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THE BELGIAN DEFENCES IN 1914.

By COLONEL LORD SYDENHAM OF COMBE,
G.C.S.I., F.R.S.

IN 1890 the late King of the Belgians asked H.M. Government to send an officer to examine and report upon the defences then in course of construction. I was selected to undertake this work, and the article by General X in the *Revue Militaire Générale*, which has been summarized by Brigadier-General J. E. Edmonds, is therefore of special interest to me after the lapse of more than thirty years.

My report was necessarily treated as secret, and I do not know whether it led to any useful result; but most of my views have been confirmed by the events of 1914. The construction of the defences of Liége and Namur as well as that of the outer ring of forts round Antwerp had been the subject of much controversy in Belgium, where General Brialmont's projects were sharply criticized. Lieut.-General Chazal, a late War Minister, insisted that the entrenched camps of Liége and Namur would require garrisons of 25,000 to 30,000 men and would, if weakly occupied, be liable to capture by a *coup de main*. It was also maintained that the measures proposed would involve a permanent increase of 50,000 men to the Army. On the other hand, General Pontus, the then War Minister, reported that:

Le dispositif proposé n'exige pas aucune augmentation de nos forces. L'effectif de notre armée ne devra être augmenté á raison de leur exécution, mais des changements devront être apportés dans la constitution et la répartition de l'artillerie.

The Clerical Party was strongly opposed to any increase of the army, and this assurance, which appeared to me to be radically unsound, may have enabled the measures to be carried in the House of Representatives by 81 to 41 votes, and the defences of the Meuse were commenced in July, 1888. A further discussion had taken place as to the objects of and the nomenclature appropriate to the new defences. The term "entrenched camps" was expressly repudiated by the Government which officially announced that:

Les têtes du pont dont il s'agit ne peuvent être confondues avec dès camps retrenchés. Ce sont de simples pivots de manœuvre, des places d'arrêt.

As I pointed out, a *pivot de manœuvre* implied the existence of an effective field army able to take advantage of fortified *têtes du pont* for operations on either bank of the Meuse. In the absence of an adequate field army, the defences of Liége and Namur could only play the role of *places d'arrêt*, and I stated that:

"It is not the protection of Belgium against invasion which is directly sought, but the closing of a route connecting the territory of two other Powers, who, it is assumed, must sooner or later be again at war, and either of which might select this route as offering advantages in striking at the other . . . If, however, Belgium possessed an effective field army, capable of being rapidly mobilized, the strategic value of the positions of Liége and Namur would assume far greater proportions."

For perimeters of 31 miles (12 forts) and 24½ miles (9 forts) of Liége and Namur respectively, I estimated total garrisons and field forces of 43,000 and 34,600; or, omitting provision for outpost systems on the inner third of the defensive lines, a grand total of 53,000 men. At this time the Belgians could only have mobilized about 80,000 men; but General Brialmont had stated his belief that Great Britain could "without much difficulty" place 65,000 to 70,000 men "in a central position in rear of the Meuse" by the end of the 10th or 11th day after a declaration of war—an achievement then impossible. I was always convinced that a violation of Belgian territory was more probable from the French than from the German side, and I maintained that, "Unless the British guarantee is admitted to be a dead letter, it would seem to be the obvious policy of this country to press upon Belgium the reorganization and increase of her army." Most fortunately the military position of Belgium had been greatly improved before 1914, and the inestimable service which her gallant troops rendered to the Allies can never be forgotten. Liége and Namur played their part as *places d'arrêt* by securing delay which was vitally important to the French Army and our Expeditionary Force.

General X claims a resistance of 13 days for Liége, which the Germans, apparently underrating its resisting power, expected to capture by *coup de main*; but they were able to pass between two of the forts, where I reported the interval to be blind and dangerous, so that the town was in their hands before all the eastern forts had fallen. Namur is credited with a longer resistance; but no attempt to carry it by storm appears to have been made, and a bombardment of only two days proved decisive. From the point of view of permanent fortification, the interesting question is whether these very expensively fortified positions justified their existence. I do not know what forces were available for each; but I consider that the heroic General Leman did all that was possible, in the circumstances, to hold Liége. The Germans had planned their invasion to the last detail and crossed the frontier before a state of war existed. There was no time for the large amount of work required to put Liége in a proper state of defence, even if adequate forces were available on the spot. My estimate in 1890 was that " the Germans could place 20,000 men in front of Liége in 5 days from the date of mobilization, to be followed rapidly by a much larger force." They had, however, partially mobilized in advance; their railway system had been developed, and they were able to improve on this estimate.

All the works were of the same type, a huge central mass of concrete surrounded by deep and well-flanked ditches. The armament consisted of 15 and 12 cm. guns, 21 cm. howitzers and 55 mm. Q.F., all in armoured cupolas of a form determined by the long experiments at Bukarest in the winter of 1885-86 which were reported on in detail by Major (now Major-General Sir D.) O'Callaghan and myself. The forts were therefore artillery positions pure and simple, the 55 mm. Q.F. guns (disappearing) being substituted for infantry. The 15 and 12 cm. guns were all ordered from Krupps and there were, I believe, long delays in delivery, while the guns themselves, of weak type, were stated to be unsatisfactory. The direction of fire in each fort depended mainly in an armoured disappearing observing station raised into position by hydraulic power.

This general conception of the fortification position appeared to me unsuited to the circumstances.

" The forts are practically isolated positions in which a certain armament is concentrated upon a very small area . . . If the fire of the forts is to be mainly relied upon for the defence of the position, large intervals are permissible only where the ground is open and fairly even. In many parts of the Meuse positions the ground is sharply accentuated and rendered very blind on account of the large amount of standing timber. Generally speaking, the forts cannot be regarded as providing adequate defence of the intervals. All the railways and the principal roads are commanded at effective ranges; but the portions seen from the works are comparatively short . . . There are, however, a number of excellent roads which cannot be said to be defended at all by the fire of the forts, while on account of the great accentuation of the country, masses of men could in many cases be brought close to the fort line. In these circumstances, the defence of the intervals by a field force, able to establish and maintain an effective outpost system, assumes the greatest importance. The indirect fire of the forts themselves—the greater part of their fire at moderate ranges—would depend on observations carried on from positions outside."

My general conclusion was, therefore, that:

" The effective defence of the entrenched positions of Liége and Namur will depend mainly on a field force guarding the intervals."

" These positions to be of any real value must be fully prepared for defence within a very short time of a declaration of war."

How far the organization of the defence, the preparation of intermediate infantry and artillery positions and the clearing of the ground had proceeded when the storm suddenly burst, I do not know, and any accounts which may be published of the attack on Liége and Namur will be instructive.

It was my view, in 1890, that the conception of the permanent defences of the Meuse was wrong. The crowding of artillery into small conspicuous areas was, I believed, a mistake. If the guns and the observing stations of the forts could be placed *hors de combat*, these expensive works could render no further assistance to the defence, which would then depend entirely upon that of the intervals. By 1914, the German provision of mobile heavy howitzers and of aeroplanes able to direct their fire had still further discounted the designs of M. Mougin and General Brialmont. On the other hand, in so far as the existence of the forts necessitated the bringing up of heavy ordnance—such as the 42 cm. howitzers—delay, which was invaluable to the Allies at this juncture, was entailed upon the Germans.

Antwerp was defended in 1890 by a ring of 12 very large forts, about 3,600 yards from the enceinte. Their design is well known and was open to much criticism. Those which I inspected were already long obsolete and were armed with old type guns "most of them cast iron." It had been decided to make an outer ring of 17 forts at a minimum distance of about 15,000 yards from the enceinte. Of these works, 6 were nearly completed, and those I saw were open to great objection. The total length of line to be defended was about 41½ miles on the right bank of the Scheldt; but reliance was placed on inundations protecting the northern sector. Six days were stated to be needed for completing this inundation; but "a good obstacle could be obtained in two days." In other sectors "a great clearance of timber, requiring a perfected organization and many days of labour," was needed to enable the forts "to defend their own immediate front and intervals." Antwerp had a respite and may have been better prepared for defence than the positions on the Meuse. From the nature of its permanent works, however, it was equally doomed directly the Germans could bring up siege artillery, unless it held a field army. Whether this was realized, as it should have been, when the decision was made to throw in a British force, largely ill-trained, I cannot tell. Several important steps were taken during the war which seemed to show ignorance of information that must have been available. Yet Antwerp, like Liége and Namur, served to gain time and to detain large German forces which, otherwise employed, might have been dangerous to the Allies.

General X laments the neglect of fortification which, he considered, prevailed in France before 1914, and it is obviously futile to build costly permanent works unless they are kept up to date, adequately armed and prepared for defence. Verdun as a fortress hardly existed ; but for many weeks the fate of France seemed to hang on the defence of this region, and nowhere did the French army acquit itself more gloriously. The permanent fortification on the Eastern frontier served its purpose in determining the line of the German invasion, and the perfection of the preparations for mobilizing the army was of infinitely greater importance than any technical additions which could have been made on the line of the Vosges. What might have happened if the Germans had respected Belgian neutrality and thrown their weight, with a powerful siege train, on the Eastern side will remain an interesting speculation.

The problem of the future of fortification awaits solution. The large expenditure on permanent passive defence, which has found favour at some periods in the past, and the formal types, which existed in 1914, are not likely to be repeated. The war has shown that, except in a limited sense, fortification cannot be substituted for men. "Invisibility,"* for which I pleaded in 1886, was found to be an essential form of protection, and has added a horrible new word to the language. The development of artillery and the even greater development of the means of directing fire have rendered the accustomed form of fort a helpless shell trap. At the same time, the tank has reduced the field fortification of the text books on which we were brought up to impotence. European wars in the future may be decided in the air. The conditions of the British Empire are, however, so varied that our pre-war ideas of fortification have not become universally obsolete. I earnestly trust that the officers of the Corps, of whom so many have gained invaluable war experience, will devote themselves to the solution of the new problems on which our security may depend.

* *R.E. Professional Papers*, Vol. XI., page 195.

TOPOGRAPHICAL AIR SURVEY.

By LT. COL. G. A. BEAZELEY, D.S.O., R.E.

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Introductory.—The survey methods described in these notes are independent of air photography. Their inception arose, and need for them was felt, in Mesopotamia, where it was found impossible satisfactorily to piece together a very large number of air photos taken in strips over enemy country far in advance of our lines, beyond the reach of triangulation, and where, as no reliable maps existed, no fixed points were available to which to tie down these scattered strips. Gaps also occurred between the strips, owing to the occasional failure of the cámera shutters, and these added to the difficulty of piecing together the patchwork

It was originally suggested to the G.H.Q. by the writer of these notes that there was no reason why a means of surveying or sketching typographically from the air should not be possible if a trained surveyor were available, and he received instructions from G.H.Q. to experiment and see what could be done in this line. A lull in the operations permitted his being attached to one of the air squadrons, and in a fortnight sufficient experiments had been carried out, the requisite instruments made, and a workable system evolved.

There was neither time nor opportunity for teaching the system to any of the R.A.F. officers. It was one thing for a fully trained and experienced surveyor rapidly to master the methods, but quite another thing to send an officer who was not a trained surveyor to carry out surveys over the enemy lines. The consequence was that the writer was shortly afterwards called upon to carry out surveys himself over enemy territory well in advance of our lines.

Five successful trips were made and a considerable area was sketched and additional useful information collected. On the fifth trip a reliable form of sun compass was evolved, as the ordinary form of sun dial was found to be of no practical use.

Unfortunately for the successful completion of exhaustive experiments, during his sixth trip the writer was shot down near Kirkuk on 2nd May, 1918, and taken prisoner by the Turks. No further experiments could be made till July, 1919, when he was passed as fit enough to fly once more and the experiments described below were carried out at Andover in Hampshire.

Methods used and Experiments carried out.—Before any attempt could be made to carry out an "Air Survey" with any degree of accuracy it was necessary to find means of keeping the sketching board constantly oriented, *i.e.*, with its true north and south lines in the plane of the meridian, and approximately level. These are fundamental principles both in 'ground' and 'air' survey. It must be remembered that an aeroplane seldom keeps a constant course, but "yaws," like a sailing vessel when under the action of waves and wind, and that consequently the board can only be kept truly oriented by being constantly moved round on its pivot. Any change in direction made by the longitudinal axis of the aeroplane must be met by a corresponding change in the orientation of the sketching board. This orientation can be accomplished either by aid of a magnetic compass whose dial index after being corrected for deviation, etc., points to the true north or by means of sun azimuths plotted on the board, as will be described later.

Dealing first with magnetic compasses, in each machine used a pocket liquid card compass was tried. In a Handley Page it had at times an amplitude of about 10° on either side of the mean line, and thus gave only a very approximate idea of where the true north was. In an Aero and Bristol Fighter the compass could not be kept steady at all, in every case centrifugal action was set up in the liquid and rendered the compass unreliable. An aperiodic type of compass in common use in aeroplanes was tried in a Bristol Fighter, and gave fair results when flying along a perfectly straight line on the earth's surface, such as an old Roman Road, the maximum amplitude being about 3° on either side of the true position. But on a constantly changing course it proved quite useless owing to inertia and the amplitude set up in the liquid by centrifugal action. It never gave true direction instantly. The course according to the compass would be somewhat similar to that shown in *Fig.* 17, in which the points *a*,*a*,*a*, are a succession of positions taken along the course by re-section from the starting point and by ground speed scale compass set with index reading true north. The course according to the compass is denoted by the firm line, the actual course was probably as shown in *Fig.* 18.

To do away with one cause of centrifugal action in the liquid—the frequent orientation of the board, to which the compass had hitherto been attached—a special compass reflector was tried in Mesopotamia used in conjunction with a reliable compass fixed to the side of the fuselage, instead of to the sketching board, details of which will be given hereafter. This apparatus proved fairly successful, and further trials of it were to have been made at Andover, but could not be arranged before the experiments there were brought to a close.

A stabilized form of compass (non-magnetic) controlled by an instrument based on the principle of the gyroscope was being tested under the Air Ministry, and if successful this instrument will be very useful for air survey work. The compass must keep constantly pointing to true north, but the complete apparatus must not be too heavy for the aeroplane.

The use of the pilot's compass is eliminated by the fact that there is no time to plot bearings with a protractor even in a machine which can fly at so low a speed as 65 miles per hour. Further, to be of any use a compass must give true magnetic bearings to all points of the compass instantly, but this is prevented by inertia which keeps it from settling down at once to the true bearing. It is unsuitable for air survey work, it was tried in Mesopotamia and given up in favour of sun azimuths.

In the experiments dealt with in this report azimuths, at half hour intervals, for the mean latitude and declination of the sun, were used. These were plotted on the board, and a long needle was stuck into it vertically in the centre of the dial. The board was turned on its pivot till the shadow thrown by the needle coincided with the time shown by a mean-time watch, which had been corrected for difference in longitude from Greenwich and equation of time. It is always possible to keep the sketching board approximately level with the help of a small circular level, or ordinary level bubbles placed at right angles to each other.

To provide for the contingency of the sun being temporarily obscured a small liquid compass was fixed and let in flush with the sketching board, it was customary on the way out to the day's work to note the position of the magnetic north when the board was oriented by the sun compass, and to shift the pointer to coincide with it. Then if the sun became obscured the board could be oriented by help of the compass until the sun shone out again. This method is of course liable to some error, which is indeterminate, but for the short period involved no great error in the survey work will be introduced, so long as no attempt is made, for instance, to fix objects at a distance on either flank.

Four patterns of sketching boards were used, three of which were specially for area work :—(1) a small board, 9 inches square, with rounded corners and a recess for the compass, used in the front cockpit of a Handley Page, where there is no room for a bigger board ; (2) a similar board 13 inches square, used in an Aero and Bristol Fighter ; (3) a board similar to (2) with an aperiodic type of compass instead of the small pocket type. For route traverse work (4) a board somewhat similar to the familiar cavalry sketching board was used, designed to hold a slip of paper 60 inches long and seven inches wide, total size over all 13 inches square. On this board paper sun dials were mounted on either side, as the paper strip had to be wound off constantly as the work progressed. Additional sun dials can be plotted on the paper itself but if they are used great care must be taken to remove the dial pin each time the paper is wound off or on the rollers. A light wooden mallet was used to drive the pin firmly into the board. The following are also required :—protractor, hair-spring dividers, proportional compass and push pins.

A set of wooden speed scales on the scale to be used is required for the following speeds :—120, 115, 110, 105, 100, 95, 90, 85, 80, 75, 70, 65, 62½, 60, 57½, and 55 miles per hour, two scales to each piece of wood. These are 'ground' and not 'air' speed scales. They can be used as sight rules for re-section from back points, or for cutting in detail to a flank. The best scale for general use is ½ inch to 1 mile, as it is easier to draw on this scale than on the ¼ inch. Larger scales require bigger boards which cannot very well be used in the machines in use.

Thin lithographic paper mounted on cloth, as used for printed maps, is the best for working on, and can be obtained from the Ordnance Survey, Southampton. Unmounted paper gets torn by the air blast.

A supply of HHH, red, blue, and green chalk pencils, knife and rubber should be kept. When actually at work in the air two or three lead pencils should be taken as they are apt to be wrenched out of one's hand by the rush of air. No coloured pencils can be used till the day's work is over and the observer is returning home. There is no time to handle them while actually at work.

Machines used.—The B.E. 8 is the most suitable type of machine, its speed is moderate, fuselage stiff, vibration not excessive, it has a roomy compartment aft for the observer to work in, and a 15 or 16 inch board could easily be used. A turntable seat, which enables the observer to turn round and face forward when necessary, and to which the sketching board can be fixed, is found to be more restful than a fixed seat on a long flight. This machine can keep in the air for four hours and throttle down to 65 miles per hour comfortably. The engine is air-cooled. The wings interfere less with the view than in any other type of machine. The pilot is close to the observer. This machine was used with success in Mesopotamia by the writer of this report.

B.E. 2.E. was tried in Mesopotamia but found not suitable as the observer has to sit in the forward compartment which has a poor field of view.

Handley Page is unnecessarily large and requires too many hands, its fuselage is too wide and it is impossible to work satisfactorily from the after compartment. The forward cockpit is too small and breezy, and a 9″ by 9″ board is the largest that can be used there. Once past the mark no back re-section is possible in this machine, drift cannot be properly estimated or course satisfactorily plotted. There is no time to make calculations with a drift instrument.

The Aero cannot remain in the air long enough, at the maximum under two hours, which gives too narrow a margin of time, its speed is moderate, vibration excessive. It is in fact a cheap type of machine and not very satisfactory for air survey work, the wings interfere with the view when sitting facing backwards and the observer cannot see vertically below the machine.

The Bristol Fighter has distinct advantages in some ways, but it is rather too fast except for a fully trained hand and the engine does not work smoothly at speeds below 80 miles per hour. The observer's cockpit is rather small, the machine vibrates a good deal, which makes it very difficult to write legibly. The examples of air sketches accompanying this report were all done from a Bristol Fighter, except the Mesopotamian sketch which was done from a B.E. 8. A board larger than 13″ by 13″ could be used if special arrangements were made for it, the cockpit would require slight modification. It is a distinct disadvantage that the machine can keep the air for only two hours.

The best type of machine would be one built on the lines of a D.H. 9 or a B.E. 8, with an engine to drive it at a cruising speed of 65 miles per hour while the observer is at work, and at other times at a higher speed, say up to 90 miles per hour. The machine should be capable of carrying two observers, one behind the other, besides the pilot. Petrol supply should be sufficient to last out fully 4½ hours.

Method of work.—The experience gained by the writer indicates that it is best that the observer should explain to the pilot only generally what course he is to take, and should retain complete control as to the exact air routes to be followed. A pilot cannot in fairness be expected to maintain a course set on a map and look after a machine properly at the same time. It is therefore essential to the observer that he should have some simple means of communicating with the pilot.

As in other branches of survey work practice is required, the principal difference between air work and ground work being that in the former the observer has to work at a far more rapid rate and the work must be carried on without relaxing his attention for a moment. After a little practice, however, it is not difficult to keep the board fairly level and properly oriented, and with further practice this is done automatically.

Care must be taken frequently to re-sect the position by rays from back points drawn in quickly with the sight rule, and having got this ray to plot the position from the starting point by means of the speed scale, after noting the time by stop-watch. The speed scales are graduated in distances covered in minutes and fractions, the actual ground speed being known with reasonable accuracy. Detail should be drawn in as it passes underneath or to either flank, using the speed scale and stop-watch for distances. The angles which roads make with the line of flight should be noted. In country similar to that shown in the sketch of ground in Mesopotamia all these operations are not difficult with a little practice, the writer felt competent to do this class of work after eight days' practice, and it is over country of this nature that this form of air survey can prove most useful. Work over highly cultivated and organized country like England is more difficult and calls for a higher rate of skill and unremitting attention on the part of the surveyor.

Over civilized countries this method of survey by eye would prove invaluable for preparing an accurate skeleton on which to tie down air-photo mosaic, it would be possible to run traverses over a large stretch of country and adjust these to include quite a sufficient number of fixed points by which to tie down all the photos, within 5 % of their true positions on the ground, given a suitable machine and trained officers. This form of frame work would be invaluable over country that cannot be triangulated or traversed. With these tie lines the same officers could go over the ground and fill in rapidly detail which is not included in the air-photo mosaics. In country similar to that shown in the detail sketch of the Southampton area it is far better only to sketch in what one can, taking great care (*a*) to keep the board level and oriented and (*b*) to keep the course carefully plotted by re-section and speed scale; then, after inking up what details are known to be accurate, to go over the ground again and fill in blanks, which is easy as sufficient detail has already been inked up to enable the rest to be done to a great extent by eye. Never get flurried. The writer confesses to having had a feeling of nervousness at first when the detail to be cut in seemed more than he could cope with, but the more practice one gets the greater one's confidence and when confidence is gained it is all right.

Three months' training is recommended, though shorter periods may suffice with officers who have a special aptitude for the work. The great thing is to learn to gauge the scale of everything quickly.

Before starting work a short run should be made between two points in a line down or up wind whose distance apart is known. This should be explained clearly to the pilot, who should show before starting that he understands what he has to do. It is assumed that the observer has previously ascertained the ground speed of the machine in still air equivalent to the air speed which he intends to maintain. The Bristol Fighter used by the writer of this report was a very reliable machine and gave a value of 83 miles per hour ground speed at 2,500 feet for an air speed of 80 miles per hour in still air. It is however always advisable to test this periodically up and down wind on a measured course.

Having run along the measured course, say down wind, with a stop watch, the speed of the wind can easily be obtained by subtracting the deduced ground speed in still air from the same down wind. Corrections can then be applied to the latter for all other courses while at work.

If time permits it is far better to run both up and down wind on the measured course. A reliable ground speed can then be obtained from the formulæ :—

$$\frac{\text{Speed down wind} + \text{speed up wind}}{2} = \text{ground speed}$$

$$\frac{\text{Speed down wind} - \text{speed up wind}}{2} = \text{wind speed.}$$

The starting point of the day's work, the direction from which the observer wishes to approach it, the speed to be maintained and height at which the machine is to fly, having been explained to the pilot, it rests with the observer once he is past the starting point to control the course subsequently taken. The simplest way of doing this is to tap the pilot's left or right arm to indicate a slight turn to port or starboard, the taps being repeated until the machine is on the desired course. When work is completed the pilot should be handed a slip of paper to that effect. No other signals should be necessary unless the engine is giving trouble and it is necessary to return home, when the pilot can tell the observer his reason for doing so.

Telephones to fit the head were not used by the writer, as the pressure on the back of his head from the propellor blast was as much as he could stand without adding to the discomfort of having the telephone headpiece fixed on his head as well. But there is no reason why a telephone should not be used. It would render communication with the pilot far easier, and the difficulty about the air blast could easily be overcome in any machine fitted specially for survey work. In fact a screen to protect the head from the air blast is a *sine quâ non* for effective work on account of the occasional necessity of turning round to look at the approaching ground. A knowledge of what detail is in advance is sometimes essential and turning round to obtain this is a very unpleasant undertaking in a Bristol Fighter which has not been fitted to protect the observer from the air blast. Exact knowledge of the ground speed and of the direction and force of the wind, the power to re-sect one's position from fixed points in rear of the machine, and reliable means of orienting the sketching board, are all essential factors in successful air survey work. The methods of ascertaining the ground speed and the force of the wind have been dealt with already. The direction of the wind can be obtained from the ground, both before starting and also on landing after a trip, by noting the bearing along which the lowest clouds are being driven. In the air a drift instrument can be used at working height in clear weather. Re-section from fixed points in rear can be done by aligning the ground speed scale rule like a sight rule on the object. Local mean time is required for the sun compass.

The observer should fly at the height of 6,000 feet if possible. At that elevation he gets a far better command of the country and can work more quickly and include a far larger area per run than at, say, 2,000 feet. But though this is practicable in arid countries, in England it is very seldom that the air is sufficiently free from clouds. At low altitudes there is a tendency to exaggerate the scale of things.

In a highly civilized country like England an area sketch cannot be done in a single operation. Route traverses must be carried out along the sides and diagonals. A sketch of an area of 500 square miles would require at first about two trips of 1½ hours each in a Bristol Fighter. These must be corrected to scale and adjusted and then transferred and fitted together on a new board. During the flight it is necessary to work out approximately the ground speed on the various courses and use the ground speed scale which most nearly corresponds in each case. The ground speeds will vary, as the prevailing wind has a different effect upon the ground speed at each change of course. The estimated speed for each course should be noted down and can be worked out again and corrected after landing, and the traverse stretched out or contracted by proportional compass. A final adjustment is made when all the tie lines are being fitted together. Here two corrections will be found necessary:—(*a*) final correction for scale, and (*b*) final correction for azimuth and direction.

The next step is to run traverses along the central meridian and central east and west line, and afterwards the detail can be filled in gridiron fashion, the number of lines and their distance apart being governed by what the observer can adequately fill in on both sides of the gridiron lines. No attempt should be made to fill in the blanks straight away; the observer should first land, pencil in and colour up the work already done and then complete the sketch by flying over the blanks and doubtful parts. Any attempt to amplify or fill in over roughly pencilled work only leads to confusion.

The control of a gridiron course cannot be left to the pilot; the writer found it necessary to keep it in his own hands throughout the whole operation, including the filling in of blanks as suggested above.

An important route should never be flown over vertically as from that position nothing can be seen of it from the machine; the observer should keep at least half a mile to one flank. If the wind is blowing obliquely to the course this will require the constant attention of the observer.

For area work a perfect square or rectangle should be adopted, and the sides, diagonals, central meridian and east and west lines should be laid out accurately on a blank board. The machine should be kept exactly over these lines by constant re-section from back fixed points. At first no great amount of detail should be included. After the course has been plotted carefully and the traverse lines have been adjusted and inked up there is no difficulty in filling in the detail.

Before commencing work sun azimuth dials should be protracted in all the four quarter squares, as the arm gets in the way of each dial in succession as the board is orientated on different courses, necessitating in each case the shifting of the dial pin.

A system of simple symbols is essential, such as :—

F. for farm buildings,	R. for road,
V.L. for valley,	W. for wood,
R.R. for river or stream,	STN. for railway station,
Rly. for railway,	and so on.

Practice at retaining in one's mind a pictorial representation of the ground is essential, as much may be jotted down on the sketch from memory after landing. The writer of this report invariably went over his work on landing and amplified his sketch in this fashion.

When learning to survey in the air the observer should compare his work with the published maps and note where he has gone wrong, for future guidance. This teaches him a lot and helps him to avoid similar mistakes in future. There is a tendency to exaggerate the scale, to draw in roads at the wrong angle and to omit important detail which is plainly visible from the air. Anything tending to affect the ground speed of the machine should be carefully noted at the time, or the scale of the sketch will vary in places from the true scale.

When altering course from one traverse to another, *e.g.*, at A, *Fig.* 19, the machine should make a wide turn, as shown in the figure, to give the observer about one minute to re-orient his board, change his ground speed scale, reset his stop-watch and be ready for work again on repassing A on the new course. To indicate his wish to the pilot the writer used to draw his attention to some prominent object vertically below the aeroplane and then circle the hand round the head. The meaning of the signal was of course explained to the pilot before leaving the ground. If this manœuvre is not carried out the observer will find—as the writer did in his early efforts—that the aeroplane is gaily sailing half-way down the next lap before he is ready to start work on the new course, resulting in a waste of time in explanations and in getting back once more to the initial point of the new course.

The sitting-down position while sketching is by no means an advantage and it would be far better if the platform on which the observer's feet rest were lowered to enable him to partially stand, supporting himself on a seat like a miserere seat in a cathedral choir-stall. The board should be raised sufficiently to enable him to use a light sight rule for re-section and cutting in or for interpolation work. Sights could be fitted to the ground speed scale rules for this purpose.

The canvas sides of the aeroplane should be cut away at the top to enable the observer to see well down on either side without having to crane his neck over the side, where he gets the full air blast which is very unpleasant. A sloping wind guard should be provided to protect his head. A dash-board is required for carrying watches, instruments, pencils, etc.; each observer must arrange these to suit himself, but he must leave plenty of room for his board to turn freely on its pivot.

In air survey, the best results would be obtained by two observers working together in one machine. No. 1 would carefully plot the course, both as to direction and distance, and would note everything affecting the ground speed, such as variations of wind, etc. He would at the same time plot or cut in any important points in order that No. 2's detail may be adjusted and fitted to these points. He should be nearest to the pilot and control the course. No. 2 would sketch in the detail and plot his course as far as he can without sacrificing the sketching in of important features. Detail is his special job.

It is easier to plot the course than to sketch in the detail. The latter work is a very severe test in England, where there is so much to be noted down. In complicated country it is almost impossible for one observer to record railway embankments, cuttings, bridges, stations, etc., as well as all the other detail such as that shown in No. 1 Sketch (*Plate* 3) at speeds of 80 miles per hour and over.

Salisbury-Winchester-Cowes-Christchurch Area Sketch.—This sketch is a copy of the actual survey made in the air. Only a few of the Railway Stations are shown. In some places the area is covered with a net-work of roads impossible to detail accurately in the time; these have been generalized, but many of the roads shown in the Ordnance Survey map (the ½ inch Winchester–Salisbury and Southampton) are disused, grass-grown, and can hardly be seen from the air. Others have sprung into existence since the war and several new villas appear to have been built, especially round the New Forest and in places like Chandler's Ford. In making this sketch no assistance was received from the Ordnance map except the names.

The base on which the work was done was a traverse from Winchester to Salisbury, which was originally made for another stretch. It was corrected for scale and traced on the working sketch. Traverses were run between Winchester and Christchurch, Christchurch and Salisbury, Salisbury and Cowes, Cowes to Winchester, Cowes to Christchurch, thence *via* Beaulieu to Calshott, and thence to Cowes, seven in all, and after being adjusted and corrected were traced on the field section. These took about 3½ hours' flight. Gridiron courses were then run all over the area, and the detail sketched in and inked up. Another trip was then made to fill in the blanks. The total time of actual work in the air was 9½ hours, and the area measured approximately 500 square miles. The fair map was then completed.

Plate 4, shows a simple route traverse. The conditions of work in this case are much like those obtaining in area work. The course should be carefully plotted and only important features cut in on the outward journey. On the return journey the rest of the detail can be filled in. Great care should be taken to note down anything that may affect the ground speed in order that the variance of the scale may be corrected as far as possible. If a larger board than 13" by 13" cannot be used the strip of paper for a route sketch will not exceed eight inches in width, and unless the pilot keeps a straight course from start to finish the traverse soon runs off the board and must be broken off and transferred to the opposite side.

In the survey of a route between two points the true bearing from starting point to destination must be known. This should be drawn down the centre of the paper and the pilot should be kept to this line throughout. Or a pilot may be directed to pass through several points to the destination, and if he knows his course it may be left to him, the observer merely keeping the course taken and shifting his work to the opposite side should he run off the board. But if there is any doubt, it is far better for the observer to retain the map, however small the scale, and control the course himself, but he must remember in this case that he cannot see the forward point, as he is seated facing backwards, and that he is responsible for arriving at each point in succession till he reaches his destination. In any case the responsibility that rests on the pilot must be made quite clear to him before starting, or the observer may find that he has completely lost his way. This actually happened to the writer on one occasion, and only the fact that he had previously been over the ground on foot, and recognized a town, enabled him ultimately to reach his destination before the petrol supply gave out. A strong cross wind was blowing at the time.

Work in Mesopotamia was a great deal simpler. Here it was comparatively easy to note down everything, keep the courses plotted and the board oriented, and cut in detail on either flank. It was possible to fly at 6,500 feet as the air was free from haze and one was seldom bothered by clouds, whereas in England it is rarely possible to fly above 4,000 feet, often much less.

Plate 2, which shows a sketch done from memory of ground similar to that surveyed by the writer before he was captured, is given as an example. The area was about 360 square miles and the time two hours.

By means of a reliable altimeter used in conjunction with a special form of clinometer it should be quite possible to deduce with fair accuracy (*a*) the ground distance between points on the earth's surface, and (*b*) ground speeds. Such data would be invaluable over unmapped areas when it is not considered advisable to land and carry out measurements on the ground.

The work in Hampshire was cut short by orders from the India Office and opportunities for carrying out further experiments were lost.

Description of Instruments.

Compass Reflector for Air Survey Work (*see Figs.* 5—7, 13, 14).

This is used for orienting the sketching board by the aid of an aeroplane compass in cloudy weather or when the sun is momentarily obscured by a cloud. AB is a hollow tube telescoping into a similar tube and admitting of extension or contraction to suit the distance of the centre of the sketching board from the central line of the axis on which AB turns horizontally, *i.e.*, axis ab. AB is mounted in this manner to enable it to be swung to one side when not in use. F is the box containing the aeroplane compass which may be of any form suitable to this class of work. Both AB and F are fixed to brackets on the side of the aeroplane. The image of the N and S line of the compass card or " grid " is reflected in mirror G, which is fixed vertically above the compass and at an angle of 45° to the longer axis of AB. This mirror reflects the image on a small elliptical mirror H, parallel to G. H reflects the image through eye-piece I to the eye of the observer, who also sees, beyond the mirror opening K, the needle J on the sketching board vertically below it. J is a thin fine needle pivoted at O, the centre of the sketching board, set stiffly to prevent it shifting easily. With O as centre a small complete arc is struck to enable the angle subtended by J to be read, and the needle J reset if it gets disturbed while the board is being used for sketching. The theory of the instrument is shown in *Figs.* 13 and 14. The image of the N and S needle of the compass is reflected first on the mirror G and then on H, where it appears as A″ B″ (*see Fig.* 13). The eye at I sees this image on mirror H projected down on the sketching board as A″ B″, the limit of the mirror being shown by the dotted lines. Now if the needle J on the sketching board is set to represent the position of the compass needle when the board is truly oriented, all the observer has to do whenever the board is swung out of position by a change in the direction of the aeroplane is to turn it till the needle J coincides in direction with the reflected image of the compass needle, J being seen vertically below the eye and beyond the limit of the mirror H (*Fig.* 14). The determination of the correct position of J is a simple operation which need not be entered into here. The instrument is held in its place by a flexible metal arc xy (*see Figs.* 5 *and* 7) and a stud f (*Fig.* 5) which engages in one of the holes hh (*Fig.* 7) according as the instrument is in use or swung on one side when not required. The brackets M and N, supporting the instrument and compass, and the arc XY are mounted on a board capable of horizontal movement fore and aft (*see Fig.* 6) which is clamped into position by four strong wing nuts. This is necessary in order to make the complete set adaptable to any form of aeroplane.

Ball and Socket Pillar Stand for Air Survey Sketching Board (Figs. 1 to 4).

The sketching board is fixed by four screws on boss A, which is fitted with a ball B held in a split cup CC. A spacing piece of suitable thickness, D, with a hole in the centre to take a bolt E, and of the same length as the diameter of H, with its ends rounded in section, is placed as shown in *Fig. 2*. The ball B is gripped in cup CC by means of bolt F, power being obtained by lever G (a wing nut would not provide sufficient power). A little grease should be rubbed on the ball. The spacing piece D keeps the inner faces of the neck HH' approximately parallel. H' is quite separate from H. H is fitted with a boss I, which is let in flush with the top of the wood pillar J and strongly screwed down to it, as shown in *Fig. 1*. Pillar J is cylindrical in section and can be moved up and down in clamp K, which is split along the line LL and can be tightened up by wing nut M. A copper L shaped split collar N is fitted, as shown in *Figs. 1 and 4*, to give a better grip—this fitting being found necessary in actual practice. Clamp K is fixed by two long bolts OO to a horizontal wooden transom (not shown) which has a hole in the centre through which pillar J can be raised or lowered. The shape of the transom depends upon the type of aeroplane to which it is fitted. The work of fitting can be easily done by any carpenter. This form of stand allows the sketching board to be levelled, turned on its pivot (*i.e.*, ball B) and raised or lowered at will.

Sketching Board.

(*a*) *For area work.*—A plain deal board with rounded corners and strengthened below by two battens; underneath the centre there is a wooden block into which the stand boss is fitted and screwed down. In size the board may vary from 9" by 9" to 24" by 24" according to type of aeroplane.

(*b*) *For traverse work (route traverses) see Figs. 8 to 12 and 16.*—The board is recessed at opposite ends to take the rollers AA. These must be set truly parallel to each other, or the paper strip rolled on them will not travel true. Each roller has a slit B into which the end of the paper strip is introduced before rolling, to give the necessary grip. A notched and milled wheel C, fixed firmly to the roller by screw D, enables the paper to be rolled up. Milling is not sufficient and notching is necessary to give the fingers sufficient grip, should the paper tend to roll stiffly. The roller must have a certain amount of stiffness to prevent the paper unrolling, and this is provided by a grip E and adjusting screw F. Stiff wax should be put between the bearing surfaces. Bearings GG are provided to take the roller, which is kept true by two screws HH which engage in small holes recessed in the centre of the solid end bosses of the hollow roller. All bearings should be waxed. The roller and its bearings are carried in a metal frame II, one end of which can be detached to assemble the mechanism. This frame is let into a recess in the board and screwed to it as shown. Two metal guides J, with packing pieces K, guide the paper between the rollers and prevent the high wind in the observer's compartment from getting under the paper and wrenching it off. Without the guides it would be impossible to keep the paper from being torn off its rollers. Underneath the board there are the usual battens L and wood boss M to take the metal-boss of the pillar stand. Two small sun compasses are provided, one on either side, and are essential as the route survey must be kept up the centre of the paper, its mean inclination to the true N and S line being taken up by sun compass. This is effected by turning the N and S line of the latter through the angle which the route traverse makes with the N and S line on the earth's surface. The sun compass card after being turned through this angle is clamped by means of mill headed screw N which keeps it in the position set. There is a small vertical hole through the centre of N in which needle O is inserted to cast the shadow on the dial. With the same centre as N a complete arc is struck on the board for setting the compass card. Either compass can be used. The dial is not drawn on the paper as the latter is being constantly rolled off and on, and this would necessitate the dial needle being taken out and refixed each time. On the paper strip N and S lines must be drawn at, say, six-inch intervals parallel to the same line on the dials, in order to preserve the direction of the true north on the route traverse sketch. The centre of the sketch would normally coincide roughly with the centre line of the paper. Should the former deviate to the left or right, the dials must be turned through an angle in order to bring the centre line of the sketch parallel to the brass strips, and the centre line of the sketch must be shifted to the centre of the paper. The new direction of true north must be ruled up afresh on the paper, or the change in arc through which the compass dials are turned must be noted down at the point on the traverse at which the change takes place, so that the direction of true north may be drawn in on return to the aerodrome or landing place. It will be seen that the compass dials can be turned in order to keep the centre of the traverse line down the centre of the paper, which is a *sine quâ non* in route traverse work. Any length of paper can be mounted on the rollers provided the gap is not completely filled. It is best to use fine lithographic paper mounted on muslin as plain paper is apt to get torn.

Sun Compass.

This is based on the formulæ for Sun Azimuth —

$$\tan A = \frac{\tan t \cos M}{\sin E - M} \text{ where } \tan M = \frac{\tan S}{\cos t}$$

A = Sun's Azimuth at time t.
t = hour angle before or after noon.
S = Sun's mean declination for the day.
E = Mean latitude of sketch.

Having calculated the azimuth for the half-hours before and after noon, the dial can readily be prepared by means of a protractor. Azimuths at quarter hour intervals can be computed if required. Greenwich mean time is used, subject to the following corrections: (*a*) a correction (in functions of time) to allow for the difference in longitude between the centre of sketch and the former station and (*b*) a correction known as the equation of time, to reduce mean time to solar time. Then the N and S line points to true north when the shadow of the vertical needle in the centre of the dial cast by the sun coincides with the time shown by the watch corrected as directed above. *Fig.* 15 shows a normal dial. Two hours before noon and four after would be sufficient for normal working hours, except perhaps in a very hot climate when it might be advisable to start earlier and recommence work later in the afternoon, in which case additional hour angles can be computed and projected. The dials shown on the sketching board are approximately those which were originally employed and can be used for all parts of the compass.

On the area sketch a dial is drawn in each quarter square, as the body and the arm necessitate a shift when the aeroplane changes direction and the board conforms to this movement. The dial needle can easily and quickly be driven vertically into the board by means of a light wooden mallet. A lady's hat pin provided with a small metal ball on the top and cut to $3\frac{1}{2}''$ makes a very good dial needle.

Clinometer for Air Survey work (*see Figs*. 20 *to* 23).

If the height above the ground is known the horizontal distance between any two points on the ground or the ground speed can be calculated by means of this instrument. Or given the ground speed or the distance between any two points on the ground, the height of the aeroplane above the ground can be calculated.

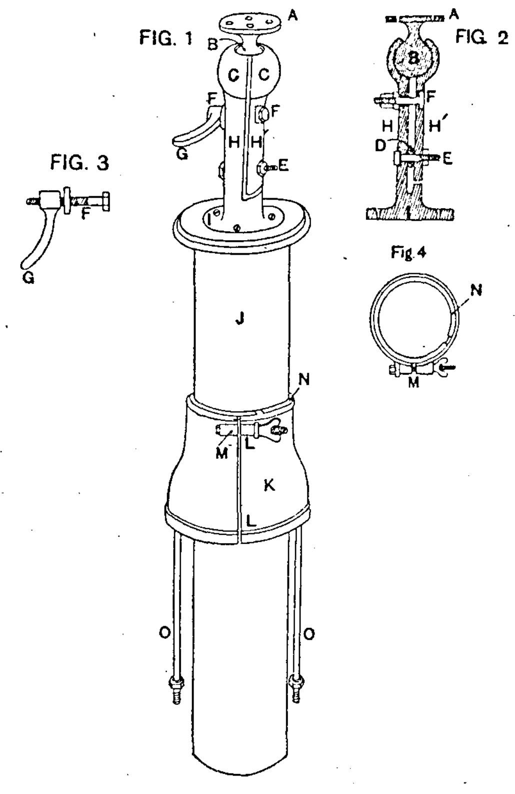
The instrument consists of a rectangular frame A B C D fitted to a yoke E F. The instrument is kept level by means of a striding level G, fixed to a bracket H which is fastened rigidly to E. E F is capable of turning on a butterfly nutted bolt I, which is fastened rigidly to a plate J, which in its turn is fixed to a slotpiece K, which slides into a groove in the bracket L. L is screwed to the side of the aeroplane. K is held in place by the stop pin M.

To correct any dislevelment of aeroplane in a fore and aft direction all that is necessary is to turn the instrument round the horizontal axis I till the bubble of G is in the centre of its run. The aeroplane must be kept on a straight course and at a constant height while readings are being taken.

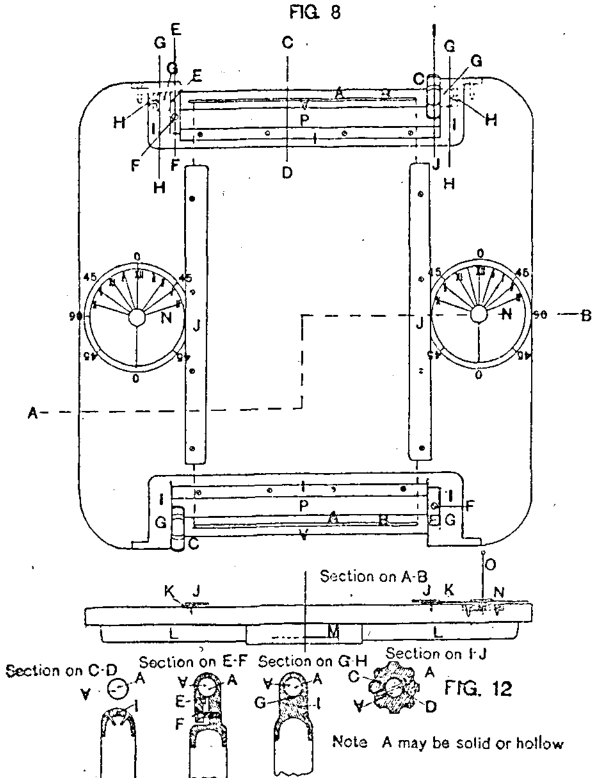
The vanes N N are capable of sliding on the bars R R until either O, or O′ or O″ or O‴, as the case may be, coincides with the object to be cut in. There is a horizontal wire at P vertically above another

PLATE 1

Ball and Socket Pillar Stand for Air Survey Sketching Board



(b). Sketching board for air route traverse work



Sun Compass Dial
given
Latitude = 51° N } approx.
Sun's Decl.n = 9° N }
for ½ hour intervals

FIG. 15

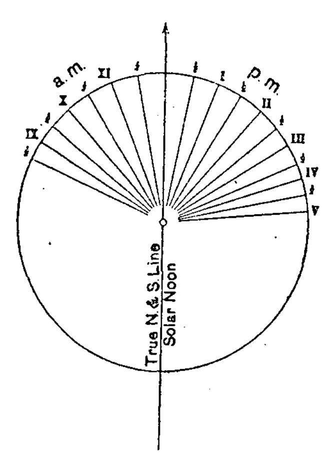
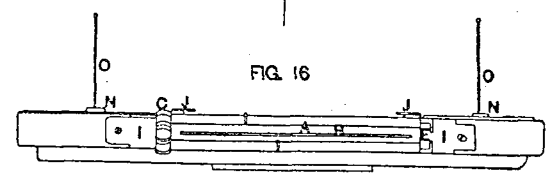
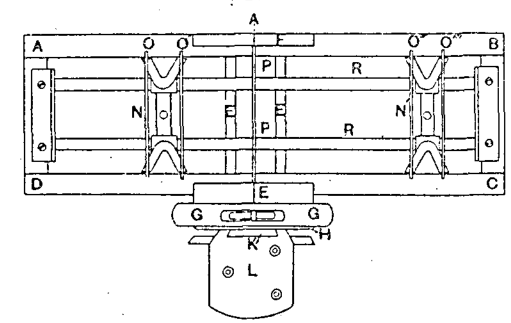


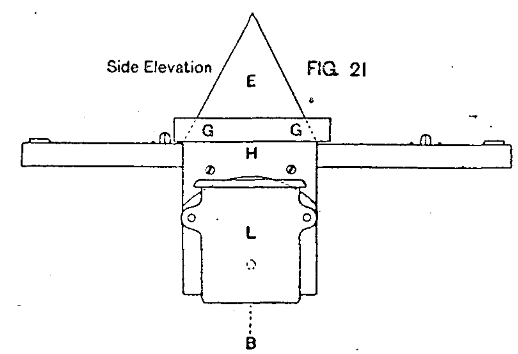
FIG. 16



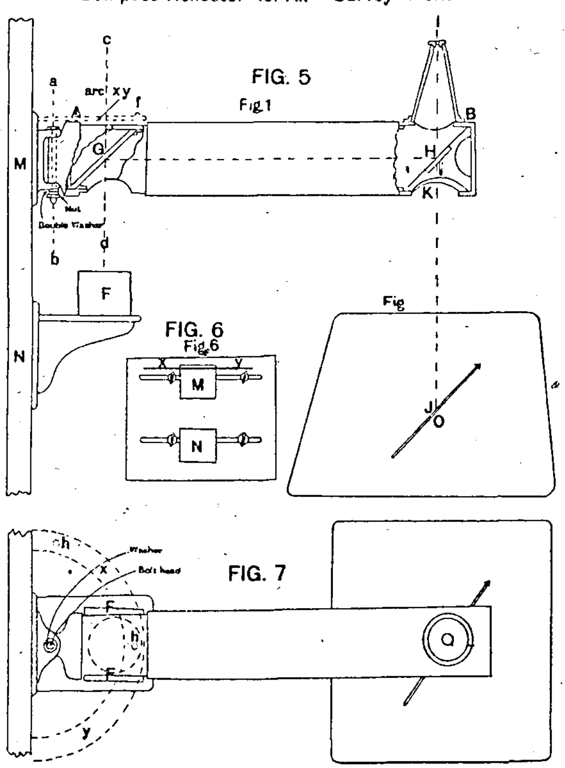
Side elevation of Sketching board vide FIG. 8

FIG. 20
Clinometer for Air Survey Work





Compass Reflector for Air - Survey Work



Compass Reflector for Air Survey Work

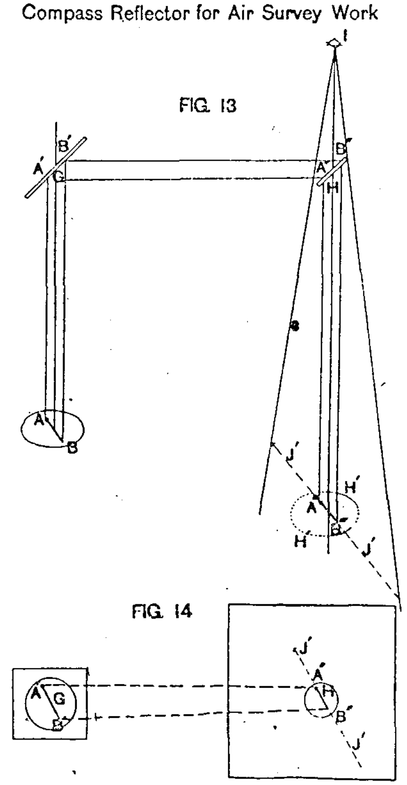


FIG. 17

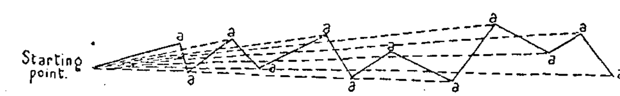


FIG. 18

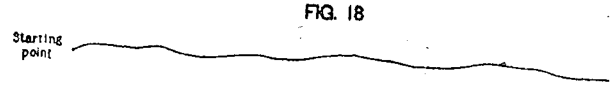


FIG. 19

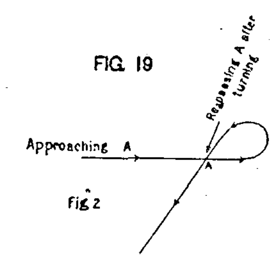


FIG. 22
Clinometer for Air Survey Work
Section on A-B

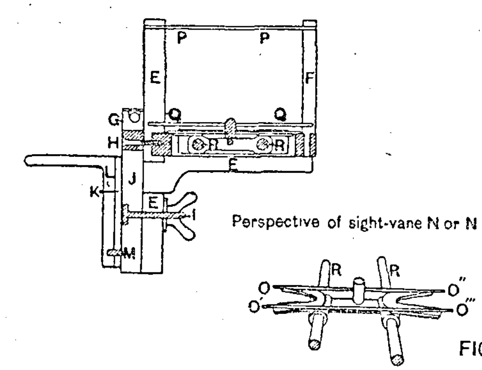
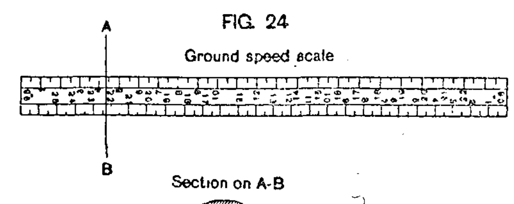


FIG. 24
Ground speed scale



SAMPLE AERIAL AREA SKETCH

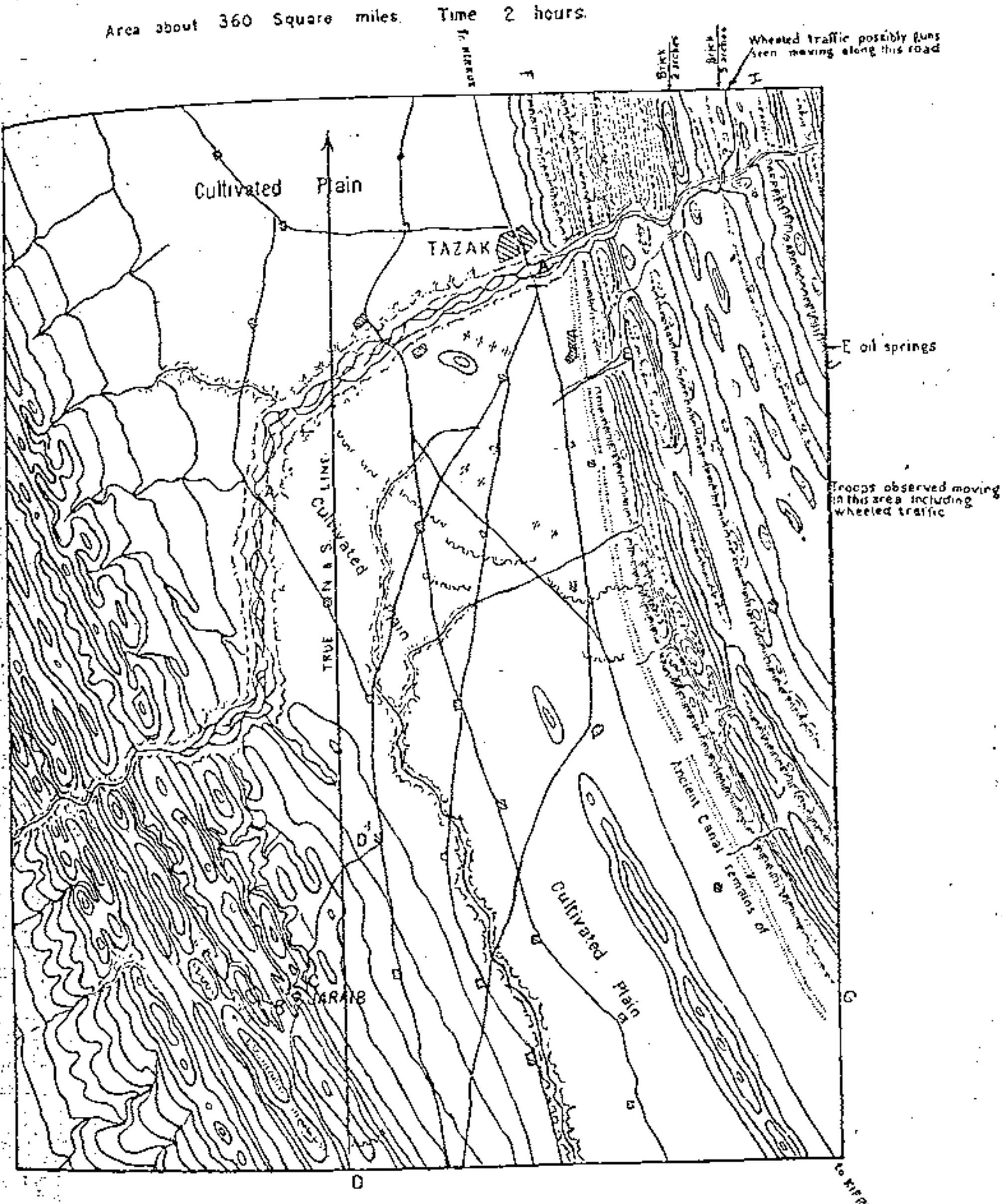
Representing ground actually surveyed in

MESOPOTAMIA

Drawn from memory

Scale 4 Miles to 1 Inch

Area about 360 Square miles. Time 2 hours.



appear to be fordable men seen crossing here on foot B camp. C serai occupied by troops.
wide track appears passable for wheeled traffic
y's defences & gun positions shown (a) at JARAIB (b) at TAZAK
these hills rise about 600 feet above the plain. H.J. about 400 feet above the plain.
veyed on the ½ inch scale & reduced by photography.

at Q. Along A B and D C an arc is protracted with centre P P. Thus the angle between an object cut in by O, O′, O″ or O‴, and that of an object vertically below the alignment of P to Q can be measured, or the time it takes for an object to travel from position O or O′, O″ or O‴ to a vertical below P can be measured by means of a stop watch. By these means the data mentioned can be calculated.

In using N or N′ the object to be cut in is brought into line with P and O or O′, O″ or O‴.

Ground Speed Scales Fig. 24.—These are similar in shape to architects' scales, but not so wide—half-inch is sufficient —and they should not be longer than 10 to 14 inches. They can be used as sight rules and can be fitted with light sight rule sights—these are not shown in the *Fig*. A complete set of ground speed scales is required, from, say, 45 to 70 miles per hour, increasing by 2½ miles per hour, and from 70 to 130 miles per hour, increasing by 5 miles per hour. Two scales go to one ruler.

PROFESSIONAL NOTES.

ENGINEERING COURSE AT CAMBRIDGE UNIVERSITY.

ON the 7th October last Nos. 5 and 6 Supplementary Classes of young R.E. officers joined at Cambridge to undergo a one year's course of engineering. This constituted an altogether new departure in the technical training of the Army, which requires some words of explanation. During the war there was only time to give to newly-commissioned R.E. officers a short "war course" before they were posted to units, and so the arrival of Peace found a large number of officers who still lacked the theoretical training without which none can expect to become sound practical engineers. To deal with this number at Chatham in addition to the normal batches joining from the R.M.A. was a physical impossibility, and temporary outside assistance had to be sought. This was found in every sense at Cambridge, where, more than at any of the other great universities, instruction in Mechanical Sciences had been developed of recent years; and where at the head of the Engineering Laboratory was Professor Inglis, whose name had become during the war a household word in the Corps. Many difficulties, which need not be further specified here, had to be met; they were all overcome, and in due course the first batch was born, and is by now (to quote the Cambridge Pocket Diary) a sturdy infant.

The Mechanical Sciences Tripos.—The usual course for the Honours Degree takes three years. The first year is mainly spent in simple laboratory and drawing office work, and (if not done before leaving school) in passing the Previous Examination ("Little-go"). This is a general examination on somewhat similar lines to the entrance for Woolwich or Sandhurst. Exemption has been given during 1920 to those with war service, and various other examinations and certificates are accepted in lieu. There is also a "Qualifying Examination" in mathematics and mechanics, which must be passed before the end of their fourth term by all candidates for honours in engineering. This examination was specially designed to stem the flood, with which the Engineering Laboratory was at one time threatened, of undergraduates whose highest ambition was to learn how to repair their motor bicycles. It appears to fulfil its purpose. It is an important examination inasmuch as it represents the datum line from which the 2nd year course starts. The recent examination in December was taken by Nos. 5 and 6 Supplementary Classes, when 30 out of 50 qualified. This was a considerably higher percentage than among the general candidates, of whom only some 20 out of 75 qualified. It is possible that future supplementary classes will be called on to sit for the examination as soon as they arrive at Cambridge. The R.E. course of instruction is to consist of four terms and to embrace as much as possible of the 2nd and 3rd years' Tripos courses. Last term most of the work was done with the second year; it will gradually have to become more independent, whilst the fourth term will be devoted entirely to third year work. The work is for the most part theoretical, though a good deal of time is spent in the laboratories. There are heat, electrical, and structures laboratories, in each of which is a large variety of plant and machinery. Owing to the very great pressure on both time and space it is only possible to carry out standard tests and experiments, and every engineering student is expected to get practical experience by undergoing a course in commercial workshops, either during a long vacation, or after leaving Cambridge. This practical workshop training will be given to Supplementary Classes at Chatham after they leave Cambridge. The instruction is given in the form of lectures. Each main subject is taken by a separate lecturer, who is probably allowed two hours in the week. He delivers his lectures and departs, and there is neither time nor opportunity to ask questions; so difficulties have to be worried out from books or taken to the College Supervisor. Every College appoints one or more supervisors to look after their students at each school, but numbers are now so great that no student can hope for more than one hour weekly with his supervisor. The same remark applies to the R.E. officers, who are looked after by two specially appointed supervisors instead of getting tuition in College. Many candidates for honours find it necessary to get private coaching, for which they make their own arrangements, and of course have to pay.

The University Year only really lasts 8 months—from October to June, and consists of three terms, each *full* term, during which lectures are given, only lasting about 8 weeks. In addition there is a more or less regular "Long Vacation" term in July and August lasting about 6 weeks, which is attended by most candidates for honours, and during which a regular course of lectures is given at the Engineering Laboratory. This will form the fourth term of the R.E. course. Although these terms sound remarkably short enough has probably been said to make it clear that few can hope to take honours without working just as steadily through the vacations as through the terms. It is in fact during vacation time that most solid learning has to be done. There simply is not time for it during term. It is perhaps unnecessary to add that learning does not fill the whole of life at the University. There is a quite unparalleled variety of other occupations to be selected from. Games of every kind and description, sport, music, art, literature, politics—all are provided for—and he must have strange hobbies who cannot find means of indulging them at Cambridge.

College Life.—There are 18 Colleges, at each of which are 2 to 4 R.E. officers. Every College is an independent republic, and so expenses and customs vary to some extent at each one of them. There are many handbooks that give full information about the Colleges, and it is not proposed to give more here. R.E. officers are in exactly the same position in College as other students. They are subject to all College and University discipline, wear cap and gown, and are in fact undistinguishable from ordinary undergraduates. In this way they have the fullest chance of joining in College life, whilst the College authorities appreciate the subordination to their authority, and are the more inclined to look favourably on a scheme, which, from their side, has no great advantages. 1,500 Freshmen came up last term, and the total number at the University is not far from double the highest pre-war figure. Every College has a long waiting list, and it was no small concession on their part to admit temporary one-year students to these much sought-after vacancies.

MODERN TENDENCIES IN MARRIED QUARTER DESIGN.

THE housing question is one of the greatest problems which the nation has to face at the present time, and the army's share in this is by no means the least of the problems before the Chief Engineers of all Commands. The provision of married quarters for the rank and file is a part only of the housing of the Army, but—with married quarters for officers—it is the matter in which, of all works questions, supply falls furthest short of demand.

The publications of the Ministry of Health lay down for the first time what may be called a "Synopsis scale" for the housing of the nation, and it is well to realize the points in which the army's needs differ from those of the nation at large. The married soldier should clearly be as well housed as his relative in civil life, and in fact, where the 1911 Barrack Synopsis has been followed, he is actually far better housed than the average of the nation at present. This cardinal difference exists between the civilian and the soldier, that while the former may live in the same house all his married life, the soldier except in rare cases lives no more than 5 years in the same quarter; and these years are normally the earliest of his married life There is therefore little objection to temporary or hutted married quarters—and indeed there is no possibility of funds being available for years to build permanent quarters on a large scale. Further, the number of soldiers' families with more than one or two children will always be small. The proportion of "a," "b," and "c" (one, two, and three-bedroom) quarters is laid down in the 1911 Synopsis as, roughly, 55 to 35 to 10, and it is not likely that this scale will be varied in any way. The "a" quarter is fully large enough for the married soldier until the second child arrives or the first grows out of infancy; and this must normally mean a period of at least 2 years after marriage.

With this exception, there is no doubt that but for the war the Synopsis scale would have risen by this time to that of the Ministry of Health's non-parlour type of cottage. Shortage of funds may compel us in some cases to work to a slightly lower standard, but it is obvious that the shorter the funds the greater the need for skill and care in planning to ensure maximum comfort at minimum expense.

The sizes of rooms laid down in the 1911 Synopsis are adequate. It is a counsel of perfection that all rooms should open on to a lobby or passage. With care, this is attainable without undue expense in the great majority of plans, and only where the site is extremely restricted should the designer be satisfied with any arrangement of rooms opening off each other. Nothing wastes the available space in a room so badly as doors. In a certain very new housing scheme (for which the War Department is not responsible) some living rooms of 140 feet super have three doors—one leading to the entrance lobby and two to bedrooms which have no other doors. The working and living space in these rooms is thus reduced to about 80 feet super. Still worse, in fact quite inadmissable, is a bedroom opening off another. The objections to this are obvious and need not be laboured. Bedrooms should never be designed without consideration of the position of the bed. In the main bedroom a 4′ 6″ bed and a small cot should be legislated for. In many small bedrooms the fireplace is so sited as to prevent a bed being placed along the wall on the fireplace side; a very small movement of the fireplace would have put matters right, but this never entered the head of the designer.

Whether cooking should normally be done in the living room or the scullery is a question still under discussion. Under the present scale of fuel allowance the soldier cannot afford more than one fire, and this fire must therefore cook his meals. During the winter the same fire must warm the quarter, and hence its proper place is the living room. During the summer, however, a fire in the living room is naturally objectionable, and it is desirable to confine cooking operations to the scullery. There are two ways of solving the problem which obviously presents itself. The first, which is the cheapest for the soldier, is the provision of a grate of a pattern like the double "Servall." This is only possible when the living room and scullery are back to back and separated by a partition wall. The double

"Servall" grate provides a fire in each room and has a single oven above the fires with doors into each room. It is possible therefore in winter to light the fire in the living room and by its heat to do all the cooking operations which necessitate the use of the oven in the scullery. In summer the fire can be lighted on the scullery side. The "Servall" grate unfortunately is rather costly and at present difficult to obtain; also, the planning of most existing quarters makes the arrangement impossible. The second solution of the problem consists on the provision of an ordinary small cooking range with open fire in the living room and a gas cooker with penny-in-the-slot meter in the scullery. The objection to this is that in winter cooking cannot be confined to the scullery unless the soldier is able to bear the cost of a coal fire in the living room, plus the gas required for cooking.

Another factor in the problem has not been mentioned; the conservative tendency of many families to eat in the room in which the food is cooked. No doubt this saves the housewife trouble in the carrying of food and crockery. It has led to the suggestion that the normal quarter should be designed with a roomy kitchen-scullery and a small living room. Whatever the views of the lady of the house on this arrangement might be, there is little doubt that it would mean a most uncomfortable quarter for the soldier. The living room would degenerate into a "Parlour" and would not be "lived in"; and the soldier would have to spend his time at home amid the operations of a scullery, which are distinctly unpleasant to live with. If cooking is to be done in the scullery therefore the latter should be just large enough for its purpose and not large enough to take a dining table as well.

The question of washing and sanitary arrangements next calls for comment. Whether there is a laundry provided outside for the use of the married women or not, there should be within each quarter facilities for the washing of clothes. Such facilities must include arrangements for boiling and rinsing the clothes. For the boiling process, a copper is required; for the rinsing, a bath is suitable. Apart therefore from the question of personal ablutions, a bath of sorts is undoubtedly desirable. In the Synopsis a copper and a sitz bath in the scullery are included, and this arrangement, though not ideal, meets the actual needs of the case; and if the scullery is large enough to take a bath there is no justification under present conditions for departing from this ruling. The provision of a slipper bath of a small size—4′ 6″—may be authorized in new quarters, and the placing of it in a separate room, where circumstances permit, undoubtedly makes it far more useful for personal use. The laying-on of hot water from a h.p. boiler, involving as it does expensive plumbing and constant trouble in maintenance, under present conditions cannot be considered, and hot water for the bath must be normally obtained from the copper. From every point of view therefore the bath must be close to the copper, and it may be possible and advantageous sometimes to put both the copper and bath in a separate small "washing-room," in which there should also be some sort of washing tub—a deep sink is suitable. If gas is provided for cooking in the scullery, the copper may be gas-heated.

The W.C. must on no account open off the scullery or living room or be adjacent to the larder, without the interposition of a properly ventilated lobby. If a separate bathroom be provided, it may be necessary to put the W.C. apparatus in it, and this sometimes saves expense in water supply pipes. It is however an inconvenient arrangement, inadmissable if the bathroom is designed as a wash-house, and can generally be avoided by careful planning.

The larder may be a small ventilated cupboard, and there is no great disadvantage in its opening off the living room or scullery, provided that it is not near the heat of the cooking stove, and that the convenience of the rooms is not prejudiced by the presence of the larder door. The coal cupboard can be smaller than is usual in civil life as the married soldier receives a weekly ration. There should if possible be a recess on the ground floor capable of taking a bicycle and perambulator. Stairs should be well lit, winders should be avoided if possible and in any case not inserted at the top of flights.

The above remarks may it is thought, be of use to officers who have to design new married quarters whether in new construction or in converted hutting. The adoption however of some of the counsels of perfection given, in temporary buildings, or in existing married quarters, must be governed not only by the availability of funds but also by consideration whether the buildings are structurally worthy of detailed improvements.

NOTES ON MILITARY BRIDGING.

1.—A great deal of discussion and a certain amount of experimental work has been carried out on military bridging during the last two years, and the whole subject needs now to be reviewed.

2.—Military bridging can be divided into four phases :—

(*a*).—The construction of a bridge to enable infantry to fight their way across an obstacle which is closely defended by the enemy.

(*b*).—The construction of a bridge to enable field guns and first line transport (light loads) to cross an obstacle which is under shell fire.

(*c*).—The construction of a bridge to enable lorries and the 6-inch howitzer and 60-pndr. gun (medium loads) to cross an obstacle.

(*d*).—The construction of main road bridges to take siege artillery and the heaviest military traffic.

It is only proposed in this paper to discuss bridging equipment and to leave out the whole question of improvised bridges. In this way we are at once reduced to two types—the service pontoon equipment, and stock span girder bridges. The former will be taken first.

3.—As regards (*a*) it is generally agreed that a light floating bridge (of the cork float type) fills our requirements. The old idea of a bridge of half sections of pontoons is too heavy and cumbersome for use under fire. A light floating bridge of this nature requires to be standardized. Many different types were used during the latter part of the war. Some were better than others, but they were all capable of improvement. An inferior design may cost the lives of many officers and men and we should not be satisfied with any but the very best possible design.

4.—As regards paras. (*b*), (*c*) and (*d*) we know at the moment that we can produce satisfactory bridges to fulfil our requirements in the following three ways:—

(1).—By constructing a light bridge by using decked-in pontoons at 15 feet intervals and a superstructure of bridging baulks and single chessing.

(2).—By constructing a medium bridge with piers which consist of six half sections of decked pontoons and 21ft. steel joists with double chessings.

(3).—By constructing a heavy bridge with piers which consist of eight half sections of decked pontoons and 21ft. steel joists with treble chessing.

We must now discuss the methods by which we can obtain the full use from these three bridges; then when we have collected our ideas as to their correct use we can proceed to discuss the more detailed designs of these three bridges.

5.—Now the suggested method of using these bridges can best be illustrated by examples:—

The infantry have forced their way across a river but are hard pressed and require field artillery support. The river is under heavy shell fire and the construction of a bridge will be a difficult undertaking. The lightest and best possible pontoon equipment which will carry field guns is required. For this work a pontoon equipment in its present form or something very like it is necessary. We will now take another example. The infantry have crossed a river and are driving the enemy back rapidly. The river is not under heavy shell fire, and will probably soon be out of range of the enemy's field guns. There is a demolished bridge on the main road across the river. In this case the river should at once be bridged at this point with a pontoon bridge to carry medium loads, for it is obvious that lorries will want to cross this river at the earliest possible moment. In some cases a light bridge will be built first and converted later to a medium bridge, but as a rule if light bridges are built first to take the field guns they should be constructed clear of the main roads. The medium bridge can then be built without interfering with the passage of artillery wagons over the light bridge. If there should be a shortage of pontoons the light bridge can be broken up at the last moment to form the last few piers in the medium bridge. In many cases no light bridges would be built at all and the first bridge put across the river would be a medium bridge. The difference in the time required for the construction of a light and medium pontoon bridge will not be great. A river such as the Aisne at Soissons may be taken as an average case and is about 200ft. wide; and the difference in bridging this river for light and medium loads would probably not be more than one hour. It is true that much more material and transport is required to bridge such a river for medium loads than light loads, but the total amount is small in either case. Fifteen lorries with trailers would be sufficient to bring up the equipment for a medium bridge across this river.

6.—The light bridges built with pontoon equipment should therefore be considered as emergency or fighting bridges. The approaches would not as a rule be required to be timbered or made good because the bridge should only be in use for a short time, and the site of these bridges might often be chosen from tactical reasons rather than from a point of view of their proximity to a road, or suitability of the approaches, etc. The equipment for the construction of these bridges would be drawn from the Divisional Bridging Train; it would be taken as far as possible by lorry, but might require to be horse-drawn to the site of the bridge.

7.—The equipment for the medium bridges should be sent up from the Corps Bridging Train, being supplemented if necessary by the Divisional pontoons.

8.—In colonial warfare the light bridges might be of comparatively greater importance, but the use of lorries and construction of main roads is extending rapidly to the colonies. Moreover, the field artillery and first line transport may become tractor drawn, in which case a bridge for light loads will probably cease to be required.

9.—As regards sub para. (*d*) in para. 2 we have seen that a bridge to take heavy loads can be constructed from the service pontoons (decked-in) by using piers of eight half sections and eight steel joists. In European warfare when the siege artillery may be close up with the field army, it might be desired to build a heavy bridge straight away instead of a medium bridge. As a rule a comparatively small number of heavy bridges would suffice; for instance on a front of three miles we might find say three medium bridges and one heavy bridge, some or all of which might be replaced later with girder bridges. In colonial warfare and even at times in a European war the army might advance purely as a field army without siege artillery, and medium bridges might cover all requirements.

10.—The present service equipment includes a bridging trestle—the Weldon Trestle. This trestle is required in connection with the pontoon equipment for the following work.

(*a*).—For use in tidal ramps.

(*b*).—To save the risk of damaging pontoons by grounding on a hard bottom near the banks.

(*c*).—For use over swampy ground on the approach to the bridge.

(*d*).—For crossing dry gaps or craters on roads.

In pre-war days when the old medium bridge (present light bridge) was the main military bridge there was every reason to retain the Weldon Trestle for the work indicated above; but now that this bridge is an emergency bridge the necessity for the Weldon Trestle is far less apparent. If the water is shallow near the banks and the end pontoon grounds, it may be damaged, but the bridge will not fail (especially with the new decked-in pontoon which is considerably stronger in this respect) and when constructing a fighting bridge the risk of damaging a pontoon is of small importance compared with the loss of time in erecting a Weldon Trestle.

During the war Weldon Trestles were used on many occasions as indicated in (*d*), but for this work it seems eminently desirable to erect a trestle which will carry medium loads.

Now a new trestle has recently been designed of steel which weighs 40% more than the Weldon Trestle but will carry medium loads (the Weldon Trestle will only carry light loads). This trestle is quicker in erection than the Weldon Trestle, and it is now suggested that this trestle should be adopted instead of the Weldon. It would rarely be used with a light bridge, but would be of great value for medium bridges, and a tower built of two of these trestles would serve to carry heavy loads.*

11.—As regards girder bridges, a large number of types were evolved during the war, but with two exceptions they all aimed at carrying the heaviest loads over spans which varied in length up to some 150ft. The two exceptions were the Inglis light and Inglis heavy pyramid bridges. Now a conference was held at Chatham in August, 1920, to consider the retention of the various bridges. The Inglis light pyramid bridge was considered worth retention to assist in the first phases of an advance. The Inglis heavy pyramid was

* *Note.*—This trestle was described in the January, 1921, number of *R.E.J.*

not considered worth retention. Of the various remaining girder bridges it was found necessary to recommend the retention of five different types and the introduction of a further light girder bridge for medium loads. Since that date, a new type of girder bridge (the box girder) has been designed, which may replace all the shorter stock span girders and this bridge is adaptable to carry any desired load (light, medium, or heavy). In a few months' time we shall know considerably more about the possibility of girder bridging in this manner and it is therefore not proposed to discuss girder bridges any further in this paper.

12.—We can now consider the detail design of the three types of pontoon bridge enumerated in the first part of para. 4. It is generally agreed that it is important to have the simplest possible type of pontoon equipment in which every part is inter-changeable and adaptable and which contains as few separate and different parts as possible. The decked in pontoon appears to be desirable in almost every way. By using decking the available buoyancy is almost doubled, and the pontoon remains quite easy to row. The swamping of a pontoon by the water rushing over the bows in a swift stream is rendered impossible. The additional weight is 600lbs. per complete pontoon at present, but this can be reduced—probably to about 400lbs. (or even less). If this can be done the decked-in pontoon appears to be quite satisfactory for all three types of bridge. It has been pointed out that the half pontoon is no longer required and that the service pontoon should be made in one piece. This however has the following disadvantages:—

(1).—A pier of six half sections cannot be made.

(2).—If one end of a pontoon is smashed the whole pontoon is rendered useless for the time being.

It would therefore appear to be desirable to retain the bipartite pontoon. In fact the present pontoon, if decked-in and fitted with strengthened couplings will provide a very satisfactory pontoon for every type of pontoon bridge.

13.—As regards the light bridge it has been urged that the bay should be made 21ft. instead of 15ft. so as to simplify the changing from light bridge to medium bridge. Now the light bridge carries a 2-ton axle load and if it were a matter of strengthening this bridge to carry a 3-ton or 4-ton axle load, it might be possible to carry out the work with little or no obstruction to the traffic. We have however to increase the strength of the bridge four times, *i.e.*, to take an 8-ton axle load. It is therefore out of the question to do this without obstructing the traffic, but can we introduce any system whereby the change over will be very rapid, so as to cause the least possible obstruction to the traffic? A suggestion has been made that the light bridge should consist of 21ft. bays and piers of two pontoons side by side. This however is not recommended for the following reasons :—

(1).—The construction of the light bridge would become a slower operation and therefore much more difficult under fire.

(2).—It is doubtful if the process of changing bay by bay from light bridge to medium bridge would be of any great advantage. On a river which was 200ft. wide the whole operation of changing from light bridge to medium bridge could be carried out in one hour by breaking up the light bridge entirely and rebuilding as a medium bridge.

(3).—In most cases the light bridge (if built at all) should be constructed clear of the site for the medium bridge, and this problem would not arise.

14.—A continuous girder has been designed by Major Inglis for use with the pontoon equipment and will be tested in some six months' time. This will probably provide a very good main road bridge for wide rivers, but will hardly fill our requirements for hasty pontoon medium bridging over average size rivers in a rapid advance. It is possible that the box girder design may be satisfactory as a continuous girder in the Inglis pattern bridge. The decked in pontoon will be very suitable for use under a continuous girder.

15.—In the equipment which has been tested at Christchurch the following are the only parts required for any of the three bridges.

(1).—Decked-in pontoon.
(2).—Existing pattern pontoon saddle.
(3).—Existing pattern bridging baulks.
(4).—Existing pattern chesses.
(5).—Existing pattern ribands.
(6).—New design of short baulk.
(7).—New design of steel joist saddle.
(8).—New design of steel joist road-bearer.
(9).—New design of steel kerb.
(10).—New design of trestle.
(11).—The existing pattern accessories such as anchors, cables, etc.

It is thought that when certain detail improvements have been made and the weight of the decked pontoon reduced, this equipment should fulfil all the requirements of the Army.

16.—There remains the question as to how and where the pontoon equipment should be carried. In the eventual future the transport of an Army will no doubt travel on tracks, but for the moment we must keep to lorries and horses. The following is therefore suggested :—

(*a*).—The Divisional Bridging Train should carry light bridge equipment only (but pontoons decked-in) ; the equipment to be carried in a strengthened type of pontoon or trestle wagon towed behind a lorry, but capable of being horse-drawn when necessary. The lorries themselves to carry a bridge equipment of the cork float bridge type. In this way the Division will be always prepared to meet any emergency with its own bridging equipment.

(*b*).—The Corps Bridging Train to carry pontoons and superstructure for medium bridge (this is also suitable for a shorter length of heavy bridge) and a small reserve of timber baulks for the light bridge. Also a small reserve of the cork float type of bridge. Medium bridge pontoon equipment would be sent up to Divisions as and when required.

(*c*).—Army Bridging Parks and Engineer Stores would hold reserves of every form of pontoon equipment, girder bridges, and bridging stores. Any girder bridges could be sent up by lorry to the Corps or Division when required.

17.—To sum up therefore the following are the recommendations made in this paper :—

(*a*).—Further detail experiments to be carried out to reduce the weight of the decked pontoon and if successful that this type of pontoon should become universal.

(*b*).—The pontoon equipment as tested at Christchurch to be standardized after further trials (and possibly minor detail alterations) as the pontoon equipment for the Army.

(*c*).—That a floating bridge of the cork float type (but not necessarily cork) be standardized.

(*d*).—That the Divisional Bridging Train should carry light pontoon bridge equipment in trailers behind lorries. The trailers to take the form of strengthened pontoon wagons capable of being horsed. Also that these lorries should carry the standardized cork float bridges.

(*e*).—The Corps Bridging Train to carry medium bridge pontoon equipment and the new type steel trestle on the same type of trailer as used in the Divisional Train. This equipment will build up into a shorter length of heavy bridge as desired.

(*f*).—The question of girder bridges to be reviewed later when we know more about the possibilities of the box girder bridge.

BOOKS ON CIVIL ENGINEERING.

(Continued from January).

7. FOUNDATIONS (INCLUDING FOUNDATIONS FOR MACHINERY).

FOUNDATIONS AND MACHINERY FIXING.—By F. H. Davies, A.M.I.E.E. Published by Constable and Co. Price 2/-.

Deals with the Design and Construction of Foundations for Machinery of various types.

Chapters I. and II., Foundations Generally. Chapter III., Design, The Proportion of Foundations for Engines, Turbines, and Dynamos. Chapter IV., Materials for Foundations. Chapter V., Holding-down Bolts and Anchor Plates. Chapters VI. and VII., Practical Construction. Chapter VIII., Vibration, its causes and effects. Chapter IX., Methods of Isolating Machinery, to prevent the Vibration affecting the neighbourhood. Chapter X., Fixing of Electric Motors.

A PRACTICAL TREATISE ON FOUNDATIONS.—By W. M. Patton, C.E., formerly Professor of Engineering at the Virginia Military Institute. Second edition. Published by Chapman and Hall, Ltd. Price 23/-.

A comprehensive work explaining fully the Principles involved, and containing descriptions of all the most recent structures with numerous drawings.

An accurate record of the Bearing Resistances of Materials as determined from the Loads of actual Structures is included.

Contents :—Part I.—Foundation Beds. Foundations. Concrete. Building Stones. Quarrying. Stereotomy. Masonry. String Courses and Coping. Ice and Wind Pressure. Retaining Walls. Arches. Skew Arches. Brick. Brick Arches. Box Culverts. Cements and Hydraulic Limes. Mortar. Sand. Stability of Piers. Water way in Culverts. Arch Culverts. Cost of Work. Dimensions. Quantities and Cost. Definitions and Tables.

Contents :—Part II.—Timber Foundations. Coffer Dams of Timber. Open Caissons. Cushing Cylinder Piers. Sounding and Borings. Timber Piers. Framed Trestles. Properties of Timber. Durability of Timber. Preservation of Timber. Joints and Fastenings. Trestle Foundations. Timber Piles. Piles. Comparative Estimates of Costs of Framed and Pile Trestles. Embankment of Earth on Swamps.

Contents :—Part III.—Deep and Difficult Foundations. Pneumatic Caissons. Caisson Sinking. Combined Crib and Caisson. All Iron Piers. Location of Piers. Poetsch Freezing Process. Quicksand. Foundations for High Buildings. High Buildings.

8. MASONRY STRUCTURES.

EARTH PRESSURES, WALLS AND BINS.—By W. Cain. Published by Chapman and Hall. 13/6.

Chapter I., Laws of Friction and Cohesion ; Tables ; Direction and Distribution of Stress. Chapter II., Thrusts of Non-cohesent Earth ; Graphical Methods. Chapter III., Analytical Methods. Chapter IV., Design of Retaining Walls of Stone or Reinforced Concrete. Chapter V., Cohesent Earth. Chapter VI., Bin Theory.

A TREATISE ON MASONRY CONSTRUCTION.—By I. Baker. Published by Chapman and Hall. 25/-.

Deals very completely with the subject.

Part I., Materials. Part II., Preparing and Using the Materials. Part III., Foundations, Ordinary, Pile and Under Water. Part IV., Dams, Retaining Walls, Bridge Abutments and Piers, Culverts and Masonry Arches.

Appendix I.—Specifications.

Appendix II.—Supplementary Notes.

9. CONCRETE AND REINFORCED CONCRETE.

MANUAL OF REINFORCED CONCRETE AND CONCRETE BLOCK CONSTRUCTION.—By C. F. Marsh, M.I.C.E., and W. Dunn, F.R.I.B.A. Published by Constable and Co., London. 1 vol. ; 8vo. ; pocket size ; 3rd edition ; 1916. Price 10/6.

Part I., Materials. Part II., Construction. Part III., Waterproofing and Fire Resistance. Part IV., Loads, Bending Moments, etc. Part V., Calculations. Part VI., Hollow Concrete Blocks. Part VII., Tables, Diagrams, and General Information.

Gives in handy form the methods employed for the solution of everyday problems, with the information most frequently required in as condensed form as possible consistent with clearness. Demonstration and reasoning upon which formulæ are based are mostly omitted. Practical construction is fully dealt with. There are numerous labour-saving tables. Strongly recommended.

CONCISE TREATISE ON REINFORCED CONCRETE.—A companion to "The Reinforced Concrete Manual." By C. F. Marsh, M.I.C.E., and W. Dunn, F.R.I.B.A. Published by Constable and Co., London. 1 vol.; 8 vo.; 1909. Price 7/6.

Chapter I., Properties. Chapter II., Behaviour under Loading. Chapter III., Assumptions for Calculation. Chapter IV., Methods of Calculation. Chapter V., Methods of Reinforcement.

This supplements the "Manual," matters dealt with there being mostly omitted from this book, while the derivation of fundamental formulæ is fully explained.

CONCRETE ENGINEERS' HANDBOOK.—Data for the Design and Construction of Plain and Reinforced Concrete Structures.—By G. A. Hool, N. C. Johnson, and S. C. Hollister. Published by McGraw-Hill Book Co., New York (Hill Publishing Co., London). 1 vol.; 8 vo.; 1918. Price 25/-.

CONCRETE, PLAIN AND REINFORCED.—By Taylor and Thompson. Published by Chapman and Hall, Ltd. 27/6.

Deals with the Materials, Construction, and Design of Concrete and Reinforced Concrete.

Chapter I., Essential Elements. Data on Handling Concrete Labour, Costs of Hand Mixing, Weights and Volumes. Chapter II., Selection of Materials, Proportions, Quantities, Tools and Apparatus, Construction of Forms, Mixing and Laying, Cost and Strength of Concrete. Chapter III., Specification for Reinforced Concrete. Chapter IV., Classification of Cements. Chapter V., Chemistry of Hydraulic Cements. Chapter VI., Specification of Tests of Cement. Chapter VII., Tests of Aggregate. Chapter VIII., Voids and other Characteristics of Concrete Aggregates. Chapter IX., Strength of Composition of Cement Mortar. Chapter X., Preparation of Materials for Concrete. Chapter XI., Tables of Quantities. Chapter XII., Preparation of Concrete. Chapter XIII., Mixing Concrete. Chapter XIV., Depositing Concrete Chapter XV., Effect of Sea-water. Chapter XVI., Laying Concrete during Frost. Chapter XVII., Destructive Agencies. Chapter XVIII., Water Tightness. Chapter XIX., Strength of Plain Concrete. Chapter XX., Theory of Reinforced Concrete. Chapter XXI., Tests of Reinforced Concrete. Chapter XXII., Design. Chapter XXIII., Building Construction. Chapter XXIV., Foundations of Piers. Chapter XXV., Beam Bridges. Chapter XXVI., Arches. Chapter XXVII., Dams and Retaining Walls. Chapter XXVIII., Conduits of Tunnels. Chapter XXIX., Reservoirs and Tanks. Chapter XXX., Pavements and Side-walks. Chapter XXXI., Cement Manufacture.

This book is especially valuable, but the Methods of Design of Reinforced Concrete, given in Chapter XXII. are not of such universal application as those given by Marsh and Dunn in their Manual of Reinforced Concrete. The author very clearly explains in Chapters XX. and XXI. certain valuable information of Tests of Reinforced Concrete.

REINFORCED CONCRETE CONSTRUCTION, PART I.—By M. T. Cantell. Published by Spon and Co., 5/-.

A somewhat elementary, but excellent little book, giving a full table of formulæ and 30 worked out examples of columns, singly and doubly reinforced beams and T Beams.

ELEMENTARY PRINCIPLES OF REINFORCED CONCRETE CONSTRUCTION.—By Ewart S. Andrews. 2nd edition. 1918. Published by Scott, Greenwood and Son. Price 5/5.

This little book of 200 pages is Vol. 1 of the "Broadway Engineering Handbooks."

From the principles of Applied Mechanics, the author evolves the fundamental equations connecting the Moment of Resistance of R.C. Beams with their size and the amount and position of the enclosed steel.

These equations are the basis of all the graphs given by modern English writers. Rectangular Beams, singly and doubly reinforced, and T beams are dealt with. A Chapter on Combined Bending and Axial thrust will be found useful in considering the stability of a small R.C. arch that does not require the Elastic Theory. Shear is rather sketchily dealt with. Columns, both simple and jacketted, are dealt with in the usual way. 25 Exercises are given at the end, but there are several printer's errors in the answers.

Appendix I. gives the Reinforced Concrete Regulations of the London County Council.

Appendix II., Numerical Tables, Logarithms, Trigonometrical functions, Squares, Cubes, etc. Areas of Circles, Metric Equivalents, Areas of Grouped Bars.

(To be continued).

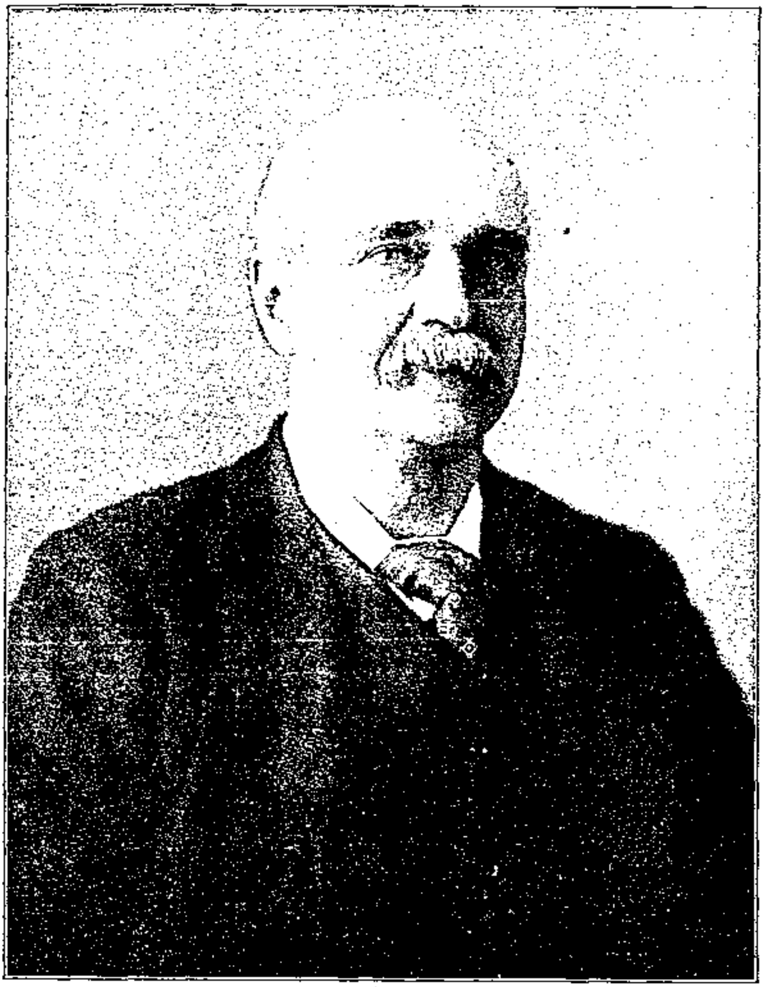
MEMOIR.

SIR W. de W. ABNEY, K.C.B., D.Sc., F.R.S.

BY the death on December 2nd, 1920, of Sir William Abney there passed away at the age of 77 one of the notable figures of the scientific world of the past forty years, and one whom the Corps of Royal Engineers can fairly claim as her own. Though he held rank as an R.E. officer only for twenty years, retiring as a Captain at the early age of 38, he never lost the sense of comradeship with and affection for the Corps and always took pleasure and pride in the fact that he belonged to it. In truth his retirement hardly severed his active connection with it. The department of Science and Art, which he had by then entered and to which the whole of his official life was thenceforward devoted, was manned nearly exclusively by R.E. officers, so that it was in effect almost a branch of the Corps devoted to civil administration. When the present organization of the Board of Education was set up in 1903 this department was abolished, and Abney, the last survivor of the R.E. staff, who had by then been promoted by successive steps to the post of Principal Assistant Secretary in the Board of Education, found himself compelled to retire, serving afterwards, up to the time of his death, in the honorary capacity of Scientific Adviser to the Board. His official career was, however, even to himself, the unimportant side of his life; what he will be remembered as, and what he himself would wish to be remembered as, is as one of the great pioneers in the sciences of photography, light and colour vision. It would be inappropriate here to undertake any detailed review of his work, but a short summary of it will not be out of place.

Abney most markedly had the true scientific spirit, the determination to know and the wish to improve, and everything he touched was imbued with this spirit. He was born in 1843 and entered the Corps through the Royal Academy in 1861. The first ten years of his service spent in part in India were uneventful. In 1871 he was appointed to the staff of the School of Military Engineering as Assistant Instructor in Telegraphy, and was given charge of a very small photographic establishment and a chemical laboratory, then constituting part of the Electrical School.

He now found himself in a position to take up original work and his first scientific paper "On Electrical Pyrometry" appeared in the Philosophical Magazine for 1872. It was however to photography that his chief attention was directed. He at once



Capt. Sir William de W. Abney, K.C.B., F.R.S.

formed classes of officers and men for studying this subject and the first edition of his book *Instruction in Photography*, destined afterwards to reach its eleventh edition and to be the guide of innumerable students of the art, was printed at the S.M.E. in 1871 as a small pamphlet for the use of his classes. Under his energetic direction the importance of photography became apparent and it was found impracticable to retain this subject under the tutelage of the Instructor in Electricity. A separate Chemical and Photographic School was accordingly formed in 1874 and Abney became Assistant Instructor in Chemistry and Photography, an office in which he had many successors, and which remained in being until recent years, when the twin schools were merged into the Survey School. In 1877 he left Chatham, handing over his school to Capt. Leonard Darwin, and joined the Department of Science and Art at South Kensington then under the direction of that able administrator, the late Sir John Donnelly, R.E. There he at once established a laboratory, placed in one of those hideous iron buildings known to two generations of Londoners as the "Brompton Boilers" and for nearly thirty years that laboratory was the source and fount of an unending stream of original experiment and research.

From 1874 onward Abney was so intimately connected with the advance of photography as an exact science that to give a narrative of his work would be in effect to write a history of that science. Those curious may read this history in the *Encyclopædia Britannica*, Article "Photography," but they must bear in mind that this article was written by Abney himself and cannot be taken as a completely adequate account of his own contributions. In 1874 the only extensively used photographic process was the collodion "wet-plate." The gelatine dry-plate, though actually first made in 1871, was then in its infancy, and the various dried collodion plates and collodion emulsions, in which Abney was one of the foremost experimenters, were only used by a few eager inquirers. In 1878 and 1879, due mainly to advances made by Bennett and Abney in this country and van Monkhoven on the continent, a rapid gelatine emulsion for all practical purposes identical with that used to-day was first produced and the modern "instantaneous" photography made possible. All the later advances; the improvement of the sensitiveness of the plate both to white light and to colours; the preparation of half-tone and process blocks for printing; the development of three-colour work; the measurement of the sensitiveness of plates and the use of photography for accurate photometry, found Abney either as discoverer or, where not the actual inventor, an early and acute investigator and critic. His communications to scientific societies and journals numbered considerably over one hundred. A mention of a few of the most important of these will indicate the variety and high character of his work. Thus we note one in 1874 on Dry Plate Processes for Solar Photography, describing the most efficient methods of preparing and using collodion dry plates; this was in connection with the Transit of Venus in that year, for which Abney was given complete charge of the arrangements for photographic observations; in 1877 one on the action of Alkaline Developers, showing for the first time the chemical reactions which took place when such developers were applied. This had been one of the great advances made in collodion dry-plate photography though their use up to that time was entirely empirical and the users did not bother about the chemistry so long as they got the results. Such an attitude was entirely repugnant to Abney's scientific spirit and to him it would have been unthinkable to employ any process without making every endeavour to understand it completely, and thus, by this understanding, render further advance possible. In 1880 the Royal Society published his great paper "On the Photographic Method of Mapping the Least Refrangible End of the Solar Spectrum," wherein he described his investigations, begun while he was at Chatham in 1875, on the preparation of a plate sensitive to rays far beyond the visible region of the spectrum. A further and more complete memoir on the same subject appeared in 1886. This was one of the most remarkable researches made by him. He succeeded in obtaining an emulsion of bromide of silver in collodion which was sensitive not only to the red and infra-red rays but was impressed even by heat rays given out by bodies far below the incandescent point. He is said to have photographed a boiling kettle in a completely dark room. With this emulsion the use of the ordinary photographers' "dark room" with its red light was impossible and such manipulations as could not be done in absolute darkness were carried out under the illumination of a very feeble green light.

In another paper he recorded the application of these hypersensitive plates to the study of the absorption of the infra-red rays by organic bodies leading to important indications of their molecular grouping. In this part of the work he was assisted by the late Col. Festing, R.E. In 1882 the Council of the Royal Society awarded him the Rumford Medal in recognition of the value of this advance and his other contributions to scientific photography.

Other notable papers were on the transmission of sunlight through the earth's atmosphere, founded largely upon an extensive series of observations carried out at the Riffel Alp where the stone pillar used for supporting his instrument is still preserved as a historical monument; several on the effect of different regions of the spectrum upon silver salts; upon the precise measurement of the sensitiveness of photographic plates, and upon colour vision. He was also the author of three standard books upon photography, each of which went through many editions, *Instructions in Photo-*

graphy, *Photography with Emulsions*, and *A Treatise on Photography*, and several books on the theory of colour and colour vision.

The scientific side of his photographic work was not the only one that interested him or in which he excelled; he was himself an artist in water colours of considerable proficiency and most untiring industry, and devoted much attention to the artistic aspect of the science and to the production of views, both in England and in the Alps, exhibiting in a high degree the picture-making capacity of the camera.

He was elected a Fellow of the Royal Society in 1876 and served, at different times, in the office of President to the Royal Astronomical, the Royal Photographic, and the Physical Societies; also as Chairman of the Royal Society of Arts. He was President of Section A (Physics) at the British Association in 1889, when he gave an address summarising in a masterly style all that was then known of the theory of photographic action. He was a keen traveller, and was filled from youth with a love of the high mountains which never deserted him; for many consecutive years he spent his summer holidays in Switzerland or in the Italian Alps. In 1874 he was in Egypt superintending the observations of the Transit of Venus as visible at Thebes and brought home a most extensive and valuable series of photographs of the tombs and temples, then known to comparatively few people. In 1882 he planned another visit to Egypt to observe the total solar eclipse in May that year but at the last moment was prevented by temporary ill-health from making the journey.

He was created K.C.B. in 1904, a compliment, as he was fond of explaining to his friends, paid to his scientific work, not to his official career, and held honorary degrees from several universities. His activities were so many-sided and so various that it is impossible to do justice to them in the space here allowable and his friends will doubtless find many omissions. He was a most lovable character and a stimulating companion and no one who had the privilege of his friendship can ever forget it. He married twice and is survived by Lady Abney, a son and two daughters of the first, and one daughter of the second marriage.

E.H.G-H.

CORRESPONDENCE.

AN EXPLORATION IN SOUTH-EAST TIBET.

To the Editor, R.E. JOURNAL.

DEAR SIR,—I observe in the number of R.E. JOURNAL for January, 1921, an interesting article by Major H. T. Morshead, D.S.O., R.E., describing his personal experiences of an exploration in South-East Tibet.

In his brief historical retrospect on page 22, he drops into an inaccuracy which has unhappily deprived a brother officer of the credit due to him. I allude to the phrase in the penultimate paragraph of the page, "the military and political expedition to Lhasa under Colonel Younghusband in 1904–5."

Colonel Younghusband was the head of the political mission that accompanied the military expedition to Lhasa under the command of Brigadier-General J. R. L. Macdonald, now Maj.-General Sir J. R. L. Macdonald, K.C.I.E., C.B., late Royal Engineers.

I feel sure Major Morshead is not desirous of suppressing the distinguished service of a brother officer of a former generation.

Yours very truly,

J. A. FERRIER, *Maj.-General* (*late R.E.*).

NOTICES OF MAGAZINES.

MILITÄR WOCHENBLATT.

NO. 17.—*The Military-Political Situation.*—French support of Poland is, as usual, attacked and so is General Niessel, in command of the French Mission in that country. The British attitude towards the Soviet Government is described as undecided, chiefly because of the sympathy with which so many of the so-called working classes regard it. Lloyd George is not acquitted of holding similar opinions. England is stated to have no desire to play at being the strong man in a military sense, and her many responsibilities are enumerated, but Germany is warned to expect no concessions from this direction, because, through the madness of November, 1918, she is too feeble to demand them. The *M.W.B.* is surprised to see that the Franco-Belgian agreement has attracted so little attention in England; it declares that the agreement is not really directed against Germany, but against England and Holland.

French Propaganda in Sweden.—The correspondent of the *M.W.B.* in Sweden draws attention to the active steps being taken in that country by France to divert her sympathies from Germany. A Swedish mission has been invited to come and study the battlefields; several Swedish officers are being attached to various units and schools in the French Army; French Universities are offering to take Swedish students at specially reduced fees; and tourist parties, to show Swedish travellers the devastated areas, are being advertised. The *M.W.B.* finds that these efforts are not being altogether unsuccessful, since the French minister in Stockholm has recently been offered 300,000 kroner to be devoted to rebuilding the town hall in Craonne.

No. 18.—*Ludendorff.*—A book on Ludendorff is reviewed at greater length than it appears to merit. The author attributes all Germany's misfortunes to this man, who is declared to have been afflicted with among other weaknesses, the following—"Paucity of ideas, helplessness, lack of foresight, dishonesty, obstinacy, a liking for public-house politics, illusions, fear of the truth, and confusion of mind." His moral character is then attacked in a way that must surely come within the scope of any reasonable law of libel. The author's strategic ideas are not less striking; according to them Germany should have dealt a heavy blow on India, through Central Asia. It is curious that such nonsense can get a hearing in modern Germany.

The Reduction of the Austrian Army.—This seems to be meeting with even greater difficulties than in Germany, and to be causing greater hardships. Austria, with 6½ million inhabitants, of whom half a million are state employees of one kind or another, can only pay the very smallest pensions to her old soldiers and particularly to such a poorly represented class as the officers. When it comes to giving out appointments, the latter get no consideration, however suitable they may be. The Institute of Military Geography, which used to print the world-famous Austrian Staff maps, is now devoted to the publication of election posters.

No. 19.—*Military Notes from South Eastern Europe.*—The "Little Entente" is taking an active line in its foreign policy and seems to lean more towards the East than the West. The adhesion of Greece, Bulgaria, and even German-Austria is discussed. Jugo-Slavia is the strongest member of the entente from the military point of view and a good harvest has placed the country on a fairly sound basis economically. Tchecho-Slovakia is organizing an army with a peace strength of 180,000 men, rising on mobilization to 1,200,000; Olmütz is to be fortified on modern lines. French influence is said to be very strong; in October there were 164 French officers attached and a further 170 were expected. Seven out of twelve divisional commanders are stated to be French. The army is to be lifted out of politics. The Tcheck legionaries from Russia are found difficult to deal with. Roumania is stated to be reducing her armaments, but she is the only country, except Russia, wherein a conscripted army of labour is in being. The intention is to allow a man to serve his time in either the fighting or the labour army. Bulgaria is seeking permission from the entente to raise a small conscript army instead of the voluntary one of 33,000 prescribed by the treaty.

The Hungarian National Army.—Good progress made in settling the country is reflected in the organization of the army, as limited by the peace treaty. There are seven areas, each raising one so called "Division," which really is no more than a strong mixed brigade. In spite of the disastrous effects of the revolution, the attack of Bolshevism and the invasion of the Roumanians, reconstruction is going on well.

No. 20.—*The Turning Point of the War*, by Lt.-Col. Muller-Loebnitz, is examined. This book appears to be one of the best which have appeared so far dealing with the Marne (1914). The general conclusion reached is that what was really a victory was changed by G.H.Q. first into a retreat and then into a defeat. The position of G.H.Q. is blamed in the first place and the personality of von Moltke in the second. The latter is compared, much to his disadvantage, with his predecessor von Schlieffen, whose plan it always was to ensure co-ordinated action by general directions rather than to interfere with initiative by formal orders. Even the latter were lacking in the case of the 1st Army from the 5th to 8th September, and the author thinks that von Kluck should himself have sent a representative to G.H.Q. failing any other method of establishing *liaison*. The dilution of the great Schlieffen turning project is emphasized by the fact that three-fifths of the German forces were held up in the German left flank, by inferior forces, while only two-fifths were allotted to the all-important right flank where they were opposed by superior numbers, and even these two-fifths were not up to the strength laid down for them. With von Schlieffen this would not have happened.

No. 21.—*The Military and Political Situation in England.*—Lieut.-General Balck says that England's foreign policy is entirely dependent on her domestic circumstances. The working classes, and in particular the "Triple Alliance," have distinct leanings towards Russia, which have influenced the government's dealings with Kameneff (*alias* Rosenfeld). If a Labour government was formed in England the writer does not think that Germany would be any better treated than hitherto, but the effects on the British Empire would be very serious. Self-governing dominions are said to be demanding more voice in Imperial politics and it is attributed to this that England has made no protest against the Franco-Belgian agreement and the projected fortification of Ostend. The Irish problem is discussed, but no solution suggested, though Lloyd George's refusal to entertain the idea of an independent Ireland is approved. British policy in Palestine, Syria, and Mesopotamia is stated to have as its main objective the formation of a pan-Arabian state, under British influence, which with a subservient Persia would give an overland route to India. Some not unfriendly moves towards Germany are noted, such as the manifesto of the Oxford professors, and questions in Parliament regarding the black troops used by the French in the occupied territory. These are, however, attributed to the increasing pressure of American commercial competition and not to any really friendly motives. The slow progress made in forming the regular and territorial armies is noted.

No. 22.—*The Military and Political Situation.*—The establishment laid down for the French Army in the coming year, 738,500 all ranks, is compared with the pious hopes of President Wilson and the League of Nations and many bitter comments made on it. Some satisfaction is found in the difficulty France is expected to meet with in filling it. The decision on the part of England to pay German individuals for their English investments is noted, but the writer is in a pessimistic mood and refuses to see any hope in any direction. Polish action in Lithuania is said to be viewed with satisfaction by the French, and it is thought that the Poles will not be easy to shift. D'Annunzio's example already has followers, in spite of the league. The publication in France of Lord Haig's volume of dispatches is noted. The writer thinks that the praises which the French have made this the occasion for giving both to Lord Haig and his men are rather uncalled for, but he likes the principle of praising generals and soldiers, and grudgingly admits that though the French may do it in a way not altogether in accordance with sober German taste, yet it is better than not doing it at all, or than flinging abuse at them, as is done in the Reichstag.

L. CHENEVIX-TRENCH, *Major, R.E.*

31. 12. 20.

REVUE MILITAIRE SUISSE.

No. 9.—*September*, 1920.

The Greek Campaign in Anatolia.—The original article is contributed by Colonel Feyler; a sketch map is provided to illustrate the phases of the campaign dealt with in the text. This campaign was undertaken by Greece as the mandatory of the Entente Powers, and, it is said, more particularly of Great Britain, whose people, it is suggested, were disturbed by the activities of the nationalist party in Turkey. The mission entrusted to the Greek Army was the seizure of the railway connecting Smyrna with Panderma, and the occupation of the southern shores of the Black Sea, the main object being to ensure the safety of the Dardanelles Channel. Colonel Feyler deals with both phases of the operations against Mustapha Kemal Pasha undertaken by the troops under General Paraskevopoulo. The first phase, which consisted in the offensive directed towards the east, began on June 22, 1919, and resulted in the capture of Ala-chehr within three days. For the protection of the Greek right flank, a detachment operated along the Meandre R., whilst the left flank was covered by operations directed against Ak-hissar. Ala-cheher having fallen on the 25th *idem*, the victorious Greek troops were at once pushed eastward to a distance of 50 k.m. beyond this place. At the same time the troops on the left flank advanced from Ak-hissar to a point somewhat to the north of Soma. The second phase consisted in the operations for the capture of Panderma. The forward movement northwards began on the 29th *idem*. In connection with this advance, a weak column was landed in the Gulf of Adramit and marched from Kemer, *via* Adramit and Agrinia on Bali-Kesser. Bali-Kesser was occupied by the Greeks on the 30th *idem*, 1,200 prisoners and 54 guns falling into their hands. On July 2, whilst the main body resumed its march northwards, a newly formed column was landed at Panderma, under the cover of the guns of the fleet, and moved southwards, joining hands with the advanced guards of the main body some 25 k.m. N. of Bali-Kesser. On July 8, the coast from Panderma to Moudania was in the hands of Greek and British troops, the latter having been landed at Moudania on that date.

No. 10.—*October*, 1920.

Gas Warfare.—Premier-Lieutenant Matthey, the author of the original article, recalls the wonderful way in which the French troops recovered from the "surprise" effect produced by the first German gas attack on April 22, 1915, and the success with which their subsequent preventive measures in relation to gas warfare met. He points out that the term "gas" is misapplied in the use which is made of it in relation to the diabolical methods of chemical warfare introduced by Germany; of the 19 poisonous substances used by the Germans 15 were liquid, 2 solid, and 2 alone gaseous. Owing to the character of Germany's chemical industry, she was in a position early in the war to obtain rapidly enormous quantities of "warfare gas" (*gaz de combat*), the total production of which is stated to have been 48,000 tons.

In the original article a list is given, in the order in which their use was introduced in the war, of the "gases" employed by the Germans from April, 1915, to September, 1918, the toxic properties of each gas being stated. A brief description is given of the methods of gas-attack employed by the Germans and the measures taken by them at different periods to obtain the advantage of surprise effect. A short account is given of the steps by which the gas helmet was by degrees improved in France, until the type known as the *Masque A.R.S.* was finally introduced in 1918. The number of gas helmets of various types manufactured in France during the war totalled 47,600,000. The original article is based on the work entitled *La guerre des gaz* by Drs. Voirel and Martin and articles on the subject by M.M. Cornubert and Florentin which appeared in numbers of the *Revue générale des sciences pures et appliquées* for January and April, 1920.

Notes and News.—Switzerland.—The demobilization of the Swiss Army was completed in August last. Economy is the order of the day, the reduction of the military budget has resulted in the annual contingent of recruits for the Swiss Army being fixed at 18,000 instead of 27,000 men. Among the other measures adopted is the conversion of fortress machine-gun companies into infantry machine-gun companies: the object of the last-named measure is political, that is to say, in order to show that the *garrisons of the fortresses have been reduced*.

France.—A special correspondent contributes some very interesting notes on the French Army. He examines the military situation in France in the autumn of 1914; starting with a "standing" army of 33,000 officers, 856,000 men and 229,000 horses, the fighting forces of France were raised on mobilization by adding some 3 millions of troops. The creation of novel units, owing to the technical developments in warfare, brought about a somewhat remarkable change in the main characteristics of the French Army. The old army reached its maximum development by May 1, 1915, whilst the reorganization owing to the technical progress was complete by October 1, 1918. A comparison is made of the percentages of combatants to non-combatants in the French Army on the two dates mentioned, the figures being as follows :—

	May 1, 1915		*October* 1, 1918.
Combatants	86·1 %	—	74·0 %
Non-combatants	4·1 %	—	12·2 %
Services	9·8 %	—	13·8 %
	100·0		100·0

The number of battalions in 1918 was 31 less than in 1914, in spite of the fact that 200,000 more men were serving with the colours: the number of cavalry squadrons, which was 510 in 1914, stood at 431 on November 11, 1918—of the latter 90 were employed dismounted; the number of batteries of artillery which stood at 1,508 on mobilization in August, 1914, had increased to 2,975 by the date of the armistice; the number of engineer units increased by 150 during the war—the allotment of *Sapeurs-Mineurs* to the divisions and Army Corps was doubled, a considerable increase took place in the number of telegraph units, novel units were formed, of which the best known are the Schilt companies (flame-throwers) and Z companies (gas warfare); the aviation service which consisted in 1914 of 23 squadrons and 4 balloon companies had at the end of the war reached to a total of 261 squadrons of various kinds and 76 balloon companies; the "tank corps" (*artillerie d'assault*) first raised in 1917 consisted of 2,500 "light tanks," and about a hundred "heavy tanks"; the motor transport with the French Army, which consisted in August, 1914, of 9,500 vehicles (all requisitioned) amounted on November 11, 1918, to 88,400 vehicles and 9,700 tractors. On August 2, 1914, the number of troops mobilized in France was 3,800,000; in July, 1915, the numbers of men serving stood at 4,978,000; whilst at the date of the Armistice the French Army mustered 4,150,000 all ranks. On August 1, 1914, the French Corps of Officers stood at 34,225, by the beginning of 1920 the number of officers had increased to 47,133. Other interesting data are also furnished.

Portugal.—A special correspondent writes that a committee consisting of officers of all branches of the service has been appointed by the War Minister to review the vast amount of legislation affecting the Portuguese Army passed during the war with a view to a simplification of the law relating to military service. It is proposed by the Minister to retain the army organization introduced in 1911, but there exists a strong feeling in military circles that a new organization is required based on the experience of the Great War.

France.—The *Revue d'Infanterie* has made its reappearance; it was not published during the war.

W. A. J. O'Meara.

CURIOSA MATHEMATICA, *No.* 2.

DEAR SIR,

With reference to the above, my problem (printed in *R.E. Journal*, January, 1892) was to use only *three* fours; and I got as many as 80 numbers out of the first hundred, the missing ones being 41, 51, 57, 67, 69, 71, 73, 74, 75, 76, 77, 79, 82, 83, 85, 86, 87, 89 91, 93.

The only extra one I ever got was in 1903 from Lieut. (now Lt.-Col.) C. Hogg, who worked out the question independently, and got exactly the same 80 numbers as I did, with the addition of 75. This was through using the sign for *per cent.*, which seems quite legitimate, though it had not occurred to me.

$$75 = \frac{\sqrt{4}}{4\,\%\,\sqrt{.\dot{4}}}$$

Of course the first missing number, 41, can be got in numerous ways with *four* fours, some of which are rather interesting, *e.g.*,

$$41 = \sqrt{\frac{4! + 4 + 4!}{4!}}$$

$$41 = \sqrt[\infty]{4}\,\%\,(\sqrt{\sqrt{4^{4!}}} + 4) = 1\,\%\,(4096 + 4).$$

But I soon decided that if I published it again, I would limit it to *two* fours, and the problem would then stand as follows:—"What numbers can be found up to 100, using the digit 4 twice in each case? Neither any other digit, nor 0, may be used; but all *signs* expressing a mathematical operation are allowed." And my answer would be, the following 26 numbers, 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 16, 20, 22, 23, 24, 25, 26, 28, 32, 36, 44, 48, 54, 60, 64, 96. The only ones that present any difficulty, and are therefore of any interest, are

$$23 = 4! - \sqrt[\infty]{4} \qquad 36 = \frac{4!}{\sqrt{.\dot{4}}}$$

$$32 = \sqrt[.4]{4} \qquad 64 = \sqrt{\sqrt{\sqrt{4^{4!}}}}$$

The infinitieth root has often been objected to, but it seems to me to come within the definition of a "sign expressing a mathematical operation." And a mathematical professor at Cambridge once objected to my using 44, saying I was bringing in a 10, as it was merely a short way of writing 4 × 10 + 4, and could not be used with Roman numerals IV . IV. But the same might be said of repeating decimals, and it seems permissible to assume that we are dealing with ordinary figures. I feel doubtful about *log*, but I think it ought to be *disallowed* (if necessary by saying so in the question), otherwise *antilog* must be admitted too, and the problem would lose its comparative simplicity, as quantities of numbers could then be got with *two* fours, and many with only *one*, provided we set to work in a sufficiently roundabout way, *e.g.*,

$$15=\log\sqrt{\ }\sqrt{\ }\sqrt{\ }\,\text{antilog}\,\underline{|\log\sqrt{\text{antilog}\,(\text{antilog}\,\sqrt[\infty]{4})}}.$$

With regard to the sign for the *summation* of a series, I thought it was necessary to show clearly what the series was, and this would require at least *three* fours, *e.g.*,

$$\Sigma\ \sqrt{4}+4+\ldots\ldots+\underline{|4}=156.$$

But if, as your correspondent suggested, $\Sigma\,4$ may be used for $1+2+3+4=10$, I think the sign ought also to be disallowed, since the following numbers, and perhaps others, could be got with only *one* four, 3, 6, 10, 21, 55, *e.g.*,

$$6=\Sigma\ (\Sigma\ \sqrt{4}).$$

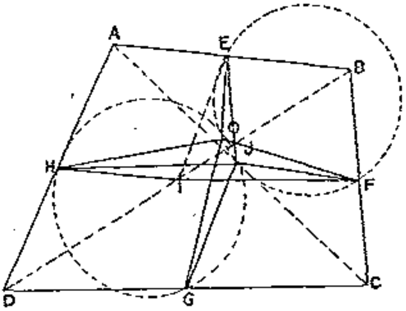
Yours, etc.,

W. H. Turton, *Lt.-Col.*, *late R.E.*

PROBLEMS.

Problem 19 (Solution).

To prove that the 9 point circles of the triangles formed from any 4 points by taking them 3 at a time meet in a point.



EFGHJI are the centres of the sides and diagonals, then the circum-circles of $\triangle$s JEF, JHG, IHE, IGF are the 9 point circles in question.

Let the circles JEF, JHG intersect in O. Then if the circle GIF passes through O, then must

$$G\hat{O}F=G\hat{I}F=C.$$

Now since GIFC is a ||m

$$H\hat{O}E=J\hat{E}F+O\hat{E}J+G\hat{H}J+O\hat{H}J.$$

This can be easily proved by drawing through O a line parallel to AC. Hence

$$H\hat{O}E=J\hat{O}F+O\hat{E}J+G\hat{O}J+O\hat{H}J=G\hat{O}F+O\hat{E}J+O\hat{H}J.$$

But $$H\hat{O}E = H\hat{J}E + O\hat{E}J + O\hat{H}J.$$

Consequently $$H\hat{J}E = G\hat{O}F.$$

But $H\hat{J}E = C$, since HJ and EJ are ∥ to DC and BC.

Hence $$G\hat{O}F = \hat{C}, = GIF.$$

and similarly $$H\hat{O}E = H\hat{I}E = \hat{A}.$$

Hence the four 9 point circles pass through O.

Q.E.D.

This problem has appeared in recent London University Honours papers.

PROBLEM 23 (A. F. S. Hills, Esq.)

In the following long division sum all the figures, except those shown, have been replaced by crosses. The division is complete, *i.e.*, the divisor goes into the dividend without remainder. Show that there are four solutions.

```
× × ×)× × × × × 4(× 4 × ×
      × × ×
      -------
      × × 4 ×
      × × × ×
      ---------
        × × × ×
          × 4 ×
        ---------
          × × × 4
          × × × 4
          =======
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PROBLEM 24.

A man has 121 francs and 70 half-crowns. Reckoning 25 francs to be the equivalent of £1, find the number of ways in which the man can pay away one-third of the money in his possession, what is the smallest number of coins with which he can make the payment?

SOLUTIONS.

Correct solutions have been received from the following officers:—Problem No. 9 from Capt. A. C. Crooney, R.A. No. 11 from Lieut. E. A. L. Gueterbuck. No. 22 from Major C. R. Satterthwaite, O.B.E.

J. M. WADE, *Lt.-Col.*