THE ROYAL ENGINEERS JOURNAL MARCH 1973
VOL LXXXVII No 1

THE ROYAL ENGINEERS JOURNAL

Vol LXXXVII MARCH 1973 No 1

Published Quarterly by
The Institution of Royal Engineers, Chatham, Kent
Telephone: Medway (0634) 42669

Printers
W & J Mackay Limited Lordswood Chatham Kent
Telephone: Medway (0634) 64381

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Brigadier J I Purser

Biographical Note

COMMANDANT, ROYAL SCHOOL OF MILITARY ENGINEERING

Brigadier John Inglis Purser, O.B.E., B.A. was educated at Wellington College and Trinity College, Cambridge. He joined the Army in August 1941 and was commissioned into the Royal Engineers the following February. His first posting was to the Guards Armoured Division Engineers. Here, as troop commander and later squadron 2IC he spent two and a half years of intensive training in England before finally disembarking with 615 Field Squadron in Normandy and taking part in the campaign across France, Belgium and Holland into Germany. Volunteering for the Far East, he only got as far as Tunbridge Wells where he was adjutant of 61 Division RE; the ending of the Japanese War saw the Division disbanded and the Sappers diverted to beach obstacle clearance.

It then became necessary to learn about professional soldiering in peace and he joined No 1 Supplementary Course at the beginning of 1946, at the end of which he became a bridging instructor at the SME, at Ripon, followed by a spell of authorship at Brompton. In 1951 he went to command 48 Field Squadron in 7th Armoured Division in Nienburg; thence to the Staff College and a posting as GSO2 in one of the first joint planning appointments in Middle East HQ in the Canal Zone and Cyprus; returning home to an enjoyable two and a half years as company commander at the RMA Sandhurst.

In 1959 he was posted as 2IC 38 Regiment at Ripon, whence, after a short interlude at the JSSC, he went as Brigade Major to 99 Gurkha Infantry Brigade in Singapore. To his regret he left the Brigade just before they flew into Brunei to return once again to Nienburg, this time as CRE 1st Division. 1965 saw him back in Singapore as a joint administrative planner in the newly created Far East Command HQ.

He left Singapore on promotion to become Colonel AQ 2nd Division in Lubbecke, but he only survived this appointment for nine months as in January 1968 he was promoted to command the recently formed 29 Engineer Brigade (V) and became Chief Engineer Northern Command. After two years of virtually independent command, it was something of a change to find himself, for the first time in his career, posted to the MOD(A). Here he has spent nearly three years grappling with some of the problems of equipping an Army on an ever shrinking budget.

Brigadier Purser has always been interested in outdoor and sporting activities. Sailing has been a prime interest, and not a few soldiers, cadets, officers—and even one RSM—have enjoyed, or suffered, their first sailing experience with him. He is now Vice Commodore of the REYC and RESA. He has also indulged in other activities such as rock-climbing, fell walking, gliding and flying. In a more sedentary fashion he is a keen painter and a member of the Armed Forces Art Society.

In 1950 he married Dorothy Tuker and they have one son and two daughters. It is perhaps appropriate that he now returns to Brompton as Commandant where he began his married life, even though Pasley House offers a different style of living to 12A Mansion Row.

* * * * *

Brigadier R M Merrell.

Biographical Note

CHIEF ENGINEER UNITED KINGDOM LAND FORCES

Brigadier Robert Maurice Merrell, M.B.E., B.A. was born in 1924 and educated at Sevenoaks School and St John's College Cambridge.

He was commissioned in 1943 and was posted first to a Beach Group Company, at that time developing techniques and training for the assault landings in Normandy. In 1944 he joined 591 Parachute Squadron RE and saw active service in North West Europe with 6 Airborne Division until being wounded during the fighting in the Ardennes early in 1945.

He rejoined the Division shortly after the end of the war in Europe and went out to the Far East with 5 Parachute Brigade which first formed part of the force which reoccupied Malaya and then went on to assist in keeping the peace in Java.

In 1947 he moved with the Brigade to rejoin the remainder of 6 Airborne Division which was by then in Palestine. Here he served first as 2IC 9 Parachute Squadron RE and later as Adjutant of the Divisional Engineers before returning to the United Kingdom in 1948 to become Adjutant of 16 Parachute Divisional Engineers (TA).

In 1950 and 1951 he attended a Supplementary Course at Chatham and went to Cambridge University to study for a degree. In 1952 he returned to Chatham as GSO 3(SD) at HQ RSME.

During 1954 and 1955 he was specially employed under the Foreign Office on service which took him to Berlin, and for which he was awarded the MBE in 1956 while attending the Staff College.

He then went to 4 Division for two years as DAQMG before being appointed to command 9 Independent Parachute Squadron RE in 1959. In 1961 he returned to BAOR as GSO 2 RE HQ 1 (BR) Corps.

In 1963 he attended the then Joint Services Staff College and then went out to Aden as GSO 2(SD) HQ Middle East Command at the time of the withdrawal to Aden of British forces from Kenya, and the campaign in the Radfan.

He returned to the United Kingdom in 1965 to become the last CRE of 53 (Welsh) Division (TA), and subsequently the first CO of the reconstituted Royal Monmouthshire Royal Engineers (Militia) which emerged from the reorganization of the Reserve Army.

In 1968 he was posted as GSO 1 in the Combat Development Directorate of the Ministry of Defence, from which he was transferred on promotion in 1969 to be Colonel GS of ASD 7 until taking up his present appointment in January, 1973. He is married and has two sons.

* * * * *

Editorial

THE aim of the *Royal Engineers Journal* is to report, comment and interpret on matters of historical, professional and technical interest to the Military Engineer. It is not unfair to say that the three fields of interest are covered; it can be argued that one or other of these interests may be neglected on occasions, at least in the opinion of some Members of the Institution. The blame for this can be laid fairly and squarely on the Members since the Institution can only publish material submitted to it. It is impossible to produce balanced issues of the *Journal* unless and until sufficient material covering the three interests is available to permit selection.

The treatment of the interests would appear to be centred on reporting with little comment and interpretation. It is difficult to believe that the reporting is of such a character that comment and interpretation is unnecessary. It may be that the habit of communicating views, either for or against, is becoming obsolete. Unless stones are thrown into the pond the ripples, which are the life blood of a living Institution, are few and far between and soon die out.

We have all been frightened by thunder and lightning at some time in our lives. Some consider thunder and lightning to be the direct result of the activities of Hephæstus, Vulcan, Thor, Agni or Pthah (depending on whether one was brought up to believe in the Greek, Roman, Norse, Vedic or Egyptian Gods). Most engineers would prefer the explanation given by Captain Young in his "Lightning Performance of Overhead Lines". Not only does he explain the phenomena, he applies reason to a number of methods of protection. Without an understanding of the phenomena it is virtually impossible to assess the degree of risk to person or installation. A military engineer who does not appreciate the risks he is running, whether it be in Combat, Mechanical or Electrical engineering, may be in good company but is he up to his job?

In "Landslide Disasters in Hong Kong—June 1972", Colonel Rickets describes in graphic terms the problems encountered with collapsed reinforced concrete structures. He records the courage, patience, skill and above all the time required to extricate the victims buried under the debris. The collapse of a single or isolated group of reinforced concrete structures creates an interwoven mass of concrete beads, weighing up to several tons each, strung together by the very reinforcement which was incorporated to prevent collapse. During the rescue attempts movement of any one bead or the cutting of any part of the string can start movement and precipitate a further disaster.

In a modern city the effects of a major natural or man made disaster will be very different from those of the past because of the predominance of reinforced concrete structures built during the last twenty years. Imagine the scene. Would the effort, time and skill be available to even contemplate rescue of the victims with our present knowledge of the art? Speed of clearance demands the use of heavy plant (possibly thermic lances and explosives), must the trapped be sacrificed for the public good? Would clearance even be attempted, would it be possible to use mining techniques to penetrate such debris, would "over the top" construction of roads and public services become necessary?

One can imagine a number of ways in which the Corps might be found dealing with this type of problem, perhaps on a large scale. Do we know all we should about how to tackle such problems?

There can be little doubt that in the aftermath of a disaster the Military Engineer will not be found wanting in courage, skill and ingenuity and will traditionally do his very best.

Can we ask for more? In this particular case, the answer must be in the affirmative.

Branch Meeting of the Institution of Royal Engineers at Sheffield

A JOINT Meeting of the Institution of Royal Engineers, the Yorkshire Branch of the Institution of Structural Engineers and the Yorkshire Association of the Institution of Civil Engineers was held at the University of Sheffield on Tuesday, 31 October 1972.

The Meeting, which was attended by some 120 people, was preceded by tea in the Senior Common Room of the Departments of Applied Science.

Brigadier G. T. E. Westbrook, OBE, the Deputy Engineer-in-Chief acted as Chairman of the meeting in place of Major-General Sir Gerald Duke, KBE, CB, DSO, C Eng, FICE, who was unfortunately indisposed.

Brigadier Westbrook welcomed the members of all three Institutions and the many others who had come to the meeting. These included representatives of the Academic and Administration Staff and of the Military Education Committee of the University together with some students of the Department of Engineering; the Academic Staff of Leeds University; the Royal Engineers Troop of the University of Sheffield Officers Training Corps and members of Leeds University Officers Training Corps. He passed on the thanks and good wishes of the President of the Institution of Royal Engineers and the Engineer-in-Chief to all those concerned who had made the meeting in Sheffield possible. In introducing the speaker he explained the importance of equipment bridging in the tactical concept and the continued need for developing bridges capable of ever increasingly rapid construction.

Lieut-Colonel J. H. Joiner, RE, B Sc (Eng), C Eng, MICE, MI Struct E, presented a paper on "The Evolution of British Military Equipment Bridging" tracing its development from the Inglis Triangular bridge of about 1913 to the Medium Girder and Air Portable bridges and the M2 amphibious bridge of the 1970s. His address was excellently illustrated with slides and films and was followed by an interesting period of questions and discussion.

In proposing a vote of thanks to the speaker Mr H. Ormiston, B Sc, C Eng, FICE, Chief Civil Engineer of British Railways Eastern Region, the Chairman of the Yorkshire Association of the Institution of Civil Engineers, said how much he enjoyed the presentation and stressed the value of such joint meetings. He emphasized the usefulness and adaptability of military equipment bridges to engineers in the civilian sector. He concluded by saying that he hoped these joint meetings would continue to be held in the future and proposed that his Association should host such a meeting in York next year.

The vote of thanks was seconded by Mr C. H. Howitz, M Sc, C Eng, FICE, FI Struct E, West Riding Highways Department, the Chairman of the Yorkshire Branch of the Institution of Structural Engineers, who endorsed all that Mr Ormiston had said, particularly about the adaptability of military equipment bridges though the cost of the latest developments were somewhat prohibitive.

The Chairman concluded the meeting by thanking the University for providing the facilities for the meeting and he invited all those present to a buffet supper at Somme Barracks which had been arranged by the University of Sheffield Officers Training Corps.

During the buffet many renewed old acquaintances and made new ones and there was an exchange of views on many matters of mutual interest. That the festivities afterwards were enjoyed was demonstrated by the lateness of the departure of many of the members.

Landslide Disasters in Hong Kong, June 1972

LIEUT-COLONEL R. A. S. RICKETS, RE

FRIDAY 16 June brought the end of another week of rain in Hong Kong. May had been one of the wettest months on record and the storms continued. The soil had absorbed as much as it could take and the barren rocky hills and mountain sides were now streaked with cascading water. The temperature was high in the eighties, humidity close to 100 per cent. Roads were flooded and many already blocked by landslips. The PWD, Police and Fire Services of Hong Kong are well equipped for emergencies but were becoming increasingly stretched as they coped with the worsening situation. Telephones were out of order over wide areas.

67 Gurkha Field Squadron, based at Bowring Camp 22 miles from Kowloon along the west coast road, had a troop employed on local works, another on a construction task on the border and the third on local leave having just finished a pier on an outlying island. 68 Gurkha Field Squadron, based nearby at Perowne Barracks, had a troop on Peng Chau Island in the far north east of the New Territories and two on border tasks. Most of the plant of 54 (Hong Kong) Support Squadron, based at Shamshuipo Camp in the outskirts of Kowloon, was out on site. Some was still on the road at Nim Wan recently completed by 33 Field Squadron, some at Luk Keng in the east of the Colony and some at a new worksite on one of the islands.

The first request for Engineer assistance came late in the afternoon following a number of new slips on the south side of Hong Kong Island one of which had blocked the only road leading to the barracks of the Irish Guards at Stanley Fort. A reconnaissance by OC 67 Squadron found the road blocked by a huge boulder some 18 feet in diameter, which could only be removed with any speed by blasting. Fortunately the site was isolated.

B Troop of 67 Squadron left Bowring Camp at 5 am on Saturday morning, joining on the way a plant detachment from 54 Squadron. Plant and equipment comprised one medium and one light wheeled tractor each with bucket, two tippers, three dumpers, two compressors and a grader with front blade. A Police escort and special ferry got them to Hong Kong Island by 6.45 am, but with roads blocked and traffic jammed it was 9 am when they reached the site.

The boulder was drilled from ground level and from a scaffolding platform erected beside it, see Plate 1. Much of Hong Kong's rock is fairly soft but this was an exception and even with three rock drills in use progress was slow. Drilling in one particular place wore out a new tungsten bit after penetrating one inch. Eleven 1 lb borehole charges were placed in the rock itself, three 5 lb charges beneath it and further charges in the hillside above to bring down the rest of the loose material. The Troop Commander had decided early in the day that he would fire the charges at 5 pm, this early decision being necessary for the Police to warn those in the area. With very little noise and only a small cloud of dust and smoke the rock was completely shattered and the Allis Chalmers and light wheeled tractors then made short work of the blockage, completing the task by late evening. During the day a slip on the road leading to the Deputy Commander Land Forces' house was also cleared and several others in the same area. On Sunday morning B Troop returned to Bowring Camp. The journey back along roads littered with landslips, boulders and abandoned cars took six hours for a distance of thirty-five miles.

Despite the rain which had fallen in torrents throughout this task morale was high and the boulder had provided a useful opportunity to carry out a live demolition with a purpose. No one could imagine the horror that this day, Sunday 18 June was yet to bring. The rain had increased in intensity. In seventy-two hours 25 in had fallen in the New Territories and no less than 40 in on Hong Kong Island. Something

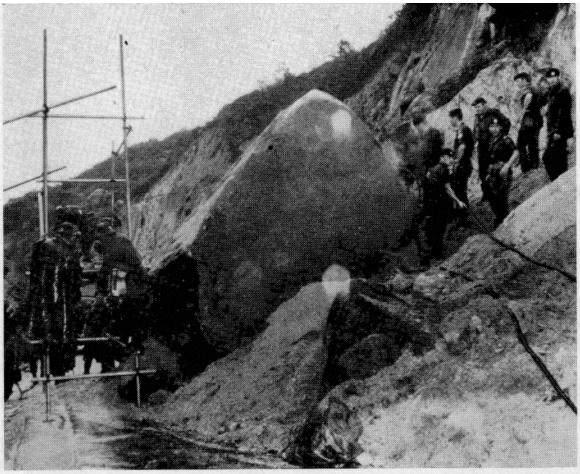

Plate 1. Clearing the boulder on the Stanley Fort Road, the scaffolding forms a platform for drilling prior to blasting.

somewhere just had to give way and in the afternoon the first of two tragic disasters occurred. At Kun Tong on the mainland, not far from Kai Tak International Airport, a hillside moved. 10,000 tons of earth sliding in one molten mass engulfed the flimsy shacks of a squatter estate below. A few of the inhabitants escaped, dragging themselves clear from the mud, but most, some sixty people, were buried. Cars and lorries were hurled and smashed like matchwood. One lorry caught fire, burning its occupants to death. Water gushed down the hillside.

News of the disaster quickly reached the Land Forces Duty Officer, followed by a request from the Fire Department for floodlighting equipment and a warning order that plant would be required. The Duty Officer consulted the SO2 RE at his home. Most of the telephones in the Colony were out of order or jammed with traffic and after managing to give only the briefest of warning the SO2 RE flew by helicopter to Shamshuipo to brief 54 Squadron fully. They reacted quickly. A recce party had already left for the site to find out exactly what was required, the whole Squadron was mustered, plant was made ready to move and ancillary equipment was changed to suit the task.

Every machine off the road and likely to be required was made taskworthy. The reconnaissance by the electrical officer showed a mains supply available on site suitable for the floodlighting equipment held by the squadron. The equipment, comprising eight floodlights, one searchlight and two towers, was despatched under police escort and erected before dark. A 27·5 KVA generator was drawn from the Composite Ordnance Depot and taken to the site as a reserve. That night the SSM with an ad hoc rescue team and 10-ton crane removed several wrecked cars from the mud and made safe a heavy lorry which threatened to fall on the rescuers. The floodlighting kit and crane were to remain in use and manned by 54 Squadron throughout the following week.

Plate 2. The landslip at Kun Tong. The tufts of grass in the foreground have slid undisturbed from the top of the slope. The earth beneath them engulfing squatter shacks similar to that on the right.

The real need at Kun Tong was for men, organized and disciplined, to dig for survivors and build sandbag walls to divert the rushing water. The Black Watch were early on the scene and worked with Police, Fire Services and the civilian organizations, desperately digging into the mud. This was to continue with battalions relieving one another for the rest of the week. Heavy plant could not yet be used while any chance of life remained beneath the mud and wreckage.

Soon after dark on this same Sunday came the second tragedy, with which we were to become more involved. In the densely populated Mid-levels district of Hong Kong City where towering blocks of flats jostle each other on the steep terraced mountainside another huge fall occurred. This was at Kotewall Road. This slip engulfed two buildings, one of two, the other of four storeys; the whole mass then slid into the rear of a twelve storey block of twenty four flats. This block, built in reinforced concrete, toppled forward and collapsed down the hillside, slicing as it fell the top four storeys of a similar building and finally settling in a twisted mass of mud and rubble. The occupants, Chinese and European, had no warning, see Figure 1 and Plate 3.

Men from 54 Squadron, already on standby for Kun Tong were diverted to this disaster and after hurried arrangements to move through the newly built cross-harbour tunnel, not yet opened at that time, joined with a company of Irish Guards, the Fire Services and Police in immediate rescue. Miraculously some thirty survivors were extricated during the night; even from the eleventh and twelfth storeys a few had survived. Most were badly injured but astonishingly one or two were physically unharmed. Almost all had lost their families and the scene was one of horror. Calls went out for compressors, flame cutting equipment, more lighting, and plant to shift the debris. 54 Squadron achieved prodigious feats throughout the night to get equipment to the site from all over the Colony.

The wreckage of the twelve storey block of flats lay on the steep hillside in the soft mud of the fall. The scene in daylight was one of broken, crushed and twisted floors, ceilings and walls, with reinforcing bars protruding everywhere. Among the wreckage lay the contents of the flats—broken furniture, washing machines, torn curtains and clothing, children's toys, bedding, smashed radios, the squashed remains of cars, broken water, sewage and gas pipes, and the bodies of the victims. Red-eyed and filthy with mud the men of 54 Squadron worked on, joined in the morning by 1 Troop of 68 Squadron who had moved down from Perowne Barracks.

Throughout the night Engineer effort at both disaster sites had been co-ordinated by OC 54 Hong Kong Support Squadron. Kun Tong remained his responsibility but on Monday morning OC 67 Squadron took over the Kotewall task, having moved his tac HQ down from Bowring Camp. He retained this responsibility for the rest of the week with at least one Gurkha Field Troop always on site supported by additional plant operators and welders from 54 Squadron. HQRE was fully manned around the clock in the Colony Storm Centre of Land Forces Headquarters, with the Engineer command net operating through a re-broadcast station on the top of Tai Mo Shan. At Kotewall Road the Fire Service were in overall control of rescue, working closely with the Sappers and Infantry, see Plate 4. The whole area of the landslip was highly unstable with mud and debris liable to move on down the hill at any moment. Water gushed beneath the fall but at last the rain had stopped. Earth and concrete still settled and from the great scar in the hillside above a new landslide seemed imminent.

At 8.30 am, when hope had begun to fade, another survivor was discovered buried deep in the middle of the wreckage. With hope renewed the original party from 54 Squadron, already relieved by the Gurkha Sappers, stayed on to help.

Three men, one Fire Services Officer, the other two from 54 Squadron climbed down into the rubble of the flats and began clearing a tunnel through the debris and mud to reach this survivor. The officer of the Fire Services directed and led the operation, and as work progressed others, from the Fire Service and from the Irish Guards joined the rescue party. Conditions in the tunnel are hard to imagine.

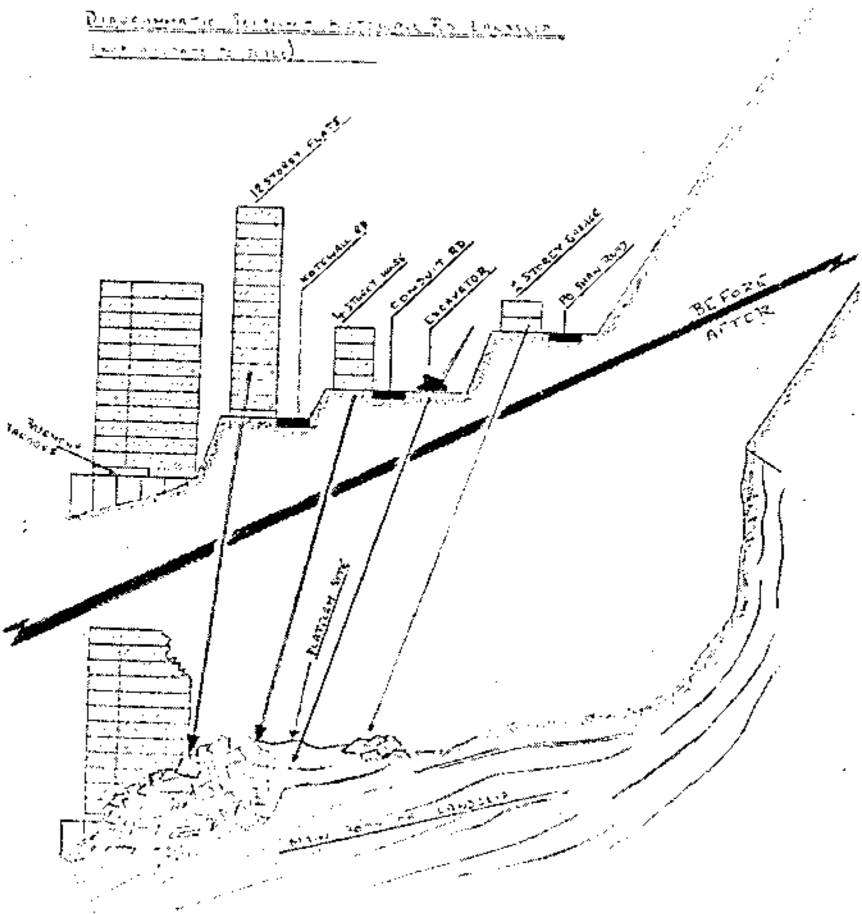

Figure 1. Diagrammatic Section—Kotewall Road Landslip.

Plate 3. Kotewall Road. In the foreground the remains of a twelve-storey block of flats lie buried in the fall and a working party pauses briefly in digging for victims. Above is a similar building also damaged as the shattered block fell past it.

Plate 4. L/Cpl Cavie and Spr Prowse with officers of the Fire Services in the rubble at Kotewall Road.

Petrol leaked from the shattered and squashed remains of private cars, sewage and gas from broken pipes. With only room for one to work, lying prone and digging with his hands, they formed a chain, taking turns to lead. The bodies of other victims were discovered.

The survivor lay trapped and buried in a small cavity, able to move only his head. Having reached him the task of freeing him continued throughout the afternoon and into the evening, when just before 9 pm, having lain trapped for 24 hours, Mr Henry Litton, QC, was brought safely to the surface and taken to hospital.

To minimize the danger of further collapse during this long and intricate rescue the site had been cleared and only handwork at the uphill and downhill extremities had been allowed to continue, while spotters with whistles and verey pistols watched for movement. Now effort was concentrated on breaking further into the rubble in the hope of finding more survivors, though little real chance remained. Progress was painfully slow. Every reinforcing bar had to be flame cut and most were an inch in diameter. Bars had to be bared by breaking away the concrete with compressors, rock picks and sledge hammers. Slabs had to be supported while cut and the clearance of one slab could bring down several others. Access to the downhill end was through the basement car park of the neighbouring block of flats with headroom of only 7 ft and the floor, 30 ft above the sloping ground below, was too weak to take heavy plant. Tons of rubble were removed through here, the Michigan light-wheeled tractor having only just headroom with cab and exhaust removed, the operator lying sideways across the controls and driving blind. In no time we were short of tyres for this machine, constantly pierced as they were by reinforcing bars protuding from the rubble.

To the uphill end of the debris there was as yet no access except on foot over the newly fallen earth of the slide. At a site conference on Monday evening, chaired by the Fire Services and attended by Public Works Department officials and the Military it was decided to construct a platform on top of this earth to take a 20-ton crane. Access to this platform was to be provided by constructing an earth ramp 110 ft long and 15 ft high from an adjoining road. The platform was to be of PSP and class 30 trackway was to be laid on the ramp. Both were to be completed by 9 am the next morning.

The original plan was to level the platform area and construct the ramp by hand, using the eighty Irish Guards and thirty Gurkha Sappers on site. It was considered too dangerous to move plant onto the fall itself, both for the operators concerned and for the risk of causing a further slide. In the event so many large boulders were unearthed that plant proved essential if a long delay was to be avoided. 54 Squadron had moved a D4 tractor to the site before dark and by midnight the Hy-Mac now converted from clamshell to back-actor, trundled through the new harbour tunnel on the low-loader. Next came PSP for the platform and at 4 am the low-loader was on its way again, this time with class 30 trackway and a forklift truck. Anyone who knows the Mid Levels of Hong Kong will wonder how a low-loader and Scammel could get in there at all and will appreciate the driving skill involved.

During the night both the D4 and the Hy-Mac moved cautiously onto the landslide and throughout the dark hours teams of soldiers, British and Gurkha, toiled with their hands, in relays. The platform was levelled and the PSP laid. The ramp took shape. The class 30 trackway was laid on the 1:7 slope by winching it with the D4 while fifty men lifted it bodily. The crane proved to be a good deal larger than expected, a huge and very splendid wheeled affair provided by a PWD contractor. Under its own power and with the D4 winch pulling from the top it moved slowly and safely up the ramp and on to the platform.

This crane took the weight of large slabs of concrete as rock breakers and flame cutters began clearance from the top of the debris. At the bottom the same work continued. The alarm system was supplemented with sirens to be heard above the noise of compressors and rock picks and during the day, now Tuesday, soldiers and firemen scattered for their lives as other small falls continued.

Clearance now became routine with troops of 67 Squadron always on the site, a company of Irish Guards doing most of the hand clearance, and the Fire Services in overall control. A number of dead were recovered but apart from a cat, released after four days trapped in a tiny crevice, no further survivor was found.

As the week progressed face masks impregnated with disinfectant were worn, with gloves, to minimize infection and reduce the penetrating odour of decay. Night work ceased as the risk from further movement which might not be detected even under spotlights could no longer be justified.

The work of clearance was terribly slow. On the top site much of the wreckage was too unstable for the welders to get close to cut the bars. They worked with their cutting torches lashed to long bamboo poles. A 1-ton piling hammer was slung from the crane and used to smash concrete so that cutting could continue. This was moderately successful on walls but had no effect at all on columns or slabs. On Wednesday hopes were raised when part of the lift shaft was found. The firemen believed that anyone still alive would be in the lift or on the stairs. Clearance of the shaft began but after a few hours it was collapsing further and had to be abandoned. Meanwhile the work of 54 Squadron continued. A size IV tractor was sent to the border to clear a fall, and another LWT to Kotewall Road. Dump trucks and tippers were sent to the Kun Tong site. Clearance at Kun Tong went on around the clock and reliefs for drivers, operators and electricians had to be found.

Late in the afternoon of Thursday 22 June at Kotewall Road a PWD Building inspector found that the load-bearing wall of another twelve-storey block was collapsing. This had been damaged in the landslide but had become an effective retaining wall holding up the earth and rubble on which the crane was operating. All work stopped on this top site while the crane platform was lowered to reduce the pressure on the wall. This of course entailed removing and replacing the platform and the ramp trackway, and a good deal of earth-moving. It was agreed that work would begin at first light the following morning and during the night a D6 tractor and a 4-ton dispenser truck were delivered by 54 Squadron to Kotewall Road. With no room for the usual methods forty men recovered and reloaded the class 30 trackway by hand.

Plant work began at 9.30 am and continued through the day until at a depth of 6 ft below the original platform a large pile-driving rig was discovered lying on its side. This had been swept down in the landslide from a contractor's works site further up the hill. With no hope of moving it this now became datum level for the new crane platform. With the crane at its new level and pressure removed from the retaining wall clearance work continued.

On Friday the Military and the Fire Services began handing over to the PWD and civilian contractors, and by 6 pm, apart from a small plant party who continued into the weekend, the Army was clear of the site. Rescue was no longer involved. The job now was recovery of the remaining fifty or sixty dead and clearance of the debris. As I write, two months after the event, this continues.

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"Not Broken, Sahib, Out of Order"

MAJOR K. E. MUIR, RE, BSc (ENG), CENG MICE, AMBIM

SWEATING profusely as I reached the fifth floor I came upon the lift standing open. "Broken again?" "Not broken, Sahib, out of order." These words, for me, summed up Bangladesh in the early summer of 1972.

Like all the best stories it started one dark winter's evening. As it was at Barton Stacey it had to be a Friday evening. The gist of my orders was that I would accompany the Colonel "E" to Bangladesh to see how best Sappers could be employed to aid the restoration of communications in the aftermath of the war that had been fought there. The Colonel "E" definitely had a return ticket but I might have to stay there to provide continuity. I was given the weekend to think about how many pairs of socks to pack in these circumstances and, also, to work out the recce kit.

Our bivvy in Bangladesh turned out to be the Hotel Intercontinental, Dacca, where the British Mission had thoughtfully booked us in. It was crammed full of United Nations advisers, representatives of voluntary agencies, newsmen and salesmen of every race, religion and creed. We were greeted by Mr Cross, a civil engineer from Rendell, Palmer and Tritton and, incidentally, a TAVR Major. He had been employed by the Overseas Development Administration (ODA) to investigate how British aid could best be employed to restore communications in the country. He had been out there one month by the time we arrived and had flown over most of the 276 road bridges that had been blown. Mr Cross had already formed a list (List A) of forty-nine gaps that were suitable for bridging with Bailey and a provisional quantity of material had been requested from the ODA.

We made some confirmatory checks on List A and found that the Indian Sappers were bridging madly, drastically reducing the list. Getting information was, as Mr Cross put it, like "shovelling smoke". After two weeks the Colonel "E" left to "gee-up" the ODA and I stayed on for a further fortnight to continue shovelling smoke. List A dwindled to twenty-two bridges and became List B, requiring 2,900 ft of assorted Bailey bridging. By the time of my departure, 6 March, the British Government had still not decided to give aid and so no firm arrangements could be made with the Bangladesh authorities on the future employment of a Sapper team.

Having shaken the dust of Bangladesh off my feet I arrived at Heathrow and on reaching the barrier was given a number to ring at MOD (A). This call told me that I was to return as OC of an RE Assistance Team.

On 1 April, an apt day, I was back in Dacca. My Team, consisting of a Garrison Engineer (Capt Chas Harrison), four Clerks of Works (Construction) and four SNCO Combat Engineers were to follow. The British Embassy had done an excellent job and found a furnished house for the Team. With the help of their Security Officer I spent my first week haggling in the market for crockery, cutlery and bedding.

To prevent confusion I must digress. As East Pakistan changed to Bangladesh, became a recognized and finally assumed Commonwealth status, so the name of the FCO presence had to change. Originally a Deputy High Commission, it later became a Mission, then Embassy and, finally, a High Commission. This kept one signwriter gainfully employed for several months!

During this first week I learnt that the Roads and Highways Directorate (R & HD) had decided that they wanted Bailey employed on a completely different set of bridges, List C. The Directorate was persuaded to drop this list and a fresh list, List D, was drawn up of eighteen bridges, seventeen of them from List B.

At the end of the week the Barton Stacey contingent of five arrived, in the middle of a storm, on board a Red Cross DC4. They had hitch-hiked from Calcutta as all scheduled flights had been fully booked. They were given a day off to acclimatize and shop, then sent off to recce Lists C and D. This was when the first snag was met. The UN Skyvan which was to fly them and their jeeps up country was "out of order".

They therefore set off on the two day journey by road and ferry.

Bangladesh is a very flat country, roughly 300 miles long and 200 miles wide. It is divided into four by three major rivers, the Ganges, the Jamuna (Bramaputra) and the Megna. The roads are narrow, built on embankments and trafficked by trishaws, bullock carts and, on foot, by a fair proportion of the 75 million inhabitants. The most vital component of any vehicle is its horn. Major river crossings were made by ferry. Where bridges had been blown the road had been diverted into the dry river bed. These earth road diversions would later become impassable when the rainy season began.

After the first recces had been successfully completed the R&HD produced yet another list, List E. Construction of this list would require 45 per cent more equipment than that ordered. The 4 Combat Engineers arrived two days later and were paired up with the C of Ws to recce List E. The information that they brought back proved this list to be nonsensical. Some gaps had already been bridged whilst others were on "kutcha" roads that would disappear in the monsoon season.

I took my problem to the Permanent Secretary for the Ministry of Communications. He had a real grasp of the situation and called a meeting on 6 May of all the senior engineers of the R&HD. He told them to draw up a sensible accurate list. This was List F.

I had decided that to prevent the misuse of Bailey it should all be routed through a Bridge Marshalling Area (BMA) where it would be broken into locality packets. At that time most of the factors pointed to Khulna as a suitable BMA. Khulna was thirty miles from the only mine-free port, Chalna, accessible from there by barge. It already had an R&HD Resources compound, albeit low lying and grassy. We therefore organized a contract to raise it, give it hardstanding and light it for twenty-four hour working. The earthmoving was carried out by 200 "head carrying" labourers who later paved it with bricks.

Three and sometimes four members of the Team were employed at Khulna. At the start, living conditions were poor and there was a cholera epidemic raging. In addition there was a drought in the area and this limited the menu. A main meal might well consist of a lump of unknown meat, a potato and half a cucumber. In

Plate 1. The Bridge Marshalling Area at Khulna.

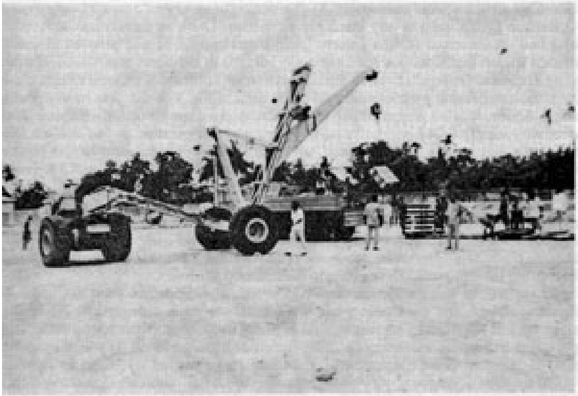


Plate 2. Stores handling with a Le Tourneau crane at Khulna.

Plate 3. Head carrying a panel at a trans-shipment point.

Not broken Sahib, "Out of Order" 2 & 3

spite of posting UKLF Hygiene Instructions, flies, who obviously could not read, buzzed everywhere. The food was prepared on an earth floor and cooked over a wood fire. Despite all water being sterilized, this part of the Team got dysentery, as indeed we all did, sooner or later.

Back in Dacca life was very much more civilized. There we had an excellent cook who had once cooked for the Queen. Until I met him I had not believed in those strange Indian qualifications but he actually told me of his clever son "failed Chittagong Technical College". Even in Dacca there were problems. Kerosene disappeared from the market and we cooked on AVTUR for a while. The diet was monotonous and I doubt whether any member of the Team can face a cucumber again. The electricity supply failed regularly, putting fans and refrigerators out of action. The telephone was usually "out of order" and if it was not it took most of the day to make a trunk call. My GE persistently passed himself off as "the Chief Engineer calling priority on urgent Government business" in order to get through.

The monsoon was due in mid March, April, May or June depending on which newspaper you read. We were therefore worried when the first trickle of bridging, due to arrive in four ships, started to arrive as late as mid May. By this time it had become obvious that no real engineering problem existed but that the problem would be moving the equipment to site before the monsoon started.

95 per cent of the Bailey was carried in two ships, originally routed to Chalna, a lighterage port. The remainder went to Calcutta and was disregarded. While the ships were at sea Chittagong was cleared of mines and one ship was re-routed to that port as it had better unloading facilities for other items of its cargo which included sixty-six trucks. The Chalna consignment had to be moved by barge to Khulna whilst the Chittagong load was trans-shipped into UN minibulkers (3,000 ton ships) which could get into Khulna. After sorting at the BMA most of the Bailey was then moved again by barge to a railhead feeding one of the quarters of Bangladesh. From this railhead trains moved the equipment close to its final destination where it arrived by lorry. Forward of Khulna all trans-shipments had to be made by hand as no mechanical handling equipment was available. The whole movement process took up to six weeks.

At each trans-shipment point a member of the Team was stationed to urge on the contractor responsible for the movement. One Team "pair" virtually hijacked a contractor to get him to work, leaving him on site in his sleeping lungi (sarong) to organize his men.

While work was progressing at Khulna, the remaining two Team "pairs" had been deployed to the North of Dinajpur and Sylhet. Their sites were to receive equipment from the first shipload. The reasons for giving them priority were:

a. Their sites contained large bridges which still had broken spans awaiting clearance.

b. As the floodwaters came from the Himalayan foothills to the North they were likely to feel the effects of the monsoon before the other sites.

c. Being the furthest away from Khulna the movement of bridging to these sites would be the most difficult.

The Dinajpur pair had four bridges to build including our longest, 330 ft. During their stay Dinajpur was hit by the worst cyclone for years. Being 150 miles from Dacca, they communicated by UN radio and used the twice weekly UN light aircraft to give written sitreps. The grass airstrip was on the town padang and landing here could be a hair-raising experience. The pilot would do a wide circuit of the town to avoid alerting the inhabitants who liked to turn out for the event. Coming into the threshold he would hold off to avoid hitting a defunct fountain and touch down immediately after (sometimes before) a transverse track. The strip was marked with six armed policemen who were there to keep the crowd out of the path of the aircraft. The dual role of the strip was a nuisance as on one take off we had to stop to get some recently erected goal posts removed.

Ostar 1972 - A Personal Account

LIEUT-COLONEL JOCK BRAZIER

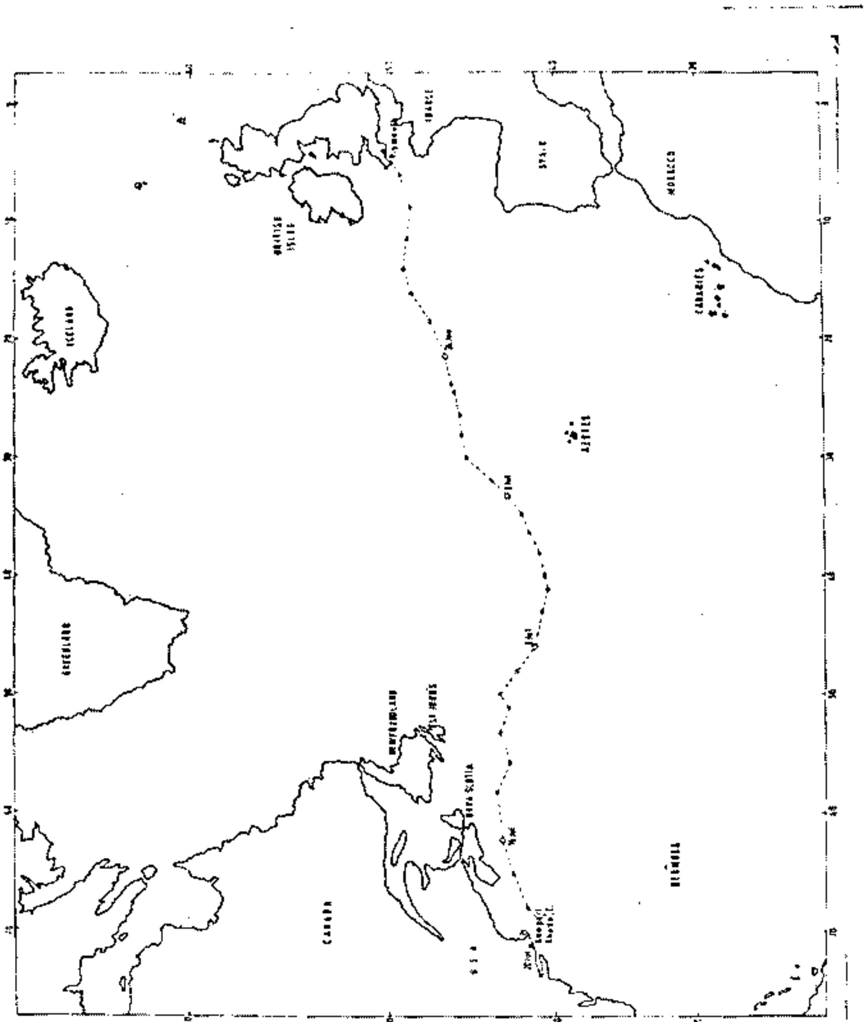
THE alarm clock rang and awakened me out of a deep sleep; the last for many days. The time was 7 am and slowly it dawned on me that the moment of truth had arrived and after months of preparation the race was due to start in only a matter of hours. I got up quickly and stowed away the last few things which I would not require at sea, whilst my wife hurriedly prepared our breakfast. Once this was eaten and washed up, it would be only a few minutes before I had to be ready for departure. Nearly all of the fifty-five competitors in the race had been lying in Millbay Dock, Plymouth and we had been warned that we must be ready for our tow out into the Sound from 8.30 am onwards; all competitors had either had their screws removed like my ketch *Flying Angel*, or their propellor shafts sealed. The organization that had been arranged jointly by the Royal Western Yacht Club and the Royal Navy was very slick as they had to get the contestants out of the non-tidal dock before the start of the race at noon.

Just before 8.30 am, two members of 59 Commando Squadron, Royal Engineers, came aboard with an inflatable dinghy which was made fast astern and after a hurried farewell, my wife went ashore and helped cast off the warps as *Flying Angel* was amongst the first to be towed seawards. Although it appeared to be a long time before the start, the forenoon passed quickly enough and the two soldiers aboard gave invaluable help, not only in initially setting sail but assisting with the continual tacking that was required within the Sound. As the morning wore on all the competitors assembled in a restricted area to the east of the start line, and beyond the limits of this area was a truly amazing armada of vessels which were forming up to watch the start.

By about 11.30 am the additional hands on all the other competitors' boats had already been taken off, but somehow none of the official launches had got round to *Flying Angel*. As a result I had regrettably to invite the two crew who had so capably assisted me, to get into their dinghy and row back to Plymouth which was a good mile and a half away and appeared a formidable task from where I abandoned them! The wind was extremely light demanding the largest genoa, however *Flying Angel* had to make do with her No 2 genoa because of her twin forestays which, though very practical for the actual race, were highly unsuitable for the frequent small tacks needed within the Sound.

The 10- and 5-minute guns came and went and the start gun found *Flying Angel* on the starboard tack close to the seaward end of the line. The start was a good one in the best racing tradition; however it was mortifying to be slowly overhauled by other yachts who were able to set their large genoas. However, much of the story prior to the race has yet to be told.

Ever since the first race in 1960 I had felt compelled to compete in what must be the premiere of Off-shore races. For Service reasons I was unable to do anything about participating in the next two, however, in 1969 I realized that I would be giving up Command of a Regiment just prior to the 1972 race and that it should be possible, if I was able to procure a suitable yacht, to apply for leave in order to enter this time. I approached a leading naval architect with a view to getting a "special" designed which would give me an excellent chance of winning the race outright. The naval architect was full of enthusiasm and kindly agreed to my using his name to try and obtain sponsors. I was advised that a promise of a minimum of £30,000 would be required before there was any point in returning to see him. Hundreds of firms were approached, but clearly none of them regarded me as a future Chay Blyth and after many months all my appeals had only produced a few hundred. It was with a heavy heart that I reluctantly wrote to the designer saying that I felt we would have to let the matter rest. This decision continued to rankle with me as I hate being defeated.


ICELAND
GREENLAND
CANADA
NEWFOUNDLAND
NOVA SCOTIA
BRITISH ISLES
FRANCE
SPAIN
MOROCCO
CANARIES
AZORES
BERMUDA

In February 1971 I returned to England on leave and stayed with friends at Plymouth. During this visit I went on to the Hoe and looked out over the Sound and at that moment decided, come what may I must be out there on the 17 June next year amongst the starters. I hardly dared raise the matter again with my wife but she did not threaten to divorce me and was, as usual, most understanding realizing only too well that I would be difficult to live with until I had got the race out of my system. She became utterly involved in the planning and execution of this enterprise, gradually taking over the mass of administrative work.

Notwithstanding the very shaky financial arrangements, I decided to buy a stock Holman and Pye design 46 ft Corsair hull from Tyler's of Tonbridge and fit it out myself.

I did not return finally from BAOR, where I had been serving, until the end of January and because of industrial disputes the bare hull was not delivered to me until mid February. This left little more than six weeks to fit out the hull sufficiently for me to sail 500 miles solo before 17 April, which was mandatory to qualify for the main event in June. This task would have been quite impossible without all the help and interest shown by everyone at Chatham. I remember with humility the many people who gave up their spare time to help me and the support I always received.

We just managed to get the boat into the water before Easter and with a crew of friends moved her to Lowestoft which was my point of departure for the qualifying cruise. No time had been available for any sailing trials before leaving on this trip. The morning after arrival at Lowestoft the weather broke and throughout the Easter period depression after depression moved across the British Isles and I suppose the weather was almost the worst over Easter in living memory. I delayed my departure for two days in the hope that conditions would improve. However, further delay could well have meant that I would fail to return before the dead line of 17 April and in consequence not qualify for the race. The delay played on my nerves as I had never sailed a boat alone at sea before; however my fear of being thought a fraud was even stronger! As soon as I had had lunch on the third day I went aboard, cast off and put out to sea. I will not recount the 5½ days I spent on this cruise which covered nearly 700 miles, running down wind nearly to the north end of the Jutland Peninsula and beating all the way back again. Much of the time the wind blew harder than I had ever known it at sea, it was bitterly cold and the yacht's deck leaked like a colander through many of the fastenings which had not been bedded down and sealed during fitting out. However, despite the weather I never had a moment's anxiety about *Flying Angel*'s ability to take it, and I felt she would see me safely through almost any weather I was likely to meet; most reassuring.

After my return to Chatham a little more internal fitting out was completed which would add to my comfort on the race and the shortcomings which became apparent during the qualifying cruise, especially the leaks, were put right. At the beginning of May, after a most moving send off attended by the Commandant and many of the staff and the presentation of a plaque by the Chief Instructor of the Field Engineer School, I sailed with a crew for the south coast where I intended to do working up trials. Again this passage was made under deplorable weather conditions but was fast by any standards giving me a good idea of just what *Flying Angel* was capable of. She covered the distance from Chatham to the Owers Light Vessel off Selsey Bill in under twenty-four hours! I put into Lymington where I spent 2½ weeks pottering around doing odd jobs on the boat but little in the way of sailing trials. This was partly because the wind blew half a gale almost continually, but mainly because I felt completely exhausted from the prolonged period of very hard work getting the boat fitted out. At the beginning of June I moved the boat down in good time to Millbay Dock at Plymouth where I was enthusiastically welcomed and looked after by 59 Commando Squadron, Royal Engineers. Now came all the final arrangements before my departure including scrutiny of the yacht by the Race Committee.

As the date of the start approached so the crowds of sightseers increased to look at the competitors who were now gathering for the event. Just before the race, from dawn to dusk, the walls of the dock were crowded by people, several rows deep, peering into the yachts and depriving the competitors of any privacy. You could not even change your shirt without an inquisitive crowd passing comments! It was enjoyable meeting the other entrants and we were kindly invited to several social functions which had been generously laid on for us. I was very touched by the many wires I received from friends everywhere wishing me well.

Plate 1. *Flying Angel*—off Rame Head after the start of the race.

This was the background story of the months prior to this Saturday afternoon in June when I found myself alone in *Flying Angel* beating down channel bound for Newport, Rhode Island.

As we cleared Plymouth Sound the wind fortuitously increased a little and continued to come in from the south west. I stood out a couple of miles due south before tacking to the west in order to give myself a reasonable offing from the Cornish coast. One of the spectator boats, which were by now thinning out, sheered over towards me and to my delight I saw my wife aboard. She must have thought I looked very dejected as I was sitting on the cabin top contemplating the sea, with my face resting in my hands, wondering just what I had let myself in for! Seeing her brightened me up and I started to move around the boat tidying up the odd thing.

Once I had gone about and was on the long leg along the Cornish coast I handed the No 2 genoa and set the big No 1 and the boat immediately became more lively and began to surge forward. Both the No 1 and No 2 genoas were of such a size and weight that it required almost superhuman effort on my behalf to get these sails up and down through the fore-hatch especially on a heaving foredeck. For this reason the yacht designer, Donald Pye, and I had decided to go for a twin forestay arrangement so that the big sails would each remain permanently hanked to one of the stays. It is normal for twin forestays to be placed side by side, but the trouble with this arrangement is that it is all too easy to get them snarled together making it extremely difficult to get the sail down. We therefore decided to set up the forestays one 18ins ahead of the other. There was no problem in tacking with the No 2 genoa as this set on the after of the two forestays, however the No 1 genoa had to be got through the narrow gap between the two stays when tacking. In a situation where one was unlikely to tack more than once a day this was no great disadvantage. Two large terylene "hold-alls" were fixed to the rail to port and starboard running back from the bows to abeam the mast each side, so that when the sails were not in use they remained hanked on to their stays but were flaked down in these and secured out of the way. This system proved very satisfactory and I would certainly use it again sailing single handed on any large yacht.

Fowey came abeam and then fell astern and just after 5 pm I tacked south to clear Dodman Point. A couple of hours later I went about again hoping to be able to lay the Lizard. Throughout the evening the wind was freshening and by 8 pm I had to change down to the No 2 and by about 10 pm it had reached a good force 7 with accompanying stronger gusts so I handed the main and allowed *Flying Angel* to press on westwards under No 2 genoa only. The yacht I found remarkable in several ways and certainly one of them was her ability to go to windward under a genoa only without her head falling off to leeward.

Shortly before midnight I was closing the Lizard light and it was touch and go whether we would clear it. It was difficult to tell exactly how close we were but I was loath to tack to the south wasting time unless I was forced to do so. I did have some qualms as the lighthouse was so close that the revolving beam was passing clear overhead without illuminating the sails. What with the strong wind and the shoaling water it really was quite a ride! In fact as we proceeded westwards the seas continued to build up and, as always in the Channel, were comparatively steep. I remember sitting down on the leeward settee in my oilskins and wondering if it was really going to be like this for the next month! *Flying Angel*'s accommodation was incomplete and with only myself on board and just enough water for the race, she was probably something like a ton lighter than she should have been. This may have produced an easily driven hull but at the speed she was travelling, did she slam, when she went into the troughs! I found after some hours that my back teeth were chattering with the continual impact with the waves.

Navigationally the beginning and end of a race are the hardest on a single-hander as rest is out of the question until well clear of any land or other hazards. This meant no sleep until I had passed through all the shipping lanes and the Scilly Isles were astern. Just before 5 am the Wolfe Rock light appeared out of the murk close on the port bow and we were all set to pass through the gap between Round Island at the North end of the Scillies and the Seven Stones Reef further to the north of *Torrey Canyon* fame. This was an anxious period as the navigational aids available to me were limited, but by keeping a check on the DF bearing of Round Island all went well. I was pleased to see the island come abeam at about 8 am as we drove westwards out into the Atlantic. The wind moderated slightly and veered so I decided to tack. This allowed me an exhilarating last view of my home country sailing down the western side of the Scilly Isles. What a wild and barren coast it presents from seawards. The long Atlantic swell runs in among the rocks up to the cliffs and appears to burst almost vertically. It is a most awe inspiring yet beautiful sight which I must confess sent a chill down my spine knowing this coast to have been the graveyard of so many fine ships. I took my departure from the Bishop Rock at approximately noon.

Now something of the course I intended to sail. Before the race I had studied at length all the pilot charts and meteorological data I could of the North Atlantic and had read every account I could get my hands on of previous races. Two things which immediately impressed me were, firstly that on the far side of the Atlantic it is imperative to sail either north or south of the easterly setting Gulf Stream and secondly, such are the vagaries of the weather in the North Atlantic, that the shortest route in distance is not necessarily the quickest. It seemed to me that many previous entrants had lost time by slavishly trying to stick to a pre-determined route. I felt certain that the important thing was to sail as fast as possible roughly towards America and leave your final decision on tactics until you were approaching the Gulf Stream. Nothing that subsequently happened to me in the race has changed this view.

For the next three or four days a strong breeze continued to blow from somewhere north of west. The continual thumping day after day was tiring and the strain it was putting on the mast and rigging began to cause me concern. It has often been said of offshore races, which are of short duration, that the crew reaches the limit of endurance long before the yacht. However, I was by now becoming inured to the motion but I wondered whether, if it was going to be like this for the next month, all the gear would stand up to it. Unfortunately diesel from the fuel tanks started finding its way into the bilges. On close inspection I discovered the leak was where the fuel pipes passed through the skin of the tanks. The tanks had never been completely filled before so that this weakness had not become apparent. This was soon cured as it turned out by the simple expedient of applying mastic tape. I had not had time to seal a number of holes in the deck where I had altered the position of the self steering gear before sailing and consequently at times there was a considerable amount of bilge water slopping about with diesel oil floating on top. Because of the very shallow bilges this had run up into all the lockers under the berths so that when the water was pumped out a film of oil was left on everything. As far as I was concerned the most serious aspect was the nauseating smell. Although I had not been sick, or indeed felt squeamish, I had felt off colour and I found this added trial the last straw. Happily by throwing some Bilgex, a very concentrated detergent, into the bilges once the leak was sealed, I was able to pump this out and within two or three days the smell had disappeared to my great relief.

For the next few days the fresh wind continued and *Flying Angel* ploughed on steadily out into the Atlantic with her mean course somewhere between south west and west. I was surprised how quickly the temperature rose and I began to see my first Portuguese men-of-war. I soon found it unpleasant working on deck in oilskins and abandoned these, accepting the odd ducking.

A word here may be of interest about my routine. First priority was always given to anything that would increase *Flying Angel*'s speed and this dominated my life twenty-four hours a day. Second only to this came the continual maintenance of the gear. On a long passage something always needs doing and I spent many hours with a marlin spike, pliers or palm and needle applying the old adage that "a stitch in time saves nine"; in particular I was always on guard against chafe. It is remarkable how quickly a sailing yacht deteriorates at sea unless the gear is constantly attended to. Although my personal comforts came a poor last it was essential that I should have sufficient sleep to remain efficient and I devised a system of a little and often. Whenever I turned in I set the alarm for 1½ hours ahead and placed the hand bearing compass by my pillow. Normally every change in motion woke me instantly otherwise I tended to wake just before the alarm and having satisfied myself on speed and course, I would settle down for another nap. However, very often either a change of sail or the trimming of sheets and consequent adjustment of the self steering gear would be necessary. I tried to maintain a fixed routine by washing and shaving every morning and having regular meals in a reasonably civilized manner. I believe that if you do not maintain your personal standards you quickly become slovenly in outlook which reduces efficiency.

By the end of the first week the wind moderated, the sun shone strongly and we entered a halcyon period. The only clothing I ever wore were my bathing trunks. Physically I began to feel on top of the world and it is hard to describe here my general feeling of elation as I sailed on under these ideal conditions.

I had been kindly lent a small prototype manpack radio by the Ministry of Defence. Except for the day after the race started, I had failed to establish contact with the School of Signals at Blandford, although I did sometimes hear them calling me. On Saturday morning, when a week out, I received a much better signal and they could hear me although it was unworkable. Throughout the forenoon I feverishly worked on the installation, re-cutting the length of the aerial to achieve the best possible tuning. The earth wire had been hastily attached to a skin fitting on the hull and this I removed and took aft to the stern tube where, with no half measure, I actually slackened back a bolt on the gland, cleaned it up with a file, fixed the wire and hove it back up tight. I gave the nickle cadmium batteries, which I had been lent, an extra long charge to ensure that they were at peak voltage. I went on deck with a rag to remove some of the encrusted salt on the aerial base fitting to ensure that none of the transmitting power drained away to earth. At precisely 9 pm Blandford came through loud and clear and I tensely acknowledged their call hoping fervently that they would hear me this time. To my delight they immediately replied "got you". I gave them a run down on my progress and messages for my family. They said that propagation conditions had been appalling and the GPO station at Portishead had had difficulty in contacting the few yachts that were carrying radios. After this shaky start, on the whole, we had good communications for the rest of the crossing. This was due in part to the enormous enthusiasm and professional skill of the operators at Blandford. We only finally failed to communicate when I had passed the Nantucket light, only 100 miles offshore, and local stations jamming the frequency made conditions impossible.

Life went on with much the same daily routine except that the winds were generally lighter. I found that *Flying Angel* slipped along in the lightest of zephyrs. One evening, when the breeze had been somewhat stronger for most of the day, quite suddenly before dark, we were hit without warning by a powerful squall. *Flying Angel* was laid over on her beam ends. By the time I had got all sail off her the sea had become very rough and the wind had not diminished at all; it was blowing a severe gale from the west. I decided for the first time in my life to try lying ahull with no canvas set, as going to windward under these conditions was clearly impossible. As the barometer had given no warning, I thought that the blow was unlikely to last long. Much has been written by blue water cruising men, who no doubt owned heavy displacement yachts, on the merits of lying ahull. My own experience was not so happy. To be sure, I never had a moment's anxiety about the safety of the yacht, however, the motion in *Flying Angel* had to be felt to be believed. Every conceivable article rattled around in its stowage place, including me in my berth, as the yacht rolled incessantly from one extreme to the other. After two or three hours the wind began to moderate but the seas were still so confused that I decided to turn in for another hour before making sail again.

On 1 July, when I was about 400 miles north west of the Azores, the time for decision had come; whether to pass north or south of the Gulf Stream. I had heard on the radio from newspaper reports that two of the largest British yachts were not very far west of me but considerably to the north and I was certain then that they intended to go north. I also heard that *Flying Angel* was very well placed on handicap, however, I took the latter piece of information with a pinch of salt, as I knew the papers only had the haziest idea where most of the competitors were because only a few of the larger yachts were carrying wirelesses. I had two alternatives, either to go north and follow the big yachts with no rational expectation of closing the gap but nevertheless ensuring a good handicap position, or to press on to the south west and pass south of the Gulf Stream working on the accepted principle of doing something different. If Lady Luck did her stuff, I could arrive at Newport at much the same time or even before the other yachts. This was not as improbable as it may appear at first glance. Although the southern route would undoubtedly mean sailing a little further, the winds predicted by the pilot charts would be consistent and reasonably favourable, whereas the area along the Nova Scotia coast is notorious for its calms at this time of year. Being an inveterate gambler by nature, I decided to press on to the south west and see if I could not pull something sensational out of the bag.

Within a day or two of this decision I sailed into an area of almost complete calm. For sixteen hours a day or more, there was literally not a breath of wind. The water temperature was 78°F and the cabin temperature hovered around the 92°F mark day and night. Much of the day my field of vision was restricted by the heat haze. It was like being becalmed in a boiling cauldron. Taking sights with the sextant was impossible except in the early morning and evening as there was no horizon. Whenever I stood still a pool of water formed on the cabin sole from my dripping perspiration; I was roasted on deck and boiled when I went below. Each evening a minute zephyr would spring up as though teasing me and the yacht would ghost on a few miles before stopping. Looking back I undoubtedly got into a highly emotional and indeed irrational state of mind. Sleep was very difficult and anyway I dared not sleep for more than a few minutes for fear of missing a breeze. I tied a chiffon scarf my wife had given me to one of the mizzen shrouds where I could see it from everywhere in the cabin, including my bunk. For hour after hour my eyes would be glued to this motionless tell-tale waiting for the faintest movement! It was purgatory. Finally, one day, out of sheer exhaustion I slept through the alarm and had a solid five hours. These conditions continued for five days and by this time I was almost in despair. I decided that to continue to the south west would be to reinforce failure as the weather forecasts were more favourable to the north, so when a breeze finally returned I reluctantly bore away to the north west and made reasonable progress for the next few days.

Although I was anxious to get north of the main flow of the Gulf Stream, I did not wish to go further north than necessary as once I closed the Nova Scotia coast my course would be south of west. The pilot stated how very unpredictable the Gulf Stream is both in respect of its limits and strength. The cold Labrador current flows in a favourable direction along the north western flank of the Gulf Stream and I very much wanted to take advantage of this. So, every few hours I brought a bucket of sea water aboard and took its temperature with a thermometer.

When almost 200 miles due south of Cape Race, on 10 July, I went on deck at dawn to find the yacht surrounded by fog. The effect of warm air off the Gulf Stream passing over the cold Labrador current produces thick fog. I found the water temperature had dropped from about 70°F to 44°F and was delighted to think that I was now in the favourable current. However, presently the fog cleared and there followed the makings of another superb day. To my annoyance I found the water, only two hours later, had risen again to 66°F. So much for my having entered the

Labrador current! Just before noon I sighted ahead what at first glance looked like a concrete block of flats right down on the horizon. On looking again I realized that it could only be an iceberg and fortunately it lay almost dead ahead. It took me some three hours fast sailing to come up on it and I noticed from time to time it completely disappeared. I realized when I got close, that the warm air as it blew over the berg was being super-cooled and creating local fog downwind of it. It was this phenomenon that produced the illusion of invisibility. I tacked as I passed the iceberg, at about half a mile's distance. I did not wish to go any closer as there were a considerable number of growlers lying in the vicinity of the berg which were nearly awash and difficult to see until you were on top of them. It is hard to describe what an awe inspiring sight I found it, especially when the sunlight got behind the berg and the vivid colours appeared around its edge through the prismatic effect of what is after all no more than a giant crystal. Strangely enough the proportion that was visible was as high out of the water as it was wide. At the most conservative estimate, it was well over 100 yds across the base and I believe it could not have been less than 300 ft high. It really was enormous and even half a mile off appeared to tower over *Flying Angel*. What is interesting is that at no time at this distance did the sea temperature materially drop when passing the berg. I am now certain in my own mind that at dawn, I must have been passing exceedingly close to another berg and that I was within the local fog belt and cold water effect of being in very close proximity.

One of the problems which I never really resolved was the question of time. The only times that were essential to me were those for navigational purposes and radio schedules and these were necessarily on a GMT basis. I felt that to retard a second "domestic" clock every few days by one hour, aboard a yacht sailing alone, was manifestly absurd. As I have said, I did my best to stick to a routine, however, this lead me into some odd situations. Towards the end of the race I would have my breakfast in pitch darkness long before dawn and my evening snifter shortly after my noon sight!

About 200 miles off Sable Island I awoke in the night to find the cabin brightly illuminated. I rushed on deck to be temporarily blinded by a search light from close at hand. It was a particularly dark night with only a light wind and little sea running. Gradually I made out the outline of a ship which over the course of the next twenty minutes slowly circled me and then crept up astern slightly to leeward. I hailed her several times but received no answer. I could now see the phosphorescence as her bow gently lifted with the swell no more than twenty yards away; too close. I yelled my displeasure whereupon the light was cocked up into the air and she very slowly started to move away. I thought I just made out the Polish ensign and the name *Humbak* which was partially illuminated by her stern light. Since my return Lloyds have confirmed that there is a Polish trawler factory ship of that name.

I was becoming daily more excited as I neared the North American continent. I had plotted my position on the very small scale North Atlantic chart and the progress day by day appeared to be minimal. The great day arrived when according to my position I had at last arrived on a "normal chart", Cape Breton to Delaware Bay, and at that moment I really felt I had crossed the Atlantic and it was just a question of finishing off the trip with a local coastal passage. I should now have been within range of the DF station on Sable Island so I switched on the DF set and instantly picked up the station. It was a great relief to find that the bearing agreed exactly with my plotted position.

Fair sailing conditions continued off the Nova Scotia coast after I had left Sable Island well to the north. On 16 July I ran into thick fog but the breeze continued to come in from a little west of south. For the next two days I sailed on with only a hazy idea of my exact position as the log got continually snarled up with weed and I could take no sunsights. Fortuitously, for the first time since leaving the Scilly Isles, I was within soundings which meant I could use my echo sounder and I was also able to pick up one or two DF stations along the coast but only at extreme range.

This area is frequented by trawlers, mainly Russian and Japanese, and usually the first I knew of their presence was their fog horn in close proximity as I imagine they had picked up my radar reflector which was fixed to the mizzen masthead. It was during this period that I saw a considerable number of sharks, however they were not very large.

In the early hours of the morning of 18 July the fog was as dense as ever but the wind took off completely and I found myself becalmed about forty miles north east of the Nantucket Light Vessel, which I had to round by the race rules. The condensation aboard was almost unbelievable; the whole yacht both inside and on deck was soaking wet. This applied also to myself and my clothes, all of which were by now impregnated with salt and consequently became sodden. However much I dried my hands over the stove they remained white and wrinkled. I found being immersed for days in the thick fog progressively unnerving especially when the wind took off completely and there was no way on the yacht. The pilot made pretty depressing reading with its warning that fog in this area could last up to three weeks without lifting. I really began to feel for the first time that there was a serious risk of collision and that I should plan accordingly. The life-raft had been lashed in the cockpit and in order to facilitate a quick retreat, I placed a life-jacket, torch, sharp knife and my distress radio beacon just inside the cabin hatch. An hour later when I was cooking breakfast and the light fell on the distress beacon, I saw to my horror, that the red plug had come away and the beacon was automatically transmitting. I hastily replaced the red plug. Seldom have I felt more embarrassed or foolish. What on earth was I to do if hundreds of ships and aeroplanes all suddenly started to converge on me in that fog! During my next routine call to Blandford I explained the position and they offered to do what they could and call me back. An hour later they told me that the distress call had not been picked up. I imagine that as the little radio with its short aerial had been lying on its side in the cabin below water level, it was probably heavily screened by the rigging. Apparently Blandford had rung up the GPO radio station at Portishead and they then wirelessed the American coast guard, who made a number of rapid enquiries and confirmed that no distress signal had been picked up. All this had been achieved within the hour! Rather more than thirty-six hours later a zephyr came in and *Flying Angel* started to work her way westerly towards the Nantucket Light.

The Admiralty List of lights showed that the light vessel had a fog horn and reserve whistle. As I approached the light vessel using the DF set I could not hear the fog horn. When I knew I was getting within a mile or two of the vessel judging by how often I was forced to tack, I started to hear the whistle. Later when I knew I must be very close, I was perplexed to find the light vessel by DF bearing dead ahead yet the whistle out on the port beam. It was an anxious period, however I consoled myself with the fact that fog plays tricks on the ear. I continued to steer on the DF bearing which, unlike acoustic noises, is never affected by fog. The noise of the whistle remained on the port side when quite suddenly I heard the noise of machinery running; not that of the main engines of a sizeable vessel but something more akin to a charging generator. To my horror, out of the murk, only a few feet dead ahead, loomed the dark slab side of a vessel. I must confess that I was seized with fear and pushed the helm hard down, in my haste getting the genoa aback, before finally managing to tack away. I grabbed my puny fog horn and squirted it several times into the fog where I had seen the vessel. I was still very shaken when two or three minutes later I heard what at first appeared to be a large explosion astern. This was the light vessel sounding its fog horn and the effect was devastating after the complete silence of the fog. It continued to operate for the next ten or fifteen minutes, where upon it fell silent again. A nice little breeze started to come in from the south west and *Flying Angel* began to romp home the last 100 miles to the Brenton Reef Tower off Newport. About half an hour after leaving the area of the light vessel I saw my stern lamp flickering and this annoyed me as it had given continual trouble and I thought I had fixed it. Watching it for some time I realized that the fog had temporarily cleared astern and there was the double flash every ten seconds of the Nantucket Light exactly over the stern. It is of interest that when I eventually reached Newport and somewhat shamefacedly recounted what I feared would be considered an unlikely story, I found that two or three other competitors who had also arrived during this period had had very similar experiences. It caused a terrific furore with the American coast guard officials who are very proud of their normally most efficient service. I was also told that there was a whistle buoy about 1½ miles from the light vessel and it was this that I had heard.

Although the wind was never strong, *Flying Angel*, as though she knew she was nearing home, with her sheets started and little sea running, sailed faster on this leg than at any other time during the race. Hour after hour we were doing between 7½ and 8 knots and it was really exhilarating sailing. I spent the whole of the day, which I presumed to be my last, making certain that the yacht was ship-shape for my arrival in port. About thirty miles off the coast, when Martha's Vineyard was abeam, I sailed out of the fog into a lovely warm day. What a relief after not being able to see more than twenty yds around the yacht for 5½ days! As we closed the finishing line off the Brenton Reef Tower the wind appeared to be dying. I could hardly believe my luck; was I to be left yet again being set back and forth by the tide within a stone's throw of the finish? Fortunately a very light breeze remained and *Flying Angel* crossed the line at 2120 hrs GMT on 20 July. It was tremendous to break out the Stars and Stripes above Yellow Jack at the crosstrees. I also hoisted the Royal Engineer Yacht Club burgee at the masthead and the ensign on the mizzen. I now began to meet a number of American yachts who all hailed me in a most friendly manner and welcomed me to the United States with typically uninhibited enthusiasm.

It took me some hours tacking to windward until I was about a mile from the narrow entrance to the sound where all the yacht harbours are situated at Newport. Two lads in a lobster fishing boat came up alongside and offered me a tow. This was a great relief as the tide was foul and there was virtually no wind. It enabled me to stow all the sails in good time. On rounding the old fort and entering Newport harbour I saw a small launch approaching and to my utter joy saw my wife aboard. Notwithstanding immigration formalities, as soon as they came alongside I grabbed her aboard. As we approached journey's end at the Port o'Call Marina, a large crowd assembled and yachts all round the harbour began to blow their sirens. It was a most moving and happy moment. A host of helping hands grabbed my rail and warps and I was able to relax completely for the first time for over a month. I am ashamed to say that I did not even supervise the making fast of *Flying Angel* alongside *British Steel*. I only have a hazy memory of the salvos of questions being shot at me and of newsreel cameramen in the background. A most friendly Customs and Immigration Officer came and joined the crowd of well-wishers already aboard!

I very much feared that because of the periods I had spent becalmed, I would be badly placed. However to my surprise, I found I had arrived fifteenth out of the fifty-four starters, which was quite creditable as *Flying Angel* was only twentyfourth in size on water line length. I was subsequently placed sixth on handicap although the handicapping, with such a disparity of vessels was inevitably rudimentary and mine was undoubtedly generous.

It is impossible in an account of this nature to pay adequate thanks to all the countless people, both within the Service and in Industry, who gave me their most generous assistance and unflagging support. As well as financial aid, much of the fabric of the hull itself and the equipment used to fit it out was either given to me or sold at reduced cost, often with only a slight chance of receiving any tangible return in the form of publicity. I am deeply conscious of the extra work which I caused to those who became involved and without whose assistance the project would have never got under way. Finally a special word to my late Regiment for their help including the provision of a crew to whom I owe the safe return of the yacht to England. To all the many people whose contributions, large and small, made this enterprise possible, I would like to give my heartfelt and sincere thanks.

Military Assistance to British Olympic Yachting

DEREK CARROLL

BY now the Kiel Olympiad 72 is but a memory. Many hopes were realized and many shattered, not least of which could have been those of the German Organizing Committee which went to unprecedented lengths to provide the best organization and support ashore and afloat. Although Kiel is 600 miles away, the tragedy of Munich had its effect on officials and competitors, indeed upon all concerned with sailing. However, the organization and host nation support continued unabated and the British team took full advantage of it. In many ways they were more fortunate than others because, as was written in *The Times*, they had good reason to be grateful to the British Army of the Rhine and the Royal Air Force (Germany) for the support they were given at Kiel.

Our thirteen aspirants toiled for years to achieve one gold and one silver. Unlike the Munich athletic and associated events, sailing is a series event. There were only six golds, six silvers and six bronzes and something like 320 competitors and twice as many official supporters worked for ten days afloat and ashore to achieve medal success. It was gratifying to British ears to hear that three out of the six "gold anthems" played were our National Anthem—it could so nearly have been four. The Australian team won two golds, we made it three.

How, you will be asking, did the Army and the Royal Air Force help?

The British Kiel Yacht Club had been established at Kiel since the end of World War II. Its board of management is shared between serving officers of the Army and the Royal Air Force (Germany) and the Commodore is traditionally the Chief Engineer, British Army of the Rhine. The Club exists to provide offshore adventurous training for all ranks of British Forces in Germany and hundreds of men are trained in this each year. As a club it owns or has jurisdiction over some twenty boats from 100 sq m to the Cutlass.

The Club itself is co-located with the Kiel Training Centre, commanded by Major Arthur Shadbolt, MC, RE, a sapper unit of 1st Division, under the technical direction of the Chief Engineer. In normal times it gets on happily with its rewarding task of teaching young soldiers and airmen to sail for adventure, and young sappers how to dive professionally. The last two years, however, have not been normal for Kiel.

Preparations for the Olympiad began in 1968 and BKYC was involved with the rehearsals held by the German Organizing Committee in 1970 and 1971. There were snags: the Finn line was too short; some windward legs were not to windward—Kiel winds are so fickle you cannot afford to lay the weather mark until the ten-minute gun. These and many other problems were experienced and, judging by the absence of valid criticism on the day, solved.

The British sent out a formidable team and these were housed in the limited accommodation of Kiel Training Centre. Some were accommodated in the Army Officers Mess with its superb view over the fjord with Friedrichsort light and the marine memorial shaped like a U-boat conning tower guarding the entrance, while others were housed in the quarters of British officers of KTC and of the adjacent NATO Headquarters, and in one of the barrack blocks. While some may not regard KTC as a paragon of disciplinary virtue, nevertheless it has a character which befits its role. Rank is less important in Kiel. You have to sail well to hold your own with corporals and bombardiers who are qualified in their own right as skippers and instructors. Could it be that our Olympic sailors, who tend not to welcome the idea of discipline or team spirit—what *prima donna* does?—might not have gained a touch of it by living together in an Army Mess and barrack room?

Specifically the Kiel Training Centre housed the contenders during Kieler Woche

71, the pre-Olympics and Kieler Woche 72; each individual paid a sum per day which satisfied the Guardians of the Public Purse. The BKYC opened its doors to all who cared to visit it; the bar did quite nicely except, of course, that Olympic sailors do not drink and drive. And they had to drive afloat every day from 1000 hrs to 1600 hrs—sometimes later. However the Australians, Canadians, Indians, New Zealanders, the Norwegians and many others found the Club a pleasant alternative to the somewhat clinical environment of Kiel-Schilksee.

Any officer worth his salt should always be looking for unusual training for his men which will offer a challenge to mind and body. The Olympics provided just this for the men of Kiel Training Centre. Five or six hours a day in an open assault boat or inflatable in all weathers in the Baltic for weeks on end soon sorts the men from the boys. Very often the Sapper operators in wet suits would operate alone at sea under orders passed to them by radio, collecting and delivering sails, succouring the afflicted, towing home the dispirited and a variety of other tasks which often called for a display of initiative and always a great deal of drive and determination.

The Australian team hired Army assault and inflatable boats. They were characteristically good enough to invite their Sapper boat operators, imported from Hameln, to their final celebration in the Australian team office and in their speeches both winners waved their gold medals and said, "we would not have these without the help of the Royal Engineers." This was Commonwealth at its best. But it was only so because the British Olympic sailing team generously agreed to it before the contract was made with the Aussies.

One of the most important race-winning factors in sailing is the ability to prejudge local weather. This is critical at Kiel which, having the German plain to the south, the North Sea to the west, the Baltic to the east and Scandinavia to the north stands, as it were, at the crossroads of Atlantic and continental weather systems. Mr David Houghton has supported the team since Acapulco and, although reception of his forecasts were usually what one would expect of a British audience, it was difficult to find any member of the team who would have foregone this fascinating daily review.

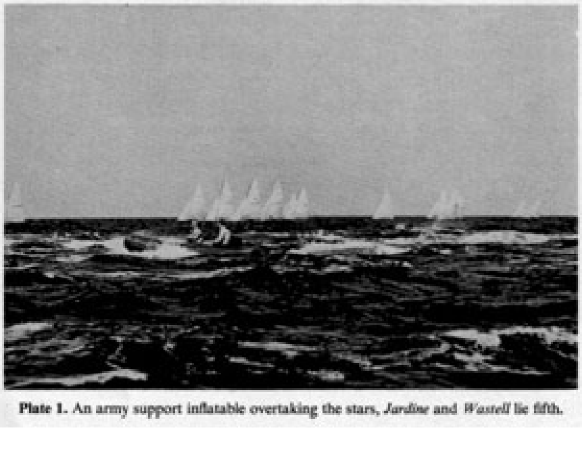
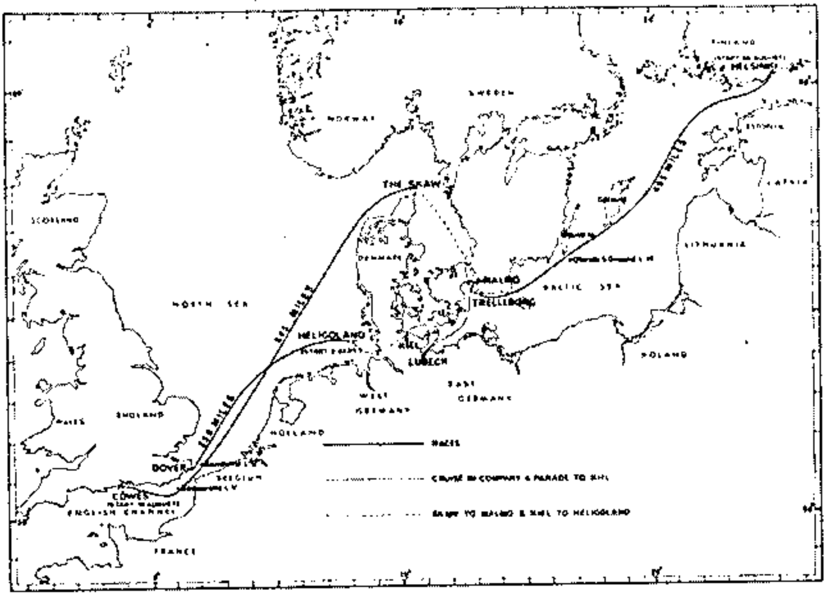


Plate 1. An army support inflatable overtaking the stars, *Jardine* and *Wastell* lie fifth.

Military Assistance To British Olympic Yachting 1

INTERNATIONAL SAIL TRAINING RACES 1972



HELSINKI to FALSTERBO

VESSEL	[illegible]	[illegible]	[illegible]	[illegible]
CLASS A				
CHRISTIAN RADICH	3 12 47 10	2 07 14 35	1	2
DANMARK	3 11 31 10	2 09 00 34	2	3
CLASS B DIVISION I				
GLADAN	3 08 42 14	2 08 29 56	1	4
FALKEN	3 09 39 40	2 11 12 17	2	5
[illegible]	4 05 05 40	2 22 52 07	3	6
GRATITUDE OF GOTHENBURG	AT SEA	3 14 09 50	4	9
ZAWISZA CZARNY	AT SEA	4 01 57 50	5	12
GRATIA OF GOTHENBURG	RETIRED			
CLASS B DIVISION II				
ASTA	2 19 52 22	2 13 05 45	1	4
ST BARBARA II	3 22 24 59	3 14 03 27	2	7
GLORIA	4 09 40 10	3 10 08 24	3	8
[illegible]	4 07 44 10	3 15 14 12	4	10
REGINA IV	AT SEA	3 38 05 44	5	11
[illegible]	AT SEA	4 18 09 06	6	13
NERISSA	RETIRED			
SANTA MARIA	RETIRED			
[illegible]	RETIRED			

ISLE of WIGHT to THE SKAW

VESSEL	[illegible]	[illegible]	[illegible]	[illegible]
CLASS A				
DAR POMORZA	4 19 16 24	3 05 25 36	1	1
GORCH FOCK	4 19 45 00	3 07 57 42	2	2
EAGLE	5 00 00 58	3 11 31 10	3	6

ISLE of WIGHT to THE SKAW (continued)

VESSEL	[illegible]	[illegible]	[illegible]	[illegible]
CLASS B DIVISION I				
SIR WINSTON CHURCHILL	4 05 42 22	3 08 36 16	1	3
MALCOLM MILLER	4 06 25 50	3 09 10 42	2	4
BELLE POULE	4 15 42 31	*3 12 07 24	3	9
ETOILE	4 22 54 09	3 13 19 28	4	12
BEL ESPOIR	5 17 42 17	*4 19 36 47	5	27
ZENOBE GRAMME	AT SEA	6 02 46 12	6	29
ASTRAL	RETIRED			
ROYALINE	RETIRED			
SEUTE DEERN	RETIRED			
CLASS B DIVISION II				
RONA	4 05 51 11	3 12 56 55	1	11
TS ACTAEON	4 02 45 27	3 16 34 58	2	15
URANIA	4 02 38 03	4 18 14 25	3	19
PETER VON DANZIG	4 06 10 50	3 20 32 05	4	21
STELLA POLARIS	4 01 41 18	3 20 43 00	5	24
NORSEMAN	5 20 18 13	5 06 02 08	6	28
[illegible]	AT SEA	DISQUALIFIED		
LA GOLETA	RETIRED			
FALADO VON RHODOS	RETIRED			
BLACK PEARL	RETIRED			
HOSHI	RETIRED			
[illegible]	RETIRED			
[illegible]	RETIRED			
CLASS B DIVISION III				
GRYPHIS	4 09 03 06	3 10 51 27	1	5
ZULU	4 08 10 22	3 12 40 54	2	7
PEGASUS	4 10 43 26	3 12 07 06	3	8
[illegible]	4 09 05 00	3 12 08 30	4	10
GALAHAD	4 12 30 38	3 14 26 19	5	13
GAWAINE	4 13 09 45	3 15 19 17	6	14
CAPELLA	4 08 23 00	3 16 49 46	7	16
ST BARBARA III	4 06 55 30	*3 17 17 57	8	17
[illegible]	4 08 55 13	3 19 12 44	9	19
[illegible]	4 18 32 55	3 18 18 18	10	20
MERLIN	4 09 24 45	3 18 50 02	11	21
MARABU	4 19 21 23	3 19 50 59	12	22
HAMBURG VII	4 08 12 30	4 21 42 52	13	23
DARK HORSE	5 10 59 45	4 11 32 04	14	26
LEOPARD	RETIRED			
[illegible]	RETIRED			
ASGARD	RETIRED			

* INCLUDES 5% TIME PENALTY

Plate 2. Race Chart produced in record time by 14 Field Survey Squadron RE.

Houghton drew from all the sources open to all teams and daily upon the efficient German Olympic met office; he was fortunate in having additionally some Army help. To help give him a statistical base, met readings were taken each day for two months prior to the Olympics on each of the three rings; wind speeds, direction, relative humidity, barometric pressure and movement of surface water were some of the data passed back to Bracknell for analysis. This information was obtained by Cpl. Baker and the crew of *Coronach*, a Royal Corps of Transport launch on loan to KTC from Gosport as a safety escort for adventurous offshore training.

The main Army contribution on the day came from the Mobile Meteorological Unit of 1st British Corps which picked up on its facsimile receiver twice a day the Bracknell broadcasts. This gave David Houghton a depth to his crystal gazing and the overall daily interpretation gave the British an edge, weatherwise, on their opponents and they knew it.

On Sunday 3 September, a rest day for the Olympic competitors, the Tall Ships arrived in Kiel, escorted by *Flamingo* and *Kranich*, 100 sq m of BKYC and many other club boats. They had sailed from Travemunda which was chosen as the RV at the end of two races of 645 miles from Cowes to the Skaw and 493 miles from Helsinki to Falsterbo.

The Assistant Director Survey at HQ, BAOR, Lieut-Colonel Ben Burrows, took advantage of these races to set up a little exercise in Survey "rapid response". The results were phoned through to 14 Survey Squadron and no more than twenty hours later 2,000 copies of the race charts with fully tabulated results were delivered. Colonel Dick Scholfield of the Sail Training Association, who paid for the materials used in this exercise, said that the British and Foreign press were astounded by this rapid reaction. They must also have been impressed by the high quality of the charts which were produced by BAOR Survey staff working against, and round, the clock.

The British could have won a gold and a silver without the help of Major Arthur Shadbolt and his wife Sheila, but it would have been more difficult. Major Shadbolt is supported by a loyal band of local Germans in addition to the soldiers and airmen under his command. Mr Heath was due to visit BKYC at 1630 hrs on Wednesday 6 September but the tragic happenings in Munich changed everything. Wednesday became a day of mourning and racing was cancelled. It was learnt that, although Mr Heath had cancelled his programme for the day, he would visit BKYC during the morning. Major Shadbolt and his staff rose to the occasion. Mr Heath attended the memorial service at Kiel-Schliksee and then chatted to members of the British team. Afterwards he motored to BKYC for an informal visit during which he met the Committee and Club members and enjoyed discussing the sea and sailing with soldiers and airmen who are also skippers in their own right.

No account of Services participation in Kiel Olympiad 72 would be complete without mention of Stuart Jardine and John Wastell. Their Duplin Star was named *Shiny Two* after Major Jardine's 2nd Armoured Engineer Squadron. Co-incidentally 2 Squadron RAF is based at Laarbruch where Chief Technician Wastell helps keep their aircraft in the air. These two men were disappointed that their win in the first race at Kiel did not lead them, in the end, to the rostrum, but to take seventh place out of the eighteen best in the world is no mean achievement. They do not make excuses, but their results, apart from the second race which was their discard, reflected the general change in form and fortune which afflicted so many in those last days. The weather turned stormy and oppressive with erratic winds which on more than one occasion on the same weather leg saw half the fleet close-hauled and the other half with spinnakers set. Winning became more a matter of luck than judgement and skill.

It was clear two years ago that Services participation in the preparations and in the Olympiad could provide a unique opportunity for publicity and a progressive plan was made by the BKYC committee. Major John Adams and Herr Gert Medoch of PR HQ BAOR took their TV cameras and kit aboard a 100 sq m of BKYC which made an excellent platform for filming and some fine pre-Olympic action films,

Plate 3. The Prime Minister and Commodore BKYC entering the club house.

particularly of Services contenders, were made and subsequently shown on various TV channels.

Radio publicity came in an unexpected way. A month before the Olympics the English language service of Deutschlandfunk asked BAOR to provide a reporter to cover Kiel. Six out of the eleven broadcasts made by the Commodore BKYC included either a direct reference to the Services' support or an appreciation of that support in the course of an interview with someone who had benefited from it.

This must have been the best Olympiad ever staged and future Olympics will have to continue this extremely high standard. For any future event the British team can be assured that the British Kiel Yacht Club and the Kiel Training Centre will give them the same support they were proud to give in 1972.

Lightning Performance of Overhead Lines

CAPTAIN M. D. P. YOUNG, BSc, RE

INTRODUCTION

THERE have been many advances in recent years in the study of the effects of lightning on overhead power lines, particularly for ehv transmission lines. The purpose of this paper is to present a broad review of the subject and to indicate a simple method of assessing the lightning performance of overhead lines, as a corollary, means of reducing the number of lightning induced faults are highlighted.

A method of assessing the lightning performance of overhead lines is required, so that the appropriate degree of protection can be adopted for the construction of a line in any given circumstances, and hence make the most effective and economic use of the resources available. In order to demonstrate the need for such considerations the lightning performance of the British system is given in Table 1. In examining these figures it should be noted that the UK is an area of relatively low lightning activity. In other countries where thunder storms are more frequent the problems caused by lightning are magnified.

TABLE I

Lightning performance of the UK System 1950–60

System Voltage kV	km Years	Number of CI	Number of LI	%LI	LI per 100 km years
Under 11	48 376	5 423	4 082	75·1	8·4
11	576 894	71 364	50 772	71·3	8·8
22	35 790	2 812	1 962	69·9	5·5
33	97 134	4 455	3 616	81·2	3·7
66	27 885	605	541	89·6	1·9
132	72 867	626	528	84·4	0·7
275	6 200	66	63	95·5	1·0

CI = Circuit interruptions

LI = Lightning incident, a system fault caused by the action of lightning.

The Electrical Research Association (ERA) proposed a method in 1945 for determining the probable number of strikes to a line based upon an electrostatic model and the ground area covered by the line. Its application requires a large number of laborious calculations and it did not seem to attract much use. It was basically superseded in 1950 by a method proposed by the American Institute of Electrical Engineers (AIEE). This was much easier to apply but limited to lines operating above 70kV. Both methods give broadly similar results. Further experience and research have indicated that there are inaccuracies in them, for example, the AIEE method predicted a failure rate of 0·3/100 km/year for a line whose actual performance was 4·5/100 km/year. This discrepancy can be partially attributed to insufficient allowance being made for line height.

THE NATURE OF LIGHTNING

Lightning Strokes

Lightning is the rapid discharge of electricity from charged clouds either to ground or to other clouds. The lightning stroke starts as a streamer from the cloud (called the leader) moving erratically downwards guided by the local field distribution at an average speed of 200 km/s, in steps or jumps of about 50 m. During its downward progression, charges from the cloud are deposited along the path of the leader. The approach of a leader to the ground is unaffected by features there until the local stress produced under its tip is sufficient to cause breakdown of the air between it and the earth. At this point an upward streamer discharge from the nearest earth point is initiated. The leader and the upward streamer meet to complete the discharge path, along which the return stroke moves at about 1/10 the speed of light to neutralize the deposited charge, and the charge in the cloud. It is the return stroke which carries the heavy current, an average value of its peak amplitude being 20,000 amps. The magnitude of the current follows a probability law, the higher currents being the least likely. The current distribution is shown in Figure 1.

More than one lightning stroke can flow through the established discharge channel, fed from different charge centres in the cloud. On average only one or two strokes follow the first discharge, although a maximum of forty has been observed. Individual strokes can be accompanied by long duration low amplitude tails. It has been found that 70 per cent of lightning strokes carry a negative current the remainder being positive.

The voltage gradient which causes breakdown of the air gap between the leader tip and the ground is independent of ground configuration, its magnitude is of the order of 500kV/m for negative strokes and 300kV/m for positive strokes. The mechanism of the upward streamer leads to the concept of the striking distance of a

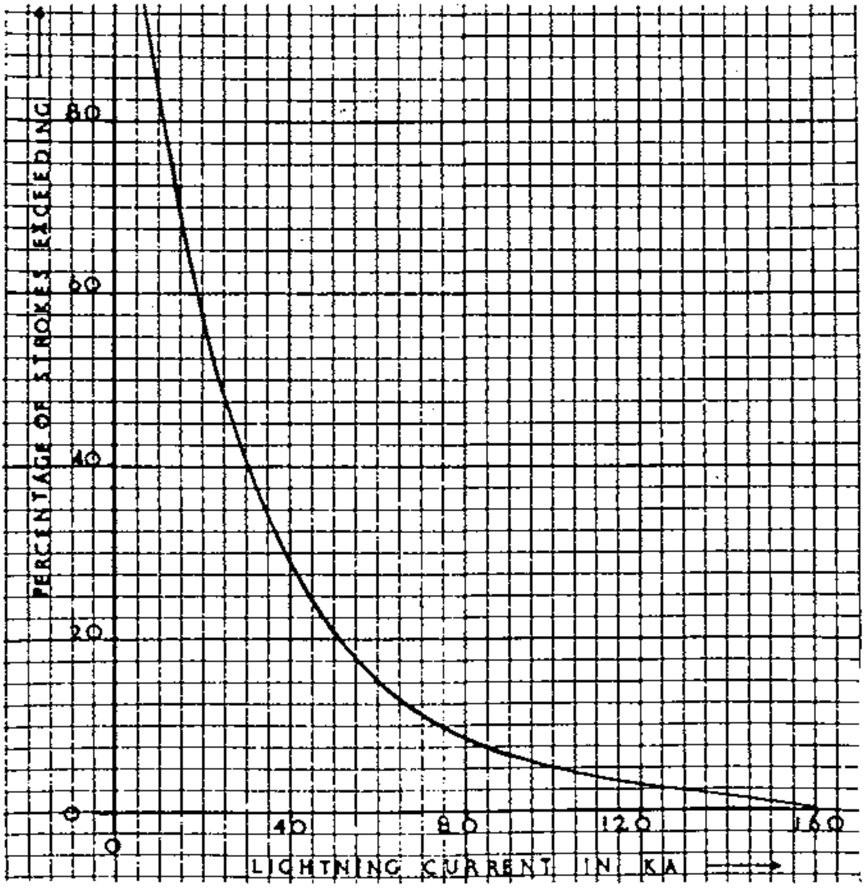


Figure 1. Magnitude of lightning stroke current.

lightning stroke, and hence to the "attraction" of lightning. The striking distance is dependent upon the charge in the stepped leader and hence upon the current which will flow in the return stroke. Values for striking distance in terms of the stroke current are given in Figure 2.

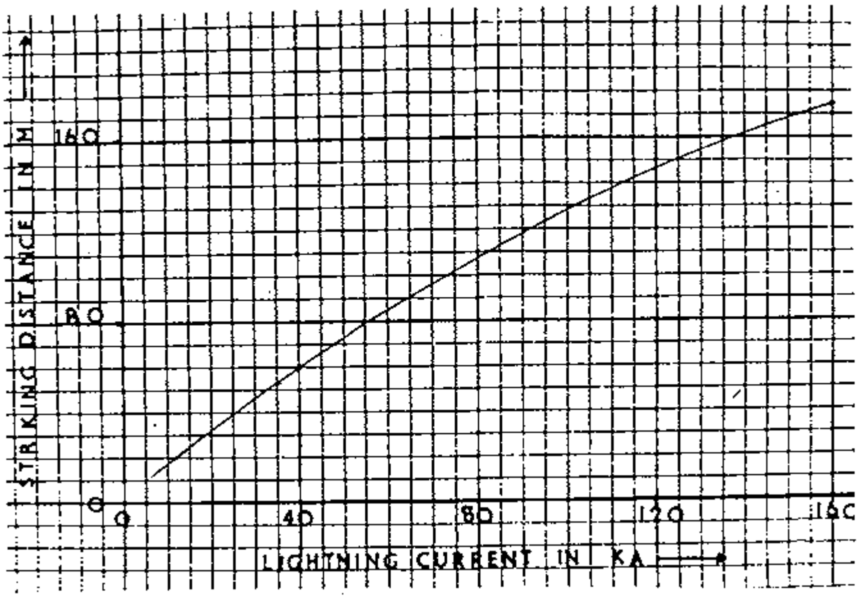


Figure 2. Striking distance of lightning strokes.

Lightning Distribution

Ideally the map showing the world lightning distribution should be based on the number of strokes to ground per sq km; however there are practical difficulties in measuring these, especially over large thinly populated areas. The only index universally available is the so-called isoceraunic level (IKL), which is defined as the number of days in a year that thunder is heard in that area. Average values of world IKL's are shown in Figure 3.

Work carried out in the USA has established a correlation between IKL and strokes per sq km to ground. The average figure obtained was that an IKL of thirty storm days per year is equivalent to 5·3 strokes to ground per sq km, direct scaling being adopted for other IKL's. However this relationship should be treated with some care as the ratio of cloud to cloud and cloud to ground strokes is not constant, it tends to increase towards the equator. Another major variable is the total number of strokes per thunder storm day and whilst the proportion of ground strokes to total strokes will be lower in the tropics, the severity of the storms may be greater. Thus although IKL generally increases towards the equator, the density of ground strokes does not necessarily increase at the same rate. An additional factor which makes the assessment of lightning activity difficult is the numerous local variations in stroke density due to the nature of the ground.

Lightning Strikes to Overhead Lines

A lightning stroke can affect an overhead line in one of three ways:

a The stroke hits the ground in proximity to the line and induces a voltage surge upon it.

b The stroke terminates on a phase conductor.

c The stroke terminates on the earthwire or tower top.

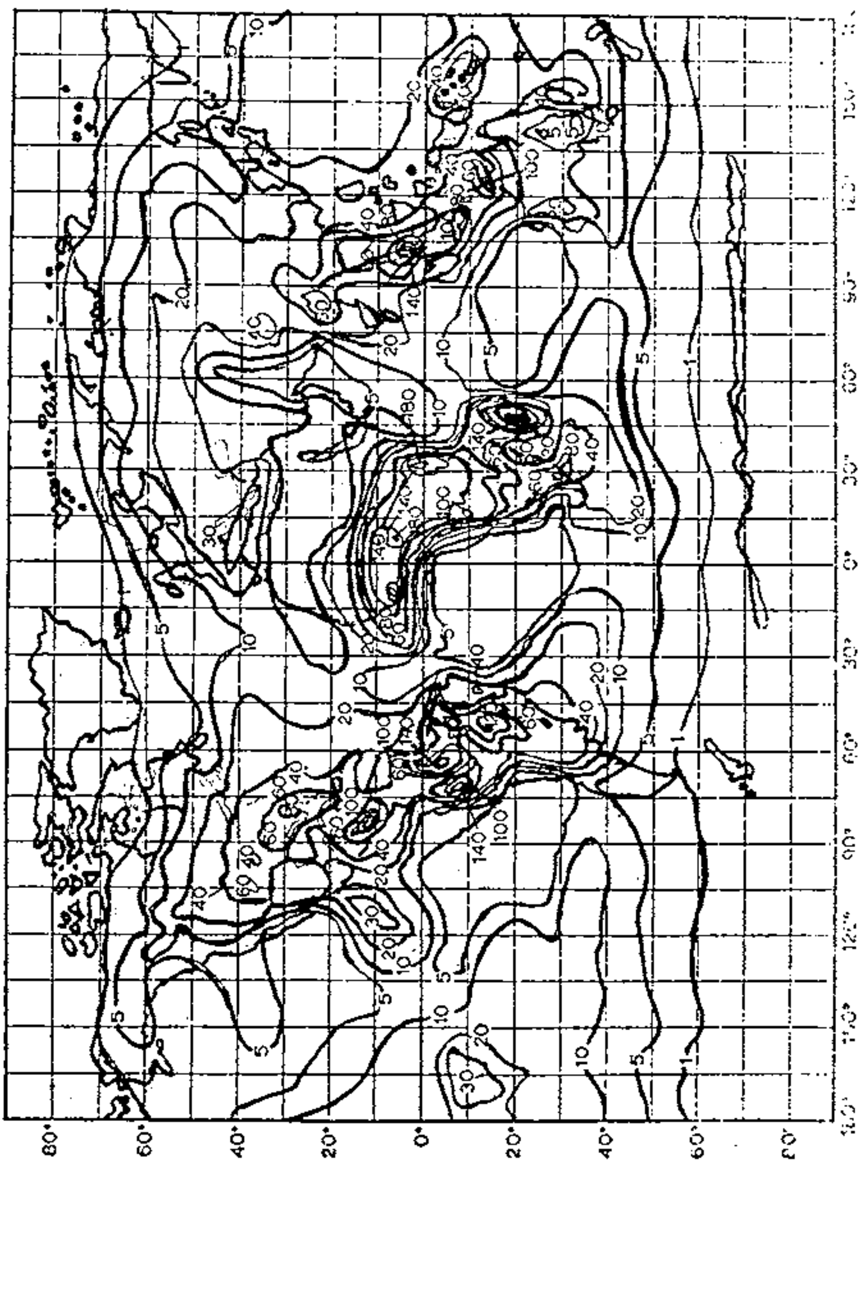


Figure 3. World Isoceraunic level map.

Lightning strokes which terminate on the line structure (types *b* and *c*), are referred to as direct strikes in this paper; they result in a current being injected into the line, and hence a high voltage surge is propagated along the line. The surge has a steep wave front with a rise time of about 2 μ sec. Direct strikes can lead to a fault by overstressing the insulation between the phase conductors and earth, and thus causing a flashover. The ionized air flashover path provides a route for power frequency current to flow through to cause a system fault.

DIRECT STRIKES

Number of strikes to Lines

Overhead lines are by their very nature prominent structures and thus tend to attract lightning strokes. Work carried out in the USA produced a graphical relationship between line height and the number of direct strikes. An empirical formula which fits this curve is

$$N = 0{\cdot}376\, K\sqrt{h} \qquad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where N = Number of strokes per 100 km/year
h = Average earthwire height in meters above the surrounding plain, eg above tree trops or bush level.
K = IKL

If there is no earthwire on the line, the height of the line is then that of the highest phase conductor.

Equation (1) presumes that the line is the most prominent feature in the area, allowance being made for minor landscape features by taking the earth plain as running at the height of the surrounding scrub etc. In mountainous or forest areas this assumption is in general no longer true and the number of strokes which hit the line is reduced since the geographical features will exert an attractive effect on the leader and the line is partially shielded by its surroundings. There is no established rule to enable the number of strikes to be calculated in these circumstances.

Strike to a Phase Conductor

When a lightning stroke hits a phase conductor half the current injected into the line will be propagated in each direction through the surge impedance of the line impressing a voltage surge upon it. The magnitude of the surge will be $\frac{IZ_o}{2}$. If the surge exceeds the insulation strength of the line a flashover will occur. The stroke current to cause failure of a line with an insulation strength is

$$I = \frac{2B}{Z_o} \qquad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Equation (2) with Figure 1 permits estimation of the percentage of direct strikes to the phase conductors which cause flashovers. For an 11 kV wood pole line the current to cause failure is 550 amps, and hence virtually all strokes result in a flashover. However for a 400 kV line only 70 per cent of strikes will result in a failure.

Shielding Failure

Overhead lines may be protected against strikes to phase conductors by the use of overrunning earthwires which perform the function of intercepting lightning strokes and shielding the phase conductors. An example of the effectiveness of this type of protection is the 105 km Wallenpaupack-Siefried 220kV line in the USA where the addition of an earthwire reduced the annual failure rate from seventy-four to twenty.

When an earthwire fails to intercept a lightning stroke and a phase conductor is hit, a shielding failure is said to occur. The reason for shielding failures is indicated geometrically in Figure 4. The perpendicular bisector of the line joining the phase conductor and the earthwire is the locus of points equidistant from both. The curved line is the locus of points equidistant from the phase conductor and the earth plain,

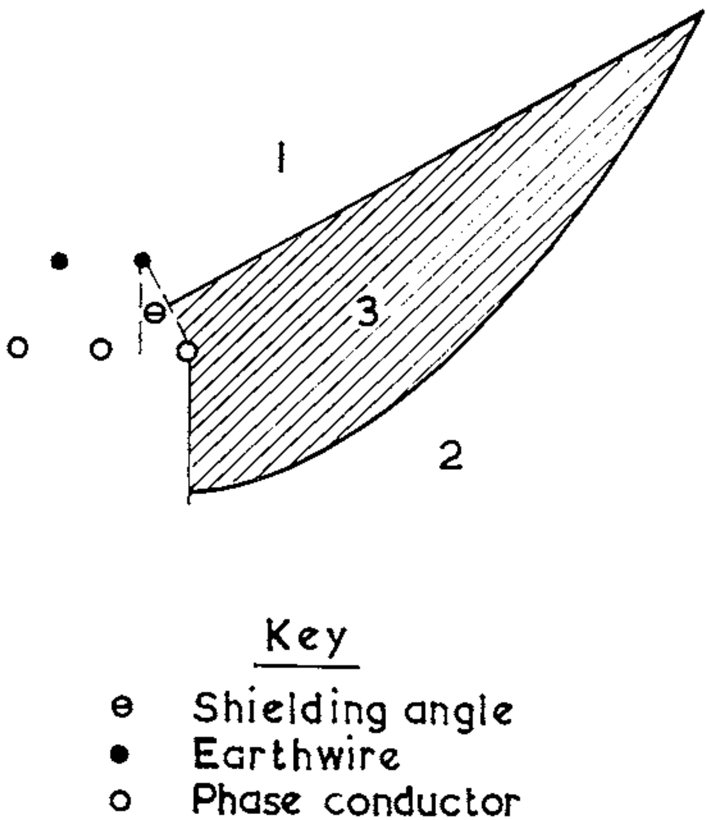


Figure 4. Geometric model for earthwire shielding.

it is a parabola with the phase conductor as focus with the ground plain as directrix. All leaders which terminate at their striking distance in area 1 will hit the earth wire while those terminating in area 2 will contact the ground. The only strokes which will impinge on the phase conductors are those which terminate in area 3.

The size of area 3 is an inverse measure of the efficiency of the protection afforded by the earthwire. As the shielding angle is reduced, ie as the earthwire is moved horizontally towards the outside phase conductor, area 3 is reduced. If the tower height is increased the shielding angle must be reduced to maintain the same standard of security. General guidance is given in Table 2 for typical values of the shielding angle to obtain "perfect" shielding. Because of the statistical nature of lightning perfect shielding is normally taken as less than 0·1 failures/100 km/year.

TABLE 2
Typical Shielding Angles

Tower height, m	15	30	45
Shielding Angle°	45	25	10

Work carried out by Clayton, Young and Hileman using a geometric model yielded a series of figures relating tower height and shielding angle for "perfect" shielding, their results can be synthesized into an empirical formula

$$\theta = 61 - 1{\cdot}1h \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

This equation is only valid for an IKL of 30. Work by Kostenko carried out in

Russia has yielded a formula which gives the ratio P of shielding failures to the total number of strikes to the line

$$\mathrm{Log_{10}P} = \frac{\theta a\sqrt{h}}{90} - 4 \qquad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where a is a constant dependent upon the IKL and is given in Figure 5.

Unfortunately there is no satisfactory correlation between the results from these two methods and a set of empirical rules due to Wagner. The methods are compared in Table 3 for an IKL of 30, together with a modified version of equation (3) given below as equation (5). It is assumed that the "perfect" shielding given by Wagner's and Clayton's methods is a failure rate of 0·1/100km/year.

$$\theta = 68 - 1{\cdot}1h \qquad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

TABLE 3
Comparison of Shielding Angles given by Different Methods for an IKL of 30

Tower ht m	Mean Earthwire ht m	Wagner	Clayton & Young	Kostenko			68—1·1h
		0·1*	0·1*	0·065*	0·1*	0·35*	0·1*
51	46	12	6	12	15	23	12
34	30	30	25	17	20	29	30
18	15	45	41	27	32	45	48

* Failures/100km/year

It can be seen that equation (5), Kostenko's formula and the rules due to Wagner all yield substantially similar results for all tower heights. For high towers Clayton's and Young's method gives a much smaller shielding angle. Kostenko's method enables the number of failures for any given line to be found and is applicable to all levels of lightning activity. The others are only valid for an IKL of 30, and they give guidance on an angle to give perfect shielding, not on the number of shielding failures.

Every shielding failure means that a phase conductor is struck by lightning. The number of flashovers which will result can be found from equation (2) and Figure 1, since not every strike will inject sufficient current to cause a flashover.

Strike to an Earthed Tower

A lightning stroke terminating on an overhead line tower which is earthed, injects current into the tower surge impedance, typically 100 ohms. Voltage surges caused by the strike are reflected up and down the tower at nearly the speed of light. For short towers, under 30m in height, the transit time of the surges is so short as to be negligible, the almost instantaneous reflections of the surges leads to the tower top and base attaining the same potential at the same time. For all practical purposes the tower does not prevent a surge impedance to the stroke after this time. The stroke current is thus effectively injected straight into the tower's footing resistance. The stroke current flowing through the footing resistance raises the potential of the tower and increases the voltage difference across the line insulation. If the stress exceeds the impulse level of the installation a flashover will occur from the tower to the phase conductor; this mode of failure is called a back flashover.

Back flashovers are chiefly dependent upon the tower footing resistance and the insulation level of the line. Lowering the footing resistance means that the current required to raise the tower top above flashover potential is raised. The efficacy of reducing tower footing resistance can be seen on the Wallenpaupack-Siefried 220kV line where the annual failure rate was cut from twenty to 1·5 when counterpoise earthing was applied.

Tower Footing Resistance

For a line with adequate shielding the greatest proportion of failures caused by direct strikes will be due to back flashovers, and hence the resistance of the tower earthing system has an important bearing on the line performance. The lower the overall footing resistance the fewer the back flashovers; for a reasonable performance it is normal to aim for a resistance of 20 ohms or less.

The footing resistance, R_c, of a steel lattice tower without any additional earthing can be taken as

$$R_c = \frac{\rho}{6r} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where ρ = earth resistivity in meter ohms
r = effective radius of tower base in meters

A typical value of r is 0·7 times the distance between adjacent tower legs or guy anchor points.

There are basically two methods of reducing the tower footing resistance:

a Driven earth rods

b Counterpoise, 2 or 4 horizontal ¼ in diameter wires buried 2–3 ft below the ground surface and bonded to the tower structure.

Driven Earth Rods

The resistance of a single rod depends on its length, diameter and on the resistivity of the earth. The latter varies with voltage and soil moisture content. On the assumption of a uniform and homogeneous earth it is possible to calculate the effective earth resistance of a rod. The resistance R of a rod of length l and radius r in soil of resistivity ρ is given by

$$R = \frac{\rho}{2\pi l} \log_e \left(\frac{2l}{r}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

If there are n similar rods at distances d_1, d_2, d_3 ...., from the centre or first rod, the combined resistance of the group is given by

$$R = \frac{\rho}{2\pi l} \log_e \left(\frac{2l}{\sqrt[n]{r.d_1.d_2\ldots\ldots}}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Counterpoise

The effect of the counterpoise wires is to both dissipate the voltage surge and act in parallel with and hence lower the tower footing resistance. This reduces the potential to which the tower is raised under the action of a lightning strike. The addition of counterpoise reduces the combined resistance R, to

$$R = \frac{Rt}{1 + Rt\sqrt{\frac{Cr}{r}}\tanh\sqrt{Rt\,Cr\,l}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

where l = length of counterpoise
Cr = leakage resistance per unit length
r = resistance of counterpoise per unit length

A ready means of assessing the combined resistance of the tower and its associated counterpoise earthing is given in graphical form by Clayton & Young. The voltage of the tower will not begin to rise until the surges are reflected back from the counterpoise, thus even if the total resistance is not lowered enough the counterpoise may delay and distort the rise in tower potential sufficiently to prevent flashover occurring.

Strike to an Earthwire

When a lightning strike terminates on an earthwire a voltage surge is propagated in both directions at nearly the speed of light. When the surges reach an earthed tower part will be reflected with its sign changed, part refracted into the tower, and the remainder is transmitted onwards. The potential at the stricken point of the earthwire would take approximately 2 μ sec to rise to its peak value if there were no reflected waves. However the reflected surges when they reach the struck point will prevent any further rise in potential at that point.

If before the reflected waves return the voltage exceeds the breakdown strength of the air between the earth and phase conductors a flashover will occur. This mode of failure is known as a midspan flashover. A midspan strike beside being able to cause a midspan flashover can also result in a back flashover since part of the surge is refracted into the towers, which will raise the tower potential.

The occurrence of midspan flashovers is mainly governed by the surge rise time, span length, and separation of phase and earth conductors. The reduction or prevention of this type of flashover is most readily achieved by increasing the separation of phase and earth conductors. The method normally employed to obtain this, without needing excessive clearance at the towers, is to arrange for a differential sag between phase and earth conductors of about 20 per cent by increasing the tension of the earthwire relative to that of the phase conductors.

Number of Back and Midspan Flashovers

A method of determining the number of flashovers as a percentage of the number of strikes to a line has been developed by Bewley, based on the application of travelling wave theory. The method is theoretically applicable to all lines, but in practice it becomes difficult to apply to lines having high towers and long spans, ie extra high voltage lines. The practicable limit of the method is reached with lines operating at 250kV.

While it is possible to extend Bewley's method to higher voltage lines a more convenient approach has been developed by Clayton and Young. They used a mixture of analogue computation and empirical results to produce a series of graphs which gives the number of back flashovers on a line for an IKL of thirty, direct scaling can be used to give the back flashover rate for other IKL's. It should be noted that this method assumes no midspan flashovers, to ensure this sufficient midspan clearance must be maintained; typical values of this clearance for no midspan flashovers are given in Figure 6.

These two methods of assessing failures are compared in Tables 4 and 5 for a 150 kV line constructed in a horizontal configuration in an area with an IKL of 30. Table 4 gives the midspan clearance which will effectively lead to no midspan flashovers for Clayton and Young's method and annual failure rates of 0·1 and 1·0 per 100km for Bewley's. Table 5 assumes no midspan flashovers and gives the number of back flashovers which will occur. It can be seen that they give similar results, which gives a certain amount of confidence in both methods, especially as the basis of them is dissimilar.

TABLE 4
Midspan Clearance, m

Span m	Bewley 1·0*	Bewley 0·1*	Clayton & Young
200	3·7	4·8	5·4
250	4·9	7·3	7·6
300	6·4	9·5	9·6

* Failure rate per 100km per year

TABLE 5

Annual Back Flashover Failures per 100km

Span m	Bewley	Clayton & Young
200	3·71	3·7
250	4·32	4·6
300	5·04	5·0

Clayton and Young's method in conjunction with Kostenko's formula have been applied to a 330 kV system in Central Africa where the IKL is approximately 80. The predicted failure rate was 0·81/100km/year which compares very well with the system performance over the period 1960–68 where the actual lightning incident rate was 0·75/100km/year.

INDIRECT STRIKES

A lightning stroke which hits the ground in the near vicinity of an overhead line will induce a voltage surge on it. The surge is caused by the field gradient established by the rapid discharge of the charge in the leader column by the return stroke. The line conductors intercepting this field have a voltage impressed upon them. This voltage surge has a double exponential wave form with a 6 μ sec rise time.

The magnitude of the induced surge is a function of the distance between the line and the stroke line height and the charge in the leader stroke. Japanese investigations on parts of their 3·3kV and 6·6kV systems have shown that many transformers and circuit breakers have been destroyed by induced surges. At operating voltages of 70kV and above the basic insulation level of the line is sufficient to protect it against flashovers or damage caused by induced surges.

Early work in calculating the value of the induced voltage by Wagner and McCann assumed a constant charge density in the leader stroke from the ground up. This approach leads to extremely high voltages for a stroke very close to the line, in the limit a stroke at zero distance would induce an infinite voltage. These assumptions are extremely conservative and more recent observations have shown that:

a The lightning charge density is not constant and reduces with height;
b The leader does not strike the ground, it only approaches to within striking distance of it.

These two facts tend to reduce the voltage gradient produced by the lightning strike. Golde has allowed for them and has calculated values of the voltage gradient for various leader tip heights and distances from the line to the stroke. Some of the results are given in Table 6.

TABLE 6

Induced Voltage Gradients

Voltage Gradient V/cm Coulombs

Leader Tip Height m	Distance from Line, m 40	80	160	240	320	450
20	85	62	41	—	22	—
52	71	58	—	28	21·5	—
98	52	47	34	26	20	—
174	—	33	29	23	18·5	14·2

Work by the ERA has shown that a charge of 1 coulomb in a lightning stroke is equivalent to a stroke current of 20,000 amps. Using Table 6 and Figure 2 it is possible to derive a relationship between voltage gradient and distance between stroke and line, this is shown in Figure 7. It is assumed that if the separation between the stroke and the line is less than the striking distance, all strokes will go to the line.

Consider an overhead line in an area where the lightning stroke density is σ per unit width, with a strike terminating in a width dx, x away from the line. If I(x) is the current which will cause breakdown of the line insulation and P(x) is the probability of that current being exceeded; then the number of strokes in dx which will cause flashover is

$$n = \sigma P(x)\,dx \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

In considering the total number of induced flashovers all lightning strokes to ground must be considered. To obtain this number equation (10) should be integrated over the range $+\infty$ to $-\infty$. However the line will attract all those strokes falling within their striking distance. If ds is the striking distance of a stroke of current I then the number of strokes which will cause flashover is given by

$$N = 2\int_{ds}^{\infty} n\,dx \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

A numerical solution of equation (11) has been carried out by considering finite widths dx of 10m in an area of unit IKL, the results are shown graphically in Figure 8. This graph is used as follows:

a From the line insulation strength and height determine the critical gradient G which will cause flashover.

b From Figure 8 obtain the corresponding failure rate.

c Multiply by the IKL to find the number of induced flashovers per 100km/year.

WOOD POLE LINES

Although lines operating up to 330kV have been built with wood pole supports their use in general is restricted to voltages up to 66 kV. In the United Kingdom many 11kV wood pole lines which have been built to British Standard 1320 or at voltages above 11kV are of BS 1320 type. These lines are built without an earthwire, usually with unearthed steel cross arms, although wooden ones can be used. This type of construction is commonly referred to as unearthed construction. Practical experience with this form of construction has shown that they have a worse lightning performance than lines built with over-running earthwires.

A wood pole line built with cross arms and other pole mounted equipment bonded to an earthed downlead can be treated as a steel tower line exactly as described in the two preceding parts of this paper. Since the earthing arrangement is often to wrap several turns of the downlead around the butt, a high footing resistance usually ensues, as a result of this the back flashover rate will be high.

An advantage in using wood in overhead line construction is its good insulation strength, even though it does vary with type and moisture content. For calculation purposes wood can be taken to have a dry withstand strength of 300kV/m, when wet this is reduced to 150kV/m. These figures will generally give lower values than are actually obtained. By using wooden cross arms it is possible to increase the insulation level of the line, and hence increase the stroke current required to cause flashover. Spark gaps and arcing horns must be co-ordinated to the higher insulation levels as the magnitude of any propagated voltage surge is raised, and this will increase the danger to pole mounted and terminal equipment.

A simple construction which utilizes the insulation properties of the wood pole to reduce the incidence of back flashovers is shown in Figure 9. The earthwire is

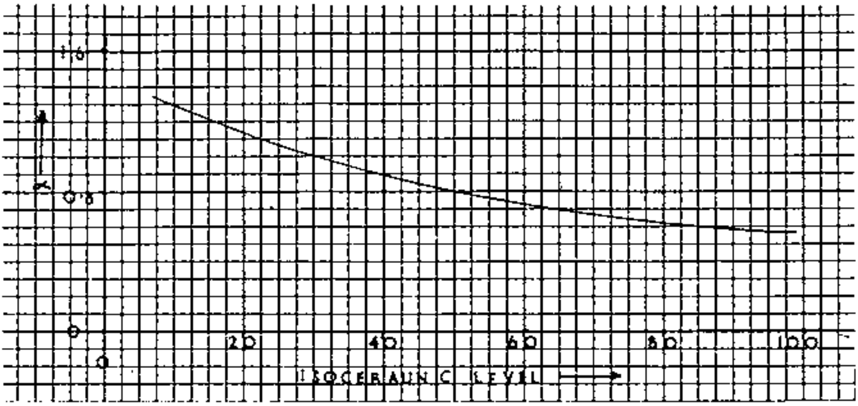


Figure 5. Variation of a with IKL.

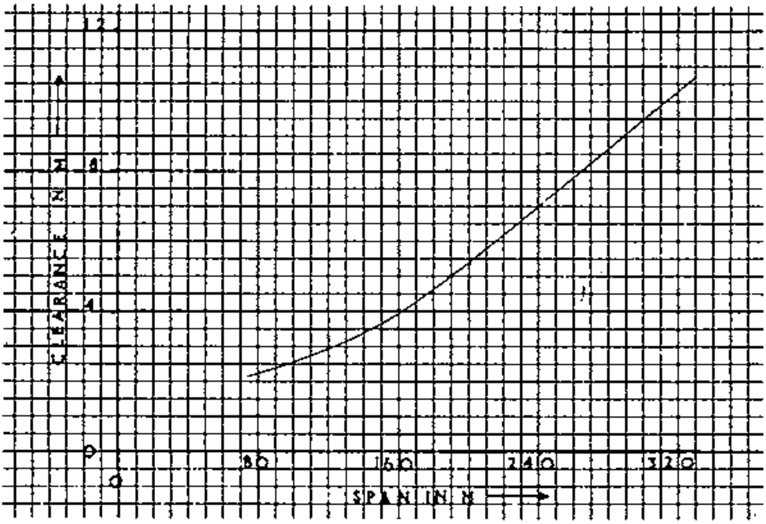


Figure 6. Midspan clearance to give no midspan flashovers.

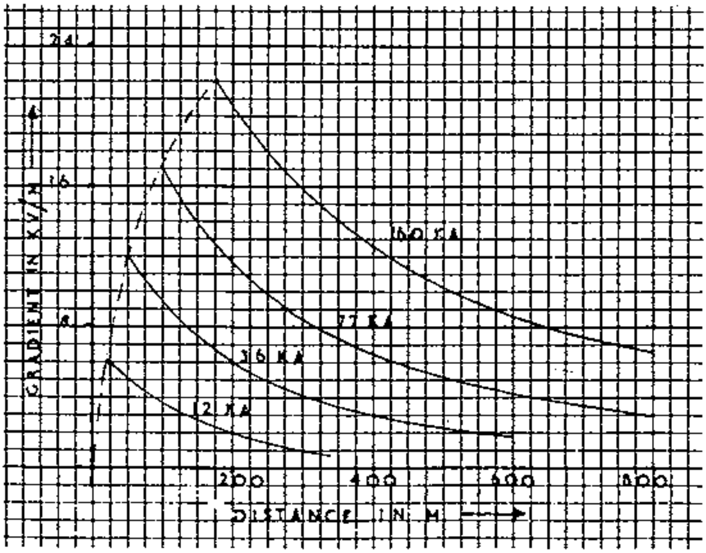


Figure 7. Voltage gradient due to lightning strokes.

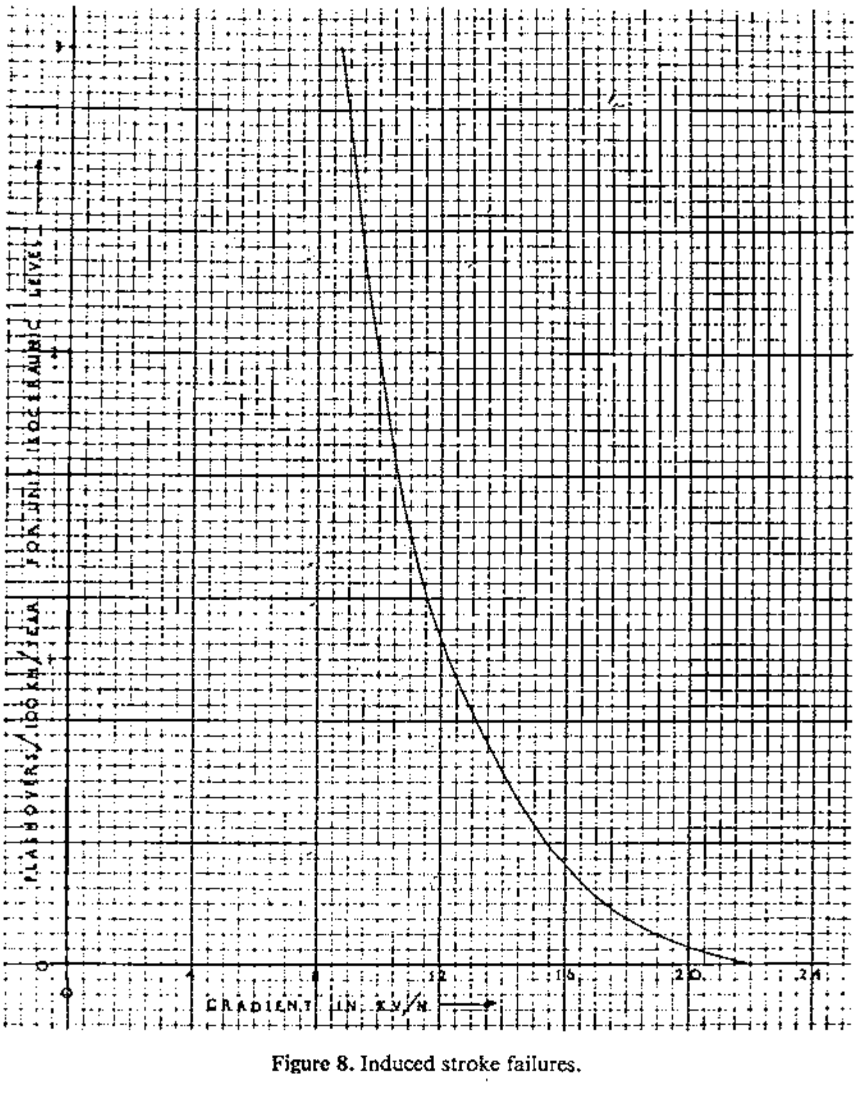


Figure 8. Induced stroke failures.

carried on the pole top and connected via an offset downlead to ground. The insulation level of this arrangement is determined either by the clearance between the downlead and the phase conductors or by the series sum of the insulators and the withstand strength of the fully insulated length of wood, whichever is the lower. In determining the impulse level of the air gap a figure of 600kV/m can be used.

DOUBLE CIRCUIT LINES

Double circuit lines are, as the name suggests, built with two completely separate circuits hung from the same tower. A stroke to such a line can cause a back flashover either on one or both circuits. For security of supply it is obviously better to construct the line so that only one circuit will flashover leaving the other to continue supplying the load.

A technique has been developed for calculating the probability of simultaneous back flashovers of both circuits by Sargent and Darveniza. It is based among other things on the use of a travelling wave on the line due to the lightning strike and on the magnitude and polarity of the power frequency voltages. The stress on the line insulation is then found by use of a step by step method. In calculating the propagation of the travelling wave this method makes allowances for effects of corona discharge; there are doubts about the validity of this assumption. However when the predicted and observed results are compared they are found to be in general agreement. The predicted results are on average within 20 per cent of the observed failure rate.

In order to ascertain the effects of various design parameters, a series of studies in which one parameter at a time was changed on a 220kV line were carried out. These results are summarized in Table 7. The parameters considered were:

a Tower footing resistance.
b Number and arrangement of earthwires.
c Relative insulation of the two circuits.

TABLE 7
Effect of Changing Line Parameters on Double Circuit Failures

Parameter Change	Footing Resistance Ohms	Earth-wires	Insulation 10 × 5 in discs		Outage Rate 100km/year		% Reduction * in outage rates		Ratio Double Circuit Total Outages
			Circuit 1	Circuit 2	Total	Double Circuit	Total	Double Circuit	
Basic Line	28	1	15	15	2·6	1·25	—	—	0·47
Footing resistance	10	1	15	15	1·0	0·31	60	75	0·31
Addition of earthwire*	28	2	15	15	1·8	0·73	30	42	0·41
Addition of coupling wire†	28	2	15	15	2·0	0·73	24	42	0·36
Change of insulation	28	1	14	16	2·7	1·03	−5	18	0·37
Change of insulation	28	1	13	17	2·9	0·73	−11	42	0·25

* Two horizontal earthwires 8m apart.

† An additional earthwire at the level of the bottom phase conductors.

The effectiveness of lowering tower footing resistance in reducing back flashovers is demonstrated but the ratio of double circuit total flashovers is also somewhat improved. The addition of a second earthwire by its coupling effect does improve the total failure rate, but it has little effect on the ratio of double circuit to total failures. When two earthwires are placed in a horizontal configuration there is an improvement in the total performance due to the reduction in the shielding angle.

Simultaneous double circuit outages are reduced by employing different insulation levels on each circuit. The minimum ratio of insulation levels to give a worthwhile improvement in double circuit failure rates is about 1·4:1. If the differential is obtained in part by reducing the level of one circuit below that which would normally be installed, the total number of back flashovers will be increased. In passing it should be noted that direct current lines have a built-in differential due to the polarity of the power conductors.

A marked reduction in the number of simultaneous double circuit flashovers can be achieved if in addition to utilizing differential insulation, a modified line construction is adopted. Instead of supporting one circuit on each side of the tower they can be arranged in two triangles as shown in Figure 10 (a), an alternative arrangement for a horizontal configuration is shown in Figure 10 (b). In both cases circuit 2 has a lower level of insulation than circuit 1.

Because of the reduced insulation and smaller coupling factors, back flashovers will first occur on the lower circuit. After the initial flashover the upper circuit is effectively enclosed by stricken conductors (overhead earthwires and faulted phase conductors), which results in large coupling factors for the upper circuit and hence reduces the probability of it flashing over. Investigations carried out in Canada have indicated that the simultaneous double circuit outage rate is halved while only a marginal increase in the total flashover rate results when a line of the type shown in Figure 10 (a) is built.

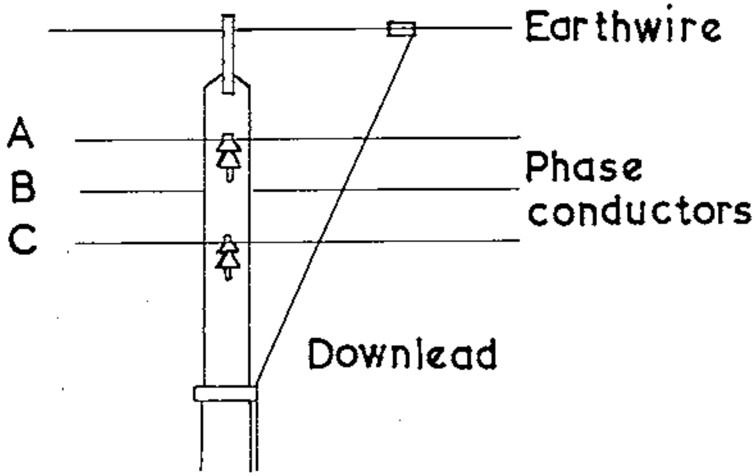


Figure 9. Offset downlead.

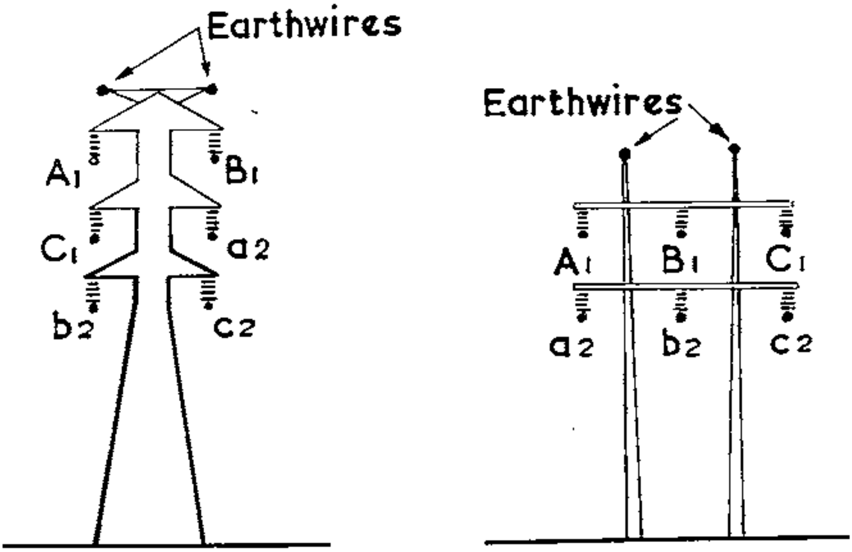


Figure 10. (a) and (b) Modified double circuit construction.

There are disadvantages in adopting the modified form of construction:

a Maintenance will have to be done on live lines or both circuits will have to be isolated.

b Conductor galloping is more likely to cause a double circuit failure, the conventional designs only suffer from single circuit outages in such circumstances.

None of these points raise insurmountable difficulties, but they do represent limitations on the employment of these constructions.

CONCLUSIONS

A lightning stroke to or within the near vicinity of an overhead line will cause a high voltage surge on the line. If the magnitude of this surge exceeds the withstand strength of the insulation a flashover either to earth or between phase conductors will occur and cause a fault on the line.

The lightning performance of a line can usually be improved by adopting one or more of the following methods.

a Provision of effective shielding to reduce direct strikes to phase conductors.

b Lowering the tower footing resistance to reduce the number of back flashovers.

c Provision of adequate midspan clearances.

d Routing the line to the best advantage, using the country to shield the line, and avoiding skylines etc.

e In the case of double circuit lines adopting a modified form of construction and using differential insulation levels on the circuits.

f The use of auto-reclose switchgear to minimize outage times due to transient lightning incidents.

g The proper co-ordination of impulse levels so that flashovers will occur at spark gaps and surge diverters.

Nearly all of the means suggested above involve additional expenditure and the extent to which this is justified in any given case should be matched against the system requirements. To achieve this it is necessary to have an estimate of the probable performance of the line proposed. The methods outlined in this paper provide a means of achieving this objective.

ACKNOWLEDGMENTS

I would like to express my thanks to the Partners and Staff of Mertz & McLellan for the assistance they have given me in preparing this paper. In particular I would like to thank Dr M. W. Kennedy, Mr R. P. Townsend and Mr J. A. Sullivan for the advice and guidance they gave me.

Editor's Note:

This article is a condensed version of a Long E & M Course "End of Course Paper" by Captain M. D. P. Young, RE. The full paper with references and data sources can be seen and/or borrowed from the Corps Library at RSME Chatham.

* * * * *

Early Days

M.L.C.

THE January 1873 *Journal* was the first in which the *Supplement* was published at the same time, but separately from, the *Journal* proper. Both continued to come out monthly. The *Supplement* always contained eight pages with the *Journal* more generally of four, all of foolscap size. The monthly list of all officers in the Corps, both by seniority and station, details of all movements ("Capt. H. D. Crozier is home on short leave from Gibraltar"), extracts from Army Orders and lists of publications, did not make the *Supplement* very exhilarating reading although it also included accounts of soccer etc matches and some correspondence. In fact, the first issue of the separate *Supplement* contains a letter complaining of the very "uninteresting and meagre contents" of the "Pickaxe"—which latter term seems to have referred to the combined *Supplement* and *Journal*. The writer complains bitterly that the "undivided contemplation of the seniority list seemed likely to produce a frame of mind bordering on despondency". His suggestion was that there should be more Corps gossip and, in particular, accounts of sporting activities such as pig sticking.

In general the pages of the 1873 *Journals* were still dominated by the Franco–Prussian war, although contributions on this subject were, as often as not, direct translations from the French or German rather than original comment. The present reader could be excused from imagining that the majority of literary minded officers were linguists rather than original thinkers! This impression is somewhat underlined when an item in the *Supplement* states that "Lt W.T. Wilson resigns his commission and has joined the Prussian Army as Lieutenant in the Rheinischer Kürassier Regiment!"

As far as the Royal Engineers were concerned, the "Franco–Prussian war" meant the siege and defence of fortresses and it is this aspect which informs the articles on the subject. This is hardly surprising when it is remembered that this was a time of intense activity in the building of coast defences in the UK. Between 1860 and 1880 most of the Forts, eg those around Portsmouth, including the Spithead Shoals, Plymouth, Dover, the Thames (not forgetting Shornmead), the Medway, Pembroke Dock and Cork etc, were constructed.

The Corps bore the whole responsibility for these fortifications. As soon as the money was allotted, the DDFW was ordered to carry out the project which was then designed and executed by RE officers. So no wonder there was this professional interest in their design, siting and use in war.

A long article, translated from the French, in the May *Journal* casts doubts on the whole idea of Fortresses. "Entrenched Camps destined to serve as a refuge for a beaten army have always been veritable traps, which the remains of these armies have only entered to be taken." It was also argued that with judiciously constructed field defences, the attacker could besiege a fortress with the same, or even less, number of men than the defenders. This was because of the "extraordinary power of the breech loader which made direct attack (by the besieged) hardly possible. The besieging force also has the inestimable advantage of being in no danger of being taken in the flank".

On the other hand there were those who said that the invader, merely to mask a large army shut up in a Fortress, must detail a force at least double its size and a siege might require five or six times the number of besiegers. "The advantage must always lie with the army at the centre rather than that scattered around the circumference." Those who doubted the efficacy of fortresses were accused of generalizing too freely from the lamentable performance of the French, eg under General Bazaine (incidentally an Engineer) at Metz.

The argument continued in subsequent issues. If fortification could not enable a small body of men to resist a strong, "then there was something wrong with the design and construction of the works". The Royal Engineer was bidden to remember that a "knowledge of the use of fortifications is one of essential value; it is mixed up in every military movement, it pervades the smallest shelter trench as well as the largest work. But that knowledge can never be found by those who view fortifications apart, as an abstract science and who disregard its close and intimate connection with other military arts".

It seemed to be then, as now, the old story. The Engineer must thoroughly understand the needs of the all arms team and any other attitude is bound to lead to the wrong conclusions. This was particularly so in designing large works, when the engineer could so easily override the requirements of other arms on technical grounds.

The arguments for and against fortresses were, perhaps, inconclusive. One correspondent finally wrote:

". . . the events of the late war were bound to excite distrust of fortified places. They were sure to excite it because great disasters throw discredit indiscriminately on everyone and everything connected with them. It falls to the Engineer to vindicate the value of their art in this, the most brilliant application of it, by analysing the broad results and challenging all over hasty deductions from them."

Sound advice indeed.

There were, as might be expected, no lack of accounts both in the Corps Papers and in the *Journal*, of experiments at Shoeburyness to find the effect of shells of different calibres on casemates etc and of remarks on various aspects of the design of fortifications. An account of how guns weighing about 35 tons were unloaded and fixed in the forts at Drake Island, Plymouth, which appeared in the Corps Papers, could well have been published in the *Journal* of today. The moving of heavy weights, including the necessary temporary works, is always a topical subject!

Still in connection with fortresses, perhaps the most interesting feature published in the *Journal* during 1873 was a reprint of a lecture given in the RUSI (the name of the speaker, oddly enough, is not given although presumably he was a Sapper) on the subject of gun carriages and mountings—in this case the "Moncrieff System". At the time, the issue of whether to have heavy guns *en barbette* or in properly protected casemates seems to have been a lively one. *En barbette* guns were emplaced in open gun positions and fired over a parapet. Thus there was no overhead cover, but given the right type of mounting there was greater flexibility as regards the direction of aim, including plunging fire, and the protection given the crew from flat trajectory weapons was good. In theory it was cheaper and the system avoided the main weakness of a casemate—the vulnerability of the front shield and, in particular, the rather exact target provided by the gun port.

The lecturer, after an admirably well reasoned argument, including a detailed "scenario" of a fleet attacking a defended estuary, comes down on the side of casemates. Having pointed out that the accuracy of fire from a moving platform, such as afforded by a ship, can never be all that exact he concludes that the "offensive power of a fleet consists in a shower of projectiles and fragments of all shapes and sizes, and coming from all directions, from which overhead as well as front cover is absolutely essential . . . The tendency at sea has been to increase the weight, to diminish the number and to increase the protection, both overhead and direct, of guns on board ship . . . Major Moncrieff's system of single gun pits, spread out along a line of coast would . . . develop into something very much like the familiar old Martello Towers . . ." He had pointed out earlier that much of the cost of a gun position was, as often as not, in the heavy foundations and such work would be much cheaper if the guns were concentrated. It seems that in the UK casemates continued to be in favour.

It is, however, interesting to note that in 1886, when doubtless this particular heated controversy had been forgotten, Sir Andrew Clarke, the Inspector General of Fortifications, when charged with the construction of defences of coaling stations for "the whole Empire" stated that among his design principles were: (1) instead of grouping heavy guns for coast defence in comparatively small and well defined batteries, they should be placed at wide intervals and different levels. (2) A more exclusive reliance on earthworks in preference to masonry and iron. (3) The avoidance of regular slopes, angles and a greater reliance on good concealment. Plus ça change . . .!

A paper on "The Art of Aeronautics Applied to War" was published in the *Corps Papers* and the *Journal*. This was another translation—this time from a German military periodical. It is mostly concerned with providing mobility and stability to balloons. The propeller, made up of two vanes each 21 ft in diameter, was turned by four men who, if relieved half hourly, could manage a speed of about 5 mph. It seems that the really important advance at that time was the suspension of the gondola from a net which enveloped the whole fuselage rather than from a yard arm, slung under the balloon. By such steps has progress in the air been achieved!

Balloons for observation, rather than movement, had of course, been in use for some time. Indeed as far back as 1794, at the battle of Fleurus, the Austrians used the services of a balloonist. These had also been used, but seemingly without great success, in the American Civil War and in the Franco–Prussian war. However, an observer with the Brazilian Army operating against Paraguay in 1867 (as quoted in the *Corps Papers*), probably had the right answer as regards this failure ". . . if the balloon has not been of much service, it is owing to our not having known how to make proper use of it". Again no lessons are ever really new. It is the weapons system that counts and not just the weapon!

"That spirit of Esprit de Corps, which exerts so long, and beneficial an interest over RE Officers" was invoked, by an unnamed correspondent from India, in an exhortation to hold local annual Corps Dinners. "On the same day on which the Corps dinner takes place in London similar gatherings of R.Es. (*sic*) should be held at the principal military stations abroad . . ." It seemed that "only a little energy" was required to remove any practical difficulties "so that such dinners are held in every place in the British Empire where half a dozen Royal Engineer Officers can be gathered together".

In a similar social vein is a suggestion published in the May issue, that a Royal Artillery and Royal Engineers Club should be started in London. The proposed Club was to afford to "RA and RE Officers just that chance of renewing old Woolwich acquaintances which we now lack". Furthermore, there was "absolutely no place for officers on leave from India and abroad to meet each other". There was to be "no outlay on an expensive building, no highly paid Secretary, no crowds of servants". In fact "no outlay on appearance only, which tends to make the existing clubs so costly and unsatisfactory". The Club was to be financed by raising £3,000 in shares of £100 each. The entrance fee was to be £5 and the annual subscription £3. Whether anything ever came of this suggestion a subsequent issue of "Early Days" may still relate. There was certainly no further mention of it, in the correspondence columns or elsewhere, during 1873. Perhaps such a Club was just a little too much of a good thing, although it seems that the Ordnance Corps had successfully run such a venture.

*   *   *   *   *

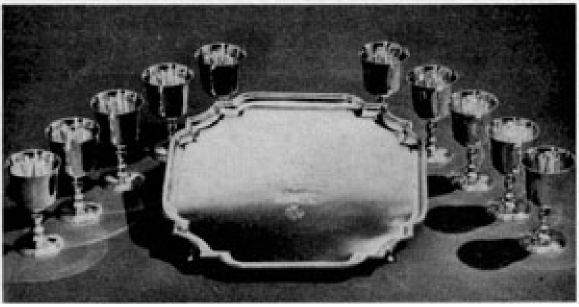
Silver Presentation

1. During the visit of Lieut-General B. N. Das, Engineer-in-Chief of the Indian Army to the Engineer Equipment Symposium at Chatham in June 1972, General Das presented to the Corps a Silver Cup with Lid and a Model Bombay, Bengal and Madras Sapper mounted on a plinth. The inscription on the silver reads:

"Presented to the Corps of Royal Engineers by the Corps of Engineers India in token of our goodwill and long association 2 June 1972"

2. Major-General F. G. Caldwell, the Engineer-in-Chief (Army) during his visit of India in October 1972 presented to the Corps of Engineers, India a 14in Silver Salver and ten Sherry Goblets in sterling silver. The inscription on the salver reads:

"Presented to the Corps of Engineers, India by the Corps of Royal Engineers in recognition of our close ties—1972".



Silver Presentation

Memoirs

BRIGADIER-GENERAL SIR HAROLD HARTLEY, GCVO, CH, CBE, MC, MA, D.Sc., DCL, LL.D, FRS, an Honorary Member of the Institution of Royal Engineers, died on 9 September, 1972, at the age of 94. A Memorial Service for his Life and Work was held in Westminster Abbey on 17 October. Full tributes have been paid to the power of his mind, the precision of his scholarship and his great influence as a bridge between the worlds of thought and action, as well as to his endearing personal qualities. But little is known of his close connection with the Corps.

It gave him real pleasure to become an Honorary Member of the Institution in February, 1966, heightened by the fact that he had wanted to become a Royal Engineer when he joined up from Oxford in 1914 but had been rejected because he was not then an engineer. Instead, he was commissioned into the Leicestershire Regiment, and became a Company Commander in the 7th Battalion. But he soon found himself appointed Chemical Advisor to the Third Army, as a Major, where much of his work was in the most forward trenches. There he won the MC, and remained in close touch with the RE Special Companies.

In July, 1917, he was selected by the then Brigadier-General C. H. Foulkes, who was both GOC, Special Brigade, RE, and Director of Gas Services, to be his Assistant Director 'B' (Defence). Thus, he never served in the Special Brigade, RE; but was held in such high regard as to be made Guest of Honour, fifty years later, at their Battle of Loos Jubilee Dinner on 25 September, 1965.

The writer was privileged to know him well during the last seven years of his life and received a number of remarkable letters, written in his own hand right up to his ninety-third birthday.

As soon as he became an Honorary Member, he asked to wear the RE tie. For Charles Foulkes's Memorial Service in 1969 he wrote: "I hate *black* ties for these occasions. May I wear my Sapper tie?" And, in 1970, after the unveiling of his portrait by Mr Edward Halliday in Goldsmiths' Hall, he wrote: "I am glad you spotted the RE tie."

The attitude of Harold Hartley and Charles Foulkes to each other exemplifies the ideal relationship between scientist and soldier, which was made possible by Hartley being soldier enough and Foulkes, as a Sapper, scientist enough to close the gap between their minds. Each respected the other's abilities and each had a keen sense of fun. At the age of 87, Hartley said to Foulkes: "You always treated me harshly. You even corrected my English. Me! a Fellow of Balliol!" But he agreed with Foulkes's general criticism that scientists too often do not know how to cut their losses, at least, in wartime. And he remained ever grateful for being recommended to Mr Churchill, then Minister of Munitions, and so "launched", as he put it, "into Industry".

Still indefatigable at the age of 90, he complained of being confined to bed: "Such a bore", he wrote, "when I had so many pots on the boil." The output of his mind was prodigious.

Though too weak to live more than a few days, it made him happy to see many friends by his bedside at the reception held for his ninety-fourth birthday.

A year or two ago, he was lent John Hemming's *Conquest of the Incas* in the expectation that he would be interested in the Spaniards' knowledge of Science, and such achievements as their detection of the presence of mercury in Peru (which they used instead of smelting for extracting silver from the ore) from the natives' use of vermilion dye. But, though very interested in the whole story, he was *thrilled* by Pizarro's original expedition, and wrote: "The courage of that small band of men, surrounded by the Indians, was amazing." The truth is that, in his own invasion of the realms of ignorance, Harold Hartley himself possessed much of the spirit of the Conquistador.

T.H.F.F.

Major General L F de Vic Carey CB CBE

MAJOR-GENERAL LAURENCE FRANCIS DE VIC CAREY (Togo Carey to his many friends) died in Guernsey on 30 September 1972. Thus sadly passed away a man of singular charm, courtesy and sagacity, who at 68 had yet much more to give and to enjoy in life.

Destined originally for a career at sea, he transferred from the Royal Naval College to the Royal Military Academy and was commissioned in the Royal Engineers in January 1924. He served successively in a Field Company, on the Ordnance Survey, with the Madras Sappers and Miners and as a Survey Instructor at the School of Military Engineering. He had already shown some of his most enduring characteristics, a seeming laziness which concealed an astute brain and an ability to get things done without fuss. In 1928 he married the sister of a brother officer and took her to India with him as still a young subaltern.

In war he served in various Survey appointments up to DD (Colonel) in France, MELF, PAIFORCE, and East Africa. Early on he formed and commanded a Field Survey Company and showed how to weld together a heterogeneous collection of regular and war-time officers and men, while remaining himself sufficiently relaxed to be able to think and look ahead. Later on he gained the confidence and support of the General Staff to whom he answered directly for the Survey Units whose work he directed.

After the war he served as a G1 and later a DD in the War Office, interspersed with tours on the Ordnance Survey, being there much concerned with the policies and development of the Department in its post-war role. His two last appointments were as D. Survey, War Office and Air Ministry, and DG Ordnance Survey, a fitting climax to a career almost entirely devoted to a small branch of Corps activities; yet one whose importance both in peace and war is out of proportion to its small size.

He retired in 1961 and returned to serve his native Guernsey, where he became a Jurat of the Royal Court of Pleas. As well as serving on numerous Committees and Enquiries in the Island, he also became Chairman of British Channel Island Airways. In paying his tribute to Jurat Laurence Carey the Bailiff spoke warmly of his firmness and impartiality as a Magistrate, the impeccable way in which he carried out his duties and his unfailing courtesy to all.

He was a very friendly and humane man. He had a delightfully urbane outlook on life, and he inspired affection and confidence in those who worked with him. There must be many, including the writer, who will remember with gratitude the numerous occasions when his advice and help warmed their hearts and guided their somewhat halting footsteps.

He leaves a widow and three married sons to whom go our warmest sympathy, with the regret that such a kindly family man did not survive longer to enjoy them and theirs.

A.H.D.

* * * * *

Brigadier W E Van Cutsem OBE MC

BRIGADIER WILLIAM EDWARD VAN CUTSEM, OBE, MC, died suddenly on 30 September 1971 at his home, 64 Montagu Mansions, London, W1.

Born on 11 July 1891, the son of K. Euler of Calcutta, he assumed the name van Cutsem by deed poll in 1928. He was educated at Beaumont and the Royal Military Academy where he was commissioned head of his Batch on 23 December 1911, won the Pollock Medal, and earned the affectionate nickname "Penjy" because of his stiff walk.

After a two year YO Course at Chatham followed by a mounted duties course at Aldershot he was posted in March 1914 to the 38th Field Company at Cork. He went with them to Salonika in 1915 and was later posted as Adjutant to the 28th Divisional Engineers, Salonika Army.

In June 1917 he was awarded the MC, promoted Captain and soon afterwards transferred to staff duty at Corps and GHQ. In 1918 he was awarded the Croix de Guerre with Palms and on 1 January 1919 he was promoted Brevet Major and held appointments in GHQ Black Sea Army until 1922.

During the next four years he commanded 23rd and 9th Field Companies at Aldershot and Shorncliffe and is remembered for the urbanity with which he met all difficulties. After two years at Staff College (1926–27) he spent four years in the War Office (MI3) followed by five years in a series of RE and staff appointments in southern England. He was promoted Lieut-Colonel in 1934 and Colonel in 1937 and returned to M13 the next year as GSOI. On the outbreak of war he became DDMI where he made a great impression on his staff by his wonderful memory and meticulous attention to detail, his execrable but lucid writing and his kindly concern for their problems. Major-General Sir Kenneth Strong recalls visiting the Maginot Line defences with him and that neither the fortifications nor their commanders impressed him.

For the next three years he worked in military intelligence and with the Foreign Office until in mid-1942 he went as BGS (MO) to the War Office and then a year later to be BGS "Post Hostilities Planning". His last appointment before he retired in December 1945 was with the Control Commission in Germany.

A bare recital of his appointments does scant justice to a man who is universally remembered with the greatest affection. Those who knew him at the Shop recall his wit and kindliness, his good temper and helpfulness, and his undoubted intellect. He became an interpreter in French and German and was an acknowledged expert on Germany. Though not a notable games player at the Shop, he was a member of the MCC, played cricket for the Corps for some years between the wars and was a frequent visitor to Lords.

In retirement he enjoyed London life and was a well-known member of the Senior where he delighted in entertaining the fortunate members of the Corps Wines Committee. The Corps owes him a considerable debt, for he served on the Committee for twenty years and his great enthusiasm for wines and excellent taste in vintage port were a major factor in the creation of a post-war cellar of fine wines worthy of the Headquarters Mess. It was typical of him, that on retirement from the Committee he presented to the Corps two magnificent antique decanters: it was we who were in his debt. It is equally typical of him that he regularly visited the sick in London hospitals, but never mentioned the fact.

He married in 1928, Dorothy, daughter of Lieut-Colonel C. W. J. Unthank, 17th Lancers, of Intwood Hall, Norwich. Though he had no children, he was a dedicated family man and our deepest sympathies are extended to his widow.

A.H.W.S.

Colonel I H R Wilson

Ian Wilson, who died in October 1972, was the last of a long line of British military officers, many of them Royal Engineers, who planned and directed land surveying in India over a period of nearly two hundred years. Among his predecessors perhaps the best known were Rennell, the first of the line, who was appointed by Clive in 1767 to be Surveyor General of Bengal, and Everest after whom the highest mountain in the world is named and whose name has become a household word.

Ian was the second son of Major J. A. M. Wilson, OBE, of the Behar Light Horse and was born in Blackheath on 11 November 1902. He was educated at Tonbridge School and "the Shop" from which he was commissioned in the Royal Engineers in January 1923. He joined the Survey of India in 1926 and from then until the outbreak of war in 1939 was engaged on geodetic and topographical surveys in India and Burma.

In 1930 he married Phillippa daughter of Mr and Mrs T. A. Le Gros at one time of Lynmouth in North Devon.

Ian Wilson was promoted to Major in 1940 and in the following year he reverted to military duty. In 1943 he was posted as AD Survey to IV Corps of the 14th Army at Imphal in Manipur, with the rank of Lieut-Colonel and he remained there during its siege by the Japanese in 1944.

For his war services he was three times Mentioned in Despatches.

After the end of hostilities Ian Wilson returned to the Survey of India. In August 1947 India was granted independence and following this his name was put on a short list of those RE officers whose services the new Government of India wished to retain. By then he was too senior to revert to duty on the UK establishment, and in 1949 he elected to retire from the Army on pension and was re-employed on a five year contract by the Government of India.

Under the new Government the Surveyor General of India, who was the head of a civil department, also held *ex officio* the appointment of Director of Military Survey and so was the head of the Survey Service in the Army. When the then Surveyor General retired in 1951 Ian Wilson and one other RE officer were the only two British military officers remaining in the Survey of India. Ian Wilson was appointed to succeed in both capacities and was granted the local rank of Brigadier.

The years following Independence saw many changes and several expansions in the strength and activities of the Survey of India which called for the closest co-operation between the Surveyor General, the Government of India and the Army authorities. On the conclusion of his first contract the Government of India was so satisfied with his work that they extended it for a further two years, thus enabling him to serve his full five years in office as Surveyor General.

Ian Wilson had a sociable disposition and a great capacity for making friends and he soon gained the friendship and confidence of the officials of the Government of India and the Army with whom he had to work and without which his task would have been virtually impossible. In this he was ably supported by his wife.

On retirement from India in 1956 he settled in Woodbury, Devon where in spite of much ill health he played a prominent part in the life of the village and especially of the church, the British Legion and the Conservative party.

He leaves his wife and two sons, the elder of whom is serving in the Royal Engineers and the younger is ordained in the Church of England. He also leaves a large circle of friends by whom he will be sadly missed.

G.F.H.

MAJOR-GENERAL C. A. WEST, CB, DSO, MC

CLEMENT ARTHUR WEST was born on 13 August 1892 and died on 4 September 1972 in his eighty-first year.

His record as a soldier shows that although he will be remembered by most as a Staff Officer he also served with distinction in combat and works units. Commissioned in 1912 he served in France and Belgium with the 59th and 227th Field Companies. He was awarded the MC in 1915.

Between the wars he filled staff and works appointments both in England and India. In 1932 he was awarded the DSO for distinguished Services rendered in the Field in connexion with military operations on the North West Frontier of India.

At the beginning of the 1939–45 War he was a Brigadier on MS Staff and in 1940 became BGS Home Forces. In 1942 after a tour as BGS Delegation to the New Zealand Government he was appointed as District Commander Home Forces as a Major General and then MGA HQ Southern Command. In 1944 he was awarded the CB.

On his retirement in January 1947 General West became General Secretary of the Royal United Kingdom Beneficient Association a post he held until 1957. In 1951 he was elected and served for fifteen years on the Council of the RE Officers Widows Society in addition to being a member of the Committee of Management of the RE Benevolent Fund for many years.

A man who served his country with distinction became a man dedicated to the service of others.

Major-General C A West CB DSO MC

Book Reviews

THE MONEY PIT MYSTERY. THE COSTLIEST TREASURE HUNT EVER

RUPERT FURNEAUX

(Published by Tom Stacey. 158 pp. £2.95)

Towards the close of the eighteenth century on a tiny island called Oak Island in Mahone Bay, Nova Scotia, an engineering genius dug a shaft 13 ft wide and 175 ft deep in which to hide a treasure believed to be two million pounds. He connected it to the sea 500 ft away by two deep tunnels, and excavated a giant "spunge" on the sea shore to collect and hold the tides. As the first eager treasure hunters dug down, breaking the waterproof seals he had cunningly laid in the shaft, the sea surged up the tunnels to engulf them. He knew that excavation could lead only to hopeless frustration.

And so it proved. Since 1795, as recorded in this intriguing book, countless adventurers and many well financed syndicates have sought to find a great treasure supposedly hid by pirates in the depths of The Money Pit, as they came to call it. So far all have been defeated and lost their money.

Rupert Furneaux has visited the island, and for seven years has investigated this fascinating problem. He suggests the awful possibility that there is no treasure to collect, for the mysterious engineer he calls "Mr X" who hid it, removed it shortly afterwards! There is evidence that he did so, for markers and a code have been discovered on the island, enabling someone in possession of the code to locate both the original Money Pit, the line of the tunnels to the sea, and the position of a treasure cache. The Money Pit was meant to be excavated by anyone who found it; the treasure cache only by someone in the know. The author finds that *both* positions have been thoroughly explored.

The Money Pit Mystery is particularly interesting to the Royal Engineers for the author comes to the reasonable conclusion that the mysterious "Mr X" was not a pirate but a Royal Engineer officer. He thinks that no pirate could have had the resources and engineering skill to dig such formidable defences to his treasure trove; while an engineer would have the scientific knowledge not only to direct a body of disciplined men to dig and revet the Money Pit, but to drive a couple of deep tunnels 500 ft long with extreme accuracy from a sump on the shore to the Money Pit shaft. He uses the position of the markers and a strange triangle of stones found on the island to establish that "Mr X" drove his tunnels 14 degrees south of the true east-west line. "Why did he do so?" asks the author. Because, using a compass, the miners would be able to steer underground by the easily seen *magnetic* west mark. From this he deduces the date the shaft was dug; the magnetic declination at Oak Island was 14 degrees west in 1780, fifteen years before the first discovery of the shaft.

Rupert Furneaux has not yet identified "Mr X", though he is convinced he is a Sapper officer—"perhaps," he says, "the greatest practical joker of all times." He gives in an appendix a list of thirty-five British military engineer officers serving in North America between 1775 and 1782. He rejects two possibilities, a John Montresor and a William Spry, but makes no suggestion that a Colonel James Moncrieff listed in the appendix might be the genius he seeks. Moncrieff was Chief Engineer to General Sir Henry Clinton in 1780 at the siege of Charlestown, and succeeded in draining off the water from a wet ditch. (RE History Volume I, pages 205, 206.) Thus he would have been an experienced hydraulic engineer, capable of designing the tunnel defences of The Money Pit. But Charlestown is 1,000 miles south of Oak Island. Nevertheless history records that Clinton, the British Commander-in-Chief in North America, hurried back to New York from Charlestown, no doubt taking Moncrieff with him, to deal with a landing of French troops on Rhode Island. Thus Moncrieff would have been present when, on Rupert Furneaux's "reconstruction", Clinton decided it would be advisable to hide his military treasure chest in a place of safety north of the war zone. Furneaux pin-points that place as Oak Island and it is hard to disagree with him. The reviewer considers that he would naturally turn for advice to his brilliant Chief Engineer, whom he had shortly before praised highly in his despatch.

The book is well written and illustrated, and is as exciting as the best of treasure hunt stories. It is well worth reading.

D.G.B.B.

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Technical Notes

National Electrical Safety Code Pt I. Published by US Department of Commerce. Price: 30 cents. Obtainable from: Superintendent of Documents, US Government Printing Office, Washington DC 20402, USA. The abstract on the last page correctly describes this book in less than 200 words. For UK readers the book appears as an amalgam of, IEE Regulations 1968, Electricity Supply Regulations 1937 and Codes of Practice. It is strictly a voluntary code and replaces a 1939 version. It has taken five years of committee meetings to draw up. A line by line comparison, on each aspect, with British Practice reveals differences as is to be expected. We cannot see that reflecting these differences would be of value to the general reader of the *Journal*. It will be interesting to see the remaining parts of this Safety Code as they are published.

R.J.L.

Civil Engineering and Public Works Review—August 1972

Development of Sheerness Docks. The first dockyard at Sheerness was established in 1670. The present dockyard built between 1810 and 1830, consisting of 2 tidal and one non-tidal basin, was used as a Naval dockyard for building and repair of HM ships until 1960. After the dockyard became privately owned in the early sixties, general cargo trade has increased until full capacity was reached. The Authority therefore decided to increase the berth capacity by constructing 2×500 ft berths and contracts for these were placed with Costain Civil Engineering Limited in January 1971 for completion in September 1972. This article describes the construction of the 2 piled platform berths from the time of site investigation right up to the installation of dock buildings and services.

Bonded Concrete Overlays for Pavements. The provision of bonded or monolithic concrete overlays to strengthen existing concrete pavements, when their condition is reasonably good is now a well established technique. The determination of overlay thickness is based on the assumption of monolithic action between the bonded overlay and the existing pavement. Laboratory sample tests have shown that whereas the flexural strength of composite samples almost equal the monolithic samples, direct shear is only about 50 per cent and direct tensile strength is only about 30 per cent of the monolithic strengths. This article suggests that the design of bonded concrete overlay thickness is not as simple as is assumed at present, and indicates an approach involving consideration of induced stresses and presents suggested practical design procedures.

Riverside. In the past the Thames was the main thoroughfare into London for commercial business. Over a number of years this traffic has deteriorated and the banks of the Thames in London are now littered with disused wharf and industrial frontages. Riverside is a feature on the development of London's riverside and consists of a series of articles on some of the projects which have been, are, or will be undertaken to put these wasted frontages to use. This issue deals with the new Covent Garden Market, Thamesmead, the new London Weekend TV studios and the Thames flood barrier project.

Civil Engineering and Public Works Review—September 1972

Riverside. This month's issue continues with the feature articles on London's Riverside Developments. It concentrates on the New National Theatre, St Katherine dock development and the construction of St Thomas' Hospital rebuild Stage 2. The main article deals with the National Theatre and the aspects dealt with range from the design and contract procedures to matters of structural and services detail.

The Port of Grangemouth. The port of Grangemouth is being developed at a cost of over £3,000,000. This major article gives the historical background to the port and the reasons for its development. It describes the major works of construction dealing with each aspect, oil jetties, container terminal, transit sheds and locks in turn. Details of back up services eg dredging, pumping plant and electrical services are also given. Also included in this issue is a description of the Research work undertaken for the Grangemouth development scheme. This deals with the Firth of Forth hydraulic model, the silt study of the Firth of Forth and a model study of the proposed new lock.

DEVELOPMENTS IN CONCRETE PAVING CONSTRUCTION TECHNIQUES. During the last few years a number of major design and construction developments have been introduced into concrete road building practice in the UK. These developments are described in this article as well as other interesting features of concrete paving. More general aspects of the design and construction of concrete roads are outlined in another article on the new Midlands Road between Monmouth and Newport.

M.F.R.C.

ORDNANCE SURVEY. Annual Report 1971–72. HMSO. Price 90 pence. Some 4,600 people are employed in Ordnance Survey, the total expenditure last year was over £9 million with a net expenditure of some £6 million. Some 4 million map sheets were issued. Just over half of the actual survey strength is employed on continuous revision. These dry facts extracted from the Annual Report give some indication of the scale of operations. The report goes further than this, it describes the progress made over the year in control survey, air photography, topographic surveys and revisions. A copy is held in the RE Library, Chatham.

E.E.P.

ORDNANCE SURVEY PROFESSIONAL PAPERS

(Published by the Ordnance Survey of Great Britain, Southampton, 1972)

Paper No. 24 "The Readjustment of the Retriangulation of Great Britain, and its Relationship to the European Terrestrial and Satellite Network" is an account of geodetic computations carried out during the last five years.

Two triangulations of this country have been carried out. The second, the Retriangulation, was observed from 1935 to 1952 and adjusted before computers were available, in seven blocks which were calculated by hand. This and the desirability of retaining co-ordinates close to the first triangulation introduced distortions into the network which were later confirmed by electronic distance measurements and the preparatory work for a readjustment of the European triangulation. The outcome was the present readjustment, which will be used for scientific purposes only.

Two separate adjustments were carried out, one at the Ordnance Survey and one at Nottingham University, both using the same network of 292 stations connected by 1,900 directions, 180 distances and 15 Laplace azimuths, but with a different system of weighting the observations.

The paper contains tables comparing the results of the two adjustments with each other and with the original adjustment. The only significant discrepancy between the two versions lies in the values of the adjusted azimuths on some lines. It seems likely that this is because the Ordnance Survey were too optimistic in the weights they applied to the Laplace azimuths. However the differences between either version and the original adjustment are significant and important and result from the scale and azimuth distortions present in the earlier computation.

The observations used form a major part of the British block for the adjustment of the European triangulation and the experience gained will be applied to the European work. The satellite triangulation network of Europe is also described although no decision has yet been taken on the combination of the two networks.

The paper is a useful contribution to geodetic literature, and it has a comprehensive bibliography. Perhaps the two most valuable topics are the demonstration of the effects of different weighting techniques and the data handling technique specially developed by the Ordnance Survey to enable the adjustment to be handled on a small computer.

S.E.G.F.

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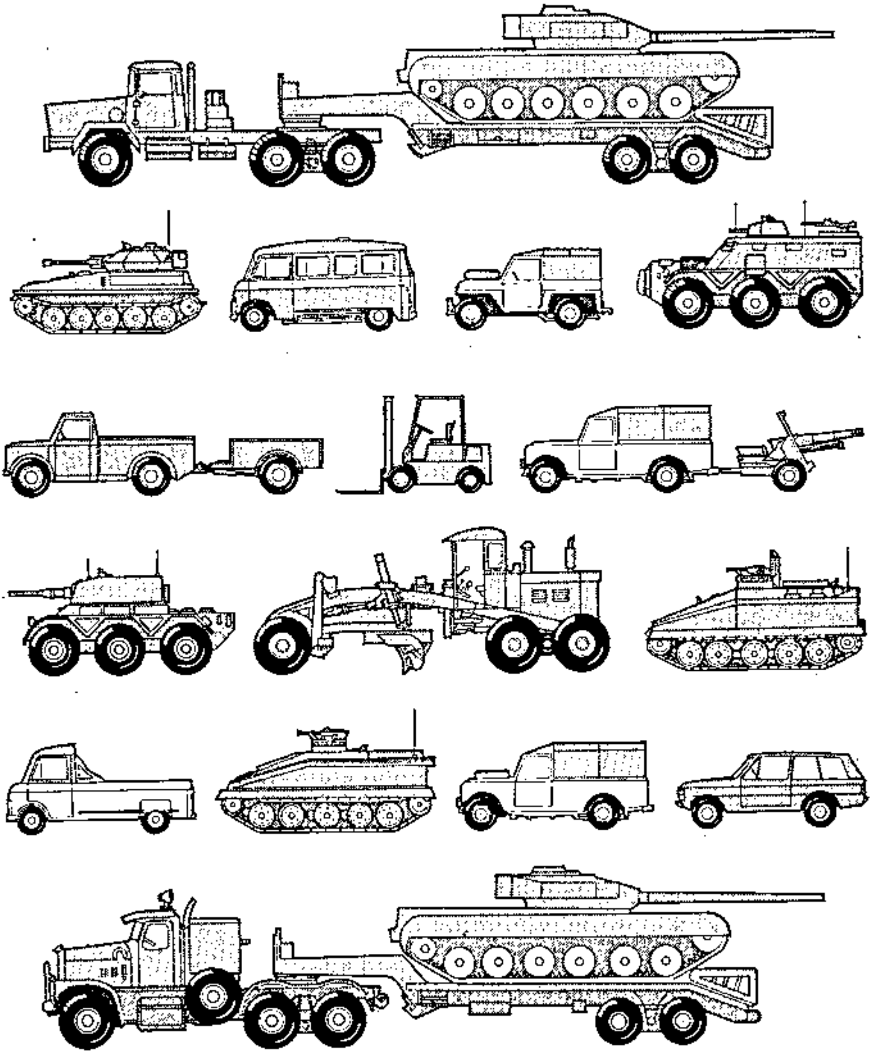

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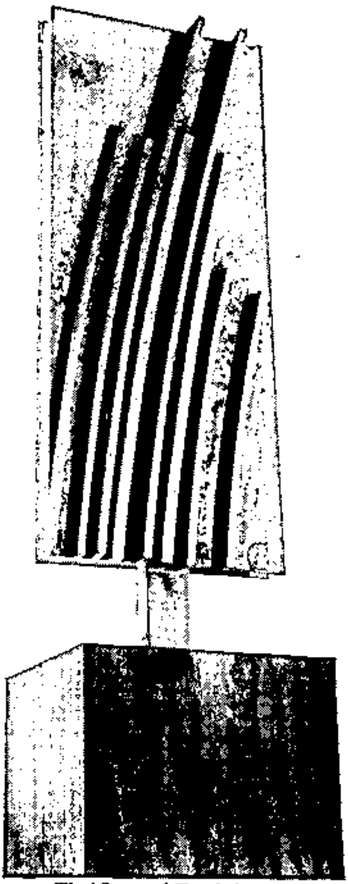

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The Pacemakers

Setting the pace in the 70's are Major John Hemsley, L.I., and WO/1 Frank Webber, R.E.M.E., representing the British Army, winners of the Forces Team Prize in the 1971 RAC Rally. Their reward? A splendid trophy designed by Alex Styles of Garrard. It is in rough-textured sterling silver; the design suggests the tracks of vehicles across rough country, the tracks of the leading vehicle being picked out in gold. People who win are above average. They deserve trophies to match. For over 200 years Garrard have been supplying civilian and military presentation pieces outstanding in design and craftsmanship. Join the pacemakers by asking Garrard to produce your next trophy. Designs and estimates are submitted without charge. Please ask for Mr. Hounsell.

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