THE ROYAL ENGINEERS JOURNAL.

Vol. XXXIII. No. 1. JANUARY, 1921.

CONTENTS.

MONTGOMERIE PRIZE.

ATTENTION is invited to the conditions under which this prize, in value about £10, is offered for competition each year.

1. The Prize shall be awarded by the R.E. Institute Council in the manner considered best for the encouragement of contributions on professional subjects, by R.E. Officers, to the Corps publications. From the beginning of 1920 it has been decided that the Prize shall be confined to Officers on the Active List not above the rank of Substantive Major.

2. The Prize shall consist of (*a*) a book on Survey, Exploration, Travel, Geography, Topography, or Astronomy; the book to be whole-bound in leather, and to have the Montgomerie book-plate with inscription inside; (*b*) the remainder of the year's income of the Fund in cash.

3. The name of the recipient of the Prize shall be notified in the Corps publications; and copies of the contribution for which the Prize was awarded shall be presented to the representatives of the donors.

The following are suggested as subjects for contributions:—

(*a*). Descriptions of works actually carried out in peace or war
(*b*). Inventions.
(*c*). Design (excluding works of defence).
(*d*). Labour organization on work.
(*e*). Scientific investigations generally.
(*f*). Accounts of exploration work and surveys.

MILITARY WIDOWS' FUND, BRITISH SERVICE INDIA.

THE Military Widows' Fund, British Service, was established in India in 1820 to alleviate the distress of families of officers of the British Service *serving in India*, and to enable them to return to England without unnecessary delay. Whenever an officer of the British Service, who is a subscriber to the Fund, dies, his family receives at once the following assistance, namely, six months maintenance allowance ranging from Rs 2,400 to Rs 3,600 according to the rate subscribed, plus Rs 1,500 as a donation for the widow, plus Rs 300 or Rs 300 as a donation for each child according to whether the child is over 12 and under 21 years of age or under 12 years of age. These benefits are secured by a small subscription of Rs 4, 3 or 2 per mensem, which is regulated by the amount of pay an officer draws. An officer, on becoming a subscriber, secures for his wife and children quite irrespective of his length of service in India, the full benefits of the Fund in case of his death after having subscribed for fully three months. In the event of an officer dying within that period, his case is specially considered by the Committee of General Management. Copies of the regulations of the Fund and other particulars relating thereto can be obtained from the Secretary at Simla.

CONTENTS.

THE INTRODUCTION OF MECHANICAL WARFARE ON LAND AND ITS POSSIBILITIES IN THE NEAR FUTURE

A Lecture delivered at the S.M.E., Chatham, 11th November, 1920, by COL. J. F. C. FULLER, D.S.O.

Opposition to the Coach.—In 1565 it is recorded that the first coach constructed in England was built for the Earl of Rutland, but on account of the execrable condition of the roads of this period and the dangers of the highways, it was not until 1669 that systematic journeys were attempted in England and then only between Oxford and London.

Coaching was a novelty and, like every rational and profitable novelty, before or since, its progress met with strong opposition. Early in the seventeenth century a Bill was brought before Parliament in order "to prevent the effeminacy of men riding in coaches"; and in 1671, Sir Henry Herbert, M.P., stated that—"if a man were to propose to convey us regularly to Edinburgh in coaches in seven days, and bring us back in seven more, should we not vote him to Bedlam." Nevertheless the coach for its period had come to stay, and on October 13, 1712, a weekly service was instituted between London and Edinburgh. The journey was made in thirteen days and the fare was £4 10s.

Opposition to the Locomotive.—In 1641, that is twenty eight years before the first coaching service was instituted in England, the Marquis of Worcester, famous as the inventor of an early steam engine, went to see Solomon de Caus in the Bicetre at Paris. Marion de Lorme who was with him when he visited this madhouse, wrote as follows:—

"We were crossing the court, and I, more dead than alive with fright, kept close to my companion's side, when a frightful face appeared behind some immense bars, and a hoarse voice exclaimed—'I am not mad! I am not mad! I have made a discovery that would enrich the country that adopted it.' 'What has he discovered?' asked our guide. 'Oh!' answered the keeper, shrugging his shoulders, 'something trifling enough; you would never guess it; it is the use of the steam of boiling water.'" Why was Solomon de Caus there? To keep his brain from mischief; he had actually suggested that carriages and ships could be propelled by steam!

In 1769, James Watt invented the first practical steam engine. He also was considered mad, but fortunately for posterity he was not locked up. In 1804 a locomotive guided by rails attained the

speed of five miles an hour at Merthyr Tydvil and ten years later George Stephenson, financed by Lord Ravensworth, to whom was applied the adage—"A fool and his money are soon parted," began work on the Killingworth Railway. He met with immediate obstruction, Lord Eldon saying, "I am sorry to find the intelligent people of the North country gone mad on the subject of railways."

Stephenson was undaunted and before the Stockton and Darlington line was completed, in 1821, he said to his pupils—"Now lads, I venture to tell you that I think you will live to see the day when railways will supersede almost all other methods of conveyance in this country—when mail-coaches will go by railway, and railroads will become great highways for the King and all his subjects. The time is coming when it will be cheaper for a working man to travel on a railroad than to walk on foot."

To this the *Quarterly Review* incredulously exclaimed—"What can be more palpably absurd and ridiculous than the prospect held out of locomotives travelling TWICE AS FAST as stage coaches! We should as soon expect the people of Woolwich to suffer themselves to be fired off upon one of Congreve's ricochet rockets, as trust themselves to the mercy of such a machine going at such a rate. We will back old Father Thames against the Woolwich Railway for any sum. We trust that Parliament will, in all railways it may sanction, limit the speed to EIGHT or NINE MILES AN HOUR, which we entirely agree with Mr. Sylvester is as great as can be ventured on with safety."

Once the locomotive began to crawl, the sluice gates of abuse were opened, and its inventor met with obstruction at every turn. A meeting of Manchester ministers denounced the railway as being 'contrary" to the law of God. Lord Derby drove the railway surveyors off his land and Stephenson had to hire a prize-fighter to carry his theodolite in order to prevent it being smashed to pieces. Pamphlets were written and newspapers hired to revile his work. It was declared that the railway would prevent cows grazing, hens laying, and would cause ladies to give premature birth to children at "sight of these things going forward at the rate of four and a half miles an hour."

Parliament supported the reactionaries; birds would be killed by the smoke, foxes would become extinct, horses would be useless and oats and hay unsaleable; country inns would be ruined, boilers would burst and blow passengers sky high, and finally, the weight of the locomotive would prevent it moving.

Nevertheless Stephenson persisted and was besought by William Brougham not to talk too much about speed before the Parliamentary Committee which was to enquire into the question, or else he would "inevitably damn the whole thing and be himself regarded as a maniac fit for Bedlam."

The Committee of the House of Commons assembled on March 21, 1825, and the opposing counsel addressed these words to the great inventor:—

"Suppose, now, one of these engines to be going along a railroad at the rate of nine or even ten miles an hour, and that a cow was to stray upon the line and get in the way of the engine; would not that, think you," asked the barrister, "be a very awkward circumstance?"

"Yes," replied George Stephenson, with his face in a humorous pucker, "very awkward indeed—*for the coo*!"

Opposition to the Tank.—Why have I told you all this? Simply in order to avoid relating to you the studied opposition which was meted out to the tank. It is right and necessary that you should realize this, for on your support, in future years, will depend the progress of mechanical warfare, which is the subject of my lecture.

In 1914 was the tank conceived; in 1915 was it built; in 1916 was it first made use of; in 1917 did it fight for its existence, and in 1918, I go so far as to say, that without its assistance we should not that year have won the war. In 1919, an experimental machine attained a speed of 20 miles an hour; and now in 1920, is it still struggling against difficulties, for prejudice to things new dies hard and vested interest is a powerful adversary.

Whatever the tank has accomplished, it is still far from perfect, it is still in the Puffing Billy stage of 1822; Puffing Billy which George Stephenson was wont to drive close by his brother's house and concerning which, when it stuck fast at a curve, he would shout out to his wife—"Hey! Jean, come oot, and gie us a shove roond the turn!" Twenty years later we read—"A few years since ninety-four coaches used to pass through St. Albans daily. On Saturday last the Leeds Express, formerly called the 'Sleepy Leeds,' which has been on the road upwards of a hundred years, ceased running, it being no longer a profitable speculation."

The coach was dead, the railway had come into its own, a new and stupendous world was born, and through mechanicalizing civi movement, by replacing the horse by the steam engine, civilization has advanced more rapidly during the last eighty years than she had advanced during the preceding eight thousand.

Here then is the gist of my lecture. What the locomotive has done for civilization will the internal combustion engine do for war. It opens up before us a new world of warfare stupendous in its possibilities. Let us enquire into it, and do not let us fall into a frenzy because possibly rifles and swords, bayonets and lances, horses and limbers may disappear, for even if they do, we may be perfectly sure that things more efficient will replace them.

Opposition to the Rifle.—I will now turn for a few minutes to what I will call the coaching period in the history of the war, chiefly in

order to obtain a background whereon to throw into relief the future tendencies of mechanical warfare.

In the 15th century gunpowder was considered useful for frightening horses, a century long argument then followed, concerning the bow and the musket, and as many arguments were launched for the retention of the bow as to-day are quoted for the retention of the lance. The bow has, however, vanished, but not without a struggle, for as late as 1797 a certain Mr. Mason once again proposed to equip British infantry with it.

In 1742, Benjamin Robins in his "New Principles of Gunnery," made a remarkable prophecy as to the eventual adoption of the rifle, which, however, did not take place until a hundred years after his day; he says:—

"..... whatever State shall thoroughly comprehend the nature and advantage of rifled barrel pieces, and having facilitated and completed their construction, shall introduce into their armies their general use, with a dexterity in the management of them, will by this means acquire a superiority which will almost equal anything that has been done at any time by the particular excellence of any one kind of arms, and will perhaps fall but little short of the wonderful effect which historians relate to have been formerly produced by the first invention of firearms."

In 1780, Major Patrick Ferguson invented a breech loading rifle. He paid for its manufacture out of his own pocket and equipped his men with it so that they might meet, on equal terms, the American backwoodsmen. He then, unfortunately, went sick and Lord Cornwallis the Commander in Chief had the rifles withdrawn and destroyed.

In 1824 the British Government refused to accept Captain Norton's cylindro-conoidal bullet. It was reproduced by Captain Minié of the French Army in 1849. The Minié rifle became the weapon of the day, nevertheless, Sir William Napier strenuously opposed it, as in his opinion, it would destroy the infantry spirit by turning infantry into what he called "long range assassins."

In 1858, Greener declared the "time and ingenuity spent in planning and constructing breech-loading cannon will always end in disappointment and failure" and again, that "striving to produce perfect breech-loading cannon is like striving to square the circle." Consequently the British Army did not permanently receive such a weapon until 1886. Even as late as 1895, when the *Victoria* went down with Admiral Tryon, some of her guns were still muzzle-loaders.

In spite of opposition, the breech-loading rifle and field gun—which I will call the "military coach," for both depended on muscular movement—came into their own.

Phantom Wars.—In August, 1914, the finest muscularly organized body of troops ever raised by Great Britain left her shores. I was

fortunate enough to see them all, and I can frankly say that in all my life I have never, before or since, seen such a perfect force of men and horses as those of the 7th Division and the 1st Cavalry Division which sailed for Zeebrugge and Ostend. The Duke of Teck himself told me that he had not a horse in his regiment under the value of 200 guineas. A fortnight later the 7th Division had almost ceased to exist. What had happened?

Many things, amongst which was one, to my mind the most important, which for long remained obscure. The war we had prepared for was a phantom, a will o' the wisp which literally led us off the highway of progress into a "slough of despond."

What had we failed to realize? We had not realized this—that an Army to prosper must be based on the civil sciences, that an Army must keep pace with the progress of industry and that an Army which does not do so is but a phantom force for war.

Irresistible Science.—Since 1842 when the "Sleepy Leeds" had run her last journey on the great north road, what had been happening in civil life? A mechanical evolution so rapid that no revolution in the whole world's history can compare to it. Every day brought to birth some new invention, every hour civilization gathered greater speed; epochs crumbled away, epochs sprang up in the night, science was sweeping brute force off the face of the earth, and was replacing muscle by mechanical energy.

In 1885, Gottlieb-Daimler designed the first practical internal combustion motor. In 1896 the first motor car in England ran from London to Cambridge preceded by a man carrying a red flag. Parliamentary opposition was revived, humanity could not live with the road car, the roads would become unsafe, children would be run over, dogs and fowls exterminated, and carts overturned. The country gentleman got his back up, but the Rolls-Royce soon got it down.

In 1770, the first patent for a footed wheel was registered; in 1888, an agricultural tractor, almost identical to the future tank, was designed; in 1907, a motor car on tracks attained the speed of 20 miles the hour on firm sand. In 1909, at the first flying meeting held at Rheims, General Grierson, an able soldier, watching an aeroplane, turned to General Stone and said—"I say, Stone, do you really think there is anything in it?" and General Stone's comment on this remark is worth recording—"That is only ten years ago, and it is a very striking fact that such a very short time ago as that some of the best brains in the Army (because I could mention other names, but I do not think it would be wise to do so) thought that anybody who took up flying seriously was a little bit 'gone in the head.' I speak of what I know."

It is indeed easy to be wise after the event, but surely it is better to be thus wise than never to be wise at all. In 1914, the armies of

Europe marched forth to fight Worth, Gravelotte, and Sedan over again, forty-four years of scientific progress had been neglected, and the bill—10,000,000 men killed and over £60,000,000,000 expended. In 1918, the war was costing Great Britain £300,000 an hour, or the present price of the yearly upkeep of two infantry battalions. Gentlemen, science is worth studying.

The Nature of the Great War.—Let us turn for a few minutes to the nature of the Great War. One of its most remarkable features was that it resembled the battle of Marathon (B.C. 490), for the greater portion of its duration the battle had no flanks. Why? Because the enormous size of armies enabled battle fronts of upwards of 500 miles to be held in strength, entrenched and wired. What had rendered this possible? The locomotive, the railway, and the steamship, the great mechanical movers of civil life. Soldiers had not considered them very deeply, then, when war was declared, they like great funnels poured forth men in cataracts. Immense tracts of country were inundated and for over three years, on the Western Front, armies lay opposite each other in stagnating puddles and slowly evaporated away.

We see a strange sight: millions of men facing each other, millions of men the subsistence of which, prior to battle, depended on every yard of rail and road behind them being utilised to the full. Lorries and locomotives worked day and night to supply this enormous muscular mass, to pile up the military coaches which, from time to time, were launched from their mechanical base into battle areas devoid of railways and all but devoid of roads. What do we then see? We see strings of pack mules and thousands of human carriers wallowing through the mud; in a single day the administrative needs of the Army have increased tenfold and the means of supplying these needs has retrogressed by several thousand years. This brings us to our first main problem in mechanical warfare, the problem of road capacity.

Road capacity.—In August, 1915, a meter gauge railway ran from Gezaincourt to Albert and I suggested to an officer, quite an able man, that if a certain British Corps made use of it considerable economies could be effected. His answer was—"It can't be done for if we use this railway we shall disorganize the whole of our lorry service!"

In the eighteenth century, the squire who brought his wife to London sitting behind him on his cob, objected to the stage coach. In the nineteenth century he had accepted the stage coach and objected to the locomotive. In the twentieth, he accepted the locomotive and fell foul of the motor car. And so in 1915, we find an able officer objecting to the light railway. Why? Because of what I will call congenital prejudice, which can only see the means and not the end, and which having made a hobby of the

initial success, which was stupendous, rapidly "Petered out" after the first day's fighting. This was due to several reasons, one being the difficulty of maintaining the energy of the battle by supply, in other words "road capacity" was insufficient to enable us to continue the advance, and would have been more difficult still had we attempted to force our way across the old Somme battlefield.

The lesson to be learnt from all this fighting, and probably the most important lesson to be learnt from the whole war is "That the chances of victory or defeat are multiplied directly by any increase or decrease of road capacity in an area of operations, and that unless this road capacity be equal to the supply requirements of the attack, either the attackers must eventually die of starvation or the attack must be abandoned."

This problem may be viewed under two main headings:—

(1).—Means of cutting down the necessity of supply.

(2).—Means of increasing the transportation of supply.

I do not intend to discuss the first beyond saying that the quicker an army can move, the less supplies, in the long run, will it require. As regards the second, it may be viewed under four subsidiary head headings:—

(*a*).—Concentration of traffic.

(*b*).—Additional road space.

(*c*).—Additional roads.

(*d*).—Dispensing with roads.

The first is gained by increasing the tonnage per road mile. The second by constructing vehicles which will move alongside a road over plough and grass land. The third by making use of badly metalled roads or by building new ones. The fourth by cross-country traction which will enable all normal country, plough and grass land desert and scrub, to be crossed as easily as a lorry to-day will move along an average road.

Can such a machine be obtained? It can!

The Administrative Link.—What will the cross-country lorry accomplish? It will mechanically link up the strategical base of operation, which consists of a network of railways, with the battlefield itself. No longer will there occur that terrible hiatus between railheads and battle dumps. You won't dump, but you will move. As the battle starts so will it be continued, there will no longer be an exchange of supply horses in mid stream. Right through the Great War this problem remained all but unrealized, and only towards the end was any notice taken of it, and yet on its solution depended the dividend of every attack.

Often was the question asked,—What happens when a penetration has been effected? The answer is "push up supplies," supplies of men, weapons, munitions, and food; the side which can do this the most quickly is the side which is most likely to win. The problem

means refuses to see the end. I will give you a typical example of this.

In the first decade of this century, a meeting of the Directors of the London General Omnibus Company was held. A young engineer got up and suggested the replacement of horses by petrol engines; he pointed out that the shares of the Company stood at a very low figure and that he could raise them several hundred per cent. This so enraged one of the elderly Directors, who could only see the existing means—the horse—and not the end, a high dividend, that trembling with rage he exclaimed, "You may take it from me, Sir, that the horse will remain the backbone of this Company for many, many years to come." Within a few years of this prophetic outburst the horse in the L.G.O. had disappeared and the Company's shares stood at a price far higher than the young engineer had ever dreamt of.

In 1914, a few score of lorries formed the mechanical equipment of the British Army. In 1917, they had grown in number to about fifty thousand, hundreds of miles of new railways and thousands of miles of tramways covered the British fronts. For three years we had been fighting for road capacity, and behind our front line we had attained it, but in advance of it, it ceased to exist. Armies became like caged animals, they could move about in their own prisons at will and in perfect safety, but to escape from them was next to impossible.

I will take a few examples to illustrate this and will select them out of the events of the last year of the war, during which the bars of the cages had become somewhat more elastic:—

(1).—In March, 1918, the Germans gained against us an overwhelming success; they advanced some 40 miles in 14 days and were then forced to halt. To many who took part in this operation, it was apparent that it was not the British Army which caused this halt, but the weakness of the German Army due to the "Petering out" of its supply system. Road capacity in the Somme area was limited, want of road capacity, which might well have been foreseen, completely wrecked the last chance the Germans had of winning the war.

(2).—In May, 1918, the Germans gained another overwhelming victory, this time over the French, the result of which was an advance of 30 miles in 4 days, and the formation of the Chateau Thierry Salient. As long as Soissons remained under gun fire and Rheims held out, road capacity, from the railway point of view, was to all intents and purposes non-existent. To remain in this salient without road capacity was to commit suicide. This is exactly what the Germans did.

(3).—In August, 1918, we attacked eastwards of Amiens, behind us was an efficient railway system, in front of us good roads, which, during the battle, were never much damaged; nevertheless, our

is, consequently, not so much a tactical as an administrative one, and looking back it can now be seen that the General Staffs of all armies never fully realized this.

The Tactical Link.—Given a mechanical strategical base and a mechanical supply system, logically, the next link to forge is a mechanical tactical striking force. In other words, to cease hauling up to the front innumerable military coaches by means of mechanical power, as the old four decker sailing ships were towed into position opposite Sebastopol and towed away again after an engagement, but instead to replace the coach by a military motor car and so render the whole army from start to finish a mechanical one.

The necessity of this was realized early in the war by a few far-seeing men, and the result was the tank—a cross-country battery which, protected by armour, was enabled to make use of protected mobility for offensive ends.

The idea of protected mobility gave birth to much mirth; one noted officer requested Colonel Swinton to abandon his "flights of imagination and come down to solid facts;" another, when he was informed that his troops were to be led by tanks through the Cambrai wire, exclaimed "fantastic! fantastic!" The press correspondents filled the newspapers with "slimy monsters and Gargantuan toads," but what was worse, a passive and effective barrier of obstructions was raised against all efforts of the Tank Corps to expand.

A bad second to the obstructor was the amateur enthusiast, who, knowing nothing about tanks, expected them to perform miracles.

In 1829, George Stephenson was faced with the problem of running a railway over Chat Moss. Mr. Alderson obstructed and made a speech opposing it which lasted two days in the Commons. Mr. Cropper, a Quaker, urged Stephenson on. "Consider sir," said Stephenson, "the heavy character of the works, and how much we have been delayed by want of money, not to speak of the wet weather. It is impossible."

"Impossible," retorted Cropper, "I wish I could get Napoleon to thee—he would tell thee there is no such word as 'impossible' in the vocabulary."

"Tush!" said George Stephenson contemptuously; "don't talk to me about Napoleon! Give me men, money and materials and I will do what he couldn't do—drive a railroad from Liverpool to Manchester over Chat Moss!"

We, to-day, are faced with our Aldersons and our Croppers, but what we want is men, money, and materials and we will then do what neither Napoleon nor Stephenson could do; move men across country faster than the Rocket ran along her rails.

I do not intend here to describe to you what the tank accomplished during the Great War, for this you already know, or if you do not,

then you ought to for its history is pregnant with the future ; neither am I going to plan for you a mechanical army, nor picture to you some imaginary Armageddon of 40 years hence. In place I am going to glance at our present military problem and point out to you how cross-country traction will help us to solve it.

Imperial Defence.—What is the present Imperial situation? Lassitude after battle, a low exchequer in debt to the tune of nearly £10,000,000,000 and enormous territorial liabilities to safeguard by means of a navy and army which will eventually be no bigger than those of 1914.

If we cannot get more money we cannot get more troops ; if we cannot get more troops and those we have are insufficient to maintain the integrity of the Empire, what can we do ? We can do one of two things :—

(1).—We can abandon large tracts of country and so enable our securities to meet our liabilities, or

(2).—We can indirectly reduce the size of our territorial liabilities by endowing our securities with a power of moving over them more rapidly than they can at present.

Thus, if I can walk from Chatham to London, a distance of thirty-five miles, in twelve hours and you can motor to London in two hours, when reducing space to terms of time you will find that you have decreased the area to one-sixth of the size it appears to be to me. Now I suggest here that it is possible by mechanical means to reduce the size of territorial liabilities of the Empire by one-half and that if then it be still found that this half is too expensive for our defence forces, instead of scrapping bits of the Empire, we set to work to improve our means of movement so that our liabilities may be reduced to within the power of the securities which our depleted exchequer can afford us.

How shall we do this ? By making the present ends just meet ? No, for judging from every day business methods, as long as this can be done no improvement is to be expected. By demanding more money ? No, for accepting human nature as it is, the more we get the more shall we spend on war carts and stage coaches. The incentive will come through economy begotten of necessity. It is prodigality and not generosity which will compel reform, and reform to be economical must be preceded by a Renaissance in military thought. We must look back and discover deficiencies, we must look forward and estimate probabilities, we must be ready on the starting point with a clear cut scheme—a winning post, in front of us, for when the flag falls there will be no time wherein to make up our minds or look around. If we have not got a plan, we shall squander the little that is given to us ; this is a certainty.

I do not intend here to work out for you a mechanical system of

defence for the Empire. I leave this to you, and I can conceive no more interesting problem. All I will now do is to place before you a few points which may guide your endeavours.

The first thing is to visualize clearly the object at issue. Which, to my mind, is not to fight another great war but to maintain the integrity of the Empire.

The second thing is to become thoroughly saturated with the principles of war and to check your reasoning by means of these at every step.

The third thing is to analyse very carefully the conditions which are likely to be met with, and especially those which affect movement.

The fourth thing is to keep your scheme sufficiently broad in order to embrace the Navy and the Air Force.

I will say a few words about the third and fourth.

Ground and Machines.—In the wars which face us it is not the enemy who counts but the nature of his country; uncivilized lands offer many difficulties, the two most important being deserts and mountains.

I do not intend here to tell you what a cross country machine can do in these areas outside mentioning to you that:—

(1).—In hill warfare, the main difficulty is the protection of supply columns.

(2).—In desert warfare, the obtaining of water.

A moment's thought will enable you to realize how cross country traction can modify these difficulties.

As regards the machine required, we shall not need a great umbering tank, but, for the main part, a light cross country chassis which can be fitted with either a lorry body, an armoured car body, or a tank body and which, as a lorry, can carry either five tons of supplies or water, or a field gun and 200 rounds.

A light speedy machine with a long radius of action is the type of machine I think we now require. It being both light and simple it can be easily built. Its cost complete would probably be well under £3,000.

Co-operation with the Navy.—Some years ago Sir Edward Grey made use of the following pregnant phrase:—"The British Army should be a projectile to be fired by the British Navy." If we consider for a moment the meaning of these words and then weigh them against our Imperial liabilities we shall realize what an enormous economy could be effected in our small wars if it were literally possible to shoot armies on to coast lines when punitive expeditions become necessary.

There is only one real difficulty in a combined naval and military operation, namely: ships cannot swim out of the sea and walk on

land. Because of this inability parties of soldiers have to be landed in lighters, rowing boats, pinnaces, barges, motor boats, and what nots, and in half an hour the beach is like Epsom Downs on a Derby morning.

It is the old difficulty of launching military coaches from a mechanical base, steamships in the present case replacing railways. If now, instead, from these ships floatable tanks and tractors be launched into the sea at say two miles from the coast line and are able to propel themselves ashore and crawl up the beach and move straight inland, confusion can be replaced by simplicity and surprise. It is so simple that people will not see it and I have been voted to Bedlam on several occasions for suggesting it, but I am not there yet. In a couple of years from to-day, I see no reason why such a mechanical force should not operate 1,000 miles from its naval base even in desert land such as central Persia.

Co-operation with the Air Force.—Punitive expeditions may, however, be required at greater distances than 1,000 miles from a naval base, how are we then to proceed? As from our battleships we launched our tanks and tractors, so from these should we now launch our aeroplanes, which should have no difficulty in extending our military influence over another 1,000 miles, that is 2,000 miles in all from the sea coast. The tanks will protect the landing grounds of the aeroplanes and the aeroplanes will carry supplies for the tanks.

With such a force Afghanistan can be attacked from its western side instead of from its eastern, or both sides can be attacked simultaneously if desired. Though I do not want once again to be voted to Bedlam or to share the fate of Solomon de Caus, nevertheless, as ships can carry tanks and tractors, I see no insuperable difficulty in aeroplanes doing the same, for machines weighing not more than 6 tons. Recently I have read a prophetic account of the next war written by a Belgian. He suggests carrying half a million men through the air. But why carry men? for at best we shall be depositing but military saddle horses (not even coaches) in our enemy's country. The "Sleepy Leeds" ceased to run because it was "no longer a profitable speculation." Masses of men do not pay, a few efficient machines do. If your strategy is based on mechanical power so must your supply system be and so must your tactics. This brings us to yet one more consideration.

Conclusion.—The soldier of the present must cease thinking purely in terms of land operations, for he must think in terms of sea and air warfare as well. To-day, warfare at sea and in the air is purely mechanical, on land it is still nine-tenths muscular. We cannot get unity of action until we have instituted unity of movement, in other words until our present muscular army has become a mechanical one.

When this is accomplished we shall be like a runner equipped in seven league boots, like a boxer with an elastic arm ; standing in one corner we shall knock our opponent down in the other, for example, we shall be able to hit people in Teheran, before they know that we have left Tilbury. This, I think, is the Imperial military unity of action we should aim at, and the problem which faces not only a few of us but all of us in the immediate future.

THE 3rd SAPPERS AND MINERS IN THE WAR.

By MAJOR A. L. PARIS, R.E.

HAVING read in the *R.E. Journal*, dated August, 1920, an account of how an ex-officer of the 3rd (late Bombay) S. and M. met with his old company in France, it has occurred to me that a short résumé of the doings of the Corps during the last six years will be of interest to many who have served or been associated with it in the past. We believe that our record in the war is second to none in the Indian Army, and that few have paid for their reputation more heavily in blood than the 3rd Sappers and Miners.

At the outbreak of the war, the units of the 3rd S. and M. were stationed as follows :—

Kirkee—17th Field Co. (old No. 1)—Capt. A. D. S. Arbuthnot, R.E. Subadar Baryam Singh, I.O.M.

Quetta—18th Field Co. (No. 2)—Capt. E. D. Tillard, R.E. Subadar Kudratullah Khan.

Quetta—19th Field Co. (No. 3)—Capt. E. J. Loring, R.E. Subadar Bhawani Singh.

Kirkee—20th Field Co. (No. 4)—Capt. A. L. Paris. R.E. Subadar Ganpat Mahadu.

Kirkee—21st Field Co. —Capt. J. S. Richardson, R.E. Subadar Malla Singh.

Kirkee—22nd Field Co.—Capt. A. M. Twiss, R.E. Subadar Keru Jamdade.

Aden—23rd Fortress Co.—Capt. C. F. Stoehr, R.E. Jemadar Lakshiman Powar.

At Headquarters at Kirkee were :—

Commandant—Lieut.-Col. U. W. Evans, R.E.
S. of I.—Major A. G. Bremner, R.E.
S. of P.—Major W. Bovet, R.E.
Adjutant—Capt. E. V. Binney, R.E.
Subadar-Major—Arjun Powar.
Regimental Sergeant-Major—W. H. Miers, R.E.

The general caste composition of the Corps, and the actual composition of most of the field units was quarter Sikh, quarter Mahratta, half Musalman (predominantly Panjabi), with a sprinkling of " other Hindus," never exceeding 10 per cent.

The first units to leave India were the 20th and 21st Companies, which went to France with the 3rd Lahore Division in August, 1914. They were the first Indian units to travel through France, and, after a short stay at Orleans, they reached the line S. of Estaires on 23rd

October. On 28th October, being lent to the 3rd British Division, they, in company with 47th Sikhs, were ordered to retake Neuve Chapelle, which had been captured by the Germans the previous afternoon. This they did, and although they lost all their British officers, they held on to the village from 11 a.m. till dusk. This action has been very highly praised in all accounts of the doings of the Indian Corps in France, and Sir J. French's dispatch of 20th November, 1914, reads :—" On the 28th October especially the 47th Sikhs and the 20th and 21st companies of the Sappers and Miners distinguished themselves by their gallant conduct in the attack on Neuve Chapelle, losing heavily in officers and men." The nature of the fighting can be judged from the fact that of the 8 B.O.'s, 6 I.O.'s and approximately 300 I.O.R.'s who went into action the casualties were :— B.O.'s, 4 killed, 4 wounded (of whom 1 was captured) ; I.O.'s, 1 killed, 2 wounded ; I.O.R's, 45 killed, 71 wounded.

The companies soon pulled themselves together after this severe test, and took part in the 1st and 2nd battles of Ypres, Neuve Chapelle 1915, Festubert, and all the trench warfare of the Indian Corps up to November, 1915, earning a good name for both working and fighting. They stood the terrible winter trench conditions magnificently. Their casualties were regular and numerous, B.O.'s in particular suffering severely, having 24 casualties in six months, out of a strength of 8. All who have served in India realise what it means to Indian troops to know their officers, and it is greatly to the credit of both B.O.'s and Indian ranks that the companies did so well under officers who were strange to the men, and, in some cases, could not even speak their language.

The 20th and 21st companies left France with the Lahore Division in December, 1915, and went to Mesopotamia, coming in almost immediately for the heavy fighting of the Spring of 1916, when Generals Aylmer and Gorringe were striving to relieve Kut-el-Amara. Their total casualties up to 31st March, 1916, were :—

20th Company. — B.O.'s, 1 killed, 7 wounded (1 captured) ; B.N.C.O.'s, 1 wounded ; I.O.'s, 4 wounded ; I.O.R.'s, 41 killed, 3 died of disease, 151 wounded (1 captured).

21st Company.—B.O.'s, 8 killed, 10 wounded ; B.N.C.O.'s, 1 wounded ; I.O.'s, 3 killed, 5 wounded ; I.O.R.'s, 45 killed, 3 died of disease, 125 wounded (3 captured).

A Field Company strength at this time was :—B.O.'s, 4 ; B.N.C.O.'s 2 ; I.O.'s, 3 ; I.O.R.'s, 189.

The 17th and 22nd Companies left India with the 6th Poona Division for Mesopotamia in October, 1914. Their record there, till they disappeared into Turkey with the garrison of Kut-el-Amara, is one long story of good work and hard fighting. Like the 20th and 21st, they were sometimes used as infantry, and, like them also, were tested by continual losses of their B.O.'s, losing both the Company

Commanders (Capt. Twiss killed, and Capt. Arbuthnot severely wounded), in their first action at Sahil on 17th November, 1914. They took part in the actions of Sahil, Kurna, defence of Shaiba, Barjasiyeh, Amara, Nasiriyeh, EsSinn, Ctesiphon, and defence of Kut-el-Amara.

Some of their numerous "mentions" are appended :—

Letter from the G.O.C. 16th Infantry Brigade to O.C. 22nd Field Company 3rd Sappers and Miners, No. B.M.1460, dated Shaiba, 16th April, 1915. "Brigadier General W. S. Delamain, C.B., D.S.O., commanding 16th Infantry Brigade, desires to express to all ranks of the No. 22 Company, 3rd Sappers and Miners, his very sincere thanks for their steadfast behaviour in the general action of the 14th instant and his admiration for the gallantry with which they pushed home an attack, in spite of heavy losses against a stubborn enemy who had the advantage of position and numbers. This is the second time in the campaign that the General Officer Commanding has had occasion to notice the gallant behaviour of No. 22 Company in action, and all ranks may be justly proud of having added greatly to the fine fighting reputation of the Corps. The General Officer Commanding regrets very deeply the loss of their gallant commander, Capt. E. C. Whiteley, R.E. (the second commanding officer who has fallen at the head of the company in the act of upholding the gallant traditions of the Sappers and Miners.)"

Dispatches of Sir John Nixon, Cmdg. Force D., dated 6th May, 1915 :—

Shaiba * * * * The brunt of these attacks fell on the 48th Pioneers and the 17th Company, 3rd Sappers and Miners, which units with ceaseless vigilance repelled every effort of the enemy * * * I wish to bring forward to special notice the very gallant defence made by the 48th Pioneers, and 17th Company, 3rd Sappers and Miners, who bore the brunt of the enemy's attacks. All ranks behaved with great steadiness and their vigilance and good shooting repelled all attempts of the Turkish forces to break through the defences.

Attack on Shaiba, 14th April, 1915.—It is impossible to conceive a more exposed tract of ground than the plain, devoid of cover, over which our infantry had to attack the Turkish trenches, cleverly concealed and sited. Our advance in the last 400 yards was down a glacis-like slope. It was on the crest of this slope that so many of our losses occurred. Splendid dash, combined with resolute courage, alone carried our men across that bullet-swept glacis. It was a sheer, dogged soldiers' fight, and no words of mine can adequately express my admiration of the conduct of those gallant regiments who won through, viz., 2nd Battalion Norfolks, 2nd Battalion Dorsets, 24th Punjabis, 110th Mahratta Light Infantry, 119th Infantry, 117th Mahrattas, 129th Infantry, 17th and 22nd Companies of the 3rd

Sappers and Miners. It is gratifying to record the fact that all the Indian troops engaged (24th Punjabis excepted) are old Bombay Presidency Regiments. They have proved on this occasion that they are worthy to stand shoulder to shoulder with the best the Empire can produce and I trust that these corps may be permitted to inscribe the battle honour "Barjasiyeh" on their colours as a fitting tribute to their gallant conduct on this hard-fought field.

Dispatches of Sir John Nixon, Cmdg. I.E.F.D., dated 1st January, 1916:—

Nasiriyeh * * * At 5 a.m. on 24th July the attack was launched. * * * During this operation the gunboat *Sumana*, carrying bridging material, fought her way up to the entrance of the creek under a very heavy fire, and, supported by the fire from the gunboats, the 17th Company Sappers and Miners threw a bridge across.

Es Sinn * * * The first troops to enter the enemy trenches were the 2nd Battalion Dorsetshire Regiment, 117th Mahrattas, and 22nd Company Sappers and Miners, who made a brilliant assault, well supported by the artillery, and soon after 10 a.m. captured a redoubt and trenches on the enemy's extreme left, inflicting heavy losses, and taking 135 prisoners.

The casualties up to 31st March, 1916, were:—

17th Company.—B.O.'s, 2 killed, 5 wounded; B.N.C.O.'s, 2 wounded; I.O.'s, 2 killed, 3 wounded; I.O.R.'s, 15 killed, 21 died of disease, 81 wounded.

22nd Company.—B.O.'s, 3 killed, 2 wounded; B.N.C.O.'s, 1 wounded; I.O.'s, 1 killed, 4 wounded; I.O.R.'s, 37 killed, 11 died of disease, 108 wounded.

With the surrender of Kut, the war career of the 17th and 22nd Companies ended. About two-thirds of the men lived through their two and a half years of captivity, and eventually returned to Kirkee. But, very unfortunately, the old companies were never re-formed. The present 17th and 22nd companies are not the original ones, but are the war-formed 101st and 104th Companies re-numbered. Perhaps this was unavoidable, but it is nevertheless very regrettable. The 17th was the oldest and 22nd the youngest of the pre-war field companies.

Another Corps unit engaged early in the war was No. 5 Pontoon Park, which sailed with the I.E.F. "B," to East Africa in October, 1914, under Capt. Tillard. It took part in the capture of Mafia Island, and Bakoba, the advance on Moshi, and the subsequent operations in German E. Africa in the Pangani and Rufiji Valleys. It was employed chiefly on bridging, hutting, road-making, and water supply. In spite of the climate, the health of the company was good, at any rate for 18 months; later there was considerable sickness. This unit returned to India, and was disbanded in March, 1918.

The 23rd Fortress Company at Aden was also soon engaged. It took an active part in all the operations round Aden, including the advance to Lahej in 1915, and subsequent retirement, also the fighting in August-September, 1915, and January, 1916. The Company also was not infrequently employed as infantry.

After the operations for the relief of Kut, the 20th and 21st Companies were joined in Mesopotamia by the 18th Company, which left India on 9th June, 1916, under Capt. Binney. With the Lahore Division, these three companies took part in all the operations culminating with the capture of Baghdad, and in the subsequent fighting on the Diyalah. In 1918, they went to Egypt and Palestine, arriving in time to participate in the great final victory over the Turks. They received the following appreciation from Maj.-General H. D. Keary, Cmdg. 3rd Lahore Division :—" Farewell order to the Sappers and Miners, 3rd Division, Mesopotamian Expeditionary Force.—On leaving the 3rd Division I desire to record my appreciation of the splendid work done by all ranks of the 18th, 20th, and 21st Companies, 3rd Sappers and Miners. The 20th and 21st Companies have been with the Division since its arrival in France, and with it have taken part in numberless battles of the first magnitude. Since the day on which they, in conjunction with the 47th Sikhs and 9th Bhopals, captured the village of Neuve Chapelle in October, 1914, to the battle of Jebel Hamrin in March, 1917, these two companies have held a record of gallantry and fine fighting spirit second to none. Among other feats must be mentioned that of Capt. Arbuthnot and his handful of men who held on to the Dujailah Redoubt to almost the last man against overwhelming odds. To enumerate all the fine achievements of these two companies would be too lengthy for the purposes of this order ; suffice it to say, wherever and whenever they have been called upon to assist in battle they have responded nobly. As sappers their toil has been unceasing, by day and by night, digging, wiring, bunding, bridging, or sapping, all three companies have laboured unremittingly under all conditions of enemy's fire, floods, heat, cold, and privation, with the utmost cheerfulness and zeal. No troops could have harder or such long hours, while the quality of work has shown ingenuity and skill of a high order. I must especially thank Colonel Stack for his power of command and for his readiness and resources under every conceivable emergency. It would be invidious to mention any others by name where all have done so well, but I can truly say it would be hard to find a finer lot of officers anywhere. I wish all ranks farewell and every good fortune, with the assurance that I shall not readily forget my association with the above three companies of the 3rd Sappers and Miners."

The 19th Field Company, as a unit, did not leave India until 10th November, 1917, but long before that date practically all its pre-war *personnel* had joined other corps units, as drafts. In

November, 1917, the Company joined the 13th Division in Mesopotamia, and in April, 1919, went to N. Persia.

The casualties of the Corps were far less in the last two than in the first two years of the war; once the companies left France and the Mesopotamia fighting that ended with the fall of Kut, and the abandonment of attempts to relieve it, was over, they became comparatively light. Many new units were formed, and in the list which follows is shewn the theatres of war in which the Corps has been engaged, including the recent operations in India and Persia.

The 20th and 21st Companies arrived at Kirkee on 17th August, 1920, after exactly six years' absence. Only about a dozen men were left in them of those who sailed in August, 1914. The most striking record is perhaps that of Liakat Ali, 21st Company, who left in 1914 as a sapper, fought through the war, and survived to lead his company home over Holkar's Bridge once more, as its subadar.

No war history of the Corps can be complete without reference to the sterling work of the following, who all served throughout the war at Kirkee, and to whose unremitting labour in the duties of a depôt is chiefly due to the fact that, after its first heavy casualties, the Corps was able to maintain its strength and reputation in the field:—Subadar Major Arjun Powar; R.S.M. W. H. Miers, R.E.; Q.M.S. (later Lieut.) J. W. Mann, R.E.; Q.M.S.I. W. Rice, R.E.; Subadar Poshati Mari. Not only had the depôt to keep our original units up to strength, but also to enlist and train sufficient men to raise the Corps to two and a half times pre-war strength.

Personal Notes on a few of the older Indian Officers.

Subadar-Major Arjun Power.—Senior I.O. of the Corps; at Kirkee throughout; responsible for every recruit enlisted. Bahaduri. Lieutenancy 1.7.20. Pensioned 1.8.20, with 31 years' service.

Subadar Poshati Mari.—Senior F.W. Instructor; at Kirkee through out; literally worked till he dropped. Bahaduri. Died at Kirkee, still in harness, on 2.3.20, with 35 years' service.

Subadar Malla Singh.—With 21st to France. Neuve Chapelle gained him great honour, but broke him up. Returned to Kirkee, and died there on 2.11.19. Bahaduri; I.O.M.; M.C.

Subadar Baryam Singh, *I.O.M. (pre-war).—With 17th to Mesopotamia; died of wounds in Kut during siege. Bahaduri.

Subadar Ismail Khan.—With 21st to France as Jemadar; later Subadar. Wounded. Bahaduri; I.D.S.M.; Russian Cross of St. George. Pensioned as unfit on account of wounds, but re-engaged for depôt, and is still Senior F.W. Instructor at Kirkee.

* Our other pre-war I.O.M., Naik Nuruddin, was killed at Neuve Chapelle, 1914.

Subadar-Major Firoz Ali.—With 22nd to Mesopotamia as Jemadar, then Subadar. Wounded. Became Subadar-Major of a Labour Corps, but returned to Kirkee later. Bahaduri, I.O.M. Lieutenancy 1.7.20. Shortly goes to pension.

Subadar Mohamed Din.—With 17th to Mesopotamia as Jemadar. Later Subadar of 22nd. Captured at Kut. Wounded. I.O.M. Bahaduri. Still serving.

Subadar Ramswami Naidu.—With 22nd to Mesopotamia as Jemadar. Later Subadar. Wounded, later killed. I.O.M. 2nd class. I.O.M. 1st Class.*

Subadar Ali Bahadur.—Joined 20th, and later 21st, in France. Wounded and lost a leg. Pensioned. I.D.S.M.

Subadar Keru Jamdade.—With 22nd to Mesopotamia. Wounded in first action. Pensioned.

Subadar Shah Sayar.—To 21st in Mesopotamia. Wounded in 1916. Bahaduri. Now Subadar of 19th Co.

Subadar Bir Singh.—To 21st as Jemadar. Now Subadar of 17th Company. I.O.M. Wounded.

Subadar Ganpat Mahdu.—With 20th to France. Wounded. Bahaduri. Now Subadar of 71st Company.

Theatres of War in which Units of the Corps have served.

France and Flanders.—20th and 21st Field Companies.

Mesopotamia.—17th, 18th, 19th, 20th, 21st, 22nd, and 104th Field Companies. 3rd Bridging Train, No. 2 Engineer Field Park, Nos. 5, 6, and 10 Printing Sections, Nos. 5 and 8 Photo-Litho Sections, Karun Front Section.

East Africa.—No. 5 Pontoon Park.

Egypt and Palestine.—18th, 20th, 21st, 72nd, 76th, 80th, and 101st Field Companies, 2nd Field Squadron.

Aden Field Force.—23rd Fortress Co., Aden Defence Light Section.

East Persia.—Seistan Detachment, 71st Field Company, 73rd Field Company (2 Sections), No. 5 Photo-Litho Section.

Marri Punitive Force.—71st Field Co. (1 Section), 72nd Field Co.

Afghan War.—17th Field Company (2 Sections), 24th Field Company, 73rd Field Company (2 Sections), 74th Field Company (2 Sections), 75th, 76th, and 80th Field Companies, 4th and 7th Field Troops, 6th Pontoon Park, No. 2 Engineer Field Park, No. 7 Printing Section, No. 6 Photo-Litho Section.

Waziristan Field Force.—74th and 75th Field Companies.

* Our other two 1st Class I.O.M.'s were Jemadar Gurmukh Singh and Naik Sone Singh.

AN EXPLORATION IN SOUTH-EAST TIBET.

By MAJOR H. T. MORSHEAD, D.S.O., R.E.

INTRODUCTION.

IN the following pages I propose to give a short description of an impromptu journey undertaken in 1913—the year before the war—with a view to proving the identity of the Tsangpo River of Tibet with the Bramaputra of the Plains of Assam.

Light literature on the subject of travel and exploration being somewhat alien to the austere pages of the *R.E. Journal*, it will perhaps be well to confess at the outset that this article is merely an account of a few personal adventures; it contains no new contribution to the art of war in general nor a single suggestion for the improvement of survey methods in particular.

THE TSANGPO PROBLEM AND PREVIOUS ATTEMPTS AT ITS SOLUTION.

Before commencing my story it may not be amiss to recall the history and nature of the long-standing geographical problem presented by the Tsangpo River, and to explain briefly the circumstances which led up to its successful solution seven years ago.

The upper course of the great river from its source near the Manasarowar Lake to the town of Tsetang, south-east of Lhasa, was first made known to us through the journey of the Indian explorer, Pandit Nain Singh, C.I.E., who was trained by Capt. T. G. Montgomerie, R.E., of the Survey of India, and whose original journey in the years 1865-66 resulted in a reliable route map of the first six hundred miles of the course of the river.

With a view to tracing the lower course of the Tsangpo and of proving its identity with the Dihang branch of the Brahmaputra River of Assam, Capt. Harman, R.E., of the Survey of India, enlisted in the year 1880 a Chinese lama whom he instructed to proceed as far down the river as possible and to throw marked logs into the Tsangpo. Watchers were to be stationed at the junction of the Dihang and Brahmaputra to note the arrival of these logs. The lama took with him, as servant or companion, a native of Sikkim, Kinthup by name, who had previously accompanied another Indian explorer on a journey in the same neighbourhood. On arrival at a place called Tongkyuk dzong, near the borders of China, the lama, becoming apparently "fed up" with his errand, sold Kinthup into slavery and returned to his own home in China, never to be heard of

again. Kinthup managed to escape and returned to Darjeeling after an absence of four years—having traced the course of the Tsangpo nearly 100 miles lower than any previous explorer, until turned back by the savagery of the Abor tribes within some 40 miles of the Plains of Assam. He even carried out the programme of throwing 500 marked logs into the river, but Capt. Harman had in the meantime died—a victim to over-work—and the logs floated unowned and unnoticed into the broad bosom of the great river of Assam.

Kinthup being quite illiterate could only dictate his experiences from memory on his return, and his information not being based on any route survey added little to the map of South-east Tibet. One alleged statement of Kinthup's created considerable interest, namely, that "at a place called Sinji-Chogyal the river falls over a cliff from a height of about 150 feet, a big lake lying at the foot of the falls, where rainbows are always observable." Falls of such a height are absolutely unknown on any of the great Himalayan rivers and are, indeed, almost an impossibility in an area of such geologically recent formation, where the strata are largely composed of uncompacted shales. Yet without postulating the existence of falls it seemed difficult to account for the huge drop in the bed of the river from 12,000 feet in the neighbourhood of Lhasa to its emergence into the Plains of Assam at a height of 500 feet above sea level.

Harman's death marked the end of the era of native Indian exploration which had produced such grand results during the previous 20 years, and interest in the Tsangpo problem lapsed until the military and political expedition to Lhasa under Colonel Younghusband in 1904–5. This expedition was accompanied by a fully-equipped Survey party under Major C. H. D. Ryder (now Colonel Ryder, C.I.E., D.S.O., R.E., Surveyor-General of India) and it was confidently hoped that at the close of the campaign an opportunity might occur for a small survey party with escorts to return to India *viâ* the lower course of the river, and thus settle the problem once and for all. Political conditions, however, rendered this impossible, and the survey party proceeded up-stream instead of down—carrying out a rigorous survey of the Upper Tsangpo Valley and of the Northern Slopes of the great Himalayan range, and amplifying and confirming Nain Singh's route traverse of 40 years before.

Six years later various events on the North-east Frontier combined to focus attention on this little known area. A punitive expedition, accompanied by a Survey party, was sent into the Abor Hills in the cold weather of 1911–12; other survey parties under military police escort were at the same time organized for work in the neighbouring valleys of the Subansiri River (Miri tribes) on the west, of the Luhit River (Mishmi tribes) on the east, and of the headwaters of the Irawadi (Kachin and Shan States) from the Burma side, with a view

to the complete mapping of the Indian N.E. Frontier. As the work was not completed during the cold weather season, 1911–12, these parties were again sent out in the following season, 1912–13.

At the close of the second field season in May, 1913, the position was as follows:—The Abor Survey Party, under Capts. Trenchard and Oakes, R.E., had surveyed the basin of the Dihang River and its principal tributaries, as far north as latitude 29° 15′ approximately (*vide* accompanying map). The Mishmi Survey Party, under Major Gunter, R.E., and the present writer, had completed the survey of the whole basin of the Dibang River, which had been proved not to pierce the main Himalayan range to the north. During the course of the latter operations a colony of Tibetans from the province of Kham was discovered at Mipi village in the upper valley of the Matun branch of the Dibang River. These Tibetans, who proved friendly, volunteered much interesting information regarding their own native country, and offered to provide guides to point out the road thither. It was felt that a unique opportunity was thus offered for a small party to penetrate the unknown reaches of the Tsangpo in the neighbourhood of the great bend, and thence possibly to follow the hitherto unexplored Frontier westwards towards Bhutan.

By great good fortune the Assistant Political Officer with the Mishmi party was Capt. F. M. Bailey, I.A., a man of boundless physical energy, a born naturalist and explorer, and possessing an intimate knowledge of the Tibetan language and customs.

Our Journey—Pemakö, Pomé, and the Great Bend.

On the conclusion of the Mishmi Survey Operations, Bailey and myself, with ten picked coolies remained behind in Mipi, where we had been able to store a two months' supply of rations and a complete outfit of warm clothing for our small party.

Having spent the first half of May in laying out depôts of rations, as far in advance along the road as the now rapidly receding snow-line permitted, we finally quitted Mipi with our ten coolies and three local guides, in pouring rain, on May 16th. The going was extremely bad, as the incessant rain and the rapid melting of the snow on the hills had combined to render the whole country a morass. Our marches were therefore short; we had, moreover, to make several halts while our coolies returned to fetch up the reserve of rations; so that it was not until 24th May that we reached the "Latsa," or hut, at the foot of the Yonggyap Pass. The next day snow fell heavily all day and our guides declared that it would be madness to attempt the Pass. On the 26th, the weather having slightly improved, we started early—ourselves carrying guns, plane-table, etc., so as to have every possible coolie available for carrying rations. Owing to a thick mist, our guides had great difficulty in finding the

Pass, which is reached by a toilsome ascent of some 1,500 feet through deep snow, and it was dark when we reached the "Latsa" on the north side of the Pass. Here we had to halt for a day, as four of our coolies were totally incapacitated by snow-blindness. There had been no apparent glare on the snow, owing to the dense mist all day, and the possibility of snow-blindness had not occurred to us. However, we received a lesson thus early by which we were not slow to profit. We were now in the valley of the Shümo, or Yonggyap River, a tributary of the Dihang, or Tsangpo.

A peculiar Tibetan characteristic may here be mentioned, namely, that of giving the same name to the two streams which flow in opposite directions from the two sides of a mountain pass. Thus from the Yonggyap Pass, one Yonggyap stream flows S.E. to join the Dibang River, while another stream of the same name flows W. to join the Dihang River.

Since leaving Mipi, not a single triangulated peak had been visible through the cloud and mist, and I began to realize the impossibility of carrying on any system of connected triangulation, or indeed, of executing any more rigorous method of survey than a route traverse by "time and compass."

One march from the "Latsa" Camp brought us to Yonggyap Da, where the streams from the Yonggyap and Pungpung Passes unite. The combined waters of these two streams join the Dihang under the name of the Shümo River. There is, however, no road down the Shümo Valley, and in order to reach the Dihang it is necessary to cross the Pungpung Pass, and follow the Chimdro stream to its confluence with the Dihang near Kapu. Just above Yonggyap Da there is a shallow lake, some two miles long by half a mile wide, formed by the damming of the stream.

On the 30th May we crossed the Pungpung Pass (14,310 feet by hypsometer), which, like the Yonggyap, was under 20 feet of snow, and next day reached the village of Gudam in the Chimdro Valley—the first human habitation which we had seen since leaving Mipi fifteen days before. From Mipi to Chimdro is a distance of nearly 100 miles through uninhabited country in which no supplies of any kind are procurable. The journey, moreover, involves the crossing of two passes which, though not exceedingly high, are yet dangerous on account of their proneness to constant snow storms and mist. The necessity of providing food for the whole party for this portion of the journey had greatly curtailed our carrying capacity; though we were able largely to supplement our food supply by shooting pheasants—three varieties of which, munal, tragopan, and blood pheasant, were very plentiful just below the snow-line.

At Chimdro, Bailey succeeded in inducing the local "dzongpen," or Tibetan official, to provide us with coolies and supplies for our onward journey. This was a most important achievement, since our

title to supplies and transport, thus once admitted, served as a precedent for the whole of our journey.

On the 5th June we reached Kapu in the Dihang Valley, and heard that the Abor Column were some 6 marches down stream. This portion of the Tsangpo valley below the great bend is known as Pemakö. It was originally inhabited by wild Abor tribes, but the latter were ousted 100 years or so ago by immigrant "Mönbas" or Bhutanese. The latter are, of course, Buddhists by religion, and still like to consider themselves Bhutanese subjects, though actually they are subjects of Pomé. From Kapu I sent a letter by native runner to Trenchard informing him of our arrival, and asking for the co-ordinates of any triangulated points which he might have fixed. While waiting for a reply we traversed leisurely down the Dihang Valley, halting at Makti (where a brief interval of clear sky enabled me to observe N. and S. stars for latitude) and finally ascending a side spur to the monastery of Rinchenpung. The river is here some 120 yards wide and the current very fierce. It is spanned here and there by single-rope bridges of twisted cane which have to be crossed "hand-over-hand" in monkey fashion—the weight of the body being supported by leather thongs fixed to a wooden saddle which slides over the rope. The river level at this point is about 2,600 feet, and the densely-wooded sides of the valley rise steeply on either hand to a height of 6,000 or 7,000 feet. Villages occur every few miles along the lower slopes of the valley on either bank. The moist, damp heat of the valley at this time of the year is most trying; combined with the perfect plague of mosquitoes, leeches, and gadflies, life would have been rendered almost unbearable were it not for the very excellent quality of beer which is brewed here in large quantities from millet.

After vainly waiting three days for a reply to my letter, we retraced our steps to Kapu, and thence continued up the valley *viâ* Kemteng and Tsangrang to Lagung, where we found the "Nyerpa," or Prime Minister of Pomé, Namgye by name, waiting for us. Namgye was returning from a winter tour in Pemakö, and had been in correspondence with the Abor Column, who had informed him that they did not intend to penetrate into Pemakö. He was, therefore, inclined to view us with considerable suspicion, regarding our arrival in the country as a breach of faith. Finally, it was settled that we were to abandon our intention of following up the valley of the Tsangpo, and were to accompany him over the Sü Pass to Showa, the capital of Pomé, where a council would be held as to our disposal.

We halted two days at Lagung. The Nyerpa came to see us on the morning of the second day, bringing a present of rice, tea, etc. He was less on his dignity than before, and had a long conversation with us. He had with him a number of Chinese matchlocks, and in the afternoon, by way, apparently, of impressing us, he fired off a

number of rounds at a mark. We joined in with a round or two from our own rifles. In the evening he came again to see us—very friendly, but as drunk as a lord.

We crossed the Sü Pass on 23rd June, and by judiciously lagging behind the Nyerpa's party, I was able to fix accurately the position and height of the Pass (13,445 feet) by trigonometrical interpolation by means of a surreptitiously observed sun-azimuth to the two previously triangulated peaks of Namcha Barwa. The crossing of the Pass involved a climb of 2,900 feet over snow which was quite hard and easy to travel over, though in places the leading man cut steps with his sword.

On the Pass we saw "munal" pheasants, and another strange game bird resembling the "ram-chukor," which we were unable to identify as unfortunately the only specimen which I shot fell 500 feet down the hillside and was lost under a snow-drift.

We reached Showa on June 25th, and were kept more or less prisoners in the travellers' house for three days, during which time Bailey spent many hours pressing our case before the Council, who affected to believe we represented a Southern flank attack on the part of the Chinese who had been expelled eastwards out of the country 18 months previously. Matters were eventually settled satisfactorily, and we were given a mounted guide and promises of supplies and transport to take us to the Tibetan border; though, at the very last moment their suspicions were again aroused, and the negotiations imperilled, at the sight of the Chinese writing on the tablet of Indian ink which I was using in inking up my plane-table.

In the Pomé valley one first began to notice a change in the type of scenery and vegetation from that of the Abor and Mishmi Hills. The dense tropical jungle of the lower Dihang valley gives way to tall pines and cypresses growing from a carpet of lush grass and vivid-coloured wild flowers; while the substantial stone-built houses, terraced fields, and avenues of peach, walnut, and pollard, willow denoted a higher type of civilization than we had hitherto met. Showa, the capital of the country is a straggling village of perhaps 40 houses, situated on the south bank of the Po-Tsangpo. There are the remains of a large palace and monastery, which, together with the bridge over the river, were destroyed by the Chinese during the frontier fighting of 1911. A fine new cantilever bridge of 50 yards span had just been completed.

The Pobas, or inhabitants of Poyul (the Po-Tsangpo Valley) claim to be independent of Lhasa, although actually they apparently pay a small annual tax to Lhasa. This tax is paid in kind, in the form of butter, madder dye, and sulphur. The Pobas have the reputation amongst their neighbours of being a tribe of wild robbers. They certainly raid the countries bordering their own frontier, and the Tibetans of Kongbo subsequently told us that we were extremely

lucky in getting through Pomé alive, as they usually kill all travellers who are worth looting. This is no doubt an exaggeration, but it shows the feelings entertained towards the Pobas by other Tibetans.

We were much struck by the immense volume of water carried by the Po-Tsangpo, which is here some 80 yards in average width, deep, and with a very fierce current. We were very anxious to explore this river to its sources on the Chinese frontier, but this the Nyerpa flatly refused to countenance—alleging as a reason that the inhabitants of the upper valleys were bandits and robbers.

Up to this point I had endeavoured, as far as possible, to conceal the fact that I was making a map; for which reason, and also owing to the incessant rain, I had avoided using the plane-table, contenting myself with a rough prismatic compass traverse, which was plotted in the evenings. Having now made friends with the Nyerpa, I explained my business to him, showing him the whole of my instruments, etc., to which he made no objection. He remarked, indeed, that once many years previously a Chinaman had come from the west, and had attempted to march through the country counting his paces and writing the numbers down in a book, but that in accordance with the custom of the time, he had been bundled out of the country by the way he came, with the intimation that such things were not done in Pomé. This may have been the Chinese monk referred to on a previous page, who decamped after selling Kinthup into captivity.

I may here remark that the policy then initiated of absolute openness in regard to the object of our journey, and the making of the map, proved completely successful. No serious objection was ever made to our operations, and we had the priceless advantage of being able to work openly and with an easy conscience.

Having meantime received Trenchard's reply to my letter, we left Showa on the 28th June, and in two days reached the villages of Tang-Tö and Tang-Me (Upper and Lower Tang), where our journey down the Po-Tsangpo was stopped by a broken bridge over the Yigrong affluent, necessitating a two days' excursion up the valley to a ferry on the Yigrong Lake. The story of the formation of this lake as told us by the natives is worth recording. Some 13 years previously the Tralung stream, a small tributary of the Yigrong ceased to flow for three days, while rumblings were heard up the valley. Suddenly, at 2 or 3 o'clock in the afternoon an immense, mass of mud and stones came down the valley completely engulfing two villages at the mouth of the stream, as well as two more on the opposite bank of the Yigrong, and forming a dam across the river some 350 feet high and 1¼ miles in width. For a month the Yigrong remained completely dammed, while a huge lake gradually formed; finally the dam was topped, and the pent-up water was released to form the famous flood which was noticed in Assam in the year

1900 as carrying the corpses of strange men and pine-trees of an unknown variety. Fourteen miles down stream from the lake, we were shown the site of an old village, 170 feet above the present river level, which was washed away in this flood. The lake to-day is nearly 10 miles long and ¾-mile in average width, and though the Yigrong is still cutting away the dam, it is probable that the lake will have filled with silt before the original level of the river bed is reached. Many villages and fields were submerged by the rising waters of the lake, the owners of which, wandering southwards in search of new homes, founded the colony of Mipi in the Mishmi hills.

The hills on either side of the Yigrong Lake contain iron ore. A vein at the S.E. corner of the lake is worked by means of a horizontal adit extending some 600 feet into the hill-side. The ore is smelted on the spot, and made into swords which are traded in Kongbo and Pemakö.

We camped for a day on the edge of the lake, in order to enable us to map its northern extremity. Bailey took advantage of the opportunity to go off shooting and returned to camp in the evening with a new species of "Gooral," which has subsequently been named "Nemorhaedus Baileyi."

On July 9th we reached Trulung. Here the road down the valley to Pemakö crosses to the left bank of the Po-Tsangpo, but the single-rope bridge which spans the river had been carried away a few days prior to our arrival, and we were consequently unable to carry out our intended programme of making good the section of the river down to where we had left it at Lagung. It may be here remarked that the bridges of Pemakö and Pomé, which are all of the "single-rope" type, are usually carried away when the rivers rise in June, and are not renewed until the following cold weather, so that travelling is only possible during the winter and spring.

From Trulung we therefore followed the Tibet road up the Rong River *viâ* Tongyuk dzong (the site of Kingthup's captivity) and the Nyima Pass (15,240 feet) to the village of Pe, on the Tsangpo, which we reached on July 13th. The river is here broad, deep, and placid, and we were rowed across to the south bank in a ferry boat. We were now in the Tibetan province of Kongbo. We were informed that two officers (whom we afterwards ascertained to be Capts. Trenchard and Pemberton, R.E., of the Abor party) and some Gurkha Sepoys had arrived here from Pemakö seven days previously *viâ* the Doshong Pass, and had returned after a halt of one day. We met the dzongpen of Tsela and other officials who had hurried to Pe on hearing of the arrival of the strangers, and from them we were able to obtain passports, which helped us materially for the remainder of our journey in Tibet.

Having collected a supply of rations we followed down the right bank of the Tsangpo to Gyala. This is the last Tibetan village of

any size on the Tsangpo during its course in Tibet proper, and is the headquarters of a "depa," or sub-official, subordinate to the dzongpen of Tsela.

Hearing some pheasant calling just outside our camp at Gyala, Bailey rushed out with his gun and a few cartridges and presently returned with half a dozen specimens of the extremely rare "Harman's pheasant." This bird is named after the late Capt. Harman, R.E., of the Survey of India, who in 1880 obtained from one of his Tibetan explorers a single imperfect skin of an unknown " eared " pheasant. This he sent to the British Museum, where it was described under the name of *crossoptilon harmani*, and remained the only known specimen of its species until Bailey's lucky find 33 years later. The bird is large and of a uniform slaty-blue colour, with red back, legs, and eye-patches.

Across the river on a small side stream are the falls of Shingche Chogye. The limestone rocks which from the bed of the stream have been hollowed out into curious caverns by the water, which falls n three successive cascades of some 50 feet each, into the Tsangpo below. A demon who gives his name to the falls is popularly supposed to be chained behind the falling waters, but is only visible at times of very low water.

Below Gyala the valley narrows and the Tsangpo gradually changes from a placid river into a roaring torrent. Pemakö-Chung which we reached on July 21st is the last Tibetan habitation. It consists merely of a humble monastery and one other occupied house. A mile or so above the monastery the Tsangpo falls over a cliff some 30 feet in height, and from here onwards can only be described as a seething, boiling mass of water. I was able to fix in the position of these falls accurately by trigonometrical interpolation from the peaks of Namcha Barwa which towered overhead 5 miles to the south. While I was working on the edge of the falls, four huge " takin " were gazing and basking in the sun on the opposite (north) bank of the river not 80 yards away. Only three specimens of this extremely rare animal had at that time ever been shot by any European, and the temptation to empty my rifle into the four ungainly unconcerned forms was almost irresistible. However, to collect their bodies would have involved at least 10 days' delay in returning up-stream to the nearest bridge at Gyala and down the other side, and as we could ill afford the time I spared their lives.

We were told that there was absolutely no road down the valley to Pemakö ; we determined, therefore, to cut a road for ourselves as long as our rations lasted, and succeeded in reaching a prominent spur, 13 miles further down the valley from which I was able to trace the general alignment of the Tsangpo for the next 30 or 40 miles of its downward course, as well as to fix the general position of the high, snowy range round which the Po-Tsangpo flows N.W. of the Sü Pass.

Returning to Pemakö-Chung we found that during our absence a party of "Mönbas" from Pemakö, escorting a holy lama on a pilgrimage to Lhasa, had cut themselves a road up the Tsangpo Valley, following the water's edge. This was said to be the first time for 20 years that there had been any direct communication through the gorge of the Tsangpo River, between Kongbo and Pemakö. Our rations were unfortunately now almost exhausted, so I returned to Gyala, while Bailey with a single coolie followed some of the returning escort and succeeded in getting a few miles below our previous limit when the Mönbas deserted him at an almost impassable precipice, and he was compelled to return, after taking a hypsometer reading at the lowest point reached on the river. In going through the thick jungle at this spot, Bailey had the misfortune to lose his camera—the only one we had with us—and we have no photographic record of the remaining portion of our journey.

Bailey questioned numerous natives regarding the portion of the river unvisited by us, whose length we estimated at 45 miles. They are unanimous in asserting that it continues the same seething, boiling current, but that there are no actual waterfalls as large as the falls at Pemakö-Chung. The following table A exhibits the heights and gradients of the Tsangpo River in the neighbourhood of the great bend. Table B gives similar information for the lower reaches of the Po-Tsangpo.

TABLE A.

Places on the Tsangpo.	Height in feet.	Fall in feet.	Distance in miles.	Gradient in feet per mile.	Remarks.
Nyuksang	8732				
Pemakö-Chung (top of falls) ...	8381	351	14½	24	
Sanglung confluence	8089	292	3	97	
1½ miles below confluence... ...	8010	79	1½	53	
2 miles below Churung confluence	7477	533	11	49	
Gompo-né (assumed)	5700	1777	20*	89	Confluence of Tsangpo and Po-Tsangpo
Chimdro confluence	2606	3094	75*	41	

TABLE B.

Showa (river level)	8312			
Tangmé (river level)	6751	1561	31	50
Trulung (river level)	6424	327	10½	31
Gompo-né (assumed)	5700	724	25*	29
Yigrong Lake	7301			
Tangmé	6751	550	17½	31

*Assumed distances. Of the seventy-five miles between Gompo-né and the Chimdro confluence, 45 miles were mapped and the remaining thirty miles filled in from native information. Diplomatic reasons prevented our obtaining a hypsometric observation of the river-level and Lagung where we quitted the Tsangpo valley.

In this table a height of 5,700 feet has been assumed for the junction of the Tsangpo and Po-Tsangpo at Gompo-né, on the assumption that the gradient of approximately 30 feet per mile deduced for the latter river, continues as far as the confluence.

Fortunately, while we were at Pemakö-Chung a spell of bright sunny weather occurred, which enabled me to survey this portion of the valley by accurate fixings from Namcha Barwa and the neighbouring triangulated peaks and also to fix the prominent groups of snows on the opposite bank of the river which culminate in the magnificent peak of Gyala Peri (23,460 feet) never before seen by any European. The stupendous nature of the Tsangpo gorge may be realized when it is remembered that the peaks of Gyala Peri (23,460 feet) on the N. and Namcha Barwa (25,445 feet) on the S. are less than 14 miles apart in a straight line, while the level of the Tsangpo River, which flows midway between them is only 8000 feet—thus on either hand the mountains rise 15,000 feet in a horizontal distance of less than seven miles.

Bailey having rejoined me at Gyala on August 3rd we crossed the river by a single-rope bridge and returned by the N. bank to Pe. There had been a ferry boat at Gyala in additon to the bridge, but unfortunately just before our arrival a woman had attempted to ferry herself across alone in the boat and was carried down-stream; neither the boat nor the woman were ever seen again; they had doubtless been dashed to pieces in the rapids below. The bridge consisted of a single-rope 150 yards long, and 50 feet above the water in the centre; the sag in the middle was so great as to render the pull-up on the far bank a considerable acrobatic feat, and the hauling across of all our baggage piece by piece was a heavy task.

Our Journey (*continued*)—S.E. Tibet, and the Head Waters of the Subansiri.

From Pe to Tsetang, which we reached on 29th August, the road calls for little comment. With the exception of two large bends in the river, which the road avoids by short cuts over spurs *viâ* the Kongbo-Nga and the Putrang Passes, there is a good riding road for the whole 300 miles on both banks of the river. We followed the N. bank as far as Tu, in the hope of obtaining a view of the triangulated peaks of the main Himalayan watershed to the S.; this, however, was not possible owing to the dense clouds due to the Indian monsoon.

Harvesting operations were in full swing in the villages through which we passed. The barley, which is the only crop grown at these altitudes, is threshed at once and parched whole on large flat iron plates, after which it is ground into a dry ready-cooked powder called "tsampa," which, mixed with tea or beer, forms the staple food of the country.

For some 80 miles above Pe the Tsangpo flows in a broad placid stream with numerous sandy islands and spits. Further upstream the valley again narrows, and from Orong and Gacha to within a

few miles of Tsetang the river is broken and rapid. The Gyamda Chu, a large river flowing in a wide alluvial valley, joins the Tsangpo at Tsela, and is noteworthy as being the only important exception to the remarkable observed fact regarding the Tsangpo, namely, that its tributaries join the main river at an angle opposed to the direction of flow of the main stream.

Tsetang, which had previously been visited by Pandit Nain Singh and other Indian explorers, is a town of 200 or 300 houses. We found here a small colony of Kashmiri Mohommedan traders from whom we were able to buy a fresh outfit of boots and clothes for our coolies, as well as a few luxuries, such as brick tea, soap, and sugar for ourselves.

From Tsetang after a two days' halt we followed the road of Nain Singh and others southwards up the wide fertile Yarlung Valley, and crossed the Yar-tö-Tra Pass (16,700 feet) to Chumda Kyang. We were now in the typical "*Chang tang*," or elevated plateau country of Tibet, far above the level of trees or fuel, and where no crop will ripen, save a little stunted barley. Villages here are few and squalid, and the undulating stony plains are void of all detail, except where a few black yak-hair tents and scattered flocks of sheep and yaks mark the presence of a "*drok*" or grazing camp. Fierce, icy winds sweep the surface of the ground continuously.

Continuing eastwards we reached Kyekye on 4th September, *viâ* the Pu La (a pass on the boundary between the Tibetan provinces of Ü and Takpo, and also on the watershed between the Tsangpo and the Subansiri River). Here we saw numbers of Tibetan gazelle, of which I shot one. On awaking the following morning we found that the box containing our store of money had been stolen from our tent during the night, and that three of our own coolies were missing. Though we sent letters to all the neighbouring "dzongpens," we never discovered any trace of the three culprits, or of our missing property. We also wrote to the head of the Kashmiri community in Tsetang, Qazi 'Ata ulla, informing him of our plight. This man very obligingly agreed to cash us a cheque on Calcutta, himself travelling all the way to Lhontse dzong with the money.

Meanwhile we continued our journey down the Char River nearly to Sanga Chöling; turning up a side valley eight miles west of this place and crossing the Kamba Pass, we found ourselves again in the Tsangpo drainage, at the head of the Trulung River. Following down the western and up the eastern branch of this river we crossed the Kongmo Pass (17,520 feet) into the head-waters of the Tsari River, another branch of the Subansiri. This valley which we followed as far as Migyitün, is remarkable for its very heavy rainfall, which is reflected in the denseness of the jungle growth on the hillsides; in this respect it differs widely from the other Tibetan head-waters of the Subansiri, namely, the Char, Nye, and Loro or Chayal Rivers, all of

which, down to the point at which they pierce the main Himalayan axis, traverse dry arid valleys.

The Tsari valley contains the sacred shrine of Chikchar, and the entire district is considered so holy that not only is no shooting or killing of animals allowed therein, but from the Kongmo Pass downwards the ground is not allowed to be broken by plough, or tilled in any way. Food is correspondingly expensive. The Buddhist religion, of course, forbids the taking of life in any form. The Tibetans, however, only apply this principle to wild animals, though they ordinarily made no objection to our shooting as much wild game as we wished for food or for sport.

Below Migyitün the road is only used by the semi-savage tribesmen from the southern slopes of the Himalayas, who come up to trade in salt, in the cold weather. At the time of our visit, the bridges had been carried away in flood and the road was impassable.

On the return journey, Bailey followed the route of the Tsari pilgrimage, starting from Chikchar, while I proceeded *viâ* the Ça Pass (16,610 feet) direct to Sanga Chöling. Here I had a most hospitable reception, and halted a day to visit the large and well-appointed monastery. I then completed the survey of the remainder of the Char River down to the point where it enters the gorge of the Himalaya at Lung. The last inhabited Tibetan village is Drü, below which the scenery changes with startling abruptness. On rounding a bend in the valley, at the deserted village of Raprang, the placid river suddenly becomes a foaming rapid with a fall of 300 feet in a mile, while the bare Tibetan hillsides are succeeded in the course of a few miles by the dark leech-infested jungles of the Himalaya.

I returned to meet Bailey at Charmé whence we crossed the Le Pass to Nyerong on the Nye River. Eight miles below Nyerong the Nye River unites with the Loro River to form the Chayul, which in turn joins the Char River at the Lung gorge to form the main branch of the Subansiri. We followed the Chayul down the extreme Tibetan village of Drötang, below which there was said to be uninhabited country for five or six marches before the first "Lopa" village is reached. "Lopa" is the Tibetan name for the semi-savage inhabitants of the Subansiri valley on the south side of the main Himalayan range. These "Lopas" come up the valley in large numbers to trade when the road is open during the cold weather, but no Tibetan ever visits the "Lopa" country, so that it is not easy to obtain information from the Tibetan side. At the time of our visit the valley road was closed and a large stretch of the middle course of the Subansiri had still perforce to remain unsurveyed. The "Lopas" will not accept money, and the trading is all done by barter, madder dye being exchanged for salt. A curious custom prevails of adulterating the salt with large quantities of a kind of dry moss which grows on the

Tibetan uplands, three parts of moss being mixed with one of salt before exchanging with the "Lopas." We failed to ascertain the precise cause or origin of this custom; it is not apparently done merely with the object of cheating the "Lopas," since the latter seem to be fully aware of the practice. One man informed us that were it not for the moss, the salt being "hygroscopic" would liquify and escape from the sacks in the damp climate of the "Lopa" country.

Returning to Chayul dzong, we followed up the Loro Valley to Trashi Tongmé. Here I recognized a group of triangulated snow peaks to the S.E., and was able to check my position by the method of "latitude and azimuth."

Two streams, the Loro Karpo and the Loro Nakpo (White Loro and Black Loro) here unite. We ascended the valley of the latter, and on 2nd October crossed a high pass, the Pen La (17,330 feet) into the head of the Seti Chu, in the drainage system of the Manas. The Seti Valley is uninhabited, and the river cuts through the Himalayan range in an impassable gorge. The road after rounding a spur crosses the main Himalayan axis by the Tulung Pass (17,250 feet), and follows a steep narrow valley down to the curious twin villages of Nyuri and Dyuri which together form the remote little district of Mago, situated in the heart of the mountains. Immediately below Mago the river enters a gorge down which there is no communication, and the only other road is one over the Chera Pass. From the top of this pass two roads diverge, one going westwards to Tawang, and one which we followed crossing the Tse Pass (15,550 feet) into a branch of the Dirang River—itself a tributary of the Bharoli River of Assam. After crossing the Pöshing Pass, the road descends a spur to the last Tibetan village of Lagam. From our camp below the Pöshing La, the plains of Assam were clearly visible in the early morning, but clouds soon obscured the landscape.

We were now amongst the Bhutanese again, and although the heat of the low-lying "Mönba" valleys was somewhat enervating, yet the verdant hill-sides had neatly cultivated fields, forming a pleasant contrast to the barren landscapes of Tibet. Millet, buckwheat, tobacco, chillies, and maize appeared to be the chief crops. The two latter were being gathered as we passed, and the red chillies spread out to dry on the roofs of the houses formed a pleasing dash of colour. The Indian madder vine (*rubia cordifolia*) grows wild in this country, and the madder is exported in enormous quantities to Tibet, for dyeing the gowns of the monks.

Three marches from Lagam brought us to Dirang dzong, where we were again on Nain Singh's old route, which we followed over the Se Pass (13,940 feet) to Tawang. The weather at this period was execrable, and I was very glad to have Nain Singh's fixed position of Tawang from which to start my traverse afresh.

All this time we had been entirely subsisting on the 70 rupees or so which we had in our belts and pockets when our money was stolen in Kyekye six weeks previously; and although we had sent two of our own servants to receive the money from Qazi 'Ata Ulla, we had not been able to arrange any place for our servants to join us again. So, although we had now accomplished our mission, namely, the exploration of the Frontier from Pemakö to Tawang, we had to return once more to Tibet to pick up our servants and money.

Leaving Tawang on October 19th, we avoided Nain Singh's route, and descended the valley of the Tawang Chu, as far as the confluence of the Nyamjang. The latter is an important river 90 miles in length, which rises in Tibet and cuts through the Himalayan range in latitude 28° 0′—28° 5′, but it has not been shown on any previous map. The villages are Bhutanese as far as Trimo, at which point we left the valley and crossed the Pö Pass (14,900 feet) to Tsöna. Here we found our two servants waiting with the money. We were now (October 23rd) once more on the Tibetan "Chang tang," and the cold was intense; but we wished to complete our survey of the waters of the Laro Karpo and the Nye Rivers before returning, so having expended our money in "Chubas" (thick blanket coats) for our servants and blankets for ourselves, we set out on the road to Trashi Tongmé. Bailey travelled *viâ* the Lagor Pass to Lhöntse, thence making an excursion down the Nye River. I halted a day at Loro to follow a herd of *ovis ammon*, out of which I got two fine males, which kept us and our coolies supplied with mutton for the rest of our journey. I rejoined Bailey at Lhöntse, travelling *viâ* the Gyandro Pass.

Below Lhöntse the Nye River flows through a narrow gorge, but the upper portion of the valley consists of a wide stony plain, or "pamir," upwards of a mile in width and containing numerous fields and scattered homesteads.

On the 31st October we crossed our last high pass, the Hor La (17,680 feet), into the head-waters of the Nyamjang Chu. The western descent from this pass is extremely narrow and steep; below Gyao, however, the valley widens and the river flows in a wide, shingly bed as far as Dongkar dzong, where it again enters a gorge. Opposite the village of Rong the slates and shales of Tibet give place to Himalayan granite and limestone, and jungle and pine trees begin to appear on the hillsides. The main Himalayan axis appears to be crossed between this village and the extreme Tibetan village of Rong.

At Trimo we were on our previous road, which we followed as far as the confluence of the Nyamjang and Tawang Rivers.

Just below this we crossed the Bhutanese frontier, and on 9th November reached Trashigang, where we found a "devil-dance"

in progress, and were hospitably entertained by the Bhutanese dzongpen. Here my survey ended, as the country between Trashigang and the Plains of Assam is already included in the trans-frontier series of the Indian survey maps. Owing to delays in collecting transport much of the last portion of our journey was accomplished by moonlight, so that surveying would in any case have been impracticable. Travelling *via* Diwangiri, we reached Rangiya junction on the Eastern Bengal State Railway at 2 a.m. on the 15th November after a journey estimated at 1,680 miles, through country which, with three minor 18th century exceptions referred to below, has never before been seen by any European.

PREVIOUS EXPLORATION IN S.E. TIBET; VINDICATION OF KINTHUP; SUMMARY OF GEOGRAPHICAL RESULTS OF OUR TRIP; CONCLUSION.

The valley of the Po-Tsangpo has not been visited by any previous explorer, and no explorer except Kinthup has previously traversed the district of Pemakö. Further westward, however, the country is better known.

The earliest record of travel in the province of Takpo appears to be that of the Italian Friars who established the Capuchin Mission at Lhasa in the year 1708. Two members of this mission diverged eastwards, crossed the Yarlung Valley, and eventually penetrated into the province of Takpo, east of Tsetang. Thence they appear to have travelled N.W. to join their brethren at Lhasa. Ten years later we hear of a branch of the Mission being opened at Drong-Nye in Takpo, which is described as near the borders of East Bhutan, about 14 days' journey to the S.E. of Lhasa* This is probably the village of Trong-Nye on the Tsangpo just north of Guru Namgye Dzong. The Capuchin Mission finally collapsed in the year 1745. The only other European traveller in these parts was the Jesuit, Ippolito Desideri, who was commissioned to visit and report on the Capuchin Settlement at Lhasa. His sojourn in Tibet extended from 1716–1721, during which time he made numerous excursions to places S. and S.E. of Lhasa, visiting Samye, Tsetang and the Yalung Valley.

From the date of the final closing of the Capuchin Mission, no further additions were made to our knowledge of this region of Tibet until the era of the Survey of India Native explorers in the decade 1874–84 The first explorer to penetrate this country was late Nain Singh, C.I.E., then known as the Pandit, who reached Lhasa, on his second and last famous journey across Tibet, on the 18th November, 1874. Thence striking S.E. to Samye he followed the Tsangpo to Tsetang. Continuing up the Yarlung Valley over the Yartö-Tra and

* "The Exploration of Tibet: Its History and Particulars from 1623 to 1904" by Graham Sandberg, B.A., pp. 31—40.

Karkang passes into the Sikung district, which is drained by the Nye Chu, he crossed the highly elevated plains of Tengsho and Tsöna, and reached Tawang, where he was detained for some three months. Escaping in February, 1875, the Pandit crossed the Se Pass and travelling *via* Dirang dzong reached Odalgiri in the Plains of Assam on March 1st, 1875.

In December, 1875, the road from Tsetang to Tawang was traversed by explorer "L," who had followed the course of the Tsangpo eastwards from Shigatse, and who wished to follow Nain Singh's route to Assam. At Tawang, however, permission to proceed was refused, and the party after having been taken before the authorities, were imprisoned for a month in the public flour mill. Subsequently three mounted soldiers were told off to escort "L" back to Lhasa. Fortunately, some informality in the documents carried by the guard induced an intermediate official, through whose hands he passed *en route*, to release him, and he was able to make his way back to Shigatse.

In 1878, Capt. Harman, R.E., trained a Sikkimese monk, Nem Singh, and sent him to Tsetang with orders to survey the eastward course of the Tsangpo. Owing to bad weather, Nem Singh had to be despatched before his training was complete; while owing to fear of robbers for whom the province of Takpo was in those days notorious, he hurried over much of his work at undue speed, keeping his record on scraps of paper which were not properly entered in the Field Book. His astronomical observations were also vitiated by an error in his dates. He finally reached the village of Gyala, near Pemakö-Chung, to which he assigned a height of 8,000 feet and a longitude of 94°. Here his traverse ended "in air."

The next explorer is Kinthup, whose work has already been referred to. Kinthup's description of the country, given from memory after his return, is in general quite accurate; referring, however, to Pemakö-Chung, the following erroneous statement is attributed to him in his report:—"The Tsangpo is two chains distant from the Monastery, and about two miles off it falls over a cliff called Sinji-Chogyal from a height of about 150 feet. There is a big lake at the foot of the falls where rainbows are always observable." Actually, the falls near Pemakö-Chung, to which the Tibetans have not given a name, are only some 30 feet in height, though it is true that a rainbow is visible on sunny days in the spray which is thrown up in immense clouds. On the other hand, falls called Shingche Chogye of approximately 150 feet, do actually exist on a small side stream, which joins the Tsangpo on the N. bank opposite Gyala. It would seem that in the course of dictation and translation of Kinthup's narrative, the accounts have been confused of the two separate falls.

After our return to India, Bailey found that Kinthup was still alive, living in retirement in his native Sikkim. He was summoned to Simla in May, 1914, where Bailey questioned the old man regarding his assertion about the falls. His statement then agreed with our observations. As the result of our favourable reports on his work, Kinthup received an additional reward of Rs.1000 from the Government of India, together with a parchment certificate of honour from the Surveyor-General. He died on 3rd November, 1919.

The only remaining travellers who call for mention are two members of the Bengal Educational Service. Sarat Chandra Das in his interesting book* has given a graphic description of the Yarlung Valley, which he visited on his return from Lhasa in November, 1882. Lama Ugyen Gyatso, who had previously accompanied Sarat Chandra Das to Tibet, was again dispatched to Tibet on special duty by the Director of Public Instruction, Bengal, in June, 1883. Travelling *viâ* Gyantse, and the northern shore of the Trigu Lake, he reached the Yarlung Valley, whence he returned along the northern bank of the Tsangpo to Samye and Lhasa. His narrative, like that of Sarat Chandra Das, does not give much new geographical information, but forms an interesting record of Tibetan social and religious customs concerning which he has many quaint stories. He particularly dwells on the freedom accorded to women in Tibet; finally laying down the maxim, as the result of much varied experience, that a fair complexion amongst the gentle sex always indicates true kindness of heart.

A brief summary of the principal geographical results of our expedition may not be amiss. Climatic conditions militated against the discovery of more than a very few new snow peaks—indeed the only ones whose positions I was able accurately to determine were those of the Gyala Peri group on the N. bank of the Tsangpo, at the great bend opposite Namcha Barwa. Gyala Peri itself is 23,460 feet in height; while an eastern satellite of Gyala Peri, and the peak of Sengdam Pu at the opposite end of the same range are both over 20,000 feet. The magnificent peaks of Namcha Barwa (25,445 feet) had of course been previously fixed from the south, both by the Abor Survey Party and by my own observations from the Mishmi Hills. Our examination of the Tsangpo gorge on its northern flanks enabled us definitely to prove this to be another striking example of the extraordinary feature of Himalayan geography, noted by Colonel Sir S. G. Burrard† namely, that when a Tibetan river cuts

* "Journey to Lhasa and Central Tibet," by Sarat Chandra Das, C.I.E., pp. 297—307.

† "A Sketch of the Geography and Geology of the Himalaya Mountains and Tibet," by Colonel Sir S. G. Burrard, K.C.S.I., F.R.S., R.E., and H. H. Hayden, B.A., F.G.S. Part III., pp. 160—186.

through the Himalayan range, it almost invariably selects the very highest portion of the range through which to pierce its gorge. We did not succeed in throwing much light on the course of the main Himalayan range east of Namcha Barwa. There is a very sharp range of snowy mountains in the curious loop of the Po-Tsangpo; N.W. of the Sü Pass, but whether this is a true continuation of the Himalayan chain further investigation can alone decide.

Our map shows one glacier flowing southwards from the Gyala Peri range, and five flowing N. and W. from Namcha Barwa, while we were informed that a sixth glacier occupied the upper portion of the Pupa Rong Valley on its south flank. These glaciers all bear evidence of slow, but prolonged retreat. The Trilung glacier, which we visited, at present ends some two miles short of the Tsangpo; the height at the foot of the "Chinese wall" being 11,400 feet. Pines of thirty years' growth were to be found a quarter of a mile below the present limit of the ice. The Sanglung glacier, which is the largest of the group, descends to within one mile of the Tsangpo, the height at the foot of the snout being only 9,030 feet.

The Po-Tsangpo and Yigrong had not been previously visited by travellers; we were also able to obtain for the first time a fairly complete picture of the courses of the various Tibetan headwaters of the Subansiri, viz.: the Tsari, Char, Nye, and Loro Rivers, down to the points at which they pierce the Himalayan chain; while further west we found in the Nyamjang Chu, a new and important Tibetan tributary of the Manas River, hitherto unmapped. It is noteworthy that the falls of 30 feet on the Tsangpo at Pemakö-Chung are higher than anything hitherto recorded on the big rivers of Tibet and the Himalaya; indeed, the only other known instance of falls on a large Himalayan river is a 20-feet drop on the Indus near Bunji.

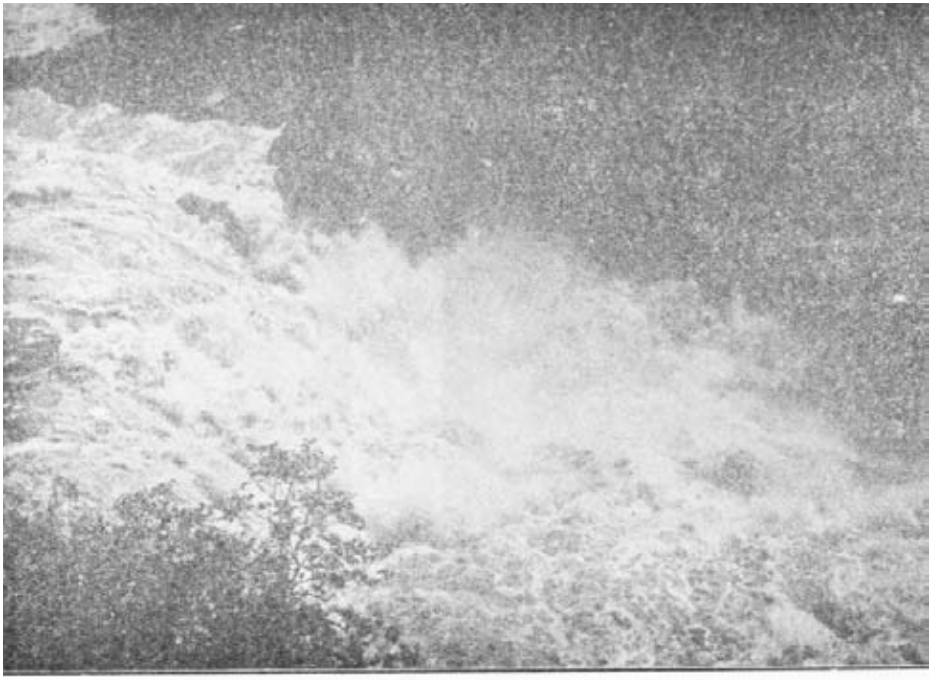
Hypsometric observations were taken on twelve passes of over 15,000 in height, while the approximate positions of numerous other passes have been indicated on the map from local information.

As has been previously remarked, I was only able in general to use the most rough and ready methods of reconnaissance survey. The system adopted was merely that of setting the plane-table by compass and estimating distances by time. As a check on the work, 20 observations were taken for latitude and seven azimuths. The instrument carried was a 3-inch theodolite by Casella, which screwed on to a light stand when required for taking astronomical observations. The same little instrument was also used, resting on the plane-table, as a clinometer, thus avoiding the necessity of carrying the latter instrument. My survey was on the scale of 8 miles to one inch. We took great care in regard to the orthography of place-names occurring on the map; these were almost invariably spelled for us in the vernacular by dzongpens, or other local officials under Bailey's super-

vision. Some 500 names are believed to be new, while in numerous instances the spelling of old names has been revised. Bailey brought back a small but interesting collection of mammals, birds, and butterflies, each of which were found on examination to contain new species.

It only remains to add that throughout our journey we everywhere met with the utmost courtesy and hospitality from the Tibetans. We carried no food with us, and were entirely dependent on the goodwill of the Tibetans for supplies, lodging, and transport.

I cannot conclude without placing on record how largely the success of our undertaking was due to Bailey's energy and resource. To him was due the original idea of the expedition, and but for his thorough knowledge of the language and customs of the country, and his almost uncanny skill in winning the goodwill of the local officials it could never have been successfully carried out.



The TSANGPO falls, at PEMAKO CHUNG.

TSANGPO FALLS

A Poba of Showa.

A Poba of Showa

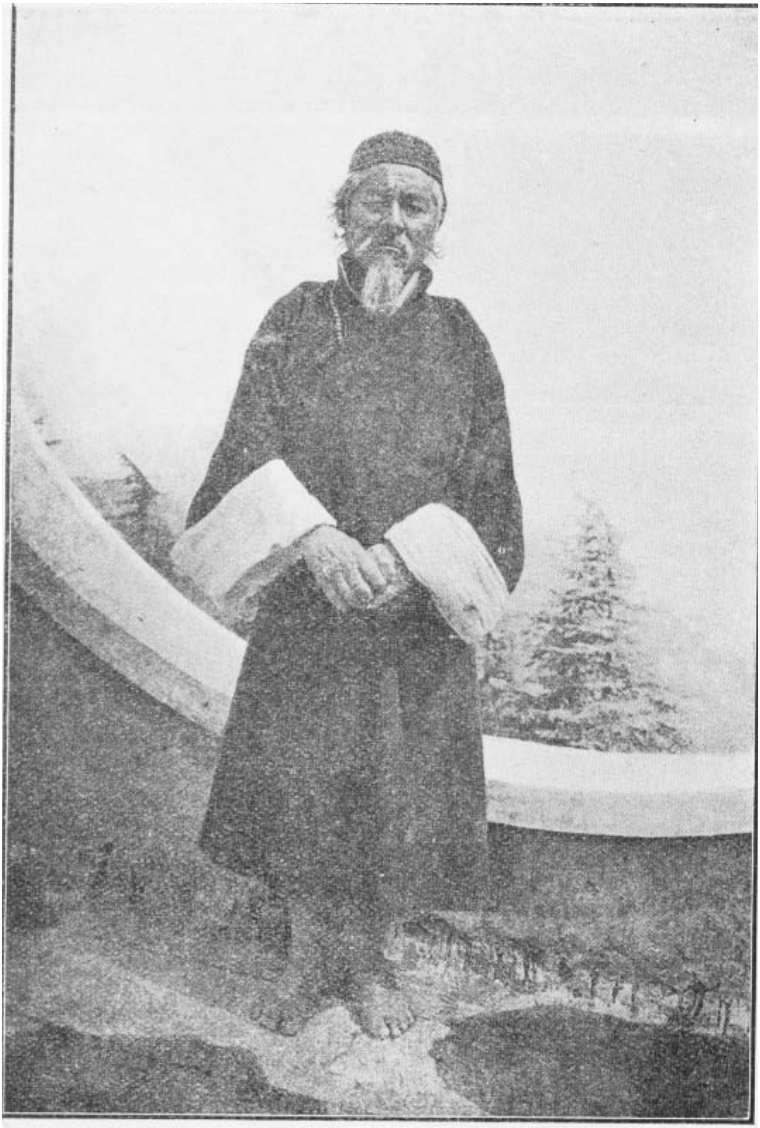
The TSANGPO falls, from water-level.

The Tsangpo Falls

Rapids on the TSANGPO, looking upstream from NYUKSANG.

View upstream from TSANGPO right bank near KYIKAR.

TSANGPO



Explorer KINTHUP, who first traced the course of the TSANGPO below PEMAKO CHUNG.

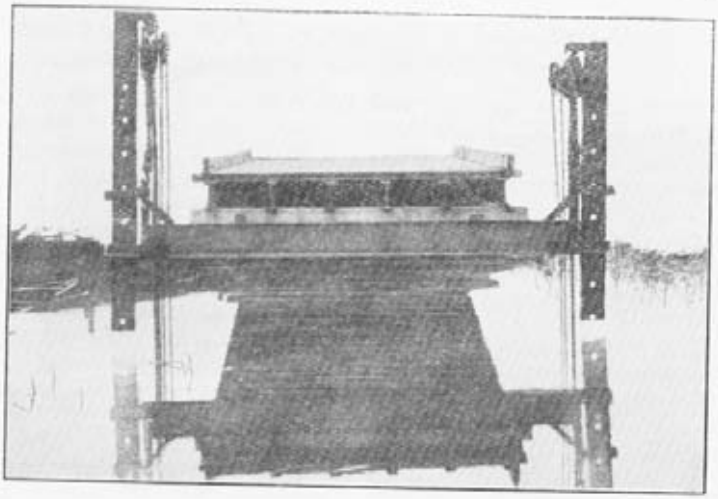
From a photo by Lieut. G. Burrard, R.F.A., May 1914.

EXPLORER KINTHUP

PROFESSIONAL NOTES.

BRIDGING.

As the pontoon equipment is now being re-designed to carry light, medium, and heavy loads, it is necessary to consider the question of a service trestle for use with this new equipment. The Weldon trestle has never been very popular and does not lend itself very well for use with medium and heavy loads. A new service trestle has therefore been designed and tested and is shown in the photograph.



The legs consist of 8-inch by 4-inch rolled steel joists and the transom is a 12-inch by 5-inch joist. The general dimensions of the trestle are the same as the Weldon trestle, but it will carry medium loads. The construction of the trestle is very simple. The transom has brackets permanently secured at each end; these brackets carry rollers through which the legs can slide. In this way the legs cannot splay or move out of line but each leg can slide up or down independently so as to suit an uneven bottom (footing) if necessary. The legs are drilled every six inches, and after the transom has been adjusted for height, it is supported on pins passing through these holes. Two types of shoe are provided. The normal shoe is of timber and measures 10 inches by 18 inches; this shoe is suitable for rocky bottom or ground which will support a pressure of four tons

SOUND RANGING.

The following article from *The Times* of the 15th November, is reproduced by the courtesy of the Editor.

IN connexion with the forthcoming decoration by the French Academy of the Abbé Rousselot for his original invention of the method of fixing the position of enemy guns by "sound-ranging," the following is an authoritative account of the early history of sound-ranging on the Western Front, and of the part played by the British in its development :—

The earliest experiments of which we have knowledge were those conducted by Professor Nordmann, of the Paris Observatory. He conceived the idea of sound-ranging at the front, and began experiments in Paris in September, 1914. His first plan was to work on a measured base with three men, each with a stop watch, who would record the instant the sound reached them ; but he also foresaw the use of microphones and automatic means of registration. In connexion with the latter, he consulted Mr. Lucien Bull, Sub-Director of the Institute Marey, who is a British subject resident in Paris. Various experiments were carried out, which developed into the Bull system, which was officially adopted by the British and later by the American Armies, and the T.M. system, officially adopted by the French Army. Other systems were developed independently, notably the Dufour and Cotton-Weiss, and were employed on the French front.

The subject had already attracted interest in the British Army, and a special committee was sent to the French front to investigate the possibilities of sound-ranging. This committee recommended the adoption of the Bull system, and a set of apparatus was bought and was delivered in October, 1915.

In the meantime the War Office had secured the services of Lieutenant (now Major) W. L. Bragg (now Professor of Physics, Manchester University) to form the first sound-ranging section and develop the method for the British Army. Bragg collected a small staff of physicists and carried on the work of the first section in the face of considerable difficulties due to lack of *personnel*, unsuitable apparatus, and ignorance of the various complicated factors which affect the subject. Though the French were ahead of us in initiating the system, the science, at the time that we began practical operations, was in a crude state, and there was much that was unknown. A good deal of original investigation was, therefore, required in order to make sound-ranging of real practical value.

PROBLEMS OF WIND AND TEMPERATURE.

The first problem to be attacked was that of the microphone, as the type then in use had many defects. Bragg, with his assistants, set to work on this, the line which experiment should take being indicated by the investigations of a French physicist, Professor Esclangon. In June, 1916, Lieutenant (now Major) Tucker invented the microphone which bears his name. This microphone was a very great advance on anything previously known, and from the date of its introduction British sound-ranging may be said to have ranked as an exact method of locating guns.

The next question was that of corrections for wind and temperature on which information was still vague and inaccurate. The formation of "wind sections" and the able investigations of Lieutenant Gray resulted in the establishment of accurate formulæ for the application of these corrections.

Other improvements in method were introduced, among the most important being the adoption of microphone bases of regular form. The advantage of this had been foreseen by Bull, and the final adoption on our part was due mainly to the advocacy of Bragg. Great attention was paid also to the training of sound-ranging sections to fit them for employment in moving warfare.

While the debt due to the French for their initiative must be acknowledged, it will be seen that, from the time that we took up sound-ranging, British scientists carried on independent investigations, and developed the method to a high degree of perfection. Opinions differ on certain technical points, but it was generally acknowledged that the British system, with its combination of the Tucker microphone and the Bull recording apparatus, was second to none for efficiency and accuracy. The Americans, when they took the field, adopted, after careful investigation, the British method and apparatus in their entirety.

Sound-ranging was not the only method of fixing enemy guns which was evolved during the war. The other principal method was that of "flash-spotting." These two systems (which may be called methods of precision, in comparison with the rapid, but less accurate, method of reporting by map position from an aeroplane or balloon) are complementary, and neither is of full utility without the other. Both methods were developed entirely by officers of the Field Survey Battalions, Royal Engineers.

BOOKS ON CIVIL ENGINEERING.

The following is a revised list of books on Civil Engineering which are recommended to Officers who wish to improve their knowledge in various branches of this subject.

Should any officer require further information on any of these books or with regard to any branch which is not fully met by any of them he should write direct to the Secretary, R.E.I., Chatham, stating as fully as necessary what his requirements are, and every endeavour will be made to supply or procure the information.

The latest editions of these books will be kept in the R.E. Library, Horse Guards, S.W.1.

1. APPLIED MECHANICS.

CALCULUS FOR ENGINEERS.—By Prof. Perry. Published by Edward Arnold. 7/6.

A most useful and interesting book, giving progressive examples of the practical application of the Calculus to Engineering and Electrical problems.

Unlike most other treatises on the Calculus, this book is essentially practical from beginning to end.

THE STRENGTH AND ELASTICITY OF STRUCTURAL MEMBERS.—By R. J. Woods M. Inst. C.E. Published by Edward Arnold, London. 2nd edition; 1 vol.; 8vo. 1906. 10/6.

Chapter I., Graphic Statics. Chapter II., Stress and Strain. Chapter III., Stress-Strain Diagrams, Working Stress, Resilience. Chapter IV., Compound Stresses Chapter V., Bending Moments and Shearing Forces. Chapter VI., Moments of Inertia. Chapter VII., Girders. Chapter VIII., Deflections. Chapter IX., Combined Stress, Non-Axial Stress, Stress at a Plane Joint, Masonry Structures. Chapter X., Columns and Struts. Chapter XI., Riveted Joints. Chapter XII., Continuous Girders. Chapter XIII., Cantilever Bridges, Suspension Bridges, Arched Ribs. Chapter XIV., Torsio.

This book was originally written as a series of lectures for students at the Royal Indian Engineering College, Coopers' Hill. It is a clearly written elementary text book.

THE THEORY OF STRUCTURES.—By R. J. Woods, M. Inst. C.E. Published by Edward Arnold, London. 1 vol.; 8vo.; 1909. 10/6.

Chapter I., Compound and Principal Stresses. Chapter II., Earth Pressure. Chapter III., Stresses due to Eccentric Loads. Chapter IV., Working Stresses. Stresses in Girders with Parallel Chords by Method of Co-efficients. Chapter V., Girders with Parallel Chords, General Method. Chapter VI., Parabolic Girders. Chapter VII., Curved Girders, not Parabolic. Chapter VIII., Wind Pressure, Portal Bracing, High Steel Trestles. Chapter IX., Continuous Girders. Chapter X., Cantilever Girders, Suspension and Stiffening Girders. Chapter XI., Riveted Joints. Chapter XII., Plate Girders. Chapter XIII., Columns and Struts. Chapter XIV., Arched Ribs and Braced Arches. Chapter XV., Reinforced Concrete.

This book is a continuation of "The Strength and Elasticity of Structural Members" by the same author. It contains several worked out examples but no drawings of actual work.

THE THEORY AND DESIGN OF STRUCTURES.—By E. S. Andrews, Lecturer at the Goldsmiths' College, New Cross. Published by Chapman and Hall, London. 1 vol.; 8vo.; 1908. 9/-.

Chapter I., Stress, Strain, and Elasticity. Chapter II., Principles of Design, Working Stress, Wind Pressure. Chapter III., Forces, Areas, Moments. Chapter IV., Riveted Joints. Chapter V., Bending Moments and Shearing Forces. Chapter VI., Stresses in Beams. Chapter VII., Rolling Loads. Chapter VIII., Deflection. Chapter IX., Fixed and Continuous Beams. Chapter X., Shearing Stress in Beams. Chapter XI., Framed Structures. Chapter XII., Columns and Struts. Chapter

XIII., Suspension Bridges and Arches. Chapter XIV., Masonry Structures. Chapter XV., Reinforced Concrete. Chapter XVI., Design of Steelwork in Buildings. Chapter XVII., Design of Roofs. Chapter XVIII., Design of Bridges and Girders.

This book covers the usual college course, and is good of its kind, but only touches lightly on questions of design. The diagrams and general presentation are good.

DEFLECTIONS AND STATICALLY INDETERMINATE STRESSES.—By C. W. Hudson. Published by Chapman and Hall. Price 19/-.

Treats of the deflections of solid and built up beams and cantilevers by the method of internal work.

The determination of stresses in redundant members by the use of Castiglioni's Theorems.

Well illustrated by Examples.

2. MATERIALS.

JOHNSONS' MATERIALS OF CONSTRUCTION.—Rewritten and edited by F. E. Turneaure. 1919. 5th edition. 33/-. Published by John Wiley and Sons, New York (Chapman and Hall, London).

The authors aim to provide essential information concerning the sources and manufacture of the principal Materials of Construction; to give carefully selected data covering the more important mechanical and physical Properties and the influence of various factors upon these properties; to show the causes of defects and variations and how they may be discovered; to furnish an acquaintance with the technique of testing materials; and to present some of the more general uses of the materials.

Chapter I. gives a synopsis of the Principles of Mechanics of Materials. Chapters II. and III. deal with Machines and Appliances for Testing, the Technique of Testing and the Utility of the various Tests. Chapters IV.—VI. consider the Characteristics, Methods of Identification, Properties and Uses of the more Important Woods, also Causes of Decay and Means of Preservation. Chapter VII. treats of the Important Stones, their Constitution, Durability, and Properties. Chapter VIII. covers the Manufacture and Testing of Structural Clay Products, together with their Mechanical Properties and Uses. Chapters IX.—XII. deal with the Nature, Manufacture, Methods of Testing and Properties of Hydraulic Cements, Limes and Plasters. Chapters XIII.—XV. fully describe Methods of Making Mortar, Concrete, and Concrete Products, also the properties and Uses of these Materials. Chapter XVI. provides a brief summary of the Utility of the Principal Metals, their Ores, and Fundamental Considerations governing their Extraction. Chapters XVII.—XIX. treat of the Reduction of Iron from its Ores and subsequent purification and Fabrication. Chapters XX. and XXI. deal with the Formation and Structure of Alloys in general, and the Constitution of Iron and Steel. Chapters XXII.—XXIV. are devoted to a discussion of the Properties and Uses of Wrought Iron, Steel and Alloy Steels. Chapter XXV. takes up the Manufacture, Moulding, Constitution and Properties of Cast Iron and Malleable Cast Iron. Chapter XXVI. treats of the Production, Properties and Uses of Copper, Zinc, Aluminium, Lead, Tin, Nickel and their Alloys. Chapters XXVII.—XXIX. cover the effects of Temperature on Metals, the Causes and Effects of Fatigue, and the Corrosion and Protection of Metals.

The book is thoroughly up to date and contains much valuable information on the latest processes, tests and specifications applied in the U.S.A., and is strongly recommended for *study* and practical reference.

THE STRENGTH OF MATERIALS.—By J. A. Ewing, F.R.S., M. Inst. C.E., etc. Cambridge University Press. 12/6.

Chapter I., Stress and Strain. Chapter II., Relation between the Elastic Constants. Chapter III., Ultimate Strength and Non-elastic Strain. Chapter IV., Testing of Materials. Chapter V., Uniform and Uniformly Varying Distributions of Stress. Chapter VI., Stress in Beams. Chapter VII., Deflection of Beams. Chapter VIII., Frames. Chapter IX., Struts and Columns. Chapter X., Torsion of Shafts. Chapter XI., Shells and Thick Cylinders. Chapter XII., Hanging Chains and Arched Ribs.

3. BUILDING CONSTRUCTION.

BUILDING CONSTRUCTION—ELEMENTARY COURSE.—By Chas. F. Mitchell, M.S.A., etc., and Geo. A. Mitchell, A.R.I.B.A. 6/6. Sub-title, "A Text Book on the Principles and Details of Modern Construction."

The ninth edition, published in 1919, contains elementary instruction in all the Trades employed in Building, with the Board of Education Syllabus the scope of which it is intended to fulfil.

BUILDING CONSTRUCTION—ADVANCED COURSE.—By the same authors. 11/-. Also in its ninth edition (1919), with the sub-title "A Text Book on the Principles and Details of Modern Construction for the use of Students and practical men."

Continues the instruction in the Trades and meets the requirements of the Advanced Syllabus of the Board of Education and other Examining Bodies; it also reviews Building Materials and summarises Building Regulations, Theory of Construction, and Sanitation.

Both volumes published by B. T. Batsford, Ltd., 94, High Holborn, W.C.

BUILDING CONSTRUCTION.—In 2 vols., Edited by F. M. Simpson, F.R.I.B.A. 12/-. each.

The various subjects being undertaken by:

Beresford Pite, F.R.I.B.A. (Brickwork)
Frank T. Baggallay, F.R.I.B.A. (Stonework)
H. D. Searles-Wood, F.R.I.B.A. (Carpentry)
E. Sprague, A.M.I.C.E. (Theory and Steel Construction)

in volume I. and by

J. H. Markham, A.R.I.B.A., Edwin Gunn, A.R.I.B.A., Alan G. James, H. A. Satchell, F.R.I.B.A., F. M. Simpson, F.R.I.B.A., and J. D. Grace, the subjects comprising Reinforced Concrete, Roof Covering, External Plumbing, Glazing, Timber, Joinery, Plastering, and Painting and Decoration, in the same order of authorship.

These volumes form part of the "Architects Library" published by Longmans, Green and Co., 39, Paternoster Row.

4. HOUSE PLANNING AND ARCHITECTURE.

THE CHEAP COTTAGE AND SMALL HOUSE.—By Gordon Allen (late R.E.), F.R.I.B.A., with the Sub-title "A Manual of Economical Building." Ninth edition, revised and enlarged. 1919. Published by B. T. Batsford, Ltd. Price 7/6.

Is intended to deal with the present situation and is illustrated with many examples of recent attempts to solve the problem of providing houses for the manual worker which shall be not only economical both in first outlay and subsequent upkeep as well as small houses of more ambitious character designed by the author in the course of practice.

From the chapter headings it will be seen that the book treats of economy in planning, as well as in treatment of elevations and the supply of External Services, shews some of the effects of legislation and helps in the selection of suitable materials.

ESSENTIALS IN ARCHITECTURE.—By John Belcher, A.R.A., Past P.R.I.B.A. "An Analysis of the Principles and Quantities to be looked for in Buildings." Published by B. T. Batsford, Ltd. Price 7/6.

The chapters deal with the Principles, Quantities, Factors and Materials in Architecture in a simple and lucid manner and the illustrations greatly add to this lucidity, the buildings illustrated being used to deduce results by analysis.

ARCHITECTURAL COMPOSITION.—By J. B. Robinson, Member of the American Institute of Architects.

This book also was first published in America in 1907, and subsequently by Batsfords in 1908, and there is at least one more recent edition which it is believed is also out of print, another being expected shortly.

The subject of Architectural Design is treated in relation to other arts in order to deduce principles which presumably must be basic and common to all.

The copious illustrations are largely of a diagrammatic nature intended to show whence these abstract principles are revived and how they affect Architectural Design.

5. HEATING BUILDINGS, HOT WATER SUPPLY AND VENTILATION.

HOT WATER SUPPLY.—By F. Dye. Published by E. and F. N. Spon. 1912. Price 3/-.

Chapter I., A brief explanation of the circulation of heated water. Chapter II., Boilers (all kinds) and incrusted deposit from hard water; also the effects of soft water. Chapter III., Cylinders, tanks, pipes and fittings. Chapter IV., The tank system of apparatus. Chapter V., The Cylinder System of Apparatus (including the Cylinder-Tank System). Chapter VI., Special features and requirements. Chapter VII., Faults and causes of failure. Chapter VIII., Explosions and their causes; use of safety valves. Chapter IX., Low pressure boilers.

Mr. F. Dye is a recognised authority on this and allied subjects, and his book gives complete information on the principles of hot water supply, in a very concise form.

WARMING BUILDINGS BY HOT WATER.—By F. Dye. Published by E. and F. N. Spon. 1917. Price 8/6.

Chapter I., The Actions of Heat, etc. Chapter II., The Circulation of heated water in pipes. Chapter III., The Advantages of Warming Buildings by Hot Water. Chapter IV., The details of a hot water heating apparatus fully explained. Chapter V., Examples of a Low Pressure Apparatus; The Two Pipe System. Chapter VI., Examples of a Low Pressure Apparatus; The One Pipe System. Chapter VII.,

Further examples of Low Pressure Apparatus; the Overhead Systems; Heating Factories; Heating Churches. Chapter VIII., Sizes of Circulating Pipes, mains and branches for two-pipe, one-pipe and overhead gravity systems. Chapter IX., Examples of low Pressure Apparatus for Glass-houses and Horticultural Buildings. Chapter X., Accelerated Circulations. Chapter XI., Miscellaneous details and difficulties.; Air in pipes; Loss of heat; conditions which interfere with the circulation; dipped pipes; causes of failure; chimneys; decorating radiators; covering pipes, etc. Chapter XII., Heat emission from radiators and pipes. Chapter XIII., Quantities. Chapter XIV., Drying-Rooms. Chapter XV., Testing heating plants when the outdoor temperature is above 32° Fahr. Chapter XVI., Boilers. Chapter XVII., Radiators; Cast Pipes and Fittings; Valves and Accessories; Pipe Joints, etc. Chapter XVIII., The High Pressure System. Chapter XIX., Warming Buildings by heated air.

Information on all hot water heating systems is here given in a concise form. Though a small book, it is very complete and there are many useful tables in the text and appendix.

A PRACTICAL TREATISE UPON STEAM HEATING.—By F. Dye. Published by E. and F. N. Spon. 1901. Price 10/-.

Chapter I., The Principles of Steam Heating. Chapter II., The Distribution of Heat. Chapter III., Steam Heat. Chapter IV., Designs of Low Pressure Gravity Steam Heating Apparatus. Chapter V., Designs of Apparatus which do not return the condensed water direct into the boiler, including exhaust steam works. Chapter VI., Quantities. Chapter VII., Boilers. Chapter VIII., Radiators, Valves, Fittings, Tubes and Appliances. Chapter IX., Heating Water by Steam. Chapter X., High-pressure heating. Chapter XI., Sundry information and data relating to Steam Heating. Chapter XII., Cooking by Steam.

This is a complete handbook of information on the subject and deals with heating by Low and High Pressure and exhaust steam, and also heating water and cooking by steam. There are many useful Tables.

6. GENERAL ENGINEERING.

STRUCTURAL ENGINEERING.—By J. Husband, Assoc. M. and Watts' Medalist Inst. C.E., etc., etc., Head of the Civil Engineering Department of the University of Sheffield, and W. Harby, sometime Assistant in the Civil Engineering Dept. of the University of Sheffield. Published by Longmans Green and Co. 8/6.

This is an excellent little book. Without being too bulky or detailed, it contains in readily accessible form a great deal of valuable information. The methods of design are modern and are treated in a very thorough and practical way, and are easy to follow.

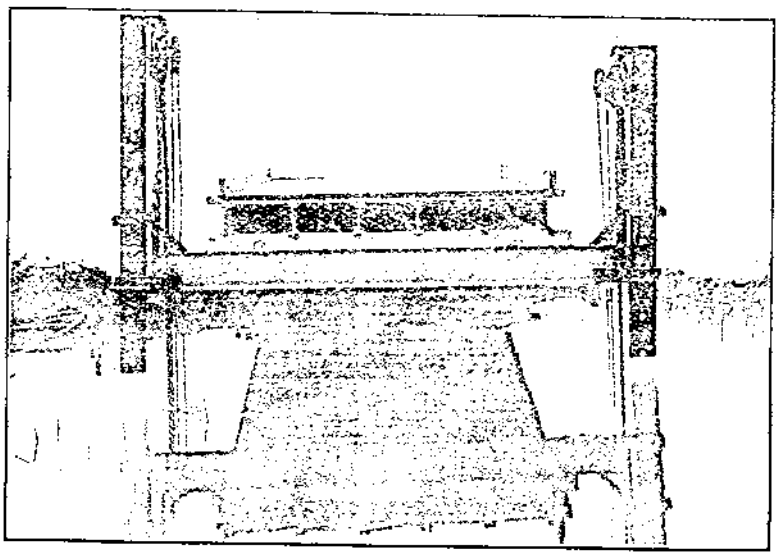
Chapter I. deals with Materials. Chapter II. with Loads and Working Stresses, and includes Tables of Traffic Loads on Highway Bridges, and equivalent Distributed Loads on Railway Bridges for varying spans; Table of Stones' "Range" Formulae, etc. Chapter III., Bending Moments and Shearing Force. Chapter IV., Beams. Chapter V., Columns and Struts. Chapter VI. gives the design in detail of a Plate Girder. Chapter VII., Lattice Girders. Chapter VIII., Deflection, including the deflection and horizontal deflection of braced girders by the method of "Work." Chapter IX., Roofs. Chapter X., Miscellaneous and Tall Buildings. Chapter XI., Masonry and Masonry Structures, Foundations, Gravity Dams, Arches (rigid and hinged), and Tall Chimneys.

(To be continued).

PROFESSIONAL NOTES.

BRIDGING.

As the pontoon equipment is now being re-designed to carry light, medium, and heavy loads, it is necessary to consider the question of a service trestle for use with this new equipment. The Weldon trestle has never been very popular and does not lend itself very well for use with medium and heavy loads. A new service trestle has therefore been designed and tested and is shown in the photograph.



The legs consist of 8-inch by 4-inch rolled steel joists and the transom is a 12-inch by 5-inch joist. The general dimensions of the trestle are the same as the Weldon trestle, but it will carry medium loads. The construction of the trestle is very simple. The transom has brackets permanently secured at each end; these brackets carry rollers through which the legs can slide. In this way the legs cannot splay or move out of line but each leg can slide up or down independently so as to suit an uneven bottom (footing) if necessary. The legs are drilled every six inches, and after the transom has been adjusted for height, it is supported on pins passing through these holes. Two types of shoe are provided. The normal shoe is of timber and measures 10 inches by 18 inches; this shoe is suitable for rocky bottom or ground which will support a pressure of four tons

per square inch. A second shoe is provided which measures 2ft. by 3ft.; this shoe can be bolted on to the normal shoe and provides a pressure of just under 1 ton per square foot. The trestle weighs 1,180lbs. or 40 per cent. more than the Weldon trestle, but will carry an 8-ton axle load. Two trestles built up side by side as a tower, will carry heavy loads. The trestle can be put together and launched more rapidly than the Weldon trestle, and the legs cannot jamb against the transom under any conditions. The transom is raised or lowered by means of two 2-ton Morris's blocks. These blocks are a considerable improvement on the differential blocks for trestle work. The trestle has been tested with a 12-ton axle load.. Further trials are to be carried out with this trestle.

THE TRANSACTIONS FOR 1920 OF THE ENGINEERING ASSOCIATION OF CEYLON.

THIS publication, a copy of which has been presented to the Corps Library by Major J. T. Rea, S.R.E.S., contains three articles on military engineering during the war which cannot fail to be of considerable value to the Corps. The first, by Major H. B. Lees, M.C., A.M.I.C.E., F.S.I., late Army Bridging Officer, Second Army, describes Military Road Bridging in France and Belgium, and includes some brief details of the launching of the various types of heavy bridges which are not contained in the reports already published in the R.E. Journal. The second article by Lieut.-Colonel F. J. Salmon, M.C., A.C.G.I., A.I.M.M., F.R.G.S., late R.E., on Survey Work on the Western Front, is a full and extremely interesting account of this important service. Colonel Salmon writes :— Never before this war have I realised the truth of the saying that "where there's a will there's a way." In the 3rd Battalion the "will" was usually Colonel Winterbotham's or, later, Colonel Keeling's. . . . Practically everything we took up was made to work. Never again will I listen to a counsel of despair! The third article gives some Notes on Mining at Cape Helles by H. L. G. Young, A.M.I.C.E., 2nd Lieut., 1/7th Scottish Rifles, attached to the 8th Army Mining Corps, and describes some interesting experiences of those operations.

F.E.G.S.

NOTICES OF MAGAZINES.

MILITÄR-WOCHENBLATT.

No. 12.—*Battle of the Marne* (1914).—Major-General Baumgarten-Crusius contributes an interesting article on the influence of Lieut.-Colonel Hentsch on the orders to retreat in the battle of the Marne (1914). He quotes Von Tappen, who was D.M.O. at G.H.Q., to the effect that Hentsch was not endowed with full powers to order or approve of a retreat; that G.H.Q. gave no orders for retreat, and that Hentsch, on arrival at 1st Army H.Q. found the order for it had already gone out. He next quotes Von Kuhl (Chief of Gen. Staff 1st Army), who declares that the retreat had not been ordered when Hentsch arrived; that the situation of the 1st Army was quite satisfactory and that the Army H.Q. protested vigorously before it ordered the retreat which the self declared G.H.Q. plenipotentiary imposed upon it. We have, therefore, here two directly conflicting statements, and the writer proceeds to justify Hentsch, who can unfortunately no longer defend himself, by extracts from the report he made in May 1917, before his death. From this report, which will shortly be published in full, it appears that Hentsch did consider himself endowed with full powers and did order the 1st Army to retreat. He seems to have considered his action was universally approved at G.H.Q., until French accounts of the battle appeared; not till then was his decision ever questioned. He claimed an enquiry, which was agreed to, and in May, 1917, the following report was issued over Ludendorff's signature:—

"Colonel Hentsch received verbal instructions on the 8th September, 1914, from the C.G.S. to go to the 5th, 4th, 3rd, 2nd and 1st Armies, and clear up the situation. In case he found backward movements already started on the right wing, he was so to direct these that the gap between the 1st and 2nd Army should be closed, and the 1st Army directed as far as possible on Soissons. He was, within these limits, empowered to speak for G.H.Q. On arrival at 2nd Army H.Q. he found that this army had already independently decided to retreat to behind the Marne. He concurred with this decision and went on to 1st Army H.Q. There he invoked his authority to speak for G.H.Q. and gave orders for the 1st Army to retreat. He was justified in doing so because the situation was actually that mentioned in his instructions, viz., 'backward movements on the right wing already started.'"

Ludendorff wisely leaves to history the decision as to whether retreat was really necessary. Baumgarten-Crusius, however, has no such modesty. He claims that his book "The Marne, 1914," is history, and declares: (1).—Von Bülow was responsible for the

retreat of the 2nd and right wing of the 3rd Army, which was unnecessary. (2).—The 1st Army H.Q. alone can be held responsible for its own retreat. (3).—Von Moltke was responsible for the whole of the western group of German armies being involved in the retreat.

From Kiel to Kapp, by Noske, ex-Minister of Defence, is a history of the revolution. Noske puts it down largely to the bad press his Reichswehr always had.

No. 13. *The Truth About the Marne*, 1914.—Nearly every number of the *M.W.B.* now contains at least one article on the Battle of the Marne, and, as Lieut.-Colonel Loebnitz now says, it is becoming more and more widely understood that it was the turning point of the war. The writer does not agree with the conclusion of Baumgarten-Crusius (in No. 12 *M.W.B.*) that Von Kluck was responsible for the retreat of the 1st Army. The whole question of Hentsch's intervention is very controversial and will no doubt be thoroughly explored for many years to come. The only point on which agreement seems to be fairly general is that G.H.Q. was much too far away and communications between it and the H.Q.'s of Armies too uncertain for it to exercise any useful control.

English Anxieties in Mesopotamia.—A not unfair description of the situation, as it was 3 months ago. The reasons given to explain our remaining in the country are (1) loss of prestige if we renounce our mandate; (2) strategic reasons which compel us to hold at least the Bagdad Vilayet, since withdrawal from there would leave Persia at the mercy of the Bolshevists and the road, in consequence, open to India, and (3) economic reasons which compel us to hold Mosul, as being the richest oil district.

Miscellaneous Notices.—The republican union intended to institute a public assembly in Munich, to which the Reichswehr soldiers were to be specially invited. This has been forbidden on grounds of public safety, in that this union works towards the arousing of political feeling in the army, and, consequently towards the estrangement of officers and men.

No. 14. *Militarism in France.*—The writer declares that France is doing all she can to increase the peace and the war strength of her army and the government knows that it can count on the nation for almost any sacrifices to this end. There are, however, many difficulties; first of all the economic situation which demands the utmost limitation of expenses, and though France has never allowed lack of money to stop her strengthening her army, this factor is bound to have considerable effect. Next there is the lack of population; in 1919 births were 200,000 fewer than deaths, and, though this rate of decrease is not likely to continue, the best she can hope for is a stationary population. The third great difficulty lies in the low physique of the recruits and it is in this direction that the greatest efforts are being made, every French boy from the age of 6 to the date of conscription being steadily strengthened in mind and body for service. The writer evidently admires the thoroughness with which this task is being undertaken and wishes Germany were able to do the same.

Officers' Pensions.—The rules regarding these are naturally very

intricate, but the following examples show the sort of scale followed; a lieutenant, with 17 years' service and two children receives in all 7667 marks or about £31 per annum at present exchange. A major with 21 years' service and 3 children gets 15,028 marks.

No. 15. *German Operations during the Campaign in Italy.*—A review of this book, by General Krauss, of the Austrian army, explains how in the autumn of 1917, it was very difficult to spare any German troops for what was practically a "side show" in Italy. That it was a "side show" was due not only to strategic reasons, but to the fact that the Austrian troops had not sufficient fighting power. If they had all been like the Tyroleans or those hardy and stout-hearted Bosnians, it would have been a different story and the war would have passed into Southern France by Lyons. There seems to have been the usual controversy as to whether the attack should follow the valleys or the mountains. The Austrians were for the valleys. Surprise is expressed that the Italians did not try to hold the line of the Tagliamento, and the river itself is stated to have shown more sense, since it came down in such heavy flood as to defy all attempts at improvised bridging and taught both Germans and Austrians that at least some pontoons must accompany the division in river country. So strong was the stream that a wagon weighted with howitzer shell and pushed into the water to form a pier for a footbridge was lifted up and tipped over. The reviewer acquits General Krauss of anti-German feeling, but has a poor opinion of his skill as a leader or his accuracy as a historian.

The Fight for Tsing-tau.—Admiral Vollerthun wrote his account of the siege during his 5 years captivity in Japan, which 5 years, he says, showed him that the boasted chivalry of the Japanese is nothing but a bluff. He states that the money spent on fortifying Tsing-tau was well laid out and resulted in 3,700 Germans with 104 guns, of which 37 were of calibre less than 37 millimetre, being able to hold out against 63,000 assailants with 160 siege guns, besides the fleet, for a period of several weeks.

No. 16. *The New Austrian Army* will consist of 30,000 men organized in 6 mixed brigades. The cost will be enormous, no less than from 1,500 to 2,000 million kroner, as against 540 million for the whole pre-war army. The cost per head of the population will be from 24 to 32 times as much as in 1914.

The Profession of the Soldier.—This is an article written to attract the shy recruit. The thought of a real old time Pomeranian sergeant trying to persuade an out-of-work spartakist to be good enough to join the army is a not unpleasant one. However, once he joins he is in for 12 years and there is no discharge except for very special reasons, so no doubt the N.C.O. gets level in the end.

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

REVUE MILITAIRE GÉNÉRALE.

June, 1920.

The Work of the High Command prior to Operations. (An extract from "Les Leçons Militaires de la Guerre), by Major Bouvard.—Napoleon says that the value of an army depends upon its mass and its rapidity of movement. The former is obtained by ensuring that reserves are available on the field of battle of the moment, and that the whole force is adequately provided with food and materials of all kinds, and means of replacing them when expended. The need for rapidity of movement intensifies the value of mechanical transport, railways and motors. But rapid concentration of the mass is not all. The front must first of all be equipped for defence, where suitable, and offence, partial or general, in those sectors which can be turned to account for that purpose. The fighting troops are too few for such work except in the actual front line, even if it did not interfere with their fighting powers and the necessity for constant training. A regular army of workmen must be provided to prepare the position in depth, including fighting and communication trenches, roads, light railways, observation posts, signals, artillery positions, ammunition depôts, command posts, shelters and camps, besides the extension of railways, extra platforms and stations, supply depôts, hospitals, etc. The problem as studied above refers particularly to the war of positions, but the difference in the case of a moving front is only one of degree.

Cavalry and Tanks, by Squadron Commander Bloch.—The writer considers that if cavalry keeps touch with recent scientific discoveries, it should play just as important a part in future wars, as it has in the past. The tasks it has to perform cannot be undertaken by mechanical devices, nor by infantry in motor vehicles. During the late war, where the two sides were extended from a foreign frontier to the sea there was no scope for cavalry, but with a moving front, in spite of its probable extent, reconnaissances of the enemy's flanks will be demanded, as also will a cavalry screen. During an action, it may be necessary to throw out quickly a cavalry curtain to cover disorganized troops, or the victor may wish for information in regard to any armies in reserve or reconstituted in the enemy's rear. Flanks may require rapid extension, for opportunities may occur of reaching the enemy's communications. Cavalry would also be required to widen an extensive breach in the enemy's lines, and to harrass his retreat. In defence they could close a breach in their own lines, or assist in a rearguard action. For such purposes cavalry could only be replaced by air-craft, swift tanks, or infantry in motor vehicles. The first is certainly necessary for the strategic reconnaissance, but cannot undertake a close and detailed reconnaissance, cannot see in misty weather, nor define absolutely the enemy's front, nor provide a screen for the main army. In pursuit aircraft can bomb a flying enemy, but cannot capture material and prisoners, nor obtain information which may enable some vital point to be struck at. If tanks, *with cavalry*, are useful in pursuit, they cannot replace the latter entirely, cannot reap the fruits of victory,

prisoners, material, and information, their view is restricted, intercommunication over an extended front is impossible, and they would be at the mercy of a single small gun. Infantry in lorries are tied to the roads, and are vulnerable while there, cannot reconnoitre, nor seize opportunities as can cavalry. However, useful as a reinforcement, they cannot replace the cavalry in a pursuit. In defence they cannot rapidly throw out a covering curtain in front of disorganized troops, their mission should be to form a solid barrier in rear of the cavalry curtain. Cyclists cannot move rapidly across country, and if called upon to act as cavalry as well as infantry would soon be exhausted. The co-operation of all these will increase the value of cavalry, but the necessity for the latter as well remains absolute. The principal hindrances to cavalry in the modern battle are (1) want of space for manœuvre and the long range of modern weapons. (2) Material obstacles and zones of heavy bombardment. (3) The efficiency and rapidity of fire (a) of artillery, and (b) of machine guns. A reference to the duties assigned to cavalry will show that in a war of movement the first three disappear more or less. To dispose of the last, cavalry can use dismounted fire and its own guns and machine guns, but the former are confined to the roads. If they had a tank, which would not impede their movements, capable of fighting with them whether mounted or dismounted, the enemy machine guns would be useless. Again in the defence the tank would be of great assistance in strengthening the cavalry curtain. The cavalry tank must move on its own wheels ready for instant action, and should be capable of travelling at 12 kilometres per hour at least, or more, if obtainable. It should be able to cross gaps two metres wide, and be proof against rifle fire. The dimensions should be as small as possible so long as the two metre gaps can be crossed, and the eye of the commander is 1 m. 60 above ground. Crew, a commander and driver. Weight 3½ tons, if practicable, to enable it to use light bridges, but the other considerations mentioned will probably entail a weight of at least 10 tons. Petrol capacity 10 hours. Each division (three brigades) of cavalry should have a battalion of three companies of tanks, and a light repair and supply section, each company comprising four sections and one echelon, and each section three tanks, one armed with a gun, and two with machine guns. The company echelon consists of four waggons for supply and repairs, and two or three lorries, which should have the same means of propulsion as the tanks, to enable them to follow over the same ground. Cavalry tanks must be spared as much as possible and not sent on small reconnaissances, or with parties of less strength than a squadron. With dismounted cavalry the tank tactics would follow those prescribed for the infantry tank. The section would be under the command of the cavalry unit which it supports. The tank company would be at the disposition of the cavalry brigade commander, and the battalion under the orders of the cavalry division commander. When approaching the enemy the tanks would be in rear of the manœuvring cavalry; when the latter forms for action the tanks would pass them and destroy obstacles to their progress, and the objective obtained would concentrate to intervene in the counter-attack. A cavalry guard must accompany

each section of tanks to cover it by mounted fire, or drive away a solitary anti-tank gun which may suddenly come into action, to maintain communication between the sections and the cavalry main body, and to act as ground scouts. The tanks with cavalry, unlike those with infantry, have not to conquer or occupy ground, but only enable it to be passed over. Cavalry and tanks are made to work together. They can cross the same ground, and the conditions suitable for a cavalry action are equally favourable to tanks. Tanks are invaluable for destroying machine guns which may tend to hold up the cavalry.

July, 1920.

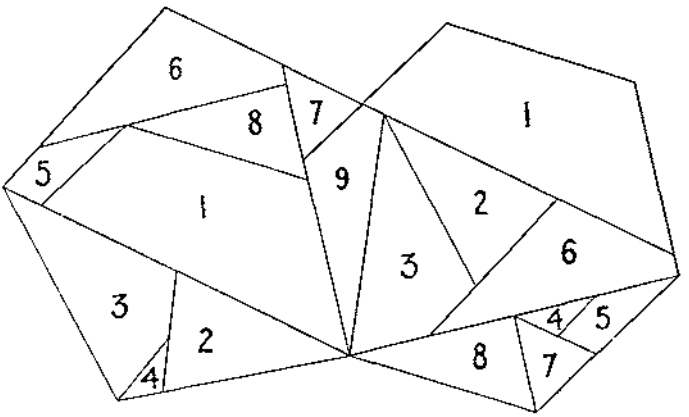
Military Legislation, by Capt. H. Mirauchaux.—A plea for the enhancement of the status of the division in the coming legislation for the future of the French army. The writer points out that the division as constituted at the commencement of the war was limited in its activities by being dependent on its army corps for so many of its essential units. When during trench warfare, it was found necessary to relieve divisions in the fighting line by fresh divisions from the rear this organization was found to be unworkable, for the division at the rear was not able to live on its own unaided resources. Gradually units were added to it, such as motor transport for the hospital, infantry and artillery ammunition columns, an extra company of engineers, and supply column, and at the time of the armistice the addition of a second squadron of cavalry with one or two M.G. sections was under consideration. In view of the fact that the division does all the work, whilst the corps only co-ordinates and commands, it is only right that the divisional commander should be provided with the necessary resources for efficiently carrying out his duties. The division should be self-contained, and a sort of small army corps. This would lead to a livelier esprit de corps, and to a better understanding between every branch of the service, including signals, aviation, and tanks, and therefore greater efficiency.

A. R. REYNOLDS.

DISSECTION PUZZLE.

THE accompanying dissection of a pentagon into 9 pieces which will form a hexagon may be found interesting. The actual puzzle is, I think new, but the clue will be found in Mr. H. E. Dudeney's "Amusements, etc." Can the transformation be made in fewer pieces? I do not think so.

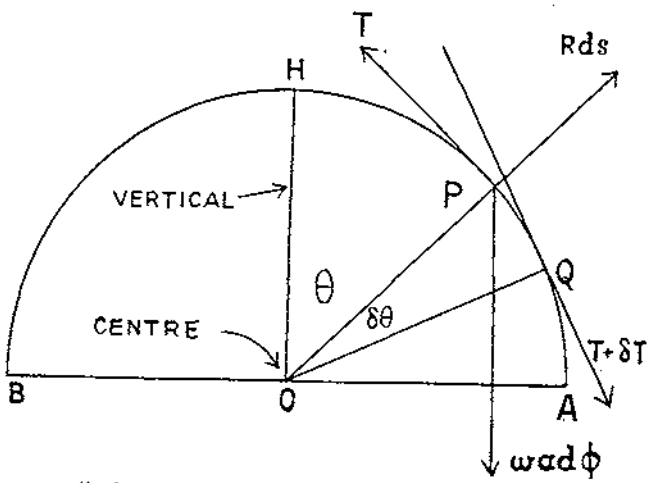
L. A. ARKWRIGHT, *Lt.-Col.*



PROBLEMS.

PROBLEM 18 (Solution).

An elastic string of weight (W) per unit of length when unstretched and of modulus of elasticity $2aW$ rests in contact at every point of a smooth vertical semicircle of radius (a) whose base AB is horizontal and whose arc is uppermost. The ends of the string reaching down to A and B. Find the unstretched length of the string.



PQ is a small element.

Suppose that PQ if unstretched would subtend $\partial\phi$ at centre.

Weight of PQ is $a\partial\phi w$ and may be supposed to act at P.

Resolution along tangent at P gives

$$T = wad\phi \sin\theta + (T + \delta T)\cos\delta\phi,$$

whence
$$\frac{dT}{d\phi} = -aw\sin\theta \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1).$$

Which is right as regards sign as T decreases as θ increases.

Hooke's law gives

$$\frac{a\delta\theta - a\delta\phi}{a\delta\phi} \times 2aw = T.$$

Whence
$$\frac{d\theta}{d\phi} = 1 + \frac{T}{2aw} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2).$$

Combination of 1 and 2 gives

$$\frac{dT}{d\theta}(T + 2aw) = -2a^2w^2\sin\theta,$$

whence
$$T^2 + 4awT = 4a^2w^2\cos\theta,$$

whence
$$T = 2aw\left(\sqrt{2}\cos\frac{\theta}{2} - 1\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3).$$

No constant is added on integration as T = 0 when $\theta = \frac{\pi}{2}$.

Combination of 2 and 3 gives

$$\frac{d\theta}{d\phi} = \sqrt{2}\cos\frac{\theta}{2}.$$

$$\therefore \quad \sec\frac{\theta}{2}d\theta = \sqrt{2}d\phi.$$

$$\therefore \quad 2\log\tan\frac{\pi+\theta}{4} = \sqrt{2}\,\phi$$

as both sides vanish when $\theta = 0$.

When $\theta = \frac{\pi}{2}$ $\phi = \sqrt{2}\log\tan\frac{3\pi}{8}$.

Hence unstretched length is

$$2a\sqrt{2}\log\tan\frac{3\pi}{8}.$$

PROBLEM 21.

Show that if $ax_r^2 + by_r^2 + cz_r^2 = 0$ where $r = 1\ 2$ or 3.

This is only a concise way of saying if

$$ax_1^2 + by_1^2 + cz_1^2 = ax_2^2 + by_2^2 + cz_2^2 = ax_3^2 + by_3^2 + cz_3^2 = 0.$$

PROBLEM 22.

Sum the series

$$\sin 2x - \tfrac{1}{2}\sin 4x + \tfrac{1}{3}\sin 6x \text{ to infinity.}$$

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

SOLUTIONS.

Correct solutions have been received of No. 16 from Major G. E. Painter and No. 17 from Major C. R. Satterthwaite, O.B.E.

THE JOURNAL OF THE ROYAL ARTILLERY.

THIS Journal, which was formerly known as the "Proceedings" of the R.A. Institution, contains articles and information on Artillery matters, some highly technical and some general. Articles on general Military topics also appear.

In the Translations and Précis, which are an important feature, an attempt is made to keep up with the progress of Artillery on the Continent.

Any officer serving in the Navy, Army, Special Reserve, Territorial Force, and Colonial Permanent Forces can receive this Journal post free on application to the Secretary, R.A. Institution, at an annual subscription of 20s.

WOOLWICH: ROYAL ARTILLERY INSTITUTION.

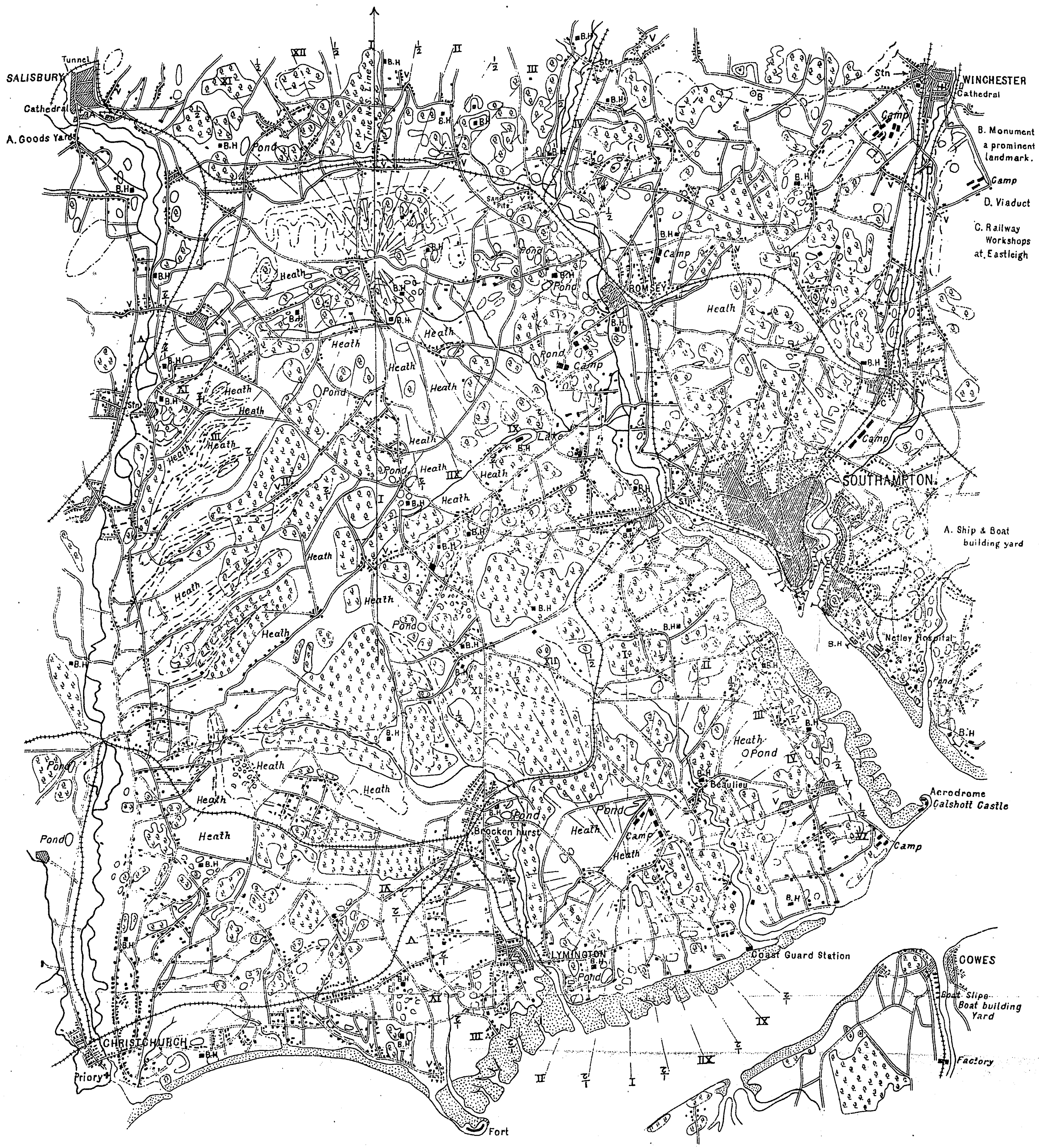
Single Copies price 2s. 6d. each, postage extra.

AIR AREA SKETCH

SALISBURY-WINCHESTER-COWES-CHRISTCHURCH

PLATE 3

Scale 1 inch to 2 miles



E. Prominent high tower

Wooded area. Villages denoted by V. Railways denoted thus

Roads where numerous have been generalised.

The 2 sun-azimuth dials actually used on original sketch have been transferred and inked up.

The detail inked up represents what was actually surveyed from the air, no assistance received from map except the names of 2 or 3 villages.

Undulating or high ground shown by chain-dotted contours.

B.H indicates a big house, hall, or castle, a prominent object from the air.

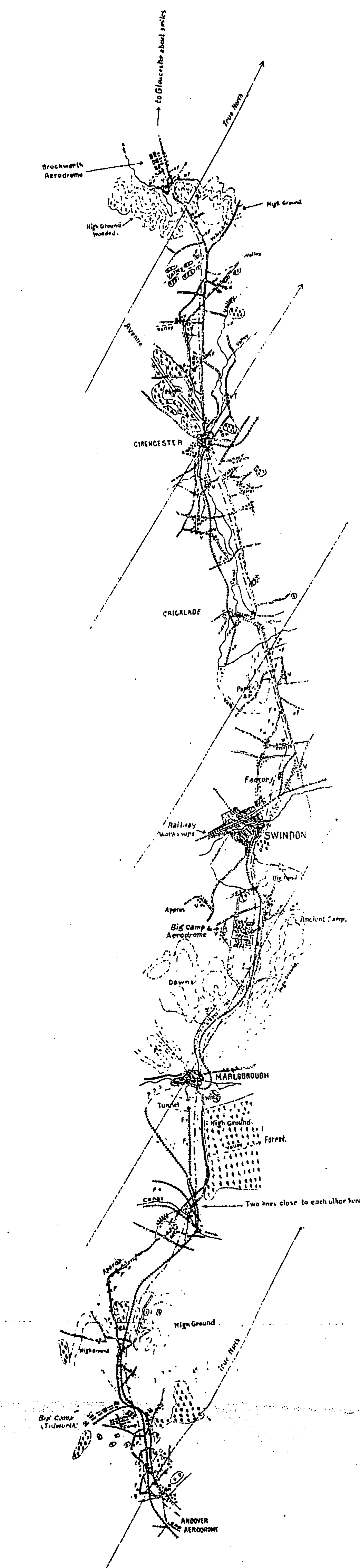
AIR ROUTE SKETCH

ANDOVER AERODROME to BROCKWORTH AERODROME & back

PLATE 4

Scale about 1 inch to 4 Miles

Distance run (estimated) 43½ Miles.



Surveyed on ½ inch scale & reduced by photography. Course taken both ways shown by chain-dotted line. Gave pilot correct course where necessary by signal. Suncompass used. Sun visible except at times when behind a small cloud, coming back clouded over wind gusty, some rain left at 3.15, arrived at 4.0 P.M. landed, had tea & got back about 6 P.M.

Farms denoted by . . . F

Big houses or Halls . . . . B.H.

Eye contours by __ . __ . __ . __

Hamlets or small villages by . . V

Direction maintained by sundial & resection from back points