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VOL. LXII CONTENTS SEPTEMBER, 1948

CANADIAN MEMORIAL WINDOW AT TRANSPORTATION TRAINING CENTRE R.E., LONGMOOR

AT a service on 25th April, 1948, the High Commissioner for Canada, Mr. Norman A. Robertson, unveiled, and the Lord Bishop of Portsmouth dedicated, a Memorial Window presented to the Garrison Church of St. Martin in memory of the staff of the Canadian National and Canadian Pacific Railways who fell in the war 1939–45.

The window, of which an illustration is shown opposite, was designed by Mr. Martin Travers, A.R.A., and matches the existing five windows presented by the British main-line railway companies and which were dedicated in 1939.

The large congregation present included many members of the staff of the London offices of the Canadian National and Canadian Pacific Railways.

The window has for its central feature a picture of St. Lawrence holding a book of the Gospels in one hand and a grid iron in the other to signify that he was martyred. St. Lawrence is not the patron saint of Canada, but is obviously a most suitable subject.

In addition to the saint, the other features in the window are the arms of Canada and those of the nine States.

The inscription at the bottom reads as follows:

"To the glory of God and in grateful remembrance of the staff of the Canadian National and Canadian Pacific Railways who fell in the war of 1939–45."

The present Garrison Church at Longmoor was a forage barn prior to 1935, but on the mechanization of the local artillery units the barn was converted into a church and duly dedicated. Since then much has been done to improve and beautify the building and, in addition to the six stained-glass windows mentioned previously, a very handsome reredos and crucifix was provided.

VISIT OF ENGINEER-IN-CHIEF TO U.S.A. AND CANADA

THE Engineer-in-chief, Major-General Sir Eustace F. Tickell, K.B.E., C.B., M.C., recently paid a visit to America as a guest of the Department of the Army. He was shown round the H.Q. of the Chief of Engineers, the Engineer Centre, Fort Belvoir, the graduation ceremonies at West Point and numerous engineer projects in connexion with large building schemes, airfields and the Mississippi flood control. The intensely friendly welcome and boundless hospitality received throughout the tour were almost disconcerting.

The E.-in-C. paid a short visit to Canada, where he also received a very great welcome and met many Canadian Sappers.

Memorial window in Garrison Church, Longmoor, to the memory of the Staff of the Canadian National and Canadian Pacific Railways who fell in the 1939–45 war.

(Photo by A. Louis Jarche)

Transportation Training Centre RE Longmoor

WATER SUPPLY PROBLEMS IN EGYPT DURING THE WAR 1939–45

By Colonel S. J. Armstrong, O.B.E., M.C.

Sources

THE River Nile is of course the main source of fresh water in Egypt and it probably provided over 95 per cent of the supply to the Allied Forces. Other sources although small are of interest as they were of great importance to our troops in the Western Desert. These other sources were tube wells, aqueducts and birs. They will be dealt with first, prefixed by a few remarks on quantity and quality.

Quantity

Potable water in the Western Desert was always in short supply and had to be rationed to 1½ gallons per head per day and at some periods to less than this. All troops had to be trained to economize in every possible way. Our armoured patrols who could only carry very little water with them brought water economy to a fine art.

Quality

The main difficulty is that all sub-soil water outside the Nile basin itself is saline to a greater or lesser degree.

M.E., Vol. VI, page 168, states that in Egypt men could drink water containing as much as 200 parts of sodium chloride in 100,000, i.e., 200 degrees of salinity. That was in the first World War. In the Western Desert during the second World War, water was safely used by the troops up to 400 degrees of salinity, provided the salinity was mainly due to sodium chloride. It is possible that the troops benefited to some extent by drinking saline water as their health was generally good in the desert and the incidence of heat exhaustion may have been reduced thereby. In some places, however, water containing substantial quantities of the purgative salts (sodium and magnesium sulphates) was found. Such water was more or less unfit to drink.

Tube Well Supplies

Several water diviners tried their hand in detecting supplies, but they were generally unsuccessful owing to their inability to judge the degree of salinity. There was never any difficulty in obtaining saline water, but it was nearly always too saline to be of any use. Fortunately we had on the Director of Works' staff in Cairo, an excellent geologist in Major F. W. Shotton, R.E., whose reports and advice were of great value. Potable water was only obtained from tube wells in very few places. The usual trouble being that saline water was tapped and on boring deeper, the salinity increased until it eventually approximated to that of sea water. Outside the Nile basin, the most successful tube well supply was at Fuka in the Western Desert (see Major Shotton's article on the Fuka Basin in the *R.E. Journal* of June, 1944). Great care had to be taken not to overpump the wells and it was essential to take regular salinity tests and keep careful records.

Aqueducts

These were interesting and unusual. The term " aqueduct " is perhaps a misnomer, but the best known were at Matruh and were of Roman origin. They were really horizontal wells or adits excavated in the soft sandstone of the coastal dunes. A layer of comparatively sweet water was found in certain parts of the dunes lying slightly above sea level. This layer was only one or two feet deep and below it lay water so saline as to be unfit to drink. These waters of different salinities were only prevented from mixing by the sandstone in which they lay, and it was most important not to excavate the aqueduct a foot deeper than necessary. The aqueducts therefore followed the water level and would often be 200 to 300 ft. long. Very careful pumping at a slow rate was necessary, otherwise the salinity would increase owing to the lower water being drawn up. Frequent salinity tests were necessary and if overpumping occurred, as it often did, to meet a heavy influx of troops, it became essential to rest the aqueduct as soon as possible to allow it to recover its normal salinity.

The most important aqueducts were developed at Matruh and Bagush and constant efforts were made to discover other places where these conditions obtained, but very few were found.

The cause of this phenomenon is not known by the writer, whose theory is that it is the result of dew condensing on the dunes. It should be noted that dew is extremely heavy on the North African Coast at certain times of the year.

Birs

" Bir " is the Arabic name for well or cistern. Large numbers of these birs will be found scattered over a large scale map of the Western Desert. They are artificial rock cisterns for collecting the scanty local rainfall and are used by the local Bedouins. They appear as mounds in the distance and formed useful landmarks in a country practically devoid of villages, trees, and prominent hills. Many of the cisterns were filled with drift sand and very few contained water. Our armoured patrols knew of those which had water in them and wisely kept the information to themselves.

Some were used as " dugouts " and a few were cleaned out and repaired and used as cisterns for the storage of water from our pipeline.

Supplies from the Nile

Long before Italy came into the war it was apparent that local supplies of water in the Western Desert would be quite inadequate, and Nile water from the Alexandria Waterworks was transported by rail, by sea and by pipe line.

The water supply for the Western Desert Railway produced a problem of its own. The local supplies being saline were quite unsuitable for locomotives. The objections to using even slightly saline water in locomotives are scale formation, the frequent need to blow down to avoid dangerous concentrations, and, perhaps most serious of all, priming, which makes it difficult to read the gauge glass. The Egyptian engine driver, moreover, is used to Nile water which is perhaps the best natural boiler feed water obtainable anywhere and Transportation quite naturally took a very poor view of saline desert supplies. Water for locomotives was therefore transported to watering stations on the Western Desert line by tank wagons and also by the pipe line which will be described later.

Water was also transported by sea from Alexandria to Matruh in small tankers, and the 18th Army Troops Company, N.Z.E., did excellent work on many occasions in taking water from Alexandria to Matruh, Sidi Barrani and Salom in water boats.

Western Desert Pipe Line

The first pipe line ran from Alexandria to Daba, and pipe of various types and sizes from 6 to 8-in. was used, much of it was Mannesmann Steel pipe with lead joints which Germany had sold to Palestine before the war. The lead joints were a liability as the local Arabs used to pick out the lead. Some was Victaulic jointed steel pipe and some was cast-iron spigot and socket. The original pumping stations contained centrifugal pumps, belt driven by horizontal oil engines. The pumping was done in five stages and the capacity of the line was 600 tons a day. The pumping sets at each pumping station were duplicated and installed in separate engine rooms in dugouts. The pipe line as far as possible followed the alignment of the railway.

On the whole, the plant was reliable, but there was constant trouble with belts, and frequent dust storms caused excessive wear on the exposed cylinder liners and pistons of this type of prime mover. Running and maintenance was carried out by 18 Army Troops Company, N.Z.E., assisted by Egyptian civilians.

By degrees demands for water increased and more suitable pipe and pumping plant began to arrive from U.K. and America. The pipe line was extended by stages nearly up to the frontier and the capacity of the original section from Alexandria to Daba was doubled by duplicating certain sections of pipe and inserting booster pumping sets in the line.

The belt driven pumps were replaced by direct-coupled Caterpillar-Gould sets, having a capacity of 24,000 gall. p.h. against 300 ft. head. These sets were excellent and worked most reliably under very severe temperature conditions. In fact, the only drawback to them was the radiator cooling, which made the underground pumping stations unbearably hot. By degrees, the radiators were replaced by heat exchange coolers inserted in the pipe line.

The pipe received from U.K. and America was mainly plain-ended steel, 8-in. and 10-in., with Johnson or Dresser couplings.

These joints have no longitudinal strength and all bends, tees, etc., have to be adequately supported with anchorages. Great trouble was caused owing to couplings arriving in different ships to the pipe and rubber rings getting separated from the couplings. Ships containing couplings were sunk and we were forced to fall back on welded joints. This caused difficulties owing to shortage of welding sets.

Pipe Laying

The pipe line was buried where possible. This was advisable to reduce temperature variations. Moreover, if the pipe was laid on the surface, we had trouble from lorries trying to drive over it.

Mechanical ditchers were found valuable in some places but generally the ground was too hard and stony, and in such cases rooters were used with one tyne to loosen the ground before excavation. Some trouble occurred due to blockages. These were sometimes due to careless laying with the pipes half full of sand, and occasionally alleged to be due to deliberate sabotage by certain locally recruited labour units.

The difficulty was to locate the blocks. One successful method was to insert pressure gauges in the pipe line at regular intervals, plot the pressure and note where a heavy drop occurred.

The " Go-devil " method was considered, but we had no pumps capable of producing a high pressure and it was feared that the method might make matters worse. The " Go-devil " is used in oil pipe lines and is a contraption which is inserted in the pipe line and forced along by the moving liquid cleaning the pipe as it goes. It was found best to reduce the number of sluice and reflux valves to a minimum and air valves were completely discarded as being more nuisance than they were worth. There was a good deal of trouble due to joints being loosened by wandering Arabs in search of water.

The hydraulic conditions in the pipe line were always most carefully calculated and considerable care was taken to ensure that the most was made of the pipe and plant available.

There were always at least two pumping sets at each pumping station and these were installed in separate, dispersed, underground pump rooms. It was found best to weld the joints in the pipe work at pumping stations.

The Axis Advance to El Alamein

The final duplication of the pipe line was interrupted by the Axis advance to El Alamein. In spite of the rapidity of this advance, most of the pumping sets were removed in time to the rear. They were all overhauled in workshops and replaced again during the advance from El Alamein.

Nile Water

The Nile was the source of all water supplied to the whole of the base and L. of C. areas and also, of course, of the water pumped into the Western Desert pipe line.

The use of Nile water for drinking presented some difficulties. One of them was that the river has a large range of levels, from high flood to low water, and many of the canals are liable to be closed at certain seasons for annual cleaning. Nile water is heavily laden with fine silt, which, in the flood season, is so thick as to make the river a deep chocolate colour. At other seasons, it contains a considerable amount of algae, which is difficult to remove by filtration. Even in Cairo one's bath has a most unpleasant smell and a green tinge at certain seasons. In addition to all the usual waterborne disease microbes, the molluscs which act as hosts to the Bilharza worm abound in the Nile. The water is therefore unsafe for washing, as well as drinking, unless it is efficiently treated.

Filtration with pre-sedimentation is essential, and was avoided only in a few places where tube wells could be successfully sunk.

We were very fortunate to obtain the co-operation of Mr. Walton of the Alexandria Waterworks. Mr. Walton probably knows more about the purification of Nile water than anyone else. He designed a suitable filter plant based on the Paterson filter and this was made in three sizes, 600,000 and 120,000 galls. per day in R.C.C., and a semi-portable type 40,000 galls. per day in steel. Some of the latter were installed in barges and many were sent to Iraq where they were found equally satisfactory for dealing with Tigris and Euphrates water.

The design is briefly as follows :—

The crude water is first mixed with alum solution in a flocculation chamber, stirred by paddles and then passes into a circular sedimentation chamber with a conical floor, where the revolving scrapers sweep the sediment to a central scour outlet. From this chamber the water passes through a rapid sand filter and is finally treated with chlorine by an automatic chlorinator and passes by gravity to an underground pure water reservoir. The paddles and scraper are operated by a water-wheel turned by the incoming crude water. The filter is back washed periodically with pure water from a high level cistern or from a wash water pump.

These filter plants were most efficient, but a good deal of supervision was necessary to ensure that they were operated properly and especially to see that the filter washing was carried out regularly. It will be noted that no compressed air agitation of the filter bed was included in the design, as this would have introduced a further complication and the necessary air compressors would not have been available in the large numbers required. Various trials were made to improve the system of back washing and several modifications in the design were made from time to time.

Mr. Walton very kindly agreed to carry out regular tours of inspection of all the filter plants, instruct the personnel and submit reports. He also took samples of the water and had these tested in his own laboratories at the Alexandria Waterworks and gave instructions as to the dosage of alum and chlorine to be used.

The advantage of having an expert available who enjoyed the complete confidence of both Medical Authorities and Engineers at G.H.Q. was very great. If such matters as chlorine dosage had been left to local medical officers in accordance with the usual practice, the resultant increase in demand for chlorine gas would have been completely beyond our power to supply.

More than twenty-five of the large size of filters were installed in Egypt alone. A complete waterworks layout for a base camp included an intake from the canal, a suction sump, raw water pumps, the filter unit, underground pure water reservoir, wash water cistern or pumps, high lift pure water pumps and the necessary rising main, storage cisterns and distribution system.

All pumps were installed in separate underground pump houses and were duplicated. The pipework involved was quite complicated and much of the jointing was carried out by welding. Pressed steel cisterns were used for high level storage in camps in the first place and were replaced later by R.C.C. structures.

As may well be imagined, the provision of the water supply installation was the limiting factor in the time it took to provide a large base camp or depot.

Design and Execution

The detailed designing of all water supply installations in Egypt, including the Western Desert pipe line, was carried out by the Director of Works branch at G.H.Q., Middle East. This centralization was necessary in order to suit designs to the availability of stores which was only known at G.H.Q. On the whole it worked quite satisfactorily as distances in Egypt were not very great and it was always possible for an officer from the branch to visit the site. There was, moreover, a serious shortage of experienced E. and M. officers and by concentrating the most suitable officers in the D.W.'s branch, it was possible to organize a really useful planning team and adopt a considerable measure of standardization.

The work at site, in the Base and L. of C. areas, was carried out by local firms of contractors, some of whom became quite experienced in the construction of R.C.C. filters and high level cisterns. The supervision was carried out by the local C.R.E. and G.E. The work on the Western Desert pipe line was carried out by engineer and labour units.

The operation and maintenance of water supply installations in the Base and L.of C. area was largely carried out by Egyptian civilians employed under the Garrison Engineer.

Later a Water Maintenance Company of South African Engineers took over some of this responsibility.

In the Western Desert although some civilians were employed, the most important Engineer Units on the job were :—

18 Army Troops Coy., N.Z.E.
A Water Supply Coy., S.A. Engineers.
A Geological Survey Section, S.A. Engineers.
and several Well Boring Sections, R.E.

Although several different units were employed on the operation and maintenance of various sections of the Western Desert pipe line, the teamwork was admirable.

OPERATION CURZON—THE EVACUATION OF WAZIRISTAN

By LIEUTENANT-COLONEL H. E. M. COTTON, O.B.E., R.E.

THE evacuation of troops from Waziristan was announced in the British Press on 19th December, 1947. To the many R.E. officers who have served in Waziristan this announcement will no doubt have caused surprise and regret. It will also have brought back many memories of past service in this wild and mountainous but most interesting area on the North West Frontier of India, as also of varied associations with the hardy, wily, sometimes friendly, sometimes hostile but always humorous, Pathans of the Mahsud and Wazir tribes. Such officers will no doubt be interested to read the story of the evacuation which follows. Certain preliminary paragraphs have been inserted for the benefit of readers who are not already acquainted with the topography and history of Waziristan.

Waziristan is the name given to that area of tribal territory on the North West Frontier of India lying between the administrative border and the Durand line, which is bounded on the north by the Kurram Agency, and on the south by the Zhob. The Waziristan Military Area (known as District prior to 1945) also includes the civil administered districts of Bannu and Dera Ismail Khan, which lie between the administrative border and the River Indus. These administered districts are largely flat and sandy desert, but certain parts, notably round Bannu, are irrigated and hence well cultivated. The tribal territory of Waziristan is, however, a maze of barren hills intersected by nalas, which have a trickle of water in them for most of the year but are liable to spate in the rainy season. The tribes eke out a precarious existence in mud walled villages located in the valleys. The difficulty of securing a livelihood from their native hills has made them predatory, and tribal raids on the fertile plains were a common feature of earlier days. Feuds between the various tribes are also common. Every man carries a gun and the villages are fortified with towers.

Since the annexation of the Punjab in 1853, British authority over the tribes who inhabit these mountainous areas has been exercised through Political Agents. This control has always been rather loose, as owing to the difficulty of penetration into the hills it has not been possible to bring the tribes under the administration of Indian Law. The tribes have, therefore, continued to administer themselves according to their own laws and the Political Agent's control has depended largely on his personality, and on a system of subsidies to assist the tribes to obtain a livelihood in their own barren hills, without having recourse, as formerly, to plundering the rich plains below.

Following the Second Afghan War in 1878 a "Forward Policy" began to be adopted on the North West Frontier. Roads were pushed into tribal areas, a railway was built up the Bolan Pass to Quetta, and Political Agents extended and increased their influence. As a protest against this penetration, tribal risings occurred throughout the Frontier in 1897, necessitating military expeditions into the Malakand, Mohmand, the Tirah, and the Tochi valley. The risings were suppressed after bitter fighting and troops remained in occupation.

Photo 1.—Wana, showing the new wall dividing the camp with two-story piquet and gateway incomplete.

Operation Curzon-The Evacuation Of Waziristan

Photo 4.—Wana—1,500 gallon petrol tank being winched on rollers.

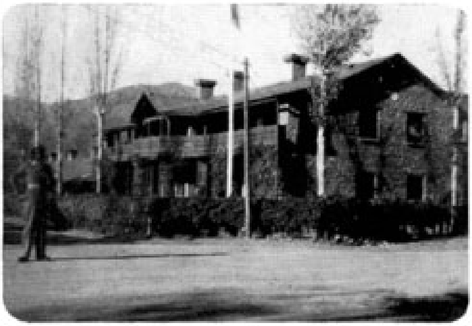


Photo 5.—Razmak—Brigade H.Q. Mess.

Photo 6.—Razmak from the air on Z − 1 day.

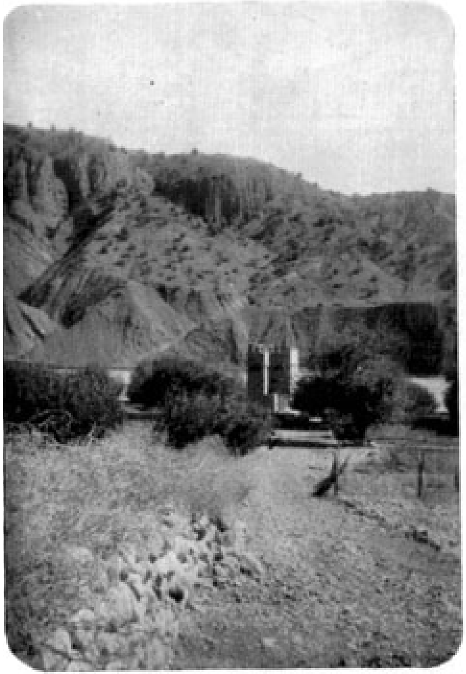


Photo 2.—Sararogha pumping station.

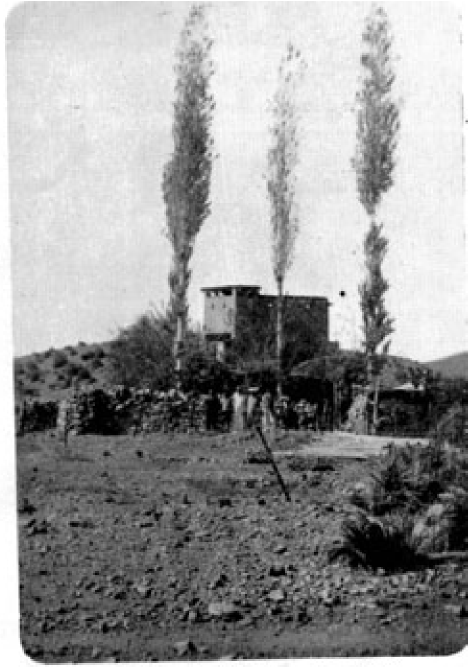


Photo 3.—Asad Khel pumping station.

Operation Curzon-The Evacuation Of Waziristan 2 & 3

However, when Lord Curzon became Viceroy in 1899, the policy was reversed. Lord Curzon was a staunch believer in the control of the tribes by a few political officers of strong personality rather than by the force of military occupation. He withdrew the troops from the frontier and introduced instead Corps of tribal militia and levies to back up the moral authority of the political agents. Thus the North Waziristan Militia, later renamed Tochi Scouts, was raised at Idak, in North Waziristan, in 1900. In South Waziristan the Wana Militia was also raised about the same time and was later renamed the South Waziristan Militia. This " Backward Policy " remained in force in Waziristan till 1923 ; but it began to fail before then. In 1919, at the time of the unfortunate Third Afghan War, the trans-border element in the South Waziristan Militia went wrong. A portion of the Corps mutinied. Wana was evacuated and the Militia was virtually disbanded. The army had to be called in. Protracted operations ensued during 1920 and 1921, at the end of which a column reoccupied Wana. It withdrew at the end of 1921. A new Corps of South Waziristan Scouts was raised at Jandola in 1920 with a nucleus of the disbanded Mohmand Militia from Shabkhadar and the loyal portion of the South Waziristan Militia. They did not, however, reoccupy Wana, which remained out of effective control till 1929, except for a couple of short visits from the Manzai Brigade. Meanwhile, in North Waziristan there was enmity between the Wazir and Mahsud tribes. The Mahsuds were encroaching on Wazir territory and pillaging their villages. In 1922 the Wazirs appealed to the British Government for protection. In response to this appeal, Brigade columns penetrated into the disputed territory from Dardoni in the north and Jandola in the south, and effected a junction at Tauda China. After this the first permanent camp was established at Razmak in February, 1923. In 1929 control was re-established over South Waziristan by a Brigade column from Manzai which finally reoccupied Wana. Permanent roads followed the troops in all these expeditions.

The " Forward Policy " was now in full swing once more and was given full rein in the hopes that it would not only control but also civilize the tribes. Based on the two Brigades at Razmak and Wana, supported by additional strong forces at the railheads of Bannu and Manzai, the military occupation of Waziristan continued methodically. Military stations were built at Mirali and Manzai, and the tented camps at Razmak and Wana were transformed into highly developed cantonments with permanent buildings, electric power stations, water distribution systems, well-equipped hospitals, cinemas and amusement parks. Roads were steadily driven into the hills to open up the area and strong Scout posts built at strategic points along them. This road building policy was the cause of most of the frontier campaigns which followed, as the tribes strongly objected to their areas being opened up. The cost of this policy to the Indian exchequer was of course enormous, but was considered to be justified as the tight control so obtained over the tribes did ensure security to the settled districts. Indeed, from 1925 to 1935 there were " ten golden years " of comparative peace, even in Waziristan itself. In 1935, however, the Bannu abduction case gave rise to the hostility of the Faqir of Ipi, which has coloured the Frontier scene ever since. Major campaigns in Waziristan took place in 1937, 1939, 1941 and 1942. The Forward Policy has had a high cost in lives, both British and Indian, as well as in money. The troops involved have of course obtained excellent training, and the technique of frontier fighting has developed into a fine art. For R.E. officers the M.E.S. in Waziristan have provided opportunities for large-scale road-building, bridging, and E. and M. projects, which rarely occur in peacetime in any other part of the world.

The above is, therefore, the background to the evacuation which has recently taken place. In October, 1947, there were four strong brigades of all arms in Waziristan Area, including no less than nineteen infantry battalions. By the end of the year every single soldier had been withdrawn from tribal territory except one, Major Towers, R.E., the Garrison Engineer at Miranshah, and Waziristan Area had been reduced to one brigade at Bannu. In January, 1948, Bannu Brigade was placed under command Peshawar Area, and Waziristan Area, which had been for many years the most active area in India, ceased to exist. The following is the story of its last operation.

Policy Decision

Future policy on the North-West Frontier came up for consideration by the Government of British India, after the end of the second Great War. The long military occupation had not resulted in the civilization of the tribes, much less in their pacification, and was a tremendous drain on the exchequer as well as on the manpower of India. There was general agreement on the necessity of withdrawing the Army from tribal territory and leaving the policing of that area to the Civil Armed Forces. Frontier defence troops could then be reduced and regrouped within the administrative border, where they would remain available for punitive expeditions in support of the C.A.F. when required. It will be seen that the pendulum had swung back in favour of the "Backward Policy." In September, 1947, shortly after Partition, the Central Government of Pakistan decided to implement the policy, which had already been agreed to in principle by the Government of British India, and ordered the evacuation of all military forces from tribal territory in Waziristan. The operation which was thereupon planned was given the name of "Operation Curzon," as it signified the return to Lord Curzon's policy of 1899.

Factors

The decision to evacuate the Army from tribal territory was communicated to the tribes by the Governor of the N.W.F.P., Sir George Cunningham, in Jirgas held at Wana, Tank and Miranshah on 6th November, 1947. The attitude of the tribes was an important factor. They had always objected to the presence of the troops, but now that they were going they were likely to realize the loss of income it would cause them, in employment of various kinds and in M.E.S. and Supply and Transport contracts. Although the Mahsuds in the south had reacted favourably to the creation of Pakistan, the Faqir of Ipi was still uncompromising in his hostility to Government, and he had great influence among the Wazirs and Daurs in the north. The withdrawal of the Army would be their last opportunity to steal rifles and other weapons, and they might be expected to make the most of it.

Another factor which complicated the issue was the presence in Waziristan at this date of large numbers of Sikhs and Hindu units and troops, and civilians in military employ (including 1,600 M.E.S.) whom it had not yet been possible to repatriate to the Union of India. The tribes would be likely to oppose their withdrawal whatever their attitude to Mussalman troops might be. One serious incident had in fact already occurred in the Shahur Tangi on 22nd September, 1947, when a convoy, containing Gurkha and Sikh troops, was attacked by Mahsud troops and suffered considerable casualties. (This incident occurred at about the precise spot and in similar circumstances to the disastrous ambush of 9th April, 1937.) It was therefore decided that all non-Muslim personnel must be evacuated from tribal territory before the operation proper began. In the event, and due to high grade staff work, this was successfully achieved, the means used being a combination of air, road and rail. The non-Muslim M.E.S. civilians presented a peculiar problem and were among the last to leave Razmak. About 1,200 men and families were in Bannu till the beginning of December, when they were eventually evacuated by rail. About 200 had previously been flown out of D.I.K. on civil evacuation aircraft. It is interesting to note that Hindus and Sikhs represented 65 per cent of the strength of the M.E.S. in Waziristan prior to Partition. The majority of those evacuated were never replaced, and the M.E.S. Waziristan thus had to cope with Operation Curzon at very reduced strength. The deficiencies were specially marked in the E. and M. supervisory grades. It is also interesting to note that whereas the M.E.S. Waziristan had hitherto retained a larger number of R.E. officers than any other area in India, and actually had fifteen up to the end of October, 1947, as a result of Scheme "Biscuit" (repatriation of non-volunteers for service in Pakistan) there were only four R.E. officers in Waziristan during Operation Curzon. There was in addition one R.P.E. officer. The remaining M.E.S. officers and all the subordinates were Pakistan civilians, the majority coping with jobs above their own grades and frequently with more than one.

The Plan

The plan covered the total withdrawal of the Army from tribal territory, i.e., from the Military Camps of :—

Northwaz	*Southwaz*
Razmak	Wana
Gardai	
Damdil	
Mirali	

This rendered necessary the withdrawal of the Scouts from the following posts, which could no longer be supported after the military evacuation.

(*Tochi Scouts*)	(*S.W. Scouts*)
Datta Khel	Ladha
Tut Narai	Sararogha
Dosalli	Kotkai
Boya	Tiarza

In Northwaz the Tochi Scouts were to take over Mirali from the Army, and in Southwaz the South Waziristan Scouts were to take over Wana.

It will be seen by a reference to the map that in North Waziristan the whole of the Upper Tochi Valley, as well as the Bannu–Razmak road beyond Isha Corner, was to be completely abandoned even by the Scouts, whereas in South Waziristan the taking over of Wana by the Scouts would leave a large part of the area, including the whole of the Manzai–Wana road, still under control.

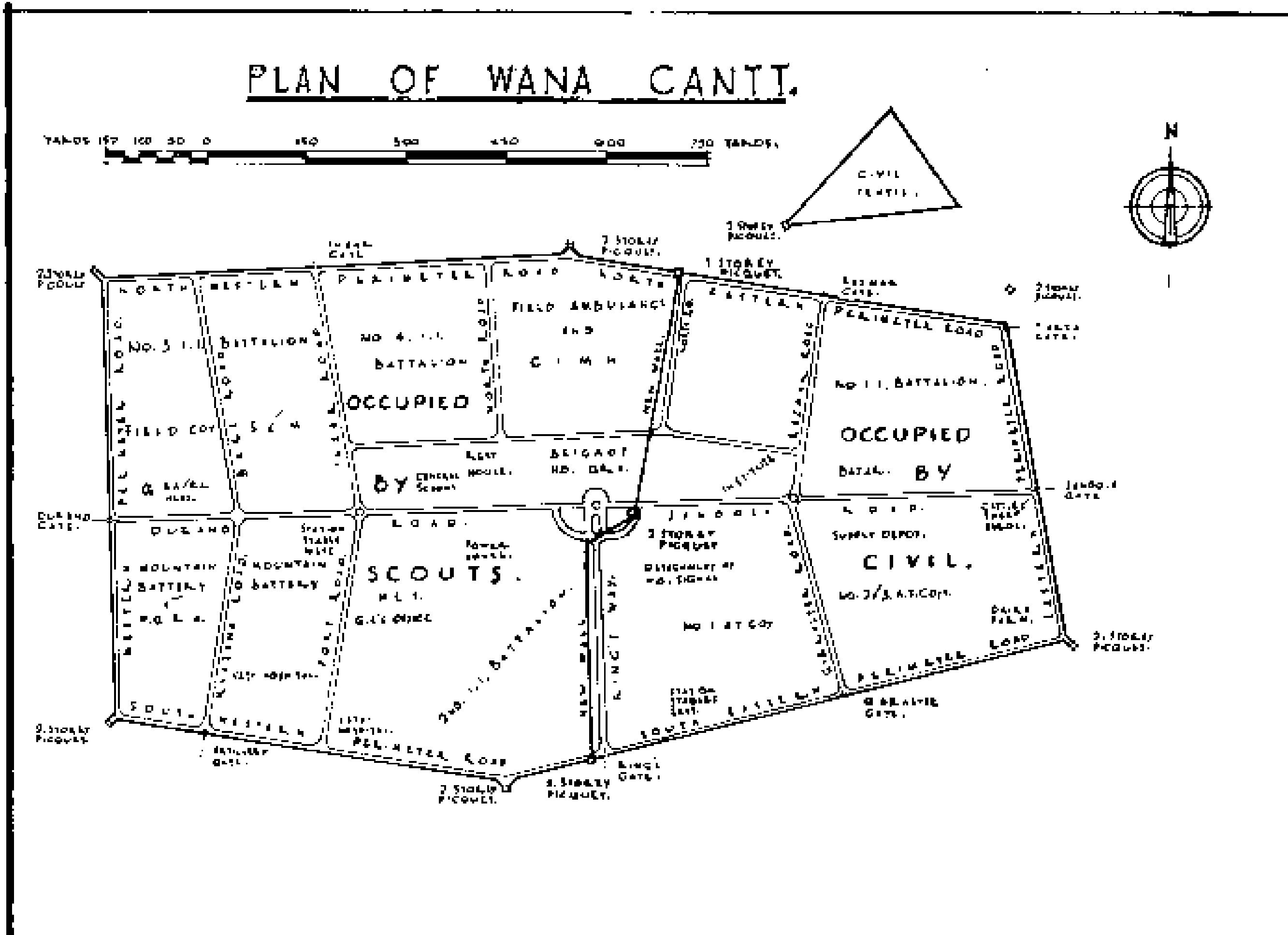
Detailed planning started early in October, but as the evacuation was a close secret till the Governor's announcement to the tribes, no actual withdrawal of troops or material could take place before 6th November (D day). Thereafter, it was essential to complete the whole operation before the coming of the winter snows, with their probable delaying effect. It was, therefore, decided that the withdrawal of troops in Southwaz was to start on 1st December, 1947, and to be complete on 7th December, and the withdrawal of troops in Northwaz was to start on 15th December and be complete by 31st December. The regrouping of the Tochi and South Waziristan Scouts, including abandonment of certain posts, was to precede the military withdrawal of troops so that the Scouts could be available to assist in the Army's withdrawal.

Prior to the withdrawal of troops every effort was to be made, within the limits of time and transport available, to salvage as much as possible of the stores and material of all kinds in the camps and posts that were to be abandoned. Any stores that could not be salvaged were to be left intact for tribal benefit. Similarly plant and machinery that had to be left behind were to be left intact and in working order. Finally there was to be no destruction of defences, walls, or buildings in any camp or post that was to be abandoned by the Army or Scouts.

The Evacuation of South Waziristan

The withdrawal of the South Waziristan Scouts from their outlying posts of Tiarza, Ladha, Sararogha and Kotkai took place immediately after the Governor's announcement on 6th November. In fact they nearly beat the pistol. All these posts except Kotkai contained electric power and water installations. One of the centrifugal pumps from Ladha had been got out via Razmak early on, as it was a standby. All the rest of the plant was rapidly dismantled by the local engine drivers and mates assisted by fitters despatched from Wana and Jandola, and they all came away with the Scouts in M.E.S. transport, except for the generating sets from Sararogha. Some of the lorries had come from Rawalpindi specially for the operation, and the Punjabi drivers were a bit scared of the farewell party of Mahsuds who came out to speed the Scouts from Ladha. They got away a lot of stores and fittings in addition to the plant, but certain stores for which there was no transport had to be locked up in a store. This was later broken into and the lot stolen, although the post was supposed to be under the protection of Khassadars. The A.G.E. at Wana was a Mahsud, and he later managed to recover a certain quantity. The generating sets from Sararogha were recovered by the Supt. E.M. from Jandola, *after* the post was evacuated. That area was a particularly quiet one at the time.

The S.W. Scouts were to take over Wana on 1st December, when the Brigade was due to evacuate, and they began to arrive in October. The first thing they wanted was a wall built from north to south across the centre of the camp, as they decided they could not hold the whole perimeter. The camp was 750 yds. across and the height of wall required (after some beating down) was 8 ft., boulders in mud. There was to be a two-story piquet in the centre, a single story piquet at each end, and the whole wall was to be electrified. Altogether quite a formidable task. At one time the "Wana Wall" was the chief factor in the planning, as its completion fixed the date of the Wana Brigade's evacuation, on which everything else hinged. However, in spite of this, permission to start building was withheld for security reasons till 20th October. By then the date of evacuation had been fixed for 1st December. So exactly forty days were left. Even so there was delay over contractor and transport, and work did not actually start till 27th October. In spite of this the wall was complete throughout its length and electrified by 30th November, although the piquets were not finished till later. The wall building was largely done by the Scouts themselves under M.E.S. supervision and became known locally as "Operation Balbus." Certain buildings were demolished in the western half of the camp (which is being occupied by the civil only) and the Wana blocks recovered from them were used in the upper half of the wall. The Sappers who built Wana will be interested in the plan attached. They will also be interested to hear that the R.A./R.E. Mess is now the Scouts' Mess in Wana, as they preferred it to the other messes. They have also taken on the Mess Abdar, Allah Baksh. Mess furniture was divided with the gunners before the hand over, and the mess dining-table and chairs are now in the



PLAN OF WANA CANTT.
YARDS 150 100 50 0 150 300 450 600 750 YARDS.
N
CIVIL
2 Storey Picquet.
1 Storey Picquet.
North Western Perimeter Road
North Eastern
Perimeter Road
Field Ambulance and C.I.M.H.
No. 4 I.I. Battalion
No. 3 I.I. Battalion
No. 1 I.I. Battalion.
Field Coy. S. & M.
OCCUPIED
OCCUPIED
BY
BY
SCOUTS.
CIVIL.
Brigade Hd. Qrs.
Rest House.
Durand Gate.
Durand
Jandola Gate.
Jandola Road
Mountain Battery
Mountain Battery
Supply Depot.
No. 2/3 A.T. Coy.
No. 1 A.T. Coy.
Detachment of Hd. Qrs. Signals
2 Storey Picquet.
G.C's Office
2nd I.I. Battalion
Dairy Farm.
Perimeter Road
South
South Eastern
Perimeter Road
Kings Way
Kings Gate.
2 Storey Picquet.
Artillery Gate.

Mess of the Royal Pakistan Engineers Centre at Sialkot. The mess billiard table was also sent there and the coloured prints of the "Midnight Steeplechase."

The Power Station and other Engineer services in Wana have remained *in situ* for use of the Scouts. The P.O.L. Depot was, however, in the wrong half of the camp. The kerbside pump and 5,000 gallon petrol tank had to be moved to the other half of the camp. There was no transporter available at the time and the 15ft. long and 8ft. diameter tank was winched 1,500 yds. on rollers, including circumvention of the flagstaff merry-go-round—quite an intricate piece of navigation!

The military evacuation of Wana was completed without incident, the whole area remaining very quiet. The mules were marched down the road by Khassadars, and the men were ferried back in lorries.

The Evacuation of North Waziristan

As the evacuation had to be kept secret till the Governor's announcement on 6th November (D day), and as the march out from Razmak had been fixed for 15th December (Z day), the total time for back loading stores and material in North Waziristan amounted in all to forty days.

In Razmak there were two power stations. The old power station contained three Ruston sets (60, 40 and 30 kw.) and a 25 kw. Petter set. The new power station contained two 60 kw. Mirrlees sets. All were 440/220 volts D.C. There were three water installations, all 700 ft. deep tube wells. No. 1 well was air lift, yielding 4,000 gall. p.h., and had two 54 b.h.p. electric motors driving two double stage Sullivan compressors. No. 2 well was also air lift, yielding 6,000 gall. p.h. and had two 114 b.h.p. Ruston Diesel engines driving two double stage compressors. There were also two motor driven centrifugal pumps for boosting from this reservoir to that at No. 1 well. No. 3 well had a fourteen-stage turbine pump driven by a 25 b.h.p. electric motor, and yielding 3,500 gall. p.h.

The problem was how to salve as much of this equipment as possible and yet keep water and light services going to the end. The first step was to stress the importance of recovering engineer plant to the General Staff. This was done and Wazir Area issued the following instructions to Comd. Razmak Bde. on 10th November, 1947.

"Owing to the value of the Engineer Plant and Machinery in Camps and Posts to be abandoned, and the extreme shortage of all such equipment in Pakistan, it is essential that all possible engineer plant should be dismantled and evacuated before the final withdrawal of troops. As the work entailed is considerable and transport requirements heavy such evacuation cannot be left to the end, and must be begun now. For this it is necessary to accept reductions in the present standard of lighting and also in the scale of water consumption."

Water rationing was immediately imposed by Razmak Bde. and the M.E.S. were given authority to disconnect the electric supply to certain parts of the camp. The water problem was also eased by the departure of 800 mules on 25th November, which marched back to Bannu under escort, leaving only the minimum for column requirements. As a result of these measures the water consumption in Razmak, which during the summer had been 2·45 lakhs gall., decreased to 90,000 gall. per day. This made reduction in the water installations possible. No. 3 well with the useful turbine pump was the first to be closed down and the equipment dismantled. It was then found that one well could supply the whole of the reduced requirements of the camp; so No. 1 well was closed down also and both motor-driven compressor sets were dismantled and back loaded. No. 2 well was retained as it was the only one which had independent prime movers, and thus did not depend on the power station. One of its two Diesel-driven compressor sets was, however, also dismantled and back loaded as well as one of the boosters.

The electric motors driving the compressors in No. 1 well had consumed 75 amps. By their elimination and other reductions in power and lighting the peak electric load, which had been 112 kw. on 31st October, was brought down to 80 kw. on 15th November and 57 kw. on 5th December. This enabled both Mirrlees generating sets in the new power house to be dismantled, and two out of the four sets in the old power house. All this equipment was back loaded.

By 5th December, therefore, ten days before D day, the bulk of the E. and M. plant in Razmak had already been got away. There remained the last Diesel-driven compressor set in No. 2 well and the 60 and 30 kw. generating sets in the old power house. The compressor set in No. 2 well had to be left, as the Khassadars, who were due to take over Razmak, had to get water from somewhere and there was no surface water for miles in the Razmak Plain. But it was decided that nothing else should be left. There were a number of semi-mobile generating sets in the area and three of these (two Tilling Stevens 22 kw. and one Caterpillar 25 kw.) were mounted in 3 ton lorries and sent up to Razmak at the end of November to take over the load. The 30 kw. Ruston was first dismantled and sent back, but just as the 60 kw. set was to be dismantled the Caterpillar mobile set failed, when there were four days to go. It had to be sent back to Bannu and the Ruston kept in commission. However, a third Tilling Stevens mobile set was called up by R/T and arrived very quickly. It took over the remaining load in time to enable the last Ruston set to be dismantled and back loaded on "Z-2". Switchboards, auxiliary machinery, and overhead cranes had already been back loaded and both power houses remained completely stripped. The actual day of the withdrawal had been kept a close secret and during the last night in Razmak the perimeter lights were functioning as usual, and internal lighting was also available till an hour before the withdrawal began. The three mobile generating sets drove out of Razmak with the column.

Early in November, the E.-in-C. had made 30 M.E.S. 3-ton lorries, from C.s R.E. Rawalpindi and Peshawar, available for "Curzon." Six of these were allotted to the G.E. Wana and the remainder were used on a constant shuttle service between Bannu and Razmak. M.E.S. Badraggas were used as escort and hence these lorries were able to run every day irrespective of "Road Open Days". As a result it was found possible to evacuate considerably more from Razmak than Engineer Plant and Machinery. The bulk of the better M.E.S. furniture was evacuated, to a total value of Rs. 2·45 lakhs. In addition, kit boxes were handed over to units as packing material and only charpoys and the less expensive items were abandoned. Three hundred tons of cement was also back loaded as well as R.S.J.s, C.G.I. sheeting, timber and other building stores.

In addition to Razmak, considerable engineer plant was installed in other posts, camps, and pumping stations in North Waziristan, and it was also necessary to recover all or as much of this as possible.

The Tochi Scouts evacuated Datta Khel and Boya posts shortly after D day. M.E.S. personnel from Miranshah went up with the supporting gashts and brought away the engine-driven water elevator in each of these posts. They also brought away tanks and piping. Centrifugal pumping sets also remained in Ghariom and Biche Kashkai posts, although these were not at this time in occupation by the Scouts. The Scouts, however, sent out special gashts with

M.E.S. personnel and both pumps were recovered, as well as the pipe line from the Ghariom pumping station to the post.

Valuable water supply plant also existed in the pumping stations at Razani, Gardai, Dosalli, and Asad Khel on the Razmak L. of C. All these were supplying troops *in situ*. Furthermore they would be required to supply water to both "Razcol" and "Garcol" during the withdrawal. The pumping plant, therefore, had to be left intact and only certain standby sets could be removed before Z Day. In Dosalli Scouts Post there was also a power station with three generating sets. Two of these were evacuated before Z day, but the largest 10 kw. set could not be removed, as the only water pump was electrically operated. The evacuation of the remainder of this equipment on the L. of C. could only be carried out, if at all, during the withdrawal operation.

The other services successfully carried out their back loading side by side with the Engineers. But the R.P.A.S.C. transport, unlike the M.E.S., was restricted to "Road Open Days." Four of these, however, were held each week and "Road Protection" troops got little rest. Apart from M.E.S. vehicles, 250 odd lorries were on the road each "R.O.D." and tired troops eagerly awaited "Roger Fox" who was always loudly cheered (the Red flag on the last lorry).

The preliminary evacuation was not carried out without opposition. "R.P." troops in the vicinity of Gardai and Alexandra piquet were attacked on three occasions and suffered casualties. Two trucks were blown up by mines near Mir Ali. Camp piquets at Gardai were also sniped.

The Final Military Operation

Owing to the peaceful attitude of the tribes in South Waziristan, it was possible to withdraw the troops from Wana as in a normal peacetime move. In North Waziristan the tribal attitude was completely different, and there had been many hostile incidents which were tending to increase. Thus it was decided that a full scale military operation would have to be staged for the withdrawal from Razmak. The problem consisted in the withdrawal of the Razmak Bde. Group, including six infantry battalions, and the Gardai Bde. Group, including four battalions, which were divided between Gardai and Damdil, along one main road seventy-three miles in length, by a combination of M.T. movement and march route. Owing to the short hours of daylight, stages would have to be short, and camp sites were also governed by the water problem. Fortunately transport was not a problem, as G.H.Q. had made sufficient reserves available. For supplies, columns were to carry several days with them in attached second line transport, and dumps were placed in position at Gardai and Damdil from which units were to refill.

The Engineer troops available for the operation, in addition to the civilian M.E.S. personnel who functioned nobly throughout, were as follows.

31 Aslt. Fd. Coy., R.P.E., Razmak, arrived 8th November, in relief of 9 Fd. Coy., R.I.E., left for India 18th November.
68 Fd. Coy., R.P.E., Bannu, arrived 30th November.
Prior to Z day these units were deployed as follows:
31 Aslt. Fd. Coy., less two Pls., under comd. Razmak Bde.
One Pl. 31 Fd. Coy., under comd. Gardai Bde. at Gardai.
One Pl. 31 Fd. Coy., under comd. Gardai Bde. at Damdil.
One Pl. 68 Fd. Coy., Force Reserve, Mir Ali, and in support Tochi Scouts.
68 Fd. Coy., less one Pl., Force Reserve, Bannu, and in support Bannu Bde.

Engineer Problems

The various engineer problems will now be described.

(*a*) *Communications*

The main axis of withdrawal was the road Razmak–Isha Corner–Bannu. This was a two-way tarmac road in good condition, which for most of its seventy-three miles wound its way through mountainous country. The lowest classification of any bridge on this road was 9, but there were only ten bridges or culverts unsuitable for Sherman tanks (Class 40), and round all these there were diversions.

Since 1st October, 1947, five culverts on this road had been blown up by hostiles, and it was very possible that they would try to interfere with the actual withdrawal in this way. However diversions existed round most of the vulnerable bridges. Also, owing to the absence of spate at this season, culverts if blown up could usually be speedily filled in to make the road good. There were, however, certain bridges in hill sections which it would be difficult to circumvent if blown up. As a precaution a D-7 angle dozer, which had been working in the Razmak area, was retained for the operation, and accompanied the M.T. column throughout on a transporter. It was also intended to use the angle dozer for snow clearing if necessary and for breaking ice which might form after rain, as both were possibilities on the Razmak Narai in December. In the event, the angle dozer was only required once, and that was to start its own transporter one cold morning when the latter's engine proved refractory! Only one culvert was blown up by hostiles during the withdrawal, and this was speedily filled in and the road made good.

Alexandra Piquet, built on the ridge of the same name, commands the Razmak Narai. It is 8,000 ft. high and, I believe, the highest military post in the British Commonwealth. The garrison of this piquet was brought up to a full Battalion before Z day. In his plan for the second day of the withdrawal the Commander Razmak Bde. planned for the piquet garrison, together with the whole mule column, to withdraw straight down Alexandra Ridge and thence along the feature known as Camel, to join the main road at about mile 60. This was to avoid going back to Duncan's piquet and thence along the winding main road. To carry out his plan a five-mile mule track along the whole ridge was made by 31 Aslt. Fd. Coy., before Z day. This was very well done and enabled the Brigadier's intention to be carried out successfully as planned.

(*b*) *Water Supply*

Marching out strengths were as follows :—

	Men	*Animals*
Razcol	4,189	521
Garcol (Gardai Garrison)	1,341	77
Garcol (Damdil Garrison)	1,590	79
Tac H.Q. Wazforce	110	
Tochi Scouts Dosalli	500	
Total	7,730	677

At a ration scale of 2 galls. per man and 8 galls. per animal, this represented a daily water requirement of 20,876 galls., say 22,000 galls. to be on the safe side. There were, however, only two days when the whole force was due to be concentrated, and that was at Damdil on Z + 4 and Z + 5.

The water situation at camps which were due to be occupied was as follows :—

Camp	*Storage Capacity*	*Supplied from*
Machi Khel ..	Nil	Nala by blowing explosive charge
Gardai ..	54,000	Gardai Pumping Station
	+ 55,000 at Razani	Razani Pumping Station
Dosalli	58,000	Well in Khaisora Nala
Damdil ..	78,000	Asad Khel Pumping Station
Nari Wela Narai	25,000	Asad Khel Pumping Station
Idak	Nil	Kand Algad
Saidgi	Nil	Tochi River
Dreghundari ..	Nil	Tochi River

The places which gave cause for anxiety were Dosalli and Nari Wela.

Dosalli

The well in the Khaisora Nala had dried up during the summer. Another temporary well had been dug, but this had fallen in during a spate. As a result Dosalli Scouts Post had been without water since August, and all water had had to be fetched in lorries from Asad Khel. Attempts to dig out the temporary well had had to be suspended after a coolie had been killed by a dislodged boulder. Action was then taken to line the well with C.G.I. sheeting. In the middle of November, however, a well-boring rig was made available and with the aid of this an 18-ft. long, 12-in. diameter strainer was driven into the bottom of the dug well. Pumping recommenced on 21st November, but it was found that the pump exhausted the water in the strainer in a few minutes. The first day a total of only 200 galls. was obtained. This was serious. The well, however, recovered slowly and it was found that by pumping and stopping for fixed intervals a total of 6,000 galls. a day could be obtained. This enabled all storage tanks to be filled, though replenishment was very slow. The situation was thus considered adequate for the two nights the camp was required.

Nari Wela Narai

There was an old 25,000-gall. tank here, fed by an 8-mile pipe line from the Asad Khel pumping station, which also filled five other tanks on the way. This tank was first cleaned and repaired and the sides built up so that its capacity was increased to 40,000 galls. The pipe line caused anxiety as it was subject to leaks and also to sabotage by hostiles. To fill the Nari Wela tank it was also necessary to shut off the connections to all the intermediate tanks. The pipe line was cut by hostiles five times between 1st November and Z day. Fortunately all the breaks but one were on the section between Nari Wela and Tal-in-Tochi. The tank was filled early in December and kept full thereafter by daily inspections and pumping. Badraggas were located on the site to prevent sabotage.

All the reservoirs and tanks on the L. of C. were filled to capacity in good time before Z day and pumping stations had orders to keep them full till no longer required, and to pump twenty-four hours a day if necessary while camps were occupied. At the same time it was desired to dismantle and evacuate the equipment from the Razani, Gardai and Dosalli pumping stations before these places were abandoned. Provided the tanks were kept full, a three-days' reserve of water (at ration scales) was assured at Gardai (and three days' more if the Razani reservoir, three miles out and connected to Gardai by gravity pipe line, remained available) and also a three days' reserve at Dosalli. Plans were therefore made to dismantle and remove all equipment from pumping stations as follows :—

Razani Pumping Station	Z + 1	Day on which Razcol withdrew to Gardai
Gardai Pumping Station	Z + 2	Day before Gardai evacuated
Dosalli Well and Power Station	Z + 4	Day of evacuation of Dosalli

As there was always the possibility of hostile action forcing camps to be occupied longer than anticipated, orders to dismantle pumps were not given till the last moment and after confirmation from "G" that the risk was negligible. In the event, the evacuation of all pumps and other equipment from all these installations, including the 10 kw. generator at Dosalli, was carried out successfully.

At Damdil where there was no water shortage, both columns spent a welcome day's rest and all troops were able to have a bath. On this day (20th December) the military piquet was withdrawn from the Asad Khel pumping station, but the pumps were left intact for tribal use, at the request of the political authorities.

The camp on the Nari Wela Narai was occupied by Damcol on Z + 6 and by the whole of Razcol on Z + 7. To ease the water situation, however, only the minimum number of mules accompanied the column. There was no shortage of water, the tank being nearly as full on departure as on occupation owing to the pipe line continuing to function.

At Idak, Saidgi, and Dreghundari camps improvised field water points were established from the Kand Algad and the Tochi, and water was available for all purposes.

(*c*) *Lighting*

Electric light was supplied to Tac H.Q., Wazforce, at all camps from Z—2 to Z + 11, and also to H.Q., Razcol, from Z + 8 to Z + 11. This was originally supplied from an American pattern 2 kw. lighting set. This set gave a good deal of trouble and eventually caught fire at Gardai on Z + 1. A potential tragedy was averted by a signalman with a bucket full of earth. Thereafter light was supplied, rather uneconomically, from one of the lorry-mounted 25kw. Tilling Stevens generating sets which withdrew from Razmak on Z day. The electric light in the evenings and dark early mornings was an inestimable boon on the operation, and was only equalled by the unlimited supply of old bullies for firewood. These two amenities contributed greatly to the festive nature of Christmas, which was spent at Idak.

(*d*) *Demolitions, Mines, and Booby Traps*

The Shora and Shandurai permanent two-storey piquets south of Razmak were demolished by 31 Aslt. Fd. Coy. on Z — 4 and Z — 1 respectively, so as to avoid provocation to the Mahsuds whose area they overlooked, when Razmak was handed over to Wazir Khassadars on Z day.

Charges used were 400 lb. of gun cotton at Shora and 300 lb. at Shandurai. This was considerably more than was theoretically required, but it was essential that the demolitions should be effective. In both cases one quarter of the charge was placed in each corner of the bottom storey of the piquet. The charges were fired electrically and both were completely successful.

It was anticipated that hostiles would make use of mines and booby traps, and both field companies (who had only recently arrived in the area without full equipment) were brought up to strength in mine detectors before Z day. On the eve of the operation, however, all detectors, except one with 31 Fd. Coy., were out of action due to dead batteries. Replacements were not forthcoming. 68 Fd. Coy. subsequently obtained further supplies, but 31 Fd. Coy. went through most of the operation with only one serviceable detector.

Incidents

The incidents which occurred were as follows :—

(1) On the night of Z + 4/Z + 5 a culvert at mile 39 was damaged by an aerial bomb which was exploded under it by the usual tribal method of lighting a fire under it. The culvert partially fell in. The damage was discovered by an M.E.S. overseer in a truck early on Z + 5 and was immediately filled in by the aid of Khassadars. The following day Khassadars found a 100 lb. aerial bomb on the khud side below this culvert. It is likely that this bomb was also meant to explode in the culvert, but the other detonated first and blew the second out. The Khassadars carried the bomb down the khudside to a place of safety, where it was later exploded.

(2) On Z + 5 a fired, but unexploded, 2 in. H.E. mortar bomb was found in Razcol camp at Damdil. It was exploded at site.

(3) On Z + 6 a booby trap consisting of a Pacific ration tin filled with picric acid exploded in the angle of a walled enclosure at Nari Wela camp site, while the gunners were establishing a command post therein. The mine blew up as a man lifted up a boulder. One officer and three O.R.s were wounded. Sappers then searched the camp with a mine detector and two more mines were found. One was another Pacific ration tin filled with picric acid and the other was a buried 5·5 in. shell. Both were exploded at site.

(4) On Z + 9 a 4·5 in. shell, filled with lyddite, placed under the berm of the main road, about 3 ft. from the edge of the tarmac, at mile 25, exploded and killed a local Pathan who trod on it. The whole of Razcol was due to go down this same road on Z + 11, and the precaution was taken of sending Sherman tanks down both berms in front of the troops. They did not strike any mines.

(5) On Z + 11 Khassadars reported suspected mines on the main road east of Khajuri post, about mile 19, as Razcol M.T. was approaching. A ring of stones had been placed round some earth in the middle of the tarmac. Sappers with the advance guard investigated and absence of any mine was confirmed by mine detector. This may have been a hoax. It succeeded in holding up the whole of Razcol M.T. for fifteen minutes.

The whole military operation went according to plan, and there was very little opposition. This can be put down to two causes :—

(1) The great strengths of the withdrawing columns which were supported by all modern weapons, tanks and aircraft, as well as by the Tochi Scouts.

(2) The excellent work of the Political Agent, North Waziristan. He accompanied the column throughout, and, through his tribal maliks, was able to disperse many hostile gangs of whose presence information was received from time to time.

By 27th December (Z + 12) all troops were concentrated in Dreghundari camp outside tribal territory, and from there proceeded out of the area by rail or march route.

So ends the story of the evacuation, and the final chapter of the twenty-five years' military occupation of Waziristan.

Conclusion

A few figures may be of general interest.

(*a*) The capital value of buildings and fittings which were abandoned in Razmak and other camps and posts in North Waziristan was approximately one crore of rupees (£750,000).

(*b*) The value of furniture recovered from Razmak was 2·45 lakhs of rupees, consisting largely of the better types of furniture.

(*c*) The value of furniture abandoned in Razmak was approximately the same, nearly all charpoys, chairs, and other common articles.

(*d*) The book value of engineer plant and machinery recovered from North Waziristan was approximately 4 lakhs of rupees.

(*e*) The estimated annual value of the term contracts for buildings and roads in tribal territory which have been cancelled is Rs. 3,15,640.

The demise of Waziristan area need not necessarily have meant the demise of the M.E.S. in Waziristan. The M.E.S. have always been responsible for Works for the Civil Armed Forces in addition to Military and Air Force Works in Waziristan ; and the Civil Armed Forces, as explained before, are to remain. Many of the roads have also still to be maintained. However it has been decided in principle that all C.A.F. Works in Waziristan and other tribal areas are to be taken over by the Provincial P.W.D. Thus, although at the time of writing (January, 1948) the M.E.S. divisions at Wana, Miranshah (ex-Razmak) and Bannu are still functioning under the C.R.E. at D.I.K., the whole of the M.E.S. Waziristan is due to disappear, except for the G.E., Bannu, who is to be transferred to the C.R.E. Peshawar. So will end the glory, the labour, and the fun, of the M.E.S. in Waziristan.

In view of this it is of interest to record that as recently as 28th October, 1947, no less than ten R.E. officers found themselves one evening in the Bannu Club. This must constitute a record even for many years in the past. On this particular evening the G.E., Bannu, had brought to the Club a wooden shield painted with the R.E. Crest, in order that it might be hung in the Hall, where hang the crested shields of every regiment which has been stationed in Bannu in the past. Needless to say the shield was hung with toasts and acclamation. It thus remains a small memorial to the work of the Corps. The real memorial is, however, the network of roads with the bridges, posts, and piquets, which remain firmly imprinted on the hills and valleys of Waziristan.

THE RIGHT KIND OF R.E. OFFICER

By COLONEL D. PORTWAY, T.D., M.A., A.M.I.C.E.
MASTER OF ST. CATHARINE'S COLLEGE, CAMBRIDGE

"THAT ould Brigadier" in his intriguing article in the March *R.E. Journal* has adumbrated problems that are engaging the close attention of Engineers, both within and outside the Corps. He claims that the primary purpose of the article is to provoke others into committing their views to paper. In this he will probably be more than successful, as the subject is both important and enthralling and paper is, incidentally, scarce. The writer of these few lines is one who has never been a regular R.E. Officer, but he has been concerned with the training of the young Engineer throughout his working life and has, incidentally, belonged to the Corps in one way or another continuously ever since he was a Sapper in the old London Electrical Engineers, R.E. (Vols.), some forty-two years ago.

Before writing anything constructive, a few lines of criticism may be excused, and the first is that the title of the article—"The right *type* of R.E. Officer" puts the subject at once in the wrong perspective, for it can hardly be doubted that with the very varied duties required of the R.E. Officer, a *variety* of types is necessary. Indeed, one of the weaknesses of the R.E. Officer in general of the pre-1914 vintage was that, with trifling exceptions (the Kingston graduate, for example), they were all trained in the same mould, all being products of Woolwich, it being then impossible to get into the Corps through a University. Luckily in those days the Institution of Civil Engineers demanded a three years' course of practical training over and above an Engineering degree or its equivalent. They allowed one year's officer training in the Corps to qualify for this, and many Engineering graduates took Special Reserve Commissions under this scheme, and were available on mobilization in 1914 to complete the officer establishment of Sapper field units. It must be admitted that the Army gave no real encouragement to the project. Such pinpricks as a requirement of five years in the rank of second lieutenant put such officers many years junior to regular officers of similar age and status—but in those days there was a genuine degree of keenness for amateur soldiering and no discouragement effectively damped down enthusiasm. The tragedy was that when, after the 1914–18 war, the Army threw open commissions in the Corps to University candidates, applicants of the right type were pathetically few.

"That ould Brigader" makes a good deal of the difference between the Chief Engineer type and the C.R.E. type in the search for the right kind of officer. This is surely very academic, since it is impossible to predict the future qualities of the Sapper Officer recruit to this degree of refinement. If one thing is more unpredictable than another, it is the degree to which the young man of twenty years of age or thereabouts will develop in the next twenty years, and anyhow the Corps will require an adequate supply of both types, and, indeed, of many others.

But he is dead right in his appraisement of the value of a high ethical standard and a realization of the importance of morale and a high degree of integrity. Whether it refers to the "russet-coated captain" or to the man of the highest birth "men of conscience are wanted who know the cause for which they live and fight and love the thing they know." Unfortunately, modern selection technique is of little use in the appraisement of such qualities. The old method of testimonial and a delving into past performances still forms the best means of determining this.

Incidentally, it may not be generally known that during the war an inquiry was set up in one of the Sapper O.C.T.U.s to compare the comparative merits of the public schools with those of other types of schools in producing efficient R.E. officers. Figures were available giving O.C.T.U. passing-out ratings, and numbers were sufficient to allow of statistical significance. It was found that the average results were roughly the same for both categories, but the public schools produced in general the men at the top and the men at the bottom, the other schools providing the intermediate grades. It is therefore fervently to be hoped that the best products of the public school will continue to find their way into the Corps in considerable numbers. Most college tutors will agree that those men who have made the most of their education at a public school are those who have the best equipment in life for any profession.

"That ould Brigader" has indeed possibly not appreciated to the full the importance of heredity. He writes that "nearly every man has inherited the germ of these qualities (i.e., leadership) and if they have not emerged, the fault lies with his environment." Many of the complex requirements of leadership can be acquired by training, but others—notably intelligence—are matters of inheritance. Incidentally, scholarship seems to be inherited more strongly than most traits and such names as Darwin, Huxley and Butler speak for themselves. It is the degree of inheritance that counts and no more foolish statement was ever made than that every soldier carries the baton of a field-marshal in his knapsack. Nature is indeed in many ways more powerful than nurture, and every one of us has, very definitely, a certain ceiling. When promotion takes a man beyond that ceiling the trouble starts, and incidentally we also want to avoid the frustration caused by a man being unable to reach his ceiling.

Luckily or unluckily, inheritance, and particularly the inheritance of ability, is too complicated a matter to allow of its appraisement by a selection board, but such boards have methods (the intelligence tests, for example) whereby a crude indication of a man's ceiling can be determined. It is no doubt due to the fact that both physical and mental characteristics are inherited on Mendelian lines that leadership based on social prestige, which was in vogue in England for many centuries, has on the whole not worked too badly.

But all this is rather theoretical, except that the Corps can ill afford to lose the type with a considerable Service and traditional background. It is the training to think for himself that is so important in the young R.E. officer. Education in the best sense is what remains behind when everything that was taught at school and college has been forgotten. The mere acquisition of knowledge—technical or otherwise—is far less important, and it seems likely that the Universities, with their long tradition of culture and learning, will prove more powerful instruments in this respect than the Military College of Science, even though the latter will no doubt produce not markedly inferior technical qualifications, and, no doubt, at a cheaper rate. For the budding Engineer, it is mind training on technical lines that is most wanted, and it is almost as important that he should have a cultural background that is comparable with that of the more literary professions. It is these qualities that promote imagination and the power of looking ahead—both so essential in the well-trained R.E. Officer.

Since its institution about five years ago, the Selection Board technique has fully justified itself and has developed into a practical and sensible system with some scientific background, and in any case, is far better than the old "hit and miss" interview. Personality is so complex an entity that mistakes will never be altogether avoided, but, given the right material to work on, the boards can be counted on to select the right potential leaders. The main source of regular officers for the Corps must always be the Royal Military Academy graduate, and it is of the utmost importance that such propaganda influences as the great prestige of the Corps should be used to the full to secure that the pick of the passing-out Sandhurst men should enter the Corps in the future as in the past, even though the financial inducements are now almost negligible. The best recruiting agency for this is the general body of R.E. officers past and present—and it is open to some doubt whether the Corps as a whole is aware of the great importance of this matter. Given the best of the Sandhurst entry, with subsequent training at the Military College of Science and in some cases at a University, this entry of the Corps should then provide men of adequate quality for normal Corps duties, and some will be men of outstanding intellectual qualities suited for specialist and other high grade purposes.

But more than this is required if men are to be found to complete the role of a Scientific Corps in a scientific age. It is surely desirable for an alternative entry system to be started at an early date. The Royal Air Force has been given a flying start over the Army in this respect, since their scheme of University entrants—over and above the Cranwell graduate—is already in full swing, whereas an alternative scheme of University entry for the Army is merely under consideration. When it comes about, it must give enough inducement to get the better type of Honours graduate into the Army in general, and the Corps of Royal Engineers in particular. This was definitely not the case before the war. At the present time and thanks to the further education and training scheme, the Universities are quite definitely picking the very cream of the nation. Refusals at the writer's own College for 1947 ran into thousands, but at the present no attempt is being made to secure the young graduate for the Army, and very soon the tradition of Army entry from the Universities will be lost.

Much water has flowed under the Thames bridges since 1939, and the warfare of the future is likely to involve nuclear and rocket technique, and the Corps will have its part to play in this. Although the majority of its officers must obviously be trained as Engineers, a proportion will be wanted with whom a training in such subjects as nuclear physics, geology, and chemical engineering will be more suitable. In Cambridge, for example, a School of Chemical Engineering is being started which involves a high grade two years' course in chemical engineering for men who have already qualified with high honours in the first part of the natural science or engineering course. Men of this training would make admirable R.E. officers for certain specialist duties, but they are not likely to offer themselves to the Corps unless full account is taken of the four years that they have already spent in such academic training. The Corps will never carry out its multiplex duties under modern conditions with only one source of entry for its regular officers, and it is high time that the alternative was instituted so as to provide that degree of versatility that will be wanted more than ever in the future.

"That ould Brigader" made no reference to the non-regular officer, but this is likely to become a more important consideration in the future than in the past. With conscription in full force the matter deserves more attention than it has so far received. The time has surely passed when consideration of the future of the officering of the Corps can be regarded almost entirely in terms of the regular officer only. In the next war it is highly unlikely that the Army will have nine months of "phoney warfare" during which the Territorial Army can be properly trained. Here again the Universities can provide a great deal of help and so can the great Engineering Institutions if boards can be counted on to select the right potential leaders. The main source of regular officers for the Corps must always be the Royal Military Academy graduate, and it is of the utmost importance that such propaganda influences as the great prestige of the Corps should be used to the full to secure that the pick of the passing-out Sandhurst men should enter the Corps in the future as in the past, even though the financial inducements are now almost negligible. The best recruiting agency for this is the general body of R.E. officers past and present—and it is open to some doubt whether the Corps as a whole is aware of the great importance of this matter. Given the best of the Sandhurst entry, with subsequent training at the Military College of Science and in some cases at a University, this entry of the Corps should then provide men of adequate quality for normal Corps duties, and some will be men of outstanding intellectual qualities suited for specialist and other high grade purposes.

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THE RIGHT TYPE OF R.E. OFFICER

By CAPTAIN T. G. LAYTON (LATE R.E.)

AS an ex-officer, who has seen Sapper Service in the ranks, as an instructor to Y.O. classes, as a serving Engineer Officer, and finally as an observant civilian, I can truly say that I have been privileged to know, think about, and build up my own particular ideal of the right type of R.E. officer.

To my mind, the right type of R.E. officer must first and foremost " love " his job, his men, and be able to live up to the tradition of being able to go anywhere and do anything.

He must be able to work with, and inspire, those under his charge, to work as a team—this last is all-important.

I use the word " love " in its finest sense—to be completely absorbed in—and be a partaker of every facet of both his job and the men, who with him create the finished service, no matter what that service may be.

His character and make up, must include that which will enable him to appreciate and use the latent possibilities of the most lowly of his " team," and to direct and control the conscious effort of every member of the same, to the one end, i.e., in getting the task completed.

All this, you will say, must necessarily mean, that your " Right Type " must be a man of wide experience, both in the practical and psychological sense. This must be agreed, and so leads on to the necessity for the " Right Type " to have lived, for some time at least, in the same social sphere, as his lowliest " team mate." To lead men, he must be of men, be respected by them, and be accepted by them as a person of wide vision, trustworthy decision and as being one of them—always in the team.

Like so many E.C. officers, I have had the privilege, and I will say honour, to have served with many Corps officers of the very finest type, and on all occasions I can say that the one trait which picked out each and every one of these Corps officers, was being *human*—the type of chap in which one could sense the humanity, who could instantly put one at ease in a case of personal difficulty, and just as easily " shoot one down in flames", should there be the slightest inkling of insincerity.

So much for character and leadership—now for his overall outlook. What has your " Right Type " to meet ? Firstly, his job may call for such widely spaced activities as building a small machine-gun post, and the design and provision of a complete scheme of water provision and reticulation—life is far too short for one man to have had experience of all the types of work which he will in all probability be called upon to carry out. Experience proved beyond all doubt during the 1939-45 war that the R.E. officer was indeed expected to be able to cope with anything thrown at him and it is to his credit that he did, in fact, cope to a very high degree. So it follows that your " Right Type " cannot be a specialist. What he must have is the catholic type of mind, which is interested in, and is capable of grasping the essentials of the elements required for, and the " know how," of getting the job done. He must think in terms of things finished and yet meet departmental frustration with the knowledge that such things are but made to be overcome.

He must have a good working knowledge of that unwritten, unprinted "book"—"THE REGULATIONS and how to CIRCUMSPECTLY CIRCUMVENT THEM."

In other words, he must use tact and cheerfulness, in dealing with smaller, but possibly senior ranking, minds.

Secondly, he must be ever ready to help out another, less well endowed than himself, with ideas—ideas that work. He must "see" the end of his schemes at the time they are conceived, and once so conceived, get going on them and complete them.

Now where are we to find this paragon? Is he the product of the University, or the barrack room? I submit that he is of neither. He can be found from both sources equally. We have the case of one useful W.O.1 C.Wks. who became, due to war emergency, a very capable D.D.W.(S), of a G.H.Q.

Many ex-W.O.s, sergeants, and even corporals, given the chance created by war emergency, gave, and still give, excellent services as D.C.s R.E., C.s R.E., C.E.s, and in a host of Civil Affairs Appointments.

If, therefore, there is a dearth of the "Right Type" of R.E. officer, then I submit that the fields for finding them have never yet been explored, since from the very great number of E.C. officers, there remains a nucleus of experienced regular ex-W.O.s who professionally, socially, and from an integrity point of view are of that class from which your "Right Type," from Sapper to E.-in-C., could undoubtedly be found.

The character, background, and interest is there, ready for use, and among the best can be found those who could be given the higher education, fitting them for the highest and most honoured appointments.

The Corps, and Britain, has I am afraid lost many a son, whose heart was right for just this kind of service and all for the want of a tiny particle of encouragement to aspire to these very heights, to which your "Right Type of R.E. Officer" has the right to desire and expect.

Perhaps it will not be too late to give due consideration to this contention, and with this my "arrow" I shoot a "possible" at the target, so bravely held up for just that purpose by "That Ould Brigader."

I find myself in agreement with much he puts forward, and while I agree with his contention that the "Right Type" will say "That is what I am going to be," I just as sincerely suggest that the "Right Type" be given the right to make his "Sapper" life—his "love"—once he has decided to embark upon it.

Department of Scientific and Industrial Research

An interesting paper has just been issued by H.M. Stationery Office, price 6d.

It is entitled Road Research Technical Paper No. 10—A Review of Available Information on the Significance of Roadstone Tests.

Much remains to be done in assessing the qualities of various types of Roadstone, but the available information is, however, considered to be sufficient to justify the adoption of approximate lower limits of crushing strength, etc., as a general guide in the selection for waterbound, concrete and bituminous roads.

SOME FIELD SQUADRON PROBLEMS

By LIEUTENANT-COLONEL M. C. A. HENNIKER, D.S.O., O.B.E., M.C., R.E.

CERTAIN administrative problems have a habit of recurring for field squadron commanders to solve. They come round like circus horses in a ring. The trainer cracks his whip or gives sugar to a horse as it comes before him ; then it canters out of sight. A second, a third, and a fourth horse, each comes in turn for correction or encouragement. Each then disappears after the first. But they all come back again : some needing the whip and some deserving sugar. The trainer always has one of these horses in his eye. The O.C. always has one of these problems before him.

I saw the process before the war. I grappled with it as a squadron* commander in the war and I watched a succession of squadron commanders tackle it ; first in an airborne division, then in an infantry division, then as army troops R.E., and, finally, with Indian soldiers in an Indian airborne division.

Each time the ring was totally different. Each time the horses were the same. Each time they responded to the same treatment. From this I make bold to say that the problems I refer to are endemic ; born with the dawn, ever present and eternal. They are therefore worthy of discussion. The views I give are not only the result of my own observation. They are the results of discussions with many squadron commanders and with many C.s R.E.

Let us consider them in turn.

EMPLOYMENT OF OFFICERS

When the unit has the proper number of other ranks and the full number of officers there is no particular difficulty. Each officer fills a space on the War Establishment. The squadron commander has some latitude and he can usually make adjustments to avoid a clash of personalities.

The difficulties begin when the O.C. runs short of officers while still up to strength in O.R.s. He is torn between a desire to keep the administration going, to keep his works or training going, and to keep the human touch upon his soldiers.

The first economy to make is to dispense with the H.Q. subaltern. His permanent duties—M.T., signals or what have you—must be loaded on to the second-in-command. His reconnaissance duties must be farmed out in rotation to troop officers or N.C.O.s. The troop officers must be left undisturbed as far as possible.

The next stage in retrenchment is to do without troop officers. The latest W.E. allows two officers in each troop, which gives a certain amount of scope ; but a time comes when, besides the O.C. and the second-in-command, there are only two officers for three troops. In theory, an attractive proposition is to divide the squadron into H.Q., a right half and left half-squadron. The second-in-command looks after H.Q., and one officer attends to each half-squadron. In practice this does not work. The troop stores do you down. Either you divide them, or you put one troop's stores in grease. If you divide them the accounting gets out of hand : if you put one troop's in grease, you go short of stores.

* It was actually a field company. For convenience I use the new name throughout.

The only practical answer is to have "Squadron Officers" as opposed to "Troop Commanders." Then you have O.C., second-in-command and one, or two, "Squadron Officers." The work of the "Squadron Officers" is apportioned on a geographical basis. That is to say, one supervises the soldiers at Dan; the other at Beershebah; one is chasing stores; the other is using them. The O.C. allots troops to each; and the second-in-command is glued to his books in the office. (It is wrong to give the S.S.M. a troop. He is more likely to sink to troop sergeant than rise to troop officer; and that is bad for morale. It is not his fault, it is because he lives in the Sergeants' Mess.)

The next stage is when there are only two officers all told. The principle then should be for the junior to run the office work while the O.C. runs the works or training.

Finally you get the O.C. all alone. If he has not already done so, he must summon his office staff and give them two orders.

(*a*) No letter is to be put on the table without an answer that merely requires signature. He will be surprised to find how many are correctly done.

(*b*) The accounts clerk must keep a duplicate copy of the account books. He must be present whenever the O.C. opens the safe and he must make an entry in his book similar to the one in the O.C.'s book. In this way the accounts clerk is soon doing all the tedious work (adding, balancing, etc.) without handling the money. Vast savings in time follow.

I have known an O.C. take his squadron single-handed on a four-day exercise and send half of them on leave at the end of it. From the C.R.E.'s point of view, the squadron was about 80 per cent efficient. The O.C. told me he was astonished at the competence of his N.C.O.s. Of course, if the officer strength remains low for long, efficiency will vanish. But for short periods, shortage of officers need cause no dismay.

In conclusion, three pieces of advice :--

(*a*) However short of officers a unit is, the soldiers must always receive their pay from an officer. It is the only occasion when everyone is "smoked out of his hiding place." It is the last, though slender, human link between officer and soldier.

(*b*) It is more difficult to organize the supply of stores than to supervise their use in works. If there is only one officer for both jobs, let him get the stores and let N.C.O.s supervise the work. The exception is, when the work is dangerous: then the officer has to be at the point of danger.

(*c*) Do not hesitate to send N.C.O.s to battalions to give engineer advice when short of officers. They are often more practical than officers as they do not think on such ambitious lines. It is as well, though, to warn the battalion first, and to brief the N.C.O. on the resources he may offer.

Shortage of Other Ranks

However many O.R.s you have, there are never enough. So in a way there is always a shortage. There are certain expedients which minimize its effect.

The first is to go through the "squadron employed" with a tooth comb, picking out all the non-essential men. This puts everyone up in arms against you—the second-in-command, who likes his fatigue men keeping everything spotlessly clean for you: the S.S.M. who likes double sentries to do you honour: the S.Q.M.S. who likes his many storemen handy in case you need them. Everyone, with the best possible intentions, conspires to make the business of cutting down overheads difficult.

The facts appear to be as follows: In the best circumstances (squadron messing, one vehicle park, adjacent barrack blocks, etc.) the "squadron employed" can be cut down to twenty-two men for periods up to a week. If you stick to this for longer periods everything begins to get dirty. At the other end of the scale you cannot have more than seventy men on "squadron employ" daily without being wasteful.

The next step is to have sick parade in the afternoon. The doctor seldom likes it; but the alternative is to have it early in the morning, which he likes less. Every day there are men who report sick, either for bureaucratic purposes —to get their documents right—or because there is no other way of getting minor injuries attended. Something can be done by having a "First Aid Centre" open after tea, so that men can get iodine, laxatives, or bandages. Soldiers returning from sick parade (if numerous) must be got out to the work. If only a few men are concerned they should be employed on S.S.M.'s fatigues after reporting sick. This frees fit men for works.

Thirdly, guard mounting should be done in the evening. If it is in the morning two guards miss a morning's work. If it is in the evening they miss an afternoon's work which is often less important. This is an undesirable expedient. Guard mounting in the morning is better for discipline. It is, however, sometimes unavoidable to have it in the evening.

The value of centralization of "services" (cooking, etc.) has been indicated. The soldiers usually prefer "troop messing": they get more personal attention. It is not so economical in manpower (or food) as central messing.

There is often a waste of men in the officers' mess and quarters. This I touch on next.

Running the Officers' Mess

There are five batmen and four batmen-drivers in a field squadron. There is also an A.C.C. cook for the officers. For nine officers this is an ample staff—too many in fact. The problem is to reconcile this large number of mouths to feed, with the officers' natural wish to have their batmen handy.

The best plan is for the five batmen and the A.C.C. cook to run the mess. Between them they call the officers, cook and serve the meals, keep the building clean and manage the drinks. For this, one of them must be made a lance-corporal or corporal. The four batmen-drivers merely clean the boots and equipment and manage the laundry of their own particular officers. In this way only six soldiers feed in the mess. (In a static rôle this may be reduced to three). The batmen-drivers' time is then properly divided between "batting" and driving.

Employment of Transport N.C.O.s

The problem is: How is the O.C. to pass orders regarding transport? He can pass them to troop commanders to pass on to their own drivers through their M.T. corporals. If he does this the Transport N.C.O. at Sqn. H.Q. may feel neglected. If, on the other hand, he passes them to the Transport N.C.O. to pass to the drivers, the troop officers may feel their authority is undermined.

The solution depends on personalities. I have known squadron commanders succeed with both methods—also I have known them fail with both methods. The best general rule is to pass the order through the officer channel ; but occasionally to give orders for all drivers and M.T. " to be at the disposal of the Transport N.C.O." In this way the Transport N.C.O. gets a run for his money and it enables the squadron commander to impose his will upon the drivers for special occasions.

Centralized squadron transport does not seem to work in practice, though the theory is attractive.

Three Final Points

Squadron H.Q. Workshop.—It is a help for the squadron commander to institute a squadron H.Q. workshop. The size depends on the employment of the unit. In barracks it need only be two or three men to repair windows, repaint noticeboards, etc. For a construction job the workshop may be considerable.

Normally this workshop should be under the squadron second-in-command. It should be near the H.Q. It gives the second-in-command a breath of fresh air from his office.

Squadron " O " Group.—The Officers' Mess N.C.O. and the A.C.C. corporal in the soldiers' mess should usually be included in an " O " group. They have to begin packing or cooking at once and it is good to give them fair warning. (The full detail of an " O " group is well known and I shall not give space to it here.)

Addressing the Squadron.—Napoleon, in his maxims, says :—

> " It is not set speeches at the moment of battle that render soldiers brave. The veteran scarcely listens to them, and the recruit forgets them at the first discharge. If discourses and harangues are useful, it is during the campaign ; to do away with unfavourable impressions, to correct false reports, to keep alive a proper spirit in the camp, and to furnish materials and amusement for the bivouac."

This applies to British majors as well as to the French generals, about whom it was written. There is, be it noted, a caution against oratory to promote valour, and a positive injunction to speak to the soldiers on certain subjects. Occasionally one of these subjects " crops up " suddenly. Uneasiness is caused throughout the unit : it may be the misrepresentation, in orders or the Press, of some fact that vitally affects the soldiery : an order may have been published about pay, whose implications the soldiers cannot understand ; a rumour may have been started about a move. These, and the like, are what Napoleon refers to as " unfavourable impressions " and " false reports " that must be corrected. When an occasion such as this arises the O.C. must immediately assemble his unit—every man, cooks and all—and explain in the simplest English what the facts really are. He must, of course, first verify his facts. He will find the fruits of his efforts ripen quickly.

Again, there are some subjects not of themselves worthy of a special harangue but collectively important. The best plan is to make a note of each as it occurs, and when a sufficient number has been accumulated to speak to the soldiers. Such subjects are : the standard of saluting, the state of the billets or a compliment from the general. These are not usually so urgent as to demand immediate action. They are the things Napoleon calls " keeping alive the spirit of the camp." Experience suggests that there is material for an address about once every three weeks.

Whatever the reason for an address, the O.C. must take care not to cover too much ground, or the soldiers get confused. All kinds of rumours are started as to what he actually said. He must also speak simply, so that the less educated men can follow. He must stage-manage the business so that everyone can hear. And, unless he has a gift for it, he must avoid oratory. Only the very great can by oratory inspire the people " to fight on the beaches."

Conclusion

These are some of the horses in the ring. Perhaps other writers will suggest other horses. Perhaps they will not agree with the treatment I offer. The *R.E. Journal* seems a good show-ring to collect them all, to put them through their paces, and to select the best. Their breeding and performance can then be put on record for present and future generations.

If this paper produces that result, it will not have been written in vain.

AN ALL-WEATHER TENNIS COURT FOR A DRY CLIMATE

An account of some experiments carried out in Jerusalem

By Brigadier H. A. Baker, M.C.

1. The tennis courts in Jerusalem Sports Club are surfaced with a special clay obtained from the Jericho road. This makes an excellent surface in dry weather but the courts are always out of action from December to April during the rainy season. This is a pity because some of the best weather for tennis occurs in January to April when it is not too hot and not so windy as in the summer.

This led me to consider whether a satisfactory all-weather court could be made. There are, of course, concrete and tarmac courts in Palestine but, as is well known, they are not nice to play on. The former crazes and cracks especially in cotton soil districts and is very hot under foot in summer ; the latter tends to make the balls black and is rather slow. It is liable to become slightly " tacky " in the hot summer sun. *En tout cas*, was not practicable since it requires water to bind it, and this was not available all the year round. The chance arose to build two courts and it was decided to experiment during the summer on a small scale with various types of surface and then apply the best to the two new courts which were to be ready for the " winter " season. The results of the experiments are set out below with a full description of the type adopted and its playing qualities.

2. The Specification for the surface.

(*a*) Must be truly all-weather and be fit for play half an hour or so after heavy rain. Must not be affected adversely by continuous rain.

(*b*) Must not require watering or rolling.

(*c*) Must not colour the tennis balls.

(*d*) Must be a good playing surface.

(*e*) Must not be adversely affected by hot sun.

3. The first idea was an *en tout cas* court but this composition is a patent proprietory brand and there was no local representative of the firm in the country. We, therefore, had to consider whether we could devise anything on somewhat similar lines using any local materials which were available. *En tout cas* appears to be crushed stone of some sort carefully graded and bound together with water. Hence frequent watering and rolling are necessary. Since water was not available in Jerusalem for this purpose, we tried various methods of binding, such as clay in very small quantities, cement, lime and bitumen. The *en tout cas* material was made from crushed, hollow, red building tiles of the type so much used in France. These are extremely hard, of excellent colour, and do not degenerate into mud as does crushed brick. They also dry very quickly. However, we found that with these binding materials it was cheaper to use crushed limestone chips and only use the crushed tiles for the colouring of the surface. Limestone is not the most suitable form of aggregate as it is so dusty and basalt would have been better but was ruled out on account of expense.

Another line pursued was the type of bituminous macadam which gives an open textured, very porous surface. There are two such courts at Chatham U.S. Club, and we made an attempt to copy these, using a dusting of crushed tile chips to give colouring and counteract tackiness and discoloration of the balls. We could not get coloured bitumen or suitable paint for colouring. Other pigments were tried but were fantastically expensive. This was quite good but expensive, and we evolved the idea of using cement instead of bitumen, thus doing away with the disadvantages of bitumen and considerably cheapening the cost. One might call this "cement-mac." Crushed tiles were used to colour the surface. No sand was used, thus maintaining an open texture.

Other experiments were tried but failed for various reasons.

In all cases the subgrade was drained carefully, and a base course of broken stone, 4 in. thick, was laid on this and well tamped. The finished surface can be level as it is entirely porous.

The following experiments were actually carried out :—

Experiment	Results and Comments
(*a*) ½ in. to ¼ in. limestone chips in equal proportions, thoroughly premixed with S125 bitumen laid 2 in. thick. Bitumen at rate of 75 kg. per m³.	Rather soft and tacky surface ; water lies about in puddles. Too small chips and too much bitumen. This was the mix recommended by a local oil company. Colour bad. Various attempts to colour this were not successful or fantastically expensive. No coloured bitumen was available.
(*b*) ¾ in. to 1 in. limestone premixed bitumac carefully spread, lightly rolled to 2 in. thickness and dusted with crushed red tiles when still tacky. Bitumen (S125) 60 kg. per m².	This was excellent in every way provided it was not over-rolled. It was, however, expensive. It was so good that it gave us the idea of doing the same thing with cement instead of bitumen, thus saving expense and avoiding all possibility of a softening or dirty surface.

(*c*) A "cement-mac" or no fines concrete composed of $\frac{1}{2}$ in. chips, 3 parts; $\frac{3}{8}$ in. chips, 2 parts, intermixed and washed free from dust before mixing; 1 part cement, mixed by machine with the absolute minimum of water. The mix to be just workable, but so dry as not to produce latence on tamping. Laid 2 in. thick and tamped with wooden rammers. The surface blinded with crushed red tiles $\frac{1}{16}$ in. to $\frac{1}{8}$ in. gauge, free from dust and this lightly tamped into surface of concrete *immediately* it is laid. This gives a permanent red colour.

$\frac{1}{16}$ in. to dust crushed tiles are brushed over the court after setting to fill interstices on surface and improve colour, but it is not desirable to leave a loose surface as it is too slippery.

The "lines" were made of wood fillets. This was not successful as they cause bad bounds whenever a ball hits them. It is suggested the court be painted with white road-paint or white chips substituted for red in the coloured coat.

Lead strip lines are rather out of the question now.

This was the specification finally adopted. It has proved most successful in play with certain reservations—see below. It dries immediately and is perfect in this respect.

It is most important, in fact vital, to success, to get the texture right. It must be open and even—no latence must appear. Great care must be taken in laying the surface. It is most desirable to lay the whole playing part in one day or, at the most, two days with a construction joint along the net line. If screeds are used to divide up the playing surface elsewhere unevenness and difference in texture will almost certainly result. Level pegs are quite sufficient. It is more important to have the court smooth than absolutely dead correct for level. It is so porous that puddles cannot form.

The court is rather hard on shoes and balls.

There were no signs of cracking or crazing after four months use and very heavy rains.

(*d*) Sawdust, 8 parts by volume; $\frac{1}{8}$ in. limestone chips, 4 parts; lime, 2 parts.

Initially a good surface but, on drying out, becomes loose. Not suitable as requires water.

(*e*) Sawdust, 6 parts by volume; sea sand, 2 parts by volume; cement, 1 part by volume.

As above. Crazes on drying out.

(*f*) Sawdust, 8 parts by volume; $\frac{1}{8}$ in. limestone chips, 2 parts by volume; cement, 1 part by volume.

Very good surface but requires watering to keep it together. The cement does not really bind the sawdust.

(*g*) Wood shavings, 6 parts by volume; crushed building tiles, 3 parts by volume; cement, $1\frac{1}{2}$ parts by volume.

A good surface. The crushed tiles give red colouring; fairly absorbent but not a good wearing surface.

4. In conclusion, I should like to thank Major Monroe, R.E. and the staff of 283 R.E. Works Section who spent much time and ingenuity on the experiments and on the full-sized courts, which gave so much pleasure during the winter.

Anyone faced with a similar problem may find these notes useful and will perhaps be able to make improvements.

IMPROVISATION IN NORTH BURMA

By LIEUTENANT-COLONEL P. A. EASTON, O.B.E., R.E.

THERE are many officers of today, who, having fought in European Theatres, have come to believe that warfare in modern times will always be fought with modern equipment. Unfortunately this is not always the case and operations take place in undeveloped countries, where for various reasons, modern equipment is very limited or completely unavailable.

Such a country was North Burma in 1944. It was developed to the extent that there was a railway and a certain amount of damaged rolling stock. The Japanese occupied most of Burma south of Myitkyina. The road from India had not been completed and communications other than by air did not exist.

This account is of the work carried out by the engineers, British and Indian, of 36 Div. from the time of its arrival by air in Myitkyina in July, 1944, until its arrival in Maymyo in April, 1945, during the whole of which time it was under the command of the American formation, first known as "Chinese Armies in India" and later as "Northern Combat Area Command."

A few factors to be considered before the "fly-in" may be of interest. Owing to the fact that the Ledo Road was not ready, transport was restricted to jeeps with trailers and the total allowed for the division was sixty. The artillery problem was solved by the loan of three Chinese batteries already at Myitkyina. This scale of transport allowed one jeep and one trailer for a field company. Scales of equipment had to be reduced on account of limited plane space, with the result that a field company was allowed approximately one-third of its equipment and the equipment for the field park company was on extremely limited scales. The nearest engineer dump was at Moran, in Assam, 190 miles away. Personal equipment consisted of what could be carried on the man.

These factors gave a good deal of food for thought. Improvisation was going to be the order of the day and "all those little things that the C.Q.M.S. thinks might come in useful" had to be very firmly left behind. Nevertheless, despite these preliminary "shocks" and their consequent worrying moments, units could move, stores were available when wanted and work was carried out.

Not even the sincerest admirer of Burma would select Myitkyina as a place for "camping out" during the monsoon, the season in which the division was flown in. Apart from the effect of monsoon conditions on health, there was the result of these conditions on the engineer aspect of an operation. Roads, a euphemism, for many miles had become marshes or drains for the surrounding country: chaungs were several feet deep with fast flowing water: paddy land had turned into a series of lakes and tanks, and the jungle, as well as forming little cover from the rain, stank of rotting vegetation. These were the rather cheerless conditions at the time of the concentration of the division near Mogaung, and which persisted until the end of August, slowly clearing until the end of December and finishing with three weeks of good winter rain at the beginning of January, 1945, when really good weather began.

Owing to the fact that there would be no Corps or Army Troops in rear of the division, an engineer battalion I.E. was placed under command. The engineer order of battle in the division then became :—

236 Fd. Coy. R.E.
30 (R.B.) Fd. Coy. I.E.
324 (R.B.) Fd. Pk. Coy. I.E.
15 Engineer Bn. I.E.

With the arrival of a third brigade group at the end of the year, 58 (Madras) Fd. Coy. I.E. made a welcome addition to the strength of divisional engineers.

Engineer Tasks

The following comprised the main engineer tasks of the division :—

Communications : roads, tracks and railway.

Bridging : chiefly timber trestles for road and railway.

River Crossings.

Fair-weather air-strips for Dakota and light aircraft.

Track cutting, dropping zones.

It is not proposed to enter into details, but to give examples of major tasks that called for a sense of improvisation on the part of all concerned.

Roads and Tracks

Until the division arrived on the Burma Road, east of Maymo, no road worthy of the name was encountered. Except for a hill road in the Northern Shan States, the "road" along which the division passed consisted of an earthen cart track, which, owing to lack of maintenance during the three monsoons of Jap occupation, had either fallen into complete disrepair or had become a main drain for the surrounding country. Depressions had become quagmires and drains had practically ceased to exist. The wisdom of restricted transport could be appreciated by the sapper, unpleasant as it was for his own administrative comfort.

Despite demolitions it was possible to use the railway from Myitkyina to Katha as the main L. of C. ; using the road as a secondary and as a feeder to units not actually in touch with the railway. Road construction consisted in getting divisional transport and attached artillery through in the first instance and in keeping the road open for limited transport for supplies. Supply being by air-drop, no long length of road had to be kept in a passable state for any great length of time.

Engineer resources being very limited, the only method of road repair was by the rapid construction of rough corduroy. Seldom was there any lack of timber and considerations of time and labour did not permit the construction of diversions. The track from the airfield at Myitkyina served as a good warning as to "things to come." This track lay through low-lying ground with no possibility of drainage and covered with secondary jungle and vegetation. Jeeps, in low gear and with luck, could cover the distance of two miles in forty-five minutes. Work consisted of laying light corduroy and brushwood, relaying and then laying again. On first sight this does not appear to be a very skilled operation, but it is interesting to note how few sapper officers and men really understand how to lay brushwood.

These conditions, although not universal, persisted over a very great proportion of the 150 miles to the Irrawaddy at Katha. On occasions low level bridges, framed trestles or timber cribs, were used over more swampy portions of the "road." Later, for a chaung crossing, a prefabricated sleeper causeway in sections was used with success.

Railways

From Myitkyina to Katha the railway formed the main axis of supply. The Burma railways are of metre gauge track, and a single way ran from Myitkyina to Nabha Junction, a distance of 140 miles, where a branch ran east to the Irrawaddy at Katha, the main line continuing south through Indaw. East from Nabha, due to air bombing, sabotage, operations of the Chindits and demolitions by the retiring Jap forces, this line had suffered considerable damage and a very high proportion of the rolling stock had become "base workshop cases." However, with repair, the line was operable and, being metre gauge, was of the correct gauge for jeeps. Rail wheels were constructed in Calcutta and a certain amount of rolling stock was put into fair running order. Twelve jeeps were allotted as "locomotives" and reliable B.O.R. drivers were selected from other arms. To the sappers fell the lot of repairing line, constructing bridges and operating the railway. A description of this line was published in the December, 1946, *R. E. Journal.*

Much time could be spent in dilating on the worries incurred in running a single-line railway with rolling stock of doubtful reliability on lines, which, although parallel, hardly followed the rules regarding curves, packing and securing. The faces of two senior sapper officers should have been seen when news came through that a specially chartered rail-jeep, laden with four senior Chinese officers, was speeding north and the evening train with bread and mail had set out south. The loss of "face" should a collision occur was too horrible to contemplate. Luckily a quick-witted subaltern spotted the danger and all was well. Responsibility again sat heavily on sapper shoulders when the month's ration of beer for the division was loaded on to two very special trains.

Lengths of track, over which the railway was operated, seldom exceeded forty miles. In the area occupied by the forward brigade, operation of the railway had to conform with any operation that might be in progress. Accordingly a small allotment of trains and drivers was made to the forward brigade who operated its portion of the railway according to the tactical situation. Operation of the railway under divisional control extended from the rear station of the forward brigade, frequently an improvised station, through three or four intermediate stations to a terminal at the most rear extant divisional dropping zone or air-strip. Here the United States engineers "took over" and drove "through-trains" at breakneck speed to Myitkyina.

Both rail-jeeps and serviceable rolling stock were limited in numbers. Accordingly the utmost care in maintenance and operation was essential. The normal jeep train consisted of a rail-jeep and two ten-ton four-wheel trucks, loaded to half capacity. This, as a rule, ensured that not more than seven tons were carried in each truck, although there were some monstrous exceptions. Later I.E.M.E. contrived two excellent locomotives by gearing tractor engines to two box-cars, so providing locomotives capable of drawing trains of six or seven fully laden trucks.

Rail repair, consisted of replacing damaged lines, straightening bent lines and improvising points and switches from the mangled remains of several damaged switches found on the site. Owing to their weight, the flying-in of spares was out of the question and successful repairs depended entirely on what could be found and extemporized on the spot. It was not at all abnormal for even the divisional commander himself to give the location of where he had luckily tripped over some lengths of rail or piles of fishplates in the jungle. An item of construction, in which divisional sappers were particularly proud, was the divisional type of portable turntable. This consisted of a light timber frame, equal in length to one and a half times the wheel-base of a jeep and of the same width as the distance between the rails. Ends of the two longitudinal members were chamfered. This frame was placed on to the lines, the centre distance piece being bored through at its centre. A block of timber with a counter-sunk hole was placed below the centre distance piece and a peg was passed through the centre distance piece into the block. A jeep was run up on to the frame and could be turned round with the aid of its driver and one man. Metal frames were tried out, but were not sufficiently light to be operated by a couple of men. "Well," as an officer, late of the Burma railways, remarked, "the railway works." An officer of the divisional staff was not so kind. He called it "old-fashioned."

BRIDGING

Consideration of weight prevented the flying-in of Bailey Bridge or any heavy bridging components. However, teak trees and a first cousin of teak abounded, which, although green, provided the material for bridges. Frequently logs were found, that had been felled before the Jap occupation and which had been floated down chaungs and left. A sugar factory at Sahmaw, that had suffered damage from air action, proved a valuable dump of R.S.Js. This wealth of equipment was not appreciated by some on first arrival in the area. A young officer, fresh from England, where he had been engaged in much bridging, declared that he was absolutely "*au fait*" with bridging, but remarked that he had not seen a dump of bridging stores. This was too much for the adjutant, who pointed to a very excellent teak forest, in which divisional headquarters was situated. This was too much for the new boy, who turned a delicate shade of green and apologetically remarked that he did not mean "this type."

Single bent framed trestles formed the normal type of pier. The careful levelling of double bent trestles for the railway took too much time. Where depths were too great for single bents, a crib base was constructed and filled with boulders and a single bent was placed on this base. Being of a very temporary nature, there was no objection to the obstruction of waterways ; speed in construction being the predominant factor.

Piles were tried without success. Not only was the ground too soft, one test pile was still moving well at 22 ft., but the time taken in selecting a tree, felling, lopping branches, hauling to site and driving took far too long, although this method was employed on a few occasions when short and light piles were used. Field pile drivers were then improvised.

Over 6,000 ft. of timber bridges were constructed, neglecting all bridges of spans less than 20 ft. The longest bridge, constructed by the division, was built by 15 Engineer Bn. across the Shweli River and was 752 ft. in length, in two sections, as an island intervened. This bridge was constructed in seven days by the battalion less one company, totalling approximately 600 men in all. The average depth of water was 7 ft. with a current of two to three knots. Quicksands, which shifted during the building of the bridge, caused some trying moments. The construction was of framed trestles at 14 ft. centres. Every timber including decking was felled and cut to shape during these seven days. Other than this, bridges averaged 120 ft. with a normal maximum of 200 ft.

To give reasonably accurate estimates of the time required to construct bridges, was often a tricky matter under these conditions. Most officers had their own methods of calculation. One method, which worked with tolerable accuracy, was to divide the length of span in feet by twenty, thirty or forty according to the depth ; the quotient giving the answer in company-days. This time included time to collect and cut materials and also the construction of spikes and dogs.

... caused a certain amount of consternation to some American engineers, who " just don't figure how the doggone thing works." This expression possibly was correct in the case of a flying ferry at Mogaung, which was constructed from derelict petrol drums, bits of houses and a steel wire rope " stolen " from another theatre. However, the ferry worked, although much debris in the river made a most uneven current for manœuvring the raft. Jeeps were passed successfully over a gap of some eighty yards.

The second flying ferry was of a more robust nature and was located at Loilaw, three miles south of Mogaung. Here a 250-yd. gap and a current of three to four knots, with good banks, made an almost ideal site for a flying ferry. The trouble was to find material for a raft. For the first time, the real worth of the Jap was discovered. Half a dozen Japanese pontoons in an almost undamaged condition were discovered at Sabmaw, eight miles away, and were moved by rail. It was not very long before a class 4 flying ferry was improvised and it was a proud day for a Naik of 15 Engineer Bn. when he ferried over no less a V.I.P. than Supremo, himself.

River Crossings

The two main rivers to be crossed during the advance of the division from Myitkyina to Meiktila were the Irrawaddy and the Shweli rivers. By the end of December a third brigade, divisional artillery and reduced scales of M.T. had arrived.

Irrawaddy

It was decided that one brigade group would cross the Irrawaddy at Tygaing and that the rest of the division would cross at Katha. Some time prior to the crossing, the N.C.A.C. headquarters had promised certain supplies of rafting equipment for this crossing. At the last moment, when the forward field company was almost on the west bank of the river, a message was received that no equipment was available. This time, the divisional commander's remark that he had every confidence in his sappers, seemed to fall rather flat. Luck held. Fifteen miles from Katha on the airfield at Indaw, sections of Japanese pontoons were found in sufficient quantity and in sufficiently serviceable condition to make three class 9 rafts. Pontoons were recaulked and superstructure and decking was improvised from locally " found " timber. Two piers were constructed at the Katha crossing, while at Tygaing approximately a quarter of a mile of " beach-roadway " was improvised over a sandy beach from timber from demolished houses, from reeds and grass.

Unlike the crossings by the Fourteenth Army further south, the crossing of the Irrawaddy by 36 Div. was unopposed ; a fortunate fact in more ways than one. Craft were mixed. At Tygaing the brigade group was passed over the river using one class 5 raft (a last-minute loan from the Americans) ; two rafts, improvised from country boats, used for stores and a small flotilla of country boats for men. The whole operation took only two days.

The crossing of the Irrawaddy at Katha was a bigger affair. In addition to the M.T. and artillery of the division less one brigade, several hundred mules had to be passed over the river. Owing to a sand bank, the crossing from Katha was downstream, giving a length of 2,200 yds.

The division had acquired a number of ranger boats and a few 9·8 h.p. outboard motors. Personnel and light stores crossed in ranger boats and country boats, while vehicles, guns and a detachment of American airfield engineers with mechanical equipment crossed on the improvised Japanese rafts. Paddling of ranger boats was a lugubrious operation, to say the least of it, so a number of "ranger-boat-tugs" were improvised, using 9·8 h.p. outboard motors attached to a frame, each towing two other loaded ranger boats. Outboard motors of 22 h.p. were obtained for the rafts; a round trip, including loading and unloading, occupied forty-five minutes.

The crossing by the mules formed a novel and exciting problem in these mechanized days. Normally small parties of mules were "launched," albeit reluctantly, and were "persuaded" to swim over to the island by a driver in the stern of a ranger boat holding out a tempting nose-bag of corn. Persuading mules to take to the water was no easy matter. Few people really understand the necessity for absolute quiet and that uncontrollable laughter is not permitted, even if the C.R.E. himself is giving manual assistance in "launching" mules.

Shweli

For the crossing of the Shweli, sapper resources in "shipping" were a little more liberal. Three rafts and forty odd ranger boats formed the bridging train. Reports indicated that the south bank of the river was lightly held and an assault crossing was planned and put into execution, but before complete engineer reconnaissances had been possible. Two companies of infantry crossed a 350 yds. gap to the south bank in ranger boats, but not without casualties to men and heavy casualties to craft. Jap reinforcements were rushed forward and the two companies were evacuated by night. In response to signalled "*cris de cœur*" made both to ALFSEA and to N.C.A.C., the heavens almost rained assault craft. Each headquarters seemed to compete with the other in sending more craft more quickly than the other. Never in the history of the advance of the division had sapper eyes been so gladdened by such an abundance of equipment. A fortnight later an assault crossing was accomplished and the Irrawaddy fleet of improvised rafts was once more put into commission.

Dropping Zones and Airstrips

During the advance of 350 miles from Myitkyina to Maymo, the division relied on air entirely for its supplies, ammunition and engineer stores. On arrival, stores were flown into Myitkyina and moved forward on the railway, but as the division advanced, "air drop" became the normal method until the land had dried sufficiently to allow airstrips to be constructed. Throughout the whole advance intrepid American pilots landed and took off in L 5's and similar craft from very improvised air strips for the purpose of evacuating casualties and carrying out reconnaissances.

During the "air-drop" stage, the first job of a field company commander was to reconnoitre and to clear "D.Zs." in the jungle close to his brigades. At first sight this was an easy matter, but during the monsoon in North Burma the ideal site frequently turned out to be a concealed swamp.

The commanding general of the U.S. Air Force had been most generous in his allocation of light aircraft and it was up to the divisional sappers to do their best for pilots, who seemed all too ready to land in pouring rain on a roughly macadamed road, a grass verge or on quickly cleared wet paddy.

When the monsoon had cleared and paddy land had dried out, supplies were brought in by Dakota, and light planes carried on as before in rather better conditions. For the construction of strips for Dakotas, a detachment of American airfield engineers was loaned to the division. Allotment of tasks was light strips to divisional sappers and Dakota strips to the Americans. This, however, seldom occurred in fact. On arrival at a site, where there were to be both light and Dakota strips, the sappers with bulldozers would start on the light strip, which with luck would be completed in four or five hours.

Shortly after the start of work, an American officer would arrive to " recce " the main strip, in the company of a divisional sapper officer. With the American usually came the welcome news that his autopatrol was just behind. By the time that the autopatrol had arrived, the main strip would be " recced " and the sapper bulldozers would go on to the main strip, leaving the autopatrol to finish off the light strip. It was not at all a rare matter to see an American lieutenant having tea with two or three Sikh operators of the field park company or to see a couple of Indian sappers on the autopatrol learning how to drive a new machine. The best time for completion of a Dakota strip on dry paddy by this allied effort working by day only was two days.

Engineer Stores

No account is complete without a word, regarding the provision of engineer stores. Considerations of weight and bulk forbade any large stocks in North Burma itself. Had large dumps of stores been brought, there would have been no transport to lift them. An engineer dump was established in Assam, under the administration of a R.A.M.O. and operated by a sapper detachment. One field engineer was placed in sole charge of the stores side and attended the daily " Q " meetings at which bids were made. Demands were signalled to the British Advanced Base at Ledo and teleprinted to R.A.M.O. With reasonable luck demands were met within forty-eight hours. The whole essence of efficient management of very limited resources in engineer stores lay in three factors ; a small mobile reserve of bare essentials, the dropping or landing of stores on the most advanced D.Z. or strip and the strictest economy in issues.

Luckily the supply of Engineer stores was not entirely dependent on what was brought in. The carelessness of the Japs in not destroying or evacuating useful stores was most remarkable. Pontoons, mild steel fit for spikes, timber, airborne mechanical equipment abandoned by the Chindits, were all found in repairable or serviceable condition. Only on one occasion did there appear to be any attempt to burn perfectly dry timber.

Conclusion

Accounts of campaigns usually end with a lesson. The lesson, learned in this campaign was that of improvisation. Not only did methods in construction have to be improvised, but also methods of organization and administration had to be adapted to various circumstances and situations. Even a language had to be improvised in H.Q.R.E. where British ranks from the Highlands, Gloucestershire and London conversed happily and freely with Mahrattas, Sikhs and Madrassis.

INDAWGYI

The activities of a Chindit Detachment on the waters of North Burma, June–August, 1944.

By Major K. M. Robertson, R.E.

Introduction

By the end of May, 1944, the Japanese army in Burma was on the verge of collapse. Nevertheless there was still some hard fighting to be done and the monsoon was about to break. The battles of Kohima and Imphal had reached their climax and were in their final stages. Meanwhile, in the north-east, General Stilwell's American and Chinese forces had debouched from the Hukawng valley and were within striking distance of Kamaing, having also included in their drive an attack on Lonkin on their right flank. Here the Japanese garrison had been routed and isolated parties were straggling southward.

3 (West African), 14 and 111 Brigades of the Chindits were among the hills of the Mangin Range south of Kamaing. Their task was to harass the Japanese in the Pinbaw-Taungni area and to prevent reinforcements reaching the 18 Japanese Division opposing General Stilwell. Our brigade was 14 Brigade and was the southernmost of the three.

As most people are aware, the organization of the Chindits was peculiar, their rôle resembling that of submarines in naval warfare. Infiltration by stealth, followed by ambush, was the method adopted by both for fulfilling their tasks.

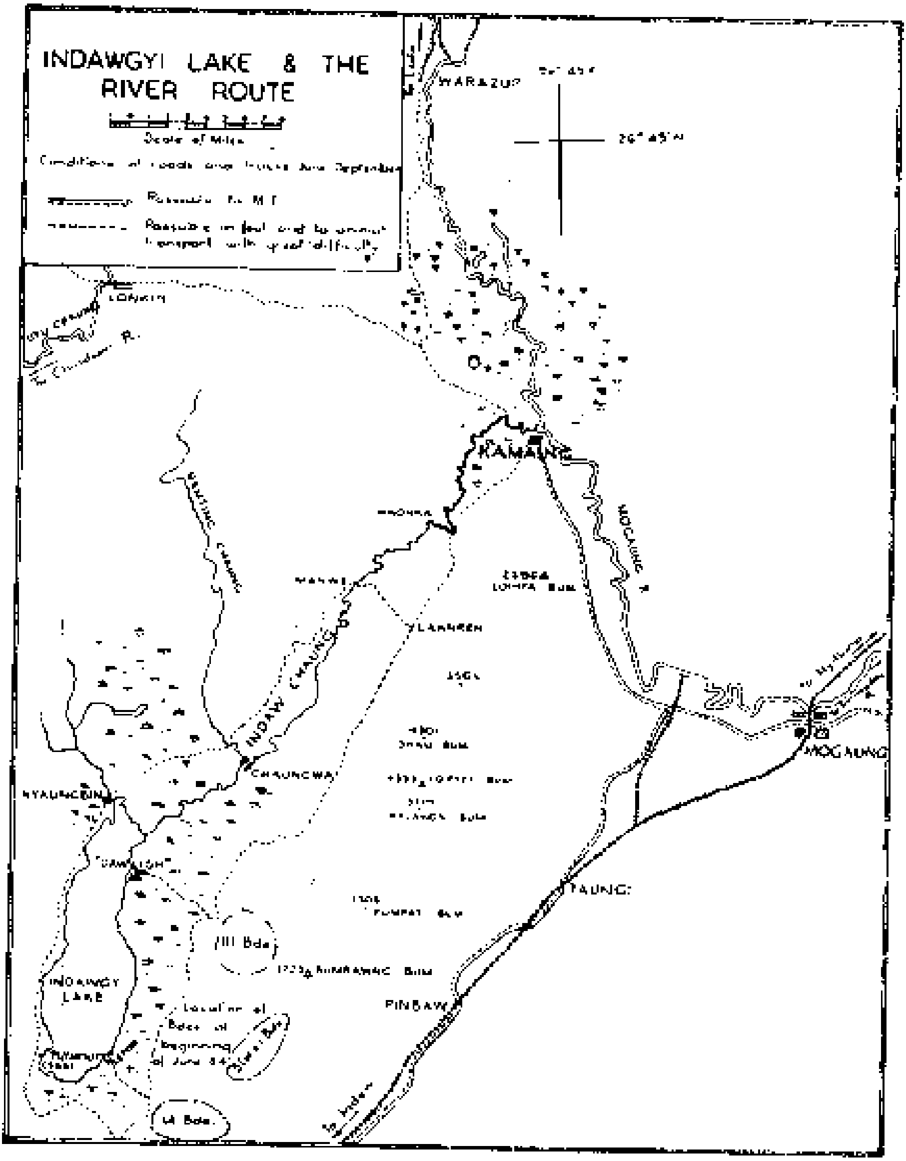
In each brigade there were four battalions. A battalion found two self-contained columns which, in addition to the brigade headquarters column, made nine altogether in the brigade.

The column was the operational entity on which everything was based, and at full strength consisted of some 400 men with sixty mules and horses for transport. Machine-gun, mortar and engineer platoons ; signals, medical and R.A.F. detachments were all permanently attached and incorporated in this body. All supply and heavy-fire support came from the air. Evacuation, when it took place, was by light plane. Columns, air bases in India and Force Headquarters were linked by wireless only.

The rôle and organization of an engineer platoon with a column deserves further mention. It was commanded by a Captain, with a Subaltern as a second-in-command, and consisted of four sections, each ten men strong. Three of these were sapper sections, while the fourth was found by the pioneers of the battalion to which the platoon was attached. Platoons, although held on the War Establishment of the Field Company, were seldon together. Thus the Field Company commander, who travelled with Brigade Headquarters, had to be a very active man with extraordinary powers of persuasion over column commanders !

Briefly the tasks envisaged for the engineer platoons were :

Demolitions,
Sabotage,
Booby trapping,
Technical direction of river crossings,
Construction of light plane strips,
The improvement of more than usually tortuous jungle trails.


INDAWGYI LAKE & THE RIVER ROUTE
Scale of Miles
WARAZUP
KAMAING
MOGAUNG
INDAW CHAUNG
CHAUNGWA
NYAUNGBIN
INDAWGYI LAKE
111 Bde
14 Bde
PINBAW
LONKIN

The lighting of fires to guide supply dropping aircraft also eventually became the job of sappers, as no one else really cared for getting a damp fire going by burning gun-cotton!

Engineer stores which accompanied a platoon were limited to those which could be carried on six mules. They consisted mostly of explosives and a few hand tools. Other types of stores supplied from time to time by air were determined by the weight and size which could be landed by parachute. Outboard motors and rubber "Ranger" boats were included in this category, but nothing much larger. If heavier material were needed it had to be obtained locally, or in special cases landed by glider or aircraft. Improvisation thus became the order of the day. Parachute rope and bamboo were the main materials, with elephants on occasions taking the place of mechanical plant.

The account which follows principally concerns the problems which arose over the evacuation of sick and wounded. Those problems increased with the intensity of the monsoon as it descended in all its force and grew more serious, as sickness, fever and the rigours of the campaign took their toll. Very soon all ground on which light planes could be landed became waterlogged, and the numbers requiring evacuation steadily mounted.

Phase I—Indawgyi Lake

Once the monsoon really set in, the plan we had often speculated upon was put into operation. Evacuation was to be carried out by two Sunderland flying boats, which were to land at the two stations of "Dawlish" and "Plymouth" on Indawgyi Lake. The story of *Gert* and *Daisy*, as the planes were called and how they operated from Dibrugarh, on the Brahmaputra, and flew through fearful weather over the forbidding Patkai hills, has been told more than once elsewhere. We were only concerned with one of them, the one which flew in to "Plymouth," at the southern end of the lake, and evacuated casualties from 3 (West African) and 14 Brigades.

Indawgyi lake is sixteen miles long and five wide at its broadest point. The eastern shore is marshy, while the western one has good shelving pebble beaches. The depth is legendary and we never ascertained it. The normally calm and placid surface is sometimes violently disturbed by very sudden squalls. Then the waves are mountainous and foam crested, and any small open boat that is caught by them is usually swamped.

The little village of Mamonkai was selected for "Plymouth" because it stood on a dry knoll and possessed a pebble beach hidden from view from above by a row of huge trees at the water's edge. The landward side was all marshland, over which we had good observation and the risk of being surprised was small. The anchorage, known as "Plymouth Sound," allowed the flying boat to come within 150 yards of the shore. There was adequate water closer in, but there was also the risk that a sudden squall might put her ashore.

The technical details of receiving the flying boat were entrusted to the Field Company commander of 14 Brigade with the assistance of one of the R.A.F. officers in the Force. Six engineer platoons, which later rose to nine, were withdrawn temporarily from their columns and put under his command to organize the station.

Work started by indenting for a large supply drop. Ammunition, food, medical supplies, petrol and R.E. stores landed in clouds of spray and mud in the marsh. Among things collected, or rather salvaged, were buoys and anchors to mark the landing strip, ten rubber "Ranger" boats and five 9·8 h.p. Johnson outboard motors.

The work to be done consisted of the following:

(*a*) charting the landing strip and anchorage,
(*b*) marking the landing strip, 2,000 yds. by 100 yds., with buoys,
(*c*) constructing jetties for embarkation of casualties into boats,
(*d*) constructing hospital accommodation in the village, in the form of bunks, cookhouses and latrines,
(*e*) siting and preparing defences,
(*f*) careful camouflage throughout.

The charting was simple and was done by parties in boats working from compass resections. The only feature worthy of comment was a storm which swamped a party working from a local country canoe. The officer concerned narrowly missed losing his life and had a long walk home in his birthday suit (why he discarded everything was never quite discovered).

The landing strip was a perpetual source of anxiety regarding security. The station on the shore was well camouflaged, but the glaring yellow buoys offshore were a big give-away. After the Sunderland had been in once we got permission to remove them.

Two jetties were made; one was a trestle affair made from jungle timber and bamboo lashed with parachute rope, the other was a half-floating bay supported on local canoes. A squall swamped and sank the latter right in the middle of the first embarkation, and after that trestles were used throughout. We considered that embarkation straight from the beach was not a good thing. Such a method nearly always resulted in a lot of shoving and pushing to get the boats ungrounded when loaded, and there were the motors to think of too.

The hospital accommodation was the pride of a West African Sapper platoon. Experts in the use of bamboo they soon had a very creditable casualty reception station organized in the buildings of the village.

Defences were normal and require little comment. There was no wire but the deficiency was made good by the use of booby traps and sharpened bamboos (panjis) instead. (A panji inflicts an ugly wound in the foot or leg which does not heal easily.)

Camouflage was all important and was carefully carried out from the first.

The organization of the boats requires explanation. A " Ranger " boat has plenty of buoyancy but little room inside it, especially for lying cases. Consequently four rafts were made, each supported on two boats and powered by one motor. In this way, excluding a crew of two, fourteen sitting or six lying cases could be placed on a raft. Speed when loaded was two and a half to three knots.

All the above work was completed twenty-four hours after the supply drop. Six of the platoons were then released for other duties and the operation of the base entrusted to the remaining three.

All was ready for the reception of the flying boat on the 1st June, but the weather was bad and we were disappointed. However it gave us the chance to rehearse again the drill which we had worked out for loading, as emphatic instructions had been received not to delay the flying boat longer than necessary since it would be a sitting target on the water.

During the day a boat on patrol discovered a number of large submerged trees and logs had drifted into the landing strip. They must have been washed down the streams into the lake during the recent heavy rain and were a most disturbing factor. The smallest of them was capable of sending the flying boat to the bottom like a stone, and they were not easy to detect. Towing them clear proved a very laborious business and we were never sure, from then on, that the strip was free of them, no matter how often it was patrolled.

Bright and early on the 3rd June, the flying boat appeared through a break in the clouds. She circled the strip once and then came down to land. For a few breathless seconds she skimmed along the surface before settling down in the water and coming to rest safely.

Meanwhile one of the boats had put out hastily towards the strip. Recognition signals had been interchanged by Aldis lamp, and a smoke flare cast adrift on a petrol tin to give the direction of the wind.

After a brief consultation with the Captain of the aircraft, embarkation started. Rafts were called forward, each to a particular hatch for loading. To emplane a party of troops through one door in an aircraft causes confusion enough ; to do it through four simultaneously produces a result inside like Piccadilly Underground in the rush hour! One unforeseen snag occurred, in that the improvised stretcher were just too long to be slung through the bomb-bays where lying cases were taken in. This caused some very awkward handling especially as there was a squall blowing at the time. As has been mentioned before, one of the jetties sank which also slowed up embarkation.

The flying boat's capacity was forty men and when these were on board she left. She made two more flights to "Plymouth" during the next week and took off forty each time. With practice the rate of embarkation increased until, on the last flight, only eighteen minutes elapsed between the time the motors were stopped till they were started again for take-off. Since on this occasion nearly a ton of stores were unloaded as well, it was not too bad.

On each occasion the flying boat was given an escort of Mustangs, whose wild gyrations over the lake made it quite obvious that they resented any delay. However, luck held, and although the enemy must soon have realized what was going on so close at hand, they never succeeded in being able to intercept a sortie or attack either lake-side station from the air. For this we were eternally grateful to the superiority which the British and American Air Forces had established over Burma, a superiority which had involved flying through apalling weather conditions over a most treacherous range of mountains.

While these operations were in progress, activities on the lake had been extended in another direction. Hitherto casualties had been brought to "Plymouth" either on horseback or in bullock carts. This had involved a twelve-mile journey over a very rough track which was steadily getting worse. A ferry service was therefore started between "Plymouth" and Lepon on the eastern shore, which reduced the land journey to four miles. Likewise two of the columns in 14 Brigade had been sent to Nyaungbin, at the northern end of the lake, and so the ferry service developed into the circuit, Plymouth-Nyaungbin-Lepon. The daily "packet boat," as it came to be called, proved extremely useful for liaison visits, the carrying of mail and the interchange of routine messages, besides the carrying of casualties. She was equipped with a No. 22 wireless set, which, apart from safety reasons, allowed her to be re-routed if necessary while still "at sea." Had a similar circuit been attempted by land it would have meant a journey on foot or horse-back lasting four to five days, so wide were the detours required to get round the lake and surrounding marsh.

In the middle of June, 3 (West African) and 14 Brigades moved northwards towards Kamaing. It was, therefore, decided to close "Plymouth" and combine both stations at "Dawlish," the command of which was to be taken over from 111 by 14 Brigade. The latter thus became responsible for the evacuation of all casualties from the lake area.

For various reasons the flying boat's operations had been temporarily suspended, so that the combining of the two stations was able to take place without prejudice to the evacuation by air. It required six twenty-two mile trips by all available craft to clear " Plymouth " of men and stores and the move had to be carried out as quickly as possible. Boats and motors were in use almost ceaselessly and crews were worked in shifts.

It was hoped that local country canoes, powered with outboard motors, would be of some use. Admittedly they were very fast, but they were too small to be of much value as load carriers and also the torque and strain of a motor soon opened up the seams at the stern. We, therefore, only kept one or two of the best ones.

A series of storms caused delays, but we managed to get the move completed in four days.

In stormy weather it was an advantage to run rafts in pairs, lashed side by side and held by a quick release knot. Each raft thus got the benefit of two motors and should one be swamped, both rafts were still under power until the storm abated, enabling the flooded carburetter to be dismantled, dried out and got going again. It was found too, that the chances of the lee-side motor being swamped were remote if the pair of rafts faced the weather at an angle.

With the end of the move each boat or raft had travelled close on 200 miles. The only motor not in running order was one which had caught fire and burned out some two miles from " Dawlish." Fortunately it was one of a pair and the officer in charge manœuvred the rafts, both fully loaded with men, so that the motor burned out upwind and not much harm was done. It is to the credit of the sapper running the motor that he got the filler cap undone which probably prevented the tank from exploding. It is one of the snags of the motors that, should they catch fire, it is almost impossible to get at the screws to unhitch and jettison them.

As most already know, the secret of keeping outboard motors running lies in meticulous maintenance. Each motor was allotted to a pair of sappers who were responsible for running and maintaining it. Overhaul and repairs were entrusted solely to one Sergeant, a first-class fitter by trade, with a small team to help him. We had asked for more motors at the time of the move; these and the ones originally dropped at "Dawlish," brought our number up to twelve which allowed for a working reserve.

By now quite an *esprit de corps* had grown up around the " fleet." All boats were christened and a friendly territorial rivalry flourished between *Thames*, *Tyne*, *Tweed*, *Mersey*, and *Severn*. All vied with one another to set up some new record and all were justly proud that, in spite of storms, no boat or raft had got into difficulties and had to be rescued.

Phase II—The Indaw Chaung

In the middle of June, General Stilwell's American and Chinese forces captured Kamaing. This meant that the only enemy now between Stilwell and ourselves were isolated and scattered parties from Lonkin and Kamaing. Meanwhile, for various reasons, the operation of the flying boats had again been postponed, this time indefinitely. It was therefore decided to evacuate all casualties remaining in the lake area to Kamaing, by way of the Indaw Chaung. Further casualties from the brigades were to be sent either direct to Kamaing by land, or via Lakhren to the banks of the Indaw Chaung, from where they would be collected by boat.

The situation at Kamaing was not fully known, but it was understood that a hospital was being established there and it was presumed that further evacuation would be carried out under General Stilwell's arrangements.

It thus became our immediate task to clear the lake area of 400 casualties, which were all that were to be allowed to collect there. Already "Dawlish" was becoming waterlogged due to the monsoon and was so overcrowded that one hundred casualties were taken to Nyaungbin instead.

The Indaw Chaung flows in a tortuous course from the north-eastern corner of the lake down to Kamaing. As the crow flies, the distance is only thirty miles, but by the Chaung it is a good fifty. The reach from the lake to Chaungwa is sluggish and often choked with weeds. The surrounding land is all marshy and towards the end of the monsoon goes below water to such an extent that it is possible to pole a boat from Chaungwa to the lake without entering the main channel at all. At Chaungwa the Indaw and fast flowing Namting Chaungs join and flow together in a swift and ever-broadening stream to Kamaing, where, as a stream some seventy yards wide, they join the Mogaung River. Below Chaungwa the course is fraught with numerous obstacles in the form of partially submerged trees and roots, together with a fair share of jagged rocks in places. It is no place for a frail hull in those reaches.

A column was detailed to picket and patrol the likely approaches to the route and give protection from any major enemy threat. However, the route was so long that a possible encounter with Jap stragglers had to be reckoned with always. It was tactically desirable that the move should be made all in one lift.

In order to control such a large party as 400 and to economize in crews, we decided to build what we called "dreadnoughts." These were large rafts primarily intended for ferrying mules over broad and fast rivers and their main advantage lay in the fact that all their essential components except one could be dropped from the air. The one exception was the frame, which in any case was to be made from bamboo and timber obtained locally.

Briefly the construction details were as follows:

(*a*) Two similar flat bamboo frames were made, and between them were lashed five "Ranger" boats.

(*b*) The hull was wrapped in a 40 by 20 ft. tarpaulin to give it a better "Streamline" and a little extra buoyancy.

(*c*) A deck was made from bamboo matting, such as abounds in North Burma, where whole villages are principally made of it.

(*d*) Between two and four 22 h.p. Johnson outboard motors were fastened to the stern by a frame designed to take their weight, thrust and torque.

(*e*) A timber cut-water was desirable to cut down excessive bow wave and to strengthen the blunt inflated bow.

(*f*) Any superstructure, in the nature of a corral for mules, or canopies were added as required.

When finished a dreadnought was 37 ft. overall and 12 ft. in the beam. Draught when fully laden was about 15 in.

The minimum crew was four men; Captain, two motor-men and a deck-hand.

In addition any of the following loads could be carried

(*a*) 6 mules, their loads and muleteers.

(*b*) 35 men fully equipped.

(*c*) 2 loaded jeeps.

The following table gives an idea of the speed in still water, when the hull was new:

	unloaded	*loaded*
with 2 motors	5 knots	3¾ knots
with 3 motors	6 knots	4¾ knots
with 4 motors	6½ knots	5⅛ knots

Consumption of petrol and oil mixture was two gallons per hour per motor, which was a big item on a long run.

Construction of our fleet, "The Indawgyi Grand Fleet," took place at Nyaungbin towards the end of June. Ten dreadnoughts were laid down and stores were delivered to us in three successive supply drops: fifty "Ranger" boats, twenty motors, tarpaulins, petrol, oil and food. For reasons that were never discovered the parachutes on the first seven motors to be dropped failed to open. One of these even failed to leave the static line and we had the chagrin of watching the plane circle out over the jungle and cut the motor away, for it to be lost for ever. The matter was taken up at Air Base in India, and, from then on, motors were dropped on men's parachutes, which were known to be sound. Of the seven motors that smashed on landing, three were eventually made to go. This feat reflected the highest credit on the Sergeant who ran the repair team.

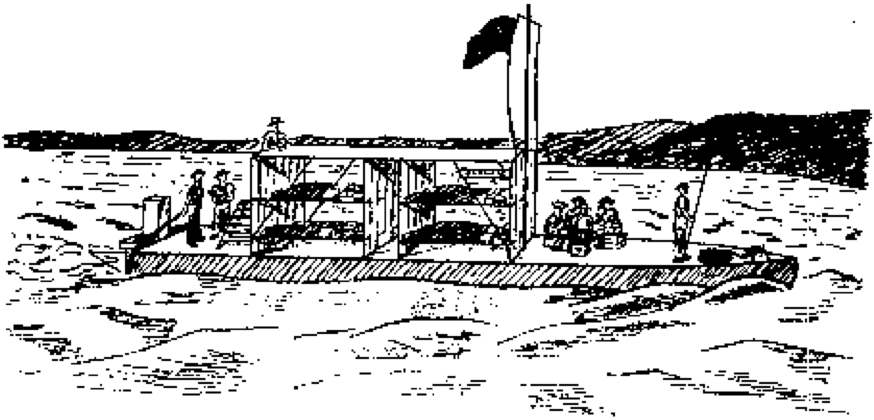
Tarpaulins too, fell short of requirements, in that most of them were nothing like 40 ft. long, although all were stamped 40 ft., the shortest was only 35 ft. It caused us a lot of trouble with a great deal of extra sewing of odd bits and pieces.

The work of building the vessels was undertaken by three engineer platoons, while infantry from the columns at Nyaungein collected in the stores from the dropping zone and delivered them to the beaches. The making of the bamboo matting decks was entrusted to the local inhabitants. No one else could have done it so well or so quickly. (Throughout the whole campaign the loyalty we received from the local inhabitants was beyond praise. On more than one occasion they paid dearly for it after we had passed on.) Each dreadnought had a canopy erected over it, while over the stern a latrine was neatly positioned between the propellors! One dreadnought even had twelve bunks built into it for the benefit of the most serious cases.

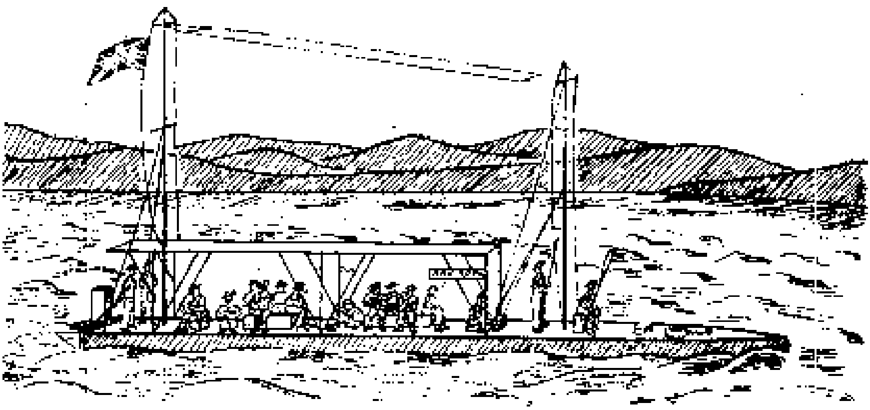
It was known that there would be difficulties over inter-allied recognition, and General Stilwell's forces had a reputation for being remarkably quick on the trigger. To make matters worse parties of Jap stragglers had already been caught drifting down the Indaw Chaung. We therefore received in our last supply drop ten glorious Union Jacks, which we took great pleasure in flaunting from our mastheads when we eventually approached the allied outposts.

The fleet was organized into three squadrons, each of three dreadnoughts, and was controlled from a flagship. The latter was fitted with wireless to keep in touch with the escorting column (and required yet another mast for it!) Each squadron became the responsibility of one engineer platoon and, as before, all vessels were named. *Ark Royal*, *Vindictive*, *Valiant*, and *Vanguard*: *Revenge*, *Renown*, and *Resolution*: *Barham*, *Benbow* and *Blenheim* all took their station in the "Grand Fleet".

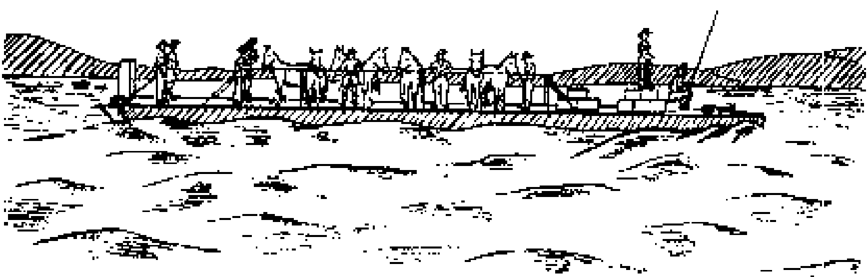
While the fleet was building, reconnaissance parties had been sent down the Indaw Chaung as far as Chaungwa. The reports they brought back were conflicting. The first said the way was clear and easy, the second said only a very narrow channel existed between blocks of weeds. The third came back early and said the way was completely blocked. Further observation showed that periodic blocks, 200 to 300 yards long, formed and disappeared according to the whim of the current as it was influenced by heavy rain in the hills. The weeds, resilient and tenacious, defied all our attempts to remove them. Explosive merely blew holes which closed up again in a few minutes. Any small boat that tried to work its way through either failed to get in at all or got hopelessly entangled and took ages to disengage. The local inhabitants were the most successful and with much effort managed to get their own



"BARHAM"



"ARK ROYAL"



"REVENGE"

canoes through. They would lie out on a broad plank chopping away with a knife and before the gap could close they would draw the canoe up into it. This was all right for canoes, but unfortunately not so for our much larger craft. There was nothing for it but to hope for the best.

On 29th June, all the dreadnoughts were ready. One squadron and all the small craft sailed for Chaungwa with elements of the escorting column, the bulk of which had already set out on foot. Nyaungbin was closed that evening when the remainder of the fleet took all that was left and sailed over to "Dawlish."

The squadron sent to Chaungwa made good time and returned to "Dawlish" early next day. In the afternoon "Dawlish" was cleared in one big final embarkation and by the evening the entire "Grand Fleet," with 400 aboard, assembled at Chaungwa. It was an imposing review and was the last occasion on which it was massed in all its strength. The headquarters of the escorting column was present as well, so that accommodation in Chaungwa was at a premium that night. So far everything had gone perfectly. Even the weeds had co-operated by not asserting themselves.

That night everything was altered. We heard that Kamaing could not receive our full numbers and that the Sunderland was to fly again. Accordingly on 1st July, only *Barham*, *Benbow*, and *Blenheim* went on to Kamaing while *Vindictive*, *Valiant* and *Vanguard* returned to Nyaungbin. The remainder stayed at Chaungwa to await developments. The turn of events had annoyed the escorting column, who had looked forward to an early release and a more profitable occupation hunting down Japs with the rest of the brigade. Now part had to return to Nyaungbin to protect the place.

Meanwhile a few casualties had already collected at Lakhren as originally planned. *Revenge* and *Resolution* were sent down to bring seventy of them back to the lake. On the way back progress against the current was slow and the journey took two days, navigation at night being too dangerous to be allowed. On arrival at Chaungwa the party had great tales to tell of a six-hour struggle to get through a block of jammed timbers and weed. Apparently much of the credit was due to a party of West African soldiers, who although stricken with fever, had not hesitated to plunge over the side to haul the timbers out of the path of the dreadnoughts. It was interesting too to know that the dreadnoughts, with their extra weight and momentum, were able to plough a way through the weeds, snorting, turning and charging, for all the world like some strange amphibious bulldozers.

The weeds between Chaungwa and the lake now reappeared and another classic struggle took place involving *Ark Royal* and *Vindictive*. These two were making routine runs between Chaungwa and Nyaunbgin for the column when they met either side of a block 200 yds. deep. It was 1400hrs. when they started working towards each other and by nightfall each had only penetrated some 60 or 70 yds. Here the weeds seemed to thicken and further progress appeared impossible. An unpleasant smell which had steadily grown more persistent, eventually revealed the bloated corpses of two buffaloes and a Jap immediately ahead of *Ark Royal*. This was enough. Both dreadnoughts decided to withdraw for the night. However, this was not to be. Whereas getting in had been just possible, getting out, broad stern first, was out of the question. To make matters worse, one of *Ark Royal's* motors failed. There both dreadnoughts were, firmly stuck in the block with no immediate prospect of release. Taking stock, petrol and foood were found to be limited, and ironically enough there was only a little drinkable water on board. As darkness fell mosquitoes came out in their millions, leaving no alternative but to pack up and seek refuge under nets. During the night a heavy storm solved the water problem by filling the bulges and folds in the overhead canopies. If the water had been precious mercury, it could not have been drawn off with more care.

The prospect at dawn was still not very bright. There was still no sign of the block breaking up, while the Jap and buffaloes grew even more offensive as the sun rose. However, *Vindictive* redoubled her exertions and by a magnificent effort not only managed to reach the crippled *Ark Royal*, but also to turn round. Both crews worked like slaves. Motor-men feverishly swung the vessels to and fro while the rest hacked away madly with knives, matchets and bayonets at weed clinging to the hulls. With *Vindictive* leading the way and *Ark Royal* following immediately in her wake, both dreadnoughts slowly but surely fought clear. Exactly twenty-four hours after entering the block, both broke free and sailed for Nyaungbin.

During the next fortnight the flying boat made another three trips to the lake and cleared 120 casualties. However, since *Revenge* and *Resolution* had brought another seventy into the lake from Lakhren, and a number more had collected again at " Dawlish," the situation was not changed a great deal. There were still roughly 100 on the lake and 200 at Chaungwa. Further flights by the flying boat were then definitely cancelled and we heard with regret, a little later, that she had been sunk at anchor during a squall on the Brahmaputra. One of her floats had been removed for repair and the wind caught her while she was unstable. Therefore the plan to evacuate casualties to Kamaing was again put into effect.

The journey down the Indaw Chaung was not particularly eventful. We left Nyaungbin at dawn for the last time and reached Chaungwa just before noon. The weeds were still in evidence but recent very heavy rain had raised the level of the Chaung to such an extent that it was possible to leave the main channel and pole round the blocks through the flooded marsh. Chaungwa, too, was going under water and everybody was glad to leave. During embarkation a supply-dropping aircraft slightly misjudged its mark. Great bags of fodder came hurtling down free and landed among the closely packed troops and dreadnoughts. If anything was needed to speed us on our way, this was it ! We made Manwe by dusk and staged there the night. The next morning we bade farewell to the escorting column, but before doing so two of the dreadnoughts were used in the rôle for which they were originally designed. The whole column was ferried over the Chaung and set on their road to rejoin the brigade. At Kohka we met the Chinese outposts and all but ran foul of a steel wire boom they had thrown across the Chaung. It struck us as odd that they should have put it there, since they knew we were coming, but apparently it was intended to catch Jap stragglers, some of whom had already been caught drifting downstream on previous nights. At Kohka too, was a race from which a number of ugly rocks and tree roots protruded. Navigation was a nightmare, and once through there was no chance of return except in a faster and smaller boat. With the reaching of Kamaing in the afternoon, the primary task of the dreadnought was ended. Other casualties did come down the Indaw Chaung but not in large numbers. They were brought from Manwe and Lakhren in smaller boats based on Kamaing.

Phase III—Kamaing

Evacuation of casualties did not stop at Kamaing. Most of them, being sickness cases, could only be properly cured at base-hospitals in India, under far better climatic conditions than existed in Burma during the monsoon. This was why evacuation by flying boat, operating from India, had proved to be so valuable and had been kept going as long as possible.

At the end of July, Kamaing was still principally supplied by air. As far as land communications went, the famous Ledo road had only reached Warazup, forty miles to the north. Between Warazup and Kamaing only a very rough track existed and this had been completely washed out, and communication between the two places was maintained by a water L. of C. operated by an American engineer unit. It was along this route that casualties had to be evacuated to Warazup. From there, or from Tinkawk, not far away, they could be flown out to India from air strips serviceable for Dakotas in nearly all weathers. As the American resources were not sufficient to cope with our numbers, we were required to supplement their efforts and to take our share in bringing stores and supplies down to Kamaing by water.

The Mogaung River resembled the lower reaches of the Indaw Chaung in all respects except that it was broader and swifter. The use of dreadnoughts was no longer considered profitable owing to the time and fuel required for a laborious upstream journey, so we collected from Warazup ten boats and motors of the pattern used by the Americans. These were the type known as M2, and were somewhat similar to British Mk. VI pontoons, only a little smaller and completely undecked. They have one great advantage in that they are made to nest one inside the other so that transport of large numbers over land is easy. The motors used were 22 h.p. Johnsons.

It was found that, with a bit of luck, each boat could just make the journey up to Warazup and back in daylight, navigation at night being forbidden as before. Twelve men, in addition to the crew of two, were carried in each boat on the upstream trip and, during July and August, 1,800 of our casualties passed through Kamaing and were taken up to Warazup in this way.

Boats were still made to travel in pairs, lashed together side by side. This method, as before, saved time when a motor had to be stopped, either to be refuelled or for a shear-pin to be replaced. The latter frequently occurred in the upper reaches of the river, which were more than usually full of snags. By now there were sufficient motors to enable two to be allotted to each boat and to be used alternately. Thus there was ample opportunity for maintenance and serious stoppages seldom occurred. Only one motor was lost, due to another fire.

Among the cargoes brought down from Warazup were a number of jeeps and trailers for use on the road, which was still passable beyond Kamaing. Each jeep and trailer was slung between two boats from long bearers resting across the gunwales. Jetties, sloping down into the water, and just the width of a jeep, were constructed at each end of the route so that boats for loading could be brought either side, the vehicles hitched to them and driven down the jetty till the boats in the water took the full load ; while, for unloading, the process could be reversed. These jetties were an essential part of the method, otherwise the boats would either have become firmly grounded, or it would not have been possible to hoist the vehicles clear of the water. This method of transport was preferable to using decked rafts, which would have needed extra work and material to construct. Moreover, for such a long journey, two boats, with a jeep and trailer slung low between, were easier to handle in the current than a decked raft with vehicles perched high up in the air.

The method became popular and was adopted by 36 Inf. Div., who eventually relieved us and who transported considerable numbers of their own jeeps down to Kamaing in this way.

Meanwhile what had become of the dreadnoughts ? *Valiant*, *Vindictive* and *Revenge* were permanently detailed as ferries at Kamaing and were used by parties of men and mules who managed to struggle down the track from

Warazup on their way to the forward area. *Resolution* and *Renown* became floating jetties and *Benbow* a floating residence for visiting V.I.Ps.! The rest were dismantled and scrapped.

One dreadnought, *Revenge*, tried to make the journey to Warazup as an experiment. But her hull was then old and full of rucks and folds, so that even with four motors she did not make much speed. However, having started at daybreak, she got within eight miles of her destination by the afternoon, when an accident occurred which put a sudden end to the experiment. She was just breasting one of the many swirls and races of the upstream reaches when one of the motors faltered. It was only for a second, but in that moment the current took charge, thrusting her up against a partly submerged tree and canting her over at an angle. Two of the remaining motors were submerged and she was completely helpless, wedged fast, partly under water with a vicious current swirling by. The passengers, mostly Gurkhas, sought refuge in the upper branches of the tree while the crew did what they could to save kit and equipment. In the end the whole party was rescued by M2 boats, and *Revenge*, less her motors, was abandoned. Even then she did not become a total loss, but eventually floated free and was reclaimed as she drifted forlornly past Kamaing. There was neither the need nor the opportunity to try the experiment again.

By the end of August the main L. of C. was firmly established by air to Myitkina, and by rail from there to Mogaung and the south, so that traffic by our river route practically ceased. Also, with the arrival of 36 Inf. Div., the Chindit Brigades were relieved and we were flown back to India from the same air strips which had served our casualties so well in the past. Our last act was to hand over the ferries, *Vindictive* and *Revenge* to the Americans at Kamaing. They were very grateful, but a little suspicious and alarmed. No American likes playing with an improvisation, however good he knows it to be.

Concluding Notes

It may be thought that the evacuation of casualties and the running of a water L. of C. in the rear of Kamaing was no job for sappers attached to a forward brigade. Under normal circumstances it would not have been so, but on this occasion it happened that the current operations were chiefly in the nature of forays and skirmishes with no major engineer work involved, so it was possible to spare three of the sapper platoons in the brigade for this task. It should be remembered too that these platoons catered for not only their own brigade but also for 3 (West African), and to a small extent for 111 Brigade as well.

The evacuation of casualties from the Chindits was always a problem and had a tremendous effect on morale. Very often casualties had to be dragged along with their columns for days before they could be evacuated, and columns always regarded it as one of their main duties to look after their own sick and wounded till they could be finally evacuated by air.

With regard to watermanship there is little to add which has not been mentioned already in text books and training pamphlets. However the following points are important and worthy of further mention:

1. Meticulous maintenance of motors, which included the careful filtering of petrol, paid good dividends.

2. Two motors were lost through fires and there were a number of others which flared up, but were got under control just in time. A liberal supply of fire extinguishers is desirable.

3. In strong currents we were severely handicapped by motors having no clutches.

4. A Johnson motor is designed for a small fast craft and there is a big loss in efficiency when it is attached to a heavy cumbersome raft. For this work the pitch and rate of revolution of the propellor need to be redesigned.

5. Where boats are equipped with only one motor each, there is a distinct advantage to be gained by lashing them together in pairs so that both get the benefit of two motors.

6. Towing a dumb raft or rafts in a strong current is not easy, especially when taking up or casting off the tow. It is recommended instead that the rafts be lashed together, either side by side or end to end and the tug or tugs made fast alongside.

7. From the shortcomings of our dreadnoughts we learned that when designing an improvised raft for use in a strong current, too much attention cannot be paid to the underwater aspects. For this reason the raft should derive the required rigidity from a framework braced and stiffened entirely on top, leaving the underwater lines as clean as possible. It may be more cumbersome and difficult to build like this, but it will be well worth it.

THE DEMOLITION OF ETAPLES RAILWAY BRIDGE

By CAPTAIN R. A. LINTON, R.E.

IN writing the story of the demolition of this bridge, I am sticking as closely as I can to the military style of writing. That is to say I am stating the facts as they occurred, and giving my actions and reasons for them as accurately as I can. But I know very well that it was not purely on the reasons given that I based my actions, I was guided at that time far more by instinct than reason. It so happened that it was left to me to take decisions far outside my responsibility as a subaltern. For the bridge had not been included in any demolition programme, and I had neither the time nor the means of communication to find out if it had been intentionally omitted. As the following account shows I took a gamble which fortunately for me came off all right.

The old Etaples Railway Bridge was a solid brick-arch bridge of thirteen arches, carrying the double track line from Boulogne to Paris over the estuary of the river Canche. It was a fairly big demolition, and even now, eight years later, the bridge has not been rebuilt. The R.A.F. were chiefly responsible for keeping the bridge broken, but the engineering difficulties were considerable due to the shifting sands in the estuary.

The importance of the bridge can be judged from a glance at the map of Northern France. The main line from the Channel ports to Paris runs down the coast from Calais via Boulogne, Etaples, Amiens and thence on to Paris. If this line is cut only a fraction of the normal daily traffic can be filtered through the subsidiary lines via Montreuil and Arras etc. The use of this line, running as it does down the coast, was later to prove itself of considerable importance to the Germans for building up installations and troops along the coast.

On 11th May, 1940, I arrived for attachment to C.R.E. Boulogne Sub-Area and was sent out to an Artisan Works Company stationed at Etaples. This company was one of the hastily recruited Works companies raised in England at that time and sent to France with not very much military training. They were employed on the construction of hospitals at Etaples, so that they were not undergoing any military training at the time, and as yet the O.C. had not made up the senior N.C.O.s. In the few days I was with the company before the German advance began to threaten us, my only duty was to put the unit through a brief range practice, so I had no opportunity of getting to know any of the men well. But being able to speak French fairly fluently I got to know the interpreter well, and we spent most evenings together in a bar in Le Touquet discussing the rapidly deteriorating situation. It seemed to us then that the German break-through would reach the coast just about at Etaples. During these days I had begun to make plans in my head for the blowing of the railway and the road bridge, for it had begun to seem probable that this would be our job before leaving Etaples.

On about the 20th May, the situation suddenly worsened. The flow of refugees from Belgium and the north was now added to by refugees and disorganized units of the French Army coming from the east. The Luftwaffe subjected Etaples to a series of bombing raids, which added to the confusion in the town. At about ten o'clock that evening a Lieut.-Colonel, whom we had never seen before, came and ordered us to prepare certain bridges for demolition. I was assigned the big road bridge and a little girder bridge (marked on Fig. 1.) which takes the railway over the road from Montreuil. The Colonel produced sketches of the girders and some rough data of how to place pressure charges on the road bridge. The explosive was to arrive next morning.

Needless to say I was staggered that no effort was being made to blow the main railway bridge; because I was under no delusions as to its importance, having watched the traffic over it in the last few days. But the Colonel had made his plans and it was no use arguing. I was ordered to destroy one arch of the concrete road bridge by a pressure charge, and this order overlooked the fact that the piers had exposed steel stanchions obviously put in to enable it to be easily demolished. There was no doubt in my mind that this Colonel was taking over a number of jobs in a hurry, and he had had no time to recce them properly ; so that these bridges were going to fall into enemy hands due to the disorganization caused by the speed of the enemy's advance. My O.C., as far as I knew, had no experience of demolitions and I hesitated to involve him in a decision that was hardly in his power to make. I made up my mind that night that it was up to me to find some plausible reason for blowing both bridges properly, but they were very big bridges and I could see that if I failed or did the wrong thing, I was not going to have a leg to stand on.

I would like to point out here, what a difference comradeship makes to all forms of human activity. When you know your O.C. as "George", and your C.R.E., whilst he is called "Sir," plays games with you, and is the kind of senior officer you can talk to, then you are in good company and you can share many of your problems. More important still is the comradeship of the sappers, who can often give you the soundest advice obtainable in their trade, when they know you. But this story is a very lonely one ; none of the people concerned had hardly ever seen me before to speak to, and none of us knew at all the capabilities of each other. Furthermore it took place during a period of such unequalled disaster, that even now, eight years later, the urgency with which one had to do things, still stands out vividly in my memory.

You can therefore understand my feelings on the morning of the 21st May, 1940, when I went down to Etaples with a Corporal and ten sappers to investigate the situation more closely. The explosive had not arrived, so the only job I could do was to prepare the girders of the little railway bridge. This I hesitated to do because it was a waste of time if I was to blow the big bridge. The sight that met our eyes was quite unexpected, the road bridge was piled high with seething humanity all jammed solid. There were

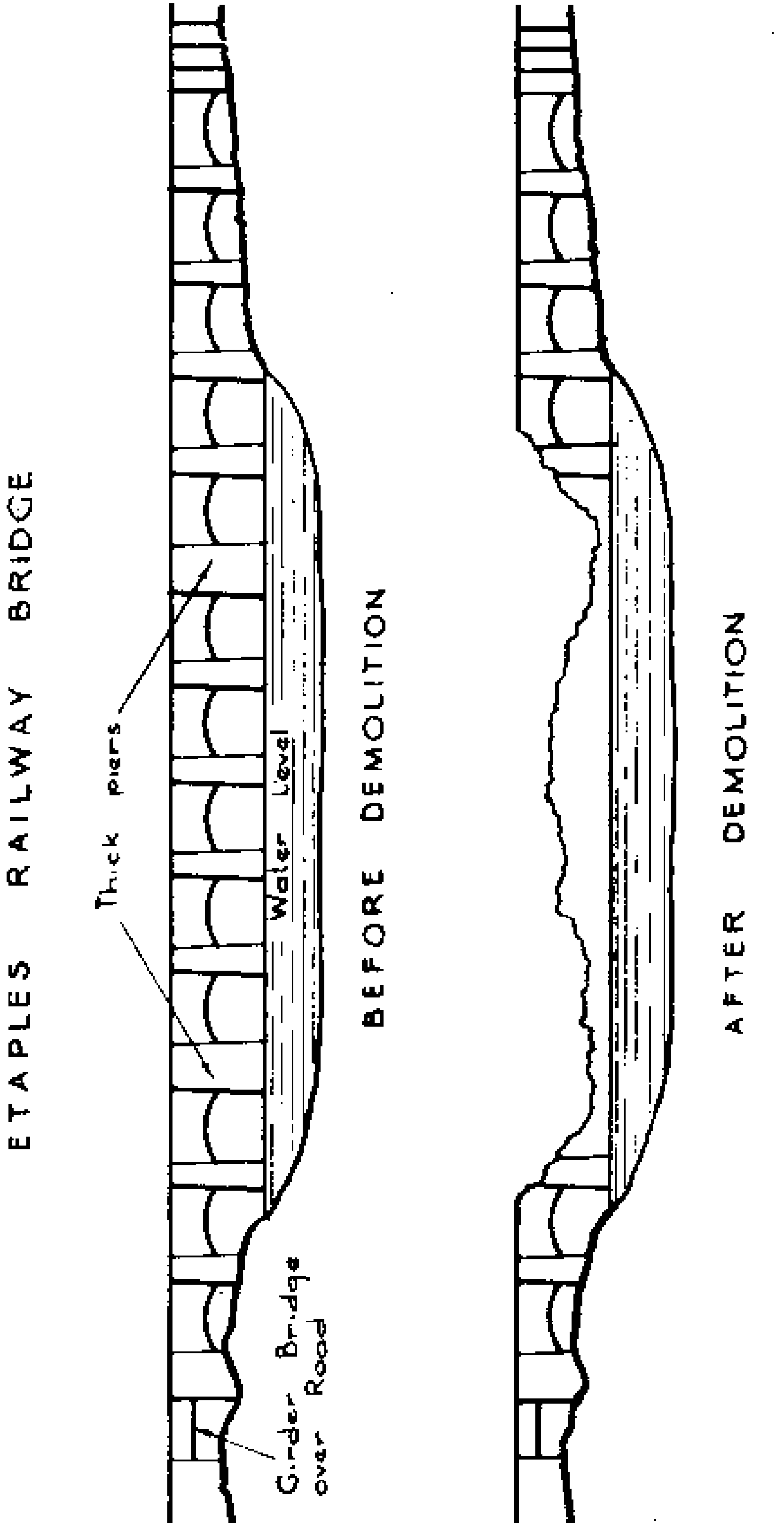

ETAPLES RAILWAY BRIDGE
Thick Piers
Water Level
Girder Bridge over Road
BEFORE DEMOLITION
AFTER DEMOLITION

FIG: 1.

pieces of heavy French artillery with troops sitting astride, and odds and ends of carts, cars, bicycles, people and even the odd French tank. Apparently the refugees were now coming north as well, and all these columns had converged on the bridge. Our ten sappers fixed bayonets and eventually succeeded in clearing the bridge and regulating the flow of traffic. But one thing was certain, I could not hold these crowds back with ten sappers and lay pressure charges on the bridge until the very last minute before the bridge was to be blown.

I decided therefore to have a look at the stanchions underneath, and Pierre, the interpreter, went to the Railway Officials to see if he could find out if there was an easy means of blowing the main railway bridge. I tried to get underneath the road bridge in a boat with the Corporal, but the current was too strong for us, as the tide was in full ebb. I did not continue my efforts because the Corporal revealed to me that neither he nor any of the sappers had ever done any demolitions at all. It was therefore going to be an arduous task placing guncotton charges against vertical stanchions with men who had never placed a charge before. I decided to go and see how Pierre had got on with his recce of the railway bridge before making up my mind as to what I was going to do.

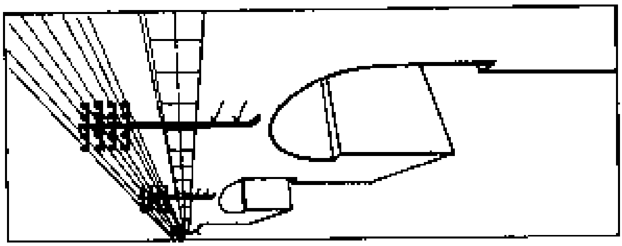
Pierre had done very well for he had noticed that the bridge had two piers thicker than the others. He had gone on the bridge and scraping the stones away with a shovel he had discovered a wooden manhole cover. I arrived on the scene just as he was about to lift it up, and sure enough it covered a vertical shaft, about 3 ft. in diameter, disappearing down into the murky depths of the middle of the pier. These piers were well out in the wet gap and separated by five arches in the middle. There was no doubt, therefore, in my mind that in the case of this bridge, given enough explosive, I could do a thorough job, even with unskilled men.

I decided therefore that I could justify my action, for my wisest course was first to make certain of the main railway bridge, using the ammonal supplied for the road bridge. Then I could prepare the road bridge using the guncotton slabs, provided for the little girder bridge, to cut the stanchions underneath. As a precaution I would order up more ammonal to use as a pressure charge if the guncotton charges proved unsuccessful.

It was two o'clock in the afternoon before the explosive arrived and we were able to start work. By that time I had rested the men, collected my stores and ordered up the additional explosive, I had also been down the shafts into the piers. The shafts went down about 25 to 30 ft. and ended in what had once been a small chamber down below the high tide level at least, and probably going down nearer the low tide level. The chamber had however filled up to within about 3 ft. of the top with slimy sand ; the dimensions of the space were roughly as shown in Fig. 2.

The piers themselves were 30 to 35 ft. across and 16 ft. thick. I calculated that to blow the whole pier down I needed 500 lb. of explosive in each pier. I was carrying M.E. Vol. IV with me and on page 76, you will find an example which I took to be similar. As I had half a ton of ammonal I decided to put a quarter of a ton in each pier. The Corporal detailed a sapper to work at the bottom of the shaft—not a popular job—and we all lowered him down. The Corporal and one sapper carried on lowering explosive down the shaft, and the other eight men carried the explosive from the truck, a carry of about 200 yds. some of it up steep banking.

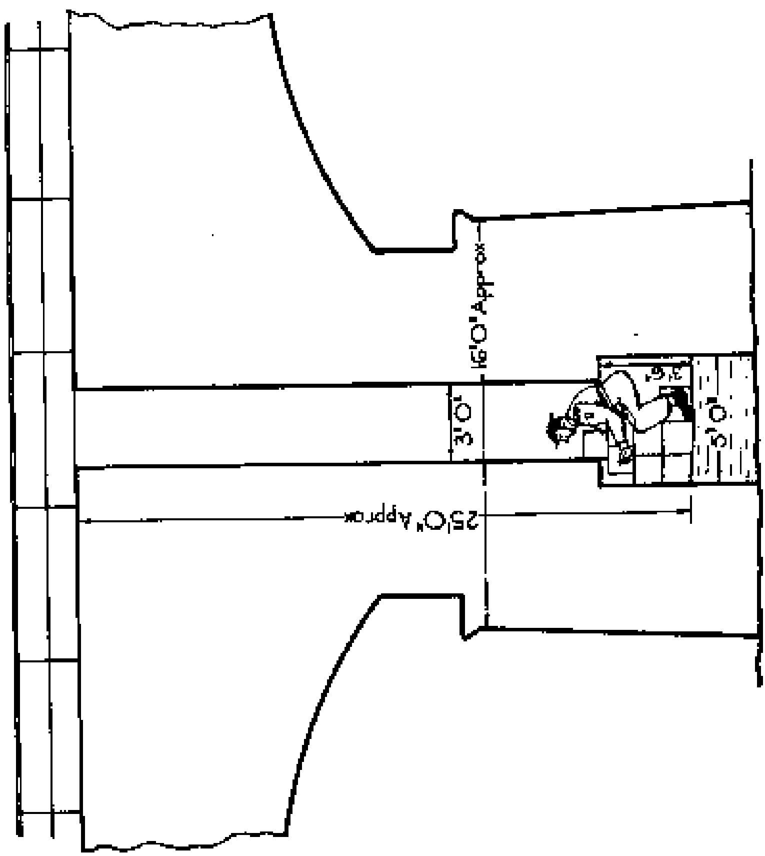
There was fortunately practically no traffic over the bridge to interfere with the work, I think the bomb damage in the station was holding up traffic, But the first interference we had came from the station master and the railway



SKETCH OF TELEGRAPH POLES ALONG THE SIDE OF THE BRIDGE

FIG: 3.

ETAPLES RAILWAY BRIDGE



SECTION OF PIER

FIG: 2.

workmen who tried to turn us off the bridge. I reasoned with them, explaining that we were only preparing the bridge for demolition in case it had to be blown; but I seem to remember I put two men on guard and I think it was the sight of the inevitable bayonet that eventually persuaded them to leave us alone.

The only serious interference with the work came from enemy raids on the railway station. The station adjoins the bridge, and we were working only 150 yds. from the centre of the target area. There was a dead French workman lying all day by the bridge where he fell; and it only shows how demoralized the people of Etaples were that no one even tried to move him all the time we were there. The men working on the bridge were exposed to bomb splinters and I told them when the raids were on, to run to the side, climb over the railings and hang on to some convenient telegraph wire supports (Fig. 3) fixed on to the sides of the bridge. Like that they were safe from bombs falling near and on the bridge, and if a bomb fell into the river on their side, it probably would not go off in the water and soft sandy bottom.

We had one big raid while I was on the bridge and in running for the telegraph poles, the sappers all came for the pole I went to. As a result there I was with four or five sappers all crowded on to the small metal pole and its supporting brackets. This particular raid was accompanied by a Henschel reconnaissance plane, and he was flying low over the station and the bridge. He must have seen us go for the pole and thought we were up to some peculiar trick, for he flew along not a hundred yards from us peering at us. I thought he was going to fire his machine gun at us, and I told the sappers if he did I was going to drop into the river and swim ashore. But he never fired, possibly he was short of ammunition or maybe he had a sense of humour, because we must have looked pretty funny all wound round a telegraph pole.

The raid lasted some time, and when we got back to the shaft, we found the sapper at the bottom was suffering from claustrophobia, so we had to pull him up. I went down next, and found the cases in a jumble, and not stacked in a neat pyramid as I had ordered. The sapper had probably been suffering from claustrophobia all the time. In the confined space, the tins of ammonal covered all the open floor area; so I had to stick my legs in round the sides in order to stand up, and there simply wasn't room to work properly. I did my best to tidy the pile up, by pulling tins out here and restacking them there to get proper contact between them. Then suddenly the sappers' heads disappeared from the top of the shaft, and the bridge began to shake. I lost my precarious balance, the tins shifted, and I found myself in such an awkward position that I could not move. My shoulder being below the ceiling of the chamber I could not get myself upright. It is not pleasant being in a hole at any time, but when you can't move, and your mates might get spirited away, leaving you there, it is not at all pleasant. I consoled myself as I had tried to console the other sapper with the thought that one could not wish for a better air-raid shelter.

The sappers eventually returned to the top of the hole and lowered the rope, with which I pulled myself upright. I stacked the rest of the cases myself, and then shouted up for F.I.D. and primers. Shouting up a long shaft your voice gets badly distorted, and the sappers had forgotten my brief lesson on demolitions. After a useless argument in which most of my language was indistinguishable, I yelled, "Lower everything down." They managed to make this out after I had yelled it several times, so everything was lowered down, except primers. I made several attempts to describe primers, but it was useless when only one word in eight was decipherable. So eventually I got them to pull me up.

the first grey light of dawn began to appear, about 0400 hrs., the deathly hush all about began to arouse my curiosity. Something must have happened to stop all the flow of refugees. I got up and went down on to the road and I heard someone running from the east along the road. Presently a very excited French poilu appeared and running up to me he broke into a torrent of hysterical French. The first thing I gathered from him was that he had a wife and four children, he supported this statement by producing photographs of them. The trouble apparently was, that the *Camion* in which he was travelling had broken down, and would I please mend it. There were thousands of Germans in Montreuil, he said, and they were advancing up northwards on Boulogne. I was very interested in this statement, because I thought something of this sort would happen, and I had recced the possibilities of evacuating my little party by fishing vessel from Etaples.

I reassured the old poilu that life in Etaples was not as bad as it looked, and that as there was nowhere to go he would be better off staying in Etaples, than joining refugee columns. In any case I had no facilities for mending his truck. So he wandered off into the town.

I had just got back to the bridge and was debating what to do, when Pierre suddenly arrived in his car. He was obviously very excited; he shouted at the top of his voice from a hundred yards away, "Make your two bangs and come back to Boulogne quickly." Then he jumped back into his car and dashed off.

This was not the sort of order I had expected for blowing the bridge, and I was very conscious of the fact that on a very flimsy order, I was blowing the main railway bridge to the south, which was not scheduled for demolition in the first place. Still I had made up my mind to blow the bridge so I went off to light the fuses.

I had allowed forty-five seconds extra safety fuse on the far pier, so I lighted the fuse whilst looking at the second hand of my watch. Then I ran to the nearer pier and waited for the full forty-five seconds from the lighting of the first charge. In my excitement I broke the match so I was a few seconds late lighting the second charge. I then ran and lay down under a railway truck on a siding near the bridge. I watched the seconds hand of my watch and was relieved to hear the first charge go off, and the second charge go off five seconds later.

I jumped up to look a bit too early, and was narrowly missed by a falling brick. But there was nothing to see, just a heavy cloud of thick dust that hung all round us like a pea soup fog. We started to move our belongings down to the truck and we were all ready to go and still the dust hung over the site. Eventually the sappers got restive to be gone on our way to Boulogne, but I had to report the damage anyway. And then at last in the first red rays of the morning sun I caught a glimpse of my handiwork. It was the most staggering sight I've ever seen, almost like a dream. I had expected to see the two piers missing and with them, the two arches on each side of them. But the whole bridge over the wet gap had gone. It was no more than a heap of rubble blocking the river. Out of the thirteen brick arches all the seven arches in the middle were gone and the others were cracked, and the one this end looked very precarious. On the far side a piece of railway track was sticking up in the air, but most of the track just lay across the gap on top of the rubble. In my excitement I jumped up and down like a small boy, and I could have stayed there hours drinking in every detail of this amazing spectacle. The strong tide at this part of the estuary had begun to sweep the debris away in parts, and I wondered how anyone would start to rebuild such a bridge on shifting sandbanks and with such a strong current. I was brought to my senses by the men shouting from the truck for me to get a move on. So reluctantly I turned away from the bridge and we started on our journey to Boulogne.

When I at last found the company again, near Boulogne, I reported the demolition to the O.C. He was busy with other things at the time, and did not attach much importance to my report. Obviously it was going to be of importance to someone so, as everything was very disorganized, I decided to go to G.H.Q. at Boulogne and report the demolition myself.

At G.H.Q. I found they did attach a great deal of importance to it, and I was ushered in to the General himself. I was covered in mud and slime from head to foot and I had a day's growth of beard on me, so I must have been a very scruffy looking object. But in spite of the fact that G.H.Q. had been bombed out twice, and that the General must have been working continuously all night, he treated me with the same courtesy as he would have treated a well-dressed visitor in his own drawing-room. "You've come to report a bridge demolished," he said. "Which one ?" "The railway bridge at Etaples," I said. "Who gave you the order to blow it ?" I had made up my mind to take the responsibility myself, so I said "I got no order, I was ordered to fall back to Boulogne, so, as I had prepared the bridge for demolition, I presumed I was to blow it." "I see," said the General. "And how long do you think it will take to rebuild it ?" You can imagine how I felt when he said that ; my head just reeled, and I thought I had committed some ghastly error which was going to prejudice the whole campaign. I felt that it was going to take years to rebuild the bridge for I had done my best to wreck it completely, and I had succeeded far beyond my expectations. At last I gasped out, "It will take a very long time, sir, all the middle arches are gone." "Oh ! " said the General. "Well it's going to be a job for the sappers rebuilding all these bridges when we want to use them again." Then he dismissed me and he said "Well done anyway," as I went out of the room. I didn't feel it was well done at all, and I thought that if he ever got wind of the extent to which I had departed from my orders, I was going to spend the rest of my days in the Tower. I was told to wait outside, and for half an hour I indulged in the most gloomy thoughts of the consequences of my action.

Then the Colonel of the night before turned up. "We'll have to go back and blow the road bridge," he said. "I'm going to get some more explosive, meet me here at 09.30 hrs. and we'll go back and blow the bridge." I felt there was a lot of rushing about going on, to very little purpose : better plan for the future than try to retrieve the past. In any case, in my opinion, the only damage we could do to the road bridge would be very temporary unless we could get a platoon of trained sappers. If we blew one span—the best we could hope for with pressure charges—it would leave an easily bridgeable gap : and if, as I believed, the Germans had crossed the river at Montreuil, the bridge had no immediate tactical importance. Still, orders are orders and it would be a good thing if we could wreck the road bridge; we might be lucky, you never know. I went off in search of food which I had difficulty in finding, and I returned at 09.30 hrs. sharp (instead of five minutes before time, as one is taught at the S.M.E.). The Colonel, I subsequently discovered, had turned up a few minutes before and, characteristically, he couldn't wait a minute, so he dashed off without me. I waited a whole hour and a half before my impatience got the better of me, then, feeling certain I'd missed him, I raced back to the company to collect explosive and safety fuse etc. The company had moved, so it was eventually about three hours later that I set off for Etaples.

About half-way there I saw two vehicles up on a hill to the left, crossing a field about a mile away. When I was about half a mile off I got very suspicious of them. I went on a few hundred yards closer and there was no mistaking their hostile nature. So I turned round and went back to a bridge about half a mile back, where a gunner Major was waiting with a French 75. "Has anyone gone down to Etaples to blow a bridge?" I asked. "Yes," he said consulting his notebook, "a Lieut.-Colonel, R.E., went down and has returned. He reported the railway bridge has been blown, and the concrete bridge is damaged." A very good effort on the part of the Colonel. I was very relieved he had got back, so my part in the demolition being over, I returned to the company.

Returning to Etaples six years later I found the place terribly changed from the flourishing little fishing village it was when I left it. Both bridges were missing, and that had much dwindled the town's assets. But the people were very friendly and gave me all the information they could. The following is a summary of the measures taken to rebuild the bridge: the information came from the S.N.C.F. engineering offices at Boulogne.

1. Early in 1941, after working for nearly a year, the Germans established a single-track bridge on piles. This was immediately broken by an R.A.F. raid; it was not very satisfactory anyway, owing to the tendency of the piles to shift in the sand. It was therefore, presumably, decided to build a more solid bridge. The Germans being rather sensitive about this failure placed a guard round the area, and the French engineers were allowed nowhere near it.

2. Early in 1943, after two years' work, a concrete bridge was completed. No traffic ran over it however, for in six heavy raids, the R.A.F. smashed it. This was a light bridge compared with the old structure, which was a more massive and nobler bridge.

3. In 1944, a single-track detour was made two kilometres upstream where the river is quite narrow and easily bridged.

4. In 1945, after the war, S.N.C.F. increased the detour to double track, and that is how the matter stands now. No plans to repair the old bridge have yet been made.

So the demolition achieved its object, and kept the main line cut for the greater part of the war. I don't think the R.A.F. in 1940 could have broken the old bridge by itself. But once the wound was made, it was the R.A.F. that kept it from healing. And during the main crisis of the war, when the Germans needed to concentrate quickly their material for the invasion of Britain, the use of that important main railway down the coast was denied them. It was certainly a great satisfaction to me to hear from the French railway engineers that I had caused the enemy an enormous amount of trouble and greatly increased the difficulties of rail transport in the Pas de Calais area.

TOURIST ON THE ALCAN HIGHWAY

By MAJOR J. M. GUYON, R.E.

THE loss of the American fleet at Pearl Harbour on 7th December, 1941, had far-flung consequences. One was that all coastwise shipping on the western seaboard of the American continent was now, theoretically at least, open to attack by the Japanese Navy. A second was the sudden creation of a very real threat to the American mainland via the Aleutian chain of islands, and in fact the Japanese got more than a footing there before they were dislodged. There were two other reasons why it was important to hold and develop the Canadian North-West ; Lend-Lease fighter aircraft for Russia in large numbers were being ferried over a chain of airfields, which eventually crossed the Bering Strait ; without a fleet in being, the shortest " land " route for a counter-offensive against the Japanese homeland lay through the North-West and down the Aleutian chain.

Apart from a few winter trails used by trappers and prospectors when the ground was frozen hard, and a few small strips used by bush pilots supplying small mining enterprises, the main communications in Yukon and Alaska were by sea and by river for the three or four months when these were ice-free. Narrow gauge railways ran from Skagway on the North Pacific to Whitehorse in the Yukon, and from Anchorage on the North Pacific to Fairbanks in Alaska. The Continental broad-gauge stopped at Dawson Creek, 1,000 miles from the Alaska border, which was also roadhead for normal wheeled traffic.

From these compelling considerations of war sprang a group of large-scale engineering projects, of which the three main and inter-related schemes were the North-West Air Staging Route to Russia, the Alcan Highway (Alaska/Canada abbreviated) and the Canol Oil Project.

The North-West Air Staging Route called for a chain of airfields, connected by radio beams, from the factories in the United States up to the delivery points where Russian Ferry pilots took over at Fairbanks and Nome, with a series of emergency strips between.

The Canol Oil Project involved sinking new wells to a field discovered in 1920, at Norman Wells on the Mackenzie River, pumping the crude oil over 600 miles of virgin territory to a refinery at Whitehorse, then distributing the spirit by pipeline to the ports and airfields and to transport using the Highway.

The Alcan Highway called for a class 70 road, 20 ft. wide, from the Continental highway system to Fairbanks, which should link the airfields and also carry a three-pair telegraph line with repeaters every hundred miles.

Thus there would eventually be a strong spine through the whole of the territory, from which large-scale offensive or defensive operations could be launched, under the protection from the sea of an almost continuous coastal mountain range.

Construction started from four headings in March, 1942, inwards from Dawson Creek and Fairbanks and outwards from Whitehorse in both directions. Winter trails of one sort or another already existed over about one third of the length, and the "tote road", or path of the leading bulldozer, tended to follow these where they existed. The " design line " for the finished road had been worked out by the American Highways Department, a U.S. Civil organization, but it became clear after fifty to sixty miles had been built, that strict adherence to the design line was going to be too slow, and so the finished highway suffers from being an obvious compromise in places between the design line and the "tote" road. Sixteen hundred miles of highway were driven in eight months by American engineers and Canadian contractors, with a total labour force which reached the 30,000 mark—good going by any standard. The Canadian section of the highway was bought by Canada as a going concern and handed over to the Canadian Army to maintain.

The maintenance organization is headed by a serving Canadian Sapper Brigadier, with Headquarters in Whitehorse, where are also the main installations connected with the year-round operation of the highway—hospital, workshops, supply depot, base stores etc. Spread along the highway at about hundred mile intervals are maintenance camps staffed by civilians responsible for routine upkeep. Local resources are limited to firewood and water; everything else that they require to support life and do their work must reach them along the highway. They have their families with them; costs of living are high on account of freight charges for the enormous distances, but so are wages. For the most part they are fit and contented, and the biggest administrative problem is to keep them so.

Superimposed on the whole road is a unique unit known as a "Road Maintenance Company, Royal Canadian Engineers" which undertakes major realignment and major bridge reconstruction. This unit is entirely military, and provides a first-class training machine for young Engineer officers and soldiers in road problems in the sub-arctic.

Here, as everywhere, the highway engineer's main problem is water, but here he has to deal not only with the liquid, but with frost in the ground which never thaws ("Permafrost"), frost which breaks up the subgrade, ice which creeps over the highway, ice building up against embankments and pushing them over, ice-floes in the spring thaw which batter his bridges, snow as fine and dry as granulated sugar which builds impassable drifts in a matter of minutes in a high wind, and two big floods every year—one at the spring thaw in early May, and a second when the high snows melt in July. Add to this that there is little or no vegetation to bind the soil, which is mainly glacial silt and volcanic ash, and you have a very pretty series of scour problems. Keeping the highway open is a full-time job. In places the highway runs over muskeg swamp, similar in consistency to a peat bog: this also has problems peculiarly its own.

From October to April all is frozen solid; the surface is kept graded down to about two inches of hard packed snow cover and a cruising speed of 50 m.p.h. is possible. All vehicles using the road are fitted with double-windows, windshield defrosters, and interior heaters. The odd blizzard may drift the snow up, but this is soon cleared by a rotary snow-plough which screws its way into the drift like a mincing machine and flings the snow through a nozzle thirty or forty feet clear of the road, followed by graders to re-smooth the surface. With only three to four hours daylight in midwinter, much of this work must be done by floodlight.

In early spring the troubles begin. With all bridges and culverts still frozen solid, the sun melts a little ice and snow on the exposed slopes: the water trickles down towards the road, meets ice in the shaded ditch and freezes again, setting solid the following night. The next day a little more comes down, flows stickily over the top of the ice and freezes again. So you may get ice building up feet above the highway and running across it, blocking traffic, while ice pressure may move the whole bank sideways. The ice on the highway must be melted off by heat, usually from a fire lit on top, blow-lamp, or steam jet. The pressure at the bottom of a considerable mass of ice is usually sufficient to liquefy the bottom layer, and unless this can be run off it will seep into the foundations of the road and soften them. So culverts and bridges have to be steamed open and kept open. Culverts are now being fitted with steam pipes which are dried and plugged in autumn. To melt out a channel the pipe is unplugged and steam blown through, whose heat melts a water channel through the ice. As soon as the flow is steady and appreciable, it becomes sufficient to maintain itself and not freeze up again.

Many galvanized iron culvert pipes were originally put in. The winter frost causes the subgrade to heave, and so many culverts are buckled and leak, eventually causing a complete washout. All such culverts are in process of replacement by monobloc timber culverts made in one piece, of box or barrel-section. These " give " to the " heaving " of the frost and swell up to seal leaks as soon as the flow starts. Such a culvert is put in by three men in about thirty minutes using an excavator and a crane, provided no rock is encountered. Many new culverts must be added each season as streams shift their courses and unusually rapid thaws bring down more water. Calculation of culvert area is nearly impossible, as maps are poor and precipitation data incomplete, and the thaw pattern varies from year to year. It is a matter of hard experience.

The further advance of the spring thaw causes every stream and gully to run with flood water and the ice in the main rivers to break up and go out. This is probably the severest testing time for the side-ditches and culverts, as the whole countryside down near the road is running with melting snow. Minor washouts are frequent and the maintenance camps are at full stretch. The ice in the rivers is first white and solid with snow on top. When the top layer thaws in the sun and freezes again at night, it turns a sinister blue-green. When the ice starts to rot and get water into it, it turns black and is then ready to break up. In a gradual thaw it honeycombs vertically and crumbles at the edge into cigar-shaped fragments which float and lie on the surface and do little harm. In a sudden thaw however the rivers rise and run very fast carrying large floes which may smash a bridge. At the Donjek River in May, 1946, the writer saw lumps of ice the size of dining-room tables travelling at 10 to 12 m.p.h. in the coffee coloured flood. Every so often one would hit the piles of a bridge and cause the whole structure to tremble. Piles are frequently sheared clean through. The spring thaw also brings down entire uprooted spruce trees. At all river crossings at this time there is the danger of ice and driftwood forming a jam against the bridge—particularly a short-span pile bridge, of which the highway was made and of which many still remain. If such a jam is not quickly cleared with axe and explosive, it builds up with terrifying rapidity and takes the whole bridge out. The only remedy is adequate waterway with long steel spans on slender reinforced concrete piers. This is slowly being achieved.

The spring thaw also indicates the current season's scour problems, which must be attended to before the July floods. Nearly all rivers here are of glacial origin, and run in a bed, one to three miles wide, within which the channels change from month to month. The original choice of a crossing place has sometimes been justified by events and sometimes not. The Slims River (Mile 1055) runs in a single channel, 200 ft. wide in a bed about one and a half miles across. When the writer saw it, it was trying to go through the bank well to the west of the bridge, and was being held by sheet piling. The bridge is on piles which were driven 90 ft. into glacial silt without finding firm bottom. They are held by skin-friction alone, and as a result the bridge deck " waves." The Donjek river (Mile 1130) runs in seven channels in a bed about a mile wide. In 1946, before the bridges could be steamed open and held open, the ice built up 3 ft. above the highway level on the upstream side, and pushed the bank on which the highway rests several feet downstream. It is planned to put three 200-ft. steel spans over the main channel this year. The difficulty is to know which is going to be the main channel! From the ground it looked as though the main ice accumulation was above Channel 1, though flying over a couple of days later it looked as though Channel 7 would continue to carry the main run-off.

Everything up here is bone-dry and the fire risk is very serious. In thirty-six hours spent in the neighbourhood of Ladd Field, Fairbanks, Alaska the writer saw the fire engines turned out no fewer than three times.

The main problem in early summer is keeping the gravel surface on the highway and keeping the dust down. The former is done by continuous auto-patrolling, scraping the gravel back from the edges, where it is flung by the traffic, to the centre. To the latter no answer has yet been found. It is a finely-divided "face-powder" dust, similar to that found in the Western Desert of Egypt, and penetrates eyes, ears, nose, and throat and clings tenaciously. It is necessary to keep about one mile between vehicles, and even then one gets the dust of traffic going the other way.

Most of the muskeg swamps thaw out and some cause trouble. There are various ways of treating muskeg. One is to cut ample ditches ten feet back from the grade and lead them right out to a good run-off. This will let the bank dry out and solidify, during which it may contract as much as sixty per cent. If drainage is impossible, a double corduroy of logs as a foundation will usually hold the road up. Where there is permafrost near the surface it can sometimes be encouraged, by insulating with moss, to come up into the subgrade and hold it set like concrete. It is a mistake to try and ditch in a permafrost area, as it renders it softer than it was before by assisting thawing.

The big problem of the year comes in July when the high snows melt. This affects the main rivers and their bridges rather than the culverts. A 10ft. rise in the level of all rivers is normal, and it may reach 20 ft. and sometimes 30 ft. with a racing current and plenty of driftwood. This places a tremendous strain on the bridges, both directly and through scour round the piers and abutments, and behind the abutments. Scour is countered by sheet piling, spruce logs dogged together, and walls of quarried rock. Even in spite of all precautions, it is a lucky year when something does not go.

In October winter closes down again.

The Alcan highway is at present a strategic road pure and simple. No considerable volume of traffic passes over it from end to end. Along its length is not to be found a single hotel or petrol filling station dedicated to civilian needs. The odd prospector wishing to drive the highway in search of gold is subjected to a rigid inspection at the Rear Headquarters of the North-West Highway System in Edmonton for roadworthiness of his vehicle and arctic survival kit, before he is turned loose. Many come to grief, and become a burden on the overloaded road maintenance system. There are no rich farmlands here—the growing season is too short, and many things will not grow at all. The great mineral wealth of the North-West can only be opened up in the three or four warm months, and fur must be sought far from the highway. The road therefore seems unlikely ever to become an economic proposition, and, if UNO succeeds, may well revert to the wilderness from which it was hewn.

Note—Since the closing words above were written, the writer learns that half a dozen hotels are already under construction along the length of the highway, with filling stations to match. The enterprising pioneering spirit of Canada clearly lives on—good luck to them!

LIGHT ALLOYS

By R. P. HAINES, A.M.I.C.E., A.M.I.STRUCT.E., E.-IN-C. DEPT., WAR OFFICE

ALUMINIUM alloys have served useful engineering purposes during the War and indeed modern development in the strength properties of this metal together with the expansion of the industry is claiming for it increasing recognition as an alternative to steel and other materials for certain structural and general engineering purposes.

In the early days of its production, aluminium was regarded as a precious metal and was employed in the pure unalloyed soft condition for making ornaments and jewellery. The advent of the aeroplane, however, created a demand for materials of high strength weight ratio and led to the development of the special aluminium alloys which possessed this quality to a marked degree and outrivalled the specially selected timbers in this field. The multiplicity of standard specifications produced to satisfy the requirements of the aircraft industry is somewhat overwhelming and for the purpose of ordinary structural work a very reduced range is required. On the Continent and in the United States great attention has been paid to the use of certain of the alloys in structural engineering and investigation in this country on the wider use of a short list of alloys is now in progress.

FACTORS GOVERNING THE ECONOMICAL USE OF ALUMINIUM ALLOYS

The outstanding property of aluminium alloys as compared with other metals is their exceptional high strength in relation to their low weight. On the other hand the material is costly and its choice in a structure can only usually be justified if the weight saving results in economies elsewhere

Aluminium alloys are only about one third the weight of steel, being 170 lb. per cu. ft. compared with steel at 489 lb. per cu. ft. The best heat-treated alloys have ultimate tensile strengths in the region of 32 tons per sq. in. and compare extremely favourably with mild steel at 28-32 tons and high tensile structural steel at around 40 tons per sq. in. or a little better. The other stresses bear relationships of roughly the same order.

On the face of it, assuming the use of an alloy with a working stress equivalent to mild steel, a weight saving of sixty-six per cent should be possible over a steel structure of equivalent strength. In practice a figure of between fifty per cent and fifty-five per cent is the best that will be realized. This divergency is mainly due to the low value of Young's Modulus of Elasticity which averages about 10,000,000 lb. sq. in. as against 30,000,000 for steel, thus involving three times the strain or deflection in a loaded member compared with a steel member subject to the same stress.

In beams, although not in all cases essential, quite often it will be necessary to counteract the excessive deflection by increasing the moment of inertia of the alloy section.

The moment of inertia I is approximately proportional to the area of the flanges and the square of the depth. Therefore in order to restrict the deflection of a light alloy beam to that of a steel beam it would be necessary to increase the flange area to three times that of the steel or alternatively to increase the depth by seventy per cent ($1{\cdot}7^2 = 3$ nearly). Using a combination of the two an increase of thirty-three per cent in the flange areas in conjunction with a fifty per cent increase in depth over the steel beam would provide equal deflection, the resulting section showing about a fifty per cent saving in weight over the steel. Obviously if deflection is the criterion no advantage exists in using the higher strength alloys as the stronger section already dictated by deflection considerations will provide the necessary resisting moment to bending using a lower strength alloy. Thus a section whose flange area and depth is increased as above to give a moment of inertia of three times the steel section which it replaces will have its section modulus automatically doubled thereby $\left(Z = \frac{3I}{1.5y} = 2\frac{I}{y}\right)$. In this case an aluminium alloy with a greater ultimate stress than 16 tons per sq. in. would be unnecessary if compared with mild steel.

For members functioning as ties the full weight saving of sixty-six per cent would be realized.

For struts where the load capacity, at least for slender columns with a high value of L/K, is a function of the elastic modulus the saving in weight would average out in the region of forty-five per cent.

Thus if an aluminium alloy of the same strength as steel is used an overall saving on a complete structure of around fifty per cent is a fairly realistic figure. The exact figure will of course depend on the relative proportions of the different types of member in the structure.

The foregoing comparison not only assumes that the two metals are of equal strength but that they are called upon to take equal load, whereas in fact the light alloy would gain an advantage on account of its lower self-weight which would permit a further additional cut in the sections. The amount of this would depend on what proportion of the total stress was due to the live or pay load and what proportion was due to the structure's self-weight.

To illustrate this, the self-weight of a steel bridge may account for from twenty per cent up to eighty per cent of the total stress, so that taking the higher figure of eighty per cent a fifty per cent saving in the bridge weight would reduce the total load to be carried to $100 - \frac{80}{2} = 60$ per cent of that to be supported by the steel construction. A further saving of around twenty per cent might reasonably be effected showing a total weight saving of about eighty per cent for the structure fabricated in aluminium alloy as compared with steel. This weight saving will also result in reductions in the supporting piers and abutments.

The type of static structure which lends itself to the use of light alloy is, therefore, one whose self weight is appreciable as compared with its load capacity. Also, especially where such structures are of a portable nature, the weight saving can be reflected in further economies in handling, transport and erection.

With mechanical equipment and gantry cranes the use of light alloy for such items as dragline booms, excavator buckets, etc, will result in increased running efficiency, which in the course of the life of the equipment can justify the higher first cost.

The production of the higher strength alloys with the exacting heat treatment required is costly and the cost of sections will be of the order of six to ten times that of rolled steel when based on weight. The cost of fabrication would not be in the same ratio although for obvious reasons more fabrication will be involved on a ton of aluminium alloy than a ton of steel.

In the example shown above the bridge structure itself might be expected to cost roughly one and a half times that of an equivalent steel construction. For lower weight capacity ratios the comparison would be less favourable. Lower handling and erection costs would however operate to make the figures more competitive.

Magnesium Alloys

Some mention here should be given to these alloys which, consisting of from ninety to ninety-eight per cent magnesium alloyed with small quantities of manganese, zinc or aluminium, are the lightest structural metals, although not as suitable as the aluminium alloys for fabricated structural work. At 116 lb. per cu. ft. they are sixty-eight per cent the weight of the aluminium alloys, and it is on account of this extremely light weight that they have received recognition for certain classes of work.

The ultimate tensile strength of the best wrought alloy is of the order of twenty tons per sq. in. giving a strength weight ratio nearly comparable with the aluminium alloys with an ultimate tensile strength of thirty-two tons per sq. in.

Their resistance to corrosion is about equal to that of structural steel and inferior to aluminium alloy. In addition their thermal expansion is in the region of two and a quarter times that of steel.

They also suffer from a low shear resistance and have rather low compressive proof stresses (7 to 14 tons per sq. in.), and an elastic modulus, which at 6,700,000 lb. per sq. in., leads to deflections of four and a half times that of steel.

On account of these unfavourable features and the tendency to work harden when cold formed, in addition to the slightly higher cost, wrought magnesium alloys seem unlikely to have wide application for fabricated structures.

The mechanical properties of cast magnesium alloys with ultimate tensile strengths of up to seventeen tons per sq. in. are, however, comparable with the high strength aluminium alloy castings and it is in this field where their light weight to strength can be exploited to advantage that the maximum development has taken place and the bulk of production directed.

It is, however, with the aluminium alloys that the structural engineer will be principally concerned.

Production

Aluminium is contained in all clays and is present in the earth's crust in quantities exceeding that of iron. The chief source of the mineral, however, is from bauxite, a claylike mineral consisting of hydrated aluminium oxide from which pure aluminium can be won in sufficiently high percentages to make its extraction a commercial proposition. Deposits of bauxite are found near the surface and after removal of the overburden are mined in open excavation.

The earthy substances associated with the ore are mechanically removed by washing after which the residual impurities are removed by reducing the aluminium oxide to a solution in hot caustic soda in which it is soluble. This last treatment leaves the impurities separated out of the solution as solids, thus facilitating their removal. The aluminium hydrate is reclaimed from the solution and calcined to a powdered aluminium oxide.

Finally pure aluminium is produced by an electrolytic refining process whereby the aluminium oxide is melted with an electrolyte and reduced to pure aluminium by the passage of a current through the bath of metal which causes the aluminium to collect in a molten layer at the bottom. The alloying elements are added to the metal by a separate melting process after which it is cast into ingots or billets.

Approximately four tons of bauxite will produce two tons of aluminium oxide which reduces to one ton of pure aluminium.

Due to the method of refining used, successful commercial manufacture will depend on the availability of cheap power and this factor is more important than the accessibility of the ore in dictating the areas of production.

Aluminium can be cast, forged, stamped, rolled or extruded. The latter process is used in the manufacture of sections, so that a greater choice of shapes is possible than with rolled steel. For instance, hollow sections impossible to produce by the rolling process can easily be extruded.

The extrusion process is a single operation and merely consists of forcing the metal, when in a hot state, to flow through a die of the requisite shape and subsequently allowing it to cool to room temperature. For the operation a billet is preheated and loaded into the container of the extrusion press. It is then brought up against and forced through a die fitted at one end by a powerful ram operating at the other.

Since the special tools required for extrusion are comparatively cheap the range of shapes is not limited to standard sections as is dictated by the expensive stepped rolls necessary in processing steel. However a list of sections that have become standardized by usage in the various branches of engineering has been published by the British Standards Institution under British Specification 1161.

A physical limitation is imposed in extrusion and the largest sections at presented marketed must be contained in a circle of 14 in. diameter. This factor which restricts the largest joist section to 12 in. by 6 in. means that built up sections will have to be resorted to to a much larger extent than is necessary with steel where rolled steel joists of up to 24 in. depth are standard manufacture and up to 36 in. will, in the future, be a quite common supply.

Aluminium alloy sheets are rolled from preheated billets to a maximum thickness of ¼ in. and to a maximum size of 4 ft. by 18 ft. or 6 ft. by 14 ft. Generally beam work will therefore be of latticed construction rather than solid web.

Castings are normally appreciably lower in strength than the wrought alloys (extrusions and rollings). They are cast in sand or dies in the normal way except that risers are provided on a rather more generous scale than for cast iron, to ensure soundness.

Heat Treatment

Pure aluminium is comparatively soft and of poor strength and the higher strength qualities can only be induced by the addition of small quantities of suitable alloying elements and by subsequent heat treatment or strain hardening after manufacture of the section. The addition of the alloys has little effect on the weight of the metal which in the case of wrought alloys will contain ninety per cent or more of pure aluminium.

Aluminium alloys are divided into two groups. Those that are non heat-treatable and rely for their strength properties on strain hardening by cold working and those that rely for their high performance on heat treatment. The best of the former group give maximum ultimate tensile strengths in the region of twenty-three tons per sq. in. as compared with thirty-two tons per sq. in. for the heat treated alloys.

Uncontrolled reheating after heat treatment in forming or welding during fabrication will result in a loss of strength, reducing the alloy to its soft or un-heat-treated condition and as the metal can only regain its original strength by further heat treatment, which may result in undesirable distortion of the manufactured member, reheating is to be avoided.

For an appreciation of the effect of these factors it should be noted that whereas pure aluminium has a tensile strength of from five to six tons per sq. in., the addition of suitable alloys can increase the strength to the region of fifteen tons per sq. in. in the annealed condition. The strength is further improved to about twenty-six tons per sq. in. after solution heat treatment and reaches a maximum tenacity, after artificial ageing, of thirty-two tons per sq. in. or thereabouts depending on the alloying elements used.

The heat treatment consists of raising the temperature of the metal to a specified point, usually around 500 degrees C., and then rapidly quenching it so that the constituents taken into solution at high temperature are maintained in solid solution when cooled.

Aluminium alloys have the peculiar property of natural age hardening which further improves their mechanical properties and this natural process is assisted with some alloys by low temperature heating after the solution treatment.

It is with the high tensile heat treated alloys that the structural engineer is principally concerned although for certain purpose where high corrosion resistance is required the work hardened type, which have a rather better performance against corrosion, may be preferred. The natural resistance to corrosion can be further improved on rollings by the application of a thin coating of pure aluminium prior to the rolling operation.

Structural steels generally are used in the " as rolled " condition and do not rely on heat treatment for their strength properties, this then is one of the main points of difference between them and the high tensile alloys.

Built-up sections in the higher strength aluminium alloys will therefore usually be riveted to avoid the loss of strength occasioned by the annealing effect of welding.

Atmospheric Corrosion

Aluminium alloys have a satisfactory performance under the action of atmospheric corrosion to which they are more resistant than steels. The metal is naturally protected by the formation of a strong thin adherent oxide film which once formed serves to protect the surface against further attack. The maintenance against the effects of atmosphere is therefore less than that required for steel although when embedded in cement, or plaster which is damp, a protective coating is required to prevent attack. It can be argued that the adoption of a minimum thickness of metal, usually ¼ in. with steel, to allow for reduction of section due to corrosion, is not as essential when using aluminium alloys.

For greater corrosion resisting properties the natural oxide film can be artificially thickened by a process called anodizing. In this process additional oxygen is caused to combine with the surface aluminium by electrolytic action in which the aluminium forms the anode of the cell. On rollings, a thin coating of pure aluminium can be added to enhance the corrosion resistance. Despite the good performance against corrosion of the aluminium alloys, painting of structural work in these metals is always recommended. The preparatory work required will be less than with steel, laborious scraping and wire brushing is unnecessary, the only preparation required being a simple treatment of the surface to ensure sound adhesion of the paint.

For marine use the lower strength non-heat-treated alloys give the better performance in withstanding the action of sea water.

Electrolytic Action

When dissimilar metals are in association with an electrolyte such as water the tendency is for a current to flow between the lower potential metal, the anode, and the higher potential, the cathode, causing the anode to be eaten away and deposited on the cathode. This is illustrated in the simple voltaic cell and is the principal upon which electroplating is based.

Pure aluminium has a lower potential than most other metals and when in contact with them in the presence of moisture will suffer preferential attack under electrolytic action unless the meeting surfaces are insulated by an unbroken protective coating.

Aluminium alloys are not so subject to attack and very little action takes place between aluminium alloys and stainless, and to a lesser degree, mild steels, but direct contact with dissimilar metals should be avoided wherever possible to avoid the possibilities of corrosion.

Mechanical Properties

A great number of standard specifications for light alloys exist, devised principally for aircraft construction, but a short list of the aluminium alloys most suitable for application to structural engineering is in course of preparation.

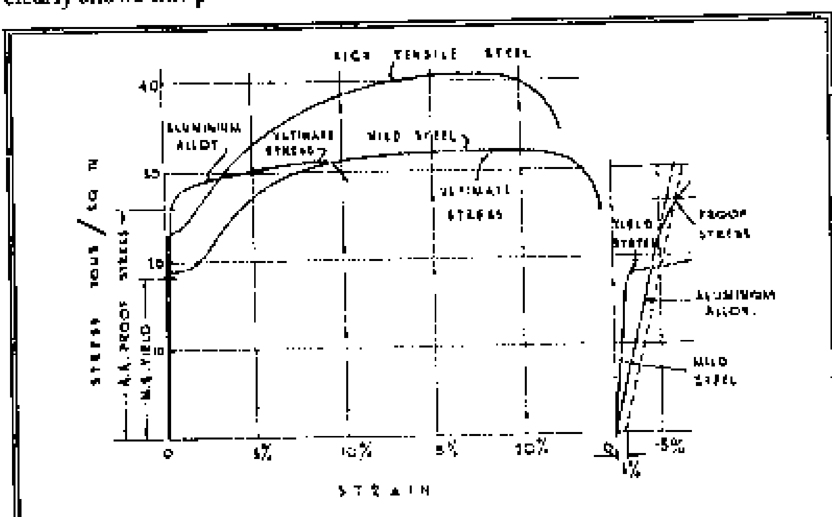
For comparative purposes the table below gives the specified minimum mechanical properties of a representative group of alloys suitable for use in structures and the comparable values for mild and high tensile structural steels. Non heat-treated as well as heat treated alloys have been included to illustrate the range of strength.

Type and Condition of Material	Material Specification	Proprietary Name	·1% proof stress tons per sq. in.	ultimate tensile stress tons per sq. in.	Elongation % on 2 in. gauge length
Extrusion (Non heat-treated)	BSS. 144		–	11	18
,,	DTD.297	M.G.7(soft)	8	20	16
Extrusion (heat-treated)	BSS.6 L 1	Noral 17 S, Duralumin B	15	25	15
,,	DTD.364	Duralumin S	26	30	8
,,	DTD.363A	Noral C 77s RR 88	33	38	8
Sheet and Plate (Non heat-treated)	BSS.146	Noral 4 S Hirmabright H Hinduminium	–	11	18
,,	DTD.182A	M.G.7	10 (approx.)	20–23	20
Sheet and Plate (heat-treated)	DTD.603B	Duralumin S	16	26	15
,,	DTD.646B	Duralumin S	23	28	8
Rivets (Non heat-treated)	DTD.303	M.G.5	9 (approx.)	16–21	–
Rivets (heated-treated)	DTD.327	Noral 16 S, Duralumin M	10	17	22
,,	BSS.2L37	Noral 17 S, Duralumin B	–	25	–
Mild Structural Steel	BSS.15		Yield Point 18½ (approx)	Limiting Range 28–33	24 (approx)
High Tensile Steel	BSS.548		19–23 (approx.)	37–43	22 (approx.)

More experience has been gained with DTD 364 during the period of the War than with the stronger and more recently developed alloys, and it may therefore be favoured until confirmatory evidence is available on the behaviour of the newer types.

It can be seen that this alloy has an ultimate strength about the same as mild steel. It can be argued that a higher working stress is justified with the heat treated alloys owing to the fact that no definite yield point occurs as does with steel and the proof stress, which approximates to the yield in steels, is much nearer the ultimate stress of the metal. If the safe working stress follows the usual practice of being fixed as a percentage of the ultimate then a greater factor of safety obtains since deformation of a structure commences only when stresses are raised to the neighbourhood of the yield and on this value a larger margin exists.

If working stresses for DTD 364 and Mild Steel are assumed as nine tons per sq. in. it is apparent that the former, with a proof stress of twenty-six tons per sq. in. is in a much more favourable position than the latter with a yield of eighteen and a half tons per sq. in. The following stress strain diagram clearly shows this point :—



COMPARATIVE TYPICAL STRESS DIAGRAM

The following comparison of the approximate strength characteristics of DTD 364 and mild steel gives a rough guide as to the stress relation :—

Material	Condition	Tension			Compression		Shear		hardness number	Young's Modulus E.
		·1% proof stress	ultimate stress	Elongation	·1% proof stress	ultimate stress	·1% proof stress	ultimate stress		
		Stresses in tons per sq. in.								
DTD.364	heat treated	26	30	10	27	30	15	18	145	10,300,000
M.S.	as rolled	18½	30	25	19	30	12	18	130	30,000,000

The quality of high strain to stress and the consequent increased resilience or ability to absorb energy renders the material particularly favourable in resisting impact forces.

Fabrication

Aluminium alloys do not present any difficulties in machining and present a finished clean neat appearance with a good surface but some modification may be desirable with cutting tools and a higher speed is possible than with steel. Holes should not be punched but either drilled full diameter or punched under size and reamed out to avoid upsetting the surrounding metal. Flame-cutting is not suitable nor is smithing recommended owing to the difficulty of proper temperature control.

Due to the high elasticity of the material cold forming and bending are not easy owing to the tendency of the work to spring back, and, in the case of the natural ageing alloys, this operation is best done immediately after the solution heat treatment and before ageing has operated to harden the metal. However, the artificially aged alloys will be more favoured on account of their higher working stresses and these will usually be preferred delivered in the fully heat treated condition to avoid the necessity of installing expensive furnaces and introducing special operations in the assembly shops. For this reason design in aluminium alloy will normally avoid details which involve forming wherever possible or alternatively a softer alloy will be preferred and the lower allowable stresses associated with them accepted.

Generally the lighter weight of the construction will permit the prefabrication of larger assemblies in the shops and result in economies in the erection due to the smaller number of site connexions. Connexions can be made by welding, bolting or riveting the later operation carried out with steel or aluminium alloy rivets being the most favoured. The smaller size aluminium rivets can be driven cold and can consequently be of a higher strength alloy than the larger hot driven rivets which must of necessity be in the soft condition when cooled after driving.

Hot driven rivets do not affect the surrounding metal but this cannot be said of welding which undoes the heat treatment in the vicinity of the weld to reduce the strength of the metal to the soft condition. Welding, therefore, is usually inadmissible unless restricted to the lower stressed portions of members.

Transportation

A light alloy structure may be only half the weight of the comparable steel structure though in most cases it will be of greater total bulk with longer individual assemblies. The much higher bulk weight ratio, possibly of the order of three to one as compared with steel, should not affect normal lorry loading in which weight will nearly always be the criterion and an economy in transport of about fifty per cent is a possibility. This factor is particularly important where long hauls are involved or in the cases of mechanical equipment and portable constructions where the effect can be accumulative.

Shipment will be more expensive on transport since shipping freight for structural parts is quite often more dependent on the volume than the weight.

The larger units possible with light alloy will effect economies in the handling times and costs, or alternatively the use of smaller units comparable with steel can permit the use of smaller capacity loading and erection aids.

Thermal Properties

The coefficient of expansion, 0.000023 per unit length per degree centigrade, is about twice that of steel 0.000012 degrees centigrade and where structures are subject to a wide range of temperature greater attention will need to be paid to temperature stresses or provision made to minimize their effect by the inclusion of adequate expansion joints. Although temperature stresses are more likely to be set up in aluminium alloy structures than in steel, their effect is not so marked since a larger movement can take place without overstress. Stress = E × strain, so that comparing a light alloy structure with a similar structure in steel under the same temperature variation light alloy would give stress f = 10,300,000 × 0.000023 (L. t°) or f = 237L t° against steel f = 30,000,000 × 0.000012 (L. t°) or f = 360L t°, so that the stress will be only 2/3 of that induced in the steel.

This high expansion has an unfavourable effect in welding where the local heating in the region of the deposited weld metal tends to cause distortion and possibly cracking unless the work is adequately held in jigs during the operation.

Examples of Aluminium Alloy Construction

The following example of a recent work carried out in the United States gives an indication of the weight-saving that can be realized. The structure, an all aluminium alloy railway deck girder, bridge span, was constructed over the Grasse River near Massena, N.Y., and showed a weight saving of fifty-eight per cent over a comparable girder span in steel. The fabrication was carried out in high strength alloy with an ultimate tensile strength of thirty tons per sq. in. and an ultimate shear strength of 18.75 tons per sq. in., the respective working stresses adopted being 9.4 and 5.6 tons per sq. in.

The rivets used were 7/8 dia., the bulk being driven cold by pneumatic squeeze riveter. The cold driven rivets had an ultimate shear stress of 14.75 tons per sq. in. and working stress of 4.5 and the hot driven rivets an ultimate shear stress 10.7 tons per sq. in., working stress 3.6.

An example of the use of small extrusions and sheet in meeting the present urgent demand for rapid house production is demonstrated in the mass produced prefabricated aluminium house made in four units, the bathroom/living-room/kitchen unit which is illustrated. (See Photo 6.)

One of the earliest applications of the use of light alloy is that of the Smithfield Street Bridge at Pittsburgh. The substitution of aluminium alloy for the existing wrought iron deck in this bridge enabled a weight saving of one ton per foot run to be made and thus permitted the bridge, which would have otherwise needed total replacement, to compete successfully with heavier modern traffic.

The Supply Problem

As compared with steel the world production of aluminium is small. Adequate supplies of bauxite exist and methods whereby the extraction of aluminium from common clay can be operated commercially may be a future development.

During the past war the bulk of available supplies was diverted to the construction of aircraft. In times of emergency manufacturing capacity might be expected to impose a severe limitation on the widespread use of the material for other constructional purposes in which its peculiar properties are not so vital. However, the saving in manpower and machines effected by the reduced weight for handling and overland transport is an attraction which might challenge the higher initial price of the material for certain equipments, although, of course, availability will always be the over-riding factor.

In conclusion a great deal of literature has been written on the subject of aluminium alloys to which the author has referred in compiling these notes. No special originality is claimed for this article which merely attempts, in a condensed form, to present the possibilities of the material for use in constructional work.

Acknowledgment is made to the Aluminium Development Association for their assistance in making available the various photographs used to illustrate this paper.

Photo 1.—Bauxite mines in British Guiana.

By courtesy of Aluminium Union L

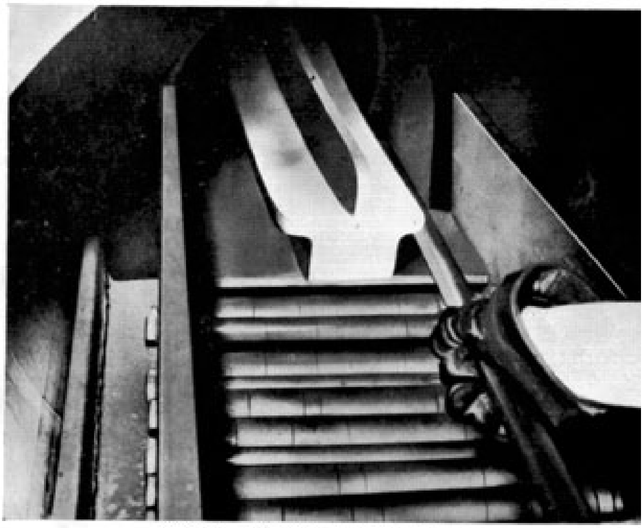


Photo 2.—Extrusion coming from the press.

Light Alloys 1 & 2

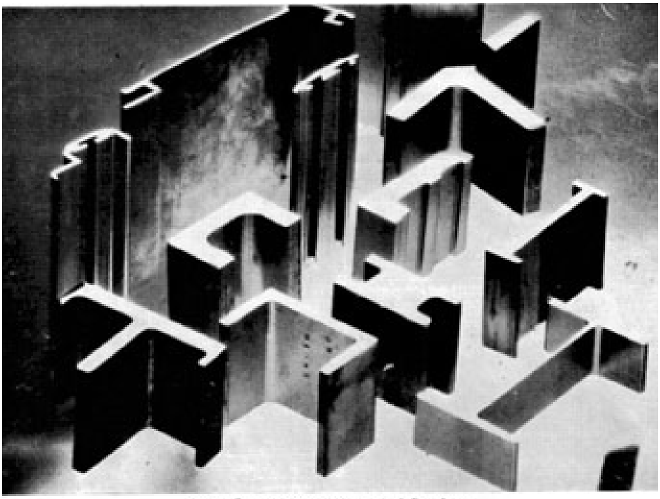


Photo 3.—Typical Extruded Sections.

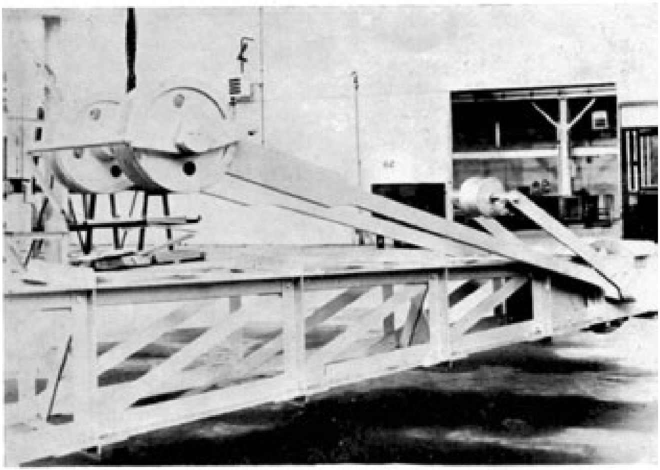


Photo 4.—Crane Jib.

By courtesy of Northern Aluminium Co., Ltd.

Light Alloys 3 & 4

Photo 5.—Aluminium Alloy Railway Bridge Girder.

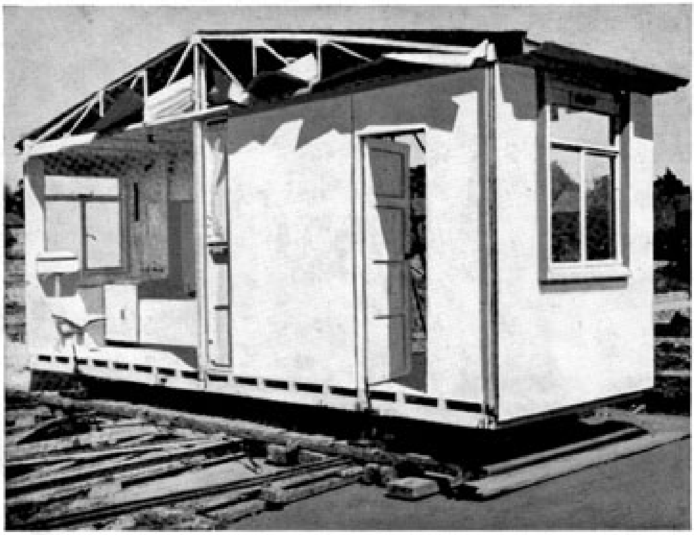


Photo 6.—Unit of Aluminium House.

ASMARA WATER SUPPLY

By LIEUTENANT-COLONEL W. B. SYKES, R.E. (T.A.)

IT will be recalled that Asmara, the capital of Eritrea, fell to the British, Indian, and Sudan forces on April-Fools' Day, 1941, during the campaign which actually started in Sudan with the recapture of Kassala and ended with the liquidation of the complete Italian East African Colonies, inclusive of Eritrea, Ethiopia and Italian Somaliland.

The population of Asmara had grown considerably since the Italian-Ethiopian War of 1935–36, due to it being the main base for all the Italian operations. It grew still further in the 1941 campaign owing to an influx of native population, whose agricultural lands had been destroyed, in addition to Italians taken and held prisoners in Asmara and also owing to the Italian population of Ethiopia having fled from the Ethiopian Patriots Army.

Not long after Asmara's fall, it was reputed to have a population of over 100,000 Natives and 26,000 Italians, in addition to the British Garrison, which at that time, although small for its responsibilities, added to an already over-crowded population.

The Water Supply of Asmara was in a critical condition due to five reasons :—

(i) Over Population
(ii) Lack of Storage
(iii) Bad Distribution
(iv) Rainfall below normal in 1940–1941
(v) Sabotage and War Damage

The sources of water were as follows :—

(i) Reservoirs
(ii) Belesa and smaller adjacent lakes
(iii) Sembel, an underground tunnel collecting system
(iv) Godaif Wells, with pumping station and storage
(v) Various local wells.

The water from Belesa and adjacent lakes ran in a gravity aqueduct to a central pumping station, where it was pumped to a higher level ; Asmara receiving it by gravity into a piped service for which no true records existed, being a typical Italian system, and no pipe exceeding 3 in. diameter was found during the writer's time there.

Pumping had to be carried out in cycles at the Central Pumping Station, as required off-take from the Gravity Concrete Tank was always greater than intake, due to the low level in the reservoirs and lakes. Practically only six hours' supply existed out of each twenty-four hours.

Sembel provided an underground collecting tunnel system, partly constructed prior to the War. It served a local hospital area, which when increased by a British hospital of 600 beds failed to meet their needs. On other occasions it did send a reserve to the near-by Godaif Pumping Station.

Godaif Pumping Station obtained its supply direct from wells, which proved fairly successful, but long queues of British military vehicles were always evident, being the main source for the British, Indian and Sudanese Garrison, and after meeting their needs little was left for the Italian population, most of which could only be supplied by mule drawn vehicles.

Local Wells, which although numerous, only supplied small quantities and, after a proclamation was issued compelling everyone to declare wells, it was not considered that they were of any serious value, although they did assist the local natives and Italians.

Wells were reconditioned and installed with pumps to add to the supply for military needs in the outer areas, as far as fourteen kilos from Asmara.

Water transport, even with Italian civil and military vehicles, was in short supply, as was general everywhere in those days in 1941.

The position was critical, and the situation required special attention. It was discovered with some difficulty, soon after the occupation, that various Italian schemes existed for improving the supply. These plans, after many threats, were obtained from the Italian Water Distribution Company and the equivalent to our Borough Surveyor, who finished up shortly afterwards in a P.O.W. Camp.

The scheme selected was a Dam across the narrows of Valley Gnechi, adjacent to the Italian Pumping Station which collected the water from Belesa and smaller lakes.

The dam had been provisionally designed by the Italians as a mass concrete structure and this design, subject to amendments, was finally adopted. It was altered in many ways to suit the British Code of Practice for Reinforced Concrete, as also were structural details.

An Italian Contractor was engaged and the actual dam was built by Italian labour, both Civil and P.O.W., under R.E. supervision, with the D.C.R.E. in control and a resident W.O.I. on the site.

Progress in many ways was not good, due to the labour engaged, lack of materials and suitable plant, but the many difficulties were eventually overcome, resulting in the dam shown in the photograph.

Cement was obtained from an Italian factory in Massawa, which was badly sabotaged, and before any concrete could be placed the cement factory had to be got into operation, which meant British personnel being engaged in a factory located in the Red Sea coastal area with a climate of great humidity and often with a shade temperature of 120°F.

Sand was obtained from a source about twenty miles away, and a local quarry was started giving a respectable granite aggregate. Reinforcing Rods were in plentiful supply, and explosives of Italian origin were easily obtained.

Work commenced in May, 1941, approximately six weeks after occupation, and there was a desperate race against time in order to catch the rains, which only occur once per year, in September, and are of equatorial severity. Very minor rains do occur early in the year, but they are of almost negligible value.

The reinforced concrete dam, in addition to spanning the neck of the valley, penetrated well into the sides, which involved considerable excavation with the use of compressed air and explosives, and it was at this stage that extremely difficult decisions had to be made.

Penetration into the sides of the neck began to exceed structural necessity and still the face of the excavations presented " fissures," or layers of soft materials, which would have allowed serious leakages to occur from the reservoir and penetrate behind the dam. Excavation was stopped and " cement-gunning " was resorted to, the plant being home-made on the site. No less than 230 tubes were driven into the rock for " cement-gunning " purposes.

It was also realized that this would not be a complete remedy and it was decided at a later date to apply similar methods to the rock faces of the neck, both on the water side of the dam and behind it. This will be referred to later.

Much better rock was found on the bed, or floor, of the neck for the footings which were of considerable depth.

Excavation first, and then the placing of the concrete were carried on twenty-four hours per day for seven days per week, with arrangements for accommodating and feeding the men on site. The quarry was working at full pressure and an organized transport system was in operation for incoming sand and cement.

Site tests took place, with improvised equipment, for cement, which did not come up to British Standard Specification, and efficient apparatus was constructed for the proper grading of the aggregate.

The dam itself was in mass reinforced concrete, with a shell of 1 : 2 : 4 mix and a core of 1 : 2½ : 5. The photograph shows the type of structure, which contained two vertical shafts with built-in steel ladders, leading down to two horizontal chambers, containing the outlet valves and which afforded permanent means of inspection of the dam structures. The chambers also took away a good proportion of unnecessary concrete.

Expansion of the concrete was allowed for, with joints into which were inserted a series of bronze baffle plates to stop any leakage.

A spillway was constructed in the centre of the dam and extended down the inclined face at the back, to enable any overflow to be controlled and the force of the spill was broken by baffle walls at the base of the dam.

The offtake of the water received special consideration and three separate valves were provided at varying levels. The offtake valves were controlled from the chambers inside the dam and water was fed by gravity to a small subsidiary 120 cu. metre capacity concrete tank, where electric pumps took it to the Central Pumping Station, which already accepted water from Belesa and adjacent lakes.

Additional pumps were installed at the Central Pumping Station. Flocculation and sedimentation tanks were built and all the water was chemically treated and purified. Many difficulties were experienced due to lack of chlorine gas and other water purifying agents. When the installation was complete the dam itself was approx. 210 ft. long, 72 ft. high and the width at the base 36 ft., tapering to 6 ft. at the top.

The concrete contents of the dam, inclusive of spillways, baffle walls, pump house and various other incidental work was 12,500 cu. yds. and the amount of steel used was 125 tons.

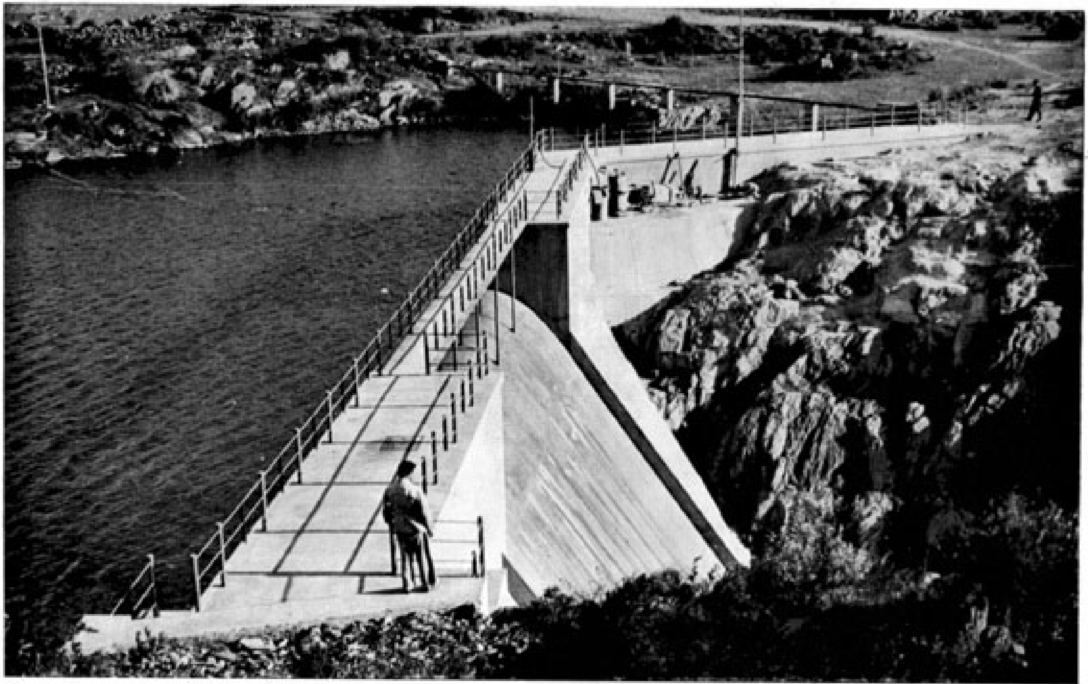
The dam and incidental works were not completed by the arrival of the rains, and the final concreting up to the spillway was actually in operation when the heavens opened for the annual tropical downpour. Luck was with the Sappers and we had the pleasure of seeing the reservoir gradually fill and the dam behave in the manner it was expected to.

Various leaks were evident through the rock strata, these were noted and when the reservoir lowered, " cement-gunning " operations again took place, which in the end, and with the aid of organic matter which percolated into the fissures, reduced the leaks and losses to a minimum.

The area which the water covered was never correctly surveyed, due to lack of staff and instruments, and estimates of the contents varied between 960,000 cu. metres and 110,000 cu. metres. It did, however, add to Asmara's critical water supply by nearly 3,000 tons per day, which meant the difference between the critical position that existed and a supply which, although still not adequate, made a wonderful difference.

The completion of the final works was celebrated by the Sappers on the dam with Italian Spumanti, which had been kept for the occasion, and an inscription incised in the concrete of the dam marks still another work where the Corps harnessed the forces of nature for the use of man, and left something behind for the benefit of humanity.

Further improvements were still needed to complete Asmara's water supply, including the laying of new supply mains, but these were left to a later administration (O.E.T.A.) to carry out.



Concrete dam constructed 1941.

Asmara Water Supply

MEMOIR

BRIGADIER-GENERAL R. F. SORSBIE, C.B., C.S.I., C.I.E.

ROBERT FOX SORSBIE, who died on 29th April, 1948, was the son of the Rev. R. Sorsbie, Precentor of Rochester Cathedral, and he was born at Rochester on 19th March, 1866. He was educated at Sutton Valence School and Woolwich and was gazetted into the Corps in 1885, and after completing the normal course at the S.M.E., he was posted to India in 1887, where he joined the Madras Sappers and Miners, going to Burma as Assistant Field Engineer with the Burma Field Force, after which he held appointments as Company Officer of " K " Coy., Adjutant and O.C. " K " Coy., " A " Coy. and 2nd Coy. respectively, between the years 1887 and 1894, being promoted Captain in 1894.

In 1896 he returned home and was posted as D.O. Limerick. Two years later he was appointed Adjutant of the 2nd West Riding of Yorks, R.E., which he held until 1900, when he was appointed O.C., 58 Coy., and Assistant Adjutant at the S.M.E. The following year he went with the 58 Coy. to Salisbury Plain, and in 1902 he was posted as D.O. (Reconstruction) at Shorncliffe and was promoted Major.

In 1905 he returned to India as Asst. C.R.E. at Dehra Dun, and in 1908 was Asst. C.R.E. at Bangalore. The following year he came home to the U.K. to attend the Indian Class at the S.M.E. On completion of the course he returned to India as Asst. C.R.E. Southern Brigade, at Madras, and was promoted Lieut.-Colonel. In 1913 he was promoted Colonel and appointed C.R.E. 9 Div. at Ootacamund.

In 1914 he was granted leave to the U.K. and was at home when the war started in August. He returned to India and was appointed C.R.E. 7 Div. at Meerut. In 1917 he was made Chief Engineer, Northern Command, India, with the rank of Brigadier-General. In 1921 he was D.D.W. Southern Command, India, and Officiating Director of Military Works at Simla in 1922. He retired in 1923.

During the 1914–18 War he had a most strenuous time on the North-West Frontier in India and on the outbreak of the Afghan War, in 1919, he was Chief Engineer to the Northern Army under General Sir Arthur Barrett. It was a great blow to Sorsbie that he was not sent overseas with the expeditionary force to Mespot, as he was not considered to be sufficiently fit.

In actual fact, although he had to be careful with his diet, none could have led a more strenuous life touring his large area on the North-West Frontier all the year round, including the hot weather, when nothing seemed to tire him. For these services he received the C.I.E. in 1917, the C.S.I. in 1919, and the C.B. in 1920.

He was a delightful man to work under and was always most kind to his subordinates. At the end of the 1914–18 War when accommodation in India was very difficult he and Mrs. Sorsbie threw open their doors and shared their bungalows at Rawalpindi and Murree with several other officers and their wives, and thanks to the wonderful kindness of General and Mrs. Sorsbie, these combined households ran on oiled wheels.

P.W.L. B-S. writes, " Sorsbie was an enthusiastic and practical engineer ; he had indefatigable energy, was always full of ideas, and gave marked attention to detail. His early treatise on Blacksmith's work was a standard in its time, and his *Geology for Military Engineers*, I am told by Col. A. H. Bell, whose firm are its present publishers, has in later years been in considerable general demand, as being valuable and unique of its kind.

" Sorsbie appreciated the efforts of his subordinates. When I was directly under him in Simla (or very much so, with the approval of the Deputy), he gave me quite a free hand, and in continuation of my previous personal experiences with him, when he used to stay with me in Peshawar and inspect my activities in Peshawar District, I found it a pleasure to work under him.

"Sorsbie did not have an opportunity of making much of a mark as D.M.W., as he was only holding the helm for Atkinson whilst the latter was on leave pending sanction to his E.-in-C. organization (in the evolution of which it fell to my lot to play a fair part). The E.-in-C. organization which was introduced in April, 1923, retrieved and greatly improved the position of the Sappers as a whole in India, and finally rescued the Military Works Services, as the Military Engineers Services, from the state of frustration into which they had been plunged in 1920 by uninformed and biased criticism in the aftermath of the first World War; in November, 1920, the D.G.M.W. had been reduced to D.M.W. under the Q.M.G. and divorced from control of Engineer Troops.

"Sorsbie loyally carried on for Atkinson in this difficult interim period, when, moreover, much was afoot on the N.W. Frontier, where the Razmak road, notably, was started, in pursuance of the policy of the military occupation of central Waziristan."

After he retired " Bob " Sorsbie went to live at Bournemouth, where he threw his heart and soul into many local organizations. He was for some time Scout Commissioner for Bournemouth and also Governor of Pokesdown Lad's Institute, but perhaps his greatest work was in connexion with the Disabled Soldiers and Sailors Workshops, on whose behalf he collected large sums of money by his strenuous efforts.

During the 1939–45 War he ran a Bureau at Bournemouth for the entertainment of service men, many hundreds of whom were grateful to him for the excellent arrangements made for their entertainment while staying there. He also took a great interest in Toc H., the Overseas League, the Fairbridge Farm Schools and India Church Aid.

In 1903 he published a book entitled *Notes on Blacksmith's work* and in 1911, *Geology for Engineers*, which for a long time was used as a text-book on geology for Military purposes. A second edition was published in 1938.

Both these books are referred to above by P.W.L. B-S.

In 1900 he married Augusta Helen, the daughter of Lieut.-Col. Ridout of the Scottish Rifles (Cameronians) and sister of the late Major-General Sir Dudley Ridout in the Corps. He had two sons, Lieut.-Colonel R. W. Sorsbie, R.A., and Julian Sorsbie.

C.C.P.

Brigadier-General R. F. Sorsbie, C.B., C.S.I., C.I.E.

Photo by Navana Vandy

Brigadier General R F Sorsbie CB CSI CIE

BOOK REVIEWS

BRITISH MILITARY ADMINISTRATION IN AFRICA, 1941–47

By LORD RENNELL OF RODD, K.B.E., C.B.

(His Majesty's Stationery Office. 17s. 6d.)

This record of the achievements of the British Military Administration of Occupied Territories in Africa is not one of the planned series of Official Military or Civil Histories of the War. Nevertheless, the author has had access to official documents and it is hard to imagine that the same ground could usefully be covered again, so that for all intents and purposes this is the official story. Lord Rennell is well qualified to write it, as he had served in the O.E.T.A. under Lord Allenby in Syria, and joined Sir Philip Mitchell's Political Branch at G.H.Q. Middle East in February, 1941. He became Chief Political Officer for Middle East and East Africa Commands, and later Chief Civil Affairs Officer for the campaigns in Sicily and Italy.

Reduced to its simplest terms the story is the answer to this question: "How did the British discharge the responsibility placed by the Hague Convention upon an occupying army?" How did they set about dispensing justice, safeguarding enemy property, evacuating and repatriating civilians, forming police forces, fostering the health and educational services, maintaining supplies, and reviving trade, and with what success?

Although the British had had some experience of these problems, it was nowhere collected in accessible form; in other words, there wasn't a manual, which provoked the cynical suggestion that the British Army was not expected to occupy enemy territory! This was undoubtedly a handicap at first, even though it meant freedom from too much planning. But the unexpected may happen again and, if so, Military Commanders and Administrators will be grateful for the care and clarity with which these African experiences have been set out. The organization of Political Branch Headquarters would be of particular value, together with the copies of actual Proclamations, Agreements, and Policy Instructions; but the whole record is so readable that its appeal will not be confined to those who have been, or may be, employed in Military Government.

Is variety the spice of life? Consider for a moment the astonishingly varied conditions with which the Military Administration was faced.

First, Ethiopia, where the Emperor, never having accepted the Italian conquest, regarded himself, with some justification, as merely resuming his throne. But the British had reconquered the country and were clearly responsible for the safety of Italian people and property. In the adjoining colony of Italian Somaliland the inhabitants were inclined to be warlike and had plenty of arms and ammunition. A gendarmerie had to be raised and disarmament enforced. Resettlement of farms was another major problem, yet in 1942 the country was self-supporting in food.

Eritrea had also been an Italian colony, but the "more than usual" lethargy of the remaining officials made it useless to employ them. Food, currency, and relief presented urgent problems, but when the Germans captured Crete a regular "gold rush" began of branches and services from Egypt, who saw the advantages of a rearward echelon in Eritrea. Then came the American Aid scheme and a rapid growth of the military population. Trade flourished, nevertheless; stimulated, perhaps, by instructions from London to pay particular attention to Latvia, Switzerland and the Philippines!

The reoccupation of British Somaliland was a different matter, for here the laws and forms of the previous administration were restored by Order in Council. The change of L. of C. to a line through Berbera in March, 1941, gave a stimulus to trade and activity generally, and it is remarkable that the financial position of British Somaliland was more prosperous in 1941–43 than at any other previous time in its history. In Madagascar we found enough French officials willing to help us at Diego Suarez, with a potentially hostile Vichy government everywhere else. In due course a High Commissioner was appointed by the French National Committee, and thereafter British Military Jurisdiction remained in force only in the extreme north.

Cyrenaica, after the false starts in 1940 and 1941, presented the problem of a wholly native country which had suffered grievously. The underlying difficulty was how to continue a latent Italian sovereignty until the Peace Treaty. Tripolitania, a country which had been materially endowed better than its economic capacity warranted, was unique in one important respect: namely, that an adequate staff with sufficient transport was available at the outset! Then there were the Dodecanese Islands, belonging to Italy and peopled very largely by Greeks.

It is true that no two problems are exactly alike, but it is obvious that in a record of achievements of such a varied nature there must be plenty of useful guidance for the future, and this is equally true of the more specialized chapters on Law, Finance (including Banking and Trade) and the Custody of Enemy Property.

Treating this volume as the first of those on "Civil Affairs," one can safely say that the series has started well.

I.S.O.P.

WAR BETWEEN CONTINENTS

By F. O. Miksche and E. Combaux

(Faber & Faber Ltd., London. 15s. 0d.)

The Czechoslovak Colonel Miksche is the author of the books *Blitzkrieg* and *Paratroops*. Colonel Combaux is a French officer.

Their analysis of the economic and political conditions obtaining at the time of the second World War emphasizes the gulf that separates the interests and ideals of the Soviet and the capitalistic spheres. On the supposition that war between the Russian and the Anglo-Saxon groups comes within the next few years, they examine the probable battlegrounds, tactics and techniques. They consider that modern science, far from making short sharp work of the next war, would greatly increase its ferocity and the extent of its devastation.

The results of a clash would be fearsome indeed, but the authors do not admit that it is inevitable. Diagnosing the dismembered scraps of Europe as "corpuscles floating in a polarization field generated by the two masses of East and West" their prescription is "Unite or die." At first there should be five federations; a Western, a German, a Scandinavian, a Danubian, and a Balkan. These should then range themselves under a higher authority at, say, Geneva. European nations cannot, in the name of their feeble 40 millions, play at being great world powers at a time when vast new empires as big as continents are being formed.

Logical as all this is, the solution is a disquieting one. Can the European nations display the vision, unanimity and self-discipline essential to such a programme? The authors think they can, and must, or . . .

I.S.O.P.

CORNWALL'S ROYAL ENGINEERS

By LIEUT.-COL. C. J. H. MEAD

(Published by Underhill (Plymouth) Ltd. Price 21s. 0d.)

This is a history of Cornwall's Royal Engineers (Auxiliary Forces) who started as Volunteer Submarine Miners in 1888, with headquarters at Falmouth. The author describes in detail the career of the regiment during its three periods of existence "Volunteers" from 1888 to 1892, "Militia" from 1893 to 1907, and finally as "Territorials" from 1908 to 1940.

He explains the main features of each type of unit and his remarks are in the main applicable to the Auxiliary Forces of the country generally during the period under review.

He goes fully into the types, characteristics and qualifications of both officers and men and describes the organization, discipline, pay and conditions of service, and uniforms.

Although the history will naturally make the greatest appeal to Cornishmen, those Regular R.E. officers and other ranks who have served with the regiment from time to time as Adjutants and Instructors will find the reminiscences interesting. They are all mentioned by name and any outstanding characteristics and achievements are given due prominence.

The heyday of the regiment was no doubt during the Volunteer period. The unit formed a pleasant association and the musical and pageant-loving Cornishmen were evidently very fond of full dress uniform and ceremonial. The officers maintained, at their own expense, a good military band which was naturally much in demand for social functions. Unfortunately, however, the Volunteers were not able to devote sufficient time to maintain a high enough standard in the technical skill required for submarine mining and this led to their disbandment in 1892 and their replacement by Militia.

Few of the Volunteers found it possible to undertake the greater obligations involved in joining the Militia, and the regiment thus lost its county aspect as both officers and men had to be recruited largely from other parts of the country.

The Militia proved to be excellent submarine miners but they lacked the electrical and mechanical knowledge required to handle Searchlights, which were introduced in 1894, and soon became an important R.E. responsibility in the defence.

When, therefore, in 1906, submarine mining was taken over by the Royal Navy, this naturally led to the disbandment of the Militia Submarine Miners.

About this time the Haldane Scheme abolished all "Militia" and "Volunteers" and replaced them by "Special Reserve" and "Territorials." In this reorganization the Cornish R.E. Auxiliary Forces became the Cornwall R.E. (T.F.) which comprised both Works and Electric Light Companies and every man was required to be a tradesman. (In the old Volunteers two-thirds only were tradesmen). The regiment maintained this designation until converted to a unit of the Territorial Army by the Act of 1921.

The author concludes with an interesting survey of the Auxiliary Forces of the country from 1888, to the present time. His remarks are applicable to the nation as a whole and provide much food for thought. He suggests that a revival of the name "Volunteers" instead of "Territorials" would have a beneficial effect on recruitment for the Auxiliary Forces on a voluntary basis.

The book is a welcome and timely addition to the History of the Corps and we should be grateful to the author for his painstaking researches in official and press records for the wealth of facts and incidents he relates. It has evidently been a labour of love, as his family were intimately connected with the Cornish Engineers for many years.

Any profits from the sale of the book are being devoted to the R.E.O.C.A. and certain other charities.

W.M.

LORD KELVIN—PHYSICIST, MATHEMATICIAN, ENGINEER

By A. P. YOUNG, O.B.E., M.I.E.E. 1s. 6d.

JAMES CLERK MAXWELL—A MATHEMATICAL PHYSICIST OF THE NINETEENTH CENTURY

By R. L. SMITH-ROSE, D.Sc., Ph.D., M.I.E.E. 1s. 6d.

These books, published by Longmans Green & Co., for the British Council, are two of a series of some two dozen books to date, entitled *Science in Britain*, and are intended to provide a survey of scientific activity in Britian. Some of the volumes, as these, are biographical, and some relate to a variety of scientific and industrial activities, such as Plastics, the Royal Institution, Sea Surveys, Patents, etc.

The two under review have each eight full-page illustrations.

Lord Kelvin (William Thomson) (1804 to 1907) was Professor in the University of Glasgow in the Chair of Natural Philosophy, which he occupied for fifty-three years and in which he influenced the scientific approach of many generations of students. He was a scientific investigator, particularly in establishing the second law of thermodynamics, and in work on electrical oscillations, which contributed to the development of wireless etc. He was also an engineer and inventor.

He took a leading part in laying the first successful transatlantic cable. Convinced that the progress of science depends on precise measurement, he invented a number of precise measuring instruments where none had existed before. As owner of a large sailing yacht he became interested in navigation and invented the mariner's compass as now known, and the modern sounding machine.

He was founder and director of Messrs. Kelvin, Bottomley and Baird Ltd., scientific instrument makers, and made a large fortune through this and his numerous directorships and patents.

James Clerk Maxwell (1831 to 1879) was a different character altogether. Probably the greatest theoretical physicist of the nineteenth century, he did not turn his talents to practical account.

He held professorships and fellowships at Cambridge, the Marischal College, Aberdeen, and at King's College, London. In the newly founded Chair of Experimental Physics at Cambridge, he decided on the layout and equipment of the famous Cavendish Laboratories, and laid down their future use as a place, not only of instruction, but of original research.

His achievements in physics include pioneer work on the rings of Saturn, on colour perception, on molecular physics, and the kinetic theory of gases, on the electro magnetic theory of light, and on the constitution of elastic solids.

" Maxwell's Law of Distribution," developed in connexion with the kinetic theory of gases, but applicable to many other sciences, is the foundation of the science of statistical mechanics and leads up to the quantum theory.

The system known as " Maxwell's Equations " first established the mathematical connexion between static electrical fields and magnetic fields of force, and his next step was to connect the electro-magnetic system with light and the velocity of light. All this was done in a comparatively short life of forty-eight years.

Both great men, here reviewed, had the inestimable advantage of being brought up in a family of considerable intellectual activity,—Kelvin's father having been professor in the same Chair at Glasgow before him, and Maxwell's much interested in practical mechanics and connected with the Royal Society of Edinburgh.

Both books under review are admirably compact and give a clear and readable picture of two great men, and have led this reader to want to know more.

E.M.E.C.

MILITARY CUSTOMS

By MAJOR T. J. EDWARDS, M.B.E., F.R.HIST.S.

(Gale and Polden, 10s. 6d.)

In this slim volume the young R.E. officer will find, compressed into a small space, a mass of information on a variety of regimental customs and peculiar distinctions of the British Army ; from military music, the " bloody sownes " of Chaucer's *Canterbury Tales*, to moustaches as a form of frightfulness ; from " grace before meat " and " the Loyal Toast " to the suspicious habits of the Cameronians at Divine Service ; from regimental mascots to red tabs. But he will find unfortunately no reference to the Corps of Royal Engineers except an illustration, wrongly drawn, of the R.E. Grenade. The Corps is perhaps too distinctive to require peculiar distinctions in manner or dress, too practical to need to be picturesque. Or is the omission and the error due to the fact that in the published volumes of the history of the Corps the author could find no reference to the dress and badges or to the lighter and more personal aspects of our Corps history. This is a gap in our records which, it is to be hoped, some future Corps historian will fill.

As a compendium of army peculiarities—of those customs at which, as the author says, the uninitiated may scoff as useless anachronisms but which are the basis of that potent driving force, *esprit de corps*—this little volume makes interesting reading and contains much that will be new to most of us. It is well printed and well illustrated with a number of coloured plates, which may account for the price but which make it a very suitable birthday gift to a budding soldier from " a polished female friend."

L.V.B.

BRIEF HISTORY OF THE K.G.V'S. O. BENGAL SAPPERS AND MINERS GROUP, R.I.E. (AUGUST 1939 TO JULY 1946)

(Published at Roorkee. Price Rs 7 or 10s. 0d.)

This brief history compiled by Lieut. G. Pearson, is, as he states in his Preface, " intended to serve as a base for a later and more accurately informed history."

He is to be congratulated on producing such a very interesting book in so short a time. The writing of any history entails an immense amount of work and the reading and sifting of very large numbers of diaries, reports etc.

The History starts with the rapid expansion and training of the Corps at Roorkee and continues with the story of the ever-increasing activities of the Corps in the many countries where they were employed.

Then follows the early days in the Western Desert in 1939 and 1940, and the first advance to Benghazi and subsequent retreat and the loss of Tobruk, when a considerable proportion of the 4 Ind. Div. were captured, after they had returned from their victorious campaign in Eritrea and Abyssinia. In 1941, the 8 Ind. Div. and part of the 10 Ind. Div. were protecting the oil fields in Persia.

Then follows the story of the campaign in Malaya and the retreat from Burma. The part played by the Bengal Sappers in the subsequent war in Burma is well described in later chapters.

Between these chapters are others, in more or less chronological order, dealing with the El Alamein campaign, Tunisia, Italy and the final clearing up in Greece.

The book contains very good and clear maps of the various campaigns and a few photos.

C.C.P.

TECHNICAL NOTES

TIMBER CONNECTORS

(*The Journal of The Institution of Structural Engineers*, May, 1948)

"Timber Connectors" are used to improve the efficiency of a normal bolted joint in a timber structure. The bolt passes through the centre of the connecter, which is of metal, and is embedded in the contact faces of the connected timbers. Increased bearing area for transmission of load is thus obtained.

This paper details the various types of connectors, which were developed during the war to improve the efficiency of bolted joints and effect a greater economy in the use of timber.

Of the different jointing mediums, adhesives are stated to give a joint efficiency of 100 per cent, timber connectors up to 80 per cent, and nails, screws and ordinary bolted joints as low as 15 per cent, in the worst cases.

Constructions using connectors can be carried out at site, but adhesives require factory control. The low efficiency of bolted connexions is ascribed to the physical difficulty of accommodating sufficient bolts in the contact areas of the members to be joined, and to the low shear strength of timber parallel to the grain and the bad distribution of stress along the length of the bolt.

Of the connectors described, the most efficient is a circular split-ring type requiring a groove pre-cut in the faces of the two members to be connected. A less efficient toothed-ring type, requires no preparation of the timbers, and is fixed by locating it between the contact faces, the teeth being embodded in the surfaces by drawing the timbers together using a high tensile steel bolt and ball-bearing assembly operated by a ratchet spanner.

A spiked grid type of connector to provide an efficient means of connecting round timbers is illustrated for use on such structures as piled piers and trestle bents.

The author has tabulated the preliminary test results of a number of load tests carried out by the Forest Products Research Laboratory on 2 in. and 3 in. diameter connectors.

Suggested working loads and design recommendations are also included in the paper.

BOLTED CONNEXIONS IN STRUCTURES

(*Engineering*, dated 7th May, 1948)

The author shows that the hitherto ignored frictional resistance of a tight bolt in connecting steel members has a large influence on the rigidity of a structure, and is as important a factor as the bearing and shear.

He has shown that the friction set up between the surface of the head and nut and the connected plate is in many cases sufficient to develop the working load in the joint, without any creep taking place, to bring into play the shear and bearing for which the joint is conventionally designed.

The elimination of creep permits the structure to act elastically up to the limit of the design load, and for structures where creep must be avoided renders the provision of tightly fitting turned bolts, in many cases, unnecessary.

Tests carried out on galvanized, weathered, wearing surfaces gave an average static co-efficient of friction of 0·42 ; thus a 1 in. diameter bolt tensioned to 9 tons per sq. in. would exert a pull of 5 tons and induce a frictional restraint of 4·2 tons for normal double-contact surfaces. This is nearly equal to the single shear capacity of the bolt (5·1 tons) and the bearing capacity on $\frac{5}{16}$ in. plate of 4·7 tons. The author has concluded that where bolts used are three or four times the plate thickness in diameter, the frictional grip will exceed the maximum bearing capacity which would otherwise determine the strength of the connexion.

In addition, the friction helps to alleviate the loss of metal from the drilled hole by transferring stress through the bolt.

Dependence on friction would require control of the bolt tension, and some form of hand or pneumatic spanner incorporating a torque control device would be required.

NAVIGATION

(Journal of the Institute of Navigation)

The recently founded Institute of Navigation now publishes a quarterly Journal.

In the first number (January, 1948), Sir Robert Watson Watt contributes a brief account of the various "Radio Aids to Navigation." Some of these aids may have applications for navigation in desert or steppe country as well as in the air or on the sea. There is also a more detailed article on "Consol."

The Astronomer Royal writes in the second number (April, 1948), on "Time Determination and Time Keeping." He gives the limitations of Shortt clocks and quartz clocks and describes the photographic zenith tube for the determination of time by astronomical observation.

"The Development of Shipborne Navigational Radar" refers to the radar used for the invasion of Europe and goes on to deal with subsequent developments and future trends. The developments depend mainly on applications of Plan Position Indicator (P.P.I.) technique. In P.P.I. radar the indicator trace which appears on the screen of the cathode ray tube is radial and its direction corresponds to the direction of the aerial beam. As the aerial rotates, the trace rotates correspondingly. Hence a map-like display is produced which shows at once the relative positions of all objects in the vicinity which are detected by the radar set. The question of very short-range radar is touched on. It seems that a P.P.I. system might be developed which could be of use in river crossings in fog or at night, but "the realization of such a proposal is not within sight in the near future."

ALUMINIUM SPAN FOR RAILWAY BRIDGE

(*The Engineer*, dated 12th March, 1948)

The latest development in the use of aluminium alloys for bridge construction is the installation of two all-aluminium deck-plate girders to form one 100 ft. span of a seven-span railway bridge over the Grasse River, Massena, N.Y., U.S.A. This bridge consists of one 90 ft. span, four of 100 ft. and two of 75 ft. Three of the 100 ft. spans are of steel and one of aluminium alloy, and all are identical in length and design requirements, so providing a comparison between aluminium and steel for bridge construction for heavy railway service. The complete 100 ft. alloy span weighs 53,000 lb., as against a comparable weight of 128,000 lb. for a steel span. No price comparison is available.

This article gives construction details and comparative design data.

A RAILWAY PRECAST-CONCRETE DEPOT

(*The Engineer*, dated 19th March, 1948)

The use of precast concrete units on railways has developed rapidly during the past twenty years. This article gives some interesting particulars on the layout and production methods at the precast concrete unit-making depot of the former London, Midland and Scottish Railway Company at Newton Heath, Manchester.

ALUMINIUM SHEATHED POWER CABLES

(*The Engineer*, dated 23rd April and 30th April, 1948)

Since the early days of electricity supply, lead has been the traditional sheathing material for power cables, although it is by no means ideal for the purpose. Lead is comparatively easy to apply in the form of a cable sheath, joints can be made without difficulty, and the sheath is impervious to air and moisture. On the other hand lead is heavy and its mechanical properties are generally poor ; its ductility, which makes it easily handled, is often an embarrassment without the complementary property of elasticity.

Aluminium is an attractive substitute, but its use before the war was delayed by its high price, and by the technical difficulties associated with the high temperatures and pressures required for aluminium extrusion, in the absence of any alternative practical method of applying a sound sheath. It is now announced that the application difficulties have been surmounted with the introduction of power cables sheathed in commercial quality aluminium. Sheathing is effected by threading the insulated core of the cable into pre-extruded seamless aluminium tube, and then subjecting the tube to a shrinking or swaging process to form a closely fitted sheath.

The main advantages claimed include light weight, high tensile strength and creep resistance, good fatigue endurance and resistance to vibration. An appropriate jointing and terminating technique has been developed, and the cables are proofed against corrosion.

UNUSUAL VIADUCT RECONSTRUCTION METHODS

(*The Railway Gazette*, dated 9th April, 1948)

To double its power output, the Decew hydro-electric plant near St. Catherine's, Ontario, has been enlarged recently, and Twelve-Mile River, which forms its tailrace, has had to be widened and deepened. As the Hamilton-Niagara Falls main line of the Canadian National Railways crossed the valley of this river on a double-line viaduct with shallow foundations, the viaduct has had to be rebuilt. The structure as originally built and as now reconstructed is shown by diagrams. The superstructure, dating from 1902, was in good order, and up to the present day has carried high-speed heavy loadings ; and this fact, coupled with the necessity for maintaining the uninterrupted flow of traffic, dictated the policy pursued. This entailed the retention of the 65 ft. and the three 100 ft. spans on the original alignment (though they were moved along it longitudinally) and also one of the abutments ; and the construction of four new deep-foundation piers of unusual design under the spans, and the provision of a new 58 ft. span and one new abutment. Details of the design of the piers and of the work involved will be found in the article describing the reconstruction, which had to be planned with even more than normal care and is of unusual interest.

SCREWCRETE FOUNDATIONS FOR BRIDGES AND PIERS

(*The Railway Gazette*, dated 23rd April, 1948)

The old type of screw pile method of constructing bridge piers and jetties or wharves in deep water has been largely superseded by the Screwcrete system of foundation, described in this article, which has many advantages. The Screwcrete cylinder is capable of supporting a heavy concentrated load by reason of its large helix, and will withstand violent horizontal shocks without any underwater bracing.