DEPARTMENT OF ENERGY
Thames House South, Millbank, LONDON, SW1P 4QJ
Telephone: Direct Line 01-211 4137
Switchboard 01-211 3000

Dr R B Nicholson FRS
Cabinet Office
70 Whitehall
SW1A 2AS

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Dear Robin

PM's SEMINAR

We spoke about the Weir down-hole pump, and I promised to let you have a little background ... information, enclosed herewith.

Yours ever

Bobby

J A CATTERALL
Head, Energy Technology Division

A.D.C.O PUMPSET PERFORMANCE SUMMARY

Downhole Pump

Pumped fluid	-	Highly Saline Water Total dissolved solids 260,000 PPM
Flow	-	405 GPM (16,600 BPD)
Generated Head	-	1485 ft
S.G.	-	1.14
B.H.P.	-	315
Pump Stages	-	7
Speed	-	9200 RPM
Setting Depth	-	3340 ft below surface

Downhole Turbine

Power fluid	-	Produced Water
Flow	-	310 GPM (12,700 BPD)
Turbine Δ H	-	4545 ft
Turbine Stages	-	7

from Weir house magazine
Summer 1982

BIRTH OF A PUMP

A million pounds is a nice round sum. Weir's new pump could save it in a year.

One day in 1979 the Offshore Supplies Office suggested that Weir Pumps Ltd. might care to get in touch with BP. It seemed they had problems. The downhole pumps they were experimenting with were failing at an alarming rate, and they needed something better. Perhaps Weir Pumps could help.

This is what emerged when the two companies met.

All North Sea wells were delivering their oil to the surface naturally, by their own pressure; but this would not continue indefinitely. As pressures dropped, water injection would have to be used, possibly followed by enhanced recovery techniques; but the day was bound to come when nothing would work but direct pumping. The trouble was that the pumps BP had been trying broke down in as little as two months. Could Weir Pumps please go away and think about it; and if they came up with something promising, BP might be prepared to underwrite part of the development costs.

The facts facing Weir Pumps' designers were formidable.

First of all, no pump working from the surface by suction could raise anything more than one atmosphere, say around 30 feet, so whatever pump was devised would have to work from the bottom of the hole and push the oil upwards. The logical way of doing this appeared to be the conventional way — lower an electric pump to the bottom and power it by a cable running down the hole. Yet, as the spate of breakdowns showed, this was a method with a great deal against it. By their very nature the facts added up to failure. The argument went like this.

The oil had to be raised anything from 2,000 to 5,000 feet, *therefore* comparatively high pressure would be needed, *therefore* the pump would have to be multistage, each stage pushing the oil on to the next until the required pressure was achieved. How many stages? That depended on two things, the diameter of the pump and its speed. Neither could be increased: the well was $9\frac{5}{8}$ inches in diameter and that was that; and the 60 cycle generators on most production platforms meant that the speed of the downhole electric motors was restricted to 3600 RPM and no faster. *Therefore* there would have to be a great many slow impellers. How many? Anything from 100 to 300, depending on the well pressure.

Therefore the pump would have to be a skinny monster, sometimes as much as 60 feet long connected by a 20 foot sealing section to a motor 60 feet long, a flexible contraption with sensitive insulation and an easily damaged cable which would somehow have to remain waterproof thousands of feet under the sea at temperatures of 100 degrees C or over, with sand wearing the seals and salt water constantly threatening the motor.

Furthermore, such a pump would be too long to transport in one piece, *therefore* it would have to be assembled on the platform, which meant risk of damage; *and* because there might be a dozen or more wells drilled from the same platform, all splaying outwards to cover the biggest possible area, the entire 140 foot assembly would have to be manoeuvred down a slanting hole.

This was conventional thinking. All electric submersibles worked like that. Could there be a different solution?

Two months later Weir Pumps came back with an answer BP were prepared to support. In the end they and Weir were joined by the Offshore Supplies Office and the British National Oil Corporation in a four-way partnership, all contributing equally to a £$1\frac{1}{2}$ million development programme. The prototype ran in Weir Pumps' Alloa

Right: Fitting the suction adaptor at the Alloa plant of Weir Pumps Ltd.

laboratory a little over a year later, in March 1981. It was a complete success.

The basis of Weir Pumps approach was to abandon electricity with all its problems of insulation, power and speed limitations and water-proofing. A very high pressure hydraulic motor, volume for volume, could be designed to produce at least 30 times as much power as an electric motor, so why not use one? There would be no need to make the pump bigger in order to get more work out of it. With virtually unlimited hydraulic power, easily installed on a production platform, downhole output could be boosted simply by making the motors run much faster. Indeed, if they could be made to work at over three times the speeds of electric motors, they would spin so fast that only eight pump stages would be needed instead of over 100 in an electric pump doing the same work.

Admittedly it had never been done before: it was equivalent to powering a hydro-station with a 12,000 foot waterfall. No high speed hydraulic motor had ever worked at such a pressure. But if it could be done, then most of the difficulties would vanish. There would be no need to waterproof the motor. The fluid powering it would just be drawn from the well and pumped back down through the hydraulic motor into the well again. And the length of the whole assembly would be reduced from 140 feet to around 10 feet.

That was the proposal put to BP. The prototype ran at Alloa for 450 hours and was so problem-free that no modifications were found necessary. The next step was to test it in the field.

No one wanted to stop oil production while a test was carried out, but Weir Pumps were lucky. The Department of Energy were running trials on a geothermal well at Marchwood near Southampton, and though it was producing hot water instead of oil, the characteristics were similar. The pump was tried 2000 feet below ground level in the Marchwood well, in 73 degrees C brine three times saltier than the sea, and when it was pulled out 2,000 working hours later and taken apart for examination, it was found to have no significant wear and no loss of performance. This same prototype has since been modified for raising water from an underground aquifer for re-injection into an oil well and is now to be installed in the Middle East. *

One of the satisfactory results emerging from the tests has been the pump's freedom from start-up problems, the commonest cause of failure in electric submersibles, and one of especial importance in fields where the oil is loaded directly from the well into tankers and stopping and starting is frequent. During the Alloa and Marchwood trials the pump was placed in various positions from vertical to horizontal and then stopped and started nearly 500 times. It did not fail once.

Failures mean lost time, and in the North Sea time is very big money. Even in the case of a relatively small well, stopping for a few days to replace a pump can cost £250,000 in crew wages and engineering costs, with another £250,000 in lost revenue. Existing pumps sometimes have a life of only a few months. In such cases the new Weir pump, with a life measurable in years, can save at least £1 million a year on every well. And the average North Sea production platform has around 15 wells.

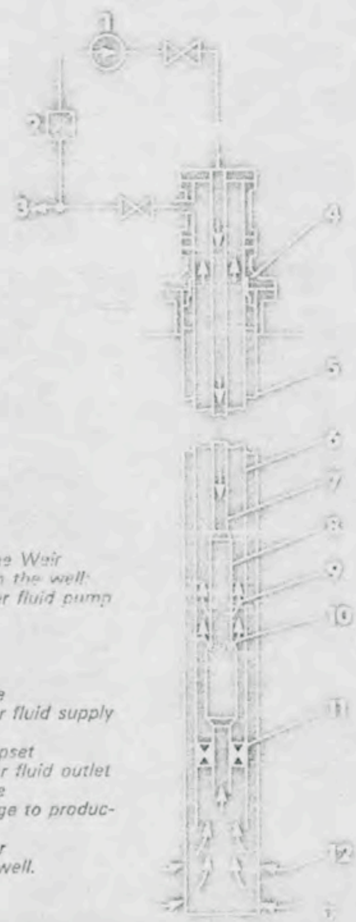
The implications are important both in the short and long term. The pump will not be used only to raise oil. It is customary, for example, to think of water injection in terms of an oil production platform pumping sea water down into its wells; but there are wells in desert regions which have no water available unless they pump for it. This could be a useful market for Weir Pumps. Most Middle East oilfields have a water-bearing layer over the oil-bearing layer, and the new pump is ideally designed to tap it.

The biggest growth market, however, will almost certainly lie in the direct pumping of oil from depleted fields, which is only now beginning. Pumping has always been used in slow-flowing wells (see, for example, the "nodding donkey" pumps scattered over the U.S.A.); but in the old days of cheap oil it was worth no one's while to tackle the fast-flowers. Today the oil companies want every barrel they can extract, and throughout the world there are fast-flowing wells which sooner or later will yield only by a resort to direct pumping. In Saudi Arabia it will be sooner rather than later (they are talking in terms of three years) and in the background are the rest of the Middle East countries, the North Sea, North Africa, Alaska, perhaps Russia, all fast producers, all with high-speed downhole pumping as the ultimate solution.

Weir Pumps have an answer to a problem which grows with every barrel taken out of the world's oilfields today. They have a pump backed by proved results and a hundred years of experience. It has come at exactly the right time.

Above left: The impeller assembly of a Weir downhole pump is examined at Alloa by some of those concerned in its development and manufacture. *Left to right:* A. M. Smith and W. McGregor (Alloa), M. L. Ryall (Cathcart) and T. Michie (Alloa). *Left:* Building up the impeller assembly.

The Weir Hydraulic-Drive Downhole Pump



Arrangement of the Weir downhole pump in the well:
1) Hydraulic power fluid pump
2) filter
3) well output
4) well head
5) casing
6) production tube
7) hydraulic power fluid supply tube
8) downhole pumpset
9) hydraulic power fluid outlet to production tube
10) pump discharge to production tube
11) sealing packer
12) oil flow into well.

The pump is designed for oil production, water lift for re-injection, water supply and geothermal reservoirs.
Performance range: Well output, 2000 - 1000000 b.p.d. Turbine power, 50 - 750 kw (65 - 1000 h.p.). Nominal speed 5000 - 10000 r.p.m.
Reliability. With the conventional downhole electric motor eliminated, there are no cables, sealing joints or insulation problems.
The short, rugged pumpset is typically only one-tenth the length of an equivalent electrical pumpset and much less susceptible to handling and installation damage.
It operates in deviated or curved wells with its axis from vertical to horizontal. It is manufactured from high chromium duplex alloy steels and stellite to resist abrasion, erosion and corrosion. All bearings are lubricated by filtered power fluid. There are no mechanical seals. The pumpset is unaffected by high well temperatures and repeated stopping and starting.
Variability. The pump can be operated down to 10% well output with valve control. The speed is infinitely variable down to 35% for continuous reduced well output by control of the power fluid. It has a reduced power requirement at low well output.
The output can be increased without withdrawing the pumpset, by increasing the pressure/flow from the topside pump.
Minimum installation time. The short, compact pumpset is easily transported and needs no site assembly.
It is run into the well on the end of the power fluid supply tube. When it is withdrawn it leaves the production tube and sealing packer in place. The setting depth is not dependent on the production tube length.
Chemical dosing through the power fluid supply tube protects the production tubing and associated equipment.

* Ran for 6 months with numerous stops & starts. In 'new' condition when pulled.

شركة ابوظبي للعمليات البترولية البرية

(ادكو)

Abu Dhabi Company for Onshore Oil Operations

(ADCO)

22nd March, 1983

TO WHOM IT MAY CONCERN

NOT FOR PUBLICATION PURPOSES

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SUBJECT: WEIR HYDRAULIC DOWNHOLE PUMPING SYSTEM

With respect to the 6 month trial of Weir Pumps Ltd's 16,700 Barrel/day hydraulic downhole pump (hereinafter referred to as the "pumpset") in one of ADCO's water source wells, we certify the following information as being correct:-

PERIOD OF TRIAL

The trial commenced on 22nd August 1982 and finished on 10th March 1983.

PERFORMANCE

During the above period, the pumpset gave its required performance in terms of output flow and pressure. In addition the pumpset was operated at approximately 4000 barrels per day for a short period.

RELIABILITY

The pumpset proved 100% reliable in the trial period, and was stopped and restarted 38 times during the trial (for field operational reasons) without any difficulty.

INSTALLATION/RETRIEVAL

Installation and retrieval of the pumpset was performed without any problem.

Contd....2/-

STRIP DOWN AFTER TRIAL

Strip down of the pumpset in the WESCO Service Centre was witnessed by ADCO and the following was recorded:-

Outer Casing	-	As new condition
Main Thrust Bearing	-	No wear evident and no scoring
Start-up Thrust Bearing	-	Very slight wear evident, no scoring
Impellers	-	As new - no erosion
Impeller Wear Rings	-	Negligible wear and slight scoring
Chamber Wear Rings	-	Negligible wear and slight scoring
Balance Drum - Turbine	-	No wear and no scoring
Balance Drum Bush-Turbine	-	No wear and no scoring
Balance Drum - Pump	-	No wear and no scoring
Balance Drum Bush - Pump	-	No wear and no scoring
Pump Bearing Sleeves	-	Negligible wear and slight scoring
Pump Bearing Bushes	-	Negligible wear and slight scoring
Turbine Stages	-	No erosion and no wear observed

GENERAL

1) When corrosion products from other components in the well were removed by light rubbing, no corrosion on any of the pumpset's components was seen.

2) The condition of the components of the pumpset after strip down indicated very long potential life downhole.

PRODUCTION OPERATIONS MANAGER