THE HAIFA–BEIRUT–TRIPOLI RAILWAY

WITH SPECIAL REFERENCE TO THE AUSTRALIAN PORTION

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Condensed from a paper read before the Kiewa Valley Group of the Melbourne Division, Institution of Engineers, Australia, on 5th September, 1951.

SYNOPSIS

The extract quoted below from the recently published War Office Transportation history of the war gives an excellent idea of the subject of the paper.

Syria and the Lebanon

"The need for direct connexion between the standard gauge railway systems of Egypt and Palestine in the south and of the Lebanon, Syria and Turkey in the north became increasingly obvious, and in 1940 and 1941 routes were surveyed as far as the Lebanese frontier. The route favoured at first was from Haifa, with many variations, to the Jordan north of the Sea of Galilee, and thence to Rayak, but very heavy rock cutting in basalt caused this route to be ruled out. An alternative up the coast from Haifa to the mouth of the Litani River and thence to Rayak was examined and subsequently ruled out owing to heavy work in the Litani Gorge. The final choice was a coastal line from Haifa to Tripoli; this also included heavy work, including small tunnels at Naqura and the Bayada headlands, and about a mile of tunneling at the Chekka headland. Several major bridges and heavy works were necessary, particularly on the Beirut–Tripoli section. On the other hand, this route had the advantage of serving Beirut and the Chekka cement works, and the rock work was not in basalt. (The map opposite shows the Beirut–Tripoli section, which is described fully in this article.)

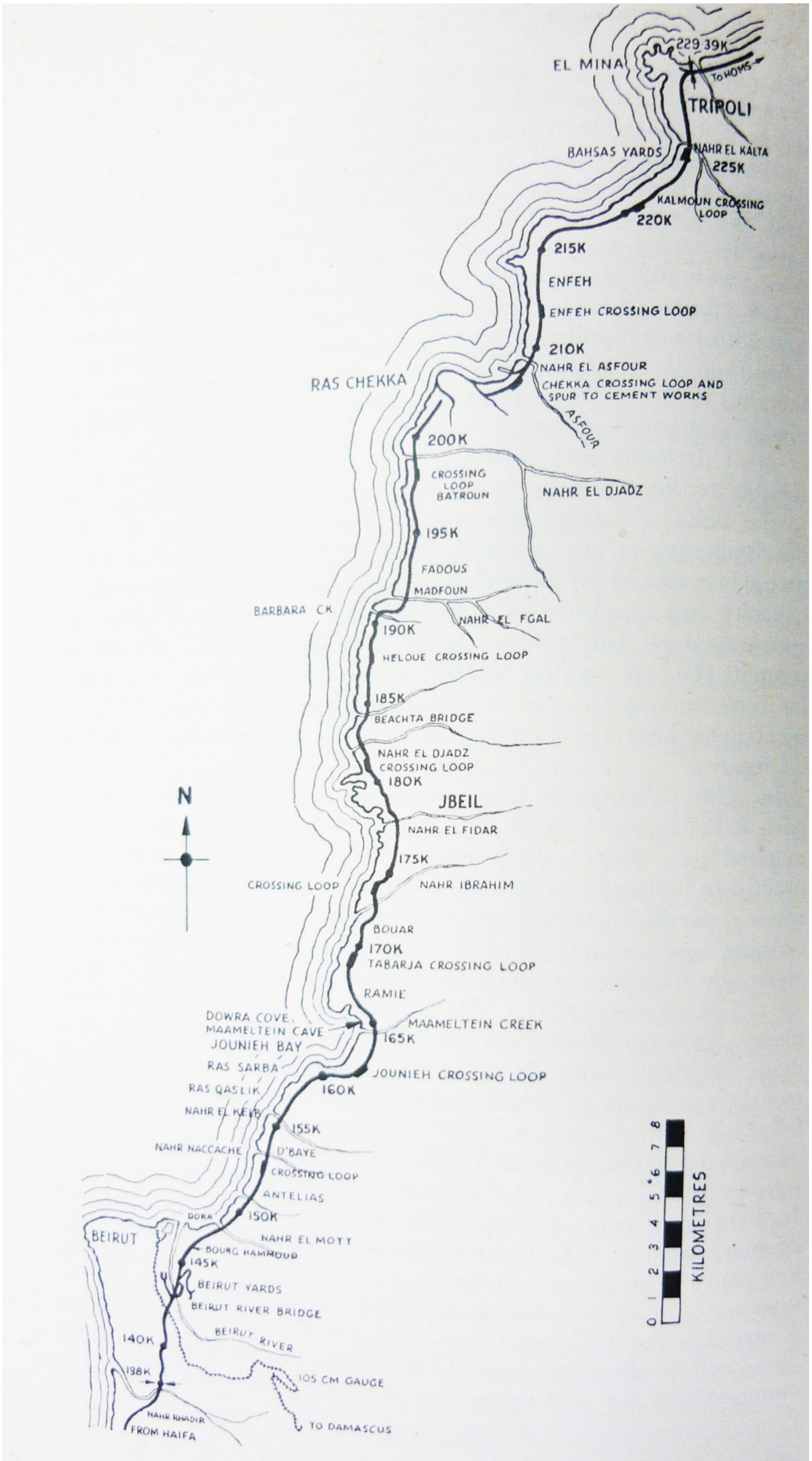
"Work began in December, 1941, and the construction troops were faced with a formidable task. South African railway construction units took charge of the Haifa–Beirut section, with a special company of miners from the Rand to go through the Chekka tunnel. Australian units took on the Beirut–Tripoli section. Hundreds of Arab labourers were employed with scores of Arab masons, the latter being ideal for the heavy masonry work, required in bridge piers, abutments and retaining walls; as much mechanical plant as possible was pressed into service to accelerate the work. In some places, cuttings sixty feet deep and embankments eighty feet high were needed to keep the grade line within reasonable limits.

"In spite of these difficulties, work proceeded at high speed. The Haifa–Beirut section was opened in August, 1942, and the whole line to Tripoli was completed by December, 1942. Thus a total of 176 miles was finished in a year, that is at a rate of approximately half a mile a day. This rapid railway construction through semi-mountainous country ranks among the more remarkable engineering achievements of the war."

INTRODUCTION

Strategical

"The more I have seen of war," wrote Wavell, "the more I realize how it all depends on administration and transportation (what our American allies call 'logistics'). It takes little skill or imagination to see *where* you would like your army to be and *when*; it takes much knowledge and hard work to know where you can place your forces and whether you can maintain them there. A real knowledge of supply and movement factors must be the basis of


EL MINA
229 39K
TO HOMS
TRIPOLI
BAHSAS YARDS
NAHR EL KALTA
225K
KALMOUN CROSSING LOOP
220K
215K
ENFEH
ENFEH CROSSING LOOP
210K
NAHR EL ASFOUR
RAS CHEKKA
CHEKKA CROSSING LOOP AND SPUR TO CEMENT WORKS
ASFOUR
200K
CROSSING LOOP BATROUN
NAHR EL DJADZ
195K
FADOUS
MADFOUN
BARBARA CK.
NAHR EL FGAL
190K
HELOUE CROSSING LOOP
185K
BEACHTA BRIDGE
NAHR EL DJADZ CROSSING LOOP
180K
N
JBEIL
NAHR EL FIDAR
175K
CROSSING LOOP
NAHR IBRAHIM
BOUAR
170K
TABARJA CROSSING LOOP
RAMIE
DOWRA COVE
MAAMELTEIN CAVE
JOUNIEH BAY
MAAMELTEIN CREEK
165K
RAS SARBA
JOUNIEH CROSSING LOOP
RAS QASLIK
160K
NAHR EL KELB
155K
NAHR NACCACHE
D'BAYE
CROSSING LOOP
ANTELIAS
DORA
150K
BEIRUT
NAHR EL MOTT
BOURG HAMMOUD
145K
BEIRUT YARDS
BEIRUT RIVER BRIDGE
BEIRUT RIVER
140K
138K
105 CM GAUGE
NAHR KHADIR
FROM HAIFA
TO DAMASCUS
0 1 2 3 4 5 6 7 8
KILOMETRES

every leader's plan; only then can he know how and when to take risks with these factors; and battles and wars are won only by taking risks."

And in the Middle East, an area which he commanded in the perilous times of 1940–1, a standard gauge railway was planned to connect the railways of Egypt and Turkey.

A 4 ft. 8½ in. standard gauge railway ran from Cairo to Haifa, and from Turkey there was standard gauge down to Tripoli and Rayak. From Haifa by way of the Plain of Esdraelon, around the Sea of Tiberias, up the Yarmuk Gorge, through Deraa and Damascus to Rayak there was a 105 cm. gauge railway with a branch over the mountains by rack railway to Beirut. This railway had heavy grades, sharp curves, was incapable of carrying heavy traffic and was vulnerable to attack.

Topography and Climate

Between Haifa and Tripoli along the coast is a narrow coastal plain vanishing in parts, particularly at Ras Nakura and Ras Bayada not far from Haifa, Nahr el Kelb near Beirut and the Chekka headland near Tripoli, all places where the mountains plunge into the sea. From the plain the foothills rise some 3,000 feet and culminate in a range of mountains known as the Lebanons with peaks of 10,000 feet. After crossing the range by continuing in an easterly direction there is flat plain country, most unexpected and of considerable extent, the Plain of Bekaa, bounded on the eastern side by the Anti-Lebanon Mountains, with Mount Hermon 9,000 feet high as the highest point. The Lebanons are drained to the west by seasonal streams which, with few exceptions, are dry or nearly so in summer but become raging torrents in winter. The Bekaa is drained and watered by the Litani River in the south and the River Orontes in the north. On the eastern slopes of the Anti-Lebanons is the Damascene Oasis and further east is the Syrian Desert which stretches across to the Euphrates. Further north than Tripoli and inland is the Plain of Aleppo, and extensive wheat growing area.

In the winter the mountains are covered with snow and occasionally there is snow on the plains. In the summer humidity is high on the coast. The rainfall, regularly confined to six months of the year averages twenty to forty inches on the coast and rises to sixty inches in the mountains; Aleppo has ten inches and Damascus less.

Population and Resources of the Lebanon

The population was a million; Moslems, mostly Arab, totaled 40 per cent, with about the same percentage of Maronites, the rest being Druzes, Greeks, Armenians and Assyrians, with some French and Turks. Beirut the capital had a population of 180,000 and Tripoli 68,000. The rural population showed obvious signs of the long period of subservience to many conquerors. They did not appear capable of hard work. Malaria was common among them. Sandfly fever was prevalent, dysentery less so. The main native language of both countries was Arabic, but French was widely known and spoken, with English not so well known.

Where there was soil it grew most crops; from bananas by the coast to apples and apricots in the mountains; olives, grapes and citrus fruits, sugar cane, tobacco and cereals. Much of the foothill country has been terraced at enormous labour. But insufficient foodstuff was grown and the people depended on imports. The starvation and consequent death roll after the 1914–18 war were still remembered.

Chekka had large cement works and Beirut quite an amount of light industry.

Two indigenous industries, shipbuilding and stonemason's work, had a history of at least 4,000 years and were still practised.

LOCATION OF THE RAILWAY

The Australian Railway Survey Company reconnoitred many proposals to connect Haifa and Rayak. As Syria and the Lebanon were then under Vichy French rule, the reconnaissance could not be pursued in detail over the border of Palestine. The route first favoured was by way of the Plain of Esdraelon, past the Lake of Tiberias and along the Jordan Valley towards Rayak. The Huleh Valley salient allowed exploration of the route for a distance of seventy-five miles to Metulla, about fifty-eight miles from Rayak, and many variations were examined.

Control of Syria was obtained by conquest in July 1941. The reconnaissance of the Haifa–Metulla–Rayak route was completed immediately. This route, 133 miles in length, was found to involve heavy rock cutting in basalt, heavy ruling grades and sharp curves because of the descent to 700 ft. below sea level at Lake Tiberias and an ascent of 3,300 ft. before reaching Rayat at 3,034 ft. The route was not served by roads except at a few points, and this together with the heavy work through basalt precluded rapid construction–a wartime necessity. In July, 1941, too, the route along the coast to the mouth of the Litani Rover and thence to Rayak was reconnoitred. At the border of Palestine is the formidable Naqura headland and a few miles further on the Bayada headland: then easy country to the Litani. But the remainder of the route is along winding gorges, through the Lebanons, a way quite impracticable for rapid war-time construction.

The coastal route through Beirut to Tripoli was next investigated. Apart from the headlands of Naqura to Tripoli the coastal plain provided for easy construction to Beirut about eighty-seven miles from Haifa. From there along to Tripoli quite heavy country was found, with numerous river crossings and mountains down to the water's edge. At one place where the mountains met the sea, the Chekka Headland, a tunnel was found to be necessary. The length of this route was 138 miles. Despite the difficulties of the route, and its slightly longer length than the Rayak connexion, the coastal route had the advantage of an excellent road with a bituminous surface along its whole length, an advantage of very great value for rapid construction. Moreover the route served the city of Beirut, a sea port of useful size, and a large cement works at Chekka; also the rockwork was in limestone, not basalt. So this route was the final choice. From the 28th to 30th August, 1941, a quick appreciation was made of the country between Beirut and Tripoli by Colonel Simner, C.B.E., D.D.Tn. (Constn.) at G.H.Q., and Lieut.-Colonel K. A. Fraser, the Railway Construction Engineer and the decision to survey, a railway from Haifa to Tripoli resulted.

On the 12th September, 1941, No. 1 Section of the Railway Survey Company moved to camp at Az-zib and commenced a location survey around Ras Naqura and Ras Bayada. On the 17th October the work thus far completed was handed over to the South African Railway Survey Company as by then G.H.Q. had detailed the South African Engineering Corps to construct the section from Haifa to near Beirut. No. 1 Australian Survey Section then moved to Maameltein for the location survey from Jounieh to Heloue. On the 13th September, 1941, No. 2 Section moved into camp at Herry and concentrated primarily on a detailed topographical survey with the object of designing a line around the face of Ras Chekka. This place was one of special difficulty and Colonel Simner arranged for the 61st Tunnelling Company, S.A.E.C. to be specially recruited from miners of the Rand for the tunnel. On arrival the S.A.E.C. Tunnel Survey Section the survey work for the tunnel length was handed over. The Australian No. 2 and 3 Survey Sections then completed the survey of the rest of the line.

To conclude this story of railway location some recent thoughts of a surveyor responsible for the excellent work done are now quoted :-

“Our attitude has changed, of course, looking back on it. It is obvious now that we had a perfect set up to do the job. What I mean about the Group is that we had the reputation established by our railway blokes in the first war; the Englishmen believed in us; we had a Survey boss who new his men, knew that they had done miles of location (number one job) in civil life, had seen them do it, had seen their finished work, gave the control, the limits, the grades, the curves, all the factors, and let ‘em go; they went, possibly not always in the best spot, but near enough for war and a hurry-up job. Survey had enough young men, some keen on the job, some keen on promotion, some keen to beat the other bloke, but enough of one sort and another to push it through.

“Then, in a way, the job was an easy one, to the extent that we had the Frenchman’s plans, which by disclosing the bad spots and by allowing the planner to see along, so to speak, from end to end, helped enormously. The story of Ras Chekka Tunnel you know. I lived there for two months, was sent a month ahead to Farley (the Construction Company’s O.C.). I imagine it was the hard nut in the minds of the Tommies. We located from there right through to Tripoli and back to Batroun; and contoured the Mountain. Then Cuttin (officer in charge) arrived with the South African survey section. They arrived without a knife, fork or spoon–thought they were to stay in hotels. I didn’t even laugh, to my everlasting satisfaction; took them by the hand up to a A.I.F. ‘Q’ bloke I knew in Tripoli and persuaded him to cut the bull and imagine they were A.I.F., so got Cuttin tents, blankets, personal and cook-house gear and arranged for rations. Cuttin was really a great bloke, had been all his life in the mines on Jo-burg; had Carl Zeiss equipment, and the best survey gear imaginable. I persuaded him that Australians knew about survey in the way that he did. I rocked him with a close round the sea side of Ras Chekka–along a goat track the sea under your feet (but about 500 feet down), against a road tunnel traverse. He took the stuff away, plans and calculations, brought them back in the morning and from that time until the job was finished he never referred to the work again. He, I think, satisfied himself that the figures I had were dinkum, adopted that method (and the figures) rather than attempt the almost impossible job of staking the alignment on the surface; fixed his height and alignment from our survey, also his side openings (adits or some such word) and before the Basutos had time to unpack they were back in the mines.

“It is worth remembering that the day the tunnel joined up, and alignment doubts were over, Cuttin mounted a bulldozer, and from then on he was a full shift operator.”

Construction

The Plan

As construction was to proceed without delay, the plan was developed as the survey work progressed. The railway was designed to be a first-class military railway of standard gauge to carry 20-ton axle loads. The ruling grade was fixed as 1 in 50 and the minimum radius of curvature at 10 chains. Passing loops were to be provided each 5 miles. Formation was to be 16 ft. wide on banks and 15 ft. wide in cuttings. The structure gauge was the Australian one for 4 ft. 8½ in. and 5 ft. 3 in. gauges–approximately the International one. To save bridging, road crossings were to be level with the rails. The line was to be located to keep demolition of houses to a minimum.

Rails and fastenings, sleepers and bridges were to be obtained through transportation stores from England, South Africa, India and America; ballast, stone and cement with a few sleepers from local sources. Plant was to be supplied as available from the Middle East pool and from local R.E. resources of the Ninth Army holding the area. The Royal Engineers of the Ninth Army were also relied on for erection of camps where required and supply of engineer stores.

The work was directly under the D.D.Tn. (Constn). G.H.Q., Cairo, and was apportioned to the South African Engineer Corps and the Australian Railway Construction and Maintenance Group, R.A.E. The S.A.E.C were allotted the length from Haifa East to Kilometre 137.6 at Nahr Rhadir, a distance of 86 route miles, and in addition to the tunneling work at Chekka from 201.4 km. to 207.7 km. The A.R.C. & M. Group were given the section of 57 route miles from Nhar Rhadir to El Mina, at Tripoli, 229.4km., including terminal facilities at Beirut and at Bahsas but excluding the Chekka tunnelling. Labour was to be drawn from the locality and reinforced by pioneer companies of Basutos, Bechuanas and Swazis from South Africa. The British War Office requested that the work be completed in eighteen months.

The S.A.E.C. Portion

Construction work by the S.A.E.C. commenced in December, 1941, and considerable difficulty was met with in rounding the Naqura and Bayada headlands in wintry weather with gales lashing the coast. In spite of the difficulties, work proceeded at high speed. The Haifa–Beirut section was opened in August, 1942, 86 route miles of standard gauge railway in eight months.

The tunneling work at Chekka was begun in February, 1942, by the 61st Tunnelling Company. Used to hard rock on the Rand, the compressor strength consisted of two units, each capable of supplying full power for the drills operating, so work need suffer no interruption if one unit broke down; in addition there was a much smaller unit for supplying air for ancillary work that might be needed. In the event, the big units were not needed, as the small unit supplied all the air necessary. The rock was mostly chalk and marl. Drilling was easy, so that with one sharpening, 15 ft. of hole was drilled instead of the 18 in. usual on the Rand. No timbering was necessary. Work proceeded on the full tunnel section at five faces at once–one at each end, one at the adit nearer to the north end and two from an adit nearer the centre. The spoil was loaded by a special machine, operated by cable from a winch on to dump trucks running on narrow gauge construction track. Most of the rock was dumped in the sea near by.

The full length of the tunnel was 4,800 ft. and it was driven at a level about a hundred feet lower than the 1,500 ft. long road tunnel on the main coastal road. The services of air-power, ventilation, water and electric light were supplied along the full length of the work in a most orderly fashion. All the material to the smallest bolt and nut were brought from South Africa with the company and this helped to avoid the delays usually met with. Work proceeded in three shifts in spite of the glare that caused the face of the headland to shine far out to sea. The risk taken proved to be justified and as a result the work was done in the extraordinarily short time of eight months. The tunnel was handed over to the Australian Company for plate-laying at the end of September, 1942. After completing the main tunnel and a short one of 900 ft. near-by, the 61st Tunnelling Company was then transferred to improve the alignment and safety of the track at Naqura Headland by driving a 1,000-ft. tunnel through it.

The A.R.C. & M.G. Portion

This section of the work will be dealt with in more detail only because it was more familiar to the author. Early in 1942 the three railway Construction Companies gathered their scattered sections from Egypt, Transjordan, Palestine and Syria to concentrate on the H.B.T Railway. The work was allotted in orderly military style with approximately equal lengths of thirty kilometres to each company; the first length to No. 1 Company, the second to No. 2 Company, and the third to No. 3 Company. Some rearrangement was made later as the second length proved to be particularly heavy. The formation and the bridges constituted the bulk of the work. Once the formation was completed the tracklaying was a relatively simple matter to the troops who had extensive experience of it.

Each company could be organized to have four sections and a headquarters. Each section could act independently and was generally employed in this way. A section consisted of an officer, two sergeants, four corporals and fifty-eight men; five-twelfths of them platelayers and one-twelfth each blacksmiths, strikers, carpenters, riggers and pioneers; the rest included surveyor, draughtsman, clerk, drivers, riveters, welder and stokers. The organization provided for a dilution by unskilled labour of four to one. This was never seen in practice as the dilution was generally ten to one and frequently a sapper became a ganger with a team of thirty.

The officers commanding the companies had ample power to arrange matters as suited the work and themselves an exhibited the initiative usual among Australians away from home. No. 1 and No. 2 Companies had some sections working independently, while No. 3 Company was concentrated as a unit. To illustrate the dovetailing of the organization to the work at hand, No.2 Company's method will be described. One of the sections, No. 4, was organized as a bridging unit to deal with the several major bridges in the length. It worked from Headquarters at Jbeil, the centre of the length. Also from this place No. 3 section dealt with earthworks, rock and platelaying for the central half. This section was finally well equipped with heavy construction plant for the deep earth cuttings involved. The outlying northern quarter of the length through broken rocky country was the care of No. 1 section with its camp at Madfoun. Similarly the heavy rock section on the south was allotted to No. 2 section with its camp at Ramie.

On arrival in February the only tools available were picks, shovels and crowbars. On the first morning, No. 2 section, fresh from the Sinai Desert, where an 8-ft. cutting in sand was a major work, was taken for a stroll over the centre line. The start was at a side cutting 80 ft. high, another rock excavation 30 ft. deep, next a bank 80 ft. high, another rock excavation 35 ft. deep, followed by a 46ft. bank and one more rock cutting of 35 ft., all within a mile of the camp. He rocks were hard after the sand, the hills were high and the crowbars and the picks looked futile. But we started where cuttings met the big bank and on the road deviation near by a cut a goat track on grade. That made a show and it was quite economical. Then the plant began to arrive, first a bulldozer which was kept at it night and day for six months, then compressors and rock drills, decauville track and wagons, till at the end of September the section was well equipped. This story of increasing amount of plant was parallelled throughout the group. In No. 2 Company it led to a reorganization to keep the mechanical plant at work. The first improvement was to arrange for the attachment of several details skilled in the use and maintenance of mechanical equipment from neighbouring Royal Electrical and Mechanical Engineer Companies, and then the attachment of a light aid detachment truck equipped with a skilled M.T. fitter. Finally all the mechanical equipment and transport was formed into a fifth section and allotted as required to the various parts of the work. Because of the large labour force employed and as survey work was completed and reinforcements came, more officers were allotted to construction work, almost doubling the number available.

THE AUSTRALIAN WORK IN DETAIL

Labour

In all, with attachments, the group numbered about 1,000. Of these, half were allotted duties on the operation and maintenance of plant and transport and on administration and stores work, and the other half were available for the supervision of labour. Military personnel had to spend a portion of their time and energy on purely military duties to be able to give a good account of themselves should the enemy come down from the north or land from the sea. The health of the troops was generally good, mainly because of the help received from the near by Australian C.C.S. and the New Zealand General Hospital as well as the untiring efforts of the M.O. and his team of medical orderlies. Malaria was less than expected and only fifteen cases of dysentery failed respond to treatment at camp hospitals. Sandfly fever was particularly bad but was quickly dealt in the two camp hospitals at No. 1 and No. 2 Companies. The work was hard and long but billets and food were good so the men came through well. There were only three fatal accidents, two caused during blasting operations and one road accident.

The labour came from two sources, South African natives from Basutoland, Bechuanaland and Swaziland, and local civilians of many races and capacities. The South African natives were organized in African Auxiliary Pioneer Companies and numbered 2,100 at the peak. Their value depended very largely on their officers but was never great. Some of the officers were quite enthusiastic, but their troops wished to bear arms and were the reverse. When shoveling ballast, the Basuto found it impossible to concentrate on both ends of the cycle; either he got a full shovel and some of it landed in the right place, or he took what fell into his shovel while he concentrated on placing it in the proper position. Their wrists, too, seemed weak. Manual labour was really beneath them. If an element of fun could be injected into the work good results could be achieved for a time. Some were known to work quite well on plant, such as a concrete mixer, where they tried to match its efforts. Machinery seemed to wield a weird fascination for them, sometimes dangerously so, as understanding it was beyond them. Others performed well as riveters, or riggers' assistants, blacksmiths' strikers and the men of one company did well as platelayers and lifters. Some Swazis under a good officer did good muck work on side drains. In other cases, attempts were made to introduce task work on excavation at the rate of 1½ cu. yds. per man-day, but the rate could not be achieved. One instance is on record where 130 Basutos excavated 150 cu. yds. in five days. Generally the South African natives were poor labourers and showed a great deal more interest in military drill and parade movements. Company cooks were to be seen teaching their helpers and drudges how to slope arms with soup ladles and brooms. Exclusion from parades was viewed by them as a greater hardship than a day's work. For the best results all Sappers called on to supervise these men should have had at the least a thorough training as anthropologists. All the same the Africans' happy dispositions, their singing at night and particularly on Christmas morning, remain very pleasant memories.

The civilian unskilled labourers were of the usual standard found in the Middle East. They know more ways of cheating the boss than the Australians ever dreamed. In the Lebanon they were generally better than in Egypt. A train journey from Kantara to Damascus showed a gradual increase in plumpness from the desert bitten Bedouin of Sinai to the fat gentlemen of the well-watered oasis of Damascus. The Arab had two qualities in common all along that way. He wore a somewhat lordly air and had an all-embracing faith in the providence of Allah.

At times our civilians suffered from lack of flour which finally was distributed by the Army to ensure fair distribution. Language proved a bar, particularly at first, till reliable interpreters could be obtained. Of course, the universal sign language proved useful. Though never accustomed to hard work the capacity of the workmen increased as time went on. Motor transport had to be used each day to bring men down to the railway from their villages in the mountains and return them. When the farms were cropped the owners and relatives were absent from time to time. As the normal army rate of pay was only 2s. 4d. sterling per 8-hour day, it did not require much expenditure to tempt the off the railway. The labour was engaged through the Pioneer Labour Corps officers, often locals, and care was taken to see that these men did not defraud the labourers or the Army.

Photo 1.- Djadz Bridge, 3/80 ft. spans (Standard Middle East spans). Invert to rail, No.2.Pier 98 ft.

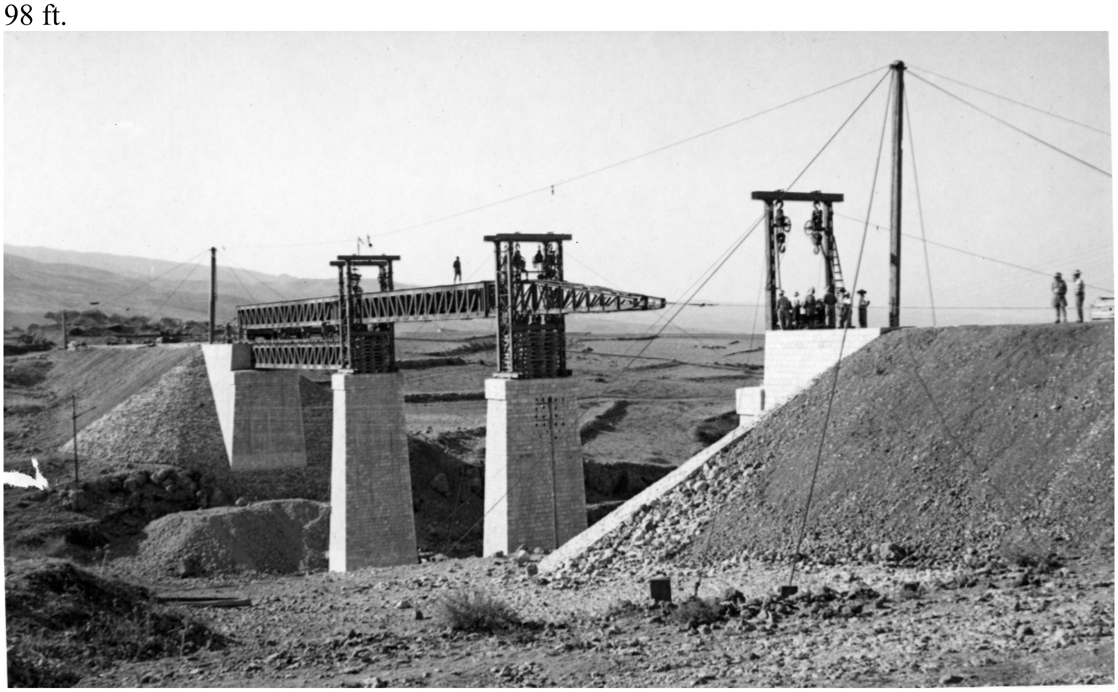


Photo 2.-Djadz Bridge under construction. Launching spans 2 and 3 together.

Photo 3.- The Big Bank at Dowra, near Ramie, 86 feet from the water.

Photo 4.- Tracklaying by Basutos, North of Maameltein.

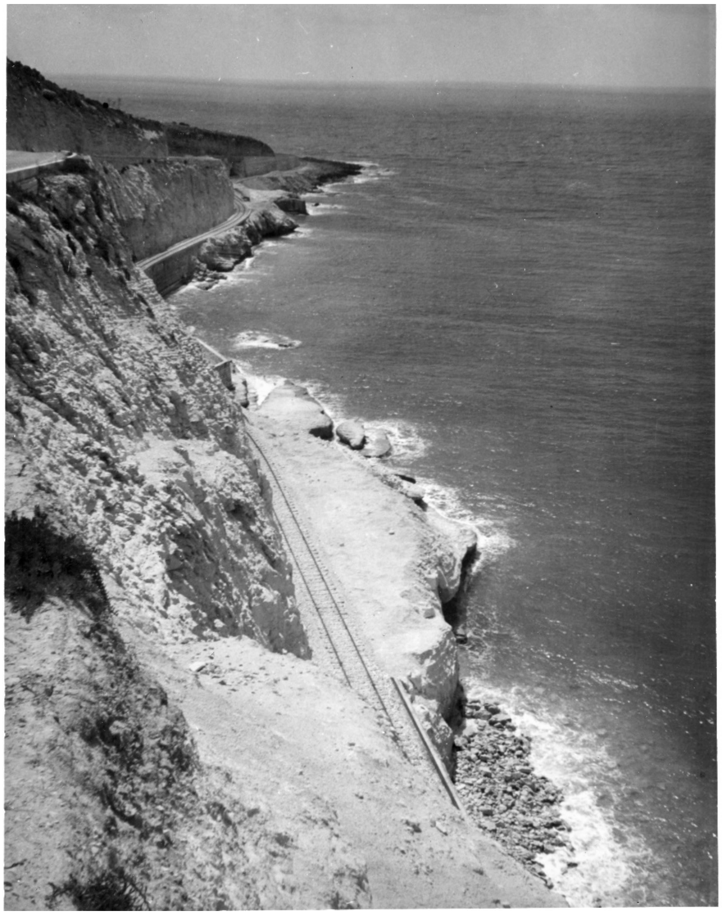


Photo 5.- Railway on bench close to sea with road high above

Photo 6.- Nhar Ibrahim Bridge under construction

Women labourers, generally under women gangers, were employed on carrying baskets of ballast to the track. We had Christian Arabs and Moslem Arabs. On one occasion to improve output it was found an advantage to dispense with the services of those under seventeen and over seventy.

Skilled and unskilled labour reached a peak of 8,000 but more could have been usefully employed if available. The skilled labour consisted mostly of stonemasons, some of them really ranking as architects. These were all particularly skillful and took great pride in their work; the craft was highly organized with many grades depending on skill.

It was found that the ways to get work from men are the same irrespective of colour, creed and race–study them, follow the golden rule, deal fairly. Tolerate no nonsense, protect them from exploitation, set a high standard–in short, treat them as men.

The Way

From Nahr Rhadir to the Beirut River the line traversed olive groves, cultivation and orchards in chocolate soil with several waterways and channels. From the Beirut River to the old Maaleltein Tramway at Dora the route was though easy country, thence it followed the tramway to Nhar el Kelb, deviated from it through orchards to Qaslik headland and through bananas to Sarba headland, where the tramway route was again adopted and followed to Maameltein. From Maameltein to Bouar there was considerable heavy rock cutting and the high bank at Dowra near Ramie. Formation through Tabarja, Bouar and Jbeil was in the dark chocolate soil of banana plantations, intersected by numerous small water channels and irrigation ditches. There were rock cuttings at Tabarja and at Fidar where a deep wadi was crossed by a high bridge.

Construction was almost continuously in rock from Jbeil to Fadous, with large cuttings at Beachta and Madfoun. High bridges were needed to cross Nahr Djadz, Nhar Fgal and numerous smaller bridges at water courses in between. From Fadous to Batroun alternate rock and soil were traversed to the bridge at the second Nahr Djadz. From here the S.A.E.C tunnel section at Chekka the construction was wholly in limestone rock. From Chekka to Enfeh the formation the formation was again in chocolate soil with many water courses but from Enfeh to Bahsas was practically all in rock. Bahsas Yard was constructed on sand adjacent to the sea. From there to El Mina, the junction with the D.H.P. standard gauge, the line traversed sandy country through orchards.

Earthwork

Earthwork was hampered by wet weather till April. The ground was waterlogged by the winter rains; in some banana plantations a man would sink to his thighs is the sodden ground. Work was commenced with local civilians using hand baskets and donkeys with panniers, mostly made of kerosene cases with a hinged bottom tied in place quite simply by a light rope. Supervision was necessary to see that the panniers were filled and that donkeys were strong enough to carry them. Dispensing with several flagrant loafers would keep things going well for a week or so, when the treatment had to be repeated. Basutos also were employed on low banks with picks, shovels and barrows in the early stages. Horses and scoops with horse-drawn ploughs were hired where they could be got, and were employed where suitable. Mechanical plant was gradually supplied and put to full use on delivery. Shift work was inaugurated and arrangements were made for regular servicing and maintenance. The plant for the most part comprised D6, D7 and D8 caterpillar tractors, with bulldozers, carryall scrapers and rooters. All did excellent work. Heavier plant was supplied later and included RB37 shovels, RB10, 17 and19, Lima and Bucyrus Erie shovels and draglines, all of which proved invaluable in the deeper cuttings. Frequently, as no tipping lorries were available, the spoil was left beside the cuttings and the banks were built from borrow pits. D6 tractors with roll-over scoops were most successful in loam and sand in sort leads. In some cases hired trucks were used. These had fixed bodies and after the load had been dumped in the trucks the soil had to be loosened again witch picks before discharging with shovels. As at least two of the native-born were necessary to man a shovel the operation was costly and tedious. The lack of suitable motor tipping lorries was a severe handicap, as if they had been available the formation would have been completed earlier. Low banks were generally well consolidated by construction traffic. High banks received no special treatment and considerable settlement was expected for at least two winters. Towards the end of 1942 after the winter rains began in earnest there were many indications that this expectation would be realized.

Rock Work

Difficult rock excavation was necessary at the Kelb headland. The main Beirut–Tripoli road had been cut out of this rocky promontory and perforce the railway was located further inland and therefore much deeper in the rock–the depth was 70 ft. Disposal of the spoil to the sea, across the road carrying heavy Ninth Army and civilian traffic, was a problem and made work slow, as well as troubling the traffic. Heavy work, too, was occasioned by Maameltein Headland near Ramie. This section has been mentioned earlier and required 35,000 cu. yds. excavation, wholly in rock. The excavated material, with a further 5,000 cu. yds., was used to make the big bank and the road diversion at Dowra. The excavation and spoil removal was done by hand with the aid of decauville track. Three shifts were worked and the job took six months. The fill, 86 ft. high, was faced on the sea side with random rubble on a 1 to 1 batter and was stepped half-way to make a berm for carrying the roadway. Other heavy rock cutting was encountered north of Beachta; at Madfoun where the railway went under the main road; north of Enfeh and along the Tripoli Road from Kalmoun. The holes were drilled with rock drills, using air supplied by portable compressors. The limestone rock was mostly soft but had frequent fissures and pockets often clay filled; in these the steels used to jam and cause delays. Blasting was dome with gelignite, ammonal and some blasting powder. Owing to the general shortage of detonators and fuses, much larger shots were forced than desirable in railway work. These caused damage to the roofs of near-by houses and telephone lines and to slopes of the cuttings. Instantaneous detonating fuse and guncotton primers were used extensively, but in some cases firing was done electrically.

Minor Bridges and Works

These comprised structures for crossing the many small streams, gullies and irrigation channels, sea walls to protect embankments, lining portion of the Chekka Tunnel, road diversions, house repairs and station buildings.

Major Bridges

The major bridges were probably the most important items in the construction work. The longest were those over the Beirut River, three 100-ft. spans; Nahr el Kelb, two 100-ft. and one 70-ft.; Nahr Ibrahim, one 100-ft. and one 70-ft.; Nahr Fidar, four 75-ft.; Nhar Djadz, three 80-ft. Others in this category ranged from 20 ft. to 80 ft. spans. Each crossing required study, which included a knowledge of the bridge material available. Timber for formwork was not obtainable but skilled masons and suitable stone abounded, so it was decided to face piers and abutments with stone built to act as formwork. The stone was usually laid in 10-in. courses, with lifts of 4ft. and the method proved most successful. Construction had to be completed during summer to avoid the trouble of flooded watercourses and fortunately the work was done in time.

The *Beirut River Bridge* had abutments clear of the stream bed and they were founded on a bed of clean gravel about nine feet below river level. The excavation was in the open. The pier caissons were sunk in gravel and loam to a clean gravel bed 20 ft. below water level. Piers and abutments were built to girder seat level in concrete. The 105 ft. through lattice girders from South Africa were erected on falsework built up of standard light steel trestle founded on the dry river bed. The lattice girders were received in sections up to 4½ tons weight. After erection on the falsework the sections were riveted. On completion the girders were lowered into position.

Construction work for the *Bridge at Nahr el Kelb* was similar to that at the Beirut River except that much more water was encountered and this required all the pumps available. The piers and the southern abutment had to be taken down to 24 ft. below water level. At about nine feet below water level a band of heavy loam was met and the extra skin friction held the caissons up. The cutting edges were cleared of obstructions, the caissons allowed to fill with water and charges of gelignite were ignited and dropped into the caisson wells. This produced the desired result and sinking was then continued till a safe depth was reached. When the pumps could no longer de-water the wells a diver and grabs were used for the final stages of sinking. All caissons were then sealed underwater using a crane and grab bucket; after the concrete had set the caissons were pumped dry. This bridge and the previous one were erected by No. 1 Company.

The *Nahr Ibrahim Bridge* was a little unfortunate as one of the spans for it was sunk on the way from South Africa and the substitute, a U.C.R.B.[1] through span did not match the lattice span which had arrived safely.

The northern abutment was founded on rock; the southern abutment, founded 13 ft. below, and the pier, 20ft. below water level, were of the caisson type. A heavy flow of water was struck at the pier and the services of a diver and grab were needed to clear the cutting edge and the spoil from the wells during the latter stages of sinking. Masonry was used in the normal way, but was notable for the particularly fine work done by the masons. Some of the limestone delivered was a slate blue in contrast to the usual white or ivory shade. And this slate blue stone was laid in a most artistic pattern. The steelwork was erected on falsework as in the bridges described previously. It so happened that on the night of the day the trusses had been made self-supporting the rain came down and the flood washed out the trestles. Excellent judgement on the part of No. 3 Company.

The *Nahr Djadz Bridge* was the occasion of some experimental work of interest. It was the first attempt in the field to launch a U.C.R.B. by the cantilever method using a launching nose. The foundations were all dry and were on rock. The higher pier was 80 ft. above its foundation. No scaffolding was required on the outside of the piers as the masonry was laid from the inside and access to the working level was by ladders attached to steel rungs set in a pier side. On completion of the work the rungs were removed. To facilitate the placing of concrete and stone in the piers, a flying fox was created with a 1-in. wire rope right across the wadi; the lifting and hauling operations were done with a double-barrel winch. While the piers and abutments were being completed, the trackwork adjacent to the abutments was laid and that on the south side particularly well packed. The trusses, 80 ft. long deck type U.C.R.B. for the first span were assembled together with a launching nose on three bogies running on the track. The nose was about fifty-five feet long and of light construction. When all was made ready a rope from a winch on the north side was attached to the nose on the south side and the signal given to start hauling. With ease, at a sure and

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[1] Unit Construction Railway Bridge. See Vol. 1 *The Civil Engineer in War*, published in 1948 by Institution of Civil Engineers – one paper on General Design of Standard Bridging Equipment by Everall and Russell and another paper on Erection of Standard Bridging Equipment by Everall and Ball

steady pace the unit was hauled across till No. 1 span was in position immediately above the opening. The dismantling of the nose 70 ft. in the air was accomplished with difficulty by the aid of the flying fox. This experience caused the officer in charge to think seriously and he obtained the Colonel's consent to launch No. 2 and No. 3 span together, thus bringing the nose onto the north side for dismantling. The two spans with the launching nose were assembled on the south abutment on five bogies, the track completed on No. 1 span and the long assembly hauled across it and over temporary supports on to No. 2 pier to rest in position under the lowering gantries on the piers and the north abutment. The experiment was a success. This particular example was described in articles in the *Railway Gazette* in 1945–46.

The next bridge ready for erection by No. 2 Company was close by at Nahr el Fidar, requiring four 75-ft. U.C.R.B. deck spans on high piers. The foundations were on rock or gravel and excavation was practically all in the dry. The highest pier was 62 ft. above foundation level. Construction of the piers and abutments and the method of erection were the same as for Nhar el Djadz. In this case, the four spans, and the launching nose were coupled together and the whole hauled across in one operation. The assembly, launching, jacking down, and dismantling the nose was executed in 389 man-hours including native labour and Australian supervision.

Another bridge of much interest was the 80-ft. U.C.R.B. deck span over *Nahr el Fgal,* a wadi 69 ft. deep. The high and large abutments with their splayed wing walls each required much stone facing and 2,000 tons of concrete. Erection was by cantilever method as at Nhar el Djadz.

Three shifts were worked on all these bridges. Another eight wadis or streams required major bridges. All bridges of importance were equipped with chambers to facilitate demolition if that should prove necessary

Trackwork

The construction companies laid a total length of 66.2 miles of track. Forty-six miles were 75-lb. flat bottomed American rails and 20 miles bull-headed English 85-lb. rails. Sleepers were 9 in. x 5 in. x 9 ft. Indian hardwood, and 8 in. x 6 in. x 8 ft. American pine untreated. In station yards and crossing loops local pine and Turkish katrani pine sleepers were used. All F.B. rails were laid on single rib rolled steel tie plates and fastened with dog spikes. The bull-headed track was supported on cast-iron chairs spiked to the sleepers, and was fastened with local timber keys. The keys had a short life if not driven home and kept tight as the local inhabitants suffered from a chronic shortage of firewood. As the timber had been cut green much energy was used to keep the wedges tight. Rail joints on the straight were laid with 3-ft. 11-in. stagger and on curves with half a rail length stagger. Sleeper spacing was approximately 2 ft. 5 in.

Speedy earthwork at the Tripoli end by No. 3 Company was followed by their platelaying, with the result that the track from El Mina to Chekka, passing loops at Bahsas, Kalmoun, Enfeh and Chekka and a spur to the cement works, was opened to traffic on 22nd July, 1942.

Trackwork is mainly a matter of material supply and distribution. So it was at this stage, when the formation was discontinuous, that the main Haifa–Tripoli road proved to have so much value. The job was really a race to get the bulk of the material out before the rains came. Transport of all the sorts available was pressed into service and the job went on night and day. By this time each company had a plant officer and the R.S.M., too, concentrated on the transport. It is well to note here that the main road was also the main line of communication for the British Ninth Army.

Ten crossing loops, each 450 metres long with 180 metres for crippled trucks, were laid as well as the terminal facilities at Beirut, and Bahsas near Tripoli. Water columns were provided at Bahsas, Batroun, and Nhar Ibrahim. Ballasting was obtained in many ways and for the most part from adjacent hard limestone rock. On some lengths of track the stone was napped to size on the formation. In others the aid of donkeys was needed to transport the stone to the track. Colourfully dressed, with many in long crimson trousers, gangs of Arab women carried ballast, some of it produced by nature, to the site. And we were provided with small portable crushers all the way from Australia with Southern Cross engines and Jacques jaws. They were awkward to move except on rails and had a low output. Six native labourers using one of them could produce as much ballast, about three cubic yards per hour, as the same six labourers napping stones. Another arrangement, this one said to be ideal, was to set up several crushers in a wadi about one hundred feet from the railway. Over the hoppers, at road level, was erected a platform on which M.T. dumped stone from the beach. With two natives pushing boulders into the hoppers, a dozer pushing the ballast from the crushers towards the railway, and a dragline shovel loading the ballast into the waiting railway trucks, the scene exhibited much activity.

Four large crushers, 10 cu. yds. per hour, were installed at suitable places. Delivery from them was effected by self unloading M.T. and by railway trucks converted with side and end doors for placing the ballast where required. Power shovels and grabs were used for the loading. The total quantity required was 140,000 cu. yds. and about half this total was obtained by local contract. Rails and ballast were completed from each end so that construction trains could operate.

The last gap in the rails was at the section near the heavy rock work at Maameltein Headland and was closed on 17th December, 1942, That day Jimmy Yorston, a locomotive driver of the section responsible for constructing that length of track, cautiously drove the first locomotive from Tabarja to Jounieh, Completion of the ballasting followed quickly and the line was made ready for the opening.

The Opening

The driving of the last spike was planned for Sunday the 20th December, 1942, and on the Saturday, the R.C.E. conducted Major-General Morshead over the route on a petrol driven inspection car; each officer accompanied the party over his length.

The place selected for the opening ceremony was Nahr el Kelb–the Dog River; the scene of many memorials of conquest. There is a band of hard limestone rock with a vertical face provided by nature for commemorative purposes. The earliest inscriptions celebrate the conquests of the country by Pharaoh Rameses II, Asarhaddon of Assyria, Nebuchadnezzar and the Greeks. Later ones include the French in 1860, and the Australians in 1918. The country up until 1941 had been free for 40 years in 3,000.

A rock was carved with a suitable inscription. A special guard of honour selected from our Sappers was well drilled for the occasion. A large Baldwin locomotive decorated with Australian and Lebanese flags and a full-sized passenger train were provided.

The day was fine and General Alexander drove the last spike home after inspecting the Guard of Honour, made a suitable speech, unveiled the inscription and declared the railway open for traffic on the 20th December, 1942, thus completing the standard gauge railway between London and Cairo. The train was boarded and travelled the remaining length of the line to Bahsas, past groups of Sappers, Basutos, and Swazis stationed on their respective lengths. The Australian Survey at Chekka was most surprised when the big Baldwin came through the tunnel without a scratch. The job was done, and the *next day* it was put to use, carrying armour to the north and wheat to the south.

In conclusion I desire to acknowledge with gratitude the ready help given by Lieut.-Colonel K. A. Fraser, O.B.E., Brigadier C.E.M. Herbert of the war Office, Sergeant Telford, Captain W. Chadwick and Major E. L. Walpole in the collection of data for this paper; my indebtedness to Major Walpole for the use of his photographs; and to pay tribute to the many who worked hard on the job and brought it to a successful conclusion. And finally after serving with it in a very humble capacity, I salute the British Army which may lose battles but not campaigns.

APPENDIX I

Experience With Plant

1. *Tractors*.–D2, D6, D7, D8 caterpillar, and T.D.40 Allis Chalmers all gave good service. The thrust bearings on the main engine governor of caterpillar machines failed persistently and were apparently too light. The Allis Chalmers machines gave persistent clutch trouble as vibration caused lubrication failure through breakage of the flexible grease pipe.

2. *Bulldozers*.–Did excellent work in earth and clay. When used to move blasted material from rock cuttings several bracket arms were broken by striking solid rock. The lugs were welded electrically and reinforced but weakness then developed in the main triangular frames and some had to be replaced. Some trouble was caused through wear of the hydraulic equipment.

3. *Carryall Scrapers.*–12 cu. yd. and 9 cu. yd. capacity were ideal for picking up, transporting and dumping earth and sand and gave practically no trouble.

4. *Rooters*–Le Tourneau type proved excellent. The axle retainers in the five-tine Britstand machine gave trouble.

5. *Dumpers*–Only a few Aveling and Muirhill machines were available but gave endless mechanical trouble, probably because the engine was exposed. Their loss was severely felt.

6. *Shovels and Draglines.*–R.B.37, R.B.19, R.B.17 and R.B.10, Bucyrus Erie and Lima. All gave excellent service. Two R.B.37 were brought to Tripoli by ship from Port Said and did good work in rock excavation at the Tripoli end. They were too heavy to be transferred to other big cuttings further away. At first rope breakages were frequent on all machines, probably because of learner-drivers.

7. *Compressors.*–Southern Cross, Worthington and Ingersoll Rand. The Southern Cross machines gave considerable trouble because of the inadequate cooling system and other faults in design – the heads were frail and the water jacket too small. Leakage occurred because the bearing keeper of the pump assembly could not be kept tight. No spare parts for these machines were available. The Worthington and Ingersoll Rand machines gave little trouble, though the radiator cores of both engine and compressor on the former could have been more robust, while on the latter the fibre magneto coupling was the only persistent failure.

8. *Rock Drills*.–Ingersoll Rand Jackhammers, Gardner-Denver, and Climax. The first two gave good service but the Climax machines were altogether too light for the work.

9. *Concrete Mixers.*–Many types of new, second-hand and rebuilt machines from 3 cu. ft. to 14 cu. ft. capacity were used and gave reasonable service. The newer mixers of Gilson and Dandie makes were excellent.

10. *Pumps*.–Southern Cross and other makes with 2 to 10-in. delivery pipes were used. The Southern Cross machines all had inherent weaknesses due to faults in design and materials. Much time was spent on their repair and maintenance.

11. *Workshop and Small Items*.–Electric welding sets, riveting hammers, wood boring machines were usefully employed. The light aid detachment equipment proved invaluable, but was rather light for the repair of parts for heavy machinery. In order to improve plant maintenance and expedite repairs, company or group workshops should be supplied with such items as 8-ft. gap bed lathe, milling machine, power hammer, heavy duty welding sets, seat and depth cutters and additional emery wheels.

12. *Motor Transport.*–Approximately 200 vehicles of all types were used by the group and had a full time job in transporting men and material for construction. A very large tonnage of plant, tools and equipment had to be brought from Egypt and Palestine by road and this kept a fleet of lorries constantly engaged. This fleet included two 25-ton low-loaders for the transport of heavy machines, both from Egypt or Haifa and about the job. The bulk of the fleet were 1½ ton capacity with 2- and 3-ton vehicles and six 10-ton trucks. On the narrow and winding roads often carrying heavy traffic, accidents were frequent and the consequent repair and maintenance problem proved too heavy for the companies. Many trucks were sent to Advanced Ordnance Workshops for repairs. Local M.T. was hired but proved most unsatisfactory as it required more supervision than was available; many of the trucks, too, were not properly maintained. The lack of tipping trucks was severely felt and caused delays in the completion of the earthworks.

APPENDIX II

PRINCIPAL QUANTITIES

Excavation, earth and sand	630,000 cu. yds.
Excavation, rock	343,000 cu. yds.
Pipe Culverts	11,050 lin. ft.
Arch culverts up to 6 ft. diameter	135 No.
Flat slab reinforced concrete	30 openings
Sea and retaining walls	4,500 lin. ft.
Bridging, Major	1,833 lin. ft.
Masonry in walls	20,900 sq. yds.
Concrete in bridges, culverts and walls	39,900 cu. yds.
Riveted steelwork in bridges	950 tons
Rivets	56,700 No.
Unit Steel Trestling (temporary)	250 tons
Track-work	66.2 miles
Ballast	140,000 cu. yds