	Running in drill pipe. Halliburton tester and rat hole rubber.
	1.55 p.m.	Set packer rubber.
	2.14 p.m.	Opened tester valve.
	2.36 p.m.	Closed tester valve.
	2.42 p.m.	Pulled packer free.
Test 4	30 th April	Interval 882'-930'
	9.00 p.m.	Running in drill pipe. Halliburton tester and rat hole rubber.
	10.10 p.m.	Set packer rubber.
	10.29 p.m.	Opened tester valve.
	11.04 p.m.	Closed tester valve.
	11.08 p.m.	Pulled packer free.

(2) In May.

Test 1	2nd May	Interval 932'-963'
	2.50 p.m.	Running in drill pipe. Halliburton tester and rat hole rubber.
	3.29 p.m.	Set packer rubber.
	3.39 p.m.	Opened tester valve.
	5.11 p.m.	Shut tester valve.
	5.13 p.m.	Pulled packer free.
Test 2	3rd May	Interval 931'-992'
	11.10 a.m.	Running in drill pipe. Halliburton tester and wall packer.
	12.00 p.m.	"Set" packer rubber at 960'
	12.34 p.m.	Opened tester valve. A.S. mud level fell away.
	12.35 p.m.	Shut tester valve and pulled packer free.
	2.10 p.m.	Running in drill pipe. Halliburton tester and rat hole packer.
	3.05 p.m.	Set packer rubber.
	3.29 p.m.	Opened tester valve.
	5.39 p.m.	Collected sample of gas over water in 10 litre bottle.
	5.57 p.m.	Shut tester valve.
	6.00 p.m.	Pulled packer free.
Test 3	7th May	Interval 1022'-1055'
	6.45 p.m.	Wound up R.P.G-3 Amerada clock.
	7.45 p.m.	Running in drill pipe. Halliburton tester and rat hole packer.
	8.48 p.m.	Set packer rubber.
	8.58 p.m.	Opened tester valve.
	9.13 p.m.	Tested gas production by burning. Collected gas sample.
	9.17 p.m.	Closed in well at surface for pressure build-up.
	11.00 p.m.	Pressure built up to 125 lbs.
	11.01 p.m.	Shut tester valve and blew off gas pressure in drill pipe.
	11.04 p.m.	Pulled packer free.
Test 4	9th May	Interval 1075'-1105'
	3.35 p.m.	Wound up R.P.G.-3 Amerada clock.
	3.48 p.m.	Running in drill pipe. Halliburton tester and rat hole packer.
	4.30 p.m.	Set packer rubber.
	4.42 p.m.	Opened tester valve.
	6.43 p.m.	Closed tester valve.
	6.47 p.m.	Pulled packer free.

Test 5	13th May	Interval 1153'-1186'
	3.50 p.m.	Wound up R.P.G.-3 Amerada clock.
	4.20 p.m.	Running in drill pipe. Halliburton tester and rat hole packer.
	5.05 p.m.	Set packer rubber.
	5.17 p.m.	Opened tester valve.
	7.32 p.m.	Shut tester valve.
	7.36 p.m.	Pulled packer free.
Test 6	17th May	Interval 1236'-1291'
	9.25 a.m.	Wound up R.P.G.-3 Amerada clock.
	9.50 a.m.	Running in drill pipe. Halliburton tester and rat hole packer.
	10.30 a.m.	Set packer rubber.
	10.43 a.m.	Opened tester valve.
	11.17 a.m.	Lit gas production at surface, collecting gas sample afterwards.
	11.31 a.m.	Closed in well at surface for pressure build-up.
	12.13 p.m.	Pressure built up to 7.1/4 lbs.
	12.14 p.m.	Shut tester valve and blew off gas pressure.
	12.18 p.m.	Pulled packer free.
Test 7	20th May	Interval 1295'-1367'
	2.15 p.m.	Wound up R.P.G.-3 Amerada clock.
	2.45 p.m.	Running in drill pipe. Halliburton tester and rat hole packer.
	3.35 p.m.	Set packer rubber.
	3.46 p.m.	Opened tester valve.
	4.47 p.m.	Closed tester valve.
	4.50 p.m.	Pulled packer free.
Test 8	22nd May	Interval 1369'-1402'
	4.50 a.m.	Wound up R.P.G.-3 Amerada clock.
	5.05 a.m.	Running in drill pipe. Halliburton tester and rat hole packer.
	5.44 a.m.	Set packer rubber.
	5.58 a.m.	Opened tester valve.
	8.37 a.m.	Closed tester valve.
	8.40 a.m.	Pulled packer free.
Test 9	28th May	Interval 1392'-1440'
	9.55 a.m.	Wound up R.P.G.-3 Amerada clock.
	10.15 a.m.	Running in drill pipe. Halliburton tester and rat hole packer.
	10.57 a.m.	Set packer rubber.
	11.08 a.m.	Opened tester valve.
	12.09 p.m.	Shut tester valve.
	12.13 p.m.	Pulled packer free.
Test 10	30th May	Interval 1442'-1485'
	9.13 a.m.	Wound up R.P.G.-3 Amerada clock.
	9.30 a.m.	Running in drill pipe. Halliburton tester and rat hole packer.
	10.15 a.m.	Set packer rubber.
	10.26 a.m.	Opened tester valve.
	10.46 a.m.	Collected gas sample in 10 litre bottle.
	10.50 a.m.	Closed in well at surface for pressure build-up.
	2.15 p.m.	Pressure built up to 536 lbs - 533 lbs. corrected gauge. Filled two H.P. gas cylinders.
	2.30 p.m.	Shut tester valve and blew off gas pressure.
	2.42 p.m.	Pulled packer free.

(3) In June

Test 1	2nd - 3rd June	Interval 1471'-1520'
	8.16 p.m.	Wound up R.P.G.-3 Amerada clock.
	8.30 p.m.	Running in drill pipe. Halliburton tester and rat hole packer.
	9104 p.m.	Set packer rubber.
	9.14 p.m.	Opened tester valve.
	10.35 p.m.	Obtained gas return through meter.
	11.46 p.m.	Shut in well at surface for pressure build-up.
	12.10 a.m.	Built-up pressure 94 lbs.
	1213 a.m.	Closed and opened tester valve to check condition of hole.
	3.45 a.m.	Built-up pressure 563 lbs.- 543 lbs. corrected gauge.
	9.00 a.m.	Built-up pressure 565 lbs. - 545 lbs. corrected gauge.
	9.35 a.m.	Collected gas sample in 2.1/2 litre cylinder.
	9.41 a.m.	Blew off gas pressure.
	9.52 a.m.	Measuring production rates by open end orifice meter.
	10.33 a.m.	Shut and opened tester valve to check condition of hole.
	12.48 p.m.	Shut and opened tester valve to check condition of hole.
	12.50 p.m.	Shut in well at surface for pressure build-up.
	3.00 p.m.	Built-up pressure 550 lbs. gauge - 526 lbs. by D.W.T.
	3.21 p.m.	Shut tester valve.
	3.23 p.m.	Blew off gas pressure.
	3.26 p.m.	Pulled packer free. N.B. The copper pin did not even shear.

Test 2	6th-7th June	Interval 1522'-1575'
	3.25 p.m.	Wound up R.P.G.-3 Amerada clock.
	3.50 p.m.	Running in drill pipe. Halliburton tester and rat hole packer.
	4.48 p.m.	'Set' packer.
	4.58 p.m.	Opened tester valve. A/S level fell. Closed tester valve.
	5.03 p.m.	Pulled packer free. Pulled out drill pipe, ran in with seating tool, and reamed for new seat.
	9.25 p.m.	Re-wound Amerada clock.
	10.30 p.m.	Packer would not go into pilot hole.
	10.35 p.m.	Pulled out drill pipe, and ran in with 5.3/8" bit to clean out hole to bottom.

Test 2	7th June	Interval 1522'-1575'
	6.25 a.m.	Wound up R.P.G.-3 Amerada clock.
	6.43 a.m.	Running in drill pipe. Halliburton tester and rat hole packer.
	7.21 a.m.	Set packer rubber.
	7.37 a.m.	Opened tester valve.
	9.44 a.m.	Closed tester valve.
	9.47 a.m.	Pulled packer free.

Test 3	10th June	Interval 1571'-1604'
	12.20 p.m.	Wound up R.P.G.-3 Amerada clock.
	12.40 p.m.	Running in drill pipe. Halliburton tester and rat hole packer.
	1.23 p.m.	Set packer rubber.
	2.20 p.m.	Opened tester valve.
	6.10 p.m.	Obtained gas return through meter.
	7.00 p.m.	Shut tester valve.
	7.08 p.m.	Pulled packer free.

Test 4	12th June	Interval 1605'-1654'
	2.35 p.m.	Wound up R.P.G.-3 Amerada clock.
	2.55 p.m.	Running in drill pipe. Halliburton tester and rat hole packer.
	3.38 p.m.	Set packer rubber.
	3.56 p.m.	Opened tester valve.
	6.03 p.m.	Shut tester valve.
	6.21 p.m.	Pulled packer free.
Test 5	17th June	Interval 1706' -1751'
	9.05 a.m.	Wound up R.P.G.-3 Amerada clock.
	9.20 a.m.	Running in drill pipe. Halliburton tester and rat hole packer.
	10.10 a.m.	'Set' packer rubber.
	10.27 a.m.	Opened tester valve. A/S level fell. Shut tester valve.
	10.30 a.m.	Pulled out drill pipe and ran in with seating tool.
	2.00 p.m.	Ran in with 5.3/8" bit and cleaned out to bottom.
	4.20 p.m.	Re-wound Amerada clock.
	4.40 p.m.	Running in drill pipe. Halliburton tester and rat hole packer.
	5.10 p.m.	Set packer rubber.
	5.26 p.m.	Opened tester valve. A/S level fell. Shut tester valve.
	5.45 p.m.	Pulling out drill pipe.
	7.33 p.m.	Re-wound Amerada clock.
	8.55 p.m.	Running in drill pipe. Halliburton tester and wall packer.
	9.42 p.m.	Set packer rubber.
	9.59 p.m.	Opened tester valve.
	10.52 p.m.	Production nil. Shut and opened tester valve.
	11.01 p.m.	Shut tester valve.
	11.03 p.m.	Pulled packer free.
Test 6	19th June	Interval 1747' - 1802'
	9.35 a.m.	Wound up R.P.G.-3 Amerada clock.
	9.48 a.m.	Running in drill pipe. Halliburton tester and rat hole packer.
	10.17 a.m.	'Set' packer rubber.
	10.29 a.m.	Opened tester valve. A/S level fell. Shut tester valve.
	10.35 a.m.	Pulled out drill pipe.
	12.27 a.m.	Re-wound Amerada clock.
	1.00 p.m.	Running in drill pipe. Halliburton tester and wall packer.
	2.50 p.m.	Set packer rubber.
	3.07 p.m.	Opened tester valve.
	4.14 p.m.	Shut tester valve.
	4.16 p.m.	Pulled packer free.
Test 7	21st June	Interval 1797'-1842'
	9.15 a.m.	Wound up R.P.G.-3 Amerada clock.
	9.55 a.m.	Running in drill pipe. Halliburton tester and wall packer.
	10.45 a.m.	Set packer rubber.
	11.04 a.m.	Opened tester valve.
	12.21 p.m.	Closed tester valve.
	12.23 p.m.	Pulled packer free.

Test 8 — 24th June — Interval 1843'-1888'

2.00 p.m.	Wound up R.P.G.-3 Amerada clock.
2.30 p.m.	Running in drill pipe. Halliburton tester and wall packer.
3.21 p.m.	Set packer rubber.
3.40 p.m.	Opened tester valve.
4.13 p.m.	Obtained gas return through meter
4.22 p.m.	Shut tester valve.
4.26 p.m.	Pulled packer free.

Test 9 — 26th June — Interval 1889'-1940'

10.25 a.m.	Wound up R.P.G.-3 Amerada clock.
10.55 a.m.	Running in drill pipe. Halliburton tester and wall packer.
12.00 p.m.	Set packer rubber.
12.15 p.m.	Opened tester valve.
12.57 p.m.	Shut tester valve.
12.59 p.m.	Pulled packer free.

Test 10 — 28th June — Interval 1943' -1995'

4.00 p.m.	Wound up R.P.G.-3 Amerada clock.
4.25 p.m.	Running in drill pipe. Halliburton tester and wall packer.
5.12 p.m.	Set packer rubber.
5.28 p.m.	Opened tester valve.
6.59 p.m.	Shut tester valve.
7.02 p.m.	Pulled packer free.

(b) PRODUCTION TESTS - DETAILS OF PARTICULAR INTEREST SUPPLEMENTING THE TABULAR SUMMARY

Tests in May

1. Test 2 on 3rd May.

3.29 p.m. Opened tester valve.

	Meter Throughput	Production rate
4.25 p.m.	10 cubic feet	257 cubic feet per day.
4.44 p.m.	10 " "	757 " " " "
5.02 p.m.	10 " "	800 " " " "
5.11 p.m.	10 " "	1600 " " " "
5.19 p.m.	10 " "	1800 " " " "
5.28 p.m.	10 " "	1600 " " " "
5.38 p.m.	10 " "	1440 " " " "

2. Test 3 on 7th May

2/1 Meter Throughput.

8.58 p.m. Opened tester valve.

	Back pressure	Meter Throughput	Production rates ft³/day On Meter	Total
9.01 p.m.	1.1/2 p.s.i.g.	10 cubic feet	4800	8400
9.03 p.m.	2.1/4 "	10 " "	7200	9940
9.05 p.m.	2.1/2 "	10 " "	7200	8110
9.07 p.m.	3 "	10 " "	7200	9020
9.09 p.m.	3.1/2 "	10 " "	7200	9020
9.10½ p.m.	3.1/2 "	10 " "	9600	9600
9.12 p.m.	3.1/2 "	10 " "	9600	9600

2/2 Production from pressure rise in drill pipe

9.17 Shut in well. Back pressure 5 p.s.i.g.

	Back pressure	Pressure rise lbs.	atmospheres	Average F.H. P p.s.i.g	Production rate ft³/day
9.30 p.m.	20 p.s.i.g.	15	1.02	12	8,800
9.55 p.m.	53 "	33	2.25	37	10,300
10.20 p.m.	82 "	39	2.65	67	12,000
10.40 p.m.	105 "	23	1.57	94	9,000
11.00 p.m.	125 "	20	1.36	115	7,700

3. Test 6 on 17th May

3/1 Meter Throughput

10.43 a.m. Opened tester valve.

	Throughput	back pressure	Production rate on meter
	12 ft³	4 p.s.i.g.	2 ft³ in 20 secs or 8640 ft³/day
	12 "	4 "	2 " " 22 " " 7860 " "
	10 "	3.1/2 "	2 " " 23 " " 7500 " "
	8 "	2 "	2 " " 25 " " 6900 " "
	8 "	1.1/2 "	2 " " 28 " " 6170 " "
	10 "	1 "	2 " " 35 " " 4940 " "
	10 "	1/2 "	2 " " 45 " " 3850 " "
11.00 a.m.	10 "	Nil "	10 " " 12 mins. 1200 " "
11.10 a.m.	14 "	Nil "	14 " " 10 " 2000 " "
11.17 a.m.	10 "	Nil "	10 " " 7 " 2060 " "

3/2 Production from pressure rise in drill pipe

11.31 a.m.	- Shut in well	) Pressure nil
11.45 a.m.	- pressure 3 p.s.i.g.	)
11.53 a.m.	- " 5 p.s.i.g.	) Overall production rate
12.10 p.m.	- " 7 p.s.i.g.	) 1400 cubic feet per day
12.13 p.m.	- " 7.1/4 p.s.i.g.	)

4 Test 8 on 22nd May (Gas and small oil show)

5.58 p.m. Opened Tester Valve.

	Meter Throughput	Production rate
6.05 a.m.	0.5 cubic feet	103 cubic feet per day
6.18 a.m.	0.5 " "	52 " " " "
6.35 a.m.	0.5 " "	42 " " " "
6.59 a.m.	0.5 " "	30 " " " "

7.19 a.m.	0.5 cubic feet	36 cubic feet per day.
7.37 "	0.5 " "	40 " " " "
7.54 "	0.5 " "	42 " " " "
8.09 "	0.5 " "	48 " " " "
8.23 "	0.5 " "	52 " " " "
8.36 "	0.5 " "	55 " " " "

5. Test 10 on 30 th May

5/1 Meter Throughput

10.26 a.m. Opened tester valve.

	Back pressure	Meter Throughput	Production rates On meter	Total
10.32 a.m.	1 p.s.i.g.	10 ft^3	2,400 ft^3/day	4,220 ft^3/day
10.35 a.m.	2 "	12 "	5,760 "	9,400 "
10.37 a.m.	4 "	10 "	7,200 "	18,140 "
10.42 a.m.	8 "	36 "	10,400 "	19,150 "
10.46 a.m.	12 "	40 "	14,400 "	25,350 "

5/2 Production from pressure rise in drill pipe

10.50 a.m. Shut in well. back pressure 25 p.s.i.g.

	Back pressure	Pressure rise lbs.	atmospheres	Production rate
11.10 a.m.	125	100	6.8	54,400 ft^3/day.
11.40 "	325	200	13.6	72,400 " "
12.10 p.m.	460	135	9.2	49,000 " "
1.05 "	527	67	4.6	13,900 " "
1.45 "	533	6	0.41	1,650 " "
2.15 "	533	-	-	-

5/3 Details of pressure build-up in drill pipe

Corrected gauge

10.50 a.m. - shut in well. pressure 25 p.s.i.g.

Time	Minutes	gauge pressure	Time	Minutes	gauge pressure
10.55 a.m.	5	35 lbs.	12.20 p.m.	90	484
11.00 "	10	62 "	12.25 "	95	495
11.05 "	15	92 "	12.30 "	100	499
11.10 "	20	125 "	12.35 "	105	502
11.15 "	25	160 "	12.40 "	110	508
11.20 "	30	185 "	12.45 "	115	512
11.25 "	35	219 "	12.50 "	120	517
11.30 "	40	256 "	12.55 "	125	519
11.35 "	45	290 "	1.00 "	130	522
11.40 "	50	325 "	1.05 "	135	527
11.45 "	55	358 "	1.10 "	140	527
11.50 "	60	380 "	1.15 "	145	528
11.55 "	65	402 "	1.20 "	150	528
12.00 p.m.	70	425 "	1.25 "	155	529
12.05 "	75	447 "	1.30 "	160	529
12.10 "	80	460 "	1.35 "	165	532
12.15 "	85	474 "	1.40 "	170	532
			1.45 "	175	533
			1.50 "	180	533
			2.15 "	205	533

5/4 Data used to construct graph showing production rates

Time interval	Minutes	Mean	Total time	Production ft^3/day
Flowing test				
10.26 a.m.- 10.32 a.m.	6	3	3	4,220
10.32 a.m.- 10.35 a.m.	3	1.1/2	4.1/2	9,400
10.35 a.m.- 10.37 a.m.	2	1	5.1/2	18,140
10.37 a.m.- 10.42 a.m.	5	2.1/2	8	19,150
10.42 a.m.- 10.46 a.m.	4	2	10	23,350
Initial build-up				
10.46 a.m.- 11.10 a.m.	24	12	22	54,400

Tests in June

6. Test 1 on 2nd June

6/1 Meter Throughput

9.14 p.m. Opened tester valve.

	Back pressure	Meter Throughput	Production Rates cubic feet/day: On meter	Total
9.21 p.m.	Nil	10 cubic feet	2060	-
9.33 "	"	3 " "	360	-
9.45 "	"	3 " "	360	-
9.53 "	"	4 " "	720	-
10.03 "	"	10 " "	1440	-
10.09 "	"	10 " "	2400	-
10.15 "	"	14 " "	3360	-
10.31 "	3 p.s.i.g.	52 " "	4680	6,780
11.00 "	5.1/2 p.s.i.g.	178 " "	8830	9,790
11.30 "	11 p.s.i.g.	345 " "	16560	18,610
11.46 "	15 "	243 " "	21900	24,690

6/2 Production from first build-up pressure in drill pipe

2nd June.

11.46 p.m. Shut in well. Back pressure 15 p.s.i.g.

3rd June	Back pressure	Pressure Rise lbs.	Pressure Rise atmospheres	Production rate
12.06 a.m.	82 p.s.i.g.	67	4.6	37,800 cubic feet/day
12.33 "	200 "	118	8.0	48,600 " " "
1.30 "	389 "	189	12.9	37,000 " " "
2.30 "	523 "	134	9.1	25,000 " " "
3.30 "	543 "	20	1.36	3,700 " " "

6/3 - Details of pressure build-up in drill pipe

Corrected gauge - (1st Building)

2nd June - Shut in well. pressure 15 p.s.i.g.

Time	Minutes	Gauge pressure
11.48 p.m.	2 mins.	22 lbs.
11.50 "	4 "	27.5 lbs.
11.55 p.m.	9 "	43.5 "
12.00 "	14 "	59.5 "
12.05 a.m.	19 "	76 "
12.06 a.m.	20 "	82 "
12.10 "	24 "	94 "
12.15 "	29 "	114 "
12.20 "	34 "	130 "
12.25 "	39 "	150 "
12.30 "	44 "	170 "
12.33 "	47 "	200 "
12.45 "	59 "	215 "
1.00 "	74 "	279 "
1.15 "	89 "	337 "
1.30 "	104 "	389 "
1.45 "	119 "	436 "
2.00 "	134 "	470 "
2.15 "	149 "	498 "
2.30 "	164 "	523 "
2.45 "	179 "	530 "
3.00 "	194 "	535 "
3.15 "	209 "	540 "
3.30 "	224 "	543 "
3.45 "	239 "	543 "
8.45 "	539 "	543 "
9.00 "	554 "	545 "
9.41 "	595 "	545 "

6/4 Production through open end orifice meter

3rd June

9.41 a.m. Blew off gas pressure

	Temp.	Orifice	" Water	Production cubic feet per day
9.52 a.m.	57°F	3/4"	12"	50,000
9.57 "	"	1"	4.1/2"	54,000
10.02 "	"	"	5"	57,700
10.07 "	"	"	5.1/2"	60,500
10.12 "	"	"	6"	63,300
10.22 "	"	"	6.1/2"	65,800
10.32 "	"	"	7"	68,300
10.42 "	"	"	7.1/2"	70,700
10.47 "	"	"	8"	73,100
10.52 "	"	"	8.1/2"	75,300
11.02 "	"	"	9"	77,500
11.12 "	"	"	10"	81,600
11.32 "	"	"	11"	85,900
11.52 "	"	"	12"	89,800
12.12 p.m.	"	"	13"	93,600
12.27 "	"	"	14"	97,300
12.47 "	"	"	15"	101,000

6/5 Production from second build-up pressure in drill pipe

3rd June

12.50 p.m. Shut in well. Back pressure Nil.

	Back pressure	Pressure Rise lbs.	Pressure Rise atmospheres	Production rate (uncorrected for compressibility)
1.00 p.m.	93 p.s.i.g.	93	6.3	104,000 ft^3/day
1.15 "	230 "	137	9.3	102,000 "
1.30 "	358 "	128	8.7	95,000 "
1.45 "	441 "	83	5.5	62,000 "
2.15 "	500 "	59	4.0	22,000 "
3.00 "	524 "	24	1.63	6,000 "

6/6 F.H.P./Production data corrected for compressibility

Average F.H.P. p.s.i.g.	Back pressure Atm.abs.	Compressibility* factor (as for Methane)	Rate of Compressibility factors	Production rate cubic feet per day corrected for compressibility
	1	1.0		
47	7.3	0.987	1.013	105,400
162	16.7	0.972	1.015	103,500
294	25.4	0.956	1.017	96,500
400	31.0	0.947	1.019	63,200
470	35.1	0.940	1.008	22,200
512	35.7	0.939	1.002	6,000

* Note. The deviation factors have been taken from the A.I.O.C. Data book, basing on Methane @ 25 °C, table reference number He 4.

6/7 Corrected gauge (2nd build-up)

3rd June

12.50 p.m. Shut in well Pressure Nil.

Time	Minutes	gauge pressure
1.00 p.m.	10 mins.	93 lbs.
1.15 "	25 "	230 "
1.30 "	40 "	358 "
1.45 "	55 "	441 "
2.00 "	70 "	485 "
2.15 "	85 "	500 "
2.30 "	100 "	510 "
2.45 "	115 "	520 "
3.00 "	130 "	524 "

6/8 Data used to construct graph showing production rates

First production test - 2nd June

Time interval	Minutes	Mean	Total time	Production ft3/day
Flowing test				
9.14 a.m.- 9.21 a.m	7	3.1/2	3.1/2	2060
9.21 " - 9.33 "	12	6	9.1/2	360
9.33 " - 9.45 "	12	6	15.1/2	360
9.45 " - 9.53 "	8	4	19.1/2	720

Flowing test

9.53 a.m.- 10.03 a.m.	10	5	24.1/2	1440
10.03 a.m.- 10.09 "	6	3	27.1/2	2400
10.09 " - 10.15 "	6	3	30.1/2	3350
10.15 " - 10.31 "	16	8	38.1/2	6780
10.31 " - 11.00 "	29	14.1/2	53	9790
11.00 " - 11.30 "	30	15	68	18,610
11.30 " - 11.46 "	16	8	76	24,690

Initial build-up

11.46 a.m.- 12.06 a.m.	20	10	86	37,800

Second production test (By open end orifice meter)

Time	Minutes	Total time	Production ft^3/day
9.52 a.m.	0	0	50,000
10.02 a.m.	10	10	57,700
10.12 "	10	20	63,300
10.32 "	20	40	68,300
10.47 "	15	55	73,100
11.02 "	15	70	77,500
11.12 "	10	80	81,600
11.32 "	20	100	85,900
11.52 "	20	120	89,800
12,12 p.m.	20	140	93,600
12.27 "	15	155	97,300
12.47 "	20	175	101,000

c. RESERVOIR PRESSURE MEASUREMENTS

Reservoir Pressure Measurements were obtained during the tests on 30 th May and 2nd-3rd June whilst recording the pressure build-up in the drill pipe. Only the chart obtained on 2nd-3rd June was calibrated and therefore this result is considered first of all.

Test 2nd - 3rd June

Depth of measurement 1483'
Reservoir Temperature Not measured - Circa 60°F
Calibration temperature 59°F
Distance of R.P.measurement to base line 0.530"
Making the pressure at the 9148' contour 592 p.s.i.g.

Test 30th May

Depth of measurement 1454'
Reservoir Temperature Not measured Circa 60°F
No calibrations
Distance of R.P. measurement to base line 0.515"
Making the pressure at the 9177' contour 576 p.s.i.g.

(d) ANALYSES OF GAS SAMPLES

The analyses of gas samples received by Sunbury Research Station are as follows:

Mol. per cent as received.

Test Interval	Acidic gases	Oxygen	Methane	Ethane	Propane & heavier	Nitrogen
931'-992'	0.4	0.25	95.8	0.95	-	2.6
1022'-1055'	0.1	0.2	90.5	2.35	0.6	6.25
1238'-1291'	0.3	0.1	89.0	2.4	0.9	7.3
1442'-1485'	Nil	0.8	88.4	1.0	0.8	9.0
1471'-1520'	Nil	Nil	90.6	2.5	0.8	6.1

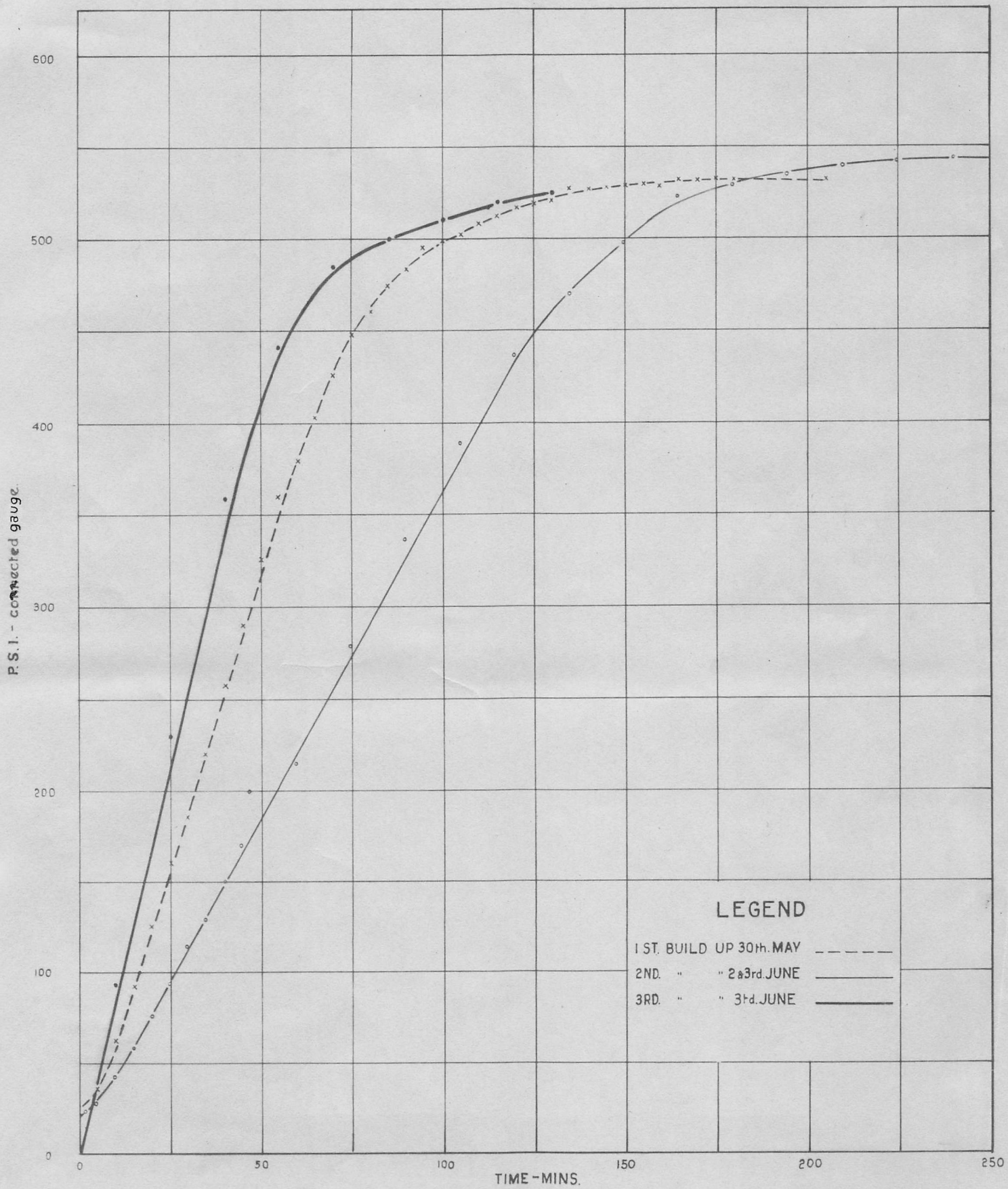
(e) ANALYSES OF WATER SAMPLES (carried out by W.W. Taylor B.Sc., F.R.I.C.)

Ref. No.	VL.	VI.	VK.	VM.	VN.	VQ.	VW
Sample	bailing	above T.V.	circ.mud	above T.V	above T.V.	above T.V.	above T.V.
Interval	280'-319'	490'-540'	490'-540'	750'-760'	1238'-1291'	1797'-1842'	1943-1995'
Parts per 10^5 Vols.							
Sodium	11.62	79.20	89.26	131.60	318.40	484.40	381.80
Potassium	0.85	0.28	1.13	3.10	2.54	11.01	6.49
Calcium	4.81	-	-	8.82	23.30	68.17	62.36
Magnesium	5.24	1.75	1.31	6.55	5.90	15.73	14.20
Chlorine	7.10	42.60	14.20	198.80	504.10	887.5	710.00
Sulphate	0.82	23.86	43.61	-	6.58	1.65	-
Carbonate	29.40	57.00	81.00	35.40	36.60	29.70	31.50
pH	8.20	9.10	9.25	8.10	7.70	7.30	7.30
S.G.@ 15.5°C	1.0004	1.0013	1.0016	1.0026	1.0060	1.0108	1.0095

Eakring
12.8.47
CMA/REE

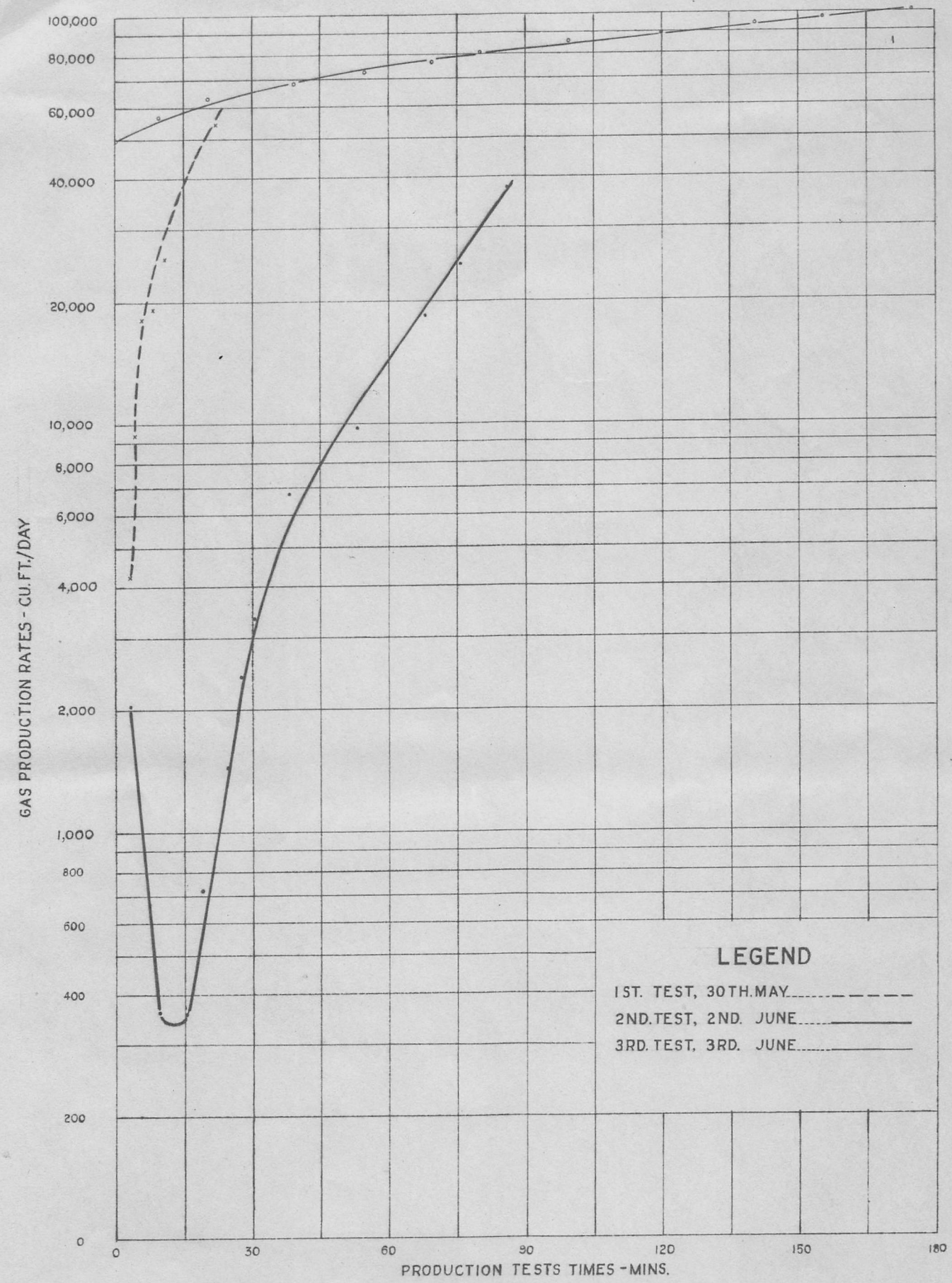
COUSLAND Nº 4 WELL

Drill stem pressure build up records obtained whilst testing the 1480'-1490' sand.



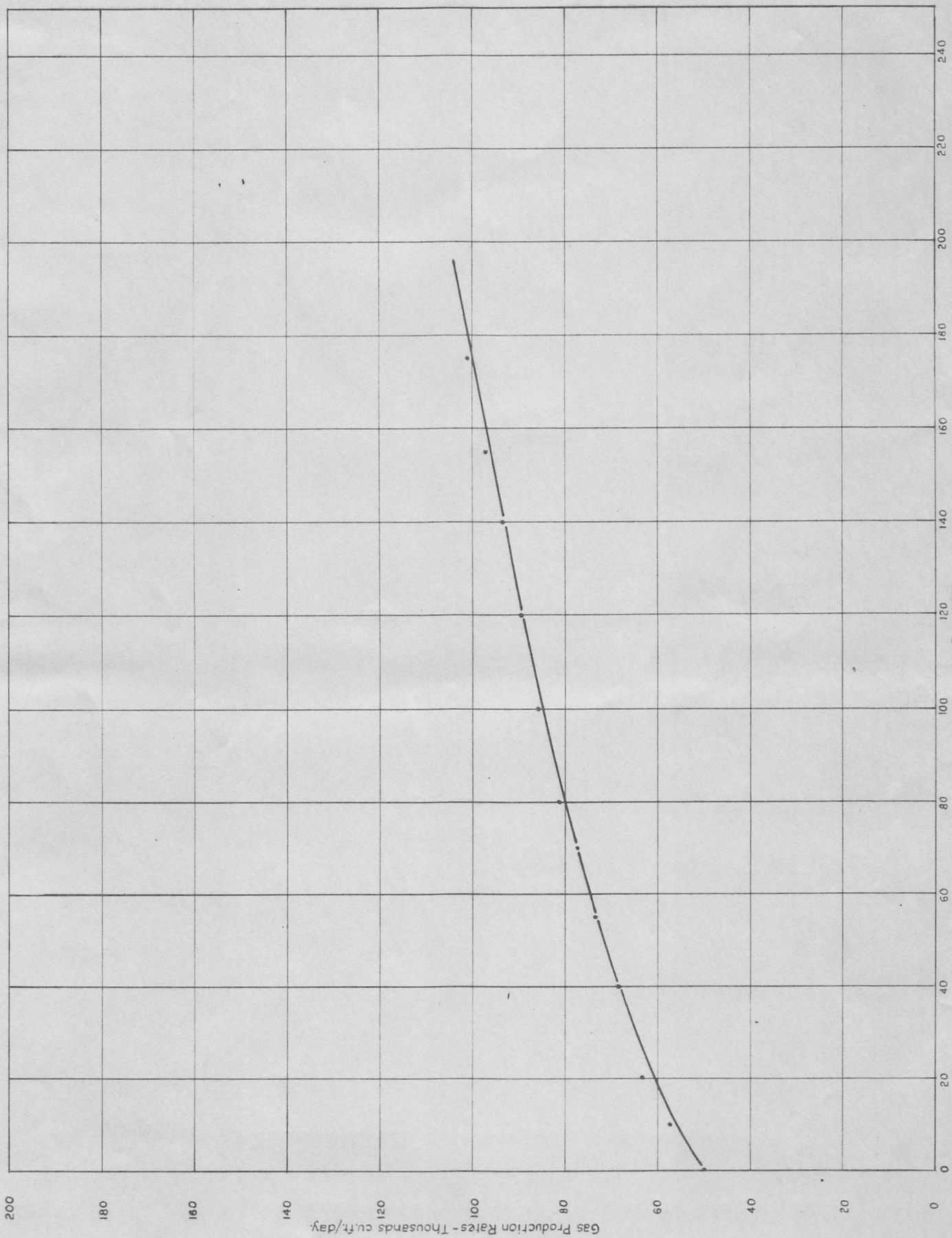
COUSLAND Nº 4 WELL

Graph showing production test results on 1480'-1490' sandstone.



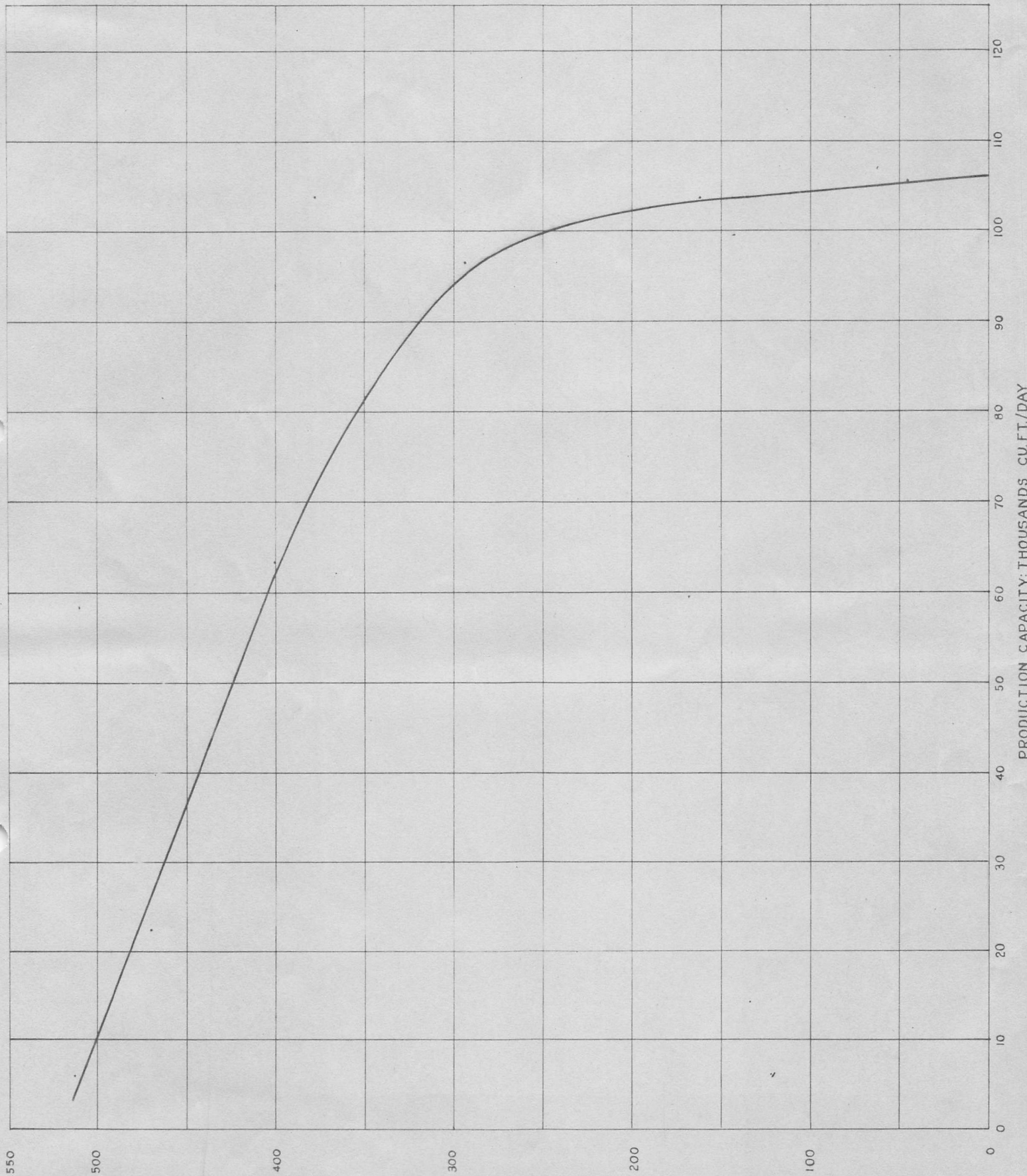
COUSLAND Nº 4 WELL

Production rates by open end orifice meter during final production test of 1480'-1490' sand.



COUSLAND Nº 4

Flowhead pressure/production graph calc. from final pressure build-up in dp whilst testing the 1480'-1490' sand.

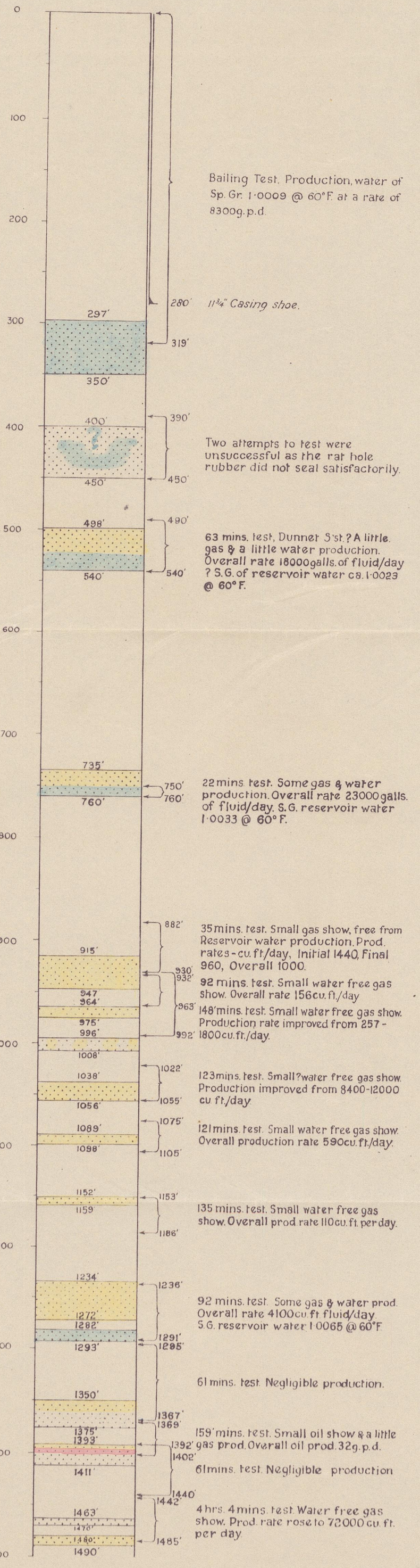


COUSLAND Nº 4 WELL

SCHEMATIC DIAGRAM

SHOWING

RESULTS OF TESTS.



Bailing Test
16th. April

Bailing Test. Production, water of Sp. Gr. 1·0009 @ 60°F. at a rate of 8300g.p.d.

280' 11¾" Casing shoe.

Packer Tests
Test 1 18th. April

Two attempts to test were unsuccessful as the rat hole rubber did not seal satisfactorily.

Test 2. 22nd. April

63 mins. test, Dunner S'st.? A little gas & a little water production. Overall rate 18000galls. of fluid/day ? S.G. of reservoir water ca. 1·0023 @ 60°F.

Test 3. 26th. April

22 mins. test. Some gas & water production. Overall rate 23000 galls. of fluid/day. S.G. reservoir water 1·0033 @ 60°F.

Test 4. 30th. April

35 mins. test. Small gas show, free from Reservoir water production. Prod. rates - cu. ft/day, Initial 1440, Final 960, Overall 1000.

Test 5. 2nd. May

92 mins. test. Small water free gas show. Overall rate 156cu. ft./day

Test 6 3rd. May

148 mins. test. Small water free gas show. Production rate improved from 257 - 1800cu. ft./day.

Test 7 7th. May

123mins. test. Small?water free gas show. Production improved from 8400-12000 cu ft./day.

Test 8 9th. May

121mins. test. Small water free gas show. Overall production rate 590cu. ft./day.

Test 9 13th. May

135 mins. test. Small water free gas show. Overall prod. rate 110cu. ft. per day.

Test 10 17th. May

92 mins. test. Some gas & water prod. Overall rate 4100cu. ft fluid/day. S.G. reservoir water 1·0065 @ 60°F.

Test 11 20th May

61 mins. test. Negligible production.

Test 12 22nd. May

159 mins. test. Small oil show & a little gas prod. Overall oil prod. 32g.p.d.

Test 13 28th. May

61mins. test. Negligible production

Test 14. 30th. May.

4 hrs. 4 mins. test. Water free gas show. Prod. rate rose to 72000 cu. ft. per day.

Test 15. 2,3rd June

Tests @ 2hrs. 32 mins. (b) 3hrs. 9mins. Water, free gas show. Prod. rate rose to 101,000cu. ft./day.

Test 16. 7th June

2hrs. 7mins test negligible prod.

Test 17. 10th June

4 hrs. 40mins. test. Small water, free gas show. Overall prod. rate 680 cu. ft./day.

Test 18. 12th June

2 hrs. 7mins. test. Small water free gas show. Overall prod. rate 174cu. ft./day.

Test 19. 17th. June

1 hr. 2mins. test. Negligible production.

Test 20. 19th. June

1 hr. 7mins. test. No production.

Test 21. 21st June

1 hr. 17mins. test. Some gas & water prod. Overall 11,500galls. fluid/day. Sp. Gr. reservoir water 1·0126 @ 60°F.

Test 22. 24th June

42 mins. test. Small water free gas show. Overall prod. rate 5800cu. ft./day

Test 23. 26th. June

42mins. test. Negligible production.

Test 24. 28th June

1 hr. 31 mins. test. Some gas & water prod. Overall rate 8,600galls. fluid/day S.G. Reservoir water 1·0091 @ 60°F.

LEGEND

GAS SAND.....

OIL SAND.....

WATER SAND.....

NOTE:- No gas/oil, gas/water, or oil/water levels are known. The demarcations shown are quite arbitrary and are only schematic.

D'ARCY EXPLORATION Co LTD	
GEOLOGICAL BR EAKRING	
AREA COUSLAND.	
REF:	
21 · 8 · 47	C.M. ADCOCK

...ence No. P.T. – 165 | Cousland | No. 4 | WELL

K.B. Elevation 631

TABULAR SUMMARY OF TESTS CARRIED OUT DURING April April May 1947

Casing 11 3/4" to 280 | Full Hole 8 5/8" to top of pilot hole | Pilot Hole 5 3/8" to bottom

A Interval tested | B Type of Packer used | C Horizons exposed

D Prodn. test time | E Overall time from setting rubber to pulling free

Pressure Records: Gauge: No gauge available | Element:

F Mud Column | G Reservoir pressure (1) falling (2) rising | H Initial p.d. across tester valve

Production from gas meter readings: Throughput (Cubic Feet, In Mins.); Production Rate Volumes per day (J Initial, K Final, L Overall; Cubic Feet, Gallons)

Production from fluid in drill pipe — Size: 4 1/2": M Feet, N Gallons, O Cubic Feet, P Vols/day (1) galls. (2) cu. ft.

Volume of Sump produced into the drill pipe — 5 3/8": Volume of Sump 4½ Gallons; No. of times Sump Volume obtained in drill pipe

Particulars of Fluid Samples — Circulating Fluid: Q p.h., R Perm., S Visc., T Dens.

Circulating fluid and drill stem samples: V Circ. Fluid, W Drill Stem (1) Top (2) Mid. (3) Bott.; % Water Sep. by settling; S.G. of Filtrate @ 60°F; Salinity parts 10^5 Chlorine; Indicator parts 10^5 dye

Test No.	Date of Test Month	Day	Casing / Full Hole / Pilot Hole / A Interval tested / B Type of Packer used / C Horizons exposed	D Prodn. test time	E Overall time from setting rubber to pulling free — Hours	Minutes	Bottom Hole Temperature Depth	°F	F Mud Column	G Reservoir pressure (1) falling (2) rising	H Initial p.d. across tester valve	P.S.I. Gauge	Throughput Cubic Feet	In Mins.	J Initial	K Final	L Overall	Production Rate Volumes per day Cubic Feet	Gallons	M Feet	N Gallons	O Cubic Feet	P Vols/day (1) galls. (2) cu. ft.	Data	Volume of Sump 4½ Gallons	No. of times Sump Volume obtained in drill pipe	Q p.h.	R Perm.	S Visc.	T Dens.	Data	V Circ. Fluid	W Drill Stem (1) Top (2) Mid. (3) Bott.	% Water Sep. by settling	S.G. of Filtrate @ 60°F	Salinity parts 10^5 Chlorine	Indicator parts 10^5 dye	REMARKS
1	18th		Pilot hole from:– 390' & 393' A (1) 390-450' (2) 393'-450' B Halliburton & rat hole C Calciferous Sandstone Series Sand 400-450'	D	–	–	–	–	F for	–										M	–	–	–	Q	9.5	V									Both tests unsuccessful, owing to the seat for the rat hole rubber breaking away. Sand was considered to be insufficiently important to warrant further testing.
				E	–	–	–	–	G(1)	–					J	–	–	N	–	–	–	R	15	W(1)									
									(2)	–					K	–	–	O	–	–	–	S	18	(2)									
									H						L	–	–	P(1)	–		–	T	1.05	(3)									
																		(2)	–															
2	22nd		Pilot hole from:– 490' A 490'-540' B Halliburton + rat hole C Calciferous Sandstone Series Dunnet Sandstone 498'-540'	D	1	3	–	–	F for	–			J	430	2700	M	102'	50'		Q	10	V	Nil	–	28	30	Possibly a little practically fresh water was produced, but the test gave no proof of this. There were indications of a little gas production, which may have accounted for the discolouration observed on the fluorescene. The concentrations were excessive & could only be measured by diluting the samples.
				E	1	26	–	–	G(1)	–					K	270	1700	N	50	48	1·0	R	7	W(1)	Nil	1·0030	48	30							
									(2)	–	12	60	L	290	1800	O	8			S	22	(2)	Nil	1·0029	38	30									
									H							P(1)	1040			T	1·20	(3)	Nil	1·0023	30	20									
																(2)	170																		
3	26th		Pilot hole from:– 750' A 750'-760' B Halliburton & rat hole C Calciferous sandstone series Sand 735-760 Sand to 760'	D	0	22			F for	–			J	5000	31,000	M	470'	10'		Q	9·5	V	Nil	–	14	32	The presence of a small gas show, & the production of reservoir water were proved in the test. The gas was lit as it bubbled up through the drill stem fluid, but no sample was collected.
				E	0	44	–	–	G(1)	–			K	1900	12,000	N	230	9	25	R	9	W(1)	Nil	1·0028	150	8									
									(2)	–	56	22	L	3650	23,000	O	37			S	19	(2)	Nil	1·0031	206	1									
									H							P(1)	15,000			T	1·22	(3)	Nil	1·0033	208	Nil									
																(2)	2400																		
4	30th		Pilot hole from:– 880' A 882'-930' B Halliburton + rat hole C Calciferous sandstone series Sand 915'-930'	D	0	35			F for	–			J	1440	9000	M	9'	50'		Q	9·5	V	Nil	1·0019	24	24	A small gas show was obtained in the test, apparently free from reservoir water production. A gas sample was not collected as it would have taken a further three hours to replace the volume of the drill (drill pipe
				E	0	58	–	–	G(1)	–			K	960	6000	N	4·4	48	1/11th	R	10	W(1)	Nil	1·0019	22	24									
									(2)	–	23	33	L	1000	6200	O	0·7			S	19	(2)	–	–	–	–									
									H							P(1)	–			T	1·18	(3)	Nil	1·0019	24	24									
																(2)	–																		
5			Pilot hole from:– A B C	D					F for				J			M				Q		V														
				E					G(1)				K			N				R		W(1)														
									(2)				L			O				S		(2)														
									H							P(1)				T		(3)														
																(2)																				

Reference No. P.T. – 165 Cousland No. 4 WELL

R.T. Elevation 631

TABULAR SUMMARY OF TESTS CARRIED OUT DURING May 1947

Casing 11 3/4" to 280
Full Hole 8 5/8" to top of p.h
Pilot Hole 5 3/8" to bottom

A Interval tested
B Type of Packer used
C Horizons exposed

D Prodn. test time
E Overall time from setting rubber to pulling free

F Mud Column
G Reservoir pressure (1) falling (2) rising
H Initial p.d. across tester valve

Pressure Records Gauge: R.P.G. - 3 amerada Element: 2200 lbs - 5041 B

Production from fluid in drill pipe Size: 4 1/2"

Test No.	Date of Test Month / Day	Pilot hole from:— / A Interval tested / B Type of Packer used / C Horizons exposed	Length of Test D / E Hours	Minutes	Bottom Hole Temperature Depth	°F	Pressure Records F / G / H	P.S.I. Gauge	Production from gas meter readings Throughput Cubic Feet	In Mins.	Production Rate Volumes per day J / K / L	Cubic Feet	Gallons	Production from fluid in drill pipe M / N / O / P Feet Galls. Cubic Feet Vols/day (1) galls. (2) cu. ft.	Data	Volume of Sump produced into the drill pipe Gallons	No. of times Sump Volume obtained in drill pipe	Particulars of Fluid Samples: Circulating Fluid Q p.h. R Perm. S Visc. T Dens.	Data	Circulating fluid and drill stem samples V Circ. Fluid W Drill Stem (1) Top (2) Mid. (3) Bott.	% Water Sep. by settling	S.G. of Filtrate @ 60°F	Salinity parts 10^5 Chlorine	Indicator parts 10^6 dye	REMARKS
1	2nd	Pilot hole from:— 931' A 932 - 963' B 4½" Halliburton & rat hole C Calciferous sst: Sands Sand 915 - 947'	D E 1	44	—	—	F for ' G(1) (2) H	No gauge available	10	92	J 720 - K 151 - L 156 -			M 9' N 4.5 O 0.72 P(1) — (2) 11.3		31'		Q 9.5 R 9 S 20 T 1.19		V — W(1) — (2) (3)	— — — Nil	— — — 1.0027	— — — 24	— — — 24	A small gas show was obtained, the mud in the drill stem being slightly 'gassy'. There was no indication of reservoir water production.
2	3rd	Pilot hole from:— 931' A 931' - 992' B 4½ Halliburton & rat hole packer C C.S.S. Sand 964 - 975' Sand from 996	D E 2	55	—	—	F for ' G(1) (2) H	No gauge available	72	131	J 257 - K 1440 - L 1790 - Max: 1800 —			M 39' N 19 O 3.1 P(1) — (2) 30		60'		Q 9.5 R 8 S 20 T 1.19		V W(1) (2) (3)	Nil Nil — Nil	1.0020 1.0028 — 1.0028	18 20 — 26	24 24 — 24	A gas show was obtained which improved during the production test, rates being measured over increments of 10 cubic feet meter throughputs. There was no indication of reservoir water production. A gas sample was collected ref: C4/1.
3	7th	Pilot hole from:— 1020' A 1022' - 1055' B 4½" Halliburton & rat hole C C.S.S. 1038 - 1056 dark Sand & Lst.	D E 2	3 16	1034'	62	F for ' G(1) (2) H	R.P.G-3 gauge now available for all tests.	76	15	J * 8,400 K * 9,600 L * 9,000 —			M 36' N 17.5 O 2.8 P(1) 20.5 (2) 32.7		33'	1/2	Q 9.5 R 8 S 18 T 1.17		V W(1) (2) (3)	Nil Nil — Nil	1.0023 1.0031 — 1.0031	48 62 — 66	16 12 — 12	The gas show obtained again improved throughout the production test. * Drill stem pressure rose to 3½ lbs during the production tests. Production rates calculated from a subsequent pressure build-up test increased to 12,000 cubic feet per day cubic feet per day. Possibly a little reservoir water was produced during the test. A gas sample was collected ref: C4/2.
		D Includes R.P. build-up time.							Pressure surveys (atmosphere in drill pipe) Record of pressure build-ups in drill pipe obtained.														
4	9th	Pilot hole from:— 1075' A 1075' - 1105' B 4½" Halliburton & rat hole packer C C.S.S. Sand 1089 - 1098	D E 2	1 17	1087'	66	F for ' G(1) (2) H	— — — —	49	119	J 580 - K 580 - L 590 -			M 10' N 5 O 0.8 P(1) — (2) 9.5		30'	1/5th	Q 9.5 R 9 S 20 T 1.20		V W(1) (2) (3)	Nil — — Nil	1.0026 — — 1.0017	16 — — 16	16 — — 16	A small gas show was obtained, with no definite indication of the production of reservoir water.
5	13th	Pilot hole from:— 1152' A 1153' - 1186' B Halliburton & rat hole packer C C.S.S. Sand 1152 - 1159	D E 2	15 31	1165'	67	F for ' G(1) (2) H	— — — —	10.4	135	J 960 - K 30 - L 110 -			M 11 N 5 O 0.8 P(1) — (2) 8.5		33'	1/5th	Q 9.5 R 9 S 22 T 1.24		V W(1) (2) (3)	Nil — — Nil	1.0023 — — 1.0007	36 — — 14	16 — — 12	Again a very small gas show was obtained with no definite indication of the production of reservoir water.

Reference No. P.T. – 165 | Cousland | No. 4 | WELL

R.T. elevation 631

TABULAR SUMMARY OF TESTS CARRIED OUT DURING May 1947

Casing 11¾" to 280' | Full Hole 8⅝" to top of pilot | Pilot Hole 5⅜" to bottom

A Interval tested | B Type of Packer used | C Horizons exposed

Test No.	Date of Test Month	Day	Length of Test D Prodn. test time / E Overall time from setting rubber to pulling free: Hours	Minutes	Bottom Hole Temperature: Depth	°F	Pressure Records: Gauge: R.P.G-3 Amerada; Element: 2200 – 5041 B; F Mud Column / G Reservoir pressure (1) falling (2) rising / H Initial p.d. across tester valve	P.S.I. Gauge	Production from gas meter readings: Throughput: Cubic Feet	In Mins.	Production Rate Volumes per day: J Initial / K Final / L Overall: Cubic Feet	Gallons	Production from fluid in drill pipe (Size: 4½"): M Feet / N Galls. / O Cubic Feet / P Vols/day (1) galls. (2) cu. ft.: Data	Volume of Sump produced into the drill pipe: Volume of Sump Gallons	No. of times Sump Volume obtained in drill pipe	Particulars of Fluid Samples: Circulating Fluid: Q p.h. / R Perm. / S Visc. / T Dens.: Data	Circulating fluid and drill stem samples: V Circ. Fluid / W Drill Stem (1) Top (2) Mid. (3) Bott.	% Water Sep. by settling	S.G. of Filtrate @ 60°F	Salinity parts 10^5 Chlorine	Indicator parts 10^6 dye	REMARKS
			Pilot hole from:– 1238'																					
			A 1238'–1291'	D	1	32		F for '	–			J	8600	–	M	196'	55'		Q	9.5	V	Nil	1.0013	22	16	Both gas & reservoir water were produced in this test.
			B Halliburton tester & rat hole packer				manometer	G(1)	–			K	2060	–	N	95	50g	2	R	9	W(1)	5%	1.0028	98	16	
6			C Calciferous sst. series	E	1	48	thermometer	(2)	–	99	35	L	4100		O	15.3			S	21	(2)	60%	1.0049	310	6	
1	17h		Sand 1234–1272				in hole	H	–						P(1)	1490			T	1.20	(3)	95%	1.0065	494	3	A gas sample was collected reference C4/3
			Sand from 1282'3												(2)	240									
			Pilot hole from:– 1295'																					
			A 1295'–1367'	D	1	1	No	F for '	–			J	58	–	M	5'	72'		Q	9.5	V	Nil	1.0023	24	64	
			B Halliburton tester & rat hole packer				thermometer	G(1)	–			K	Nil	–	N	2	66g	1/33	R	10	W(1)	–	–	–	–	
7			C C.S.S.	E	1	15	available	(2)	–	0.5	61	L	12	75	O	–			S	21	(2)	–	–	–	–	The horizon tested appeared to be too tight to be appreciably productive.
2	20h		Sand from 1350'					H	–						P(1)	–			T	1.24	(3)	Nil	1.0023	24	64	
															(2)	47									The high mud density was due to no bentonite being available for mud conditioning
			Pilot hole from:– 1368'																					
			A 1369'–1402'	D	2	39	No	F for '	–			J	103	640	M	7'	33'		Q	9.5	V	Nil	1.0021	24	48	The fluid in the drill pipe consisted of mud & a little oil, indicating that a small oil show had been proved. There was also a little gas production, but no evidence of reservoir water production.
			B Halliburton tester & rat hole packer				thermometer	G(1)	–			K	55	340	N	3.5	26g	1/7	R	10	W(1)	Nil	1.0021	18	48	
8			C C.S.S.	E	2	56	available	(2)	–	5.0	158	L	46	290	O	–			S	18	(2)	–	–	–	–	
3	22h		Sand from 1393'					H	–			slowest rate	30	190	P(1)	32			T	1.24	(3)	Nil	1.0020	26	48	
			oily from 1400												(2)	–									
			Pilot hole from:– 1390'																					
			A 1392'–1440'	D	1	1	No	F for '	–			J	6.5	41	M	–	–		Q	9.5	V	–	–	–	–	
			B Halliburton tester & rat hole packer				thermometer	G(1)	–			K	1.9	12	N	–	–	–	R	11	W(1)	–	–	–	–	
9	28h		C C.S.S.	E	1	16	available	(2)	–	0.15	60	L	3.6	23	O	–			S	18	(2)	–	–	–	–	In this test which included the whole of the oily sand, no appreciable production was obtained
4			Sand 1393'–1411'					H	–						P(1)	–			T	1.19	(3)	–	–	–	–	
															(2)	–									
			Pilot hole from:– 1441'																					
			A 1442'–1485'	D	4①	4	No	F for				J *	4,220	–	M	13'	43'		Q	9.5	V	Nil	1.0026	16	16	The gas show obtained on proved throughout the production test.
			B Halliburton tester & rat hole packer				thermometer	G(1)				K *	25,350	–	N	6.3	42g	1/7	R	12	W(1)	–	–	–	–	* Drill stem pressures rose to 12 lbs during the production test. Production rates calculated from a subsequent pressure build-up test increased to 72,400 cubic feet per day.
10	30h		C C.S.S.	E	4	27	available	(2) 1454'	576	14	21	L *	14,400 *	–	O	–			S	18	(2)	–	–	–	–	
5			Sand 1463–70					H		Production from Primary rise (atmosphere) in drill pipe					P(1)	–			T	1.17	(3)	Nil	1.0027	20	12	
			Sand from 1480	① Includes R.P. build-up time.						Record of pressure build-up: 13.6 in drill pipe obtained. –					(2)	–									There was no evidence of reservoir water production. Gas sample C4/4
										9.2 30 ③ 50,000 –															

* Pressure rise in drill pipe whilst producing through meter has been allowed for in production rate.

① Pressure rise 25 – 125 lbs i.e. 100 lbs.
② 125 – 325 lbs i.e. 200 lbs
③ 325 – 460 lbs i.e. 135 lbs.

Reference No. P.T. -165 | Courtland | No. 4 | WELL

R.T. Elevation 631

TABULAR SUMMARY OF TESTS CARRIED OUT DURING June 1947

Test No.	Date of Test Month / Day	Casing / Full Hole / Pilot Hole; A Interval tested; B Type of Packer used; C Horizons exposed	Length of Test: D Prodn. test time; E Overall time from setting rubber to pulling free — Hours	Minutes	Bottom Hole Temperature: Depth	°F	Pressure Records: Gauge / Element; F Mud Column; G Reservoir pressure (1) falling (2) rising; H Initial p.d. across tester valve	P.S.I. Gauge	Production from gas meter readings: Throughput Cubic Feet	In Mins.	Production Rate Volumes per day: J Initial; K Final; L Overall — Cubic Feet	Gallons	Production from fluid in drill pipe: Size; M Feet; N Galls.; O Cubic Feet; P Vols/day (1) galls. (2) cu. ft.	Data	Volume of Sump produced into the drill pipe: Gallons	No. of times Sump Volume obtained in drill pipe	Particulars of Fluid Samples: Circulating Fluid — Q p.h.; R Perm.; S Visc.; T Dens.	Data	Circulating fluid and drill stem samples: V Circ. Fluid; W Drill Stem (1) Top (2) Mid. (3) Bott.	% Water Sep. by settling	S.G. of Filtrate @ 60°F	Salinity parts 10^5 Chlorine	Indicator parts 10^6 dye	REMARKS
1	June 2½	Pilot hole from:— 1470' A 1471'-1520' B Halliburton & rat hole packer C C.S.S Sand 1480-1490 fine grained & oily	D (a) 2 32; (b) 3 9; E 18 22		No thermometer available		F for ' G(1) (2) 1483' 592 H		See details in test report		J See details K in test of L report		M 36' N 18 g O 2·9 P(1) (2)		See details in test report		Q — R — S 20 T 1·17		V (2) (3) W(1)	Nil Nil	1·0020 1·0024	24 24	12 6	Mud loss to formation 40 cubic feet during Sunday shut down. The connection to the formation broke free during the test. In the first production test the rate increased to 25,000 cubic feet per day, & in the second test the rate increased to 100,000 cubic feet per day.
2	July 7½	Pilot hole from:— 1521' A 1522'-1575' B Halliburton & rat hole packer C C.S.S 1522-23 (hard) 1532-44 (loose)	D 2 7; E 2 26		1534	63	F for ' G(1) (2) H		0.93	125	J 48 K Nil L 11	300 — 69	M 4·5' N 2·25 g O — P(1) 25 (2)		53' 49 g	1/22	Q — R — S 17 T 1·17		V (2) (3) W(1)	Nil Nil	1·0020 1·0020	20 18	6 6	The horizon tested appeared to be too tight to be appreciably productive. There was possibly a little gas production.
3	July 10½	Pilot hole from:— 1570' A 1571'-1604 B Halliburton & rat hole packer C C.S.S Sand from 1593' silty & grey at top	D 4 40; E 5 45		1583'	65	F for ' G(1) (2) H		132	280	J 5760 K 320 L 680		M 27' N 13·5 g O 2·2 P(1) 70 (2) 11		33' 32 g	1/2	Q — R — S 18 T 1·17		V (2) (3) W(1)	Nil Nil Nil	1·0051 1·0040 1·0040	64 60 68	8 4 4	A small gas show was obtained with no indication of the production of reservoir water.
4	July 12½	Pilot hole from:— 1604' A 1605'-1654 B Halliburton & rat hole packer C C.S.S 1617-1632' (sands 1651'-1654')	D 2 7; E 2 43		1617'	65	F for ' G(1) (2) H		15	124	J 1400 K 90 L 174		M 10' N 5 g O — P(1) 55 (2) 9		49' 47	1/10	Q 9·5 R 10 S 20 T 1·18		V (2) (3) W(1)	Nil Nil Nil	1·0014 1·0014	18 24	24 24	A small gas show was obtained with no indication of the production of reservoir water.
5	July 17½	Pilot hole from:— 1694' A 1706'-1751 B Halliburton & wall packer C C.S.S. 1710'-13' V. f.g. silty sst. interbedded 1733-1750 ssts & shales	D 1 2; E 1 21		1750'	66	F for ' G(1) (2) H		0.05	62	J Nil K Nil L Nil		M 6' N 1·5 g O — P(1) — (2) —		45' 25	1/17½	Q 9·5 R 10 S 20 T 1·17		V (2) (3) W(1)	Nil Nil Nil	1·0033 1·0020	16 8	12 6	The horizon tested appeared to be too tight to be productive.

Reference No. P.T. -165 | Courland | No. 4 | WELL

R.T. elevation 631

TABULAR SUMMARY OF TESTS CARRIED OUT DURING June 1947

Test No.	Date of Test Month / Day	Casing / Full Hole / Pilot Hole; A Interval tested; B Type of Packer used; C Horizons exposed	Length of Test: D Prodn. test time; E Overall time from setting rubber to pulling free; Hours; Minutes	Bottom Hole Temperature: Depth; °F	Pressure Records: Gauge: Element: F Mud Column G Reservoir pressure (1) falling (2) rising H Initial p.d. across tester valve; P.S.I. Gauge	Production from gas meter readings: Throughput Cubic Feet; In Mins.; Production Rate Volumes per day J Initial K Final L Overall Cubic Feet; Gallons	Production from fluid in drill pipe: Size: M Feet N Galls. O Cubic Feet P Vols/day (1) galls. (2) cu. ft.; Data	Volume of Sump produced into the drill pipe: Volume of Sump Gallons; No. of times Sump Volume obtained in drill pipe	Particulars of Fluid Samples: Circulating Fluid: Q p.h. R Perm. S Visc. T Dens.; Data	Circulating fluid and drill stem samples: V Circ. Fluid W Drill Stem (1) Top (2) Mid. (3) Bott.; % Water Sep. by settling; S.G. of Filtrate @ 60°F; Salinity parts 10^5 Chlorine; Indicator parts 10^6 dye	REMARKS
6 / ~~1~~	June 19h=	Pilot hole from:— 1741' A 1747'- 1802' B Halliburton & wall packer C C.S.S. Silts & no sands	D 1 7 E 1 26	1801' 66	F for ' G(1) (2) 0.32 67 H	J Nil K Nil L Nil	M 8' N 29 O - P(1) - (2) -	55' 30g 1/15h	Q 9.5 R 10 S 20 T 1.18	V Nil 1.0048 18 6 W(1) - - - - (2) - - - - (3) Nil 1.0049 20 6	The horizon tested appeared to be too tight to be productive.
-1 / ~~2~~	21 6h=	Pilot hole from:— 1792' A 1797'- 1842' B Halliburton & wall packer C C.S.S. 1827'- 32' - Sst.	D 1 17 E 1 38	1841' 67	F for ' G(1) (2) 99 77 H	J 2880 K 960 L 1850 11,500	M 996 N 485 O 78 P(1) 9100 (2) 1460	45' 25 19	Q R S T	V Nil 1.0048 26 6 W(1) 5% 1.0051 28 6 (2) 95% 1.0123 776 1/2 (3) 100% 1.0126 804 Nil	Both gas & reservoir water were produced during the test, the gas bubbling up through the water in the drill pipe.
8 / ~~3~~	24h=	Pilot hole from:— 1822' A 1843'- 1868' B Halliburton & wall packer C C.S.S. 1854 -58' 1868'- 71' from 1882'	D 0 42 E 1 5	1887' 67	F for ' G(1) (2) 140 35 H	J 5800 K 5800 L 5800	M 25 N 6.4 O 1 P(1) — (2) 34	45' 25 1/4	Q 9.5 R 9.5 S 19 T 1.18	V Nil 1.0016 24 1 1/2 W(1) - - - - (2) - - - - (3) Nil 1.0016 28 1 1/2	A small gas show was obtained with no indication of the production of reservoir water.
9 / ~~4~~	26h=	Pilot hole from:— 1822' A 1889'- 1940' B Halliburton & wall packer C C.S.S. 1880- 96 1924'- 31'	D 0 42 E 0 59	1939' 69	F for ' G(1) (2) 0.03 42 H	J Nil K Nil L Nil	M 7' N 1.8g O P(1) (2)	51' 28g 1/16h	Q 9.5 R 11 S 20 T 1.18	V — — — — W(1) — — — — (2) — — — — (3) — — — —	The horizon tested appeared to be too tight to be productive.
10 / ~~5~~	28h=	Pilot hole from:— 1822' A 1943'- 1995' B Halliburton & wall packer C C.S.S. 1972'- 90'	D 1 31 E 1 50	1994' 73	F for ' G(1) (2) 86 90 H	J 1920 K 910 L 1380 8600	M 528 N 215 O 34.5 P(1) 3400 (2) 546	52' 28g 7.7	Q 9.0 R 11 S 18 1/2 T 1.17	V Nil 1.0016 44 16 W(1) Nil 1.0018 48 12 (2) 95 1.0065 496 1 1/2 (3) 100 1.0091 710 1/2	Both gas & reservoir water were produced during the test.

43

WR/Cous/4/T.2.

o.846.

Copy

Job No. 1825/02.

From Research Department, SUNBURY.

To Production Department, (Refining Branch.)

Our Ref. S/L.1003/47 Your Ref. Date 25th June, 1947.

Subject GAS SAMPLES FROM COUSLAND NO. 4 BOREHOLE. (Reference C4/4 and C4/5.)

WR/Scot/T.46

Two samples of natural gas were received from the D'Arcy Exploration Company with a request for a quantitative analysis of each (reference Memo. DEC/300/PE dated 6th June, 1947.) Further details contained in the latter are given below:-

Ref. C4/4. This sample, contained in a 5 litre cylinder, had been collected on 30th May after a formation test over the interval 1442' - 1485', of sandstones from 1463' - 1470' and from 1481' to bottom. The memo stated that the cylinder had been filled at a pressure of 530 lbs., but only a pressure of 280 p.s.i. was recorded at Sunbury.

Ref. C4/5. This sample, contained in a 2½ litre cylinder, had been collected on 3rd June after a formation test over the interval 1471' - 1520', of sandstones from 1481' - 1490' and from 1497' - 1505'. It was stated that the cylinder had been filled at a pressure of 550 lbs and a value of 500 p.s.i. was present just prior to analysis.

The following results were obtained:-

/.....2.

Constituent.	Podbielniak analysis - mol. per cent - as received. C4/4.		C4/5.	
Acidic gases (CO_2, H_2S)	nil		nil	
Oxygen	0.8		nil	
Methane	88.4		90.6	
Ethane	1.0	90.2	2.5	93.9
Propane and heavier	0.8		0.8	
Nitrogen	9.0		6.1	
	100.0		100.0	

The above results were telephoned to Eakring on the 23rd instant and also confirmed by letter.

DJL.

CAM/JG.

D.A. Howes.

(3) Well 4 Reservoir Waters

Interval	750'-760'	1238'-1291'	1797'-1842'	1943'-1995'
Sand	735'-760'	1234'-1293'	1827'-1832'	1972'-1990'
S.G. @ 60°F.	1.0033	1.0065	1.0126	1.0091
Solids per 10^5	384	897	1498	1206
Gram Equivalents				
Sodium (& K)	5.80	13.92	21.35	16.77
Calcium	0.44	1.16	3.40	3.11
Magnesium	0.54	0.48	1.30	1.17
Chlorides	5.60	14.21	25.03	20.02
Sulphates	-	0.14	0.03	-
Carbonates	1.18	1.22	0.99	1.05
Ionic %				
Sodium (& K)	42.8	44.7	41.0	39.8
Calcium	3.2	3.7	6.5	7.4
Magnesium	4.0	1.6	2.5	2.8
Chlorides	41.3	45.7	48.0	47.5
Sulphates	-	0.4	0.1	-
Carbonates	8.7	3.9	1.9	2.5
Sunbury Ref. (or W.W.T.)	W.W.T.	W.W.T.	W.W.T.	W.W.T.
Remarks:	Good sample of edge-water. Some 25 sump volumes prod. into d.p. Fluorescein decreased from 32 to Nil parts. Gas produced.	Probably some contamination with drillg. mud. Some 2 sump volumes produced into d.p. Fluorescein decreased from 16 to 3 parts. Gas produced.	Good sample of edge-water. Some 19 sump volumes proded. into d.p. Fluorescein decreased from 6 to Nil parts. Gas proded.	Fairly good sample of edge-water. Some 8 sump volumes prod. into d.p. Fluorescein decreased from 16 to ½ part. Gas produced.

1.11.47.

CA/103

Reference TOB/10

Formation Characteristics from Core Analysis

Report 2.

This report should be read in conjunction with Report 1 in the series.

1. Summary

Core tests were carried out during the drilling or deepening of the following wells:

Eakring: 75, 179, 180, 181, 182.

Farndon: 1. Cousland: 4.

Average figures for porosity, permeability and oil and water saturation were obtained for the following sands:

Eakring — Sandstone 'E', Rough Rock, Longshaw grit, Chatsworth grit, Kinderscout grit, Lower Carboniferous group (limestone and sandstone treated as one group).

Farndon — Rough Rock equivalent.

Cousland results do not warrant this form of presentation.

Eakring 75, a deepening operation in Rough Rock, was cored with oil as drilling fluid. The average oil and water saturation figures show no striking departure from those of Eakring 181, the nearest well drilled with a water base fluid, but in this connection it should be noted that the average permeability of the Rough Rock in both these wells was below 10 millidarcys, confirming the view that core contamination by drilling fluid is negligible for these low-permeability sands.

Fluoresceine has been used as a core contamination tracer in all wells drilled with water base fluid excepting Cousland 4 and Farndon 1, an effort being made to keep up the concentration in the mud to 100 parts per million by weight, the highest practicable concentration. Results show that cores will absorb the fluoresceine

without absorbing the drilling fluid. The use of fluorescsine as a drilling fluid contamination tracer has therefore now been discontinued.

2 Presentation of Results

Individual cores tests are shown in tables 3 to 9.

Average figures for each formation are shown in tables 1 and 2.

2.1 Core recovery

The assumptions made in the first report in this series as to allocation, in the succession, of unrecovered core, and also representative core sampling, are continued in this report.

2.2 Impermeable Bands in Permeable Strata: The Pay Factor

In Rough Rock particularly, and to a lesser extent in other Eakring reservoir formations, the occurrence of impermeable shale and fireclay 'lenses' necessitates the division of the core log into 'pay' and 'non-pay' systems. 'Pay' is defined here as a formation permitting easily measurable fluid flow under laboratory conditions, i.e. having a gas permeability of more than 0.1 millidarcys. 'Non-pay' is defined as 'impermeable' formation, i.e. having a permeability considerably less than 0.1 millidarcys.

Core tests are not carried out on formation which is obviously non-pay, since although they may contain a high proportion of connate water, it cannot be produced into a well. Non-pay is therefore assumed to have zero porosity, permeability and oil and water content.

Table 1 shows an analysis of pay data for each sand in each well cored.

To facilitate comparison of the results for the whole formation in one well with those from other wells having different lens systems, the average figures for pay formation only (from table 1) are multiplied by the 'pay factor' which is the ratio of feet of pay sand to feet of total formation (pay plus non-pay), and shown in table 2. Oil/water ratios are not adjusted in this manner, since the pay factor in both numerator and denominator of the ratio cancels out.

2.3 Averaging of individual results for many samples

The average figures for oil/water ratio and oil reserves are the average of data determined on each sample, and do not necessarily bear any fixed relation to the ratio or the product of the average porosity and oil saturation figures for the whole formation. This is justified by the statistical law which states in effect the average of several products is not necessarily equal to the product of several averages.

A simple example will clarify this rather important point.

	A	B	A x B
	1	2	2
	2	3	6
	3	4	12
Average	2	3	6.67

The average of all As is 2. The average of all Bs is 3, so that the product of these is 6; but the average of all A x Bs is 6.67. Where A represents porosity, B represents oil saturation and A x B represents oil reserves, then 6.67 and not 6 is the figure most representative of any given formation interval. Thus A x B is worked out for every core sample, and averaged to give mean oil reserves. A similar reasoning is applied to oil/water ratios.

In practice, the discrepancy between the two averages may be as much as 100% for oil/water ratios (Eakring 181 Rough Rock, and 12% for oil reserves (Eakring 181 Lower Carboniferous group).

2.4 Graphical Results See figs. 1 to 7.

The results from tables 3 to 9 are shown graphically in figs. 1 to 7. Formation logs are included.

A small arrow indicates anomalous results, i.e. where the total measured fluid content is greater than the effective porosity, 100% fluid saturation is assumed and porosity and oil and water saturation figures are adjusted accordingly.

2.5 Well site map. See fig. 8

This map shows the relative positions of all wells cored, in the Eakring field only, since the deepening of Eakring 7.

3. Interpretation of Results:

3.1 Use of tables 1 and 2

When comparing the characteristics of the same formation in different wells, it must be borne in mind that the 'quality' of a formation, that is, its capability of producing oil or receiving injected water or gas, is dependent on two factors: (a) The amount of impermeable strata in the whole formation and (b) The characteristics of the pay sand alone. Deterioration in the quality of a formation may thus be due to a decrease in the pay factor, or to decrease in the porosity or permeability or oil saturation characteristics of the pay sand only, or to both (viz. Eakring 182).

Thus table 1 will indicate the effects of changes in condition (b) only, and table 2 will indicate changes in both conditions (a) and (b) at the same time.

3.2 Productivity Index

Unfortunately, the factor which determines the quality of a well from the oil producing viewpoint only, (i.e. the productivity index, which relates the three measured quantities of porosity, permeability and saturation) cannot at present be evaluated until work is carried out on the relationship between the

gas permeability (which is tabulated here) and water permeability, and also on relative permeabilities for the three-phase system gas-oil-water for varying degrees of saturation with each phase.

However, a maximum flow may be calculated for each well as follows, without taking saturation figures into account:

$$\text{Maximum flow} = \frac{3.07 h \times k \times \Delta P}{\mu \log 10 \frac{R}{Y}} \quad \text{bbls/day}$$

where h = total formation thickness - feet
k = average gas permeability - darcys.
ΔP = pressure differential P.S.I. between reservoir and bottom-hole.
μ = fluid viscosity under reservoir conditions - centipoises.
R = drainage radius - feet
Y = well bore radius - feet

This is Muskats modification of D'Arcy's Law, for radial flow of a homogeneous fluid. It should show a higher rate of production than steady-flow production tests, due to the high value of permeability measured in the laboratory, and also to the assumption of 'maximum flow' i.e. 100% fluid saturation of the pore space. The formula has been used on Eakring 7, 179 and 180 with the following results:

Well No.	Packer Test Production G.P.D. Fluid	Calculated Maximum Flow G.P.D. Fluid
7	63	17
179	1230	458
180	640	353

Fluid viscosity at formation temp. assumed to be 10 centipoises in each case.

800-foot drainage radius assumed in each case. This quantity is not critical.

It is generally agreed that, except for very large or very small producers, packer tests indicate about 3 times the steady-flow fluid production rate. This tends to bring the calculated and actual fluid production rates into line. Comparison of these calculated and measured rates for all wells will be shown in a further report.

4 Work in hand

Eakring 74: All tests completed except porosity.
" 183: Saturation tests only completed.
" 76: " " " in progress.

5. Development of Testing Procedure

The following apparatus is on order from Sunbury:

Toluene Extraction apparatus This is hoped to eliminate the retort method of saturation testing, which required calibration to determine the loss of oil due to coking in the retort.

Improved porosimeter It is expected that porosity measurements may be made with this apparatus without bringing the sample into contact with mercury as at present. Repetition accuracy measurements for both porosity and permeability may then be made. This is impossible at present since core sample pore spaces are filled with mercury during porosity measurements.

No increase in the absolute accuracy of testing is envisaged.

TAOB/REE
Eakring
12.11.47

TABLE 1

Formation Characteristics from Core Analysis.

Analysis of results for Pay Formation only ⊕ See Table (2) for weighted figures.

N = No. of Samples tested.

Formation	Well	Formation Thickness Feet	Feet Cored	Effective Porosity Vol.%				Permeability Millidarcys				Oil - Water Ratio				% Pore space Oil-filled				% Pore space Water-filled				Oil Reserves per Acre-Ft.		Remarks
				N	Max	Min	Mean	N	Max	Min	Mean	N	Max	Min	Mean	N	Max	Min	Mean	N	Max	Min	Mean	Bbls	Tons	
SANDSTONE 'B'	180			1	-	-	8.3	1	-	-	0.3	0	-	-	-	0	-	-	-	0	-	-	-	-	-	
	181	10	10	5	24.4	18.3	22.7	5	1200	2.0	468	5	2.1	0.5	1.0	5	23	7	14	5	23	9	17	247	33.1	
ROUGH ROCK	75	53	40	28	17.6	5.3	11.3	23	883	0.0	6	28	1.6	0.0	0.5	28	42	0	16	28	100	14	54	152	23.5	
	179	67	67	20	21.0	6.1	14.1	19	65	0.3	22	20	2.4	0.0	1.0	20	30	0	20	20	77	9	32	220	29.5	
	180	58	47	36	23.4	4.1	14.0	33	47	0.1	12	36	1.3	0.0	0.4	36	44	0	14	36	95	5	43	160	21.5	
	181	75	60	29	21.6	(3.5)	11.4	26	35	0.1	4.4	31	2.1	0.0	0.6	29	42	0	16	29	96	14	48	157	21.0	
	182	79	79	30	18.3	3.8	12.0	27	30	0.1	9.9	29	0.7	0.0	0.2	29	32	0	11	29	100	35	68	103	13.8	
LONGSHAW GRIT	181	31	26	17	27.7	13.2	20.1	17	1140	0.6	329	17	1.4	0.4	0.8	17	26	9	18	17	50	10	25	266	35.6	
CHATSWORTH GRIT	181	214	39	22	26.9	(9.8)	17.5	22	54	0.1	16	23	0.9	0.1	0.4	22	34	4	15	22	(80)	20	44	196	26.2	
KINDERSCOUT GRIT	179	42	36	14	19.5	9.0	14.0	14	251	0.1	71	14	5.0	0.0	1.0	14	55	0	25	14	69	1	37	265	35.5	
	181	2	2	3	15.8	15.0	15.3	3	2.3	0.5	1.3	3	1.2	0.7	1.0	3	20	18	19	3	27	15	20	226	30.3	Kinderscout Member 'A'.
LOWER Carboniferous	181	33	12	6	15.2	2.7	5.6	6	0.5	0.1	0.2	6	0.5	0.0	0.2	6	18	0	10	6	(90)	8	53	48	6.4	Includes Limestone & Sandstone
ROUGH ROCK EQUIVALENT	F1	62	42	10	22.7	17.7	20.8	9	494	30	165	10	0.05	0.01	0.03	10	4	0	2	10	96	34	72	33	4.4	Farndon well

Conversion Factor Bbls to Tons, = 0.134, Based on Average Kakring Crude Factor of 261 Galls/ton.

TABLE 2

FORMATION CHARACTERISTICS FROM CORE ANALYSIS

Average Figures for total cored interval, corrected according to 'pay factor'.

Formation	Well	Formation Thickness Feet	Feet Cored	Feet Pay (in cored interval)	Pay Factor	Corrected Porosity %	Corrected Permeability MilliDarcys	Oil/Water Ratio	Corrected % Pore Space Oil-filled	Corrected % Pore Space Water-filled	Corrected Oil Reserve Per Acre-Ft.		Remarks
											BBLS.	TONS	
SANDSTONE 'B'	181	10	10	10	1.00	22.7	468	1.0	14	17	247	33.1	
ROUGH ROCK	75	53	40	31	0.78	8.7	4.6	0.5	12	42	118	15.8	
	179	67	67	52	0.78	10.9	17	1.0	16	25	171	22.9	
	180	58	47	35	0.75	10.4	8.6	0.4	10	32	119	15.9	
	181	75	60	49	0.82	9.3	3.6	0.5	13	39	129	17.3	
	182	79	79	54	0.68	8.2	6.7	0.2	7	46	91	12.2	
LONGSHAW GRIT	181	31	26	26	1.00	20.1	329	0.8	18	25	266	35.7	
CHATSWORTH GRIT	181	214	39	39	1.00	17.5	16	0.4	15	44	195	26.3	
KINDERSCOUT GRIT	179	42	36	24	0.67	9.3	48	1.0	17	25	177	23.7	
	181	2	2	2	1.00	15.3	1.3	1.0	19	20	226	30.3	KINDERSCOUT MEMBER 'A'
LOWER CARBONIFEROUS	181	33	12	12?	1.00	5.6	0.2	0.2	10	53	48	6.4	INCLUDES LIMESTONE AND SANDSTONE
ROUGH ROCK EQUIVALENT	F1	62	42	32	0.76	15.8	126	0.03	1.5	55	25	3.3	FARNDON WELL

CONVERSION FACTOR, BBLS. TO TONS, = 0.134, BASED ON AVERAGE EAKRING CRUDE FACTOR OF 261 GALLS/TON.

Individual Core Tests

Tables 3 to 9

1) Porosity is the effective pore space, i.e. is due to communicating pores only, and is represented as a volume percentage.

2) Permeability K is the gas permeability measured with dry nitrogen, in millidarcys.

3) Bracketed figures

Where, due to unrepresentative sampling, 'fluid/100 gms.' is greater than 'pore volume/100 gms', then the fluid figures are assumed to be correct and 100% fluid saturation of the available pore space is assumed, so that porosity figures are increased and '% pore space oil and water filled' figures are decreased accordingly. These adjusted figures are shown in brackets, and are used in the calculation of average data.

Figures 1 to 7

1) Small arrows in the oil/water ratio column indicate anomalous results as in (3) above. The bracketed figures of tables 3 to 9 are used here.

3) Permeabilities are shown on a logarithmic scale. Permeability profiles for a formation may then be conveniently classified into the following permeability ranges:

less than	0.1	millidarcys
0.1	- 1	"
1	- 10	"
10	- 100	"
100	- 1000	"

TABLE (9)

COUSLAND 4

Cored with mud; oil and water figures tentative, pending special retort calibration.

Sample No.	Assumed Depth Feet	ml.per 100 GMS. DRY SAND Oil	Water	Fluid	Pore Vol.	OIL WATER	Porosity %	K mD.	% Pore Space OIL	WATER	Remarks
CD2	299	1.6	0.7	2.3	3.7	2.3	6.9	0.0	43	19	
CD1	301	1.9	3.2	5.1	6.1	0.6	14.2	1.8	31	53	
CD5	307	2.2	3.1	5.3	8.0	0.7	17.8	3.4	28	39	
CD3	310	0.3	3.3	3.6	-	0.1	-	-	-	-	
CD4	318	0.2	2.6	2.8	5.6	0.1	13.2	0.2	4	46	
CD12	496	0.0	3.6	3.6	9.4	0.0	29.5?	-	0	38	
CD13	498	-	-	-	5+1	-	13.8	1.9	-	-	
CD14	500	1.2	4.5	5.7	2.4 (5.7)	0.3	6.0 (14.2)	0.0	50(21)	188(79)	
CD15	507	0.6	3.8	4.4	7.4	0.2	16.2	12.3	8	51	
CD6	750	1.1	2.9	4.0	3.7 (4.0)	0.4	8.6 (9.3)	0.2	30(27)	79(73)	
CD11	750.5	0.0	1.8	1.8	8.0	0.0	17.6	10.8	0	23	
CD7	880	-	-	-	7.2	-	17.8	1.1	-	-	
CD8	931	0.4	2.4	2.8	4.2	0.2	10.0	0.3	10	57	
CD9	934	0.4	2.9	3.3	7.0	0.1	7.0	0.4	6	42	
CD10	936	0.0	1.9	1.9	4.1	0.0	9.8	0.3	0	46	
CD16	942	0.0	1.9	1.9	5.1	0.0	12.0	0.6	0	37	
CD17	943.5	0.0	2.1	2.1	2.6	0.0	6.4	0.2	0	81	
CD18	1160	0.3	0.5	0.8	1.4	0.6	3.4	0.4	21	36	
CD19	1243	00	1.9	1.9	7.4	0.0	16.4	170	0	26	
CD20	1247.5	-	-	-	-	-	-	-	-	-	Silty Fireclay
CD21	1486	0.0	1.8	1.8	7.3	0.0	16.1	43	0	25	
CD22	1487.5	0.3	2.0	2.3	6.1	0.2	14.2	1.2	5	33	
CD23	1489	0.1	2.9	3.0	3.6	0.03	8.8	-	3	81	
CD24	1524	0.6	1.3	1.9	-	0.5	-	-	-	-	
CD25	1540	1.0	0.9	1.9	2.3	1.1	5.6	0.1	44	39	
CD26	1594	0.1	0.4	0.5	3.2	0.3	7.7	0.8	3	13	
CD27	1595	0.3	0.4	0.7	5.1	0.8	11.8	6.0	6	8	
CD28	1597	0.2	0.9	1.1	-	0.2	-	-	-	-	
CD29	1598.5	0.2	1.4	1.6	5.4	0.1	12.2	9.8	4	26	
CD30	1600	0.5	1.3	1.8	5.8	0.4	13.1	33	9	22	

FIG.7

COUSLAND 4 (CORED WITH MUD)

OIL AND WATER FIGURES
PENDING SPECIAL RETORT CALI

SAMPLES CD1 – CD30