ROYAL ENGINEERS
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Operation Overlord and the Royal Engineers (1944-5)

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Introduction

From the final days of June 1940, when the last British troops were evacuated from France, it was clear that final victory over Germany could only be achieved by returning to the Continent to defeat its forces.

This major operation, known as 'OVERLORD', the code name for the Invasion of Normandy; took place on 6 June 1944 D-Day.

Planning

Planning began immediately. Early studies, in December 1941, were carried out at Minley Manor near Aldershot, today home to part of the Royal School of Military Engineering.

Information about possible landing places was gathered from all available source ranging from published travel guides to holiday postcards, and special- maps incorporating this information were drawn by Royal Engineer Surveyors.

The selection of the landing area was governed by several factors including the length of the sea passage and the ability to provide air cover. The choice of the Normandy coast was also influenced by the geology of the terrain behind the beaches, which Royal Engineer Geologists indicated was particularly suitable for the speedy construction of temporary airfields

Although the Normandy beaches were mostly flat and so generally suitable for a seaborne landing, it was believed that in some areas there were deposits of peat and clay. These could cause enormous problems for vehicles' moving up the beach should the exit coincide with them.

Accordingly it was necessary to examine the ground. This work was carried out by Combined Operations Pilotage Parties (COPPs). A Royal Navy midget submarine with its normal; crew of four carried a Royal Engineer reconnaissance team of two. The submarine was towed to mid-channel by a Royal Navy trawler. It then carried the Sappers to within a few hundred yards of the enemy shore and they completed the journey in inflatable dinghies. The submarine meanwhile retired to a safe distance and waited.

The tasks of the Sappers included locating the high and low water marks and the distance to the back of the beach; checking surf conditions, beach surface, and the presence of rocks, peat or clay which could impede the landings; establishing the geology of the beach, taking auger samples down to 18 inches looking for runnels which might hold water at low tide thus impeding men and vehicles; identifying exits from the beaches noting sand dunes, sea walls, shingle and seaweed; and investigating man-made obstacles and defences.

These missions were extremely hazardous and on several occasions the Engineers found themselves close enough to German sentries to hear them talking and to see the light from their torches. After completing the mission a signal was sent to seaward and the submarine picked up the Engineers. It withdrew offshore and, remained submerged during daylight. Batteries were charged and-the whole exercise was repeated the following night in a different location often for a week at a time. In addition the submarine gathered much useful information by periscope search in daylight.

On returning across the Channel the submarine was met by the trawler off the Isle of Wight and towed back into Portsmouth. Conditions aboard for the crew and the Sappers were cramped and uncomfortable and the air became increasingly foul during the long periods submerged. These missions were carried out throughout 1943 and into early 1944. The

resulting intelligence was regarded as of immense value and helped to pinpoint the landing beaches.

The Assembling of the Armada

Training for the assault on Normandy had been carried out in many coastal areas of the British Isles, but by the end of April 1944 the units selected for the first seaborne landings had moved to locations between South Devon and Sussex. Follow-up forces were on standby in Cornwall and around the Thames Estuary.

D-Day had originally been planned for 5 June, and some of the blockships for the MULBERRY Harbours had left Scottish ports by 31 May. Loading of the formidable range of landing craft and support vessels proceeded, but by 4 June, the weather had deteriorated, to the point where landings on the planned day were considered impractical.

Delay was impossible. Vessels were loaded with troops, supplies, guns and armoured vehicles and could not stay in limbo. for long. Even if the weather improved the required conditions of tide and and moon would not continue for more than a day or so, and further deferment would necessitate a delay of at least two weeks.

However, the weather did improve slightly and General Eisenhower. the Supreme Commander, decided to go ahead with the landings on 6 June. Everything had to be put on hold, and this led to sea-sickness for the troops whose vessels were forced to lie pitching at anchor in bad weather for 24 hours.

The seaborne forces finally converged on a point south of the Isle of Wight, Piccadilly Circus, and headed for the coast of Normandy through a swept channel, the Spout. At the same time British and American airborne forces were preparing to land on the extreme flanks of the combined front.

Each of the five seaborne assault groups was preceded by mine-sweepers, which also marked the swept channels with buoys. Ahead of the mine-sweepers, midget submarines showed marker lights to seaward to indicate the precise positions of the chosen beaches, as the approach would be in darkness for the first waves of landing craft.
At the same time, comprehensive air cover was provided by the Royal Air Force, antisubmarine patrols were constantly maintained by the Royal Navy, and a substantial fleet of warships; to provide early gunnery cover, was moving into position.

Airborne Invasion - 6 Airborne Division

Although H-hour time for the first seaborne landings, was 0725 hours on 6 June 1944, in most of the British Sector, the first airborne landings by parachute troops and gliders took place just after midnight on the night of 5/6 June. Further landings continued throughout the night so that mass gliderborne.

Divisional Objectives

- There were two primary tasks for the Airborne Division:
- The capture of the bridges, intact if possible at Benouville and Ranville, over the Caen Canal and the River Orne respectively, and the establishment of bridgeheads each side.
- The destruction of the heavily fortified battery of guns at Merville.
- There were also two secondary tasks:
    - To mop up and secure the area between the Rivers Orne and Dives, north of Troarn.
    - To prevent reinforcements from reaching that area from the East and South East.

Sapper Tasks

The tasks which the Royal Engineers were required to carry out were many and varied, necessitating a considerable dispersion of Sappers in small parties throughout the area.

Priority tasks were:

- To assist in the seizure of the bridges at Benouville and Ranville, and to remove or neutralise any demolition charges.
- In the event that these bridges had been blown, to assist in the crossing of the Caen Canal and the River Orne. For this purpose, a detachment of Sappers, with collapsible dinghies, was dropped with 7 Parachute Battalion.
- To create a demolition belt River Dives Troan and Varaville. This included the destruction of five road or railway bridges.
- To destroy the guns and equipment of the Merville battery.
- To clear landing zones for gliderborne forces, which were to include 17-pound anti-tank guns, and bulldozers for the Engineers.

These zones were then to be extended and cleared of glider debris for the second wave, due later on D-Day.

With the exception of the operation at Merville, all these tasks were carried out successfully. The Benouville and Ranville bridges were seized intact and held. The demolition belt along the River Dives was complete by 0930 hours.

However, the Sapper troop responsible for the destruction of the Merville battery was dropped over a wide area and was unable to join up with 9 Parachute Battalion for its allotted task. The battery was finally silenced by direct assault without the guns actually being destroyed. This was a vital objective, as the battery could have wreaked havoc among the seaborne armada had it not been put out of action very early on D-Day.

8 Parachute Battalion was given the task of destroying two bridges at Bures and one east of Troarn. Then they were to assist in forming the bridgehead, by occupying an area south of Le Mesnil. The drop of this battalion was also scattered, a number of sticks being dropped in 5 Parachute Brigade's area with the result that the Royal Engineer detachments became separated and could not reach the battalion rendezvous in time. They therefore proceeded direct to the objective independently. Sergeant Jones was captured, but snatched a machine-carbine from a German, killed eight of the enemy and escaped. At Bures the Sappers linked up with the advance elements of 8 Parachute Battalion, did not meet any enemy, and blew both bridges successfully. At Troarn the leading elements of the battalion encountered opposition on the northern outskirts of the town. The engineer detachment of seven under Major JCA Roseveare RE, mounted in a jeep and trailer, heard this action in progress as they approached Troarn from the west. They rushed through the town firing blindly from their vehicles as they went. At a level crossing in Troarn they ran into a barbed wire knife rest, and took 20 minutes to cut themselves free. They went on to reach the bridge and successfully blew the gap. After this feat they ditched the jeep and made their way back to Le Mesnil on foot.

As soon as the primary tasks had been completed, 3 and 591 Parachute Squadrons Royal Engineers concentrated on the mining of the approach roads to the area and on the laying of anti-personnel minefields.

Other Sapper units involved in these operations and secondary tasks were 249 Airborne Field Company, 286 Airborne Field Park Company and 6 Airborne Division Postal Unit Royal Engineers, the latter providing postal support to the Division.

The Beach Assault

Each of the three Infantry Divisions involved in the first assault on the British and Canadian front - Gold, Juno and Sword beaches - included two Assault Squadrons from 5 and 6 Assault Regiments, Royal Engineers.

Royal Marine Commandos on the divisional flanks had the responsibility for linking each division into a single bridgehead, and also for joining up with 6 Airborne Division.

The primary objective of each pair of Assault Squadrons was to clear lanes across the beaches and to establish up to eight exits from the beaches onto the first inland lateral road, suitable for tracked vehicles.

Clearing the beaches involved:

- Removing a wide variety of beach obstacles which were exposed at low tide so that they were not a hazard as the tide rose.
- Disarming and removing mines and other explosive charges from these obstacles.

Establishing the beach exits involved:

- Breaching the sea wall, where one existed, and creating and maintaining ramps and firm access routes through the soft sand above the high water line.
- Removing knocked-out vehicles which were obstructing these exits.

All this had to be done under fire from buildings on the seafront, and also under mortar and artillery fire from positions further inland. Clearly, the breaching of these coastal defences and the silencing of enemy positions were of paramount importance to the success of the whole operation.

Each Assault Squadron was equipped with a number of Armoured Vehicles Royal Engineers (AVREs) - which were Churchill tanks, modified in various ways to suit the needs of Assault Engineers. In addition, the assault teams included a number of Sherman 'Crabs' from 30 Armoured Brigade; these were Sherman tanks, with a full-width, heavy duty, rotary chain flail mounted in front which destroyed any mines in its path, thus clearing the lanes up the beach.

The AVREs then turned their attention to the first line of land defences, using their spigot mortars, and with self-propelled guns providing artillery support. More Sappers landed to continue the clearance of the beaches. All the time, infantry were moving through into the growing bridgehead.

Further support was given by DD (Duplex Drive) tanks. These were also Sherman tanks, but with a flexible skirt which enabled them to float. This allowed them to leave the landing craft some way offshore, and to propel themselves with a marine propeller until their tracks grounded. The skirt could then be collapsed or discarded.

The different equipment carried by the AVREs was wide ranging and in many cases used unconventionally, but nevertheless it was respected and effective. Several beach exits were open within an hour of first landing, allowing conventional armour to start moving inland and Beach Sub Areas, under Royal Engineer control were being established. These acted as collection and distribution areas for the vast range of supplies which were starting to come ashore - food, fuel, ammunition, medical supplies, mail and so on.

By 1130 hours on D-Day, more beach exits were open, lateral tracks were being cleared, and momentum was growing steadily.

As the tide rose, the beach area became smaller, and obstacles which had not been removed or destroyed became hazards once again for succeeding waves of landing craft. However, beach clearance continued in conjunction with naval specialists in underwater explosives and the build-up of armoured vehicles, guns, troops and supplies continued unabated.

With a steadily growing bridgehead, the Sapper role spread inland. Mine clearance, followed by mine-laying to secure captured positions against counter-attack, was a vital function. Maintenance and repair to beach exits, destruction and removal of inland obstacles, repairs to cratered roads, establishing water points - all were vital functions in support of the massive number of troops involved.

By 7 June (D+1), advance parties from specialist Royal Engineer units had arrived to begin the construction of temporary airstrips, and to bridge the Caen Canal and the River Orne, in between the areas held by 6 Airborne Division and 3 British Infantry Division.

All of this was not achieved without loss. In some sectors, up to 50% of the flail tanks, AVREs and armoured bulldozers had been knocked out, with high casualties among the crews. But many of the basic objectives for D-Day had been achieved, and the build-up of troops and armour across the beaches continued steadily until completion of the first section of the MULBERRY Harbour offered an easier and safer way of getting ashore.

Engineer Equipment for the Landings

Armoured Vehicle Royal Engineers (AVRE)

One stark message which came from the unsuccessful raid on Dieppe in 1942 was that Assault Engineers, who had sustained heavy casualties under fire while breaching the sea wall and other beach defences, needed some form of armoured protection.

Proposals were submitted for the conversion of a tank into an armoured vehicle suitable for this purpose, and in October 1942 the go-ahead was given for the production of a prototype, based on the Churchill tank. This prototype was completed by December 1942. Internal modifications allowed the carrying of engineer stores in place of the normal ammunition, and the turret was adapted to mount a Petard spigot mortar in place of the 2-pounder gun fitted to the standard tank.

Trials were successful, and the concept was taken forward to the Mark 3 and 4 versions of the Churchill, where the Petard, by now christened the 'Flying Dustbin' because of the shape of its bomb, was adapted to replace the 6-pounder gun which was normally fitted to these later models. This somewhat unusual vehicle was designated the Armoured Vehicle Royal Engineers (AVRE).

The Petard, with a calibre of 290 mm, was hand-loaded from inside the tank, and could fire up to 4 rounds per minute, depending on the skill and experience of the loader. The 40lb projectile, carrying a 261b demolition charge, was accurate to a range of 80 yards. In addition, two 7.92 mm BESA machine guns were carried, one in the turret and the other in the front plate of the hull.

The basic AVRE had an all-up weight of 40 tons and carried a crew of six - commander, driver, demolition engineer, wireless operator, mortar gunner and co-driver/mortar loader. A Bedford flat Twin Six 12 cylinder petrol engine developed 350 bhp and gave a maximum speed of 15.5 mph.

In late 1943, the 1st Assault Brigade Royal Engineers was formed as part of the 79th Armoured Division which, under the command of the one-time Sapper, Major General Sir Percy Hobart KBE CB DSO MC, had been given the task of coordinating the development of special armoured assault techniques and equipment.

Time was short, and during the early months of 1944 numerous trials and demonstrations of various novel attachments and equipment were carried out. Many of the more bizarre ideas were discarded, but several variants of the AVRE were prominent in the first assault on the Normandy beaches on D-Day. They were often referred to as 'Hobart's Funnies', but were much respected for their effectiveness and versatility and for the protection they gave Assault engineers working under fire.

Some of the tasks carried out by AVREs during the assault included:

- The destruction of gun emplacements and defended buildings.
- The breaching of sea walls and other obstacles.
- The scaling of walls and the crossing of antitank ditches and bomb or shell craters.
- The laying of flexible matting, fascines and log carpets to provide firm going for tracked and wheeled vehicles.
- The placing of demolition charges for remote detonation.
- Destruction by flame-thrower (Crocodile).
- The breaching of barbed-wire defences and minefields (Bangalore Torpedo).
- Mine clearing with ploughs

Fascines

Fascines consisted of bundles of brushwood and were developed for the crossing of ditches, craters and similar obstacles. They were carried on the front of the AVRE on a specially designed cradle and could be jettisoned from inside the vehicle.

Assault Bridging

An important role for the AVRE in Normandy was as a carrier/launcher for the Small Box Girder (SBG) assault bridge. These bridges were placed against sea walls to enable them to be surmounted by armoured vehicles, or placed over shell or bomb craters and over anti-tank ditches and natural obstacles such as watercourses.

Where appropriate, another AVRE, carrying a fascine, would drop this at the foot of the obstacle in order to provide a base on which the end of the bridge could rest

In its original form, the SBG bridge was cumbersome as its length was nearly 50% more than that of the AVRE itself. To overcome this, a folding version was developed and used later in the campaign.

Mat-Laying Devices

Various different systems were evolved for the laying of flexible surfaces on the ground.

Systems used included:

- Log Carpet - This comprised a carpet of up to 100 logs, each 14 ft long, with an average diameter of 6 - 8 in, laid side by side and joined with wire rope passed through each log.

  The carpet was carried on a steel frame, mounted above the AVRE turret, and held in place with wire lashings at the forward end.

After positioning the AVRE, small charges were fired to cut these cables and the first section of the carpet fell towards the ground. The weight of this pulled further logs off the frame in front of the AVRE and when the first few had reached ground level, the AVRE drove slowly forward over the logs until the entire length of the carpet had been laid. The length of carpet was up to about 80 ft.

- Bobbin - Reconnaissance prior to D-Day had revealed that on some sections of the beaches there were strips of clay, on which vehicles were likely to become bogged down. To overcome this problem, a stretch of similar beach was found at Brancaster, in Norfolk,. and trials for the laying of flexible carpet by an AVRE were carried out.

  The Bobbin comprised a large steel drum, carried on two support arms fixed to the sides of the AVRE, and the carpet consisted of hessian reinforced with scaffolding tube across its width.

  To lay the carpet, the Bobbin was lowered over the front of the AVRE and the material allowed to unreel. As the AVRE moved slowly forward, it ran onto the carpet which continued to unreel until it had all been laid.

Experience showed that these carpets, while satisfactory for wheeled traffic, would not stand up to tracked vehicles for long and that they needed replacing by Pierced Steel Planks (PSP) - which had to be laid by hand - as soon as conditions allowed.

Airfield Construction

The time which individual fighter aircraft could spend over the beaches was severely limited, due to the need to return to base for refuelling. It was therefore essential that temporary landing strips were constructed in Normandy at an early stage.

There were three types of landing strip:

- **Emergency Landing Strip** (ELS) -This called for flat ground, roughly graded, with a minimum length of 1,800 ft.
- **Refuelling and Rearming Strip** (RRS) - A minimum length of 3,600 ft, with two marshalling areas.
- **Advanced Landing Ground** (ALG) - A minimum length of 3,600 ft, for fighters and 5,000 ft, for fighter-bombers with dispersal facilities for 54 aircraft.

Five (13, 16, 23, 24, 25) Airfield Construction Groups of the Royal Engineers were available in the British and Canadian sector.

Each group comprised two Road Construction Companies and two Pioneer Companies. The plant available included crawler tractors, motor graders, scrapers, rollers, tipper trucks and transporters. Square Mesh Track (SMT) was used as ground surfacing material.

The initial plan called for one Emergency Landing Strip to be available by the end of D-Day, the first Refuelling and Rearming Strip by D+3 (9 June) with five Advanced Landing Grounds by D+8.

Advance parties from these Airfield Construction Groups landed on D-Day, with the main bodies of each unit plus their plant, equipment and stores following during the next 2 - 3 days. In some cases, the start of the actual construction was delayed, as the site was still in enemy hands.

Despite these delays, the first Emergency Landing Strip was constructed at Asnelles by 16 Airfield Construction Group and was operational by D+1 (7 June), the first Refuelling and

Rearming Strip by D+3, and the first two Advanced Landing Grounds by D+7 (13 June), one day ahead of schedule.

In all, ten of the planned total of fifteen airfields were operational by D+25 (1 July).

Bridging

The first significant bridging operations in the British and Canadian sector took place on the extreme left flank and involved a number of Bailey bridges over the River Orne and the Caen Canal.

One of the major objectives for 6 Airborne Division was to capture intact the bridges over the Caen Canal at Benouville and the River Orne at Ranville.

They were captured intact, with all demolition charges being successfully removed by the Sappers. However, their load carrying capacity was inadequate for tracked vehicles or for heavy trucks and transporters, but they did provide access to both banks.

In all, a total of eight major Bailey bridges were constructed across these two waterways. The first two of these, at Benouville and Ranville, constructed under almost constant enemy fire, were completed by early on the morning of D+5 (11 June). Pontoon bridges and, in some cases, where the river or canal banks were high, special floating piers were built.

Roadwork

Once off the beaches, all vehicles, wheeled and tracked, faced a number of options. There were three basic classes of route available:

Existing macadam roads, 13 - 15 ft wide. Many of these had been damaged by mines or shellfire; most had poor drainage and their verges churned up badly if traffic left the carriageway for any reason.

Gravel roads, 10 - 15 ft wide. These were normally used for local traffic only; they were dusty in dry weather and muddy when wet.

Earth tracks. These were formed by traffic across the fields, after mine clearance had been completed. They were also dusty in dry weather and liable to deteriorate very quickly during rain. A motor grader was essential to repair damage and to regrade badly rutted sections

Most of the beach exits led directly or indirectly to a village, where narrow streets and damage from shellfire created frequent bottlenecks. Immediate steps were taken to ease sharp corners by demolishing damaged buildings and walls and one-way traffic circuits were set up.

It was also clear that existing roads would break down under the volume of traffic and a number of new roads were constructed. Rubble from damaged walls and buildings was plentiful, and in some areas there were good stocks of broken stone in local quarries. 75 tons of tar were discovered in Bayeux and, with the help of some quarrying and macadam plant brought in by the Sappers, facilities for laying metalled surfaces were soon available.

In addition, various forms of temporary tracking were used. These were delivered either in roll or sectional form, and once the ground had been levelled and stabilised where necessary, they could be laid quickly. Constant maintenance was required, but the tracking could be lifted and then re-laid, either in the same place after remedial work to the sub-base, or in a different location as a particular section of track became redundant for any reason.

Road signs were of great importance, firstly to identify each village, and then to indicate the traffic routes for tracked and wheeled vehicles of different units. In the absence of such signs, everything tended to keep to the same line in order to reduce the risk of straying into a mined area, but this led to rapid surface deterioration when tracked vehicles had to slew at corners. Separate routes for tracked and wheeled vehicles were used whenever possible.

Constant maintenance of these roads and tracks, particularly at the approaches to bridges, was essential. Where possible, bridge approaches were surfaced with macadam. Traffic volume grew to a point where some roads were carrying 5,000 vehicles per day in each direction. In one instance, there were peak figures of 13,000 in one direction and 5,200 in the other.

The demand for stone steadily increased. Several quarries were quickly opened up, initially drawing on existing stocks of quarried material and crushing it down to the sizes required for road construction. French civilians assisted in these quarries, each of which was initially capable of producing up to 300 tons of crushed and graded stone per day.

Later, as the road construction and maintenance programme expanded, more quarry plant was brought in, giving capacities of up to 600 tons per day, plus the ability to produce coated tarmacadam for use on metalled roads and bridge approaches.

The road construction, repair and maintenance programme continued unabated throughout the whole of the campaign in Northwest Europe.

Main supply routes were given a code-word with the addition 'up' going towards the front and 'down' going to the rear, thus CLUB ROUTE UP. Units were allotted a route and a time slot in which to traverse it.

Each formation and unit had a tactical number and road side signs displaying such numbers led straight to the harbour area of the formation or unit.

Movement Control

During the build up for the invasion the Royal Engineers Movement Control units (Marshalling Area Movement Control) were responsible for marshalling and the dispatch of troops to their point of embarkation.

The Coast, Sector and Embarkation Movement Control units were responsible for implementing the very detailed instructions of the 'Q' Movement Staff which involved the allocation of accommodation in shipping and the carrying out of physical embarkation if troops, weapons and stores.

Movement Control personnel assisted with the flow of troops, traffic and stores off the beaches. Movement Control Groups involved in the invasion were Nos 6, 17, 18, 19, 20 and 27.

Once the invasion force was established a Movement Control Depot was established at Sully, near Bayeux and later at Amiens.

Water Supply

While there were many sources of water in Normandy, it was not known in advance just what the yield and quality from these sources would be. By D+1 (7 June) the existing supply network had virtually ceased to operate, due to the failure of the electricity supply to the pumps from the power station in Caen, still in German hands. Units landing on D Day and D+1 carried water in containers in their own transport, sufficient to provide ½ gallon per man

per day up to the evening of D+2 (8 June) . Additional water in containers was carried to provide a further 2 gallons per wounded man per day. Tanks were allowed 2 gallons per day, and other vehicles ½ gallon.

As the bridgehead was enlarged, so the demand for water grew. Intelligence collected prior to D Day had suggested that to the east of the River Orne the area where 6 Airborne Division landed - little water other than from some shallow wells was available, but to the west the situation was better, with water in adequate quantity in deep limestone wells plus some small rivers.

A network of water purification and storage points was speedily established. These comprised mobile pumping sets, mobile filtration and chlorination plants and sectional steel storage tanks. Output varied widely - 10,000 gallons per day was considered the minimum realistic figure - but by noon on D+1 (7 June), one water point with a capacity of 20,000 gallons per day was open with steadily increasing output in subsequent days.

Eight water points had been established in " the area covered by 1 Corps by D+4 (10 June), and these were supplemented by local wells where these were available. There was always the risk that water sources had been polluted by retreating troops, but there was little evidence that this actually happened.

It was found during the first week that each division required approximately 50,000 gallons per day from Royal Engineer sources, with any other needs being met by the exploitation of local wells and streams.

As the advance continued, many of these water points were converted into permanent installations, leaving the mobile equipment free to move forward into newly occupied areas.

The Mulberry Harbours - '*Piers for use on beaches*'

As plans for the invasion developed it was clear that the Allies would need a port to sustain their forces ashore. On the stretch of Normandy coast chosen, there was no port of any size. The Dieppe raid, in which 900 men were killed and 2,000 taken prisoner, had shown the difficulties of capturing one and so it was accepted that an artificial harbour would be necessary until a large port was captured.

Major B (Bruce) White RE, was responsible for Ports in the Directorate of Transportation at the War Office from May 1940. With service during the First World War in the Royal Engineers (Inland Water Transport Section) and being in the Emergency Reserve, he had been called up early in the War. He quickly drew up a list of 150 civil engineers `with relevant experience who would be available to the military when the time came to design the installations which would inevitably be required.

On 30 May 1942, Winston Churchill issued his famous memorandum:

> *Piers for use on beaches - They must float up and down with the tide. The anchor problem must be mastered. Let me have the best solution worked out. Don't argue the matter. The difficulties will argue for themselves.*

Three schemes were put forward. That selected was proposed by the Transportation Staff at the War Office. Known as WHALE, it consisted of floating pierheads, carried on legs resting on the seabed, at which ships could unload, connected to the shore by an ingenious floating roadway. Its operational life was to be 90 days.

In late 1942, Findlay's of Motherwell, Scotland were instructed to build prototype pierheads for trials. The floating roadway was designed by Colonel W T Everall, a successful engineer with the Indian railways, and the prototype was built by Pearsons Engineering.

Prototype equipment was tested off the west coast of Scotland in the summer of 1943.

Breakwaters were needed to form protected areas for the MULBERRY Harbours. These would consist of lines of sunken ships called GOOSEBERRY and concrete caissons called PHOENIX. Further out to sea a floating breakwater called BOMBARDON would be installed.

At the Quebec Conference in August 1943 it was agreed that the design and manufacture of MULBERRY would be a British responsibility. The Royal Navy would be responsible for GOOSEBERRY and BOMBARDON, the Royal Engineers for PHOENIX and WHALE.

Two harbours were required: MULBERRY A to be installed by the Americans to supply their forces at the rate of 5,000 tons a day and MULBERRY B by the British with a capacity of 7,000 tons a day.

MULBERRY B would enclose an area almost twice as large as Dover harbour at low water and three times as large at high water. At Arromanches where it was to be built, the tidal range was 24 ft and the beach sloped at 1:200.

Design of PHOENIX began on 1 October 1943. Construction sites for the MULBERRY units were set up all around the coast of Britain including Scotland and Wales. By the end of May 1944 - only 8 months later - 147 PHOENIX, 24 pierheads, 10 miles of WHALE roadway and 2 miles of BOMBARDON were ready.

Harbours travel to France

Rear Admiral W Tennant was appointed Rear Admiral MULBERRY/PLUTO. The installation of 'MULBERRY B' was under the joint command of Captain C H Petrie RN, and the Sapper, Brigadier A E M Walter.

A fleet of tugs under Captain J (Johnny) Luck RE, reinforced by an American detachment of Motor Towing Launches (MTLs) under Warrant Officer J Herring gathered the units on the South Coast. No moorings were available so the WHALE units were concentrated in the Solent and the PHOENIX caissons were flooded and parked on the seabed at Dungeness and Selsey Bill. Problems arose when the PHOENIX units had to be raised ready for the 100 mile tow across the Channel. Eventually the Port of London Authority and the Admiralty completed the task but it was a close-run thing. One caisson was lost when it suffered irreparable damage after being sunk a second time. Six small caissons were lost from scour at Dungeness and two were lost to German E boats whilst crossing the Channel.

The Sapper, Colonel S K Gilbert, commanded the Port Construction Force with Lieutenant Colonel R Mais RE (later Lord Mats, Lord Mayor of the City of London) responsible for the pierheads and roadways and Major R J P Cowan RE in command of the Port Floating Equipment Companies RE (969 and 970).

The construction force began its work soon after D-Day. The Port Floating Equipment Companies moved from the Isle of Wight, where they had been training on WHALE, to London Docks on 2 June, they boarded The City of Canterbury and sailed on the same day. They anchored off the French coast until 7 June (D+1) when they landed on a beach near Arromanches, did some mopping up in the town and awaited the arrival of WHALE.

Harbours are operational

By 9 June (D + 3) , 1,500 ft of the centre pier and 600 ft of the east pier had been completed. On 10 June (D + 4) the first PHOENIX was planted.

During the morning of 19 June (D+13) a fierce storm blew up from the north-east and continued to blow unremittingly until the night of 22 June (D+16) with waves up to 14 ft high.

All the BOMBARDON floating breakwaters broke from their moorings. At 'MULBERRY B' they were swept clear of the harbour although a few had to be sunk by Sappers using PIAT anti-tank rounds. Johnny Luck and his tug crews did sterling work getting lines aboard drifting vessels and units and towing them clear.

At 'MULBERRY A' however the BOMBARDONS were directly upwind of the harbour. They bore down upon it and caused extensive damage. The WHALE roadways were wrecked and many vessels foundered.

Even so, 7,000 tons of stores were unloaded during the storm with 800 tons of ammunition coming ashore on the worst day.

The storm abated on 23 June (D+17). At 'MULBERRY A', debris was piled high on the beach and the harbour was so badly damaged it was abandoned. Equipment salvaged from 'MULBERRY A' was used at 'MULBERRY B' where it took 2-4 days to repair the damage.

In June 1944 it was decided to extend the operational life of 'MULBERRY B' beyond 90 days and modified caissons, reinforced and decked over, were built. Others were filled with sand by suction dredgers requisitioned from the Mersey Dock and Harbour Board.

'MULBERRY B' continued operations until November 1944. Later the new caissons were pumped out and used in flood relief work at Walcheren and the WHALE roadways were recovered and used 'as floating bridging on French rivers and canals. The caissons surviving today at Arromanches are the old models. Other WHALE units were salvaged and brought to Marchwood for dismantling and. storage. PHOENIX was also used at Le Havre to form deep water quays in winter 1944/45. Some WHALE roadway units are still in use today on the River Thames at Grays in Essex.

It handled an average daily load of 6,000 tons with a maximum throughput of 10,000 tons. The WHALE pierheads and floating roadways were a great success turning round a Landing Ship Tank in 40 minutes. The design gave rise to the modern Roll-on Roll-off ferry.

Several other elements contributed to the success of the whole operation, they included:

The invention of 'chocolate' by Major V C (Vassall) Steer-Webster RE. This was a reinforced concrete mattress 3 ft 4 inches by 2 ft by 5 in weighing 350lbs and looking for all the world like a bar of chocolate, designed to bridge the gap on the shore between high and low water;

The Tank Landing Craft, which could carry five 40-ton tanks or eleven 30-ton tanks;

The American Naval Lighter pontoons which were built up into causeways within the harbours and Rhino ferries.

The DUKW seaworthy, roadworthy amphibious vehicle with a 2½ ton payload which could be loaded over the side of a freighter out in the harbour, then driven ashore to unload directly at an inland dump.

The Men

The MULBERRY harbours were intended as a temporary measure until port facilities had been captured. These ports would be extensively damaged by Allied bombing and by the withdrawing Germans.

One of the first tasks of the Transportation Staff was to assemble a dossier of all the technical information known about each port. Details were gathered from all available sources including holiday snaps and reminiscences. Many of these dossiers are held today in the Royal Engineers Corps Library.

The PC&R Groups controlled the work of the other specialist units allotted to them.

The PFE Companies were formed specifically to handle MULBERRY equipment.

The personnel all received normal basic military and field works training before progressing to specialist technical training. All units gained valuable experience before D-Day during the construction of No 1 Military Port at Faslane, No 2 Military Port at Cairn Ryan and the Port and Inland Water Transport Repair Depots at Marchwood and Richborough. The units were later deployed in all theatres of war.

The PFE companies conducted the experimental work and full-scale trials of floating equipment at a special establishment known as the Floating and Fixed Equipment Training and Development Depot.

The PFE companies assembled the WHALE equipment in home waters, crewed during the tow, then installed and operated them.

The Dredging Companies first worked at numerous MULBERRY construction sites in home waters. After D-Day, 982 Company worked at 'MULBERRY A' and 983 Company at 'MULBERRY B'. Both these units worked continuously until July 1945. The dredger fleet included several French vessels which had escaped to England in 1940.

The Causeway story

In addition to the MULBERRY Harbours, the Causeways provided an alternative method of landing men and vehicles dryshod on the Normandy beaches. They were a last minute conception and because their construction and operation was confined to one Field Engineer formation the story is not well known.

It has been mentioned that some landing beaches might contain patches of peat and clay, a hazard to vehicle movement. Further, since it was impossible to waterproof all vehicles, this meant landing them dryshod.

The Causeways offered a solution to both problems. The correct name of the equipment was American Naval Lighterage Pontoons or NL pontoons for short. They consisted of steel tanks 5 ft long, 7 ft wide and 5 ft deep. They could be connected together by steel angles into strings up to thirty pontoons long. The strings could be connected side by side by means of tie rods to form rafts or barges up to six or more strings wide. The decks formed a roadway strong enough to carry tanks.

By placing rafts end to end the gap between high and low water could be covered. In some places this gap was half a mile wide.

If the pier was extended into deep enough water a Landing Craft - Tank (LCT) could drop its ramp and unload at all states of tide. Alternatively, if the pier were sunk to form a Causeway the Craft could proceed inshore and unload where the Causeway was just exposed. Personnel could land dryshod on the Causeways, an important morale consideration.

15 (Kent) GHQ Troops Engineers was available for the task, and were well trained in watermanship. They built six Causeways on the British beaches. Four Causeways on the American beaches would be built by US Navy Construction Battalions - Seabees.

It was decided that the equipment would be used as Causeways since the problems of securely mooring a long floating pier on an exposed beach were too complex.

Each Causeway would consist of a number of 2 x 30 'sinkers', that is two strings each 30 pontoons long connected side by side. A sinker was 176 ft long and drew 1 ft 8 in of water unladen. The average Causeway was expected to be some 14 sinkers long, about half a mile.

Originally, landing craft were expected to unload onto a 4 x 30 'floater' which would be drawn up and down with the tide alongside the Causeway but this solution was found to be unsatisfactory. Instead 4 x 10 `blisters' were sunk on either side of the Causeway at various points up the beach. Each blister would cover a 2 ft tidal range. The incoming LCT would choose the appropriate blister, one just awash, at which to unload.

NL pontoon equipment was also used to build tugs to handle the Causeways into position. Their propellers could be raised safely out of the way when in shallow water or beached. Bulldozers would assist in beaching the sinkers and act as mobile anchorages. Training began in February 1944 with the US Navy Seabees at Falmouth.

It was originally thought that floaters, sinkers and tugs would be provided, ready made, by the US Navy. In the event the Engineers had to assemble the equipment themselves in Southampton Water during April and May 1944. This strange fleet assembled in Osborne Bay ready for action.

Advance parties of 15 (Kent) GHQ Troops Engineers landed in France late on D-Day followed by the first of the Causeway equipment on D+1 (7 June). The leading sinkers were each loaded with 10 tons of Pierced Steel Plank for Second Army Engineers. Positioning the sinkers began on D+2 (8 June). By D+5 (11 June), three Causeways were in operation with a fourth opening the next day. Custom was slow to begin with since Tank Landing Craft preferred to beach and unload but Infantry Landing Craft became regular users.

15 (Kent) GHQ Troops Engineers continued to operate the Causeways until 29 July 1944 when they were handed over to No 3 Inland Water Transport Group. In all they had handled 1,606 major landing craft and 13,947 vehicles and 115,000 men had come ashore. They were avert' effective insurance and made a significant contribution to the Normandy landings.

Fuel Supply

In the early stages all fuel had to be landed in containers and distributed to individual units. However, a bulk fuel storage installation was planned for Port-en-Bessin near Arromanches. A similar installation was planned for Cherbourg to supply the American forces.

Work on reopening the Channel ports started as soon as possible but was delayed at Port-en-Bessin by the German resistance. Construction of the bulk fuel installations was carried out by two Oil Groups Royal Engineers consisting of a number of specialist engineer units supported by Royal Army Service Corps and Royal Pioneer Corps units.

At Port-en-Bessin by 5 July 1944 (D+29), two ship-to-shore pipelines with pumps and 7,200 tons of storage capacity were complete. A pipeline was being constructed towards Bayeux and another to the West to connect with the Americans at Cherbourg.

By 25 July (D+49), 68,000 tons of petrol and oil had been pumped ashore, some 10% of all the tonnage landed in the period.

The development of these installations continued until the end of September when 15,000 tons of storage capacity was ready and the pipeline to Cherbourg was complete. Two pipelines were built across the River Seine, near Rouen, complete with intermediate storage facilities.

With the opening of the Channel ports, anew system was introduced. At Ostend in September, storage was built to receive fuel direct from tankers, a rail connection was established with the Americans and a triple pipeline was opened to Ghent.

Boulogne was then developed in a similar manner with a 90 mile pipeline bypassing Dunkirk - still in German hands - and linking in to the Ostend - Ghent system.

In December a third pipeline system was started, running from Antwerp to Eindhoven and eventually across the Rhine. This was later connected to Ghent.

In all the Corps laid over 1,100 miles of pipeline. The first pipeline across the Channel, PLUTO (Pipeline Under The Ocean), ran from the Isle of Wight to Cherbourg. A second crossing, DUMBO, ran from Dungeness to Boulogne.

The undersea pipeline was laid by the Royal Navy. The Royal Engineers built the complicated shore installations at Dungeness and on the beach at Boulogne.

PLUTO was hardly used but as more lines were laid on the DUMBO crossing, fuel deliveries were 3,500 tons a day by April 1945.

It is of note that diesel fuel hardly featured in these operations. The high speed diesel engine had not been adequately developed by 1944.

Regular deliveries of huge quantities of fuel, mainly petrol, were vital to the success of the Allied operations.

Bomb Disposal

On D day, 21 Army Group had under its command five Companies (5,19, 23, 24, 25) with a total of 33 Bomb Disposal Sections. Their initial task was to dispose of unexploded bombs on the beachs, but due to an absence of major aerial attack they were engaged in mine clearing tasks. Throughout the campaign they were deployed on the basis of one company to each of the two armies. From the 6 June 1944 to 25 August 1945 the five Royal Engineers Bomb Disposal Sections Groups disposed of 939,061 unexploded bombs, mines and other explosive devices.

Engineer Stores

5 Engineer Stores Base Depot was established to handle the stores required to support the engineering activities. They were divided into four categories:

- Airfields
- Pipelines
- Bridging
- Other stores and plant

In August 1944 it was importing 90,500 tons and the Depot handled 4,015 tons in one of that month.

Electricity

The Royal Engineers were responsible for the supply of electric power and lighting for base installations and in the first instance a number of generating sets were imported, but as soon as Caen was captured (10 July) work was started on the rehabilitation of it's power station. After a precarious start the power station was coaxed into life and thereafter provided much of the electrical requirement of the invasion forces in the Normandy area.

Forestry

Two Royal Engineers Forestry companies landed in the early stages and were located in the wooded areas south of Bayeux and Caen. By the end of August those companies were producing about 1,000 tons of useful timber a day and thereafter averaged about 2,000 tons a

day, excluding pit props for mines, but including long piles for use by American engineers in Cherbourg.

Postal Services

General Montgomery considered that a speedy and efficient mail service was a major contributor to the maintenance of troops' morale. Accordingly when he took over responsibility for the planning of Operation OVERLORD in 1943 more emphasis was placed on its provision in the overall plan and the Royal Engineers postal planners were given appropriate access to all aspects of the plans. This did not happen in 1942 during the planning of the invasion of Algiers (Operation TORCH) and resulted in a serious detriment to the postal services provided to the troops.

To maintain secrecy during the invasion build-up all British invasion troops were given a 'closed address' (i.e. Number, Rank, Name, Unit, APO England). Under this arrangement all military mail presented to the General Post Office so addressed was sent to the Home Postal Centre RE, in Nottingham for distribution to the Field Post Offices (FPO) established by the Royal Engineers in all the Marshalling areas. These Field Post Offices were the only official conduits of communication between the troops and the outside world.

On the night of 5/6 June 1944 members of the 6 Airborne Division Postal Unit, parachuted into Normandy along with the rest of the Division, and made their first despatch of mails back to England on D+2 (8 June). In the late morning of D Day elements of Postal Units attached to the Special Services Group, Beach Group and Commandos established Field Post Offices on the beachheads and began to distribute and collect mail.

40 'Posties' were in Normandy by the end of D Day, their numbers increased daily. The responsibility for the whole postal operation fell upon Colonel WR Roberts, Deputy Director Army Postal Services, 21 Army Group who landed with his deputy Lieutenant Colonel JN Drew RE on D+3 (9 June).

The Base Army Post Office 8 arrived in theatre on D+9 (15 June) and established itself at Crepon, approximately 7 miles south west of Arromanches. On 6 July (D+30) a two-way airlift system was established between England and airstrips in Normandy for the exclusive transportation of letters and newspapers ensuring an average mail transit time of 2-3 days from posting to delivery.

Quarrying

Supply of stone for repairs was at first a problem. That in the quarries in Normandy was soft and unsuitable but had to be used for lack of anything better. No machinery was found in the existing quarries but the Royal Engineers Quarrying Units installed their own and organized production on a large scale amounting to a maximum of 4,500 tons per day. From one quarry alone, that at Creully, a peak output of 1,500 tons a day was reached.

Though small quarries of better stone were found and worked, it was not till those at Marquise, near Boulogne, were captured that the position in this respect became satisfactory, and meanwhile stone had to be imported at the rate of 10,000 tons a day.

Survey

The maps needed by assault formations and units had been issued to units before embarkation. These arrangements worked well though there were occasional troubles for which allowances had been made and were soon remedied. One formation headquarters forgot to take its maps with it in the ship. This was reported to Assistant Director Survey, 21 Army Group, at 0100 hrs on D Day. A message was sent back, the necessary maps were drawn from a store in Essex, sent by truck to Southend, from the pier at which place they were loaded into a naval launch and delivered to the erring headquarters in mid-Channel.

Till the arrival in Normandy of Headquarters 21 Army Group, survey responsibility in the bridgehead fell on the Deputy Director Survey Second Army, Colonel A. W. Heap. The first survey personnel to disembark on D Day were four sappers with ten tons of maps to form the nucleus of a store. These were soon followed by the major portion of 3 (Army) Field Survey Depot RE with a further sixty tons of maps and a small quantity of transport. This unit was followed later in June by 4th and 5th Field Survey Depots, to build up a map depot in Caen after its capture.

Other early arrivals in France were 519 and 521 Field Survey Companies which started work checking up the existing triangulation and survey data.

Transportation

The Royal Engineers Transportation Services were responsible for the Railways and, as already mentioned, the running of the Ports.

In readiness for the advance out of the bridgehead four railway construction groups and fourteen railway construction companies were formed in July 1944. After the enemy had been cleared from Bayeux and Caen they were tasked with getting both railway yards operational and routes cleared for traffic.

Once the enemy had been pushed clear of the ports on the northern coast of France, Royal Engineers were tasked with clearing them and making them operational. Work at Dieppe was started on 4 September 1944, four days latter work on constructing as train ferry terminal which became operation on 29 September. On that same day work began on the port of Boulogne and was completed on 21 November. Work began at Calais on 26 October and was also completed on 21 November. All these ports after they became operational improved the ability of the Allies to sustain their battle against Nazi Germany.

Conclusion

This account summaries the remarkable variety of activities in which the Corps was involved in support of Operation OVERLORD, fully living up to its mottoes - *Ubique* (Everywhere) and *Quo fas et gloria ducant* (Where right and glory lead) - and performing many vital roles without which the Invasion might not have succeeded

The Royal Engineers are justly proud of their contribution to the Liberation of Europe.