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THE ROYAL ENGINEERS JOURNAL

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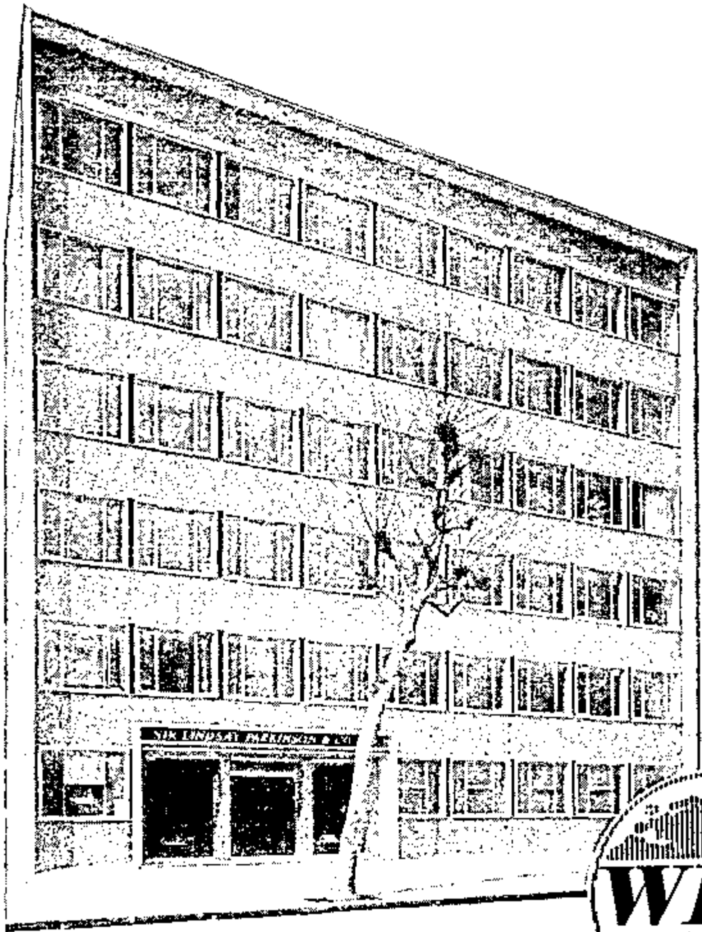

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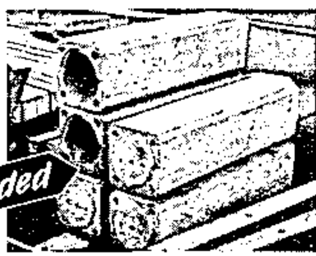

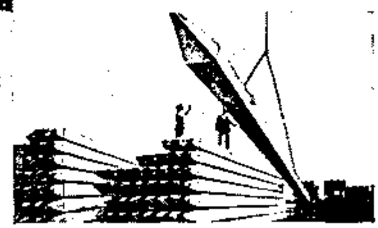

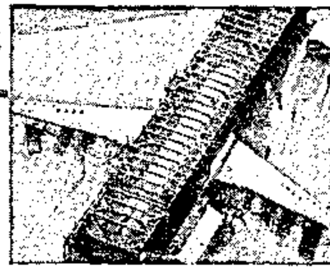

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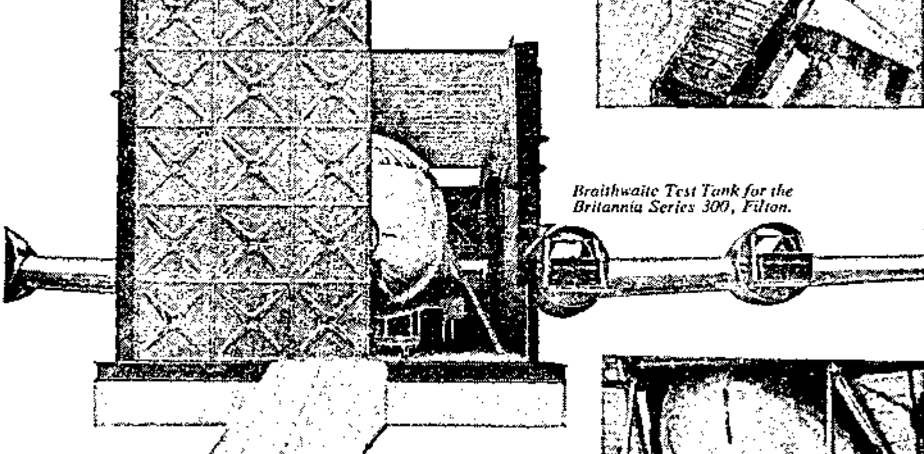
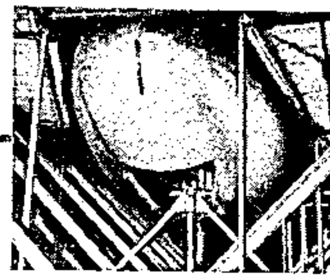


Braithwaite Test Tank for the Britannia Series 300, Filton.



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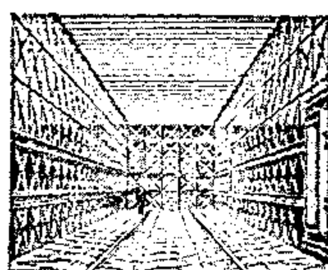

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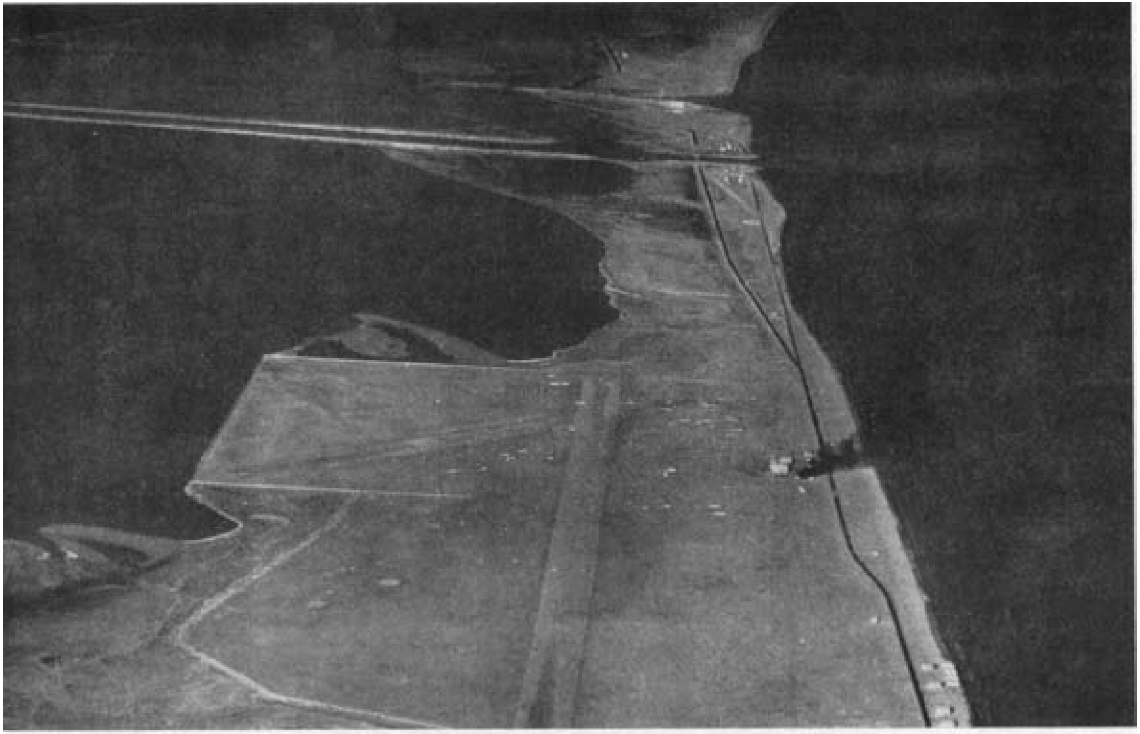


Photo 1.—Gamil Airfield soon after the drop, showing the fire near the control tower.

Airborne Sappers on Operation Musketeer

By Captain P. H. Brazier, R.E.

This has been written with no idea of providing a detailed account of operations at Gamil, but rather to tell simply, the story of the Sapper troop who dropped in support of the force.

It was originally intended that the airborne and sea assault at Port Said should take place virtually simultaneously. "L" day (Landing Day) was fixed for Tuesday, 6th November, 1956. In the event, part of the airborne assault was brought forward twenty-four hours. This consisted of the 3 Parachute Battalion Group to seize and hold Port Said airfield to the west of the town and two companies of French paratroops, with a small detachment of British, including Sappers, to capture two bridges to the south. These were over the Inner Basin at the southern extremity of Port Said and were vital to us when breaking out of the city.

Although this article does not directly concern the French party, some brief details are worth mentioning. It was a most gallant affair; after a brisk fight they captured intact the main swing bridge (class 60). The Egyptians managed to blow the smaller pontoon bridge before it was overrun. The swing bridge was successfully held against counter attacks for nearly thirty-six hours, until relieved by the 6th Royal Tanks.

Returning to the assault at Gamil Airfield the force consisted of:—

3rd Battalion The Parachute Regiment.
3 Troop 9 Indep. Para. Fd. Sqn.
A Field Surgical Team of 23 Para. Fd. Ambulance.
A R.A. F.B.O. (Forward Bombardment Officer).
An A.C.T. (Air Contact Team).
A detachment R.A.S.C. for D.Z. clearance.

the total force was approximately 650 all ranks. This included a small tactical Brigade H.Q. which was to co-ordinate the British and French forces taking part in the operation.

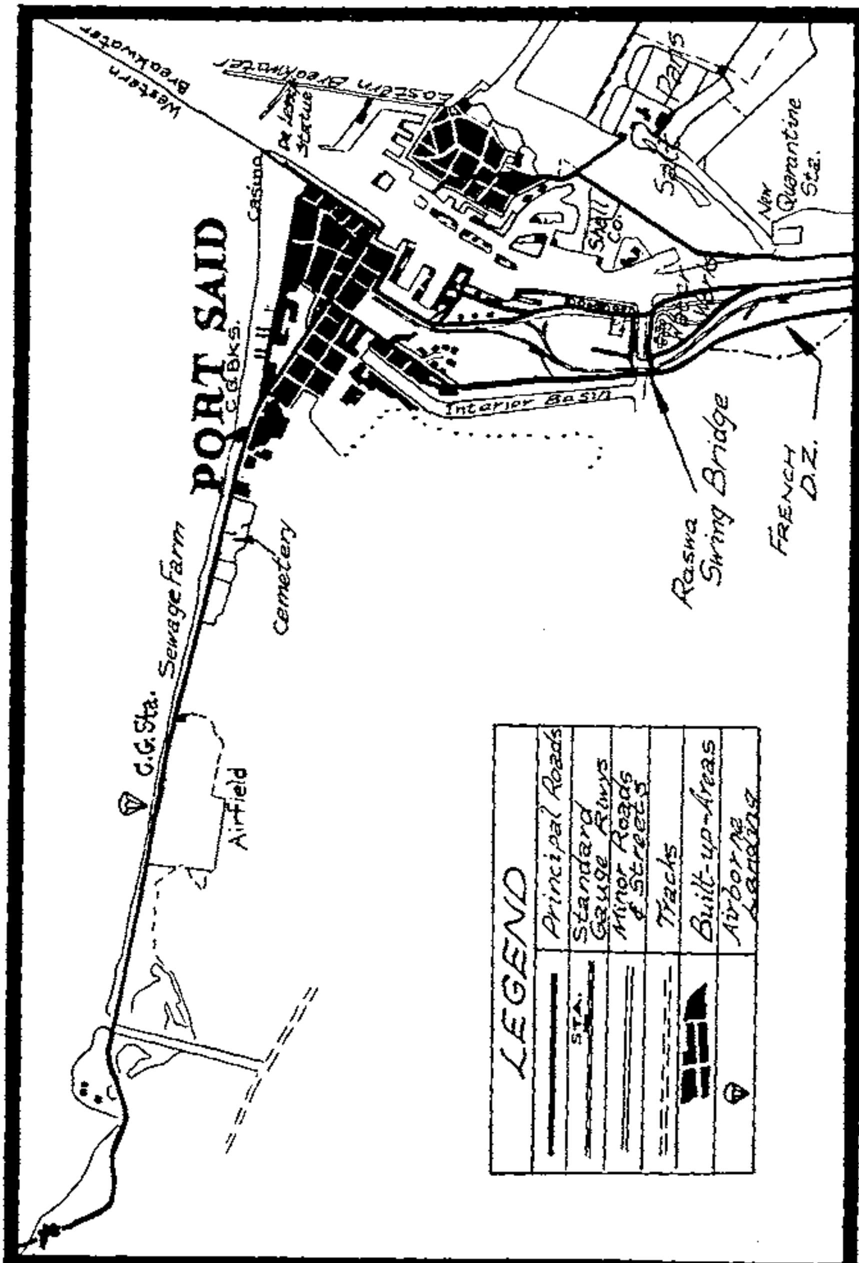
The Sapper tasks were initially threefold:—

1. To prepare the bridge a mile to the west of the aerodrome for demolition.

2. To clear the runways of obstructions and if necessary repair them.

3. A small party of two men, were to try and locate, repair, and operate a pump over a well believed to be in the vicinity of the control tower.

Our main task was considered to be a very tough proposition as the bridge concerned was reported to be class 100, R.C. construction. All we could hope to achieve with our limited resources, was to blow in the abutments with cratering charges and overload the three nearest arches with pressure charges. We had packed rather more than one ton of plastic H.E. to do this task, together with a few general field engineer tools, into C.L.E.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Eastern Breakwater
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C.G. Bks.
Interior Basin
Shell Co.
New Quarantine Sta.
Raswa Swing Bridge
FRENCH D.Z.
Cemetery
Sewage Farm
C.G. Sta.
Airfield
LEGEND
Principal Roads
STA.
Standard Gauge Rlwys
Minor Roads & Streets
Tracks
Built-up Areas
Airborne Landing

containers. The containers were spread over several aircraft to make certain that at least a proportion should arrive. Similarly all essential items had to be duplicated when loading containers. The troop had received a detailed briefing of the engineer plan so that whatever happened everyone knew exactly what was required.

The R.A.F., twenty-four hours before the landings, began to systematically soften up the whole area, destroying known enemy positions, including radar installations. Tac. R. photographs revealed that obstructions were being placed all over the airfield and that the beaches on the northern edge were being mined. Reveille on 5th November was at 0200 hrs. During breakfast the C.O. arrived with the latest Tac. R. photographs taken only the evening before by the R.A.F. To our consternation there was an enormous gap in "Our" bridge made by bombing the previous day. Being robbed of our main task at the eleventh hour was a great disappointment. Anyhow by now there was no time to rebrief the men, as we were about to leave for the airfield at Nicosia and take-off. We arrived at the airfield round about 0330 hrs. The previous afternoon we had fitted parachutes and stacked them, together with our weapon containers, in the different aircraft to which we had been allocated. All that was left for us to do was to put on our parachutes and emplane at the required time.

The troop-carrier force going to Gamil comprised Valetta and Hastings aircraft and the first Valetta taxied away for take-off just before 0500 hrs. The air plan was such that we would all be dropped over a short space of time in order to produce a heavy density of men on the D.Z. quickly. Unfortunately a slight tail wind had been forecast and, in fact, a 10 m.p.h. head wind was encountered. This had the effect of slowing down some of the Hastings aircraft, with crated Jeeps underneath, more than was expected. A few Hastings did arrive slightly late over the D.Z. but it did not affect the issue. The stream of troop-carriers crossed the Egyptian coast at Damietta about twenty-five miles west of Port Said and then turned east for their run in towards the D.Z. at Gamil Airfield.

Looking out of the open door of the aircraft, it all seemed rather quiet and peaceful. Below us the fishermen were quite visible tending their nets and the Feluccas were still plying in the Nile delta, just as they have done for thousands of years. As we approached the D.Z. we could see the coast road running towards Port Said and there appeared every prospect of seeing our ill fated bridge. Unfortunately some Egyptian light ack ack spoilt things, and the pilots of the Hastings aircraft had to take violent evasive action. This threw over many of the troops who were by now standing, with their weapon containers, ready to jump. However, they did not take long to sort themselves out, once the aircraft was on even keel again. After leaving the aircraft one could see there was a fair amount of firing across the D.Z. both from L.M.Gs. and mortars. Also a fuel store near the control tower was burning furiously, emitting a great sheet of flame and thick black smoke.

Directly men landed, weapon containers which were attached to them during their descent, were opened and their weapon and personal equipment were removed. All men then made for their respective sub unit R.V.s. Men began to arrive at our R.V. in twos and threes from all corners of the D.Z. with commendable speed. It was not long before all the troop had reached the R.V. less one man. We were pleased to find out later that the

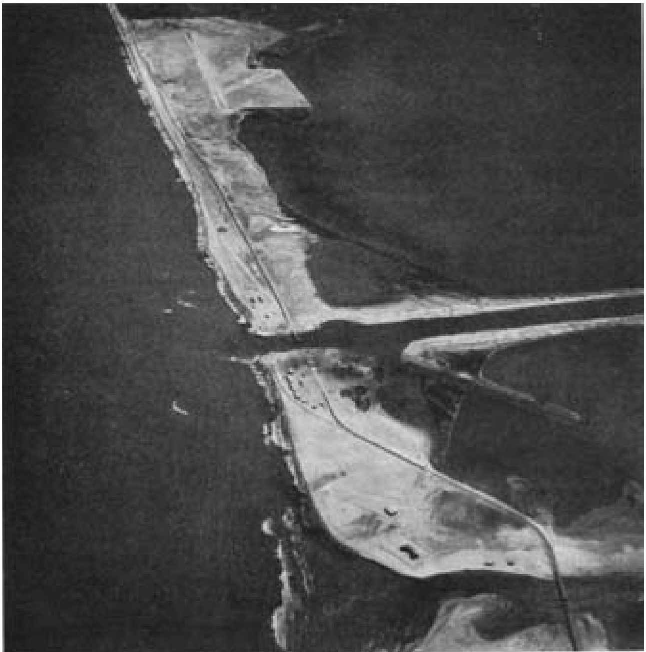


Photo 2.—The fated bridge the night before we dropped.

Photo 3.—The troop position showing the control tower in the background, by kind permission of the *Illustrated*.

Airborne Sappers On Operation Musketeer 2 , 3

missing man was safe, having been carried into the R.A.P. by stretcher bearers. He had evidently fouled someone else's equipment during his descent which had collapsed his parachute approaching the ground. Apart from concussion, he had broken both his ankles and fractured his spine and pelvis. He was evacuated by helicopter later that morning.

Because the bridge had been blown, and we had now no immediate task, we took up a position of all-round defence and started to dig in. The speed with which this was effected was phenomenal, and would have pleased even the most critical umpire under exercise conditions! No more than shell scrapes were practicable as the water table was only 1 ft. 6 in. below the surface. Later in the morning, with C.L.E. containers and 40-gallon drums we had collected, we improved the shell scrapes with effective breast works.

The Troop Commander called his "O" group and gave orders for the revised Sapper plot. Roughly half the troop went off to collect in our C.L.E. containers, many of which had luckily landed in, or near, our troop area. A small recce. party went off, with an infantry patrol, to report on the damaged bridge. It had also to report on the feasability of the Egyptians being able to force a crossing at this point. One section then set about clearing and inspecting the main runway. The Egyptians had placed rows of 40-gallon drums at intervals across the runway. These drums together with disused parachutes and containers had to be dragged clear. One or two containers were smashed or on fire, these had exploding ammunition in them. These were caused mainly by containers hitting the runway surface hard, this in turn sufficiently distorted the No. 80 (white phosphorous) grenades causing them to burst into flames immediately.

Two hours after landing all 1,600 yds. of the main runway had been cleared and found to be undamaged. This information was passed to Battalion H.Q. Before long all our C.L.E. containers which had landed on the D.Z., which were about two thirds of the total, had been collected into the troop area. The remainder must have fallen off in flight or dropped wide into the sea, which even the odd man had done. The patrol on returning reported an 80-ft. gap in the bridge, which was not R.C. at all but masonry! Several other arches were very badly cracked in addition. Further the water was deep and the next bridge another half a mile along the road was also destroyed by our bombing.

No well or pump was found in the vicinity of the control tower but there was a tap with water still running. The weather was still warm and the water situation was likely to become acute if the supply ceased. The only receptacle which would satisfactorily hold water easily to hand were our Mae West life jackets. These we ripped open and collected as much water as we were able for the force. Unfortunately, after a short while water ceased to flow out of the pipe, which, to put it mildly, was tiresome.

Towards midday we lent a hand clearing the D.Z. of parachutes and empty containers. This had to be done so that the parachutes of the resupply drop could be quickly spotted as soon as they came in.

During the first two hours after landing, the force was subject to considerable mortaring and shelling. One quite severe "Stonk" straddled the control tower area, with the "overs" falling in the troop position. Fortunately only two of the troop were slightly injured, although it shook the 31 set enough to break it internally and ruined a 3.5-in. rocket launcher which was on the top of a slit trench. A large proportion of the shells landed in the sea, just off the beach about fifty yards to our flank. Our air strikes must have denied the use of suitable O.Ps. to the enemy. As the morning wore on the shelling died down until only a stray shell came over now and then.

The Battalion was steadily fighting its way into the western outskirts of Port Said. In the afternoon a message was received that a hole in the road towards the city required filling to allow the passage of anti-tank guns. On arriving at the site we found four large craters, which the Egyptians had blown as our leading company approached the area. It was evident from the shape of the craters that the Egyptians used pipe pushing equipment of the type we used in the last war. After a quick recce, which revealed the craters were not mined, it was decided the only solution at the time was to make a diversion. This we did by breaking off lumps of tarmacadam from around the craters, and making a track to one side. The base for the diversion could hardly have been worse, as it was on very soft sand of the same consistency as found in sand dunes.

Our position was a none too happy one at the moment as the road ran straight down into the city. Overlooking us about 700 yards ahead was an Egyptian army barracks still occupied by them. The troop subaltern passed through the men working on the road in a jeep. This he parked by a wall 200 yds. ahead and he then went across to an enemy anti-tank gun which had been reported to him as requiring demolition. Our friends in the barracks spotted him and began to fire bursts of L.M.G. fire at him. Every time he went round from our side of the gunshield they gave him this treatment. Eventually he managed to position the charge, light the fuse and then bolt back across the road to safety.

That evening the whole force had to withdraw back to the airfield, so as not to become involved with the Naval bombardment early the next morning. To our great joy we heard over the Brigade net that the Egyptians had asked for a cease fire. All details being passed in clear to save time. The local garrison commander had to discuss our terms with Nasser, who pepped him up sufficiently to turn down the surrender terms and he decided to fight on.

As the battalion fought its way farther into the town the next day we went forward and improved the diversion. That night the force had linked up with the Commando Brigade and the diversion had to be brought up to class 9 and over. The only hardcore available was the wall of the cemetery some thirty yards away. This we partially demolished and moved the rubble in our small airborne trolleys to the diversion. The task took us about five hours to complete. The troop spent the night dug in, with on the one hand the cemetery and on the other, craters filled with sewage from a broken main.

It would be wrong not to mention the superb support given to us by the Fleet Air Arm, whose air strikes on targets were delivered swiftly, accurately and with devastating effect. A request for air support on the Battalion command net was immediately passed to the A.C.T. who in turn would barely finish speaking to the cab rank, before three aircraft would peel off into a dive on to the target. Also great credit should go to the helicopter pilots who commenced to evacuate our casualties after no more than three hours had elapsed after our initial landings by parachute. It cannot be emphasized too greatly how the knowledge that the wounded were receiving such excellent treatment raised the morale of the force. On the enemy air side, a lone M.I.G. shot across the airfield the first evening, shooting it up as it went at an enormous speed. We had three visits from a lone M.I.G. the next morning. This was the only enemy air interference we had during the whole operation.

It is now past history that the Suez dispute returned into the hands of the politicians at midnight on the 6/7th November, little over thirty-six hours after the initial landings. There is, never the less, one factor worth pondering in these days when military pundits are saying parachute troops are outdated. This factor is that a lightly equipped British and French parachute force of 1,000 men compelled a garrison of four times their size to ask for a cease fire within twelve hours of landing. Admittedly we had great air superiority but their ground forces were excellently equipped with both modern small arms and heavy support weapons including tanks.

After an operation of this kind, many shortcomings in equipment and procedure are bound to become apparent. Apart from these, there are a few lessons of general interest worth mentioning, these are expressed below.

1. When a force is operating on an independent mission as we were, it was evident how essential it is to have a properly balanced force comprising all arms, even at battalion level.

2. Only lip service is given these days to air sentries. We found that the sentry must not let his eyes leave the skies around him. Modern fighters fly so fast that otherwise the first warning of their approach is the bursting of their shells.

3. It is essential to dig in at all times when halted; our shell scrapes undoubtably saved many casualties.

4. We went to Port Said having trained hard using a minimum of water; we also exercised strict water discipline. We found going short of food easy, but water soon became a necessity. Water was very short for seventy-two hours and life would have rapidly become most unpleasant if the shortage had not been eased later on.

This story may not close, without saying that tragedy finally overtook us in a most unexpected way. One of the Sappers involuntarily poured the whole rum ration from a jerrycan into his shaving water, to cool it down for washing.

The Study of Nuclear Surface and Sub-Surface Bursts

By Major A. H. W. Sandes, R.E.

The attention of those who have ventured to theorize about nuclear warfare has focused almost entirely, and in the author's opinion too much by far, on the airburst atomic weapon. Such an attitude is logical for several reasons. Published figures show that the airburst is directly lethal over a wider area than is the surface or sub-surface burst. Until nuclear weapons are plentiful, commanders planning operations against an enemy whose strength lies in mass manpower will naturally concentrate on killing power, and will favour airbursts. Conversely, the surface or sub-surface burst produces radio-active contamination of the ground and radio-active fallout, both of which might hamper military operations. Finally, although there have been both underground and underwater trials no details have been published on the former, and the latter yielded information mainly of interest to sailors. So it is not surprising that it is difficult to find, at any rate in British military journals, much information or speculation about the use of nuclear weapons in other than the airburst role.

The author believes that discussion of the possible application of ground, underground, and underwater-burst atomic weapons in land warfare should be encouraged in case it may one day be profitable to use nuclear energy in this way. He, therefore, ventures to drop this modest (*unclassified*) pearl into the dark pool of Sapper wisdom hoping that it may raise ripples of interest in a subject that has been too little covered in this Journal.

Surface Bursts

A weapon burst at ground level or at a height above ground less than that of the radius of the resultant ball of fire is generally known as a surface burst. By comparison with an airburst its effects are more localized initially, but last longer and may eventually spread further. The blast effect of the explosion is reduced because much energy is spent in cratering and melting the ground. Heat and direct radiation effects are likely to be reduced by the shielding effect of irregularities in the ground. It is the residual radiation from the explosion that is significant in space and in time. Residual radiation is emitted from decaying fission products of the explosion; from decay of such portion of the fissile material of the weapon as may not have undergone fission; and from activity induced in the soil by neutrons emitted by the explosion. Soil particles sucked up from the ground and contaminated in the explosion by the adherence of radioactive metallic oxide particles, are carried downwind and spread radioactive contamination known as "fallout". The fission products and the neutron-induced activity in the soil give out highly penetrating gamma radiation and less penetrating beta particles; the unfissioned remnants of the fissile core, decay very slowly by comparison emitting alpha particles of negligible penetrative power. Thus there is a short term residual radiation hazard which, being penetrative, cannot be countered by protective clothing, and a longer term non-penetrative residual hazard which can be countered by preventing ingress of the contamination into the body itself through wounds, inhalation or ingestion. To quote some published figures* for a 20 KT surface burst, the radiation dose rate one hour after the burst would vary from 5,000 r/hour at 100 yards from GZ† to 600 r/hour at 200 yards from GZ, to 150 r/hour at 300 yards and only 30 r/hour at 400 yards. The decay of this radiation is according to the $t^{-1 \cdot 2}$ law: that is to say that the dose rate would decrease to the following fractions of its initial value (at 1 hour after burst in this particular case): ½ at 2 hours; ¼ at 3 hours; 1/9 at 6 hours; 1/20 at 12 hours; 1/50 at 1 day; 1/100 at 2 days; about 1/500 at 1 week. Thus the dose rate at 100 yards from GZ of a 20 KT surface burst after one week would be 10 r/hour, and the employment of men in that area would have to be restricted to a few hours only if they were not to become radiation casualties since a 400 roentgen dose will cause 50 per cent deaths and far smaller doses can cause serious incapacity. But it is important to note that even after a much longer time, when this penetrating residual radiation has decayed to a negligible level, the contaminated area will still be dangerous because of the continued presence of slower decaying alpha particles; this will force those who stay in the area to wear respirators, to take instant action to cleanse any wound, and to leave the area and wash thoroughly before eating. The author has no knowledge of the effects of weathering on the contamination, but it would seem fair to assume that wind and rain would tend to disperse the contaminated material and so decrease the duration of its harmful effects in the area around the point of burst.

Underground Bursts

The effects of a weapon burst underground will obviously depend upon the depth of burst. The formula quoted in the American text book *Effects of Atomic Weapons* (1950) yields the following crater diameters in average soil for a 20 KT weapon:—

Charge depth (ft.)	Crater diameter (yds.)
0	200
25	230
50	260
100	350
200	450
300	520
710 (optimum depth)	630

A 50-ft. deep burst would yield a crater 100 ft. deep, from which the spoil would weigh over half a million tons and might spread ¾ mile upwind and 4 miles downwind. If only one-sixth of the activity of the fission products were to remain in the crater, the dose rate 1 hour after the burst would be 500,000 r/hour, rendering it uncrossable. From the decay laws quoted it will be seen that even after a week the dose rate at the centre of the crater

* The Effects of Atomic Weapons, U.S. 1950.
† GZ means Ground Zero, the point on the ground directly below the burst.

would be about 1,000 r/hour. Presumably the alpha contamination would last no longer for an underground burst than for a surface burst because it appears to depend on the efficiency of the fission process and not upon the depth of the burst or the volume of the crater.

The author has been unable to discover any published figures on the height of the lips of a nuclear crater, nor on their extent. For conventional mined charges the generally accepted proportions of lip height and width are that the width is about equal to the charge depth unless the mine is overcharged when it may be greater, and the height averages about one-sixth of the charge-depth, but is very variable. The appropriate formula for depth of mine craters blown with conventional explosives indicates that the depths of the craters mentioned above should vary from about 200 feet for a burst close to the surface to about 400 feet for a charge depth of 300 feet, while the widest crater would be slightly under 400 feet deep. These figures do not agree with the American figures already quoted. However, they do suggest that if nuclear explosions no more than approximate in behaviour to chemical explosions (to produce a crater deeper than the depth of the bursting charge) then craters from 20 KT weapons should be from 200 to 600 yards wide and from 100 to 300 or 400 feet deep, with lips as much as 100 feet high extending up to 200 yards or so beyond the crater edge proper, while a thinner spread of spoil might extend from one to several miles around the burst according to the direction of the wind. It is interesting to compare these dimensions with those of the largest individual mine crater blown at Messines on the 7th June, 1917. A charge of 31 tons of explosive at a depth of 100 feet produced a crater almost 90 yards in diameter, 50 feet deep, with a lip averaging 17 feet high and 20 yards wide. This was a slightly overcharged mine. Those who witnessed the springing of the system of nineteen mines at Messines, totalling about 500 tons (½ KT) of explosive, commented on the very perceptible earth shock. For a 20 KT underground burst the earth shock is stated to be similar to that of an earthquake of small focal depth, and to be destructive at up to 1,100 yards. The resulting pressures and displacements would severely damage sewers, gas mains, and water mains, though underground power or communications cables would be less vulnerable because of their ductility.

Underwater Bursts

Information on underwater bursts appears to be based mainly on the trial held at Bikini and reported in the American publication already mentioned. This was a deep water burst, which cratered the sea floor beneath the weapon to a depth of 20 to 30 feet over 165,000 square yards, threw up a column of water 2,000 feet in diameter, estimated to weigh a million tons, produced a "base surge" and a fallout cloud containing highly radioactive water drops, and created a system of damaging waves. In relation to land warfare, bursts in deep water are hardly likely to be of much significance except if onshore winds blow fallout ashore. It has been surmised that in shallow water the base surge and fallout may not be so great a hazard, but the wave system might be as big as 40 feet from trough to crest at 1 mile from surface zero, and 20 feet at 2 miles: such waves could prove a serious menace to ports and the ships in them. The residual radioactivity from an under-sea burst will, in addition to fission products and unfissioned elements from the fissile core of the weapon, include radioactive sodium from the 3 per cent of that element present in sea water. This will prove a hazard in wetted areas for some hours at least.

Delivery of Weapons

The means of delivering nuclear weapons on to their targets must be mentioned briefly: they comprise aircraft, missiles, normal land or water vehicles, and finally men alone. Although the huge destructive radius of airburst nuclear weapons can partly offset the effect of bombing errors and missile inaccuracies, the surface burst's more concentrated destructive zone might call for errors of not more than 100 yards or so, and these accuracies may be very hard to achieve by aeroplanes or missiles. In terms of time the question is not likely to be how accurately by the clock the weapon can be delivered, but how long it will take to arrange the operation and how reliably it can be mounted in face of certain counter action against airfields from which nuclear attacks could be flown. Until aircraft can achieve independence of large permanent airfields it is hard to imagine that such targets will not be constantly attacked and probably put out of action completely. The main merit of manned aircraft is that until missiles of comparable range payload and accuracy have been proved in service they are the sole means of nuclear firepower which can use warheads larger than can be contained in a shell fired by a gun. Effective gun range can hardly exceed 25 miles, and even for such a range the gun must be in the super heavy class, such as the American 11-in. weapon, which is reputed* to fire a 14 KT shell. For shorter ranges there are reports† that the Americans are developing 8-in. and 155 mm. nuclear shells, and for medium ranges one is led to understand that fighter aircraft and missiles such as the Corporal can be armed with nuclear bombs and warheads respectively. It seems then that guns can use low yield but accurate shellfire to give results up to about twenty-five miles: but beyond this, because of the unreliable accuracy of aircraft and missiles it would be necessary to compensate by using higher yield weapons to ensure results.

The delivery of nuclear weapons to their targets by land or water vehicle merits brief mention. In river crossing or amphibious assaults and in the defence against such operations, or indeed in any phase of battle near waterways, small vessels might be used to convey nuclear weapons to their target, probably by covert means. On land it is conceivable that some form of remote controlled armoured vehicle might be used to position a nuclear charge in face of the enemy. All such weapons would necessarily be fired on the surface of the ground or in shallow water. Their merit would be that their firing could be very accurately controlled both in time and space.

The remaining means of delivery is by men using hand placed charges, which implies, as far as land operations are concerned, Royal Engineers. Nuclear charges might be used offensively or defensively by the R.E., and could be placed as surface, underground, or underwater weapons. There is even the possibility that in favourable circumstances captive balloons might be used to raise the charge to a few hundred feet above ground level so as to increase the blast, heat, and initial radiation effects and reduce the residual contamination. Hand placed charges should prove to be the most reliably

* *L'Explosion Thermonuclear.* Camille Rougeron.
† *Atomic Weapons and Armies.* Mikschi.

controllable in time and space, but because of the vulnerability and limited mobility of men compared with armoured vehicles, missiles or aircraft, it is fair to assume that hand placed weapons would be best suited to defensive demolitions in orthodox land operations. In clandestine operations, however, small portable nuclear charges pose a threat perhaps more deadly than the Intercontinental Ballistic Missile with megaton warhead.

Scaling Law

Armed now with some facts about the effects and means of delivery of nuclear weapons, it is possible to discuss their application to land warfare. Before doing so, however, the scaling factor must be mentioned. The effects of nuclear explosions are not directly proportional to their power, but vary somewhat as follows. Blast effects are proportional to the cube root of the power; heat effects to the square root of the power; and radiation effects are not expressible in a simple mathematical form, though they increase as the power increases. Most of the direct material destruction resulting from a nuclear burst is caused by blast, and it seems logical that the crater formation, involving excavation, should conform to the same cube root law. Since much of the heat effect of a surface or sub-surface burst is lost inside the crater, it should then be a fair generalization for such types of burst to relate their effects to the cube root of their power. This means that a 160 KT burst would form a crater twice the size of a 20 KT burst, and 540 KT would be needed to triple the crater size. Scaling downwards, a crater half the size of the 20 KT would need only 2½ KT, and one-third the size less than 1 KT. Other factors being equal, therefore, the economical method of use appears to be the combination of a number of small charges to give the same effect as one large one, for instance three 1 KT charges to make a crater system the same width as one 20 KT charge. In this application the time factor becomes important, since prepositioned charges close enough to each other to form a continuous crater would have to be detonated absolutely simultaneously if they were not to destroy each other. The firing point would have to be at least half a mile or more away, well dug in, and preferably upwind to avoid fallout. Simultaneity might be achieved by radio firing or by equalizing the length of firing cables very exactly between firing point and each charge. If such methods were not accurate enough it would be necessary to position and fire charges one at a time, which because of the contamination after effects in the crater area would take so long as to be useless except for very deliberate demolitions. In this respect the bomb, shell, or missile has the advantage in that there need be only a delay of perhaps a few minutes between one burst and the next: provided the shoot is efficiently done the accuracy attained at short ranges should be sufficient for the large crater system produced.

Target Categories

In considering the application of surface, underground, and underwater nuclear charges, targets can be classed as tactical, strategic, and engineer. Tactical targets are those whose destruction directly affects the battle; strategic targets are those whose destruction affects the means of fighting the battle or the war as a whole; engineer targets are those attacked by the engineers for their own ends.

hand placed charges would surely prove the most reliable for such targets, it is conceivable that nuclear shells could be used for tactical demolitions over ranges short enough to ensure accurate shooting. Other tactical use in the withdrawal would be to improve natural obstacles such as mountain passes by cratering and causing large avalanches, and to create inundations very quickly by breaching dams or dykes. These targets would almost certainly require the use of hand placed charges. In defensive fighting it is difficult to find any tactical use for surface and sub-surface charges except in the rapid creation of an inundation to swamp an enemy assault, particularly a river crossing. The temporary contamination of the water should further embarrass any of the enemy who might have the ill fortune to fall in. In an attack, conversely, it is equally possible that enemy defences and obstacles along a river line could be swamped out to allow an assault in amphibians. While the idea of achieving a dry shod crossing by draining a river is at first attractive, one feels perhaps that the business might be even more tricky than the classic Israeli withdrawal across the Red Sea, particularly for the engineers trying to build routes across the river bed in the mud of ages. In such an operation as a protracted battle to penetrate a deep and strongly held position, the ground burst nuclear weapon might be used to contaminate a vital enemy strongpoint, so that even those defenders who were not direct casualties would have to withdraw before they could take off their respirators and eat: otherwise they would probably become casualties from alpha contamination. The hazard from such contamination on a defensive position under attack would be greatly increased by dust clouds from conventional bombing and shelling. In the last phase of tactical operations, the advance, no application for surface or sub-surface bursts comes to mind: no one in his senses will want to move through his own craters and fallout zone.

Engineer Targets

Engineer targets are few, since engineers seldom use explosive unless they wish to remove obstructions and afterwards to work on the cleared site: with nuclear ground bursts that is the very thing which is difficult to do in comfort and safety unless one has time to let the contamination die away. But time does not wait, particularly for engineers. The only self-cleansing site is one washed by water. So it looks as though engineer uses will be confined to drainage and irrigation unless plant operators and others can be trained to work in totally enclosed cabs or suits with respirators to protect them from alpha contamination. If, however, it should prove practicable to fire nuclear charges suspended from captive balloons, as suggested earlier, the ground contamination could be reduced at will according to the height of burst, and although balloons could hardly be flown in the face of the enemy, this method might be of value for engineer demolitions since one could hardly expect any of the other methods of delivery to be used.

Organization, Command and Control

The foregoing discussion of the uses of nuclear weapons other than in the conventional airburst role would be incomplete if it did not lead to brief mention of the problems of organization, command and control.

The different types of weapon can be assigned to the R.A.F., the R.A., and the R.E. according to their method of delivery. Although this article deals specifically with land operations, R.N. aircraft missiles and guns should also be included since naval armament may well be more important than ever in future land operations. So long as nuclear weapons are a novelty to the Services; so long as they can only be delivered by novel or special armaments such as the immensely complicated and expensive V class bomber, the Corporal and other new missiles, and super heavy artillery; and so long as they remain wrapped in secrecy, then it seems that special units must be formed, trained and equipped in each Service and user arm to operate the weapons. Behind them will be required corresponding specialist supply and maintenance units and training organizations. If nuclear weapons should ever become conventional, which will be unlikely until they have been widely used, the need for special organizations should go.

Command and control will be complicated by the need for decisions at the highest political level not only on the over-all policy but on the actual operational application of nuclear weapons, particularly when because of their high yield or their use as surface or sub-surface bursts the radioactive fallout may spread further than is militarily desirable. The ability of both naval and air weapons to affect the land battle will make it essential that the use of such weapons by all three services is integrated through joint planning and control staffs, together with parallel integration with any Allied forces possessing nuclear capability. Specialist staff officers who can work out the best ways of using nuclear weapons will be needed to advise commanders on what to do with the doubled edged weapons allocated to them, and to control the nuclear portion of the over-all fireplan. In allocating weapons to commanders it might be feasible to relate the level of allocation, e.g. division, corps, etc. to the probable danger area. This would mean that airburst weapons could be allocated to lower commanders than surface or sub-surface burst weapons. This in turn implies that nuclear weapons used by the R.E. would almost always be under at least corps if not army control.

Conclusion

The author is diffident about conclusions, since so much of what he has written seems to be surmise. Suffice it then to suggest that, unless there are very good reasons unpublished why nuclear weapons should not be used in the surface and sub-surface roles as well as the airburst role, there are a number of ways in which nuclear weapons can be so used in all phases of war to obtain certain definite results which are not obtainable in other ways. Particularly in withdrawals do such uses have advantages, and the arm most suited to the circumstances of a withdrawal is the Royal Engineers. In the hands of the R.E. the author considers that the nuclear weapon may yet become, if not a battle winner, at least a battle saver.

Strategic Targets

Strategic targets by their definition are likely to be outside the battle area, if only because the nuclear destruction of such a target within the battle area can hardly be effected independently of the tactical plan. They can therefore only be attacked by very long-range guns, by missiles and aircraft, or by placed charges. Because of their distance from our own troops, such attacks should prove less embarrassing to us from fallout and this would allow the use of larger yield weapons than could be used for nearer tactical targets. Indeed, if fallout is used as a means of radiological warfare to put out of action enemy bases and communication zones without the wholesale material destruction which would result from the use of high yield airburst weapons, this appears a very suitable role for larger yield nuclear weapons burst on the surface or below. If, however, the burst is to be used destructively, suitable targets would be those requiring very long-term obliteration and which were too large, robust, or vitally important to be destroyed economically in any other way. Typical targets might be strong points such as Gibraltar; permanent airfields for large aircraft; dock areas; mountain passes or tunnels of strategic importance; oil refineries, particularly those which could easily be repaired if only partly put out of action by piecemeal attack with conventional explosive; and engineer stores depots. The means used to deliver the weapon would depend on many factors: the most important would surely be that of air superiority and whether the current strategy was offensive or defensive. All the available methods of delivery could be used in withdrawal, pre-positioned charges being fired by Royal Engineers: if the withdrawal were taking place in face of enemy air superiority our ability to use aircraft or heavy guns or even missiles might be small, especially if such means were devoted mainly to immediate tactical targets. In such circumstances weapons fired by the Royal Engineers might prove the mainstay of the strategic nuclear effort. In offensive operations on the other hand we would probably have air superiority, and apart from sabotage, guerilla, commando, and S.A.S. operations, distant strategic targets would be inaccessible to ground troops. Here then aircraft and missiles would be the delivery agents for all weapons larger than could be manhandled or fired from heavy artillery.

Tactical Targets

Tactical targets are considered by the author to be less suitably generally for surface or sub-surface attack because of the fallout problem. Very accurate weather prediction would be insisted upon by any commander faced with the possibility of having to dodge the fallout from his own weapon. However, assuming that the commander was willing to try it, several possible types of target can be suggested. In the withdrawal, very large or very important tactical demolitions are the most obvious choice. With Royal Engineer resources strained as always in such circumstances there should be an invaluable saving in man and machine-power, transport, and time, in destroying large bridges by nuclear charges: the crater contamination would greatly increase the problem of replacement: there would be no repair. Indeed the new bridge would have to be built well clear of the contamination area and the construction of approaches could be a major task. Though

Readers are reminded that statements made and opinions expressed in all articles are those of the author alone.

"Fangs *v.* Belly"

By MAJOR A. J. I. POYNDER, M.C., R.E.

INTRODUCTION

The "Animal"

MANY people have written on the subject they have called "Teeth *v.* Tail." Their object has been, or should have been, to show how much of the Army is designed for fighting, and how much is needed to support and keep this fighting portion in the field.

"Teeth and Tail" is a misleading title. A tail is usually long, thin and whippy, and has no direct relation to the teeth. In fact, an animal can survive with no tail at all, but surely no-one can think that an army can exist without some form of administrative backing. It is the "belly" that should be taken as being analagous to the administrative part of an army, since it keeps the animal alive, and allows the teeth to do their work.

"Teeth" again is an inappropriate description for referring to the fighting portion of the Army. Teeth are usually blunt and well rounded; when they are sharp and pointed we call them "fangs", and our fighting units must of course be sharp and well pointed.

Finally, an animal must have a head to house its brain in order to direct its "fangs" what to do and to control the "belly". This "head" represents the H.Q. elements of the army.

APPROACH TO THE PROBLEM

The old "teeth and tail" approach has been to try and find ways and means to prune the tail in order to increase the teeth. Even substituting the more realistic word "belly" for "tail" it is still, logically, the wrong approach. The supporting arms and services have been designed to support and maintain particular forms of fighting units and formations: that a small amount of pruning can be done while the organization and equipment of the fighting troops remains unaltered is true, but the only way to deal with the problem is to start at the "sharp end" and work back.

Therefore the first thing to do is to reshape the fighting portion of the Army. In fact the "teeth" have got to be sharpened into "fangs" so that they can bite deep and fast. When this has been done it will be found that a much smaller "belly" is required to support these "fangs", and the present "head" will be too cumbersome to allow the "fangs" to move and strike quickly. Thus the "head" will have to be reduced too.

This proposal to start by slashing at the fighting units may incense the fiery old "die-hard", but most sensible people will agree that it is the logical approach as one's administrative arrangements must depend on the size and composition of the fighting units and their requirements.

Between the wars we have been very prone to copy the pattern of the previous war and to allow our army to become bloated with a large stomach, a large head and very blunt teeth. It is no good resting on our previous successes and getting complacent. Factors are continually changing and we must continually reshape our army to meet present commitments and now also to be prepared for the possibility of nuclear war.

The main factors that affect us as a nation when producing an army now are:—

(*a*) Our limited manpower resources and the fact that after two world wars we are a poor country.

(*b*) Our geographical position which, with the advent of air power, means our army must be able to move around the world using the air for supply and transport in the same way as in the past it used the sea.

(*c*) Our "Cold" war commitments.

(*d*) The modern tendency for devising too complicated and regulated routine and procedure.

(*e*) The fact that we still have a high proportion of men with imagination, initiative and technical ability.

(*f*) And most important of all the advent of nuclear weapons.

Conclusions

The conclusions reached from these factors are that first and foremost priority must be given to the air if we are to exist at all, and that our army must be efficient and yet economical. All the frills and complications must be cut out and initiative and technical skill given full rein. We must forget the ponderous slow motion picture of 1944–5 and, should a "hot" war come, play on our enemy's weakness in being large, cumbersome and rigidly controlled.

It is against this background of what we have, and what we are likely to have against us, that we must, therefore, reshape our army to be like a "wolf", hard and lean and swift. It will then be an economic proposition and able to use its speed and "fangs" to attack its enemy from any quarter. The immediate problem that confronts us, therefore, is to convert our army into a slim beast of prey. Its "teeth" must be "fangs", the "pot-belly" reduced and its "head" must be finer shaped to conform to the sharp "fangs" and small "belly".

Method

Transport

A reduction in transport is far the most important and most urgent single step that must be taken now; and one that, if started at the front with the fighting portion of the army, will have an immense cumulative effect as it works back. On no account should units be "asked" to cut down their transport or "make recommendations", otherwise the results would be negligible. Unit commanders always have a hundred and one reasons why each bit of their unit is essential and usually take the opportunity to try and obtain more. It is an extraordinary fact that if a sweeping cut is made people will still manage to carry on, but if there is any hope of getting extra they are always finding it "impossible" and asking for more.

Starting with the Infantry Battalion. It is essential to reduce the numbers of types of vehicles used for the carriage of personnel, petrol, G1098 and even ammunition. This can be done by putting infantry battalions on a ¼-ton truck and trailer basis and reducing the total number of vehicles overall. This would enable the battalion to become truly mobile and air-transportable. It would of course mean that less equipment and ammunition could be carried, but would cut down the spares, repair organization, P.O.L. requirement and present complicated M.T. administrations. All infantry weapons and wirelesses could still be carried.

Field Artillery units present a slightly different picture as it has become the custom for all their personnel to be carried in vehicles. This policy should be revised: agreed that the guns and gun crews, O.P.s and G.P.O.s must be mobile as this extra mobility gives them quicker and longer hitting powers, but as the Infantry they support, march, so should the remainder of the gunner unit. In a road move a pool of transport from divisions or corps is used to carry the infantry, in the same way this can become the case for a large proportion of the gunner personnel.

Also much too much ammunition is carried in unit transport. With ammunition replacement being automatic (from rear areas forward) units should be relieved of carrying their own stocks. Again by eliminating trucks 1 ton and 3 ton, and replacing with trucks ¾ ton and using trailers, there would be a saving in drivers, fitters, petrol, M.T. spares and types of vehicles. This presupposes a lighter gun, and the need for a light field gun is argued later in this paper.

The Field Engineer Regiment in an Infantry Division will give us an even greater saving if we make more use of feet and pool-transport, and give up the idea of putting every man in a vehicle. Again the ¾ ton truck and trailer must be the standard vehicle, and light weight plant and equipment trailers used. This also will automatically mean less G1098 carried—no bad thing as much too much is normally carried "in case it is needed". Engineer resupply from behind and natural resources must be relied upon to a greater extent.

When one applies similar cuts to Brigade and Divisional H.Q.s and the Divisional signals regiment one would arrive at an immense saving in vehicles, M.T. staff, P.O.L., and spares, added to which there will be added simplicity and economy in standardizing on one type of vehicle in the fighting or "fang" arms.

These cuts will automatically impose reductions on the R.A.S.C., R.A.O.C., and R.E.M.E., and less petrol will be required, less troops, and less and simpler repairs. These cuts will increase in size with each step back. At divisional level, at corps level, at Army and in the Base areas. There is also, to the country, a huge saving due to reduced and simpler production, less petrol, and economics in training skilled drivers, fitters and mechanics. Added to which all infantry formations and their supporting arms will become entirely air transportable, and therefore truly mobile both for "cold" or "hot" war tasks.

When helicopters or vertical lift aircraft become available as second and third line transport, they will increase mobility, speed and flexibility, and the vast number of administrative vehicles behind Brigade area will also be able to be reduced.

Throughout this proposal regarding transport, armoured formations have not been mentioned. It is considered essential that they should remain fully mobile, with a similar elimination of trucks 1 ton and 3 ton and their replacement by tracked 5-ton cargo carriers. They should have a new form of heavy gun tank, and less G1098, coupled with an increased use of trailers, and a pooling of administrative transport; a considerable reduction could then be made in the cost and complexity of armoured formations yet with increased efficiency.

Tanks and Anti-tank Defence

At present our theories are based on a general purpose tank and a heavy gun tank. The tank is certainly out of place in infantry divisions, which should be light and able to move through forests, across rivers and marshes, and in hills, and should not be tied to a road or cluttered up with a large amount of petrol and ammunition carrying lorries. The requirement for the infantry division is a really good anti-tank gun mounted on a ¾-ton chassis mobile and easily dug in. It is primarily the gun that is the most important thing and secondly its ability to move. In open country it is the job of armoured formations to look after the infantry, and if it is required, they should incorporate a heavier type S.P. anti-tank gun in their organization, but cut out the turretted heavy gun tank which is a bad compromise of gun, armour, and mobility.

It is proposed, therefore, that at present the Infantry division should have an anti-tank regiment armed with a light anti-tank gun with priority of design being given to the gun, and mobility. This should be easier for bridging and carriage on transporters or trains, and, made light enough to be air transportable.

In armoured formations the general purpose tank should remain and should be aided by a tank destroyer, on the same chassis, with an armoured front, in which priority is given to the gun, and the turret eliminated.

The consequent savings would be mainly in production, in economy of steel, and costs; there would also be a saving in petrol consumption in the infantry division and skilled personnel, repair facilities and carriage of spare parts in both infantry and armoured formations. These savings would become progressively greater behind the division, in transport services, workshops, in A.R.D.s, in the storage and handling of P.O.L., and in design, construction and strengthening of bridges.

The proposals outlined above only cover the interim stage. The final answer is undoubtedly to eliminate the anti-tank gun on the ¾-ton chassis and replace it with a guided missile launched from a light wheeled or tracked chassis.

Weapons

In general the tendency must be for light robust efficient weapons. For the infantryman the automatic pistol, machine carbine, the grenade, the L.M.G., mortar, and rocket launcher. The infantry should rely on mines, rocket launchers and grenades for their own close anti-tank protection. The commander of the formation should use the anti-tank regiments, the tanks allotted to him, and rocket firing aircraft, in their proper role of killing tanks. The reduction in vehicles this brings about has already been dealt with, and if we eliminate the anti-tank platoons from the infantry battalions the additional saving in manpower also gives more riflemen.

For the artillery in the infantry division a light field gun that can be towed by a ¾-ton truck, is easily dug in and can fire in the upper register is needed for "cold" and "hot" war. It has got to be able to go where the infantry go by air to a theatre of operations, and then across all kinds of terrain when it gets there.

At present an improved 3.7-in. pack Howitzer should be able to be provided without undue additional cost or trouble; at a later date a light recoilless gun or rocket discharger may be the answer.

For the armoured formations, S.P. field and medium guns should remain, and for heavier artillery we have the atomic cannon and guided missile.

The administrative personnel in all types of artillery regiments must be armed with carbines, and rocket launchers and be organized so that they can defend their gun lines.

For the Sappers the need is for additional arms in the field regiment so that the "wisdom teeth" can also be used as "fangs". Automatics, carbines, and grenades for all men, L.M.G.s and rocket launchers, and 2-in. mortars. Then the "Sapper" squadrons can fight as infantry companies; and the divisional commander in the defensive has that tenth battalion that he is always wanting for use in reserve or for counter penetration. The addition is small and can come from current production of weapons and be carried by the reduced vehicle scale, but the dividend will be large.

All other arms and services must be given the sten or equivalent as a personal weapon, and only a very limited number of L.M.G.s and rocket launchers. At present too many rifles, L.M.G.s and rocket launchers and their ammunition are handed out and carried by untrained personnel in rear areas who even if surprised behind the main battlefield would not have them manned or in such a position that would be effective. It is very wasteful and unnecessary to give units such as R.E.M.E. Workshops so many L.M.G.s and P.I.A.T.S. or rocket launchers on their establishments. Let each man always have with him and be able to use a sten and have one or two L.M.G.s and rocket launchers as an emergency reserve in each unit; then there will be increased efficiency with greater economy.

G1098 Equipment and Spares

At present all units carry a mass of G1098, which "might come in useful". In actual fact during the last war most units dumped a great amount of this, and used the vehicles for other and usually nefarious purposes such as converting to caravans, keeping livestock, and carrying "booze". If G1098 stores and equipment are not needed in war they should be reduced in peace. Units on L.E. scales can all operate with that amount of equipment when brought up to H.E. strength except for additional weapons, wireless equipment, and camouflage nets. Thus if we are to take L.E. scales and even reduce them slightly it will be nearer to the war requirements. This particularly applies to spare parts, which are so often carried and never used.

This should be done now, and would give an immediate saving in manpower, vehicles, and office work in all units and more particularly in the present large R.A.O.C. organization. In addition there is of course the saving to the nation of money and production potential.

Air Support and Air Transport

The army must become air minded and be prepared to use the air as artillery, as a channel of supply, and a means of transport. The previous proposals have gone a long way to fine down the infantry division; the final touch is to ensure that each part of it is air transportable so as to enable it to bite quickly and deeply where it hurts most and is least expected.

In order to economize in communications and additional units the Gunner F.O.O.s should be trained to control the air strikes to supplement their own guns. Sappers must practise and improve their technical ability to clear D.Z.s and L.Z.s, and to make air strips or repair captured ones. This becomes in future war one of their main tasks.

The Army requirements from the R.A.F., in addition to the normal protection and support from the air, are freight aircraft and helicopters and later vertical lift aircraft. These can earn us money in peacetime and be immediately available in war for carrying men, stores and equipment and evacuating casualties.

Simplification

The theme of the preceding paragraphs has been that we need fewer and simpler vehicles, tanks, weapons and G1098, but the process must go further than this. Not only must the tools be made simple and robust, but the method of using them must be simple. There is far too much time and labour wasted in accounting and paper work. To keep ten vehicles on the road in a fighting unit needs at least ten men, over and above the drivers and mechanics, to do M.T. clerical work, P.O.L. accounting and spares accounting. It is the same in the Quartermaster's stores, and even worse in the unit office where the documentation, pay and welfare of the men of the unit has to be dealt with.

Once again if the cut starts at the front it works back cutting out more and more the farther it gets back; thus elimination of complicated accounting systems in a unit will throw up a great number of surplus staff officers, clerks, ordance personnel and storemen farther back. The effect on Headquarters would be tremendous and going hand in hand with the reduction in transport would reduce the "head" to conform to the changes in "fangs and belly". The amount these complicated accounting systems save stores being misused or wasted will be more than repaid in the men, vehicles, accommodation and office machinery that would be released if they were so simplified.

It has always been an accepted fact that an officer in charge of men or equipment should be responsible for them, and *he should be responsible in all respects: make this quite clear and then cut out all the rules and regulations that hedge him round and which now make him less responsible, less efficient and thoroughly overburdened.* The more complicated the rules the more people cheat, and as it is impossible to cover every contingency the answer is to go to the other extreme, and have the minimum of paper rules and the maximum personal responsibility. This should apply to all forms of accounting, staff authorities, regulations, returns, and "through the normal channels" applications; and it should be applied now. If the initial abuses are dealt with quickly and severely this new system would soon settle down with immense benefit to the Army as a whole, and, indirectly, to the Treasury as well.

Welfare and Administration

The welfare and administration of the army has got completely out of hand, and instead of being a means to an end it has now become the major preoccupation of a large proportion of the officers and men in the Army. Too much stress is put on comfort and leisure. These admittedly help to keep up morale, but, to quote *Conduct of War*: "Morale in modern war depends increasingly on equipment, especially weapons." This is the important factor. Good modern well designed arms, equipment and vehicles will do the soldier far more good than artificial welfare frills.

It is far more value, to give the soldier a decent waterproof sleeping bag than to give him a bedside lamp, to produce efficient field cooking equipment which can be used in barracks and in the field rather than installing vast steam cooking in barracks, and to teach the soldier how to look after himself rather than to spoon feed him.

Too much is done for the soldier, and not enough use made of the soldier himself. A great deal of work to make himself comfortable can be done by the soldier if he is given a few materials and a little guidance. Most men enjoy doing odd jobs about the house, and trying their hands at minor carpentry, painting and electrical work, so while the Army is their home they should be encouraged to do the same for the Army.

Following on this, field units should revert to being allowed to provide their own specialist cooks, fitters and signallers. This would help to cut down the "Empire building" among the Services and encourage *esprit de corps* in the unit. Give specialists some training outside the unit if necessary, but let them be an actual part of the unit from the moment they join.

Finally, the greatest change necessary in the system of administration as a whole is to use civilian resources more. Messes, canteens, clubs and even static cookhouses should be civilian run, and they would be far more efficient and less wasteful. Laundry, tailoring and cleaning can be "farmed out" to local firms and inhabitants wherever one is stationed. Quartering and engineer services are best done by civilian firms, and perhaps even static supply installations and workshops could be wholly civilian manned.

The Navy have always followed this policy and found it works very well. The Army can well follow the Senior Service's example in this respect.

Summary

All the proposals above will go a long way to transforming our present Army into a slimmer, stronger and faster fighting force. The "fangs" are sharpened by reducing vehicles and equipment, and by changes in weapons and tank design. This automatically reduces the "belly" and throws up an ever increasing number of redundant men, vehicles and equipment which can be used to increase the "fangs".

The reduction in the waist line is aided by the elimination of unnecessary complicated routine and procedure, a decrease in unnecessary welfare and administration and an increased use of civilian resources to help the Army. All these proposals are easy to implement, and should be acted on at once.

The Result

When all these changes have taken effect and the Army has a stronger, faster, fighting element and a less cumbersome administrative portion, new tactical doctrines can be evolved. The present technique of using road bound formations can be thrown aside, and by use of the air the infantry formations of the Army can move wherever they are required, and having arrived can then move swiftly across the ground without being dependent on road and rail. If our air arm is developed, as it must be, with overriding priority, first to protect our country and its approaches and second to transport and support our armies, we will have an offensive weapon that can strike where and when we please, and having struck can be picked up again and used elsewhere. This is vital for us so that we can use our limited manpower most efficiently in the "cold" war, in a limited war or in a nuclear war.

Divisional Engineers in the Atomic Era

By Major J. D. Goodship, R.E.

Introduction

The author has for the past few months been divorced from active "Sappering" and has thus been able to turn his thoughts to more abstract problems, rather than to wrestling with the innumerable day to day bedevilments which face the Field Squadron Commander. Such thought has, in part, played on the role and organization of R.E. in the atomic era and their training for this role. It is felt that these abstract thoughts may provoke further argument amongst other Sapper officers, which if not of direct value to the Corps as a whole, may at least make amusing reading and help to focus attention on the problem. Owing to the author's lack of experience in other fields, he has restricted himself to thoughts on the Divisional Engineers.

The Problem

The introduction of the atomic bomb and shell have vastly changed the whole conception and nature of war. The question is, are we in the Divisional Sappers now organizing and training ourselves so that from the outbreak of any war we are ready to play our part and enable the rest of the division to "move and fight"? Or are we to enter the next contest equipped for, and still thinking about, the last one? What changes do we need to make in our organization and training? An attempt to answer these questions is given below.

The Nature of Atomic Warfare in the Tactical Battle

Defence

Successful defence in the atomic age hinges on two main factors:—

(*a*) the disposition of our own forces so as *not* to present a worthwhile *atomic target*;

(*b*) the choice of a defensive position which is so strong that the enemy must deploy and concentrate a force, which is *an atomic target*, in order to have any chance of succeeding in his attack.

This means widely dispersed positions well prepared, dug in and protected with minefields. The Sappers must be able to lay extensive minefields rapidly, and to assist other arms in the preparation of really strong defensive positions including "dug outs and all that". In the event of an atomic attack we must be in a position to restore communications quickly and repair any damage done, ready for the next attack.

Attack

Basically a successful atomic attack would be on the following lines:—

(*a*) the obliteration of the enemy forward positions;

(*b*) "the drive through" as soon as possible after the explosion;

(*c*) mopping up.

It is in the second phase that the Sappers greatest problems will arise. How are we to claw a way through the resulting damage in sufficient time to allow the attacking forces to break through while the effects of the explosion are still felt by the enemy? This will probably entail rapid mine clearance, bridging, and opening up of routes.

Speed

The accent on all Sapper work in this atomic age must be on speed, and more speed. Speed to restore a position as soon as possible after an enemy attack, speed to take advantage of the effects of the atomic explosion when we are attacking. But speed in engineering can only be obtained (assuming the task organization and training are up to scratch) by more men and more machines. Any increase in the size of the Sapper units in the battle area is unlikely to be acceptable. We must therefore get this speed by improving our organization and training.

Organization

The Section

Any organization in the atomic age must be small, highly mobile and, from the author's point of view, "armoured" in order to give some protection against atomic blast and flash if troops are caught in the open, and to enable it to move with armour. It should also be capable of dilution with unskilled labour and of controlling civilian labour in large scale tasks. To build up from the bottom, how can we design a "work unit" that complies with these necessities? A suggestion is given below for the Section R.E. which must be the basic "work unit".

Men		*Vehicle*	*Equipment*
Cpl.	1	A.P.C.	One set Handyman's tools.
L/Cpl.	2		Two Mine Detectors. Exploder.
Sappers	8		200 lb. Explosive and ancilliaries.
Driver	1		6 Picks. 6 Shovels. 1 Geiger Counter.

This section has the advantages that it can be split into two sub-sections and with three N.C.O.s can accept, if available, a large proportion of unskilled labour to work under it. There will be many occasions when this is possible.

The Troop Headquarters

Working on the basis of three sections in the troop and endeavouring to keep it as small as possible, the author would limit it to one officer, one sergeant and six other ranks. The organization would be:—

Men	*Vehicle*	*Stores*
O.C. Driver Wireless Op.	Ferret	Recce Kit Wireless Set
Sgt. Storeman Cooks, 2 Driver	One ton vehicle	Cooking equipment Spare tools such as power saw

Plant Troop

In order to provide the plant requirements that it will always need, the Squadron should have a small Plant Troop. In view of the maintenance problem it is not considered advisable to put plant with the troops. The organization of this troop might run on the following lines:—

Troop H.Q.

Jeep	O.C.
	Driver
	Wireless Op.
1 Ton	Sgt.
	Fitters, 2
	Driver

Dozer Section	*Excavation Section*	*Power Section*
Two size II Dozers	Trench Digger	Compressors, 2
One Armed Dozer	Mobile Excavator	Bench Saws, 1
One Mechanical	on lines of Coles	
Minelayer	Crane	

This proposal may cause rather a stir amongst those who consider that plant should be held centrally, but as far as can be foreseen any requirement for plant in the forward brigade areas will be such that the delay of getting it forward from a field park will be unacceptable. Plant properly used will never be idle, and it will be under the hand of the person who knows where and when it is going to be required, namely the Squadron Commander. Maintenance can be provided by touring teams of fitters visiting the plant on the various works sites, which is on the lines of present civilian practice.

Squadron Headquarters

In the author's opinion the size of Squadron Headquarters can be considerably pruned, thereby achieving efficiency and increasing mobility. The basic requirements for a Squadron Headquarters are a command element, a reconnaissance element and a very small administrative element. The days of massive Squadron G1098s are or should be out. They present an accounting menace in peace and a carriage risk in war.

The author would like to see Squadron Headquarters organized as under.

Reconnaissance		
Jeep	O.C.	Wireless Set
	Driver	Small Recce Kit
	Wireless Op.	
Ferret, 1	I.O.	Wireless Set
	Driver	Recce Kit
	Wireless Op.	
Ferret, 2	Wireless Op.	Provides Sqn. Com. net
		Recce Kit
Command		
Half track plus	2 i/c	52 Set (C.R.E. rear link)
trailer	Driver	19 Set (Bde. net)
(Command Veh.)	Sigs. N.C.O.	Spare batteries
	Wireless Ops., 3	
M.C. 1 and 2	D.R.s	

Administrative

1 ton 4 × 4	S.S.M. Driver Sappers G.D.	Harbour recce
3 ton 4 × 4 plus trailer	S.Q.M.S. Driver Cooks, 2 Storeman, 1	Cooks vehicles Small reserve of clothing Rations Trailer for Officers Mess
3 ton 4 × 4 plus trailer	Tp. Sgt. Driver Fitters, 2	Reserve G1098 Small FAMTO Reserve Petrol
Water Truck	Driver Sapper	
M.C.3	M.T. Sgt.	

Some officers may say this is too small. It is, however, workable and in exercises has proved extremely mobile.

The Field Park Squadron

The role of the Field Park Squadron has not changed, but its work has been vastly increased. There is still the requirement for the plant troop; in fact, this sub unit is probably too small and should be increased. The workshops will always be as busy as they have always been in war (but not on exercises). With the vast requirements of stores for defence works the stores troop will have its hands full. Here there is room for increased mechanization, perhaps some Park Squadron Commander may wish to comment on this.

The Regiment or the Divisional Engineers

The problem of the full Colonel C.R.E. and the Engineer Regiment as opposed to the three Field Squadrons has been debated ever since the change took place. The author feels a trifle wary over entering the fray except to say that he feels that any headquarters interposed between the R.E. Commander at Divisional Headquarters and the R.E. Commanders supporting the brigades, wastes time and thus militates against efficiency. In peace, however, the Regimental system has much to be said for it, in increased training and sports facilities.

TRAINING

The points given below only touch on the fringe of the problem. They are, however, the ones which the author has found to be the most important.

Morale

Napoleon's adage of "morale is to material as three is to one" is still applicable. In fact, the next contest will depend on "guts" to a greater degree than ever before. It is the soldier who has been trained and disciplined to experiencing the effects of an atomic explosion who will win battles. Our basic training and our man management have much ground for improvement, especially amongst the young officers, who make or mar a unit. We in the Sappers must press for and accept only the best in both officers and men. Anyone second grade is useless. Let us be short rather than accept poor material. In this connexion we are apt to look over the young officers shoulder too much. No one can develop if constantly watched. Every troop commander should have the opportunity of taking his troop out by himself for at least a fortnight during the year, and apart from a very occasional "social" visit by his Squadron Commander for a gin he should be left alone. At the end of this time, the Squadron Commander, if he is any good, can very soon tell what shape the troop is in when they return. If it is a success you have made a troop and a troop commander, if it is a failure, you have lost a fortnight. At present the only time when a troop commander really gets his troop to himself is on Saturday morning, when that wonderful phrase "troop commanders disposal" comes into its own.

Trades

Far too much emphasis is at present placed on trade training. The Sapper in the Divisional Engineer requires first of all to be a first-class soldier, then an all-rounder, who can, if necessary, turn his hand to bits of any trades. The place for the tradesman is in the Field Park and Construction Regiments. Let us in the Divisional Engineers reduce our establishment for tradesmen and replace them by Field Engineers, we will save a lot of money and worry of R.E. Records in attempting to keep right "up to establishment in trades", which it never does any way.

Technical

One bridge built under active service conditions, away from the normal site, is worth twenty built on a bridging hard. Some suggestions for training Sappers in their atomic role are given below. These would mean R.E. units carrying out work for Government and civilian agencies, much as is done by the American engineers.

Slum Clearance

The use of Sappers for slum clearance projects in England and Germany would give excellent training for our likely tasks in the atomic era. Demolitions, the use of plant, and opening up routes. It is on this type of training that a troop can be detached for a fortnight at a time. The soldiers love it, and it assists the civilian authorities. How one gets over the Trades Union objections is a point that the author leaves to others to work out.

Forestry

The present day Sapper has little or no knowledge of the handling of uncut timber. He is unwieldy in the preparation of large timber "sets" and is clumsy in the use of simple tools like the crosscut saw. While financial restriction will always impose limitations on training in large scale defence works, there is little hope that we can improve this in the normal run of unit training. The attachment of troops to various Forestry schemes in which they can gain experience in the use and handling of large size timber and the tools used in this type of work would pay dividends.

Wireless

The standard of communications on the average R.E. net does not bear comparison with that of an Armoured Regiment. The reason for this is partly due to the poor frequencies allotted to us. We must therefore continue to press for the allocation of better frequencies. It is, however, vital that we improve our training in wireless. Far too frequently we don't get through. Unless the Squadron Commander is in instant touch with the troop commanders and his Recce officers he cannot deploy his Squadron adequately to meet the ever-changing needs of atomic warfare. A much greater interest taken by officers, in wireless is in part the answer, some are scared to pick up a headset, or are prepared to accept the word of the operator that he is out of range. Experience shows that the operator who gets his bottom well kicked when he is out of touch by an officer, who is prepared to get through himself, soon becomes a very much better operator. Can we not include more wireless training for the Y.O. while he is at the S.M.E., even if it is only in reporting the progress of the drag!

General

What is needed is a very different approach. Training programmes look very nice on the office wall, but they are often stereotyped and provide no change. Training could, should, and must be the most enjoyable part of the soldiers life. It is not so in some units at the present time.

Summary

Basically we have the right organization for the atomic war, we want, however, to streamline it more and induce more plant into the Field Squadron. As regards training, can we do something to get more interest into it? Others may have some suggestions?

Construction of a Bridge on the G.I.P. Railway over the Nerbudda River in India

By Lieut.-Colonel W. V. Ribbins, M.I.Struct.E., M.R.San.I. (late R.E.)

On the 21st of September, 1926, an exceptionally high flood in the "Nerbudda" river, near Jubbelpore, India, destroyed the railway bridge on the "Great Indian Peninsula Railway," linking Bombay and Calcutta.

The Old Bridge

The old bridge, which was erected in 1862–66, consisted of five 150 ft. wrought iron, pin jointed, deck spans, carried on block masonry piers, set in lime mortar, the abutments being of the same material. The over-all length of the bridge being 870 ft.

The bottom of the deck spans being 77 ft., and the top of the railway track being 95 ft. above the bed of the river.

The Flood

On the 21st September the river rose to an abnormal height of 98 ft. 6 in., i.e. 3 ft. 6 in. above the rail level on the bridge.

During the "monsoons" the flood waters of the Nerbudda river carry an enormous amount of brushwood, dead logs, etc., on its surface, this flotsam lodged against the deck spans, rapidly building up into a solid mass which presented an area of approximately 13,626 sq. ft. of resistance to the flood waters, the pressure on this surface resulted in the total destruction of the bridge, some of the spans being carried 200 ft. down stream.

Erection of Temporary Foot Bridge

There being an urgent necessity for a temporary foot bridge to enable passengers to be transhipped across the river, the Railway Administration requested assistance from the Army and on the 12th October, 1926, a detachment from the 22nd Field Company of the Bombay Sappers and Miners under the command of Lieutenant G. E. H. Philbrick, R.E., now Colonel Philbrick (retd.), arrived on the site.

The detachment consisted of two British officers, Lieutenant G. E. H. Philbrick, R.E., and Lieutenant D. S. Gibb, R.E., one British N.C.O., Sergeant Casey, three Indian officers, Subadar Nur Alam, and Jamadars Shah Jahan and Gunpat Powar, and 111 Indian R. & F.

The temporary bridge was composed of nine military pontoons, the connexions to the banks being effected by pole trestles and old sleepers lashed together over which planks were nailed. The over-all length of this bridge being 1,100 ft., it was completed on the 3rd November, 1926, and was dismantled in May, 1927.

Design of New Bridge

Following the destruction of the old bridge, the Railway Administration called for the submission of designs for a new bridge and the design submitted by Messrs. Braithwaite & Co., Engineers Ltd., was accepted, this design was for six steel "through" spans, each of 169 ft. in length, and two "deck" spans of 45 ft. the main spans being carried on seven steel trestles and the deck spans terminating on either shore end on masonry piers and abutments. (See Plate 1.)

The over-all length of the bridge, as now designed, was 1,194 ft. 8 in., the four legs of each steel trestle were to be carried on four 12 ft. diameter steel cylinders, sunk to an average depth of approximately 36 ft. below the river bed, the final founding of each cylinder to be determined as work progressed.

The "through" spans were designed with box-section booms, plated sides with lacings on the upper and lower facings, the vertical and diagonals having plated sides with double angles back to back and interior lacings, the end rakers being of box section with plated sides. The railway sleepers for the track being carried on two longitudinal stringers. Provision was made for a footpath to be carried on angle brackets riveted to the stringers, on the upstream side of the bridge. The land spans were designed as deck plated girders, 43 ft. long by 4 ft. 1½ in. deep.

The seven rectangular steel trestles were similar in design, the legs being of box-section with two sides plated and two with lattice bracings, the horizontal ties on all faces being spaced at 18 ft. 4 in. centres with diagonals running from the centres of one tie to the junction with the legs of the next horizontal tie above, in the form of a V. All ties being composed of four angles 5 × 3 × ⅜ in. with 2½ × 2½ × ½ in. lacings. Of the seven trestles, five were 97 ft. in height and the remaining two 75 ft.

A special feature of the design, in the "through" spans, was the incorporation of lifting plates in the four ends of the bottom booms, these plates were drilled to take the shackles for the "fall blocks" that were to be used in raising the spans from the river bed to the tops of the trestles. (See Plate 2 and Photo 1.)

Photo 1.—One of the through spans erected in Poraith Waite's yard. Note drilled plates with eyes at ends of bottom booms.

Photo 2.—Through spans being lifted from river bed.

Construction Of A Bridge On The GIP Railway,India 1 , 2

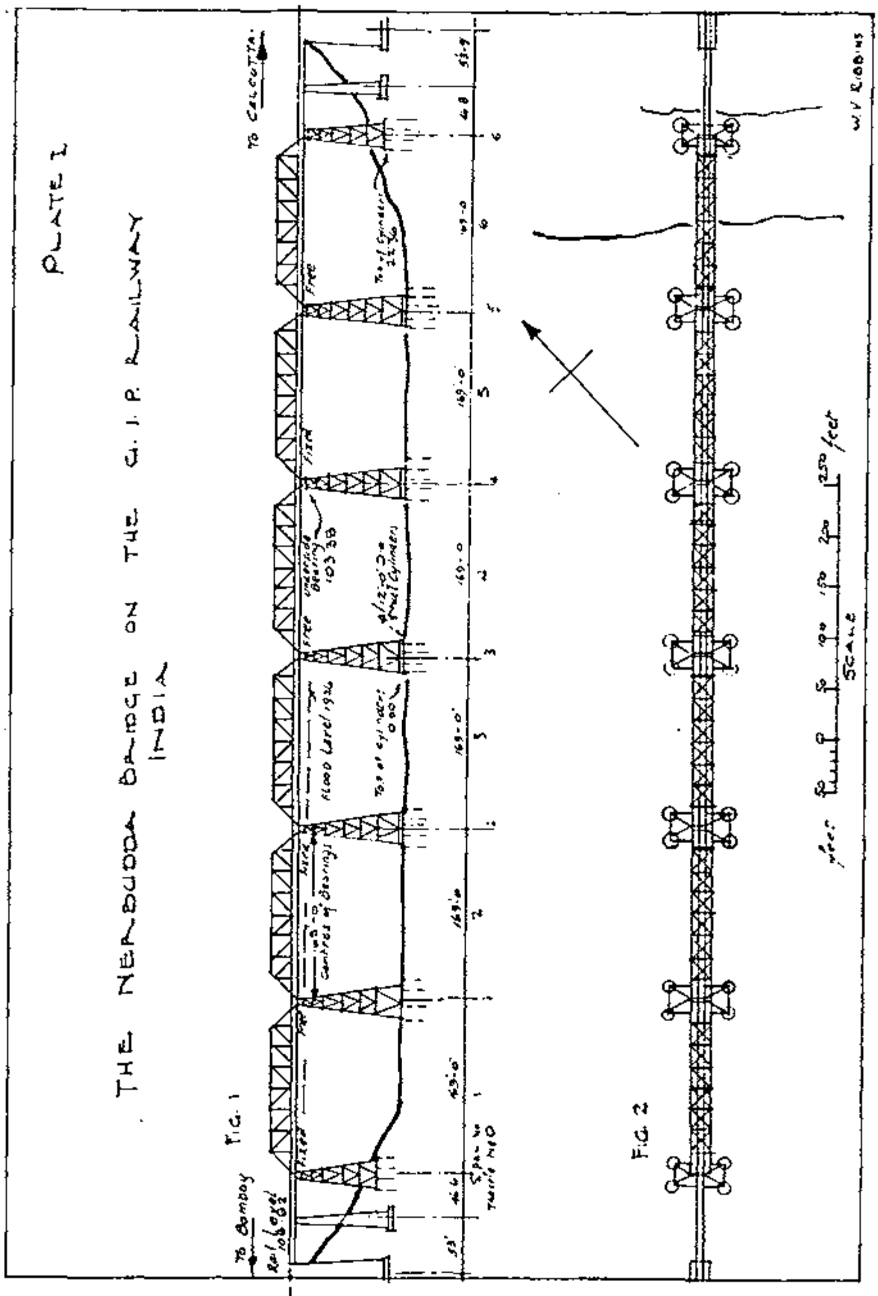


PLATE I
THE NERBUDDA BRIDGE ON THE G.I.P. RAILWAY
INDIA
FIG. 1
FIG. 2
TO CALCUTTA
TO BOMBAY
SCALE
W.V. ROBBINS

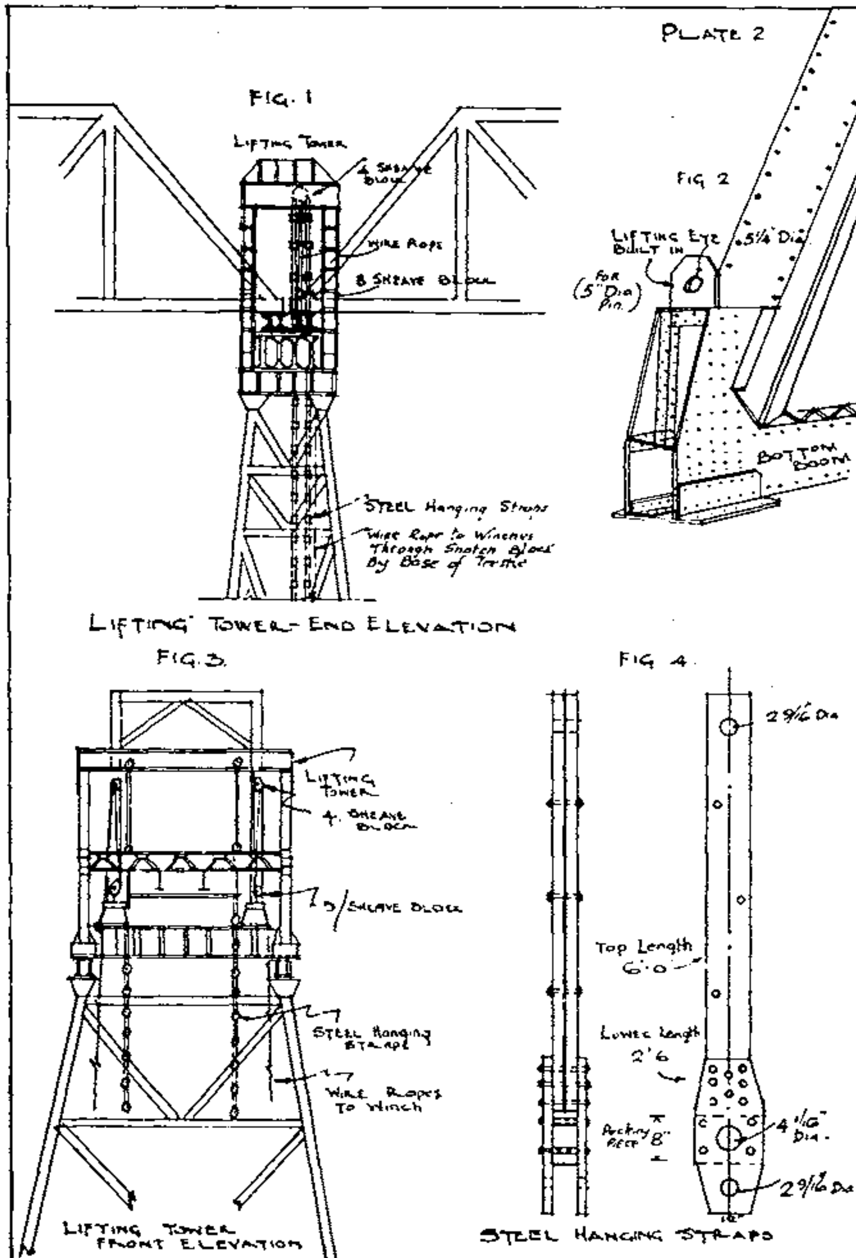
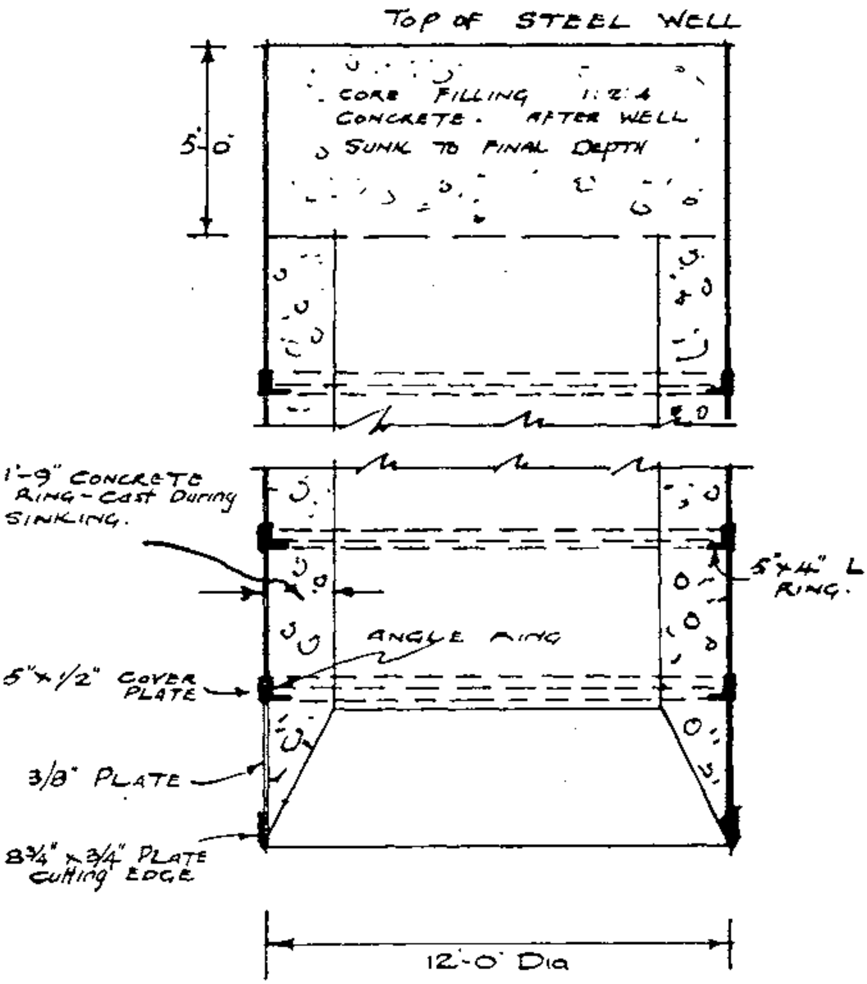


PLATE 2
FIG. 1
LIFTING TOWER
4 SHEAVE BLOCK
WIRE ROPE
8 SHEAVE BLOCK
STEEL Hanging Straps
Wire Rope to Winches Through Snatch Block By Base of Trestle
LIFTING TOWER – END ELEVATION
FIG. 2
LIFTING EYE BUILT IN
5¼" DIA
(FOR 5" Dia Pin.)
BOTTOM BOOM
FIG. 3.
LIFTING TOWER
4. SHEAVE BLOCK
5/SHEAVE BLOCK
STEEL Hanging STRAPS
WIRE ROPES TO WINCH
LIFTING TOWER FRONT ELEVATION
FIG. 4.
2 9/16 DIA
Top Length 6'0
Lower Length 2'6
Packing Piece 8"
4 1/16" DIA.
2 9/16 DIA
STEEL HANGING STRAPS

PLATE 3


TOP OF STEEL WELL
CORE FILLING 1:2:4 CONCRETE. AFTER WELL SUNK TO FINAL DEPTH
5'-0"
1'-9" CONCRETE RING - Cast During SINKING.
5"x4" L RING.
ANGLE RING
5"x1/2" COVER PLATE
3/8" PLATE
8¾"x¾" PLATE Cutting EDGE
12'-0" Dia

The weight of each "through" span, including all rivets, was 258 tons, the weight of each "deck" span was 165 tons. Of the trestles, five weighed 156 tons each and the remaining two were 116 tons each. The weight of the steel used in the cylinder linings was 392 tons, and the total weight of steel, including the bearings was 3,024 tons.

Piers and Abutments

The piers and abutments on the two banks were of masonry construction, the erection being carried out by civil engineering contractors under the direction of the Railway Administration.

Construction of New Bridge

Well Sinking

Steel sections for the 12 ft. diameter cylinders, on which the trestle legs were to be supported, started arriving on the site by mid-November, 1926, together with well sinking plant and on the 30th December, 1926, the assembling of the first cylinder for trestle No. 5, was started at the Jubbelpore end of the new bridge. The assembling of the cylinders was assisted by two 5-ton travelling cranes running on two sets of broad gauge tracks between the lines of the sites for the cylinders.

By the 5th January, 1927, a sufficient number of sections of the cylinders had been assembled to enable the first cylinder to be pitched in position in the N.W. corner of trestle No. 5, this was followed by the cylinder in the S.W. corner on the 8th January, being followed in turn by that in the N.E. corner on the 10th January and the S.E. corner on the 14th January, 1927.

The assembling, pitching and sinking of the cylinders continued until the 29th May, 1927, when work was stopped, plant removed from the river bed, and partly sunk cylinders temporarily sealed off, due to the imminence of the monsoons.

By the 24th May, 1927, twenty-four out of the twenty-eight cylinders had been assembled and pitched, i.e. for the trestles from No. 1 to 6, of these twenty-one had been sunk to their final depths and three had been partially sunk. Pitching and sinking of the remaining four cylinders was again started on the 17th September, 1927, and all sinkings completed by the 23rd December, 1927.

The wells consisted of $\frac{3}{8}$ in. steel plates, curved to the required radius, all sections being butt-jointed, all joints being covered by $5 \times \frac{1}{2}$ in. steel plates, internal angle rings being provided at all horizontal joints, the cutting edge being formed of $\frac{3}{4} \times 8\frac{3}{4}$ in. steel plates, and all connexions being riveted (see Plate 3).

Concurrently with the start of the assembling of the cylinder sections borings were taken on the line of the cylinders, by a hand operated "Ingersoll" drill. The results gave indications that the strata was not uniform, but in the main was composed of stiff red or yellow clay with an occasional outcrop of igneous rock.

A total of approximately 2,700 ft. of boring was carried out and from the information gleaned as a result of these tests it was obvious that it would not be necessary to sink the majority of the wells to a greater depth than 40 ft. The actual depths at which the majority of the wells were finally founded varied from 18.36 ft. to 38.92 ft. In only two cases was it found necessary to exceed 40 ft., i.e. the well for the S.E. corner of trestle No. 1 which was driven to a depth of 42.23 ft., and the S.W. corner of trestle No. 2 which was founded at 44.21 ft.

The total depth of well sinking was 832 ft. and was accomplished in fourteen months. The excavation of the cylinders was done by manual labour using pneumatic spades in the clay and chisels for breaking up the rock formations. The clearing of the cylinder excavations was carried out by self tipping skips operated by 5-ton travelling cranes. Occasionally sinking had to be assisted by a load of Kentledge blocks and in two cases charges of gelignite were used to dislodge pockets of igneous rock.

As each new section of ring was riveted on, an inner lining of 1 ft. 9 in. thick 1 : 2 : 4 concrete was poured, leaving a clear working diameter of 8 ft. 6 in. As each cylinder had been driven and passed for founding by the Resident Engineer of the Railway Administration, it was filled with a 1 : 2 : 4 mixture of concrete. In the tops of each cylinder six M.S. holding-down bolts, 2 in. in diameter were incorporated, those in the up-stream side being 12 ft. long and in the down-stream 6 ft. long, with a grillage of old steel rails, in two layers, at the bottom of each set. All work on the cylinders was completed on the 10th March, 1928.

Preparation for erection

During the period from May to September, 1927, when the river was in flood, erection plant and steel work for the new bridge were arriving at both the banks of the river and in the first week of September the river had subsided sufficiently to allow the laying of the railway tracks in the river bed, this work started from trestle No. 5 and progressed towards the opposite bank. A fair amount of earth levelling had to be undertaken to ensure a level track and by the third week in September sufficient was laid to permit the operation of two 5-ton self propelled steam cranes and one 10-ton steam derrick crane, mounted on bogies, to be brought into operation.

Erection plan

The erection plan decided upon was to assemble the "through" spans on the river bed, between the trestles and to raise them to the tops of the trestles by means of four 10-ton steam winches with twin cylinders, from the drums of which $1\frac{1}{2}$ in. steel wire ropes were to be passed through snatch blocks anchored to the feet of the trestles, passing thence upwards and threaded through a four and a three sheave block, the diameter of the pulley wheels of these blocks being 1 ft. 8 in., the four sheave block being suspended from a specially designed lifting tower and the three sheaves being secured to the lifting eye on the ends of the bottom booms of the bridge.

As it was necessary to remove the side horizontal and diagonal ties of the towers whilst the lifting was in progress, these members were to be bolted in position on erection, being subsequently riveted on the completion of the lifting operations.

Erection

Trestles

On the 1st December, 1927, the erection of trestle No. 6 was started followed by No. 5 on the 5th January, 1928. By the end of March, 1928, all the steel trestles were in position.

Trestles Nos. 5 and 6 were erected by the aid of a 14 in × 14 in. × 40 ft. long oregon pine pole and a latticed steel pole of 100 ft. The remaining trestles were erected by a travelling steam derrick, having a lifting capacity of 10 tons at 65 ft. radius and 6 tons at 85 ft. radius. The mast of this crane was 35 ft. in height and the length of the jib 136 ft. The heaviest single lift in the components of the trestle was approximately 10 tons.

Through spans

The component parts of the through spans from one to five were assembled on the river bed, between the trestles, and riveted in position, being supported on old railway sleepers. As the river bed started to rise between trestles Nos. 5 and 6, No. 6 span was assembled resting partly on the bank at trestle No. 6 and on sleeper cribs at trestle No. 5.

The assembling was started at No. 5 span on the 26th December, 1927, followed by No. 4 on the 8th January, 1928, No. 6 on the 15th January, No. 3 on the 18th January, No. 2 on the 22nd February and No. 1 on the 21st March, 1928. The assembling and riveting of the various members was carried out night and day. For the night shifts power was provided by a 14 b.h.p. oil engine driving a 7 kVA. dynamo.

During the period when the assembling and riveting of the spans and trestles was in progress, preparations for lifting No. 6 span were going ahead. The special lifting towers were erected on the tops of trestles Nos. 5 and 6, these towers were rectangular in shape, the lifting head being composed of two short built-up beams, one to each short end of the rectangle, supporting two built-up girders, the whole being supported on four legs, the bases of these being firmly secured to the top members of the trestles, by bolts.

Suspended from the lifting head of the tower were four lines of supporting detachable links, these were in pairs and positioned to allow them to fall vertically down the inside of the trestle, two tothe outer side and two on the inner side of the end girders of the span, on the bed of the river. These links being formed of 8 × 1½ in. flat plates in various lengths. At the junctions of the links, 2⅝ in. holes were drilled to take a 2½ in. steel pin, the holes in each pair being opposite each other, the purpose of these link slings was to take the weight of the span at the end of each pause in the lifting operation, this was achieved by threading the 2½ in. steel pins through the 2⅝ in. holes under the end girders, and lowering the span until the full weight was taken by the steel slings (see Plate 2 and Photo 2).

By the 28th February, 1928, the assembling and riveting of the members of span No. 6 was completed and on the 29th a trial lift of 1 ft. was carried out, all anchorages, slings and winches were thoroughly examined and the span then lowered, the staff concerned with the lifting operation were then thoroughly briefed in their various duties and all preparations made ready to lift the first span the following day.

At 7.30 a.m. on the morning of the 29th, the Indians carried out a religious ceremony, a small goat was sacrificed to ensure that all went well with the operation, for the lifting of 258 tons of steel overawed them considerably and indeed the European staff said a silent prayer and all, without exception, had "butterflies" at that moment.

When the ceremonies had concluded, Messrs. Braithwaite's Senior Resident Engineer mounted the Jubbelpore end cross girder, placed a large spirit level at his feet and gave the signal to start and inch by inch the span began to rise, this lift was stopped when the end of the bottom boom was 6 in. from a horizontal tie of No. 6 trestle, the Engineer then crossed over to the other end of the bridge and once again the lifting was-continued, the span was lifted one end at a time in steps of 2 ft. until it was placed in position on its bearings on the tops of towers Nos. 5 and 6 on the 9th March, 1928, the first lift having taken nine days to accomplish, this rate of progress was soon speeded up and reduced to six days when the drill had been mastered by the staff.

The apparent slow progress was due to the fact that the horizontal and diagonal ties on the trestles, that had been bolted in position on erection, had to be progressively removed in bays to permit the ends of the span to pass upwards and then replaced. Further, before the ties were removed the spans were brought to rest on the steel pins in the lifting slings, this removed all strain on the steel ropes and winches. All lifting was carried out during the day.

On the completion of the lifting of No. 6 span, the lifting tower on No. 6 trestle was dismantled and re-erected on No. 4 trestle, this was done by the 10-ton steam derrick crane. Lifting operations on No. 5 span started on the 18th March and were completed by the 25th March.

On the 27th March whilst the lifting tower on No. 5 trestle was being dismantled a steel wire rope sling broke, caterpulting two legs and a cross head of the tower down to the river bed, fortunately this section did not strike any part of the trestle on its way down, as, had this happened it might have had very serious consequences and resulted in a serious loss of life, four gangs of Indian riveters and spider men were working on No. 6 span, as it was, the only one whose life was endangered was the Author, who was standing on a horizontal tie at the top of the trestle, just under the position where the sling broke and as the section of the lifting tower passed him, the jagged end of the broken sling tore off the back of his shirt and ripped his back. The accident caused a day's delay whilst new parts for the lifting tower were fabricated on site.

On the night of the 29th March, pandemonium broke loose in the Indian labour lines, which were situated in the bed of the river. Seen from the top of the Jubbelpore banks, where the Europeans huts were situated, it appeared as if the whole of the labour in the camp were deserting on the run, inquiries elicited the fact that cholera had struck and in ten days there were fifteen deaths. Fortunately the *Pathan* riveters, from the north-west frontier of India stood fast to a man, as well as a sufficient number of *Khalasies*, "spider men", from Calcutta and Bombay, to enable the work to continue. Incidentally, this was the second occasion when cholera was experienced on the site, the first being in July, 1927, during the monsoons, when there was a reduced staff, on that occasion there were six deaths, all Indian. No Europeans were affected throughout the period of this work.

The raising of the spans progressed steadily without further incident. Lifting of span No. 4 started on the 1st April and was completed on the 4th April, No. 3 on the 18th and completed on the 21st, No. 2 on the 27th and completed on the 29th and No. 1 on the 4th May and completed on the 7th May, 1928. The land spans on the Jubbelpore end were placed in position on the 11th March and those on the Bombay end on the 10th May, 1928.

By the 25th May, 1928, all erection work on the bridge had been completed and arrangements were made for the Railway Authorities to carry out tests for deflection and oscillation on span No. 1 by means of a card and pencil self-acting recording apparatus and stress recorders, and on the 29th May a goods train, approximately 160 ft. long with two engines, one to the front and one to the rear of the wagons was used. One standing test and a series of speed tests ranging from dead slow to 40 m.p.h. were carried out, these tests being satisfactory the bridge was opened to traffic on the 1st June, 1928.

From the 1st June, work progressed night and day in removing the erection plant from the bed of the river as the monsoon was due to break within a few days and on the 18th June the monsoon was heralded in by a tropical storm and torrential rain which lasted for five days, and on the 21st the river started rising at the rate of an inch an hour, fortunately all plant had now been cleared from the river bed.

On the 19th June, 1928, the Author entrained for Calcutta on a short visit to H.Q., leaving his wife and three small children in a hut on the Jubbelpore bank of the river, this hut being situated 75 ft. above the river bed. On the night of the 22nd June the flood waters had risen 74 ft. and the local permanent-way inspector advised the Author's wife to vacate the hut. Arrangements were made immediately and at midnight the Bombay-Calcutta mail was stopped at the bridge and the party entrained for Jubbelpore where the Author met them the following day, on his way back to supervise the construction of a large power station in Indore.

During the whole of the period of the construction of the bridge the climatic conditions were severe, during the hot season the temperatures rose to 119·F. in the shade, and torrential rain and severe storms during the monsoons, yet in spite of these difficulties the European staff and their families managed to keep free from any severe illnesses.

For recreation there were abundant light games and shooting all around the area. The Author had for his additional recreation an occasional indoor shooting practice, the targets offered were massive rodents which periodically appeared on the top of the partition dividing the bedroom from the dining-room, these were shot by means of a .22 rifle whilst sitting at dinner at night.

SUMMARY OF SALIENT DETAILS FOR STEEL WORK ON BRIDGE

Total weight of steel used in bridge	3,024 tons	
Weight of steel per central trestles	156 tons, height	97 ft.
Weight of steel per end trestles	116 tons, height	75 ft.
Weight of steel per through span	258 tons, length	169 ft.
Weight of steel per deck span	165 tons, length	45 ft.
Weight of steel in wells	392 tons, toal No.	28.

Total volume of 1 : 2 : 4 concrete used in wells 21,810 cu. yds.
Date construction work started 30th December, 1926
Date construction work completed 30th May, 1928
Type of steel used, Tata Iron & Steel Co. Ltd.
Supervision by Europeans
Labour: Riveters, *Pathans* from the north-west frontier of India.
Spider men, *Khalasies* from Bombay and Calcutta
Other labour: local.

The Compaction of Soil

By Colonel E. W. L. Whitehorn

Introduction

Soil is an engineering material and though it has been used as such for centuries, relatively little is known about its characteristics.

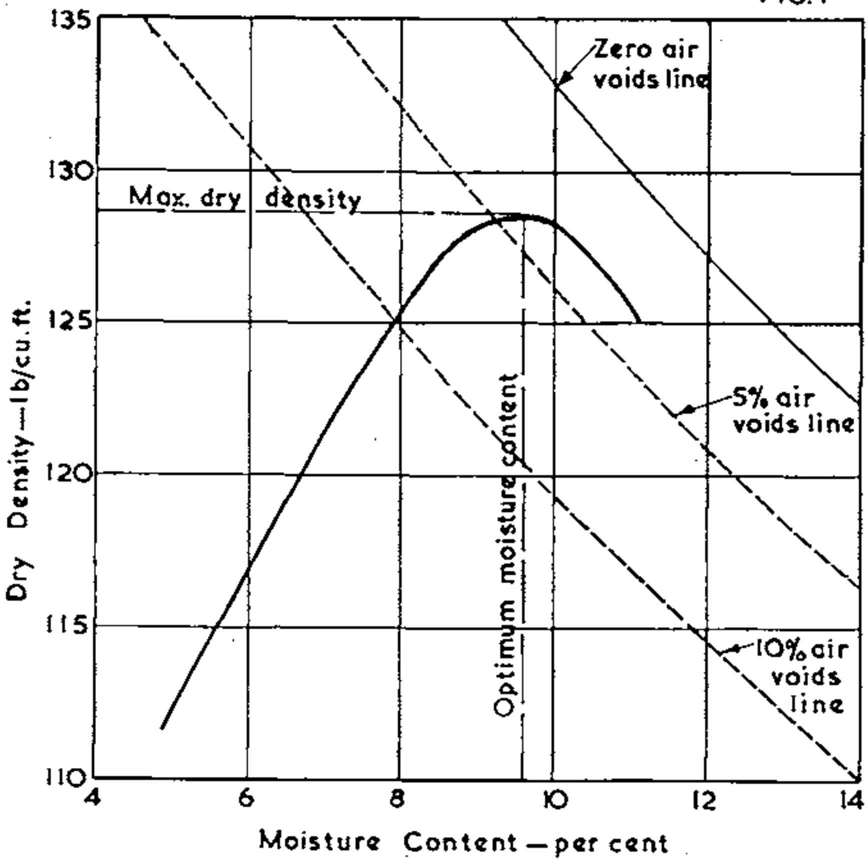
Because of this, the engineer who has to compact soil in order to improve its load bearing capacity, is forced to rely on past experience and is, therefore, subject to the shortcomings of all empirical methods.

Unless he has a fundamental understanding of the problems of soil compaction, it is difficult for him to control the influences of the many factors which arise and he will become involved in much controversy about the choice of type of roller, their proper use, the maximum soil density that can be obtained economically, field and laboratory control etc.

The following brief notes give some idea of what is now known about soil compaction.

Fig. 1 shows the general relationship between dry density and moisture content for a given soil and a given compactive effort.

FIG. I



RELATIONSHIP BETWEEN DRY DENSITY AND MOISTURE CONTENT FOR A PARTICULAR SOIL AND A GIVEN COMPACTIVE EFFORT

Variables

In soil compaction there are a number of variables which must be considered if satisfactory work is to be done. They include:—

Soil	*Compactor*
Type	Type
Natural bearing capacity	Weight
Moisture content	Contact area
Density required	Contact pressure
Lift thickness	Number of passes
	Speed

Moisture Content

A soil mass may be regarded as being composed of solid particles, water and air. The compaction of a soil mass is the process of forcing the soil particles closer together and thus reducing the air voids. The effect of adding water is to decrease viscosity and increase the distance between particles.

At low moisture contents, cohesive and semi-cohesive soils usually have a high strength and are stiff and difficult to compact, with the result that low densities and high air void contents are obtained. At higher moisture contents the strength is less and it becomes easier to reduce the air voids and compact the soil. At still higher moisture contents a condition is reached at which the soil is sufficiently weak for the air voids to be reduced to a very small value. If more water is added the dry density decreases because excess water occupies the space which would otherwise have been filled with soil particles.

For cohesive or semi-cohesive soils, the compacted dry density is nearly directly proportional to the moisture content until the "Optimum" is reached. For materials containing very little or no fines the moisture content has almost no effect on the density other than acting as a lubricant between the grains.

Optimum Moisture Content

It is often assumed that there is an optimum moisture content for every type of soil at which it can be compacted to reach its maximum density. This is not so. Each compactive pressure or effort has its own optimum moisture content and the optimum moisture of a soil type is that for one compactive effort only.

In general, as the amount of compactive effort is increased, the maximum dry density increases and the optimum moisture content decreases.

Laboratory Tests

The optimum moisture content of a soil type determined in a laboratory by Proctor tests may differ widely from the optimum moisture content of the same soil which is to be compacted in the field, because no account is taken of the characteristics of the compacting machine and hence the compactive effort. Moreover, laboratory compaction tests are done only on material which has passed a ¾-in. sieve and results have to be adjusted if the soil contains any large material.

The laboratory compaction tests are valuable standards for use in studying the compaction behaviour of a soil, but they should only be used as a rough guide to the moisture content which will give maximum compaction in the field.

It may be necessary to vary one or more of the details of a standard laboratory procedure—e.g. the weight of the hammer, the height and number of blows, etc.—in order to obtain a more nearly exact relationship between optimum moisture content of the material and the roller to be used.

Selection of Moisture Content

The moisture content for the compaction of a subgrade should not be selected solely as the result of a laboratory test, but should be related to the existing moisture content of the soil so as to ensure that there will be little change in moisture content after the completion of the work, since, with all types of soil, an increase in the moisture content of the subgrade after the pavement is constructed will cause decrease in strength which may affect stability of the pavement.

The selection of the moisture content for compacting soil for fill in low embankments is not so critical as in the case of subgrades, nevertheless, extreme conditions of moisture content should be avoided. In high embankments and earth dams, the selection of suitable moisture content limits is important and their evaluation requires the investigation of the physical characteristics of the soil and a stability analysis of the embankment.

There are often situations in which the natural existing moisture content of the soil to be compacted is such that its modification for efficient compaction by a particular matter is economically impracticable. For example, the fill may be so wet that drying may be impossible because of the large volume involved and the time required. Since the moisture content under such conditions is nearly a fixed value it follows that the "optimum compacting pressure" must be determined. This is a trial and error procedure in which the pressure of the roller is varied until the field optimum moisture content it produces nearly coincides with the existing water content.

Bearing Capacity

If the stresses applied to a soil by a compactor exceed the shearing strength or resistance of the soil, local failure begins and the load starts to sink into the soil, pushing the soil under it downwards and outward. There is then an increased resistance due partly to the increase in soil density resulting from the settlement motion and partly to the lateral confinement of the displaced soil.

With some compactors (e.g. smooth-wheel or pneumatic tyred rollers) as sinkage occurs, there is a greater area in contact with the soil so that the stresses are reduced. Sinking stops when equilibrium between stresses and resistance is reached.

Although some compaction of the soil is achieved under the load, the soil at the sides is loosened so that the total net reduction of voids is questionable, and inefficient at best, for energy is spent in compacting one part of the soil and, at the same time, loosening another.

The optimum roller pressure is that which is large enough to produce local shear failure without going into complete failure of the soil mass. High pressures are more critical in cohesionless soils than in those having some cohesion and if compacting soil which is substantially wet of optimum.

Since the bearing capacities of soils vary, it would be possible with the ideal roller to vary the contact pressure produced by a compactor if the most efficient use is to be made of it, i.e., so that the greatest contact pressure can be obtained without shear failure of the soil.

Variation can be done in two ways—altering the total weight of the compactor or altering the area on which it makes contact with the soil.

It is highly desirable that the total weight of the roller should be kept as great as possible but that the contact area should be adjusted to the bearing capacity of the soil.

This can be done in the case of sheepsfoot rollers by changing the ends of the feet or in pneumatic tyred rollers by altering the tyre pressures.

Size of Roller

The importance of roller size is in the way it controls the bearing pressure and the depth that is significantly stressed. With cohesive soils, the bearing capacity is independent of the size of the loaded area. Hence, so long as the bearing pressure does not exceed that for local shear failure, for a given roller load a small contact area is more efficient for compaction than a large contact area. For a given contact pressure, however, a greater depth of soil can be effectively compacted by increasing the contact area, and therefore the roller load.

With cohesionless soils, the effect of the roller size is more critical since the bearing capacity is roughly proportional to the square of the width of loaded area and also increases significantly with depth. For a given roller load, shear failure will start sooner under small contact areas than under large ones. If the contact pressure is kept the same, however, differences in size of the loaded area have less effect on compaction than is the case with cohesive soils.

Other things being equal, the volume of soil being effectively compacted is dependent on the energy input and its distribution in the soil mass, which are both directly proportional to the roller load and contact area.

Thickness of Lifts

As the soil depth increases, the pressure caused by a load decreases and the bearing capacity of the soil increases. The yield, and thus the compacted density, will decrease with depth and the effective compacting depth will depend on the size of the loaded area.

A heavily loaded pneumatic tyre having a width of, say, 18 in. will probably compact to a greater depth than a sheepsfoot roller having tamping feet whose area is of the order of square inches.

It is obvious, therefore, that the practice of adopting an arbitrary thickness of lift without reference to the type of compactor to be used may lead to a considerable waste of energy.

Large and heavily loaded compactors may well be able to compact much thicker depths of loose soil than are usually specified for lifts, but this increase in depth may require a modification in hauling and spreading equipment to prevent heavy machines from breaking through loose surfaces and becoming bogged.

Number of Passes

When loose soil is first spread out in layers ready for rolling its shearing resistance is low so that the roller sinks into the soil and reduces the loading pressure by increasing the contact area. The soil will be compacted to some extent from the first pass of the roller and every additional pass is on a stronger soil. For a given roller on a given soil, there is a definite number of passes which will give the maximum return in increasing density for energy spent and for this roller there is a maximum density of soil that can be compacted under any practical condition. Too many passes beyond that for maximum return is a major source of wasted energy. If a greater density is required, a heavier roller must be used.

Stage Compaction

If a very heavy roller is used on a layer of newly spread loose soil, it may prove too heavy because the soil is incapable of supporting it at the start. However, assuming that this condition is not quite reached and that the soil is compacted to a slight extent, which increases with subsequent passes, the efficiency of the roller is low. As rolling proceeds, the efficiency increases until a maximum is reached, after which it decreases because no further compaction will result from additional rolling.

Light pressure rollers have a much higher starting efficiency than heavy pressure rollers, but a heavy roller may compact a soil to a greater density than a light one. It may, therefore, be an advantage to start compaction with a light roller working with reasonable efficiency for a few passes until the soil density is high enough to support a heavy roller which can then replace it and work under favourable conditions near its maximum efficiency. Usually only one roller is used.

Speed of Rolling

There is probably an optimum velocity for compaction in so far as the energy input into the soil is a function of the time that a given roller load is applied. However, it is difficult to determine the relation between soil resistance, settlement, roller mass and velocity and in practice the speed of rolling is usually governed by the speed of the towing vehicle (e.g. tracked tractor) or, in the case of self-propelled compactor, by the motive power installed by the manufacturer. In general, pneumatic tyred rollers, sheepsfoot rollers and smooth-wheel rollers are operated at speeds between 2 and 5 m.p.h. while vibrating compactors work at between 1/10th and $1\frac{1}{2}$ m.p.h.

Specifications

Dry Density

It is fairly common practice to specify the state of compaction required in earthwork construction as a percentage of the maximum dry density obtained with a standard laboratory test. As shown earlier, this procedure has serious drawbacks. If the moisutre content selected for compaction is based on the natural moisture content at the site and is much lower than the optimum moisture content obtained in the laboratory test, a poor state of compaction—measured in terms of the air voids content of the soil—will result in the field, even if a high relative compaction is achieved.

On the other hand, if the moisture content selected for field compaction is much higher than the laboratory optimum, the specific relative compaction may be impossible to obtain.

A more satisfactory way may be to specify (*a*) the moisture content (or moisture content range) at which the soil should be compacted based on the natural moisture content at the site, (*b*) the state of compaction to be obtained in the field in terms of maximum percentage of air voids for the compacted soil.

Lifts

The practice of adopting an arbitrary thickness of soil layer leads to one of the major sources of wasted energy during compaction, and it is done because of a lack of established relationship between types of roller and soil thickness of lift.

Important savings may result if thick lifts can be spread and compacted.

Compactors

Unless based on field tests, a specification which lays down the compactors to be used should be avoided as the performance of the roller depends on many variables. A compactor whose weight and contact area can be varied by easy adjustments should be selected.

Types of Compactor

There are four main types of compactor:—

Smooth wheel rollers
Sheepsfoot rollers
Pneumatic wheel rollers
Vibration rollers or tampers

and each of these types can be divided into several sub-divisions.

It is difficult to say in a short article which is the best type to use for any particular project but the following gives a rough guide to performance.

Smooth wheel. These rollers work well over a wide range of soils and leave a smooth finish, but their performance is limited by their comparatively small weight and contact area—the maximum size being in the region of 20 tons.

Sheepsfoot. These compact effectively in the cohesive and semi-cohesive range but are not effective in cohesionless soils. Furthermore, they compact best in dry soils and do not work well in the United Kingdom because the natural moisture content of the soil is generally too wet for them.

One drawback is that they leave a disturbed top surface.

Pneumatic wheel. These are made in sizes from 10 to 200 tons and with tyre pressures ranging from 40 to 150 p.s.i. They compact effectively in the cohesive and semi-cohesive range.

Vibration. These compactors are most efficient in the non-cohesive and semi-cohesive range of soils.

The roller types usually have the advantage that they can be used as static rollers, e.g., with the vibrator switched off, and so can do preliminary compaction of weak soils where stage compaction is an advantage.

Vibration compactors are also very useful for vibrating a filler such as sand into the voids in a gravel layer.

While for each type of soil and fill material there may be one type of roller that compacts to a denser state than the other types, many of the latter can produce an adequate degree of compaction for the particular job. Therefore, the principal factors to be considered in the choice of a roller for each job are generally the relative working costs and availability of alternative types which will satisfactorily compact the particular material.

ACKNOWLEDGMENT

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Running a Desert Railway

By Major G. Horne, A.M.I.C.E., R.E.

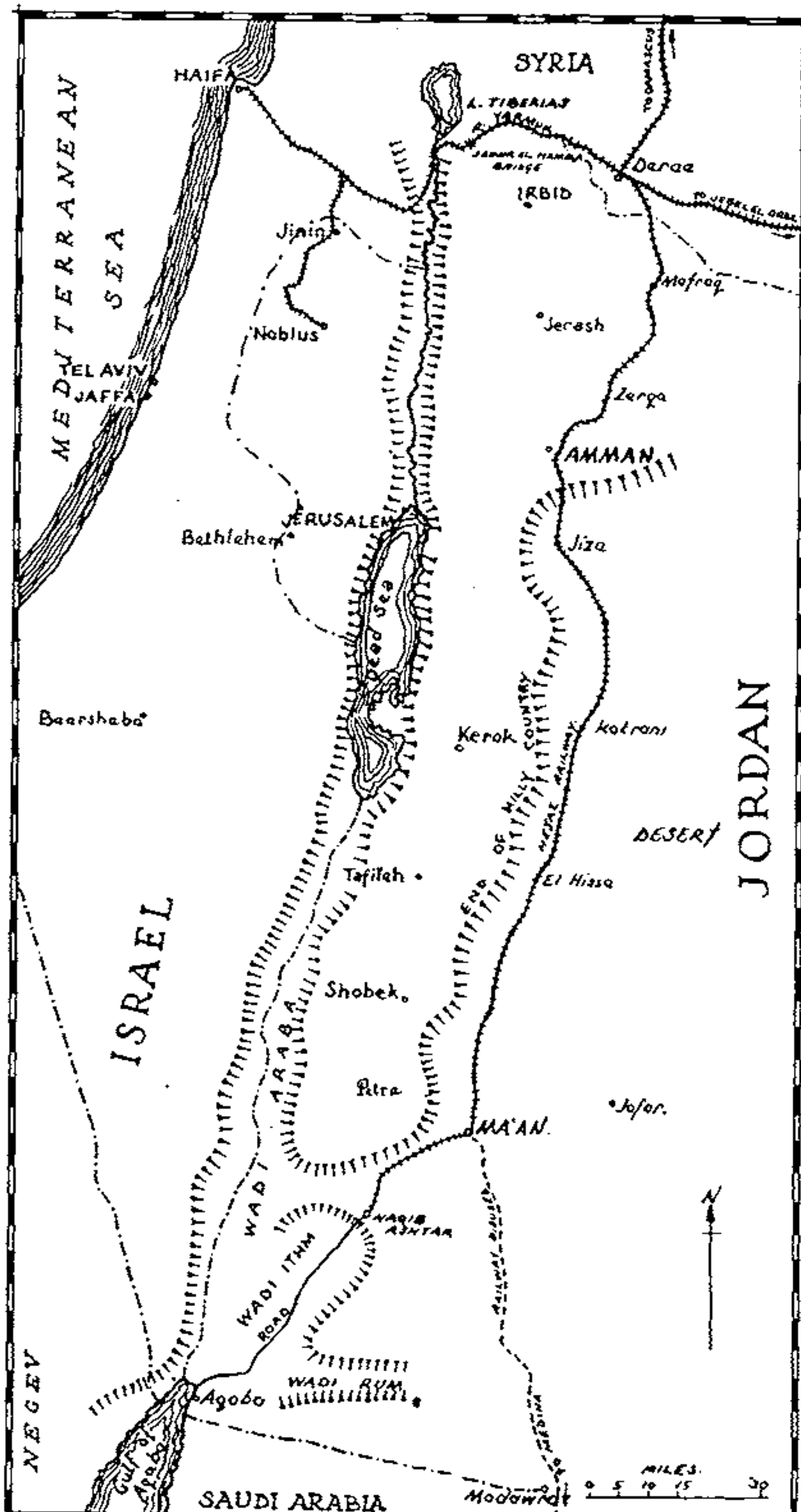
The last year in Jordan has seen the end of the old Arab Legion. The "Pasha" and the majority of British officers have been dismissed and its name and famous red headdress are no more. These events, together with the article on the Arab Legion Engineers in the June, 1956, issue of the *R.E. Journal*, have caused me to shake off the lethargy of the Middle East and to recall the time when the Engineers of the Arab Legion could be said to have their own "Tn." organization.

At the turn of the century the Turks built, within their Empire, a railway from Damascus to Medina, "the station for Mecca". This line, constructed mainly by German and Italian engineers and contractors, was to carry the faithful on their pilgrimages, and subscriptions towards it were collected throughout the Muslim world. By the will of Allah it also happened to be a vital link in the internal communications of the Ottoman Empire. The gauge chosen was 105 cm., a gauge not normally in use and one in which the provision of locomotives and rolling stock would prove difficult for any invading army.

The line was laid along the western edge of the great desert, which stretches from the Dead Sea hills in the west to the River Euphrates in the east, and later on was linked to the Mediterranean ports of Haifa and Beirut. It was a single track with crossing stations, and on the section south of Amman the bulk of the water required for the locomotives was obtained from cisterns, built by the Romans and kept in repair by the Turks, along the pilgrim route.

During the first World War the line was frequently raided by Lawrence and his Arab Army, and signs of their demolitions and of the Turkish trenches round the stations exist to this day. In 1918, on the break up of the Ottoman Empire, the 105 cm. system covered Syria and Lebanon, where it was operated by the French, also Palestine and Transjordan, where it became the narrow gauge section of the Palestine Railways, with all major repairs and administration carried out at Haifa. The badly damaged section south of Ma'an and into Saudi Arabia ceased to be operated.

In the second World War a spur line was added from Ma'an to Naqib Ashtar, from whence a road was built down the great escarpment and along the Wadi Ithm to Aqaba. After the heavy war time traffic the southern part of the system became once more the "sleepy" branch line of the Palestine Railways. Then came the post-war troubles in Palestine, during which the Jewish terrorists destroyed the Samna-El Hamma bridge in the Yarmuk gorge. This cut off the section of the line in Transjordan from all workshop facilities and "marooned" all locomotives and rolling stock which were either in the workshops at Haifa or in operation on the Palestine section of the line. At the end of the Mandate, Transjordan became a separate country, Jordan, and was left with a long "single line" railway from Deraa, on the Syrian frontier, to Naqib Ashtar in the south, three Hartmann oil burning locomotives built in 1918, a fair amount of old rolling stock, very few spare parts, no breakdown crane and only very minor workshop facilities at Amman.


SYRIA
HAIFA
MEDITERRANEAN SEA
L. TIBERIAS
YARMUK
TO DAMASCUS
Deraa
IRBID
Jinin
Mafraq
Jeresh
Nablus
TEL AVIV
JAFFA
Zerqa
AMMAN
JERUSALEM
Bethlehem
Jiza
Dead Sea
Beersheba
Kerak
Katrani
END OF HILLY COUNTRY
HEJAZ RAILWAY
JORDAN
DESERT
Tafileh
El Hissa
ISRAEL
Shobek
WADI ARABA
Petra
MA'AN
Jafar
N
NAQB ASHTAR
WADI ITHM ROAD
WADI RUM
NEGEV
Aqaba
Gulf of Aqaba
TO MEDINA
SAUDI ARABIA
Modowra
MILES
0 5 10 15 30

Very soon after joining the Arab Legion, in the spring of 1948, I was somewhat shaken upon being told that, in addition to raising the first field engineer unit, I had also to run Jordan's newly acquired railway. Previous to this my entire knowledge of railway operating, which had been gleaned at Longmoor on a supplementary course, consisted of how to carry out "end on" platelaying and cut a piece of rail, and I also recalled that "points" were called "turnouts" and that "Jim Crow" was a thing, not a person. All these gems of knowledge were no doubt of great value, but none of them seemed to be applicable in running a desert railway. As in most jobs I started off by collecting "the file" to read through; I was then told that the Madawra Section was not now operating, as the culverts had all been blown up. Not being very sure as to where Madawra was, and as the Palestine troubles had only just finished, I inquired, "who blew them up, the Jews?" and was told, "no, Lawrence".

Though the rolling stock was old and needed painting it did "roll" and though the permanent way was fairly ancient it was adequate, whilst bridges and culverts, except those on the "Madawra Section", were built of solid masonry in a land of good masons. The great problem was to keep the three old oil burning German Hartmanns in action with a deplorable lack of spares. Breakdowns were frequent and many an unfortunate passenger was stranded in the desert until a relief locomotive could be got on steam and sent to the rescue. From the Traffic Office in Amman, the centre of all things, the movements of "the train" would be watched with tense interest as various telephone messages came in reporting its progress, or lack of progress. Tension only eased when it reached its destination safely, "praise be to Allah", and coffee all round would be called for. However, by building up a stock of spares, hiring Syrian locomotives and using the workshops at Damascus, all at a fairly high cost, breakdowns were greatly reduced and the number of trains increased to cope with the extra freight which started to come into the country via Damascus and Aqaba. The staff was also increased by many skilled ex-employees of the Palestine Railways, who were amongst the Arab refugees driven into Jordan by the new state of Israel.

It was about this time that I decided that trains should start on time. Arriving on time was of course completely out of our hands, but I felt that starting at the advertised time would be a step in the right direction. Consequently the first morning we got the "Ma'an Flyer" away on time it was considered a great achievement and I was just celebrating it by having a coffee with Izzard Effendi, the supervising station master, when some rather angry members of the Air Force arrived from the near-by R.A.F. Station. It was, I was given to understand, most unfair that the train should start on time, everyone knew that the trains never started on time and consequently passengers from the R.A.F. Station always arrived half an hour or so late when they had to travel to Ma'an. However, at that moment all was saved by a telephone call to say that the train had got delayed at the next station so the irate travellers were able to catch it up by truck. This strange "Ingleez" habit of starting trains on time caused quite a few locals to miss them. However, their philosophy seemed to be that waiting on Amman station for three days for the next train was preferable to being stranded in the desert, a fate that was bound to overtake any train that set off in such a hurry.

Photo 1.—One of the through spans erected in Poraith Waite's yard. Note drilled plates with eyes at ends of bottom booms.

Photo 2.—Through spans being lifted from river bed.

Construction Of A Bridge On The GIP Railway

Amman is surrounded by hills and the station is sited on a level area cut into the side of one of them, thus making any expansion difficult. The line from Zerqa and the north approaches the station up a long incline, whilst the line to the south climbs and twists through the hills, passes through the one tunnel and then drops down on to the desert. Trains coming from the north would herald their approach by a tremendous amount of puffing to get up the incline, whilst trains departing for the south had to get up sufficient speed to make the gradient. The departure of the bi-weekly "Ma'an Flyer" was always an exciting affair. Passengers would be all aboard, sweet-meat vendors and folks without ticket chased off the train and then with a lot of shouting, whistling and steam the train would move, backwards. This was to enable it to get as long a run as possible before tackling the slope out of the station. Then it would come back through the station (see Photo 1) gathering speed with the brakemen crouching in their little seats on the carriage roofs, for we did not enjoy the luxury of vacuum brakes. It would then roar over the level crossing and, with a long farewell whistle, disappear round the bend and up the hill on its long trip to the south. One morning whilst showing a friend this "stirring" sight I was somewhat shaken to see the train appear again, returning to the station backwards. It had failed to "make it" first go. However, Allah was kinder on the second attempt.

These hills often caused trouble and on one occasion our small shunting tank, a Hohenzollern built in 1900 and on hire from the Syrians (see Photo 2), whilst moving some trucks was allowed to go too far north and off the level station area. The trucks took charge and pushed the loco, angrily whistling and with wheels slipping, off down the long incline towards Zerqa. After preventing the threatened fight between the driver and the shunter we had to produce another larger engine to go and collect the runaways.

The "hazards" of the desert were many, the main one being the lack of water. All trains had to have either a flat truck carrying water tanks or else a spare tender to keep them going between the filling points (see Photo 3). These filling points were at crossing stations and consisted of wells or the old cisterns mentioned earlier on. Water levels would get very low towards the end of the dry season and in the case of the open cisterns there was often brisk competition between the Hejaz Railway and the flocks of the Bedouin for the use of the water. A mechanical failure between stations often meant that the locomotive had to go off steam for lack of water and that a relief train would have to go to the rescue.

Strangely enough another "hazard" was too much water. Deserts, though traditionally dry, have areas which flood very quickly during the seasonal rains and consequently a great deal of our line ran on embankments. In spite of there being many culverts there was always the danger of washouts during the winter months. Some years before, a fatal crash had been caused by such a washout and a very careful watch was always kept during the danger period.

Winter brought the problem of cold and made travelling in unheated wooden carriages an uncomfortable business. It also made the handling of fuel oil, locally known as "Mazut", rather difficult as the viscosity increased. If it got too cold the oil would cease to flow into the locomotive injectors. However, the footplate staff were equal to the occasion and immediately a train had to stop for this reason all the passengers would be ordered out to scour the surrounding desert for camel thorn. When sufficient quantity had been collected it would be piled on top of the tender and a match applied. Thus the oil would be warmed and able to flow once more and provided there was the steam available to work the injectors it would not be long before the train was under way again, the passengers nicely warmed by their exertions.

Jordan usually gets one or two falls of snow during the winter and it does not take very much blown snow to form drifts in the cuttings. As will be seen from Photo 4 we had our problems in keeping the line open. A locomotive without a proper snowplough soon builds up a pile of snow in front of it even when the drifts are very shallow. The falls usually occurred on the hills around Amman and we would clear the line by getting a locomotive to "bulldoze" the snow into piles which were then removed by hand. Once the area through the hills was cleared the rest of the line could then be operated.

On one occasion a snow fall also covered areas of the desert. This completely closed the line as we were unable to clear all the drifts which had formed in the cuttings. However, snow over such a wide area was not likely to lie for long and in fact after two or three days it had all gone, but not before we had had the excitement of the "marooned platelayers' gang".

For the routine maintenance of the permanent way platelayers' gangs were based on the various crossing stations. Each of these stations had a small village, which had grown up alongside and in which lived the local railway staff, including platelayers, and their families. The gangs would set forth from these stations with their hand trolleys and spend several days away from home passing the nights either in platelayers' shacks or in deserted station buildings, of which there were a number up and down the line. As their work proceeded they would move their tools and themselves on the light hand trolley, but for a long move they would board a passing train taking the trolley, which came to pieces, with them.

On the occasion when snow had closed the line one such gang was marooned in a platelayers' hut. After a day or so they reported by telephone, into which the gangs could tap, that they had run out of food and water and were "starving to death". I, believing this tale of woe, felt that a rescue expedition was called for, so six of us plus rations and shovels set forth in the four wheeled motor Drewry Car. My companions, with true Arab hospitality, had ensured that a shovel for me was included, thus I had to do my share of digging and soon found out how heavy snow can become. It was a long journey with many cuttings, through which we dug our way, and night had fallen long before we reached the marooned party. Fortunately we were assisted by a full moon which made the silent, snow-covered desert rather a wonderful place. Just before reaching our goal I gave instructions that the marooned platelayers, having been for some time without food, must not be allowed to bolt their first meal too quickly. For "starving" men the gang looked pretty fit and the dramatic force of our arrival was somewhat spoilt by the platelayers insisting that, as we were the guests, we must eat first. Thus, with our appetites sharpened by snow digging, we had a good meal, waited on by the "starving" folk we had come to rescue, whilst the tale about "not bolting food" was told amidst howls of laughter. The Arab is indeed a born exaggerator, but not without a sense of humour. Upon being asked why snow had not been used as water the platelayers said that they did not like drinking the solid type of water.

The Drewry Car used in the snow was a closed one, there was also an open car, both driven by small petrol engines. They were used for getting up and down the line on inspections and, being somewhat quicker than the trains, were often hired out for special runs. Travelling at speed in these cars was quite a nerve racking experience, as they would rocket along the line and although they had brakes, which made a horrible grating noise when applied and frightened people out of the way, they never seemed to slow down the car. The chief hazard, especially at night, was camels, herds of which roamed the desert. Once the closed car hit a camel whilst it was travelling at speed, damaging the front of the car quite a bit and completely damaging the camel. The drill on such occasions appeared to be that the crew of the car would leap out intent upon beating-up the camel herdsman for allowing his flock to wander on the line, but he would invariably escape upon one of his undamaged camels. The Bedouin tribes were always a bit of a hazard, and it was due mainly to their light fingered habits that the lines were laid on metal sleepers, wooden sleepers would have provided the tribes for hundreds of miles around with a constant supply of firewood.

No reminiscences of the Hejaz Railway would be complete without mention of the staff. These were the folks who gave, and no doubt continue to give, the line its character; the eastern equivalent of Emmett's gentlemen in *Punch*. Many had been on the railway since Turkish times and still talked Turkish, these the leisurely life of a quiet branch line suited well. Others, as was mentioned before, were refugees from the railways in Palestine who were brought in to help with the increased traffic on the line. However, though one tended to laugh at these folk and get a lot of amusement from them I should like to make it clear that they were delightful people to work with and that it was due, in the main, to their efforts that the line continued to run in spite of shortages and difficulties and, what is more, to flourish.

The Turks had originally chosen the railway staff with a view to keeping the line operating during troubled times and nearly all the older members were either Circassians or Ma'anis. The former had been given refuge by the Turks at the end of the last century and consequently were very loyal supporters of the Ottoman Empire. The latter all came from the same town, Ma'an, and in the event of their failing to carry out their duties, it was very easy to send a squadron of Turkish cavalry to beat up the "home town". A method possibly not quite in keeping with our modern ideals, but one must admit it had its practical advantages.

The key men were mainly from the ranks of the old timers, the chief one being Izzard Effendi, the Supervising Stationmaster, who controlled all traffic on the line by long and excited conversations on the somewhat antiquated telephone system. A system which was not powerful enough to operate all the way from Amman to Ma'an and consequently all conversations to stationmasters on the southern half of the line had to be conducted through the stationmaster at Katrani. The traditional "range telephone" had nothing on ours and to talk to Ma'an, with the help of Katrani, was an exhausting business requiring much time and patience. Abu Yussuf was the loco foreman, whilst Ahmed Effendi kept the track and buildings in good repair with his gangs of platelayers. Two of our greatest towers of strength came from

Palestine as refugees and were Mr. Spiro, a Greek, whose technical knowledge on locomotives was invaluable and Mr. Naddy, an Arab, who built up the accounts branch, which previously was non-existent as everything had been controlled from Haifa. Mr. Naddy always made sure that all our tickets were printed in Damascus, as to have them printed locally would have flooded the town with "free tickets".

All together there was a staff of about 300 up and down the line, the oldest being the "Ancient Shunter" at Amman, who would dash about with a whistle in his mouth and, day and night, a lantern in his hand. He always reminded me of the character in the *Ghost Train* who sang "Rock of Ages". His shunting methods were somewhat weird, but we never dared interfere with him. He would be told what was wanted and then after a period of intense chaos, which included a great amount of whistling, he would have all the trucks sorted out as required. Only once did he fail and that was in the sad affair, already recounted, of the runaway train; and even then he swore that with such a fool of an engine driver no self respecting shunter could hope to achieve success.

Trips up the line always entailed drinking tea at every station and with every ganger. It was impossible to avoid this as news of one's movements always preceded one and the trolley was invariably met at each stopping place by gentlemen with battered kettles and trays of glasses which always seemed to be used instead of cups for tea drinking. In the cold weather unofficial stops were usually necessary between stations.

In 1950 the Arab Legion handed control of the Hejaz Railway over to the Jordanian civil authorities and thus ended the "transportation" side of the Arab Legion Engineers, which had existed for nearly two years. Today, I am told, it is becoming modernized with shiny new locomotives and rolling stock, also that plans are being discussed for reopening the "Madawra Section" and extending the line to Aqaba. However, though the march of progress may affect the line I am certain that its character will change very little and that the "will of Allah", the all merciful, will continue to play a very large part in the running of the Desert Railway.

Administration and Management of Earth Moving Machinery

By Colonel P. A. Easton, O.B.E.

Aim

In 1955 and 1956 considerable amounts of earth moving machinery were used in Malaya on normal work and on operations in connexion with the Emergency. Although the conditions under which most of the work was done came within the normal peace time procedure, lessons were learned which require consideration both in war and peace.

The aim of this paper is to state the factors relating to the administration and management of earth moving machinery that must be considered when the use of machines is being planned for large tasks, and to give certain conclusions that may assist in this planning, as the result of lessons learned in Malaya.

Introduction

Situation prior to January, 1955

Prior to January, 1955, holdings of earth moving machinery were dispersed to C.R.E.s and D.C.R.E.s These holdings belonged to a works pool under the control of the Chief Engineer. While undoubtedly useful at times on small works projects, this method was not economical. Machines were dispersed throughout the length of the country and C.R.E.s had no adequate staffs for inspection or maintenance. A Malay Field Engineer Regiment also held a small amount of earth moving machinery in its field park squadron and its field squadrons. A Gurkha Engineer Regiment, with no field park squadron, was arriving shortly. A plant troop R.E. was operating on a large project near Kuala Lumpur. Many small detachments of the plant troop were also dispersed over the peninsular at work on the construction of airstrips in the jungle with pieces of light machinery, obtained from Federal sources.

As the result of this dispersion of men and vehicles, at no time could there be an accurate assessment and forecast of the fitness and availability of machines. Obviously, if any large tasks were to be undertaken, some form of a central control was essential in order that planning should be realistic. Further factors at the time were the shortage of trained R.E.M.E. fitter staffs and a shortage of adequate floor space for repair in R.E.M.E. workshops. R.E.M.E. fitter staffs could not be dispersed and remain effective bodies. Limited floor space demanded some form of estimate regarding future casualties.

Future Tasks

At the end of 1954, it became clear that tasks in 1955 would be large and that this situation would continue well on into 1956. The tasks envisaged, and which materialized, were the earthwork for the construction of a permanent military cantonment and the construction of two roads, one in Perak of ten miles in length and one in Johore thirteen miles in length, both through jungle. Both roads were in connexion with the Emergency in Malaya and the staff required details regarding that Sapper bogey, the expected date of completion. Earthwork on the accommodation project had to be planned to agree with future letting of contracts for building. A flexible central control was, therefore, essential in order that planned amounts of machinery could be sustained and forecast dates be realized.

Available Vehicles

The approximate average number of earth moving machines available in Malaya Command amounted to:—

(*a*) Dozers Class I, II, III, IV	55
(*b*) Scrapers 12 yd., 8 yd., 6 yd.	23
(*c*) Excavators $\frac{5}{8}$ yd. and $\frac{3}{8}$ yd.	14
(*d*) Graders	18

In addition to these machines there were the usual ancillaries of road rollers, rubber tyred rollers, ploughs, rooters and dumpers. This force was held in the Chief Engineer's pool on charge of C.R.Es. and of the E.S.D. The remainder was held by units. The first step in centralizing control of machines of the pool was effected by withdrawing them from works units and putting them under the command of the E.S.D., which was under direct technical control of the Chief Engineer. The E.S.D. remained the holding unit, but pool vehicles were to be placed in support of D.C.R.E.s working on large projects and of units working on emergency roads, as increments to their own small numbers to suit the size of tasks. Civilian operators for pool vehicles were held by works units and paid from project funds: in the case of the two field units they were paid from funds allocated for the road work. Thus it was possible to retain operators with their machines, which is an essential factor in their use.

By the beginning of 1955, centralized control was effected and operators were reasonably well organized. In order to plan future loads on workshops and demands for spares, it was now necessary to obtain a "bill of health" regarding condition of vehicles, as well as an assessment both of repair facilities and of machinery for obtaining spare parts.

Control

A flexible centralized control of allocation of machines is vital both to enable forward planning as well as to ensure a sustained fixed potential of machines on tasks. Most tasks executed by field units in Malaya during 1955 and 1956 were of a size that required machines additional to those held as unit equipment. Strict instructions were, there for, necessary that all machines would be used only on those tasks to which they were allocated. In planning tasks, care was exercised to ensure that unit machines were allocated to the particular task on which the unit was working and that replacements of unserviceable machines, as well as repaired casualties ex-workshops, were dispatched to correct units.

To enable control to be effective and flexible, accurate and "up-to-the minute" information is essential regarding the location and state of serviceability of machines. To enable this to be done, a system of reporting of casualties was evolved similar to that used for the reporting of battle casualties in war. For instance, a "break-down", which was beyond the capability for repairs of the unit or works organization and its attached R.E.M.E. element on the site, was reported by signal. Urgent requirements for "spares" were similarly dispatched.

In the "plant" section of the Chief Engineer's office a location board was held which showed the types of machines held in the Command and their location. Coloured discs were held for every machine on charge; on each disc was printed the number of the machine to which it referred and the colour of the disc corresponded to the unit which held machines on charge, e.g., green discs for machines held by the E.S.D. as the holding unit for the Chief Engineer's "pool of plant". Other colours denoted machines held as part of unit equipment. Blank yellow discs were used to denote deficiencies or requirements, either for forward planning or to indicate a deficiency on a task in consequence of a machine being evacuated and not yet replaced. A red disc was used for a machine whose replacement from base had been notified, but about which details had not been received.

Estimating Machines

A Bill of Health

Before any planning for tasks is possible the planner must have a clear picture regarding the "health" of his machines. At the end of 1954, it was known that many machines were old: in fact the documents of one dozer extended back to the battle of El Alamein. It was realized that inspection and maintenance was faulty and that the performance of machines was suffering both for this reason and due to age. Arrangements were made for a team from the Central Inspectorate of Vehicles to carry out a detailed inspection of each machine and to make a full report. Unpalatable facts had to be faced and the sooner the better for all concerned. During the first four months of 1955 this team carried out its inspection. As an example: a figure of thirty-two allegedly serviceable dozers in January became fifteen in April. In rough outline this team categorized machines either as fit, or fit with a few unit repairs, as workshop jobs, or as beyond local repair. From this categorization a programme of workshop repair by unit and R.E.M.E. could be worked out. Again troubles were encountered. Due to lack of rigorous inspections in earlier years and consequent lack of assessment of repairs, the true position regarding spares was not known by Ordnance, who, therefore, had not provisioned accordingly. A number of vehicles, evacuated to workshops for repairs, could not be repaired immediately until spares arrived, so robbing the workshops of much wanted floor space. Clearly co-ordination of effort was essential.

A Standing Committee was established at Command Headquarters, which assembled frequently to co-ordinate the workshop effort and supply of spares, as well as to "iron out" difficulties. Meetings were presided over by a senior "Q" staff officer and attended by R.E., R.A.O.C. and R.E.M.E. The beneficial effect of this small and active committee was immediate.

This apparent sorry state has been described in some length and may resemble closely the confessions of a Communist Terrorist. The object is, however, to drive the point home that without a clear and accurate knowledge of the health of his machines, a planner is unable to organize a programme of tasks to be executed by earth moving machinery. The method by which this knowledge was obtained in Malaya may be of assistance.

Statistics

In planning tasks, the planner requires to know what allowance he must make to sustain a given number of vehicles on a job after due regard has been paid to the maximum numbers of vehicles of each category that can be employed economically on the job at any one time so that a target date may be achieved. The needs of unit inspection and maintenance as well as allowances for casualties are too frequently forgotten with the result that the estimated duration of the work is frequently exceeded.

During 1955 and 1956 statistics were kept for holdings of machines with the unit, in workshops, and evacuated to base as beyond local repair. Special detachments for field repairs had been attached by R.E.M.E. to units on certain tasks as forward repair echelons. Although these detachments were with units, once machines had passed from the hands of Unit Repair organizations to these detachments, they were regarded as being in R.E.M.E. Workshops.

Table I has been compiled from these statistics. The figures in each case are monthly averages.

TABLE I

	Holdings		*With Units*		*Workshops*		*Beyond Local Repair*	
	1955	1956	1955	1956	1955	1956	1955	1956
Tractors	46	53	27	39	13	13	13	1
Scrapers	22	23	16	21	5	2	11	0
Graders	14	17	9	14	4	3	1	0
Excavators	12	13	8	10	3	3	1	0

Clearly the figures for "non runners" for 1955 are abnormally high and are due to reasons given earlier. The figures for 1956 show marked improvement and provide material for figures for planning. It can be argued that with vehicles of a more recent vintage the figures for "workshops" and "beyond local repair" should reduce, those "with units" should increase. However, the figures for 1956 correspond to recent figures given by the P.W.D. in Malaya and Nigeria. Such figures again will vary with the type of work. The figures given in the above table are obtained from continuous work in making roads through primary and secondary jungle and also over open but hilly ground. In all of such work, casualties are liable to be on the heavy side.

From the above table can be deduced "round figures" for planning purposes. These are given in Table II as percentages of total holdings for 1956. In this table, the column "workshops" includes vehicles evacuated from the unit to R.E.M.E.

TABLE II

	From Table I		*Round Off*		*With allowance for lighter work*	
Vehicles	*With Unit*	*Workshops*	*With Unit*	*Workshops*	*With Unit*	*Workshops*
	%	%	%	%	%	%
Tractors	74	26	75	25	80	20
Scrapers	90	10	90	10	95	5
Graders	82	18	80	20	90	10
Excavators	77	23	80	20	85	15

Non Runners

Consideration must now be given to those vehicles with units, which are "non runners", due to the necessity for inspection and maintenance. No apology is offered for including these details here. Too often does the planner "turn the blind eye" to these important factors, the disregard of which is liable to produce the unhappy state of affairs described earlier in this paper.

Daily Maintenance

Task: A general check by the operator of oil levels, fuel levels, leaks and breakages and cooling system. Adjustment of tracks and a greasing of rollers and bearings. In countries where condensation is likely, fuel tanks must be filled overnight.

Effect: A minimum of half an hour is required. Normally this should not affect hours on work, but may have to be taken into account when operators have to be withdrawn a long distance from their work, or when daylight hours are short.

Weekly Maintenance

Task: To be carried out by the operator and a unit fitter. This is a more detailed version of daily maintenance and gives full opportunity to get matters right on the "stitch in time" basis and prevents small defects from becoming great and eventually causing evacuation to Unit or R.E.M.E workshops.

Effect: One half to one day is required weekly, depending upon the type of the machine.

Monthly Inspection

To be carried out by a competent unit fitter and to be checked by an officer or senior plant N.C.O., who can interpret intelligently the results of his inspection into workshop tasks.

Task: A thorough clean down of vehicles followed by a detailed inspection according to A.B. 408.

Effect: Half a day cleaning, followed by half a day inspection, with possible subsequent workshop attention.

Periodical Inspection

Experience has proved that periodical inspections are of vital necessity when vehicles are working on a prolonged task. Should 250 hours be reasonably close to the monthly inspection, the two can be combined. However, when machines are working shifts of 70 to 80 hours a week, this may not be the case and an additional inspection is necessary.

Effect: As for monthly inspection.

Summary

A summary of time required for unit maintenance and inspection can now be forecasted. An arbitrary ruling was given that any repair exceeding three days in unit workshops was a R.E.M.E. repair and was proved to be a reasonable figure. Allowances for "non runners" for routine reasons can now be made.

TABLE III

Time required each month for maintenance and inspection

Vehicle	*Daily Maintenance*	*Weekly Maintenance*	*Monthly Inspection*	*250 Hours Inspection*	*Total*
Tractor	Need only	4 days	*	1 day	5 days
Scraper	be allowed	2 days	*	½ day	2½ days
Grader	in special	2 days	½ day	1 day	3½ days
Excavator	cases	4 days	*	1 day	5 days

*Replaces one of the weekly maintenance periods

An average of 1½ days per month for each type of vehicle to be in unit workshops is not unreasonable. Table IV below shows the effect on Table III of this allowance for time spent in Unit Workshops in a month of thirty working days.

TABLE IV

Vehicle	*Table III*	*Total Time each month*	*Percentage of time off work*	*Percentage of time on work*
Tractor	5 days	6½ days	22%	78%
Scraper	2½ days	4 days	13%	87%
Grader	3½ days	5 days	17%	83%
Excavator	5 days	6½ days	22%	78%

Machines Available for Work

By applying Table IV to percentages given in Table II, figures can be produced to show the number of vehicles required to sustain a fixed working force. The higher figure in Table II is taken.

TABLE V

			Actually Working	
Vehicle	*Holding*	*With Unit*	*Proportion of Unit Holding*	*Proportion of Total Holding*
Tractor	100%	80%	78%	62%
Scraper	100%	95%	87%	83%
Grader	100%	90%	83%	75%
Excavator	100%	85%	78%	66%

Maintenance Pool

From the figures in Table V reasonably accurate figures for planning machines to tasks can be ascertained. Allowances have been made for all known reasons for machines not being on work. There yet remains the unknown. As stated earlier, the object of administrative planning and centralized control is to endeavour to ensure that the number of machines on the task is fixed and to ensure that this fixed figure is sustained. Experience proved that some reserve is necessary to compete with the unknown. A wash out on the railway: the collapse of a road bridge: slipping over the side of a hill road were all encountered in Malaya in 1955 and 1956. It was, therefore, found prudent to hold a small pool to guard against such contingencies.

The number will depend not only on the special circumstances of the tasks but also on various local factors particular to the country, the climate and the individual.

To give adequate reasons to a senior officer for witholding machines from tasks for this purpose is frequently difficult, but hard facts in two years in Malaya proved the necessity for this step.

Accommodation

Requirement

The fact that garages have not been built in the Army for M.T. or earth moving machinery in Malaya, has caused the necessity for the housing of these valuable machines to be disregarded. Earth moving machinery can be housed in the open, but its needs do not stop at that. The following are considered to be bare essentials:—

(*a*) Hardstandings.
(*b*) Wash down platforms.
(*c*) Covered repair bays for unit workshops.
(*d*) P.O.L. Stores.

Additional and separate repair bays are required in the event of a R.E.M.E. detachment being attached to the unit.

Hardstandings

Naturally climatic conditions have to be taken into account when deciding for or against cover to hardstandings for this form of machinery. In Malaya, overhead cover is not essential, and this is generally the case in the United Kingdom under field conditions. However, it is on the hardstanding that unit inspections and minor repairs are executed, so some form of prepared hardstanding is essential, varying in degrees of permanency according to the anticipated length of occupation, ground and climate. Three factors are vital:—

(*a*) Standings are and will remain hard.
(*b*) Freedom from dust and mud.
(*c*) Drainage.

In Malaya where deposits of laterite are normally found with ease, perfectly effective temporary hardstandings can normally be prepared locally. Temporary improvized standings can also be prepared from sleepers and packed hard core but in the event of a lengthy task, money spent on concrete standings is normally more than saved by the fact that inspections and repairs can be carried out efficiently and machines remain in an efficient working condition. Whatever type of accommodation is selected, it must be ready for occupation before the vehicles arrive on the site. Should this not be the case, hard earned experience has proved that the jobs will start in a muddle and will remain so for a long time.

Wash Downs

The provision of adequate washdowns is a *sine qua non*. Dirty and muddy vehicles can neither be inspected nor repaired with efficiency. A concrete washdown is not merely an ideal, it is a real and urgent need. Cover is not essential, but an adequate water supply is vital. In the event of shortage of water, an arrangement will be necessary for cleaning water before re-use in order to extricate all mud. Again washdowns are required to be ready before vehicles arrive on site.

Unit Workshops

A light covered structure to give protection from sun as well as from rain or snow is essential, together with a hard and well drained floor. The scope of unit repairs is limited and any blandishments by unit commanders to provide an extravagant "shop" must be firmly resisted. To surrender on this point results in units endeavouring to carry out repairs for which they have neither the man power, the knowledge nor the experience. Lighting is normally essential and a "warm up" point is necessary in cold climates.

R.E.M.E. Detachment Workshops

The scope of repairs that will be carried out by a R.E.M.E. detachment will be laid down by the R.E.M.E. staff of the local formation. Such scope can normally be expected to be smaller than "Field Repairs" carried out by permanent workshops. A proper workshop will be necessary with a concrete floor, space for a work bench and forge, and space for welders. A small store for spare parts is also required. Lighting will normally be required and the structure should be of sufficient strength to take a 10-ton gantry.

P.O.L. Store

Large quantities of oil, grease, light diesel oil, etc., will be held and the type of container will vary. Cover from the elements is essential, together with security arrangements. Precautions for protection against fire must be considered. A small office for "booking" issues is desirable at the site of the store.

General Lay Out

In deciding the lay out of accommodation, the sequence of events should be studied. On return from work, the most important task in countries, where there is liable to be condensation, is to re-fuel before vehicles are parked. On no account should muddy vehicles, or vehicles covered with dust, be allowed in repair bays or on hardstandings. If, therefore, it is not possible for vehicles to be passed through the wash down before being "parked", there should be a "clean up" area before vehicles arrive at the P.O.L. store to "fuel up".

Scales of Accommodation

From Table IV it has been calculated that approximately 15 per cent of unit holdings are off work at any one time. Of this percentage, 10 per cent are undergoing inspection, etc., *vide* Table III and 5 per cent are in Unit Workshops. Allowance must be made for the unforeseen, such as two vehicles "overlapping" in workshops. Allowance must also be made for every vehicle to be washed thoroughly before inspection. Bearing these factors in mind, minimum accommodation required in the unit based on percentage of holdings are as follows:—

Hardstandings	100 per cent (includes allowance for non-working days)
Wash down	15 per cent
Repair Bay	10 per cent

Miscellaneous Points

For turning of vehicles a wide area of approximately fifty feet in diameter is required. In repair bays an economical method is to give a depth of "two vehicle bays" to eliminate gangway space. Consideration must always be given to the removal of towed equipments from repair bays and parking bays. The minimum height in covered buildings should be 13 ft. to allow for a 12-yd. scraper. Before entering repair bays, excavators must be dismantled to base machines only.

Essential Equipment

Cleaning

By far the most important task is that of keeping machines clean. Equipment found generally to be most suitable with units is the normal pressure pump giving a pressure of 150 lb./sq. in. For each vehicle that is being washed, two hoses giving such a pressure are desirable. Two types of such pumps are required: portable for use in the field: fixed in static locations. The number required is one for each vehicle for which washdown space is provided.

On return to the pool at the E.S.D., it was found in Malaya that normal cleaning by the pressure pump was insufficient to obtain the high standard of cleanliness required before inspections and before painting. A small mobile pressure steam cleaner plant was purchased and used with success. The effect is to remove all grease as well as dirt and mud with the result that after use a detailed and thorough lubrication is essential. Such a cleaner is not, therefore, suitable for units, but would be held with advantage in holding units, such as plant park squadrons. By using this cleaner the labour required for cleaning the average machine was reduced to a sixth of the labour required to perform the task manually, and cleanliness was of a high standard.

Pressure Greasers

It was found that bulk portable pressure greasers of the type normally found in local garages were of great value. In addition a "lubrication lorry" was obtained. This vehicle was fitted with a small compressor connected to drums, fitted with pressure greasing attachments. With small modifications, this lubrication lorry would be of distinct advantage on locations where machinery is dispersed, as all lubrication and inflation of tyres can be carried out on the spot.

Fuel-Vehicles

When vehicles return to the P.O.L. store for refuelling during hours of work, much delay is unavoidable. On one project a truck was loaded with cans, and fuel was delivered on the spot. This idea could be improved upon with advantage by the use of small "fuel tankers" to be provided when the number of machines justifies their use.

Pressure Release Valves

"Broken oil seals" were found to form a very high percentage of the reasons for breakdowns. The principal cause of this failure was found to be over-zealous greasing. Too much force by the "ham handed" caused the grease to break the seal. A small attachment in the nature of a spring-operated pressure release valve was found locally, and was purchased and fitted. Results were astonishing.

Hand Books

Too often is there the need for more handbooks, whose "disappearance rate" is high. Difficult to obtain and expensive to produce, their necessity is great. The greatest discipline and care during inspection is essential to ensure their continual presence with machines or in Unit Workshops.

First Aid Outfits

Every vehicle has its first aid outfit at the start. Again parts are frequently used and not replaced immediately. This was overcome to a great extent by each vehicle having its own first aid outfit placed in an ammunition box with hinged lid fitted with lock and key. A list of the first aid outfit, which varies with each type of machine, was pasted on the inside of the lid, and a duplicate held by the holding unit. On return to the holding unit the contents of the box was checked with the list by an officer.

Vehicle Management

The Old and the New

In the "bad" old days before the advent of mechanization, motive power was provided by the animal: horses, mules, camels and elephants all played their part in providing power. In those days, not only did all officers and a number of N.C.O.s and Sappers learn to ride, but they were given veterinary training as well as training in animal management. There were a few specialists, but generally speaking it was the "general duty" officer in the unit who was responsible for the efficiency of the animals in his unit and efficiency depended upon their well being. And so with earth moving machinery the situation is similar. Without proper vehicle management and a knowledge of the diseases of vehicles and their remedies, an officer or N.C.O. of the Royal Engineers cannot expect his machines to give a fully efficient performance. Again just as he was only permitted to treat minor ailments appertaining to the animal, so is he only permitted to deal with minor defects of his machines.

Responsible Individuals

In field units the analogy of the animal remains. As in the "bad old days" of the animal when there was an O.C. mounted section, so in these mechanized days there must be an O.C. Plant on the same lines as a M.T.O. Experience has proved that only by this means will efficient maintenance be found. Naturally in a field squadron where the number of vehicles is limited, this task must be given in addition to other duties, but the task is real. As usual, the C.O. or O.C. is "personally responsible". However, in the same way that he was responsible for the efficiency of his animals, so must he undertake responsibility for the efficiency of his "C" vehicles. Every Commanding Officer must be able to carry out a general inspection of his machines and, far more important, be able to interpret defects and decide on their disposal: whether beyond unit powers of repair, whether they can be repaired in unit workshops or whether they can continue under observation.

It has often been argued that to be an efficient officer in charge of earth moving machinery an officer must undergo a specialist course in its maintenance and repair. Experience in Malaya has proved this to be unnecessary. When a plant officer had been found for the Engineer Stores Depot, courses were run for selected individuals. The basic requirements were common sense, ability to understand and to interpret regulations and instructions, knowledge of the operation and potential of machines and a sense of responsibility.

A trained senior N.C.O. is essential. Trained junior N.C.O.s are also necessary. It is the N.C.O. who carries out the detailed inspections and is able to interpret the results to the officer for a decision. He also understands the various and different types and scales of spare parts. At the beginning of 1955 there were no such N.C.O.s in Malaya. However, some were found and were posted to the plant troop and to the Engineer Stores Depot. The increase in efficiency of machines was very greatly the result of their labours, so proving their necessity.

Experience in working on large projects in Malaya has proved the necessity for a unit team for inspection and repairs. It is a *sine qua non* that operators shall remain with their machines, while they are undergoing unit and field repairs, wherever possible. By so doing, they are always "in the know" regarding weak points in their machines. Further they can indicate suspicious points to an inspecting officer or N.C.O. For efficient inspection and repair at the unit level, experience proved that they were carried out more efficiently by a small team of a junior N.C.O., a fitter, a plant hand and the machine's operator.

The shortage of fitters and operators was felt keenly during 1955 and 1956. Plant operators and fitters, like their machines, fall sick. Lessons were clear. First: there must be one trained operator for each machine; second: there must be a reserve of trained operators or plant hands learning to become operators, up to a scale of 25 per cent of the operators; third: fitters require special training in the repair of machines and must understand fully the scope of repairs which they are permitted to carry out; and fourth: there must be a reserve of fitters.

Responsibilities

Reference has been made earlier to the fact that regulations clearly state up to what stage units may carry out repairs. Such experience proved that the "keen fitter" should be regarded as "public enemy No. 1". Too often in the course of the two years under review did endeavour to repair vehicles in units beyond the scope of instructions result in failures and ultimate delay to the return of the machine to work. When eagerness was diverted to good inspections rather than to repair, efficiency increased.

Liaison

No unit commander can ensure that a high percentage of his machines remain on work without close liaison with those responsible for their repair—R.E.M.E. Liaison could not be better than that which existed in Malaya in 1955 and 1956, both at the planning and control level and at the execution stage. Personal discussions at all levels between R.E. and R.E.M.E., with a real appreciation of each other's difficulties, did much to clear the way for quick and efficient repair.

There are probably other and better systems, but in an area where a shortage of machines prevents a quick replacement some form of priority demanding of spares is required. Staff agreement is first essential to ensure that too wide an application of such a method does not choke the system.

Movement of Earth Moving Machinery

The importance of adequate means to move large vehicles such as earth moving machinery is generally insufficiently appreciated. In Malaya in 1955 and 1956 there was a shortage of transporters and low-loaders. Machines of a great width could only be moved by rail "out of schedule" owing to the gauge being insufficient to cater for such widths. Some bridges on the main roads were not strong enough to take a machine on its transporter: on one occasion serious consideration was given to the possibility of using a tank landing craft to convey a crane. Coupled with the problem of movement by rail is the problem of availability of end and side loading ramps and these may have to be improvized. The problem of movement is, therefore, very closely linked with the planning of the allocation of machinery.

Summary of Conclusions

This paper has been written as the result of two years of experience in Malaya, where due to various circumstances, including the lack of clear ideas regarding administrative demands of earth moving machinery, lessons have been learned in the hard way. Many of these lessons become self evident when consideration is paid to them.

In order to plan a task or tasks to be performed by earth moving machinery, it is essential that planned numbers of machines be sustained on the task. Nothing is more difficult to the engineer on the site than to have a frequently fluctuating number of each type of machine. Every effort must, therefore, be made to maintain a fixed figure. To enable this to be done, main factors, given below must be considered in each case:—

(*a*) A clear assessment of the total number of machines required to sustain a fixed number of machines on the task bearing in mind all "reducing" factors.

(*b*) A clear knowledge of the state of efficiency of each machine. To put machines of unknown reliability on a task is to invite disaster.

(*c*) The maintenance of efficiency by insistence on regular inspections and maintenance, with proper facilities to carry these out.

(*d*) Proper accommodation to enable inspection, maintenance and repair to be carried out.

(*e*) Ability to move machines without delay, entailing a correct provision of transporters and low loaders, as well as a clear knowledge of the capacity of road and rail communications.

(*f*) A maintenance pool to allow for the "unknown".

(*g*) Close liaison with R.E.M.E. at all stages of planning for repairs, and proper provisioning arrangements for spares together with a priority method for the supply of important spare parts.

(*h*) An absolute insistence that units carry out only those repairs which are authorized.

(*i*) Careful training in the methods of inspection and the clear and correct interpretation of the results of such inspection.

(*j*) Well trained administrative and repair organization within the unit, together with a reserve.

None of these factors are new: they recur daily. But, due to the fact that they are not included in any hand book or text book, they are overlooked. There may be more, but it is contended that if care is paid to these important administrative points in planning the employment of numbers of earth moving machines on large tasks, work will proceed smoothly, delays will be reduced to the minimum, and the task will be completed on time and in an efficient manner.

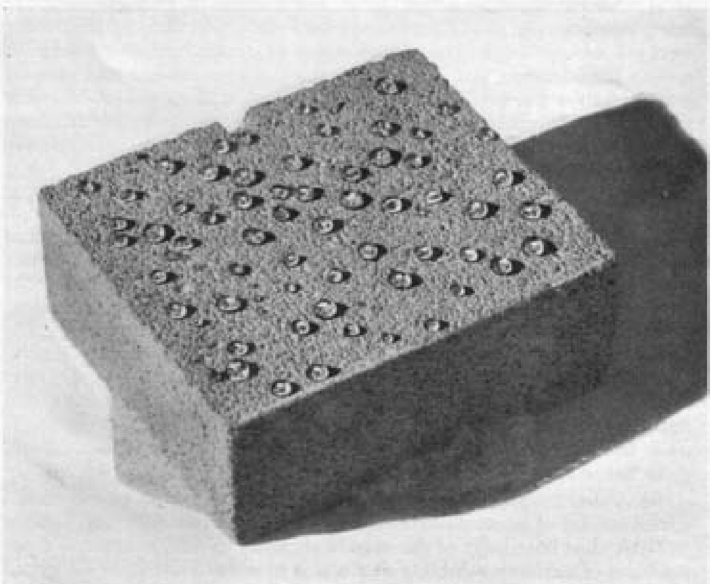


Photo 1.—A piece of Thermalite, very porous air-entrained concrete, rendered water repellent.

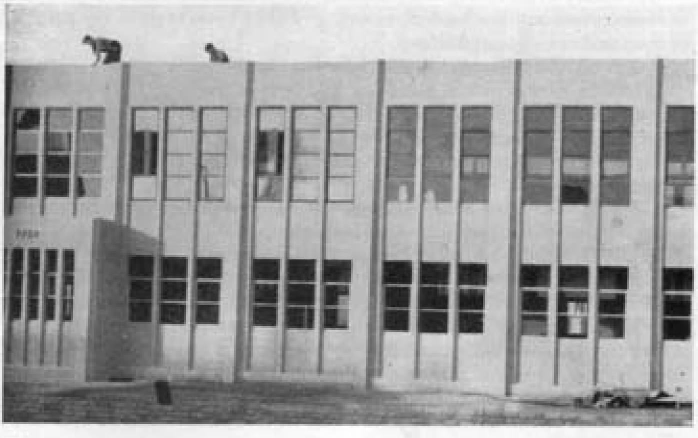


Photo 2.—A pre-cast concrete building treated with silicones and rendered water repellent.

Silicones for Sappers

By Brigadier A. M. Anstruther, C.B., O.B.E. (Retd.)

Plastics are fairly new, silicones are newer. Plastics are already used for a wide variety of purposes scarcely envisaged in the early stages of their development. Silicones were originally developed towards the end of World War II as high- and low-temperature lubricants, primarily for aircraft engines. Since then their range has similarly been extended over a wide variety of uses. They are already known to the public as a constituent of floor, furniture or car polishes, and as water and stain resistant dressings for textiles. Their uses are, however, potentially very much wider as this article will attempt to show.

Silicones are compounds of the element silicon, a metal not unlike aluminium, which occurs very widely throughout the earths crust as silica (sand) which is a silicon oxide. Other well known compounds of silicon are the silicates, of which waterglass is one example. Silicates must not be confused with the siliconates of which more will be said later.

Silica can be reduced to silicon by exposure to prolonged high temperature in an electric furnace, and in Europe this process is mainly carried out in France, where cheap hydro-electric power is available.

Starting from basic silicon one type of process produces silicones, and another siliconates; both of these are organic compounds. Both silicones and siliconates are polymers or "large molecules". The precise composition of these "large molecules" can vary enormously and each variation produces a slightly different compound with slightly differing properties. All, however, exhibit the same characteristic properties of resistance to high or low temperatures, chemical stability, non-toxicity, good dielectric properties, good release (non-stick) properties, ability to spread themselves in extremely thin but continuous films, and ability to repel water.

This property of water repellency, which is probably most interesting from the sapper point of view, derives from an electronic force inherent in the molecules of the compound. This force alters the interfacial tension between water and the surface of the material upon which the compound is spread, forcing the water into globules like beads of mercury. The water is thus prevented physically from passing into that material, however absorbent or porous it may otherwise be. The illustrations in Photos 1 and 2 show a piece of Thermalite, a very porous air-entrained concrete, and a pre-cast concrete building both of which have been treated with silicones and thus rendered water repellent.

Both silicones and siliconates being stable chemicals of a resinous or treacly consistancy have to be dissolved in liquids to facilitate handling and to allow them to be spread thinly upon surfaces to be treated. The silicones are normally put into a petroleum solvent, whilst the siliconates are soluble in water or alcohol. On evaporation of the solvent both combine chemically with the structure of any porous material upon which they are spread and produce a microscopically thin film on the walls of the pores. This film will repel liquid water, but cannot repel water vapour since the latter is a gas having no mass upon which the electronic forces of repulsion can act. Thus the water vapour, air or other gasses can pass freely through a treated surface

Photo 3.—A mixed train on the desert. The extra water tanks can be seen behind the locomotive.

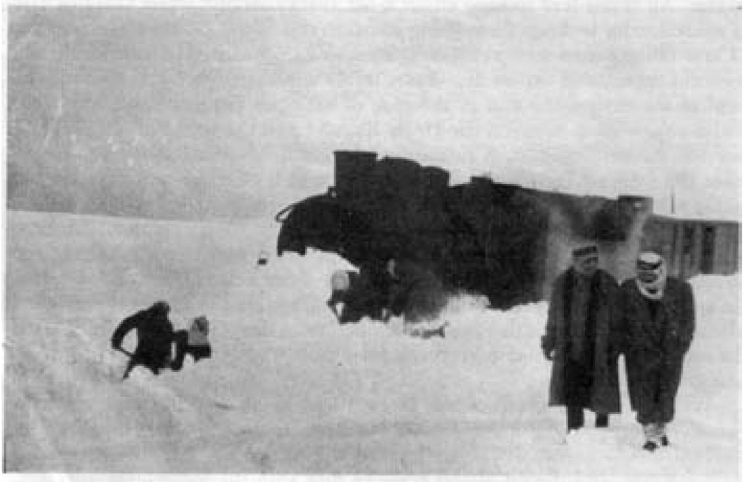


Photo 4.—Using a locomotive to charge snow drifts.

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whilst water or mist (consisting of globules of water) are prevented from doing so. A bead of water is retained on a piece of netting $\frac{1}{16}$-inch mesh which has been treated with a silicone, showing that small gaps such as hair cracks, or crazing on a treated surface or an open weave in a material do not impair its water repellency. Moreover the material can continue to "breathe" after treatment. The cost of treatment is low, the solution costing about two-pence per square foot treated in the U.K., and it can be applied by unskilled labour using brushes or a low-pressure, constant-pressure, spray gun. Small articles can be dipped.

A certain amount of "know how" is, however, necessary in selecting the best silicone or siliconate for the treatment of a given material under specific conditions. For instance the siliconates are much more effective for the treatment of limestones, gypsum plaster or damp surfaces such as green concrete than are silicones, though they will cause discolouration in limestones with a high iron content.

Then again, there are certain dry cleaning problems in connexion with textile materials treated with silicone solutions.

The manufacturers of the various solutions should be expected to provide technical advice on the use of their products and to carry out tests of materials where any doubt exists. It is, however, important for sapper officers to have a working knowledge of the problem so that they may foresee possible difficulties.

Since silicones were not produced commercially in U.S.A. until 1950, and only within the last two or three years in the U.K., very little literature is available as yet on the technique of using them. They have, however, been used successfully for such widely divergent purposes as lubricants, release agents in moulding, the preservation of timber, concrete, brickwork and masonry, and for waterproofing such unpromising materials as hessian, canvas and breeze concrete blocks. The "life" to be expected from silicone treatment will vary with the material treated and the use to which it is subsequently put. Bearing in mind the stable nature of the silicone, and the chemical bond formed between it and the material treated, it is clear that the main factor adversely affecting "life" will be abrasion. For the treatment of building materials a firm in the U.S.A. is already guaranteeing a five years life and "rapid ageing" tests have shown that the treatment outlasts all other forms of colourless surface treatment. Rapid ageing tests are not, however, conclusive. Normal ageing tests, begun three years ago at the Building Research Station are still in progress, and have so far shown excellent results with solutions prepared according to the U.S. Federal Specification. It may, therefore, be predicted with confidence, that under reasonable conditions properly prepared silicone treatments will be very durable indeed. Work is in hand on the preparation of British Standard Specications for silicone treatments, but there are considerable technical difficulties in specifying a means of testing such inert substances within practical time limits.

Photo 3 shows bulk spraying of silicone solution on the New York–Buffalo motor road called the New York State Thruway.

In both the building and civil engineering industries the primary advantage of silicone treatment is the exclusion of water, thus preventing frost damage, rot, destruction of water soluble portions of the material, and the attack by water borne acids. However, a number of secondary advantages are also obtained, and in some cases these may be of the greatest importance. For instance, low grade materials such as breeze concrete, burnt clay blocks or even stabilized earth blocks, plaster boards, and ply woods can be used satisfactorily for external work if made water repellent by silicone treatment. This reduces considerably the cost of many types of structure. The "release" properties of a silicone treated surface prevent dirt from becoming attached to it, and water borne dirt from being washed into it. Treated buildings and textiles will, therefore, keep clean very much longer. This is of particular value in the case of light coloured materials, such as limestone, and brick or concrete buildings decorated with oil paint, cement paint or distemper. Carpets, net curtains or furniture upholstery similarly stay clean much longer and do not rot. The saving in cleaning costs far outweighs the cost of treatment. Heat losses are reduced in treated buildings, since the "butter cooler" effect of the evaporation of absorbed water is prevented. This is of particular importance in boiler houses, or brick or concrete ovens, or furnaces, where the extra fuel consumed on wet days may amount to some 40 per cent.

Improvement in dielectric strength of treated material is obtained in two ways, by exclusion of moisture from the material treated and by the prevention of the formation of a continuous film of moisture on the surface. This is of particular value in the case of electrical substances, concrete poles for power lines and concrete sleepers for railways.

The release properties again facilitate the cleaning down of cowsheds, pigsties and stables, and such areas as railway platforms and quaysides which require frequent cleaning.

Where concrete roads and runways have been treated to prevent frost damage, or to assist curing the concrete, added advantages are that the surfaces do not get darkened down by rain, with a consequent fall in intensity of artificial lighting. The saving in quantity of artificial lighting needed in towns may greatly exceed the cost of treatment. Similarly buildings, harbour works, sea walls and concrete roads when silicone treated do not suffer from dampness owing to impregnation with salt from sea spray or salt put down to melt snow, nor is the concrete damaged by the salt in solution.

Water is repelled from treated canvas sails and awnings, so that weight aloft is kept down and sail drying and sail covers are unnecessary. Bunting is protected from rot by silicone treatment. The treatment will also make water repellent clothing used in all forms of outdoor occupations, sports and pastimes. The clothing will also become non-absorbent and undergarments should, therefore, be excluded from the treatment.

The foregoing remarks by no means exhaust all the possible peace-time uses of silicone treatments, but will serve to indicate the width of the field of their possible application.

For sapper officers employed in "works services" the scope for cutting maintenance costs is enormous and a stock of suitable solutions and spray guns should form part of the equipment of every D.E.L. maintenance gang. The advantages of the silicone treatment of all new buildings on completion are obvious. Provided account of it is taken in the design stage it should be possible to effect savings which will more than cover the cost of treatment. For instance, cavity walls with all their complications will not be necessary if the outside of the building is treated; more absorbent and therefore cheaper bricks, blocks and tiles may be used and much glazed tiling may be found to be unnecessary in cookhouses, ablution rooms, etc. A lighter gauge of material, such as asbestos sheeting, may be found to be adequate if rendered water repellent and therefore proof against acids.

So far as the use of silicone treatments for war purposes is concerned there are many possible applications to military equipment, from uniforms, tentage and hutting to weather proofing packages of stores of all kinds.

So far as the military engineer is concerned the main advantage will be ability to reduce the tonnage of imported engineer stores in the theatre of war. Silicone treatment will enable a far greater use of local materials for construction purposes. Photo 4 shows a wall built of blocks made of loam compressed in a block making machine, jointed in cement mortar, and made water repellent by silicone treatment. It has stood in the open at Rochester without noticeable deterioration for three years. Any textile materials found locally in a theatre of war, blankets, sheets, carpets or curtains can be made water repellent and used for the construction of weather proof shelters. Porous materials from internal partitions of damaged buildings can similarly be used for external work, while the life of sandbags and hessian will be prolonged indefinitely if treated.

In order to save shipping tonnage, concentrated silicone solutions could be imported into the theatre and diluted in the field provided that a certain number of engineer officers had a little training in the technique required.

Enough has perhaps been said to stress the importance of sappers acquiring a working knowledge of silicones for both the war-time and peace-time activities. This is not easy to do since development of new silicones and new techniques for using them is constantly taking place.

The writer of this article will, however, be pleased to give such help as he can in dealing with specific problems, if queries are addressed to him through the Secretary of the Institution of the Royal Engineers.

The Professional Papers of the Royal Engineers

By Brigadier C. C. Phipps, C.B.E., M.C. (Retd.)

It may not be known to all officers of the Corps of Royal Engineers that before the *R.E. Journal* was started in 1871, and as far back as 1837, the Corps published a series of "Papers on subjects connected with the duties of the Corps", later known as "Professional Papers".

When the *R.E. Journal* was started, it contained only a very few articles of a technical nature, and the greater part of the monthly issue corresponded to what is now the monthly *Supplement* and the *R.E. List.* The more technical papers continued to be published separately as *Professional Papers.*

In 1905 the *R.E. Journal* was divided into the three separate parts we have today: (*a*) the *Journal* containing technical articles, Memoirs on deceased officers and extracts from Books and Technical papers. It was issued monthly until 1923, when it became a quarterly journal.

(*b*) The monthly *Supplement* containing everything of a domestic nature, exactly as it is today.

(*c*) The *R.E. List*, which was also published monthly until 1920, when it became quarterly, and is now issued half yearly.

With the advent of a technical journal, the necessity for *Professional Papers* was not so great, but they still continued to be issued occasionally, and normally covered special subjects which could not be condensed into the normal length of an article for the *R.E. Journal*.

With rising prices for printing, the *Professional Papers* have had to be very greatly curtailed since the 1914–18 War, and only three *Papers* have been published since 1945.

A study of these old *Professional Papers* is well worth while. They contain a wealth of engineering details and show that the Corps was working and thinking on lines well in advance of its times. This fact was well emphasized in the international journal, *Geotechnique*, Vol. 3, No. 6 of 1953.

In this number Dr. Jacob Feld, Ph.D., wrote an interesting article entitled "A Historical Chapter: British Royal Engineers' Papers on Soil Mechanics and Foundation Engineering 1837–1874."

His opening paragraph reads as follows:—

"From 1837 to 1874, the Corps of Royal Engineers of the British Army published regular journals of 'Papers on subjects connected with the Duties of the Corps'. These reports not being easily available, a bibliography and summary of the pertinent work should be of use and interest. The range of theoretical and practical subjects included is practically identical with the list of subject matter now considered the field of soil mechanics and foundation engineering. Practical discussion of fortification and revetment design is to be expected. However, there are also reports on laboratory and full scale earth pressure tests, analyses of wall and cofferdam failures and repairs, theory of underpinning of structures, use of sand as blankets and as piles for stabilizing marshy soils, descriptions of pile driving and of various pile types, including screw piles for holding down brushwood on river slopes, and even a theoretical study of the nature of clay. Much can be learned from a study of these reports, when problems were simpler, descriptions more definite, and lack of equipment and materials required greater use of ingenuity in the problems of soil evaluation and control."

He then goes on to give details of some of the work done and experiments and tests made with references from some twenty-nine of the *R.E. Professional Papers* which contain particulars of what is now known as Soil Mechanics.

He concludes his article as follows:—

"The above references merely cover a special selection of the reports and discussions found in the Corps Papers. Almost every subject of engineering, civil and military, can be found covered in one or more reports, from topographic surveying to the aerodynamic instability of cable suspended bridges. To any who find clarity of explanation a joy, the writer commends a complete perusal of the Papers with the promise that much knowledge will be found included in these early practical performances which is recently attributed to modern invention and developments."

This is high praise for the Corps and coming from such an international source should stimulate our own members to read and learn what their predecessors have done. All the volumes of the Professional Papers are available in the R.E. Library, Chatham, as well as in Canada and the U.S.A. A set is also available for sale, see *Supplement* for June, 1957.

Red Patch

(Concluded)

By the Late Colonel A. C. Mitchell, O.B.E.

Bosky Days

The war was at a crisis and our captors' strength was fast collapsing. But as prisoners of war we were almost completely in the dark as to what was really happening or what we should do. We had already prepared plans for a mass break-out of camp, either quietly if the situation allowed or by the use of such force as we could command should this be necessary; but some amongst us, realizing the difficulties, were not too confident about the idea of a forceful break-out in mass. Our captors, however, had almost ceased to care what happened, either to themsleves or to us. Calamity overshadowed them and for the most part each man thought only for himself. Only the Commandant seemed to retain a sense of duty but, realizing that he could no longer effectively guard us, he saw no reason to hamper our own efforts to save ourselves: he had never been a staunch supporter of the regime. So in the end we simply walked out, each little party with its own plan for reaching freedom. But if things were easy within the camp they might be very different outside. The country was split by faction and whilst some were for peace, others were for prosecuting the war at any cost to the bitter end. To these, we were warned, we were still enemies and must be on our guard. We must regard the country as still hostile though we might find friendly elements.

Four of us had planned to make for the near-by hills as a first step. The essential was to get clear of camp in case it was taken over by other troops. We hoped for many things—immediate Allied landings, parachutists, aeroplanes to take us away, even peace. None of these was yet to be, however, as far as we were concerned, and a difficult stage of the long road still lay before us. We were perhaps a hundred miles from the sea on the one hand or from a neutral frontier on the other. None of the four of us was a sailor so, without help, we could not hope to escape by sea: on that side the Allies must come to us. Of the frontier and what lay beyond, however, we knew little: it gave no direct access to Allied territory and we felt little inclination for possible internment. In the long run, of course, we would have to go somewhere as we could not indefinitely roam about a hostile country. But for the moment our aim was the hills and there, later, we could decide. It broke our escape game principle of having a final objective and every step to it worked out, but the circumstances had been slightly different and there it was.

We had a blanket apiece, light kit and rations for ten days. But with our reduced strength even that seemed a tremendous load. For over two years we had lived on a meagre ration of about ten ounces a day and such Red Cross parcels as came our way; and, although the parcels had recently improved a lot, we were thin, weak and far from fit for any considerable effort. We staggered off with our loads but were soon ready to drop. We almost ran into an enemy tank column but managed to get behind a hedge in time. We made for a hilltop where a friendly farmer gave us some soup and from where we could watch another enemy column in the valley below. A third followed that and entered the camp we had just quitted: we had escaped its clutches by a narrow margin. But we were still in the danger area and when aircraft circled low over our hilltop we felt we had better be moving on. We climbed through scrub and trees for another mile, but it was then dark and we sank exhausted on a grassy slope. We hoped nobody would hunt for us during the night: we talked in whispers and showed no lights: and we would move again at daylight. We were free in a fashion and freedom proved a heady wine.

For the next two months we, like others of our kind, were to live a hide and seek, Peter Pan existence in the woods and hills. In one sense nothing happened during the time and we just waited; in another, it was crammed with tension and incident. Our feelings were frozen, yet we were intensely keyed up—just how keyed up, we did not realize till later. We were fugitives; we lived furtively and most uncomfortably. We did not hope for miracles, but we refused even to think of failure. We depended largely on our wits, yet in time we came to be tremendously helped by a few friendly peasants. Without their help we would not have been safe for a day and would never have reached freedom, yet not one of them thought to gain the reward offered for our recapture. Contact with these homely, honest folk who had the courage to help us, let us come away with gratitude in our hearts towards them and a better taste of their nation in our mouths.

Our night on the hillside was undisturbed but we moved again early. Keeping to cover where we could, we climbed so as to get right away from the main valley which carried so much enemy transport. Although our first farmer had been friendly we could not tell the feelings of the inhabitants as a whole, and our early attempts to ask for water at isolated farms were unsuccessful. There were soon people about the paths and fields and, although we managed to avoid them, we decided it was better to lie up during the day and to move only by night. We were still exhausted and our loads seemed no lighter on these slopes. Hidden in thick bushes, therefore, we rested and repacked our food in four small emergency packets and a general pool: we might be surprised and have to scatter, and the emergency packets would then last us a few days. The weather, fortunately, was glorious and we still hoped vaguely for the Allies. After dark we moved on but the going was sometimes steep and we made slow progress. Daylight found us on another wooded ridge, out of sight of the main valley. But the country ahead looked open and dotted with farms, whilst the main ridge of mountains still lay a longish way before us. We must cross that open belt in one night if we were not to risk discovery, and for that we must first rest and regain our strength. One of us already had blistered feet, a second had a groggy back and none of us had much stamina. But we got a fright that morning which nearly made us change our minds at once. Without warning, an enemy patrol of about fifteen men appeared on the path about 150 yards away. We crouched rockstill in the bushes and it passed without properly searching the ground. Then it halted and sprayed the wood with tommy-gun fire, but none of us was hit. The incident showed us how careful we must be, and another incident next day reinforced our precautions. Whether halted or on the move, we could not relax vigilance: there must be no noise, no lights or smoke, and no unnecessary movement. Halted, we took it in turns to maintain continuous watch during the hours of daylight. And we were ever ready to run for it.

We again discussed plans. We were definitely not fit enough at the moment to trek 100 miles either to a frontier or the sea, within such time as our food would last: we must therefore find contacts and help if we were to get free. The farther we went into these mountains the farther we would be from possible contacts, water and additional supplies, for they looked uninhabited. Moreover, they were in the direction of the sea and of a populous coastal area which we had already decided was of little good to us unless there was an Allied landing we could make for. Our rations had been calculated for ten days and we might not be free in that time. By cutting them down to two small biscuits and a fragment of chocolate each day we might make them last a month, and this we decided to do until we could get extra supplies. But that was no diet for continued trekking. On the third day a local farmer found us and proved friendly: he brought us bread, but insisted we must not come near his farm or move about in daylight. We built ourselves light shelters of branches and fern, more for concealment than for protection as the weather was dry and warm: from twenty yards away we were quite invisible if we kept still. We maintained constant watch: only at dusk or before daylight did we go down to a stream in the valley for a drink or a wash. We limited our rations and we made no fires. It was all very primitive, not very comfortable and we had occasional excitements with snakes; but until blistered feet, groggy backs and exhaustion disappeared it was sufficient. And gradually we realized that by sheer luck we had stumbled upon one of civilization's little backwaters, where we might be much safer for the time being than if we continued to roam. We had a friendly contact and were getting a little more food: no more patrols or scares had come our way. We decided to stay.

The fine weather would not last for ever so, after a week, we moved to a thicker part of the wood and made a better shelter under a big tree. By bending down its long boughs and lacing in loose branches overhead and round the sides we made a tent-like shelter about four yards in diameter. But the effort had been tremendous: for a whole day we had tugged and cleared and hacked: our hands were torn and blistered and we were giddy with exhaustion. We had not been keeping watch as we were all busy on the work, and we were surprised by two men. We were about to rush them when one called out "Friend" in the language and we were soon chatting on the best of terms. One of them was the owner of the wood and we apologized for damaging his trees. It was nothing, he said, and he would come again with some bread. It was fortunate that we had made that shelter as that night and for the next three days it rained unceasingly. Our branches could not possibly keep it all out and we were soon wet through. We dared not light a fire in case its smoke might be seen across the valley: our beds of fern were soon too wet to lie on and we could only sit huddled on stones, vainly trying to cover ourselves and our food with blankets. They were not cheerful days: we ate sparingly and lived furtively: we shivered with cold and damp and developed back pains that did not quickly go away. But we kept free from real sickness, we played as a team and we remained undiscovered by our enemies. On the third evening the farmer's sister appeared with a bowl of hot soup—our first hot meal in ten days and grand it was. Next evening she brought more and, as it was still raining heavily, said we could sleep at the farm. We loaded up, struggled through the scrub and darkness and crawled into the straw of a big barn. That straw was perfect heaven—warm, dry and blissfully soft—and we blessed the family, for we knew the risks they took. Next morning we were back in our wood soon after first light: it was foggy and damp but the rain had stopped, and we all felt better for a good night's rest. But summer was evidently over and as there was still no sign of the Allies we again discussed plans. Our farmer was evidently willing to give us a certain amount of food but he had no outside contacts who could help us to the frontier. The country was still very disturbed, he said, and we would be better to stay where we were for the moment: we would be all right so long as we did not move about by day. He would build us a better shelter, a cave cut into a bank. It was all very indefinite and we seemed to be getting nowhere; but ideas were hatching in that farmer's mind and he was eventually to prove of enormous help in getting us away.

Our cave was ready in a few days, but we found we had to share it with other fugitives whom the farmer had also found. Cut into a bank, it had three sides of earth and a roof of fern and branches over an old and very leaky tarpaulin. But a brushwood hurdle across the front not only kept out the rain and wind but also screened the light of a small fire inside which did much to make us comfortable. Though warmer and fairly dry it was more cramped than our previous shelter. We now got food twice a day, so could save our own supplies for emergency. We did not have to maintain constant watch, but did not move out of the wood during daylight. A few other small parties of British were in the area, but we did not encourage visiting. We had no further adventures with patrols, though once or twice on our walks after dusk we were stopped in friendly fashion and warned to turn back. "Two police with guns on that hill," a small goat-boy told us on one occasion. "Soldiers have just gone to that farm," another man said. Our farmer, as much for his own safety as for ours, had evidently organized his brother and his goat-boy into a system of watching patrols, with the result that neither police nor soldiers could get within a mile of the farm without his knowing pretty quickly.

Our contacts gradually extended, though not at our wish. An old peasant woman who had been in America as a young bride came to see us just to hear English spoken again. A retired industrialist who lived in the neighbourhood offered us meat and money. Our farmer brought his number one girl friend to see us and a most charming girl she was: we were invited to a meal at her father's house. It was a longish way off and in the main valley we had tried to avoid, but we were escorted there by side tracks. We had an excellent meal, then managed to get the American news on the family radio. Not many weeks before we had walked that road in crocodile, flanked by guards, on our weekly exercise. Now, suitably disguised, we walked it free in a sense and had meals with those who were officially our enemies. The owner of the wood, whom we had nearly assaulted at our first meeting, came several times and once took us to supper at his house. And there were others, most of them coming timidly, almost apologetically, and proffering bread as a sort of universal visiting card. We did not really like all this publicity as obviously these people talked amongst themselves of the British fugitives. Though we believed them friendly and trustworthy, their words might be overheard by others less friendly or else repeated by children. We knew the methods of our enemies and how their police had ways of extracting information. But we knew, too, that these peasants risked much in helping us and that if they felt things were safe enough we need not be too fussy. We still took precautions, however, and were ready to run for it at a moment's notice.

A stranger with a shotgun appeared at our cave one afternoon and perhaps we looked at him rather suspiciously and aggressively. But he said he was a friend of our farmer and had the local shooting rights: would we come to a meal with his parents who ran a small country hotel in the valley. We were certainly going about in the local society but it seemed all right. Two of us went and it was the occasion of a somewhat alarming incident. We were escorted there after dark and slipped into the kitchen. Soon we were sitting down to a really splendid meal with the father, mother and son; but then a lorry halted outside and the front door was violently banged. The father opened it to find a party of soldiers demanding drink and pushing their way into the entrance. We were in shabby civilian clothes collected from our contacts, but on close scrutiny or interrogation we could never have passed as locals. Only a glass-panelled door separated us from the soldiers. Mother looked a bit pale but said: "Go on eating." The soldiers looked through the glass door, but did not come farther as father quickly reappeared from the bar with their drinks. They stood about for a while but then went off without further incident, and we continued our meal with all the greater relish at our fortunate escape. But it had been a difficult fifteen minutes. One began to see how these country people hated their government, their soldiers and police, and how it never entered their heads to betray us. Only one pair of visitors did we really distrust and we never found out how they discovered us. One afternoon, "out of the blue", two very smartly dressed young women walked up to our cave, smiling and speaking broken English. Their town clothes, patent leather shoes, enamelled lips and fingernails certainly did not belong to these country parts, but they were friendly and offered us cigarettes. They were on holiday, they said, in a village not far off and had been walking in the woods: we must come and see them in the village. We did not believe a word of it, and after they had gone we anxiously contacted our farmer. Who were they and should we get away at once? He had no idea, but his sister, who had seen our visitors, was angrily emphatic as to exactly what sort of women they were. We did not move and we never saw them again.

Summer had gone and there was less cover in the woods: we were generally damp and not infrequently very wet. We got little news of the war and seemed to make no progress towards our final escape. The strain began to tell on all of us: tensions and irritabilities increased, and what had been fine teamwork in the early days under our first tree became selfish competition when we had to share the cave with others. Soon there were two distinct sides in the cave and relations were rarely far from flash-point. The spirit of romance with which our adventure had begun was fast disappearing and that none of us committed murder was little short of a miracle. Quite wrong that things should have got like that, since our continued safety depended largely on our co-operation. These peasants, too, though glad enough to help us at first, when they and we believed our stay would be of short duration, might not continue so indefinitely. We were eating into their winter food reserves and we had little money to offer them: if we were discovered there would be savage reprisals against them and their homes. Again and again we discussed plans: we were slightly fitter and had acquired some mufti clothes: we must do something. But always our farmer said "Wait"; and then, one October night, we understood why: out of the darkness arrived "The Gangster" with plans for our salvation.

There was a crashing through the bushes outside our cave, a muffled curse as someone slipped down the bank, and then the owner of the wood crawled into our cave. With him was another man whose name we did not catch, but whom we at once thought of as "The Gangster". He had a strange tale to tell. For years before the war he had been part of a secret organization which had helped out of the country those who had felt it was healthier to go and who could pay the price. Now he was willing to help us and we did not have to pay. As an earnest of his good intentions he had brought some food, but first he had two propositions to make. He could take us to a house right up in the mountains which he would stock with food and where we could live far more safely and comfortably until the situation in the country improved. Or else, given time, he could put us over the nearest frontier. The two then went out and returned with the food. We could hardly believe our eyes as three large sackfuls were poured out on the floor of the cave—a heavenly ham weighing about ten pounds, apples, biscuits, rice, cheese, jam. We had not seen the like of some of these things for about three years: our friend was evidently in the black market, as well as in the smuggling business. He would be back next night, he said, with more, and we could tell him our decision on his proposals. He came again the next evening with blankets, two suitcases full of mufti clothes, several bottles of whisky and brandy. Plans were again discussed, and it was soon evident that he was in touch with other fugitives in the area. All but one of us in the cave decided for the frontier but the odd man, for reasons he would not explain, decided to stay where he was.

The next three weeks proved to be the most unpleasant of our whole two months in the woods. Tension and rivalry increased—for the mufti clothes and for the order of going off, as we learnt we would go singly or in small parties. It was only then that we realized how many other fugitives were in these hills. One amongst us tried to organize things and make out a list of names in the order of going. But there was argument about that and it did not please our farmer. "That to your list," he said one night, snapping his fingers under our self-appointed organizer's nose. "I will take whom I like when I like, and first I will take the colonel here as I have known him longest. Some of those on your list I have never seen." He had agreed to join "The Gangster" as a guide to take parties to the frontier, and naturally he wanted to clear his own area and his own friends first. We soothed him down and eventually got things working better. But these peasants were getting nervous and we realized we were outwearing our welcome: we must get everyone away as quickly as possible. The weather, too, had become bitterly cold, with six inches of snow on the ground: our cave was very damp and uncomfortable. The first party of two went off in the last week of October and crossed the frontier without mishap. Two others followed, our farmer as their guide; and of those in the cave only two remained, one of them the man who would not budge. Each round trip took the farmer three days, and from the second of these he came back worried: he thought the police suspected something. Then two officers who had been hiding some distance away were "shopped" by a private guide they had arranged and went to prison. Rumours of spies floated round these hills and nerves got more on edge. On the 9th November the last starter from our cave party was warned to go that afternoon. He went just in time, for at dawn the next morning troops ringed in a neighbouring farm, caught a party of British and took the farmer off to prison. Our backwater was no longer safe.

It had been a strange two months, physically uncomfortable, a considerable nervous strain and a testing time for friendships. Starting in high adventure and a September heatwave, it had until the final phase retained much of its original character. But the strain was too long maintained, especially as we had not been physically fit at the start. Cold and damp, poor and insufficient food, constant watchfulness, occasional shocks from our minor encounters with the enemy had all begun to take their toll. So long as we had no definite plans we had lived hopefully and had never seriously considered failure. But now with a plan, and the tension of waiting our turn, we became more anxious. Freedom seemed so much nearer and we were afraid to miss it. But above our own petty problems stood out the courage and helpfulness of our farmer friends: they had been splendid in every way. At first they had known nothing about us except our nationality: they could have easily betrayed us and gained a reward. We had eaten their food and could pay them little for it. During every moment of these two months they had run great risks, for themselves, their families and their property. Yet they had been glad to do all these things for us and now it was with genuine sorrow that they said good-bye. We had learnt to think of them as real friends and we, too, said good-bye with regret. "We'll meet again," both sides said, but would it ever happen?

Under the Frontier Wire

Two months hide and seek in the woods as escaped prisoners of war had put us somewhat out of touch with civilization and crowds; and it was with certain misgivings that we viewed our impending journey to the frontier. The least thing might spoil it all. We had been living a queer, tensed-up existence, but had got accustomed to it, and were perhaps not too sure of ourselves in new surroundings. Four of our party of six had, however, reached the frontier safely and, of the remaining two, one man steadily refused to budge. On the 9th November the other, who was myself, was told he would start that afternoon alone, with our farmer friend as guide.

A meal, a hasty change of clothes, and a few gifts to the farmer's family of such things as I had left. How grateful they were for these trifles. "Good wool stuff—English. Two can sleep inside," they said, fingering a worn Jaeger sleeping bag as a treasure. "Such chocolate and soap only come from heaven—or the English." But I could not thank them enough for all they had done. My own "going away" kit had at first consisted of a "cycling suit" of belted jacket and knickerbockers, much too small for me and of distinctly Victorian cut; but at the last moment I had managed to exchange the knickerbockers for a pair of old flannel trousers. I had a battered felt hat, a very fancy shirt and a tie that was a crime against humanity. My bright yellow boots laced almost to the toe and were far too tight, but I had been advised that they gave more local colour than my British Army boots: there was certainly no doubt about the colour. Altogether, I looked awful and felt worse, but there was nothing to be done about it. What was the plan for the move, I asked, but the farmer merely said: "Never speak to me after we leave the wood. Keep in sight but not too close." That was all I was told for a somewhat hazardous trip of 100 miles through enemy country. Well, I had learnt not to worry or to expect too much: it was something to be doing and moving again after all these weeks of waiting and it would probably be all right. But the last lap was to hold almost as many minor excitements as the previous two months.

We had left ourselves little enough time to catch the four o'clock train at a small station five miles off in the valley and, although we ran most of the first three miles till we got to a road, it was of no avail: we were still some way short of the station when we saw the train pull out. The farmer was ahead and disappeared into the station. I followed casually but could find no trace of him. A noticeboard told me there was no other train till 6.30 p.m. I felt horribly conspicuous in such a public place, but decided I could not stray far until I had again found my guide. I got into a dark corner of the waiting room where, with hat well over eyes, I pretended to sleep. I was not accosted by the few people about, but the incident had hardly given a propitious start to the adventure. In half an hour the farmer returned with a hired car, signalled me to get in, and we drove to a town about fifteen miles away, where we dismissed the car at the station so as to break our trail.

Separately we mingled with the crowd in the station booking hall for a few minutes and then I saw the farmer walk out across the open square in front. I followed at a distance and in this manner walked through the town for about a mile, until the farmer entered a large garage. Confound the man! There had been no mention of this, and I could not speak to him. Did I follow him in, go on or loiter outside? There were no handy shop windows to gaze at. I walked into the garage to find the farmer talking to the "Gangster", but in a few minutes we continued our way through the town. In another mile, a turn into a cul-de-sac just as it was getting dark, and then through a doorway into an astonishing room. It was furnished in Turkish fashion with low divans and tables, cushions on the floor, black crescent moons on the red wallpaper, and a smell of staleness and cheap scent. This is the "Gangster's" and quite safe, the farmer explained when he saw my surprised look. He would go out for food and would come back with some other fugitives the "Gangster" was moving to the frontier. He returned about 8.30 p.m. with two more guides and ten more British—far too big a party, it seemed. He himself might not go farther but he would leave us to the mercies of the new and somewhat unprepossessing guides.

Some food, a few hours sleep and at 3.30 next morning we were astir. A quick wash and a few biscuits, then each of us was given a railway ticket and a coin as tram fare. Beyond that, however, no instructions or information as to what we were going to do. The local curfew was raised at five o'clock and singly, or in pairs at about thirty yards spacing, we followed the guides through the dark but surprisingly busy streets. Our farmer was still with us, I was glad to see. In the big crowd and half light of the station we felt reasonably secure from the police scrutiny at the barrier and we followed the guides to a train of goods wagons at one of the platforms. We scattered ourselves amongst the trucks and these were soon so full that one could only stand squashed in the crowd: fortunately I found a corner and pretended to sleep so as not to be drawn into conversation. In time the train stopped at another large town and many people got out. So did some of us until we noticed our guides still on the train. Confound them again, for there had been no indication of where we were going, and in the crowd it had been difficult to see the guides. Our return to the wagon of course attracted attention: did we want to go to the East or Central Station? How did we know and, anyhow, which was this? Damn these guides, for they stood there never batting an eyelid. As I went back to my corner I was tackled by a woman who explained that it was the recent bombing which had caused certain diversions on the line: could she help me? Not wanting to be dragged into conversation, I quickly tried the old gumboil trick, puffed out a cheek, mumbled something incoherent and retired to my corner. It worked, for I was bothered no more; but in the semi-darkness I could smile as I heard the woman continue the conversation with a friend. She felt sorry for me, obviously in pain, but would I find a dentist open at that hour before going on to my work? The incident rather amused me, for I was long past the stage of worrying about things; but how many more such contretemps lay ahead?

At the next stop everyone got out and we casually tailed our guides to a tram-stop outside. There was no trouble over tickets as we each merely presented the conductor with the coin we had been given. But then came a brick of imperial size. The tram being crowded, I got up and offered my seat to a lady. She took it with a very surprised look and others around gazed curiously. I realized that tram-car manners were no part of the Axis wartime set-up and that here was one of these unusual actions which attracted suspicion. Under the gaze of some twenty pairs of eyes it was hard to look unconcerned, harder still not to feel conspicuously British. Fortunately there were no police on the tram, and with the going and coming of passengers at the various halts I hoped the incident was soon forgotten. But, one way or another, I was certainly having my pennyworth of quiet fun out of our excursion. We crossed the town to another station, where the guides disappeared to get tickets and then quietly passed one to each of us as we stood about in the crowd. But we had to wait some time and again began to feel conspicuous: we looked so very different from these people around us. The platform was stiff with security police as it was the frontier express we awaited and a close check-up was to be expected: most of us would have given much to bury our faces in a newspaper during that half hour. In the rush for places when the train arrived many of us found ourselves in the same pullman coach, but standing so tightly packed that it was impossible to disperse. The crush, however, meant that no train check of tickets or identity papers was possible, and so long as nobody pointed at us and shouted "English" we were reasonably safe. An hour's run brought us towards the mountains and our destination, but I did not like the look I got from the barrier policeman as I walked out of the station. This was another important check point, and it was here, too, that our farmer had felt he had been suspected on his earlier trip.

Plans again began to go wrong and for some time we wandered round the town like lost sheep, silently cursing our guides. Eleven badly disguised Britishers tailing each other about the streets of a foreign town were not very easy to miss, we felt. The first intention had evidently been to go somewhere by steamer, but there were no steamers. Then all three guides disappeared to inquire about a bus. We lost them completely at this stage and for forty-five very long minutes the eleven of us hung about various parts of a public square. We loitered: we gazed intently at shop windows: we walked around a bit, then loitered some more—always on the lookout for some sight of our elusive guides. Time passed, nothing happened and we felt ourselves becoming a public spectacle: the British were not very convincing loiterers, I felt, and merely looked more British than ever. Then one of the two new guides was seen streaking across the corner of the square without any attempt to ensure that we had noticed him. Where was my farmer? Did we follow the first man or wait? But we were refusing no chances, so one by one we followed casually—and, we hoped, unobtrusively—at about a hundred yards interval. But another lounger in that square followed us, though we did not know this till later. I was near the tail of the long procession and as we gradually drew away from shops and crowds into the quieter streets of a residential area our purpose looked horribly obvious. Still only one guide and then—bang at a road fork—the damned fool stopped to buy something at a shop. Which fork did we take? Soon the eleven looked rather like a traffic jam and all this was getting rather wearing. Where the devil was my farmer?

Not long after we got going again and the man behind me, last in the procession, closed up on me and muttered: "Did you see a little twirp in a green coat at that bus-stop in the square? He's following." It was impossible to warn all the others ahead so we had to take our own measures and hope not to lose the column: Greencoat might not have spotted us all, we hoped. We slowed down to let those in front get farther ahead and then, coming to a twisty bit of road, we turned into a side road while Greencoat was out of sight: then into another. There was a maze of roads at that point and we had been lucky. Greencoat lost our trail and if he had not spotted the others all might yet be well. We eventually caught up with the tail of the column and we never saw him again. By then we had walked about six miles and in my tight yellow boots my feet were not improving. Soon after losing Greencoat we were overtaken by a police cycle patrol who dismounted ahead of us and watched us all go by. Then he cycled on again and repeated the performance. I took a dislike to that policeman and when a lorry load of police came along I had serious thoughts of taking to the wooded slopes above the road. But just then my farmer appeared on a bicycle and gave me a quick smile as he passed: evidently all was well and I was mightily relieved to see him. In the early afternoon we turned off the main road and climbed a narrow road to a small village halfway up the hillside. There we followed one another into a small restaurant where we were introduced to a wiry little chap with a monkey face and a perpetual grin on it: this was the chief smuggler of these parts, we were told, and he would put us over the frontier. Meanwhile, we were quite safe as he had evidently "bought" the village and the local officials. We would get some food: we must keep indoors and must be ready to start up the mountain after dark. We felt we could relax. Could the smuggler get us any cigarettes? Most of us had not tasted one for weeks. Officially only the Customs had cigarettes, but he would see what he could do. Half an hour later a uniformed official walked into our room at the restaurant. We wanted cigarettes, did we? How much money had we got? And at an exorbitant price we each got one or two of the vilest cigarettes we had ever tasted. But the episode made us laugh for it came as such an anti-climax to the previous twenty-four hours. Here was an Axis Customs official openly cracking jokes with eleven people he knew quite well to be escaped British prisoners about to cross the particular bit of frontier which it was his duty to control. Yes, we could relax: the real danger was now over, and if we had money we could get anything we liked—even freedom.

About six o'clock another party of eight arrived, making nineteen in all but at that stage crowding did not seem to matter. An hour later we all prepared to move and I took a final farewell of my farmer friend who had helped so magnificently through these last two months. Then we climbed steeply in single file up a narrow mountain track. It was a gloriously clear starlit night and the valley below looked peaceful and beautiful. Yet it was now a land of bitter hatreds and we were not sorry to leave it. Here and there along our route we passed isolated houses and at the top a frontier police barracks: we strung out at these points and went past quietly on tiptoe in case of barking dogs. But all was well and we were not challenged. We reached the top in about two hours and then another few minutes downhill brought us to the actual frontier wire, a close mesh fence about nine feet high. But a hole had already been dug by the smuggler's advance scouts and through this we crawled. A path was pointed out to us: the smuggler shook hands all round and then disappeared up the slope into the darkness of the trees.

Sanctuary, but at first we could not fully realize it or be sure of our feelings. Two months hide and seek in the woods and these last thirty hours escape had all led to this, and here was the moment we had lived for through all our years in prison camps. In all that time we had kept but one thing—liberty of spirit—and kept it for this very moment. Now, as a priceless, cherished treasure, we could take it out of its careful wrappings, as it were, and enjoy it. We could really relax, could have a lovely stretch and let out a long pent-up breath. It was too great a moment for anything but silent thankfulness. So, high on that mountainside, with the wire fence and the Axis at last behind me, with peaceful sanctuary before and below me strangely beautiful in the moonlight, I said, quite simply: "Thank you, God." And I recalled the sentence where Pallas Burmester says: "There are some things that one should be alone for: great joys—perhaps great sorrows. Just for the first moments, I mean—alone, you know, with God." I felt like that. I wanted to hold that precious moment, and to hold it alone. So, as the others moved on down the path, I dropped behind and for a little longer held my sense of solitude and my overflowing heart.

We came to a farm and whilst trying to explain ourselves heard a slight noise behind: turning, we found ourselves confronted with four bayonets and four very Axis-looking steel helmets. Had we been shopped at the last moment? Again we explained and all was well but we would have to come to headquarters on top of the next mountain. We had another two hours hard climbing, most of the time pushing, pulling and almost carrying one of our party who had had a heart attack. At that headquarters, after midnight, we found we had been forestalled by another party of refugees, including some women and children, and that the headquarters had no spare blankets left. But we got hot tea and slept on the floor in front of a log fire. Some of us were pretty well whacked, but we could sleep warm for once and with minds at rest: it was the morning of 11th November, Armistice Day. Next day we marched down the mountain to a town where the Red Cross took charge of us, gave us hot shower baths, socks and a medical examination. Then two days rail travel, contact with a British Consul, a certain amount of unnecessary local officialdom, and eventually we reached a centre for escaped prisoners and were more or less in British hands again. We were taken to an hotel and were given battledress and an advance of pay. We could go into shops and actually buy things again. Two of us went to a teashop, ate enormously of rich cakes and hot chocolate and decided we liked the girl's ankles. Then back to our hotel for the first taste of Scotch whisky and the first real long bath in thirty months.

That evening after my bath I changed into my new finery with deliberation and a sense of well-being. From one of my new socks I pulled out a slip of paper from a Red Cross unit in England, and it bore these words: "God deliver me from the hand of my enemies."

The long road was over.

Armywife

By "Memsahib"

In that excellent quarterly magazine, *The Royal Engineers Journal,* one reads of men's problems, solutions and achievements in the field of engineering, and it is felt that the time has come in this world of (near) equality of sex, for the woman's part in the army of today to be expounded.

Men, in choosing a career, combine their like or love of a particular profession with their ability for it: the two need not necessarily be compatible, but one concludes that in choosing the arm of the Corps of Royal Engineers, they have combined a liking for engineering with that of soldiering. How very much better still they would fare if they chose their "helpmate" with similar thought for ability and love of the job. Ability must be of prime importance; not so much for that of a housewife, but for that of an armywife. The two are completely dissimilar. Not only does the "little woman" have to possess all the attributes of a housewife—sufficient in themselves to be a full-time job—but as an armywife she must also combine with them a happy knack of being able to move husband, house and home quickly, efficiently and at very short notice (sometimes). Seldom can she call upon the services of a Pickford's van to pack and move the house in a matter of minutes, much as would be the lot of her civilian counterpart. No, she must be able to pack neatly and speedily (as well as coping with her every day chores) her house into boxes, her husband into his new job, and her dogs, cats, chickens, white mice and guinea-pigs into new homes; be able to wield a hammer accurately; dismantle electrical devices with a nail file; sell the car at a profit and outsmart the Quartermaster on "marching out" of the quarter. Because her husband will have decided, given half a chance, that for the smoothness of the move it would be best if he acted as advance guard to reconnoitre the new territory, and preceded the main party by at least three months, thus well establishing himself comfortably in his new Mess and as a keen type in the eyes of his new Commanding Officer; at the same time tasting the fruits of a little stolen freedom to go on a blind without fear of retribution the following morning.

It is therefore proposed, in this respect, to enlarge upon "Operation Overseas" for the benefit of less fortunate men who have always had to help with the packing up of a house and had the misfortune to get an "accompanied passage" and thus prolong the agony of a posting from anything from twenty-four hours up to twenty-eight days at sea.

Operation Overseas

On receiving advance news of a posting overseas, do *not* rush out and equip yourself with tropical/arctic uniforms. It is highly likely that the posting order will be changed several times before you get moving. However, it is quite a good thing to stock up on boxes and trunks preparatory to the move itself. You will always be amazed at the amount of stuff you have collected during the past year, this will be an annual surprise, do not think you will ever anticipate it. The boxes can always be converted into a chicken coop if the posting is cancelled. Too bad about the ant-proof trunks.

Ensure that your departure is precipitated at the last moment, thereby making it impossible for the family to travel with you. If you play your cards carefully, you should now be free from any further family commitments and free to enjoy a leisurely sea voyage, happy in the thought that your wife is an admirable organizer and will do everything just the way you like it. Curse frequently and heartily on the voyage when buttons come adrift, socks need mending and tropical uniform needs more frequent dhobying. Letters home about your progress across the world from the ports of call *en route* are a nuisance, but perhaps small atonement for the carefree voyage. Do not omit to go ashore at every opportunity and see the places you would never take a woman. This fact can always be used to great effect in future conversations "But, of course, you never saw the *real* Port Said, my dear."

On arrival at your destination you book your family into the nearest (but not necessarily cheapest) accommodation and the rest of the time is yours.

Back home things are proceeding smoothly, of course. Your wife has had herself and the children vaccinated and inoculated with T.A.B. without much difficulty (apart from little Johnny's rooted objection to hypodermic needles). She has attended a centre farther afield for Typhus, and gone up to London on a "cheap day return" for Typhoid; she is a little tired from the journey, but still fresh enough to feed the children before putting them to bed prior to a little packing. After which she must write a few letters to the Bank, Passport Office, War Office, friends and relations about her impending departure. A few weeks and several bad tempers later her papers for her passage arrive and the packing proceeds at greater pace. Perhaps at not such a speed as she would like owing to the fact that the children always want to play with the toy nearest the bottom of the box, and enjoy rummaging about in boxes anyhow. Dear sweet things, they do so miss their father!

Things are really getting on well now. Most of the packing is done, she has almost decided what to take and what to leave, and someone has volunteered to have the chickens. Emily has a runny nose and Willy's school has got measles. (Can one disguise spots on a child's face with make-up? She's going to have a darned good try.) No one will buy the car (and who blames them at *that* price?), and the dogs, sensing an impending calamity, have decided to chew the carpet. (Perhaps a chair put over it will hide the hole from the Quartermaster's X-ray eyes). The tradesmen are told of the date of departure and are asked to present their bills in good time.

Twenty-four hours later a telegram arrives from the War Office announcing a delay in sailing, so with a cheerful smile your wife sets about telling the butcher, the baker, the grocer, the Quartermaster, her parents, and her husband of the new sailing date. After all, she has nothing to do all day, so she won't mind writing a few letters. School term has meantime ended and the children are at home all day, but they do so like helping, so she is really very happy. Boxes are now fastened down prior to dispatch to the station ("Willy, where did you put that hammer?"), the dogs are in new if indifferent homes, and no one as yet has bought the car. Not to worry, after all, people move house every day of the year.

Comes the great day. She is particularly charming to the Quartermaster (must remember to stand on the hole in the carpet), dispensing tea and conversation to all concerned in a suitably light and counter-suspicious vein ("The children are so excited at the thought of seeing their father again, they can't sit still") (Could they ever?), and the car is left for someone else to dispose of. She gets the right train (check passport, tickets, embarkation cards, children 3, hand-luggage, pieces 10), duly arrives at Port of Embarkation, passes through formalities and is taken to the allotted cabin on board. She has made it! Her troubles are over. For the next few weeks all she will have to do is to prevent Willy from falling out of his top bunk and/or porthole, mop up after Johnny's sea-sickness and prevent Emily from achieving her ambition to climb up one of those ladders to the top of the mast. Don't be too sympathetic if, when she arrives at her destination, she looks a trifle tired and is short-tempered with the children. After all she enjoys being married to the army.

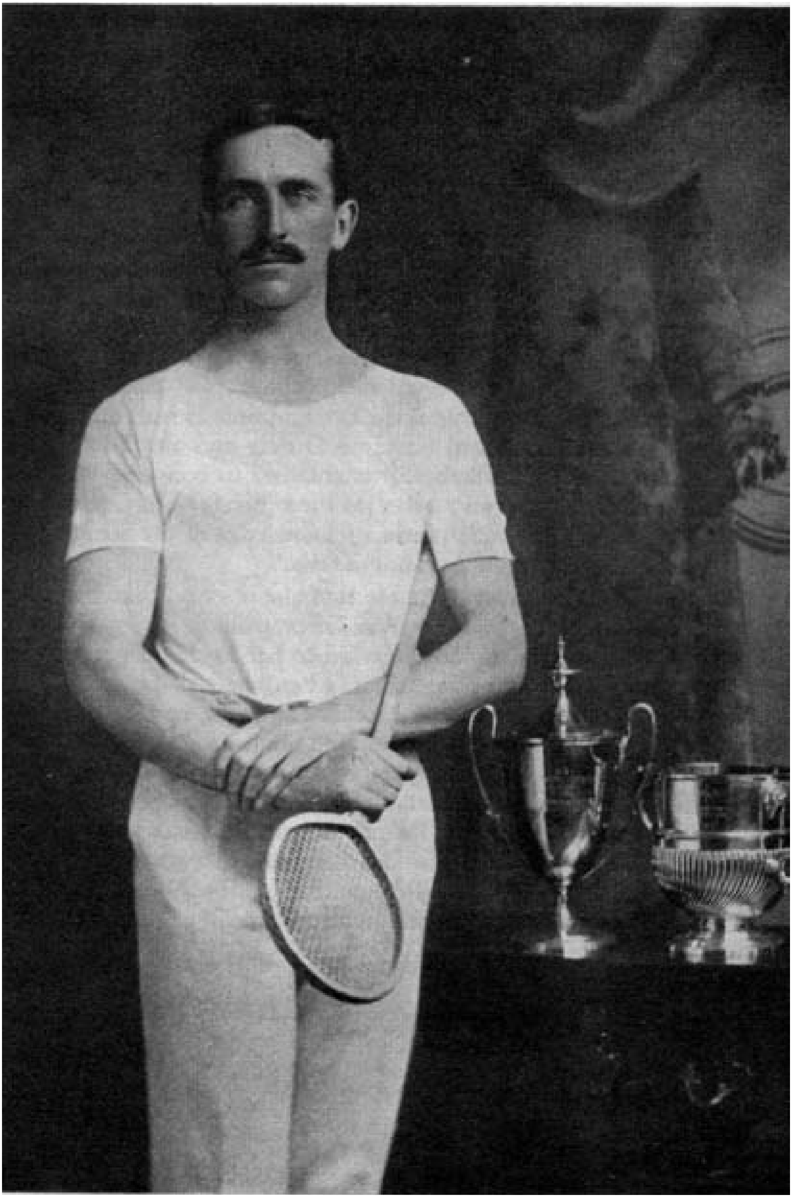
Once arrived in the new station twenty-four hours is reckoned to be sufficient time to unpack and make a presentable home for the family and in which to do battle with a new Quartermaster who in his turn will be standing on that hole in the carpet; to digest names and their places in the hierarchy of the new job; find a new school for the children, convincing the headmaster at the same time that the children are exceptionally bright and should be in a higher class; make her number with the guardians of her body and soul; come to terms with the tradesmen who have a sense bordering on that of genius for discovering that one is only recently arrived in the station; inform her own and her husband's families of the change of address (since her marriage her husband will have given up completely the need for letter writing, knowing full well that in order to keep the peace at home, and to convince mother-in-law that she really is a suitable wife for her son, his wife will be only too glad to take this little job off his already over-loaded shoulders); and to start collecting dogs, cats, mice and several varieties of indigenous livestock. Beware of snakes, centipedes, mammoth spiders, typhoid, typhus, malaria, diphtheria, mumps, measles, and whooping cough. Don't think that living in a hot (or cold) climate relieves one of taking the usual precautions. From now on the care of the family must be doubled. After this suitable lapse of time for settling in, the armywife is free to plunge into an orgy of household duties, to entertain and be entertained, and to choose friends for both adults and children. (The latter on principle will object to their mother's choice.)

At all times your wife must appear neatly dressed, *au fait* with Regimental/Garrison/World affairs, to have suitable refreshments ready for the highest to the lowest visitor, to be ready to do the bidding of the highest and to see to the welfare of the lowest, and to be prepared to move home again at the slightest whim of a bod in the War Office. The very fact that these moves are sudden and totally unexpected add a certain spice to her life.

In her spare time it is a great asset if she can find time to read up the Army Council Instructions, Routine and Garrison Orders and any Military textbooks she can lay hands on, which will enable her to converse with some authority with other husbands and wives on the subjects of pay, allowances, privileges and entitlements. And an intimate knowledge of the Seniority List will help her to see that nobody speaks out of turn.

And the armywife need never grumble that she does not like her house, the town or the country. It is not, the War Office willing, for long, and as a long term policy she can always look forward to her husband's early retirement on a generous War Office's pension, when she will be able to bore countless people with her experiences in other countries, be able to collect a permanent selection of dogs, cats, horses (the children will, by now, have grown out of white mice and guinea-pigs) and be able to devote the rest of her life to making her husband comfortable. Because now she will have plenty of spare time with no interruptions for packing up the house, and he, poor thing, will have had such a hard life moving about the world. Don't complain if she says she finds life dull by comparison; a few holidays to distant parts will help keep her young and you can always arrange things so that you are back in England for the cricket.

A helpmate? It's a career!



Major General SH Sheppard CB CMG DSO

Memoirs

MAJOR-GENERAL S. H. SHEPPARD, C.B., C.M.G., D.S.O.

SEYMOUR HULBERT SHEPPARD, after a short illness, died on 7th February, 1957, at his home in Hove, Sussex. Born on 24th December, 1869, he was the son of G. F. Sheppard, J.P., who retired from the I.C.S. in 1888. He was educated at Haileybury and passed into the Royal Military Academy, Woolwich, in March, 1888, where he gained the Sword of Honour. He was commissioned in the Royal Engineers on 14th February, 1890, and was at the S.M.E. Chatham till March, 1892, after which he went to India where he was attached to the Military Works Department at Rawalpindi.

Promoted Lieutenant in 1893, in July that year he was posted to the Bengal Sappers and Miners at Roorkee, where he joined the 5th Company. In February, 1895, he accompanied that unit to join the Waziristan Field Force and received the Waziristan 1894/95 medal and clasp. In May, 1896, he went with the Company to Peshawar, in December, 1897, was with the Peshawar Column of the Tirah Expeditionary Force and from June to July, 1898, was with the Khyber Force, afterwards returning to Peshawar. He received the Tirah 1897/98 medal and two clasps, with a mention in dispatches. He then went to England on long leave and, after doing temporary duty for a month at the S.M.E. Chatham, returned to Roorkee in July, 1899.

In August, 1900, he joined the 1st Company at Peshawar, and there in May, 1901, took over command of the 3rd Company. He had been promoted Captain on 31st December, 1900. He took part with his Company in the Mahsud-Waziri operations 1901/2 and was awarded the D.S.O., was mentioned in dispatches and received a clasp to the Frontier Medal. In February, 1903, the 3rd Company returned to Roorkee and Sheppard went home on leave, did a refresher course at the S.M.E. Chatham and returned to Roorkee in December, 1903. Meanwhile the 3rd Company had moved to Sikkim to join the Sikkim-Thibet Mission, where he rejoined it in January, 1904, and took part in the operations in Thibet, receiving the Thibet medal and clasp and a mention in dispatches and was promoted Bt.-Major on 10th November, 1904. He returned to Roorkee in the autumn of 1904.

In 1906 he was attached to the A.G. Branch, Simla, and in September went to the Staff College, Deolalai, and in 1907 to the Staff College, Quetta. In April, 1908, he joined the Staff of the 2nd Division at Rawalpindi as D.A.A.G. Promoted Major in February, 1910, he was G.S.O.2 from August, 1910, to September, 1912, when he joined the Military Works as G.E. Nowshera, returning to Roorkee as officiating Superintendent of Park, 1st K.G.O. Sappers and Miners in December, 1912. From March, 1913, he was G.S.O.2 at the Staff College, Quetta, until the outbreak of the 1914–18 War.

Late in 1914 he went to East Africa with the Indian Expeditionary Force "B" and served continuously in East Africa till the end of 1918. From September, 1914, to January, 1916, he was G.S.O.1 to the Expeditionary Force, from 1st February to 18th March, 1916, he commanded the 2nd E.A. Brigade and afterwards acted as G.O.C. 1st E.A. Division from 19th to 31st March, during which he fought the action of Soko Nassai. From April, 1916, to January, 1917, he commanded the 1st E.A. Brigade and from then till 31st December, 1918, he was Brigadier-General General Staff (Chief of Staff) East African Field Force. He was mentioned in dispatches six times, promoted Bt.-Colonel on 24th July, 1915, awarded the C.M.G. in 1917, and the C.B. in 1918. He was promoted Major-General on 1st January, 1919.

He took part in the 3rd Afghan War, 1919, when he commanded the 5th Infantry Brigade, and received the medal and clasp. After officiating as G.O.C. 2nd Division at Rawalpindi in 1920 and 1921 he was Major-General R.E. and Pioneers, Army Headquarters, India from July, 1921, to December, 1922. He retired on 1st December, 1922 and was appointed Colonel Commandant R.E. on 8th November, 1933.

On his retirement Sheppard lived first in London and later in Hove. He never married. Throughout World War II he served as an air raid warden and in the spring of 1940, as Rep. Colonel Commandant R.E., he visited most of the R.E. units serving with the Expeditionary Force in France. After the war, overhearing a parson in his club at Brighton saying he could get no help in his garden, Sheppard, then aged about 78, volunteered to work in it. This involved a long bus journey three or four days a week, but he enjoyed the work and carried on with it till the end of his life. He was a regular Sunday visitor at the Hospital for Convalescent Officers in Brighton, where he will be greatly missed.

Sheppard will be remembered not only for his outstanding service in the Army, but also for his tremendous energy and wonderful physique. He excelled at games, especially at rackets, in which he had a fine record. He was Army Champion rackets, singles, 1903, 1906, and 1921 (as a Major-General), and was Amateur Champion Rackets 1906; in 1934 he successfully represented R.E. *v.* R.A. He was also keen on shooting both in India and after retirement, when he used to shoot regularly in Scotland. All his life he took great pains to keep physically fit, and a contemporary writes: "When a Y.O. at Chatham he used to take long walks to keep fit, 10 miles was little to him and few fellows would accompany him. He persuaded me one day and we walked to Cobham and after two or three hours he wanted to walk back, but I jibbed and we came back by train to S.M.E." When in Thibet in 1904 he took his subalterns for long treks in the mountains, sometimes climbing 10,000 feet a day. He was always keen to encourage the younger generation at games, and was himself a splendid example to them; he and a friend used to go round the country playing rackets with public school boys to coach them for their championships.

He liked music and poetry, which he could quote to the end of his life, especially Kipling and Adam Lindsay Gordon. He had a keen sense of humour and a genial and generous nature, and throughout his service and after his retirement he always had many friends. Two of his cousins assisted at his funeral service, the Rev. P. T. B. Clayton of Toc H, and the Rev. David Sheppard the England and Sussex cricketer. Seymour Sheppard was a fine soldier and sportsman, a good friend, and a very gallant gentleman.

E.F.J.H.

MAJOR-GENERAL SIR PERCY C. S. HOBART, K.B.E., C.B., D.S.O., M.C.

MAJOR-GENERAL SIR PERCY HOBART died at his home at Farnham, Surrey, on 19th February, 1957. He was born in 1885, the son of R. T. Hobart, I.C.S., and educated at Temple Grove, Clifton College, and at R.M.A. He was commissioned in the Royal Engineers on 29th July, 1904. After leaving the S.M.E. at Chatham he went to India and joined the Bengal Sappers and Miners. He went to France in the First World War and was at Neuve Chapelle, where he gained the M.C. at Festubert in May, 1915. He then served with the General Staff in January, 1916, and went to Mesopotamia. By October, 1918, he had joined the Egyptian Expeditionary Force in Palestine. He was mentioned six times in dispatches and was awarded the O.B.E.

In 1923 he transferred to the Royal Tank Corps, in which he completed the remainder of his service. Captain Liddell Hart wrote a long obituary notice in *The Times* of 21st February, 1957, giving in considerable detail an account of his services in that Corps.

To this account Field-Marshal Lord Montgomery in *The Times* of 4th March, 1957, added the following remarks, which bring out so clearly Hobart's character and ability. These remarks are reproduced by permission of Lord Montgomery and of *The Times*.

"I would like to add something of a more intimate nature to the obituary notes by Captain Liddell Hart. 'Hobo', as he was known in the Army, was my brother-in-law. I had never met him until I married his sister in 1927, though I had heard much about him. I soon found out that he was a man of strong character and marked personality; he had read widely and could talk well on almost any subject. In addition he had a brilliant brain. I suppose that those who came into contact with him between the wars would say that he was inclined to be intolerant; many of us are the same, particularly when young. Hobo certainly did not suffer fools gladly. He was a forward thinker and was a constant thorn in the side of senior officers less able than himself, particularly those who were inclined to plan the next war in terms of the last—an error common to military men. In the end this led to his downfall and he was retired from the Army when a major-general. We lost one of our most brilliant soldiers when in his prime, and the early days of the late war found him a private soldier in the Home Guard. The whole episode was unfortunate and a sad reflection on those in charge of our Army affairs at that time. The story of his reinstatement is well known.

"When I was ordered back from the Eighth Army to command 21 Army Group in January, 1944, Hobo was a major-general again and in command of all the specialized armoured units that were being formed for the campaign in north-west Europe. I have no hesitation in saying that he and his specialized division played a major part in the operations of 21 Army Group, which ended in the surrender of some two million German fighting men, soldiers, sailors, and airmen, on Luneberg Heath on 5th May, 1945. He was originally far senior to me and to all the Army and Corps Commanders in 21 Army Group; he had been a major-general when we were colonels and majors.

Major General Sir Percy CS Hobart KBE CB DSO MC as Colonel Commandant Royal Tank Regiment

Yet he never complained; he gave of his best and served loyally under us all, himself remaining a major-general. Hobo will long be remembered by the Army in general and by the Royal Tank Regiment in particular. For myself I have lost a real friend and one that I admired tremendously—generous, warm hearted, and full of character. His home at Farnham was not far from mine and I often visited him. On such occasions one could be sure of stimulating conversation and mental uplift, even latterly when he was forced to spend much of his time in bed—suffering from a tired heart, which in the end just faded out. The deep sympathy of all his many friends will be extended to his widow, the gracious lady who cared for him devotedly to the last."

BRIGADIER W. H. EVANS, C.S.I., C.I.E., D.S.O., F.Z.S.

WILLIAM HARRY EVANS was born at Shillong, Assam, on 22nd July, 1876, the fourth of seven children of Major Horace M. Evans (later General Sir Horace Evans, K.C.B.), 43rd Gurkha Rifles. He died in his sleep on 13th November, 1956, at the home, near Dover, of a beloved niece, where he had only just gone after giving up his London flat.

Evans was remarkable for his memory of the details of everything of interest to him, for the meticulous care which he gave to everything and for a capacity for ceaseless work. He was sociable and kindly at all times, but was occasionally too outspoken to be tactful. He would not tolerate fake, nonsense of any sort or idleness. He was always ready to help anyone in difficulties and had an astonishing knowledge of the personal affairs of those who worked under him, British or Indian. As result, all under him were devoted to him and were stimulated to do their best. Very keen on sport all his life he had the bad luck, at the age of 19, to injure his knee. This very much restricted his activities in later life, as did also a torn ligament.

Brigaier WH Evans CSI CIE DSO FZS

When 9 years old he was sent home from Assam to be educated and, from King's School, Canterbury, he passed into "The Shop" in 1894 and was commissioned in September, 1896. The highlight of his "period of instruction" at Chatham was probably the near-wreck of *Buccaneer* near Selsey Bill!

Posted to India in 1898 he went first to the Lahore District and later to Dalhousie, Roorkee and Chitral. While with the Bengal S. & M. he started shooting both large and small game, polo and pig-sticking (he had his pony killed under him near the Lakhsar Forest), and got two good markhor and a medium urial in Chitral. Posted to Muttra in 1901 he found life so enjoyable that in 1902 he refused his C.R.E.'s offer of a better job in Meerut and was consequently, and promptly, transferred to Lucknow! Here he met Winifred Harvey, an Australian, whom he married in November of that year. A month later he mobilized for the Somaliland campaign. Arrived at Obbia he joined Manning's Force. In August he was made Intelligence Officer at Hais and thereby was not with Manning's Force when it was massacred by the Mad Mullah. He went from Obbia as Intelligence Officer attached to the Navy and later he suggested to the Admiral an attack by landing parties on Illig, well away from the sea! The suggestion was accepted and the battle was a great success and practically finished the campaign.

Landing in Bombay, in May, 1904, he met his wife and went to Australia. On return to duty he was posted to Jabalpur where, as G.E., he was under E. Stokes-Roberts, who, as Evans naïvely says, "taught him to work". He was there until 1911. It was during this period that he invented the cantilever stable truss which was standardized in the M.W.S. In 1912 he went to Simla as Dy. Asst. D.G.M.W. and wrote the fourth edition of the Military Works Handbook, which even today is used by some consulting engineers in England as a *vade mecum* on building.

On the outbreak of the World War I, Evans was sent to England and, in October, 1914, was promoted Major. He raised three units, including a field squadron which in April, 1915, was attached to the 51st (Highland) Div. near Merville. From October, 1916, to February, 1919, he was C.R.E. of the Cavalry Corps (five divisions) with the rank of Temporary Lieutenant-Colonel, winning the D.S.O. in 1918 and getting a Brevet in the New Year's Honours List 1919. He took part at the Somme, Arras, Peronne, Cambrai, Le Cateau, and finally Tournai and the Crossing of the Rhine. It is of interest that after the war he started "handyman" schools for his men, but that these were stopped by the Trade Unions!

On return to India in 1919 he was posted as Dy. C.E. Northern Command and in 1922 he returned to Simla, as D.D.M.W. He was responsible for the reorganization of the Military Works Establishments and re-wrote the Military Works Accounts Code, simplifying that enormously. For this work he was made Brevet Colonel in 1924 and also was made a C.I.E. in 1926. In 1925 he was again appointed Dy. C.E. Northern Command, which post then meant also being Secretary P.W.D., N.W.F.P. Two years later he became C.E. Western Command and Sec. P.W.D. at Quetta. There he was responsible for the electrification of the Cantonment, the whole of the Civil Lines and the City and also for a great expansion and improvement of roads and irrigation in Baluchistan. For his work he was made a C.S.I. on retirement in 1931.

Throughout his life Evans collected butterflies and started to do so "seriously" in Chitral where he captured specimens of the first species to be named after him. He always spent his leave going to odd places to collect butterflies and even much of his leisure time while he was "on duty" was taken up with this hobby and writing about it. After his retirement he devoted his whole time to it. On leave he visited the Teesta Valley, the Andaman Islands, Malaya and Burma. After retirement he visited some of the East Indies, Japan and Australia. Returning to England in 1932, he settled near the Natural History Museum where he employed himself in going through the National Collection. During this process he discovered over 500 entirely new species which had been unrecognized as such. After about ten years the Rothschild Collection was sent over to him from America for similar review. Seven years' work on that freed him to get down to his own collection of about 2 million, which he had presented to the Nation. It is characteristic that he refused pay for his work at the Museum and worked purely as a volunteer so that he would retain his independence. While working in London he used his evenings to write his work on the *Hesperidae* (the "Skippers") of the World (5 vols.), on which he was the greatest living expert. Other works written during his life were *A List of Indian Butterflies* (1912); *The Identification of Indian Butterflies* (1927); and *The Butterflies of Baluchistan* (1932). The second of these books was considered of great importance. His last work, finished only just before his death, was a booklet on the *Arhopala* (the "Blues") of the World. The completion of this, just as he reached his eightieth birthday, was a great satisfaction to him as it brought to an end the programme he had set himself some forty years before.

During his later years Evans suffered from severe bronchial trouble as the result of being gassed in the Great War. Pneumonia in 1952 made this worse and for the rest of his life he suffered from partial heart failure. He could hardly walk at times owing to rheumatism and trouble from his damaged knee and varicose ulcers. In 1954 he had a severe heart attack from which he barely recovered. It was heart failure that caused his death in the end.

He worked, without doubt, too hard and too continuously, whether on duty or at his hobby, and did not devote a great deal of his time to his family. As a result, in 1938 he and his wife agreed to part. She died of a stroke in January, 1945. His only son, an agricultural entomologist in Australia, had been away for some years when Evans decided to give him all his savings. He lived thereafter on his pension only. It is characteristic that he made this gift chiefly because he thought that his son needed the money more than he did.

E.L.F.

Book Reviews

HISTORY OF THE SECOND WORLD WAR
GRAND STRATEGY—VOL: VI

By John Ehrman

(Published by H.M.S.O. Price 30s.)

Diplomacy is not the business of Chiefs of Staff, but both in America and England the Chiefs were the sole continuous advisers to Heads of Government who personally exercised supreme control. Thus as victory approached the Chiefs were involved, particularly in America, in military decisions whose consequences were politically important.

This official account, written from the British point of view, covers the period October, 1944, to August, 1945, and is a vivid and human story of the debate between the Anglo-American leaders at a time when dramatic events overtook the grand strategic design in Europe. It is an erudite and impartial review, based on a wealth of authentic documentary and personal evidence, and is undoubtedly an important contribution to the literature of the period. Mr. Ehrman recaptures the wartime atmosphere of strain and tension in Washington and London. Against this background he describes the repercussions of operations on the centre and appraises the personalities, motives and relationships of the famous leaders on whose decisions so much depended.

The triumphant advance of the Allied armies raised, with growing urgency, questions of postwar importance. The final dispositions were to shape in Europe the tragic pattern of a new world; a world of East and West, of Iron Curtains and cold wars, of refugees and oppression. The American Chiefs of Staff who, by 1945, had assumed paramount control of strategy, refused to consider British advice on political issues. Churchill foresaw the dangers, he and the British Chiefs urged Washington to direct Eisenhower first to Berlin and later to Prague; their suggestions were not accepted or welcomed. The judgement of history must be that Washington was responsible for decisions that were politically unimaginative, though they were made in good faith for what seemed to the U.S. Chiefs to be sound military reasons and at a time when Roosevelt's death threw the whole burden of the global war on their shoulders.

Meanwhile the plan for the reconquest of Burma, with reinforcements from Europe, was upset by the check at Arnhem in September, 1944. To the Americans the original aim of the Burma campaign had been to open a way through China to Japan. To the British the reconquest of Burma had, by 1945, become vital to their S.E. Asia concept as a step to Singapore and Malaya. Air lift from India was the key to operations in both Burma and China and the airlift was American. The Anglo-American conflict hinged round the aircraft. Mountbatten and the British Chiefs had to struggle hard to obtain the absolute minimum required to support General Slim and the Fourteenth Army in the glorious campaign which was crowned by the capture of Rangoon three days before V.E. day.

It is difficult to assess the full impact of the reconquest of Burma on the war against Japan. By 1944 the concept of attacking Japan via China had been discarded, and subsequently both the China and Burma operations must be judged on their value as diversions in sapping Japanese strength. In the event the Japanese war effort was severely taxed and their forces suffered their greatest single defeat in the Far East. For the British the reconquest of British territory and the opening of the route to Malaya and the East Indies were important secondary results.

The author ends by describing British offers to join in the final Pacific campaigns, the plans for liberating S.E. Asia and the negotiations with Russia before the Japanese surrender. The main military interest in the closing phases is, inevitably, centred in the proceedings which resulted in the use of the "A" bomb. The British took no part in the plan; Churchill was asked to consent, "for the record", and since he had no power to influence the decision gave concurrence in principle without more ado.

The Americans had to choose between two alternatives, either to allow the Red Army to advance in Manchuria while the U.S. forces undertook the costly operation of assaulting Japan or to rely on the "A" bomb for a quick decision. The former had such weighty disadvantages that as a strategic plan the latter selected itself, if only on negative grounds. Politically the State Department supported the "A" bomb strategy because it did not desire Russian participation against Japan. Also the existence of the weapon, in this instance, was probably a strong incentive to its use; as a dramatic display of power and prestige, to justify to Congress the money spent on the project, and to fulfil the aims of the influential group of men who had successfully completed it. An air burst salved the consciences of those sensitive to the Geneva Convention; and there was always the pious hope that this terrible weapon might prove a deterrent to war in the future.

The logic of the argument at the time was that there were no valid reasons against its use and a large number of inconclusive advantages in favour. Whether any democratic nation would be able to bring itself to a similar decision at the beginning of a war is a problem for the future, but there is no doubt that the mere fact that it has once been used, successfully, will influence future thinking.

Volume VI is a fascinating book to read. The supreme test of the Anglo-American war machine, which had been so successful in adversity, was in this year of success.

G.N.T.

THE WAR AT SEA Vol. II

By Captain S. W. Roskill, D.S.C., R.N.

(Published by H.M.S.O., 1956. Price 42s.)

This second volume of the splendid official history of "The War at Sea" covers the tremendous events, which took place between January, 1942 and May, 1943. In the first seven months of this period the fortunes of Britain and her Allies receded to their lowest ebb, but by the end of May, 1943, the tide of victory was running everywhere in their favour.

Captain Roskill describes with sober judgement the mistakes which good military history is bound to reveal. Perhaps the most important of these is the danger inherent in the distant control of battles at sea. The intervention of the Admiralty was, without doubt, the chief cause of the terrible losses suffered by the Arctic Convoy PQ17 in July, 1942. Nor to the layman does Admiral Vian in his flagship seem to have been much helped, in "Operation Vigorous" for the relief of Malta, by the control of the C.-in-C. on land.

Another controversial issue is the neglect of the Royal Air Force to give Coastal Command the requisite aircraft and equipment for the support of the Navy at sea. Alleging, rather surprisingly, that heavy bombing of Germany would diminish the threat to our sea lanes, it was tardy in supplying long-range aircraft with properly trained crews to cover the Atlantic and obstinate in using bombs rather than torpedoes for the attack of shipping. Furthermore, Coastal Command had no organized striking force, so that when the *Scharnhorst* and the *Gneisenau* escaped up the Channel, the air attack against them had to be improvised and though pressed home with the greatest gallantry failed to achieve any decisive result.

The main outline of the plan for Dieppe was radically bad since the presence of its French inhabitants precluded the support of heavy guns and bombers, which the frontal assault on the very centre of the town seemed to demand. Nevertheless such a costly failure was no doubt a weighty argument against the parrot cries of the ignorant for "A Second Front Now." It also showed that an invasion of Northern France could not be attempted with the assault techniques of a bygone age. Something new had to be evolved and in due course was.

We also learn that in 1942 the Navy ran short of destroyer torpedoes and that the Japanese ones were heavier and more to be feared than our own.

Errors and omissions are, however, only a small part of the story. They pale into insignificance alongside innumerable examples of the traditional skill and daring of the Navy. Particularly pleasing in this respect, was the complete success of Arctic Convoy JW51B which, so soon after the disasters of PQ17, showed how the job should be done.

A thoughtful paragraph mentions the Japanese misconception of the principles of maritime war in neglecting to convoy and escort their merchant ships. As a result, they ran out of new materials for their war industries much earlier than they need have done. The way in which they crowded huge garrisons on to a multitude of islands is further evidence of the same failing. The Germans are criticized for not pursuing most promising courses of naval action right to the end. This is not a usual German characteristic and is a measure of the confusion which existed at the top. The chronic shortage of destroyers will impress most readers of this excellent book. Perhaps it will also impress the reformers of our military defences and persuade them that we require a sufficiency of small fast warships. They are the infantry of the sea, in nuclear or any other kind of warfare, and must be available. B.T.W.

THE DEFENCE OF THE UNITED KINGDOM

By Basil Collier

(Published by H.M.S.O, 1957. Price 50s.)

It is often forgotten that about 1905 the threat of an invasion from the Continent gave considerable anxiety both to the inhabitants and to the government of Britain. Books and plays such as *The Riddle of the Sands*, *John Bull's Other Island*, *An Englishman's Home* and *The Invasion of* 1910 (a *Daily Mail* serial story) bear witness to unusual perturbation. After much bother and palaver, however, Mr. Balfour and the strategists of the so-called "Blue Water" school decreed that a raid of 30,000 men was the maximum danger which Britain need prepare to face. This view seems to have been accepted as the correct answer to the invasion problem, not only by the British, but also by the German authorities. There the matter mercifully rested right up to the defeat of France in 1940. Thus Hitler suddenly found himself without a practical plan for the far more important task of invading England.

This being so, a particular interest attaches to the information which Basil Collier's inter-service history provides on the measures taken to resist German landings. Apart from this, the *Defence of the United Kingdom* does not provide much new material either for the general reader or the military expert. Every aspect of the war in the air over Britain has already been described in detail elsewhere and only an outline of the sea war is provided. Its great value will be as a reliable book of reference describing how the manifold dangers which beset these islands were overcome. Touching this, it seems a pity that there is no comprehensive chapter on Civil Defence, which has to be studied in the civil series of military histories and will therefore probably escape the full attention of the fighting services. The set-up in Eire and Northern Ireland is hardly mentioned and perhaps deserves more extensive treatment.

Most readers will rejoice to see that Mr. Collier accepts and repeats Winston Churchill's story of the bodies of German soldiers washed up during August, 1940, on the shores of England. The 1914–18 war had its special train speeding through Great Britain full of Russians. Why should not the last war have its little myth as well? B.T.W.

INTRODUCTION TO ASTRONOMY

By Cecilia Payne-Gapochkin

(Published by Eyre and Spottiswoode, London. Price 50s.)

The aim of this book is to introduce to the general reader a broad outline of the various aspects of astronomy. This it certainly achieves. About half the book is devoted to the solar system and also includes descriptions of instruments and current techniques; the remaining half is concerned with the stars and stellar systems. Throughout the work the author has been careful to avoid becoming involved in mathematics and the reader must be prepared to take a lot for granted; nevertheless, by the use of skillful description and analogy, numerous aspects of the subject have been satisfactorily explained. It should perhaps be pointed out at this stage that the book is unsuitable as a work of reference for those branches of astronomy concerned with geodesy, field surveying and navigation.

Although the pattern of the book bears a striking resemblance to previous works of a similar nature this is inevitable in an introduction of this scope, the treatment however is unique in so far as the author has achieved an integration of current factual material and the relevant historical narratives. A reader must, of course, condition himself to the North American idiom and spelling.

The section devoted to the Solar System is both readable and comprehensive. The elements are described in considerable detail and although the dynamics of the system are outside the scope of the work, interesting accounts are given of the discovery of both Neptune and Pluto. On the other hand the controversial question of the rotation period of Venus is summarily dismissed as being at least a month. Numerous attempts to solve this problem have been made and results ranging from twelve hours to thirty days have been obtained by investigation of the Doppler effect between opposite limbs. Recent observations of radio signals from Venus suggest a period of about thirteen hours and so the problem remains unsolved.

The shift of emphasis from the solar system to the stellar system in the study of modern astronomy is evident in the latter part of the book. The remarkable advances in the study of nuclear physics over the last two decades have revealed new and powerful methods of investigating the composition of stars and stellar systems. The chapter concerned with the physics of the stars deals lucidly with mass-energy relationships and discusses stellar structure and evolution in the light of contemporary thought on regenerative reactions. Again the chapters on double, multiple and variable stars are most comprehensive for a book of this nature and provide a wealth of up-to-date information.

The book concludes with a short chapter on cosmic evolution which provides an age correlation of various matter in the universe ranging from radio active atoms to clusters of galaxies.

The work is at once informative and refreshing, simple to follow yet comprehensive. Diagrams have been used to full advantage and numerous splendid photographs are included, many of them from the new 200-in. telescope at Mt. Palomar observatory.

T.R.B.

INVESTIGATIONS ON THE THEORY OF THE BROWNIAN MOVEMENT

By Albert Einstein, Ph.D.

(Published by Dover Publications, Inc., U.S.A. Price $1.25)

The discovery in 1828 by Robert Brown, the botanist, that small particles of organic substances dispersed in water were in uninterrupted and irregular motion, led him to believe he had discovered the primitive molicule. It was this movement to which the name Brownian movement was ascribed. It wasn't until nearly the turn of the century that the movement was explained by Einstein who related it to the Laws of Diffusion and Osmotic Pressure. The book is a collection of five articles by him that appeared at about the turn of the century in German periodicals. There is much that is therefore repeated, and many expressions which appear in these papers which may have been clear to the readers of the article; but which do not follow from the text. Also because the articles have been translated from the German they suffer from errors which could not have appeared in the original. To the average reader it renders work, which is not easy to understand, confusing. It is refreshing, however, to read the exposition of a great master in its original form, and if time does not permit all the articles to be read then at least the article on the Elementary Theory of the Brownian movement should be read by any one who is interested in modern physics.

J.P.F.-S.

NUMERICAL INTEGREGATION OF DIFFERENTIAL EQUATIONS

By Bennett, Milne and Bateman

(Published by Dover Publications Inc., U.S.A. Price $1.35)

The phrasing describing the various methods of numerical integration used in this book are rather formal and cumbersome which does much to reduce the value of the work. The quotation below from the chapter by Bennett on the method of successive substitutions in differential equations will illustrate the point:—

"A chosen form of approximate solution is assumed as suitable for each interval of the equation. The parameters in this solution, and the length of interval such that a satisfactory pre-assigned degree of agreement is assured in this interval are determined. The work is then repeated for the next interval and continues thus until the desired pre-assigned total region of the real axis is covered."

Readers who in the above description recognize Simpson's rule will find some value in the book, which in general refers to methods of numerical integration in such terms.

The book is a collection of three works by the above authors, its value lies more in summarizing the methods available, and in indicating references where detailed information may be sought, than in the clear exposition of the methods themselves.

The second chapter by Bennett is of historical interest, while the chapter three by Milne indicates some examples of the numerical methods outlined in chaper one. This is not a book for the general reader. J.P.F-S.

RAYLEIGH'S PRINCIPLE AND ITS APPLICATIONS TO ENGINEERING

By G. Temple and W. G. Bickley

(Published by Dover Publications Inc., U.S.A. Price $1.50)

The authors are to be congratulated on the clear exposition of their subject, which will do much to popularize the method. Engineers will find the work easy to follow, and with the aid of the numerous fully worked examples they will find many otherwise difficult problems easily analysed by this powerful method. Mechanical engineers will find the work on vibrating systems, and whirling of shafts especially interesting, while the direct method of approach by way of energy equations to problems on stability of structures will appeal to civil engineers. The application of the method to the stability of deep narrow cantilevers and beams is particularly interesting.

The book also deals with numerical and graphical solutions to such otherwise intractible problems as the stability of struts of varying section. The authors never forget that the method was devised for the rapid and direct calculation of critical conditions in this class of problem and this is a characteristic of all solutions set out in the book.

The method is not usually taught in University degree courses; but it is one that would repay study by all engineers. J.P.F-S.

Technical Notes

ENGINEERING JOURNAL OF CANADA

Notes from *The Engineering Journal of Canada*, December, 1956

Highway Interchanges

On modern motorways designed to carry a large volume of fast traffic, the simple roundabout introduces a considerable bottleneck at intersections, and all traffic streams must weave with others during transition. Flyover crossings can minimize interference but, to permit drivers on any approach to turn in either direction without affecting through traffic, design becomes complicated and construction is necessarily expensive. This paper describes three basic conceptions of layout, the cloverleaf, the rotary, and the turbine.

X-Ray Techniques

X-ray techniques are being applied increasingly both in research work and in industry. This short paper summarizes the general principles on which these techniques are based, and it should encourage the engineer to accept data provided by the laboratory.

Notes from *The Engineering Journal of Canada*, January, 1957

Precast Panels as Formwork for a Gravity Dam

In the construction of the Cluanie dam, in Scotland, precast concrete formwork was used. For a project big enough to warrant the establishment of a block-casting yard, this method has economic advantages, since it obviates the use of wrought timber, which is expensive, and of steel, which is scarce. It also shows a saving in skilled labour, and renders external scaffolding unnecessary.

This very short description is somewhat inadequate, but some excellent photographs help to explain the principles and general procedure.

Ore Transfer Facilities at Contrecoeur, Quebec

Until such time as the St. Lawrence Seaway project is completed, much of the iron ore shipped at the port at Seven Islands must be transferred to smaller ships, or to railway freight, in order to reach lake ports in the U.S.A. During 1956 the specially built transfer facilities at Contrecoeur, some twenty-five miles downstream from Montreal, reloaded over 2 million long tons to canal shipping, and nearly ½ million long tons to rail. This comprehensive description of the installation, and of the organization of unloading and reloading, provides an interesting example of modern methods of mechanical handling, and of the use of dolphins to facilitate the manoeuvring of shipping without tugs.

Notes from *The Engineering Journal of Canada*, February, 1957

Economic Fuelling of Nuclear Power Reactors

The Engineering Journal of Canada for December, 1955, contained an interesting paper on "Atomic Power Development" (see *R.E. Journal* of June, 1956) showing that the main obstacle to the general distribution of nuclear power is now the economic factor. The present paper gives a clear and comprehensive picture of experimental work now in progress, and of the trend of design. The author concludes that economic fuelling, to compete with ordinary thermal power stations, is possible and that practical limitation of costs will probably be achieved in the near future. It seems likely that nuclear power plants will provide a rapidly increasing proportion of generating capacity within the next two decades.

Plastic Design of Structural Steel

Most engineers are aware that elastic design methods, developed when normal building materials were stone, timber, and cast iron, often produce uneconomic steel structures. This paper sets out the basic thoughts behind the idea of plastic design, and considers the effect of built-in residual stresses, the redistribution of stress through the ductility of steel, and the practical significance of factors of safety.

The author claims that plastic methods can predict ultimate loading with sufficient accuracy for design purposes, and forecasts that plastic design specifications will soon be generally accepted. Some interesting examples of practical fabrication methods are also included.

DESIGN AND CONSTRUCTION OF EARTH DAMS IN WESTERN CANADA

The science of soil mechanics has revolutionized earth dam engineering but, to prevent widespread damage and possible loss of life through failure, previous experience and careful observation during construction should over-ride theories whose validity has not been substantiated in practice.

Recent developments in design and construction are clearly described in this interesting paper, which includes typical cross-sections of existing and proposed dams. The analysis of stability is discussed, and methods of seepage control, in different geological conditions, are simply explained. Valuable information is given about construction methods.

THE MILITARY ENGINEER

JOURNAL OF THE SOCIETY OF AMERICAN MILITARY ENGINEERS

November–December, 1956

"Wanted—Regular Army Officers—What the Army Augmentation Program Means to the Engineers," by Colonel Stephen R. Harmer, Assistant Chief of Engineers for Personnel.

This article is interesting as it shows what is being done to increase the officer strength of the U.S. Army.

The author explains the "Armed Forces Regular Officer Augmentation Act" of July, 1956 which makes it possible to add some 7,000 Regular Officers to the existing strength of 28,000 within the next eighteen months. Regular commissions will be granted to Reserve Officers, former Army Officers, and a limited number of civilians with special qualifications. Initially Commissions will be given in all ranks below general officer in accordance with existing vacancies and the qualifications and experience of applicants; further increases of strength will be in the rank of Lieutenant. Some 600 of these new commissions will go to the Corps of Engineers.

The purpose of this intensive Officers recruiting campaign is to bring the Regular Officer strength more into line with the Army's heavy world-wide commitments, as well as to balance its Regular Officer structure by filling existing gaps. Selection is through two Boards, each headed by a General and composed of Colonels. One a Selection Screening Board, the other a Final Selection Board.

Applicants must be able to complete twenty years of active commissioned service by the age of 55. Credit may be taken for commissioned service completed prior to appointment. Specialists with Doctor's or Master's degrees are being sought in the fields of nuclear engineering, nuclear physics, hydrology, electronics, and all the major fields of engineering. Prior military service is not essential for these specialist appointments.

"Conditions in Germany Today", by Brigadier M. C. A. Henniker, C.B.E., D.S.O., M.C., British Army.

The author, a well known Royal Engineer Officer, has recently served with the British Army of the Rhine in the British Zone of Germany, and gives a concise and well balanced pen picture of the economic and political conditions obtaining in East and West Germany from the chaos of 1945 to the present day.

He examines in detail the comparative rates of recovery and reconstruction on either side of the iron curtain and concludes by reminding the reader that the apparent miracle of Western Germany's remarkable recovery is more readily understood when one remembers that philanthropic Governments in the West have paid many of the bills.

CIVIL ENGINEERING

Notes from *Civil Engineering*, November, 1956

Relaxation Methods for Pipe Network

For those who may not be familiar with Southwell's relaxation methods, the problem of solving the pipe flow in a complex network, described in this article, is a simple and useful introduction. The simple differential equation used to determine the unit operators is simply derived from logarithmic differentiation; and the article sets out the steps in a thoroughly practical manner. There are some arithmetical errors in the working, but these will be obvious to anyone who has understood and followed the method.

Steel Tunnelling Shutters

A system of steel shutters designed by Edmund Nuttall has been devised to enable them to place the lining of the tunnel in their Breadalbane contract continuously. The steel shutter which is 240 ft. long, will permit 15 ft. collapsible sections to be removed from the completed end to the face where concrete is proceeding. This is done by arranging three hinges in the steel ring, which allows the ring to collapse into a smaller area on to a carriage. This transports it forward on rails to the tunnel section in process of construction.

It is estimated that the rate of working will be 1,200 ft. to 1,400 ft. of lining in a week. There is one photograph which clearly shows the general arrangement.

The Avon Dam

Tarmac's contract for the construction of a concrete arched dam on the Avon has some interesting features. It was estimated that the present storage requirement of 305 million gallons would need supplementing in the future. Provision at only a fraction of the cost, that such subsequent increase in the capacity of the dam would entail, has been made by building in ducts and a pressure head which now allows the height to be increased by adding prestressed concrete. The article gives details of the geological nature of the site and describes the various construction phases. The problem of heat dissipation encountered when large masses of concrete are poured has been economically solved by the use of Trief concrete in the heart of the dam. Recording thermo couples have disclosed that the maximum rise in temperature so far has been 20°F. The article is illustrated by five photographs and five drawings which adequately describe the work.

The Vibration of Concrete

The report of the Vibration of Concrete prepared by the Joint Committee of the Institution of Civil Engineers has been published in the form of an illustrated booklet. Many of the eleven points the Committee make of course apply to ordinary concrete. They are:—

(*a*) Control to provide uniform workability.

(*b*) Mixes should be properly designed and minimum strength specified.

(*c*) Samples should represent the supply.

(*d*) Formwork should be clean, and strong enough to prevent distortion under vibrators.

(*e*) Batching plant should be of sufficient capacity to ensure vibrators are fully employed, and capable of dealing with mixes of low workability.

(*f*) Vibrators should match the work.

(*g*) Immersion vibrators should be kept running.

(*h*) Clamp-on vibrators should be spaced to ensure all parts of the concrete are vibrated equally.

(*j*) Table vibrators should be rigid enough to avoid edge whip.

(*k*) Hand-propelled vibrating beams should be lifted to new positions, not slid along, so as to avoid honeycombing.

(*l*) The contractor should supply advance evidence that the aggregate and mix will produce the required strength and workability.

Flexible Support for a Sewer

The problem of providing approximately uniform support conditions to a relatively inflexible sewer carried by a single span bridge in which the deflection would vary with the load in the sewer was solved by the British Rubber Producers' Research Association.

The pipe was supported at three intermediate points on rubber blocks the size of which were carefully calculated so that under maximum load conditions the three support thrusts varied by no more than 7 per cent of the mean value.

Since construction the pipe has been completely filled twice and has behaved entirely satisfactorily. The rubber blocks are easily inspected and could be replaced without difficulty at any time.

Notes from *Civil Engineering*, December, 1956

Higham Service Reservoir

The article describes the construction of a 5 million gallon capacity service reservoir at Higham. The reservoir has a roof area 296 ft. 9 in. by 156 ft. 9 in. The maximum depth of water contained is 20 ft., but by sloping the floor towards the centre, wall heights were kept down to 10 ft. These were designed to withstand internal water pressure without the assistance of the external ground pressure. Prestressed concrete main beams and precast prestressed secondary beams with lightweight concrete infilling enabled the designer to reduce the number of supporting columns necessary. In the design finally adopted only fifty precast columns were needed, a reduction from the 200 or more columns which would have been required in conventional construction. Because the reservoir is situated in a subsidence area, the design was arranged to permit differential settlement. The walls were constructed in separate units and the floor was similarly placed as a system of independent panels. The key to success in this form of construction is efficiency of the joints which accordingly received special attention. The floor consists of a base course of 3 in. unreinforced concrete, and a top course of 7-in. concrete reinforced top and bottom, laid as alternate squares of a "chess board", with the joints staggered between upper and lower courses. Vertical joints between floor panels consisted of a coat of bituminous paint. Rubber water stops were inserted at all vertical joints, and where awkward junctions occurred these were prefabricated and vulcanized to the required shape and length in the supplier's factory. There were twenty-eight contraction joints in the total length of wall, each consisting of a water stop and a layer of bituminous paint. Caulking was achieved by forming V grooves on the face of the joint and filling with a sealer of rubber composition. Expansion joints were arranged at each third point in the length of the reservoir. These joints were continued through both walls and floors. Each joint consisted of a 1-in. gap filled with "flexcell" joint filling compound. Here again V grooves were formed on the joint face for later caulking. The main and secondary beams in the roof were precast and pre-tensioned at the contractor's factory on the long-line system. A reduction in the overall depth and weight of the main beams was made possible by further post-tensioning them after the secondary beams were in position. This was done by the Gifford-Udall-CCL system.

The spaces between the secondary beams were filled with aerated concrete of 70 lb./ft.^{3}, which in addition to being half the weight of normal concrete gave better thermal insulation than normal concrete. Additional thermal insulation for the reservoir was provided by a 2 in. thick blanket over the entire roof.

Concrete Road Construction Today

The contents of this article will come as a surprise to those engineers who believe that Westergaard's Pavement design method had opened the way to a true understanding of this problem through inductive reasoning.

It is true that the approach now recommended is an empirical one to the problem; but as it is pointed out, the stresses imposed in concrete road slabs are less easily predicted than those experienced by a structure. The views expressed in the article are backed by such authorities as the Road Research Laboratory and the Cement and Concrete Association.

Only five conditions of subgrade are considered:

(*a*) Very stable C.B.R. value greater than 100.

(*b*) Very susceptible to non-uniform movement C.B.R. 2 per cent or less.

(*c*) Embankments higher than 4 ft.

(*d*) Sub-grades where water table level may rise within 2 ft. of the formation.

(*e*) Normal, not covered by any of the above extremes.

Base courses for these sub-grades vary from nothing for the very stable sub-grade to 6 in. for those with C.B.R. of 2 per cent and for those within 2 ft. of the water table level. Slab thicknesses are affected by both sub-grade condition and traffic intensity, for the normal sub-grade, it varies from 10 in. for very heavy traffic to 5 in. for very light traffic, and thicknesses are increased by only 1 in. for sub-grades worse than normal. This information is summarized in a most useful table, to be used with a second table which classifies traffic into seven categories based on the number of vehicles and the daily aggregate tonnages. The aggregate tonnages being the more important figure.

The article is very authoritative on reinforcement. Unreinforced roads are *not* recommended; but the reinforcement that is included is put in as much to counteract the effects of thermal movements as for distribution of loads. The reinforcement required for very heavy traffic is 14 lb./sq. yd. to as low as 5 lb./sq. yd. for very light traffic.

For concrete quality a compressive strength of 4,000 lb./sq. in. at twenty-eight days is reported as satisfactory for road slabs, while for workability using spreading machines a compacting factor of 0.82 is recommended. The article is to be concluded.

The Osmotic Method of Increasing Concrete Strength

Experiments based on Bohr's Atomic Theory have shown that the theoretical strengths of materials like glass, iron and concrete are 1,000 times the values normally achieved in practice. This discrepancy is explained by the presence of micro and macro pores which have the effect of weakening the structure of the material. Micro photographs have disclosed that the origin of these pores in concrete is high water cement ratio. The author agrees that methods which aim at reducing water cement ratio viz. ramming, spraying, compressing, shaking, vibrating, spinning, vacuum processes, steam heating, or heating by the thermo electric method are useful for plastic concretes; but the method under discussion was the only one suitable for liquid plastic, or liquid concrete.

Essentially the method consists of passing a direct current between a round iron bar, which is the anode, and a perforated steel tube, which is the cathode, and also enables surplus water to be drawn off. Vibration is recommended to minimize the pores from which the water has been removed.

Occasionally temperature rises accompany the passage of the electric current but this should not exceed 50° C., since above this temperature, evaporation would increase the size of pores. Electro osmosis is only produced when the potential differences are less than 1.7 volt/cm., while 1 volt per centimeter is considered most advantageous. Above 1.7 volt/cm. not only water but cement-milk passes to the cathode and this has a weakening influence.

The author points out that in the first phase of hardening, Darcy's equation for electro osmotic water motion in soil applies, thereafter this equation is modified to meet the condition of decreasing permeability with increased hardening. The article discusses the effect of variations in the parameters of the ruling equations and arrives at practical limits for these variations.

In conclusion it is pointed out that electro osmosis of itself is not sufficient to increase the strength of the concrete. The pore space must be closed by tamping, vibration or compression. Also, that theoretically the whole of the water content not required for hydration of the cement can be removed, but each concrete has a limit beyond which it is uneconomical to remove water, this critical point being a function of quantity and quality of the cement. A final warning is included on the necessity of insulating workmen from the effect of these direct currents.

A PRACTICAL METHOD OF ANALYSING STRUCTURES USING LARGE MODELS

The growing use of structures with large numbers of redundant members is leading to wider use of models in analysing the stresses present in these structures. The method is basically that first demonstrated by Beggs. The unusual features described in the article are the use of large models, and the method of introducing unit deformations. The author points out that the error of inducing the large deformations he used is only in the order of 4 per cent. One advantage of the method is that the largest and most complicated frameworks can be built out of strips of perspex with specially cut end connexions instead of large single sheets. The whole being connected together by close fitting pins which transfer the load from the members to the end connexions. The author discusses the effect of drilling these holes and concludes that the effect of so doing is negligible. There follows an extremely practical and detailed account of the method of marking out and cutting the strips, which together with the worked examples and sketches clearly illustrates the several steps in the method. The article is to be concluded.

Correspondence

WATER DIVINING AS AN AID TO ENGINEERING

From: Lieut.-Colonel H. R. P. Hutchins,
Magazine Gap,
Nightingale Lane,
Bickley, Kent.

To Editor, *R.E. Journal.* 18th March, 1957.

Sir,

Colonel Grattan is to be congratulated on his excellent, and most interesting article in the March issue of the *R.E. Journal*. It is to be hoped that it may inspire other Sapper officers to recount their experiences of water divining; if not in articles then perhaps in your "Correspondence" pages. These are so frequently bare that one wonders whether the spirit of controversy between Sapper officers is dying out! There was a time when the exponents of hot tar waged ceaseless war with the exponents of cold bitumal emulsions, and your "Correspondence" pages made interesting reading.

Colonel Grattan expresses the opinion that about half the population are, in some degree, sensitive to the phenomenon of water divining. It would be interesting to know on what grounds he bases this estimate of 50 per cent sensitivity. I should not place it higher than 5 per cent.

In India, before the war, water divining was always taken seriously. G.H.Q. at Delhi maintained an official list of qualified water diviners or dowsers. These dowsers were from all arms of the Service both British and Indian, and additions to and deletions from the list were published at regular intervals in Indian Army Orders. Perhaps Colonel Grattan himself was on the list when he was G.E. Parachinar.

No major water supply scheme was embarked on without the advice of one of these official dowsers, and an official rate of emolument was laid down for their services. When a dowser visited a station he was often given the opportunity of testing for, and recruiting, fresh talent. This happened when I was commanding a Madras Sapper Army Troops Company in Quetta in 1933. The station was visited by a Colonel from G.H.Q. who was I believe the senior official dowser at that time. Of his talent there could be no doubt, and it applied to metals as well as water. He was in great demand at dinner parties where his divining rod would unerringly locate a single rupee hidden under the drawing room carpet! Our Chief Engineer, the late Brigadier Haswell, asked him to test all R.E. Officers, B.N.C.O.s, Indian Officers and some N.C.O.s of Sapper and Miner units, for dowsing ability.

I was in the party containing the Madras Sapper and the three Bombay Sapper Coys. We were all paraded together, shown how to hold the forked hazel twig, then set to walk a certain course two or three at a time while the rest of the party looked on. After all B.O.s, I.O.s, B.N.C.O.s, and Havildars had been tested with completely negative results we were all getting very bored and somewhat sceptical. Suddenly a Sikh Naik who was walking the course shouted "Dekho Sahib, Dekho!" and his twig appeared to jump about in most convincing fashion. Everyone got very excited, but when the great "Dowser" himself tested the spot where the Naik had had his reaction, he said there was no water whatever there, and the Naik retired crestfallen. Possibly he had thought that the honour of his Company was at stake and that it was up to him to do something about it. He had certainly enlivened the proceedings and succeeded in pulling everyone's leg.

In the other party tested, consisting of M.E.S. staff, there were I believe two or three who showed that they possessed the dowsing gift in some degree. The point I wish to make, however, is that out of an average selection of about seventy or eighty officers and N.C.O.s both British and Indian, only two or three were in any way sensitive to the dowsing forces.

Later on as A.C.R.E. (E. and M.) Lahore District, and S.O.R.E. (E. and M.) Northern Command at Rawlapindi between 1937 and 1941 I had frequently to employ official dowsers on water supply schemes. Their diagnoses of the depth at which water would be found were sometimes reasonably correct, but frequently badly out. I can remember two occasions on which we had to abandon well boring after we had exceeded very considerably the depth at which water had been forecast. These failures led the Chief Engineer (now Lieut.-General Sir H. E. Roome) to issue instructions that geologists, not water diviners, should be used as consultants on all further water supply projects in Northern Command. Only after the geologist had selected an area for well boring was it permitted to call in the water diviner, to pin point the spot within the selected area which would give the maximum yield.

This policy undoubtedly saved a lot of fruitless digging and I am convinced that it is the correct way to use the water diviner to assist the engineer. Colonel Grattan brings out clearly in his article, that he first employed the German geologists, and then confirmed and supplemented their findings by his own dowsing ability.

Incidentally all the official water diviners with whom I had contact in India were British. I do not remember ever coming across an Indian who had the gift. It would be interesting to know whether the gift is shared by other races, or whether it is Europeans who are specially favoured.

One last point. A dowser, by laying his hands over those of a non-dowser, who is holding the hazel twig, can impart his dowsing abilities for so long as the contact is maintained. I am told that the non-dowser feels a tingling sensation in his hands. It might be interesting to hear from Colonel Grattan, whether when he was carrying out his dowsing on horse back, there was any reaction in the horse!

Yours faithfully,

R. H. P. Hutchins,

Lieut.-Colonel (retd.).

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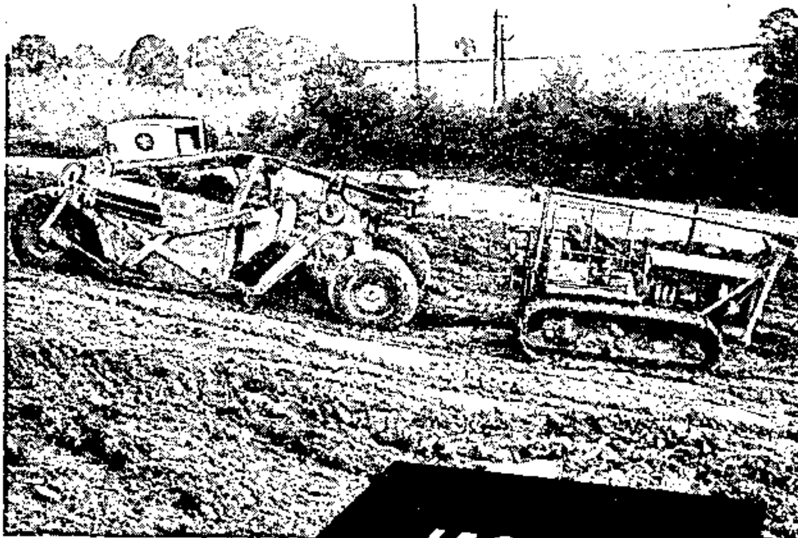

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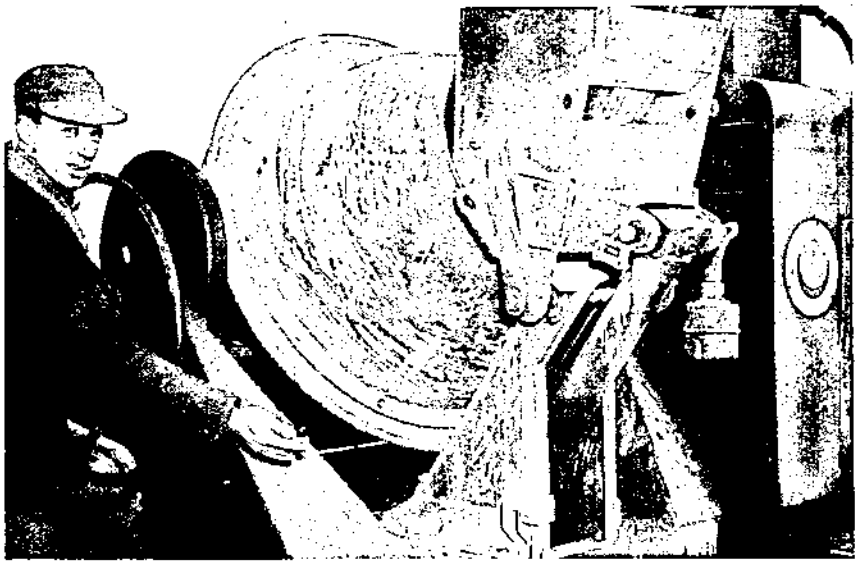

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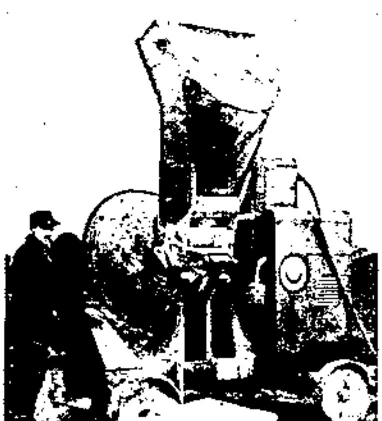

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