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CONTOURING BY THE STEREOSCOPE ON AIR PHOTOS.

By MAJOR AND BT. LIEUT.-COLONEL S. F. NEWCOMBE, D.S.O., R.E.

SOME experiments have been made with Thompson's Stereoplotter on air photos with successful results. Given ordinarily good conditions, it should be possible to measure differences of height to within 5 ft. to 10 ft. of accuracy, and, provided certain fixed heights are available, as part of the trig. survey, it should be possible to draw contours to say 10 ft. accuracy and to show the shape of the ground extremely well, by combining contours with shading.

A description of Thompson's Stereoplotter is given in the *Geographical Journal* of May, 1908.

For the present purpose, one need only describe the stereo microscope with a hair line in the centre of the glass which can be used as an indicator. The plotter is not used.

The photos, half-plate, are placed in two holders on a frame which can be moved from right to left or vice versa. The two photos are directly under two prisms one foot apart, which deflect the rays into the microscopes or eyepieces. Thus the base of the stereoscope is 1 ft. The stereoscope has a motion up and down the vertical lines of the photos at right angles to the horizontal motion of the photos.

The left negative can be moved right and left, independently of the other, by means of a slow motion screw which records on a drum the distance moved.

The total movement of the left photo on the particular instrument used is only 2 in. One complete turn of the drum measured ·1 in. on the photo. Movements of ·001 in. can be easily measured.

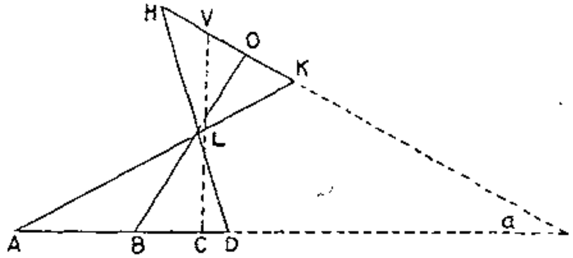
It is well to have certain definitions for clearness. A negative is said to be horizontal when it has been taken (or has been mechanically corrected to be) absolutely parallel to a flat earth surface.

The optical centre, O, is the point obtained on any negative at the intersection of the lines joining the collimating marks on the middle points of the edges.

The vertical centre, V, is the point on the negative where the perpendicular from the centre of the lens to the earth's surface cuts the negative. Thus in negative HK, having tilt α to the earth's surface, CLV is perpendicular to the earth, V is the vertical centre, O is the optical centre of the negative, given by joining the collimating points, and BLO is perpendicular to HK.

$VO = LO . \tan VLO = \text{focal length} \times \tan \alpha$ (tilt), and VO is measured along the prime vert.

The horizontal line of a negative is a line through the optical centre O, parallel to the line made by the plane of the negative with the horizontal earth plane.



The prime vertical is a line in the negative at right angles to the horizontal line through O, the optical centre. Thus a horizontal negative has no prime vertical or horizontal line.

To use two overlapping photos under the stereoplotter, the following steps are necessary:—

(1) Enlarge both negatives to fit trig. points, to get rid of tilt and make the enlargements exactly the same scale.
(2) Find the vertical centre of each negative.
(3) Mark on each negative the line joining these two vertical centres.
(4) Reduce these enlargements on to two half-plate positives, keeping the line joining the vertical centres horizontally along the centres of the plates, parallel to the longer side.
(5) Insert these positives in the frames under the stereoscope.
(6) Adjust the positives by the slow motion screws until they become absolutely parallel. This can be seen through the stereoscope by moving the microscopes over each corner of both positives, and seeing that the verticals or hairs in the microscopes cover the same vertical position over each negative. They will not cover the same horizontal position, if of unequal height, unless parallax is adjusted by the spiral drum. To do this adjustment for parallax, turn the drum to infinity and then bring the vertical centres of both negatives together under the indices in the eye-pieces. Suppose the reading to be 1·4 in. or 14 turns of the drum. Then move the stereoscope over various points over the positives, recording the readings on the drum.

It is useful to have a bromide enlargement to assist one in realizing the country as shown on the photo, and one can mark on this photo each point as it is observed.

In the experiment tried with some overlapping photos of hills near Cairo (see *Plate*), the scale of the original negatives was 1/4800 measured by comparing certain distances on the photo with the 1/5000 map (uncontoured) of Cairo.

The distance between the vertical centres VaVb measured 1·25 in. Hence the base was 4800 × 1·25 in. = 500 ft.

The focal length of the lens was 6 in.

The height at which the photos were taken (assuming Va and Vb to be the same height) can be determined (*a*) by the formula $h = f/\text{scale}$, thus 6 in. divided by 1/4800, and checked by (*b*) measuring a known height on the two negatives of a tower, say 100 ft. high, the reading on the drum being ·1.

$$\begin{aligned} \text{Height of plane} &= f\,.\,\text{base}/{\cdot}1 - 100 \\ &= {\cdot}5 \times 500/{\cdot}1 - 100 \\ &= 2400. \end{aligned}$$

So far, except for this last check, the work has been independent of the stereoscope.

In the experiment the base measured 1·4 in. instead of 1·25 in. since the original negative had been enlarged. This is equivalent to having a focal length of 6 × 14/12·5 (or 6·72).

Suppose the height of the point Va on the map to be 100 ft., and the vertical hairs on the stereoscope coincide when bringing Va on each plate directly under them reading 1·4 in. on the drum. Move the stereoscope over the plates and wherever the vertical hairs coincide on the same point, on either plate, while reading 1·4 in., such points will also be 100 ft. high. Where points are not 100 ft. high, the hairs will not coincide. It will be necessary then to move the left plate through a certain distance till the point A on both plates coincides, giving a reading of say 1·39 in. on the drum. This distance ·01 in. is the parallax.

As shown in Capt. Thompson's article in the *G.J.* of May, 1908—

$$\text{Parallax} = f \times \text{base}/\text{height},$$

or

$$\text{Height} = f \times \text{base}/\text{parallax}.$$

$$f = 6{\cdot}72,\ \text{base} = 500,\ \text{parallax} = 1{\cdot}39,$$

$$\text{Height} = 6{\cdot}72 \times 500/1{\cdot}39 = 2417 \text{ ft.}$$

i.e., A is 2417 ft. below the aeroplane when the photo was taken or 17 ft. below the plane of the trig. points.

So with the other points,

$$6{\cdot}72 \times 500/1{\cdot}415 = 2374{\cdot}5$$

and

$$6{\cdot}72 \times 500/1{\cdot}420 = 2366{\cdot}2$$

and

$$6{\cdot}72 \times 500/1{\cdot}375 = 2443{\cdot}6$$

and since the height of the aeroplane was 2400 above the flat plane of the trig. points, we have,

1st point dist. below aeroplane	2417·0	ht. refd. to trig. pts.	− 17·0
2nd „ „ „ „	2374·5	„ „ „ „	+ 25·5
3rd „ „ „ „	2366·2	„ „ „ „	+ 33·8
4th „ „ „ „	2443·6	„ „ „ „	− 43·6

Having obtained various heights over the photos, it is extremely easy to put in the contours, taking more height when necessary and viewing the photos stereoscopically to see the shape of the ground, though the light and shade of the bromide is an almost sufficient indication. The photos touched up, with the contours drawn on, make the hilly grounds stand out more truly and more vividly than any contoured map or any map shaded by a draughtsman who has never seen the original country.

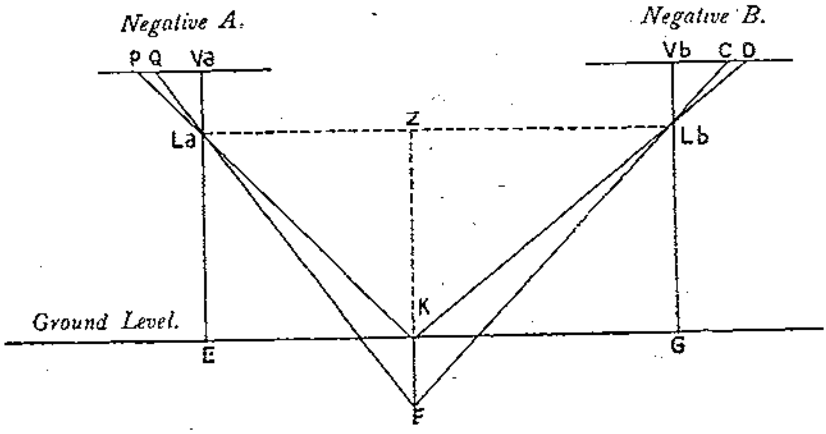
It must be noted in the above example that the negatives used were supposed to be absolutely corrected for tilt, by enlarging them to fit trig. points all of the same level and lying in one horizontal plane. The base is the distance between the two vertical centres (*vide* definitions). Hence the vertical centres must be found; the distance between them can be measured either by piecing the two photos together and measuring them off according to the scale of the photo, or by measuring the distance on the drum. The scale of course is known by referring the trig. points on the photo to those on the map. The formula

Height of aeroplane=focal length × base/parallax

is adapted from Thompson's article. We require, however, the height above or below the level of the trig. points. This formula is,

h=focal length × base/parallax – height of aeroplane.

Now whether the photos be originally taken at a tilt or not, the parallax measurement would not vary, but one cannot get the base correctly measured unless tilt is corrected and one can measure the distance between the vertical (and not optical) centres. Suppose the two photos to be taken at different heights, it would (very slightly) affect the parallax measurement, but as flying would be 10,000, say, and differences only 100 ft. or so, the error would not be of importance, especially as both photos are brought to the same scale to fit the trig. points. Further, since during the trig. work,



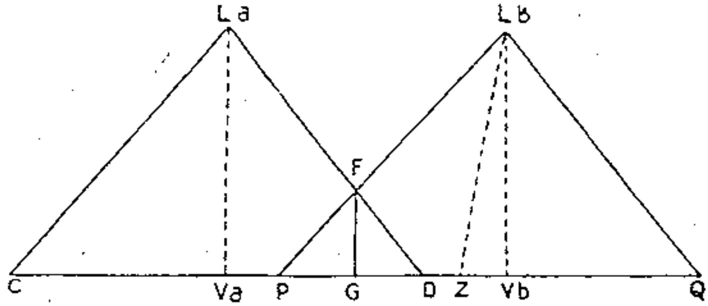
certain heights will be determined, should any error be perceptible, it can be quickly checked and distributed between these points.

Given then the assumption that the photos are made to fit the trig. points and vertical centres are found, the use of the stereoscope for contouring seems eminently practical and accurate for general purposes to say 1/5000 scale, or at least 1/10000 scale.

In above figure let PQVa, DCVb be two negatives, La and Lb the lenses, and EKG the horizontal ground. Let F be a point below K.

Then ELa = height of plane = 2400 ft. LV = focal length 6 in.

Parallax of K = PV + DV   Depth FK $= \dfrac{f \times \text{base (LaLb)}}{\text{QVa} + \text{CVb}} - \text{ELa}.$



In above figure, if CD, PQ represent areas covered by two lenses La and Lb and FG be a tower, provided La Lb be known, (or Va Vb), and PD the parallax is measured on the stereoscope, the height FG can be determined.

Suppose one negative is tilted, and hence the vertical centre Vb is thrown out by 2° to Z,

Then   ZV = LV . tan 2° or 1/30 height of plane.

PD is not altered by the tilt, but the base Va Vb is largely altered by this 2° tilt. Hence the importance of getting the vertical centre.

Suppose now that one photo is taken at 10,000 ft. and the next at 10,050 ft.

Then if f = 12 in., base = 2,000 ft., and height = 10,000 ft., the reading 2·4 in. on the drum represents the distance between two vertical centres, and for every ·01 in. reading on the drum, the

$$\text{Height} = \frac{12 \times 2000}{2{\cdot}41} - \text{H} = 41{\cdot}494 \text{ ft.}$$

If the height be 10,050 ft., the reading on the drum is 2·388 with the base of 2,000 ft., and for every ·01 in. reading on the drum, the

$$\text{Height} = \frac{12 \times 2000}{2{\cdot}398} - \text{H} = 41{\cdot}660.$$

Hence a reading of ·01 in. on the drum reads only ·17 ft. difference with these differences of height.

ADJUSTMENT OF AIRPHOTOS TO FIXED POINTS OF UNEQUAL HEIGHTS.

If the trig. points are not of the same height, one must find a plane which passes through three of these points.

Suppose A and B to be of the same height and C of different height. This is the simplest case. Then AB will be the horizontal line, and the inclination of the plane ABC to the horizontal can easily be calculated by drawing a line CD from C to AB.

Then $$\sin \alpha = \frac{\text{height of C}}{\text{CD}}$$

If A, B are unequal heights, the locus of the plane can be found, that is, its angle of tilt to the horizontal; and also the horizontal line through A, *i.e.*, the line where the plane ABC joins the horizontal plane through A.

In practice, (1) Plot A, B, C, in the plane inclined at angle α to horizontal, on a given scale. Assuming that the tilt of the negative is not excessive, make the three points P, Q, R, in the negative corresponding to A, B, C, and fit them on the plotted diagram. This can be done with the enlarging camera, just the same as getting rid of tilt to fit trig. points on a horizontal plane.

If we place a plane AED passing through the horizontal line through A and making an angle α with the plane ABC, and remove the plane ABC, the negative will be projected correctly on to the horizontal plane, which AED represents. It would not be the required scale, nor probably in focus, but any points A, E, D, F, lying in the horizontal plane of the earth, would be correctly and proportionately represented.

The high points, C and B, which we might suppose to be tops of towers, would be thrown out of position according to parallax, or according to the angle they subtend at the lens with the perpendicular from the lens to the earth: the feet of these towers would be correctly represented, if visible. Hence on any one photo it is obvious that uneven ground can never be to scale.

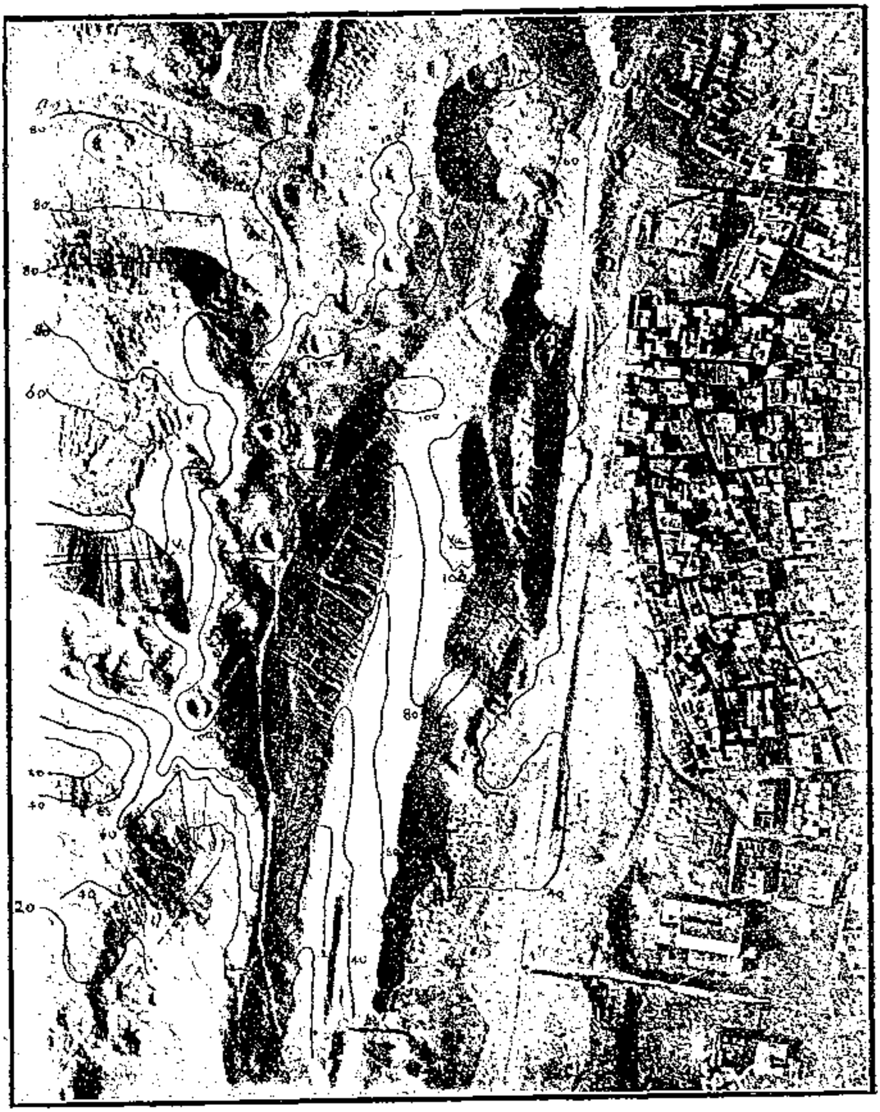
But by using overlapping photos corrected to the horizontal, one can correct, by the stereoscope, the positions of C, B, etc., which are out of the horizontal, and plot them in their correct position.

To preserve focus, one would enlarge the photo PQR to fit the points ABC: and then, with that enlargement, make a photo of equal size through the enlarging camera, and give a tilt of α to the photo ABC and α to the screen AED.

In the attached figure, let ABC be three trig. points of unequal height. The plane ABC is found to pass through these three points making an angle α with the horizontal plane AD.

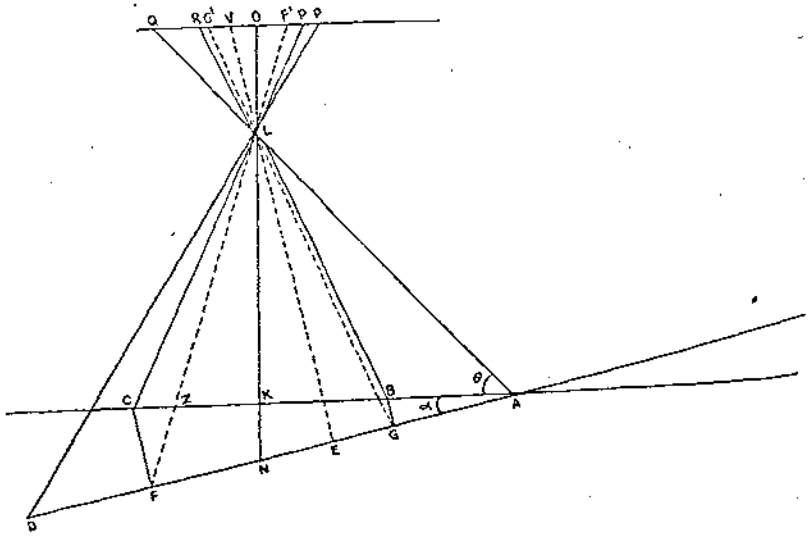
The negative QRP which had a small tilt in any direction has been made to fit parallel to the plane ABC, and the points PQR to fit the points CAB on the map by the enlarging camera. Draw

CONTOURING BY THE STEREOSCOPE ON AIR PHOTOS.



Map of Hills on East edge of Cairo roughly contoured by the Stereoscope from 2 overlapping air photos.
The contours have not been checked, and no true heights were obtained.
The intervals between the contours should be found to be consistent, and generally they should describe the ground.

OLKN perpendicular to QP and CA. Then O is the optical centre of the negative in its present position and if ELV is perpendicular to AD, V is the vertical centre.



$$OV = LO \tan \alpha = f \, . \tan \alpha.$$

Draw CF, BG to AD; let them represent two towers, C and B the tops, trig. stations, F and G the feet in the horizontal plane AD.

Join FL, GL, cutting the negative in F^1, G^1.

Then F^1, G^1 represent the feet of these towers on the photo.

Hence, if the positions F^1, G^1 are calculated and marked, and if B, C are plotted as usual and reduced to the horizontal plane, the photo QRP can be tilted through the angle α, so that QF^1G^1 fit the positions ABC reduced to the horizontal plane.

Provided the optical centre O can be found, OQ can be measured, and LO=focal length; hence angle QLO is known and angle CAL. There are enough known angles and lengths to calculate F^1P and RG^1.

Hence, diagrammetically or mathematically, the photo can be reduced to fit three trig. points of unequal height and reduced again to the horizontal plane.

In the final map, it is obvious that the only points correct to scale are those of the same level as A (except the point under the vertical centre).

EXPEDIENT FOR CROSSING RIVERS UNDER FIRE.

By Capt. E. Moore, M.C., R.E. (S.R.).

The problem of forcing a crossing over a fairly wide river which cannot be forded, the opposite bank of which is held by an enemy, is one which throughout the war has considerably intrigued the sapper. The part played by the sapper is naturally one of vital importance to the success of the operation, and I venture to suggest therefore that no efforts should be spared in reaping to the full the experience gained in the past War to devise a really practical and efficient method of effecting this end. With this idea in view I am going to describe as briefly and concisely as possible a method which my company put successfully into practice a few days prior to the Armistice which enabled infantry to cross the river Scheldt.

It is true that at the time referred to the situation developed so rapidly that, unknown to ourselves, the enemy had left the opposite bank and no opposition was encountered.

However, the operation was carried out during the night on the assumption that opposition might be expected; furthermore the difficult part of the job—namely, the bringing up and successfully hiding near the bridging sites the large number of rafts and bridging material—was carried out on bad roads and wet weather and under a considerable amount of shell fire.

I think readers will agree in the particular type of bridging operation I am going to illustrate, that provided everything necessary for the operation is found at site, the actual launching of the bridge has very nearly as much prospect of success as infantry having to ford a river under fire.

The river to be crossed was about 100 ft. wide and had a current flowing at from five to six miles an hour. Five places in all were selected and allotted to my Field Company to tackle.

The method consisted of booming out and connecting up a series of rafts 9 ft. by 8 ft. made to the dimensions shown on accompanying *Plan* A with a 2 ft. duck-board walk running through the centre.

Plan B shows how each raft is interlocked and fastened together with two short lengths of spun yarn at E and F to keep them from floating apart. The stability of this bridge depends entirely on this interlocking device, which is the most important part of its design. It is advisable therefore—as well as skew nailing together with 6" nails the component parts of each raft—to also lash with wire the ends G. H. K. L. as a big strain comes on these ends, tending to draw any nailing done here.

The dimensions and shape of this raft were evolved by actual experiments with rafts of different combinations of timbers, and this particular design and shape were found to give the most effective buoyancy for weight of timber and convenience in handling.

The rafts and duckboards were built separately a convenient distance behind the line and carried up in pontoon and G.S. wagons under cover of darkness, and dumped in farms and against odd buildings which happened to be situated not more than about 100 yards behind the river bank. In no case was there a very big carry from the dumping ground to the sites chosen for crossing.

Pontoon wagons were naturally found more suitable than G.S. wagons for carrying up the ready made rafts. The duckboards were carried up separately, as they packed better this way, and it was found that there was a tendency for them to be broken and torn away from the rafts in transit if brought up in one piece.

For a river up to 100 ft. wide, with about five miles an hour current flowing, one u.s. cable made fast on shore and connected to the centre raft is sufficient to keep this bridge from bulging, and if time and situation permit this can be increased and a hand rail added.

The method of constructing is by booming out one raft after another from ways made fast on the shore, when the far side is reached the end rafts are lifted up on to dry land and picketed down.

Before Zero hour the rafts would be brought up by a separate carrying party from the dump to the actual bridging site just behind the river bank if it has one and each raft laid out on the ground.

At Zero special picked bridging party of one officer, three N.C.O.s and 16 men form bridge according to the simple drill or organization which I have written out and which is self explanatory.

It will be noted that this drill is of the simplest character and involves no effort of memory so that it is possible to replace any casualties by any technical or non-technical man who happens to be available at the time.

The only requirements of this bridge in the way of ropes are two head ropes, one on each side of bridge on the first raft, to steer the bridge as it is being boomed out and one u.s. guy made fast to the centre of the bridge and anchored on shore as indicated in *Plan* C.

As in all bridging operations light easily handled boats are a "Godsend." I have included in my accompanying drawings a dimensioned plan of a very easily constructed and serviceable boat.

I do not lay any claims to the invention of this design and have only introduced it in case it may not yet have found its way into any military publication, or have been permanently recorded for future use.

I have built and used this type of portable boat in night operations and think it a very practical and useful design, and it deserves wide circulation.

DRILL FOR FORMING WOODEN RAFT FOOT BRIDGE.

1. *Assumption.*—Rafts laid out in convenient piles of four on some covered place about 40 yards from water's edge.

2. *Required.*—Three detachments of one N.C.O. and six men and one officer or senior N.C.O. in charge of whole.

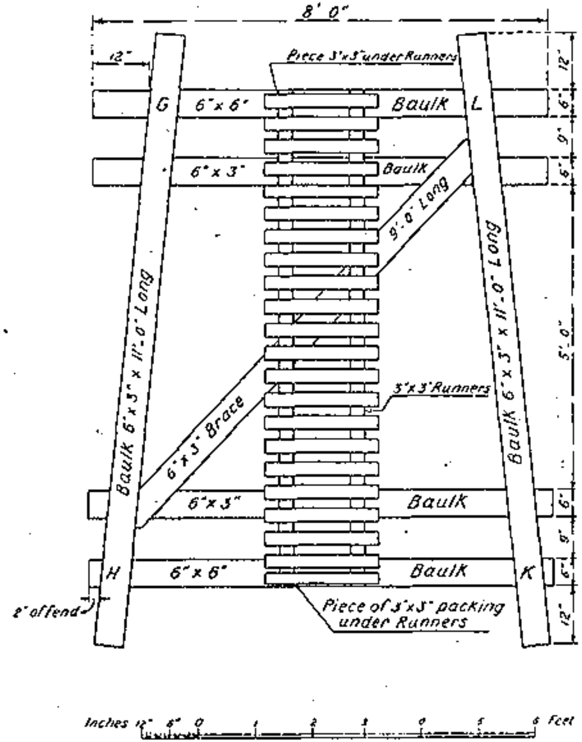
3. *To form bridge.*—Nos. 1, 2, 3 and 4 of "A" detachment carry up two launching ways and two short square pickets and a maul, and picket down the two launching ways, and stand by to take over the u.s. and d.s. head ropes of bridge. Nos. 5 and 6 of "A" detachment remain on either side of launching way during booming out and assist in locking rafts and lash each raft to the other with spun yarn. The N.C.O. of this detachment is responsible for the correct alignment of the bridge.

The remaining two detachments "B" and "C" bring up rafts in turn, and boom out. As soon as bridge touches opposite shore "B" detachment go across to opposite shore, heave up the head raft, cast off the two head ropes, and make fast the head raft in the shore and the u.s. cable to the centre of the bridge.

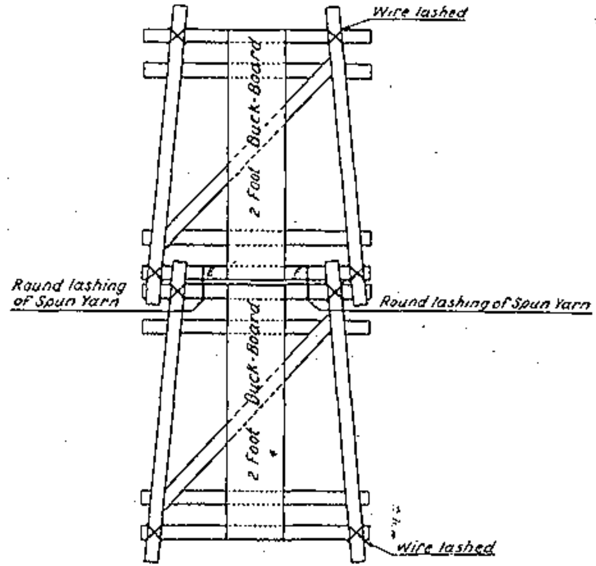
"C" detachment do likewise to the last inshore raft and make fast the centre u.s. cable to a shore anchor.

FLOATING BRIDGES FOR INFANTRY

— Plan A showing details of one Raft —



— Plan B showing —
Method of interlocking the Rafts



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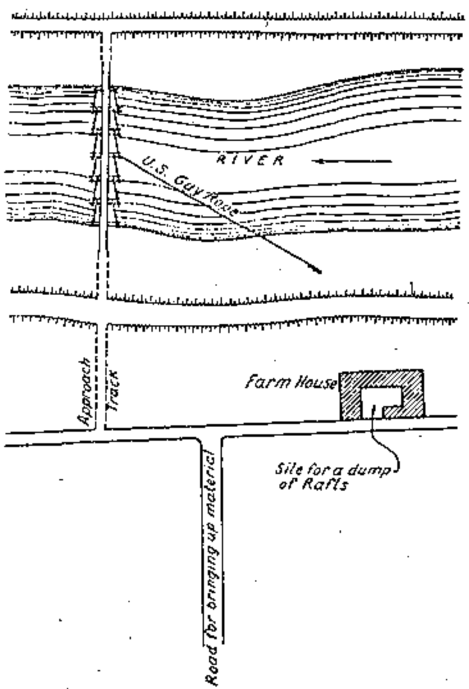
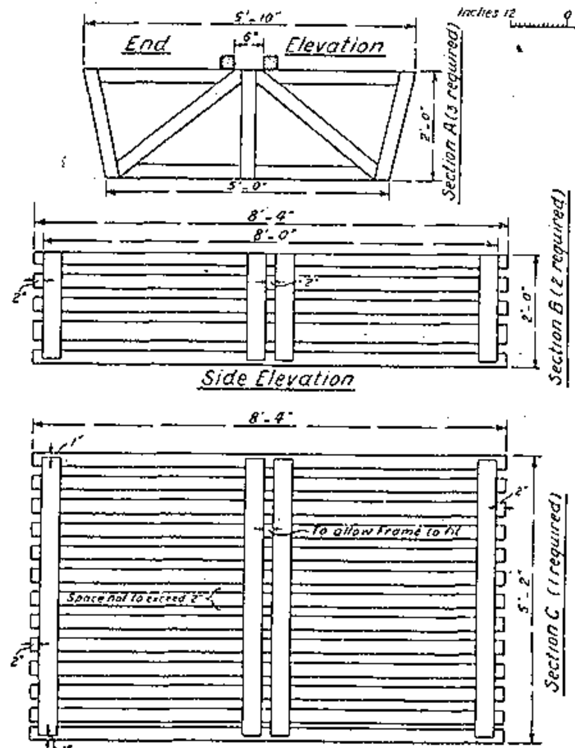
FLOATING BRIDGES FOR INFANTRY

— Plan C showing — a general view of a suitable site



— Improvised Boat for 12 Men —



Stores required to make Boat

6 Timber Sections.
1 Bivie Sheet 13'-0" x 10'-0".
10 1" Lashings or Spun Yarn each 3 fathms in length.

Stores to accompany each Boat

1 Maul & 2. 6 ft. Pickets.
1 Breast Line for painter.
3 R.E. Shovels as oars.
1 Cable (2") depending on width of stream.
1 Baler
2 Spare Breast Lines

To make Boat:

Lash the 6 sections together with spun yarn.

Place the skeleton on Bivie Sheet layed out on ground, fold sheet over sides and ends of boat and secure with lashings where necessary.

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SCIENTIFIC MANAGEMENT AND MOTION STUDY.

A Lecture delivered at the S.M.E., Chatham, on 12th January, 1921,
by F. JAMES BUTTERWORTH, ESQ.

I HAVE been asked to give you an address on the subject of Scientific Management, and Motion Study. This whole question of the reorganization of industry is so vast, and can be approached from so many different sides, that I can only hope to give you a very general idea of its possibilities in the course of one evening. When you consider that not only the engineers, but the psychologists, the physiologists, the economists, and the sociologists, are all falling over each other in their eagerness to contribute their share of knowledge for the good of the workers, and the betterment of working conditions, I think you will agree with me that to-night I shall only be able to show you the "high lights."

The late war was the most incalculable disaster to the human race, but in spite of this it has, in certain directions, done much good. To mention one aspect only, it has been the means of arousing a national conscience in all classes of the community. People have come to realize that the very least that can be done in return for the sacrifices that have been made is that no effort of mind and heart and will should be spared in the task of making this country and the empire generally a fit one for everybody to live in.

There are different ways of trying to do this. To each country its own method. Personally I believe that we in Great Britain will be able to evolve a method which shall be a model to the whole world. But we shall only be able to do this if we avail ourselves of what the scientists and engineers in this and other countries have discovered, practised, and are continually improving upon by patient and laborious research.

For the last three generations the working people of this country have not had a square deal. On the other hand, the employers will make the same complaint. The reason for these two statements is not far to seek. In the past, under the old or traditional forms of management, the interests of the employer and employee lay in opposite directions. Hence, mutual mistrust, ever present suspicion, rate cutting by the management, shirking by the workers, continual friction, strikes, lock-outs, each side trying to get the better of the other, the inevitable result being a low standard of living for the workers, and a high cost of production for the management. This last factor reacts in its turn on the workers, causing as it does an ever increasing cost of living with which rising wages are not able to keep pace. Thus traditional management with its non-economic foundations, makes for a vicious circle. Nobody benefits by it, markets are lost, and the workers get the worst of it every time. *The interests of masters and workers are identical.* When this is realized, and not until then, we shall get that co-operation, that united, instead of divided, effort, which at one stroke will do away with half the moral and material waste from which this country is suffering to-day.

It is this problem of how to combine short hours and high wages, in other words, a high standard of living for the workers, with low costs of production to the management, and a consequent cheapening of the product to the public, that the new or scientific or measured functional management has set itself to solve.

The late Dr. F. W. Taylor, of Philadelphia, who died in 1915, was the first to call the attention of the present generation to his discovery of Scientific Management, although his claim to be the discoverer is now contested, it having been found that Marcus Aurelius, born A.D. 121, in his *Meditations*, book 4, page 33, called attention to unnecessary actions—physical, and in speech and thought—and advised their abandonment. Francis Bacon (1561) in his 25th essay, on "Dispatch," travelled upon the same lines, and in later, but far distant days, the French Physicist, Coulomb (1736), Adam Smith (1723), in his *Wealth of Nations*, and Charles Babbage (1791), the inventor of the calculating machine, all had wise things to say on the subject.

Many of the ideas of Scientific Management can thus be traced back to these mighty philosophers of past ages, but the science of management, as we now know it, was discovered and its principles made practicable when Taylor invented time study and used these units of measurement, *prior to performance*, to determine the amount of work a worker could do, and the amount of rest necessary to overcome fatigue. Not until then did management become a science.

Management may be divided into three types:—(1) Traditional; (2) Transitory; and (3) Scientific, or measured. In the first, the managing is usually done by a capable "allround" man—thus authority is clear, fixed, and single. The second is self-descriptive, and the third is a real science.

As there are probably some among my audience who have not had the opportunity of studying the text books on the subject—they are mostly of American authorship—a list of the leading works on the subject is to be found at the end of this lecture. I will give you a brief outline of what is meant by Scientific Management, and then speak of one of its sub-divisions, namely, Motion Study.

I have been interested in these questions for years and have kept in close touch throughout that period with some of the leaders of the movement, through my friendship with Major Frank B. Gilbreth, the author of *Motion Study*, and jointly with his wife, of *Fatigue Study*, *Applied Motion Study*, *Motion Study for the Handicapped*, and other works. Assisted by his gifted wife, the author of *The Psychology of Management*, he has made the psychology and welfare of the worker a special study.

There is confusion in many minds to-day as to the meaning of Scientific Management, but when I state that it is management based upon actual and accurate measurement, its scope and object will be made clear to such an audience as I am now addressing.

Its skilful application is an art that must be acquired, but its fundamental principles have the exactness of scientific laws, the study of which is open to all. There is nothing secret or hidden about it, for it is a science that is the result of accurately recorded, exact investigations, the results of which have been formulated, and further findings are being added to it every day. The scope of this science is unlimited, for it applies to every field of activity, both mental and physical, and its laws are universal. Its fundamental aim is the elimination of waste of every kind with the attainment of the desired results by the least necessary amount of time and of effort; it may and often does result in expansion, but its primary aim is conservation and saving, by making adequate use of every particle of any type of energy expended.

The old saying, "The proper study of mankind is man," has assumed new meanings since the votaries of this new science have divulged their findings to the world, for they have taught us that success in handling both the human and material elements depends upon the exact knowledge of the element itself and the acquired experience as to how either or both can best be handled. Through motion, fatigue and time study the capabilities of the workers have been determined. The exactions of the work and the fatigue of the workers which result, together with the amount and nature of the rest to overcome such fatigue, are known, and their practical application of the findings to the industries have been fraught with the happiest results to employers and employed alike, for they have increased output, decreased working costs, and added to the wages earned by the workers. Agriculturists have taught us that it is possible to get great annual outputs and conserve producing force unimpaired by judicious use of suitable fertilizers. The knowledge of how to keep the soil at its fullest producing capacity, making provision for depleted energy, is largely standardized and widely practised. Industrialists should realize these facts and apply them to their workers. The sooner these workers can be treated to overcome fatigue and regain their normal working capacity in the shortest possible time, the quicker will the toiling masses and their employers benefit. Suitable provision for such recovery in the industries, before the days of scientific management, was unknown.

I therefore appeal to all to increase their knowledge of industrial conditions and necessities so as to increase production, which alone can prevent disaster and ruin to the nation.

The management of all works, great or small, must realize it is absolutely necessary that a "thinking and planning" department be established in the very beginning. If any person's ambition leads him to wish to win races or other athletic contests, he can find out the recorded times of performances of previous champions; and if he desires to lower the record, he knows exactly the time he has to beat, and practises and trains accordingly. The annals of sport are full of such records. Can any of you tell me where such records are available to the industrial worker anxious to improve his craft skill, and earn more money? Which of such records would be most productive of material prosperity and happiness to the nation? The records were not taken in the case of the athlete to "speed-up" or "drive" him, but to co-operate with him in showing what was reasonably attainable.

As "standards" will be referred to later I will explain what the term means.

Mr. M. L. Cooke, of Philadelphia, has said a "standard" under modern scientific management is simply a carefully thought-out method of performing a function or carefully drawn specifications covering an implement or some article of stores or of product. The idea of perfection is not involved in standardization. The standard method of doing anything is simply the best method that can be devised at the time that the standard is drawn; further progressiveness is desired and is adopted whenever and wherever found, after being carefully scrutinized. Standardization practised in this way is a constant invitation to experimentation and improvement.

This experimentation and improvement is done by time and motion study (*i.e.*, the study of the body's or machine movements) before the standards are made; thus the resulting standard is in so far protected that only the invention of a new device will make the change in such standard necessary. Standards have been advanced by a mere timing of the operation by mental counting. Good work has been done by stop-watches, but where exactness, precision and a permanent record are necessary, micro-motion studies, elaborated by Major Frank Gilbreth, of which I will show examples presently, give the best results.

In practice it has also been found that such studies bring out many hitherto unsuspected defects in surrounding conditions, most of which are beyond the power of the worker to change, but which enable the management to eliminate many drawbacks, and thus increase efficiency and output. In one case I have heard of, a drilling machine was fitted with a claw-operated heavy jig; the machine had high-speed drills and was not suitably speeded, and the 15-lb. parts to be dealt with were on the floor, entailing lifting up and putting down when finished. By a suitable re-arrangement of the machine and letting gravity deal with the parts, an increase of 120 per cent. was gained with less effort to the operator.

In another case close observation and timing showed that a machine could be slightly accelerated, thus gaining 1½ seconds in the cycle. This seemingly small improvement, when applied to a number of similar machines in use, amounted to a total of over 20,000 hours in the year—a truly remarkable and substantial economy. The savings indicated in the foregoing instances do not mean the reduction of employment, for alternatively two things might happen. Firstly, another country might discover the cheaper and faster method, thus causing us to lose the market; secondly, if all nations keep the faster method from being adopted costs will remain high and the article will remain a luxury.

We have illustrations of this in all trades. For instance, take boots. Until the past few decades most workers had to use clogs; their grandfathers were probably bare-footed, and it was only when elaborate boot-making machinery was invented that good boots were reduced to a price within the reach of all classes. Increased production here meant health and comfort to millions, and greatly augmented good and steady employment to scores of thousands.

The first step in introducing Scientific Management is the adoption of "*standards*" throughout a works. By this is meant not only standard machinery and tools, but standard methods of performance, standard mnemonic symbols, standard phrasing of instruction cards —of course this means that an investigation and planning department has been established—but even standard clothing, which should be provided by the management, together with a proper dressing room. This would mean clean and tidy workers in the trains, trams and busses.

To a careful observer there is nothing more disheartening than a study of many workers' clothes, especially those of women workers. One has only to consider how this question has been thought out where sport is concerned, to see the enormous strides which could be made for increasing the efficiency of the worker, by having well-thought out, substantial garments, suitably designed to fit the particular occupation of the worker.

For tennis, football, running, boxing, golf, etc., the garments worn do not in themselves increase fatigue. Why should not the workers' clothes receive the same attention as those of the athlete?

Functionalization or the sub-division of labour, is the aspect of Scientific Management which has perhaps come in for the most criticism. This is what Prof. Jules Amar, the great French physiologist, says on the subject—"There is in the division of labour a scientific solution of the problem of occupying everyone on the work that best suits him. And there are so many developments possible to human activity that every worker ought to find his niche without delay." Functionalization endeavours to do this; its aim is to take round pegs out of square holes, and *vice versa*, and fit them where they will have a chance of developing their individuality, and to put all workers at the work for which they are physically and mentally fitted.

Under this system the planning is separated from the performing; the hitherto overloaded function of foreman is split up under various heads, and all workers know exactly what is expected of them, and how they are to do it. This method not only increases the productivity of the worker, but diminishes executive fatigue, which is one of the main causes of slipshod management. I will enumerate the eight main functionalists, four in the planning and four in the performing departments—Order of work and route clerk, instruction card clerk, time and cost clerk, disciplinarian, gang foreman, speed foreman (to speed the machines *not* the men), repair foreman, inspector. I have not time to go into this fully now, but I would like to say a word about the disciplinarian. He is not so alarming as he sounds. He is a man chosen for his tact and judgment who deals with all questions relating to discipline, fines, discharges, etc. He is really a peacemaker. A complete record is kept of every man's work, whether good or bad, and this is at the disposal of the disciplinarian. In this way every man is sure of a fair hearing, and he knows that he will not be fined, punished or discharged through the personal spite or dislike of his foreman. In some cases, even the latter, if making an unfounded complaint, is disciplined.

These *records* which I have just mentioned are an important part of the system. They are kept not only of the individual performance and behaviour of every worker, but of the work itself. There are no "book-keeping" records as such, but time and cost records, of the time and efficiency of performance. Just as records are kept whilst the work is going on, so *programmes* are always made before starting fresh work. New programmes are based on past records, and so, as more and more records become standard, the drafting of programmes becomes constantly an easier and cheaper process.

Analysis and *Synthesis* appear late in the science, and are of course based not only on measurement which I have not yet touched upon, but upon previous records. The nature of the work must determine the amount of analysis practicable, and in determining whether the work shall be scientifically analysed it is necessary to consider whether it is of sufficient importance to warrant the expenditure of a large amount of time and money upon it, prior to the undertaking. The process of division continues as long as it can show itself to be a method of cost reducing. "Work may be divided into processes; each process into sub-divisions; each sub-division into cycles; each cycle into elements; each element into time units; and each unit into motions. The work of the synthesist is to study the individual results of the analyst's work and their inter-relation, and to determine which of these should be combined and in what manner, for the most economic result. He has to conserve all that is valuable in old methods and combine it with the new.

A complete lecture could be delivered on *teaching* under Scientific Management, but I have only time to touch upon it now. Under the old systems, there was practically no definite scheme of teaching by the management, and the apprentice learned in a haphazard way, and often from poor methods; the old belief being that the worker must go through all possible experiences in order to acquire "judgment" as to best methods. In other words that he should learn by his own mistakes, an expensive process for the management. Under the new method, the apprentice is taught by a definite system, the right way from the very beginning. As he can start in where others left off, he can learn much quicker and go much further.

Incentives, under scientific management, can be defined as inducements to the worker to increase his efficiency, and a stimulant to prevent indifference to the work. Under "stimulants" we can place pleasant and sanitary working conditions, good heating, cooling, lighting and ventilating, and the recognition of individuality under the record system. Under inducements, the knowledge that if a man works his best he will be benefiting himself, but not doing his fellow-worker an injustice. There are far more chances of promotion than under the old system, for the simple reason that there are far more executive posts to be filled. Finally, there is the important question of pay, with fewer working hours; for every man may earn abnormally high wages provided that he works faithfully according to instructions and completes a task that has been fairly determined by scientific—and in the future I hope—psychological and physiological data.

Might I ask whether improvements could not be effected in shovelling, of which there must be a great deal done in the army. The late Dr. Taylor when manager of the Bethlehem Steel Works was struck by the fact that there was only one type of shovel in use for all purposes. He found that the maximum weight that a man could lift, without undue fatigue, was 21.5 lb., and he had the shovel blades altered accordingly. He had smaller blades made for coal or ore than for breeze. Finally, some thirteen different types of shovel were used in the works. The effect of the change was that in a given time the weight lifted per man per day went from 16 to 56 tons.

Tall men should be put to work on excavating, or where material has to be lifted to a height; and the short men to turn over material on the ground, such as mixing concrete, mortar, etc. The latter not having to stoop so far as the tall men, will get less fatigued, whilst the latter would have the advantage in trench digging, not having to throw their spadeful so far.

In some cases the individual cannot work more than 42 per cent. of his time; 58 per cent. of rest being necessary. Consequently, at the steel works above mentioned, rest periods were regularly given. In heavy labour if they made a man rest 58 minutes in 100 minutes he would do three or four times the work in a day than if he was employed continuously. Dr. Taylor found that when a man lifted continuously more than 92 lb. at a time he was over-fatigued, and that weight was therefore made the limit, the pigs of iron being cast at that maximum. When a man had carried five pigs he was made to sit down and rest for a rather longer time than he had been carrying. The man at piece work earned 70 per cent. more wages per day, and whereas he formerly carried 12½ tons, he was able to handle 47½ tons, though he worked less than half time. Very similar experiments in trench digging in France during the war led to exactly the same results. By giving the men periodical rests, over three times the amount of work was done in a day, the rest periods being strictly enforced. Production in many industries is seriously reduced, because the men work too long without rest, and so are over-fatigued. As an instance in one works men turned out 16 articles per hour when working at their own pace. Working 25 minutes and resting five minutes alternately, they made 18. Working 17 and resting three, they produced 22, and finally, working 10 and resting two, they did 25. Short period and short rests give better results than long periods and long rests.

Time study is one of the most important factors in scientific management, its function consisting of ascertaining with accuracy the minimum times of all operations. Those who have never investigated such operations cannot realize the enormous benefits to be derived from such study. Under the old methods the foremen and shop managers were considered to be the only competent judges in such matters. Their opinions were sought, as they were supposed to have experience, and perhaps data from previous operations. Usually such notes, if found, were discovered to be too rough and lacking in essential particulars. In spite of this, they were left to fix times and prices, often with disastrous consequences. As a case in point I may mention the following incident. During the war a French works had to repair a torpedoed ship. The head foreman spent about six hours in looking over her, and estimated it would take 12,000 hours to repair the damage and perhaps mean a 30 per cent. time bonus to the men over their ordinary pay. The work was begun, but here the new timing department took a hand in the game.

They checked up the work by the new methods and found it should only take 4,600 hours, and they fixed this as the basis of payment. It was done in even less time, and the men earned a 45 per cent. bonus.

It has been asserted that "what Darwin was to Science, Taylor was to Industry." To sum up, he puts forward in his book *The Principles of Scientific Management* the following five principles:—

1. Science not rule of thumb.
2. Harmony not discord.
3. Co-operation not individualism.
4. Maximum output in place of restricted output.
5. The development of each man to his greatest efficiency and prosperity.

The foregoing are all sound and good, and his system is practically perfect.

Before starting new methods and going to the trouble and expense of subjecting them to an intensive study, it is advisable, where possible, to begin with a survey of the old existing conditions. Gilbreth says that such survey may consist of a written description, supplemented by all available data—such as drawings, sketches, photographs, etc.—for recording what exists, what is taking place, and the times taken over the operations. It will serve as an important basis for the necessary future comparisons, and show what improvements in time or method are to be aimed at. The difficulty in preparing such a survey is to set down correctly what does exist. There is great temptation, especially if it is being done by an interested party, to set down instead what ought to exist, what is hoped will exist, what is planned should exist, rather than what is actually there. Try it for yourselves.

When you return to your work set down, or get a competent substitute to do so, what actually occurs in your place during one typical half hour. Add to this drawings showing the "set-up" or "lay-out" of your work, and where each piece of working equipment is placed, etc. Where plans exist, use them as a basis, drawing in the small objects. You will find this most interesting and stimulating as an attempt to make a survey of your own working conditions and practice, and you can then review it intensively, and then begin to introduce motion study.

Motion study is the science of eliminating wastefulness resulting from unnecessary ill-directed and inefficient motions. There are no ravages going on in nature to-day that equal the hourly losses the whole world is suffering from as the result of the wastage of human energy. Wasted motions cause wasted effort and time, and one of the results is unnecessary fatigue, another prime cause of high costs. Time is our greatest asset, and to waste it is to squander our inheritance. To waste time and to suffer unnecessary fatigue simultaneously can be excused only by ignorance. When we come to necessary fatigue we cannot proceed far without recourse to careful measured investigation. These always show that less fatigue is necessary to do the work that has been anticipated.

In the final analysis, whether the fatigue proves to be necessary or not, it must be eliminated or cured, that is, recovery periods must be instituted. There are two methods of fatigue elimination—one the short method of removing the cause, the other by supplying the remedies.

What is not generally recognized is the following physiological fact pointed out by Professor Amar: "The fatigue of the nervous system is in proportion to the number of motor impulses which it is obliged to furnish to the muscular system in order to cause the latter to function, and here we see why in certain kinds of work which do not require strength there is considerable nervous exhaustion, while fatigue soon makes it appearance." Dr. A. F. Stanley Kent also believes that "the seat of fatigue is rather on the nervous than on the muscular side." You must realize from the beginning that fatigue study is a necessary complement to motion study, and that the fatigue which is the outcome of the motion must never be forgotten.

For instance, a long motion may occupy no more time than a short motion, but the fatigue will be greater with the amount of the distance traversed, all things remaining the same. Motion economy also involves a consideration of delays, the reasons why they occur, and a reconstruction of the method to such an extent that avoidable delays are eliminated, and that unavoidable delays are made rest periods or otherwise utilized.

The great and important result of motion study will be the change in your mental attitude. Nobody can really appreciate the benefit of motion economy who has not made motion study in his own work-place upon his own work, for you will see your own work-place yourself, and all that you do, in a new light. All activity outside and away from work will have more significance, and, perhaps the most important of all, you will see, more and more each day, the underlying elements of likeness in all types of activity. Just as there are physical elements, so there are elements of skill. You will come to distinguish between skill and mediocre activity or bungling activity, and to note that an expert in any line bears certain resemblances to experts in other lines.

Motions of experts in all activities are alike; all are smooth, all are graceful, all show decision without hesitation, and all produce that satisfaction in the spectator that they produce in the creator of the motion.

I will now show you a series of pictures, a few of many thousands, taken by Major Frank B. Gilbreth. In the evolution of scientific management, motion study as elaborated by him, and his application of psychological laws to the workers, have become important items.

In all motion study you must first have your units to measure, then your methods of measuring, and finally, devices to measure quickly and cheaply. Measurement is indeed the foundation, the base line of scientific management.

Many may consider the apparatus he uses expensive and elaborate, but I wish to emphasize particularly the fact that such equipment is not necessary for preliminary study. In fact, to realize thoroughly the need of more accurate measurement, it is first necessary to devote much thought along the lines of motion economy, and to work without any equipment. To make accurate studies of operations being performed wrongly, is a waste of time, energy, and money.

Many photographs were then shewn, of which we reproduce seven* with descriptions.

1. A micromotion photograph enables the worker, with all surrounding conditions, to be permanently recorded. The elapsed time of an operation is visually recorded in a series of pictures, by means of the clock, the single hand of which moving through 100 divisions in three seconds, measures 1-2000th of a minute. The extent of the motions made are measured against the screen in the background, which is cross-sectioned into 4-inch squares. Major Gilbreth is standing behind the clock.

2. By means of an electric lamp attached to the hand, or other working member of the body, or the parts of a machine, the path of the motions executed can be traced in the cyclegraph photograph.

3. Various types of cyclegraph time spots, usually numbering 20 to the second. By counting the spots in the photograph the elapsed time of a motion is ascertained. When spots of different types appear in a picture, it shows the separate paths of the motions of various working members.

4. Learning the paths of least waste. Models in wire of the motions of the left hand of a man using a drillpress, a machine he had not touched for 25 years. Note the gradual progress to the practically perfect motion.

5. Cyclegraph of the perfect motion, after considerable practice, on the same machine by the foreman. The "kink" shows where the piece dealt with was "positioned" during the time of transport loaded. This study and the rearrangement of the feed-boxes, etc., cut down the operating time by one-half.

6. A Gilbreth assembly packet. Formerly all parts were kept in boxes or bins on the floor, benches, etc., entailing turning and stooping. Arranged in proper sequence on these wall packets, with table at the right height, tools in their standard locations, the workers were enabled to assemble 66 machines per day against a former output of 18, in less time and much less fatigue.

* The photographs are from Major Gilbreth's collection, and we are indebted to him for permission to make use of the same.

7. Picture of an American Amateur Champion Golfer. Lights attached to his head and hand, and to the head of the club. Note the movement of his head, it was found that all players *do* move the head. The beautiful regularity of the stroke is clearly seen. Its extent is measured on the screen, and the time taken over it can be ascertained by counting the number of spots.

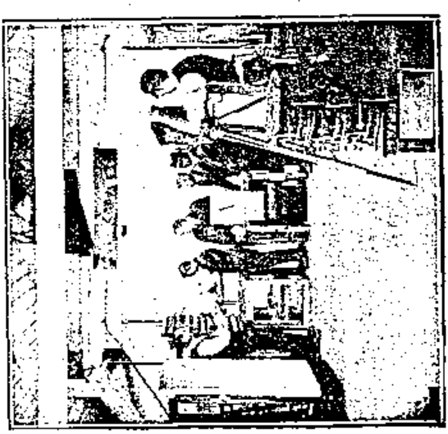
If I have convinced at least some of you that scientific management is not, as some from honest ignorance think, a mere device to exploit the workers, but a real living force capable, when properly installed and handled, of conferring untold benefits on all concerned, I shall feel rewarded.

I cannot finish better than by quoting Professor Amar's dictum on Scientific Management: "Selection and order are in truth the characteristics of the new method, which will presently work an economic revolution to which no other can be compared. It is not purely mechanical, it does not turn a man into a soulless body, a blind and tireless force, it embraces all the data of physiology and psychology, of which it alone is able to display the parallelism and the unfailing harmony. It would seem to have taken for its guide this saying of Montaigne's: 'It is not a body, it is not a soul that we are forming, it is a man, we must not make two of him.'"

Books on Scientific Management.

The Principles of Scientific Management and *Shop Management.* Both by late F. W. Taylor. (Harpers).—*Motion Study.* By F. B. Gilbreth. (Constable).—*Applied Motion Study.* (Routledge).—*Primer of Scientific Management.* (Constable). and *Fatigue Study* (Routledge). By F. B. Gilbreth and L. M. Gilbreth.—*The Psychology of Management.* By (Mrs.) L. M. Gilbreth, Ph.D. (Pitman).—*Work, Wages and Profits* and *Organizing for Work.* By H. L. Gantt. (Bird).

No. 2.



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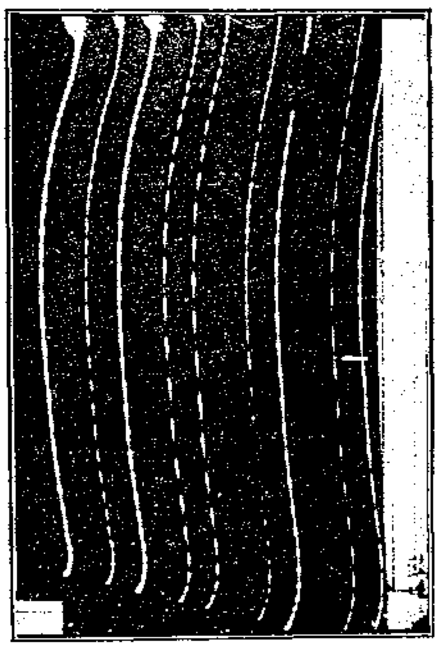

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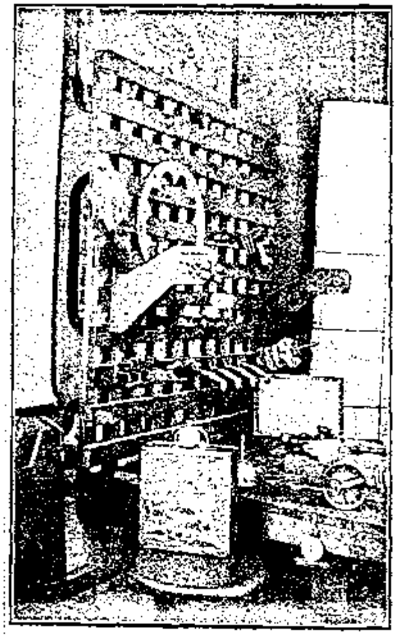

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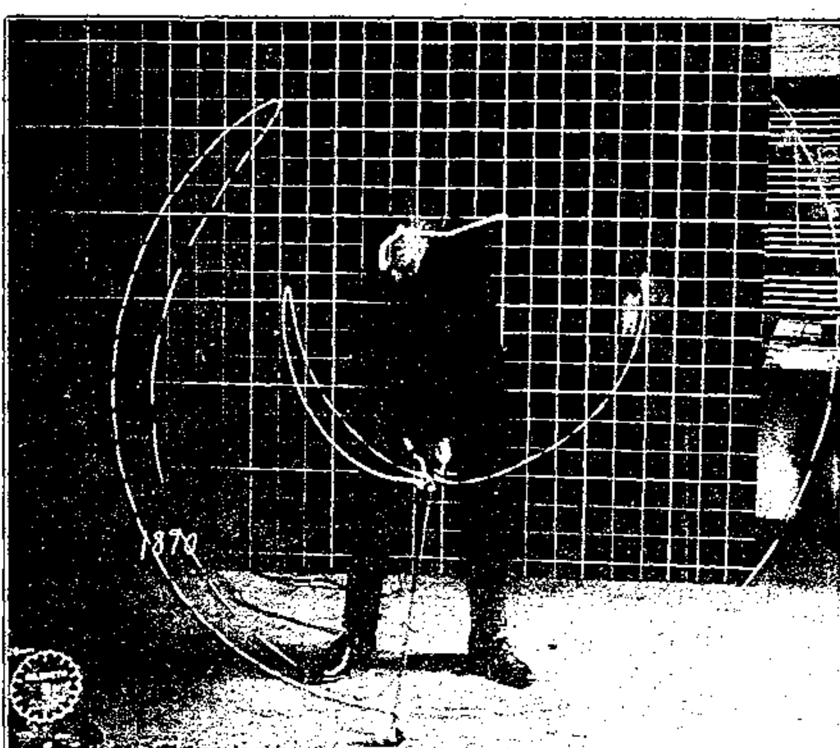

No 7.

VERDUN AND METZ.

A Comparative Study of the Fortifications, taken from an Article in the "Revue du Génie Militaire" of January and February, 1921, by General Benoït, Chief Engineer of the Military Command of Metz.

By CAPT. C. LA T. TURNER JONES, D.S.O., M.C., R.E.

(*Concluded*).

VI. THE CONDITION AND COST OF THE FORTIFICATION OF VERDUN AND METZ AT THE COMMENCEMENT OF THE WAR.

Verdun.—At the commencement of the War, Verdun had two rings of detached forts in addition to its citadel and its old enceinte. The inner ring varied between 2½ and 6½ km. from the town and, with the exception of Tavannes and Souville, was without armour or concrete. These two had some concrete shelters and Souville had a turret for a 155-mm. gun; the outer ring, 5 to 8 km. from the town, had concrete works and a certain number of guns behind armour or concrete.

The fortress had in all:—

6 disappearing turrets for 155-mm. guns for long-range firing;

14 disappearing turrets for 75-mm. guns (28 guns) for firing on the foreground and for flanking fire;

23 Bourges casemates (46 75-mm. guns) for flanking the gaps; in addition, 203 revolver guns (guns with 12 chambers), eight 90-mm. guns for enfilading the ditches, 86 smooth bore mortars of little value and 210 machine guns available for the forts or the gaps.

The guns for the artillery battle and for long-range firing were distributed in about 130 batteries and consisted of 670 guns, many of obsolete type—12 batteries had concrete shelters for the gun teams and for the ammunition, the remainder had only masonry ones. The artillery munitions were stored in eight main magazines dug into solid rock, whence they were distributed to intermediate underground dumps and battery magazines by a well-organized light railway of 60-cm. gauge. 611,000 rounds, or an average of 800 per gun, were stored in the fortress. Observation of fire could be carried out from 45 armoured O.Ps. in the forts and 23 concrete O.Ps. in the Bourges casemates. 16 company, 18 half company, concrete dug-outs, as well as some deep dug-outs, had been made in the gaps between the forts.

The perimeter of the outer ring of the forts is about 45 km.; the forts are $1\frac{1}{2}$ to $2\frac{1}{2}$ km. apart, except Charny and Froideterre, on the banks of the Meuse and on the down-stream side of the fortress, which are $3\frac{1}{2}$ km. apart.

The forts of the Heights of the Meuse had not been strengthened since they were built, except the fort Liouville which had a few concrete shelters and some armour, viz., one turret of cast-iron for a 155-mm. gun, one for 75-mm. guns, and one for machine guns.

The forts of Verdun, armour included, cost from 1874 to 1914 about 55 millions of francs, about 70 millions if the engineer services carried out during the same period are included, and 78 millions, including the guns and ammunition. This is less than the cost of a single battle cruiser.

If the cost of the guns and ammunition placed in the gaps be included, although in actual fact these were placed at the disposal of the field army, the cost is brought up to 127 millions. Adding the value of the enceinte and the citadel, the total cost is brought up to 165 or 170 millions.

The engineer work on the forts of the Heights of the Meuse cost an additional 17 millions, bringing the total cost to about that of two battle cruisers.

Metz.—Of its ancient citadel, Metz has only retained the old forts of Moselle and Bellecroix; the remainder was demolished in 1902 and replaced on the south by a defended iron fence. It also possessed two rings of detached forts, one 3 to 4 km. from the town and the other 5 to 11·5 km.

The inner ring consists of nine forts of which two, Saint-Quentin and Plappeville, are joined by a continuous obstacle protected by infantry works. This ring contains 6 guns in revolving turrets in the forts, and 22 guns, also in revolving turrets, outside the forts, distributed in six armoured batteries.

Between the forts are numerous batteries in earth-works most of which are near concrete shelters for the gun crews and for the ammunition. These concrete shelters, 80 in number, are scattered over the whole area and consist of 25 for ammunition, 25 for gun crews and 30 for infantry.

The outer ring contains concrete works supplied with 70 guns in revolving turrets (44 of 10 cm. and 26 of 15 cm.) and many batteries outside the works provided with concrete shelters for personnel and stores. There are no isolated armoured batteries, since all the armoured guns have been placed either in the *feste* or can be considered as forming part of the *feste*. This ring has in front of it a strong though unfinished line on the French frontier side. The works in the gaps are also unfinished. The enfilading of the gaps by artillery fire is arranged for only by 10 77-mm. guns in five casemates. The ring itself is also unfinished for the *feste* only exist on a semi-circle with its diameter running N.E. to S.W. joining the *feste* Lothringen and Von der Goltz. North of this line there are only two forts, Lauvallière and Mey, the latter being 8 km. distant from Lothringen. The Germans proposed to construct a work on the high ground south of Malroy to fill this gap, but nothing further was done, and they merely threw two pile bridges across the river, one at Thury and the other at Olgy.

At the time of mobilization the fortress of Metz had in all 98 pieces of armament in turrets, of which 60 were on the left bank of the Moselle (22 of 10 cm., 34 of 15 cm. and 4 howitzers of 21 cm.). By their long range of about 10·8 km. the 10-cm. turret guns of the outer ring were able to cover with their fire all the country towards the frontier up to the road and railway, running from Chambley to Conflans; the 15-cm. howitzers, though having only a moderate range (7·2 km.), were able to search the valleys in front of the ring of forts.

The 60-cm. gauge railway did not supply all the works, more particularly certain outlying ones, including the batteries of the line Sainte-Barbe—Sorbey.

The *feste* Wagner and the magazines and batteries of Hospital Wood were supplied by the normal gauge line.

The perimeter of the outer ring is 54 km. or 1-5th more than that of Verdun, and the forts are at distances apart varying from 1 to 4 km. with the exception of the *feste* Lothringen and Mey on opposite banks of the Moselle, and the *feste* Haeseler and Wagner on opposite banks of the Seille, in both of which cases the distances are 8 km.

It would have been almost impossible to determine the cost of Metz as the Germans removed every document dealing with the matter, but documents giving the cost of all the works at Thionville were found there. Germany spent about 50 millions of francs on Thionville, comprising three *feste* with 16 10-cm. guns; this sum being made up roughly as follows:—

6 million marks for Illange, 7½ million marks for Koenigsmacker, 13 million marks for Guentrange (including 2 millions for repairs due to settlement), before the War; 900,000 at Illange, 6 millions at Koenigsmacker, 4½ millions at Guentrange, during the War. The balance is made up in expenses due to the fortification of the enceinte and in the cost of the artillery depôts.

From the above figures and comparing the cost to France of similar works it has been possible to arrive at an estimate of the cost of the works at Metz. This estimate is for example:—

Leipzig, 7 million francs; Kaiserin, 18 million francs (including much underground communication work); Von der Goltz, 19½ million francs (probably would require 5½ millions to complete).

The cost for the double ring of forts including the permanent fortifications on the left bank (Horimont, the Quarries of Amanvillers and the position of Bois-la-Dame) appears to be 210 million francs. If the cost of the armoured batteries outside the forts, the various shelters, the strategic roads and the 60-cm. railway be included, the total reaches 250 million francs.

VII. WORKS CARRIED OUT DURING THE WAR.

At Metz, at Thionville and also at Verdun, the completion of works begun and the strengthening of existing works were carried out up to 1916. From the outbreak of war, gaps were defended by trenches and isolated works.

At Metz these works were of more permanent design than at Verdun, concreting being done to the shelters and to the machine gun emplacements, many of which were intended solely for enfilading the gaps.

Dykes were made on the Seille for causing defensive floods and at the same time the gap between the works of Horimont and Mey was closed by the digging of works along the general line Semécourt—Rugy—Chailly—Antilly—Failly. The enfilading of the gaps between the works was carefully studied and was carried out by means of machine gun fire from concrete shelters. An almost continuous line was made on the left bank of the Moselle at Thionville running *viâ* Guentrange and resting on the river, level with Koenigsmacker and Illange. This line had small concrete shelters and a double thickness of wire obstacle 8 m. wide in front of it. There was left only a curtain of less than 14 km. between Metz and Thionville, formed by the Moselle, which could be crossed only by one bridge at Blettange defended by several field works on both banks.

At Verdun, centres of resistance were taken up on advanced positions between the plateau of Sivry la Perche to Côte du Poivre; a certain number of deep dug-outs were made along the line of forts, notably south of the forts of Douaumont and Vaux and at the fort of Belrupt.

Later on, when the fortress was attacked, shelters for the forts and works were extensively increased by the construction of numerous underground galleries, ventilated and lit by electricity and opening into casemates or M.G. emplacements placed outside the forts for the defence of the approaches to them.

At Metz, when the battle became stabilized in the neighbourhood of the fortress, the Germans began the construction of an advanced position towards the south resting on the Moselle near Arry Hill; but it was chiefly after April, 1916, when the attack on Verdun did not come up to expectations, that they really pressed on with these works. They had at this time between Marieulles and Sorbey on an average depth of 500 m. to 600 m. a large number of shelters having thickness of concrete varying from 0·60 m. to 1·20 m.

These shelters were built either for 12 men or for searchlights, as O.Ps., or for enfilading guns and machine guns; they were spread over three, four and even five successive lines on military crests or on reverse slopes with more or less completed obstacles in front of them. The connecting trenches were hardly begun.

Between Marieulles and Haute-Grève there are nearly 800 of these shelters, many of which were completed by the spring of 1917. This number would seem to be out of all proportion to the garrison usually allotted to a defensive position, but it has the advantage of denying to the enemy knowledge of what points are being lightly held, and gives the defence shelters and opportunities for flanking fire in a lightly fortified area.

The whole of this advanced position was provided with water by pumps from Cherisey and Coin-sur-Seille.

In addition the installation of electric light was proposed by means of power supplied from Diesel engines in Lothringen, where they had been installed for lighting the Horimont position.

VIII. The Effect of Bombardment on, and the Part Played by, these Fortresses during the War.

The Effect of Bombardment on Verdun.—The fortress of Verdun was attacked on the 21st February, 1916, by a strong army with much artillery, including very powerful guns. The violence of the fire passed all expectation.

For the defence the French Artillery fired 9,795,000 rounds in the first three months of the attack, 23 million rounds in the first seven months, of which 16 million were from 75-mm. guns. This gives a daily average of 100,000 rounds, a number more than doubled on days of attack; for instance, when Douaumont was retaken on the 24th October, 1916, 240,000 rounds were fired.

Vacherauville (8,000 rounds, including 110 of 420 m. and 2,140 of 380, 305 and 280 mm.), Froideterre, Souville, Tavannes and La Laufée 30,000 to 40,000 each), Moulainville (8,500, including 330 of 420 mm. and 770 of 305, 280 and 210 mm.) were the forts most heavily bombarded by the enemy. Thiaumont, Douaumont, and Vaux were bombarded by both sides. The town of Verdun received more than 50,000 shell, including about 380 of 380 mm.

The effect of prolonged bombardment showed that:—

(1). Earth-works were completely flattened out; defended railings, wire obstacles and ordinary masonry were entirely destroyed;

(2). Concrete works survived in proportion to their mass;

(3). Heavy shells, notably the 420 mm. ones, made themselves felt at considerable depths up to 14 metres.

As a result (*a*) underground communications, if at insufficient depth, were frequently rendered impassable but if deep enough were quite safe and the men in them were safe from concussion; (*b*) small isolated concrete works, such as those at Thiaumont, were more rapidly destroyed than if they had formed part of a large mass of concrete. It was also found that works with a layer of concrete over a layer of sand had the concrete penetrated if this was less than 2½ m. thick, but not if more than 2½ m. thick. Ferro-concrete was pierced if of less thickness than 1·75 m.

The armour survived in an extraordinary way; in the forts of Vaux, Douaumont, and Thiaumont only a few O.Ps. of little mass and machine gun emplacements were destroyed, these not having been built to resist heavy shell.

Damage done to the gun turrets was generally quickly repairable, and none were long out of action. The only turrets for 75-mm. guns which were destroyed at Verdun (Fort Vaux) were destroyed by charges exploded in their barrels by the French.

To sum up, the active elements and the chief passive elements of the forts defied the heaviest artillery attack. Except for the small work of Thiaumont, all the forts of Verdun remained fit for action at the end of the attack.

The Effect of Bombardment on Metz.—It is impossible to guess with any accuracy what would have been the effect of bombardment on Metz. The inner ring could probably have been destroyed by fire from artillery of heavy calibre, as the protection afforded by 1 m. of concrete or 2 m. at the most over 1 m. of sand is quite insufficient. The underground communications of the outer ring were far from being sufficiently protected and might have been destroyed by lucky shots. The batteries and concrete barracks would have required an accurate and prolonged bombardment to do them much harm. The armour, being of only half the thickness of that used by the French, was probably not nearly strong enough.

The Part played by Metz during the War.—The fortress of Metz and the fortified area of the Moselle were not attacked and its long-range guns were not used except that a few 10-cm. rounds were fired from Kronprinz against the Americans in the direction of Rupt-de-Mad. But if the individual forts took no part in the war the fortified area as a whole completely fulfilled its purpose. It covered the concentration of the German troops in Lorraine, it permitted the quick and easy intervention of these troops in the battle of Morhange in August, 1914; under its cover were assembled the troops for the attack on Troyon on the 8th Sept., 1914, and on Saint-Mihiel on the 24th of September; under the screen of its forts was collected a large proportion of the troops for the attack on Verdun in 1916.

It formed a big depôt for munitions and supplies for the German armies of the Woëvre and Lorraine. The fear of seeing large forces appear from the fortified area must have had some influence on our movements on this part of the frontier in August, 1914.

The Part played by Verdun.—Verdun had to meet very powerful attacks, in which its forts played very important parts. The forts were incorporated into the various lines of defence held by the Army and were, thanks to their situations, excellent observation posts, and, thanks to their concrete, excellent shelters for the men. The few turret guns, in spite of their fewness, were most useful at longish ranges. For instance, the turret guns of Vacherauville fired, on the 24th and 25th of February, 1916, and again on the 24th October, on the enemy troops and positions towards Beaumont and Louvemont; the turret gun of Souville fired on Poivre Hill; the turret guns of Moulainville covered the retreat of the troops in the Woëvre from the 25th to the 28th of February, 1916, and then delivered constant harassing fire for several months. The turret gun of La Laufée took an active part in the defence of Vaux from the 1st to the 8th June, 1916.

But, as has already been pointed out, this fighting at considerable ranges was not one of the primary intentions of the guns, since the forts were designed in the first place to ensure the enfilading of the gaps between them. This rôle was never fulfilled, as the enfilading guns were removed at the end of 1915. The importance of the effect of their fire on the approaches to Douaumont, to take an example, can only be surmised.

There remains to be mentioned the defence of the forts themselves. All the forts, with the exception of Douaumont, captured when ungarrisoned, put up a tremendous resistance: Vaux only fell to thirst, Froideterre stopped the enemy's attack dead on 23rd June, 1916, with the help of rapid fire from its 75-mm. guns, and Souville did the same on the 11th of July, its garrison emerging unharmed from its shelters at the decisive moment. The defence of Verdun was successful owing to its being undertaken along the general line of the forts of Froideterre, Souville and La Laufée, the only places in possession of safe cover. The Fortress of Verdun and the fortified area of the Heights of the Meuse played a most important part in the whole war. They covered and protected the concentration of French troops in that region and, during the battles in the Woëvre in August, 1914, they aided the movements of the French troops. It was to avoid this fortified region, known or believed to be well defended, and behind which the centre of the French Army might be encountered, that the Germans undertook the wide turning movement through Belgium. Verdun acted as a pivot during the French retreat in August and September, 1914, and to enable this retreat to be carried out in safety it was essential that Verdun should remain intact.

German attacks on the centre of the Heights of the Meuse broke down early in September, and again on the 24th and 25th of that month with the small successes of the capture of the fort of "Camp des Romains," the crossing of the Meuse at Saint-Mihiel, and the capture of Chauvoncourt. All attempts to widen the salient of Saint-

Mihiel made during the war broke down, thanks to the defences resting on the forts of Paroches and Liouville.

Thus Verdun and the Heights of the Meuse contributed largely to the victory of the Marne in 1914, and inflicted an irreparable check to the German Armies in 1916. France, therefore, has no reason to regret the monies spent in fortifying this area. What are 85 to 90 million francs in consideration of the lives saved and the results obtained thanks to permanent fortification? Not even the cost of the War for one day.

ERRATA.

The Reference table (*Legende*) printed under the figures on page 22 (July *R.E.J.*) refers to the figure on page 24, which latter should be described "Underground Plan of" and not "Section through."

NOTES ON THE CO-OPERATION OF THE INFANTRY AND ARTILLERY OF A DIVISION.

By COLONEL H. W. NEWCOME, C.M.G., D.S.O., R.A.

"Artillery cannot ensure decisive success in battle by its own destructive action. It is the advance of the infantry that alone is capable of producing this result." (*Artillery Training*, 1921, Vol. III., para. 23).

THIS must be constantly borne in mind by the artillery, and the infantry must realise that, under modern conditions, they will be unable to maintain their mobility and offensive power without undue loss, unless their artillery support is effective. An infantry officer recently put the thing in a nutshell when he said that he liked to fight two to one, *i.e.*, with his infantry and artillery against the enemy's infantry. The ideal to aim at is that our infantry should receive the support of their own artillery in the fight and that the enemy's artillery should be unable to help their infantry.

This ideal cannot always be attained, but our object should be to get as near to it as possible and for this the closest co-operation between infantry and artillery is essential. Now it "takes two to co-operate" and each party must do its share. We want to consider the respective duties of the infantry, the artillery, and the commander of the force.

The Commander's Responsibility.—Every plan for attack or defence must be considered from both the artillery and the infantry points of view. The requirements of the two arms are often conflicting, and to make the plan to suit one arm and tell the other to conform does not always result in the most suitable combination of the two. At tactical exercises, the solution often offered is that the infantry will attack over certain ground or take up a certain defensive position and that "the artillery will co-operate," regardless of the fact that efficient artillery support would be very problematical under those particular circumstances. The various methods of carrying out any tactical operation should be discussed by the infantry and artillery commanders concerned, and it then rests with the commander of the force to decide how much weight should be given to the capabilities of each arm and to settle the final plan.

The Artillery Share.—The primary objects of artillery fire are:—(i) to assist the movements of our own infantry, (ii) to prevent the movements of the enemy's infantry (*Artillery Training*, 1921, Vol. III, para. 23). It is therefore the duty of the artillery to ascertain the progress and needs of the infantry and to give them such support as they require. To enable them to carry out these duties they must have (i) good observation, (ii) good communications, (iii) good information. *Artillery Training*, 1921, lays great stress on the importance of good observation in all the stages of attack and defence, and this implies good communication between the battery commander at his observation station and his battery. Otherwise he will find himself in the unfortunate position of the officer who, during the retreat from Mons in August, 1914, saw a German battery with its wagons moving across his front at easy range, and could not fire a round because his telephone line had been cut. We must therefore consider observation and communications together, as one is no use without the other.

Increased facilities may be provided in the future for observation from the air and the more universal introduction of wireless telephony may simplify the question of communications, but in the meantime the artillery is largely dependent upon ground O.P.'s and the telephone line or visual signalling. Commanding ground is usually necessary for the first and short distances for the second, so the original selection of ground for attack or defence is an important factor in considering the question of effective artillery support.

In any defensive position there is usually one portion of the ground which gives a more or less extensive view over the scene of the proposed operation; the principal O.P.'s and the guns for the defence of the main battle position should be in this area. Telephone lines may then be short and quickly repaired or visual signalling may be resorted to. If the majority of the O.P.'s are in or near the front line, observation becomes difficult and intermittent owing to the enemy's fire; if a large proportion of the guns are placed near the front line they get in the way of the infantry and are apt to be overwhelmed by the enemy's artillery; it follows that, from the artillery point of view, the infantry should occupy the ground for at least three thousand yards in front of the main artillery position on the high ground, in order to allow of sufficient depth in the distribution of the guns and to secure efficient artillery fire. And from the infantry point of view this appears to be the best arrangement. Although they may be faced with difficulties of supply, carrying out of reliefs, positions for supports and reserves, etc., in the forward position, they can usually find better ready-made obstacles in the lower ground and are better screened from the enemy's O.P.'s and artillery fire. Infantry on the forward slope of high ground make a good target for the enemy's artillery; if they are withdrawn behind the crest, distant observation is impossible and the artillery is very seriously handicapped.

A good example of the advantages of the forward position of the infantry is the holding of the line of the River Ancre by the Third Army in March and April, 1918. The O.P.'s were on the hills north of the river, where they had excellent observation over the north side of the peninsula between the Ancre and the Somme, and the guns were close to the O.P.'s The line of the Ancre was held by the infantry where they had the river and marshes in front of them, and where the enemy's artillery had great difficulty in locating them. Various hostile attacks were nipped in the bud as they attempted to deploy from the crest of the hill, and our infantry, weak as they were, had no difficulty in dealing with those which reached the river bank. In fact the principle of two to one was largely obtained in this case.

In the attack the same general principles hold good. The guns must be near good O.P.'s but in this case they should be close up to the infantry so as to cover the advance as far as possible without change of position. The objectives selected should be screened from the enemy's artillery, or our infantry will be shelled off the position, as occurred at Delville Wood. It was not until the attack was continued for one or two thousand yards beyond the edge that we succeeded in holding the wood permanently.

In addition to good observation and good communications brigade and battery commanders require good information both as to the general situation and the progress of the troops they are supporting. It is the duty of the C.R.A. of a division to keep his brigade commanders in touch with the progress made by other divisions on their right and left. To help him to do this, brigade commanders must link themselves up with the main signal centres explained in *Artillery Training*, 1921, Vol. III, para. 142, and the C.R.A. will also employ his staff officers and mounted orderlies; good information from the flanks should thus be secured.

To keep touch with the actual position of the troops in front is more difficult. First it is essential that the artillery brigade commander should be in close personal touch with the officer commanding the infantry whom he is supporting and obtain all available information from him. He should also be in a position to see what is going on from his O.P., and every opportunity must be seized by his battery commanders to keep him fully informed of events passing on their front. But it is often impossible to actually see from the O.P.'s what is going on, so the brigade commander should organize within the brigade a regular system of officers' patrols, which should be given definite tasks and used to keep touch with the headquarters of battalions when required. In addition it will often be advisable for the divisional artillery headquarters to organize a special information party which should be sent out for the day and given a roving commission to gain information by any means which may suggest themselves; special arrangements will be required to enable this party to transmit the information obtained.

These are the principal means by which the artillery endeavour to gain the information necessary to enable them to support their infantry.

The Infantry Share.—The needs of the artillery and how far these needs can be met by a suitable selection of ground have been pointed out in the above paragraphs. It is the duty of the infantry concerned to meet these needs as far as they possibly can within the limits of the orders given to them. To be in a position to decide how far they can go in this direction, they must have a knowledge of the difficulties connected with the observation and control of artillery fire, and they will then realize also the disadvantages attending a change of plan at the last moment.

One very important point in this connection is the selection of infantry brigade headquarters and *F.S.R.*, Vol. II, Sec. 107, 7, puts this case very clearly. "To ensure that intimate co-operation between the infantry and their supporting artillery which is essential to success, it is necessary that their respective headquarters should, if possible, adjoin." The artillery brigade commander's choice is restricted as he must be near his batteries in order to control them, so the infantry brigade commander should, if possible, select his own headquarters in close proximity to those of the artillery. These latter are chosen with a view to observation, control, and communication with the division, so that the best positions for the two headquarters usually coincide.

But there is a further duty incumbent upon the infantry, and that is to keep the artillery constantly informed as to their whereabouts and difficulties. In the early days of the war attempts were made to carry out this duty for them by sending artillery *liaison* officers to battalion and even to company headquarters, but it was eventually found that the resources of artillery brigades were insufficient for this purpose. A *liaison* officer must have considerable experience before he can give useful advice to his infantry and must have good communication to his own unit to enable him to convey their requirements to the proper destination; the number of suitable officers, telephonists and linesmen was insufficient to keep the system working satisfactorily on this scale. In theatres of war where the infantry is distributed over a wide front and where the hostile artillery is not very powerful, these considerations may not apply equally; but in normal conditions of civilized warfare it is probable that "the subordinate artillery commander who has been allotted a task necessitating co-operation with a certain force of infantry" can afford only one *liaison* officer with signallers and orderlies. If the two headquarters cannot adjoin, this *liaison* officer must be at infantry headquarters (see *Artillery Training*, 1921 Vol. III, 31). In normal conditions a large share of the infantry in co-operation consists in sending the necessary information back from their front line to their brigade headquarters, where it will be picked up by the artillery. To enable them to perform this duty efficiently, a certain knowledge of artillery methods and of practical gunnery is required by all infantry officers. Some of the points which they should study are :—

(i). Method of describing targets. The infantry and artillery must "speak the same language" if they are to work together and any call for fire from the infantry must indicate clearly to the artillery where such fire is required. The clock code with some conspicuous reference point is the normal method of describing targets, but it is necessary that the observer's position should be stated. It has been suggested that the adoption of the aeroplane clock code would obviate this difficulty, but this requires demonstration.

(ii). Moving of guns. Constant change of position means loss of power, as a battery takes a considerable time (varying with the equipment) to limber up, get to a new position, range and get to effective fire. Artillery is powerless when on the move, so all positions should be selected with a view to covering an advance or retirement as long as possible without change of position.

(iii). Allotment of zones. Indiscriminate shooting by batteries over the battlefield may be fatal to effective fire. A German machine gun battery retiring from the Petit Morin in September, 1914, escaped practically untouched in full view of the whole divisional artillery, the reason being that every battery commander started shooting simultaneously and no one officer could distinguish his own ranging rounds. Zones or tasks must be allotted to brigades and careful arrangements made for ranging if a concentration of fire is required.

(iv). Supply of ammunition. Except when time is available for the accumulation of a large reserve, the ammunition available with a battery is very limited, and large barrage or bombardment programmes are out of the question. Infantry officers should bear this in mind when calling for artillery fire. With heavier natures of guns, the weight of ammunition to be handled is also a serious item.

(v). Enfilade fire. This is very effective when it can be employed, but infantry officers must remember that their guns are not then behind them and that communications become long and difficult. They must keep to the programme as the artillery plan cannot be changed at short notice in the middle of the operation. The failure to realise this was the cause of the so-called "short shooting" when the infantry wanted to pursue the enemy after the capture of Beaumont Hamel in November, 1916.

(vi). Range of various weapons. The effective and maximum ranges of guns and howitzers are given in *F.S.R.*, para. 12, 4.

(vii). Effect of various natures of shell, shrapnel, high explosive, gas, smoke, incendiary, etc.

(viii). 100 per cent. zone. A number of rounds fired from any gun or howitzer even under experimental conditions and with every round accurately layed, will not fall on one spot, but will form an elongated pattern on the ground, the size of the pattern varying with the weapon and the range. The centre of the pattern is known as the mean point of impact (M.P.I.), 50 per cent. of the rounds falling in the vicinity of the M.P.I. In order to obtain effective fire, the M.P.I. must be on or near the target, and this means that a proportion of the rounds must fall short of the target, *i.e.*, in the case of the enemy's front line trench, in "no man's land." Therefore, if our troops are too close to the proposed target, they must be withdrawn to a safe distance or the battery commander will be tempted to place his M.P.I. beyond the target and the fire will probably be ineffective. The shape of the zone also shows the advantage of enfilade fire, especially in the case of a shrapnel barrage.

(ix). Mean point of burst of shrapnel. Infantry officers often used to ask why the artillery were ordered to have a certain percentage of bursts on graze. The reason is the same as in the case of the 100 per cent. zone, *viz.*, that all fuzes at a given setting will not burn for exactly the same time. Fifty per cent. of the bursts will be near the mean point of burst (M.P.B.), but others will burst short or long of this point. The object of ordering a proportion of grazes is to eliminate the short bursts, which are ineffective and tend to prevent the infantry from keeping close up to the covering artillery fire.

Conclusions.—Under present conditions the efficacy of artillery support is largely dependent upon the selection of suitable ground for O.P.'s and battery positions, with sufficient depth in front of this area. The requirements of the infantry and artillery are often conflicting and the relative importance of each arm in any operation is the main factor which must decide the question, always bearing in mind that it is the advance of the infantry which alone is capable of producing decisive success in battle.

It is the duty of the artillery to assist their infantry by every means in their power and to find out their needs by personal *liaison*, observation, patrols, and information parties.

It is the duty of the infantry to make themselves acquainted with artillery requirements and to meet these requirements as far as they possibly can. They must also use every means of sending back to their artillery such information as may obtain for them the support which they require.

THE ROYAL SANITARY INSTITUTE CONGRESS, 1921.

By F.E.G.S.

As last year, the Council of the R.E. Institution sent a representative to the Congress of the Royal Sanitary Institute, which this year was held at Folkestone at the end of June. The following few notes made at various meetings do not pretend to give any detailed description of the work of the Congress but may possibly contain matter which will be of interest to some officers of the Corps, who if they so desire it can obtain further information on any of the subjects mentioned either through the Secretary, Institution of Royal Engineers, or from the publications of the Royal Sanitary Institute.

President's Address (Engineering and Architecture Section).

In his presidential address to the Engineering and Architecture Section Mr. P. Palmer, M.INST.C.E., said that in the new housing schemes one sees many artistically designed buildings and many inartistic ones. A great deal can be done in the design of chimneys, if well proportioned they can produce a general effect which is pleasing to the eye. One result of the modern conditions in this country is that the skilled craftsman is dying out, there is too little advantage to be gained by the skilled over the unskilled. Further, owing to the call of economy architectural embellishment has too often to be abandoned and utility alone is the prime mover. Only in design is it possible to obtain a pleasing effect and in this the architect and the engineer must work hand in hand.

London County Council Township, Becontree.

Mr. G. Topham Forrest, M.INST.C.E., described the designing of the new London County Council Township on the tract of land in Essex known as Becontree, for 120,000 inhabitants. Referring to cottage construction he said that " after careful consideration of the various methods of concrete construction, including block-making machinery and different kinds of shuttering, it was decided to erect a proportion of the cottages on the first section in the following systems :—

Witan No. 3 *System*.—A hollow-wall system, employing blocks made on the Winget pressure machines, enabling cottages designed for brick construction to be carried out in concrete. The external walls of houses are built 11 in. thick, made up with outer lining

$4\frac{3}{8}$ in. gravel concrete—gravel suitable for making a fine quality of concrete was available locally—$2\frac{1}{4}$ in. cavity and $4\frac{3}{8}$ in. inner lining of concrete blocks. The cross walls are 9 in. thick, and the ground floor weight-carrying partitions, $4\frac{3}{8}$ in. thick, are constructed of clinker concrete. In this system the external faces of cottages will in some cases be rough-cast and in others plain fair-faced blocks and rock-faced.

Composite Concrete Construction System.—This system is a revised form of that originally known as the "Fidler system." The external walls are 9 in. thick, made up as follows:—Outer leaf, 3 in., cavity 3 in., and inner leaf 3 in., both leaves being constructed of clinker concrete slabs and the cavity between them filled with poured gravel concrete. The external surface being of clinker necessitates the application of rough-cast or similar protection. The weight-carrying partitions on the ground floor are also built of blocks. Special hoop-iron ties 1 in. wide, split at the ends and turned up and down to hold the blocks in position to receive poured concrete, are used in this system. Monolithic bands formed at the first floor and ceiling levels give continuous ties round the building, and provide the bearing for the first floor and ceiling joists.

Witan No. 1 System.—Consists of a cavity wall constructed in the following manner:—The thickness of outer slab to external walls is 3 in., width of cavity 2 in., thickness of inner leaf 4 in. Open cavities are provided where floor joists project into the walls, and the adjoining principal wall areas above and below the floor are formed with closed cavities. The through concrete which closes the cavities will also tie the outer and the inner leaves of the wall together. The outer leaf is treated with a waterproofing compound. The cross walls are of 9 in. clinker concrete, and weight-carrying partitions as before. A rough finish to the external face is obtained by placing fibre matting in the moulds before the concrete is poured, giving effect of rough-cast.

Dry Walls System.—A form of poured concrete construction consisting of an inner leaf 5 in. thick and an outer leaf 4 in. thick, the outer leaf being of gravel concrete and the inner of clinker concrete, with a vertical damp course sheeting between the two leaves. Patent climbing shuttering is employed in erection."

In carrying out the work of erecting these cottages the London County Council claim to have reduced many difficulties to a minimum by placing the whole of the work in the hands of one "master contractor."

UTILIZATION OF SEWAGE SLUDGE.

Mr. J. D. Watson, M.INST.C.E., lecturing on "The Utilization of Sewage Sludge" stated that with regard to activated sludge, "If this sludge could be dried and made available as a fertilizer—and under certain conditions it can—the problem of efficient disposal of sewage would not be far from solution; but so far, no one has succeeded in freeing activated sludge from water to such a degree that it has become available for manure, and made portable enough to be applied to arable land. The growing knowledge of colloids makes one sanguine that research will be rewarded, and that the nitrogen, which is generally as high as five per cent., will ultimately be utilized and made available as a fertilizer; but, so far, the difficulties have not been overcome. . . ." Many experiments have been made at Birmingham with a humus which is practically identical with activated sludge, and none of them have been successful; ". . . they included an endeavour to filter it through a sand filter built like an ordinary waterworks filter; turning it into long deep trenches and covering it over with dried grass to keep down smell; lagooning it into shallow square plots of gravelly soil; irrigating grass meadows with it; centrifuguing it; pumping it back into the silt tanks through which the sewage passes before it is sprayed over the bacteria beds; but they all failed. The solids and the water emulsify so completely that humus is still like a jelly after lying in shallow lagoons for ten years."

In the discussion one engineer held that de-watering was unnecessary and that the sludge should be piped on to the land. But this opinion met with no support, partly because the land would not require the sludge at all times, and further it was not to be expected that schemes for sewage works would be accepted if they were saddled with expensive pipe systems in addition to their own cost.

The Design of Hospitals.

Mr. E. T. Hall, F.R.I.B.A., gave a most interesting lecture on "The Design of Hospitals," in which all branches of this important subject were discussed by one of the highest authorities on the subject in England. Particular interest attached to the King Edward Memorial Sanatorium at Pontywal, in Breconshire, for 304 beds. "It is of entirely novel construction, permanent in character, without sunk foundations. The contract price before the war, including all engineering, boilers, electric generating plant, accumulators, laundry machinery, kitchen plant, heating, lighting, etc., was about £175 per bed." The single storey rooms were carried on concrete rafts, 6 in. in thickness. Mr. Hall insisted on the psychological value of providing a chapel to every hospital.

Roads in Relation to Health and Prosperity.

In the Engineers and Surveyors Section Mr. H. T. Chapman, County Surveyor of Kent, gave an interesting lecture on "Roads in Relation to Health and Prosperity." After mentioning that his predecessor, Sir Henry Maybury, was one of the first to adopt surface tarring on an extensive scale, he said that "with the increase of heavy motor traffic, it became evident that surface tarring of water-bound macadam would not suffice and the use of tar macadam and other bituminous surfacings were extensively adopted." But they were still searching for a waterproof road which would stand heavy traffic. "Whatever type of surfacing is adopted, it is absolutely essential that adequate and compact foundations be provided, and this can be effected in many instances by utilizing the material in the existing road crust (if of sufficient thickness), scarifying and screening the same and treating it with pitch, tar, or bitumen to form a base-coat for the subsequent surfacing or 'carpeting' with a sand and bitumen mixture." In the discussion one member, a Royal Engineer, suggested the use of tins and other iron refuse as a foundation peculiarly suitable to country roads, and the President, Mr. H. P. Boulnois, M.INST.C.E., further pointed out their use as reinforcement for concrete roads. The latter also mentioned a road embankment built up of layers of sludge and clinker, which gave a perfect foundation like concrete. He said that supports to the sides of roads, to prevent lateral splay, must not be forgotten and described how in one case he had laid nearly twenty miles of concrete *in situ* curb with this object.

THE EXHIBITION.

The Exhibition was small but contained many interesting items. Messrs. Doulton exhibited their Eastern native latrine fitting specially designed for the new buildings at Delhi. Their ball valve silencers, porcelain enamelled bib valves, and the Lambeth combination of bath and lavatory basin for small bathrooms are also worthy of mention. The Firth Brearley Stainless Steel Syndicate's exhibit was interesting; and also the London Warming Company's "Kooksjoie" anthracite ranges, one capable of cooking for 300 is said to burn only 18 tons of anthracite in a year. The "Wifesjoie" one-ring gas cooker (Florence pattern) exhibited by the same firm, with water boiler attached, is an extremely economical fitting. The Paterson Engineering Company exhibited their new Chloronome for chlorinating drinking water. This important device is being largely adopted by the Metropolitan Water Board. Meldrum's portable "sack" steam disinfector should be useful on service. Pontifex's rubber composition float, without outside nipple, appears to be a great improvement on copper for ball valves. G. W. Harrison, Jennings, & Woodhead Bros. each exhibited novelties in latrine fittings. The Lacre Closed Circular System Gully Cleanser appears to be a very useful article and well adapted to emptying cesspits.

Among exhibits which did not immediately concern engineers it may be allowable to mention that of the Tintometer, which included their latest effort to design a screen which will produce artificially the full effects of daylight.

ENGINEER INTELLIGENCE.

By LIEUT.-COLONEL R. P. T. HAWKESLEY, C.M.G., D.S.O., R.E.

THE lecture on Engineer Intelligence delivered by Brig.-General J. E. Edmonds, C.B., C.M.G., on the 17th February, 1920, and reported on in the *R.E. Journal* of June, 1921, is full of interest.

The study of future and current wars by an organization wherein Military Engineers work side by side with the existing Intelligence officers is the only solution.

Engineer Intelligence is as important, neither more nor less, as is every other branch of Intelligence, whether tactical or supply. That it requires Engineers to collect Engineer Intelligence, while any capable officer can, after a short training, carry out other varieties of Intelligence, is the only apparent difficulty which, other points such as funds, being equal, strange as it may appear, cannot be overcome.

To broaden the argument further, I. is a branch of the General Staff and is inclined to devote more attention to what may be termed General Staff Intelligence than to any other branch of the subject. In practice, schemes for operations are brought down to hard bed-rock facts, sometimes, it is feared, from realms of fantasy in the clouds, but more frequently, it is believed, from similar realms on the map, by the stern and practical requirements and limitations of Q. and E. Intelligence is therefore equally important for Q. and E. as for G.

It would be interesting to know what the average business man would think of the following examples:—

1.—During a certain campaign a Brigade of Cavalry accompanied by a Field Troop of Engineers arrived at a damp spot in the sand which was described by I. as "water plentiful."

2.—A certain army was sitting outside and in sight of a certain city for some eight months. I. had issued information as to two wells in the city and in spite of pressure could produce no more information. Nearly at the last moment before operations it was discovered by accident that an enemy officer deserter, lately the borough surveyor of, or who was intimately acquainted with, the city, was at the immediate disposal of I. This officer was hurriedly invited to a Corps Engineer office where he gave every possible information as to all the wells in the city, numbering 20 or 30, which information was eventually found to be correct.

3.—In a certain campaign maps were issued by I. showing certain roads behind the enemy positions in broad red lines, indicating first-class metalled and bridged roads. High authority ordered, presumably acting on this information, and on arrival in the area, the maintenance of 200 miles of such roads to be carried out by local labour and transport, as neither troops, labour corps or military transport were available. On examination of the situation it was found that:—

(*a*).—50 or 60 miles of these roads did not, in a military sense, exist at all;

(*b*).—100 miles consisted of a few inches of metal without foundation;

(*c*).—While the bridges were fair, the culverts were, in nearly all cases, of weak construction.

(*d*).—The population, of whom 50 per cent. had previously died of starvation, were, except for the profiteer class, fit only for famine relief and soup kitchens;

(*e*).—The enemy had commandeered nearly all carts and horses.

While this sort of thing obtains the position is well-nigh hopeless, the military engineer is forced to bear a cross which could, with ease, be lightened, and operations run the risk of serious breakdown.

The ordinary members of I. cannot help themselves or us, they do their best and are always anxious to help, but, not being Engineers, they are simply incapable of producing Engineer Intelligence.

BOMB-PROOF BREASTWORKS AND PILL-BOXES.

THE following quotations from Mr. Neville Lytton's *The Press and the General Staff* may be of interest to the Corps.

(1) "In the Lys sector most of the trenches were of the breastwork order and such trenches offer little protection from a heavy bombardment unless they are heavily cemented, but we were never the equal of the Germans in ferro-concrete fortifications."

(2) "The pill-boxes were small fortresses garrisoned by about a dozen men; they were completely *bomb*-proof, and from them the machine gunners could fire in every direction."

J.E.E.

PROFESSIONAL NOTE.

THE TRAINING OF THE R.E. DISMOUNTED RECRUIT.

COMMUNICATED BY THE COMMANDANT S.M.E.)

THE following notes on the training of the recruit sapper at Chatham may be of interest.

During the last 18 months recruiting for the Royal Engineers has increased in a very marked manner. This has been due to several causes; firstly, to a systematic "campaign" set on foot by the War Office to stimulate recruiting for the Corps by establishing special recruiting Officers and N.C.O. Recruiters at various industrial and other centres; secondly, by an expansion and revision of the instructions to recruiters all over the Kingdom so as to make much more clear to them the class of qualification required and the standard of proficiency that is likely to lead to acceptance for the R.E.; but most of all by the decision to recruit a much larger proportion than formerly of semi-skilled or unskilled men, *i.e.*, men of the "pioneer" standard.

This last decision has arisen out of the adoption of the principle that the Divisional Engineers of our Field Armies shall in future include in their organization the Divisional Pioneers which in the European War were formed as separate battalions. This entails a greater strength in Engineers in the Division but allows of a considerable proportion of them being of the "pioneer" standard of trade skill. In connection with this change an interesting circumstance is worthy of note. Under the pre-war Pay Warrant "Pioneer" was a *rank*. As long as this condition existed it was found that recruits who when tested in their trade were found not to come up to the standard for the lowest rate of engineer pay, would almost invariably decline to enlist in the rank of "Pioneer." Under the new Pay Warrant "Pioneer" is no longer a *rank*, but it is included as one of the trades in Group E of the list of trades. All recruits can therefore be enlisted in the rank of "Sapper," and when a man fails to fulfil the test for the lowest classification in one of the skilled trades (Groups A—D) he may be *rated* as a Pioneer (Group E). The difference in pay between a Sapper rated as a Pioneer (Group E) and a Sapper rated as a tradesman (Groups A—D) is exactly as it was before, nevertheless directly the change above described was made it was found that nearly every recruit who failed to qualify as a tradesman (Groups A—D) willingly agreed to enlist as a Sapper rated as a Pioneer (Group E) and a steady stream of recruits of this type began to come in and has continued to do so. It would appear that the rank of "Pioneer" carried some inferiority of status, or some idea of less prospects of promotion or of acquiring trade skill. At all events the mere change of name has effected a marked difference and indicates the advisability of carefully studying the psychology of the recruit and the young soldier when framing conditions for enlistment.

The result of the increased flow of recruiting was that the strength of the Training Battalion, R.E., went up beyond any peace time precedent and now amounts to over 1,800 of all ranks, of whom about 1,300 are recruits under training, and looks like remaining at about that figure.

This large number has necessitated an overflow from Brompton into a hutted camp on the Great Lines where about 700 are now accommodated. The unfortunate destruction by fire a few years ago of the barracks in the old North Square has raised the question of provision of additional permanent accommodation, since the hutted camp cannot have many years of life before it. It will not be possible, however, to get any decision on this subject until it is decided whether Chatham Barracks is to continue to be the location of an Infantry battalion or not.

The lessons acquired during the War have naturally led to considerable changes in the course of training of the recruits and in the organization of the methods of training. Outside the Corps itself there is often found a belief that the training of the recruit sapper at Chatham consists largely of teaching him his technical trade skill, and senior officers, even of the Staff, have sometimes expressed surprise on learning that skill as an artificer can only be acquired by several years' apprenticeship, and that we aim at getting men who are already skilled at their trade, employing the short time we have them in training them as soldiers.

As a matter of fact, however, an attempt is now made on a small scale to improve the trade skill of some of those who on enlistment fall a little short of the standard. Recruits who, when tested, are not up to the qualification standard, but are believed to be capable, after six months training in the S.M.E. Workshops, of attaining to it, are rated as "Pioneer" (Carpenter) or "Pioneer" (Fitter), etc., and classified as "Fair." At the conclusion of their full recruits' training, application is made, if the accommodation in the shops permit, to the Colonel-in-Charge Records, in the case of such men, to allow them to be retained at the S.M.E. for a six months' course of trade training at the S.M.E. Workshops. Unless urgent demands for drafts prevent it this is done, and in the great majority of cases they improve in skill sufficiently to qualify.

Nevertheless, the number of skilled tradesmen obtained by direct recruitment from civil sources is still far from adequate to the requirements of the Corps, and with the high wages obtainable by artisans it is difficult to see how it will ever be otherwise. It is probable that the only really satisfactory remedy will be to enlist as many as possible of our skilled tradesmen as boys at fourteen or fifteen years of age and train them ourselves in the same way as the Navy have for many years done for their seamen, and in particular for their Engine-room artificers. A small beginning in this direction has already been made. Some 432 boys are at present under trade training in the Corps, and of these about 134 are under training at Chatham, in addition to 84 buglers, 136 at the Electric Light School, Gosport, and the small remainder at other stations.

This number is quite inadequate, but cannot be increased on account of want of accommodation and of training facilities. A scheme for establishing a Boys' Trade Training Centre for 600 boys in the hutments near Darland Fort has been worked out, and is under consideration at the War Office. The question is bound up with the larger one of training boys as tradesmen for the whole army and cannot immediately be decided. There can be no doubt that such an establishment, attracting as it assuredly would a good class of boy with a good standard of education, and assuming a good system of training not only in handicrafts, but also in general education and of physique, would go some way towards supplying the Corps with tradesmen and with good material for our future N.C.O.'s.

The stay of the sapper at Chatham whilst undergoing his recruit training is some 36½ weeks, of which from three to four weeks are spent on the necessary preliminaries, before a platoon can be formed up and actually launched on the barrack-square; later on, if the time can be spared, it is proposed to add two weeks' instruction in heavy bridging, which will bring the total course to 38½ weeks.

R.E. Recruits are trained in the following subjects:—

Drill,	Swimming,
Musketry,	Field-works,
Gas,	Bombing.

Drill Course.—The drill course includes physical training, semaphore signalling, bayonet fighting, preliminary musketry, section, platoon, and company drill, rifle exercises, extended order, guards and guard mounting, the company and platoon in attack and defence, protection while on the move, in the advance and during withdrawal, and march discipline.

Musketry Course.—The musketry course includes preliminary training, visual training, miniature, classification and field practices, as laid down in Musketry Regulations for R.E., and elementary Lewis gun training. It may be noted that under the latest orders the Musketry Courses both for recruits and trained men of the R.E. are identical with those of the Infantry.

Gas Course.—The gas course includes inspection and disinfection, complete protection from the "Alert" and "Normal Slung" positions, gas zones, gas shell training, clearing trenches, methods of entering and leaving dug-outs, and standard tests.

Field-works Course.—The field-works course is divided into two parts, and includes training in earthworks, all kinds of bridging, obstacles, use of spars,, knotting, lashing, and field geometry, camouflage, light railways, slab roads, shelters and dug-outs, concrete work, demolitions, rowing and pontooning, and demonstrations. Further details of the field-works training are given later.

Bombing Course.—The bombing course includes lectures on the construction and use of all kinds of bombs, hand and rifle grenades, practice in throwing bombs and firing rifle grenades, practice with live bombs and rifle grenades, and practical instruction in trench fighting, both with bomb and bayonet.

A portion of the training in each subject is carried out at night under service conditions, or during the day with use of goggles. The *sequence* of instruction throughout, is lecture, demonstration, practical instruction, test.

During the field-works course Saturdays are devoted to recapitulation in drill and other military training which have already been learnt.

The time allotted to the various subjects is at present approximately as follows :—

Formation, including trial of trade, inoculation, vaccination, clothing, etc.	3 to 4 weeks.
Drill	9 weeks.
Gas	½ week.
Musketry	3 weeks.
Bombing	½ week.
Field-works, Part I	7 weeks.
Field-works, Part II	11 weeks.
Furlough (during courses)	1½ weeks.
	36½ weeks.

The recruit on joining is taken to the Registration Office where his particulars are recorded and thence on to the Company receiving recruits where he is interviewed by the O.C. Company, and issued with a clean shirt, a pair of socks, towel, knife, fork, and spoon, shaving-brush, razor, toothbrush, and a canvas suit ; he is given a bath and a hair-cut, draws his bedding and is shown his barrack-room and bed. From this point he is, dependent on N.C.O.'s being available, put under the Section Commander who will put him through his drills. After medical inspection he is tested at his trade, which takes about two days, if successful he is finally approved and given his number. He is then issued with a full kit and necessaries and his clothing fitted by the master tailor. The Company Commander then arranges for vaccination, inoculation, and the employment of the recruit either at his trade or at drill or fatigues as may be required until the platoon is formed up. While waiting to be formed up every effort is made to instil the recruit with military spirit, to make him feel that although not in uniform he is nevertheless a soldier, and to teach him to take his place in the military organization of the battalion.

The first step after the formation of the platoon is the clothing inspection, after which the recruit is shown the R.E. Museum and the Headquarters Mess and gets his first inkling of the past deeds of the Corps illustrated by medals and relics, pictures and portraits.

The fundamental principle of all instruction imparted to recruits is the employment in regular sequence of the four methods, viz. :—lecture, demonstration, repetition or practice, test; whilst keenness and the spirit of emulation are aroused by competition.

A complete record of the recruit's performance at drill, gas, musketry, bombing, field-works, is kept for every man and on the qualifications obtained in each subject is based the final classification of each sapper.

Competitions, with prizes, are held in bayonet fighting, swimming, musketry, and field-works, whilst competitions to determine the champion sections in each platoon are held periodically at drill, pontooning, barrel piering, wiring, etc., etc. Finally an extended series of competitions at drill, field-works, barrack-room discipline, musketry, also sports and games such as football, cricket, boxing, athletic sports, tug-of-war, etc., are held during the quarter to determine the champion company for the ensuing quarter. The champion company, platoon, or section is accorded privileges such as the right of the line on parade, special leave, etc.

The effect of all this is to produce a very high standard of keenness and it has been found that no matter what the standard of knowledge arrived at the recruit is always keen to learn.

On finally completing their courses the recruits are classified as 1st, 2nd, or 3rd class Sappers and the qualification is entered in A.B. 64. To secure a 1st class qualification a man must be keen, intelligent, well educated, of good character, and have obtained 80% of marks in the oral examination.

Education.—All recruits are required to attend school until they have obtained a 3rd class certificate, and after obtaining this they are encouraged to attend voluntarily with a view to obtaining a 2nd and 1st class.

Games.—Although a recruit only stays at Chatham some eight to nine months it is found that men soon acquire keenness in games, and in these, as in military training, everything is done to foster the platoon spirit. Owing to the fact that platoons are constantly coming and going the competitions are generally on the "knockout" principle, but league competitions are adopted wherever possible, *e.g.*, in Association football.

There is no doubt that the platoon, party, or squad, for they all mean the same, is the centre round which the recruit's thoughts revolve and is the unit on which he lavishes most of his *esprit de corps* as in the school the small boy's ambition is to play for his house; but afterwards when he is good enough to play for the school he begins to realize and incidentally grafts *esprit de l'école* on to his *esprit de la maison*; so in the Training Battalion, the recruit whilst gradually acquiring *esprit de corps* never loses his *esprit de peloton* and it is the latter, acquired in the right way, which is the foster-parent of the former.

The O.C. of a Recruit Company is necessarily much occupied with administration and it is mainly to the platoon officer that the recruit looks for advice and assistance. The principle which is aimed at and as far as practicable carried out is that the Platoon Commander (an officer), the Platoon Serjeant and the four Section Commanders are in charge of the Platoon from the day of its formation to the day it finally completes its course, and that they are responsible for the whole of its training and for everything connected with its administration, health and comfort, sports and games. In the majority of the subjects the Platoon Commander himself carries out the training under the general supervision and co-ordination of the specialists in each subject, *e.g.*, the Major in charge of Field-works, the Musketry Officer, etc., It is only in the first course of drill on the Square that the instruction is actually given by the staff of Drill Instructors under the Adjutant, but the Platoon Commanders are always present, watching the progress of their commands. Also in general education the preparation for school certificates has still to be carried out by personnel of the Army Educational Corps.

This system requires an officer for every platoon, and with recruiting at its present rate it is not always possible to provide one. To admit of it platoons are formed as strong as possible, *i.e.*, from 60 to 80 recruits, but even then the number of officers available seldom permits of every platoon having one. Where no officer is available a selected warrant or non-commissioned officer is placed in charge of the platoon and exercises the same functions.

It is impossible to over-estimate the enormous advantages which have accrued from the present system, and the necessity for its continuance, which will only be possible if the officers are forthcoming, as it is sincerely hoped they will be. Not only in work but also in games the platoon subalterns work with their men and give up practically all their time to and for their men. The result of this and the effect of this system on the recruit cannot be put into words, but anyone who has charge of training knows that it is the right system;

it is the system which made our armies in France and which will make our armies in the future.

Syllabus.—This is laid down in "Syllabus of Training, R.E. Dismounted Recruits, Military Duties" issued with W.O. Letter 27/Gen.No./7592, and the portions affecting field-works are extracted below. To the syllabus has been added the name of the field-work ground where each portion of the training takes place.

PART IV.—PRELIMINARY FIELD-WORKS.

Subject.	*Lecture.*	*Days.*	*F.W. Ground.*
Use and care of Tools	1	3	Darland.
Brushwood	1	3	
Obstacles	1	5	
Earthworks—Trenches, revetting, revetting frames, trench boards, field level and field geometry, experimental, and filling in ..	6	13	
Knotting and Lashing (distributed by hours) ...		3	Upnor.
Bridging—Barrel piering, trestle and light bridging, pile driving, improvised bridges	4	8	
Camping arrangements and water supply ..	2	2	
Blocks and Tackles	1	2	
Examination		1	Barracks.
	16	40	

PART V.—ADVANCED FIELD-WORKS.

Subject.	*Lecture.*	*Days.*	*F.W. Ground.*
Earthworks — Camouflage, M.G.E.'s, O.P.'s, concrete shelters, dug-outs, mining, defence of localities, siting of trenches	6	17	Darland.
Light Railways, slab roads, and overland tracks	2	4	
Demolitions	3	6	Ravelin and Darland.
Heavy Bridging	2	8	Ravelin.
Pontooning	2	14	Upnor.
Examination		1	Barracks.
	15	50	

The total course is 90 working days which, at five days a week, makes it extend over 18 weeks.

	Hours.		
	Summer.	*Winter.*	*Remarks.*
Monday	0730—1600	0800—1600	Lunch on the work, three quarters of an hour allowed.
Tuesday	0730—1600	0800—1600	
Wednesday	0930—1600	0930—1600	Dinners in barracks at 1630.
Thursday	0730—1600	0800—1600	
Friday	0730—1315	0800—1315	Dinners in barracks at 1330.

Object of Field-work Training.—The object is to continue the recruits' education as a soldier and to cultivate his soldierly spirit as well as to ensure he has a thorough grounding in the subjects named in the syllabus.

Field-work Platoons.—The training is carried out in platoons. Strength of platoons from 60 to 80 recruits. Each platoon is commanded by a subaltern officer who is responsible for its training and is excused as far as practicable all company, regimental, and garrison duties which interfere with the hours of training. To assist the Platoon Commander a Q.M.S. Instructor in Field-works is detailed from the Fortification School. And there are the platoon sergeant and four section commanders. These latter N.C.O.s are available for regimental duties, but every effort is made not to change the section commanders if it can possibly be helped.

Field-works Major.—A Major is borne on the establishment of the Training Battalion to superintend field-work training. He has a whole-time officer assistant who is responsible for the continuity and superintendence of platoons at the Darland Ground; and a part-time officer assistant similarly assists at Upnor and the Ravelin. A senior Q.M.S. Instructor in Field-works, a draughtsman and an N.C.O. i/c Darland Dump complete his staff. He issues orders as regards Field-works direct to Platoon Commanders, keeping Company Commanders informed. He is responsible for keeping instruction up-to-date, for keeping in touch with the Fortification School to prevent clashing with officer and other classes, for keeping track of each individual recruit, in order that he may receive the full instruction, and for general superintendence. He issues orders to Platoon Commanders on Fridays for the following week's work.

Lectures.—These are given by the Platoon Commanders or the Q.M.S. Instructor with the platoon. Platoon Commanders are issued at the commencement of the course with a detailed synopsis of the lectures. No lecture is to be longer than three quarters of an hour. Lectures are given when the men are fresh, immediately after leaving the morning parade and before commencing work.

Note Books.—The men are issued with these and it is left to the discretion of the Platoon Commander as to what use he makes of them. The men are not marked on these note-books but on the results of the oral examinations held at the end of Parts 4 and 5.

Examination and Classification.—At the end of Parts 4 and 5 each recruit in a platoon is examined orally by a Board of Officers and is marked. In addition a report is obtained from the Platoon Commander as to a man's keenness, smartness, ability to work, and on the combined result of this and the oral examination each man is classified as *Excellent, Very Good, Good, Fair*, or *Indifferent*, and this classification is entered up on the Platoon Classification Sheet. Indifferent men are put back for further instruction.

Sequence of Training.—This usually follows the order given in the syllabus. An occasional variation is sometimes required to fit in with other training, but to keep to the same sequence greatly expedites dealing with casuals.

Casuals.—These unfortunately occur owing to sickness, put-backs, punishments, etc., and they are placed in a new platoon according to the progress they had made before becoming casuals.

Dress.—Drill order in canvas with canteens.

Night Work.—Dark goggles are used to produce the effect of night and the training is carried out during the usual hours. Wiring, digging, revetting, and pontooning are practised in goggles.

Box Respirators.—These are carried on Fridays, and the platoons wear them for periods varying from 10 minutes up to two hours according to the stage of training. The normal work is carried on while wearing them.

Use of Tools.—Great attention is paid to the proper use of the pick and shovel. A drill has been devised and the men are taught by numbers as they are taught the rifle exercises. Practice in this drill is given for short periods throughout the course. Task work is also given at intervals in order that the men may realize their progress.

Darland Field-works Ground.—A trench system has been developed with its trenches, shelters, mined dug-outs, machine gun emplacements, observation posts, etc., etc. This gives an opportunity for every section of every platoon to construct all types of revetment, to see other work that they may not be able to do and gives them the feeling that they are constructing, not merely doing something which will be pulled down. The necessary materials are obtained from a dump near the site of work.

Competitions.—In the platoon section competitions are arranged in wiring, barrel-piering, pontooning, and rowing, and at the end of the course all the men of the best section are presented with prizes by the Commanding Officer. Times are kept in the competitions and in that way platoons can be compared with one another.

Best man in Platoon.—At the end of the course the eight best men of the platoon chosen as the results of examinations and platoon commander's report are presented with prizes by the Commanding Officer, and the best man receives the Haynes Memorial Medal.

General.—The utmost is done to make the training real and interesting to all concerned. The Platoon Commander is really responsible for the training of his platoon and is not taken away on petty side issues. If he makes his platoon better than others he scores marks towards the Champion Company of the Battalion. The Section Commander is with his section and has an incentive to make it the best section in the platoon. The best section is allowed a number of privileges. The individual man has his section to work for and also the individual prizes. The result is that each recruit gets good training in field-works and also becomes a good soldier with great pride in his Corps, Battalion, Company, and particularly his Platoon.

REVIEW.

TREATISE ON AIR SCREWS.

By WHYRILL E. PARK, A.R.C.Sc. (Chapman & Hall. 1920. 21/-).

This very technical and exhaustive treatise deals with the mathematical principles involved in the design of aircraft propellers. The principal problems investigated are :—(*a*) The thrust developed by a propeller ; (*b*) The stresses produced in the same under given data. It is scarcely necessary to say that such problems are highly difficult and complex. The work is a mine of information in the field which it professes to cover.

J. M. WADE, *Lieut.-Colonel.*

NOTICES OF MAGAZINES.

MILITÄR WOCHENBLATT.

No. 47.—*Summary of the Military and Political Situation.*—The difficulties of France in raising her Army are appreciated. The *M.W.B.* does not think her yearly recruit class will amount to more than 200,000 men, which, with 18 months' service, only gives a peace strength of 300,000. The remaining 460,000 have to be made up of volunteers, re-engagements, and, above all, coloured troops. But, as the *M.W.B.* bitterly remarks, the utter defencelessness of Germany makes it a matter almost of indifference to her, what the figures may be. While France is budgeting for 33 milliard paper marks, Germany can keep all the army she is allowed to for three milliard. Poland's action over Silesia is, of course, remarked and Mr. Lloyd George's speech does not give much comfort, because, says the writer, he has so often led simple Germany into a trap. In S.E. Europe French influence is said to be on the up-grade. Belgium's army, temporarily fixed at 100,000 men, exclusive of officers and colonial troops, is said to be too small and too little trained for French ideas ; since Belgium must be relied on to stand side by side with France, when action against Germany is contemplated. The acceptance by Germany of the Allied Ultimatum has left the writer in a very pessimistic mood. Above all he is disappointed in Mr. Lloyd George, and asks if anyone will now doubt that Albion is perfidious.

The Mission of Lieut.-Colonel Hentsch and the coup-de-main at Liége in 1914.—Lieut.-General Schwarte contributes some interesting remarks on these two subjects. As regards Lieut.-Colonel Hentsch, he says that the conference, which concluded with his despatch, was attended by von Moltke, Colonel Tappen, Lieut.-Colonel Hentsch and Colonel (now General) von Dommes. The latter declares that von Moltke, fearing that the commanders of the 1st and 2nd Armies did not, on September 8th, 1914, properly appreciate the situation, and in consequence were inclined to retreat instead of holding on, decided to despatch Hentsch, and gave him the following verbal orders :—" Go to the headquarters of 1st and 2nd Armies and stop them beginning any withdrawal (*und verhindern Sie dass dort rückgängige Bewegungen angetreten werden*). If you do not arrive in time and a withdrawal has already begun, direct the inner flanks of the Armies on Fismes." General von Dommes regrets that he did not at the time write down the words used, but declares that he has so often recalled them that it is out of the question that he can be mistaken. The conference, which was very short, took place in the forenoon of September 8th, 1914, in the Schoolhouse at Luxembourg. General von Schwarte says that it is established that when Hentsch reached 2nd Army headquarters no withdrawal had begun. General von Bülow's report shows that he explained the situation to Hentsch and announced his intention to retire, which Hentsch agreed with. The latter does not appear to have fulfilled his instructions to prevent any withdrawal being commenced, for von Bülow would certainly have mentioned such a thing in his report. Whether Hentsch would have succeeded in making von Bülow change his mind cannot be stated, but von Schwarte considers it clear that Hentsch did not fulfil the first part of his orders, and consequently must bear a great part of the responsibility. He allowed himself, already pessimistically inclined as he was, to be influenced by the still more pessimistic atmosphere of 2nd Army Headquarters, and then, when he got to 1st Army Headquarters had to announce that the 2nd Army was withdrawing.

As to Liége, he says that it is incorrect to attribute the project of the *coup-de-main* to Ludendorff. It was von Moltke who was responsible for the idea, for he in 1906 decided that, in accordance with the Schlieffen plan, Liége must be quickly captured, if Dutch neutrality were to be respected. The plans were accordingly all worked out in the greatest detail years before Ludendorff went to the Operations Branch of the General Staff. It only remained for him to keep them up-to-date, and see that the necessary troops were told off. The commanders of the six assault columns were naturally not so well aware of the vital importance of their task as was Ludendorff, who had for years worked on keeping the plans up to date. Therefore, when the commander of the 14th Infantry Brigade was killed, Ludendorff being at Montjoie with the Headquarters of the 2nd Army, was able to appreciate the critical nature of the situation. Acting with the utmost energy, he took command of the Brigade and personally led it to victory. The cause of the failure of the other five columns told off for the assault is, so far, not known. To Ludendorff is due the credit for the actual capture of Liége, but not for the plan.

Comparison between the present German and Austrian Establishments of Officers.—The establishments have been fixed as follows:—

	Germany.	Austria.
Generals and Lieut.-Generals	17	11
Major-Generals	28	25
Colonels	110	134
Lieut.-Colonels...	200	321
Majors	400	249
Captains and Subalterns ...	3245	670
	4000	1500

No. 48.—*Attack on German Corps of Officers.*—The paper *Freiheit* has attacked the pre-war Prussian officer in the following terms:—"The Prussian officers before the war constituted the scum of the

nation. They were stupid, brutal and quite unmoral. Their conception of honour and duty placed them below the level of dogs. Their sole idea of ethics was summed up in standing strictly to attention before their superiors, and they had made no progress since the middle ages. The 2,500 milliards that the Entente has charged Germany for ridding her of this pest is not too high a price . . ." and so on. The *M.W.B.* points out that the losses sustained by the Officers' Corps form in themselves sufficient refutation of these calumnies. 40 per cent. of the officers who were on the active list in 1914 were killed and 24.6 per cent. of all officers on the active list between the outbreak of war and 1st January, 1919. On the other hand only 15.4 per cent. of the other ranks fell during the same period. The *M.W.B.* regrets that previous experience has shown that legal action by the Officers' Association against such libels is almost certain to be useless.

No. 49.—*South Eastern Europe.*—The writer says that in spite of the policy of the "Little Entente" having been originally directed against France, the predominant influence in S.E. Europe is French.

Checko Slovakia.—The organization of the army is not yet complete but its peace strength is placed at 180,000 men. The Chief of Staff is French and many important positions are filled by French officers, which, when taken with the distribution of the Army, indicates that offence and not defence is contemplated. The greatest number that can be mobilized is 1,750,000 men, forming 12 active and 24 reserve divisions. The army has not been placed beyond the reach of politics. Of the returned legionaries no less than 18,500 have been incorporated in the peace army.

Jugo Slavia is preparing a new defence law which will cover all men between 21 and 50. She has at present 190,000 under arms, *i.e.*, five yearly classes. Discipline in the Croatian and Slovene contingents is not so good as in the Serbian. The disposition of the Army shows that it is directed against Albania, Greece and Bulgaria.

Greece has fully half her army in Asia Minor, driven thereto by England.

Bulgaria has an army of 20,000 with 60 guns and a gendarmerie of 13,000 mostly mounted, and organized on a military basis.

Roumania is still negotiating with Russia, but appears to have come to an arrangement with Poland, in case of an attack by Russia. The deplorable railway situation would render any mobilization or troop movements very difficult. Out of the 23 Infantry Divisions eight are on the Dniester and in Moldavia; six are in the Dobrudja and in Wallachia, the remainder in the Siebenburg mountains.

Hungary.—Thanks to Karl's unlucky coup, the Hapsburg hopes have been dashed, and with them the hopes of a Danubian alliance. These were backed, unofficially but in influential circles, by France in order to erect a barrier against German expansion to the south east. The common danger from the Bolsheviks has driven Hungary and Poland together, for the time. Politically and economically France has a strong position and works against Germany whenever she can. The reduction of the Army from 130,000 men to the permitted 35,000 is in hand.

Austria is in every way the weakest State, and will almost cease to exist when France has done with her. Thanks to the absurd Soldiers' Council *régime*, the Army is more of a danger to the State than a support.

The Demolition of the Wireless Station at Kamina in Togoland in August, 1914.—The Kamina station was only completed a short time before the outbreak of war, and though only a few messages came through it for Togoland itself, it proved invaluable as a transmitting station. A message from the German Admiralty to a cruiser arrived *via* Nauen, Kamina and Windhoek in German South West Africa, in 10 hours. As soon as the outbreak of war was known in Kamina on 2nd August, all German Colonial Governors, merchant and warships within range were notified; the cruisers *Königsberg* and *Eber* being thus warned. In the early days of August, no one thought that hostilities would be extended to Africa, and in any case a successful defence of the wireless station was out of the question. Soon, however, it was seen that it would have to be demolished and after it had dealt with a mass of telegrams coming from South America *via* Duala for Germany, it was destroyed on the 25th August, shortly before the approach of the enemy.

England's Great War Crime.—Before the war Germany was the best-fed country in Europe, but the blockade changed all that. German losses in the field amounted to 1,822,545 of all ranks killed and died of wounds and disease. Her losses through the blockade were far heavier. Her pre-war scale of living allowed a daily average of 2,400 calories per head, but by April, 1917, this had been reduced to 1090. Lack of fats caused great increase of all illnesses, and 30 years' work against tuberculosis was undone. In so far as the damage due to the blockade can be put into terms of money, it is estimated to amount to 56 milliards of marks.

No. 50.—Major-General Waechter gives a long review of Colonel Bruchmüller's book on artillery in attack. The gradual development of the creeping barrage is traced and the difficulties met with in organization are dealt with. Much of the failure of the Rheims, 1918, attack is put down to over-centralization of artillery command, whereby the divisional commander had nothing left in his hands.

L. Chenevix-Trench, *Major, R.E.*

REVUE MILITAIRE SUISSE.

No. 2.—*February*, 1921.

A Scheme for the Reorganization of the Swiss Army.—In the original article Colonel Sarasin gives an outline of the army reorganization scheme prepared by the Swiss General Staff and approved by the Commission for National Defence. The scheme aims at increasing the machine gun armament of infantry and cavalry regiments and in bringing the artillery armament into line with modern requirements, *e.g.*, the present field guns are to be replaced by guns having a range of at least 10 km., and firing a shell of at least 10 kilos. in weight; by providing mobile trench mortars; and by increasing the number of howitzer batteries. The training period for recruits and "young officers" is raised to 85 days. On the completion of this course 25 per cent. of the young soldiers—chosen from among those who are required in the civil branches of the public service, and those who show small aptitude for the military profession—are to be permanently transferred to the Reserve; they will only be called up for further military duty in a national emergency. The remaining 75 per cent. of the young soldiers will, under the proposed scheme, be posted to the Élite, and will be called upon to go through five annual trainings, each of a duration of 20 days. On reaching the age of 28 years, the trained soldiers will be transferred permanently into the landwehr.

A New Book on Marshal Foch.—The original article is a review by Colonel Fonjallaz of a book entitled *Foch: Essai de psychologie militaire*, by J. R. (Payot, Paris, 1921, at 6 francs). The view is expressed that, in his conduct of the latter part of the Great War, Foch showed that he possessed a genius in which were combined the striking features of the genius of those two great Captains: Napoleon and Moltke.

NOTES AND NEWS.—*Switzerland.*—The demand of the Socialist Party for the abolition of the military code and trials by court martial in Switzerland has been rejected by a large majority of votes. It is announced that the Federal Council proposes to recommend a modification of Article 77 of the Law relating to the organization of the army. This Article provides that the cavalryman shall have reimbursed to him one half of the price paid by him for his horse; it is hoped by this means to effect a saving of half a million francs on the Army votes.

France.—A Special Correspondent deals with a book entitled *Réflexions sur l'art de la guerre* which is attracting a considerable amount of attention. Owing to the Ministerial decree forbidding officers of the French Army to publish their writings, the author of this work has had to hide his identity under the symbol XY; he is a distinguished general who held a very important appointment on General Pétain's Staff during the War.

Portugal.—A Special Correspondent furnishes a few details relating to the new organization recently introduced into the Portuguese Army. The annual levies of recruits will join the infantry in two contingents, namely in January and May of each year; in the case of the other arms of the service the recruits will join their depôts once in the year only. The period of training for recruits will vary according to the requirements of each branch of the service. Military service will be on a Militia basis; on the completion of the recruits' course, the permanent cadres will alone be retained with the units whilst the majority of the young soldiers will return to their normal occupations. The men in the ranks will subsequently undergo seven annual trainings of from 15 to 20 days—in camps to be formed in September of each year. The men required for the permanent cadres of units will be retained for service with the colours for periods of from 18 to 24 months after the completion of their recruit's course. The retention of trained soldiers in the permanent cadres, it would seem, is held to be necessary as a precautionary measure to meet the contingency of Bolshevist disorders. In an editorial note it is pointed out that the mobilization of an army is a most efficient method of coping with a Bolshevist rising; the adoption of such a course enabled the Portuguese Government to suppress such a rising within three days of its outbreak, and without the loss of a single life from acts of violence.

W. A. J. O'MEARA.