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# NOTES ON EXPERIMENTAL APPARATUS FOR SETTING OUT MODELS OF TRENCHES.

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THE object of this Experimental Apparatus was to provide a quick and inexpensive means for carrying out the following :—

(*a*). To set out a model of an existing trench system to any given scale.

(*b*). To set out a model of proposed new work.

(*c*). To set out practice trenches for Infantry practice attacks.

(*d*). To set out on the ground a defence line in a rear position. (The use of the apparatus for this purpose is subject to restrictions depending on the nature of the ground.)

The above are referred to in various official pamphlets and the proposal of supplying the Infantry with a model of the trenches they are to occupy is admitted to be the quickest and surest method of supplying them with the necessary information.

The method involves making one lineal measurement only. The relative positions of all points being determined by setting out angles direct from the map. In cases of extreme urgency, when a definite map does not exist, an aeroplane photograph can be used provided the distance apart of any two recognizable points on the photograph is known. When using an aeroplane photograph the resultant model, would not of course, be so accurate as when a proper map is used.

The method depends on the similarity of triangles. Great accuracy is not required, but a very fair degree of accuracy can be obtained. For example :—With fairly rough apparatus a model was constructed on the ground which was correct to within 1 per cent. The whole idea is to produce a model as quickly as possible.

Five men are required and if trained the whole operation resolves itself into a series of very simple operations which are rapidly carried out.

The apparatus consists of :—

(1). Two tables, A and B (see sketches) mounted on tripods and provided with sight arms.

(2). Two pairs of sighting rods, CE and DF.

(3). Two Field Telephones and electric cable. (Only required when the base exceeds 100 yards.)

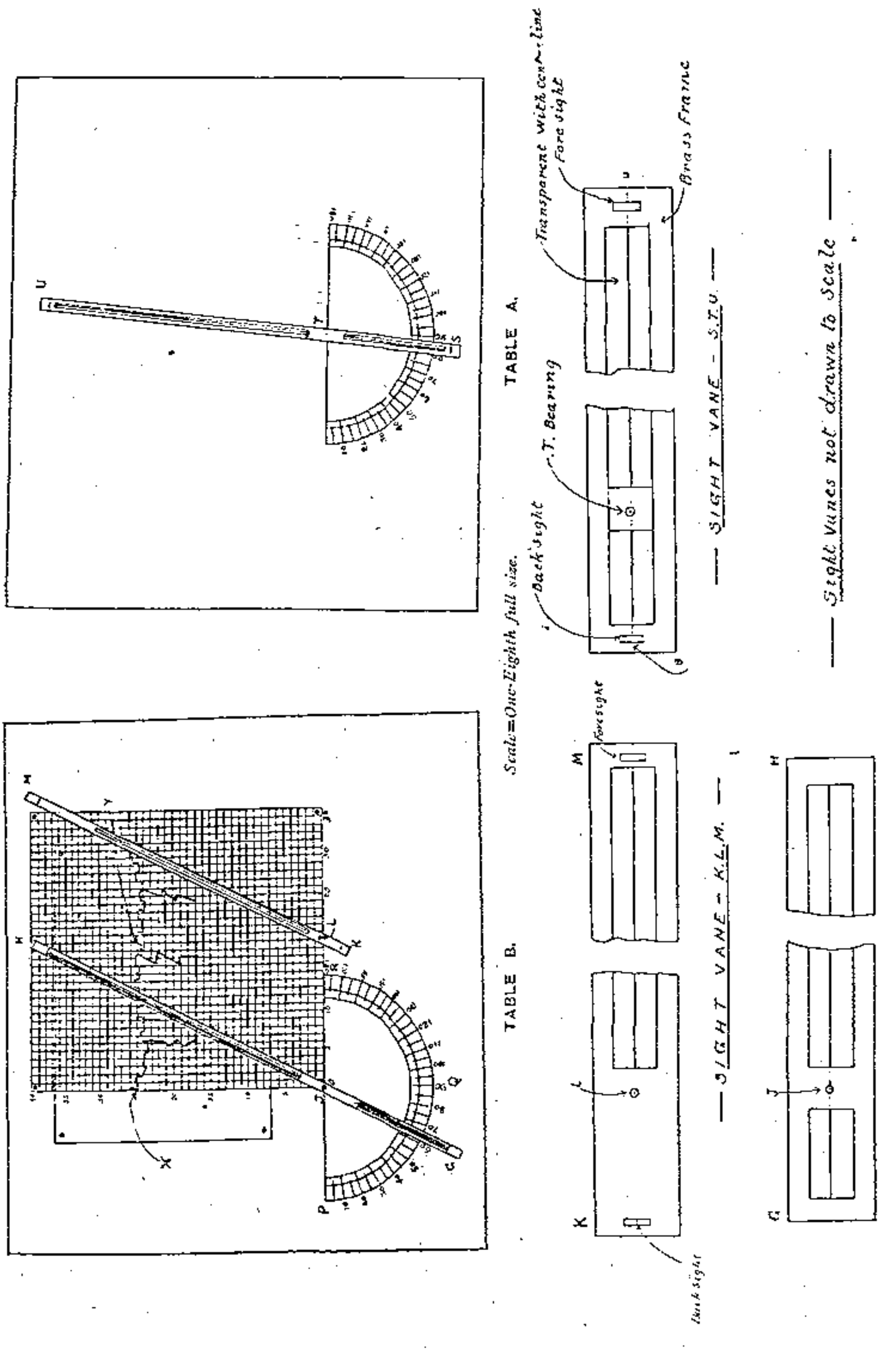
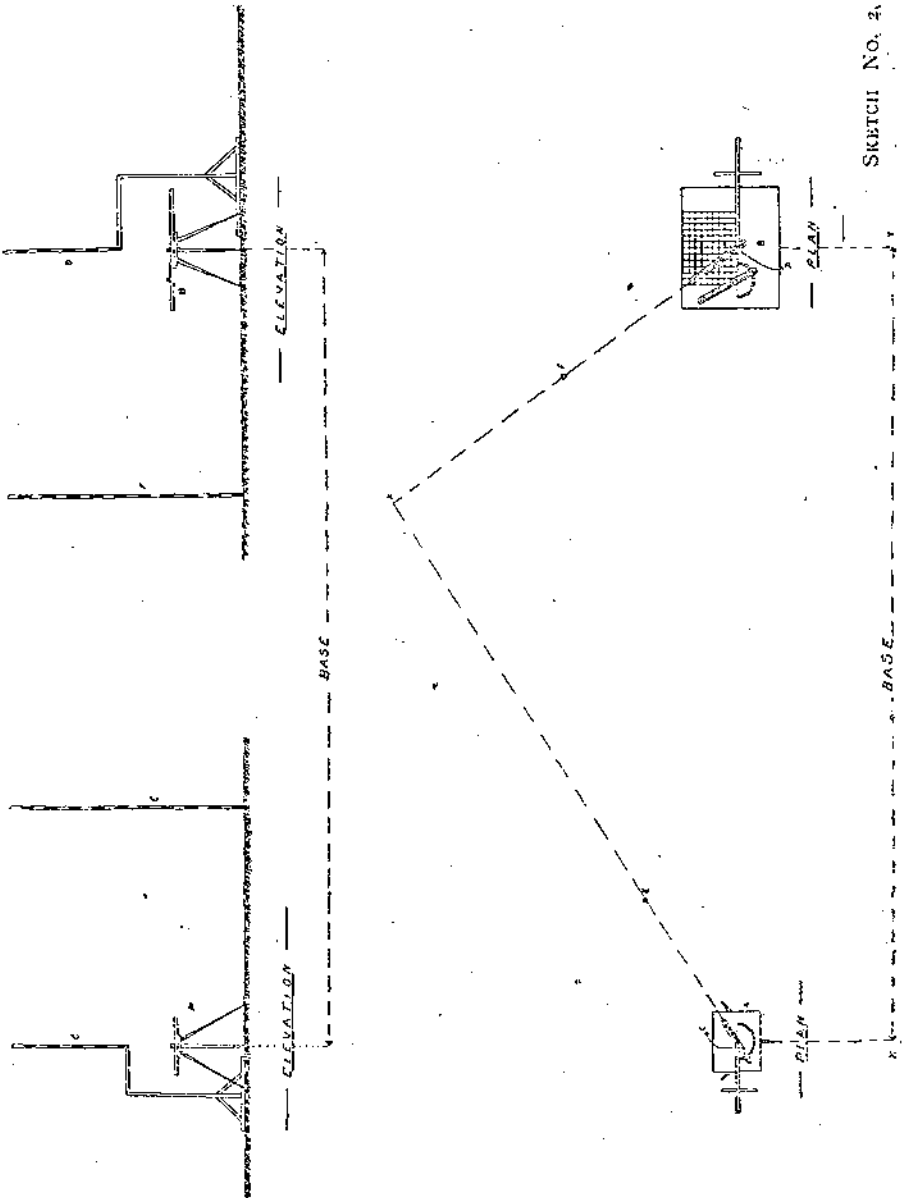


TABLE A.
TABLE B.
Scale=One-Eighth full size.
Transparent with centre line
Fore sight
Brass Frame
T. Bearing
Back sight
— SIGHT VANE - S.T.U. —
— SIGHT VANE - K.L.M. —
— SIGHT VANE - G.J.H. —
— Sight Vanes not drawn to Scale —

SKETCH No. 1.




SKETCH No. 2.

*Method of Use.*—Assume that the apparatus is required for "*a*" referred to above.

A map is provided and a tracing made of the part under consideration. The table B has on it a number of horizontal and vertical lines marked 0—40 (or other convenient number), and a degree scale as shown. The map of the trench system is pinned to the table (as indicated), in such a way that a point X is on the vertical line marked O and a point Y is on the horizontal line through X. The points X and Y are a known distance apart on the ground. Assume this to be 400 yards. GJH is a degree arm, pivotted at J and arranged so that the angle subtended by any point on the map to the base JL is read directly on the degree scale PQR. KLM is a sight arm, but no degree scale is provided and the pivot L is adjustable and its position is adjusted until JL is equal to XY on the map. The table A is provided with a sight arm STU and degree scale so that the position of GJH can be reproduced on A. Now assume that a model is to be set out representing the trenches between X, Y, to a scale of 1/10. The procedure is as follows:—Table B is set up on the ground with a sighting rod D, the latter being vertically above the pivot L (see sketch 2). Table A is set up 40 yards from B, with sighting rod C vertically above the point T. Tables A and B are lined up by means of the sight arms. A and B are connected by telephone if over a hundred yards apart. The apparatus is now in position ready to set out the model.

To fix the point X on the ground:—

Two operators work at A and B respectively. The man at B takes control. He sets GJH over X on the map and reads the angle on degree scale, which he telephones to A who sets STU to the same angle. GJH is then moved to the left and KLM is set over X. Two other men take the sighting rods and place them about 20 yards from A and B in line with the sights on STU and KLM. The operators at A and B shout orders to the men at E and F until the correct positions are obtained. A fifth man at X (on the ground) adjusts his own position until he is in line with CE and FD. He then puts a picket in the ground thus marking the position of X. A similar method is adopted for all other points and the result will be a model to the scale of 1/10th. In practice it is found convenient to number all important points on the map and to read off all the angles for the operator at A before commencing to set out. The operator at A then has a list of points and corresponding angles. A and B set their sight vanes for point No. 1, and the fifth man signals when he has marked the position. A and B immediately re-set for No. 2 point and the fifth man marks the position, and so on until all points have been marked on the ground.

The rule for determining the length of base, *i.e.*, the distance apart of the two tripods A and B is :—

Length of base in yards $=$ Distance on ground between X and Y $\times \frac{1}{N}$

where $\frac{1}{N}$ = the scale of the model required.

*Setting out Contours.*—The method of setting out contours is obvious. A number of points are taken on each contour and these are then set out on the ground, the pickets used being of such a size as to correspond to the particular contour concerned. That is :—Contour marked 30 ft. can be represented by 3-ft. pickets. The tops of all pickets on one contour are joined by a string. The same is done with other contour lines and earth placed on the ground up to the strings.

*General.*—It is suggested that squads of one N.C.O. and five men, with an Officer in charge of several squads, could move quickly from place to place and in a very few hours tape out models near the troops concerned. Such squads to be attached to Field Survey Cos. and not to form a new unit.

*Results of Practical Experiments.*—(1). The apparatus used consisted entirely of cardboard models mounted on two barrack tables and was made without the use of any special tools.

(2). At 9 a.m. a model of 570 yards of fire trench (ours and enemy position) was commenced. The resultant model to be 1/10th full size. Before commencing to set out, a tracing had been made of the angles measured for the operator at A.

| | | |
|---|---|---|
| Time taken to place all pickets in position | ... | ½ hour. |
| ,, tape in ... ... ... | ... | 1¼ hours. |

In the above a double line of tape was used to show fire trench, single tape to show communication trench and a double tape with diagonals at about every 6 ft. to represent wire. Contours not shown.

(3). At 12 noon an order was received to construct the above in another field situated about two miles away. The apparatus was shifted, placed in position, and a model produced to the scale of 1/10th by 3.30 p.m.

(4). The party engaged on the above consisted of one officer, one sergeant, and four sappers, exclusive of transport. (Transport was only required because experimental apparatus was mounted on barrack tables and not on tripods).

(5). The above experiment demonstrates the rapid use of the apparatus.

# *DEMOLITIONS UNDER FIRE.*

*By* T.E.L. Lawrence of Arabia.

WE were interested in the Hejaz Railway, and spent nearly two years on it. The Turkish counter-measures were passive. They garrisoned each station (an average of 14 miles apart) with half a company, entrenched, sometimes with guns, and put in between the stations a chain of small entrenched posts, usually about 2,000 yards apart, and sited on small knolls or spurs within 200 yards of the railway, so that each post could see its neighbours and command all the intermediate line. Extra posts were put on one or other bank of any large bridge. The 15 or 20 men in the post had to patrol their section of line after dawn each day, and in the afternoon. There was no night activity on their part.

The Turks arrived at their system of defence after considerable experience of our demolition parties, but we were able, till the end of the war, to descend upon the railway when and where we pleased, and effect the damage we wished, without great difficulty. At the same time our ways and means had constantly to be improved. We began with small parties of ten or fifteen Beduins, and we ended with mobile columns of all arms, including armoured cars; nevertheless I believe that it is impossible for a purely passive defence, such as the Turkish, to prevent a daily interruption of the railway traffic by a decently equipped enemy. Railway defence, to be inviolable, would require a passive force, entrenched with continuous barbed wire fence, and day and night patrol, at a considerable distance from the line, on each side of it; mobile forces, in concentrations not more than 20 miles apart; and liberal air reconnaissance.

The actual methods of demolition we used are perhaps more interesting than our manners of attack. Our explosives were mainly blasting gelatine and guncotton. Of the two we infinitely preferred the former when we could get it. It is rather more powerful in open charges in direct contact, far better for indirect work, has a value of 5 to 1 in super-tamped charges, is quicker to use, and more compact. We used to strip its paper covering, and handle it in sandbags of 50 lbs. weight. These sweated vigorously in the summer heats of Arabia, but did us no harm, beyond the usual headache, from which we never acquired immunity. The impact of a bullet may detonate a sack of it but we found in practice that when running you clasp it to your side, and if it is held on that furthest from the enemy, then the chances are that it will not be hit, except by the bullet that has already inflicted a mortal wound on the bearer. Guncotton is a good explosive, but inferior in the above respects to gelatine, and in addition, we used to receive it packed 16 slabs (of 15 oz. each) in a wooden box of such massive construction that it was nearly impossible to open peacefully. You can break these boxes with an entrenching tool, in about four minutes slashing, but the best thing is to dash the box, by one of its rope or wire beckets against a rock until it splits. The lid of the box is fastened by six screws, but even if there is time to undo all of these, the slabs will not come out, since they are unshakably wedged against the four sides. I have opened boxes by detonating a primer on one corner, but regard this way as unnecessarily noisy wasteful and dangerous for daily use.

*Rail Demolition.*—Guncotton in 15-ounce slabs is convenient for rail cutting. The usual method of putting a fused and detonated and primed slab against the web is quick and easy, but ineffective. The slab cuts a six-in. section out of the lie, leaving two clean fractured surfaces (Hejaz rails are of a mild Maryland or Cockerill steel). The steel chairs and sleepers are strong, and the enemy used to tap the broken rails again into contact with a sledge, and lay in a new piece whenever the combined fractures were important enough. New rails were ten metres long, but the line worked well on unbolted pieces two or three metres long. Two bolts are enough for a fish plate, and on straights the line will serve slow trains for a mile or two without fish plates, owing to the excellence of the chairs. For curves the Turks, after we had exhausted their curved rails, used short straights. These proved efficient even on 120-metre curves. The rate of repair of a gang 100 strong, in simple demolition is about 250 cuts an hour. A demolition gang of 20 would do about 600 cuts an hour.

A better demolition is to lay two successive slabs on the ballast beneath the bottom flange under the joint and fish plate, in contact with the line. This spoils the fish plate and bolts, and shortens each of two rails by a few inches, for the expenditure of two slabs and one fuse. It takes longer to lay than the simple demolition, but also takes longer to repair, since one or other rail is often not cut, but bent, and in that case the repair party has either to cut it, or to press it straight.

The best demolition we discovered was to dig down in the ballast beside a mid-rail sleeper between the tracks, until the inside of the sleeper (iron of course) could be cleared of ballast, and to lay two slabs in the bottom of the hole, under the sleeper, but not in contact with it. The excavated ballast should then be returned and the end of the fuse left visible over the sleeper for the lighting party. The expansion of air raises the middle of the sleeper 18 in. from the ground, humps the two rails 3 in. from the horizontal, draws them 6 in. nearer together, and warps them from the vertical inwards by the twisting pull of the chairs on the bottom outer flange. A trough is also driven a foot or more deep across the formation. This gives two rails destroyed, one sleeper or two, and the grading, for two slabs and one fuse. The repair party has either to throw away the entire track, or cut a metre out of each rail and re-grade. A gang of 100 will mend about 20 pairs an hour, and a gang of 40 will lay 80 an hour. The appearance of a piece of rail treated by this method is most beautiful, for the sleepers rise up in all manner of varied forms, like the early buds of tulips.

Simple demolitions can be lit with a 12-in. fuse. The fish-plate-flange type should be lit with 30-in. fuses, since the fragments of steel spray the whole earth. The "tulips" may be lit with a 10-in. fuse, for they only scatter ballast. If however, the slabs have been allowed to get into contact with the metal of the sleeper they will throw large lumps of it about. With a 10-in. fuse most of these will pass over the head of the lighting man who will be only 15 yards or so away when it goes off. To be further is dangerous. We were provided with Bickford fuse by Ordnance. The shiny black variety causes many accidents, owing to its habits of accelerating or smouldering. The dull black is better, and the white very good. Our instantaneous fuse has an amusing effect if lit at night among friendly tents, since it jumps about and bangs; but it is not good for service conditions. The French instantaneous fuse is reliable. Detonators should always be crimped on to ready-cut fuses, and may be safely carried in the pocket or sandbag, since great violence is required to set them off. We generally used fusees for lighting.

Speaking as a rule rail demolitions are wasteful and ineffective unless the enemy is short of metal or unless they are only made adjuncts to bridge-breaking.

A pleasant demolition, of a hybrid type, is to cut both rails, and turn them over, so as to throw them on their face down the bank. It takes 30 men to start this, but a small gang can then pass up the line, bearing on the overturned part, and the spring of the rails will carry on the reversing process, until you have done miles of it. This is an effective demolition with steel sleepers, since you wreck the ballasting. We tried it once on about 8 miles of a branch line, with a preponderance of spiked wooden sleepers, and it made such a mess of rails and sleepers that the Turks washed their hands of it.

The Hejaz line carried a minimum of traffic, so that there was no special virtue in destroying the points of crossing places.

*Bridge Demolitions.*—The lightness of traffic affected the tactics of bridge demolition also, since a single break was met either by transport or deviation. As with the rails however, the methods we used are perhaps more important than why we did it. Most of the bridges are of dressed limestone masonry, in 80 to 100-pound blocks, set in lime mortar. The average spans were from four to seven metres, and the piers were usually 15 ft. wide and 4 ft. 6 in. thick. It is of course better to shatter a bridge than to blow it sky-high, since you increase your enemy's labours. We found that a charge of 48 pounds of guncotton, laid against the foot of the pier on the ground, untamped, was hardly enough, and that 64 pounds was often a little too much. Our formula was therefore about $\frac{1}{5}BT^2$ for guncotton charges below 100 pounds, untamped. In a pier 15 ft. broad, had the feet been marked off on it, we would have had no explosive between feet 1 and 3 and 12 and 15. The bulk would have been against 4, 5, and 10, 11, with a continuous but weaker band uniting 5 and 10. Dry guncotton is better than wet for such work; gelatine is about 10 per cent. stronger for these open charges. With charges above 100 lbs. $\frac{1}{6}BT^2$ or $\frac{1}{7}BT^2$ is enough. The larger your object the smaller your formula. Under fire, the inside of the bridge is fairly safe, since enemy posts enfilade the line and not the bridge arches. It is however seldom leisurely enough to allow of tamping a pier charge by digging. When it is, a trench a foot deep is all that is possible, and this does not decrease a guncotton charge by more than 10 per cent. Gelatine profits rather more in proportion by simple tamping.

A quick and cheap method of bringing down the ordinary pier or abutment is by inserting small charges in the drainage holes that are usually present. In the Hejaz line these were in the splay of the arch, and a charge of 5 lbs. of gelatine, or 25 of guncotton, in these would wreck the whole line. The depth and small size of the drainage holes tamp the explosive to an extreme degree. Where the bridge was of many spans we used to charge alternate drainage holes on either side. In the ordinary English abutment where the drainage holes are small and frequent, it would be wise to explode several simultaneously by electricity, since the effect is much greater than by independent firing. Necklacing and digging down from the crown or roadbed are methods too clumsy and slow for active service conditions.

In North Syria, where we came to bridges of great blocks of basalt, with cement joints, we had to increase our charges for untamped work to $\frac{1}{4}$ or even $\frac{1}{3}BT^2$.

We found guncotton most convenient to handle when we knotted it up into 30-slab blocks by passing cords through the round holes in the middle of the slabs. These large bricks are quick to lay and easy to carry. An armoured car is very useful in bridge demolition, to hold the explosive and the artist. We found in practice that from 30 to 40 seconds was time enough to lay a pier demolition charge, and that only one man was necessary. We usually used 2-ft. fuses.

Girder bridges are more difficult. In lattice bridges where the tension girder is below the roadway, it is best to cut both compression beams. If the tension girder is overhead, it is better to cut both tensions and one compression. It is impossible to do a bridge of this sort very quickly. We had not many cases, but they took ten minutes or more each. When possible we used to wedge the gelatine in the angles of meeting girders. The only quick way is to lay an enormous single charge on the top of the abutment and root it all away with the holdfasts. This may require 1,000 lbs. of gelignite, or more, and a multiplicity of porters complicates things. I never blew up a plate girder.

Mining trains pertains perhaps more to operations than to engineering, and is, any way, a special study in itself. Automatic mines, to work on rail deflection always sounded better than they proved. They require very careful laying and to be efficient have to be four-charge compound. This involves electrical connection. The best mine action we had was made for us by Colonel R. E. M. Russell, R.E. and we were about to give it extended use when the enemy caved in.

The ordinary mine was fired electrically by an observer. It is an infallible but very difficult way of destroying hostile rolling stock, and we made great profit from it. Our standard charge was 50 lbs. of gelatine. Guncotton is very little use.

However mining is too large a subject to treat of. The army electrical gear is good, but the exploder seems needlessly heavy. By using a single strand insulated wire (commercial) we fired four detonators in parallel at 500 metres; army multiple-stranded insulated cables will fire two at 500 metres. In series I have never had occasion to fire more than 25 detonators (at 250 yards), but I see no reason why this number should not be greatly increased. The army electric detonators never failed us. A meter test might show that some of them were defective, but even the defective ones will fire on an exploder. It is usually unnecessary to insulate your joints. The exploder goes out of action quickly if knocked about in a baggage column, or slung on a trotting camel, so I usually carried two as reserve.

# ROADS.

THREE important papers were read at The Institution of Civil Engineers, on the 3rd December, 1918, and we are indebted to the Institution for the following abstracts :—

## ROAD CORRUGATION.

By ERNEST LEONARD LEEMING, M.Sc. Tech., Assoc. M.Inst.C.E.

The introduction of mechanically propelled vehicles on highways has produced a troublesome and perplexing feature of road wear, namely, corrugation, which, owing to the existing war conditions, when the main roads of this country are heavily trafficked and their maintenance much neglected, has become serious.

The object of this Paper is to state the present position of the problem with regard to road construction and vehicle design, and to indicate probable causes of the trouble, with some suggestions for preventing or alleviating it.

The phenomenon of wave formation or corrugation is met with in most cases of rolling motion on a plane surface. As a general rule, the formation of waves on a road surface is accompanied by longitudinal movement of the road material in the direction of the traffic, and this movement usually depends on the tractive resistance of the particular material; consequently, water-bound macadam is more likely to become wavy than tar macadam, and so on.

Horse traffic alone may cause waves to develop, but the damage to a road in this respect is only slight compared with that done by motor traffic. The action of the driving-wheels of motor traffic is similar to the pulling action of horses' hoofs, and causes the upper layers of the road material to be moved backwards,—*i.e.*, in the opposite direction to the traffic; sets, for instance, are tilted backwards. And therefore the combined effect of forward movement as a whole and tilting or backward movement of the surface is to produce ridges and hollows.

The effect of a wheel passing over the hollows of a corrugated surface, or over potholes, is to produce a blow on the opposite side of the hollow, and this is shown to depend upon $\frac{Wv^2l^2}{r^2}$ where $W, v, l$ and $r$ are unsprung weight, speed, width of hollow, and radius of wheel.

It is generally admitted that the road roller will form initial waves unless great care is exercised, and that traffic will quickly accentuate them. The Crompton three-axle roller introduces a principle which is of great importance in considering the road wave problem.

The action of a two-axle motor-vehicle may be studied by observing the effect when the front wheels meet with an increased resistance due to a ridge or a pothole. The lead of the body of the vehicle on the front axle is increased and the lead of the back axle on the body is likewise increased, owing to the greater resistance to the driving effort; in other words, vibration of the vehicle as a whole is set up by the distance between the front and back axles changing with a definite period, according to the type and suspension of the vehicle. The wheel-base appears to have some definite relation to the period of the waves formed, and a long wheel-base assists the springing of the vehicle, and enables it to hold the road at speed when the surface is rough or wavy.

Considerable improvements in the suspension of the heavier motor vehicles are needed, the present practice only allowing of the absorption of shocks vertically, and not in the direction of the reaction of the blow on the road; in this respect, auxiliary springs, check springs, and shock-absorbers are very useful.

The effect of the differential gear in continuing waves along and across a road cannot be too strongly urged, and it is this feature of motor omnibuses which probably accounts for the rapidity with which they propagate waves. If one wheel leaves the road surface, racing takes place, and impulsive driving in both wheels is set up; when the wheel returns to the surface of the road it produces a strong grinding effect on the material. The same action takes place when braking the rear wheels, except that the grinding action is in the direction of motion of the vehicle.

An interesting feature of road corrugation is, that it often commences earlier on downgradients and at bends than on straight level lengths of road. In the case of the down gradient, the reasons for rapid wave-development may be stated as follows:—

(*a*). It induces increased speed and vibration.
(*b*). It increases the unsprung weight.
(*c*). Driving action and braking action are greater than on level roads.
(*d*). The road material is subjected to very great pushing stresses in a downhill direction.

The increased wear at bends is due mainly to the action of centrifugal force bringing greater weight on the outer wheels, and to the differential gear assisting racing and grinding action. The camber of a road, also, has some influence on wave formation.

The pitch of the waves is not easily determined from vehicle dimensions, since it often varies at different points on the same road under similar conditions of traffic. The occurrence of rudimentary waves, together with fully developed waves, is another interesting feature of road corrugation. Generally, the pitch is less when the speed is greater; it is also quite independent of the kind of road material laid down.

With regard to the different classes of roads laid at the present time, set-paved roads are only capable of offering resistance to wave-formation when laid on a concrete foundation. Where sets are laid on a yielding and inelastic foundation, corrugation will be quickly set up and considerable tilting and lateral movement will result from heavy traffic. Moreover, Durax paving and wood blocks do not seem able to resist the destructive forces of modern traffic, and sooner or later waves develop.

It is suggested in this Paper that, wherever possible, sets or blocks should be laid arch-shape, in plan, to oppose the movement caused by traffic in a particular direction, so that the paving may be rendered unyielding both vertically and horizontally.

In the case of macadam and tar macadam roads the former is quite useless where heavy traffic is concerned, and even tar macadam offers no real solution to the problem.

The bituminous road-surface appears to be the most suitable for modern traffic, on account of its great strength, and also its elastic qualities, which go far to compensate for the unsprung weight of vehicles. Further, traction and vibration are reduced to a minimum. The development of waves on a bituminous surface is analogous to the formation of waves in the rolling of hot armour-plate.

It is possible that concrete as a surface, under good conditions, might prove a suitable material, but it has not been sufficiently tried in this country to enable definite conclusions of its wave-resisting qualities to be formed.

The conclusions of the Paper show that unless two-axle vehicles can be provided with reasonably good springing, such as results from the air-cushion of the pneumatic tire, some development in the direction of providing three axles and increasing the number of driving-wheels accordingly, for heavy vehicles, is necessary to alleviate the trouble of road-waves.

## INVESTIGATIONS IN THE STRUCTURE OF ROAD SURFACES.

By Francis Wood, M.Inst.C.E.

Prior to the War, the question of the structure of roads was being brought into prominence through the advent of mechanically-propelled vehicles; there can be little doubt, however, that the transport needs of war have brought about a climax and emphasized the imperative and urgent need of providing roads with a structure that will (1) ensure a good and even surface, (2) be suited to the traffic, (3) be reasonable in first cost, and (4) be easily and cheaply maintained.

Considerable expenditure has been incurred in the past in providing elaborate foundations, which were in many cases necessary owing to the indifferent character of the surface, but there are many cases in which the strength and cost of this section of the road structures are such as would not have been necessary if the surface had been kept even and regular.

The Author suggests that, provided a homogeneous mass of material is interposed between a stable sub-structure and the wearing surface (also homogeneous), the foundations need not be, in effect, more than 4 ins. in depth, and such a combination will satisfy all traffic which reasonably conforms to the regulations that apply to vehicles in this country. It is common knowledge that no failure of the foundation of newly-laid wood pavements is noticeable until the surface begins to develop hollows through wear; it is then that the foundation of concrete begins to show defects.

An apparatus was designed and attached to the rear part of a motor car which would trace on a moving piece of paper the action of the wheel and the body of the vehicle as it passed a hollow in the pavement 18 ins. long and $1\frac{13}{16}$ ins. deep at a speed of 5 to 7 miles per hour. From the resulting diagram various deductions are made, but the most important is that the vehicle was actually stopped in its progress, thus indicating that the momentum acquired by the load on the wheel had been expended on the side of the hollow. It is evident that a continued series of similar blows would cause a very severe strain to the strongest foundation, and would be proportionately greater from commercial vehicles.

The test over an obstruction of the same height did not stop the progress of the vehicle.

The test emphasizes the importance of "stitch in time" repairs, and also the provision of a wearing surface that will resist the wear to the greatest extent, so that hollows do not quickly develop through wear.

Probably the bituminous type of pavement satisfies this demand better than any other that is known at the present time.

The Paper deals with the two-coat mechanically-mixed or artificial asphalt type, as the cost of this construction is less than of natural asphalt. For average traffic it consists of a wearing surface about 1 in. to $1\frac{1}{4}$ in. deep laid on a 3-in. to 4-in. bituminous base coat.

Experiments proved that the base coat itself could be made to act not only as a base, but also to give the wearing surface, and would wear more economically than water-bound macadam. Disintegration began in the third year; the coat subsequently recovered, but disintegration again developed later, and eventually it failed under heavy traffic after about six years. The causes are investigated, and the failure is attributed to the expansion and contraction of the bitumen in combination with the use of large-sized stones.

The conclusion arrived at is, that the surfacing material which is exposed to considerable variations of temperature should not have any particles larger than about $\frac{1}{4}$ in. when used with bitumen.

This points to a justification of the separate wearing surface coat laid on a base which can be made with a composition of large, medium and small-sized stone mixed with a suitably prepared tar.

In regard to the wearing surface coat many different compositions have been laid, and there has been a noticeable proportion of comparative failures. There has been a tendency to attribute these wholly to the bitumen used in the composition. In the Author's view, although the bitumen plays a very important part, it is almost of minor importance compared with the grading of the mineral matter and the distribution of the bitumen.

Calculations are given which consistently indicate that the thickness of the film of bitumen on the surface of the particles of natural and artificial asphalt is such that Nature employs 50 per cent. less than is used in the synthetic asphalt. A Table is given indicating the amount of bitumen required to cover any particular grade of material. From this Table the percentage of bitumen required to coat any specified mixture of grades of material can be readily determined. The Table will be advantageous in helping to ascertain whether the cause of the failure may be attributed to the lack of bitumen.

In the above comparison of natural and artificial asphalt, the percentage of bitumen by weight of analysis is very similar to that of the artificial material. There would be a different result if volumetric analysis had been made. An example is given of two analyses of the same grading of bitumen contents, yet when the specific gravities had been determined, one shows 25 per cent. bitumen less than the other. Hence misleading conclusions may be arrived at unless the whole of the factors are taken into consideration.

In connection with the design of the structure, it must not be assumed that any grading of material can be used, or similarly that the grading should be so arranged as to give a voidless structure. A voidless structure *per se* will not necessarily give a good road structure; in fact a designed voidless structure will give a percentage of voids when in the road, because it is laid when the bitumen is in an expanded state, and as soon as it is cold it contracts and must leave voids. A rolled and tamped surface coating will show about 15 to 20 per cent. voids on the underside of the coat, while at the surface it is free from voids.

Examples are given of aggregates of various sizes to bring about a near approximation to a voidless composition, the amount of bitumen that would be necessary to fill the void is calculated, and it is shown that it would not properly coat the surfaces.

Pavements that have proved satisfactory show that the fine particles must predominate. It is probably the case that the bitumen containing what are technically termed colloids (*i.e.*, impalpable material of such fineness that if mixed with water it will not settle out after 20 minutes' quiescence) will be more successful than the bitumen that contains no colloids or their equivalent. Apart from this, the opinion is expressed that in the bituminous wearing surface coat about 40 per cent. of the aggregate should be of 200, 100 and 80 mesh (the larger proportion being 200 mesh), 40 per cent. of 50, 40 and 30 mesh, and 20 per cent. of 10 to ¼ in., and that the film thickness on the surface of the particles should be at least 0.00065 to 0.00070 in.

The Author further indicates that there is no advantage in any particular material that is used as the aggregate, that almost any that is locally obtainable, provided it is in a free state and of suitable grading, may give equal results ; *e.g.*, clinker from a refuse destructor ground to the necessary sizes, grit swept from macadam roads, wood-fibre, etc.

## NOTES ON ROAD CONSTRUCTION AND MAINTENANCE.

By THOMAS BOWYER BOWER, Assoc.M.Inst.C.E.

Roads are one of the most important of an army's needs. The improvement of the roads of the United Kingdom is a subject of increasing importance, and experience shows that the possibility of military considerations becoming involved should not be neglected in their design and construction.

The average English roads and by-roads are, as a rule, well made, but to carry military traffic they should be not less than 24 ft., and, if possible, 30 ft. wide.

The roads to France, chiefly constructed under Government supervision, were excellent for the traffic likely to use them.

For civilian traffic in peace time, consisting chiefly of slow carts and light motor cars, they are no doubt adequate, but both construction and material—largely a friable limestone—have proved unsuitable for heavy and fast military traffic. The original good condition of the roads, with favourable weather, delayed the appreciation of this, but after the second winter of hostilities, the road surfaces having become bad, frost got into the foundations, and with further increase of traffic the roads got into a deplorable condition. Material was scarce, and temporary measures had to be adopted.

The commonly accepted view that the excessive amount of mud on the roads of France is due to the metal being forced down to the chalk or other subsoil, which then comes to the surface as mud, is disputed.

by the Author. Excepting the case of *pavé* roads, and roads badly worn in holes, he is of opinion that no mud rises to the surface by pressure from above. The true cause of mud formation is the poor quality of the material used, viz., limestone of very soft and porous nature, which, by attrition through some inches of depth, forms the mud, while destroying the surface. The only other materials available in France were pit-props, whole or split, brick rubble, and a poor quality of flint gravel.

The Author then describes methods of repairing holes, deep holes being dealt with by "pigstying" with pit-props, filled in with earth and covered with a foundation of soling rock and a coat of macadam.

The Author has reached the conclusion that there is but one way, as now given, of constructing a road fit to stand abnormal traffic for long. Drainage must first be dealt with. No ditch should be nearer the road than 6 ft., the bottom being 1 ft. below road formation. Side drains from road edge to the ditch should be not more than 50 ft. apart. If the road on one side cuts into a hill slope, culverts must be formed under the road leading from one ditch to the other—these, whether of stone slabs or wood, should not be less than 18 ins. square. Side tilted roads draining across the surface are to be avoided. The edge of the road next the falling ground, if wanting from any cause the 6 ft. margin between the road and the ditch, must be securely supported to take the pressure induced by road traffic, which has a tendency to push the edge of the road outwards, causing the road to lose its camber. A method of securing road edges is then described.

Road excavation must be taken out across the whole width to 18 ins. below the finished road-surface, the bottom being curved to conform to the road camber, which may vary between 1 to 12 and 1 to 50, 1 to 25 being a fair average.

It is well to have upon the ground soling rock, seconds and macadam, in advance of excavation, to avoid delays which may expose the foundation to weather influences. Excavation being completed, the bottom is covered with a 2-in. layer of ashes, or clinker; this, though not essential, is desirable. The soling rock is then packed and rolled as already described for mending holes. Where the soling rock, when set and keyed, is rough it will be well to hand-pack the rock seconds that come next, if only for one stone thick, "throwing in" to make up the desired thickness; 9 to 12 ins. of soling rock is sufficient. If this is not procurable hard block chalk will serve, though not so good. The "seconds" should be from 4 ins. to 6 ins. thick, as also the macadam finish. Each layer should be rolled as completed.

This makes a good road easily maintained, and serviceable even when the macadam is worn away.

Corduroy roads are possible only in a well-wooded country, and last but a short time unless well covered with metalling, without which the foundation soon becomes wet and soft, with consequent disturbance of the timbers.

To construct a good corduroy road attention must first be given to drainage and excavation carried out as for metalled roads, when "beds" to receive the longitudinal stringers should be excavated, one on each road edge and one at the centre, with two intermediate channels, the centre channel being of width sufficient to take two timbers spaced 2 ins. or 3 ins. apart.

When laid the corduroy must be secured by ⅛-in. diameter wire fastened by staples to each timber. At every 15 ft. it is desirable to drive pickets, to secure the timbers from shifting. On completion the corduroy should promptly be covered with a thin layer of ashes, or dry soil, followed by a layer of seconds and macadam well rolled in.

Some principal faults in road construction are :—Delay in drainage arrangements until late in the work; careless laying of soling rock on irregularly formed bottom. Packing soling rock on edge with length of stones transverse to road, in which case the stones are liable to tilt forward in the direction of traffic with consequent disturbance of road surface.

# TRANSCRIPT.

## CAMP DRAINAGE AND SANITATION.

*By* W. H. Beswick, Assoc.M.Inst.C.E., Assistant Sanitary Engineer, Salisbury Plain Command.

The following paper, which was read at Swindon Sessional Meeting, July 13th, 1918, is reproduced from *The Journal of the Royal Sanitary Institute*, Vol. XXXIX., No. 2, October, 1918, by the courtesy of the Committee of the Institute.

Camp drainage and sanitation comprise many variations from ordinary municipal practice. For the civil engineer it is quite a new experience, or, rather, adapting experience to new conditions; and previous to the outbreak of war Royal Engineers had no doubt mainly considered the subject from the summer-camp point of view, with the exception of Bulford, Tidworth, and others, which latter camps or barracks were carried out in peaceful times when rapidity of construction was not so essential, and well thought out schemes were first prepared. The problem of new camp drainage became more difficult from the fact that construction and scheme had to proceed at the same time, not scheme first and construction afterwards, but the reverse: as one General put it to the author, "Do the work first and make the plan afterwards!"

The author was engaged by Messrs. John Jackson, Limited, to take charge of the drainage of the Salisbury Plain Camps, comprised in their agreement with the War Office, and he arrived at Bulford on the 12th of October, 1914, to find that drainage was urgently required to enable the camps then under construction to be ready for occupation before the approaching winter.

At this time no general scheme for dealing with camp drainage had been issued from the War Office; and, apparently, individual contractors or agents devised schemes most suitable to the camps they had under construction. In November, however, a memorandum was received, issued by the sanitary adviser to the War Office, setting out simple requirements for settlement tanks and land irrigation. These instructions read:

"Small settling tanks should be constructed of a content equal to about one-tenth to one-fifteenth of the daily flow—the smaller proportion being for the larger volume."

(This is equal to 2.4 or 1.6 hours' flow).

A camp may consist of one or more units having the same or similar characteristics, and the Salisbury Plain camps with which the author is most closely associated comprise the following :—

Sling Plantation (adjoining Bulford), 10 units (originally 11).

Larkhill (including Durrington and Rollestone), 40 units (originally 60).

Perham Down, 8 units.

Parkhouse, 4 units.

All the foregoing camps were under construction, and all required drainage. At first it was only considered necessary to provide drainage for ablutions, bathrooms and cookhouses, with provision for floor washings and slop water from concrete areas, etc. Urine was not to be taken into the drainage system ; and all latrines were on the pail system, the contents of which, as well as urine, were to be incinerated. Water supplies were then under construction or being considered, mostly by pumping schemes, so the question of daily allowance was important, and it was decided to make provision in drainage schemes for daily supplies not exceeding ten gallons per head.

No rain or surface water is provided for, as in most units this was afterwards dealt with separately in open gutters, etc.

For purposes of outfall sewers and works units had to be grouped, and in the camps under consideration this grouping worked out as follows :—

Sling Plantation to one outfall (Bulford hospital being drained into the existing system).

Larkhill, Durrington, and Rollestone, twelve outfalls (varying from 1 unit to 16).

Perham Down, originally six outfalls, now five.

Parkhouse, one outfall.

In accordance with the memorandum from the sanitary adviser to the War Office, a typical drawing for outfall tank for one unit equal to 1/10th the D.W.F. was prepared and issued to the various camps, these tanks being increased in number, and built in parallel to provide for the requirements of two or more units ; those for Sling comprised five tanks. These were so arranged that sludge could be run off to sludge pits from any tank as occasion arose ; neither screening nor grit chambers were provided.

It was soon found that these tanks were too small ; in the case of Sling Plantation complete new works had to be designed, in which the existing five tanks were utilized as screening and grit chambers. In several installations, however, these small tanks are still in action after three years, and giving fairly satisfactory results, although requiring more regular and constant attention.

With a view to simplicity in working, more particularly as it was thought that complicated works would be neglected if left to the care of constantly changing troops, a design for tanks in duplicate was prepared.

The sewage first passes into a screening chamber common to both tanks, then through a screen and, by submerged inlets, into the tanks, which have steep, inverted pyramid bottoms. The effluent is drawn off over a full width weir, first passing under a scum board. The screening chamber is also an inverted pyramid with a sludge valve at the bottom, while from the tanks sludge pipes are carried to a valve chamber leading to the sludge lagoon, (the sludge being removed by hydraulic head), about 3 ft. head being found very effective. The screening chamber and tanks form two ponds, with a difference of from 2 ft. 3 ins. in water-level, so that solids passing into the inlet channels are carried through the inlets to the tanks with an increased velocity, the effect of the continuous weir outlet being to prevent currents, and, at the same time, discharging the effluent in a thin film.

These tanks are found to answer excellently well for slop-water drainage, but where a water-carried system of drainage is installed, some modification of the screening and grit chamber is required to provide a flow through the screen so that the fæcal matter will be carried forward into the tanks.

In November, 1915, the author was transferred to the Royal Engineers, and has been employed since then in completing works designed by him for Messrs. John Jackson, Limited, and carrying out works, the designs for which have been prepared by the sanitary adviser to the Southern Command. These latter comprise works at the East and West Valley, Larkhill, and new works at Bulford for the existing camp.

In these works three different types of tanks have been installed, the largest being at the West Valley, where four tanks in parallel have been constructed, two being Dortmund and two being semi-Dortmund tanks, the effluent from which is carried across the valley in a 10-in. C.I. Syphon on to suitable land more remote from the camps. The East Valley works comprise three rectangular tanks in parallel, while Bulford extension consists of a roughing tank and four sedimentation tanks of rather novel construction. None of these works, however, have been in action long enough to allow any sufficiently correct data to be obtained which would permit conclusions to be drawn. It had been found in the existing works, both at Bulford and Tidworth, where large numbers of horses are kept, that scum on the tanks increased so rapidly that it reached the underneath of the concrete covers, and was gradually pressed down into the tank until scum and sludge met. The roughing tank at Bulford has been designed to obviate this difficulty, but it is too early yet to state results.

No filters have been provided for any of the foregoing works, disposal of tank effluent by irrigation having been found quite satisfactory; and where effluents have been discharged on to previously cultivated land concrete carriers have usually been provided, while on Down land dugout carriers have proved effective. Where possible, carriers have been arranged to allow for separate daily discharges, so that each portion of land can be given six days' rest if found necessary. One acre per 1,000 population, or thereabouts, has been provided where possible, but most Down land is so suitable for purposes of irrigation that much smaller areas have given excellent results. On the East Valley Outfall, Larkhill, where temporary works have been in operation since the summer of 1915 until the permanent works were completed this spring, ten units, or a population approximately of 11,000, with a daily flow of 110,000 gallons or thereabouts, have been most successfully dealt with in an area under three acres.

Generally, the author does not advise that irrigation areas should be cultivated, especially on non-permanent camp sites, as he considers that if land under irrigation does its legitimate work of sewage purification satisfactorily, it is all that can be expected from it, and where cultivation is undertaken on these areas there is a liability to neglect either the irrigation or the crops, often to the detriment of both; therefore, one should be satisfied with work well done in the essential requirements for which the land is being used, viz., sewage purification.

This does not apply to Down land, where with proper attention excellent grass crops can be obtained; and, as proof of this, last year the author cut and supplied in the form of green forage to the Army Service Corps at Larkhill, over 160 tons of grass—the small area of under three acres above referred to being cut four times, with a total yield of 60 tons.

Unfortunately, on these irrigation areas, no final effluents are procurable for analysis, and no actual results of purification are available for comparison.

Many variations from the original conception of the requirements for the drainage system developed as the camps became occupied. First urine was added; then small concrete areas were provided at cookhouses for waste receptacles which had to be drained; overflows from horse troughs in most cases had to be provided for, and generally the drainage system as originally laid down had to be extended. One of the most troublesome questions, however, arose when it was found that large quantities of grease accumulated on the surface of the settling tanks, and stoppages in drains took place. It soon became necessary to consider the provision of grease traps, and, seeing that at this time all drainage was practically complete, this meant considerable and somewhat costly alterations. It was decided to provide grease traps to all cookhouses.

MR. A. A. G. MALET (Sanitary Adviser, Southern Command) said some of the chief points to be considered in designing sewage disposal works, apart from the special circumstances of the site, was the water consumption: it was not safe to allow for less than ten, but it might go up to thirty-six, gallons per head per day; the certainty of great variations in the strength, as certain "lines" in a camp would at times be empty for considerable periods, and at other times would be overcrowded for short periods.

A Cavalry camp might be transferred to Infantry or to the Tank Corps, or *vice versâ*, or a camp might be transferred to the Royal Air Force or converted into a hospital, with corresponding variations in strength and consumption of water, even if the hutments were not increased, reduced, or misappropriated.

The essential points in designing sewage disposal works for a hutted camp seemed to be: the interception of grease at its source of origin; good detritus chambers, perferably in duplicate, with automatic sludging through bottom plug valves (not side valves) having a full bore lift; the bars of screens or removable cages to have a clear spacing of not less than 2 in.; the weirs of storm overflows to be protected by a dip board to reduce the risk of floating solids being carried over the weirs; tanks in suitable units to allow of cutting out when the strength in camp was reduced, with efficient valves for drawing off the supernatant water and removing sludge. The total capacity to be six to twelve hours D.W.F.

if the effluent was finally treated on land, and fifteen to twenty hours D.W.F. if the effluent was finally treated on filters. The form or type of sewage tanks to be adopted depended on the local circumstances in each case, but he preferred a rectangular tank where the sewage was on water carriage, and a modified Dortmund type when the system was not on water carriage. Sedimentation and not septic action should be aimed at; if there was final land treatment, arrange for surface irrigation, not soakaways; if filters, he felt sure that a duty of 45 gallons per cubic yard per day was too high for camp sewage, and if a high standard effluent was required, he doubted whether it was possible to secure one without double filtration; humus tanks of two to four hours D.W.F. if necessary. If suitable land was procurable within a reasonable distance, it would give better results and avoid possible trouble to pump the tank effluent to land rather than to provide filters. No feed channel pipe or inlet at the disposal works should have a less depth at any state of flow than 2 or 3 ins., so as to ensure solids being carried forward but this did not apply to the discharge weirs of tanks or special gauging weirs. The design should allow for extensions or additions as the personnel of a camp was sometimes doubled or trebled.

# NOTICE OF MAGAZINE.

## *REVUE MILITAIRE SUISSE.*

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### THE STRATEGIC FRONTIERS OF BELGIUM.

The author of the original article states that Belgium has, strictly speaking, no "strategic frontier;" she is entirely without natural defensive positions on every side, North, East and South. At one point only —between the two Limburgs—a river line forms part of her territorial boundary; but even here owing to the mistrust which the Great Powers had of Belgium in 1839 to Holland was given the important bridgehead at Maestricht, although it is situated on Belgium's side of the river.

An inspection of historical and physiographical maps of the Low Countries, however, shows that on the North and on the East Belgium, at one time, was covered by exceedingly strong positions. Had the frontiers of Belgium not been altered, she would have had in 1914 three positions of the highest military value upon which to oppose the invading hordes of Germany. The paring of her frontiers in 1815 and in 1839 robbed Belgium of her natural frontier defences.

The possession of Luxemburg gave Belgium the positions on the line of the Moselle; these positions, extending from Sierck to Treves, were exceedingly important as the right bank of the river, varying in depth from $1\frac{1}{2}$ to $6\frac{1}{4}$ miles, belonged to Belgium up to 1815. The citadel of Luxemburg, which was occupied by the Prussians in 1867, in rear of the Moselle positions, had been recognized, from Vauban's time, to be the strongest fortress in Europe.

In 1914, the Grand Duchy of Luxemburg, neutralized and disarmed as it was, afforded an easy approach for forces intending to invade Belgium from the S.E. and France from the N.E. The absence of strong positions in E. Belgium compelled the Belgian General Staff to uncover completely the Belgian province of Luxemburg, and to take up a first line of defence on the left bank of the Meuse in the Namur region.

Up to 1815 there lay in continuation of the Luxemburg position the region of the Eiffel. Prior to the time when the central portion of the province of Luxemburg was nominally constituted a Grand Duchy—from 1815 to 1839—it comprised a mountainous region, on the right bank of the Our, contiguous to the present frontier of Prussia. This region extended northward along the high plateaus of the Eiffel, its edge formed the river partings of the Rhine and the Meuse basins. The whole of this country consisting of a dozen cantons, which had for centuries been Belgian, was obtained by Prussia in 1815, in spite of the declared intention of the Powers to make the Low Countries a powerful kingdom.

The camp at Elsenborn and the considerable detrainment centre at Weismes, used by the Germans in 1914 as mobilization centres for the invasion of Belgium, were at one time Belgian territory.

Had the former frontiers of Belgium been preserved to her she would, in 1914, have possessed a suitable zone for the concentration of her army; under the actual circumstances, however, her eastern frontier was a mere *place d'arrêt*, with the heart of Belgium but two days' march from Germany.

Owing to the establishment, in the 17th century, of the Dutch enclaves at Maestricht and at Faquemont, the E. Limburg position was very much weakened. Although the situation was restored in Belgium's favour in 1815, yet in 1839 the establishment of Holland and of the North German Confederation on the right bank of the Meuse and the creation of the strong bridgehead of Maestricht, on the left of the river, again robbed Belgium of all that she had gained in 1815.

It was the existence of the Limburg "pocket" which caused the Belgian General Staff to concentrate the Belgian army on the line of the Gette, mid-way between Brussels and the German frontier; a Belgian concentration on the line of the Meuse, south of the Dutch frontier, would have been, in 1914, a hazardous measure owing to the possibility, always existent, of Germany violating Dutch neutrality for the purpose of invading N.E. Belgium *viâ* Dutch Limburg.

It is hinted, in the original article, that Belgium is laying "claims", on her eastern frontier, to the "strategic positions essentially and historically Belgian;" it is admitted that Belgium cannot be accused of "imperialism" on this account.

Had Belgium been allowed to retain her "natural frontiers," she would not, it is suggested, have submitted to the neutrality *imposed* upon her under the guarantee of the Powers.

Belgium, it is stated, has nothing to fear from Holland; the two countries must, owing to a community of interests, establish the closest of relations with and repose the utmost confidence in each other. The question of the Scheldt is touched upon in the original article, for the reason that its author considers it to be a matter of greater importance from the international standpoint than from that of Belgo-Dutch interests. The Lower Scheldt is the natural frontier of Flanders. At first sight it would seem that Belgium should exclusively control the left bank of the river. But Holland established herself on the Belgian side of the river in 1648, in order to carry out her particular policy of competition and in order to close the river and thus stifle Antwerp.

To-day, Belgium and Holland exercise a *condominium* on the Scheldt, which has never been clearly defined in law, and which since the beginning of the war, has been exceedingly precarious and almost non-existent. Both the Lower Scheldt and the Lower Meuse continue to be regarded as Dutch territorial waters. It would seem that owing to the force of circumstances Belgium has provisionally renounced the idea of making a military use of the Lower Scheldt.

The situation described above had a marked influence on the defence of Antwerp in 1914; the revictualling of the city and fortress was hampered, and the British fleet had to give up the idea of steaming up the

Scheldt to co-operate in its defence. The retreat of the defenders was rendered more difficult by the existence of the strip of neutral territory along the south bank of the Scheldt, and the evacuation of the fortress had to begin sooner than would have been the case had what now is Dutch been Belgian territory. The vast national "keep" which, it was believed, had an exit to and an entry from the sea through the "free channel of the Scheldt" was found to be hemmed in by the neutral territory of Holland, and 30,000 men, belonging to the garrison of the great Belgian fortress, crossed into the neutral belt and, in consequence, had to suffer internment in Holland.

MONSTER ARTILLERY.

Public opinion, says the author of the original article, became exceedingly apprehensive when it was made known that the Germans had bombarded Compiegne, Dunkirk, Belfort and Paris at extraordinarily great ranges; the human imagination was quickened by the uproar caused by the explosion of giant shells.

It is pointed out that the recent progress in the development of firearms and of artillery has been largely rendered possible owing to new discoveries in chemistry and physics and to the improvements in industrial processes. Two absolutely opposite effects have been produced by the discoveries and improvements brought about in the fields of chemistry, ballistics and technology; whereas in the case of small arms a progressive diminution has been taking place in the calibre of the barrel of the rifle, on the other hand, in the case of artillery a constant increase in the calibre of heavy guns has been the order of the day.

The appearance of monster artillery on the battlefields of Western Europe was no surprise to students of ballistics. The presence of 12-in. guns on the Western and Russian Fronts was noticed early in the war; later there appeared announcements concerning the German 16.5-in. gun, the French 17.25-in. gun and the American 16.5-in. gun; and finally the construction in America and in France, of even 20.5-in. and 21.5-in. pieces was being discussed. In the case of the gun which caused the houses of the Isle de France to rock and to shake, it was not the magnitude of its calibre, but rather its extraordinarily great range which upset every one's calculations. The author of the original article states that it has yet to be learnt whether monster artillery will, on the modern battlefield, come up to all that is expected of it. It is suggested that the experiences of the war, now practically concluded, will, have provided the materials for the solution of the problems relating to monster artillery which, at the present time, are exciting the interest of so many persons.

Two questions are discussed in the original article, namely :—

(i.). What is the cause of the increase in the calibre of the gun?

(ii.). In the present state of modern science is there a limit to the continued increase in the calibre of guns?

It is pointed out that the question which the artillerist has to consider is the design of a projectile possessing great destructive effect at very long ranges. At short ranges the shell fired by field pieces and howitzers meet the requirements of the case effectively. But in the case of projectiles having a diameter of 6 ins. and over the destructive effects of such projectiles when exploded are insufficient ; neither the mass of the shell nor the explosive charge are large enough for the purpose required. It is difficult to reconcile in the design of projectiles the conflicting claims of an increase in mass, on the one hand, and of an increase of the bursting charge, on the other.

Given that a shell can be designed to contain a sufficiently powerful bursting charge and, at the same time, to possess strength sufficient to prevent it from breaking up prematurely on discharge, then, in order that it may accomplish the destruction of the target at which it is fired, such a shell must possess a certain minimum energy on arriving at its destination. The kinetic energy (E) or vis viva of a body moving through space is given by the well-known formula :—

$$E = \frac{M V^2}{2} = \frac{W V^2}{2g}.$$

that is to say, that the energy of a projectile is directly proportional to its weight and the square of its velocity ; consequently, the greater its weight and the higher its velocity the greater will be its energy.

In order to ensure that $\frac{W V^2}{2g}$ shall possess a large final value at long ranges, *i.e.*, when the projectile reaches its target at such ranges, it is essential that the shell shall have a large calibre and also considerable weight ; hence it is that in modern times both the diameter and the length of projectiles have been increasing.

Further, the penetrative power of a shell into compact masses of material depends upon its diameter. In order to destroy large masses of concrete, or steel cupolas of thick armour, very heavy shells travelling at high velocities and possessing a considerable bursting charge are necessary ; they alone retain sufficient energy on arrival at their target to accomplish the object in view.

The increase in the range of guns is due to the progress made in the manufacture of explosives which can now be produced with such perfection that any desired explosive force can be obtained in the propellant, with great precision of calculation, from the ingredients employed. The high quality of the slow-burning propellants and the certainty of their action are the factors which have made it possible to build the monster artillery which made its appearance on the Western Front.

With the very long shell in use in modern times a considerable rotatory spin, on its longitudinal axis, has to be given it in order that it may continue its flight steadily in a parabolic path. In order that the initial strain on the inner tube of the gun may be reduced as much as possible the pitch of the rifling has to be made small at the breech end and gradually increased until the muzzle of the piece is reached, where it is at a maximum.

Although in theory no limit need be set on the increase of the calibre of monster artillery, yet, on the other hand, experience dictates that there are practical difficulties which will finally determine the utmost limit of the calibre of such guns.

The progress in metallurgy has been as great as that in the manufacture of propellants and explosives; the advances and improvements in these two fields have mutually reacted on one another. The guns of the present day are constructed of nickel-steel; some idea of the properties of this steel may be gained, when it is stated that, in order to obtain the initial velocity required in the case of very heavy projectiles, the breech of the gun has to be constructed so as to withstand pressures reaching 3,000 atmospheres, *i.e.*, about 19 tons to the square inch.

The use of slow-burning propellants renders it necessary that guns shall be extremely long; it is essential that a sufficient time shall be given for the whole of the charge to be converted into gas before the projectile leaves the muzzle of the gun. The inner tubes of heavy guns (especially those of the naval type) vary from 45 to 60 ft. in length, *i.e.*, they are from 45 to 50 calibres long. The German "Big Berthas," which fired into Paris, had inner tubes varying from 72 to 84 ft. in length, and therefore their length was at least 100 calibres.

The increase in the length of the shell also imports an increase in the length of the inner tube of the gun; this is necessary in order to give the shell a spin, on its longitudinal axis, at a suitably high angular velocity. Long projectiles require two driving bands, so that the increase in the pitch of the rifling must be gradual throughout the whole length of the inner tube, otherwise torsional stresses would be produced on such projectiles, stresses which would cause disturbances during the flight of the projectile and would result in inaccuracies in ranging.

Another matter which affects the accuracy of fire of monster artillery is that connected with the vibrations set up in the inner tube on the discharge of a gun. Such vibrations are in the nature of damped sinusoidal longitudinal waves, and, the material of the inner tube is consequently compressed and extended longitudinally along alternate portions thereof, in the same way that alternate stretches of condensations and rarefactions of the air are produced within a hollow cylinder when a sound wave is propagated through it.

These vibrations produce fissures in the metal; in consequence, these vibrations constitute a serious detrimental factor in very long inner tubes of guns, and as they cannot be eliminated a limit is reached in practice beyond which it would be unsafe to lengthen the inner tube of a gun.

The wear of the inner tube is also a serious question in the cases of monster artillery. Such wear arises from the mechanical action caused by the inevitable friction between the driving bands of the shell and the lands in the rifling; from the chemical action on the metal of the inner tube, producing erosion due to the high temperature (which often reaches 2,000° C. and more) of the gases formed from the combustion of the propellant; from the calorific action of the hot gases which destroys the temper of the metal of which the gun is constructed.

The wear of guns depends on a number of factors; among which are the quality of the steel used; the care exercised during manufacture; nature of the propellant used; weight of the charge; muzzle velocity of the projectile, etc. The most important of these factors is the weight of the charge; it has to be considerable in order to attain the muzzle velocities required. Whereas in ordinary field pieces muzzle velocities of 1,300 to 1,600 ft. per second are sufficient, in the cases of heavier guns muzzle velocities of 2,300 to 2,600 ft. per second are necessary. The Big Berthas that were used for the bombardment of Paris appear to have had a muzzle velocity exceeding 3,200 ft. per second. The charges used with ordinary heavy artillery are very large; in the case of a 12-in. gun the charge weighs about 6¼ cwt.

Field guns have, it is stated, a life of from 500 to 600 rounds; the lives of heavy guns are very much shorter, for instance, that of the 12.5 in. being 102 rounds and that of the 16-in. gun only 83 rounds.

Monster artillery occupies a secondary position in warfare; its value is much less than that of smaller guns. The want of mobility on its part much detracts from its usefulness. In order to confer the maximum advantage to its side on the battlefield artillery should be capable of moving off the roads and away from railways.

Some idea of the transportation problem in connection with heavy artillery is obtained from the weights of guns now in use. The French naval type of 12.5-in. gun is 59 ft. long and weighs, without its carriage and platform, nearly 80 tons. The celebrated 42-cm. (16.5-in.) gun weighs, without its carriage approximately 88 tons, whilst the weight of the American 19.5-in. gun is 130 tons and that of its carriage and platform another 360 tons. These monster pieces have to be dismounted and taken to pieces in order to be moved from one position to another. It is said that 12 wagons are required for the transport of the 42-cm. gun, which, when ready for removal, consists of 172 different pieces; no allowance is made for ammunition in these wagons. Moreover, several days are required to mount and adjust one of these monster pieces, and it is inconceivable that they will ever be available in a war of movement.

The fire from these guns cannot be regulated by any existing means; even aircraft observation is out of the question. The successive shots must be fired haphazard, and therefore it can only be by chance that any particular target aimed at can ever be hit; the dispersion with these guns is very great, as so many variable factors have to be reckoned with in connection with the flight of the projectile.

The ammunition supply for the heavy guns presents questions of considerable difficulty owing to the weights of the projectiles. The shell for the German 15-in. gun weighs 14¾ cwts. and that for the 16.5-in. gun 15 cwt. The projectile for the American 19.5-in. gun beats all records, it weighs 21½ cwt. Ammunition of this description is as difficult to move as the gun itself; hence, if the position of the gun is often changed, there is always a danger that the ammunition may run short, owing to its being stored at a depôt too far away from the emplacement occupied for the time being.

The cost of building giant guns is very great; that of the French 12-in. gun is said to amount to £16,000, and the cost of firing a single shot therefrom is £190 approximately. The German heavy naval guns cost £16,600 a piece, and the firing of a single shot involves an expenditure of £340. Monster artillery is, therefore, a most expensive luxury, and the taste for it can only be indulged in on a very limited scale.

In spite of the difficulties connected with their use and the defects existing in them, the steel monsters, which played a part in the struggle on the Western Front, were none the less wonders of modern technical enterprise. The long period of trench warfare which followed on the decisive check to the advance of the German hordes after the first battle of the Marne afforded many opportunities for the utilization of heavy guns of position (brought into action in rear of a screen of field guns) for the destruction of the more formidable types of defensive works constructed by the belligerents on both sides.

The German 42-cm. gun may have been something to be proud of as a creation of modern science but it possessed little military value; the use which was made of it to bombard towns far beyond the zone of contact between the fighting troops remains on record as one of the many indiscriminate and treacherous acts against innocent humanity of which the military and political leaders of Germany have been guilty, since the date, in 1914, when the frontiers of Belgium were crossed by the German armies.

### MILITARY TRAINING AND MORALE OF THE SWISS SOLDIER.

The article on the above subject begun in the October number of the *Revue* (vide *R.E. Journal* for December, 1918), is continued in the number now under notice.

The author of the original article gives a description of the early experiences of a distinguished Swiss citizen, now a veteran in the Landsturm, in the Swiss Army as related to him by the latter; it is not altogether complimentary. There was however, a redeeming feature in the situation described: a subaltern officer responsible for a part of the training of those called up in the now far-distant days to which the account relates possessed the capacity of interesting his men in their military duties and of instilling a proper spirit into them.

The object of military training, says the author of the original article, is to prepare young men to fulfil the greatest of their *civic duties*. It comprises two distinct aspects; moral education and technical instruction. These two branches of the duty imposed upon a chief instructor are inseparable.

All military education, possessing real value, is based on *a sense of duty*; a great variety of motives give rise to the sentiment involved herein, the chief among them being *love of country*. Patriotism, however, seems to-day to be at a discount, to some extent, in Switzerland as in some other parts of the world. A fashion has sprung up of replacing it by doctrines with bombastic titles having nothing Swiss about them; internationalism, cosmopolitism, communism, even bolshevism, and many other words ending in "ism" expressing similar sentiments; at one end of this scale stands "imperialism."

In France, too, some of these novel doctrines, introduced as a substitute for patriotism, were at one time making headway. The French nation have had to pay a heavy penalty in consequence. The war sprung upon them in 1914 has brutally dissipated these chimeras. In Switzerland, however, the situation is to-day far from satisfactory. A word of warning is raised by the author of the original article, who calls upon his countrymen to take the lessons taught by the recent lamentable experiences of Russia to heart; he advises them to beware of living in a "fool's paradise." The day has not arrived when Switzerland can trust the defence of her frontiers to others, or place reliance on smooth promises or on "scraps of paper." Switzerland still needs an army, whose duty is a simple but a great one; to preserve the Republic from invasion and the horrors of war. The mischievous anti-militarist propaganda now in progress in Switzerland is, it is said, seriously undermining the very existence of the State.

The duty of the officers, on whom naturally devolves the responsibiliy for the efficiency and *morale* of the Swiss Army, is, under the existing circumstances, vey clear. It is incumbent upon them to eradicate the virus of the anti-patriotic doctrines which is poisoning the minds of those under their command. They must not be afraid of refuting the sophisms which now have a vogue in Switzerland, of combatting the prejudices known to exist, and of providing a true explanation of things as they find them, without attempting to gloss over or to shirk matters which are disagreeable and unpleasant to handle; it is possible for them to get their men to see things in their true perspective and to realise that the soldier's duty to the State and his real interests as a citizen are closely bound together.

The subject of "Discipline" is touched upon in the original article, and it is pointed out therein that the Greeks and ancient Romans, fanatical democrats as they were, insisted on maintaining a high standard of discipline, a standard which has passed into a proverb, and whereof they were justly proud. The need for discipline remains as strong to-day as at any epoch of the world's history.

There are many definitions of military discipline. In practice efforts are sometimes made to create and maintain good order in an army, by methods which can only be referred to as caricatures of discipline. These methods are made use of by officers who have little or no acquaintance with the laws of psychology. A true view of discipline is to be found in Capt. de Traz's work *L'homme dans le rang*, which the author of the original article advises every soldier to read.

The author of the original article has also something to say on "Drill"; a subject which has given rise to much controversy and criticism in Switzerland owing to the misapplication of the rules relating thereto laid down in the Regulations for the Swiss Army. At one time, the real value of drill as an aid to discipline was so misconceived in Switzerland that even the men's dinners were practically served by a drill manœuvre, the cook's mates being formed up in line, called to attention, made to dress, to pick up mess tins by word of command and to march to the kitchens (using the ceremonial step).

The Swiss are exhorted to copy the example of the British and American Armies in their use of drill as a means to get the greatest output of energy from the soldier and to obtain the highest value from the military training given him. (*To be continued.*)

## Notes and News.

*Switzerland.*—The editor publishes a letter dated Basle 5th October, 1918, received by him from Lieut.-Colonel Carl Frey of the Swiss General Staff, wherein complaint is made of the notice published, in the number of the *Revue* for September last, on Professor Allier's book *Les Allemands à Saint Dié*; the notice in question should not, in Colonel Frey's opinion, have appeared in a *neutral technical and scientific publication* in view of the nature of the criticisms contained therein, which are alleged to indicate an unneutral attitude on the part of the writer of the review, who stated, *inter alia*, that Germany was responsible for the great world war.

The editor contests the views of Colonel Frey, whose notions on "neutrality," he says, are synonymous with "abdication." There is no reason, he continues, because, in certain quarters of Switzerland, a "capitulation of the heart and of intelligence" has distorted the views of a section of the people on certain matters that others should also surrender their spiritual independence.

Dealing with the queston of the responsibility for the war, the writer of the original Note points out the absurdity of the view that no reference in relation thereto can be made until such responsiblity has been judicially established. Attention is also drawn to the fact that both the *Berliner Tageblatt* and the *Frankfürter Zeitung* admit that the imperial military and naval authorities in Germany have been constantly and criminally guilty of telling lies on the above subject.

It is stated that Switzerland has had to mobilize her forces just at a time when America and the remainder of Europe were on the point of disbanding portions of their armies. Not having occasion to fight a foreign foe, Swiss troops have had to be called out in order to avoid Civil War. The cause of all the trouble in Switzerland arises from the fact that Zurich is under the domination of Germano-Bolshevik elements. The Swiss troops have, it is said, behaved in an exemplary manner in very trying circumstances. The situation in Switzerland is a peculiarly difficult one at the moment, but she has no need, it is pointed out, for a Hohenzollern with clay feet.

The influenza epidemic has claimed many victims in Switzerland; among those that have succumbed to the disease is Lieut.-Colonel Rouge Commanding the 5th Regiment of Infantry.

*Great Britain.*—An abridgment is published of the articles by R. K. Tomlin, Junr., which appeared in the number of the *Engineering News Record* for the 13th and 20th June last. The light railways constructed in the British sector of the Western Front are dealt with therein.

*International News.*—A short description is given of the allied "push" on the Somme, which began on the 8th August last; the events down to the 12th September are very briefly sketched. It is stated that during the period in question the French light tanks played a conspicuous part. There were three types of these tanks: the Saint Chamond, weighing 23 tons, armed with one long 75 mm. gun and 4 machine guns; the Schneider, weighing 13 tons, armed with one short 75 mm. gun and two machine guns; and the Renault weighing 6 tons, armed with one 37 mm gun and one machine gun. The last mentioned type can travel at a speed of from 7 to 8 miles per hour; numbers of tanks of this type have been engaged since the 27th May, and, during the period June to September last, have been daily making charges at the head of the French infantry, much as Murat's cavalry did at Eylan.

Notices on two books, *À l'École de la Guerre* by Major Jules Henches and *Traité de la Guerre*, anonymously published by Bossard of Paris, appear in the section of the *Revue* entitled *Bulletin Bibliographique*.

W. A. J. O'MEARA.