which the Prime Minister's action implied. A number of questions were asked in the House of Commons about the treatment of the Shaykh. As for the Company, the arrest had been carried out so unexpectedly and efficiently that none of the terrible consequences anticipated arose, although London was worried.[254] In a sense it was an anti-climax, because local power was already being enforced by the military Governor-General for Khūzistān, as Arabistān had been renamed, General Fazullāh Zahedi, who has master-minded the arrest, the first of many exploits in the service of his country. Assured and capable, he started the practice of posting government representatives, police and military guards at the Company's installations.

As the Company's management in Persia realised, it was the calibre and capability of the local officials that was crucial to the success of the Company's relations.[255] In this sense the removal of Shaykh Khaz'al was ultimately irrelevant to the Company. General Zahedi established a very favourable precedent, a real improvement in relations, which Jacks candidly acclaimed as being, 'a steadily improving feeling in evidence towards our operations in the mind of the new régime and the idea at first prevalent that our work was influenced by political motives is steadily giving way to the opinion that our objects are directed only towards the work of the Company.'[256]

By 1925, therefore, the disturbances in governmental and concessionary affairs seemed to have subsided. Misunderstandings appeared to have been clarified. Relations generally improved, though little could be taken for granted in the interaction between politics and business, which had a kaleidoscopic quality of almost infinite changeability and permanent interest. The relations of the Company with the British Government had become more stable, while relations with the Persian Government were satisfactory on the surface.

10

TECHNICAL ACTIVITIES: YEARS OF ENDEAVOUR AND ACHIEVEMENT 1918-1932

I INTRODUCTION

Greenway, at the annual general meeting in 1924, referring to the progress of the Company since its formation, declared effusively that it was 'a record of development which, I am confident, has not been equalled in the same short space of time by any other concern in the commercial history of the World'.[1] It was a large claim and it certainly contrasted with the precarious financial circumstances of a decade earlier, when he was negotiating for the Admiralty supply contract and the Government shareholding. Success on such a scale was unexpected. Indeed not only was the pre-war work of the Company in Persia fraught with inexperience, particularly at Ābādān, but during the war, as revealed in Chapter 7, the unexpectedly large demand for products strained resources and staff in the most difficult conditions. Not only were production and refining facilities fully stretched, but assistance and supplies were provided for the expeditionary force in Mesopotamia. Production from the wells was maintained, but the fear of falling gas pressure, which would have necessitated pumping the oil worried the staff, who understood little about the behaviour of the oilfield on which they were working. There was little appreciation of the interrelationship of the different aspects of the technical operations. Because the plant frequently arrived with parts missing or broken and because there were no local suppliers, it was necessary for the Company to provide almost everything that was required itself from its own stores or workshop in Ābādān or the Fields. Obviously, the First World War stimulated advances in the technology and applications of oil. Consequently the consumption of petroleum products increased spectacularly.

Nevertheless, what was the particular reason for the Company's ability to supply its share of market demand at an economic cost? Naturally there were a number of contributory factors: managerial enterprise; the natural productiveness of its wells; the economies and flexibility of its own tanker fleet; but perhaps most important of all, the growing appreciation of the way. The early disasters of the refinery at Abadan had nearly bankrupted it. Experience and practical hard work, the jackets-off manner of Scottish engineers, retrieved the situation and characterised the approach to technical problems. The lack of local industry and the absence of skilled labour in Persia meant that the Company was almost entirely dependent on its own facilities. These were equipped to service the mechanical, electrical and constructional activities in which it was engaged throughout its extensive operations. Plant was made and repaired in the workshops from the parts and machinery that were stocked in the stores. A sense of self-reliance arose for there was no alternative given the distance and the time it took to freight supplies along the sea lanes. There was little local linkage, few local contractors. The Company was obliged to create its own self-sufficiency, train its own employees and solve its own problems. It thus acquired a depth and width of oil industry expertise under exacting working conditions on which it could draw, a human reservoir of practical experience and knowledge. Research was directed to application not abstraction, to the accumulation of data for use, rather than theoretical formulation.

Yet, however important was human endeavour and ingenuity, it was the natural prolific productiveness of the Persian wells which was the principal economic advantage. The wells of Persia were the first to come on stream in the Middle East, the forerunners of the great productive oil fields of the region, which in 1980 contained 55.3 per cent of the world's "published proved" oil reserves, over three and a half times that of the total western hemisphere and nearly six times that of the Soviet Union. In the 1920s only in Persia were there wells like F7 and B17 capable of producing 586 000 and 880 200 tons (12 000 and 18 000 barrels a day) respectively a year. Yields elsewhere were minor in comparison. For example, in the United States they averaged less than 4000 tons a year. A remarkable phenomenon of the Persian wells was that, unlike those of many areas where a gusher might be capped but subsequently dwindle to a trickle, they tended to increase in productivity whilst flowing as oil was released from the limestone fissures and pores. The gas pressure was better conserved so no pumping was necessary. Thus when the bottomhole pressure at Masjid i-Suleimān was measured accurately for the first time in November 1923 at well Sh84 it was 478 p.s.i. By 1940 it had only dropped to 413 p.s.i. In the United States, however, production and pressure decreased considerably over years, so that, for example, the Glenn Pool in Oklahoma produced at a rate of 400 barrels a day (19 510 tons a year) but three years later production had fallen to 62.6 barrels a day (3050 tons a year). This favourable natural feature of the Persian wells and the mastery

competitiveness of the Company. The success of upstream performance more than compensated for any deficiencies in downstream operations.

The early wells were the result of tracing the seepages and the tell-tale geological anticlines, but the more profound knowledge of what constituted an 'oil field' depended upon the probing of the drill, the patient examination of temperatures, pressures and formations, the detailed analysis of oil, gas and water and that element of luck, which often favours the adventurous. In the years after the ending of the First World War the extent and natural characteristics of the oilfield of Masjid i-Suleimān were elucidated by a series of experimental scientific investigations of its physical properties, and its production was controlled on the basis of this information. In the laboratory the chemical elements of the crude oil were analysed and assessed to improve refinery processes and their suitability for an increasing range of products. Between the well-head and the customer was a vast number of intermediate stages including the production, the pipeline and the refinery operations before transportation and distribution to markets took place. All these stages had to be technically as well as administratively managed and maintained to appropriate standards and manning levels with the right degree of training and knowledge.

The outstanding contribution of Cadman to the Company's technical progress was his realisation of the overriding importance of an integrated scientific effort and the interrelationship of the various technical activities and functions. The engineer and the chemist had to collaborate with, not ignore, each other. Because of his early technical training and the administrative experience, which he had acquired as a mining inspector in government service, Cadman was ideally equipped to stimulate from the early twenties the scientific attitude of the Company, an outlook which permeated all levels of staff in Persia and elsewhere. He understood the principles and the practice and communicated easily and without condescension to the geologist, engineer and chemist no less than to his colleagues on the Board. He was concerned with what was industrially significant for the Company. A badly designed valve connection which prevented simple routine maintenance was, in its way, as important as establishing the hydraulic equilibrium of the porosity of oil-bearing rock strata. His technical expertise and experience were exceptional. His range of industrial understanding was immense. These qualities did not float to the top of experience or remain sediment at the bottom of his knowledge. They were held in suspended animation in his mind, just as the gas which provided the energy drive in production was naturally active in the oil.

ment of the Company, it was complemented by capable geologists, a notable production management and a sound research organisation. Under the overall responsibility of S. Lister James, who had first gone to Persia in 1913 on secondment from Burmah at the recommendation of Sir Boverton Redwood, and who had been appointed chief geologist in 1919, a number of geologists were working in Persia. Because of the relative independence of their activities, and the scale and diversity of the geological conditions, these geologists had plenty of opportunity of responding to the challenge posed to their professional abilities. They gradually accumulated an understanding and knowledge that was to provide the basis for a remarkable tradition of successful exploration, which was to ensure the Company's pre-eminent oil reserves position into the 1970s when the traditional concessionary system more or less ended. As for production, J. Jameson was primarily responsible for it from 1920 to 1928. He had gone to Persia as assistant to Charles Ritchie in 1909. A natural engineering genius with a practical flair and an affable personality of great organising ability, he became pipeline superintendent, assistant fields manager, fields manager, general manager in Persia and eventually a director of the Company.

Dr A.E. Dunstan was the founder, with Dr F.B. Thole, of the Company's research work at Sunbury. Though his initial investigations were into crude oil viscosity, all aspects of oil technology were grist to his intellectual mill. *The Science of Petroleum*,[2] of which he was principal editor, remains the *magnum opus* of its subject, a testimony to his width of oil knowledge. A jovial person, he was much appreciated by his staff and colleagues. Patient and capable, he recognised that

> it is inevitable, as the very nature of research, that a great number of ideas are tested experimentally and yield purely negative results. These are sometimes as important and as instructive as positive results, and although they are not conspicuous, the time and effort expended on them must not be regarded as wasted. In fact, a successful piece of work is often the ultimate result of many abortive experiments.[3]

It may not have represented a fundamental philosophy but it was a practical discipline.

In reviewing the nature and scope of the technical work undertaken in Persia and elsewhere or in exploration in North and South America, Africa, Europe and Australasia, it is important not to forget the human dimension of the Company's operations. From fewer than 117 European staff in Persia in 1919 and 3979 Persian and 2688 others, in 1930, the year of maximum employment in the period under review, the comparable figures were 1191, 20 095 and 9960. Table 10.1 shows the total overall

Year	Persians	Indians	Others	Europeans	Total
1919	3 979	2 641	47	117	6 784
1920	8 447	3 616	35	244	12 342
1921	9 009	4 709	51	271	14 040
1922	18 441	4 285	2 940	490	26 156
1923	20 762	4 715	849	644	26 970
1924	18 384	4 731	648	738	24 501
1925	15 820	4 890	7 201	994	28 905
1926	15 843	3 588	6 042	1 020	26 493
1927	17 887	3 272	7 009	1 055	29 223
1928	16 382	3 050	5 365	1 000	25 797
1929	15 245	2 518	5 273	980	24 016
1930	20 095	2 411	7 549	1 191	31 246
1931	14 797	1 675	3 178	989	20 639
1932	10 343	1 420	2 346	744	14 853

Source: BP reports to Imperial Commissioner and BP 78/63/1–205

employment figures for all the centres of the Company's operations in Persia whilst Appendices 10.1–3 show comparative employment figures for the different centres. It required an immense administrative effort to manage, house and satisfy the social life of the expatriates in an alien environment in which practically all the facilities and amenities had to be

Bakhtiari tribesmen in the workshops at Masjid i-Suleimān 1914 provided by the Company itself. A few passages to Persia were provided in tankers, but many journeyed overland from Beirut to Baghdad by the enterprising Nairn transport convoys of cars and thence to Ābādān. Moreover the life of many of the tribesmen employed changed once they had accepted a settled sedentary, industrial occupation. Many of the predominantly Hindu Indian clerks, artisans, orderlies and cooks found the Persian ambience unsympathetic to their customs which contributed to their discontent in the early 1920s.

The period covered by this chapter leads on from the developments in Persia during the First World War, when production increased tenfold. Keeping refinery throughput up rather than economic processing had been the order of the day. The first four or five years were marked by endeavours to stabilise the situation in administrative and technical affairs. The remaining years of the D'Arcy Concession were distinguished by achievements as geological reconnaisance revealed promising sites, and a new oilfield, Haft Kel, was discovered. Data on oil reservoir conditions made possible a new concept of production, unitisation, the complete development of a single oilfield. Improved refinery processes led to better products and the dredging of the Shatt-al-'Arab eliminated inefficient lightering off Ābādān.

2 EXPLORATION AND PRODUCTION IN PERSIA: YEARS OF ENDEAVOUR 1918–1924

The primary objectives of the Company's exploratory effort at this time were firstly to determine the productive capacity of Masjid i-Suleimān and secondly to discover additional oilfields. Whilst the potential life of the Masjid i-Suleimān field remained unknown and the possibility existed of water encroachment into the oil zones, as was happening in Mexico, the Company could not rest easy with only a single proved field. These objectives seemed simple, but, in the absence of much verifiable data, there was much debate about the best methods of achieving success, particularly when it had not been definitely established that the oil reservoir was in the Asmari limestone.

Garrow, who was then the director in charge of technical affairs, on his visit to Persia in 1919 was greatly concerned about balancing market expectations with the productive capacity of the oilfield. He stated that anticipated crude oil demands represented 2 100 000 tons in the short term, 2 900 000 tons in the medium term and 3 070 000 to 4 120 000 tons in the long term (these figures were actually reached in 1922, 1923 and 1924–25 respectively). At the time of his visit there were 48 wells in sound producing condition which, he believed, 'in my humble opinion, is not

nearly enough compared with our future crude commitments'.[4] While he regarded the producing area as extraordinary, he advocated as a precautionary measure against any unknown contingencies like 'a sudden drop in gas pressure' or a 'sudden influx of water from the flanks', a large increase in 'our reserves of drilled wells in the fields ready to be brought into immediate production in case of need'. He therefore recommended a crash five-year programme of drilling 15 wells annually to give a total of 123 producing wells.

In comparison with 1911–19, when the average footage drilled in a year was 6457 ft, the equivalent of five average wells, the effort required in terms of manpower and resources would have been extraordinary in the conditions then prevailing. It was an insurance policy on a grand scale and he was pessimistic about obtaining sufficiently accurate information to plan otherwise because, 'we have not seen and are unlikely to see for years any figures reliable and with any degree of accuracy representing the average decline in gas pressure per well over the whole field'. Garrow underestimated the progress of scientific investigation, for only three years later fifteen wells alone were producing over 2 000 000 tons.

By 1920 considerable geological research and observations were being done, 'the most important work yet undertaken by a geologist at Fields', according to Thompson, the fields manager, whose collaboration with geologists had become a distinguished feature of his time in Persia.[5] F.D.S. Richardson, a geologist, was preparing sections showing surface geological conditions, correlated in the same section with known underground evidence as revealed by drilling operations. In June 1920, Thompson issued his valedictory comments on the oilfield for which he had been responsible for five years.[6] Between 1912 and 1919 some 5 250 000 tons of oil had been produced. He believed that the conditions encountered were different from any other known oilfield, not necessarily unique, but arising from the fact that in 'no other proved oil bearing territory has the development been under the control of one management'. This was the real difference, the extraordinary opportunity for the Company, because elsewhere, suggested Thompson, 'the sole idea of the various interested Companies has been an anxiety to tap the oil horizon before their rivals, regardless of the damage done to the oil-bearing strata by faulty drilling to the detriment of the prolonged productive capacity of the field'. Figure 10.1 gives a diagramatic view of the careful manner in which the Masjid i-Suleimān oilfield was operated by 1930.

Thompson concluded that gas pressure was constant throughout the field which was itself continuous throughout its extent. He advised that it should not be overdrilled. He argued for a major change in drilling strategy, a new approach to petroleum engineering, believing that 'If, and

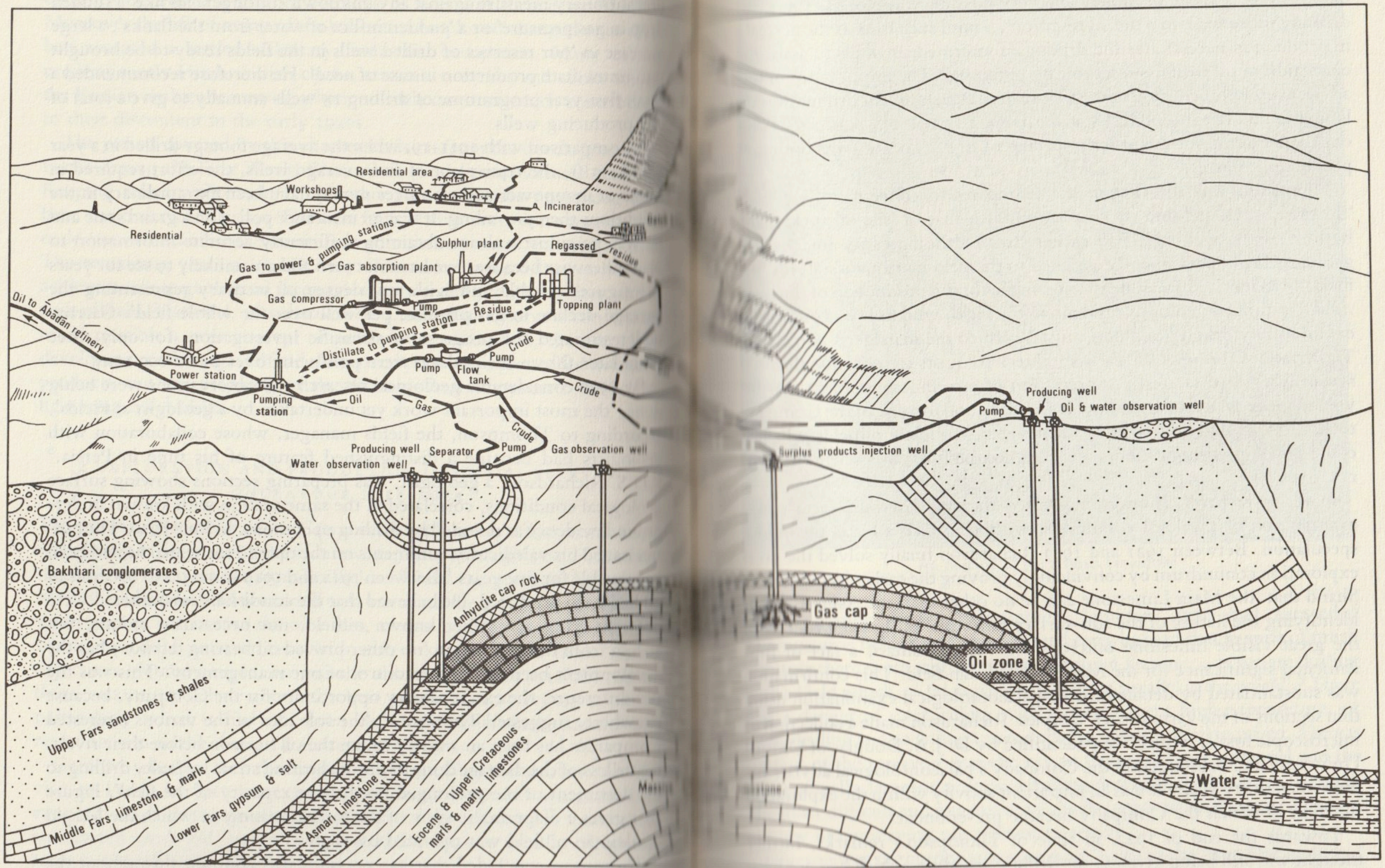


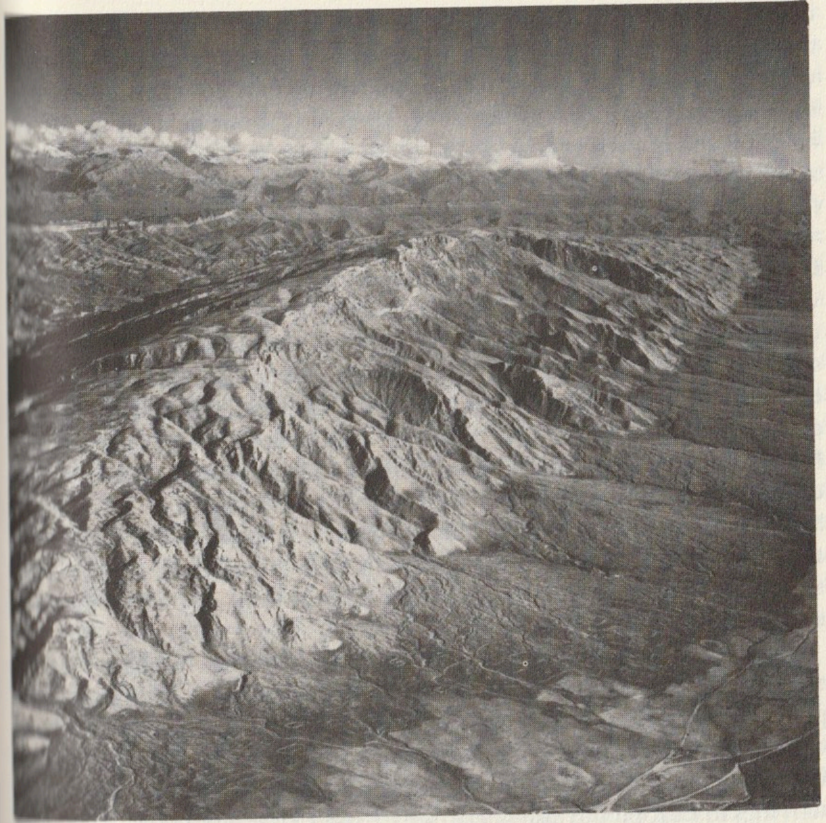
Figure 10.1 Oil production, Masjid i-Suleimaān
Source: BP

there does not seem any reason to doubt it, the central wells do draw their production from the whole of the oil producing rocks of the Field it would obviously be a waste of money and very possible waste of gas energy to drill any more wells *into* the oil reservoir ... until such time as the decrease in production necessitates the drilling of intermediate wells to assist the extraction of oil from its reservoir by pumping.' The implications of this advice were momentous for the Company. Development drilling was no longer to be a fairground lucky strike game, rows of steel derricks staking out chance sites, but the orderly spacing of rigs delineating the optimum production centres.

Thompson was the first in the Company to concern himself with 'flowhead pressure' and its correlation with that of 'the oil rock at the bottom of the well'. He had earlier stressed the necessity for a senior geologist being permanently attached to the field manager's staff for 'the Fields Manager and he alone is responsible for the production of the Field ... and without a geologist resident on the Field, who follows continually exploration work, a good deal must be left to the manager's initiative'.[7] Thompson was one of the earliest oil technologists to recognise the need for an integrated scientific appreciation of a technical problem that involved more than one discipline. It was the good fortune of the Company to have in its exclusive concessionary area, complete oilfields which it could develop without hindrance from competitors, in a scientific manner.

In many respects Thompson pointed the way forward for a closer examination of the local conditions, without which all was theoretical speculation. Between 1921 and 1923 Richardson finally solved the great exploration conundrum by convincingly proving the earlier hypothesis of Shand that 'the Main Limestone can be no other than the Asmari',[8] thus identifying the nature of the sub-surface limestone oil-bearing rock with the great visible limestone outcrops known as Asmari, a fact of fundamental significance for the Masjid i-Suleimān field. This confirmation was substantiated by detailed micro-palaeontological examination using thin sections of the various rock samples. Richardson made a collection of microscopic fossils, which were identified by Dr J.A. Douglas of Oxford University and subsequently the Company's palaeontological adviser for more than thirty years. It was an important activity within the exploration function in which the Company became pre-eminent.

Towards the end of 1922, in spite of Thompson's remarks, further thought was still being given to the drilling schedule, which had not been implemented on the scale envisaged by Garrow, because of the lack of trained staff, shortage of rigs, failure in electricity supplies, insufficiency of accommodation and the absence of coordinated management to undertake



An outcrop of the Asmari Limestone

such a comprehensive programme. Jameson, who had succeeded Thompson as fields manager, reflected early in 1923 that in spite of much progress there were still 'so many unknown factors ... as we are dealing with a Field which, as far as we know, has no parallel in the world'.[9] There was a danger of overdrilling with its consequent high expenditure, or underdrilling and so failing to produce the volume of oil required. The gas content of the reservoir was the key to the production potential and the siting of wells. Jameson proposed drilling down the flank, which although 'the most difficult and expensive seems the wiser to adopt from the point of view of conserving our natural resources'.

Jameson was suggesting a compromise between the 'Step Out' policy of siting rigs adjacent to each other and the 'Big Jump' proposals of placing them further apart according to the geological evidence. He was prepared to carry out the fifty rig programme propounded in London, but without much enthusiasm. He believed his instructions to be out of proportion to the drilling hitherto actually achieved and inappropriate in comparison with the existing production drawn from fourteen wells. He did, however, recognise that all the oil eggs were in the one field basket for 'we have not so far a reserve Field' and there was no knowing 'what effect an annual rate of production of over 4 000 000 tons would have on the Masjid i-Suleimān field'. This was the crux of the production problem.

It is at this stage that Cadman's influence began to be felt. After a year familiarising himself with the Company's activities, its strengths and weaknesses and having established himself in the Company's management, Cadman was ready in spring 1923 to assert himself. He posed the question, 'where, in the present state of our geological knowledge, should existing drilling resources be principally concentrated, Maidan i-Naftun extensions, or outside areas?'[10] Problems could not be solved in isolation. Priorities had to be established and information assessed before decisions could be made. *Festinate lente* might have been Cadman's watchword, as he was convinced that 'no large new programme of outside testing can be submitted at this stage with reasonable confidence that the most promising areas are selected and that the possibilities are commensurate with the costs involved'.

So Cadman decided that new test drilling was to be concentrated on extending the productive capacity of Masjid i-Suleimān. This was not a policy of retrenchment, though its modest proportions may well have been partially determined by the financial crisis through which the Company was then passing as a result of the expansion of marketing activities in Europe and elsewhere (see Chapter 8). It was a tactic of mature consideration on which later to base a more forward policy. A better understanding of the behaviour of the oil reservoir was beginning to emerge as a result of some early investigations, which needed correlating and further examination. Firstly, the lack of success of outside testing had to be examined, and, secondly, an exploration policy formulated on the basis of assessing the failures of previous exploration and the opportunities for new initiatives. Cadman was certain that a detailed programme was essential, 'whereby the whole concession may be surveyed rapidly and effectively. After this has been done, and only then, will it be possible to settle upon a development programme calculated, in the period available, to make the most of all the potentialities of a concession of which so much still remains unknown.'

A useful view of the unimpressive state of the operations at this time to an outside observer is contained in a report compiled by three members of the staff of Standard Oil (NJ), Messrs Corwin, Seidel and Haynes, who visited Persia in mid-1924.[11] It contrasted with the enthusiastic later

remarks of Greenway to the shareholders in the same year, for although they praised the extent of the Company's achievement they were less certain of its quality. They commented that drilling had been concentrated in the Masjid i-Suleimān area in 'connection with the exigencies of promoting the company and raising capital rather than to the wise and economical development of this field'. They were complimentary about the Fields staff by whom 'on the whole the undertaking is well and wisely managed' and 'carried on under adverse and severe desert and climatic conditions in an outlaying isolated region remote from any center of modern civilization'. The nature of the topography with its evident folding, faulting and non-conformity of the formations' was perplexing for the geologists, who were disappointed in their results. Their opinion of the refinery was bad, as it did 'not seem to have been very well planned and its present condition and arrangement is unsatisfactory'. The condition of the tankers they saw 'did not appear to be in the prime ship shape conditions one expects of a well managed, well handled fleet'. Fortune had favoured the Company, they believed, for it had been built 'on a far larger scale than production prospects might have appeared to warrant', with the result that they had sufficient 'facilities to warrant their present scale of operations'. It was Cadman's success within a few years to replace the element of chance with that of scientific control.

Meanwhile, by mid-1923, whilst Cadman was contemplating the issues, the boundaries of the unknown were steadily contracting. The oil reservoir code was being cracked, for on 8 June 1923 a notable draft was circulated on 'Gas Pressure Problems on Maidan i-Naftun Field with reference to the Conservation of Supplies and Future Drilling' by D. Comins, an engineer, and E.W. Scofield, a geologist.[12] Lister James in forwarding the report to Cadman described it as 'the most complete study of the producing field, which had yet been made from this point of view'. He believed that 'it should form a very sound basis for the collection of data of utmost importance to the Company in gauging the life and potentialities of the field which is at present the only developed source of supply in the Company's hands' and he generously attributed all the credit to the authors as the work was undertaken on their initiative. Cunningham Craig, more reserved as befitted the geological adviser, was no less complimentary, praising it as 'a great advance upon any work of this kind that I have seen attempted in other oilfields'.[13] It was of seminal importance and Cadman immediately recognised its significance as a basis towards 'a really adequate knowledge of the under ground conditions' and that it provided 'reasonable hypotheses on which to base further developments and investigation'.[14] He summarised its conclusions:

(a) The Maidan i-Naftun field is a single dynamic unit.

(b) Water pressure is apparently absent, and there appears at the moment to be no evidence of extraneous compensation for gas and oil extracted.

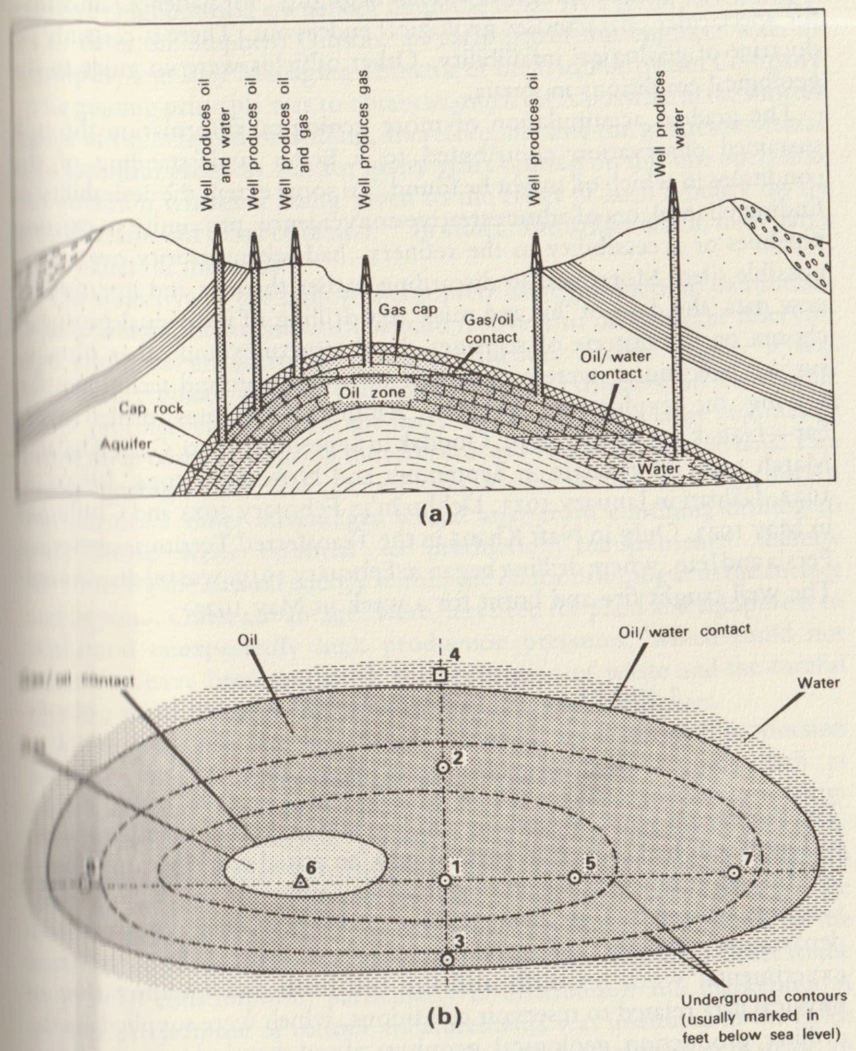
(c) Pressure measured at the surface appears to be dependent on the ground elevation and the character of the column of oil, gasified oil, or gas, in the well.

(d) The rate at which the oil will flow at the mouth of the well depends upon the relative elevation of the well and upon the porosity of the oil rock encountered by the well.

(e) There is a gradual fall in the oil level, which, 18 months previously, appeared to be something under 10 feet per 100 000 000 gallons of oil extracted.

The Asmari limestone oil reservoir was postulated to be a 'homogeneous hydrostatic unit, that is to say that there is free, if slow, communication between all oil'.[15] The implications of this for a controlled drilling schedule were immense in terms of manpower, resources and expenditure. The possibilities of improved technology for developing oilfields as separate self-contained units of production determined by their own individual characteristics were very advantageous in properly phased productive terms. The life cycle of a field could be determined, resulting in calculations of its reserves, flow rates, oil, water and gas levels and pressures. An idea of the typical relationship of the oil, water and gas levels to each other can be seen in Figure 10.2. In the following years more sophisticated measuring devices, more rigorous statistical analysis and more practical experience were deployed to establish with greater certitude the principles of 'unitisation', that is, scientifically controlled integrated oilfield development, which had been initially formulated through individual efforts encouraged by an enlightened local management, rather than by any consistent and coherent research team effort.

Exploration in general, however, beyond the only field which had been proved, Masjid i-Suleimān, was disappointing between 1919 and 1924, an unsuccessful procession from one site to another. At first in 1919 exploratory drilling was undertaken with tempered urgency, but as one dry hole followed another or difficulties occurred in drilling, it was replaced with undisguised anxiety. In 1918 one outside test well was being drilled, in 1919, 3, 1920, 4, 1921, 6, 1922, 11 and 1923, 17. In the same period the number of geologists employed rose to 7, 8, 10, 14, 18 and 26, the maximum employed in Persia. There was no single reason for failure, rather a number of factors.[16] They included differing and conflicting geological interpretations of the evidence, lack of management coordination, initial geological inexperience, inadequate practical appreciation of the conditions, accommodation difficulties and some security problems with surveys. Much competent topographical work was achieved on a



Wells which struck oil – No.1 (Discovery Well) 2, 5, 7and 8
Well No.3 Struck oil and then passed into water.

Well No.6 Struck gas and then passed into oil.

Well No.4 Struck water.

Figure 10.2 Cross-section and contour map showing oil and gas levels
Source: *Our Industry Petroleum* (British Petroleum Company Ltd, 1977), p. 125

very detailed scale, giving a very positive aspect to an otherwise rather negative impression. Progress was not negligible, for patience rather than the spectacular characterises geological endeavour. There is certainly no doctrine of geological infallibility. Other oilfields were no guide to the geological conditions in Persia.

The gradual accumulation of more geological information through sustained observation contributed to a better understanding of the conditions in which oil might be found. To some extent the desirability of finding oil in places of administrative convenience, proximity to existing pipelines or accessibility to the refinery, had taken priority over other possible sites. Moreover, in discarding earlier theories and interpreting new data, the days of 'hit and miss' test drilling of individual prospects chosen on the criteria of seepages, local structures and other obvious surface indications, were giving way to more profound techniques for solving the exploratory puzzles. Amongst the sites drilled were Sar-i-Naftak in October 1919, Qundak in September 1920, Gach Khalaj in March 1921, Marmatain in September and November 1924, Bikarz in 1922, Dālparī in January 1923, Dehlurān in February 1923 and Chillingar in May 1923. Only in Naft Khana in the Transferred Territories between Persia and Iraq, where drilling began in February 1919, was oil discovered. The well caught fire and burnt for a week in May 1923.

3 YEARS OF ACCOMPLISHMENT 1924–32

(a) Improvements and innovation

The pioneering work of Comins and Scofield and other members of the technical staff had to be transformed into 'an actual working proposition and not an impractical vision of purely academic interest'.[17] So in 1924 Comins, assisted by L.A. Pym, was put in charge of the physical research department (drilling and production policy) with a brief covering experimental work on wells and the collection and interpretation of physical data related to reservoir conditions, which were supplied by the drilling, production, geological, geophysical and chemical sections. It was an inter-disciplinary approach. The object was 'to develop uniform and long-sighted drilling and production policy applicable to the total reservoir unit for which a precise knowledge of the subsurface and reservoir conditions was essential'.[18]

The Company was not the first, let alone the only organization to take an interest in the scientific development of oilfields, but in the United States comparable activity was hampered by legislation enshrining the law

of capture by which land owners who had sub-soil rights could drill to deprive neighbouring owners of oil in the field. As a result, according to H.S. (later Sir Stephen) Gibson, an early petroleum engineer with the Company and later Managing Director of the Iraq Petroleum Company, 'The guiding principle was to obtain as much oil as possible in the shortest space of time. Speed of drilling, therefore, became the greatest essential, and technical progress was for many years centred on this one operation, no attention whatever being given to the effect of such a policy on the ultimate amount of oil obtained.'[19] In effect, 'the driller was in sole charge of production methods'.

The objective of the policy of comprehensive production, unitisation, was to obtain the maximum ultimate recovery of oil from the reservoir and eliminate uncontrollable over-production. In this manner it was hoped to regulate supply, and achieve better estimates of recoverable crude oil reserves, obviating the need for the storage of large volumes of crude oil in tanks by utilising the reservoir as a vast underground tank. Fire risks, tankage cost and evaporation losses would all be reduced. Furthermore, other advantages would arise from confining drilling to only those wells essential to production requirements, thereby maximising the natural energy within the oil for bringing it to the surface and beyond. Other advantages were, less need for plant and equipment to withstand unexpectedly high production pressures, which could not otherwise have been predicted, the prevention of waste and the careful phasing of all demands for utilities, services and manpower.

There was also the benefit of operating to a definite production schedule, the prevention of avoidable production hazards such as blow-outs and the improvement of staff conditions following a better understanding of reservoir performance. It was upon such material, economic and social consequences of a well developed production programme that the Company was able to base its growth strategy in the most efficient and effective manner and in so doing offset some of the formidable advantages of its competitors, whose wells were closer to the centres of consumption, particularly in distribution and marketing. A proper programme of routine measurements was instituted in the fields area and new instrumentation was frequently designed and made or acquired to cope with the high pressures encountered.

New wells were drilled progressively down the south-west structure at Masjid i-Suleimān till, in 1924, one of them passed through the oil column and struck water. This was left as an observation well to establish the oil–water contact level, that is to say, whether it remained more or less constant between the two liquids. Fortunately little movement was detected, confirming the supposition that water, if present, was not freely connected to an external source, thus firmly refuting the strongly held opposite view of some of the Company's geologists. This was important because, in other limestone fields, water had been known to rise with great rapidity corresponding to a fall in pressure. It had been ascertained that the gas–oil level fell about 15 feet per each million tons of crude oil produced. The correlation of these factors led to a tentative calculation that the crude oil reserves were, in fact, considerable. By the end of 1926 further field delineation work had revealed the overall position of the edge water round the reservoir which showed conclusively that the pressure was constant overall.

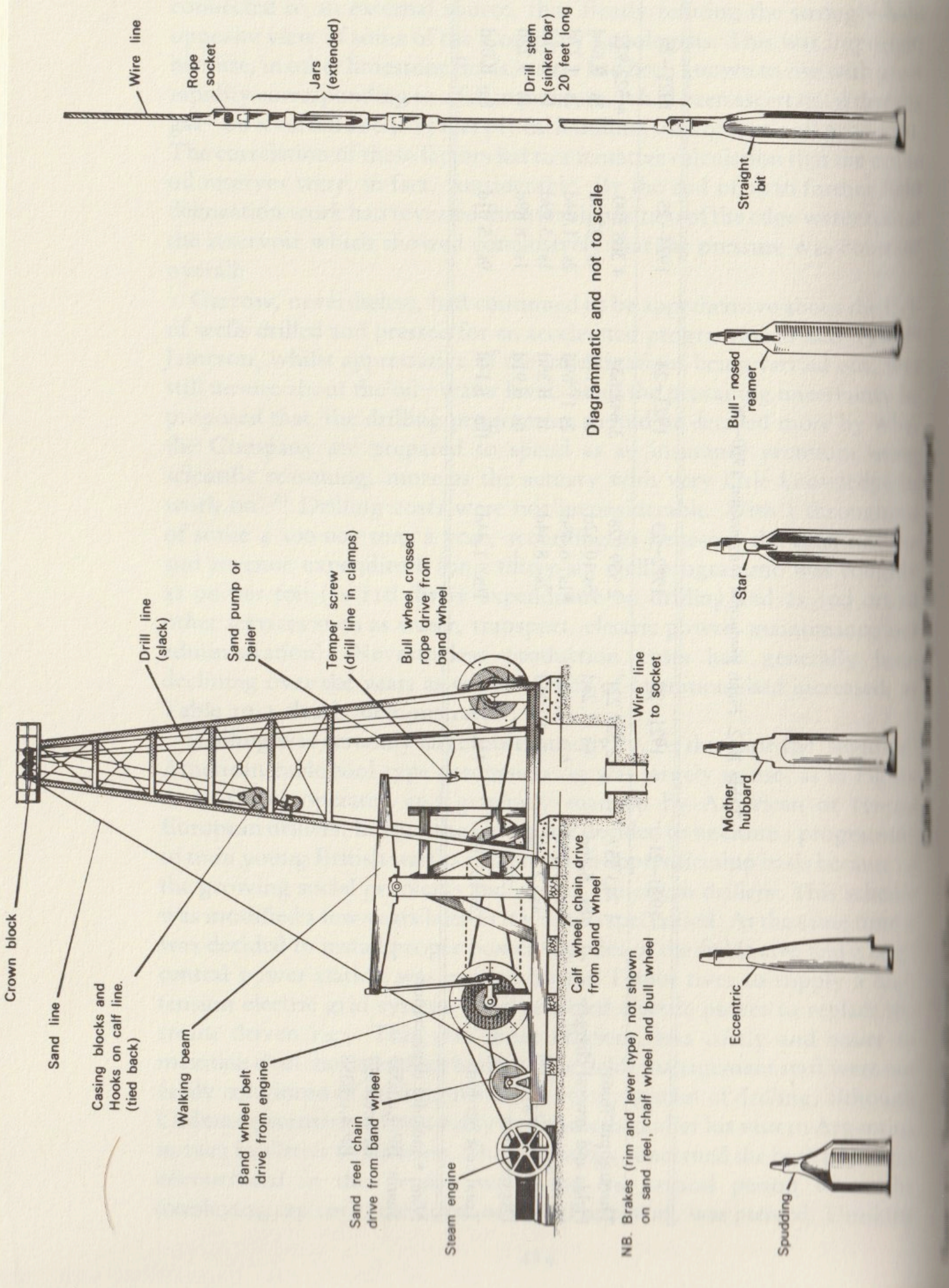
Garrow, nevertheless, had continued to be apprehensive about the lack of wells drilled and pressed for an accelerated programme in mid-1924. Jameson, whilst appreciative of the investigations being carried out, was still unsure about the oil–water level. So in the prevailing uncertainty he proposed that 'the drilling programme should be decided more by what the Company are prepared to spend as an insurance premium using scientific reasoning, more as the actuary with very little knowledge to work on'.[21] Drilling costs were not inconsiderable. With a throughput of some 4 500 000 tons a year, according to Jameson, the total drilling and revenue expenditure for a thirty-six well programme was roughly 4s 9d per ton (1s 11d direct expenditure on drilling and 2s 10d on all other services such as water, transport, electric power, maintenance and administration). Nevertheless production costs had generally been declining over the years as the efficiency of operations had increased, as Table 10.2 clearly demonstrates.

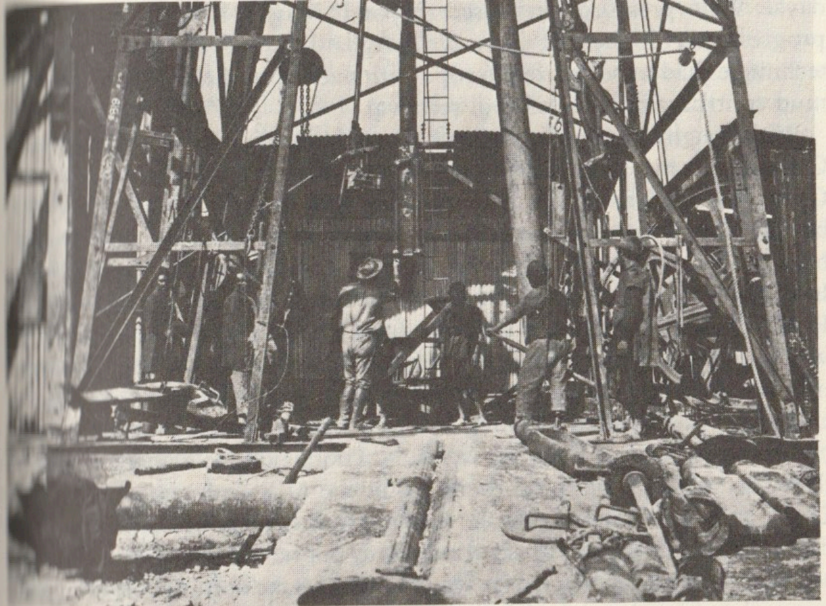
Drilling was certainly an important activity. At this time the 'standard' American cable tool type percussion rig was largely in use, as in Figure 10.3, steam operated and generally manned by American or central European drillers. In 1921 the Company decided to institute a programme to train young British staff as drillers on an apprenticeship basis because of the growing social problems and cost of American drillers. This scheme was modified a few years later as it was too specialised. At the same time it was decided to install proper power supplies in the fields area and a large central power station was erected by the Tembi river to supply a high tension electric grid system which enabled electric power to replace the steam driven rigs. This was more efficient, less costly and easier to maintain than the corroding boilers. The fields management staff were not easily convinced of the benefits of the rotary system of drilling, although Cadman commented favourably on the method after his visit to Argentina in 1923 in a letter to Jameson. The difficulties concerned the high pressures encountered in the Persian wells and the critical period when the overlaying cap rock, the dome of the oil reservoir, was pierced. Until the

Table 10.2. *Fields production costs per ton 1920–26*

	1920–21	1921–22	1922–23	1923–24	1924–25	1925–26
Throughput (tons)	1 743 557	2 327 221	2 559 028	3 648 634	4 308 500	4 522 922
Fields and general charges	8s 5.46d	6s 1.25d	5s 10.32d	5s 2.19d	4s 2.29d	3s 8.69d
Boring wells	*1s 2.39d	*1s 2.54d	*1s 6.48d	2s 11.69d	2s 1.84d	2s 1.77d
Pipeline charges	4s 2.34d	3s 10.94d	2s 8.64d	1s 8.35d	1s 3.99d	1s 0.41d
Depreciation	—	—	—	0s 6.91d	1s 8.89d	1s 9.22d
Total cost per ton	13s 10.19d	11s 2.73d	10s 1.44d	10s 5.14d	9s 5.01d	8s 8.09d

Note: * includes depreciation
Source: BP 4.c.6353
BP 4.c.6357
BP 4.c.6358



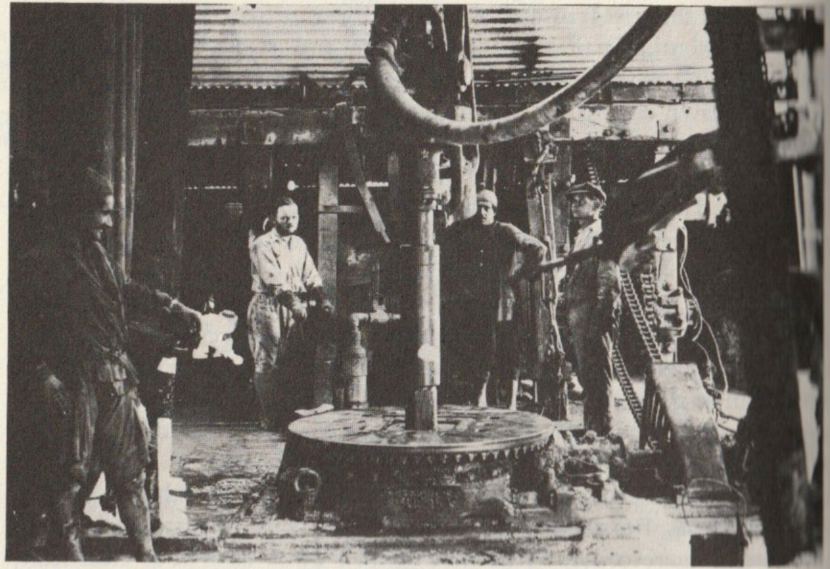


The floor of a 'Standard' cable tool type percussion rig 1924

mud used in rotary drilling had become more specialised and reliable and the crews more skilled in its application a well was liable to blow out, as happened in the first Iraq well at Baba Gurgur in 1927. Jameson as late as 1926 was unenthusiastic about its prospects and worried about the safety aspects. Two such rigs had been imported in 1922 from the United States with their own crews, but although they could drill deeper more easily, the rapidly changing and often soft formations encountered necessitated frequent and laborious changes of bits. Gradually bits were improved, the drilling mud more reliable and blow out preventers utilised, and the rotary rigs were converted to motor-driven use. By 1926 the last of the American rotary drilling personnel had left Persia.

In March 1925, fifty-eight rigs were employed, but the number subsequently declined. In coping with the high pressures, 2500 p.s.i., and deep wells encountered in the drilling at Naft Khāna, rotary drilling was successful in 1927. As a result of this it was decided in 1928 to give rotary rigs a chance on the Haft Kel field in order that it could be put on production in as short a time as possible. The success was beyond expectations and cable tool rigs were soon replaced there, though utilised in outside tests. Rotary drilling had come to stay and in 1930 three motor driven rigs were ordered, the first of their kind, as well as electrically operated rigs, one of which actually drilled 8960 feet, a record in those days. Well pressures increased beyond Masjid i-Suleimān, getting progressively higher at Haft Kel, Āghā Jārī and Pāzanun, so new techniques had to be devised to cope with these as well as problems such as mud control, fire risk and tool retrieval.

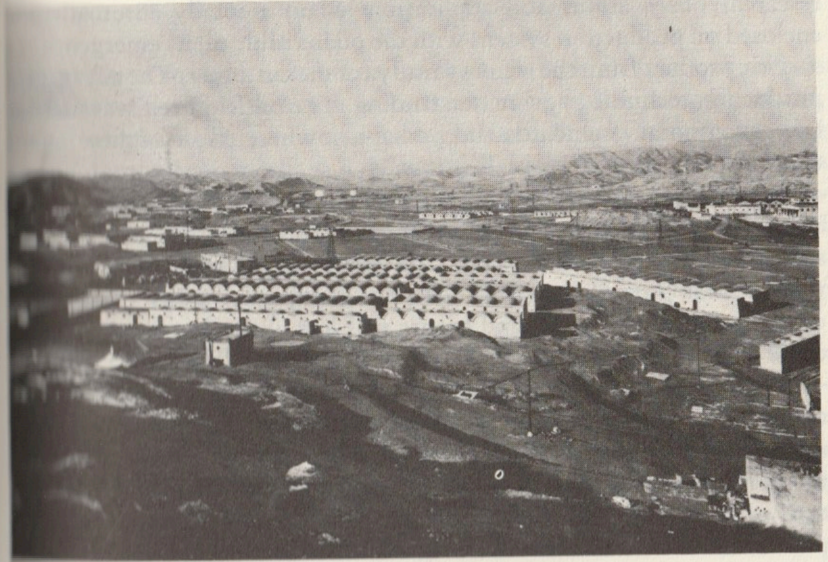
Within eighteen months, as a result of the studies and observations of Comins and his colleagues, Jameson was more confident, in a letter to Cadman on 12 January 1926, about the flowing life of the field.[22] He believed that 'a safe estimate of the time which will elapse before pumping has to be resorted to would now appear to be nearer fifteen years than ten'. In the event the Company never had to resort to pumping its wells in Persia. The reassurance was welcome for 'at the present time the drilling of wells on fields, purely for production is not warranted'. Indeed he was more certain that 'the outlook on fields is even brighter than it was a year ago'.[23] He was satisfied that there was already a safe productive capacity of 7 000 000 tons a year and that as a result of not having to embark on a new thirty-six well programme there would be a direct saving of at least £300 000 a year. This was a watershed in production policy. The theoretical claims of Comins had been vindicated, but he continued to widen the scope of the research, to analyse water samples, take bottom hole temperatures, investigate gas solubility, and assess limestone porosity and permeability.



A rotary type rig showing turntable and stem 1924

It was not all plain sailing. Although the discovery of a second field at Haft Kel in April 1927 had engendered a feeling of productive invulnerability, this complacency was shattered in August 1927, when well No. 56 on the Masjid i-Suleimān field began to produce salt water in some volume, although the bottom of the well was apparently some two hundred feet above the estimated oil–water levels. Tests soon showed that the phenomenon was very localised and explicable. Measures were taken to correct the gas–oil and oil–water levels and they responded to the appropriate attention.[24]

This rather frightening demonstration that the reservoir connection was not uniformly free throughout the oil reservoir, as had been assumed, and that partial barriers to oil migration within it were present, stimulated further efforts to determine a tighter application of reservoir control. These concentrated on maintaining a uniform pressure in all areas by carefully adjusting offtake as required, thus ensuring uniformity in the general oil–water level to prevent oil and water mixing. This could be achieved over time by a continuous process of monitoring the possible production variables so as to regulate normal production at its optimum rate. The quick diagnosis and immediate remedial action taken by the petroleum engineering department confirmed its indispensability as otherwise the field might have gone to water with calamitous consequences, if it had not been operated on a unit basis. During 1928 Haft



Masjid i-Suleimān from the main office 1926

Kel was planned methodically in a unit manner and in the same year Masjid i-Suleimān achieved its maximum rate of production, 5 358 000 tons in a single year.

Comins, addressing the American Petroleum Institute in Chicago, in 1928, was able to affirm that, as a result of a unit operation 'on our main field, it has been possible to collect, interpret and apply the data of the unit to the purposes of conserving capital instead of putting it in the ground, of conserving gas content and rock pressures, of estimating roughly the reserves, and of distributing the accorded allotted production of the unit in such a way that wells do not prematurely go to gas and do not go to water at all'.[25] The fears of a decade earlier had been finally dispelled. As an American geologist, Hugo Kamb, acknowledged in 1928 'The Masjid i-Suleimān field is probably the most efficiently developed oil pool in the world.'[26]

During the remainder of the D'Arcy Concession until 1932, there were further improvements in the techniques and apparatus used in petroleum engineering, important developments in the treatment of gas and a major innovation, the recycling of products surplus to immediate marketing requirements. Important aspects of this work received public acclamation in the papers delivered by members of the petroleum engineering staff to the First World Petroleum Congress held in London in July 1933.[27] Thus those who had seemed to be mad boffins, with their crazy schemes and Heath Robinson contraptions, had become recognised authorities, whose research, observations and application led to a totally automatic and enclosed oil production system with the oil invisible till its emergence as a specific product from the refinery ready for the customer. The advances in production technology were outstanding. The oilfield itself was massive by contemporary standards and perhaps nowhere else was there such a concentration of technical talent in such a self-contained community so exclusively engaged on such a large programme of work with so few distractions. The Fields Management under the encouragement of Jameson inspired by Cadman was practical and appreciative. A strong sense of purpose was present amongst those who lived and worked on site. The distinction between work and leisure was less noticeable than in a more usual office routine.

Gas had been a constant preoccupation in the Persian operations since the earliest days, when it was remarked that Masjid i-Suleimān 'all day and night smelt like a cataract of rotten eggs'.[28] By 1924 considerable improvements had been made in the recovery of gas, for Cadman stated that 12 000 tons of oil and 60 million cubic feet of gas were being extracted with practically no outward or visible sign of oil or smell of gas. This was the result of the flow system being operated in which

the producing wells are linked up from casing head to the receiving tanks at Tembi by a closed pipe system in which are incorporated high pressure gas separators on the field near the wells, and low pressure tank separators at Tembi. About one third volume of the total gas is led away from the high pressure separators by burning lines; the oil and residual gas passes on, under the influence of the reduced well-head pressures to two large separator tanks at Tembi.[29]

This flow system was then an improvement, but it was still wasteful and not particularly efficient. It was progressively improved from 1926 onwards with both high and low pressure separation systems. As Cadman realised 'the economic utilisation of fields gas is undoubtedly a very formidable problem, and its solution presents great difficulty'. W.L. Morgan, a gas expert from Standard Oil (NJ) who had gone out to Persia with Cadman in 1924 gave very useful advice. It was Gibson, however, who perfected the multi-stage gas separation plant, the first of which operated in 1929, as in Figure 10.4. The advantage was that the separation

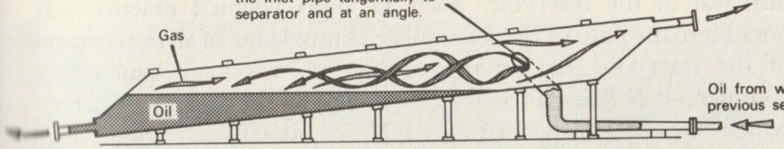


Figure 10.4 Inclined oil–gas separator 1930
Source: *Our Industry Petroleum* (British Petroleum Company Ltd, 1977), p. 138

and retention in successive stages of the volatile high fractions such as pentanes was as satisfactory as in conventional gasoline recovery plants, but far simpler in operation and more economic in capital and operating costs.[30] Further research by C.J. May and A. Laird indicated the optimum number of stages for various compositions of oil and the optimum pressure at which each stage should be controlled for the maximum recovery of some of the utilisable gases, resulting in the design of simple efficient horizontal cylindrical separators, particularly useful in high pressure oilfields[31].

The recycling of surplus products was a tremendous innovation, an admirable combination of practical requirements and theoretical considerations. The nature of Persian crude oil and the availability of better refining processes in 1928 meant that refining was out of balance with the market mix, leading to a surplus of fuel oil supplies in relation to rising benzine demand. There was therefore a dilemma for the Company of either reducing the price of fuel oil or storing it at a cost, in either case leading to a loss on sales, unless another solution could be found. About this time it began to be realised that although many of the technical staff believed cracks and fissures in the main limestone accounted for the largest volume, the porosity of the reservoir rock was not negligible.[32] In fact it was subsequently discovered in the mid-1930s that only some 10 per cent of the production of oil was from the cracks and fissures. Jameson in particular, Gibson, and others, therefore argued that if the surplus fuel oil was pumped back to the field and injected through specially selected wells located high in the gas dome, it would make its way through the gas–oil level before being reabsorbed in the oil saturated limestone. In this way not only would the reservoir act as a storage but there would be the advantage of activating some of the lighter fractions of the crude oil.

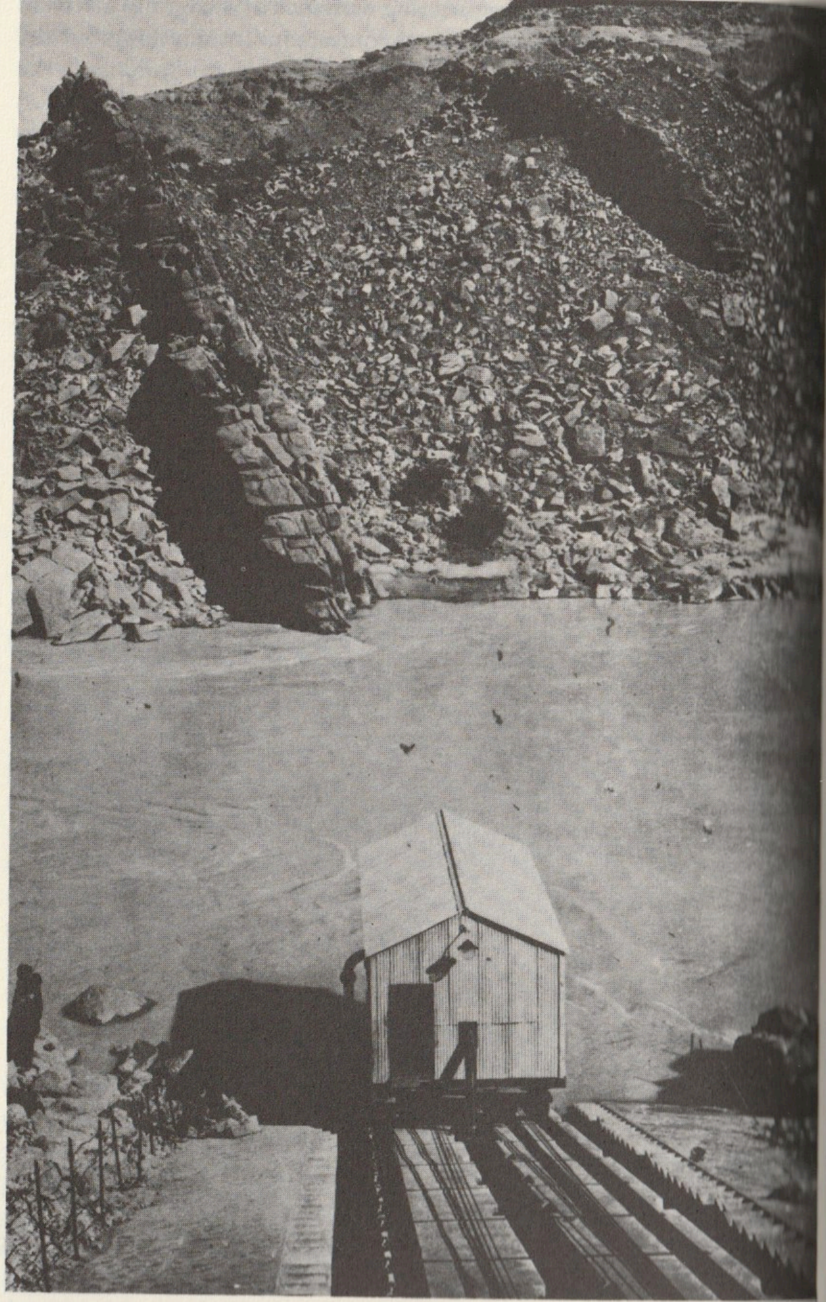
In spite of some well-meaning but anxious opposition, fearful lest the pores and fissures be choked, the recycling of fuel oil was introduced in a carefully controlled manner in April 1929, initially at a rate not exceeding 400 000 tons a year. By 1931 the amount of fuel oil being recycled had doubled with its viscosity being reduced by gas treatment to facilitate its dispersal in the reservoir. Such an unprecedented practice was only possible in the light of the accumulated knowledge of all the characteristics of the reservoir. Its practical usefulness was very beneficial in the commercial circumstances of the Company. It was like a safety valve which bypassed unwanted fuel oil back to the reservoir, sensitive to market demands by regulating quantities accordingly, a very practical application of scientific data for industrial purposes. In 1930 a topping plant distillation unit for the removal of the volatile fractions from crude oil was built at Masjid i-Suleimān by which the fuel oil surplus to marketing requirements could be removed from the crude oil and directly injected into the reservoir, thus dispensing with the need to pump it back along the line from Ābādān. The recycling circuit was made tighter and more efficient. Between March and August 1931, 521 000 tons of fuel oil residue were recycled back to the oilfield. In May 1933 a comprehensive report concluded that recycling was extremely advantageous with no adverse side-effects on the productive functioning of the oilfields.[33]

An incidental but significant economic consequence of recycling was the enhanced value of the oil tonnage exported in relation to the royalties paid to the Persian Government, which were based on exportation not production. Since exports were mostly at this time in the form of refined products rather than crude oil, the return on sales of a higher valued product like motor spirit in comparison with fuel oil, was much greater, but the royalty payable was the same.

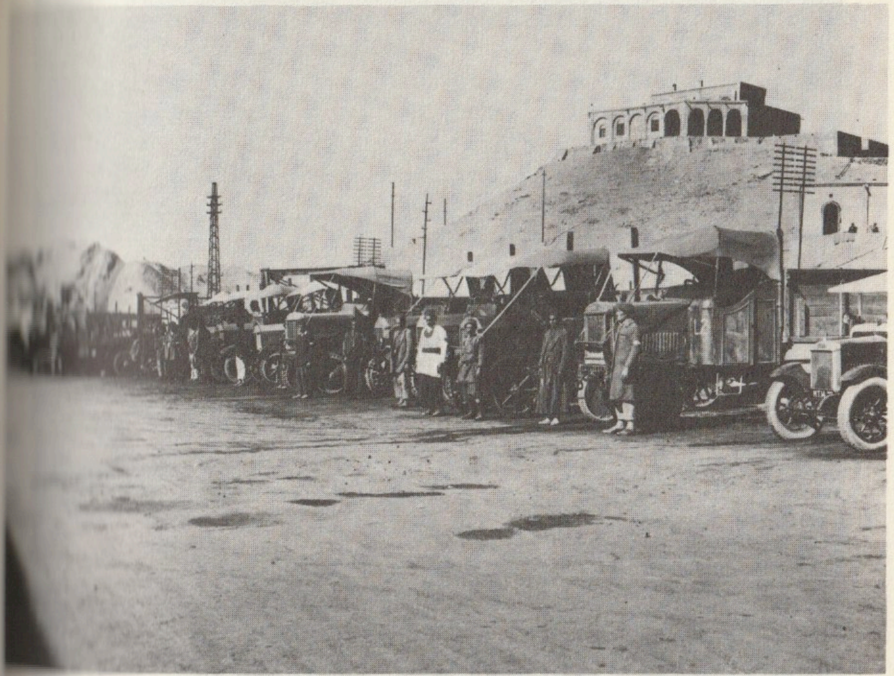
It is unnecessary to go into detail but it would be inexcusable to ignore the provision of the basic services upon which a great industrial

undertaking relies. The civil engineering activities of the Company were essential in the virtual absence of local contractors for anything but the simplest of operations. The erection of all kinds of buildings, the construction of bridges, jetties and railway tracks, the making of roads on a large scale were needed. Water supplies had always been a serious problem not only because of their scarcity but also because of their corrosive contents. A major achievement in 1926 was the siting of a pumping house on a sliding track by the River Kārūn at Godar Landar to allow for the differences on levels at various times of the year. This supplied good water throughout the fields area. Ābādān had its own supplies for cooling, steam and other purposes. Power supplies were developed on a massive basis, as none existed at all. The Company had to become self-sufficient because there was no provincial or national administration capable of providing the facilities at that time until the centralising measures and authority of Rizā Shāh in the late 1920s began to provide the rudiments of an industrial infrastructure on a limited scale.

'The Golden Stairs' road to Gach Sārān 1925



The water pumping station at Godar Landar 1926



Transport at Masjid i-Suleimān 1924

(b) Success in exploration

The years 1923–29 were vintage ones for exploration. In the previous five years the geological branch had grown in numbers and its activities had widened in scope, but it was indifferently administered, suffered from undue individualism and lacked professional cohesion. It had not been successful in finding new fields. From 1923 onwards, however, it was more coherently organised and had matured in experience. It had been difficult for the chief geologist, Lister James, to be engaged in field work and at the same time be responsible for planning exploration programmes in a number of countries (see Chapter 12), and cope with all the requirements of his staff. Cadman recognised the problem and, from his appointment in 1923 as the director for the fields, refineries and geological department, he was able to coordinate the technical activities of the Company from a central position. In mid-July H.T. Mayo was appointed principal geologist in Persia to coordinate all exploratory activities there.

Professor Hugo de Böckh (left) and G.M. Lees 1925

Yet the most important geological appointment was made earlier in 1923, that of the eminent Hungarian geologist, Professor Hugo de Böckh, formerly of the University of Budapest, as geological adviser. It was an inspired if controversial choice, which galvanised the geological function and gave it a confidence and direction which had been lacking. He did not

replace Lister James, with whom, though quite different in character, there was a warm personal relationship. De Böckh was a well-informed able field geologist of outstanding stamina, confidence and presence, who brought a new geological perspective to Persia. He encouraged the younger geologists by his commitment and knowledge. His surveys were grand progresses not furtive forays.

De Böckh's strength lay in personal example, in the spoken rather than the written word, for, although he was fluent in English, he was impatient in presenting his conclusions, which were not always logically or concisely expressed. His reports, therefore, tended to be a miscellany of observations and inferences, imperious in manner. Occasionally ideas were stated as facts, when they were only suggestions. His judgements were sometimes more sweeping than was geologically justifiable and he was wrong about Arabia and Iraq, but if style reflects the man there was no visible inconsistency. Thus his important report on his remarkable survey of 1924–25, which was his major contribution to the Company's exploratory programme in Persia, ended with the statement that 'if there is any larger oil field left in Persia, which we are fully entitled to believe, then it must be contained in the areas recommended and described above. It is a matter of chance how many of them may be proved to be really good fields.'[34]

His assertiveness was justified, as, out of his six 'immediate' recommendations, four proved ultimately to be major discoveries, but qualified by the fact that eight fields were later discovered in areas which he rated poor or ignored. De Böckh was aware of the value of geophysical aids to exploration and he had early experimented with them in Hungary. Though not employing such techniques in his two Persian surveys, probably because of the limited time at his disposal and the vast distances he covered, he encouraged their application by others. In 1923 the Company engaged its first geophysicist, W.R. MacDonald, who, with J.H. Jones and R. Davies, conducted the first geophysical survey in Persia near Ahwāz in 1924, applying the principles of physics to the study of sub-surface geology through measuring the variations in the magnetic and density properties of underground formation and so establish the existence of sedimentary basins where oil might have accumulated. By 1930 Jones, who had succeeded MacDonald as chief geophysicist, had undertaken his own seismic refraction parties using sonar techniques with geophones spaced out at equal intervals to establish the trends of buried anticlines, the first generally reliable method of detecting the Asmari limestone under irregularly folded strata rock.

In February 1923 Cadman had been reluctant to authorise a further programme of testing outside the main field at Masjid i-Suleimān until it had been arranged 'to devote at least one, possibly two more seasons to intensive survey and to employ a much larger geological staff than is at present available in Persia'. This intensive survey was to be the responsibility of de Böckh. He made a preliminary reconnaissance on his first visit to Persia in the winter of 1923-24, on which was based his more comprehensive survey the following year. He returned with an impressive entourage including Lister James, Richardson and G.M. Lees, a geologist of great promise, who had recently joined the Company from Imperial College after a distinguished war service and a spell as a political officer in Kurdistān. In determining his priorities de Böckh had the advantage, not only of his own observations, but also of conferences with the geologists and the benefit of the knowledge contained in earlier reports. This was important as successful exploration is largely dependent on the accumulation of previous experience on which to base new findings. This gathering of information, topographical no less than the geological had been an important feature of the exploration function. Nearly all the geologists were at one time or another employed on mapping, allowing them together to compare and exchange ideas and information, so helping by their individual expertise and experience to solve the problems that confronted all those engaged in exploration and production activities in Persia. This spirit of professional cooperation in the Fields, (rather than an isolated kind of study mentality) was encouraged by de Böckh.

As a result of his survey, de Böckh was able to mention specifically some localities, to which he gave prospective ratings. Out of those recommended for immediate tests, Haft Kel, Āghā Jārī, Pāzanun, Gach Sārān, Zeloi and Gach Khalaj, only at the first locality was oil discovered while de Böckh remained with the Company, though it was K. Washington Gray and T.F. Williamson on Mayo's advice who actually chose the site before de Böckh had visited it. At Gach Sārān the first well was spudded (drilled) in on 19 April 1926 and oil struck with the third well in November 1928. Because of geological difficulties, the coming in of Haft Kel, and the effects of the Depression, further drilling was abandoned in October 1930, after five wells had been drilled. The first well was spudded in at Āghā Jārī on 6 November 1926 and later caught fire before being deepened to 6070 feet and abandoned. At Pāzanun a well was spudded in on 22 September 1926 before being suspended at 5320 feet in October 1930. Later these three areas were proved to be notable fields though Pāzanun was essentially a gas/light distillate field.

Near Zeloi three wells were drilled without success between 1925 and 1929, but the nearby field of Lālī was discovered when drilling was resumed in 1937 and the second well struck oil in July 1938, though it was not until June 1946 that it was proved commercially. No oil was discovered at Gach Khalaj. At the least, as a result of de Böckh's efforts the Company was no longer dependent on a single field. The Company's exploratory activities in Persia 1901-32 had been expensive and intensive.[35] Some 400 000 square miles out of the total concessionary area of 480 000 square miles had been examined, some 150 000 square miles in detail, during 382 surveys in 141 different areas, 23 sites had been tested and 51 wells drilled, excluding Masjid i-Suleimān and Haft Kel. The footage drilled totalled 139 659 feet at a cost of some £1 000 000 (see Table 10.2). As seen from Appendix 10.2, costs at Masjid i-Suleimān and Haft Kel amounted to some £500 000.

In the long term the Company was sure that its concessionary area was potentially rich in oil resources and that it could plan its policy accordingly. The exploratory work undertaken in this period underpinned the growth of the Company in the decades that followed, till it lost its exclusive concessionary rights in Persia in 1951. It established the reputation of its geologists, whose professional abilities have been a prominent feature of the Company's success. It assured the foundations of the Persian oil industry.

4 THE ĀBĀDĀN REFINERY

The outstanding successes of exploration and production did not apply to the refinery at Ābādān. During the war it had functioned with difficulty and the demands of war service for the Mesopotamian expeditionary force had increased the already formidable burdens on the management, who just concentrated on keeping going. The expansion in output had been achieved at a cost, as Garrow noticed on his visit in 1919 when he commented that 'the Abadan area is unquestionably congested … overloaded with refinery extension, barge and tanker work'.[36] He suggested freezing output 'until we have every department, including shipping and marketing, in thorough proportion all round, properly organized as there is, in my opinion, sufficient work ahead of Abadan in construction work to last them at least two years'. Nichols too on his visit in 1920 was aghast at 'the appalling condition in which some of the material had reached the site due to inefficient storage, bad packing and general rough handling'. For Nichols there was a different priority, 'we have always had to aim at the maximum throughput, let us now organise and organise, and whilst still maintaining that throughput, aim at economy of running and so on'.[37] It was, however, a large refinery with an industrial momentum of its own and required more than just exhortation to remedy its defects. It was still limited by the nature of its plant to refining 65 per cent of its output as fuel oil and limited quantities of benzine and kerosine.

In the early twenties much attention was paid to providing better facilities, accommodation, workshops, jetties, the utilities of power and light, security, medical care, lighterage, etc. No comprehensive plan had been submitted for Ābādān's development. The productive capacity of Masjid i-Suleimān was uncertain and it was debatable whether it was right to rely exclusively on Persia, particularly if there were imponderable concessionary perils ahead and whilst exploration was being carried on elsewhere. In 1923 Lloyd was advocating that 'the obvious place for any extensions of the Refinery seems to me to be India. There you have the advantage of much cheaper labour and better facilities, and also a large existing trade in Fuel Oil'.[38] Indeed he went so far as to suggest that 'it certainly seems advisable that whenever possible all capital construction of a permanent nature should be constructed outside Persia, until an extension of the Concession has been obtained'. Technical and economic, not political reasons, ultimately decided the fate of Ābādān. The 'balance' of products had to be maintained in relation to market demand and productive proximity, though shipping, as at Ābādān, was expensive due to the narrow channels and the need for lightering.

Nevertheless, the state of the refinery was very unsatisfactory, caused by inadequate management struggling to bring new plans into operation, whilst coping with a backlog of imperfect maintenance. The managing agents' system had singularly failed to coordinate the different aspects of management. The role of the chemist was virtually neglected and so the performance of the refinery suffered in consequence. When Neilson was posted to London in 1921, two joint works managers were appointed, which really only increased confusion and uncertainty, until L.F. Bayne became the sole works manager in 1924. By the end of the war refinery throughput was about 1 000 000 tons a year. Within four years it had virtually doubled, but between 1922 and 1923 expectations were disappointed, falling in 1923 by about 700 000 tons and not realised till 1925. This shortfall reacted unfavourably on marketing prospects. (For refinery throughput and product yields see Table 10.3.) In late 1921 there was a disastrous fire, which meant that refinery throughput for 1922–23 hardly exceeded that of the previous year. The plant was suffering from extensive deterioration with an adverse affect on performance. Andrew Campbell, then manager of refineries branch, on a visit to Ābādān in late 1923, described the refinery as 'a crippled plant which will take some time yet before it is brought up to the same new standards as the Fields and Pipeline' and noted that its various units were out of balance.[39]

Table 10.3. *Ābādān Refinery throughput and production 1919–32*

(long tons 000s)

	Through-put	Production											
		Benzine	%	Kerosine	%	Crude distillate	%	Fuel† gas oils	%	Other products	%	Loss	%
1919–20	1 167	203	17	140	12	—	—	742	64	—	—	82	7
1920–21	1 534	333	22	134	9	—	—	970	63	—	—	97	6
1921–22	1 780	394	22	163	9	—	—	1 138	64	—	—	85	5
1922–23	1 886	349	19	142	8	78	4	1 217	65	—	—	100	5
1923–24	2 138	*223	10	125	6	334	16	1 334	62	—	—	122	6
1924–25	2 890	310	11	181	6	326	11	1 920	66	—	—	153	5
1925–26	2 945	363	12	197	7	277	9	1 970	67	—	—	138	5
1926–27	3 125	409	13	192	6	331	11	2 060	66	—	—	133	4
1927–28	3 286	531	16	228	7	252	8	2 137	65	—	—	138	4
1928 (9 mo.)	2 938	694	24	289	10	1	—	1 876	64	—	—	78	3
1929	4 156	1 156	28	359	9	13	—	2 676	64	—	—	55	1
1930	4 547	1 131	25	456	10	20	—	2 902	64	—	—	38	1
1931	4 388	1 166	27	370	8	74	2	2 631	60	84	2	63	1
1932	4 979	1 066	21	380	8	—	—	2 429	49	1 054	21	50	1

Notes: na not available
* refined benzine only, previous to 1923–24 figures include unrefined benzine
† cracking stock + process oils
Source: BP AC 21

It was not only the state of the plant that was unsatisfactory at Ābādān. Labour relations too were suffering from neglect. The town itself, administered until 1924 by Shaykh Khaz'al, was cramped, unsanitary and lacking the facilities for a large and expanding population of differing nationalities and creeds whose customs were not always accorded the toleration which in such a society is requisite. To this artificial settlement which owed its existence to the presence of the refinery had been attracted a variety of local traders and unskilled labourers upon whom was superimposed a changing layer of Indian workers and artisans on contract living in their own quarters, and a small European staff on three year terms of service. War-time exigencies and the relative fewness of numbers kept discontent to a minimum, but conditions and the cost of living subsequently provoked protests from all sections of the work force, particularly among the Indian employees amongst whom some semi-organised political agitation had broken out, as a consequence of the bitter resentment in India following the Amritsar riots of April 1919. On 9 December 1920, the Indian imported labour, some 3000 strong, went on strike and Nichols, who had only just arrived in Ābādān on a visit, was obliged to concede their demands for an 80 per cent increase in wages and other improvements. The following day Persian and Arab labourers also struck. Their demands too were accepted.

As a result of this experience, an overdue reconsideration of the terms and conditions of contracts for all the workforce was made. It is significant that the militancy was confined to Ābādān, for no such action took place elsewhere amongst the Company's operations in Persia. Nevertheless a comprehensive solution was required. With some modesty in view of the immensity of the task undertaken for the first time in the Company's administration in Persia, Nichols reported on his visit that

the wages, working and living conditions of every man jack in the Company's service have been investigated. They have all been classified according to their employment, and wages have been standardised everywhere. The general service has been immeasurably improved, and there is some sort of system now. When it is remembered that over 15 000 employees are concerned, and the various nature of this employment, it will be appreciated that this has been some task.

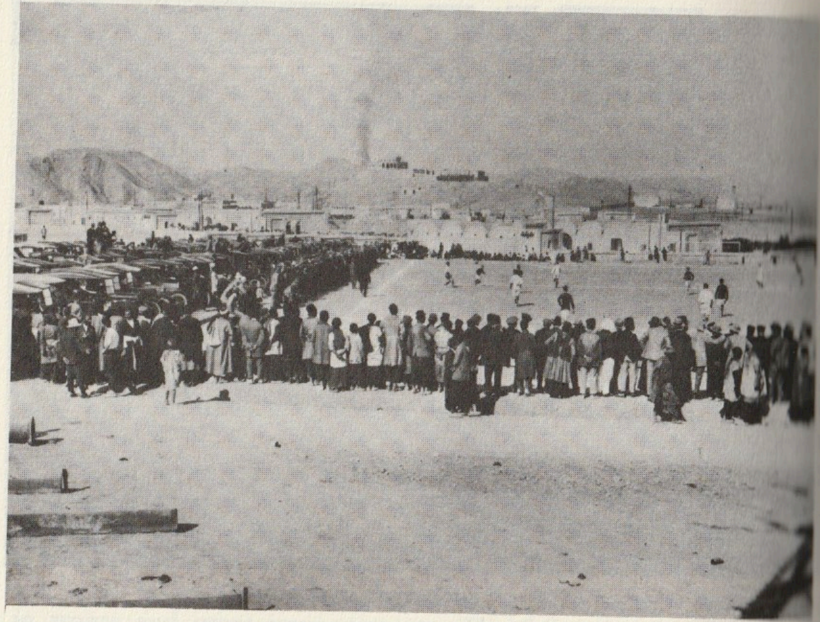
He had not solved all the problems for some, like accommodation, married quarters, medical services, leisure amenities, exchange rates and the sale of discharge certificates of Indian employees, needed more attention.

Eighteen months later in May 1922 another strike of Indian skilled labour broke out, but after a failure to reach a settlement with the leaders, the men were repatriated to India. It left the refinery seriously undermanned, but it provided an opportunity for Persians to fill the

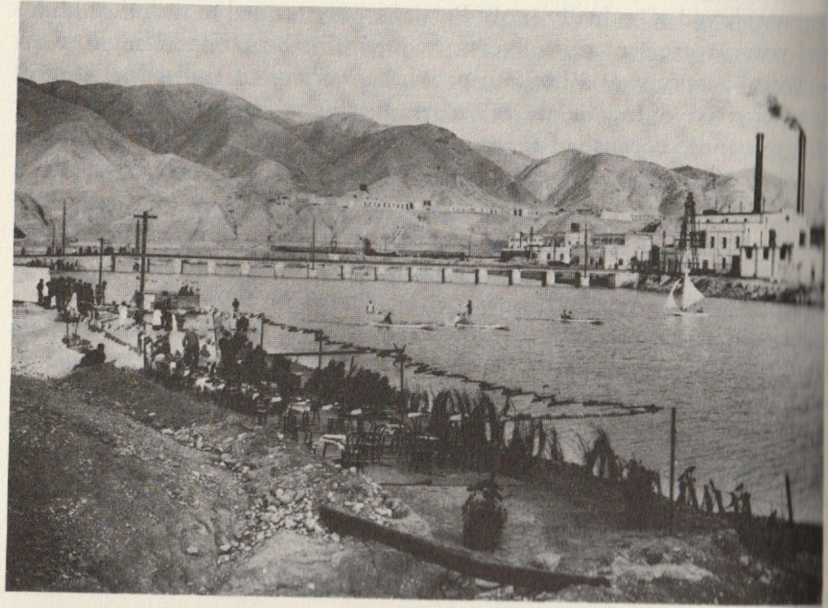
Young Persian apprentices at Masjid i-Suleimān 1924

vacancies, as it was decided not to fill the positions with such labour from India, though Indian clerical staff, orderlies, process staff and cooks were still employed. Gradually more Persians were trained in technical trades and some were sent on university courses in the United Kingdom. A technical institute was built to provide a variety of skills. In 1924 yet another strike of Indian labour occurred, which the Company was better able to handle because of the success in training Persians. Gradually the number of Indians was reduced and that of Persians increased, a much more satisfactory state of affairs (see Table 10.1). The state of industrial relations, the pattern of Persian employment and the administrative organisation during the Company's concessionary period in Persia to 1951 will be more fully treated in a separate chapter in the next volume.

The expatriate community provided its own social life in a region where the countryside offered little to attract the European except mountaineering, riding or bird watching. So concert parties, amateur theatricals, sports and other forms of amusement and entertainment were organised voluntarily under the watchful eye and assistance of the Company. It was usually good natured, but occasionally the petty jealousies seemingly inseparable from such a life enlivened the tea parties and bars, but there was little real social discontent once the housing situation had improved, more married quarters became available and better medical facilities were provided.



A football match at Masjid i-Suleimān 1924



A regatta on the lake by the Tembi power station 1924

A fancy dress party at Ābādān 1924

Medical officers and hospital staff with Dr Young, centre left 1926

In the absence at that time of comparable Persian company, since few educated Persians were attracted by the opportunities available or the living conditions experienced in the humid climate of Ābādān, it was regrettable that aloofness rather than companionship came to characterise the social relations of the two peoples. Moreover that informality between the sexes which is publicly usual in European society did not then exist in Persia, a Moslem country. Later, when more educated Persians went to live in Khūzistān, there was resentment at what appeared to be the imperious manner in which they were treated, but nevertheless over the years many lasting friendships were made.

Difficulties continued over the refining of benzine and kerosine. In August 1921 the large-scale operation of the hypochlorite process for benzine began at the refinery. This too was dogged by misfortune over electricity supplies, failures of electrodes, impurities in supplies of brine and corrosion to the plant. In 1924 the troublesome electrolytic method of manufacturing hypochlorite solution was replaced by the simpler and cheaper method already in use at Llandarcy, on the advice of the research centre at Sunbury, of dissolving bleaching powder in water. The desulphurisation of kerosine by filtering through roasted bauxite was also attended by breakdowns in the plant, problems of handling and insufficient temperature in the furnaces. Indeed the demoralised management at Ābādān, according to Lloyd in 1923, 'seem to be agreed that it is impossible to satisfactorily desulphurise kerosene with bauxite'.[40] There were mistakes, but it required special training at Sunbury and Llandarcy for C.E. Spearing, the plant operator, before the process was working satisfactorily. Spearing had joined Sunbury in 1921 and much later became general manager of refineries department. Jameson, who had been appointed general manager, fields and refinery, expected early in 1924 that 'by the end of the year quite a different spirit will pervade the place and that the old departmental feeling will have been dispelled'.[41] This lack of effective coordination was acknowledged to be a serious defect at the senior management conference on the Persian operations held in Cairo in March 1924 summoned by Cadman. It was agreed that 'the course of past events, largely unavoidable, has brought about a position in which there is now a regrettable lack of balance and correlation between the refinery proper and its various auxiliary establishments'.[42]

The most penetrating comments on Ābādān were made after Cadman's visit there in November 1924. It was the first comprehensive technical appraisal of the refinery made by the Company and laid the foundations for most subsequent developments. Critically but reasonably, he reported that:

> The Refinery is an impressive sight and occupies, with storage tanks, jetties, the bungalow accommodation for European Staff and the village for native employees an area of about 3000 acres.
>
> The total cost of the Company's property on the island is in the neighbourhood of [illegible] million sterling, and the monthly wage bill for the present staff of 366 Europeans and 9000 Natives is about £75 000.
>
> As is well known, this refinery for a very long time after its inception was virtually a war centre. Its early growth therefore took place under circumstances which could not well have been more discouraging and confusing to those then responsible, and it is much to their credit that so much was done in the face of so many difficulties. With such an initial handicap, however, it is not surprising that it is still very far from being an effective unit in the general organisation, having regard to the magnitude of present-day throughput.
>
> During the last 5 years adjustment under post-war conditions to any settled form of policy, has been lamentably slow, and the Refinery, as it exists today, is far from being stabilised on a sound profit-earning basis.
>
> I must strongly emphasise the need – exemplified by all that can be seen at Abadan today – for planning the broad outlines of refinery policy of the future ahead of actual mechanical and scientific development. In the case of Abadan the monthly throughput has practically doubled as between 1920 and 1924 (34 000 000 gallons to nearly 65 000 000). It is doubtless the case the momentum of the war 'push' reinforced by the attractive market conditions of 1919 and 1920, led to bench construction being pushed far in advance of all the needed collateral equipment. Hence it is not strange that Abadan, as it exists today, is not a refinery in the proper sense of the word, but merely a gigantic topping or distillation plant, producing petrol, unrefined kerosine and fuel oil. In addition, the means by which these products are obtained still leave much room for technical improvement and working economies. The criterion of a first-class refinery is its capacity for reducing crude oil into terms of its most valuable constituents by the most economical processes, and hence we can obviously not yet regard Abadan with any degree of equanimity.[43]

Cadman was scathing about 'a state of chaos', caused by badly designed plant. He was scornful about the design of the bauxite plant, 'wondering if the designers are mentally defective'. Garrow on his visit in 1919, had been surprised that the managers of the refinery and fields and the pipeline superintendent had not met each other because 'the closer the intimacy between these heads of departments, the greater will be the cooperation, which will all be to the good of the work'. Cadman too was disappointed at the lack of liaison between London and Ābādān. He insisted on 'unification of engineering control, the fullest possible application of engineering principles to the Company's technical operations, and closer contact, particularly on all technical sides between London and Persia'. Thereafter Cadman instituted regular annual conferences involving technical management in London and Persia. Collaboration, not isolation was his managerial touchstone.

It was clear, nevertheless, that more was wrong than just the management, which had certainly improved after Jameson had been transferred from Fields and given overall responsibility for Ābādān. He was accompanied by H.Y.V. Jackson, the chief engineer in Fields, whose experience was broader than that limited to service in Burma which most managers had hitherto possessed. E.H.O. Elkington, who had served in the Indian army, after joining the Company had been posted to Fields, was put in charge of administration. Thus was new blood, new ideas and a renewed sense of purpose brought to Ābādān. The refinery was out of date, its equipment virtually obsolete. It was metaphorically little more than a gigantic pot for boiling up crude oil. Ten of its fifteen benches were old-fashioned stills with a combined throughput of 4800 tons a day, four others together had an output of 4100 tons a day, but a later unit to be commissioned, bench 30, had a capacity of 1500 tons a day. An idea of the earlier kind of benches used can be seen in Figure 10.5. None of them was preheated or able to achieve any precise degree of fractionation of distillate into regular narrow cuts, as was done in standard later practice of the kind shown in Figure 10.6. The first so-called 'fraction' to be separated from the crude oil was the same in 1924 as it had been since 1912, ORD, once-run distillate, a semi-refined benzine, which then had to be redistilled in a further bench in order to separate out the benzine and kerosine products. It was inefficient and uneconomic.

During 1925 there was much discussion about the need for reliably fractionated distillates in relation to the properties of Persian crude oil and the requirements of the market, the elimination of wasteful practices and the proper economics of scale appropriate for large throughputs.[44] An important result of the installation of proper fractionating columns, which were supplied by the American contractors, Badger & Co., at the crude oil benches of the refinery (the principle of which is illustrated in Figure 10.7), was that by September 1928 there was no further need for two distillations to take place. The Board was informed that this 'completed an important phase in the evolution of the Company's refinery and distribution policy'.[45] The change in the scale of the operations can be gauged by comparing the original complete refinery programme of two benches, which had a throughput of 260 tons a day with a single bench (no. 35) capacity of 3800 tons a day in 1928. In 1929 the first four thermal cracking units of the American Cross design, of which two had already been installed in Llandarcy in 1926, were ordered costing some £2 000 000, from M.W. Kellogg, the American contractors, for the processing of some 1 000 000 tons of fuel oil a year to yield 440 000 tons of benzine for improved quality motor spirit.[46] These were finally all commissioned by November 1931.[47]

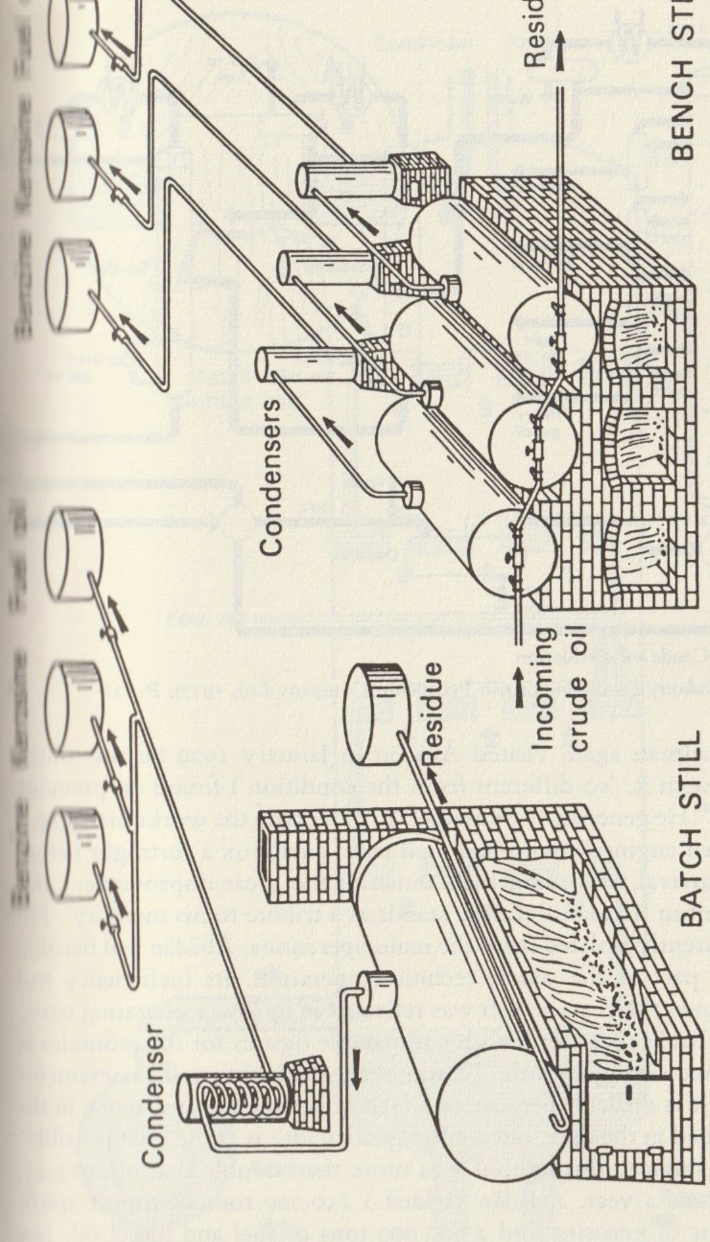


Figure 10.5 Batch and bench stills c. 1912
Source: After Kendall Beaton, *Enterprise in Oil. A History of Shell in the United States* (New York, 1957), p. 86

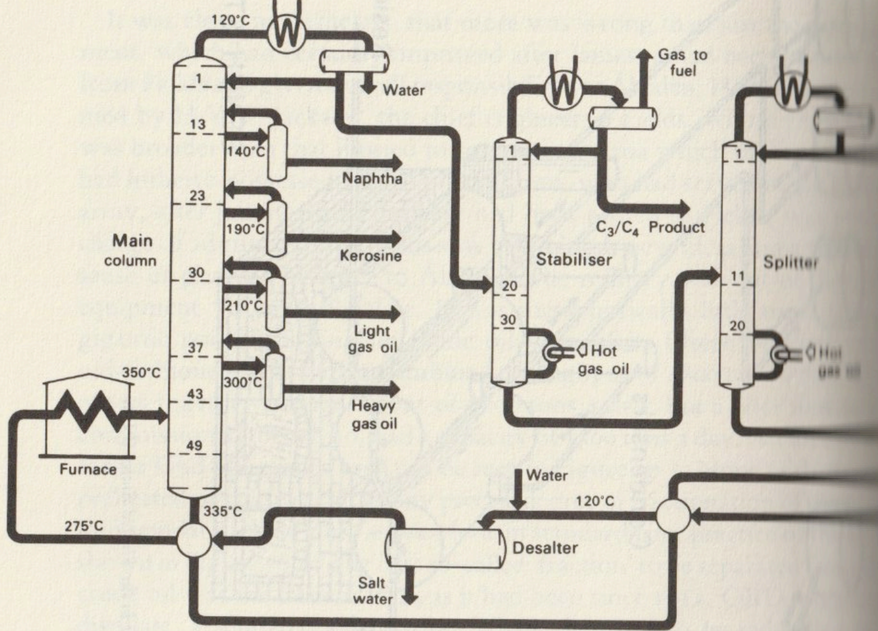


Figure 10.6 Crude oil distillation
Source: *Our Industry Petroleum* (British Petroleum Company Ltd, 1977), P. 231

When Cadman again visited Ābādān in January 1929 he was much impressed with it, 'so different from the condition I found on previous occasions'.[48] He generously praised H. Y. V. Jackson the works manager, a very talented engineer, who had died from smallpox a fortnight before Cadman's arrival, recording that 'much of the great improvement and development in Abadan Refinery stands as a tribute to his memory'. No longer apparently isolated from the main operations, Ābādān had become an integral part of the whole technical operation. Its inefficiency had improved over the years which was reflected in its lower operating costs detailed in Table 10.4 along with comparable figures for the refineries at Llandarcy and Grangemouth. To some extent making valid assessments of such costs is difficult because of a lack of complete consistency in the items included in the data, but a good general idea is at the least possible.

By 1930 refinery throughput was more than double that of 1923–24, 4 550 000 tons a year. Ābādān yielded 1 130 000 tons of motor spirit, 456 000 tons of kerosine and 2 900 000 tons of fuel and diesel oil, (see Table 10.6 for detailed volumes and percentages). In the same year [illegible] tankers shipped 5 500 000 tons of crude oil and products. The improvements and the construction of new storage tanks, loading systems, extra

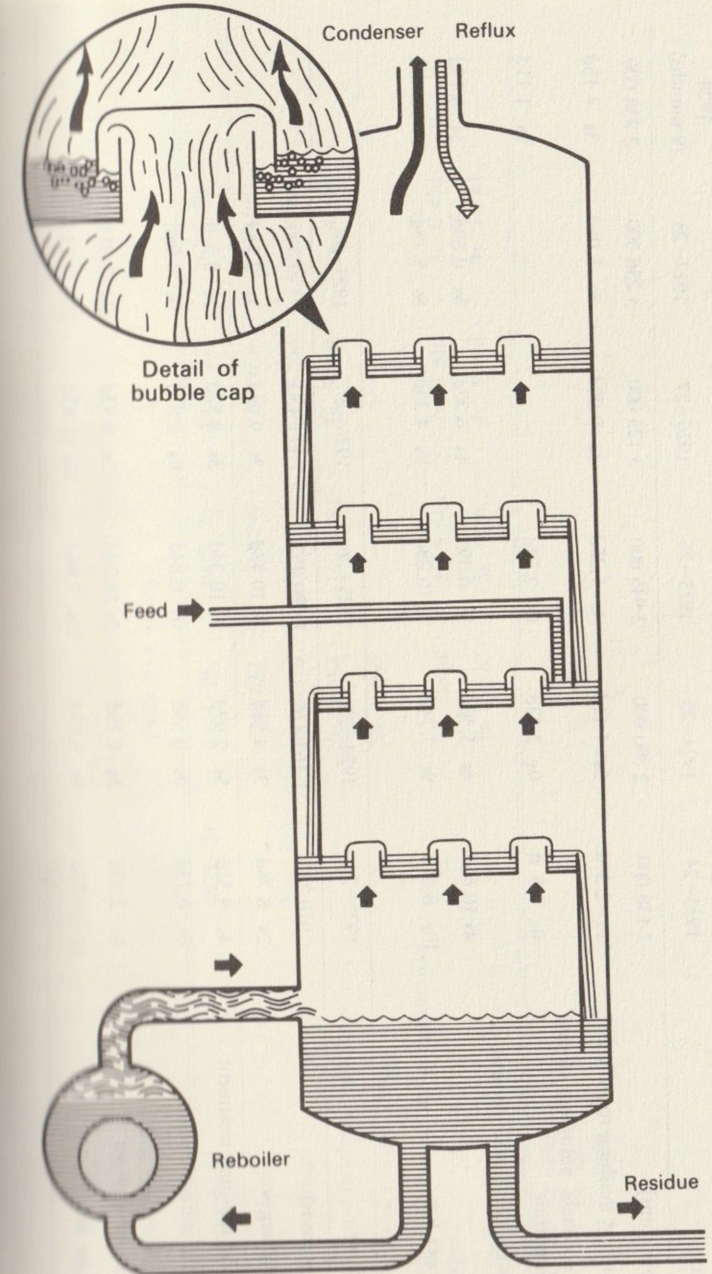


Figure 10.7 Fractionating tower
Source: *Our Industry Petroleum* (British Petroleum Company Ltd, 1977), p. 230

Table 10.4. *Anglo-Persian Oil Company group refinery costs per ton 1923-28*

(a) Ābādān	1923–24	1924–25	1925–26	1926–27	1927–28	1928 (9 months)
Throughput (tons)	2 138 000	2 890 000	2 945 000	3 125 000	3 286 000	2 938 000
Distillation and finishing treatments	5s 2.38d	5s 1.11d	4s 7.35d	3s 9.96d	3s 5.06d	3s 4.15d
Finishing products, pumping, storing and transporting	0s 7.5 d	0s 3.33d	0s 2.54d	—	—	0s 1.11d
Indirect and general establishment charges	4s 10.66d	4s 3.30d	5s 0.39d	4s 6.37d	5s 0.69d	3s 5.19d
Total cost per ton	10s 8.61d	9s 7.74d	9s 10.28d	8s 4.33d	8s 5.75d	6s 10.45d

(b) Llandarcy	1923–24	1924–25	1925–26	1926–27	1927–28
Throughput (tons)	910 757	1 165 876	1 080 252	1 111 430	1 199 300
Distillation charges	2s 8.76d	3s 4.91d	3s 10.48d	3s 9.04d	3s 2.34d
Chemical and finishing treatment	4s 9.31d	5s 2.92d	3s 10.34d	3s 8.52d	3s 5.9 d
Pumping and storage charges	0s 0.73d	0s 0.59d	0s 0.84d	0s 0.81d	0s 0.98d
General establishment and administration charges	4s 2.93d	3s 9.15d	3s 10.20d	3s 9.93d	3s 7.01d
Total cost per ton	11s 9.73d	9s 5.57d	11s 7.86d	10s 11.63d	10s 4.23d

Table 10.4. (*cont.*)

(c) Grangemouth	1923–24	1924–25	1925–26	1926–27	1927–28
Throughput (tons)	—	263 637	317 249	355 604	379 069
Distillation charges	—	1s 0.21d	0s 9.21d	0s 11.36d	0s 7.96d
Chemical and finishing treatments	—	2s 1.25d	1s 9.45d	1s 5.96d	1s 4.90d
Pumping and storage charges	—	0s 0.56d	—	—	—
General establishment and administrative charges	—	3s 1.80d	2s 5.54d	2s 3.33d	2s 0.41d
Total cost per ton	—	6s 3.82d	5s 0.20d	4s 8.59d	4s 1.27d

Sources: BP 4.c.6353
BP 4.c.6357
BP 4.c.6358

steam and power generation, water pumping, accommodation and amenities reached a peak in 1930 when 110 staff and 5500 workers were employed on them. The volume of construction materials reached 183 000 tons and the capital cost of refinery construction and improvement in hand was estimated at £2 000 000. A floating dock had been installed in 1928 and an aircraft landing strip was added in 1929 to what was already becoming one of the largest refineries in the world. After 1930 drastic economies were made as a result of the work already completed and the effects of the Depression. The labour force fell to 7500 in 1932. Imports of refinery equipment, with most planned construction work completed, dropped to 20 000 tons.

Ābādān, which was low, humid and hot, lacking the fresh climate and geographical interest of Fields, was never an easy place in which to work and live. The variety of people employed and the diversity of their occupations complicated social relations. It was a huge industrial enterprise of much complexity, remote from the main centres of national activity. So there grew up in it a fairly self-conscious alien community in an unrepresentative Persian environment living rather apart from the disparate Persian society present. The expatriate body, self-centred, and never deeply rooted, with its social distinctions and Company grades, had a sense of its

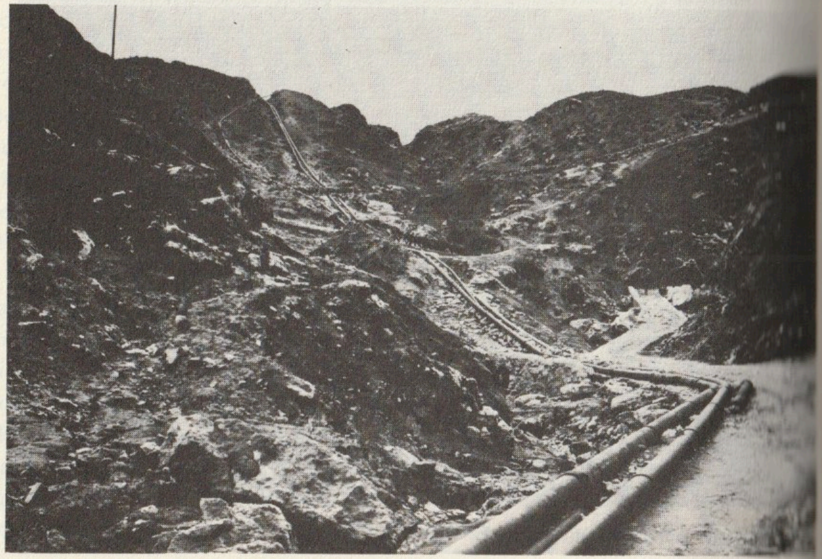
The ending of a shift, Ābādān 1926

Aerial view of Ābādān 1930

own self-importance, as it lived and worked and played together. By 1930 the refinery had been re-equipped and properly organised. It was no longer the weakest, but an indispensable and properly functioning link in the industrial chain of interconnected and interdependent activities from the well head to the petrol pump.

5 THE PIPELINE

As the Company was satisfying the demands of the market, production was increased and it became necessary to expand the capacity of the pipeline. At the end of the First World War the cost and scarcity of pipe made it preferable to install pumping plant rather than enlarge the pipeline.[49] So it was decided to erect three intermediate boosting stations between Tembi and Ābādān at 30 to 40 mile intervals located near the River Kārūn for boiler and water condensing supplies. Each station was originally planned to contain two pumping units, which would ensure adequate standby capacity for maintenance or breakdowns. The stations were situated near the small riverside villages of Mullāsānī, Kut 'Abdallāh and Dorquain and set up as self-contained small communities with brick houses, their own electricity supplies, power and water, clubs, medical dispensaries and sports amenities. The river steamers plying on the river made frequent calls and the desert tracks were passable for vehicles in the



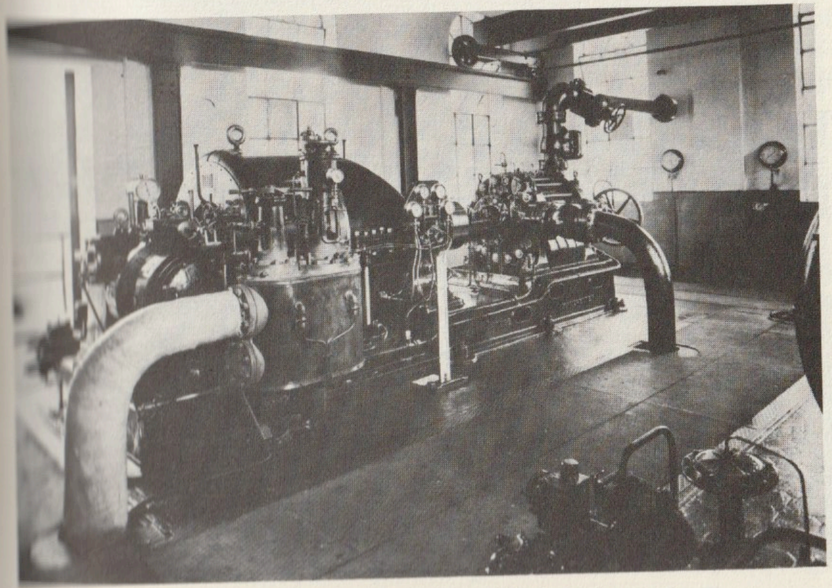
The pipeline on the Imām Rizā slope c.1924

dry weather, but communications in the rainy season were liable to be cut off for weeks at a time.

An interesting and important innovation initiated by the Company's engineer was the use of large centrifugal pumps directly driven by condensing steam turbines. Normally for this kind of purpose reciprocating pumps had been used in the United States. So this was a major change in pumping technology, later to become general practice throughout the world in pipeline pumping stations.[50] The main advantage for operations in Persia was in the lower mechanical maintenance required, a major factor when skilled labour was scarce and continuous service required, so offsetting the admittedly lower hydraulic efficiency of centrifugal pumps and their higher fuel consumption. Tank storage for crude oil at the wells and the refinery was kept to a minimum by a careful adjustment of production to refinery requirements. Moreover, until the mid-1920s continuous operation was essential, as it was impossible to close in some of the larger older wells, because they had not been fitted with high pressure main valves to regulate the oil flow. Indeed some, like F7, had to be mudded off (shut-in) when their casing had become so corroded that there was a danger of their fittings not holding under pressure and blowing off, allowing the well to run wild.

The capacity of the pipeline was increased during 1920–23 to 5 000 000 tons yearly by 'looping', (that is adding pipe in the sections where throughput was restricted), because of growing demand. So in 1920 56 miles of 10 in. pipe was laid, in 1922 37 miles of 12 in. pipe, the first time such a diameter used in Persia, and in 1923 39 miles of 10 in. pipe. The use of mechanical transport had been developed for pipeline purposes including track vehicles with 10 ton trailers and six-wheeled 12 ton Scammel lorries. A 2 ft. 6 in. gauge railway from Dar-i-Khazineh to Tembi was also constructed during this period. A new pumping station was erected on the left bank of the Tembi River to separate it from the main power station for Fields on the opposite bank, to minimise fire risks. More pumping units were added to the boosting stations and the lay-out arranged to reduce fire hazards and facilitate operations and maintenance. By 1924 each of the four stations at Tembi, Mullāsānī, Kut 'Abdallāh and Dorquain were equipped with four identical pumping sets, which were mostly in service at the end of the concessionary period in 1951, so reliable did they prove.

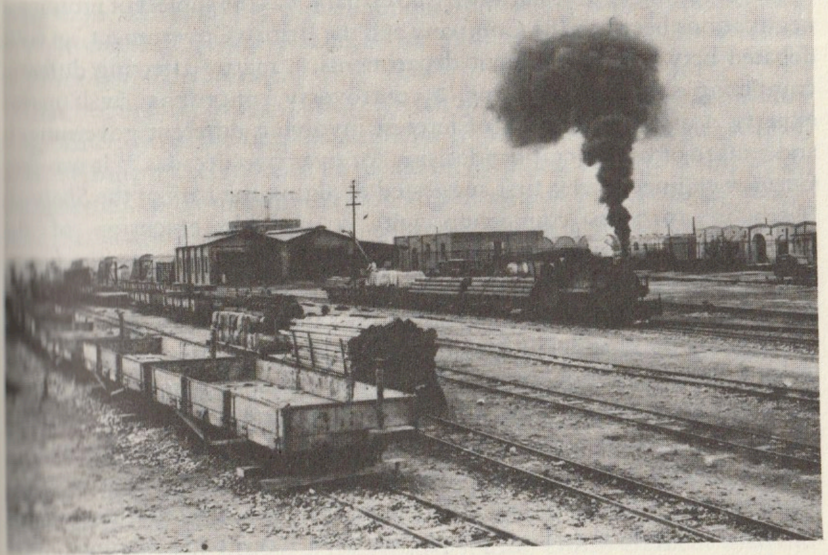
In 1928 pipeline throughput was 5 700 000 tons, but with the discovery of oil at Haft Kel in 1927 plans were made to lay a line from the new field to join the pipeline at Kut 'Abdallāh. At first no pumping station was needed at Haft Kel itself, because well-head pressure was sufficient to force the oil to flow to tanks located at heights above the field elevated high enough for



Turbine-driven centrifugal pump, Tembi station 1926 the oil to flow by gravity down the line. 67 miles of 12 in. pipe were laid between Haft Kel and Kut 'Abdallāh and two pumping units, twice the size of the existing units, were placed at Kut ʿAbdallāh and Dorquain, during 1929 and 1930. In 1929 the pipeline was required to recycle the fuel oil surplus to marketing requirements from the refinery storage tanks back to the fields. No particular difficulty was experienced, except in cold weather when the viscosity of the oil had to be kept down by reheating in Ābādān and at Tul i-Khayyat. Recycling and the later improved practice of injecting separated gasoline from the gas separators on Fields into the crude for Ābādān, or even batches of 'fuel oil' in a 'plug', a set volume of oil to the refinery with a reduced content of lighter fractions, increased the need for vigilance.

The inclusion of volatile fractions in the crude necessitated special measures to prevent gas leaking from the suction glands of the pumps. The pipeline system, therefore, was more than usually elaborate to cope with the demands made upon it, including provision against corrosion from the natural elements and soil conditions, in both of which there were considerable variations and temperatures between below freezing point and 170°F. In the late twenties, welding was beginning to be used in maintenance but earlier all pipe joints were screwed couplings. Pipe corrosion occurred after only two or three years of being buried in the soil and in 1931 it was

River transport and offloading facilities at Dar-i-Khazineh 1926



Railway marshalling yards, Dar-i-Khazineh 1926

decided to lift all pipe and place it on sleepers, zig zagging it to counter the problems of expansion and contraction. Above the surface atmospheric corrosion was insignificant.

The pipeline organisation was called upon to operate the main lines of communication to the oilfields from the coast. It handled the transportation of material and personnel by river and road within its area. A fleet of river steamers and barges had to be maintained, roads surfaced, vehicles serviced, telephone and telegraphic lines operated. The headquarters was established in Ahwāz, the nerve centre, to ensure the security and safe operations of the pipeline. A company area was developed including warehouses and docks for the transportation of material, workshops, offices, a housing estate for all grades and nationalities, complete with amenities and facilities for clubs and hospitals. In 1930 employees engaged in pipeline activities numbered 3300 with some 100 British staff. These activities had become an essential function in the Company's operations in Persia.

6 THE DREDGING OF THE SHATT-AL-'ARAB

The lightering of tankers at the bar of the Shatt-al-'Arab below Ābādān was a time consuming and dangerous operation. It restricted shipping to low draughts, thereby greatly increasing costs.

The dredging of the Shatt-al-'Arab estuary was the subject of protracted negotiations between the Company and the British Government, an issue debated between government departments, a matter affecting different competing shipping concerns, a controversy concerning rival marine experts, a diplomatic focus of interest involving different governments and a maze of bureaucratic indecision for over two decades.[51] It was two German engineers who first suggested dredging the bars of the Shatt-al-'Arab in 1910 in connection with a possible extension of the Constantinople–Baghdad railway to Basra. In January 1911 the Company proposed to the British consul and the Turkish Governor at Basra the formation of an Anglo-Turkish Board for the purpose of dredging and maintaining the channel by levying dues on shipping using the waterway. In July the British Government suggested a riverain commission to the Turkish Government. The surveying of an Anglo-Russian Boundary Commission, 1913–14, delayed further action over the Shatt-al-'Arab.

At the beginning of 1914 Greenway informed the Foreign Office of the 'considerable difficulties and loss under the present conditions which necessitated lightering a large proportion of such cargo to moorings ... We are desirous of dredging being undertaken at the earliest possible date', because no laden vessels of more than 10 000 tons d.w.t. could approach or leave from the jetties.[52] The outbreak of the First World War, the entry of Turkey on the side of the Central Powers and the arrival of the British expeditionary force changed the situation. The military authorities appointed a port officer at Basra, who admitted that 'I have only a very slight idea as to what is the best way to go about dredging the Mohammerah Bar and outer bar' and so it proved by his choice of unsuitable dredgers. A competent report was prepared in 1916 by Sir George Buchanan, the first Director General of Port Administration and River Conservancy, but never implemented.[53]

So far it had been a saga of inactivity and in November 1917 the Company raised the subject officially again, which later resulted in a conference being convened on 9 April 1919 with officials of shipping interests, the Admiralty, the War Office and the Mesopotamian authorities but no agreement was reached on responsibilities and financial guarantees.[54] After more meetings it was decided in the absence of informal cooperation that it would be preferable to postpone the scheme until a port authority was in existence, which could enter into a more definite arrangement. This happened in 1922, with the formation of Basra Port Authority. During the winter of 1922–23 Mr F. Palmer of Rendel, Palmer and Tritton, consulting engineers, carried out a thorough survey of the Shatt-al-'Arab.[55] His recommendations were embodied in a report of June 1923. He advised dredging a new channel to a depth of 18 ft at low water

spring tides, by removing some 9 million tons of silt with two dredgers, the *Tigon* and the *Liger* and placing the operations under Col. John Ward of the Basra Port Directorate.

Work began early in 1925. On 11 March 1925 the Company entered into an agreement with the Iraq Government by which the Company loaned the Government £500 000, to be repaid by dredging dues from shipping. In return the Government undertook 'to continuously carry on the dredging of the Shatt-al-'Arab bar so as to provide a channel of not less than 300 ft wide and having a clear depth at its shallowest point of not less than 18 ft'.[56] By September 1925 Ward was dissatisfied with the alignment and set the dredgers in a different direction, which became known as the Rooka Channel. By April 1926 steady progress had been made and the channel was formally inaugurated by King Faysal on 29 April 1929.

The benefit to the Company's shipping operations was most marked. During the year March 1925 to 1926 453 tankers left the port carrying 3 690 000 tons of oil of which no less than 2 174 000 tons had been lightered. In the following twelve months with the Rooka Channel in use 4 113 300 tons were loaded at the Ābādān jetties. On 28 October 1926 the Company decided not to press for a broad two way channel but to request a depth of 19 ft subject to covering the extra expenditure and agreement with the Iraq authorities. By March 1928 a depth of 19 ft had been obtained throughout the channel. With production continuing to increase, further provision was thought necessary and discussions took place on widening the channel to 600 ft to minimise the risks of accidents blocking the channel. As it was anticipated that the largest offtake from Ābādān would not exceed 6 400 000 tons till 1931–32, a figure which was not actually reached till 1934, the further widening was not then regarded as urgent. Moreover an offtake of 8 000 000 tons was then possible and anything beyond that amount would have required an enlargement of the refinery beyond what had been contemplated and might have led to the development of a site at Khūr Mūsa, which was further downstream.[57] It was therefore agreed to keep the existing width of 300 ft but dredge to a depth of 20 ft. These improved conditions resulted in sixty-six ships being loaded and dispatched from Ābādān in one month, May 1930, a record that was not bettered till three and a half years later, in November 1933.

A new factor was introduced in 1930 with the proposals for a new international load line convention, that is decreased free-board for ships, which resulted in an additional permitted draught of one foot in the case of a 10 000 ton tanker, enabling it to be deeper laden. The convention came into effect in July 1932. To take fullest advantage of the new regulations the Company proposed that the channel width should be increased to 400 ft and its depth to 21 ft 6 in. As a result of extensive negotiations with the

Iraq Government a further and more comprehensive agreement was reached on 2 June 1932 embodying these new channel arrangements and superseding those concluded earlier.[58] As the greatest single user of the Shatt-al-ʻArab the Company had most to gain or lose over the dredging. Until the Treaty of Sacdābād of 8 July 1937 between Persia, Iraq, Afghanistan and Turkey, and even later, the Company was, nevertheless, in the unenviable position of being criticised by Persia and Iraq for favouring one or the other because of its shipping interests in the Shatt-al-ʻArab. The Persians objected to the jurisdiction exercised by the Basra Port Authority and both Persia and Iraq disputed the provisions of the 1913 Agreement on boundaries. Nevertheless, those shipping interests were indispensable in carrying supplies from Persia to the Company's markets. The dredging of the Shatt-al-ʻArab greatly facilitated and reduced the costs of this transportation.

7 RESEARCH

The Company had early in 1917 realised the need for specialised research facilities and expertise to help solve its technical problems as they arose. During the first few years after 1917 research at Sunbury had concentrated on the problems of fuel oil gelling, thickening, toluene production and improvements in the refining of Persian distillates. With the end of the war there was renewed concentration on solving the distillation problems to increase product yield in both quantity and quality. Indeed research tended to be linked closely to dealing with problems rather than engaging in work of a more fundamental nature. Activities were essentially industrial rather than strictly academic in emphasis, practical rather than theoretical in application. Dunstan had hoped in his first annual report that 'it should be emphasised that one of the functions of the Research Department is to discover new components in the crude, new products therefrom and new applications for them. Just as the coal tar industry has flourished because of the utilisation of waste and by products, so in the case of petroleum it is desirable that the fullest use should be made of the wide range of chemical compounds existing therein.'[59] Occasionally during this period efforts were made to conduct more fundamental research, particularly after research advisers were appointed, but in general Sunbury was concerned with solutions rather than propositions.

Dunstan in 1916, before the establishment of Sunbury, attempted to treat benzine with an acidified solution of potassium permanganate. This worked well in the laboratory but had to be abandoned in 1917 because the quantities required in practice were so enormous. The upgrading of refining processes for benzine and kerosine remained an important priority in

Sunbury's programme of research. Another constant preoccupation in this period was dealing with the associated gas in the production of oil, which was not only dangerous but wasteful.

In 1918 Dunstan and Thole turned to the idea of using sodium hypochlorite to desulphurise Persian benzine and kerosine. It seemed an attractive possibility, having been first patented by Herman Frasch in the United States in 1894,[60] and required chemical constituents that could be manufactured easily by the electrolysis of brine in plant, which was already available and utilised in the bleaching industry. Dunstan and Thole successfully realised the necessity for keeping the sodium hypochlorite reagent in a slightly alkaline state to keep it stable. By the end of 1918 the process seemed promising, though it was recognised that after treatment the benzine developed an unseemly yellow colour which required filtration to remove it.[61] This was found to be possible through bauxite and much ingenuity was spent on the mechanics of such treatment through roasted bauxite granules. In his second annual research report Dunstan wrote that 'this discovery supported by independent analysis and by work, we may fairly claim to be of first importance, seeing that it is a step towards the elimination of chemical treatment'.[62]

Neither discovery was a guaranteed success in operation and a few years and much effort was required for results to be commensurate with expectations, but it was a significant achievement within the context of the research organization's resources and facilities, which were then simple pots, pans and bottles rather than sophisticated apparatus, which was not then available.[63] Indeed conditions were so primitive in the laboratory installed in the basement of the country house, Meadhurst, that passed for the research centre, that Nichols, visiting Dunstan after he had been taken seriously ill with pneumonia, was horrified at the conditions in 'that cellar' and the Board soon authorised the construction of a proper laboratory building on an additional 2.7 acre site.[64] It was completed in 1921 with workshops, a drawing office, boiler house, and outbuildings for plant experiments and chemical and engineering stores. It was a vast improvement.

A contemporary development of great importance for the Company and incidently for the research function had been the erection of a refinery called, imaginatively, Llandarcy, at Skewen near Swansea.[65] After delays during the war and the withdrawal of priority licences (see Chapter 6), work on the refinery did not begin again till February 1919, with Andrew Campbell in charge as Managing Director of National Oil Refineries. The first distillation operations commenced in July 1921. In some respects Llandarcy acted as a proving ground for Sunbury, but equally the refinery had its own laboratory and cooperation was close, unlike in Ābādān where distance and local conditions were not conducive to easy collaboration. It was at Llandarcy that the sodium hypochlorite and bauxite treatment was first introduced. In the three years that followed operational problems were overcome. The actual treatment of benzine was satisfactory but the electrolysers were inadequate and their malfunctioning made the process initially more expensive than was estimated. A modification was introduced in 1922 with the availability of cheaper bulk supplies of liquid chlorine in favour of a chlorine/caustic soda solution. This resulted in the first sale of rights in a Company process to another firm. In 1923 the cost of treatment was further reduced by using calcium hypochlorite instead of sodium hypochlorite.[66]

Ābādān experienced many problems, not only with this process, but because of weak management, an insufficiency of competent chemists and the difficulties resulting from high ambient temperatures.[67] The sodium hypochlorite treatment was started in August 1921 and was eventually in 1923 proved satisfactory with calcium hypochlorite, as in Llandarcy.[68] The bauxite aspect proved more troublesome.[69] No less than 300 tons of bauxite were in continuous use, and 50 tons of raw bauxite had to be crushed and roasted each day to provide a daily make up of 30 tons.[70] Cadman in 1926 commented that 'subject to reservation as to the heavy cost of maintaining the mass of machinery involved, the process may now be said to be established'.[71] It had taken a long time of trial and error and it may well be wondered whether this experience did not colour the Board's thinking when it came to making a decision on the cracking plant to be ordered in 1925.

The physical process of cracking, the breaking up of hydrocarbon molecules by heat application, had been an early interest of Dunstan and Thole and other petroleum chemists. There were limits to distillation treatment, even when efficiently applied and effectively controlled. There was a need to change the nature of the crude oil so as to produce more lighter fractions of which motor spirit was composed, rather than heavy fuel oils, as the consumption of benzine, motor spirit, was increasing. The light crude oil found in Pennsylvania and Burma, for example, yielded good quality motor spirit in quantity, but Persian or Californian crude oil was heavy in character and yielded less quantity of motor spirit in proportion to fuel oil. The trick was to change the nature of the crude oil by cracking.[72]

By 1919 a number of cracking patents had been registered, but few were commercially viable, apart from the Burton process pioneered by the Standard Oil Company of Indiana in 1913.[73] A vapour phase cracking process invented by a Dr Ramage had been drawn to Cadman's attention whilst in the United States in 1921, but was disappointing. During 1922 a

liquid-phase' approach was being investigated by Col. S.T.M. Auld, a junior member of the staff at Sunbury, which by the spring of 1923 had reached the pilot stage and was known as the 'A.D.H. Process', after the three scientists primarily involved, Auld, Dunstan and Holley.[74] A 50 ton proving unit was constructed at one of the Scottish shale oil plants, Uphall, and was ready in April 1925. The yield of benzine from Persian crude was quite insignificant for rising market demands from the existing refinery methods, so, rather than wait for the successful Sunbury developed process to be scaled up, the Company in 1925 decided to buy an 'off the shelf' package based on the Cross process first used commercially in 1920, from the American contractor, M.W. Kellogg & Co.[75] It was installed at Llandarcy in 1927.

While the Cross units were being installed, consideration was being given to a second cracking installation, the Dubbs process licensed by the American company, Universal Oil Products Ltd. This was particularly suitable for fuel oil as a charge stock and operated at a lower pressure. It was commissioned on 15 December 1927. The importance of motor spirit was not only related to the need for the cracking process, but also to the need for improved performance through additives. In 1924 the Board acknowledged that simple straight-run petrol was becoming unsatisfactory because of the growing number of high compression engines.[76] Later in 1926, for this purpose and in order to undertake controlled tests on a comparative basis, it was decided to form an engine research branch under the charge of L.J. Le Mesurier.[77] This branch functioned very efficiently and acquired a considerable reputation in engineering circles for its expertise and knowledge which was largely due to the dynamic personality of R. Stansfield, who was primarily responsible for the engine testing facilities, which were housed in a new building in 1930.

Another important aspect of early research done at Sunbury was the utilisation of gas.[78] Persian crude oil as it emerged from the well was not a simple liquid, but a froth. For every million gallons of crude oil produced, some 20-25 million cubic ft of gas was released, mostly methane and ethane, but as it bubbled out of the oil it flashed off light hydrocarbons like butane and pentane, of value for use in motor spirit. In the early days the toxic dangers from hydrogen sulphide were realised and measures taken to prevent its dangerous ill effects, but the positive qualities of the gas were ignored. Imagination, technology and finance were all lacking. Some early gas separators were ordered in 1917 from Messrs Trumble and Co. in the United States, but did not reach Fields till December 1919, by which time they were too small to be of any use. Garrow on his visit in 1919 reported that 'immediate action is imperative if the field is to remain inhabitable'. He arranged with Dunstan and the Engineering Department that equipment should be designed to treat 1 000 000 ft of gas a day and that some of it should be used as boiler fuel, though it was 1922 before a boiler of the right kind was available. By the end of 1922 some progress had been achieved, but in relation to the extent of the problem it was a minor palliative.

Lloyd, in 1923 on his visit, put the problem into perspective, when he reported that 'the statement was made that there is enough gas in Fields to light the whole of London. It seems obvious that if all this gas which is now wasted could be converted and utilised in some commercial form at a profit, the Company would gain enormously. The problem is crying out for a solution ... the very best chemists available should be sent out to investigate, and as soon as possible.'[79] The fabulous orange and yellow coloured flickering flares were a perpetual reminder (and reproach) of the energy that was going up in flames for it was estimated in 1924 that some 75 000 000 cubic feet of gas were being burnt off. Jameson too felt that 'as every day adds to our responsibility for this colossal waste we consider that services of a fully qualified expert [should] be urgently procured'.[80]

A tentative start was made when Auld came to Persia early in 1923[81] and at the small Fields laboratory where a single Fields chemist, M.S. Mainland, began some experimental work on gas recovery.[82] In 1925 the chemical work at Fields was upgraded to a separate small research department under W.H. Cadman, brother of Sir John Cadman. The chemical staff tried to make carbon black for printers ink, but failed. Sulphur, however, was produced, though as it could not then be utilised, the commercial benefits were minimal.

Sulphur, however, was later used in 1931, in the refining of spirit produced from the cracking plants. Much effort was expended on passing gas through tubes at high temperature (pyrolysis) to produce liquids, but in spite of tremendous encouragement from Professor Thorpe little emerged because of the failure of the metal tubes employed to withstand the high temperatures required. 'The Fields Benzole Plant' became a technical white elephant. The time was too early, the technology too complicated, the demand in Persia too small for a solution to the problem of utilising the gas at the right cost apart from the extraction of a small percentage of light fractions for enriching benzine.

In Sunbury tests were carried out on uses for methane and ethane. At Ābādān attention was paid to practical steps for eliminating gas losses in the plant and the recovery of light fractions for motor spirit. It was not, however, till Cadman's visit to Persia in autumn 1924 that a real impetus was given to the problem, when he was accompanied by a gas expert from Standard Oil, W.L. Morgan. Cadman regretted the delay in using gas as fuel for boilers.[83] Morgan's proposals were accepted and H.Y.V. Jackson, the chief engineer in Persia returned with Morgan to the United States on a further briefing for six weeks. Jackson's report was regarded as 'a suitable model for all who may be called upon to make enquiries' and his proposals were accepted and quickly implemented.

He recognised the technical advances made in the United States and decided therefore that advantage should be taken of past American experience and instead of treading the same torturous path, the design of the APOC plants should commence where American designers had left off'.[84] C.F. Braun and Co of Los Angeles provided the gas absorption units; the compressors were Swiss and the boilers, pumps and water coolers were purchased in the United Kingdom. Jackson's scheme provided for the substantial recovery of 100 000 gallons of gasoline a day from a crude oil throughput of 3 300 000 a day. The first units were operating in November 1926 and by January 1929 the volume of recovered gasoline injected into the pipeline amounted to nearly 2 per cent of the total volume of crude going to the refinery, a welcome addition to benzine supplies. The flaring of gas was a terrible waste of natural energy, in Persia and elsewhere. It has, however, to be set against the highly successful harnessing of the natural resources of the oil reservoir in the unitisation developments, which conserved the pressure and released them under control as productive energy.

Towards the end of 1924, Dunstan was transferred to London to become the Company's chief chemist in charge of all research and chemical affairs and to be close at hand to integrate such matters into the Company's management and so influence its policy in this respect. Thole took his place at Sunbury as chief research chemist. As Sunbury settled into its routine as a research establishment it may be observed that a sense of immediacy came to be lacking, a spark was missing. From a staff of two in 1917, by the end of 1924 the staff comprised forty-six people as can be seen from staff numbers in Table 10.4. Salaries and wages, which were £6031 in 1921–22, were £14 396 in 1923–24. Dunstan had controlled it all in the early days by himself with no assistance from committees, but by 1922 research had become so widespread that better administration was necessary at Sunbury no less than in other activities of the Company.

Cadman was concerned that intellectual stimulus should not be lacking and that the staff at Sunbury should be kept in touch with current academic research. So on 12 January 1923 he chaired the first meeting of the 'Research Advisory Committee' which included Dr J Thorpe (Royal College of Science), Professor F. Soddy (Oxford University), Professor R.V. Wheeler (University of Sheffield) and Dr Dunstan. On the subject of the Company's research work Cadman felt that 'the work should not necessarily have commercial aims in view specifically, and that certain purely scientific matters should be investigated which, at the outset, might not appear to have any commercial bearing. At the same time the solution of these problems might lead to better refining methods, more marketable products and the discovery of new processes, which would be patented, if necessary, by the Company.'[85]

The research advisers have always remained a feature of Sunbury's activities, but it is questionable if the original high hopes were realised as far as fundamental research was concerned. The contacts were beneficial and even indispensable in scientific terms, preventing research from becoming introspective or insipid. Yet the support of the advisers did not actually succeed in turning Dunstan's desire of laying before the Company 'the full chemical and physical history of their raw material' at least in the period under consideration. Nevertheless, the conferences of the Company's chemical staff, first held in 1926, were an opportunity to demonstrate that 'the Company's chemical problems are common to all the chemical staff and are not in any way parochial'.[86] These meetings helped to create a technical *espirit de corps* which permeated the Company.

After 1925 research work was concentrated primarily on product improvement with particular attention being paid to producing better kerosine for special purposes like long-time burning oil for use in railway lamps and for fuel in tractors and fishing boats. Motor spirit and possible anti-knock additives were subjected to exhaustive tests. It was the beginning of a real drive to improve motor spirit with all its benefits for the motorist and because of the increasing competition from other oil companies. A much closer liaison was kept with the distribution department on the reactions and requests of customers. Aviation spirit was prepared. In 1925 only about ten private aircraft were in use in the United Kingdom, but three years later there were 200 owners of private planes and some 45 flying clubs. Provision of supplies was guaranteed to the Imperial Airways on its eastern routes to Cairo and Karachi. Diesel oil was prepared for a market that was minute in 1930 with only 18 diesel engined vehicles on the road but with over 1300 two years later.

Much work was carried out on manufacturing lubricating oil. Limited production was carried out at Llandarcy from 1923. A decision was taken in 1925 to erect a plant there, but it was not till October 1927 that five grades were being produced at a rate of 1300 tons a month. Process improvements enabled this to be increased with a special distillation unit, engineered by the contractors, Foster Wheeler, to 3000 tons a month by late 1931. In France too, at the Company's refinery at Courchelettes, near Douai, a lubricating plant was successfully brought into operation in late 1927 and by March 1928 was producing 1325 tons a month. Thus the range and quality of products was greatly enhanced in these years with an eye to

the market. The gears of the Company's respective departments were meshing better.

In comparison with what had been attempted it may appear that the contribution of research to the Company's growth was less than that anticipated by Dr Dunstan and his colleagues. Yet in retrospect the research work which had from a dingy cellar laboratory spread out to the Company's operations throughout the world in a decade was sufficient to provide the basic expertise in most directions of petroleum technology and in some, associated with petroleum engineering, to make very significant progress. It is no disparagement to the efforts of the scientists to recognise the handicaps of the lack of accurate instrumentation, the absence of standardised testing procedures and the inadequacy of chemical engineering to permit the controlled degree of experimentation which was needed to substantiate the results achieved. These restrictions applied equally to scientists in other establishments such as Dr H.M. Stanley at the laboratories of Distillers Company at Epsom where in the early 1930s he was carrying out research into cracking techniques. It was often years before the pieces of research fell into place, like the alkylation process for making aviation spirit which was developed by Sunbury in the late 1930s. In the 1920s the foundations of research were well laid and its practical applications of growing importance to the Company's success.

Controversy surrounding concessionary relations has often tended to obscure operational achievements. The engineer or chemist is less in the popular limelight than the accountant or lawyer. Yet, the technical accomplishments of the Company in the decade 1920–30 were notable. The geological features of Persia became known in detail. Information on the behaviour of oil reservoirs was accumulated so that the totally new concept of unitisation was established and new methods of production practised. The nature of Persian oil was understood and better refinery processes devised. Techniques of drilling were adapted for Persian conditions. A vast network of supporting services was created, roads, electricity, water supplies, telephone lines, jetties, landing sites, transportation, accommodation, social amenities, education, security and so forth in a region devoid of the elements of an industrial base. The whole enterprise had to be administered not only in accordance with directions from London, but also to the satisfaction of the management and workforce in Persia with their multiplicity of jobs and variety of nationalities, the local population and the Persian Government. Moreover, the Company had to respond to the demands of the market, particularly in respect of motor spirit, to ensure that its products were acceptable to the customer. Its research staff needed to be aware of changing technologies and scientific advances so as to utilise them for the advantage of the Company. In the technical success and application of scientific coordination, which had previously been lacking and which had a beneficial cross-pollination effect on all aspects of the Company's technical operations.

II

DOWNSTREAM ACT

1919-28

I INTRODUCTION

'An absolutely self-contained organisation'. Thi
of the Company, which cannot be sufficiently e
policy of supplying petroleum products directly
there may be a profitable outlet for them withou
third parties'.[1] The Admiralty supply contract in
for a marketing strategy, it was part of it. The
Dutch-Shell in 1912 were not an admission of
were a recognition of adverse commercial circu
straints and refinery inadequacies 1912–14, as inc
prevented the earlier realisation of a more inde
market. Once the war was over and restrictions
products had been lifted, and when the Pool Boa
the end of 1919, the Company did not delay i
action. In December 1919 Greenway informed th
that 'we are making extensive additions to bot
depots throughout the UK with a view to establ
tion that will be second to none in this country
position that will enable us to cater for a substa
trade in Petroleum products of all kinds'.[2]

There was, thus, no mistaking the intentions
involved. This was the justification for a distribu
depended on an economic–technical relationsh
aspects of the oil business, the links in the chain
exploration, production, refining, transportatio
related to the particular nature of Persian oil and
which it was then possible to refine.[3] Crude o
substance. Different markets do not have identi
the distributor lies in optimising the availability
to the peculiarities of demand. The success with
one of the determinants of the profitability of t