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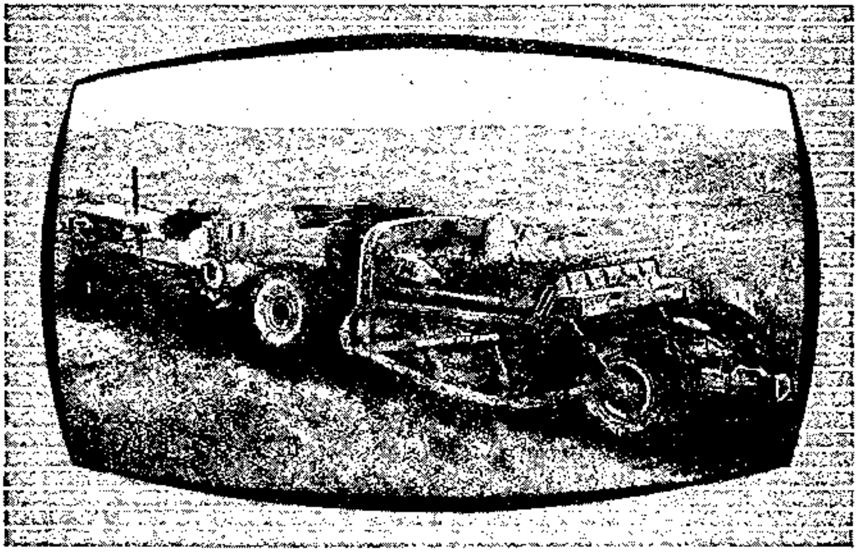

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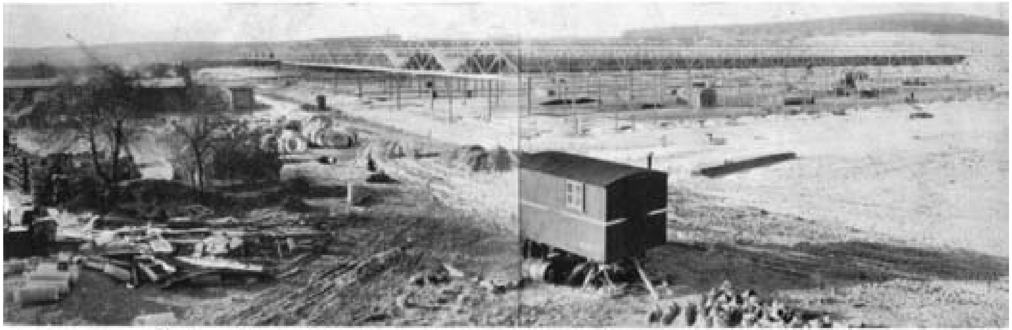


Photo 1.—Photo mosaic giving general view of site, steelwork complete, sheeting in progress.

Photo 2.—Photo mosaic showing the five sheds completed.

A Vehicle Covered Storage Project At Ludgershall 1,2

A VEHICLE COVERED STORAGE PROJECT AT LUDGERSHALL

By Lieut.-Colonel J. G. O'Ferrall, R.E.

(Note. This article was written in 1953)

Introduction

THIS paper covers the first phase of a works service at Ludgershall, Wilts, which, together with similar services in other parts of the U.K., is fulfilling a major defence undertaking to provide vehicles covered storage accommodation together with workshops and other ancillaries.

The narrative is split up under the various sub-headings of the service and the work is itemized to allow description and observations to be confined within paragraphs relating to each item.

Any criticisms of design, expressed or implied, are accompanied by the realization that the design instructions and requirements are not fully available to the writer. It is hoped that the remarks which prove of interest will counteract those of doubtful validity.

Scope

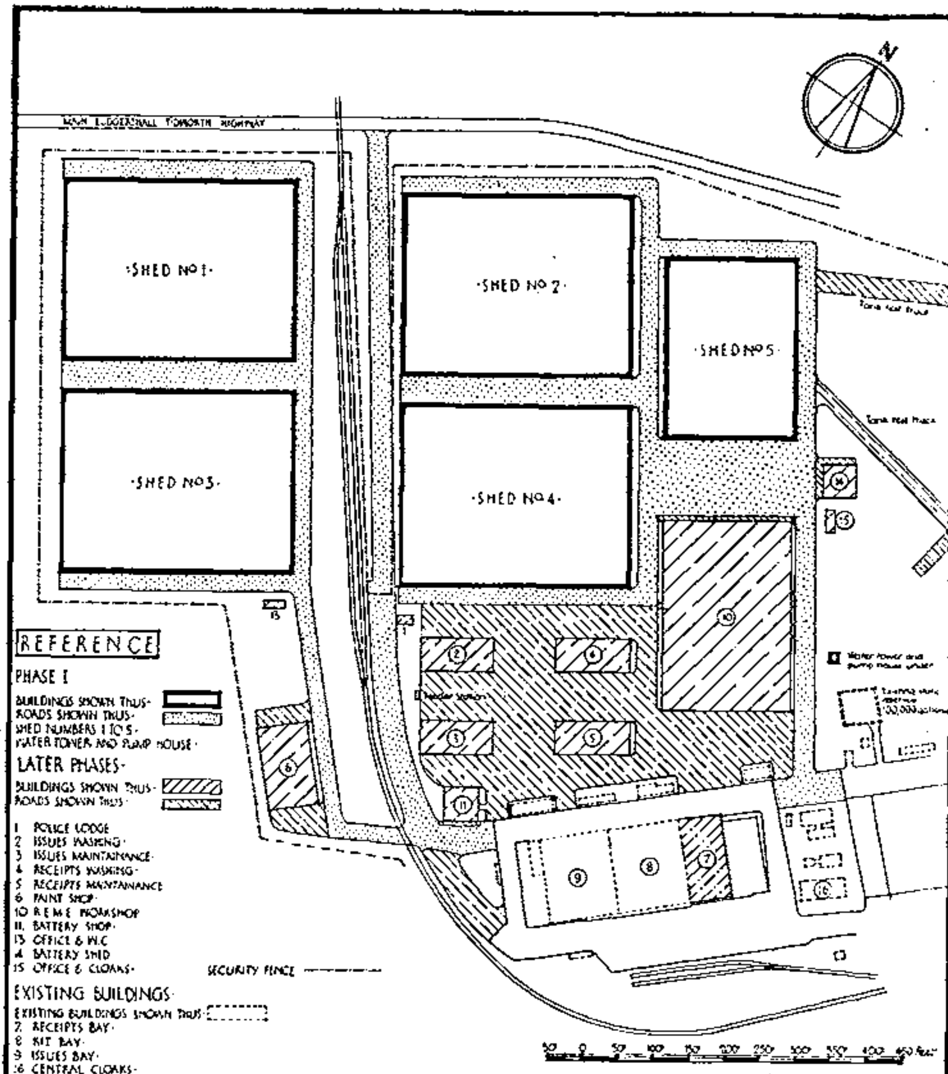
The project is an extension to the west of 13A Vehicle Depot R.A.O.C. to provide covered storage accommodation for Class A vehicles, a R.E.M.E. workshops and various ancillaries. The whole project consists of the erection of five store sheds, a R.E.M.E. workshops, ancillary buildings and the necessary roads, hardstandings, water mains, drainage system, street and interior lighting. It also includes a concrete tank-testing track on the site of the existing tank-testing area and a tank wash, about a quarter of a mile from the site where tanks leave the open plain and take to public or War Department roads.

Phase I of the project, with which this paper is concerned, consists of the erection of the five store sheds together with the larger part of the roads, a water tower and pump house supplying ring mains, feeding hydrants around the sheds, and almost all the drainage system which empties into five large soakaways. The electrical supply for the sheds is included and is fed in from a feeder station which will supply the future phases.

The layout of the site and services for Phase I are shown on the plan on page 322.

Design

The five store sheds are to War Office design. These are a standard design, the steel structure providing bays 48 ft. wide and 262 ft. 6 in.



LUDGERSHALL · COVERED STORAGE PROJECT ·
PHASE I · BUILDINGS · ROADS · FENCES ·

long. Four sheds are of 7-bay and one of 4-bay construction. Dwarf exterior walls of hollow block construction are carried up with asbestos cement sheeting which also covers the roof, but each shed bay has two continuous lines of patent roof glazing extending the length of the sheds.

Continuous lines of sliding doors occupy the ends of each shed. The four larger sheds are subdivided by fire walls of hollow block construction.

Two road areas adjacent to one shed were designated by the War Office to the Road Research Laboratory for experiments in the design of tank road surfacings. Also a part of the entrance road was used by the R.R.L. to experiment with expanded metal surface reinforcement in asphalt. As these will be the subject of a separate report, they will not be enlarged upon in this account.

Experiments to determine the effectiveness of eleven proprietary floor hardeners and waterproofers in concrete were carried out on the floor of Shed 5.

Organization

All contracts were superintended by C.R.E., N. Wilts. Messrs. R. Travers Morgan and Partners, who were employed by the War Office as consulting engineers, were responsible for the external services and roads. Lieut.-Colonel G. W. Kirkland, a senior partner of the firm, was a frequent and welcome visitor to the site and one on whom the C.R.E. could always depend for expert opinion and advice. Site supervision and administration were carried out by a resident engineer with an assistant, both of whom were recruited from the staff of the consulting engineers. The same site supervision continues for Phase II, now under way.

While this proved a most satisfactory arrangement and continues to do so, one cannot help feeling that the Works Service has lost an opportunity of giving some very useful training and experience to one of its more promising junior engineer officers.

An assistant quantity surveyor was nominated by C.E., Salisbury Plain District from his own staff. The work itself took place in the area of G.E. Tidworth.

Contracts

The civil engineering contract was let on 28th April, 1952, and work on site started on 19th May, 1952. The initial contract completion date was 19th February, 1953, which had to be extended to 31st August, 1953. The main delays and reasons were:—

Four months for inclement weather. The winter months alternated with rain and frost periods, both severely limiting progress on compacting chalk and laying concrete.

Three weeks for extra work deviated into the contract.

Five weeks for the completion of the electrical sub-contract which had been delayed through supply difficulties.

The steelwork contract was let on 9th January, 1952, and work on site started on 23rd September, 1952. The initial completion date was 28th January, 1953, which was extended to 31st August, 1953. Main delays were as follows:—

Two months for late delivery of steel.

Two months for delay due to hold up of the civil engineering contract by inclement weather.

Two months due to late delivery of steel for work deviated into the contract.

One month to allow the work on both contracts to be taken over simultaneously by the W.D. on 2nd September, 1953.

Labour

At peaks, 170 men were employed on site by the civil engineering contractor (Messrs. Wilson Lovatt), of which about 80 per cent were imported and the rest local. Messrs. Braithwaite totalled fifty, of which about half were imported.

The full welfare clause applying, accommodation had to be provided and this was arranged for in the excellent Ministry of Works hostel at Aliwal Barracks, Tidworth (approximately three miles from site), which was being operated by their contractor on the barrack modernization project at Tidworth.

The operation of this hostel was taken over by Wilson Lovatt in December, 1952, when the M.O.W. contract was closing down.

The lavish scale of equipment, including curtains and bedside mats, etc., provided by M.O.W. was not quite catered for in schedules for War Department contracts. However, precedent and, if you like, *noblesse oblige*, demanded that the standard should not fall and equipment and furnishings were taken over *in situ* from M.O.W. at second-hand value. As the M.O.W. were undertaking the modernization project for the War Department, I only hope they were not paid twice on this account!

We had one unofficial strike at the site which lasted two days and only affected the labour employed on the civil engineering contract. It was alleged to be a protest against the rise in the price of a cup of tea at the hostel and a lowering of the messing standard when the new caterer took over. Whatever the reason, it resolved itself pretty quickly and to everyone's relief.

Site Clearance and Excavation

The site was open grassland which had been used during the war as a P.O.W. camp, relics of which in the shape of old huts, concrete bases and dilapidated dannert and barbed wire fencing had to be cleared. A human obstacle in the person of a squatter who refused to leave her wooden shack presented quite a problem. Her hut lay across the alignment of a main road. Nothing would make her budge, even when machines appeared to be menacing her on all sides and despite the dust and noise they created. When at last alternative accommodation was found and she was persuaded to accept it, she was due for her confinement. When the happy event was over, she moved peacefully, and much to everyone's relief, to other quarters, in, I hope, more congenial surroundings.

The site is on chalk which was covered by about fifteen inches of topsoil. The stripping of topsoil and main levelling of the chalk to a rough formation was carried out by scraper. The final adjustment of chalk levels was carried out by graders. During this process the stanchion bases were excavated by hand and the main shed drainage lines excavated, laid and backfilled.

The chalk used as fill under shed floors was compacted in 6-in. layers by tractor and scraper, while that under roads was spread in 6-in. layers and compacted by a smooth wheeled roller to not less than 90 per cent of the original density of the solid chalk. This figure was periodically checked by site tests.

STORE SHEDS (see Photos 1 and 2)

There are five store sheds in the project. While the work involved is fairly straightforward, it is thought that some features of it in this contract may be of interest. Accordingly these are mentioned in subsequent paragraphs under item heads.

Shed Floors (Photo 3)

The specification originally called for a 2-in. layer of sand between the chalk and the 6-in. concrete shed floors. When the steelwork contractor refused to erect steel on chalk during the winter months, gravel was substituted for sand, which when compacted with an 8-ton roller gave a better base on which to erect steel. With the contractor's agreement, this change involved no extra cost.

It proved a wise decision not to erect on chalk, as unprotected chalk becomes unusable in wet weather. The structure of chalk with its many fissure planes is eminently suitable for the quick disposal of large quantities of surface water, but if wet chalk is disturbed by traffic, its structure breaks down and the top layer becomes sticky and impervious. Recently compacted chalk then loses its compaction and the area becomes impassable.

If, however, the chalk is compacted in dry weather and is then covered with a well rolled layer of gravel or hoggin, the surface of the chalk is protected from traffic and its draining qualities in wet weather are only minimized by the degree of imperviousness of the gravel layer. Although there may be ponding of water on the gravel, the site remains perfectly usable by traffic or plant without affecting the chalk. The gravel used in this case was a natural well-graded river gravel which compacted on rolling into an almost solid mass with low air content. This made an ideal carpet for steel erection.

In the case of the last shed for erection (Shed 5), the chalk subgrade, which was largely fill, was alternately frozen and flooded which prevented the compaction of the last few inches of filling to the final levels and the laying and rolling of the 2-in. gravel layer. To avoid a considerable delay, it was decided to lay an extra layer of gravel over the site of this shed which might stabilize the surface and allow erection. This was done and proved extremely successful, the steel erection proceeding immediately. When the steelwork and cladding were finished the chalk had dried out and stabilized and it was possible to recompact by rolling and then to lay and roll the remaining 2 in. of gravel.

Due to late delivery of the steel at the commencement of the steelwork contract, it was decided to cast one shed floor before steelwork and cladding were erected. However, on commencement of the floor concreting it was found that the specified mix gave very poor results. The specified mix was 1 : 2 : 5 (by volume), with no minimum compressive strength or water/cement ratio stated. The contractor was given the option of using vibration and adjusting the water/cement ratio to suit. He chose to hand tamp and finish the concrete and, using the excellent local aggregates, found the 1 : 2 : 5 mix very unworkable. Not unnaturally he attempted to remedy the situation by adding more water.

It was soon obvious that the concrete we were getting was not of the desired quality and, after numerous site trials, it was decided to change the specification, and a mix was designed using the local aggregates (1 : 2.22 : 4.98 by weight) and light (Johnstone) vibration. A water/cement ration of 0.62 and a minimum 28-day cube strength of 3,000 lb./sq. in. were specified. The new concrete proved very successful and the remainder of this and all other floor sheds were of very good quality. This change involved us in an extra of approximately £1,600.

As the floor slab to the original specification was also the floor cast before shed erection, this slab suffered more from exposure to the elements and to traffic than the others. It was also cast during the hard winter months of 1952/3 and despite curing blankets and careful protection, extensive frost damage was suffered by two bays (which were removed and replaced at contractor's expense) and there was minor surface damage to other bays.

This again shows the advisability of laying the floor after the building has been erected, particularly in winter weather and on exposed sites.

Two interesting cases of temperature movement of the concrete floors occurred during the progress of the contract.

The first and most important movement was due to frost heave of the chalk under the floor of the exposed shed. The frost penetrated the 6-in. floor slab and the 2-in. gravel layer to form, presumably,

Photo 3.—General view across bays in Shed 3 with central drainage channel and under floor drainage being laid, near bay covered with gravel but with no floor laid.

Photo 4.—Detail of underside of roof, glazing and sheeting complete.

A Vehicle Covered Storage Project At Ludgershall 3 , 4

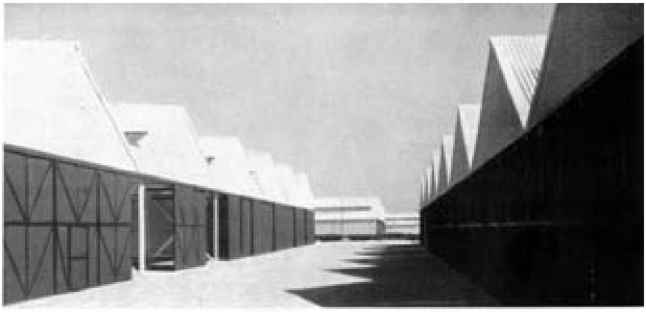


Photo 5.—A view showing sliding doors on Sheds 1 and 3.

Photo 6.—Soakaway cap, R.C. work complete.

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the typical horizontal layers of ice lenses, causing lifting of the slabs. It was possible to observe and measure this against the concrete surface water channels at the centre of each bay which, due to their extra thickness of construction, were unaffected. The maximum movement observed was of the order of ½ in. which occurred after a 10° F. frost, which was preceded by an extended period of frosty weather. Traffic was, of course, kept off the floor until it returned to its normal position, which took about five days of warmer weather with only slight night frost.

Other floors were completed after the frost period and while no observations on frost heave were possible, slight cases of floor heave were observed during the very hot weather. The movement of the floor slabs was of the order of ⅓ in. The cause of this movement was probably the small allowance for expansion of the slabs. In one direction, building paper dipped in bitumen was provided at 12 ft. 6 in. intervals while in the other direction the same joint occurs at approximately 24 ft. centres, with ⅜ in. expansion joints only at walls. The provision for expansion, particularly in the latter direction, would appear inadequate.

Floor Hardener Experiments

Experiments to determine the effectiveness of eleven proprietary floor hardeners and waterproofers were carried out on the floor of Shed 5, where heaviest tank movement was expected. The products involved three types of processes: (*a*) surface treatments applied after curing, (*b*) integral treatments applied to the concrete in the mixer and (*c*) one example of a special granolithic topping. A careful log was kept and details of layout, difficulties experienced and cost of each treatment were submitted to higher authority in an initial report. Reports on wearing qualities will be provided in half-yearly reports.

This work was carried out by the main contractor and, of course, an agreed rate (star price) had to be fixed for each when materials and daywork basis was not acceptable. With limited experience of the work involved with so many types of treatment, the contractor pressed for a rate which appeared high to cover the "unknowns". In these circumstances, perhaps a more favourable price can be obtained when the rate is agreed *after* the work is completed—contrary, of course, to all approved procedure.

Shed Steel

Due to shortage of U.K. stocks at the time, the steelwork for the sheds had to be imported. The only faults noted were slight but unimportant bowing of a few stanchions and the softness of the nuts and bolts. Apart from the end frames, all bays are identical and this leads to great ease of assembly and erection. No difficulties at all were experienced with the steelwork.

Shed Cladding (Photo 4)

The cladding of the sheds is asbestos cement sheeting. Bitumen dipped asbestos cement valley gutters, and asbestos cement rainwater pipes are provided. While the sheeting was perfectly satisfactory, some trouble was experienced with the valley gutters due to insufficient curing of some units before dipping. The defect was evident by brown patches on the gutters, where the bitumen coating almost disappeared. The contractor was ordered to repaint these gutters with bitumen and the treatment appears to have been successful.

The roof glazing of sheds is Georgian wired with aluminium glazing bars and is very satisfactory in all respects. It might be well to mention here that the design does not provide for roof ventilation. I understand that before this was omitted it was given consideration with users and it was agreed to be unnecessary in view of the static nature of the vehicle store. Initial experience, however, does seem to indicate that some form of roof ventilation would be desirable.

Shed Doors (Photo 5)

As mentioned, continuous lines of sliding doors occupy the ends of each shed. These doors are on two tracks, running on bottom rollers and supported by horizontal top rollers running between guides. The doors are steel framed and sheeted with Robertson's protected metal.

Before the final grouting of the door tracks takes place, there is a cavity between the tracks and on each side of them which is large enough to take the bottom roller if a door is derailed. The resultant dropping of the door is sufficient for the top rollers to clear the guides and the door is free to fall. A recent fatality on another site when this occurred led to the contractor ruling that no work must take place on doors (i.e., sheeting, painting, etc.) until this final grouting was completed. It is considered that a suitable instruction on the standard drawing might prevent future accidents.

When a shed floor is not stepped it is possible for all the doors to be moved into one half of the shed leaving the other half completely open. This means that each door can be moved along a considerable length of track. As all doors vary very slightly in size and setting of rollers, there is a tendency for some doors to jam in a position which they do not normally occupy. Considerable adjustment was necessary to make all doors free over the complete length of their travel and this seems to be a difficult and unnecessary requirement. An advantage in door serviceability might be gained by door stops at each bay. This would allow 50 per cent opening of each bay which should be quite sufficient. Erection would be greatly simplified and a potential source of damage to doors when operated by playful troops would be eliminated. There is considerable scope for "hide and seek" with doors with the present arrangement.

The door drop bolts proved to be inadequate for their purpose. Consisting of ⅝ in. mild steel bars, they are easily bent when a moving door collides with a bolted door. The door with a bent bolt cannot then be opened. Due to the design of the doors an easy remedy is not to hand, but an endeavour is being made to overcome this fault.

The concrete channel in which the tracks run is constantly filled with water in wet weather and there should be some form of drainage here, although it is realized that this is liable to be constantly blocked with dirt. Apart from the tendency to rust the bottom tracks, the effect of the freezing of this water may be to jam the doors in winter months.

Already a tank which was slewed at the entrance has caused damage to a door track.

The disadvantage of using bottom guides where tanks are to use the entrance was, I understand, appreciated but for standardization sake and the expense of alternatives the pattern was retained. I do feel that experience will show that this decision was wrong and that "door trouble" here will be one of the G.E's. maintenance headaches.

Shed Walls

During the progress of the contract it was decided to change the dwarf walls and firewalls from *in situ* reinforced concrete to hollow concrete block construction, reinforced integrally with concrete plinths around stanchions. This resulted in a considerable saving of time and money.

The only fault which has appeared in these walls is a crack in many bays from the damp-proof course to the top of the wall. This is due to the movement of the steelwork with temperature changes. Not much harm is done, however, except to allow some dampness to penetrate, as the friction across the cracks retains most of the strength of the wall.

A possible remedy would be to enlarge the concrete plinths around the stanchions, leaving them integral with the block walls, but to box out around the stanchions themselves in the centre of each plinth, so that the movement of the stanchions would not be communicated to the walls.

Stormwater Drainage

The underfloor drainage system collects water from the shed down pipes and floor gullies and delivers it to the main stormwater drainage system. The floor drainage system entails a drainage slope on every floor bay to the centre which means extra grading and labour items at considerable expense for the apparent purpose of collecting water, presumably, from drained radiators. It appears that if this is the only purpose of the system it could well be dispensed with, as small quantities of water would readily evaporate from a flat floor and considerable expense could be avoided. If this was a user requirement it should, in my opinion, have been overruled on the ground of cost.

The main problem encountered during work on the drainage system was compaction of the backfilled chalk in drainage trenches. The compaction called for was not less that 90 per cent of the solid chalk. Mechanical rammers proved more successful than hand ramming, but any compaction method in chalk which does not depend on the optimum water content of the chalk for compaction is doomed to failure and all specifications on this subject should make this clear so that the contractor will plan this work for execution in suitable weather conditions.

Much inferior compaction had to be rejected as a result of site tests, while some was spectacularly revealed by heavy continuous winter rain on gravelled shed floors awaiting steelwork before the concrete floor was laid. The water ponded on the almost impervious gravel surface and entered the chalk beneath at positions where compaction was poor, notably around the shed manholes. This resulted in large scale subsidence around the manholes, and as the water drained into the subsided areas it ran along the bottom of the back-filled trenches on the "base" formed by the concrete surrounds to the drain lines. During this process it washed away chalk particles causing considerable subsidence along the complete lines of the drains. Subsidence of the order of twelve inches along the drain lines and two or three feet at the manholes was experienced. This was complicated by the circumstances that the shed drain lines ran under completed concrete roads causing several serious examples of "suspended" road slabs. The suspended slabs had to be supported by pressure grouting through holes bored in the slab, after "cut off" walls of concrete had been formed at each side of the road. The treatment appeared to be completely successful and was, of course, at the contractor's expense.

The backfilling of trenches with weak concrete, while it is probably worth while under extremely heavily loaded floors, is only dictated by a lack of confidence in compaction methods. It does appear that efficient compaction of various soils by suitable plant deserves more study than it has hitherto been given.

The final disposal of water in soakaways was a large problem as the complete project will render quite large areas impervious and the disposal of very large quantities of water is involved. Extensive storage volume and large chalk contact areas for rapid soakage are demanded. The rate of soakage is dependent upon the head of water and a deep pit is desirable.

The five soakaways built are circular in plan and 18 ft. in diameter. Four are 35 ft. deep from the surface and one 12 ft. 6 in. deep. These holes were dug in the chalk quite quickly, using small compressed-air clay spades.

The vertical walls were lined with 18 × 18 × 9 in. hollow concrete blocks, with the cavities horizontal, thus allowing the water to be in contact with the chalk over a large area. A conical concrete roof, partly precast, was used; supported partly by the hollow blocks and partly by the surrounding chalk (Photo 6). The floors of the soakaways were covered with sand, except under inlet pipes, where a brick and concrete splash compartment is provided to prevent damage by the falling water.

After a winter's use these soakaways are working very efficiently and their rate of disposal of water when operating under a near maximum head, is impressive.

Roads

The roads are constructed of 4 in. well compacted gravel on the chalk base with a 6 in. reinforced concrete slab covered by 2 in. of asphalt.

The strict specification of the gravel compaction to a required density was very successful and excellent results were obtained. The concrete slab was vibrated by Holman compactors to give a minimum cube strength of 4,000 lb. per sq. in. at 28 days. Generally, the concrete was of very high quality.

The wearing surface of the roads is mastic asphalt at all points where tanks will normally be turning, and rolled asphalt elsewhere. The economy in using rolled asphalt (approximately 20 per cent) may not prove justified when considering the greater resistance of the mastic and especially when in tank depots the movements of vehicles are largely unconventional, with heavy wear occurring at unlikely places.

On the advice of the Road Research Laboratory the consultants proposed a change in the specification for the rolled asphalt during the progress of the asphalting, which was adopted, to give a smoother, denser surface. The result of this change must await adequate traffic wear, but early indications are good.

Experiments were conducted by R.R.L. in the design of tank road surfacings and joints on some of the roads, but full details and report are not available as yet to the writer.

Water Supply

The water supply in this project consists of ring mains fed from a water tower and supplying fire hydrants for all buildings. This main also supplies stand pipes in the main store sheds and will supply other buildings in future phases. Due to long supply delays of asbestos cement pressure piping, cast iron water piping, which was more available, was used instead.

The necessary head of water is provided by an 80-ft. water tower and 50,000 gallon tank, supplied by an electrically driven centrifugal pump, operated by an automatic float switch in the tank. In the event of an extensive fire, which would empty the tank before being brought under control, it is possible to feed the ring mains direct from the supply mains at a rather reduced pressure.

No snags arose during construction of the system and it is efficient in operation.

Fence and Gates

The security fence around the site consists of reinforced concrete posts, supporting chain link fencing, surmounted by three strands of barbed wire. Observation posts are placed at intervals to enable guards to view the outside of the fence lines.

Large tubular steel gates across the railway and entrance road proved very successful and easy to operate.

Electrical System

The electrical supply for the project is fed from a feeder station, built in Phase 1. The distribution for this phase consists only of the lighting and power circuits for the store sheds.

The *in situ* concrete under-floor ducts, originally specified, were replaced by salt-glazed stoneware pipes surrounded with concrete, with the necessary manholes. The change, besides saving money, avoided the necessity of leaving bays unconcreted until the cables were laid.

The distribution from the cut-outs in sheds is T.R.S. cables on battens and the lighting consists of 5 ft. fluorescent lamps, of which there are some 316 in each large shed.

Cost

The accepted contract figures were in the order of £220,000 for the civil engineering work and £190,000 for the steelwork. V.O.Ps. on the civil engineering contract were an addition of approximately £19,000 or about 9 per cent of the over-all cost. V.O.Ps. on the other contract were not finalized at the time of writing.

Alterations and additions to the steelwork contract were about £830, while on the C.E. contract they amounted to approximately £14,000, or nearly 7 per cent of the contract figure.

Conclusion

The project proceeds, with Phase II in its infancy, and already there are signs that Phase III may soon be on the horizon. It is not for this pen to complete the picture. Such is the turnover in Cs.R.E. that the project will shortly have its third superintending officer.

For all but the very experienced works officers, there were lessons in plenty to be learnt from Phase I; not new lessons but old time-honoured ones which must be learnt and relearnt by the works neophyte. All are more than adequately covered in Regulations and

Technical Notes and Instructions. In this instance, they could nearly all be summarized as follows:—

(*a*) A very thorough and detailed knowledge of the work called for in the contracts is essential. This entails hard work and continuous study.

(*b*) Firm control must be established from the commencement of work. Good site relationships must be built up on this basis.

(*c*) Good detailed supervision can only be achieved by the careful planning and organization of it at site. Co-operation from contractors will greatly facilitate this task.

(*d*) The value of holding regular monthly site meetings with full representation on both sides, especially during the development stages of the contracts.

(*e*) The immense importance of detailed and accurate site records, including a very complete diary of events.

(*f*) The importance of preparing accurate forecasts of expenditure on the project. Your whole reputation may depend on this!

From this, the reader will appreciate how much depends on the quality and competence of those engaged on site supervision. This, of course, has application to all works services, large and small.

In this respect, we have been very fortunate on this project in having in Mr. Hayter such a capable and energetic site engineer.

AIRS IN A STRINGBAG

By Lieut.-Colonel J. H. S. Bowring, M.C., R.E.

THE term "Stringbag" is usually applied to the gallant old naval Swordfish. I hope I may be forgiven for using it here in the wider sense, to cover any machine whose speed may be gauged by the note of the wind in the rigging, and in which pretty keen racing may be had with express trains.

The stringbag in question was a Tiger Moth bought by the R.E. Flying Club from the R.A.F. for £50. I had the use of this for some time for getting round a scattered C.R.E. works area in East Anglia, with the H.Q. in one corner. If you consider it odd that, after fifty years of flight, the only way an army officer can fly round his parish is by using a private machine of ancient vintage almost entirely at his own expense, I would be the first to agree. I will not bore the reader with accounts of the official attitude, beyond saying that I never succeeded in getting more than the lower rate of 2d. a mile. I was refused the use of Air O.P. Austers which were available near to hand, and I received a great deal of help from the R.A.F., none whatsoever from the Army.

The points which follow may be of interest to anyone contemplating doing something similar, by which time, let us hope, a more positive attitude towards army flying may have been adopted by those in authority.

The Tiger as a Tourer

The Tiger Moth is a delightful aeroplane to handle, and in spite of having no flaps or brakes, has a remarkably short take-off and landing run, and a high rate of climb. But as a tourer, it has its snags. Being open, it is unconscionably chilly in the winter, and any attempt to unfold maps in the air almost inevitably leads to their disappearance. You have to dress up like a man from Mars, and there is little luggage space, though a narrow suitcase can be substituted for a passenger in the front seat. The cruising speed is low, which greatly affects progress in high winds, and this is obtained with a high fuel consumption compared with a monoplane. The low wing-loading severely limits the wind which can be safely negotiated on the ground. In the air, when it is rough, the compass swings wildly, and there is no gyro direction indicator and no radio. It is meant for elementary instruction, and not touring, and is excellent for that purpose.

For all that I travelled some 5,000 miles across country in it, and dearly loved it. It was at least an aeroplane and a well-mannered one at that, and it induced a kind of amused nostalgia at all the R.A.F. stations it visited. One day at Watton, a ground crew of very young airmen, summoned to start it, brought out an enormous battery on a trolley and chocks two feet high. I had to give them lessons in prop-swinging in front of the officers in the control tower, who pretended to be looking the other way. At Benson, a search was made for an old Warrant Officer, who, someone thought, remembered how to do it. He did, and it made his day.

The Base

If you were to suppose that a R.A.F. station operating light aircraft, like Henlow, would form an ideal base for a private aircraft flown by an officer on duty, you would be quite wrong. The Air Ministry lays down exorbitant hangarage charges for private aircraft, irrespective of their purpose, and will not provide fuel or oil, except in emergency, or do any maintenance. After months of negotiation I did obtain from them a letter allowing me to draw petrol at R.A.F. stations on prepayment (repayment was refused). This procedure entailed searching out the stores officer, filling in a form, then finding and paying an accounts officer, before proceedings could begin. This may appear rather cumbersome until one remembers that it would have been quite impossible to get petrol out of the Army at all!

I therefore used a civil airfield—Cranfield, the home of the College of Aeronautics, where they gave me very reasonable terms. They could not have been more helpful and efficient, though the matter was of no financial interest to them, rather the reverse. The snag was that, like many minor airfields, they closed at 5 p.m. and at week-ends, so that a satellite was necessary. This turned out to be Old Warden, near Biggleswade, where sometimes the Tiger was added temporarily to the famous Shuttleworth Collection of museum pieces, most of which still fly and are often to be seen at flying displays. Being a private field, it could, unlike an official one, be used at any time, whether manned or not—an odd bureaucratic paradox. It looks alarmingly small and the grass is apt to be three feet high. But it is all right for small aircraft.

The Tiger had its major maintenance at the main base at Rochester. Cranfield only did daily and ten-hour checks.

Cost

As hangarage and daily handling rates at Cranfield were much the same as at Rochester, the club allowed me the use of the machine at normal club rates per hour, but I had to pay any extras such as landing fees and hangarage away from base. This worked out at roughly 6d. a mile, but it should be remembered that the club is subsidized. The normal civilian rate for light aircraft is £3 an hour, or about 9d. a mile, and this would be a fair figure for a travelling allowance. This is of course an expensive and wasteful way of doing things when many Army and R.A.F. light aircraft are available but little used.

Landing Grounds

It is not as practicable as it might seem to use ordinary fields near the destination. The combination of a sufficiently large and flat grass field, with clear approaches, no livestock, and an agreeable owner, is fairly rare, and a guard is necessary against cows and small boys' penknives. This also applies to disused airfields, which usually have squatters in the derelict hutments. It is therefore best to use proper airfields, which have the advantages of a met. office, a crew for starting, and a telephone system to other airfields. Civil airfields in East Anglia are very few, but R.A.F. stations would never refuse a visit provided one gave previous warning. Not having radio, one had to keep a sharp look-out for jet aircraft and wait for a green. The staffs of these R.A.F. stations were always most helpful.

The local G.E. would either meet me himself or send a clerk of works.

USEFULNESS

Time is not often saved by flying distances up to fifty miles, but for greater distances the saving rapidly increases. I found that on return journeys of an hour each way—say eighty miles out and back as the crow flies—the time saved, door to door, compared with travel by car, was about three hours. Most journeys varied between seventy and a hundred miles each way, so a saving of one and a half times hours flown may be considered a fair average. The number of trips which can be made is governed by the necessity of seizing weather opportunities, which cannot be predicted far in advance.

High winds and bad visibility are the main hindrances, especially the latter. Surface winds of 20–25 knots can be negotiated with great care on the ground, but this usually means a rough passage with 35–40 knots at cruising altitude, which begins to be uneconomical. On a return journey at an air speed of 80 m.p.h. and a head and tail wind of 35 knots, the reduction of average ground speed, and range, is 25 per cent. With the same wind on the beam, the reduction is 12 per cent. Visibility can be very unpredictable, and vary rapidly, both in place and in time, so that it constitutes the main hazard. It is seldom good in England, and if any considerable use is to be made of the air, it is often necessary to fly in marginal conditions, which becomes easier with experience but requires meticulous navigation and plenty of reserve fuel. In unstable conditions, rain and thunderstorms can sometimes be by-passed, but not always, and squally weather is apt to cause so much delay that it is hardly worth flying in, at any rate on business.

All this makes flying a bad way of keeping firm dates, and if one is away for more than a day or two, one may get stranded at an outstation. It is therefore best used for day trips for special purposes rather than for tours. In winter, short daylight hours and bad weather reduce the scope very greatly, but even then overnight trips will often pay. I would say that in England in this kind of job, if money were no object, it would be possible to do ten hours a month of useful duty flying in the summer months, and anything from nil to five in the winter, a total of around eighty a year. This represents a saving of about fifteen working days or three weeks' work. This rate of use would not justify the sole use of an aircraft: what is wanted is ready access to a pool.

But the value of light aircraft is not to be measured alone in time saved in travelling. The best way to appreciate a country is to float over it fairly slowly at a moderate height. Unlike the blinkered and foreshortened view from a road, nothing is left out or over-emphasized and everything is seen in its due place and proportion. The value to the soldier is obvious, and how much more to the engineer. And there is a world of engineer air reconnaissance technique still to be developed.

Besides, it is great fun, and a good mental tonic,

Navigation

This is not a treatise on air navigation, but there are a few things which I have found by experience to be useful, though they may horrify the real flying pundits. In this context, the main object of flying is to save time, and therefore one wants to waste as little as possible in preliminaries. And it is not always convenient to carry around such gadgets as protractors and computers, even if one possesses them. In an open cockpit it is practically impossible even to refold a map, let alone lay off courses and such—or at any rate I find it so. My aids to navigation were therefore only two—maps, and a flying notebook.

The latter contained three tables, which could easily be consulted in the air if necessary. The first was a list of magnetic tracks both ways, distances and times at 80 m.p.h., between any airfield and any other I was likely to use. The second, which is shown here, gave the amount of "lay off" necessary to counteract drift, and the resulting ground speed, for various strengths of wind at angles of 0, 45, 90, 135 and 180 deg. to the track, assuming an air speed of 80 m.p.h. (I also had a second set of figures in pencil for an air speed of 70 m.p.h., but this has been omitted for simplicity.) The third table showed the time taken to travel various distances at intervals of ten miles at ground speeds of 70, 80 and 90 m.p.h. (60 and 100 being too easy!). The book also contained telephone numbers of all airfields and offices I might want to get in touch with, and some information relating to the Continent, which is not strictly to the point.

Predicted wind speed and direction at a given place and height is never quite right, and in a slow machine the resulting errors in course can be considerable. One must therefore correct early, and keep on correcting, by observation, and it is no use being too academic at the start. A man who works out the theoretical answer to the nearest degree with a computer will probably be no more correct in the event than I am with my simple table. It is easy to interpolate mentally between the five angles and the wind speeds, and get a serviceable answer to start off with. You can probably guess your ETA near enough to give to Flying Control, and then the whole thing can be done in the cockpit while the engine is warming up, which wastes no time at all. I had all the usual tracks ruled permanently on the maps.

You will notice that in the table the wind speed is given in knots, but the ground speed in m.p.h. This is because met. offices always quote in knots, but most light aircraft have air speed indicators calibrated in m.p.h., for some perverse reason.

For checking time and distance, some people like to plot predicted time intervals on the maps. This not only wastes time in getting off, but if you cover the same territory a lot, the map soon becomes a mess, because the answer is different each time. I prefer the alternative of marking the usual "rabbit runs" at ten-mile intervals. Then, by using the third table and your watch, you can instantly check either your position or your ground speed, according to which you know. If you don't know either it's too bad. It is also useful to mark the 15-mile point from each end, owing to the rule of thumb that 1 mile off track at 15 miles represents an error of 4 deg. This helps the initial course correction.

Generally the ½-million I.C.A.O. map is the most convenient to use, as one sheet covers a sizeable area, and it concentrates on the features that matter and show up. But if visibility is bad or one has to fly low, the ¼-in. air edition comes into its own. It is a work of art, but its use entails much fumbling and folding. If going any distance, it is best to fold the successive ¼-in. sheets into strips along the desired track, before setting off.

Alternatively, if you don't like my notebook system, you can buy a *Swissair Navigator* for four guineas, which will do all this and also tell you your true airspeed at 300 knots indicated at 20,000 ft., besides various other exotic and improbable answers. But it won't get you to the Bar de l'Amirauté at Le Touquet.

At Airspeed 80 m.p.h.

Wind	5	10	15	20	25	30	35	40	Knots
Angle Wind-track			Layoff—Degrees						
45°	3	6	9	12	15	18	21	24	
90°	4	8	12	17	21	25	30	35	
135°	3	6	9	12	15	18	21	24	
Angle			Ground Speed—m.p.h.						
Wind-track Ahead	74	68	63	57	51	45	40	34	
45°	76	71	66	62	57	51	46	40	
90°	80	79	78	76	75	73	70	65	
135°	84	88	91	94	98	100	103	117	
Astern	86	92	97	103	109	115	120	126	

ARCTIC AIR BASE

By MAJOR A. C. COOPER, R.E.

THULE is situated in north-western Greenland, only some 900 miles from the North Geographical Pole. The United States Government was given permission to build, operate and maintain certain defence areas in Greenland under an agreement concluded with Denmark under N.A.T.O. auspices in April, 1951.

Thule Air Base comes under command of the C.-in-C. U.S. North-East Command and the reasons for constructing an air base at Thule are best expressed in the C.-in-C's. own words:—

"The air routes through the Arctic provide the shortest distances for air travel between major economic and industrial centres of Europe and the United States. A defence in this part of the world—and a strong one—is a requirement that cannot be ignored, for the following reasons:—

(*a*) This area lies on the direct sea and air routes between the north-eastern parts of the U.S. and the N.A.T.O. nations in Europe. Personnel and material shuttle to and fro along this line of supply.

(*b*) This area contains that portion of the western hemisphere which lies closest to Europe.

(*c*) This area covers the air routes which a potential enemy could use to the greatest advantage in striking at Canada and the U.S.A.

(*d*) This area provides an unexcelled vantage point from which to study mass air movement and forecast weather for military operations in the North Atlantic and in Western Europe."

In Christmas week, 1950, the Secretary of the Air Force acquainted Lieut.-General Pick, Chief of Engineers, with the project of building an air base in North Greenland. The airstrip, and sufficient facilities to support it properly, were to be operational not later than 1st October, 1951. A small survey and reconnaissance party landed on the old Thule airstrip (built for the Danish weather station) in early 1951.

The advance party arrived in May, 1951, and prepared the beaches for off-loading, and erected temporary living quarters. The first sea convoy arrived off Thule on 9th July, 1951, and over 300,000 tons of cargo were discharged over beaches and the pier, in the short sixty-day period the sea was ice-free. The first plane took off from the new airstrip on 11th September, 1951.

The local conditions at Thule provide the engineer with a number of problems. The winter climate is rigorous; temperatures of 40° F. below zero and lower, and winds of 125 m.p.h. and higher are recorded. No effective outside construction work can be carried out between November and April. Between early November and mid February there is total darkness, and between 1st May and 20th August there is continual daylight. Drilling for water established that permafrost extends to 1,000 ft. below ground surface and probably lower. The active layer (which freezes in winter and thaws in summer) is between 3 ft. and 5 ft.

How the U.S. Corps of Engineers overcame these natural difficulties and built a $200 million air base would be of general interest but much of the information concerning Thule is still classified. This article describes the organization of the work, the port facilities, the construction of the main airstrip and certain details of the structures and utilities in the base.

Organization in Thule

The main point of interest to Royal Engineer officers is the way civilian contractors and architect/engineers have been organized for the task. There is a small U.S. Corps of Engineers H.Q. (similar to our C.R.E. Works), controlling a firm of contractors and a firm of architect/engineers. Briefly, the architect/engineers prepare plans and specifications and inspect the work carried out by the contractors, while the contractors (North Atlantic Constructors—N.A.C. for short) procure materials, equipment, hire civilian workmen and carry out the work. Over-all control of the project is retained by the Area Engineer, U.S. Corps of Engineers.

The contractors operate on "cost plus fixed fee". When the project was started there were so many unknowns about construction on permafrost that no contractor was willing to tender. However, it is claimed the "cost plus fixed fee" has the following advantages:—

(*a*) The fee is not varied should the actual cost differ from the estimate.

(*b*) It is to the contractor's advantage to spend less than the estimate, for prestige. There is no advantage in spending more than the estimate, as the fee does not rise.

Organization in the U.S.A.

N.A.C. have a screening and hiring base in Minneapolis, where men are trade tested, given arctic indoctrination, physically examined and trained in first aid. Norfolk, Va., is the port for receiving, processing, warehousing and loading cargo for surface shipment, and Westover Air Force Base, near Springfield, Mass., is used as the airlift port for freight and passengers.

Working Hours and Rates

During the construction season, work is in two ten-hour shifts, seven days a week. Earth compaction can only be carried out between mid-April and mid-September, as before and after these dates the earth is freezing.

Rates of pay are high and relatively higher in the unskilled rates that the skilled. A heavy truck driver will earn $3.55 an hour for the first 40 hours and thereafter $5.55 an hour for the balance of the normal 70 hour week. Out of this a man pays income tax and $40 per month for board and lodging. Comparable rates for a light truck driver would be about $3.25 and $5.25, and for an unskilled man $3 and $5.

Port Facilities

Prior to the project there were no port facilities at Thule and the bay is only ice-free from 1st July to possibly mid-October. In 1951, 95 per cent of the cargo was landed by lighter on eight finger piers, several D.U.K.W. ramps or by L.S.Ts. beaching on prepared hard stands. The finger piers consist of eight old L.S.T. hulks with the superstructure removed, grounded on the beach with earth ramps built up to them. The permanent dock for the base is the De Long dock. This consists of four 50 ft. wide by 250 ft. long patented barges which were towed up from the Gulf of Mexico. The barges have tubes from bottom to deck level, which hold caissons. The caissons were inserted in the tubes and stood high above the deck level. The barges were positioned end to end, caissons were lowered to sea bottom, the barges were jacked up on their caissons, and the caissons were cut off at deck level. Finally, the caissons were filled with concrete and the barges were decked over with planking.

The barges now provide a 50-ft. by 1,000-ft. dock which can handle two Victory ships simultaneously. A 50-ft. wide stone causeway was built out to the dock and extended to one side of the dock, giving a width of 100 ft. for the 1,000-ft. length of the dock. In 1952, 190,000 tons of cargo were landed, 95 per cent on the pier. The forecast for 1953 was 90,000 tons.

Foundations for Buildings

When designing foundations for building on permafrost, it must be decided whether the natural thermal balance is to be maintained, or whether the permafrost table is to be allowed to recede. The latter course usually brings foundation settlement and excessive ground water, as permafrost is usually composed of frost-acting soil, i.e. soil which materially changes its volume when freezing or thawing due to its composition, or due to embedded ice (ice lenses). The normal course is to try and maintain the natural thermal balance so that the permafrost table can be used as the permanent base for foundations.

The thermal balance can be maintained in three ways:—

(*a*) Ventilation.
(*b*) Insulation.
(*c*) A combination of both.

The combination method was used in the majority of cases at Thule.

Combination Method was used for the majority of buildings, such as barracks, warehouses, stores, offices etc. First, a test pit is dug, and soil samples are sent to the laboratory, where scientists compute the required thickness of the non-frost-acting "pad". The pad is usually a minimum of 3 ft. and seems to approximate to the thickness of the active layer. The pad is composed of well-graded sand and gravel which does not materially change its volume when freezing and thawing.

Mudsills of 12 in. by 12 in. timber are then placed at 8 ft. intervals at right angles to the long dimension of the building, and buried 6 in. into the fill. Dwarf columns about 9 in. high, surmounted by 2½ in. packing or shims are placed on top of the mudsills. Stringers of 6 in. by 12 in. timber are placed on top of the dwarf columns parallel to the mudsills. The stringers carry the insulated floor of the building.

This method raises the floor about 2 ft. 9 in. above the non-frost-acting pad and the only contact between the building and the ground is through the dwarf columns which are poor conductors of heat and are exposed to cold air.

Ventilation Method—Plus Insulation was used for boilers, generators and other heavy equipment. For such equipment, a concrete slab is essential; and as concrete is a poor insulator, ventilation under the slab is necessary. A foundation for a diesel generator consisted of a R.C. slab 18 ft. 7 in. long by 2 ft. 8 in. thick supported on eight timber piles, sunk a depth equal to twice the active layer and frozen in. So changes in the active layer would not affect the stability of the piles.

In addition, the normal insulating pad of 3 ft. of non-frost-acting material was placed on the surface, and about a 2-ft. air space was left between the bottom of the slab and the top of the pad.

Insulation Method—Plus Ventilation was used for certain types of buildings (such as garages, fire stations, hangars), which require floors flush with the adjacent ground. The floor slab was placed over the normal 3-ft. pad of non-frost-acting material, but included a 4-in. layer of foam glass insulating material.

In the case of hangars, under-floor ventilation was provided by 12 in. diameter corrugated metal pipes, at about 3-ft. centres, placed in the non-frost-acting pad. The pipes take in cold air on the up-wind side of the building and discharge on the down-wind side. Temperature recording instruments have been placed in the ventilation channels, and records to date show the system is functioning as planned.

Maintenance of Foundations

Routine inspections are made as follows:—

(*a*) *Pads.* To ensure designed levels and slopes are maintained.
(*b*) *Mudsills.* For warping, shrinkage and rot.
(*c*) *Air Spaces.* Must be kept free for air circulation.

In addition, care must be taken that no water or sewage is dumped in the vicinity of buildings, and that no heaters are installed in buildings designed to be unheated.

Types of Construction

All general purpose buildings such as barracks, warehouses, offices, heating and power plants are of Clements panel construction with timber or steel frame. The Clements panel is prefabricated with aluminium and plywood outer and inner skins enclosing a layer of insulating material, and is used for floors, sides and roofs. They are light, quick to erect, easy to transport, weather proof, require no paint or varnish, fire resistant and 100 per cent recoverable. (See Photo 1.)

Water Supply

In the first year three enormous seawater distillation plants were built. There are nine units of 12,000 gallon/day capacity, totalling 108,000 gallon/day. At present water is distributed by heated tank truck from a lake about three miles away from the camp, and the distillation plant is used as a stand-by.

Other Construction Data

The total number of buildings is 226, and 16.5 miles of permanent roads have been built. The total cost excluding the 1953 programme was $182.7 million. Including the 1953 programme the cost was estimated at over $200 million.

The Airstrip

The main air-strip is 10,000 ft. long by 200 ft. wide. The specification for the runway is as follows:—

(*a*) *Fill*

Bottom 3 ft. of up to 24-in. rock.
Next 2 ft. of up to 8-in. rock.

(*b*) *Surfacing*

Bottom 6 in. of up to 2½-in. rock as base.
Next 2½ in. of hot-mix asphalt concrete (aggregate up to 1½ in.) as binder course.
Next 1½ in. surface course of hot-mix asphalt concrete (aggregate up to ¾ in.).

About 2 million cu. yds. had to be excavated. The permafrost had first to be loosened by blasting. The depth of hole and size of charge varied, but holes were generally on a 4 ft. spacing pattern, and 1½ lb. of Atlas 40 per cent powder were used per cu. yd. of cut. Excavated permafrost was only used as fill on the 200-ft. shoulders of the runway and not on the runway itself. About 10 million cu. yds. of fill has been used and the average haul was 1½ miles. Fill was all of non-frost-acting material. Compaction was by 100-ton rubber tyred rollers and wobbly-wheel rollers.

There were two crusher units (primary only) and four crusher units (primary and secondary) with average production of 3,000 cu. yds./day. The hot asphalt plants produced 1,000 tons/day of the 2½ in. binder course and the same quantity of the 1½ in. surface course.

Work was started in July, 1951, and 7,000 ft. of usable temporary surface was completed by September, 1951. The runway was extended to 10,000 ft. and paved in 1952. (See Photo 2.)

Mechanical Equipment

The amount of equipment required to carry out such a task so quickly should come as no surprise. The following is a list of the equipment at Thule.

D-8 Bulldozers	132	DW-10 Cat wagons	55
Cranes and shovels	64	Motor graders	32
Dump trucks—Euclid	60	Cargo trailers	160
Dump trucks—Chevrolet	124	Ford pickups	99
Jeeps	46	Tanker trucks	42
Rollers—steel wheel	16	Super compactor rollers (100 ton)	3
Compressors	68		
Welding machines	46	Wagon drills	68

Maintenance was carried out by N.A.C., mainly with mobile gangs working on site. There was also a central repair shop.

Conclusions

Thule Air Base is the first major installation to be constructed inside the Arctic Circle and entirely on permanently frozen ground. From the engineer point of view, the main points of interest are:—

(*a*) The speed in which a large runway can be constructed, given sufficient machines and skilled men.

(*b*) The way buildings have been constructed, without disturbing the thermal balance.

There is no doubt that the U.S. Department of Defense Agencies have done a magnificent job.

Photo 1.—Clements panel construction with timber or steel frame.

USAF-NEAC photos

Photo 2.—Thule Air Base—with Mount Dundas looming in the background, and the runway in the foreground.

Artic Air Base 1 , 2

Photo 1.—Landing bay on landing bay raft ferried across to the far bank.

Photo 2.—The complete bridge, with one bridging crane.

Caesar's Footsteps 1 , 2

CAESAR'S FOOTSTEPS

(Week-end Training by 114 Army Engineer Regiment T.A.)

By Captain D. W. Townshend, R.E.

IT all started in October, 1953, when we were preparing our training programme for the year. Our main subject was Bailey pontoon bridging and we decided to culminate our training by building an actual bridge during a week-end.

After this initial decision the logical questions requiring answers were *when* and *where*. The first question, *when*, was pressing since extra widened Bailey pontoon bridging was new to most of us and we had to allow sufficient training time to become familiar with the equipment. On the other hand we did not want the exercise to be too near to annual camp. In the event only one date was possible. We calculated that we would need about seventy lorries to carry the bridging equipment and this meant a Bridge Company. A Bridging Company, R.A.S.C., an A.E.R. unit, was due to camp from 25th April to 8th May; we plumped for their middle week-end at camp, 30th April to 2nd May, 1954.

So far, so good, but the next problem was *where* should we bridge. It sounded easy, all we required was a stretch of river approximately 200 feet wide with an approach to the river bank on one side and a clear stretch of a hundred yards along the bank for construction.

The initial reconnaissance was made on the river Medway towards the end of October, and two days were spent examining both banks of the river and its tributaries. All to no avail, either the river was not wide enough or there was no suitable approach to the bank.

We decided to be more ambitious, we would bridge the Thames. Our regiment is located in London so we decided to start at the nearest site and work outwards. After a long search we found three suitable sites between Marlow and Pangbourne, and approached the owners. We had no powers of requisition and negotiations took some time. It was not until February that we received the final refusal.

After another fruitless day in reconnaissance a site was eventually found at the end of Papist Way, near Wallingford, approximately midway between Reading and Oxford. This site was 60 miles from London, much farther than we had hoped. Our thoughts again returned to transport, how could we transport the regiment to the site? Again the A.E.R. came to our rescue, a G.T. Company, R.A.S.C. would be at camp at the time, and would provide personnel transport. The story was beginning to unfold, but there were plenty of headaches in store.

We had the transport but what about the equipment? The bridge had now grown to nearly 240 feet and this meant 250 tons of stores. All this had to be sorted into parcels, banded with steel tape, and loaded into lorries. Eastern Command Bridging Camp came to the rescue and did a magnificent job.

With the main essentials fixed we began to think of the frills, that is we originally thought of them as frills, but we very soon found out how vitally essential they were. First traffic control, we approached 56th Armoured Division Provost Company, T.A., and they jumped at the chance to take part in a full-scale exercise.

If we were to complete our task we would have to work shifts continuously throughout the week-end and this meant working at night. The calender showed no moon, but how about artificial moonlight? We approached the gunners and they provided a detachment of three searchlights manned by 873rd Movement Light Battery T.A.

We arranged for all the bridging equipment to be loaded in packages, each weighing approximately a ton, and this meant unloading by crane. We had one 7-ton Coles bridging crane and this looked like creating a bottle neck, but we borrowed two more from two Field Engineer Regiments. Crane operators have an enormous capacity for work provided they are left with their machines, and our crane operators did a stalwart job.

Rumour, still unconfirmed, has it that Julius Caesar crossed the Thames in the neighbourhood of Wallingford (the first ford over the Thames at Walling) when advancing on London from the south coast. Rumour or not it sounded all right and we nicknamed our exercise accordingly.

An operation order consisting of eight pages of foolscap, nine appendices and a trace, and written in the latest American style, appeared eventually and two co-ordinating conferences were held.

H.Q. Engineer Group had offered to handle publicity and their signal troop agreed to supplement communications.

The big day eventually arrived, but the weather prophets forecast rain. Bad weather could delay the operation by several hours and we had only a small time margin. We kept our fingers crossed.

The Bridge Company had loaded up the day before and travelled up to their marshalling area on Friday, 30th April. Our advance parties travelled up during the afternoon and settled down in the harbour areas to prepare for the arrival of the main body. The Provost signposted the area.

The first two snags both concerned Bridge Company vehicles. A decking lorry shed a wheel at the entrance to the lane leading to the site. There was complete blockage to the main Pangbourne-Oxford Road while a crane unloaded the lorry, dragged it out of the way and reloaded on to another lorry which had been emptied for the purpose.

A 10-ton lorry containing track stores was discovered broken down off its route forty miles from the site. This was the very first vehicle we required, since we had intended to lay a metal track across the fields to the construction sites. Without this all our seventy bridging lorries would be bogged down as soon as the rain came. The 10-tonner could not be recovered until five hours after the operation was scheduled to start, we could not afford the delay and decided to risk the weather.

T.A. soldiers are civilians until they have finished work on a Friday and can report to their drill halls. Most of the chaps had reported in London by 8 p.m. and all convoys were on the road by 9.15 p.m. All were in harbour areas by 1 a.m. on Saturday and working parties were on the site to unload stores at 2 a.m.

We had one bivouac between two men and lived under field conditions for sanitation, cooking and sleeping. Each squadron had a harbour area on waste land or in a field loaned by a benevolent farmer.

We had wireless communications between the bridge commander and a liaison officer with the bridging vehicles at the marshalling area and to the squadron harbour areas. The Provost set up a regulating headquarters next to the bridge commander's wireless truck and they had wireless communication with the bridging vehicles and four traffic control points. Thus we had a firm control of the movement of the bridging vehicles and called them forward for unloading in a prearranged order.

We carried on unloading for the rest of Friday night and at 8 a.m. on Saturday morning fresh shifts arrived to start construction.

The bridge was to be made up of extra widened Bailey bridge parts as follows:—

Home landing bay D/S	80 ft. 6 in.
2-end floating bays each 31 ft. 6 in.	63 ft.
2-floating bays each 22 ft.	44 ft.
Enemy landing bays S/S	50 ft. 6 in.
Ramps	20 ft.
Total length of bridge	258 ft.

The site was constricted on the far bank due to a bay which was not wide enough to take a tripartite pier. Consequently the inshore pontoon of the enemy landing bay raft could not be brought close to the bank for launching. We were faced with the alternative of either building a long landing bay on the far bank on a restricted site, or building the enemy landing bay on the home bank and ferrying it across.

We decided on the latter and built 60 ft. S/S on the home bank and launched it on to the landing bay raft. Next a bipartite pier, on to which were strapped rollers on 15 in. of packing, was floated in. The landing bay was boomed out until it rested on the bipartite pontoon of the enemy landing bay raft could not be brought close the rollers canted in dangerously, but the whole was turned round and ferried over to the far bank without mishap. (See Photo 1.)

On arrival at the far bank the landing bay was landed on to rollers and the extra 10 ft. of nose removed. The bipartite pier was partially submerged and floated out. Jacking down was normal.

Construction was well under way by midday on Saturday when the press arrived. The fine weather still held and things were going fairly well to plan. The B.B.C. had sent a television cameraman and he took several shots which were eventually made into a film and produced as a feature in television newsreel. Considering that it was Cup Final day we were indeed fortunate to receive so much publicity.

The first vehicle crossed at 6 p.m.; 210 working numbers, on shift work, had achieved the following timings:—

Unloading 7 hrs. (1 a.m. to 8 a.m., 1st May).

Construction 258 ft. pontoon bridge 10 hrs. (8 a.m. to 6 p.m., 1st May).

It was a Class 30 bridge and looked fine indeed carrying two bridging cranes, each weighing 24 tons. We were justly proud. (See Photo 2.)

Unlike an operation in war, our task was only half complete. We had still to dismantle. Again the time factor came in, everyone had to be back reasonably early on Sunday evening ready for civilian work on the Monday.

We broke bridge and decided on a plan for dismantling and back loading. The troops were much too tired to work continuously, so we decided to work from 8 p.m. to midnight on Saturday, break off for six hours and then carry on until the job was done.

It was at this stage, on Saturday night, that the weather broke and in a very short time four bridging lorries were stuck in the mud. The 10-tonner containing the tracking stores had been recovered, but the gear selector was still faulty and it only worked in top gear. During the night it had broken loose and crashed through a hedge and into a ploughed field, but the beast was now tamed and limped down to the site. We laid a circuit of tracking, but the heavens opened and the recovery vehicle was never short of customers.

Morale might have suffered, but happily both the rum, and the officer authorized to issue, married up on the site and spirits were restored. We continued back-loading during Sunday and were clear of the site by 2 p.m.

In retrospect it seems amazing that Territorial and A.E.R. units accomplished so much in a single week-end. We built, and dismantled a 258 ft. extra widened Bailey pontoon bridge over the Thames at a point 60 miles from our drill halls. Has any T.A. unit done more?

INDEPENDENT INDIA

By MAJOR D. V. DEANE, C.I.E., O.B.E., R.E. (Retd.)

THE author will shortly be the last of the many Sappers who have served in India throughout their careers. One by one, he has seen the disappearance of the survivors from the great exodus caused by the grant of Independence in 1947. From the Railways, the Military Engineering Services, the Sappers and Miners (now renamed as Engineer Groups) and the Survey of India, each of the past eight years has seen a further reduction in numbers, and it will shortly be the lot of the Indian Mints to be the last organization in the country to sever their continuous association with the Corps—an association which commenced for them 130 years ago when Major John Hawkins of the Bombay Engineers and Lieutenant William Nairne Forbes of the Bengal Engineers were respectively appointed to build the Mints at Bombay and Calcutta, and which has thereafter continued up to the present day.

There are many hundreds of Sapper officers, either serving or retired, who have spent varying periods of service in India prior to 1947, and who must still retain a friendly interest in the progress that is being made by that country since the first Independence Day was celebrated in 1947, and who would like to know something about the present conditions of living and of working in India, as compared with those of the British era. It is principally for their information that this article is being written, although it may also be of interest to those who have never even visited India. It must be made clear, however, that the writer is not qualified to describe the progress of events from the Army aspect, except in the most general terms, as his services were permanently transfered to the Mint Department more than twenty years ago, since when he has had little opportunity of keeping in touch with military affairs.

The year 1947 was one which will be noted in India's future history books as a year of triumph followed by calamity. To those British officers—both civil and military—who were in the service of the Government of India at that time, the outlook for the immediate future was uncertain even to the most optimistic, and was extremely stormy to the remainder. As a result, the great majority of these officers, who had no faith in India's ability to govern herself, and who anticipated that the position of any Briton who remained in service would rapidly become untenable, decided not to stay. By their subsequent mass exodus they were unwittingly the cause of yet one more headache to the new Government of India, which itself had to change overnight from a band of ardent nationalists with no policy except to accelerate the end of British rule, to a sober and responsible body of men, with 350 million people to govern, and with an ever-growing number of major problems to attend to, which would have tested the ability of a far more experienced Government.

The nation-wide demonstrations of joy and enthusiasm on that first Independence Day—15th August 1947—were only to be expected, but what was quite unexpected to those of British nationality who were present at that time was the over-night disappearance of anti-British sentiment, and its replacement by a genuine spirit of friendliness which had not been apparent for many years past. That spirit still persists to a great extent, and it is remarkable that even now a British national will normally receive more friendly and courteous treatment than is accorded to an Indian national of equal status, whether he is visiting the Secretariat in New Delhi or searching for bargains in the depths of a city bazaar. Whatever verdict history may give to the correctness of the decision to solve the Indian problem by the partition of the country and by the grant of immediate independence, there can be no doubt that it had the approval of the overwhelming majority of the population at that time. The harsh experiences of the subsequent years—some caused by world events over which India had no control, some by Nature's calamities such as droughts and floods, some by the unnatural division of a geographical entity into two separate countries, and some by the inexperience of those appointed to govern the country—have resulted in a certain degree of nostalgia for the "good old days" of British rule, a sentiment which has been confided to the writer by a strangely varied assortment of persons, including more than one well-known former nationalist. Certainly the Party in power, i.e., the Congress Party, has lost much of its former prestige and popularity since it took over the reins of Government, but it still remains by far the largest and most influential party, and many of the criticisms levelled against it are unfair, as the former régime would itself have been powerless to avert most of the unfortunate events which have since taken place.

It is worth while listing some of the major problems which have had to be tackled during the last eight years, and tackled by a new and untried Government, many of whose Ministers had no previous experience as administrators, and whose usual qualification for office in most cases was to have spent some years in jail during the Civil Disobedience Movement period. (For instance, the very able Minister under whom the writer is now serving, started his career as a Terrorist, and has spent twenty-three years of his life in prison.)

The list below is by no means complete, but it affords some idea of the magnitude and variety of these problems:—

(*a*) The communal massacres, which started in the Punjab in the Autumn of 1947, and which led to retaliatory massacres of Hindus and Mohammedans respectively for several months thereafter throughout India and Pakistan. The number of those slaughtered during this period will never be accurately known, but it was recently estimated by *Time* to have amounted to 400,000 persons.

(*b*) Consequent on the foregoing massacres, the migration into India from Pakistan of several millions of Hindu refugees, most of whom were destitute, and for whose food, clothing, accommodation, employment and rehabilitation the Government of India had perforce to assume responsibility.

(*c*) The "incident" in Kashmir. Although an uneasy truce has now been in force for several years, the Kashmir problem is still the largest single item in dispute between India and Pakistan, and the only one which could conceivably lead to war between the two countries. For this reason, both countries still allocate almost 50 per cent of their central budgetary incomes to expenditure on defence—money which is desperately needed for nation-building activities instead.

(*d*) The integration of the former Princely States into the Indian Republic. In general, this was achieved with masterly diplomacy through the skill and untiring efforts of the late Sirdar Vallabhbhai Patel—one of the outstanding figures in the Old Guard of the Congress Party. In one or two instances, notably Hyderabad, British opinion revolted against the forceful method by which the problem was solved, but few would deny the eventual necessity of absorbing this land-locked State into the Indian Republic, albeit in a less violent manner.

(*e*) The outbreak of war in Korea, with the consequent creation of artificial shortages in many essential commodities, due to stockpiling, and the resulting sharp increase in all prices, which was largely responsible for the index figure for the cost of living in India advancing from 308 in 1947 (1939 = 100) to 457 in 1951.

(*f*) A succession of unusually severe droughts in certain parts of the country, and disastrous floods in other areas. These, together with the loss (through the creation of Pakistan) of some of the former United India's richest agricultural areas, resulted in such scarcity of rice and wheat—the two staple foodstuffs of India—that a rigid system of rationing was introduced for several years in all urban areas, whilst valuable foreign exchange had to be used to purchase and import millions of tons of cereals from abroad.

(*g*) The temporary disruption of the Fighting Services, due to the partitioning of India, which resulted in the disintegration of many famous Indian Army regiments, whose personnel was formerly composed of men recruited from Pakistan as well as India.

(*h*) The disorganization caused to the entire administrative machinery of the country, both civil and military, by the premature retirement of many hundreds of British officers, due to the grant of Independence to India. Although the Indianization of the administration had been greatly speeded up in the years prior to 1947, nearly all the most senior posts were still occupied by British personnel, and only a handful of these elected to remain to serve under the new régime. The result was that the vacancies caused on this account had to be filled by the promotion of junior Indian officers, many of whom were still too inexperienced or too immature in character to be able to shoulder the responsibilities of their higher posts. In the Army, Subalterns and Captains blossomed overnight into Majors and Lieut.-Colonels, and in the civil administration, Deputy Secretaries became Joint or Additional Secretaries. This inevitably caused a general slowing down of the administration, as the youthful occupants of their new posts were reluctant to take decisions which would have been made by their predecessors in office, and relatively unimportant matters were thus passed up for disposal orders to the few experienced men at the top, who themselves were already overloaded with the work involved in the creation of a new Constitution, and in adapting the administration and economy of the country to the new regime.

The birth of the new India was also accompanied by other "Labour" pains. At the outset, the Congress Government, whose political colour has always been a deep pink, encouraged the Trades Union movement and the emancipation of industrial labour to such a degree that within a few years the whole economy of the country was becoming endangered as a result of constant strikes for higher pay, and by a general reduction in output per man-hour. Foreign capital ceased to be attracted to India, several old-established foreign firms sold out to Indians, and one of India's former advantages in the markets of the world for enabling her to sell her goods at competitive prices, viz. cheap labour, was soon eliminated by the combination of higher wages and reduced output. (In the Mints, for example, an unskilled labourer in 1939 received Rs. 18 p.m. In 1955 the total emoluments of the same man—exclusive of overtime pay—are Rs. 95 p.m., and it requires nearly 1,400 men to obtain the same output which 650 men were able to produce in 1939.) The general increase in wages was of course necessitated by the high post-war prices of all commodities, and also in order to improve the still pitiably low standard of living of the poorer classes, but the disastrous reduction in output is quite unnecessary, and is entirely the result of the strongly pro-Labour and anti-management tendency which became all too evident in the first years after Independence. There are now signs that the Government of India is adopting a more realistic policy in this respect, but corrective action can only be taken very slowly, if major stoppages of work are to be avoided, and in order not to alienate the electorate from the present Government.

The situation today is by no means one of unrelieved gloom; in fact, there are several very bright patches amongst the clouds, and these are likely to increase, provided that the country continues to enjoy a reasonably stable Government. The first five-year plan is now in its fourth year, and although it got away to a slow start, it has even so achieved a surprising amount. The second five-year plan is already being finalized on paper, and is a far more ambitious affair than its predecessor. Provided that the necessary finance can be found for its successful implementation, India will be a very different country industrially in 1962 from what she is today. Even now, almost every month sees the completion of some large new undertaking, aimed at making the country self-sufficient in food production, or in her own requirements of manufactured goods. Irrigation projects, hydro-electric schemes, oil refineries, steel-works, research laboratories, shipyards, and factories for producing motor-cars, machine-tools, fertilizers, penicillin, chemicals, locomotives, diesel engines, and almost every other necessity for a modern industrial country—all these are either in production, under construction, or scheduled to be built in the near future. Foreign aid has been generously given to help with the implementation of the country's programme, either as outright monetary gifts, or as loans, or by the provision of special machinery and equipment, and by the loan of foreign experts to act as technical advisers. The total financial requirements for the period of the second five-year plan are at present estimated to be about £12,000 million. The greater part of this is expected to be obtained through (*a*) normal budgetary income, (*b*) domestic savings and investment (*c*) foreign aid, and (*d*) investment of foreign capital. The balance will be made up by deficit financing—i.e., by printing and putting into circulation paper money, to the extent required to cover the deficit. Within reasonable limits, India's financial position is considered to be sound enough to enable her to employ this potentially dangerous method of raising money, but the scheme will have to be carefully and skilfully implemented to avoid renewed inflation, and also to ensure that the administration of the country is suitably geared up to cope efficiently with the rapidly increasing rate of public expenditure. The Central Government expenditure during 1954–5 was approximately £485 million, of which £135 million was capital expenditure under the first five-year plan. It will thus be appreciated how steeply the rate of expenditure must shortly rise in order to average more than £2,000 million yearly during the second five-year plan, even though a portion of this sum will be provided by the various states out of their own financial resources.

The Finance Minister has already started to pave the way for an austerity régime in the current year's budget, wherein a "levelling-down" of incomes has been effected, partly by increases in Income Tax and Super Tax, and partly by the inclusion for Income Tax purposes of certain concessions and allowances, such as free cars, rent-free houses, entertainment allowances and expense accounts, which particularly affect the well-to-do members of the business community. It has also been made abundantly clear that these new measures are only a foretaste of considerably heavier taxation in the years to come, with the ultimate object of setting an effective limit—at a comparatively low level—to the net income that any individual can draw in future. (A disgruntled British business magnate remarked after the last Budget that the country was being turned into a Welfare State for Indians, and a Farewell State for all others.)

It is thus clear that the India of the future will no longer be a country in which the merchant adventurer—or even the more prosaic business-man—can make a fortune and then return to his own country to live on the proceeds. In any case, most of the remaining foreign-owned firms have seen the writing on the wall, and they are fast replacing their former staffs by Indian nationals. For some time to come, there will continue to be a demand for foreign technical experts, but even in this respect the country is progressing very rapidly, and it is likely that within the next ten or fifteen years it will have become self-sufficient in all respects. The one essential condition is that a strong and stable Government should continue in office, and this is likely to be so, at least for as long as Pandit Nehru, the present Prime Minister, remains at his post. His methods and policies since Independence have attracted many criticisms, but there is no other living Indian who could have achieved what he has done towards evolving a homogeneous nation out of the disorganized hotch-potch of communities, religions, political creeds and factions which he inherited in 1947. His westernized background has made him a natural bridge between the Occident and the Orient, and undoubtedly his personal influence was mainly responsible for India's continued membership of the Commonwealth, in spite of her open hostility to it least one member thereof, and of her non-recognition of the Crown as the unifying symbol of such membership.

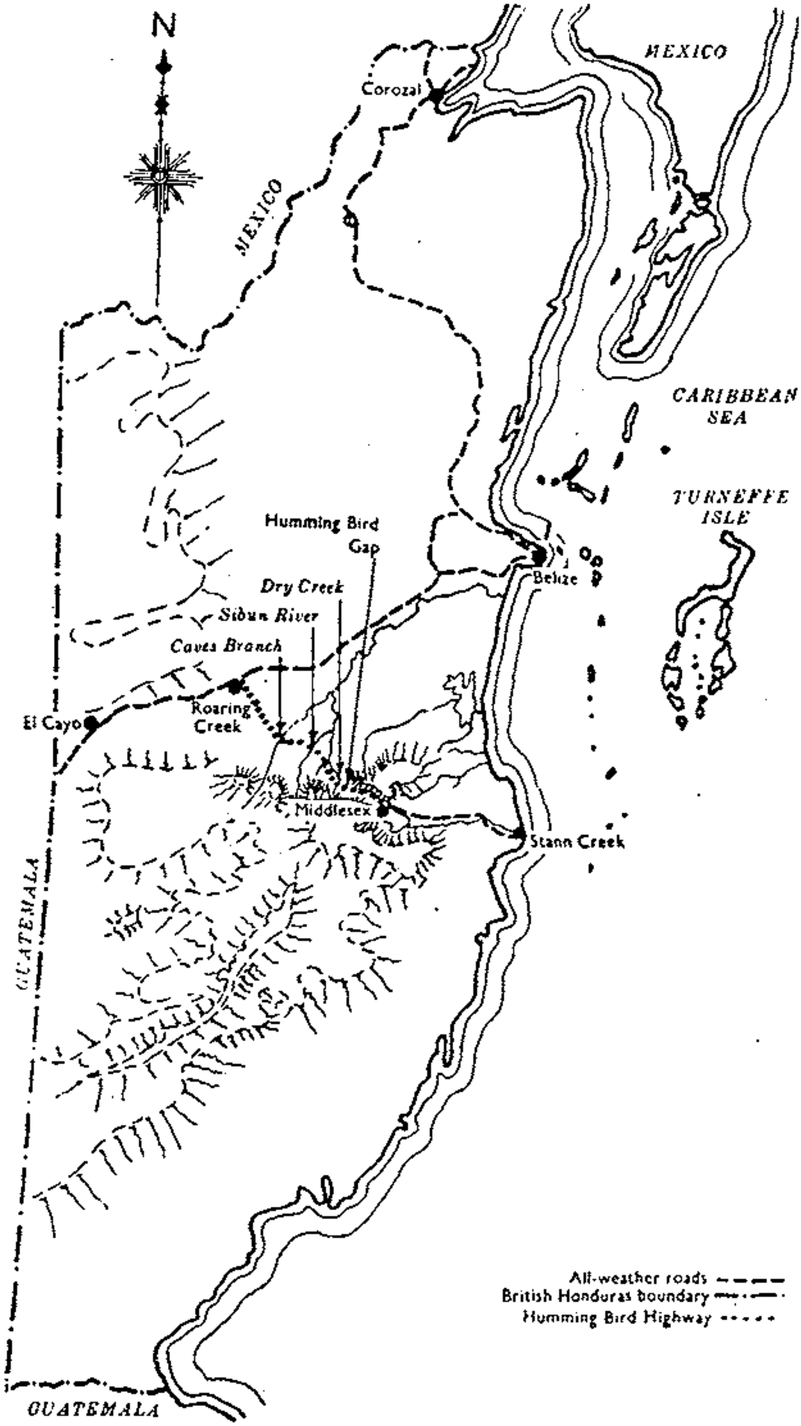
The writer will be leaving India as it is on the point of changing from the "British" India that it still is in so many ways even after eight years of Independence, to a more truly Indian India. Life in the big sea-port cities, and in Delhi itself, has hitherto been very similar to what it has been for the past half-century or more. The British community in these cities (though not, of course, in the smaller up-country Cantonment stations, in most of which it is now rare to see a European at all) is still as large as it has ever been, and it is still possible to travel around India without knowing a word of the national—or any local—language, as English is still taught in all schools and is in fact the actual medium of instruction in universities and colleges, and is still also the "Official" language of the country. The position in this respect must inevitably be altered in the years to come, although an important minority of educated and westernized Indians will continue to cling to the "foreign" way of life. Nor must the conservative attitude of the Fighting Services be overlooked, each of which at present still retains its former customs even to the extent of using English words of command, and of continuing to teach Western music to their bands. (It is always something of an anomaly to attend an "Independence Day" parade, which usually includes a speech by some high political personage, with an inevitable reference to "the liberation of India from the oppression of the British Raj", and then to find the Navy marching by to the strains of "Hearts of Oak", and the Army to "The British Grenadiers".) Nevertheless, the declared policy of the Central Government is to replace English by Hindi as the national language within the next decade, and several of the State Governments have already started to conduct their proceedings and official correspondence in either the national or the regional languages. As the English language and the British community gradually disappear, so will the veneer of Western influence as regards dress and customs be largely replaced by Indian ways, though these may perhaps be modernized and adapted more suitably to the requirements of the twentieth century. Total prohibition (with limited concessions for "foreigners") is already in force in several parts of India, and this is likely to be extended throughout the country within the next few years. Horse racing is only being kept going with difficulty, as there is a virtual ban on the import of race-horses, and few persons are now wealthy enough to be able to afford to own a stable.

In spite of India's high hopes of being able to improve the lot of the masses as a result of the successive five-year plans, and of the attempts which are now under way to create a classless society, without great disparities in income, it is difficult to envisage such a transformation taking place within a lifetime, much less in a decade. No amount of "levelling-down" of the few thousands who are wealthy can appreciably assist the tens of millions who still exist at a level between subsistence and starvation. And all the efforts of the planners to create more jobs and to increase productivity will be wasted unless the present rate of growth of the population can be checked. This is the biggest problem of all—each year there are 5 million more mouths to feed and 2½ million more youths wanting to secure employment. Unless this appalling rate of increase can be stopped, all the resources of the country will continue to be devoted to finding ways and means of feeding the extra mouths, instead of putting more food into the existing mouths, and at the best the various five-year plans will merely maintain the *status quo* without improving the general living standards of the ryot and the factory labourer. The magnitude and importance of this problem has been appreciated by the Government of India, which has even instituted clinics where free advice on birth-control is given (a surprisingly progressive step in a mainly Hindu nation), but—as is always the case—it is the poorest classes who produce the largest families, and it is these classes who are most unable to afford to buy even the cheapest types of contraceptives, and who also are generally too unintelligent to appreciate the benefits of such measures. On the satisfactory solution of this immense problem will depend the future well-being of the Indian masses.

Although it has been stated earlier in this article that the "British" India of former years will now gradually be replaced by a more "Indian" India, this should not be taken to imply that the country will revert to oil-lamps for illumination, and to bullock-carts for travel. The successive five-year plans will effectively prevent any such retrograde movement. It has also been realized in recent years that India has much to offer the tourist, and that she can obtain valuable revenue from the tourist trade, provided that in return she provides comfortable travel and good hotels. All airlines and railways are now nationalized, and the internal air-services, although still using obsolescent Vikings and Dakotas (which are shortly to be replaced by Viscounts and Herons) are operated reasonably efficiently and remarkably safely. All the principal trains now have air-conditioned coaches, which are kept clean and in good order, but the standard of European-type food available from the restaurant cars or refreshment rooms has deteriorated considerably as compared with the pre-1939 quality. Luxurious modern hotels have been built in most of the major cities and tourist centres, some of which are air-conditioned throughout, and all of which are air-conditioned in the public rooms and in certain bed-rooms. Air-conditioning has indeed become commonplace in recent years, and most new offices and public buildings of importance are equipped with this hot weather boon, as are the bedrooms in the better class of flats and houses. Horse-drawn vehicles and rickshaws are rapidly disappearing from the streets of the larger cities, and are being replaced by fleets of "baby" taxis (which take up to three passengers for only 6d. a mile, in Bombay) and by three-wheeled motor-cycle rickshaws. In Bombay, and to some extent in Calcutta and in Delhi also, most of the business areas and better-class residential areas are now permanent Silent Zones, and only those who have endured the former bedlam of motor horns in those busy streets can appreciate the relief that has been afforded thereby. All internal mails are now carried by air, the nucleus of the system having been introduced five years ago, when it was arranged that every night a mail-plane would leave each of the four major cities of Bombay, Delhi, Calcutta and Madras, and would meet in the centre of India, at Nagpur. Here they would exchange their mail-bags and then return to their parent city, reaching there by dawn. By this simple and ingenious scheme a letter posted in any of these four cities one afternoon is delivered in any of the other three cities—over distances ranging between 1,000 and 1,500 miles—the next morning. All the other important towns and cities are now also served by scheduled air-services, which carry mails as well as passengers.

These few instances will help to show that Independent India is keeping pace with modern developments in a variety of ways, and there is no reason to anticipate that this progress will be retarded merely because British influence over Indian affairs will gradually decrease in future. There will certainly be—in fact there already is—a degree of relaxation of the fairly high standards maintained in former years, with particular regard to cleanliness, hygiene, maintenance of plant, buildings and roads, and efficiency generally—but these standards are unlikely to be permitted to drop below a certain level, which itself is well above that maintained in most Oriental countries, and is certainly no worse than that of some European countries. Those of us who have spent our working lives in India can appreciate the many difficulties that are confronting her, and even though we may disagree with certain of her post-Independence policies, we can at least understand the motives that lie behind them. In spite of her many imperfections, there can be few who know her well who do not wish her well in her gallant attempts to obtain self-sufficiency and to raise the living standards of her people. This fight is also a fight against the Communist menace, which is creeping nearer to India's shores each year. If the ideals of work for all and sufficient food for all can be attained, it is highly unlikely that India will ever embrace Communism, and for this reason alone it is essential that she should succeed in her self-imposed task.

Anyone who has served in India will remember the inevitable ending to those all too numerous letters asking for employment, wherein the applicant states that if his request is granted, he will "evermore pray for your future happiness and prosperity". At the end of thirty-one years of service under the Government of India, the writer gladly conforms to this customary method of displaying gratitude to his employer, by himself praying for the future happiness and prosperity of Mother India.



Map of British Honduras, showing route of Humming Bird Highway.

THE DESIGN AND CONSTRUCTION OF THE HUMMING BIRD HIGHWAY

By Lieut.-Colonel E. R. Rowbotham, M.A., R.E. (Retd.)

This article is based on a paper read by the author at the Institution of Civil Engineers and is reproduced by permission of that Institution.

Introduction

BRITISH HONDURAS is one of the two British possessions on the mainland of the American continent, lying, as it does, in the tropic zone between Mexico and Guatemala. Unlike some of its neighbours it has a low population and of this over one third live in the capital. Thus the density in rural areas is very small. It is thickly forested and this fact combined with the low density of population means that large areas, including most of the area now traversed by the Humming Bird Highway, were at the time of construction virtually untrodden. The forest is extremely thick, impenetrable, and hard to traverse, and even in areas of stony outcrop where the soil is poor and the timber light, the undergrowth is thick, thorny, and tenacious. It harbours every variety of poisonous insect and snake, baboons which are reputed to carry yellow fever with them when they move from Guatemala, poisonous lizards, and myriads of very tiny ticks.

One of the staple industries is timber extraction, involving a seasonal traffic of tractors and logging trailers, which form heavy and ponderous loads by Colonial standards.

The rainfall is high. Records for past years of rainfall over the line of the road are not available, but during construction the rainfall in the labour camp was recorded at about 150 inches in the year. The rainfall at the Humming Bird Gap which was the highest part of the road, was much more, probably over 200 inches.

These three factors—the denseness of the forest, the nature of the timber traffic, and the high rainfall—had a profound influence on the design and construction methods.

The Problem

The intention in making the road was to join the embryo port of Stann Creek, which had only local roads round it, to the capital and other centres of population. The method chosen was to join the village of Middlesex, already connected to Stann Creek by road, to the hamlet of Roaring Creek on the Belize—El Cayo road. The reason for choosing this line rather than the coastal line to Belize was probably the valuable and richly timbered nature of the country traversed by the inland route.

The route chosen was 32½ miles in length. Starting, as construction did, from Roaring Creek, the line passed over twenty miles of flat country. Apart from the impenetrable nature of the tropical forest, the line, once cleared, could be classed, over these twenty miles, for road making purposes, as easy. Only one major obstacle was situated in that stretch—that was the Caves Branch River, the bridge over which will be described later. After about twenty miles the line started to traverse the Mountain Pine Ridge (or Reach). In the last thirteen miles nearly all the difficulties were encountered. Most of the river crossings were found in this stretch, and this was the area of high rainfall. The Mountain Pine Ridge is crossed over the Humming Bird Gap, the highest point on the road, from which the name of the road is taken. The Humming Bird Gap is no true gap, but a minor bump among higher crests and ridges.

The nature of the country while hilly cannot be classed as mountainous by Asian or even European standards. However, when considered with the rainfall and the nature of the soil and forest it presents a sufficient problem. In this connexion Mr. Williams of the Department of Scientific and Industrial Research has officially stated his opinion that the road is "a shade worse" than the Temerloh-Maran Road in Malaya.

The soil which is a light sandy clay over the first twenty miles of the road becomes a heavy fat red clay in the Mountain Pine Ridge area.

Work on the road started in February, 1950. The author took over control of the job in December, 1952. Below is a table summarizing all the work involved in the road and that remaining in January, 1953.

Item	Total	Completed prior to 1st Jan. 53	Remaining to be done 1st Jan. 53
Survey	—	all	
Forest clearing	32½	25	7½
Formation earthworks	32½	21½	11
Base course	32½	21	11½
Metalled surface	32½	19	13½
Seal coat	32½	12	20½
Major bridges over 225-ft. span	2	⅓	1⅔
Other major bridges	3	½	2½
Medium bridges	5	1	4
Minor bridges	8	5	3
Culverts of various types	140	58	82

The first step was to make an examination into the financial position of the project. The work still to be done as outlined in the foregoing table was assessed and priced at existing estimate prices. This figure which included an allowance for contingencies came to $911,537 or £227,884. The available balance was $759,429 or £189,857. The short-fall of £38,027 was slightly offset by the value of stores in hand. At this stage the existing estimate of £520,884 for the whole road was itself a revised estimate carrying with it a request for additional funds which had not yet been granted, so it was clear that no further applications for funds could be contemplated except as a last resort. Since it was also clear that the short-fall had arisen since submission of the last estimate—a matter of a few months only—it was necessary, very rapidly, to go again through that manœuvre so often performed in the Colonies, of arranging work and specification to suit a ceiling expense, a proceeding which is so much less satisfactory than determining the work necessary, pricing it, and then carrying it out.

Some small reductions were very reluctantly made in the specifications for the roadwork, and some important savings were made by a complete and ruthless redesign of all bridges. Further savings could have been made if equipment had been available .

The largest savings were made in overheads. The estimate in force was based on progress at about the same rate as before, bringing completion early in 1955. It was decided to complete all the roadworks at twice this rate. That meant that the whole of the remaining earthworks had to be completed during the dry season of 1953 since it was not possible to work machinery usefully in the wet season. If the earthwork and base course could be completed by May, 1953, work could then commence on all bridges and they could all be worked on together during the rains. Piece work rates, task work arrangements and bonus rates were chosen or adapted to offer maximum incentives and the work went forward. In fact the formation was finished early in May. The gravel base course, nearly all the culverts, and most of the temporary bridges and fords were finished a week or so later and the road could be travelled on by lorries throughout its length in all weathers. This meant that work could and did start on all bridges and carry on throughout the wet season until completion.

The General Plan

The general plan arose directly from the examination of the problem as outlined in the last paragraph, and was very simple. It was a fortunate circumstance that work had virtually come to a standstill in December, 1952, and so there were no programmes to be set aside or feelings to be hurt.

Briefly the plan can be outlined as follows:—

(*a*) Forest clearing was put in hand forthwith.

(*b*) Formation earthworks were to follow behind forest clearing as soon as machines could be put into repair.

(*c*) A gravel sub-base gang was organized. The aim was to keep one day's work behind the earth work but they were usually a week or more behind the leading machines.

(*d*) As many gangs as could be suitably manned were organized for culverts. These worked generally behind the gravel sub-base gang.

(*e*) The Colas surfacing gang was reorganized into an "additional sub-base" gang, thickening up the gravel carpet when and where necessary.

(*f*) Forest clearing gang, when finished, reinforced the formation party (machines), and commenced making temporary log bridges over the larger rivers (axemen).

This operated until May when:—

(*g*) Bulldozers, except such as were required for bridge approaches and similar work, were dispersed.

(*h*) The Colas surfacing gang resumed its own function and commenced working forward.

(*i*) The gravel sub-base gang finished the initial gravel carpet and then took over the work of "additional sub-base" from the Colas gang.

(*j*) Culvert gangs went on to bridges as the culverts were completed.

(*k*) The Sibun Main Bridge (q.v.) was erected during the dry weather of 1954.

Construction: Roadwork

General

In this paragraph on construction, and the succeeding one, emphasis will be laid on construction carried out after the 1st January, 1953, partly because it was the work of most general interest, and partly because it was the portion with which the author is acquainted.

All rates quoted are works costed. That is to say, the figures take up for depreciation charges for all mechanical equipment as well as for full maintenance costs and operation. They also include transport costs and all general site costs, but do not include H.Q. charges which are dealt with in a later paragraph.

Forest Clearing

Forest clearing was carried out by two D8 tractors fitted with cable-operated angle-dozer blades. The different design of the idler in the tractor compared to the dozer led to several breakdowns. All the D8s employed on the highway were of this pattern. The two D8s were supported by a ganger with ten men. The chief duty of the gang was the construction of log bridges over the numerous creeks. Without them the tractors spent far too much time getting bogged and pulling each other out of trouble. The gang also felled trees on side-cuts, and trees too large or too dangerous for the D8s.

The bushing party completed their 7½ miles on the 27th February, and on the 5th March, H.E. the Governor drove through from Belize to Stann Creek, the first person to make the journey by road vehicle.

The bushing party lived on their own in tents and home-made huts. Until spares for other tracked vehicles arrived the only means of communication with the bushing party was by foot. On an inclement day it would take three hours to reach the road-head, and another three hours to mark a stretch of road for the bushing party to work on, half to three-quarters of a mile long, according to the density of the forest. Fuel was moved on a wooden sledge towed by a tractor.

The piece rate for clearing was 3 cents ($\frac{1}{16}$ of a shilling) per linear foot to each tractor operator for a bushed trail 100 ft. wide. On side-cuts where a 100-ft. trail was impossible the operators were paid by time.

Total cost of the 7½ miles was $9,317 or £2,329, and the rate per mile averaged $1,242 or £310.

Earthwork in Formation

The earthwork was carried out by such tractors as could be made available. This number was never very large and at its best included some machines which would not normally be considered fit for heavy work. As stated in a preceding paragraph, great importance was attached to the completion of the formation early in May, 1953, and it was natural that great effort was made to keep every machine on the job. But the best will in the world will not compensate for the absence of spare parts. The vital necessity of maintaining a sufficient and efficient flow of spare parts will be touched on in a later paragraph. Two D8s were initially available and they worked on clearing. Later, two more were put into commission and were used on earthworks. After the clearing was finished there were four working on earthworks. These four machines worked without an undue proportion of breakdowns. To these must be added one old D8 and one H.D.14; both these were in such an advanced condition of age and disrepair that their contribution was small. Neither of them could push a blade and they could handle only a small-capacity scraper at a slow speed. Each spent about twice as much time in the repair bay as on the job. Their use would not have been considered but for the decision to make the all-out effort to complete the formation in 1953.

The earthworks were set out in the following manner. The centre line of the road would be staked out by the resident engineer. The surveyor attached to the staff would follow, replacing the stakes by his own at 100-ft. intervals, closer in difficult country. Along these the surveyor would run a line of levels and add the stretch done to the road profile. On the road profile the resident engineer would set out the final road level. The surveyor then put in level pegs, running cross-levels, and marking edges of banks and cuttings. This process would be kept going half a mile ahead of the tractors. No personnel were employed on earthworks other than the machine operators and their assistants, the survey party, and supervisory staff.

Earthworks were paid for in an unusual way. The system is fairly old established in the Colony. The rate for earthwork by piece-work, by volume, is 1¼ cents (¾d.) per cubic yard. This is paid to each tractor operator no matter how many are on the job. Thus if one machine is employed and moves 1,000 cu.yds. the operator receives 750 pennies. But if there are eight machines and they move 8,000 cu. yds. between them, each operator gets 6,000 pennies. Apparently the system was worked out on the basis of four working machines, the number being restricted to four and falling below four only on account of breakdown. The system is designed to make operators careful. As a result, at the commencement of the year when one or two machines were on earthworks the work went slowly but cheaply, and the operators fortnightly wage packet was thin. Later when more machines were on the job, up to six, the work went quickly but the cost was higher.

In the following figures, the quantities include a small amount of blasting which was necessary, but exclude the comparatively easy work of bridge-approaches which was charged with the bridges.

Total cost of earthworks	$44,588 or £11,147
Cubic yards placed or moved	190,238
Cost per cubic yard	23.44 cents or just less than 1s. 3d.

The cost per mile averaged $4,206 or £1,052.

Base Course and Surface

The base-course used during the early construction was quarried rock, dolomite, and limestone, laid in a course about 11 inches thick, rolled and blinded with spalls. This was found expensive and unsatisfactory, and in 1952 a change was made to a gravel base-course, with gravel, mostly granitic alluvium, that was readily available all along the route. The gravel was first laid in an even carpet 13 in. thick from end to end of the formation. This was to enable lorries to get forward. The gravelling followed a week or so behind the tractors on earthworks. When the first carpet was completed, the gravelling was thickened by additional gravelling where required. The thickness of this second coat varied from a few inches to a few feet. Some places were considered unsuitable for gravel and quarried stone was laid. In other places quarry waste was substituted for gravel.

The gravel for the base-course was mechanically excavated by shovel or traxcavator, and loaded into 5-ton tipper lorries. It was spread by a motor grader, and rolled with a ten-ton roller. A ganger and about seven men were employed to assist in spreading. Since gravel was available along the line, the average haul for the initial carpet was short, and was about two and a half miles.

Owing to the varying thickness and type of base-course it is difficult to quote rates which will be of value. However, the rate, for the initial carpet is quite clear; this cost $20,853 or £5,213 which corresponds to a rate of approximately 5s. 4d. per linear yard for a carpet 14 ft. wide and 13 in. thick (before consolidation).

Before consolidation the 12-ft. wide metalled surface was 6 in. thick, semi-grouted with Colas at the rate of 1 gallon per square yard. A final seal-coat at ¼ gallon of Colas to the square yard was afterwards applied. The only point of interest is the cost which was $10,000 per mile (£2,500). This includes the cost of Colas from the U.S.A. and the cost of the drums which were not returnable. Many of the drums were subsequently used on the construction of drum culverts and as shuttering for jack-arches. No transfer of funds was made on this account, and to this extent bridging was subsidized by road-work.

CONSTRUCTION: BRIDGING

Bridges

Most of the bridges were built to a standard design and all were designed to carry four-fifths of the Ministry of Transport loading, or 12 units of the British Standard Loading Train.

Briefly the design can be summarized as follows:—

Foundations	Reinforced concrete caissons with or without piles.
Abutments	Reinforced concrete usually designed as propped cantilevers.
Piers	Concrete with token reinforcements.
Wing walls	Reinforced concrete in vertical cantilevers.
Superstructure	R.S.Js. with light concrete jack arches.
Hand rails	Angle iron.

Foundations

Reinforced concrete caissons were formed, 18 in. thick. In outside dimensions they were 18 ft. long over all with semicircular ends, 6 ft. wide. They were sunk by a R.B.22 or R.B.19 using a grab bucket. Where the nature of the soil demanded it piles were sunk in the bottom of the caisson, in every case driven to refusal. Wooden piles were used cut on the spot from sapodilla trees which give an extremely hard and resistant timber much used in British Honduras for similar purposes. (It is from the sapodilla tree that chicele is extracted from which chewing gum is made.) The tops of the piles are cut off and embedded in the concrete with which the reinforced concrete caisson is filled.

The bed of the rivers was in every case composed of boulders and shingle to a greater or less depth. In some cases the boulders and shingle were as deep as investigations were carried. In other cases they overlaid clay. Owing to the nature of the country no preliminary investigation into bridge sites had been made. This meant that all investigation had to be confined to the period between March, when the forest clearing was complete, and May when work on bridges began. So for practical purposes there was no preliminary investigation at all and each problem was treated *ad hoc*.

Fortunately, in every case, a stratum impenetrable to piles was found at a reasonable depth.

One of the most troublesome types of foundation was the boulder and shingle bed which extended to considerable depth. It was not easy to sink the caissons in such a formation and it was sometimes difficult to drive piles. Some would go in quite docilely and some would not.

If equipment had been available or could have been procured in time the problem could perhaps have been tackled more efficiently, by limiting the depth to which the R.C. caisson described was sunk into the shingle to a depth of about two feet and then consolidating the underlying shingle by means of the injection, under controlled pressure, of suitably conditioned cement or sand cement grout, according to the voids encountered in any particular case, through holes specially drilled for the purpose. Provided the voidage is sufficient and the treatment is taken down below scour danger level such a consolidated foundation is practically disaster proof.

Girders

These were 44-ft. R.S.Js. Four were used to a span giving an 11 ft. 3 in. deck.

These girders were transported on an improvised trailer made up of an old back axle and a length of 4-in. pipe. Towed behind an ex-U.S. Army half track they came over the roughest surfaces and through deep mud and slush without any trouble.

Bridges were designed with sliding joints, though in view of the small range of temperature this was probably unnecessary.

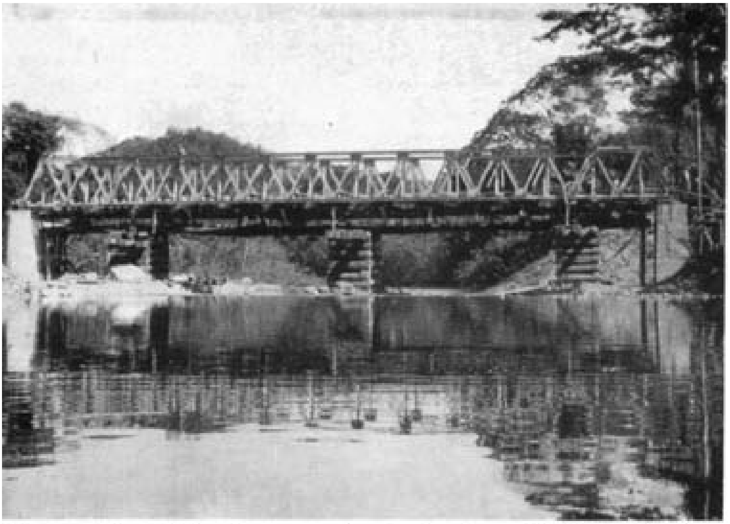


Photo 1.—Sibun Bridge under construction, showing the 140-ft. Callendar Hamilton being erected on a staging formed of the temporary log bridge. Two additional standard spans were added to complete the bridge.

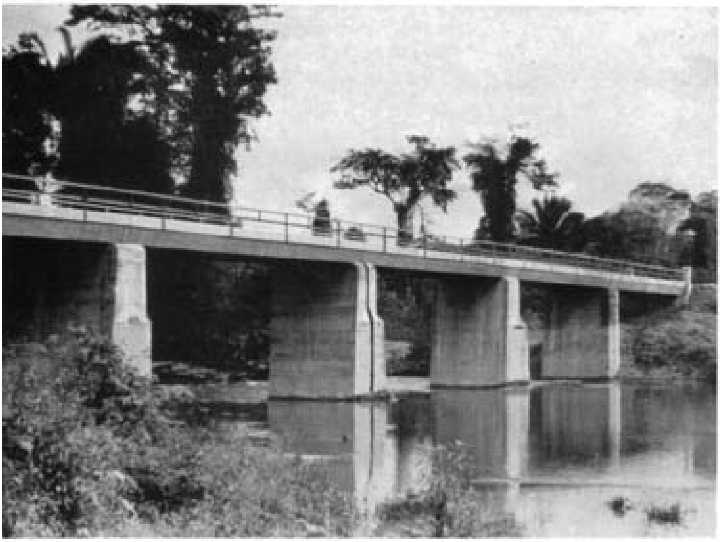


Photo 2.—Caves Branch Bridge. Six spans of 44 ft. steel girders and jack-arch deck.

The Design And Construction Of The Humming Bird Highway 1 , 2

Photo 3.—Dry Creek Bridge under construction showing jack-arch design.

Photo 4.—Triple parabolic culvert under construction, showing shuttering for headwalls being erected.

The Design And Construction Of The Humming Bird Highway 3 , 4

Deck

During a temporary shortage of reinforcing steel a light jack arch deck was designed, using old Colas drums as shuttering. This proved a success and the design was retained throughout, the slight extra cost of cement being more than offset by the speed of erection.

The external concrete casings to the steel girders were not strictly necessary but as can be seen from Photos. 2 and 3 they add considerably to the appearance. One set of kerb shutters was made which lasted the whole course of eighteen spans with only minor repair. This illustrates the quality of the Honduran timber.

The width of the deck (11 ft. 3 in.) is somewhat more than is usual with a single track bridge. This width was chosen to accommodate the ponderous timber trailers referred to above. The spacing of the girders was also arranged with this type of load in mind.

Size

In arriving at the height and number of spans required, calculations were based on rainfall of 4 in. per hour continuous. This seems high but subsequent observation has shown it to be not excessive.

Sibun Bridge (See Photo 1)

The Sibun River is one of the largest in the colony and one of those most liable to flooding. This crossing, which is in fact the only crossing over the river, is comparatively near the source, where the catchment area is only about a hundred square miles. Even so the river has been known to rise ten feet in an hour and to subside as rapidly.

The bridge is non-standard, being designed to consist of a 140-ft. Callendar Hamilton main span with two subsidiary standard spans.

A temporary log bridge was erected on the alignment in 1952 This was used for ordinary construction traffic until the time came for the erection of the Callendar Hamilton. The temporary log bridge was then used for staging for the erection of the steel bridge, and traffic was diverted to a ford. This plan was very simple and had the merit that the Callendar Hamilton was erected *in situ* instead of being launched. The latter process might have been too much for civilian operatives to whom it would have been a strange method. It had the disadvantage of inflexibility since work was necessarily confined to the dry season, it being impossible to maintain a ford over this river during the wetter months. There were thus two crucial dates in the construction of the road: the end of the dry season 1953 by when the formation, sub-base and culverts had to be finished, and the end of the dry season 1954 by when the Sibun Bridge had to be open to traffic. The first was touch and go. The second was achieved with a week or two in hand.

Rock was encountered for the foundations at either end of the long span—at 16 and 14 ft. below river bed level. In one foundation, which was an abutment, the caisson made a nearly perfect fit on the rock. Three pumps kept the water down and a layer of concrete was laid without difficulty. Holes were drilled through the concrete into the rock and dowel bars grouted in. The caisson was then filled up solid with concrete in the normal manner. In the case of the other end of the long span, attempts to keep the water level down in the caisson once bedded on rock resulted in sand being washed in, in large quantities. Eventually it was necessary to place concrete outside the caisson in a Tremie tube. By lowering the water level inside, the concrete was sucked in, and eventually a water-tight seal was effected. The remaining piers and abutments provided no real difficulty, though sinking the caissons and piles was a laborious process and the work would have been more efficiently done by the cementation process already described.

The main abutment under one end of the long span was comparatively high. It was constructed monolithically with the wing walls, and designed, and the reinforcement arranged, in the manner of a rectangular tank or bunker. No allowance was made for negative pressure from the clay back filling and reinforcement was provided to resist all external forces.

The deck was constructed of local timber of high resistance value. Care was taken to leave gaps between both stringers and deck planks.

There was no other point of interest in the construction of this bridge except the cost which amounted in round figures to £19,500.

Caves Branch Bridge (See Photo 2)

Caves Branch Bridge consists of six 44-ft. spans. The standard caisson foundations were used, with standard 44-ft. girders and jack-arch deck.

Caves Branch River derives its name from the fact that the entire river goes underground about two miles below the bridge site. Normally the flow is broad but shallow, filling five of the six spans of the bridge. In dry weather the flow sometimes ceases altogether and the bed dries. A normal flood may raise the water level six or seven feet. Sometimes the entrance of the "cave" into which the river flows becomes blocked, the river banks up and may rise to a height of fourteen feet.

The bridge was not separately costed during the early stages of construction and an exact cost is not available. By extension of known costs, $60,000, or £15,000, may be taken as a rough figure.

Other Bridging

The term "major" was applied to bridges of more than one standard span—i.e., more than 44 ft. A bridge of one standard span was called "medium" and R.C. beam and slab bridges were called minor bridges.

Major bridges of interest were:—

Dry Creek Bridge—three standard spans—cost just under £8,000.

St. Margaret's Bridge—two standard spans—cost £6,500.

St. Margaret's Bridge was constructed on a longitudinal slope, one abutment being 4 ft. higher than the other. Both abutments were cantilevered from caissons, one being founded on rock, and the other on sandstone. The lower abutment was designed to absorb the horizontal forces. The other abutment and the central pier were given sliding joints and in their case it was assumed that the only horizontal force they would have to withstand would be those transmitted by friction.

The lower abutment was designed to resist the following forces:—

(*a*) Downhill

Horizontal components of dead and live loads.

A load assumed as a proportion of the live load to cover the effect of braking on the bridge. This proportion was taken 30 per cent downhill and 20 per cent uphill.

No negative pressure from the back fill was allowed for.

(*b*) Uphill

The horizontal thrust due to the clay backfill when damp and exerting pressure, together with supercharge according to maximum bridge loading.

The braking force as above.

From these was deducted the horizontal component of the dead load.

The site of St. Margaret's Bridge was constricted and congested which accounts for the relatively high unit cost as compared with Dry Creek.

Dry Creek Bridge was more straightforward. One abutment was founded on rock and the other cantilevered from a caisson. Photo 3 facing page 367 shows an unusual cross-sectional view which clearly indicates the design and construction. As can be seen from the different colours of the concrete, the kerbs and centre arch were poured in one operation and the two outer arches subsequently.

The highest rise recorded during construction in the Dry Creek was 6 ft., and in St. Margaret's 5 ft.

Culverts

The culverts completed in 1953 were costed and the figures are shown in Table 1.

The principle of the parabolic culvert is not new but the size here used may be of interest. These culverts were 8 ft. by 6 ft., with a cross-sectional area of 32 sq. ft. They were designed for deep fills. This size was found extremely useful in dealing with those creeks which were not large enough to warrant minor bridges. They were slightly cheaper than an equivalent box-culvert and decidedly quicker to build. In addition to the nine parabolic culverts mentioned below, one triple parabolic and one double-parabolic on 2 ft. dwarf walls were used for gaps which would otherwise have been bridged by medium or minor bridges. Photo 4 facing page 367 shows the triple parabolic under construction; this was designed and sited to pass a maximum of 650 cusecs. Twenty feet of shuttering were constructed which sufficed for the nine culverts proper as well as for the triple and the double.

Drum-culverts were circular culverts of concrete using empty Colas drums as centring. They had 12 in. of cover at the top, bottom, and sides. The difference in cost between the two- and the three-drum culvert arose because it was usually worth while temporarily to divert a dozer to do the excavation for the three-drum culvert, but seldom for the two-drum.

Miscellaneous culverts constructed were 4 Armo 4-ft., 5-ft., and 6-ft. type; 8 four-drum; 3 five-drum, and 4 of the box type.

In the construction of these culverts it was found that work became considerably quicker and cheaper, when the gangs got used to the work and its organization. Apart from excavation, every gang knew their day's work well in advance. According to length, they knew just how many days were allotted to each culvert, and they worked to a set pace and programme. In the case of parabolic culverts, there was no waste, for the shuttering for the culverts only needed greasing before being used again.

TABLE I

Type	Number	Total length: feet	Cost	
			Dollars	Pounds
Parabolic	9	375	18,119	4,525
One-drum	15	414	4,516	1,129
Two-drum	22	656	8,688	2,172
Three-drum	17	665	5,928	1,482
Miscellaneous	19	792	24,807	6,202

Bridging Costs

The costs of bridging mentioned in preceding sub-paragraphs give widely varying results when expressed in the usual standardized form of cost per superficial foot of deck area. It is natural that the cost of superstructure should remain fairly constant, while the cost of piers, abutments, wingwalls, and foundations vary from bridge to bridge. Nevertheless some form of common denominator is useful, not only for the purpose of comparing bridge with bridge but also to serve as a basis for future rough estimating. It was decided, with all the standard bridges of similar design, to extract the cost per cubic foot of concrete. This was done and some of the figures are summarized in a later paragraph. As would be expected the figures do not show much variation from one bridge to another, and the bridge with the lowest cost per cubic foot is in fact the one that gave least trouble in construction. The bridge which was the first standard bridge to be built has, not unnaturally, the highest unit cost. The next highest unit cost is that of the bridge which gave by far the most trouble.

To arrive at the unit cost, the total cost of the bridge is divided by the number of cubic feet of concrete in it, no differentiation being made between mass and reinforced concrete.

Equipment

It has been stated that the forest clearing and earthworks were carried out with four D8s, with the dubious assistance of a veteran D8 and a veteran H.D.14 which used a great quantity of fuel to move a small load and spent most of their time in the repair bay. The repair bay had other occupants. One D8 spent one week working and was then out of commission until the end of the earthworks. Spare parts arrived in time for it to be overhauled and transferred. In a similar way, a D7 and a D6 stood idle waiting for parts and did no work on earthworks, though these two machines did useful service later in bridge approaches, filling over culverts, and in quarry work. The earthwork was finished by the required date with the machines employed, but only by working long hours from dawn to dusk seven days a week. One more serviceable machine would have made certainty out of uncertainty.

The lesson to be learnt is the overriding necessity for some arrangement whereby a reliable supply of spare parts is assured. It does not matter what the arrangement is so long as the supply is assured. The cost to the project of an idle machine is far more than the cost of the dead hours of the operator and others who may be temporarily idle. It is the disrupted programme which causes the loss. Nothing leads to economy so much as a well ordered programme smoothly carried out.

In the case of the Humming Bird Highway there were factors which made it necessary to improvise a fresh arrangement for the supply of spares at short notice. These factors might well have proved more expensive than they did.

Labour

There was no fundamental difficulty in obtaining labour. The labour is of two types; the normal Caribbean of ultimate African origin, and the Spanish type. There is nothing to choose between the two types, but the quality of the labour varies greatly. Compared with labour in other Caribbean territories it may be said that the British Honduran is good at concrete-placing and working with power tools, but is bad at pick and shovel work and similar tasks.

As is usual the enthusiasm of the labourer was aroused when working on bonus or piece rates. But, as was pointed out in the paragraph on culverts, even on time, the quality and speed of output go up rapidly on repetition work on an ordered programme. Once convinced that a task is a fair one, a gang will work quite well on task rates.

Throughout the project the labour was housed in labour camps. The highest figure of labour force was 400. The men made their own arrangements for messing using Government-provided facilities.

Week-end leave with free transport was granted once a month. In addition, on other week-ends a few liberty lorries were provided to allow some men to get into neighbouring towns for a few hours and shop for themselves and for others. These liberty lorries were keenly appreciated, as indeed were all welfare works. They probably stimulated output considerably.

Summary of Costs

General Costs

The project was completed in April 1954 with a £10,000 balance in hand. Of this £5,000 was placed in reserve for resurfacing of bridge approaches after twelve months of traffic consolidation and other known liabilities, such as the passage home and leave pay of the author. The remainder was declared saving. This gave an over-all cost of £515,884 for 32½ miles of road including bridging, a cost of £16,000 per mile average over all from end to end.

The cost for roadwork alone was £10,661 per mile, average over all. For the period before 1st January, 1953, the average cost per mile was £11,779, and for the period 1st January, 1953, to completion, the cost per mile was £7,600.

The foregoing figures are all embracing. They include all charges on the project, of which the more important are:—

(i) Full depreciation of machinery.

(ii) Full cost of maintenance of machinery.

(iii) All Headquarters charges, such as salaries of senior and junior supervisory staff including the author, his assistant, and their predecessors, passages to and from the contract, and leave pay, and similar charges for staff domiciled in the colony.

The cost of construction of labour camps, their maintenance and operation; the cost of a resident dispenser and drugs used by him.

Welfare, such as the construction of a football field and a recreation room, liberty lorries, etc.

Detailed Costs

As has been stated the figures just quoted which are over-all construction costs are all embracing. It is thought that it will be of greater interest if detailed costs are given "works costed" without Headquarter charges. For this project H.Q. charges were on the high side, being just short of 20 per cent of the whole, and it will probably give a clearer view of costs if they are omitted. To obtain the fully costed figure add 25 per cent.

It may be taken that the works costed figures given below include all costs for machinery, such as depreciation operation maintenance and spares, but do not include any proportion for labour camps, welfare, leave passages, etc.

Item	Amount	Total Cost £	Rate
Forest clearing	7½ miles	2,329	£310 per mile
Earthworks	190,238 cu. yds.	11,147	1s. 3d. per cu. yd.
Gravel carpet 13 in. × 14 ft.	11 miles	5,213	5s. 4d. per lin. yd.
Macadam 6 in. thick (before consolidation) semi-grouted and consolidated. Seal coat	13½ miles	*	£2,500 per mile
Parabolic culvert	375 ft.	4,525	£12 per ft.
One drum culvert	414 ft.	1,129	£2. 15s. per ft.
Two drum culvert	656 ft.	2,172	£3. 6s. per ft.
Three drum culvert	665 ft.	1,482	£2. 5s. per ft.
Misc. culverts	792 ft.	6,202	£7. 16s. per ft.
Dry Creek Bridge 3-span standard	1,400 sq. ft.	8,000	£5. 15s. per sq. ft. 14s. per cu. ft. conc.
St. Margaret's Bridge 2-span standard	925 sq. ft.	6,500	£7 per sq. ft. 14s. 9d. per cu. ft. conc.
Sibun Bridge 140-ft. Call. Ham. 2 standard spans	2,520 sq. ft.	19,500	£7. 17s. per sq. ft.
Caves Branch Bridge	2,800 sq. ft.	15,000	£5. 7s. per sq. ft. 15s. 6d. per cu. ft. conc.
North Branch Bridge, medium bridge, single span	472½ sq. ft.	3,473	£7. 7s. per sq. ft. 13s. 6d. per cu. ft. conc.

*Bridge approaches not yet completed.

SAPPERS VERSUS THE VAAL RIVER IN FLOOD

By CAPTAIN C. J. SPILLER, S.A. ENGINEERS

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RUMOURS and reports of excessive rain and floods throughout the country caused a certain amount of concern to be felt for the 200-yd. Bailey Pontoon bridge over the Vaal River. Sooner or later the Vaal River would come down in flood and, although the bridge was designed to ride a 25 ft. difference in the water level, some concern was felt with regard to driftwood and debris which is such an outstanding characteristic of South African rivers in flood.

Certain precautionary measures were taken and 3-ton cargo-carrying vehicles were serviced and loaded with the necessary equipment, ready to leave Potchefstroom, 65 miles away, in case of an emergency.

The first warning of an approaching flood was received at Potchefstroom one morning at ten o'clock—the Vaal River was rising. Two Sapper officers left immediately for the bridge. It was found that although there was a marked difference in the water level, it had apparently no effect on the bridge. The officers returned. At approximately 1 a.m. the next morning another phone call came through. The bridge was in danger. A later call came through stating that the bridge was breaking up; but at this stage the S.A.E.C.[1] personnel had already left for the bridge site. At approximately 2 a.m. the first vehicle was on its way to the bridge, arriving there at about 3.45 a.m.

At the bridge it was found that a swirling mass of water was passing noisily underneath the bridge. Approximately 50,000 cusecs were flowing past the bridge at the time, at a very high velocity. The level of the water was approximately eleven feet below normal, as the sluice gates at the Barrage had been opened completely.

Some logs and driftwood could still pass underneath the bridge; but the majority was held back by a continuous line of boats jammed against the bridge. Weeds, grass and debris were so tightly jammed against the pontoons that in some cases one could walk out on the debris for approximately two yards upstream, from the pontoon piers.

A Cofferdam, 42 ft. × 42 ft. × 10 ft., with closed ends, ready for floating into position, had filled with water, and weighing nearly 800 tons had crashed into one of the landing bays at 6 ft. per second. The landing bay and end floating bay hookposts were ripped to shreds and the bay was forced about fifteen feet out of alignment,

[1]South African Engineering Corps.

opening a 2 ft. 6 in. gap in the downstream truss. The Cofferdam then swung diagonally and holed the bow pontoons of the next two piers. It then passed underneath the bridge. The bridge was thus forced completely out of alignment.

Soon after 4 a.m. the weight against the other end floating bay was tearing the hookposts apart, opening a smaller gap in the downstream truss at the other end, forcing the bridge farther out of alignment.

Due to the low water level and hopeless alignment of the bridge, the up-stream bearings had moved so much that any further movement threatened to force the bearings and baseplates off the concrete foundation blocks.

Although ¾-ton ship's anchors were used upstream, it was found that trees up to 60 ft. in length had caught in the anchor cables, moved the anchors, and the velocity of the water had forced these trees underneath the pontoons where they were firmly held in position by the doubled-up anchor cables, the one end pulling on the bollard, forcing the bow section down and the other end slowly moving the anchors downstream and the trees moving farther and farther underneath the pontoons, threatening at any time to hole the bottoms of the pontoons.

The bridge was in a most critical condition, threatening to break up at any moment and become a total loss.

It was absolutely essential as first priority to remove all the additional pressure against the bridge caused by the pleasure boats, driftwood and debris against the bridge. Most of the boats were impailed on the transoms, the current and weight of driftwood forced the boats partially under the bridge. Ropes were tied to bollards, and a pulling party placed on the banks. The remainder of the Sappers with their backs against the panels had to push the boats away and beyond the transoms, with the strength of their legs. The boats that were salvaged could only be moved with the absolute maximum effort on the part of the Sappers. Many boats being partially tipped underneath the bridge had filled with water and sank immediately on being pushed off the transoms.

The boats had caused driftwood to become entangled in dangerous masses and in many cases no manœuvering with boat hooks and 1-in. pipes could dislodge these trees from the bridge. Lifelines were tied to the Sappers who had to get on to these trees and stumps to chop and saw them to smaller pieces in order to enable these pieces to pass underneath the bridge. The possibility of these trees and stumps puncturing the pontoons was a very vital danger, and while the breaking up of these trees was in progress other Sappers had to do their utmost to keep the sharp points away from the pontoons.

At the same time ⅝-in. S.W.R. slings were drawn as tightly as possible around all hookposts and connecting posts to stop further movement in the downstream trusses.

Everyone on the bridge lost all count of time; but ultimately the accumulated debris was cleared, although a continous stream of more driftwood had to be dealt with.

Later the aid of a powerful craft was procured, Sappers were supplied, and by using S.W.R. large trees and stumps were intercepted about two miles upstream and pulled into the bank and then pulled out with the aid of Diamond Ts.

This greatly relieved pressure and responsibilities of the personnel on the bridge. Anti-aircraft searchlights were installed to assist with the battle against logs and trees during the night.

Every effort was made to pull the bridge into alignment with all the available manpower; but without success.

Trees trapped by the anchor cables underneath the pontoon piers could not be dislodged, unless the anchor cables were cut, which in turn could not be done until land anchors were attached. Temporary land anchors, from the superstructure, were attached to suitable trees on one bank, but these were ineffective as the manpower was insufficient to take up the necessary slack in the S.W.R. On the other bank there were no trees at all and excavations were started for baulk holdfasts. In the meantime every effort was made to obtain bulldozers to supply the necessary mechanical power to pull the bridge into alignment.

The piers holed by the Cofferdam were now sinking fast, and no effort could stop the process. The upstream sections were going down fast, lifting the downstream sections above the water, twisting the whole bridge sideways and threatening to break the whole structure. These piers had to be cut loose from the bridge. One complete pier turned over by the current, sank almost immediately, while the other caught in the downstream anchors and was later salvaged.

With two piers missing, this section of the bridge sank into the water and the water flowed over the decking. Most of the decking and stringers were removed to decrease the weight, without much effect. This low portion now became an absolute debris trap, and each portion of driftwood had to be worked through, inch by inch underneath the bridge.

When the bulldozers arrived, the landing bay pier on the O.F.S.[1] side was pulled into alignment by means of ¾-in. S.W.R. which was anchored to baulk holdfasts. The slings around the hookposts were tightened up.

On the Transvaal side a size 4 bulldozer snapped a ½-in. S.W.R. and with a ¾-in. S.W.R. was unable to move the landing bay, as the sodden ground made thorough traction impossible. A Diamond T was sent for and by anchoring the Diamond T, this section was pulled into alignment on the following day and anchored on the bank.

[1]Orange Free State.

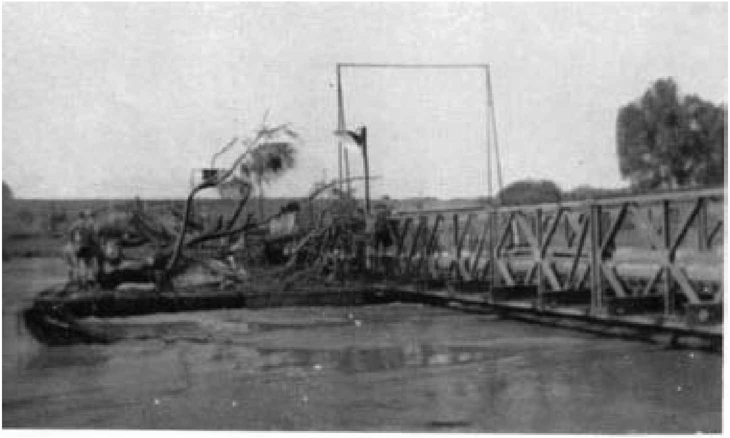


Photo 1.—An example of some of the trees and driftwood which threatened the bridge.
Kommando photo

Photo 2.—After one landing bay had been pulled into alignment. The low portion where the pontoon piers had been lost is clearly visible, as well as some of the boats saved.
Kommando photo

Sappers Versus The Vaal River In Flood 1 , 2

Photo 3.—Keeping the steel pipe away from the pontoons to avoid damage.

Kommando photo

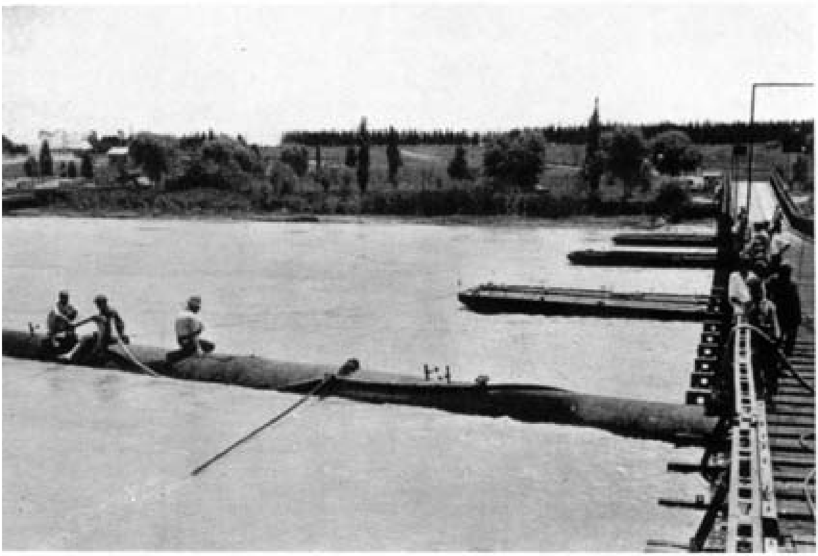


Photo 4.—The steel pipe nearing critical buoyancy.

Kommando photo

As soon as the land anchors were attached, all underwater anchor cables were cut and the trees underneath the pontoons were cut up and worked through underneath the bridge.

Once the bridge was aligned and anchored, it was a continual battle against driftwood and debris, which came down continuously for about four days and nights.

Gradually the position was brought under control and the anchor system, to the banks, was improved upon, while the superstructure, at the places where the anchor cables were tied, was reinforced by welding on additional chords and rakers.

At the peak of the flood it was estimated that approximately 75,000 cusecs passed under the bridge at a velocity of 8 ft. per sec.

It was essential that this bridge be opened to traffic as soon as possible. The first priority would be to raise the sunken portion of the bridge. It would be impossible to replace the pontoon piers as the bottom chords of the transoms were well below the water. An initial lift was consequently necessary. For this purpose the engineer at S.A.S.O.L.[1] designed two pipe piers consisting of sections of steel piping welded together into a cylinder 4 ft. in diameter by 50 ft. long. These pipe piers were constructed with three bulkheads, each with a hatch and the necessary fittings for forcing in compressed air.

These cylinders were launched, and by means of S.W.R. from the bow portion to winches of Diamond Ts. on either bank were floated downstream to the bridge, where they were filled with water to negative buoyancy and by additional Sapper-weight were moved into position underneath the bridge, one at a time.

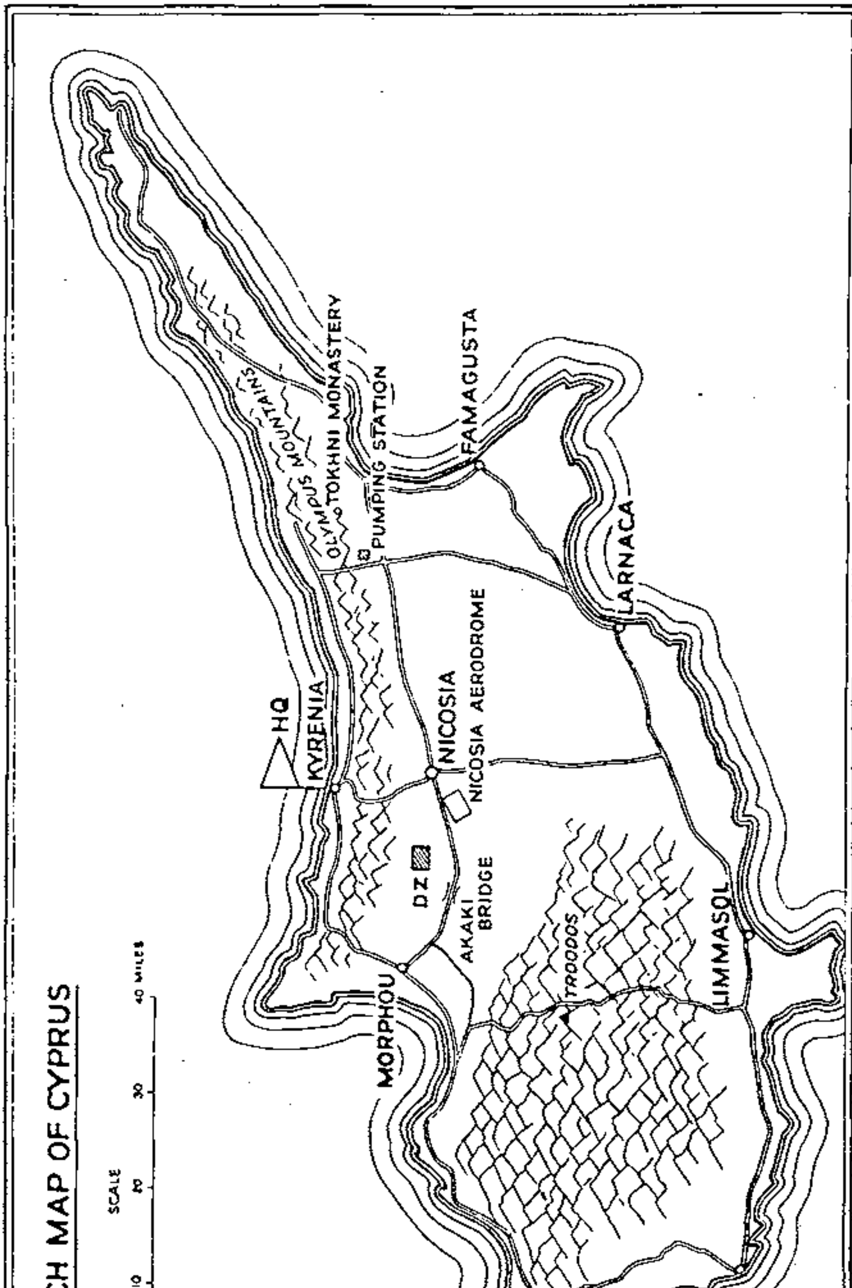
The water was forced out by means of compressed air. The bottom chords of the trusses rested on wooden saddles on the cylinders. This gave the bridge sufficient lift to enable pontoon piers to be "walked" in, but the velocity of the water was still dangerously high for this operation and it was decided to wait until the flow had subsided.

The flow of the water was down to 5 ft. per sec. when it was considered safe enough to bring in the pontoon piers.

Higher upstream, sixteen rowers controlled the complete piers with ease, but it was found that nearer the bridge there was an additional suction force which caused the rowers to lose control and if the precaution had not been taken to have bow and stern ropes on to the bank the first pier would most certainly have been severely damaged. It was however brought into position by guide ropes, the necessary amount of water pumped in and the first pier walked into position. The second pier was guided into position without mishap.

Due to the anchor system and velocity of the water it was considered unsafe to replace the damaged hookposts, these were consequently welded together *in situ* and the bridge opened to traffic again.

[1]South African installation for the manufacture of petrol from coal.


SKETCH MAP OF CYPRUS
SCALE
0
10
20
30
40 MILES
HQ
KYRENIA
NICOSIA
NICOSIA AERODROME
OLYMPUS MOUNTAINS
TOKHNI MONASTERY
PUMPING STATION
FAMAGUSTA
LARNACA
LIMMASOL
PAPHOS
MORPHOU
AKAKI BRIDGE
DZ
TROODOS

AIRBORNE OPERATIONS AGAINST THE FANTASIANS, 1953

By "AJIPO"

Editor's Note.—This article describes the training activity of an Independent Parachute Brigade Group in the Middle East. Owing to other commitments it was seldom possible to free more than a sub-unit at a time for airborne training. This made it necessary to carry out continuation training in rôles more normal to the Special Air Service Regiment than to the Parachute Regiment. Readers must not assume from the article that a Parachute Battalion is normally employed in the fashion described. Small party raiding and deep reconnaissance is normally the rôle of the S.A.S. Regiment or Royal Marines—who may, of course, be suitably supported by the Royal Engineers.

BACKGROUND TO THE "CRUSADER" OPERATIONS

IN October orders were given to the 16 Independent Parachute Brigade Group to carry out a number of small-scale raids against Cyprus with the object of destroying key points, harrassing the Fantasian occupation forces and establishing contact with the "Zift" resistance forces, who were still holding most of the mountainous parts of the island. The air situation still remained adverse to us, which meant that we could only use transport aircraft singly, or in pairs as intruders, relying on surprise in order to bring in any parachute forces with any degree of success. Preparatory training for the raids included marches of 15–20 miles across country, map reading and use of compass, night rallying and night attack.

THE "CRUSADER" OPERATIONS

The first raid was carried out on 3rd November by a platoon of the 3rd Parachute Battalion, accompanied by a N.C.O. and a sapper of 9 Independent Airborne Squadron, Royal Engineers. They attacked and captured a vital bridge on one of the main roads of the island. The two Sappers then blew a 60 ft. gap in the bridge and the whole force met up with the "Zift" forces at a pre-arranged R.V.

This was the beginning of a series of such raids continuing throughout November and December. Striking at bridges, power stations and radar installations, these raids caused the enemy to become demoralized and his air offensive disrupted. On three occasions enemy commanders were ambushed and killed. The raids were carefully planned and increasing help was obtained from the "Zift" partisans in spite of savage reprisals on their countrymen. The local inhabitants, however, could no longer be expected to assist our forces for fear of retaliation, and all roads were patrolled by the enemy by day and night. This called for greater initiative and courage on the part of the platoon commanders and men who carried out the raids: sometimes dropping at dusk and melting into the darkness, sometimes by night, often dropping near one objective and then doing a forced march away from it to another in order to delude the enemy, and always trying a different and bolder technique.

Usually these raids were given to one of the Parachute Battalions to plan, and were carried out as often as not by young subalterns, with, if a demolition task was envisaged, a N.C.O. and a sapper from the Airborne Squadron accompanying them. When major demolition tasks were required to be carried out they were given to the Airborne Squadron to plan, and were allotted to a Sapper Troop. The tasks for these demolition raids became progressively more ambitious.

At the end of November, 3 Troop, 9 Independent Airborne Squadron, R.E., dropped near the east coast of the island, marched ten miles across country and attacked and destroyed the most important pumping station on the east side of the island, situated on the edge of the Olympus hills. There they met up with the partisans at Tokhni Monastery, where they evaded an enemy force sent to intercept them, and withdrew into the hills held by the "Zift".

In early December, 2 Troop dropped at night near the west coast as if intending to capture the uranium mines at Morphou, but doubling back ten miles on a dark moonless night carrying 240 lb. of explosives they made a silent attack on the Akaki bridge. They captured it with little resistance from the enemy platoon holding it, blew up the eastern portion of the bridge, and moved off some four to five miles to reach a prearranged R.V. with the partisans before dawn.

By the end of the first week in December ten platoon raids, and two raids by Sapper Troops had been successfully carried out and the Fantasians were thoroughly demoralized. The "Zift" forces from the mountains south-west of Nicosia then decided that they were strong enough to capture and destroy the main enemy airfield at Nicosia. Their leader, Pano Zhodia, asked for a troop of Engineers to demolish the enemy's concrete strong points on the airfield as he had no trained sappers nor sufficient explosives.

This request was immediately agreed to and 9 Independent Airborne Squadron was given the task.

"Crusader Special" Operation

Time was short, as "D" day had been selected for the 15th December, and planning and preparations had to go hand in hand. A plan of the airfield, details of the pillboxes including some snapshots, and details of enemy dispositions had been sent by the "Zift" forces, which gave enough information for the attack and demolition. A photographic reconnaissance was flown, and in spite of heavy "flak" was able to bring back a high-level photograph of the airfield, and low-level cover of the proposed D.Z. While all the briefing material was being prepared, and a model constructed, the normal preparation for an airborne operation proceeded smoothly. The Officers, N.C.Os. and men selected carried out their synthetic training, checked over explosive loads, airborne equipment and life jackets, weapons, wirelesses, and personal clothing and equipment. Containers were collected and loaded with tools, sandbags, and explosives; 24-hour ration packs were drawn and issued; and all the details of aircraft loading, preparation of flight manifests, movement to the take off airfield at Fayid, and the administrative arrangements before take off were completed.

The Army/Air plan was made by the unit, the R.A.F. Transport Squadron, which was providing the two Valetta aircraft allotted for the operation, and the Brigade Air Control Officer at Fayid. The flight plan and timings were agreed, and all was set for the briefing. This was carried out in three parts. An initial briefing by the O.C. Squadron for the Troop Commander, Troop Officer and Troop Sergeant on the 12th December. A briefing and final tying up of all details of the plan between the Troop Commander and all his N.C.Os. on the 13th December, and the full briefing of all troops taking part on the morning of 14th December.

All additional information and all details of the pill boxes were given verbally. All was ready on time, and the troops rested for the 24 hours prior to the operation.

The Troop emplaned at Fayid at 1600 hrs. on the 15th and had a bumpy two and a half hour flight. A number of men in both aircraft were sick, but in spite of this the aircraft arrived on time at 1830 hrs., and both sticks were fast and well controlled.

As "P" hour was 1830 hrs. it was a night drop, but there was a good moon and the R.V. party were very rapidly in position on the south-east corner of the D.Z. with a Wald light winking away for the troop to rally on. The Troop Officer went straight through to locate the containers, some of which were fitted with lighted locating devices.

At the R.V. one man was reported missing, and as he was carrying a demolition accessory kit-bag the Troop Commander sent one section to search the D.Z. while the remainder of the force under the Troop Officer collected the stores from the containers and distributed them round the men. In fact, the casualty was reported in error, and valuable time was wasted, but by the time the section returned, the containers, all of which had landed safely, were unloaded and the force moved off at 1945 hrs.

On several occasions during the march across country the troops saw patrols on roads and had to take evading action. On one occasion an illuminating flare went up quite close to them just as they were about to cross a road. However, they froze and lay low where they were and the mobile patrol, apparently satisfied, moved on.

The force arrived at the R.V. at 2230 hrs. as arranged, only to find no "Zift" force representative there, so leaving the Troop Officer with two men and a 32 wireless set at the R.V. the Troop Commander moved the troop away under cover, and started a recce of the enemy positions covering the airfield.

At 2300 hrs. two men strode out of the darkness towards the troop officer, they were dressed in a combination of allied uniforms, and the leader, a tall man with a bandage round his head, a blanket bandolier fashion over his shoulder, rows of medal ribbons and an assortment of weapons strung about his person, rushed forward and threw his arms round the surprised Troop Officer. "Last", he exclaimed in bad English flavoured with a strong smell of even worse brandy, "You av cum". He then proceeded to draw a large flask from his pocket and hand it round to the Troop Officer and the wireless operators. After much back-slapping and far too much brandy he volunteered the information that the "Zift" forces were attacking the airfield as planned at 2330 hrs. and were expecting the troop to do their part. By now the Troop Commander had made his plan and moved his troop round by a covered approach to the north of the enemy pillboxes.

The attack went in at 2330 hrs., using approximately half the troop in the first wave, and attacking as they did from the flank and the rear achieved complete surprise, overrunning the pillboxes and killing their occupants within some ten to fifteen minutes.

Consolidation after the attack was quick, and the remainder of the troop moved up to the edge of the airfield. Here the force was divided into four, as had previously been arranged, each under a sergeant or corporal. Each party moved off independently to its allotted pillboxes when the "Zift" force success signal was seen at midnight.

The moon was due to set at 0300 hrs. so they had to work quickly, but soon after moving over the airfield a complication arose as enemy aircraft came in and tried to land. Some succeeded and had to be dealt with by the partisans. Because of all this, work did not begin on the demolitions themselves until 0115 hrs., but all were completed and blown by 0400 hrs.

All demolitions were completely successful and the troop, having reported to Pano Zhodia, the "Zift" Leader, who had set up his H.Q. in the Control Tower, were ordered to withdraw to the escape R.V. some three miles south of the airfield. On the way they ran into a small enemy party of men who had escaped from the airfield and rallied on a ridge some two miles south along the escape route. The enemy opened fire too early and gave away their position, and a quick attack by the troop drove them off in complete rout.

The R.V. was successfully reached at 0445 hrs. and guides led the tired but triumphant troop off to their lying-up area in "Zift" controlled territory.

THE UNION JACK IN VIRGINIA

(A Vision of the Eighteenth Century)

By Brigadier J. V. Davidson-Houston, M.B.E.

TRAVEL in America is full of surprises, whether one comes upon a dazzling white mosque in the diplomatic quarter of Washington, or herrings rising to a fly as they fight the muddy waters of the Potomac. For a unique experience, however, I am indebted to Mr. John D. Rockefeller, jun., whom I have never met.

Robert and I left the capital on a clear, fine morning in early spring, and set off in his Humber Snipe along the Virginia Highway. Many hundreds of Americans had evidently decided to do the same thing, and many an eye was turned towards the unusual spectacle of an English car cruising on the open road. We drove through mile after mile of dense forest, mostly beech and birch, and were disappointed at the smallness of its trees. Sometimes the woodland opened out to give a view of tobacco plantations and fields of maize and wheat, not yet grown up. One realized how green is England compared with the sober shades of this landscape, but to Americans it is full of verdant beauty. "Keep Virginia Green", "Break your Match", "Don't be a Fire Bug", cautioned the notice-boards as we bowled along between the trees.

Far from the turmoil of Europe, it was somewhat startling to come upon large placards announcing that "In the Event of Enemy Attack this Highway will be Closed to Traffic", but we pursued our way without encountering Redskins or other hazards until the sight of a road-side café made us mindful of coffee, hot-dogs, hamburgers, and cheeseburgers. We drew up at the gasoline station next door where, as the tank was filled, men busied themselves with cleaning the windscreen ("windshield" to them), polishing the bodywork, and generally giving us gratuitous beauty treatment. Behind the glass doors of the cafe hung a card inscribed "White Only", so we boldly entered to hear a juke-box disgorging negro melodies evidently in response to the dime inserted by an earlier customer.

One must admit that it is easy to eat in America, although the profusion and volume of snacks and hot dishes almost takes away the desire to eat. Here, however, my appetite was whetted by a coloured poster representing a cock (rooster) wielding a golf club in a tangle of long grass.

"Is that something to eat?" I asked.

"Sure its something to eat," answered the girl behind the counter, with the attractive accent met south of Washington, "It's Chicken in the Rough. Can I serve you?"

This sounded like pioneering, so I ordered some and discovered it to be pieces of fowl cut up for eating in the fingers. Here at last was honest recognition of the facts of life, and I set to with relish. Robert was overwhelmed by his Tee-bone steak, which overhung both sides of his plate, and was probably a survival of a grosser age.

We thanked the waitress who brought us the food, receiving a bright "You're welcome" in reply. We began to realize that the habit of saying "Thank you", which has become almost automatic in England, is treated far more seriously across the Atlantic and calls for a suitable answer such as "Yes, Sir!", "Sure!" or "What's that?"

Soon after leaving the "diner" we began to sense the atmosphere of an earlier epoch. In this part of the country memories of the Civil War, "the war between the States" as the Southerners prefer to call it, are still going strong. We had already passed the site of the battle of Bull Run, but now the roadsides blossomed with notice-boards and memorials describing those bloody battles in which blue-clad Federals and Confederates fought it out grimly in the Virginian woods. One realized how blindly the opposing armies must have groped for one another in the forests, and how sanguinary were the close-range struggles when they met.

One was reminded also of the differences which still persist between North and South over the matter of colour. As we drove on we noticed more and more negroes; in the fields, in the country towns, driving in carts along the dirt roads. There were boarding-houses designated "Colored Tourist", and near Richmond we came upon an open-air cinema with entrances respectively marked "Drive in Whites" and "Drive in Colored". The two factors seemed to fall naturally together; the more negroes, the more segregation.

It was still early in the afternoon when Motor Lodges, Auto-courts, Motels and Motor Courts began to gather thickly upon the highway. These all proved to be the same thing under various names, a group of cabins where visitors could park themselves and their cars for the night.

"We're getting into Williamsburg," announced Robert, "I think we'd better look round for a doss-down."

"Tell me about Williamsburg," I said. "Is it a place worth stopping at, or does it go in for textiles, non-ferrous metals, end-products, and so forth?"

"You wait!" returned Robert mysteriously. "It's something you won't have seen before."

The first place we tried was full, and the manager told us how sorry he was.

"We'd be mighty glad to have you stop over with us; it's just too bad you didn't make a reservation. Say, I think I can fix it: won't you sit down while I give a call?"

The consequent telephone conversation, rich in picturesque idiom, secured us a room in a Motor Court, and thither we departed with the fullest instructions as to how to avoid losing our way.

The Motor Court, fronting the highway, consisted of some twelve bungalows arranged in a semi-circle, with a central wooden building containing the office and cafe. We were given the key to one of the rooms in a two-piece hut, and found unexpected luxury within. Besides well-appointed beds and a writing desk, the place was air-conditioned and the bathroom tumblers were each sealed in a "sanitary envelope". As we entered the verandah a little cardinal bird, like a splash of vermilion, hopped away to the far end of the balustrade. One could almost describe the cardinal as the patron bird of Virginia, rivalled in brilliance only by the wild creeper which this state has presented to the walls of the Old World.

Leaving our baggage, we drove on for a couple of miles until, to our surprise, we were confronted by a massive group of red brick and stone buildings of early eighteenth century style, completely out of keeping with the white-painted timber houses that dot the Virginian countryside. A notice reading "William and Mary College" reminded us that we had reached one of the few towns called after those sovereigns.

The college stood at the end of a long straight street flanked by low wooden houses with small diamond-paned windows, and I felt I was looking at a scene little changed from Colonial days. The very name of the thoroughfare, "Duke of Gloucester Street," was painted up in an archaic style that seemed to fit the atmosphere we had suddenly encountered.

We found ourselves setting forth on foot down the strange street. There were others about, dressed as we were, but the only vehicle in sight was an open carriage driven by a negro coachman in knee breeches and an enormous three-cornered hat, who slowed down as he approached us, evidently in hopes of taking us up. I was fully engaged, however, in looking at the shop-fronts with their little built-out show windows and swinging signboards. An apothecary, advertising Physicks and Cordials of all kinds, as well as Perfumes for Ladies and Gentlemen, received our attention first. The man behind the counter wore a short pig-tail tied with a ribbon and a long dark red coat; upon the shelves behind him were large porcelain jars inscribed "Zing. Sin", "Turkey Rhubarb", "Mandragora", "Cassia" and so forth. He bowed low as we came in, and announced himself at our service. Still somewhat bewildered, I asked if we might look round his wares, to which he replied "Sure", and shaking back his lace cuffs began to exhibit some of the mysteries of his period: whole nutmegs, a surgeon-barber's formidable instruments, and little hand-made glass bottles with a pungent scent perhaps suited to a stronger-smelling world than twentieth century America.

Determined to surrender myself entirely to this dream-like experience, I asked for a glass of metheglin.

"Say, we don't have any of that," replied the apothecary, "you see, Virginia's a dry state."

Unabashed we stepped into the late afternoon sunshine and turned out of the main street alongside a pleasant green where we would have expected geese or cricket. Fixed to the wooden palings enclosing a small orchard I caught sight of a notice to the following effect:—

To Whom it may Concern

"Ye Owner of this Orchard hereby gives notice y[t] he Keeps a Great Dog within, which will not suffer any to enter but he will run upon him. Wherefore take heed of him."

Across the board some rude hand had scrawled: "You don't have a dog," so we passed on reassured till we reached a piece of open ground in the centre of which stood a brick building like a small fort. I drew Robert's attention to a flag hanging from a short staff in front of it.

"Am I seeing straight?" I asked, "But is that really the Union Jack?"

We both approached the fort and, sure enough, there flew the British Flag. But we soon noticed that it was the flag of the old Union, without St. Patrick's cross, and we realized that we had not reached 1801. There were other people about, evidently undergoing the same experience, so we followed them into the brick building. Here we met a wizened-looking man wearing a tricorne hat, a full-skirted coat, black breeches, white stockings and buckled shoes, holding a heavy horse-pistol in his hand.

"Now, friends," he was saying, "I have primed the ole pistol and if the wind be right I calculate she ought to fire."

There was a click as he pressed the trigger, but nothing else happened.

"Maybe the powder was wet," he observed, "The ole powder must be proper dry."

So saying he went through the laborious process of loading and priming, and pointed his pistol in the air.

"Creep up on it from behind," suggested one of our companions; but a loud report, accompanied by a few feminine squeaks, demonstrated that this was still a contemporary weapon.

We followed the armourer through a doorway into a round chamber whose walls were lined with muskets, powder barrels and piles of shot.

"These ole muskets," He explained, "were made in England, friends. Yes, friends, they done bring them all the way from the Tower of London."

Satisfied that Williamsburg was in an adequate posture of defence, we wandered out on to the green towards a solid-looking building with a clock-tower. On the way we came to another brick structure in front of which stood a pillory and some stocks. These were unoccupied, but a bandy-legged individual in black knee-breeches appeared out of a doorway carrying a bunch of large keys.

"Would you folks like to look over the gaol?" he asked, and led us into a large cell capable of accommodating several prisoners. It was empty save for the austere furniture proper to the entertainment of felons, together with some leg-irons for the more refractory characters. In the corner, however, were three steps, apparently leading nowhere, but with two round holes in the top tread; these, it was explained, communicated with the basement below and ushered in the era of indoor sanitation in America.

The quarters occupied by the jailer and his family were conveniently situated above the cells, and after a cursory glance at them we pursued our way out into the twilight, and continued towards the clock-tower. As we came to the handsome Georgian doorway we again saw the old Union Jack flying from a staff upon the tower. This was evidently the Governor's palace, for we passed into a series of lofty rooms with ornate ceilings and elegant brocaded furniture. Several pieces of Chinoiserie enlivened the solidity of the Chippendale and the heavy folds of the curtains.

It was already darkening indoors, and a woman in a white cap and bright yellow wide-hipped petticoat came into the room with a taper and began to light the candles.

"Good evening, folks," she said, and asked if we would like to see the apartments. We followed her obediently from room to room, and as we went the soft lights sprang up in the many silver candlesticks, falling upon the oil paintings in rich, heavy frames along the walls. Charles II, "a blacke man, two yards highe", looked down sardonically upon us; while local celebrities like George Washington and Thomas Jefferson mingled with the Hanoverian Georges and earlier Americans in Elizabethan beards. I began to wonder what authority occupied the palace at this moment.

Three lovely chandeliers glittered and twinkled as our fair light-bearer glided through the ball-room.

"These were lost," she observed somewhat mystifyingly, "when the palace was burned in the riots. But when the Governor fled, he made a complete list of everything and claimed compensation from the Colonial Office in London. One of the chandeliers, or one exactly like it, was found hidden away in an old junk store in Canton, China."

Our conductress took us up the massive staircase and into the Governor's bedroom, furnished with a great four-poster bed ready to receive his Excellency when his evening draught had done its work. His writing desk and quill stood ready to draft highly confidential dispatches such as might disturb my Lord North in London.

The walls of another room were lined with embossed leather instead of wall-paper.

"I'm glad this stuff survived the riots," observed Robert.

"No, Sir; it was all burnt up. But when Lord Crewe sold his home in England this was taken down from the walls and fixed right here."

The eighteenth century atmosphere had by now become rather oppressive and even thirst-making, so we made our way out through the dusk to where the lights and sounds of a tavern cast a welcome into the deserted street.

We found a snug and bustling little room, with panelled walls and hard seats. The soft light of lanthorns fell upon the bright polish of Pewter, copper kettles, and brass warming pans. Other customers surrounded us in the shadows, and in and out moved the servitors in buckled knee-breeches and white shirts.

"Any metheglin or mead?" we asked one of them.

"No, Sir: we don't have that," replied the man, handing us a bill of fare for study. A quick glance at it was enough to set the salivary glands working. Passing over the "Difh of Salmigondin" and "Scuppermong Grape Wine", my eyes lighted on "Brunfwick Stew, made from a young fowl with Frefh Garden Stuff feafon'd to Tafte and Serv'd up hot" followed by "Beer Tidbit Platter: minc'd Virginia Ham on crackers, grat'd Cheefe Tidbits, some crift Potato Slices, and pickl'd Cucumbers."

"But listen to this," read out Robert, "Between 6 p.m. and 9 p.m. guests may order A fine Sirloin Steak; but since it is charcoal broiled out of doors, it can only be ferv'd when the Weather permits."

"In case we are still hungry after that," I rejoined, "we can have a difh of Tarts, Cuftards and Cheefecakes."

I caught sight of a serving man's powdered wig over my left shoulder, and tried again:—

"What about a Sherry Cobbler?" For answer he indicated a passage at the foot of the menu which announced that

"Inafmuch as the laws of this Commonwealth prohibit the Sale or Confumption of Spirits and other ftrong Waters in Publick Places, fuch liquors are neither fold, ferv'd nor permitted to be confumed in this place."

"But," he added consolingly, "Youse kin order a champagne cocktail."

Robert and I looked at one another as though a spell had been suddenly broken.

"John D. Rockefeller can have his Colonial reconstruction," we agreed, "Let's enjoy something twentieth century."

THE NEW ARMY ACT

By MAJOR D. M. R. ESSON

ONE of the last statutes to receive the Royal Assent in the last Parliament was the new Army Act. The National Press did not report the causes, debates and consequences of this enactment very comprehensively; it may interest more than Staff College and promotion examinees to read the story.

As a result of the great constitutional struggles of the seventeenth century, the Bill of Rights, 1689,[1] prohibited the raising or keeping of a standing army in time of peace without consent of Parliament. As, of course, a regular army was essential to the safety of the nation, Parliament gave its consent, but for only one year at a time. This consent at first consisted of a series of Mutiny Acts, providing both the permission to the Crown to raise and maintain an army, and the code to keep that army disciplined. Until 1879 the entire code was debated afresh every year in both Houses of Parliament and then re-enacted. Even in that leisurely era the inordinate waste of Parliamentary time caused grumblings from our legislators. Accordingly they enacted an Army Discipline and Regulation Act in 1879,[2] and subsequently the Army Act in 1881,[3] to be brought into force for a year at a time by an Army (Annual) Act: since 1917 this has been called the Army and Air Force (Annual) Act. By this device the Government of the day hoped that the interminable wrangles over amendments would be brought to an end, and some expedition seen in our parliamentary affairs martial. But although this alleviated the problem for the time being, the Annual Act was an excellent instrument to amend the principal statute and to fix billeting prices; and what was good for a Government goose was good for an Opposition gander. Although as a result of the annual spotlight our military code was the most modern and up to date part of our law, the shortage of parliamentary time was again becoming acute; for instance, as a result of the Boydell case[4] in 1948, a loophole in the principal Act[5] was stopped up a few months later by the Annual Act.[6] In the spring of 1952, an opposition member of Parliament, pointing out some glaring anomalies, persuaded the Government to appoint a Select Committee to investigate the

[1] Bill of Rights, 1689 (1 Wm 3 and Mary 2, Sess. 2, c. 2).
[2] Army Discipline and Regulation Act, 1879 (42 and 43 Vict. c. 33).
[3] Army Act, 1881 (44 and 45 Vict. c. 58).
[4] R. v. Governor of Wormwood Scrubbs and the Secretary of State for War, *ex parte* Boydell [1948] 2 K. B. 193; [1948] L. J. R. 1327; [1948] 1 All E. R. 438.
[5] Army Act, 1881, s. 158.
[6] Army and Air Force (Annual) Act, 1948 (11 and 12 Geo. 6, c. 28) s. 6.

situation and recommend such changes in the law as appeared desirable. He pointed out that the prices for billeting had last been fixed in 1939 and were grossly inadequate; that the billeting provisions were archaic; and the anomaly that the dates for the duration of the Act varies between the British Isles and other places. To bring these two dates into harmony the Act was extended for fifteen months in the British Isles instead of the usual year.[7] As a result of the delay occasioned, a complaint was made in the House of Lords that there was insufficient time left for debate, and consideration of such amendments as they might think desirable. The Select Committee, consisting of members from both sides of the House, was duly appointed. Some conception of the morass of detail through which they had to plough may be gathered from looking at the Army Act in the seventh edition (1929) of the *Manual of Military Law*, duly amended to 1951. This is a fearsome document, not from its complexity alone, but from the doubt whether all the amendments have been correctly inserted. Periodically parliamentary counsel to the Treasury used to issue a copy of the Army Act, amended to date, and showing in the margin the authority for such amendments. In the 144 pages of the 1949 edition there were only six pages on which the purity of the 1881 enactment was unsullied by amendments; on the other hand section 145 of the Act showed sixteen amendments. The Select Committee sat for over a year and finally produced its report in the form of a draft Bill.[8] This Bill commanded a very wide measure of support from both sides of the House of Commons, and after some amendments became law in May 1955, together with a Transitional Provisions Act[9] to cover the change-over period.

It is not intended to catalogue the analogous sections of the old and new Acts, as it is to be hoped that the authors of the ninth edition of the *Manual of Military Law* will do this; the purpose is rather to point out the framework of the new disciplinary code.

The great feature of the new Act is of more interest to the constitutional lawyer than to the soldier. The Act itself provides that it shall be continued in force from year to year by Order in Council following an affirmative resolution of both Houses of Parliament, but this sort of continuance may not exceed five years.[10] This dispenses with the need to introduce an annual Bill in Parliament, whilst preserving the principle of strict parliamentary control over the Army, and ensuring that the whole code shall be revised during each Parliament. Only once in each Parliament will an Army Bill be presented for its approval with all its concomitant stages of

[7]Army and Air Force (Annual) Act, 1952 (15 and 16 Geo. 6 and 1 Eliz. 2, c. 24) s. 2.
[8]Report of Select Committee on Army Act and Air Force Act, House of Commons Paper 223/1953-4.
[9]Revision of the Army and Air Force Acts (Transitional Provisions) Act, 1955 (3 and 4 Eliz. 2, c. 20).
[10]Army Act, 1955 (3 and 4 Eliz. 2, c. 18) s. 226.

parliamentary procedure: in all the other Sessions the Government will merely ask for the permission of both Houses to lay the necessary Order before the Queen in Council. The desperate need for more parliamentary time is thus achieved without detracting from constitutional convention. The main body of the Act will not be altered so rapidly and perhaps the new *Manual of Military Law* will take considerably longer to look like a paradise for a baby with a pair of scissors.

So far as the disciplinary provisions are concerned there are few substantial changes, although the whole has been rewritten in a much more intelligible fashion. Cowardice is no longer to be punishable with death.[11] The offence of desertion is now defined in the Act itself,[12] and specifically includes certain forms of fraudulent re-enlistment. The attempt to commit any offence is now recognized in all cases instead of only a few.[13] The comprehensive offence of conduct to the prejudice of good order and military discipline is now shorn of all its provisos.[14] The difficulties of dealing with witnesses who have left the service or the station where a trial is to be held have been overcome in some measure by allowing evidence to be given by statutory declaration, subject to certain safeguards.[15] Courts-martial, in future, will be allowed to "take into consideration" other offences committed by an accused person, when they are considering sentence, if he admits them and so requests the court, again subject to certain rules, which have not yet been published.[16]

There is less change in the substance of the enlistment sections, although these now come at the beginning of the Act instead of second. Under certain circumstances a parent may object to the enlistment of a minor.[17]

The provisions for billeting in time of peace are not re-enacted. A modified form of billeting in an emergency has been introduced, allowing the Secretary of State to bring into operation sections dealing with both accommodation[18] and the impressment of vehicles[19] for one month only. Within this time he must inform Parliament; if both Houses so resolve, his order may be extended for such time as they think fit.[20] Furthermore, the prices to be paid for billets are to be fixed by the Army Council with the consent of the Treasury.[21]

The sections dealing with exemptions have deleted the old provision of no process against a soldier for debts less than £30.[22]

[11] Army Act, 1955, s. 26.
[12] Army Act, 1955, s. 37 (2).
[13] Army Act, 1955, s. 68.
[14] Army Act, 1955, s. 69.
[15] Army Act, 1955, s. 99 (2).
[16] Army Act, 1955, s. 105.
[17] Army Act, 1955, s. 20 (3) and 2nd Schedule.
[18] Army Act, 1955, s. 154.
[19] Army Act, 1955, s. 165.
[20] Army Act, 1955, s. 174.
[21] Army Act, 1955, s. 158 (4).
[22] Army Act, 1881, s. 144.

This originally began as a measure to obtain the services of volunteers, not to protect their goods from seizure; but before long it provided a ready supply of recruits only anxious to avoid incarceration in a debtor's prison. As recently as 1952 this section was invoked by an aircraftman to avoid paying costs in a divorce action.[23] No process, however, may issue against either an officer's or a soldier's arms, ammunition, instruments or clothing.[24] The exemption granted from payment of tolls by regular personnel on duty[25] is re-written in much clearer language. It is supplementary to the Crown prerogative exemption from tolls thorough, that is a toll charged on the users of a route which has been repaired, as opposed to tolls traverse, which is where the route is a new one.[26]

Under the old Army Act a civilian serving overseas with the Army could only be tried by a court-martial when those forces were on active service.[27] This immunity from criminal process by British courts is ended,[28] and civilians, who are either employed by, or accompany the Army, or who are members of service families, or their servants, will be amenable to the jurisdiction of courts-martial when outside the United Kingdom. They will, however, only be punishable for forcing a safeguard, obstructing the police, disobeying orders, resisting arrest, escaping from custody, contempt of court-martial, false evidence, or for any civil offence. In such cases as these a court-martial may impose a fine. There is no named limit to this power, but by the Bill of Rights such fines must not be excessive. Any other less punishment than imprisonment is expressly excluded. There is provision for dealing with such civilians summarily with a limit of a fine of £10.

The old Act has been specifically continued in force until the end of 1956:[29] the new Act will come into force on a date to be decided by the Queen by Order-in-Council, presumably the following day. Some may wonder why such a long period is necessary; new Rules of Procedure have yet to be made, and after that the whole of the new code must be taught to those concerned. It is essential that those who administer justice shall know what that justice is. A year or more is not too long to make that certain.

[23]Boon v. Boon [1952], P. 114; [1952] 1 All E. R. 760; [1952] 1 The Times L. R. 764

[24]Army Act, 1955, s. 185.

[25]Army Act, 1955, s. 184.

[26]Nyali, Ltd. v. Attorney-General [1955], 2 W. L. R. 649; 99 S. J. 218; [1955], 1 All E. R. 646.

[27]Army Act, 1881, s. 175 (7) and s. 176 (9) and (10).

[28]Army Act, 1955, s. 209 and 5th Schedule.

[29]Revision of the Army and Air Force Acts (Transitional Provisions) Act, 1955, s. 1.

SURVEYING IN TANGANYIKA

By CAPTAIN A. G. BOMFORD, R.E.

TANGANYIKA is one of the less developed African territories, and the Southern Province the least developed part of it. An earth road runs 350 miles inland from the coast to Lake Nyasa, but for five months of the year there is no road north to the rest of the territory, and there is no bridge over the Ruvuma into Portuguese East Africa. The whole province is covered with close bush, the grass beneath the trees burning off every year.

Some of the territory had been triangulated by the Germans before 1914, and much more had been completed by 1939, but until 1953 there was no triangulation in the Southern Province. In that year, the Directorate of Colonial Surveys, to which I was attached, began work on a chain of triangles running south down the coast from some old German trig points near Dar es Salaam, inland along the Portuguese border, and up the east shore of Lake Nyasa, closing on some trig points fixed about 1932. This new chain is about 650 miles long, the sides of the triangles averaging rather over thirty miles.

The first part of the job was to site the trig points and design a geometrically strong chain. This entailed climbing all the best hills in the area, and in good country recce for primary triangulation is very enjoyable. After anything from thirty minutes to three days walk, we would arrive on top of a hill and look out over the great plain of Africa, with isolated rocky peaks or the wooded coastal plateaus rising from it like islands from the sea. On bare or sparsely wooded summits, where we could clear a view in an hour or two, we would set up the theodolite, shoot the sun for an azimuth, and draw a detailed panorama of the whole horizon, taking angles to every hill that might possibly be useful. On thickly wooded hills compass bearings from the top of a tree had to suffice for the panorama, but many of the hills were very magnetic, with up to 10 deg. deviation between two points 100 ft. apart. We would build a cairn on the selected site, and then return to camp.

With hills under two hours from the truck, we used to try for a hill a day, eating at dawn and getting off on foot before sunrise, returning to camp about noon, and then off maybe seventy miles in the truck in the heat of the day. Pitch camp about four with luck, compute the sun azimuth quickly on a slide-rule, and plot the angles to see how the chain was turning out. Eat again at dusk, and to bed soon after. I gave up eating at midday. When we passed into more remote country, we might be away from the truck for ten days at a time, doing a round trip taking in three or four hills. Then food, tent, bedding and instruments all went on to the boys' heads, and we would set off in single file in the best Livingstone tradition. The boys carry up to 60 lb., and we would walk for seven or eight hours a day, though twice when food ran short we walked for twelve. Usually we would start off along native paths, and then strike off for the hill on a compass course through the bush.

Down the coast, the country was at first difficult, with low heavily wooded hills. Towards the Portuguese border, we arrived among the insulbergs, domelike outcrops of rock, sticking out of the plain, anything from six inches to 3,000 feet, often interesting to climb, and perfect for triangulation. Inland we climbed gradually to the grassy 8,000-ft. summits of the Livingstone Range, the eastern edge of the Great Rift Valley, beyond which the ground drops abruptly into Lake Nyasa, 5,000 ft. below. Then we worked north to the head of the Lake, and finished on Mt. Rungwe, an extinct volcano with a fine crater, just under 10,000 feet. It was our sixty-fourth hill.

Having selected the hills, we had to clear the wooded ones, and build concrete trig pillars, rather like those used by the Ordnance Survey. Pillars are like icebergs: there is more beneath the surface than above. In soft soil where a large foundation is needed, about twelve loads of cement and ironmongery have to be carried in from the truck, and maybe twenty-five loads of sand and water from the nearest river bed. We carried hammers and broke aggregate by hand on the summit. A pillar on bare rock needs no foundation, but three 6-in. holes have to be jumped in the rock for the reinforcing rods. So pillar building is hard work, but one does have something to show for one's efforts: a gleaming white and black pillar, inscribed with its number and the year, built to last through the ages. It pleases me to think of someone in a couple of centuries' time climbing up one of our better and more remote hills, muttering "Bet this is a first ascent", only to be confronted with our ancient monument.

Observing is a slower business, as one is dependent on good visibility. We were measuring each angle thirty-two times, and tried to observe half our shots on to heliographs by day, and half on to electric lamps by night, to help reduce refraction errors. We finished several stations within twenty-four hours, but bad visibility can hold one up indefinitely. In the rainy season we were observing quite happily on to 1-watt bulbs at 50 miles, but in the dry weather, haze sometimes made it impossible to observe a heliograph in bright sunshine even at 20 miles. With two observers leapfrogging each other from hill to hill, we averaged a hill every four days over several months. As soon as we had observed all the angles of a triangle, we used to add them up, subtract a correction to allow for the curvature of the earth, and see how near they came to 180 deg. This is an exciting business, as a bad misclosure may mean that several hills have to be re-visited and re-observed at a cost of maybe £200 and a couple of weeks' delay. A misclosure of over two seconds is a cause for some misgiving, and we had several, but the average misclosure of our first 125 triangles was about three-quarters of a second.

We always camped just as close to the pillars as we could, usually within twenty feet of the summit, and some of these high camps were most enjoyable, especially in the rains. The bush would then be bright green, and there would be water high on the hill. Unless it was actually raining, visibility was invariably of the order of 100 miles, and picking out hills we had been up, seventy miles and more away, always gave me pleasure. It was always good to see the helios on the distant hills flash on for the first time. One saw then exactly where the other pillars were, and knew that the lamp boys had arrived and seen the call-up signal all right, and that everything was running smoothly.

We tried to make the most of good visibility and work fast, but in between there was a surprising amount of leisure, and you can read or teach yourself Swahili, or collect flowers or rocks or insects, or just lie in the sun, as you feel inclined. You can eat and dress how you please. Those to whom, for example, the carrying of canes and gloves is extremely distasteful, can wear merely shorts and canvas shoes, with a couple of handkerchiefs knotted round the head. But those who prefer to eat tinned tongue and strawberries and champagne, and feel better with their clothes starched and pressed, can do so. Nobody cares.

Except in the reserves, wild life is diminishing fast, as it is the African's only source of meat; tsetse make the keeping of domestic animals impossible. I don't shoot for sport, but shoot meat whenever opportunity offers. Giraffe and ostrich don't come so far south as Tanganyika, but all the other large mammals are there. A .93 Mauser and a dozen men with axes combine to form quite a frightening "animal", and except for rhino, everything seems to be more scared of us than vice versa. Rhino are exceptionally stupid and may not move off however loud you bang and shout; but they cannot climb trees of course, and the only real danger is that one might tread on the theodolite while you peer down anxiously from above. We all have snake-bite outfits, and see snakes fairly frequently, but I don't think anyone has had to use his outfit since Colonial Surveys started up, and mine usually stays in the truck; but I always carry a razor blade and a packet of permanganate just in case.

In the dry, the bush feels clean and healthy. Water is often scarce, and is sometimes salty, white or brown. I always boil it. In the rains it is not so healthy, and scratches go sceptic unless you put iodine on them at once. Sulpha powder seems to be the only thing that clears sores up quickly, and one cannot always get it. I had fever twice, but think it was due to my own carelessness in taking paludrine. There are many tsetse flies, but sleeping-sickness is easily curable in the early stages by injection. Many people do a couple of tours without a day's sickness.

Recce is ideally a one-man job, and you may go several months without seeing a friend, not speaking English for days on end, and cutting your own hair. There were two of us observing, but while one was observing the other was moving to his next hill, and we used only to see each other once or twice a month. At one stage we had small V.H.F. radios for speaking along the lines of sight between the hill-tops, and it was certainly nice to hear one's partner's voice for a minute or two each evening. District Officers and missionaries are always pleased to see one and usually very hospitable, and one makes many transient friendships. No up-to-date newspapers or cinemas of course, and many of us preferred not to have a radio. When one did hear the news, it always seemed extraordinarily unimportant. I have the *Sunday Express* and the *Spectator* sent out sea-mail now, and they seem all the better for being six weeks old.

The main snag is being separated from one's family. They can now get one free return passage in two years, and in the West Indies, for instance, it may be feasible to take them out, but on fast-moving work in Tanganyika it would not be possible to see much of them. However, one accumulates five days leave a month, with a free passage home every year, and the pay and allowances are very generous. So that for those who like to intersperse relative hardship with periods of high living, it is not too bad; and there is positively no washing-up.

E. AND M. ODDMENTS

TRENDS IN MODERN ALTERNATOR DESIGN

"Self Regulation" or not "Self Regulation" that is the question

By LIEUT.-COLONEL R. F. PRATT, R.E., A.M.I.E.E.

THE uninitiated are often shy of E. and M. subjects, especially those with an "E" flavour, and thus tend to leave it to the so-called specialists. There is no "black magic" involved. It is just engineering, and as engineers we should all know something about it and keep ourselves up to date. Comparatively few articles on the subject appear in our journal, and the aim of this present attempt is to discuss, in an informal way, some modern trends in alternator design.

Machines working on the principles to be discussed are likely to appear in the Service shortly. Although most of them are in the sizes which are of R.A.O.C. provision, the E.-in-C. may be the technical sponsor for some of them. We shall all use them at some time of our life and, if we are worthy of our cap badge, we should know something about their inner workings.

The present article does not attempt to give the full textbook theory and intricacies of design. The reader must realize at the outset that there is a good deal more in it than meets the eye.

Let us begin at the beginning. At the risk of boring those who know their electrical theory let us consider the alternator from first principles, and develop the modern alternator from them.

All will know that if a coil is rotated in a magnetic field, an alternating voltage is induced. The magnitude of the voltage is proportional to the speed of rotation and the strength of the magnetic field for a given coil. In practice it is often more convenient to rotate the magnetic field and have the coil stationary.

The simplest magnetic field is that produced by a permanent magnet and such a scheme is used in the bicycle lighting "dynamo" of today. It should not be called a "dynamo" of course as this term is usually associated with a D.C. generator.

In the cycle lighting "alternator" we have a magnetic field of fixed strength and a variable speed. The faster you pedal therefore, the more volts you get. The lamps forming the load are so rated that you do not burn them out too often even if you are very energetic! Here we have then a simple machine with constant load, constant field and variable speed. It does the job required of it. The frequency is immaterial.

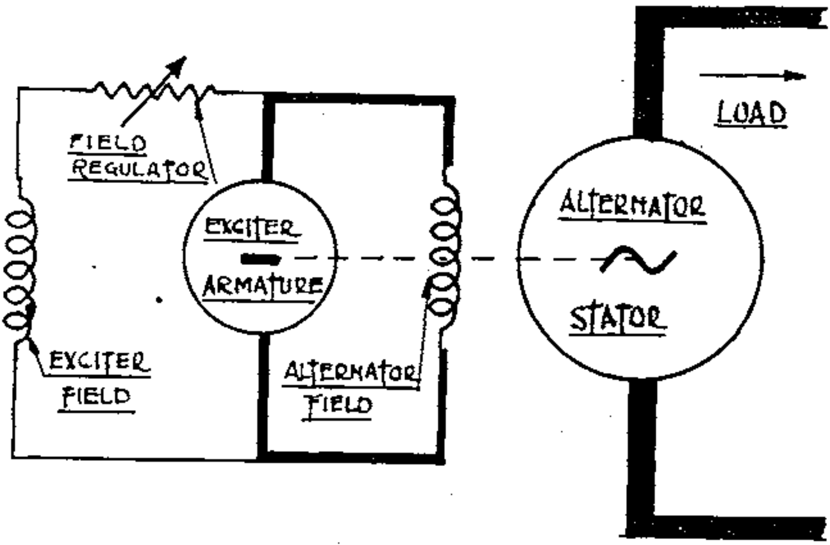
If we tried to use this type of alternator for supplying a normal commercial load, which is varying, we should have no success at all. For normal use we require the frequency to be constant, which means a constant speed of rotation. This is taken care of by the engine governor. With the constant field of the permanent magnet our volts would drop right away as we increased the load. As in the old military cliché there would be "bags of movement and no control whatever!" The only quantity with which we can monkey about is the strength of the magnetic field, if we changed our permanent magnet for an electromagnet. If now we strengthened the field as the load came on we could maintain the voltage at the correct value at the governed speed. This is how all normal alternators work and we have to keep the voltage at the consumer's terminals within $\pm$ 6 per cent of the declared voltage. The permissible variation of the alternator terminal volts has got to be a good deal closer than this.

Our A.C. machine now takes the form of a rotating electromagnet, the "field", and a "stator" which is an iron circuit on which coils are suitably wound. There are occasions when the components are reversed, but the principle of operation is the same. We have got to supply the field with a direct current which we must be able to vary to meet the various conditions of loading. Here we should notice that a comparatively small alteration in the field current is required to produce a large change in the alternator output current. In a typical 50 kVA. alternator, with a variation of field current from 10 amps to 25 amps at about 50 volts, the output current will rise from no load to full load condition (at 415 volts this is from zero to 70 amps). This is the first stage of amplification of the outside control.

An alternator nearly always has another little machine somewhere connected to its anatomy—the "exciter". This is nothing more than a D.C. generator, the duty of which is to supply the D.C. for the field system of the alternator. All will know that a D.C. generator can start from rest and build up its voltage without any external help. It also has a field system, but as there is a commutator on the shaft, the generator output is D.C. and can be used to supply its own field coils.

A voltage starts to build up due to the residual magnetism remaining from a previous run. The iron circuit of the field is in fact a weak permanent magnet. Contrast the build up of D.C. voltage with the starting up of a plain alternator. The alternator output is alternating and therefore cannot be used to excite its own field, although there is residual magnetism in the iron from a previous run.

The simple alternator has the elementary circuit as shown in



— FIG 1 —

Fig. 1, where the thickness of the lines represents the magnitudes of the currents flowing. Notice that with the introduction of the exciter into the circuit we have another stage in the amplification of any control we care to exercise. A small variation in the current flowing in the exciter's field circuit will have a large effect on its output, which in turn will have an even larger effect on the output of the alternator. The prime mover driving the machine supplies more power, under the influence of its governor, to meet the changed electrical conditions. The control, in the conventional machine, is usually exercised by a variable resistor in the exciter field circuit. This is known as the "field regulator". Notice that it is only handling a small current and it is usually mounted on the switchboard.

Now let us turn to the intricacies of voltage control. We have seen that the cycle lighting dynamo has no control whatever in the sense we are considering here. In fact, it has certain inherent control as it is essentially a constant current machine. In normal alternator applications we are much more concerned with keeping the voltage constant, because on this "hangs most of the law and the prophets". We must therefore measure the voltage.

The first method of control we can use is "manual control". We put a voltmeter on the switchboard and station a man there to watch it. We give the man orders to twiddle the knob of the field regulator to keep the voltmeter needle on the approved mark. The man then becomes a "voltage sensitive device" which alters the field resistance in accordance with the "error signal" of the voltmeter, detected by his eye and translated into the correct movements by his brain. This system works all right, but a man cannot act quickly enough for electrical conditions and it is a gross waste of valuable manpower!

Man is by nature a lazy animal and the engineer has sufficient cunning to devise other methods of saving himself trouble. The "Automatic Voltage Regulator" or A.V.R. is the result.

In essence, the A.V.R. is merely a robust voltmeter, which by its mechanical movement is capable of altering the field resistance by itself. It is a *mechanical* device which balances the varying pull of the voltmeter coil against a spring. The movement of the armature of the coil alters the resistance direct by compressing or releasing a pile of carbon plates (as in the Stone regulator), moves a contact over a tapped resistance (as in the Brown Boverie regulator), or varies the time of dwell at maximum and minimum resistance as in the vibrating types (an example being the Isenthal regulator). The A.V.R. is a thoroughly reliable instrument, but it is mechanical, can get out of adjustment due to wear or maltreatment, usually needs skill and delicacy in its readjustment. It is therefore not altogether suitable for rough conditions. It has given yeoman service and will be with us for many years yet, especially in static installations.

Now what about these so called "self regulating" alternators which have appeared on the market in recent years. It depends very much which components you associate with the term "alternator" whether the definition of "self-regulation" can apply or not. If you consider the basic alternator only, without any of its excitation circuit, no alternator is self-regulating. If you include the exciter, the Macfarlane alternator with "Magnicon" exciter is the nearest approach, though there are still a few components on the switchboard. The Magnicon exciter contains the voltage sensitive device actually within its own frame. We can say that the Macfarlane alternator is self regulating within the meaning of the act, in that it does not have an A.V.R. on the switchboard. If, however, you consider the alternator to include its exciter and switchboard then all alternators with an A.V.R. are self-regulating. They need no manual control. It is important to be clear on this matter as there are many "self-regulating" alternators on the market now, which are not self-regulating in the same compact way as the Macfarlane. They are all very cunning and seem good but, with one exception, they all have a voltage sensitive device (not an A.V.R. in the old sense) somewhere in their circuits.

We have seen how the A.V.R. works. We will not spend too much time on the Magnicon exciter as it has been adequately covered elsewhere, including E.M.E.Rs. These alternators are now in service (in the form of the 27.5 kVA. Meadows-Macfarlane set). The

Magnicon is the crafty part of the arrangement, the alternator is the same as any other. The Magnicon is an "amplidyne" with a magnetic voltage measuring device incorporated in its complicated windings. Its response to an electrical change is extremely rapid, a matter of 10 cycles (0.2 secs.) sufficing for it to adjust itself to new conditions. It dispenses with the need for a delicate A.V.R. and although still a rotating machine is reasonably robust. It is however manufactured to very close tolerances on which its close control of the alternator voltage depends. This close control suffers badly when, due to wear, dirt or other interference, its mechanical condition departs from its original designed criteria. This is due to the colossal amplification of the original voltage error signal which takes place within the exciter. It is in the order of 20,000. It is attractive, however, from the military viewpoint and that is why it is in the Service now.

It is not the only alternator which departs from the old conception. There are others, and it was due to a certain amount of trouble in the early days and the constant desire not to put "all our eggs in one basket", that other makes were studied. We will look at a few of them now.

Another so called "self-regulating" alternator is the Brush "Amplidex". This in its elementary state, is simple to understand. The Magnicon, working on the amplidyne principle produces its amplification of the error signal all within one machine. The Amplidex amplifies its error signal in two stages. There are two exciters connected in cascade. The principle, in block form, is shown in Fig. 2. Again the thickness of the lines indicates the relative magnitude of the currents flowing. The exciter and sub-exciter are mounted in the same frame. They look like an extra long exciter, but on closer inspection it will be seen that there are two commutators. The exciters are not unduly complicated like the Magnicon, but some refinements are incorporated.

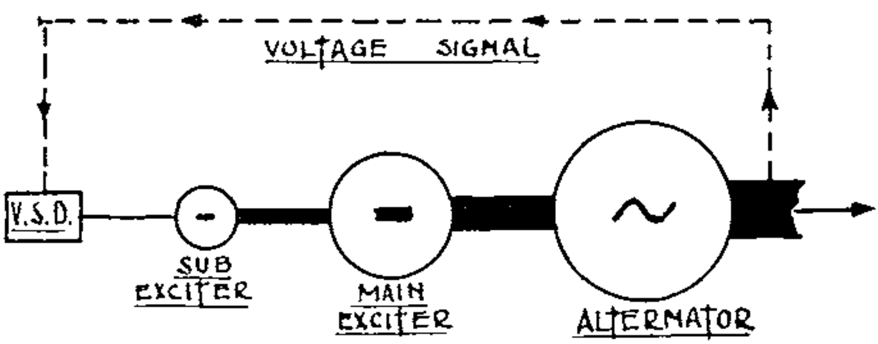


FIG 2

In the Amplidex, another form of voltage sensitive device (V.S.D.) makes its appearance. It is usually mounted on the switchboard. The term "V.S.D." is used rather than A.V.R., as the latter name is usually taken to mean the voltmeter type of mechanical regulator. The V.S.D. on the Amplidex is a circuit of static components only. The details will not be discussed now, but suffice it to say that it produces a small current, automatically varied according to the variations in voltage of the alternator, which feeds the field winding of the sub-exciter. Amplification in the order of 500,000 then takes place throughout the system. The V.S.D. circuit compares two electrical quantities in order to produce its error signal.

The Amplidex is not so rapid in response as the Magnicon, the correction taking place in about 0.7 secs, according to the maker's claims.

Up to the present we have touched on three basic methods of automatic voltage control. To summarize our thoughts therefore we have first the older A.V.R., secondly the Magnicon exciter and thirdly the electrical circuit of which the Amplidex is a simple example.

The A.V.R. is mechanical in action and is delicate. It is usually regarded as a switchboard instrument and is treated as such. (Except perhaps the Isenthal.) Its response is reasonably rapid and the regulation of the alternator can be kept within the prescribed limits with modern designs. It compares the magnetic pull exerted by the voltage to be measured with the pull of a spring.

The Magnicon is entirely magnetic in action and compares the magnetic field due to the voltage of the alternator against a magnetic standard within the exciter frame. As this comparison takes place close to the coils producing the alternator's field current, and because the error signal is conveyed to them in magnetic form, the response is extremely rapid and the regulation is close. Its disadvantages are that the closeness of regulation is disturbed if the fine manufacturing tolerances are lost due to wear or other causes. It is very sensitive to the exact position of the brushes on the commutator and to the brush-commutator resistance.

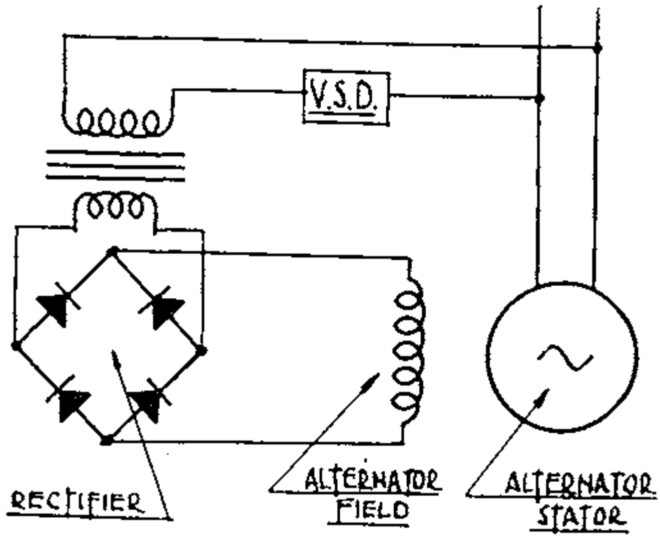
The voltage sensitive devices which are electrical in principle compare two electrical quantities by means of static circuits. They are not easily damaged by rough treatment, but certain electrical disadvantages appear more markedly. Such difficulties as temperature compensation, power factor correction, waveform distortion and ageing effects rear their heads. An electrical inertia is also introduced which makes them less rapid in response than the Magnicon. They are comparable with the A.V.R., but much more robust. Circuits can be devised to give control over voltage within $\pm \frac{1}{2}$ per cent if required.

Having got so far with our discussion, let us think more carefully on the action of all the above forms of automatic control. In all these systems, the error signal is amplified up to produce the correction. In order to hold an alternator's performance to any new condition of loading, the error signal originating the correction *must remain on the whole time.* This gives us the clue to the variation which must always be accepted from no load to full load. We can reduce the variations to very small limits, at the expense of other properties, but with this form of control we can never eliminate the error completely. The power for the necessary change in field currents is derived from the magnitude of the error signal, after suitable amplification. The situation is precisely analogous to the usual centrifugal governor fitted to a diesel engine. There must be a displacement of the governor weights from the no load position, in order to supply more fuel to the cylinders. The weights can only take up a new position with an alteration in speed.

With manual control however, if we had a very accurate voltmeter, the man could apply his correction to the field regulator so that there was no deviation from the approved voltage as registered by the meter. In this case the man's brain and muscles are supplying power to eliminate the error altogether. There are electrical devices working on this principle, but they are nearly all motor driven and are far too sluggish for the control of an alternator. They have other uses.

For an alternator regulated by the above forms of V.S.D., we must accept the fact that there will always be a deviation from the nominal voltage. This deviation for normal purposes is now specified as $\pm 2\frac{1}{2}$ per cent with the usual 4 per cent variation in engine speed from no load to full load. If we attempt to go closer than this we must sacrifice something else. We get into trouble with normal engine governing limits and we may not get the same sensitivity at other settings of the main controls. As usual the military requirements are very exacting. The dual voltage, dual frequency alternator sets are required to hold their voltage within $\pm 2\frac{1}{2}$ per cent at 415/240 volts $\pm$ 10 per cent manual setting at 50 cycles and at 208/120 volts $\pm$ 10 per cent at 50 and 60 cycles. All the above figures must be achieved over an enormous range of ambient temperatures. This is setting designers a very hard task, but some have achieved the aim.

There is yet another group of alternators which are claimed by their makers to be self-regulating. They are more correctly defined as "statically excited". Let us go back for a moment to the basic alternator without any of its trimmings. The alternator field system is composed of iron and retains some residual magnetism from a previous run. Why not make use of this? With the advent of reliable metal rectifiers capable of handling heavy currents, we



— FIG 3 —

can take off some of the output of the alternator, rectify it and apply it to its own field. A transformer is normally inserted in the circuit to reduce the voltage on the field coils to the usual value of about 50 volts. The arrangement is shown in Fig. 3. A V.S.D. is usually inserted in the primary circuit of the transformer and in the makes which have been studied this is also a static circuit. An example of this form of excitation is made by E.C.C. Ltd., of Wolverhampton. The sizes go up to about 27.5 kVA (military rating).

This system has reduced the pure voltage controlled alternator to its lowest terms. There is only one rotating machine of conventional form and proved construction. We have eliminated the exciter and A.V.R. and substituted a collection of transformers, rectifiers, chokes, condensers and resistors, all of which are fixed in the switchboard cubicle and it is hard to see how these components will get damaged. The box of tricks comprising the static exciter and its control is not unduly large and compares favourably in weight and cost with normally excited machines. The attraction is its robustness and elimination of moving parts. The over-all control is good, and a small machine which the writer saw at the maker's works easily held its voltage within $\pm \frac{1}{2}$ per cent at all loads, on all power factors, down to about 0.3, at a setting of 410 volts at no load.

For larger sizes of machine, the same firm has produced a compromise. A normal exciter was used with the alternator, but instead of making the exciter supply its own field, a static circuit was used. The machine seen was rated at 125 kVA. with an "in line" exciter. A small box of tricks containing the static exciter field circuit and the

V.S.D. was mounted over the exciter. The size of the box was such that it did not extend beyond the over-all diameter of the alternator frame. Messrs. Asea Electric Ltd. market a similar device for use with a normal exciter. There would seem to be a future for this arrangement.

Another very simple alternator is the "Stamford", marketed by Arthur Lyon & Co. Ltd. This is best defined as a "compounded, statically excited" machine. It is not voltage controlled as with an A.V.R. It is load controlled. Its action is similar to a compound wound D.C. generator. It is made in all sizes up to 75 kVA. but works best in the three phase form from, say, 10 kVA. upwards. There have been teething troubles and the sample tested at M.E.X.E. recently did not perform very well. The manufacturers state they have now overcome most of the trouble. The circuit is very simple (Fig. 4). At no load the field is produced by the potential transformers (PT). As the load increases an element of boost is applied to the field by the current transformers (CT). The current transformers act in the same way as the series coil of the compound wound D.C. generator. The makers claim that the arrangement works at all power factors. The diagram shows the principle. There are some complications, one of which is an auxiliary rectifier circuit to ensure a start from rest.

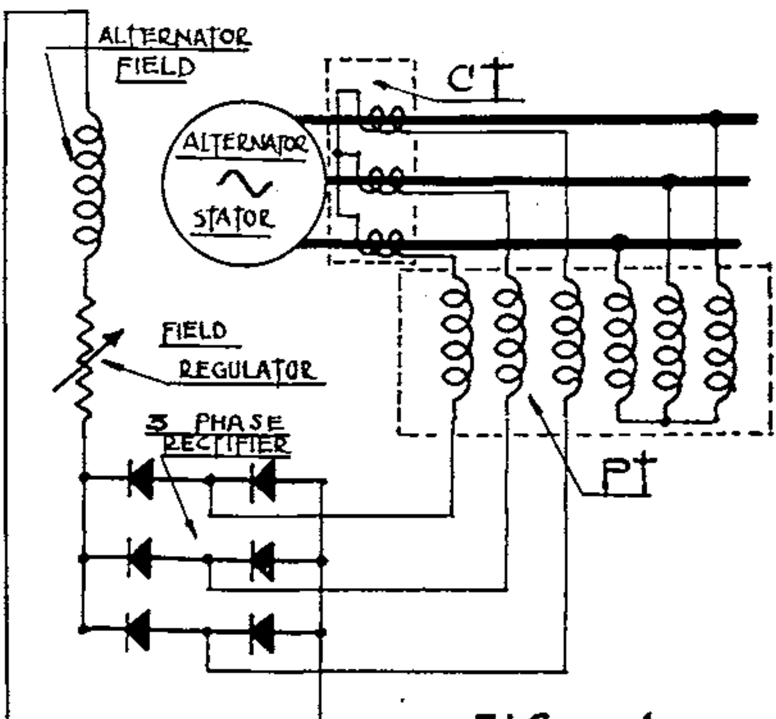


FIG 4

It is hoped to find time and space to discuss more fully the details of the various arrangements in later articles. This article may have stimulated some interest in these things and to conclude, it is strongly urged that these modern alternators should be tried out more thoroughly. There is not much running experience in civilian applications as yet. Firms appear willing to loan sets for military trials. These should be accepted gratefully and taken up with the utmost vigour. There are bound to be teething troubles as there were on the Magnicon and Amplidex, when tested at I.E.M.E. against M.O.S. contracts. Let us get them ironed out now, so that we can assess the worth of these modern developments which look so attractive on paper.

ARTICLES FOR THE R.E. JOURNAL

1. Articles for the "R.E. Journal" will be typewritten and submitted in duplicate, one copy being the original.

2. Line drawings must be in Black ink. Ink tracings on linen are very suitable. All lettering must be clear and bold to allow for reduction in size when reproduced. Scales will be drawn and not worded.

3. If tracings are submitted one print should be sent for the duplicate copy.

4. Photographs should be on glossy prints, and no writing should be on the photograph itself. Any reasonable size print may be submitted.

Not more than four photographs can normally be reproduced with any article. More photographs may be submitted and the Editor will make a selection.

5. Contributors to the Journal are reminded that under Queen's Regulations any information of a professional nature acquired while travelling or employed on duty is regarded as the property of the War Department and will not be published in any form without the previous sanction of the War Office.

It is suggested that prospective authors should read carefully Queen's Regulations, 1955, paragraphs 679 and 680.

6. War Office sanction to publish can be obtained, if desired, by the Editor, but authors must obtain a statement from the authority under whom the applicant is immediately serving that such authority has no objection to War Office permission being applied for.

MEMOIRS

LIEUT.-COLONEL SIR ALAN H. L. MOUNT, Kt., C.B., C.B.E.

ALAN HENRY LAWRENCE MOUNT was born in 1881 and was educated at Bradfield and the Royal Indian Engineering College, Coopers Hill, where he was selected, in 1902, for one of the two commissions in the Corps which were then available each year for Coopers Hill candidates.

After joining Kirke's batch for the Chatham course, and doing a Railway course, he was sent to India and appointed Assistant Engineer on the North Western Railway. In 1911 he was in charge of the construction of the Delhi Durbar Light Railway system, a strenuous rush job through an exceptionally trying hot weather, for which he was awarded the Kaisar-i-Hind medal. Thereafter he was placed on special duty in India and England to report for the Railway Board on the best scheme for the railway layout to serve the proposed new Imperial capital at Delhi.

In 1914 he went to France with the 3rd (Lahore) Division, but his railway experience soon led to his appointment as A.D. Railway Construction at G.H.Q., and subsequently as Deputy Chief Engineer Railways, till the end of the war; he was promoted Brevet Major in 1916 and was awarded the Legion of Honour in 1917.

In 1919 he accepted an appointment as one of the Inspecting Officers of Railways, Ministry of Transport, and in 1929 he became Chief Inspecting Officer, in succession to Colonel Sir John Pringle, a post which he held till his retirement in 1949. After retirement he was, for a short time, employed by the Railway Executive as consultant on safety measures, but his health broke down and he was practically an invalid till he died on 10th August, 1955.

In 1938 he went to India, at the request of the Railway Board, as Chairman of a special Committee of investigation into unexplained and serious derailments of some Pacific type locomotives recently put into service in India. This Committee, of which Sir William Stanier, Chief Mechanical Engineer, L.M.S.R., Mr. R. Carpmael, Chief (Civil) Engineer, G.W.R., and Mons. R. Leguille, a distinguished French Railway Mechanical Engineer, were members, made an exhaustive investigation of the interrelation between this type of locomotive and the track, and produced a detailed and classic report, which had substantial effect, not only on certain technical aspects of locomotive design, but also on the organization of the Indian Government Railway Inspection system.

On the outbreak of war in 1939, much of the normal work of the Inspectorate was suspended, but this reduction was far outweighed by additional responsibilities of advising on and controlling the execution, usually very urgent, of new railway works required for war-time traffic, repairs of bomb damage, and protection against enemy attack; there was also the endless reaction of A.R.P., and particularly the blackout, on an organization which had, probably more than any other, to work at high pressure, through the night, in the open, all over the country. Despite additional staff the tax on the Chief Inspecting Officer was heavy, and there can be little doubt that continual overwork during the last ten years of his service was responsible for the breakdown of his health shortly after retirement.

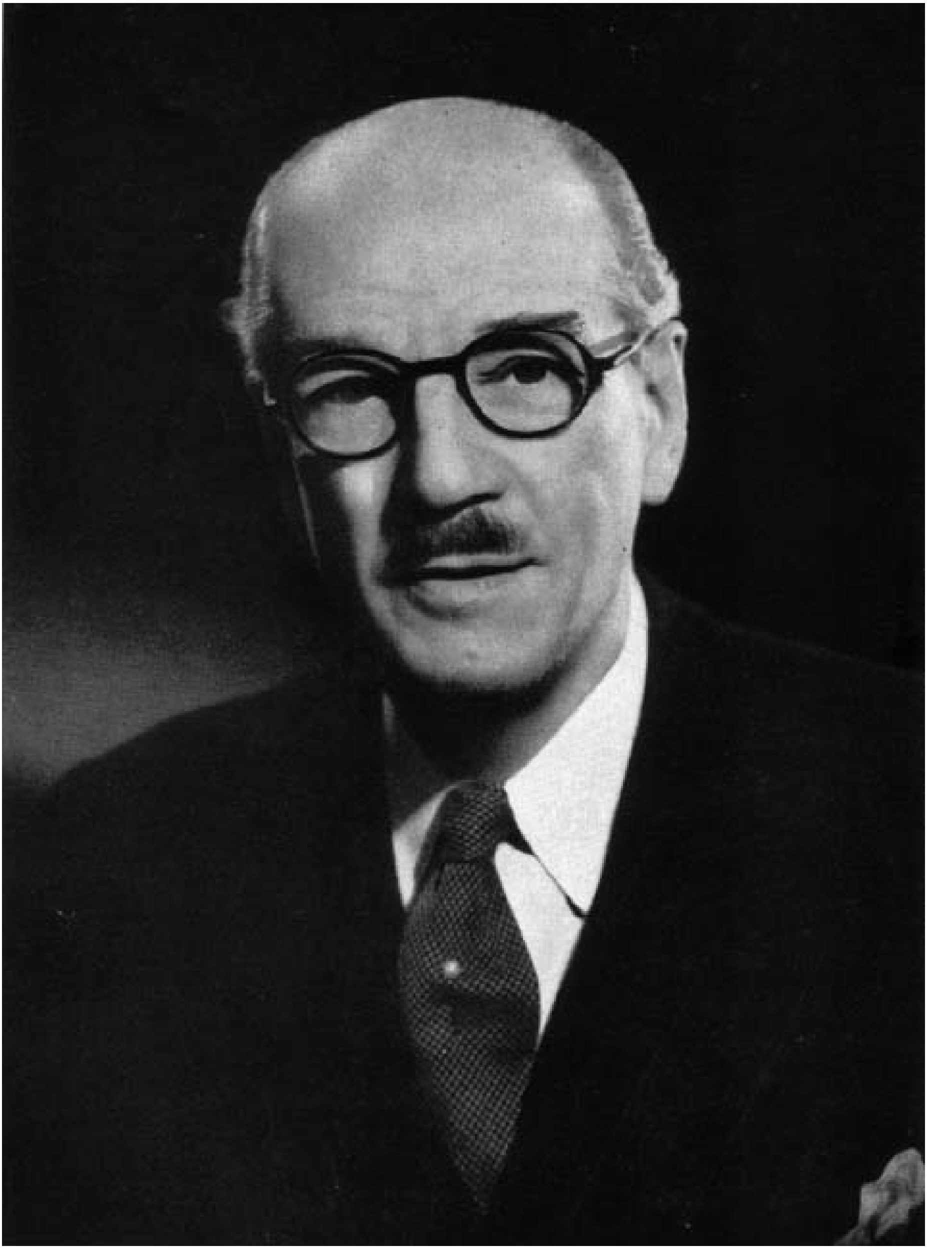
He was made C.B.E. in 1919, C.B. in 1931, and received a Knighthood in 1941. He married, in 1905, Margaret Sybil, daughter of the late Colonel Edmond D'Arcy Hunt, who survives him, together with a son and daughter.

Mount had great charm of manner and a wide circle of friends. He took pride in the fact that, ever since a Government Railway Inspectorate had been set up, over a hundred years ago, its technical staff had been provided by officers of the Corps, and he was able to show good reason to the authorities why this practice should be continued when there were vacancies to be filled. To reinforce other reasons, he could point out that an adequate degree of Government supervision was exercised, with the minimum of Statutory powers, and with an economy of staff unequalled in any other country.

His name was of course, primarily known to the public in connexion with his reports on railway accidents, which were exhaustive and scrupulously impartial, but these reports are, fortunately, not the major part of the work of the Railway Inspectorate; it was in the daily routine of approval and inspection of new works, and discussion of safety measures, that he showed his talent for persuasion, and, most important, for maintaining and improving friendly co-operation with the Railway Companies' staff in the pursuit of the common aim of safety. He was justifiably proud of the outstanding record of the British Railway Companies in this respect, and of the share of the Inspecting Officers in contributing thereto.

Mount was good with his hands and a neat free-hand draughtsman. He was fond of games and sport, but in his latter years he never gave himself any opportunity of leisure to indulge in them.

A.C.T.



Lieut Colonel Sir Alan HL Mount Kt CB CBE

Major-General Sir Clive S Steele, KBE DSO MC ED BCE MICE MIE,Aust. Colonel Commandant RAE

MAJOR-GENERAL SIR CLIVE S. STEELE, K.B.E., D.S.O., M.C., E.D., B.C.E., M.I.C.E., M.I.E. Aust., COLONEL-COMMANDANT R.A.E.

MAJOR-GENERAL SIR CLIVE SELWYN STEELE, who died in Melbourne on 5th August, 1955, was the first Engineer-in-Chief ever appointed in the Australian Army.

Born in 1892, Clive Steele was educated at Scotch College, Melbourne, and later at the University of Melbourne, from which he graduated as a Bachelor of Civil Engineering. During these early years he was a prominent sportsman: at Scotch he was in the boat for two years and in 1910, his final year at school, he was Captain of Boats. At the university he rowed in three successive winning crews.

In 1915 he enlisted for active service in the Australian Imperial Force, being appointed to a commission in the Australian Engineers and posted to the 5th Field Company. He disembarked in Europe in March 1916, and between then and the end of the war he was employed on the Western Front. He was promoted Captain in September, 1916. Early in the following year he commenced a series of secondments during which time he held the rank of temporary major. In March, 1918, he rejoined the 5th Field Company and in August was promoted major and appointed to command the 1st Field Company.

During this period he was slightly wounded, but stayed on duty. For conspicuous gallantry, initiative and devotion to duty at Peronne in August, 1918, he was awarded the Military Cross. The incident related to the reconnaissance and repair of a bridge over the river and canal during a heavy shelling. History repeated itself in April, 1941, when as Chief Engineer of the Anzac Corps in Greece he organized the repair of the bridge at Pharsala under continuous dive bombing. This action allowed the withdrawal to continue and Brigadier Steele was awarded the D.S.O. for personal bravery—an unusual achievement for an officer of his rank.

At the end of the first World War Clive Steele returned to civil life. In 1923 he commenced practice as a consulting engineer. In the next fifteen years he steadily built up his practice and reputation, not only in Melbourne but elsewhere throughout Australia and in New Zealand and Fiji. He and his associates specialized in structures, and a great many important buildings are lasting memorials to their success in this field. By 1938 Clive Steele was among the leaders of his profession in Australia.

All this time he retained close association with the Army through the Militia. In 1926 he became C.R.E. of the 4th Division. In 1933 he was appointed to command the 14th Infantry Battalion, and he held this command until 1939.

At the outbreak of the second World War Lieut.-Colonel Steele joined the Second A.I.F. He was appointed C.R.E. 6th Australian Division, but relinquished the appointment to become Chief Engineer on the formation of H.Q. 1st Australian Corps. He went with this H.Q. to the Middle East, where he saw service in the Libyan campaign of 1940/1, Greece 1941 and Syria 1941.

Still with H.Q. 1st Australian Corps, he returned to Australia in 1942 by way of the Dutch East Indies. In May of that year he was promoted Major-General and appointed Engineer-in-Chief at Allied Land Headquarters, South-West Pacific Area. In this appointment he built the magnificent engineer organization of some 42,000 all ranks, without which the island campaigns to the north of Australia would not have been possible.

In 1946 he returned to civil life, continuing to practise as head of his firm, and taking an increasing part in commercial affairs.

A foundation member of the Institution of Engineers, Australia, he was Chairman of the Melbourne Division in 1946. In May, 1955, he was accorded the rare distinction of being appointed an honorary member, one of only five. In 1954 he had been elected to be an honorary member of the Institution of Royal Engineers.

He was a member of the Institution of Civil Engineers, being Chairman of the Victorian Committee of Management of that Institution in 1946.

In 1944 the University of Melbourne awarded him the Kernot Memorial Medal for distinguished engineering achievement.

He was knighted in the 1953 birthday honours. The citation dwelt upon his war services, mentioning the heavy burden imposed on him by war-time engineering operations.

On 1st January, 1953, he had become Honorary Colonel of the Corps of Royal Australian Engineers, an appointment which had been in abeyance since 1938. The designation of the appointment was changed to Colonel Commandant in January, 1955.

At his death many prominent men paid tribute to him. The Prime Minister said "Sir Clive had been a great all-round man. In his youth he was a noted athlete and a brilliant student. He became a celebrated engineer, a distinguished soldier and a fine business administrator. Nobody who knew him could fail to be the better for his friendship. He will be greatly missed."

Clive Steele's salient characteristics were penetration of mind, determination to fulfil the task in hand and impatience of obstruction. He was known for his loyalty to his subordinates, and it is not surprising that they in their turn were loyal to him. In fact his personal ascendancy in his corps was remarkable. Whether or not they knew him personally, every officer and soldier who served in the Royal Australian Engineers after 1942 looked to Clive Steele as leader and paragon.

A.C.S.

BOOK REVIEWS

GREEK ENTANGLEMENT

By BRIGADIER E. C. W. MYERS, C.B.E., D.S.O.

(Published by Messrs. Rupert Hart-Davis. Price 18s.)

Underground war gained an importance in 1939–45, which it had not enjoyed to the same extent in 1914–19. Already during the preliminary "war of nerves", Hitler was working on the fears of his neighbours with "tourists" and fifth columns. In due course the Allies took a hand in the game and finally went one better than the Axis by expanding small beginnings into full blooded resistance movements, which tied up many enemy divisions far away from the vital points of the war. In the years to come, resistance movements are likely to be more common than nuclear Armageddons. They therefore deserve the attention of soldiers, especially in relation to their always complicated political settings.

In *Greek Entanglement* Brigadier Myers, a distinguished Royal Engineer, has written a book, which is a valuable addition to the variegated literature on this very subject. Dropped by parachute into enemy-occupied Greece in 1942, for nearly a year he played a leading part in the British direction of Greek resistance. For reasons, which the reader will easily determine, permission to publish has been refused for nearly ten years. Yet the story is soberly told in particularly good English and every page bears the stamp of truth. Perhaps the lapse of time has cooled the political passions, which once made the truth unpalatable. Although this is doubtful in a country like Greece, the long delay does not detract from the value of the book.

The Brigadier's account of the military part of his mission makes it evident that the military planning, both at Cairo and also in Greece, was of a high order. The destruction of the Gorgopotamos viaduct established the author's skill as the leader of a difficult minor operation and as the resourceful co-ordinator of rival bands of partisans. Later on, in interesting contrast, a rapier thrust of sabotage by four officers, of whom two were Sappers, and two N.C.Os. destroyed the heavily guarded Asopos viaduct without a shot being fired by either side. The Germans were so dumbfounded that they are said to have shot most of the garrison in the belief that there must have been treachery.

All this was admirable. Unfortunately the political trumpet did not sound from Cairo with the same clear note as the military one. Brigadier Myers criticizes this weakness on the political side with commendable moderation. The political direction of resistance in such a political hornet's nest as occupied Greece was manifestly most difficult. But Cairo seems to have discovered this rather late in the day—to say the least of it.

The description of the Robin Hood existence of the members of the mission is quite excellent. The hospitality and loyalty of the Greek villagers, who never betrayed, made up somewhat for the exasperating vagaries of their politicians. The R.A.F. with a few Liberator aircraft, on which the whole enterprise depended, performed prodigies of transportation.

The assured success of *Greek Entanglement* will be a recompense to its author for frustrations and disappointments which, about the time of his departure from Greece, must have been almost unbearable. His consciousness of a job well done will now be shared by most of those who read his most interesting book. B.T.W.

THE GUARDS ARMOURED DIVISION

By Major-General G. L. Verney, D.S.O., M.V.O.

(Published by Messrs. Hutchinson & Co. Price 15s.)

The Guards Armoured Division was created in 1941, after the 1940 defeat of France had brought the supreme importance of armour into prominence. Since the Guards Division had been one of the most famous of the "shock divisions" of 1914/18, it was only fitting that another division of "the ever-open eye" should be in the fore front of the armoured battle in 1944/5.

It was not without some reservations, that the Foot Guards, who for over three centuries had fought as infantry, turned their attention to tanks. Their battalions did not become armoured regiments. They were called armoured battalions and were subdivided into squadrons and troops. Thus, in the main, the traditional nomenclature was preserved. Moreover, directly after V.E.-day, the armoured battalions handed in their tanks and rejoined their comrades of the Foot Guards at a ceremonial parade near Hamburg.

Yet needless to say, the Guards Armoured Division fulfilled its unfamiliar rôle with great distinction. It fought in the "Goodwood" operation East of Caen. It helped to knock away "the hinge" in the Caumont–Mt. Pinçon area. A fortnight later, it crossed the Seine and bounced the Germans out of Brussels, covering over 250 miles in seven days, which was farther and faster than the German advance to the Channel ports in 1940. The division then assisted in the crossing of the Albert and Escaut canals, before leading the long advance on one road to secure Nijmegen. It took part in the Rhineland thrust towards Wesel and finally crossed the Rhine at Rees on 30th March to finish the war near Hamburg on 5th May.

All this fighting and movement is well set out in this short book of 184 pages, which is most successfully designed to tie up the detailed narratives of the regimental histories with the action of the division as a whole. Appendices give the order of battle together with lists of senior officers and of quartermasters, chaplains, medical officers and senior warrant officers.

The story sheds little new light on the strategy and tactics of the campaign. It is, however, interesting to note that the grouping of armour and infantry, which started in the bitter fighting south of Caumont, became an established practice in the division until the end of the war. Some of the flexibility of the divisional organization was thereby wasted. Another important point was the failure of the map supply during the rapid advance to Brussels. Modern armies seem urgently to require small-scale road maps of the Michelin type, of which two or three would cover the whole of Northern Europe from the Atlantic to beyond Berlin.

The maps in the book are good as far as they go, but the many places not shown on them might have been related in the narrative to places that are. This failing makes the story sometimes difficult to follow, especially towards the end.

The author adds to the appeal of the history by linking up the names of a great number of the killed and wounded with the places at which they became casualties. Amongst these are some Sappers.

Former members of the Guards Armoured Division and a host of connexions, friends and admirers will welcome this compact and well-written account of its achievements.

B.T.W.

ABODE OF SNOW

By Kenneth Mason

(Published by Rupert Hart-Davis. Price 25s.)

Some people enjoy climbing mountains; others get a vicarious thrill from reading about the adventures of those who do. Both these types will enjoy this book.

Kenneth Mason was a regular R.E. officer employed in the Survey of India, and was for many years editor of the *Himalayan Journal.* He thus not only knows personally much of the area of which he writes, but has also been closely in touch with the leaders of Himalayan travel and climbing.

The book is divided into sections. The first of these gives a general description of the Himalayas; their area is so vast that the author has had to exclude from his story some interesting regions just outside the Himalayas proper. Subsequent sections deal with the history of Himalayan exploration and climbing from the earliest times to the present day. The earlier travellers were more interested in the passes than the peaks, and serious attempts on the latter were not made until the closing years of the nineteenth century. Thereafter the story becomes more and more concerned with the attempts on individual peaks and culminates in the ascent of Everest. The accounts are vividly written and the hardships and, on occasions, the heroism of the climbers, not least of whom are the Sherpa and other porters, are made very real. Some readers might have liked to have heard more about the early travellers and especially the "pundits", but with so much to select from, much obviously had to be shortened or omitted.

To the Sapper one of the chief merits of the book is that it puts the work of the surveyors in its true perspective. They were the first to explore most of the region, but unlike the climbers who came after them, few attempted to leave any account of their work written in popular style; it is thus generally completely unknown to the general public. Had Montgomery, who carried out the first survey of Kashmir and who subsequently trained and directed the work of the transfrontier surveyors, had the aptitude for popular writing what a book he might have given us! As it is, his reports make (to one reader at least) somewhat heavy reading despite their great intrinsic interest, and his name must be virtually unknown to the present generation. Kenneth Mason has rendered a service in giving some account of his work in very readable form.

It is interesting to find confirmation on page 76 of the story that the world's altitude record was for many years held by a Survey of India *khalasi*. The tradition current in the department is that he was sent by his triangulator to set up a mark on a particular top, but mistaking his instructions climbed the wrong peak, thus setting up a world's record by mistake.

The book contains four useful appendices, which give respectively the heights of the main Himalayan peaks, a note on the determination of Himalayan heights, a chronological summary of the main journeys and climbs and a bibliography. That on the determination of heights contains one slip on page 350 which may confuse the careful reader. K2 is only in danger of losing its position as second highest mountain in the world to Kangchenjunga if the position of the spheroid under it is found to be *lower* in relation to the geoid (not *higher* as stated in the text) than was assumed in the computations resulting in the height accepted at present.

The addition of lithographically produced maps which could be folded out and read alongside the text, would have been an improvement, but modern production costs may have made this impracticable. The eastern portions of the Punjab Himalayas and the Assam Himalayas, though referred to in the text are not adequately represented in the maps provided.

Abode of Snow will for many years be the standard work on Himalayan exploration and climbing. It can, however, be confidently recommended not only to readers interested in these, but to the much larger number who enjoy a good travel and adventure book about any part of the world. G.F.H.

PHARAOH TO FAROUK

By H. WOOD JARVIS

(Published by John Murray. Price 21s.)

Those who have read and appreciated *Let the Great Story be Told*, Mr. Wood Jarvis's earlier book about our Empire-making, will be well advised to get hold of this new book of his. He does, indeed, bravely attempt to squeeze a quart of Egyptian history—some 5,000 years of it—into a pint pot of 290 pages: and he has succeeded remarkably well. He writes in popular style and takes the tale along at a cheerful canter, and thus avoids the *longueurs* inevitable in the more pedestrian pace of some historians.

Starting off in 3,200 B.C., the Pharaonic dynasties are covered in four chapters and give a summary account of the first 2,500 years, during which Egypt was an independent and sovereign country, occasionally of great power and wide dominion. The remainder of the book deals rather more fully with the subsequent 2,500 years, during the whole of which Egypt was under alien domination and which is only ending at this very moment with the dubious decision of Great Britain to remove all her armed forces from the country.

In coping with this immense period of time the author has wisely treated the duller portions, for instance from the Turkish occupation to the rise of Mahomed Ali, very scantily—dismissing four centuries in as many paragraphs; on the other hand he has at intervals given generous space and detail to a few better known episodes and people such as Alexander, Cleopatra, Bonaparte, Gordon, Kitchener and Cromer. And yet throughout this long story all the essential characters have been included and their relevant doings sketched in, with the dates duly noted: factual accuracy has been ensured by constant reference to and liberal quotation from the best authorities upon each period, and the author has woven the whole together by his graphic and vivid writing, thus giving us a clever combination of compression and expression.

He does not patently point a moral, but the percipient reader cannot help deducing one for himself. One must perforce notice that through the long tapestry of this tale there runs from first to last a sorry thread of corruption and intrigue, and it is punctuated periodically with barbaric and uncontrollable outbursts of arson and murder. The clock is now put back to 3,200 B.C. and Egypt is once again a sovereign power: one can but hope that she strikes better times in the future.

Meanwhile, my own reaction after reading this book once is that I now want it always at hand for reference—it tells me quite clearly all I need to know of Egyptian history and is an eminently readable document. E.E.B.M.

A TREATISE ON SURVEYING

By MIDDLETON AND CHADWICK

Sixth Edition

General Editor: PROF. W. FISHER CASSIE

(Published by E. & F. N. Spon, Ltd., London, 1955. Price 32s. 6d. each volume.)

Vol. I Instruments and Basic Techniques

Vol. II More Advanced Techniques and Modern Developments

This is a new edition of a work of which Vol. I was first published in 1899 and Vol. II in 1902. This time Vol. II has been entirely rewritten on fresh lines and it is unfortunate that there is some lack of co-ordination between the two volumes. Thus in Chapter 8 of Vol. I there is much out-of-date information about scales used for maps and plans, in particular those of the Ordnance Survey (p. 330), whereas in Chapter 14 of Vol. II the correct information is given.

Volume I deals with the general principles and practice of ground surveying from an engineering point of view. The subject is fairly clearly set out but the volume would have benefited from a more thorough revision and a restatement of much of the matter to suit modern practice.

In Chapter 1 Tacheometry is mentioned for locating somewhat indefinite detail, but its use for picking up well-defined detail is not mentioned: this is now a standard method of large scale detail survey in the Ordnance Survey and has been in use on the Continent for some years.

The chapter on plane-tabling is rather confused and the reviser has evidently not drawn on the wide experience accumulated in India and elsewhere.

Vol. II is a much more useful and up-to-date work, and the various chapters have been contributed by a number of authors. The volume continues the study from Vol. I, introducing minor triangulation, precise levelling and traversing, but does not touch on geodetic survey, although there is a brief chapter on the Figure of the Earth. There are two chapters on Photogrammetry and one each on Cadastral Survey and the Reproduction of Maps and Plans.

However, the author has tried to cram too much into one book and the various subjects have been dealt with rather too superficially. In the case of the chapter on Hydrographic Surveying one gets the impression that complete sections have been omitted.

The work also suffers from some overlapping and inadequate editing.

There are two chapters dealing with errors and adjustments. The theory is somewhat summarily dismissed, but there are several examples of practical value.

The chapter on field astronomy deals with this subject adequately and it is satisfactory to find the author referring almost exclusively to the *Star Almanac for Land Surveyors.* However, virtually the only timepiece mentioned is a stop-watch and there is no information about wireless time signals.

Of the two very useful chapters on Photogrammetry, Chapter 9 deals with the elementary principles, but one has to cover twenty pages before there is any mention of stereoscopy, the basis of all photogrammetric work. Chapter 10 is an excellent summary of modern photogrammetric instruments and there is a valuable table on pp. 314–15 showing some typical examples of air survey work and the accuracies to be expected in each case.

Chapter 12 on Engineering Surveys is a welcome innovation and there is also a sound introduction to Cadastral Surveys in Chapter 13. This is perhaps the first time that the latter subject has been included in a text book on surveying.

Chapter 14 is an excellent summary of modern methods of Reproduction of Maps and Plans. It is very valuable to include an exposition of the subject in a work on surveying. However the progress in this field has been so rapid in recent years that some of the processes described have already been partly superseded by others. For instance Scribing, and Colour Proofing on Astrafoil are not mentioned.

The book ends, oddly, with the chapter on the Figure of the Earth and there is a short appendix on the geometry of the sphere.

To sum up. Volume I would have been much improved by a more drastic revision. Volume II contains several excellent chapters, but from the point of view of concise completeness in each subdivision of the subject the book does not achieve the same standard as in certain existing works. Too much has been attempted within the compass of one volume. The editing leaves a good deal to be desired. There is also no bibliography.

A.W.W.

TECHNICAL NOTES

CIVIL ENGINEERING

Extracts from *Civil Engineering*, April, 1955

Fire Protection for Structural Steel

Vermiculite is a hydrated magnesium aluminium silicate, a micaceous mineral which expands to many times its original thickness when heated. It was marketed commercially in its expanded form in the United States in 1915. Vermiculite has shown its value as an insulating material, particularly for high temperatures, since its fusing temperature is 2,460° F. A number of tests have been carried out to measure the fire resistance as defined in B.S.476, of various elements of structure in which the main part of the protection was provided by vermiculite. Tests on steel stanchions and standard size steel beams have shown that this material may be highly recommended. In the article various tables have been compiled to show the effect of heat on the steel sections for various thicknesses of vermiculite covering.

Vacuum Concrete

The recent rapid increase in the study of concrete technology in this country has shown to contractors and consultants alike the need for a method of producing a dry mix without its normally inherent placing difficulties. The vacuum processing of concrete not only allows the placing of a more workable mix with subsequent dry mix characteristics, but also produces a concrete with a compaction equivalent to a compacting force of $\frac{3}{4}$ ton/sq. ft.

The theory underlying this process depends on the creation of a pressure difference between the side shutters and the open face of the concrete. The article is well illustrated with photographs of tests and of vacuum concrete work under construction. It is interesting to note that the quality of the final product may not, at first glance, appear to have more than a secondary place in determining the economics of a particular contract, but is obviously important from the point of view of maintenance cost, since a high quality product requires less maintenance than a lower class product. The vacuum concrete process by virtue of its ability to produce concrete of at least 25 per cent more strength than a similar unprocessed concrete, has therefore two possibilities:—

(*a*) The increased quality of the concrete can be regarded as an additional refinement, or

(*b*) A reduction in the cement content can be made to reduce the strength of the concrete to a specified figure.

Seepage Discharge and Uplift Pressure

Designs of hydraulic structures such as dams, power houses and weirs founded on compact but pervious foundations would be incomplete without satisfactory examination of the influence of seepage of water through the pervious foundations on the stability of the structures. Various methods, some based on theoretical derivations and others depending upon empirical formulae, are commonly employed to ensure the adoption of safe designs of structures based on permeable foundations. This article is well illustrated with diagrams of likely flow nets, the influence of the length of the structure and the influence of a single operational cut off. This is the first part of a very interesting article which is to be continued.

Review of Contractors' Plant

The New "Eimco" Tractor

Readers will be familiar with the famous "Eimco" mucking machine which is still used in tunnelling. The Eimco Corporation, U.S.A., have now produced a new tractor, a machine with 120 h.p. diesel engine with a rated speed of 1,800 r.p.m. The drawbars are heavy duty steel construction and an oversize industrial type radiator provides ample cooling capacity for long full load operation in desert temperatures. The track for the tractor is of heavy duty all steel construction and alloy steel cast pads are used with forged links. Hollow cast alloy steel diagonal braces are welded to the track frame and correct alignment of the tracks is maintained by the low deflection under heavy loads. Maximum drawbar pull is 45,000 lb. and maximum speed is given as 480 ft. per min.

Epping Auto-Shunter

Specially designed for railway sidings and docks, a useful machine, the Epping Auto Shunter is now being manufactured by F. E. Weatherill, Ltd., London. The machine is diesel powered and is capable of shunting loads over 150 tons on straight level rail. Adequate ballast over the driving axle provides high tractive efficiency. The compact design of the shunter allows it to operate successfully in confined spaces and it is likely to prove an asset in yards, etc., where space is limited.

Extracts from the *Water Well Journal*, January–February, 1954.

An article entitled "Gravel Packing Water Wells" by Harman F. Smith appeared in the above number of the *Water Well Journal* and has been reissued as Circular No. 44, 1954, by the Department of Registration and Education, State Water Survey Division, Urbana, Illinois.

The article makes recommendations as regards the grading of gravel packing for water wells based on a sieve analysis of the water bearing formation coupled with recommendations as regards appropriate slot openings in the well screen.

The gist of the article is as follows:—

(*a*) Gravel packing should be of uniform grain size and not graded.

(*b*) The mean size of the particles in the gravel pack should be about five times the mean size of the particles in the water-bearing formation.

(c) The slot openings in the well screen should be such as will retain not less than 90 per cent of the gravel pack.

The article is accompanied by photos illustrating typical formations with associated suitable gravel packs as a rough and ready guide where sieve analyses cannot be made.

Extract from *Civil Engineering*, May, 1955.

Plywood for Concrete Formwork

The light weight of plywood and its relatively high strength and ease of working make it a very suitable material for use as sheeting in concrete formwork. Strength data for Douglas fir plywood have been published and deflection charts for use in form design have been determined. For many other species of plywood now manufactured, however, data of this type have been generally lacking. As a consequence the use of these plywoods has depended more upon rule of thumb methods than upon correct design. This article outlines the procedure adopted in the design of concrete forms and presents strength and deflection charts which may be used for any species or construction of plywood. It is an extremely interesting and useful contribution to the design of timber shutters.

Australian Prestressed Concrete Bridge

The first concrete bridge in Australia with continuous beams has recently been opened at Teven Creek, N.S.W. The present bridge was constructed to replace an old timber bridge. The bridge was constructed on existing concrete piers and has a central span of 66 ft. and two approach spans of 29 ft. making a total length of 124 ft. The prestress to the three 37 in. deep main beams was provided by the Lee-McCall system, using $1\frac{1}{8}$ in. diameter high tensile alloy steel bars, two of the bars being coupled at two points in the length of the bridge so that the side spans could be erected first and used to support mobile cranes which lifted the centre span beams into position. After these were placed the through bars were coupled up and the beams made continuous by stressing these bars from the end of the bridge. The article is well illustrated with sectional drawings and photographs of actual construction on the site.

Compressed Air Plant

During the last three decades there has been an increasing demand for portable, semi-portable and mobile air compressors for use on all types of civil engineering schemes. To meet these requirements, manufacturers have carried out much development and can now supply units suitable for every purpose; designed and built to ensure a most efficient performance under all conditions of working in climatic extremes. The article is devoted to a detailed description of the most popular makes and types of mobile compressors and makes interesting reading.

Review of Contractors' Plant

New 23-yd. Scraper

The Le Tourneau Westinghouse Co. U.S.A., are producing a new machine known as the B Tournapull. It is a 23 cu. yd., single engine, heavy, self-propelled scraper. The over-all length of the machine is 40 ft. 6 in. and it is 11 ft. 8 in. wide and 12 ft. 7 in. high. The scraper is powered by a 293 h.p. Cummins diesel engine and it is provided with ten gear ratios giving speeds ranging from 2.4 to 28.4 m.p.h.

Extract from *Civil Engineering*, June, 1955.

Alexandria Main Drainage Extensions

The engineering problems in this scheme are extremely difficult owing to the flatness of the ground and the lack of sea currents. The article, which is well illustrated, describes how they are being overcome.

Wire in Prestressed Concrete Beams

Pre-tensioning requires sufficient bond to prevent slipping of the tensioned steel. This was the reason why, originally, only piano wire of 2 mm. diameter was considered suitable by Hoyer some fifteen years ago. However, smooth British wire 0.2 in. diameter has been successfully used for pre-tensioning for more than ten years. The article describes a series of tests which have been carried out on the bond strength of tension wires in concrete beams. One of the conclusions reached was that smooth tensioned 0.276 in. diameter wire spaced as closely as $1\frac{1}{8}$ in. will ensure sufficient bond resistance in concrete of a prism strength of 6,000 lb. per sq. in.

The Effect of Soils on Asbestos Cement Pipe

Detailed information regarding the effect of soil exposure on the properties of asbestos piping has resulted from field studies recently completed by the National Bureau of Standards. Representative specimens were exposed to a wide variety of soil types for periods up to thirteen years and, upon removal, the physical and mechanical properties of the pipe specimens were carefully investigated. The data thus obtained provides an over-all picture of the rate and extent of alteration of this type of pipe in soil study. In some cases the average tensile strength of pipes after thirteen years exposure was as high as or even higher than that of unexposed pipes. Even under the most adverse conditions to which the specimens were exposed, the bursting and crushing strength of all samples after tests were higher than the requirements of the U.S. Federal Specifications for asbestos cement pipe. The article contains a number of graphs showing tensile strength against time in years for soil exposure.

Review of Contractors' Plant

Soil Compaction by Vibroflotation

Vibroflotation, for which Vibrofounds Ltd., Southall, Middlesex, has obtained licence rights in Great Britain, is a patented process by which granular soil, sand or gravel of loose packing is compacted by vibration to a greater density. The compaction is effected by what is known as a "vibroflot", a 6 ft. long tube of 15 in. diameter, containing a powerful vibrator, and water supply systems for creating the jets which play an important part in the operation of the vibrator and in cooling. Vibroflotation may be used for compaction of concrete and for consolidation of pre-packed aggregates and granular strata, into which grout is injected and for similar processes using chemical consolidation. The process can also be used effectively under water.

Neale Mobile Crane

The type QM Mobile Crane manufactured by R. H. Neal & Co. Ltd., London, can travel safely with its maximum load of six tons suspended from the hook. The superstructure may be slewed through 360 deg. either as an independent motion or with other motions. Direct drive from a single power plant, either petrol or diesel, provides the power for the operation of one or more motions selected by the driver. The specification gives a hoist speed of 6 tons at 37 ft. per minute or 2 tons at 150 ft. per minute.

ENGINEERING JOURNAL OF CANADA

Notes from *The Engineering Journal of Canada*, June 1955.

A New Idea in Circuit Breakers

Circuit breakers using oil as a dielectric became standard equipment in the 1920s, but the 1939–45 War produced a change in European design owing to the shortage of steel and the war-time fire risk occasioned by the use of oil. Air blast breakers, mainly using large and costly porcelains, came into fairly general use.

In the early 1950s Canadian engineers decided, for economic reasons, to evolve a new design, better suited to their own material and labour costs and with improved performance features. The new breaker, the Jetaire, is rugged, simple and accurate in operation. It uses a grounded steel tank which is itself a pressure vessel containing the air for insulation and extinguishing the arc, and for the operation of breaker contacts. Deionization takes place in a cooler below the interrupter. Infiltration of condensed moisture is avoided and bleeding of dry air is obviated. Design and test results are briefly but adequately described.

Gas Turbines

This paper deals mainly with the economics of gas turbine power generation on the basis of conditions in Canada, but the author also discusses the types available on the market and their characteristics, and gives some details of design and operation practice. Where gaseous fuel is readily available costs are lower than those of a steam plant of equal output.

The main economic factors are:—

Low first cost.
Comparatively small space required.
Simple operation and servicing, reducing labour costs.
Availability for almost instant service, without a long warming up period.
Low fuel consumption for starting.
Adaptability to varied climatic conditions.

Although gas turbines are at present used mainly for electric power generation, locomotives of about 2,500 h.p. are undergoing practical trials.

Problems in Construction in the Far North

Much has been said and written in the last few years about construction within the permafrost zone. This paper sets out the general problem in a simple and rational form, and it is well worth reading.

There are three inter-related aspects of the problem, technical, economic and logistical, and the author explains very clearly that the last of these is the most important. Technical methods, of which some interesting examples are quoted, are comparatively straightforward; the economic aspect is very largely a matter of transportation costs; but meticulous planning is always necessary to ensure the co-ordination of the available transport methods, the supply of material and the constructional programme. Design and construction procedure are themselves influenced by logistics, and storms, breakdowns or the lack of an essential item may disrupt the most careful organization.

Water transport is feasible during only a short summer period when land movement is usually impossible. Tractor trains can operate only during the winter. Air transport is possible whenever landing strips can be kept open, and where water or ice surfaces are available, but it is in practice subject to interruptions. Further development of the helicopter, to transport a greater payload over longer distances, would do much to simplify the problem.

Notes from *The Engineering Journal of Canada*, July, 1955.

Fuel Transportation by Pipe Line

Several papers on Canada's oil pipe lines have been the subject of Technical Notes in the *R.E. Journal*. The present paper is concerned almost entirely with the utilization of Canada's enormous reserves of natural gas, and it deals mainly with the economic aspect and the encouragement of potential markets. Some enlightening facts and figures are, however, given relating to supplies available from Middle East oilfields.

Refrigerated liquid methane, which has twice the heat value of manufactured gas, could be transported to the United Kingdom in insulated tankers and delivered at a tanker terminal at an estimated cost some 30 per cent below that of manufactured gas. In these circumstances it seems a pity that the wastage of gas from oil production in the Middle East should continue at an estimated rate of a billion cubic feet per day.

Control of Air Pollution in Great Britain

This is a concise and factual summary, by Sir Hugh Beaver, of our air pollution problem and of the work of his Committee after the great London "smog" in December 1952, which was calculated to have caused 4,000 deaths. It is estimated that the direct costs attributable to pollution, through corosion, depreciation, cleaning and preventive measures, amount to some £150 million annually, while indirect costs, mainly due to ill-health and loss of work, probably total at least £100 million.

The Committee's proposals are comprehensive and would involve somewhat expensive measures in large industrial undertakings such as power stations.

Notes from *The Engineering Journal of Canada*, August, 1955.

Colour Television

Television programmes in colour have been broadcast in the United States since August, 1954, and it is anticipated that, by the New Year, some sixty hours per month of regular transmissions will be available on U.S. networks. This paper includes some very interesting general information as well as a straightforward technical description of basic design.

Hydraulic Design of Outlet Basin for Single Culverts

The proper design of drainage structures is a vital feature of engineering construction in areas liable to heavy storms. This paper describes experimental work undertaken, by the use of models, in order to evolve a standard hydraulic design for culvert outlets, to minimize the potential damage that can be caused by erosion.

Even without the theoretical background on which the experimental procedure was based the results of these investigations are most interesting, and a very good series of photographs demonstrates convincingly the inadequacy of the generally accepted type of culvert outlet as compared with the type now evolved. The suggested design procedure is unduly cumbersome for military purposes, but should be susceptible of simplification.