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MINING.

AERIAL ROPEWAYS.

By CAPT. and BT. MAJOR F. H. BUDDEN, M.C., R.E.

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I.

AN aerial ropeway is a means by which loads can be transported from one place to another in carriers suspended from cables, which are supported on standards spaced at various intervals. By this means it is not necessary to prepare an expensive roadway such as is required for motors, railways, etc., nor is it necessary to follow the contour of the ground, but gaps can be crossed, mountains climbed, without very great expense.

II. TYPES.

1. Aerial ropeways may be divided into two distinct types: (*a*) Monocable, where a single endless rope is used to support and move the loads; (*b*) Bicable (or Tricable, as it is called on the continent in Europe), where the loads are supported on two carrying ropes and moved by one endless hauling rope.

2. There are also certain variations of these types, such as the "Fixed Clip System" on the Monocable type, and the "Jig-back" or "To-and-fro System," which is applicable to both types. As a general rule, both the Monocable and Bicable types are so arranged that it is not necessary to stop the hauling rope to attach or detach loads at the stations at either end of any one section.

III. CHOICE OF SYSTEM.

1. There is a certain amount of difference of opinion as to which system, the monocable or the bicable, is the better. On the continent the bicable (or the tricable) system is preferred, while in England the monocable is generally installed. The reasons for this difference of opinion are that, when aerial ropeways were first introduced, the bicable system was adopted by continental makers and was developed to such an extent by two German firms that for many years the bicable system was in practice the better of the two for all heavy work and steep gradients. Since then the monocable system has been improved by English firms, especially by Messrs. Ropeway, Ltd., so that it is now a serious competitor to the bicable system, and in many cases has ousted the latter system.

2. *The advantages claimed for the bicable system are that :—*

(*a*) the carrying and hauling ropes have different functions to perform and can be designed to fulfil them, *i.e.*, the carrying ropes can be made large and stiff enough to carry heavy loads, while the hauling rope can be made flexible. Also in the case where the loads in one direction are heavier than the loads in the opposite direction, the carrying rope for the lighter loads can be made smaller. This is not possible in the case of the monocable system ;

(*b*) the life of the ropes is longer ;

(*c*) gradients as steep as 1 in 1 between tops of trestles can be traversed ;

(*d*) heavier loads can be carried ;

(*e*) trestles can be spaced at a greater distance apart.

3. *The advantages claimed for the monocable system are that :—*

(*a*) it is cheaper in first cost ;

(*b*) easier to transport and erect ;

(*c*) easier and cheaper to maintain ;

(*d*) there is less likelihood of damage to the system in high winds, as with the bicable system the hauling and carrying ropes are liable to get caught up together ;

(*e*) it is safer, as the single rope is always passing under observation at the terminal stations and can be watched for the first sign of wear, and moreover can be more easily lubricated. Also, when the rope on the monocable system breaks the loads merely sink to the ground, whereas in the bicable system when the carrying rope breaks the hauling rope still goes on and the loads are liable to damage the trestles, and should the hauling rope break, the loads still remain on the carrying rope and are liable to crash into each other ;

(*f*) for all practical purposes the monocable can traverse all hills that are likely to be met with, as, with the improved carriers introduced by Ropeways, Ltd., gradients of 1 in 1½ can be climbed ;

(*g*) loads can now be arranged to be dumped automatically where required, although at first this was only possible with the bicable system.

4. From the above it will be seen that each system has certain advantages, and it depends on the ground to be covered, the loads to be carried, and the total tonnage to be transported per hour whether the monocable or the bicable, or a combination of both, should be installed, and only an expert can decide this.

5. For instance, in case of a long line in which occurs a very large span, and which with a monocable might entail the use of a very

heavy rope throughout the section, it might be advisable to instal a bicable line and use heavy carrying ropes over the long span only, the remainder of the section having carrying ropes of smaller diameter.

6. In all cases the advice of an expert should be obtained, and any extra expense entailed will be repaid many times over by a decrease in the running costs.

IV. Location and Design of Ropeways.

1. After it has been decided that it is desirable to join up two places by an aerial ropeway, various details in connection with the exact location and design of the ropeway have to be settled.

2. *Location of stations.*—In this connection attention must be paid to the following points:—(*a*) loading and unloading stations should be at convenient points for transhipment; (*b*) the straightest route is preferred, provided that it does not entail too great spans. Details of limiting spans are given later; (*c*) length and grades of each section should be adjusted so that suitable positions can be found for intermediate stations and the power of the motors selected for use can be fully utilized. Where the gradients are favourable, sections have been made as long as five miles on the monocable system, such as for the Pure Salt Co., Spain, but the normal section is, of course, less.

3. *Positions of Motors and Tensioning Arrangements.*—A line of considerable length consists of a number of sections, each of which is worked by its own motor or motors, and for each of which there are separate tensioning arrangements. For convenience of supervision and cheaper cost of running it is generally preferable to have the motors of two adjacent sections together so that in a line of two sections, the tensioning arrangements might be at the loading and unloading stations, while the motors working both sections might be situated at the intermediate station for convenience of supervision.

4. But there is another factor which must be taken into account, and that is that it is preferable to have the motor, if possible, at the higher station, in order to have direct haulage on the rope. This is said by Italian experts to reduce the power necessary by 20 per cent., and also the wear of the rope.

5. *Gradients.*—In the case of the bicable system gradients of 45°, or 1 in 1, can be surmounted, whereas with the monocable system the limiting gradient is 1 in $1\frac{1}{2}$, and this is only possible with a much-improved clip introduced by Ropeways, Ltd., and described under "carriers." Previous to this the limiting gradient was 1 in $2\frac{1}{2}$, and this was said to be one of the disadvantages of the monocable system.

6. Italian experts state that for heavy lines the change of grade at any trestle should not ordinarily exceed 3°, and the maximum

allowable is 4°. For light lines, however, the change of grade may be as high as 8°.

7. *Curves.*—Curves are not desirable on either system, but are less harmful on the monocable system. In any case the change of direction at any one standard should not exceed 1°. An example of what has been done in the way of curves can be found at the Shropshire Mines Ropeway, Minsterley, England, built on the monocable system.

8. This line is 25½ miles long and is designed to carry 20 tons per hour. A curve occurs about 13,910 ft. from the loading station and is 2,703 ft. long. The angle between tangents is 6° 43′, and the curve is completed in eight spans with a deviation of about 1° at each trestle. On the trestles in the curve the sheaves are mounted as usual on balance beams. The balance beam carrying the sheaves is suspended on a laterally-swinging arm which permits the beam and sheaves to swing outwards or inwards from the standard while the load passes, and this obviates any tendency for the rope to mount the flanges of the sheaves owing to change of direction. The wear on the sheaves is admitted to be slightly increased owing to the curve, but it is not great (*vide Sketch* 1).

9. *Spacing of Standards.*—It is difficult to lay down any definite ruling on this point. The spacing may vary in the case of a bicable system from 1,500 metres, when crossing a gap, to 25 metres, when changing slope at the crossing of a spur.

10. In the case of a monocable system one of the largest gaps crossed was 1,090 metres between standards on a ropeway for the Porco Tin Mines, Ltd., Bolivia, S. America. The longest recorded span, however is one of 3,600 ft. in the Andes. An average spacing on ordinary ground would be anything between 100 and 200 yds. between trestles.

11. *Capacity of Line and Individual Loads.*—When possible, individual loads should be kept to about 1 per cent. of the hourly capacity for capacities above 10 tons per hour. Heavy individual loads tend to increase prime costs.

12. Most ropeways are designed for a capacity from 20 to 50 tons an hour, but even with the monocable system a capacity of 150 tons an hour has been obtained (for the Compañia Española de Minas del Ref, Spain).

13. If, however, special loads, such as timber in log, have to be carried, the problem becomes different. In this case the design has to be worked out for the maximum load anticipated.

14. Generally the prime cost of the installation is largely dependent on the maximum individual load to be handled.

15. The following table, giving a rough idea of the capabilities of the various systems mentioned, shows the maximum lengths,

capacities and loads carried on various lines at present working or in course of construction :—

System.	Present maximum lengths.	Present maximum hourly capacity.	Present maximum individual load.
Monocable ...	80,196 yds.	200 tons	1½ tons
Bicable	38,800 ,,	250 ,,	2 ,,
Fixed Clip ...	2,330 ,,	8 ,,	4 cwts.
To-and-Fro ...	1,850 ,,	Passenger's weight unknown.	17 tons

16. *Speed of Hauling Rope.*—The usual speed is about 2 metres per second, or about 400 ft. per minute, although in some cases a speed of 2½ metres per second has been allowed. In case of urgent necessity a speed of 3 metres per second can be allowed for a short time, but it has been found that carriers can best be fed on to the rope at a speed of about 400 ft. per minute, and as it is very desirable that the carrier should be travelling at the same rate as the hauling rope when the clip engages, this is the usual speed, otherwise the hauling rope is liable to be worn out too quickly.

17. In many cases automatic regulators are used to regulate the speed of the motors under a light load.

18. *Dip.*—Italian experts allow in practice a dip of 4 metres vertical in 100 metres of span. It often happens that the dip is the determining factor in calculating the diameter of the carrying rope. In calculating the catenary, the ropes are selected to carry a load greater by 50 per cent. than is expected for the actual total load.

19. The dip can also be obtained from the formula

$$\text{Dip} = \frac{L^2 W}{8 T}$$

where L = span, W = weight per unit length, 8 = constant, T = tension, and from this the supporting trestles can be placed.

20. It sometimes happens, however, in practice, that when the rope is fully tensioned it floats or rises up from the supporting trestle, due to some slight error in calculation. To overcome this, some Italian makers provide clips to hold the carrying rope down on the supporting saddles. This is only done for light lines which are erected in a hurry, as often happens in war.

21. Otherwise a so-called factor of safety is employed by continental makers, that is, the denominator 8 T in the formula $\text{Dip} = \frac{L^2 W}{8 T}$ is multiplied by some constant which varies according to the ropes employed. In the case of locked coil ropes, the factor may be 1·1, and in the case of spiral ropes up to 1·5. By a use of some such factor the calculated dip is less than the actual, and so the supporting trestles are made slightly higher than it is theoretically necessary, but any possibility of floating is obviated.

22. *Diameter of Carrying Ropes.*—It has been proved by experience that most trouble is caused by breaking due to bending near the saddles, and for this reason, in order to obtain the diameter of the carrying rope required, some firms employ formulæ based on stresses due to bending.

23. A formula often used is :—

Weight per metre of rope $= \frac{0{\cdot}85}{100}$ [(weight of carrier) + (distance between carriers in metres) × (weight of hauling rope per metre)].

This is for spirally-wound ropes.

With locked coil ropes the factor 0·85 becomes 1·05.

This formula works well for small lines up to about 50 tons capacity hourly. For each additional 5 tons, 0·05 should be added to the factor 0·85.

24. *Diameter of Hauling Ropes.*—The diameter of the hauling rope depends upon the highest tension occurring in it.

Tension of rope in lbs.

$$= \left\{\text{initial tension} + \left(\frac{W}{S} \times H\right) + \left(w \times H\right)\right\} + \{(w \times \mu_1 \times N) + (L \times \mu_2 \times w) + (R \times 2)\}.$$

where W = weight of full carrier; S = spacing of carriers in feet; H = difference in level between stations in feet; w = weight per foot of hauling rope; μ_1 = coefficient of friction of cars; μ_2 = coefficient of friction for hauling rope; L = length of line in feet; N = number of carriers on one side of line; R = number of supporting rollers on one side of line.

This tension, if multiplied by the factor of safety—6 to 8—and divided by the breaking stress, gives the area of the rope necessary. This is for the general case with the drive at the upper terminal and the loads ascending. When the loads are descending, the plus sign in the centre of the formula becomes minus. To obtain the tension when the ropeway is just put into work, the second half of the formula should be doubled.

25. The usual breaking stresses of hauling ropes are from 80 to 115 tons per square inch. The surge of the hauling rope tension sheave depends upon distance apart of the carriers, long spans occurring in the line, etc. As an average, 6 ft. play may be allowed for to commence with, and then an additional 12 ft. for each mile of length. In some cases, in long lines it is necessary to split up the line into sections, to avoid excessive tensions occurring.

V. Ropes.

1. *Types.*—There are three main types of ropes used on aerial ropeways: (i) Lock coil and semi-lock coil; (ii) spirally-wound or helicoidal; (iii) stranded rope with Lang's lay.

2. On the bicable system carrying ropes are generally of lock or semi-lock coil in the case of heavy installations, and spirally-wound in the case of lighter installations.

3. There are three types of lock or semi-lock coil rope, as shown in *Sketches* 2, 3 and 4.

The semi-lock coil consists of a spiral coil surrounded by a layer of round wires kept apart by wires drawn to a special section. Though with not quite so smooth a surface, it has the advantage of being cheaper.

4. The special advantages claimed for lock and semi-lock coil ropes are that :—

(*a*) there is minimum friction ;
(*b*) they have a longer life (Messrs. Spadaccini, an Italian firm, put it at 50 per cent. longer than that of stranded ropes) ;
(*c*) ropes are not deformed if one strand breaks ;—broken strands are liable to derail carriers.

5. The disadvantages are :—

(*a*) greater cost, at least 30 per cent. greater than spirally-wound ropes ;
(*b*) steel of maximum tensile strength cannot be employed in their manufacture ;
(*c*) cannot be spliced,—special sockets must be used for joining.

6. Spirally-wound ropes are cheaper than lock or semi-lock ropes and can be joined by splicing, and so are often used for lighter installations, as there is not much friction and they are better than stranded ropes with Lang's lay.

7. Stranded ropes with Lang's lay are used as carrying ropes when other types are not available, but with a hemp core they are nearly invariably used as hauling ropes.

8. Stranded ropes with ordinary lay are not used either as carrying or hauling ropes except as a last resort.

9. *Wear and Life of Rope.*—In the bicable system the wear to the carrying rope occurs on the top side of the ropes in spans, and on the bottom side in saddles ; and in addition, the vibration occurring in spans is damped down near saddles, causing fatigue in the wires. For this reason, to obtain the maximum life out of the carrying ropes, they must be shifted periodically and shortened at couplings so that positions of wear and fatigue may be changed.

10. In the monocable system the wear to the rope is distributed, and as the rope is continually passing round the terminal sheaves, inspection is easy, and a broken wire is easily detected and can be repaired before any damage is done. So, with the monocable system complete rope failure with efficient inspection is practically unheard-of, whereas even with the most careful inspection the carrying rope

in the bicable system may fail completely, as it is very difficult to find out the state of the rope.

11. Italian experts attach great importance to the fact that in the monocable system the rope tends to revolve during its passage, but is prevented at the points where it is gripped by the carrier clips, and for this reason the life of the rope is very short. English experts, however, state that this has very little effect on the life of the rope, and point out that, if this was so, the same thing would happen to the hauling rope in the bicable system, which apparently is not the case.

12. Messrs. Spadaccini and other Italian firms estimate the life of lock and semi-lock coil rope at 12 years and of other types at about 8 years, when used on a bicable system, but put the life of a rope on a monocable system at about one year.

13. English firms, however, disagree and put the life of a rope in a monocable system at about two years, and of a lock-coil rope on a bicable system at about eight years. These figures are calculated on a basis of eight hours' work a day and 250 working days in a year, under peace conditions.

For war the above figures, showing the average life of a rope, should be halved.

14. The number of years a rope lasts is not altogether a true criterion of the life of a rope, as, in the case of a heavy installation the life of the rope is shorter, and the total tonnage moved must be taken into consideration.

15. It has been found that for locked-coil ropes a breaking stress of about 65 tons per sq. in. is about the best and for spiral ropes about 95 tons per sq. in. This is much the same as has been found by Italian firms, who state that the breaking strain of a rope in kilos is :—

In case of lock and semi-lock coil ropes—
number of wires × cross sectional area of a wire × 100.
In case of other ropes—
number of wires × cross sectional area of a wire × 150.

16. *Lubrication.*—The hauling rope of a bicable system and the rope of a monocable system are lubricated at the terminal sheave by some form of drip-feed, while to lubricate the carrying ropes of a bicable system it is either necessary to send a man standing in a carrier at a slow speed, or to use an automatic lubricating machine attached to a carrier, but the latter is not altogether satisfactory, as the lubrication is not under observation, although with large spans it is often necessary to use it.

17. A mixture of Swedish oil, tar, tallow and pine resin is often used for lubricating the ropes. The tar acts as a water-proofing agent.

18. *Splicing of Ropes.*—Lock and semi-lock coil ropes cannot be spliced, and for them special clips are necessary, examples of which are shown in the accompanying *Sketches* 5 and 6. The individual

wires of the rope can be opened out and wedges driven in and a cap screwed on or molten lead run in. For all other ropes splicing is used. One Italian expert stated that they allowed one metre of splicing for each mm. in the diameter of the rope.

19. *Cost of Ropes.*—Post-war figures of the cost of ropes are not available, but ropes should only be bought from well-known wire rope and cable firms. Lock-coil ropes are the most expensive and are probably not less than 30 per cent. more expensive than spirally-wound ropes.

20. *The Relative Position of the Carrying and Hauling Ropes in the Bicable System.*—Some firms prefer the hauling rope above the carrying rope, as the type of coupling used is lighter and cheaper, and the length of the stations is shorter because the hauling rope may be led in and out of the jaws without interfering with the shunt rails.

21. But the overhead type of coupling has one great disadvantage when ascending a steep gradient, as the hauling rope reaction falls outside the wheel base, and this tends to make the carrier rock, and in some cases forces it off the carrying rope. In such cases the under-type grip should be used. Italian practice, as a whole, is in favour of the under-type coupling, while English practice prefers the over-head type, except on steep gradients.

22. *Varying Stresses Caused by Hauling Rope in the Bicable System when the Hauling Rope is Below the Carrying Rope.*—It sometimes happens at a trestle, on either side of which there are long spans, that there is a considerable downward pressure at the trestle caused by the hauling rope, and not only has the trestle itself to be strengthened, but in some cases the carrying rope, where it passes over the saddle, has to be protected by means of a steel plate cap, over which the carrier runs, as the pressure on the rope is greater than that allowed for. Some authorities recommend the use of a steel cap when the hauling rope reaction exceeds 450 lbs. per sq. in., but there is a difference of opinion whether steel caps are necessary or not.

23. An opposite reaction occurs at the centre of a long span, as the hauling rope tends to bear part of the weight of the carrier, and this makes the runners less secure on the carrying rope, and more liable to be blown off by high winds.

VI. Carriers.

1. These may be divided into:—(A) those used on a bicable system; (B) those used on a monocable system.

2. Taking the former (A) first, carriers may be divided into: (*a*) those employing screw grips depending on the weight of the load, and (*b*) those employing counter-weighted lever grips, each group being subdivided into those employing the overtype or the undertype grips.

3. It is not proposed to give a detailed description of every type of carrier in use, but only to describe certain typical examples. The advantages and disadvantages of the overtype and undertype grips have already been discussed under "Ropes."

4. A carrier on the bicable system consists of three parts :. (*a*) the runners; (*b*) the box or receptacle; (*c*) the hanging frame with coupling.

5. *Runners.*—The runners consist of one, two or four wheels deeply grooved which run along the carrying ropes. The usual runner has two wheels.

6. The running wheels should be of high quality steel, and the diameter of the wheels depends on the load, and type of rope. Larger wheels are required with spiral ropes than with lock-coil ropes.

7. The following table gives, according to one authority, average size of wheels for carriers with two wheels on lock-coil ropes.

Weight of load and carrier.	*Diameter of wheel.*
14 cwt.	8 inches
30 ,,	10 ,,
40 ,,	12 ,,

8. The wheels may or may not have ball bearings. Such bearings are said to reduce by one-third the traction power required, but their cost is double that of the ordinary type.

9. Italian firms state that on lines with small gradients where practically all the traction force is used in overcoming friction, the use of ball bearings is worth the extra cost, but that this is not the case on lines with steep gradients where the greater part of the traction force is used in raising the load. Whatever type is chosen, the runner pins should be self-oiling, to reduce friction as much as possible.

10. *Boxes or Receptacles.*—These are of various types and are made to suit the loads to be carried.

Common forms are :—(i) open wooden boxes with low sides; (ii) iron bucket pattern; (iii) long iron stretcher-shaped frames with wire-netting bottoms and sides.

11. Special single loads, such as baulks of timber or guns, are carried by using two sets of runners, to which the loads are slung by means of ropes.

12. *Couplings.*—The advantages of couplings employing counter-weighted lever grips are :—(*a*) the cost is much lower than those with screw grips depending on the load; (*b*) on small installations, where shunting devices are not used, the coupling and uncoupling can be done by hand without stopping the motor; (*c*) certainty of action and easy regulation of the grip on the hauling rope.

13. Their disadvantages are that they cannot be used on steep gradients or for very heavy loads.

14. The coupling is actuated by the counter-weight lever which, as the load is pushed forward by hand along the shunting rail at the loading station, meets and bears against an inclined plane which turns the lever over one-third of a circle and forces the jaws to grip the rope. On reaching the unloading station it similarly meets an inclined plane which reverses the process. The jaws open and the carrier runs on to the shunt rail. The system is automatic and simple.

15. An example is shown in the accompanying *Sketch* 7.

16. Typical examples of couplings employing a screw grip depending on the load are shown by the "Ideal" couplings, made by Ceretti and Tanfani, and another form of coupling where the grip acts through a simple system of levers.

17. The "Ideal" coupling is actuated as follows (*vide Sketches* 8 and 9):—When running on the carrying rope the weight of the carrier keeps the jaws of the grip closed. As the carrier reaches the unloading station the runners leave the carrying rope and are run along a shunt rail. As they do so, a wheel fixed at one side meets an inclined plane up which it is forced, and thus takes the weight off the runners, releases the jaws and moves the grip clear of the hauling rope.

18. To ensure that the runner wheels shall not rise from the shunt rail at the time when the side wheel engages the inclined plane, an upper guard rail is fixed to keep them in place.

19. The following are some of the advantages claimed by the makers for this type:—(*a*) simplicity, in that there are no levers or springs to weaken the device; (*b*) by varying the slot the speed at which the grip is applied at the moment of starting can be regulated, sudden jar on the hauling rope can thus be avoided, and the life of the rope thereby lengthened; (*c*) the force of the grip remains constant, whatever the gradient of the carrying rope; this type is effective up to gradients of 1 in 1 (according to makers); (*d*) certainty of action.

20. In the second type the pressure of the grip is applied by the weight of the carrier and the load acting through a simple system of levers to give a multiplied pressure on the jaws. The grip is released by lifting the load, which is accomplished by means of small rollers running on to the shunt rails in the stations (*vide Sketch* 10).

21. Another type of coupling in which the grip is a function of the load is the "Vatellina" coupling, made by the B.B.B. firm (*vide Sketch* 11). The arrangement is as follows:—

22. The runner wheel has a hook below it. In this hook are two rings held together at the bottom by the eye of a second hook, in which hang the carrying chains.

23. The hauling rope passes between the rings, and the weight of the load forces the latter to grip it. This form of coupling cannot be used on the automatic system, as the hauling rope must be stopped

when the carrier gets near the end of its run. It is therefore only suitable for short lines of small capacity.

24. It is cheap, simple and reliable, and a very convenient one for carrying long loads, such as guns, as two couplings can be used, one at each end.

25. In case the runner should jump off the carrying rope, a safety-chain is passed round the hauling rope and both ends are hooked through the ends of the supporting chains. In the case of a break of the carrying rope, the hauling rope would, within the limits of its strength, support the load.

26. In conjunction with this coupling a small clip is fixed on the hauling rope close to each grip as a further safeguard against slipping.

27. The B.B.B. make a speciality of a form of grip to reduce tensional friction both for the monocable and bicable systems.

28. The grip, which is actuated on the counter-weight principle, consists of a single roller which holds the rope against a jaw, or of two rollers which grip the rope between them; in either case the rope, though gripped, is allowed to rotate.

29. The grip has to be adjusted to each rope by means of packing pieces, a somewhat clumsy expedient. The design, however, overcomes what Italian firms call an important defect, especially of the monocable system.

30. This coupling was not seen at any of the installations visited, but the single roller and jaw type was said to have been largely used in the installations (bicable type) at Monte Pesubic, and to have been effective on gradients as steep as 4 in 5, and to be capable of taking loads up to 800 kilos, using a special heavy coupling.

31. Among the best-known couplings for the monocable system are Roe's patent Toggle and Saddle clips.

32. The clip, shown in *Sketch* 12, is capable of sustaining a load at an angle of about 45° and in theory is the most efficient of all clips actuated by the load, as the whole of the tare weight also is used for gripping. Another type, which is more usually employed, as it is cheaper, on gradients which do not exceed 1 in $2\frac{1}{4}$, is shown in *Sketch* 13.

33. The gripping in this type is performed by two cast chilled saddles, the sides of which are inclined, one side having a feather projection. It is so formed that it disengages itself without damaging the strands when the carrier enters a station.

34. A rough sketch of a type seen at an Austrian Installation at Matarello in the Trentino is given in *Sketch* 14.

When the wheel A is on the shunt rail it supports the carrier and the jaws are open. As it leaves the shunt rail the jaws are closed by the pressure of the cable on the two forked prongs at the mouth of the jaw.

VII. Trestles.

1. Trestles can be of steel or wood, and may have one, two, three or four legs. Some typical examples are shown in *Sketches* 16 to 19.

2. Trestles are usually set in concrete, but this is not done in light portable installations. On the large lines it is the Italian practice to erect the trestles vertical, but on the lighter lines they prefer to have the trestles normal to the line of the rope, though this is not always done. When crossing a span it is important that the trestles should be adjusted to form equal angles with the rope on either side.

3. Trestles vary in height from a theoretical minimum of 2½ metres upwards.

4. In an aerial ropeway between Manizales, Columbia, and Mariquita over the Andes, there are eight steel trestles over 130 ft. in height, two of which are 217 ft. high.

5. Along ordinary ground of even grade the height is regulated by:—(*a*) the desirability of keeping the grade as even as possible; (*b*) the headroom required in the centre of the span.

6. When there is a large difference of level between two points the line of the catenary is plotted on the profile, as already explained, and the heights of the standards regulated to suit this.

7. Some firms make standards which can be heightened by increments of one metre, but this is not universal and would be suitable only for light installations.

8. The chief point of interest in a trestle is the method by which it supports the carrying rope.

9. In the bicable system the carrying rope is supported in grooved fixed or oscillating saddles, whereas in the monocable system the rope is generally supported on revolving sheaves arranged in groups of two, four or eight according to the calculated pressure the trestle is expected to bear.

10. These sheaves are mounted on balance beams in such a way that each sheave takes its correct share of the pressure. Their use enables a trestle in a monocable line to take pressures which, in case of a bicable, would have to be met either by putting in an extra trestle or by providing rail supports. A monocable line may, therefore, be constructed with less trestling than a bicable, and thus save in material and expense. An example of a balance beam is shown in *Sketch* 1, and examples of trestles for a monocable line in *Sketches* 18 and 19.

11. In the bicable system pairs of saddles are employed where there is a great change of slope at any one trestle or where the pressure is more than one saddle can bear.

12. Oscillating saddles are as a rule preferred, and to save the wear on the ropes, the ends of the arms of the saddles are sometimes made of soft iron so that the saddle should wear and not the rope.

13. In the bicable system the trestles are fitted with pulley wheels over which the endless hauling cable runs, and with guides to ensure that the hauling rope returns to its position on the pulley wheel after the carrier has passed. Examples of these are shown in *Sketches* 15 to 17.

14. To prevent wear of the hauling rope the pulleys are often fitted with removable soft iron treads which can be replaced when worn. This tread is a ring made in two sections which can be replaced without dismantling the complete pulley.

VIII. STATIONS.

1. Stations can be either:—(*a*) terminal stations for loading and unloading; (*b*) intermediate motor stations; (*c*) intermediate tension stations; (*d*) angle stations; or a combination of two of the above.

2. Stations on the bicable system are much bigger and more complicated affairs than on the monocable system, but the bicable has the advantage that, as the carriers are always gripped by the hauling rope, the working at stations where there is no unloading or loading can be made automatic.

3. On the monocable, however, when a carrier leaves the rope it must be pushed by hand, although the labour of pushing the carriers on the shunt rails can be minimized by grading the shunt rails.

4. *Shunt Rails.*—For a line to have any large capacity it is necessary to have some means of loading and unloading without having to stop the motor. This is done by the use of shunt rails on to which the carrier runs when it reaches the unloading station, and from which it is launched from the loading station.

5. Two small rollers are provided on one side of the coupling which are not in use when the load is on the carrying rope. On re-entering a station these two rollers run along the shunt rail, which is at a different angle to the carrying rope, and so take the weight of the carrier and at the same time allow the jaws of the grip of the coupling to open and disengage from the hauling rope. The carrier is then run along the shunt rail to some suitable place for unloading, or on to the next section of the ropeway.

6. Stations can be large closed-in buildings built with concrete and iron roofs, or small open buildings with some light form of roof. Some form of light roof is always provided.

7. *Driving Power.*—Various types of power can be utilized for driving a ropeway, such as petrol and electric motors, oil and steam engines, etc.

8. The amount necessary is obtained from the following formula:—
Power in ft. lbs.

$$= \left[\left(W_1 \times W_2 \times \mu_1 \times \frac{N}{2} \times V\right) + (w \times 2L \times \mu_2 \times V) + (2R \times V) + F\right]$$

$+$ or $-$ theoretical power

where W_1=weight of full carrier; W_2=weight of empty carrier; μ_1=coefficient of friction for cars; N=total number of cars on line; V=velocity in ft. per min. of cars; w=weight per ft. of hauling cable; L=length of line in ft.; μ_2=coefficient of friction for hauling cable; R=number of supporting pulleys; F=power required for station friction.

9. The first four factors give the power necessary to overcome friction, and the theoretical power required or developed depends upon whether loads are ascending or descending.

10. The factor for station friction varies greatly for different lines and is solely a matter of experience, although 0·02 of the total weight of the moving parts in the station multiplied by the speed may be taken as a good mean.

11. As already explained, some motors are fitted with a governing arrangement so that the speed of the hauling rope should not increase under a light load.

12. Special motors have been designed for light portable installations to work over lengths of 1 to 2½ kilometres with individual loads not exceeding 180 kilos, and spans not exceeding 250 metres, by Messrs. Spadaccini of Milan and Messrs. Badoni Bellari and Benazzoli of Lecco and Milan.

13. In permanent installations the motor is, as a rule, set in concrete. In light installations, however, the under-frame is often bedded into the ground for a few inches and filled with boulders, the motor itself being bolted to the under-frame and in some cases further steadied by sand-bags piled on the top of the upper-frame.

14. *Types of Tensioning Arrangements—Carrying Rope.*—The Italians and the Austrians tension the carrying ropes by hand-winch block and tackle, the strain being applied to the rope by a separate wire rope clipped on to it.

15. After getting the requisite tension, the rope is, in the case of light installations, made fast, either to the framework of the motor bed, or to some anchorage.

16. In the case of heavy lines it is made fast to a counter-weight. In Italian practice this counter-weight is usually a large box loaded with stone or other weighty material. The Austrians employ in their large installations counter-weights made up of layers of concrete segments which can be added as required to get the desired weight.

17. *Hauling Rope.*—On light lines tension is got by adjusting the distance between the driving and idle pulleys at the motor station by means of a wheel actuating a screw-threaded tension bar.

18. On heavy lines tension is applied by adjusting the idle pulley wheels at the tension station by block and tackle, and then either making fast to some anchorage or attaching a counter-weight, as in the case of carrying ropes.

19. If the station is not raised, a well must be dug to allow for the

rise and fall of the counter-weight. In the case of the Austrian Installation at Calliano the passage of a light load was seen to cause a rise of 6 ft.

20. The tension of the carrying rope is generally about 3 to 4 tons per kilometre. That of the hauling rope is, of course, less.

21. An instrument for registering the tension is often provided.

22. *Framework of Stations.*—Both timber and steel are used, according to local conditions. The light Italian installations seen were mostly built of "L" steel.

A light roof as protection from the weather is always provided.

23. *Sketch* 20 shows an arrangement used by Ropeways, Ltd., which combines a multiplying and taking-up device. The two sheaves at A are attached to the tension trolley, the winch and the differential drum being mounted on an independent frame placed over the tension pit; one end of the rope B is anchored, the other being made fast to the tension winch drum. By this arrangement the resultant pull at A is four times the dead weight applied at C, and the weight can always be kept in suspension without the necessity of a deep pit by taking in the slack with the winch.

IX. Automatic Dumping.

One of the most common uses for ropeways in commercial work is the automatic dumping of refuse from mines.

Until recently the automatic dumping was possible only on the bicable system, but the principle has now been applied with success to the monocable. How this is carried out is shown in *Sketch* 19 of a monocable installation at Tredegar.

X. Fixed Clip Single Rope System.

1. This type of ropeway is only applicable for light capacities, and is used largely on plantations and for the transport of valuable ores, where comparatively small quantities are handled.

2. The carrier head, *Fig.* 21, is permanently attached to the rope by means of a spring steel strap, and is designed in such a way that it can pass freely over trestle sheaves, under depression wheels and round the terminals, without being detached from the rope. As both rope and carriers are in constant motion, loading has to be done by hand, or by means of a travelling hopper, which is usually hung from overhead rails at the terminal. The terminals are extremely simple and compact, as all shunt rails are done away with. The tension terminal is usually mounted on a trolly or on skids, the whole being movable by means of tension gear, to allow for stretch of rope, etc. Angles can be worked with the fixed clip system but they should be avoided if possible, as they tend to produce excessive rope and gear wear at such places.

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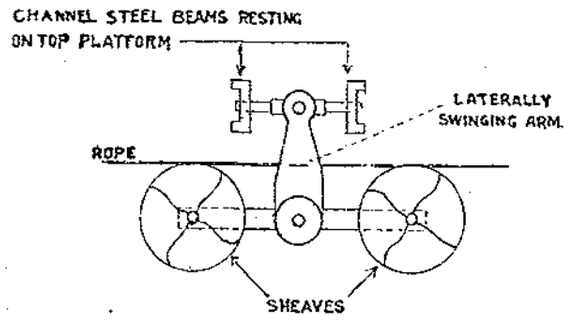

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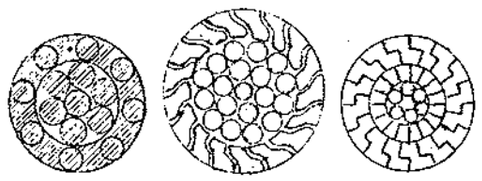

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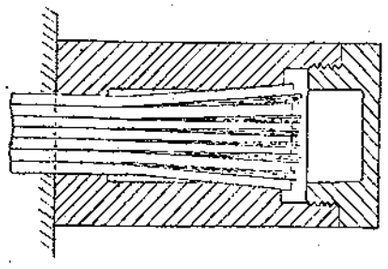

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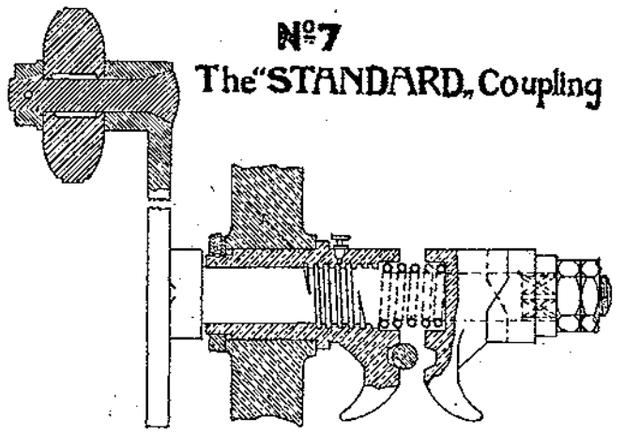

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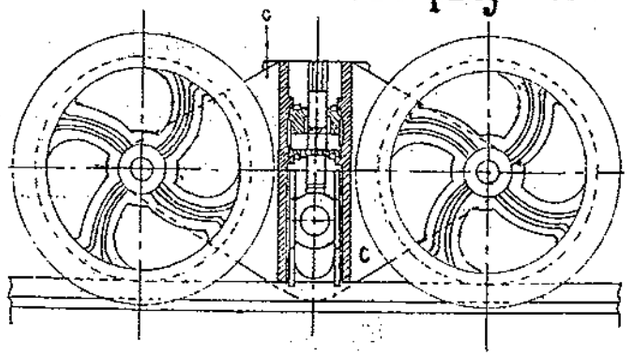

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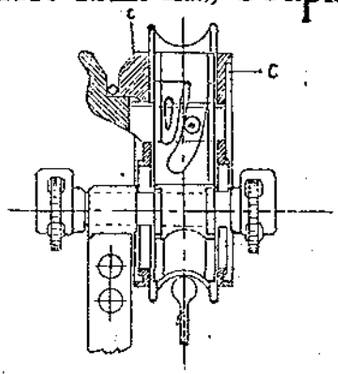

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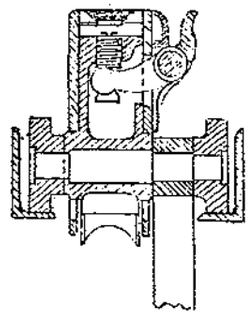

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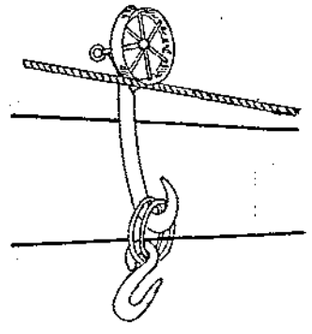

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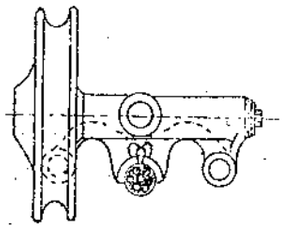

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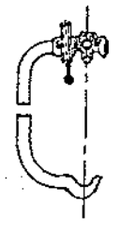

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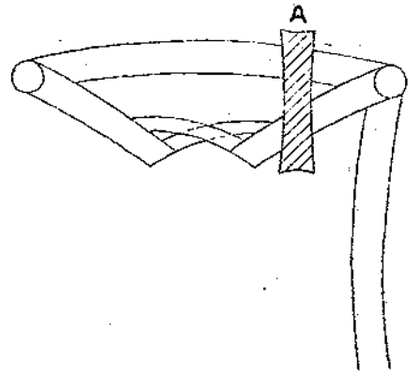

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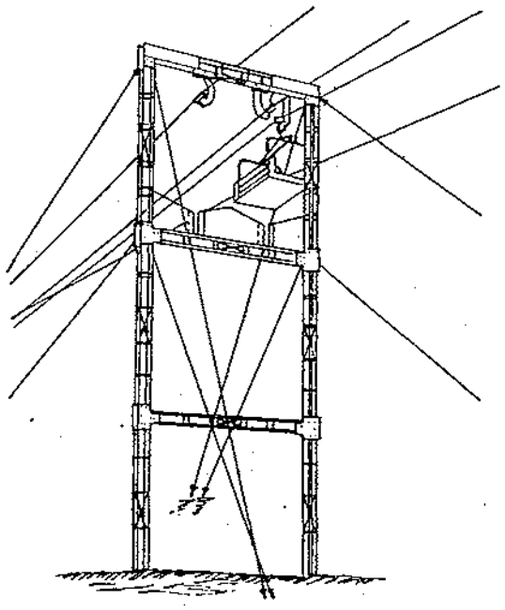

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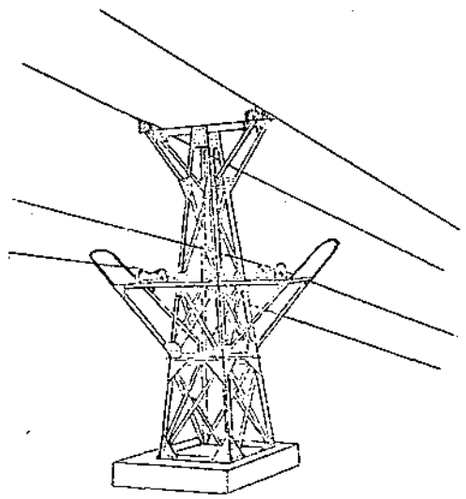

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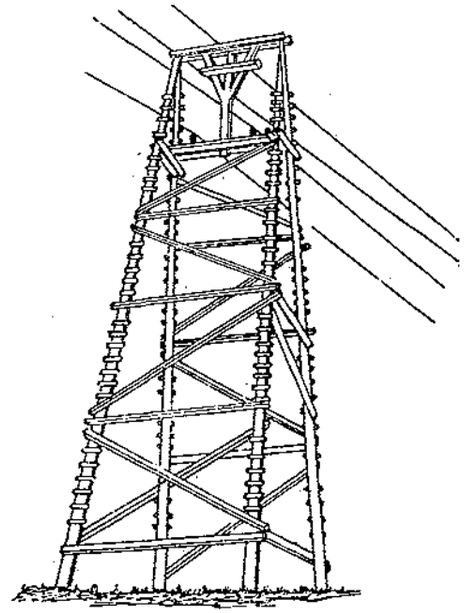

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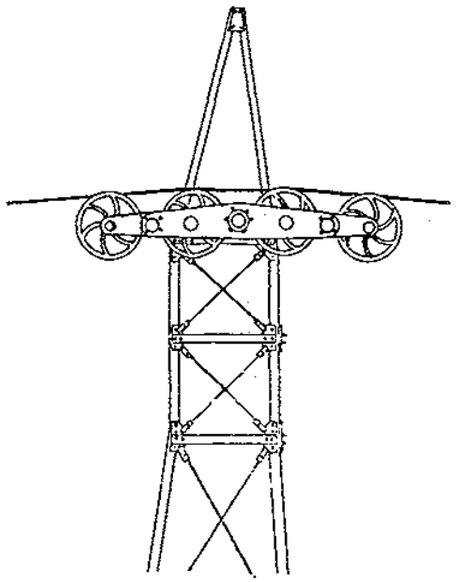

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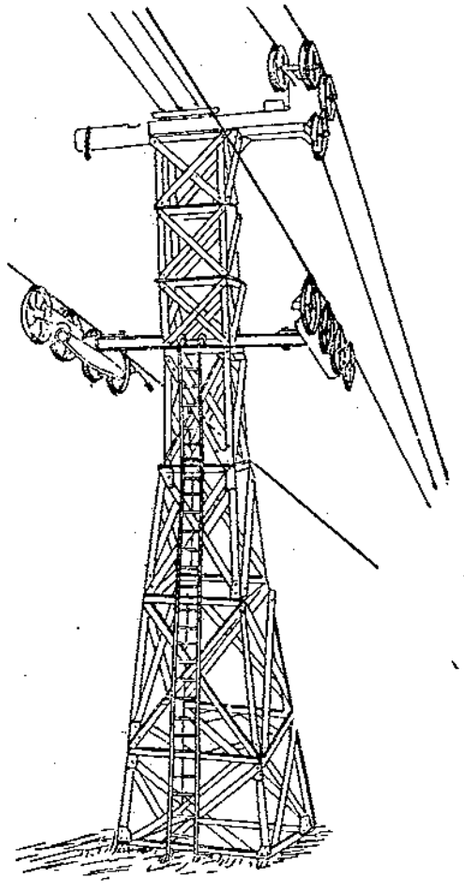

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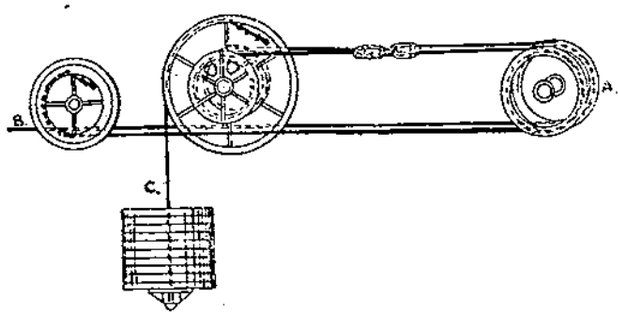

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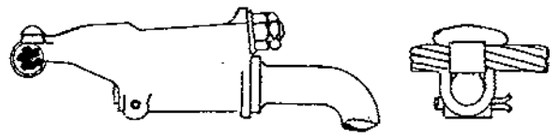

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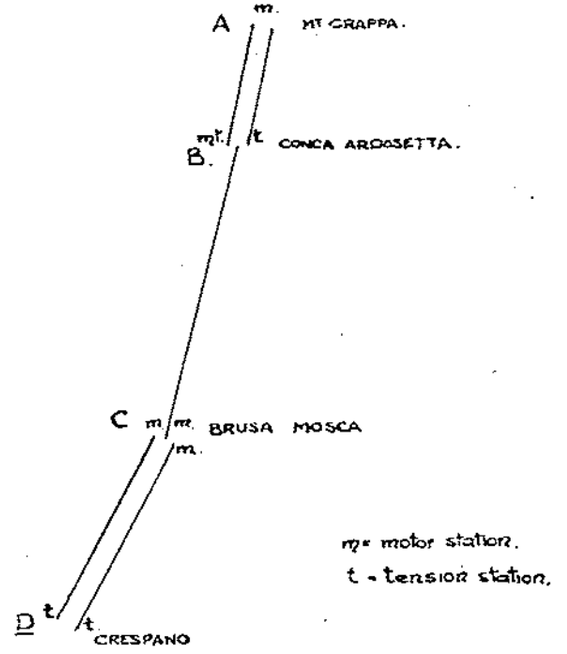


This type of line is run at a slow speed, namely, about 200 ft. per minute, and the only advantages it can claim are its simplicity, adaptability to steep grades, and its low prime cost when light capacities and moderate lengths have to be dealt with.

XI. Jig-Back or To-and-Fro System.

1. This type of ropeway is useful for short distances, and is operated with a pair of carriers that travel in reverse directions and are loaded or brought to rest alternately at the opposite stations, but which do not pass round the terminals: it is, therefore, intermittent in its action, and the direction of travel is reversed after each journey. Where loads are to be carried which are heavy individually in relation to the capacity, and where the distance is short, the "To-and-Fro" system is particularly applicable. A high carrier and rope velocity may be adopted during the run, especially where a clear span occurs between terminals, and where there are no intermediate trestles.

2. These installations may be on the "Monocable" or "Bicable" principle, and in either case the moving rope is clamped to the carriers, and is not usually disconnected from them at the terminals.

3. It should be mentioned that, up to the present, the "To-and-Fro" ropeway is the only system that is used for regular passenger traffic, as the carriers lend themselves to the adoption of a safety grip used in conjunction with an auxiliary standing rope, but with such appliances these installations are very costly and present mechanical difficulties on lines of any length.

XII. Costs.

1. Post-war costs are not available, but as a general rule a bicable line is more costly in the first instance than a monocable.

2. The bicable has twice the length of rope that the monocable has, its carrier couplings are heavier and more complicated and its stations are larger, have heavier anchorages and involve much framework and foundation masonry.

3. The first cost of a bicable line is said to be generally about 20 per cent., but may be as much as 40 per cent. more than that of a monocable. As a general rule a bicable is considered by English firms to be more expensive to maintain than a monocable, but it is doubtful if Italian firms would agree to this.

4. There can be no doubt that in favourable circumstances with a well-designed ropeway there is a considerable saving in transport costs over other means of transport; and in many cases it is possible to construct a ropeway over ground over which it would not pay to construct a road railway, etc.

XIII. METHOD OF ERECTION.

1. After the line has been surveyed, stations sited, and height and position of standards decided on, the work in the stations is started and standards erected.

2. Whenever possible, both carrying and hauling ropes and engines are taken to the upper station by tractor, etc. One of the carrying ropes is then unwound from the upper terminal, placed in the standards, tensioned, and used to help in unwinding the other carrying rope, and hauling rope downhill. These latter are then tensioned and erected.

3. Sometimes, however, it is difficult to carry up the heavy carrying ropes and motor. In this case the hauling rope only is taken up. It is then unwound downhill from the drum, placed in position on the standards, tensioned by a hand-winch placed round the terminal wheels, and used to haul up one carrying rope at a time by means of manual power applied to the hauling rope. Subsequently, when all these ropes are in position and tensioned, the motor is taken up in parts by means of the ropeway, operated by hand. Carriers loaded with stone on the down rope are used to help the motor up.

4. If there is no need, or if there are any other circumstances which prevent the transport of the ropes on their drums to the upper terminal, the hauling rope is carried up along the intended line by a file of men each carrying a portion of the rope in a small coil. When the hauling rope has been put in position, the carrying ropes are hauled up as already described.

5. The Italians seldom employ mules for carrying up ropes; if tractors cannot be used they prefer men. If, however, mules are employed they are loaded with a small coil. For a 20 mm. rope they would be spaced about 20 metres apart.

6. *Time Required for Erection.*—Italian technical officers state that 100 skilled men can erect and complete two kilometres of light line in ten days.

The transport and erection of the standards is the most difficult part of the work. This and the erection of the terminal stations take about six days. The ropes can be laid and tensioned in another four days.

XIV. TYPICAL INSTALLATIONS.

Italian Installations between Crespano and Mt. Grappa.

Type.—All the lines were of the 3-cable type and consisted of:—Two lines, Crespano (D) to Brusa Mosca (C), capacity 4 tons per hour each. One line, Brusa Mosca (C) to Conca Ardosetta (B), capacity 15 tons per hour. Two lines, Conca Ardosetta (B) to Mt. Grappa (A), capacity 6 tons per hour each. (*Sketch* 22).

To feed the line C to B the lines D to C worked longer hours than the line C and B, and material was also brought to C by lorry.

A large amount of the material sent up was used near B and so only light lines were required from B to A.

Loads.—On lines B to C the carrier will take loads of 500 kilos, spaced at 300 metres. On other lines the carrier will take loads of 300 kilos, spaced at 200 metres. The largest single load sent up did not exceed 500 kilos.

Bends.—There is one change of direction of 50° at C.

Length.—The lengths of the various lines are as follows :—

D to C	...	1,675 metres	Total 5,880 metres
C to B	...	3,255 ,,	
B to A	...	950 ,,	

Section of Ground.—The following are the differences in level between the various stations :—

Between D and C	...	112 metres	Total 1,463 metres
,, C and B	...	1,033 ,,	
,, B and A	...	318 ,,	

The greatest span in the line DC = 275 metres horizontal
,, ,, ,, CB = 1,150 ,, ,,
,, ,, ,, BA = 645 ,, ,,
The steepest gradient in the line DC = negligible
,, ,, ,, CB = 4/7
,, ,, ,, BA = 2/3

Ropes.—All ropes were of steel wire of the following types :—

Carrying Ropes.

AB and CD ... 20 millimetres diam. hemp core Lang's lay.
BC ... 26 ,, ,, ,, ,, ,, ,,
Speed of hauling ropes on lines AB and CD ... 2 metres per sec.
,, ,, ,, ,, BC ... ... 2½ ,, ,,

Lubrication.—The lubrication of the carrying ropes was by automatic means and also by hand for the smaller lines. The hauling ropes were lubricated at one of the terminal stations.

Tension.—The tension for the carrying rope of the large line was obtained by the weight of a large wooden cylinder filled with stone and suspended over a pulley wheel.

Standards.—All standards were of steel. The different types used for the large and smaller lines are shown in *Sketches* 16 and 17.

The standards had concrete foundations and those for the light lines had wire guys.

The highest standard, one of those on the line BC, was 30 metres in height.

The standards on the line BC were erected vertical, but the others were normal to the line.

Carriers.—Two types were met with, one of the bucket form of iron, and the other of the platform type of wood and iron.

The couplings used were made by Ceretti and Tanfani, and were of the automatic type where the grip depends on the weight of the carrier.

Motors.—Motors were installed :—

One at A
One at B } for lines A to B, each a 30 H.P. Lancia.
Two at C for lines D to C, both 30 H.P. Lancia.
and two at C for line C to B, one electric motor of 100 H.P., one Diesel motor of 120 H.P.

This allowed one spare motor for the large line.

Consumption.—For the Lancia motors, 3 litres of petrol per hour. For Diesel motor, 10–12 kilograms of heavy oil per hour. The electric motor took its current from a private company's mains.

Terminal Stations.—There is one large well-built station at C with closed sides, where the motors for the lines B to C and D to C are installed and the necessary shunting arrangements for transferring the loads from the lower lines to the big line, and *vice versa*, have been fitted.

There is also a large store-shed for spare carriers, ropes, parts, etc., at C.

Smaller stations have been built at D, B and A with all necessary shunting arrangements.

Personnel.—This can be shown under two headings :—

Operating party :—for large line (BC), 12 men.
for small lines, 6 men each.
Labour party :—for large line (BC), 20 men loading, 20 men unloading.
for small lines, 6 men loading, 6 men unloading

Cost—No information of practical value.

Shropshire Mines Ropeway, Minsterley.

2. This line was completed in 1919. It is about 5½ miles long and is laid out to carry 20 tons per hour for barytes and 5 tons of anthracite (return traffic).

In 1919 the line was equipped (as regards buckets only) for half the capacity, as the mine had not yet reached its full capacity.

Curve.—A curve occurs in the line between points 13,910 and 16,612 ft. from the loading station.

Length of curve—901 yds.

Angle between tangents—6° 43′. The curve is completed in 8 spans ; the deviation is about 1° on each trestle.

On the trestles in the curve the sheaves are mounted as usual on balance beams. The balance beam carrying the sheaves is suspended on a laterally swinging arm, which permits the beam and sheaves to swing outwards or inwards from the standards while the load passes (*vide Sketch* 1).

Thus any tendency for the ropes to mount the flanges of the sheaves, owing to change of direction, is obviated.

The wear on the sheaves is admitted to be slightly increased owing to the curve ; it is not great.

Loads.—5 cwt. (at present, line is carrying broken stone, which is lighter than barytes and loads are only about 4½ cwt.).

Speed.—At present 100 yds. a minute, will be increased later to 120 yds. a minute when the line has been running some time.

Motor.—Electric, 60 H.P., 3 phase, 500 volts, 726 R.P.M., 62·5 amperes per phase. 25 H.P. is sufficient to operate the line when full load is carried downhill.

Rope.—3⅛ in. circumference, stranded, Lang's lay. The whole rope has seven splices, each 40 yds. long. Weight of the heaviest of the continuous length as erected was 7 tons.

Lubrication.—At driving terminal by a drip feed from a tank.

Trestles.—Most of these are steel, but some are of wood. Steel trestles are three-legged and made of 90° "L" steel, compressed to 60° where the horizontal braces are fixed. Trestles are bolted throughout, and erected *in situ* in 2-metre stages.

Average height of trestles, 7–8 metres. Maximum height, 23 metres. Foundations, concrete block under each leg. Timber trestles, owing to local conditions, are cheaper in first cost for average heights. Trestles have pair beams or quads as required. Ball bearings are not used for sheaves. Total number of trestles, 75.

Carriers.—Bucket type.

Spacing.—98 yds.

Terminal Stations.—Loading terminal. Has motor as described, hoppers for loading, shunting arrangements for carriers, and tension arrangements for rope. Tension of rope—16 tons applied by a 4-ton concrete counter-weight through a 4 to 1 system.

The station is provided with a pair of bell spacers mounted together and driven by a chain off a sheave which revolves with the rope. The sounding of the first bell indicates the moment of approach of a carrier, and the second, the moment for launching one.

The arrangement is ingenious, but seems to be an unnecessary complication, the workmen preferring to space loads by eye.

Unloading (or return) Terminal.—Is a raised structure on steel framework with hoppers below for dumping barytes, and a raised hopper for loading anthracite for the return journey.

Intermediate Unloading Station.—For unloading anthracite on the return journey. Requires no detailed description.

Erection of Line.—A length of 2,880 yds. of cable were drawn out from the drum fixed at the return terminal and erected on trestles in one length by 40 men (without horses) in 12 hours, the cable being hoisted by tackle on the trestle in turn.

Running Costs.—The line had been working too short a time to give complete working costs.

Loading station, 1 man for loading, 1 man for shunting and attending motor.

Unloading station, 1 man and 1 boy (exclusive of men working the shoots).

On line (including intermediate station), 2 boys.

Total, 3 men, 3 boys. Wages, £2 10s. a day, totalling £750 for a year of 300 days.

The total yearly capacity will be about 38,000 tons, and on the above,

labour costs work out at		4·75 pence per ton.
Power ... with coal at 40s. per ton, say,		4·5
Renewals ... stores (oil, grease, etc.) at		
	§ths of a penny per ton per mile	3·75
		13·0

or a little over 2d. per ton per mile on the present reduced tonnage. The previous cost of transport by carts and tractors was about 19s. per ton or approximately 3s. per ton per mile.

DORADA ROPEWAY.

3. This installation is being supplied and constructed for the Dorada Railway (Ropeway Extension) Ltd., to join up the town of Manizales with rail-head at Mariquita in the Republic of Columbia, South America, and performs the duties of an ordinary light railway—excepting that no passengers are carried. The terminal and intermediate stations are arranged in warehouses or godowns where goods of all sorts—perishable and otherwise—are stored and delivered to or from the ropeway.

The ropeway will have a total length of 47 miles; at present 25 miles are in operation and the remainder of the length in course of construction. The supply of material for the completion of the line was held up during the war.

The 25 miles constructed have been running since 1915, and the venture shows a very substantial profit even on the tonnage at present dealt with—varying from 100 to 1,500 tons per month. This was likely to be greatly increased in 1919.

The capacity of this line will eventually be 20 tons per hour of general produce from Manizales down to rail-head, and 10 tons per hour of general merchandise in the reverse direction.

At present the ropeway is equipped to carry 7½ tons per hour down from Manizales, and 3 tons per hour in the return direction.

Various types of carriers are employed suitable for the variety of loads which have to be handled, these varying from crates of china to light motor cars, and even occasionally a grand piano.

Present working costs, including stores, renewals and local administration charges, appear to work out at between 5d. and 6d. per ton per mile.

There will be 15 sections on this ropeway.

The power required is generated by Robey High-Speed Double Cylinder engines, placed generally at the divide-stations between sections, and developing 30 H.P. The boilers were supplied by Merryweather and Co., and are of the multi-tubular type with large fire-boxes for burning green wood or brushwood.

All parts of the power units were so sectionalized as to be easily conveyed by mules over the rough mountain paths—which provide the only alternative method of transport.

This type of power unit was decided on after very thorough consideration of all the questions involved, the original proposal being to instal a hydro-electric plant. Though ample water-power was available, the cost of the installation of such a plant was, however, considered and found to be excessive as compared with the power units decided on and supplied.

The power required by any section varies considerably in proportion to the loads being carried in either direction, and provision had to be made to meet all circumstances; for example, when loads were carried in both directions, or only from Manizales, or only in the reverse direction, and as some of the sections have a very considerable difference in level apart from the power unit—an automatic brake and regulating device had also to be supplied for such sections. This device takes the form of a hydraulic regulator, worked on much the same principles as a turbine, but so arranged that the speed can be varied and at the same time kept constant.

These regulators—though only 3-ft. diameter—are capable of absorbing anything from 5 to 40 B.H.P., allowing the ropeway to run at any speed between 100 and 150 yds. per minute.

It is believed that this is the first ropeway of its kind, *i.e.*, for the transport of ordinary merchandise between two towns, situated at a considerable distance apart, which has been constructed, and there seems an undoubted future for similar plants both in South America, India and other parts of the Globe.

XV. AUTHOR'S NOTE.

The author is indebted to Colonel A. R. Winsloe, C.M.G., D.S.O., R.E., and Major E. W. C. Sandes, D.S.O., M.C., R.E., for certain notes on English practice and for descriptions of the Shropshire Mines Ropeway, Minsterley, and Dorada Ropeway, and to *Kempe's Engineers' Year Book for* 1920 for certain of the calculations and some extracts.

The following firms have very kindly supplied information to Colonel Winsloe, Major Sandes or to the author:—

Messrs. Ropeways, Ltd., of Eldon St., Finsbury Circus, London.
Messrs. British Ropeways, of 34, Fenchurch St., London.
Messrs. Luigi Spadaccini, of Milan.
Messrs. Ceretti Tanfani, of Milan.
Messrs. Badoni Bellani and Benazzoli, of Lecco and Milan.

THE BUILDING OF A HOUSE IN N. RHODESIA.

By MAJOR J. KIGGELL, M.C. (late R.E.).

I ARRIVED on a farm in Northern Rhodesia in 1920 and lived in a C. I. hut with two small unburnt-brick rooms built on. To live in a tin hut in Africa is enough incentive to anyone to build a brick house.

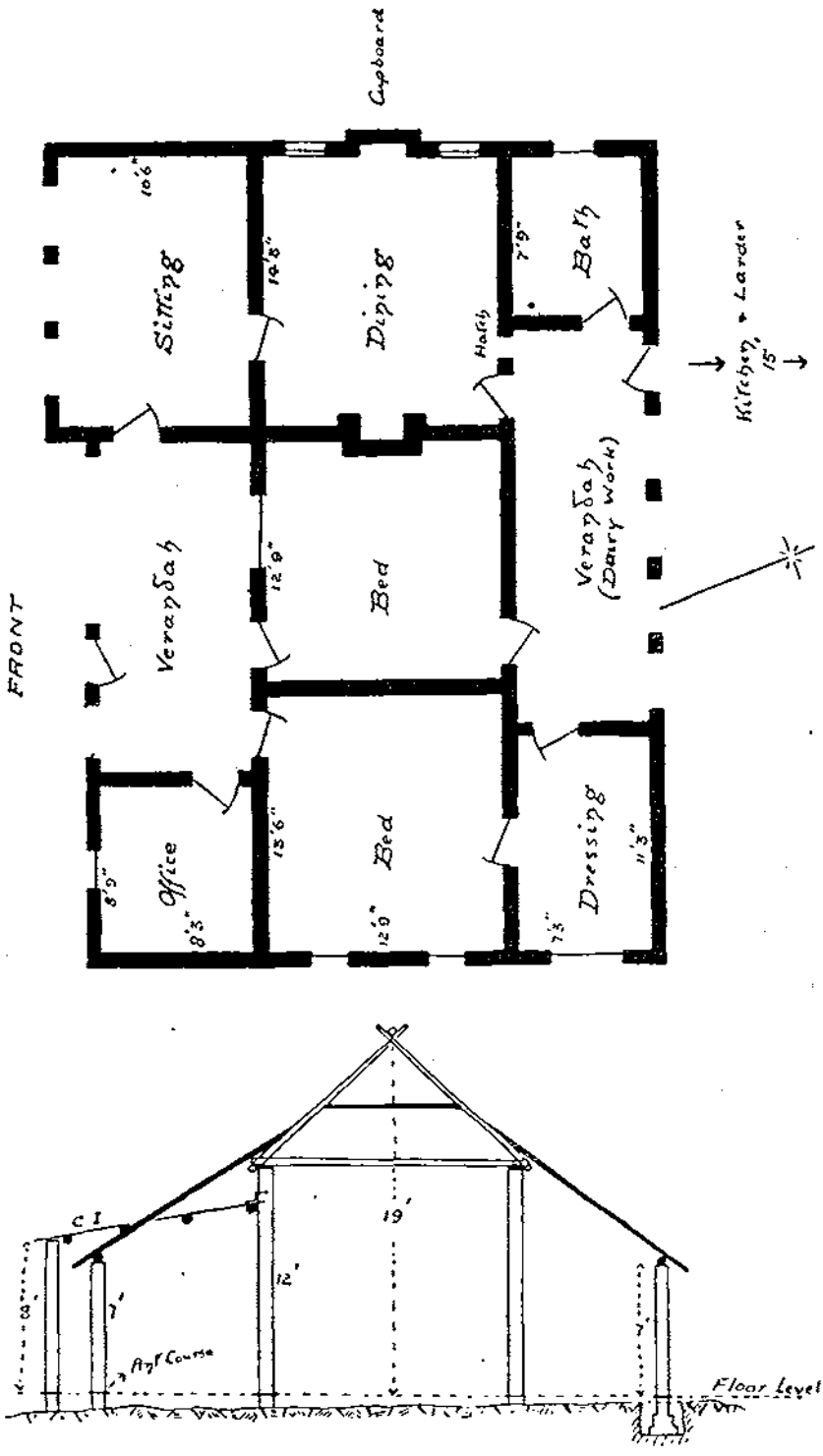
There is no need to discuss the plan from the point of view of convenience of internal arrangement. Everyone has designed the ideal house ; but when it is going to be built by oneself these designs get very reduced both in frills and size. Suffice it to say that now it is finished we do not wish we had done anything different. While I am confident that it will be easy to criticize the design and methods of construction, it must be borne in mind that speed was essential, labour all very unskilled (or comparatively skilled in theory only !) and with farm produce selling at considerably below pre-war level one did not want to buy *anything*.

The first thing to do was to find suitable soil to make bricks with. My Construction School notes were consulted, and volunteered that a Stourbridge fire-brick contained 63·4 per cent of SiO_2 ; so I took a native to a spot near the site and water and asked him if that were good soil for bricks. He said it was. We made half a dozen bricks, adding in varying quantities of ant-heap and sand, and burnt them as a test. The soil was red loam and the bricks were very successful.

Brick moulds were made out of good packing case wood, bound with hoop-iron, three bricks to a mould. Allowing for shrinkage, we aimed at turning out bricks 9½ in. by 4½ in. by 3½ in., hoping not to notice the extra weight in the handling and giving about 17 per cent. less bricks to lay.

To make bricks here, one clears and smoothes about a quarter of an acre of ground, takes off the very top surface at one end and boys pick it up, pour water over it and tread it into *daga* (mud). This is dumped near a boy, the brick-maker, who is in a waist-deep hole. He slaps it into a mould, cuts off surplus *daga* with two sweeps of a stick, and it is carried off to another who turns out the bricks. The mould is brought back, washed (in another hole), sanded, and passed again to the brick-maker. The bricks are at once covered with grass.

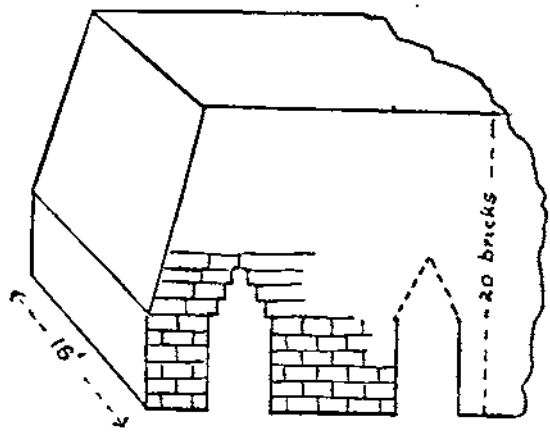
All the books I have seen that mention brick-making under similar



SKETCH I.—Plan and Elevation of House.

conditions advocate the boys standing on the ground and working to platforms. This seems rather unnecessary.

Eight boys can turn out a thousand bricks a day with ease. The bricks are turned on edge in two or three days—it is very difficult to persuade a boy merely to push the brick over on to its edge, instead of picking it up, turning it and putting it down again. Long before the ground is covered, the first bricks are dry enough to build into a kiln.



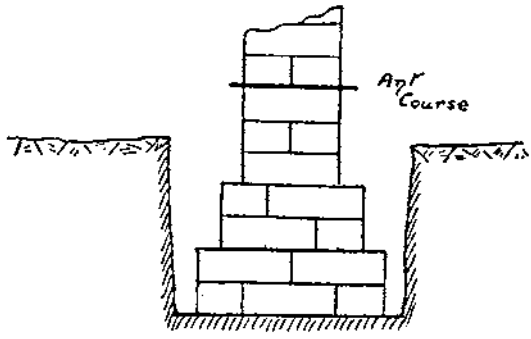
Sketch II.—Brick Kiln.

They must be laid on edge in the kiln; because when originally turned out of the mould they take a slight curve according to the lack of regularity of the ground, and any weight put on the brick in this position, with no mortar underneath, would break it.

Trees are felled, green or dead, dragged up by oxen and sawn into handy logs. Twice as much wood is required as could be thought possible. The flues are stoked and lit and the ends closed with bricks, if one has remembered to leave any for the purpose. I do not know what one does otherwise—I have always remembered. The whole is then plastered with *daga*, recharged every five or six hours and burnt for four days and nights. Some people advocate putting six inches of kraal manure on top, and say that when that is burnt so are the bricks; but as I did not know just when manure can be called burnt—and do not now—we built a small kiln of 10,000 bricks first and burnt it for the mean time of all suggestions received. The kiln takes about a fortnight to cool.

Meanwhile the house had been pegged out and the foundations digged. Eighteen inches down we came to gravel and settled this was good enough. The last two or three inches had to be done by oneself, as the "water-in-a-stick" (or level) is more of a god than an instrument to the native. Even a fair native bricklayer will put his level against a leaning wall, slowly pull out the bottom until the bubble is central, and then go on with the next course entirely

satisfied. The bottom of the trench was levelled off all round and wetted, and the first course laid straight on to it.



SKETCH III.—Foundations.

It was intended to build these in lime mortar; but through accidents and circumstances we finally built with *daga*, foundations and all. Other houses built similarly have been quite successful. When the footings were finished earth was well rammed all round them. I felt rather doubtful about these foundations, as all the houses near had them made of stone; but I knew a little about brick footings and nothing at all about working with stone, which would have had to be quarried and transported. Concrete would have been reassuring; but cement costs a pound a bag. Our only worry now is that what we did may be too good.

With this straight-ahead work, which would never be seen, it was soon found possible to lay a thousand bricks a day. However, out of consideration for Unions and my own hands, this was actually done only once.

At floor level came the job of putting down the ant-coursing. This is 26-gauge flat galvanized iron, cut into strips one foot wide, which are soldered or lapped together. It projects an inch or so both outside and inside the wall. It would not keep ants out of the walls, but as they cannot get through the iron they have to make a mud tunnel outside to get round it, and can thus be located and disappointed.

Door frames were made out of 3 in. by 2 in. native wood sawn up locally. We did order two from some big saw-mills at Livingstone. They cost a lot of money and were made in Sweden.

The courses kept pretty level. One would go and look at the walls from a distance, and having gloomily noted any special bumps would put rather less *daga* there for the next course or two. The next excitement was an arch over the fireplace. To save laboriously chipping and rubbing bricks, a wedge had been put in the bottom of one of the moulds and so we had some wedge-shaped bricks that were rubbed together to make a decent fit and only had a thin film

of *daga* between them. It seems very difficult to make an arch that, once up, *can* collapse; but strength was the only virtue of this one. Later on, when one had built arches over all the doors and windows, to save buying timber for a second top lintel, one used to show them to visitors.

From about five feet to seven feet I built the walls by standing on packing cases or on rough poles laid across them. Then we put up scaffold-poles of sorts with putlogs let into the wall and poles laid across them to stand upon. Everything was lashed with *intambo* of bark, soaked in water.

About then two boys arrived and asked for work as bricklayers. They only wanted fifteen shillings a month and were able to lay fairly well as long as the corners were put up for them. This gave us time to attend to one or two other things on the farm. By now we were quite determined not to make the walls any higher than necessary. You may design your bungalow to have 15-ft. walls; but by the time you have laid ten of them you will be curious to see if twelve would not do. In this country a verandah is very necessary —for extra accommodation, coolness, and to keep the rain off the walls. It is a pity to make it less than 8 ft. wide and the front must be at least 6 ft. 6 in. high, or 7 ft., to allow for the overhang of thatch. The thatch must be at 45°, so the main walls of the house must be 15 ft. high. It seems incontestable; but laying bricks must quicken the brain.

Having got the walls up to height, I left the bricklayers with the chimney and took a wagon off to find *mopani* wood. This is so hard that borers find difficulty in getting into it, and one thus avoids a gentle, but continuous, rain of wood-dust covering everything in the house, including lungs. Also it grows fairly straight, is very strong, and the heartwood is ant-proof in case of accidents. This was rather an interesting trip, as I did not know the country out that way (Kafue) at all, and had no idea where the *mopani* belt was. A guide I had arranged for failed to turn up, but I luckily discovered that another man had gone off to get wood some days before and that his wagon had a 5-in. tyre. We followed this spoor for over thirty miles, past the last farm and through a port in the Nega Nega Hills to near Kafue, where I found that the belt ran along the Kafue River. We camped there for two days and cut some quite nice poles. I came across plenty of game as this is really part of the Kafue Flats—zebra, koodoo, roan, lots of small buck, and rumours of lions; but, after all, this article is supposed to be about a house.

Trusses were as simple as possible, as can be seen in the elevation. All nails had to be well started with an auger. Joints were bound with wire as well as nailed. The "leaners" or trusses at the ends were similar. (We hipped the roof back at the ends to allow for an

all-round verandah and to save bricks. The hip rafters were made into a truss on the ground so that we could put them up quickly to stabilize the roof). Long poles were leant against the ends of the house and the trusses pushed and hauled up on to the roof where they lay flat with the tips supported by cross walls and poles.

We tied a long wire to the " leaner " and got it up to nearly vertical. With the only lashing on the farm we got the end truss vertical in position and then gently lowered the leaner down on to it.

It annoys me that this sounds so simple. *Mopani* is very heavy The labour available consisted of boys who were too frightened even to stand up on the walls and who had only the vaguest idea of what we were trying to do. Also they only imperfectly grasp what they are told to do in a sort of pidgin language of which they know about a hundred words all told and half of these refer to food.

However, having threatened each boy separately with death if he let go, I had now to climb to the top of this very insecure erection and join the two trusses, with auger and nail if they lay conveniently and with *intambo* if they did not. The long wire was made fast. Two similar trusses were put up at the other end. The centre truss was hauled up and held in position by two boys sitting on cross walls and holding the ends of the lashing clove-hitched to the apex. A long composite ridge of round poles, scarfed, and nailed, and wired together, was hauled up the side of the building, carried up the three rafters, rested in the V at the top and fixed there. One then felt much better. My complacency was disturbed by an exhausted voice, saying—" *Mina ifa* [' I die '], *Bwana !* " I looked round and saw a boy still grimly clinging on to the lashing of the centre truss, now quite firm. With much persuasion we made him slack it off, and his discomfiture—not at seeing that it was now unnecessary to hold it, but that to his mind he need never have held it at all—made his *confrères* laugh so much that one of them fell off and broke his arm.

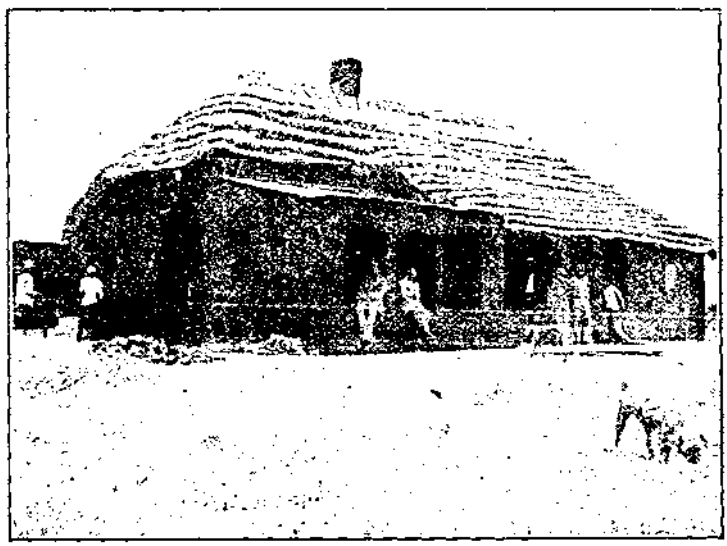
Fortunately the other trusses swung into position and fitted all right. Under each one we put a small wall-plate of packing-case.

The main walls were only about 12 ft. high. To get an adequate pitch on the verandah rafters, these were adzed and nailed to the truss rafters, (*vide* elevation). This solved the problem of fixing them at their top-ends (as there was no wall-plate to speak of on this wall) and it allowed for circulation of air above the ceilings which makes a house so much cooler. Two purlins were put on as scaffolding to stand on and the whole roof was then wired parallel to these purlins—round and round, with boys on the ground straining on the wire as it was stapled to each rafter. Thatch, " cleaned grass," was tied straight on to the wires.

The sitting-room had to have a C. I. roof because of its pitch. Floors were made by laying half bricks, or well-rammed brick rubble, and covering with cement mortar on to which red oxide was sprinkled

and trowelled in. If this is well done, the floor will take a polish and is of a comparatively agreeable colour. Walls plastered with *daga* and sand, whitewash and later sized and distempered, look very well. White *limbo* (calico) ceilings can be put up, stretched on laths and whitewashed to hide the joints. They look more like a pukka ceiling than one would believe, and cost about 17s for a room 14 ft. by 12 ft. *Beaver Board* looks very little better and, of course, costs a good deal more here. It is well known what a lot can be done with brown paper as a foundation for a frieze.

The whole house and a detached kitchen and larder, from clearing the brick-field and including cost of native labour; making, burning, carting and laying bricks; cutting, carting and cleaning grass, etc.; two doors and frames, and wood to make others; wire, ant-coursing, cement, nails, lime, etc. (excluding only personal work, windows, and two doors we had before), was under £110.



The photograph shows the house unfinished; the C. I. roof had grass mats laid on the top later, the thatch is unfinished and there is no mosquito gauze along the verandah, nor any front door! Also it was all lime-washed.

I drove over and had lunch there yesterday. With flowers all round it, a tennis court, and a boy hurrying about with glasses and things on a tray, it seems extraordinary to me how like a house it is; though it is such a short time since its constituents were just trees and grass and mud.

NOTES ON WORKING FOR THE EXAMINATION FOR ADMISSION TO THE STAFF COLLEGE.

By CAPTAIN AND BT. MAJOR A. V. T. WAKELY, M.C., R.E.

PART I. GENERAL.

1. INTRODUCTION.

THESE notes are written with the object of assisting officers who intend to present themselves for the examination for admission to the Staff College. The notes are the result of experience in working for and doing the examination, but the writer does not claim that they are infallible, nor that better advice on working for the examination could not be given. His experience, however, leads him to believe that many officers waste valuable time when preparing themselves for this examination, firstly, through not fully realizing the best way to set about the work, and, secondly, through doing much unnecessary work. It is with the object of assisting the average officer who, alone and unaided, desires to prepare himself for the examination that these notes are written. Officers who are in a position to obtain expert advice and assistance may find below much that is unnecessary or superfluous and perhaps too detailed, but if these notes are of real assistance even to one or two less fortunately situated officers, their object will have been achieved.

Work should be begun at least a year before the examination. It may be divided into three parts:—

(1) Groundwork, from March to the middle of August;
(2) Detailed preparation, from the middle of August to the middle of February;
(3) Recapitulation, from the middle of February to the 1st March.

In these notes it is intended to give a brief outline of the groundwork necessary and to deal in detail with the various subjects under (2) above. Before doing so, it is advisable to discuss one or two points which apply generally to the whole work.

2. SELECTION OF OPTIONAL SUBJECTS.

To enter the Staff College by competition, it is absolutely essential to take three optional subjects. The choice of these is important,

as it vitally affects the whole work. Assuming that French is taken, there is a choice of two other subjects. Referring now to *Staff College Regulations*, 1921, the following points should be borne in mind when selecting these two voluntary subjects :—

Languages (*b*).—If the candidate knows a second language *well*, he should take it ; the papers are fairly easy, but it would be hopeless to start a language afresh.

Principles of Business Organization and Administration (*c*).—This is an easy subject, but requires much reading and experience which officers are not likely to possess. On the other hand, the questions set are easy, and anyone who has a bent in this direction could easily do well in this paper.

Political Economy (*d*).—This is an easy and interesting subject, and the questions set are very fair. One object to be aimed at in selecting voluntary subjects is to choose one which will overlap the obligatory subjects. The one under discussion overlaps Imperial Organization and consequently has much to recommend it. This is, moreover, a subject of considerable practical value.

Elements of Engineering (*e*).—A fairly easy subject for an R.E. officer, but it necessitates rubbing up matter which one probably has not touched for years, and it does not overlap obligatory subjects. This is a distinct disadvantage. The difficulty is that the syllabus covers a wide range, and though one could easily answer at least two questions without doing any special work, the remaining questions necessitate much reading which is unproductive as far as the obligatory subjects are concerned.

Chemistry and Physics (*f*) and (*g*).—Not recommended for the average officer, because they do not overlap.

History of Europe and U.S.A. (*h*).—This is the most popular subject of all, and it overlaps Imperial Organization. The syllabus is very wide, however, and much reading is required. It is also difficult to get books giving sufficient detail, but on the other hand, the questions can be answered well without great detail, and a close study of detail would be a waste of time.

History of British India (*i*).—Much the same remarks apply as for (*h*) above. An easy subject for officers who have been in India, but otherwise it is hardly advisable to take it.

Movements by Road, Rail, etc. (*j*).—This is really the easiest subject of all, and the best one to take. The syllabus seems wide, but detail is not asked for in the questions, and there is one book which gives everything. The subject overlaps *both* Imperial Organization and Organization and Administration. This is one of the strongest arguments in favour of it. In this year's examination, three questions in Imperial Organization and two questions in Organization and Administration could have been answered on the candidate's reading

for (*j*). These five questions were worth 1,100 marks. Further, the whole paper set for (*j*) could have been answered after reading a lecture given by a distinguished R.E. officer in the R.U.S.I. in November, and any officer who had served in France could have got at least half marks without doing any reading at all. A further argument is that this subject is a most valuable one, if not a vital one, for a Staff officer to study, and a knowledge of it will be of great value at the Staff College.

Mathematics (*k*).—Too difficult and does not overlap.

To summarize, (*j*) might easily take first place, and then either (*d*), (*h*) or (*i*), according to present knowledge and experience, choosing the one for which the least amount of reading will be required.

3. Assistance in Working for the Examination.

The syllabus for the examination is so wide, and such a great range of knowledge is required that the writer has been forced to the conclusion that some assistance is absolutely essential in working for the examination. This does not mean to say that it is necessary to employ a tutor; the writer's considered opinion is that it is not. On the other hand, any officer, however capable, who took the examination without having had his work criticized and directed into the proper channels would stand but a small chance of success. The object of getting assistance in the work should not be to obtain "crammed" knowledge, but to cultivate a good style, clear and concise expression, relevancy, and precision; not to obtain and learn by heart masses of detail, but to cultivate the power of forming and expressing an opinion on various problems, such opinions being based on a knowledge of the causes leading to such problems; and finally not to learn prepared answers to questions likely to be set, but to cultivate rapidity, accuracy and conciseness of expression, and to apply this to the particular problem under discussion to the exclusion of all irrelevant matter. It should be possible for every candidate for the examination to obtain the help of a senior officer or of an officer of the Army Educational Corps in correcting and criticizing papers. The candidate will then get another point of view; but let him first think out the problem and express his own point of view, then get another opinion. The reverse process is a mistake, and leads to "crammed" knowledge. The value of a tutor lies in the preparation of tactical schemes, but here again the assistance of another officer is more advantageous. It is a good scheme for two officers to work together at tactical schemes; the second officer may be going up for a promotion examination. One officer should set a scheme, both work it out independently, then compare results and discuss it. Discussion is more valuable than written criticisms as far as tactical schemes are concerned.

4. Groundwork.

The groundwork for the examination really extends over the whole of an officer's service, and in the examination all this knowledge has to be written down concisely, quickly and clearly. The gift of a fluent pen is therefore very desirable, if not essential in this examination. The reading of really good books and practice in writing will, however, develop power of expression. For the groundwork it is a good plan to devote about five months, beginning in March, to reading only. Practice in writing will be obtained later. Read a little and think a lot. Do not go too much into detail. The broad lines on which this reading might be tackled would be as under :—

(*a*) *Training for War.*—Chiefly strategical. Read *F.S.R.*, Vol. II (1920) Chapter I, and learn the principles. Then read *Military History* and think out examples of the successful and unsuccessful applications of those principles. Of course, questions can be set on any campaign, but 1914–18 is by far the most important. The following books are suggested for reading during the groundwork period.

The Science of War ... ... Henderson.
The Direction of War ... ... Bird.

It is well to begin the more or less detailed study of campaigns now, and the following campaigns are suggested :—

1914–18 in France (especially first two months and last four months) ;
1915–18 in Mesopotamia ;
1915–18 in Palestine ;
1805 Ulm ;
1806, Jena ;
1815, Waterloo ;
1861–64, Shenandoah Valley.

These do not require to be studied in great detail, but the point is to bring out the application of the principles of war and know definite examples of their application. For the tactical side of this subject it is well to read the more important parts of the new Training Manuals, *e.g.*, *F.S. Regs.*, Vol. II (1920) Chapter III and VIII to XI.

The question of training should not be neglected, and *Infantry Training*, Vol. I, should be read.

(*b*) *Organization and Administration.*—Very little can be done in this subject as regards reading, as there are no books on it. The history of the British Army may be studied in *Outline of the Development of the British Army up to* 1914 (Major-General Anderson).

The *Army Quarterly* and the *R.U.S.I. Journal* should be read.

(*c*) *Imperial Organization.*—This will probably be a more or less new subject to most officers. The reading should aim at getting hold of the broad facts and principles.

The best books are :—

The British Empire, Past, Present and Future ... POLLARD.
Foundation and Growth of the British Empire J. H. WILLIAMSON.
The British Empire ... ... LUCAS.
The Government of the British Empire ... ... JENKS.
Naval and Military Geography of the British Empire
Dr. VAUGHAN CORNISH.
Outlines of Military Geography ... ... MACDONNELL.

Get the *Times* daily, and read all important articles.

5. PROMOTION EXAMINATION. (*d*).

Many officers take (*d*) for promotion in October for experience in examination work, and the scheme is a good one. A study of 1914 is required for (*d*), and this is useful, but on the whole the writer is inclined to think (*d*) a waste of time. The knowledge required for it is more elementary, and an officer would necessarily have to spend much time on detail of administration, etc. ; otherwise there would be a risk of failing in (*d*) and the moral effect of that would be distinctly bad.

6. BOOKS.

The supply of books and papers must be properly organized. They divide themselves into three catagories :—

(1) Library Books ;
(2) Books and Reports, costing not more than 3/- or 4/- each ;
(3) The Press.

As regards (1), most officers should have two sources of supply : the Garrison Library and his own Corps Library. For R.E. officers, the Corps Library, as far as its funds admit, will buy any book recommended ; the difficulty is that there is a great demand for these books and one cannot usually keep them more than a fortnight ; but the Library will occasionally get two or more copies if necessary.

The small books must be bought, but money spent in this way is well invested. It is best and quickest to get all books through one publisher. The undernamed are very good, and will find and get any publications required :—

Messrs. SIFTON PRAED & CO., LTD.
67, St. James's Street,
London, S.W.1.

They keep a special bookshelf for the Staff College examination, and it is worth while paying a visit to their place. Official publications divide themselves into two kinds—War Office publications and those issued to the public through the Stationery Office.

The former can always be obtained from Official sources. The great difficulty with the latter is to find out what is published. Sifton Praed have a list which can be consulted in London. It is worth having a look at this, as the Stationery Office publications are a most valuable source of information, and the price is seldom more than 1/6 each, *e.g., Esher Committee Report on Indian Army*; *Montagu-Chelmsford Report*, &c., &c. It is well worth while becoming a member of the Royal United Service Institution. The entrance fee is £1 1s. od., and annual subscription, £1 1s. od. The *R.U.S.I. Journal* publishes all the lectures given at this Institution.

For notes on the Daily Press, see para. 4, part II.

In the lists of books recommended below the letters in brackets in front of the titles of the books refer to the following :—

E. = Very good book and essential to read ;
G. = Good book, but not absolutely essential ;
L. = Library Book ;
R. = Reference book to be bought and kept.

PART II.

Detailed Preparation.

The detailed preparation for the examination will now be considered. The work must be properly and systematically organized, otherwise one does not get a true perspective of the syllabus and many important matters may be overlooked.

1.

The first question to decide is the amount of time available. This depends on how fully one is employed by one's ordinary work during the day, and must be governed by individual circumstances. *At least* 24 hours per week should be devoted to the Staff College work, and it is better to aim at 33 hours per week. Opportunities occur for Staff College work in one's daily duty and should not be missed. If one is unfortunate enough to be fully employed at one's ordinary work for nine or ten hours a day, it is a good plan to take a month's leave previous to the examination, as a month's solid work is more valuable than the odd ends of days one can devote under these circumstances while on duty.

2. DIVISION OF TIME.

The next essential is to divide up the available time between the various subjects, more or less on a basis of mark value. The tendency is to spend too much time on the most interesting subject, *viz.*, Imperial Organization. Assuming that 33 hours a week can be devoted to the work, make out a time-table something like that shown below. There are 11,000 marks for the examination, so each 1,000 marks is worth three hours a week.

On the other hand, if only three hours a week is spent on French, it will not be much good, and a loss of marks here would, in a competitive examination, be more serious than the corresponding potential gain in marks which extra time spent on Training for War would give. The same argument applies to other subjects.

SUGGESTED TIME-TABLE.

Day.	Training for War.	Organ. and Admin.	Imperial Organi-zation.	French.	Opt. Subj. Strong.	Opt. Subj. Weak.	Total Hours.
Sunday ...	1½	2	—	1½	—	—	5
Monday ...	1½	1½	2	—	—	—	5
Tuesday ...	3	—	—	1	1	—	5
Wednesday	—	2	2	—	—	1	5
Thursday ...	1½	—	—	1	1	1½	5
Friday ...	—	1½	2	—	—	1½	5
Saturday ...	1½	—	—	1½	—	—	3
Total Hours	9	7	6	5	2	4	33

If the total time available per week is less than 33 hours, the time given above for the various subjects should be reduced in proportion. This Time-table should be modified about every month as progress is made, the tendency should be to *increase* the time given for Training for War up to 12 hours per week, *i.e.*, its mark value.

It is important to keep to the time-table, tick off each day the time spent on the various subjects. On Monday, say, one might spend five hours at Training for War, but the total at the end of the week should agree with the table.

3. NOTE-BOOKS.

It is of great value to keep a note-book for each subject, so get six "Army Books, 129s" or similar books. Everything of importance should go into these books, and they will constitute a valuable stock of information to read up just before and during the examination.

It is *essential* to *index* them as each series of notes is entered in the book, otherwise much time is wasted later on searching for some particular subject. Cuttings out of newspapers should go into these books. The best way to make up these notes is not to slavishly copy out articles and papers. Read the article over twice, the second time very carefully, then putting the article aside, on a rough piece of paper put down the headings, and write in the note-book a *précis* of the article. This fixes the facts and arguments in one's memory much better than anything else. It will be found in the examination that, if a question is given on something dealt with in this way, even after a lapse of two or three months the facts and arguments come back without the least effort.

4. The Daily Press.

The *Times* is undoubtedly the best paper to read; it gives more news than any other daily paper. The best way to deal with it is to look it through carefully *every day* and cut out important articles and stick them in the note-book dealing with the subject. Do not cut out too many articles, there will not be time to read them and they only fill up the book. Do not cut out articles on *undeveloped* situations, these are not of much value. Cut out articles on Military subjects and the debates in Parliament on Naval, Military and Air Force Estimates. These give valuable indications of Military policy. It is a mistake to spend much time reading and trying to understand a complicated article on a subject not previously studied. Put the article in the note-book and refer to it later on when the essential groundwork of the problem has been mastered. For example, it is not every officer who knows exactly the difference between an Executive Council and a Legislative Council, and it is positively a waste of time to try to understand an article on Colonial Government without first reading the chapters in either Lucas or Jenks dealing with it. Then, having mastered the essential features, read the article, perhaps two or three months after it appeared in the *Times*, and *mark in red* the important points. Marking these makes it easier, just before the examination, to rub up facts without wading through much small print.

5. Training for War.

Turning now to the separate subjects, "Training for War" is by far the most important.

It divides itself into three parts:—

(*a*) Strategy;
(*b*) Tactics;
(*c*) Training.

(*a*) *Strategy.*—However interesting and instructive it may be, much reading of books on strategy is a mistake for two reasons—firstly, it is very difficult to read a great deal and to retain what is read; and, secondly, such reading takes time, which is not available.

The groundwork reading of Military History should give a fairly good idea of strategy and the principles of war, and during the period of detailed preparation for the examination it is well to work up a few examples from the campaigns studied. The method of working up these examples is important. The writer considers that the best method is first to read up some particular operation or series of operations; then think out what principles of war were involved, what information did the commander have on which to base his plan? was his plan in accordance with the principles of war? were any principles violated or neglected? was the operation successful or not? what were the reasons for success or failure? did the commander adopt any new methods of applying the principles of war, &c.? The student should think out these problems for himself, after reading the narrative of the campaign. Then see what General Bird has to say on the problem under discussion. Compare the points thought of with those mentioned by General Bird.

Again, compare the operations of one commander with those of another; *e.g.*, how does the German plan in 1914 compare with that of Napoleon at the opening of the 1815 campaign? There are many points of similarity as regards principles, though the conditions are, of course, vastly different. It is a great mistake to read Clausewitz, Hamley, Foch, Bernhardi, &c., from cover to cover. Read less and think more. Also, it is a good plan to get a senior officer or anyone who is willing to help to set some questions on strategy, such as Question 2, 3rd Paper, *Training for War*, 1921; and Question 1, 2nd Paper, 1922. Do these questions properly and get them criticized.

(b) *Tactics.*—The tactical schemes are by far the most important part of the whole work. In the 1922 examination they carried 3,250 marks. It is utterly useless to go up for the examination, unless some hard work is put in at these schemes. Some people do them automatically, but the average officer, even given much fighting experience, is not altogether at home when confronted with a map and a book of narrative. Rapidity is essential. Schemes must be fully worked out against time. For a suggested method of setting schemes, see Part I, para. (4) above. It is most important to discuss the schemes or to get them criticized. The following should be dealt with:—

Advanced Guard, Rear Guard, Encounter Attack, Outposts, Outpost Zone, Defensive Position, Flank Guard, Marches, Mountain Warfare, Bush Warfare and Desert Warfare, Convoys, Position

Warfare—Counter Attack, Position Warfare—Raids, Ammunition Supply, Supplies, Evacuation of Wounded, Inter-communication, Guerilla Warfare and Drives.

There are here 18 different schemes. *At least* one scheme a week should be worked, using different kinds of maps. It is useless to read through a scheme set in previous examinations and say the solution would be this or that. The schemes must be worked against time, but at first *with the help of F.S.R. and notes*, so take about an hour longer than examination time until proficiency is attained. Then in the last two months or so, work several under examination conditions. There is a great variety, but it is extraordinary how similar several of the solutions are. Generally speaking, work with an Infantry Brigade Group and Cavalry both attached and independent.

(c) *Training.*—It is a sound scheme to spend a fortnight with an infantry battalion if possible and see what they do. If this can be done, get hold of their training programme for the season, and work out the why and the wherefore. The sequence of training operations is important, and the various things done in each period.

Bibliography.—

(E L) The Direction of War.—*Major-General Bird.*
(E L) The Science of War.—*Colonel Henderson.*
(G L) The Operations of War.—*Hamley.*
(G L) The Principles of War.—*Foch.* (Use the French edition.)
(E L) Stonewall Jackson.—*Henderson.*
(E L) Forty Days in 1914.—*Maurice.*
(G L) Napoleon and Waterloo (2 vols.).—*Becke.*
(G) Waziristan, 1919–20.—*Official.*
(E L) Small Wars.—*Callwell.*
(E L) The Last Four Months.—*Maurice.*
(E L) Story of the 4th Army.—*Montgomery.*
(G L) Battle of the Marne.—*Perris.*
(G L) French's Dispatches.
(G L) Haig's Dispatches.
(E R) Notes on Infantry Tactics and Training.—*Sir G. M. Harper.*
(E R) F.S.R., Vol. II (1920).
(E R) Infantry Training, Vols. I and II.
(E R) Artillery Training, Vol. III.
(E R) Armoured Car Training, 1921.
(E R) Cavalry Training, 1920.
(E R) Tank Training, Vol. I.
(E R) The Division in Attack, SS 135.
(E R) Artillery Notes No. 4.
(E R) Platoon Training.
(E R) The Division in Defence, SS 210.
(E R) Signal Training, Part VIII (provisional).
(E R) *R.U.S.I. Journal.*
(E R) *Army Quarterly.*
(E R) Report on Examination for Admission to Staff College, 1921.
(E R) Report on Examination for Admission to Staff College, 1922.
(G R) Report on Examination for Promotion, 1920.
(G R) Report on Examination for Promotion, 1921.

6. ORGANIZATION AND ADMINISTRATION.

This is a most difficult subject to deal with, because there are no books whatever on it. The pre-war books are worse than useless, as they are out of date, and they deal with facts rather than problems, though Collin's book is useful for reference.

A good scheme is to write down all the problems which may form the subject of a question. This does not mean that prepared answers are to be learnt by heart, but such a list should rather give a basis upon which to work up the whole subject. Think out the various problems, and find out the causes which led to the change of organization, or, for future problems, find out what are the arguments for and against certain proposals. The mere discussion of these problems will give rise to others. Discuss them with other officers who may be working for Staff College or promotion, or with senior officers, and make them the subject of an essay in the Organization and Administration note-book. There are sound reasons for every change in military organization, and every fresh change must be carefully considered before it is adopted. Think out these reasons in each case, apply them to past history and future requirements. The whole subject of Organization and Administration requires thought and reasoning rather than much reading. The following are a few suggested subjects for discussion :—

Action in aid of the Civil Power, Cost Accounting, Cavalry and Tanks, Cavalry and Aircraft, C.I.D., Co-operation with the Dominions in Military Organization, Clothing Allowances—New Scheme, Conscription *v.* Voluntary Army, Divisions of U.K. for Administration, Dominion Armies (see *F.S.P.B.*, and bring it up to date), Demobilization, Defence Ministry—Arguments for, Daily Messing Account, Educational Training, Expansion of Regular Army in War, Foreign Armies, Geddes Economy Report—Effect of Reduction, Headquarters Units, Indian Army Reform, Linked Battalions and Depôts—Draft Finding, Mobilization, Mechanicalization of the Army, Officer i/c Records, Recruiting during the War and at Present, Reorganization of the various arms (post-war), Recreational Training, Regimental Paymaster, Territorial Army, Terms of Enlistment—Reserve and Colour Service, The highest self-contained tactical unit—Brigade or Division, Two Brigades *v.* Three Brigades, Four Companies *v.* Eight Companies, Battalion Guns, Transfer Act during the War, Traffic Control, Divisional Control *v.* Brigade Control for M.G.'s, T.M.'s, &c., Brigade Control *v.* Battalion Control for M.G.'s, T.M.'s, &c., Transportation Organization in France, Organization of Sea Transport, and so on, *ad infinitum*.

The best sources of information on these subjects are the *Army Quarterly* and the *R.U.S.I. Journal*; the articles in these periodicals touch on most problems, except perhaps those which are apparently too simple and well-known to need mention, but which one finds

one knows nothing about when it comes to putting cold facts on paper, *e.g.* :—Which is the better plan, to provide drafts for abroad from the linked battalions at home, or from the depôt direct ? There are strong arguments in favour of each plan.

The History of the British Army has not been included in above, as Major-General Anderson's book gives a very clear account and is very valuable.

There are several questions in " Organization and Administration " on Military Law. It is very important to get *M.M.L.* and *K.R.'s amended up to date*. Stationery Office issue amendments periodically. Note that no question is asked in the examination on matters published less than six months before the examination. The questions carry only low marks, but it is worth while working out a few examples so as to get to know the way about these books.

Bibliography.—
(E L) Military Organization and Administration.—*G. R. N. Collins.*
(E R) Outline of the Development of the British Army up to 1914.—*General Anderson.*
(G L) The Body and Soul of an Army.—*Sir Ian Hamilton.*
(E R) Statesman's Year Book.
(E R) *Army Quarterly.*
(E R) *R.U.S.I. Journal.*
(E R) M. M. L.
(E R) K. R.
(E R) T. F. Regulations.
(E R) Esher Committee Report on Indian Army.
(G R) Geddes Committee Report, Part I.
(E R) F.S.R.'s, Part II.
(E R) F. S. P. B.

IMPERIAL ORGANIZATION.

This is the easiest and most interesting subject of the obligatory ones, but avoid spending too much time at it. The best way is to lecture to N.C.O.'s and men on it. The 2nd Class Certificate of Education includes a good proportion of what is required and the instructor can choose his own syllabus.

Write out the lectures, it gives very good practice, and write them out more fully than is necessary for the delivery of them. It is not necessary to give the complete lecture to the men ; it would be beyond their requirements, but it should be possible to get the lectures criticized by an officer of the A.E.C. Of course, further reading must be done for this subject, and the object aimed at should be to get a thorough grasp of the main principles of Imperial Organization and to think out the problems now confronting us, both within the Empire, and as regards foreign policy.

A good atlas is essential. The *Times* Atlas is the best, but it is bulky and heavy. *The Comparative Atlas* (Meiklejohn, price 4/6) is handy, and though it does not give much detail, is useful when reading articles in the Press.

It is not a good scheme to concentrate on one or two colonies and learn everything about them, for two reasons: firstly—too much detail will be learnt; and, secondly, the question in the examination is more likely to deal with a general problem.

There is no short cut for this subject; it is essential to read the best books and to think out the problems oneself. On the 1st of each month the *Times* reviews the monthly magazines, and there are often very useful articles in some of them. These can usually be seen in any club, and it is hardly necessary to buy the magazines. *The Round Table* is a quarterly review (5/-), and is excellent for current Imperial questions.

Bibliography.—

(E L) British Empire; Past, Present and Future.—*Pollard.* (Groundwork of history up to 1907.)
(E L) Foundation and Growth of the British Empire.—*J. A. Williamson.* (Elementary.)
(E L) The Government of the British Empire.—*Jenks.*
(G L) Expansion of the British Empire.—*Woodward.*
(E L) The British Empire.—*Sir C. Lucas.*
(E L) Rise and Expansion of British Dominions in India.—*Sir A. C. Lyall.*
(E L) Influence of Sea-Power upon History.—*Mahan.* (First part only.)
(E R) Frontiers.—*Fawcett.*
(E R) Imperial Military Geography (a lecture).—*Vaughan Cornish.* (1/-.)
(E L) Imperial Military Geography.—*J. Fitzgerald Lee.*
(G L) Outlines of Military Geography.—*Macdonnell.*
(G L) Britain and the British Seas.—*Mackinder.*
(E L) The Future of the Empire, 1918.—*Mills.*
(E L) Seaways of Empire.—*Sargent.*
(E L) Sea-Power in the Pacific.—*Bywater.*
(G L) The Truth about China and Japan.—*Putnam Weale.*
(E R) Statesman's Year Book.
(E R) *Army Quarterly.*
(E R) *The Round Table.*—5/-, quarterly.
(G R) Summary of Proceedings of Imperial Conference, 1921 (Comd. 1474), 9d.
(G L) Imperial Defence, 1903.—May. (Out of date, but useful.)
(G R) *Aeronautical Journal.*
(E R) *R.U.S.I. Journal.*
Magazines: *Fortnightly Review, Contemporary Review, Nineteenth Century,* &c., when suitable articles appear.
(E) Comparative Atlas.
(E) The *Times.*

8. FRENCH.

The standard is very high in French, but there is not much difficulty, given a previous knowledge of French. It is a waste of time to go to France especially to study French for the examination, as there is no oral examination, and one would never in ordinary conversation hear the military words required in the examination.

The best scheme is first to go carefully through *Hugo's French*

Simplified and make absolutely certain of all the grammar, if one is not already an expert French scholar. Then do translations and essays. Select pieces for translation from *F.S.R.*, *Army Quarterly*, etc., and other books. Translate them, and get them corrected by a Frenchman if possible. The present writer can give any officer the address of a Frenchman who will help for a small fee, and who takes much trouble.

These translations are very difficult, but the examination papers are very difficult, and unless one does some beforehand one has no chance in the examination. It is very important to write essays on military subjects, and these exercises can well be combined with the obligatory subjects. Always use a *French* dictionary, *i.e.*, one written in French whenever possible, and only look up an English-French dictionary when one is absolutely stuck for the word. Translate several military terms into French. The usual French Military Term Book is pretty useless and does not give any of the words met with in *F.S.R.*

Read a French newspaper occasionally, and also read the French Training Manuals. This is most important and is essential. The object is to work up a *military vocabulary*. Later on, when reading *F.S.R.*, etc., translate it straight off into French without writing it down.

Bibliography.—

(E R) French Dictionary, Larousse Élémentaire Illustré (7/6).
(E R) Hugo's French Simplified (6/-).
(E R) French and English Technical Military Terms.—*Deshumbert* (3/6).
(G R) Règlements sur le Service des Armées en Campagne 1916.—*Ministère de la Guerre*, Paris.
(E R) Règlement Provisoire de Manœuvre d'Infanterie. Première Partie, 1921.—*Ministère de la Guerre*, Paris.
(E R) Règlement Provisoire de Manœuvre d'Infanterie. Deuxième Partie, 1921.—*Ministère de la Guerre*, Paris.
(G) *Revue Militaire Française* (monthly, 3/6).
(G) Les Principes de Guerre.—*Foch.*
Chambers' French-English—English-French Dictionary.
(G R) Half Hours of French Translation.—*Mariette.**
(G R) Key to Ditto.—*Mariette.**

* Very advanced, but extremely useful.

9. Political Economy.

The writer did not take this subject, but the best way to treat it is to write notes on the principal subjects, after reading the books recommended. The subject is interesting, and does not require much reading, since practically every officer has a good working knowledge on which to base his preparation for the examination.

Bibliography.—

(E L) Political Economy.—*J. S. Mill.*
(E L) Principles of Economics.—*Marshall.*
(E L) Elements of Economics.—*Marshall.*
(E L) Manual of Political Economy.—*Henry Fawcett.*

10. HISTORY OF EUROPE AND U.S.A. SINCE 1848. HISTORY OF BRITISH INDIA.

The writer did not take these subjects, so does not feel competent to tender advice to those working at them.

The general principles governing the work noted above will, however, always apply, the chief of which is to read a limited number of the best books and think out the problems involved.

Bibliography.—
Outline of Modern European History.—*Rogers.*
Select Treaties and Documents to illustrate development of Modern European States.
Modern Europe.—*Grant.*
The Development of European Nations, 1870–1900.—*Dr. Holland Rose.*
The United States in our own times, 1865–1920.—*Haworth.*
The United States from 1765.—*Channing.*
History of the United States.—*Elson.*
Sir Charles Lucas's Historical Geography, Vol. III (India), 2 parts.
History of India.—*Sir W. Hunter.*
Rise of British Dominions in India.—*Lyall.*
Montagu-Chelmsford Report.

11. MOVEMENTS BY ROAD, RAIL, CROSS-COUNTRY, WATER, AIR.

The paper set this year shows a reversal of policy as regards this subject. Nearly all the questions bore upon Transportation problems in France, 1914-18.

If this type of question is to predominate in future, the subject becomes very easy, but it would not be safe to entirely neglect the syllabus. The best sources of information as regards the military side of this subject are the *R.U.S.I. Journal* and the *Journal of the Institute of Transport.* Kirkaldy & Evans' book gives practically everything about all the other questions. The subject is very interesting and an easy one to get hold of. It is further of considerable value in working for the obligatory subjects.

Bibliography.—
(E L) The History and Economics of Transport.—*Kirkaldy and Evans.*
(E R) Elements of Railway Economics.—*Acworth.*
(G L) Rivers, Canals and Traffic on Inland Waterways.—*Vernon Harcourt.*
(E R) *Journal of the R.U.S.I.* (quarterly).
(E R) *Journal of the Institute of Transport* (monthly)
(G R) *Aeronautical Journal* (monthly).
(E R) Report of Civil Committee of Aerial Transport (9d.).
(G R) Airships for Commerical purposes (3d.).
(E L) Seaways of Empire.—*Sargent.*
(G R) Lloyd's Calendar.

12. RECAPITULATION.

This consists chiefly in reading up notes and papers. During the last fortnight before the examination it is not worth while embarking

upon fresh investigations which will take time. It is better to consolidate and fix in the memory the facts already noted. The whole programme of work may be compared with the operations of the photographer. He first takes a negative, then develops the plate and then fixes it. The groundwork and preliminary investigation of any branch of a subject corresponds to the taking of a negative. The student then thinks over the arguments and points, and *develops* them in his mind. He then *fixes* these arguments and points by reading them over and perhaps writing a paper on them. In the examination he produces the finished *print*.

13. THE EXAMINATION.

So many mistakes are made in procedure during the examination that a few notes on it will not be out of place.

The War Office issue :—

(1) Report on previous examinations, giving the papers set and the examiners' remarks ;

(2) Notes on Staff College Entrance Examination, 1921.

Read both of these very carefully. (1) is essential during the whole course of preparation, but the student should *read, mark, learn and inwardly digest* (2).

14.

The question of a proper distribution of time in the examination is of vital importance. Allow 15 minutes per 100 marks, and *do not spend longer* than this on a question carrying low marks, *e.g.*, in "Training for War," 1st Paper, 1922, Question 1 is worth 100 marks, Question 2, 300 marks and Question 3, 250.

Some officers spent one hour on Question 1 and had no time to even begin Question 5, which was worth 150. In the Imperial Organization papers each question is worth the same marks—250 if four questions, and 200 if five. Therefore spend three-quarters of an hour on each question in the first case, and just over half-hour each in the second. *It is vital that this allocation of time be strictly adhered to.* The marks gained by titivating answers to one or two questions will not compensate for those lost through completely spoiling the answer to the last question in the paper.

15.

In "Training for War" papers first read the *whole* scheme through, *underline* the salient words, and write notes in pencil on the left-hand side of the page on the principal points of the scheme. Cut out all non-essential. Number the remainder in the order in which they will be taken. Never write out the *scheme* again, but fasten on to the points that matter, *i.e.*, the governing factors. Rapidity is essential. If you have done schemes *against time* there should

be no difficulty. If the facts and factors are fixed in one's mind it does not take long to write them down. What is written down must be clear and concise.

16.

Organization and Administration papers and Imperial Organization papers give a choice of questions. Read the whole paper through first, then consider carefully what questions will be answered, and mark them. Tackle first those you know best, and think out carefully exactly what is meant by the question. Each question is an essay in itself. Write down on the left-hand side of the paper the points bearing on the subject, *i.e.*, headings of the answer. Leave room to insert other points thought of afterwards, cut out those not essential and number the remainder in the order in which they will be taken. Keep any strong argument for the last and make the conclusions convincing. Having decided how to deal with these questions, commence writing. In a half-hour question take ten minutes to consider it and do the above rough work and allow twenty minutes to write the answer. If there is time, read the answers over to correct spelling mistakes and punctuation errors.

17.

Finally, it is very important to bring into the examination room a complete equipment of writing materials, etc., so that no time may be lost when actually working the papers and so that clear sketches may be drawn. The following will be found useful :—

Field Service Pocket Book.
A fountain pen which one can write quickly with.
A red ink fountain pen (not essential).
Coloured chalks.
Pencil.
Rubber.
Map measurer (very useful).
Protractor.
Scales with miles and yards marked :—
(*a*) 1 inch to 1 mile ;
(*b*) 1/20000 ;
(*c*) 2 miles to 1 inch ;
(*d*) 1/100000.

These scales are most useful to get artillery ranges, frontages, etc., quickly off the map. They can be drawn on a piece of drawing-paper if the protractor does not give them. They save time in the examination.

Always draw sketches to a large scale, and indicate very clearly the exact location and units of all troops in questions necessitating the disposition of troops on the map.

Major-General Sir R. S. Curtis, K.C.M.G., C.B., D.S.O.,
A.A.-General, R.E., 1. 4. 13 to 23. 2. 17.

From a photograph by the Press Portrait Bureau.

MEMOIRS.

THE LATE MAJOR-GENERAL SIR REGINALD S. CURTIS, K.C.M.G., C.B., D.S.O.

THE writer's first recollections of "Reggie" Curtis are as a young officer at Chatham, a sturdy, square, strong-faced young officer—a face wrinkled with smile and cheeriness—Curtis playing mediocre accompaniments on the piano to a noisy chorus on a guest-night, or chaffing his fellows with a dry humour always to the point.

Serving as a subaltern in the 1st Divisional Telegraph Battalion at Aldershot for two or three years in the eighties, he soon began to show himself as an officer whose strength of character, carefulness in detail and innate common sense, combined with good humour, would carry him far. His record of service amply fulfilled this promise.

In 1888 he left Aldershot for a short tour at Gibraltar. In 1889 he went to Egypt. Joining the Egyptian Army in '91, he saw his first fighting in the Soudan War of that year and was given the Medjidieh for his good work. After a spell of home service he was sent as Director of Telegraphs to the Ashanti Expeditionary Force (1895-96), and for the able way in which he carried out that duty was awarded a brevet majority. It was here that he contracted a fever which was the foundation of much ill-health in later years.

In 1899 he was selected for special duty under the Admiralty in the Falkland Islands. Two months after his return from this work he started for the South African War of 1899–1902 as A.D.C. to Sir Elliott Wood, the Chief Engineer to the Expeditionary Force, shortly afterwards becoming Assistant Director of Army Telegraphs, and acting for some time as Director.

In November, 1900, he joined the newly-raised South African Constabulary and rose to the very responsible post of Inspector-General in 1905, an appointment he relinquished in 1908 for a well-merited tour in England.

After one and a half years as C.R.E., Edinburgh, Curtis returned to his old home at Aldershot as O.C. Troops and Companies; some two years later the Army Signal School was formed and he was posted to it as commandant. Thence to the War Office in 1913 as A.A.G., R.E., where he stayed four years, two of which were war

years. We went to war in 1914 with a strength in officers and other ranks of about 6,000 and finished with something like 300,000—figures which alone are sufficient indication of the organizing power required of the A.A.G., R.E., and of the hard work involved. We Sappers are wholly to be congratulated that in Curtis we had the right man at the right time—but the long hours at the desk during these two strenuous years proved too much for him, and, early in 1917, he was obliged to give in. After a few months' rest as Commanding the Garrison at Cromarty, he became Major-General of Administration, Aldershot Command, and here he remained until the end of the War. He retired in March, 1920, with nearly 37 years of distinguished service to his credit; of these he would probably have counted his years with the South African Constabulary, where he gained the confidence and affection of the whole force, as his happiest; the years at the War Office, away from the front, tied to his desk and fighting all the time against ill-health, as his worst.

The writer, visiting him at his home in Kent, found him a victim to a painful illness, but he showed himself still the smiling, chaffing "Reggie" Curtis of old days, full of brave humour, keen and interested in anything that his enfeebled body would allow him to do. He died at West Farleigh on January 11th of this year—a fine character in every respect.

G. M. H.

GENERAL-OBERST VON BESELER.

GENERAL-OBERST VON BESELER, who died on the 21st December, 1921, was one of the most distinguished officers of engineers in the German Army. He was one of the half-dozen officers whose names were mentioned as possible successors to Graf Schlieffen when the latter ceased to be Chief of the General Staff in 1905 and the ex Kaiser nominated Moltke; and, in his arm, he was only surpasse in his professional career by General von Mudra, who at the close of the war became an army commander. Very like General Sir Herbert Miles in appearance, he was always interested in officers of Royal Engineers who visited Germany before the war, and went out of his way to be courteous and obliging to them.

The following particulars of his career are taken mainly from *Technik und Wehrmacht*:—

Born in 1850, in 1868 he entered the Guard Pioneer Battalion. After passing through the Kriegsakademie he, as usual with engineer officers, served a year in command of a company of an infantry regiment, returning to that arm later to command a battalion for a short time. He held, among Staff appointments, that of Instructor at the Kriegsakademie and Chief of the Army Section of the War Ministry, and under Schlieffen, was one of the three Deputy Chiefs

of the General Staff. In the years shortly before the war he was Chief of the Engineer and Pioneer Corps and Inspector-General of Fortresses, succeeding Field-Marshal von der Goltz in that post.

During the war he was in charge of the siege of Antwerp, commanded the III Reserve Corps (nearest the coast) at the first battle of Ypres, was in charge of the siege of Novo-Georgievsk, and then, until the collapse, was Governor-General of Poland.

J.E.E.

REVIEW.

LA GUERRE MONDIALE, 1914–18.

By LIEUT.-COLONEL H. CORDA (Librairie Chapelot, Paris. Price 25 *fr.*) THIS book of over 400 pages, with a portfolio of 85 plans, should be a useful book of reference to the student who wishes to refresh his memory on the military history of the various events of the Great War. Each incident is described clearly and in a few words, and may be understood by the help of its plan in the shortest possible time. The plans are excellent, and have been provided in lavish abundance. The chief defect of the book is that it has no index. It is also unfortunate that the author did not rewrite some of the earlier incidents, and especially the Battle of the Marne, but contented himself with publishing several pages of *Additifs*, which, though they give correct information on certain incidents, including the action of Lieut.-Colonel Hentsch, which have now been public property for some years, do not succeed in removing the false impression given in the text of the causes of the victory and of the credit due to certain units and unit commanders who participated in the great struggle. The author shows fairness in his references to the action of the allies and his praise of Lord Kitchener and of the British soldier is obviously sincere. He also shows grateful appreciation of the work of the British Navy.

SAPER Î INŻYNIER WOJSKOWY.

THE *R.E. Journal* welcomes the appearance of this new Polish Engineer Journal. No. 3 of the 1st volume contains original articles on the following subjects :—Anti-Tank Warfare ; Permanent Fortification in the War (with special reference to the Verdun Forts) ; Calculation of Mine Charges ; A Reconnaissance of the German Lines between Roie and the Oise ; Fire-fighting Methods. There are several good maps.

F.E.G.S.

NOTICES OF MAGAZINES.

MILITÄR WOCHENBLATT.

No. 35.—*Washington and the Submarine Question.*—Admiral von Grapow commences by giving a résumé of the results of the Washington Conference, which he summarizes as a gigantic bluff on the part of England and America to save themselves unproductive expenditure. What has been achieved in Washington is that the relative strength of the navies of the world are fixed at to-day's ratio in respect to ships of the line and battle cruisers, and are to remain unchanged for the next ten years. England, however, agrees to allowing America a navy equal to her own.

He describes the resolution respecting submarine warfare as an agreement come to in order to save the face of the Conference and one which in practice can never be carried out. According to it, submarines can only attack merchantmen when they do not stop at request. Other ships can only be sunk after the passengers and crew have been placed in safety.

He goes on to describe Britain's policy in arming her merchantmen for defence and in denying the enemy's right to declare a blockade in her territorial waters, whereby every captain of an armed merchantman can regard the stopping of his ship in such waters as an attack, giving him the right to shoot in self-defence, conditions under which even the best-equipped submarine is at a great disadvantage to the most ordinarily armed tramp.

He draws the conclusion from the second paragraph of the agreement that submarines may sink a merchantman and, from precedents established by Britain, that they cannot be expected to take on board the crews of their victims who may be found in the boats or swimming in the sea. The precedents quoted are the sinking of the L19 and various torpedo-boats in the North Sea; the *Scharnhorst* near the Falklands, and *Cap Trafalgar* near Trinidad, where it is alleged that the German crews were left to drown, an act unjustified by either tactical necessity or the weather conditions, and this notwithstanding the fact that in contradistinction to the submarine, ample accommodation for the beaten crews was available on board the victorious ships without sacrifice in offensive power.

He quotes further :—" Other ships may be sunk after the crew and passengers have been placed in safety." Does a ship's boat in the open sea comply with this requirement? How can a submarine take on board the passengers and crew of a steamer that has obediently heaved to? The first prize taken would so hamper the submarine as to preclude further operations.

Under these regulations, England, he declares, would make submarine warfare impossible by placing on board such vessels numerous passengers, including preferably some "American citizens" whose duty it would be to embroil Germany with America, as was so successfully done in the last war.

Those not in sympathy with the views expressed are invited to study samples quoted for their benefit from the literature of France and England, written before any idea of the Conference was mooted, and, therefore, unbiassed, to wit:—the prize essay entitled "The Influence of the Submarine in Naval Warfare in the Future," published in the November, 1919, issue of the *Royal United Service Institution Journal*, and Captain Castex's well-known article in the *Revue Militaire* of January, 1920.

Admiral von Grapow concludes his article in declaring that unscrupulous England will ignore in the future, as she has done in the past, laws which stand in the way of her victory, for Lord Fisher was right when he declared:—"The essence of war is force; moderation is folly."

Au 3ième bureau du 3ième G. Qu. G. by Major Laure.—This book is very favourably reviewed by General von Kuhl, who declared it to be a valuable contribution to military literature, and as being especially interesting as portraying the changes in tactics followed by the French during 1917 and 1918.

No. 36.—*Poland and her Neighbours.*—According to the *M.W.B.* the Poles are rapidly reducing their army to peace establishment. It dates the inception of the movement to the decision of the Supreme Council respecting Upper Silesia, which it declares is favourable to Poland.

The country is divided into ten commands, comprising 28 divisions, including five newly-formed. The latter were brought into existence by reducing by one the four Infantry regiments of a division, and reorganizing the other arms. The artillery of a division in peace-time is given as:—

1 Brigade Staff;
1 light artillery regiment, subdivided in three groups, each group comprising three batteries, one group being armed with howitzers;
1 heavy artillery group (to be increased in war-time to a regiment with two groups).

The centre of gravity of the Polish Army remains as before on the Western frontier.

A new conscription law proposes terms of service as under:—
2 years with the colours;
18 years in the reserve;
12 years in the Landsturm (home defence).

The air force is said to consist of four regiments organized in 25 sections, totalling 600 aeroplanes of French and Italian manufacture, and four battalions for airship service. The whole is concentrated on the Western frontier.

The artillery is armed with French guns.

Communists have attempted to undermine the army, but so far without success.

The Navy consists of six torpedo-boats. The construction of the harbour of Edingen progresses. Coast defence armament consists of 21 cm. howitzer and 15 cm. guns.

Poland and Czecho-Slovakia have concluded political treaties, designed, it is stated, to overthrow Germany's former economic predominance.

Tension still continues to exist between Poland and Russia over the execution of the Treaty of Riga, but it is not expected to provoke war.

Military and Political Report from Switzerland.—The bad effects of the high value of the Swiss exchange on the economic life of Switzerland is portrayed; to this fact the prevailing unemployment is ascribed. On the other hand, the military spirit of the Swiss is favourably reported on. In all branches great keenness is evinced, which is voluntarily carried on beyond the period spent with the colours. The standard of shooting is said to have attained remarkable efficiency. The machine-pistol is suggested as likely to become the rival of the light machine-gun.

Alleged Espionage in Military Clubs.—Regimental and Officers' Clubs are warned to be on their guard against Entente officers, especially English, who are alleged to be endeavouring to attend meetings as guests for the purpose of espionage, and especially to obtain copies of their rules.

No. 37.—Nothing of fresh interest.

No. 38.—*Soviet Russia.*—"Von W" gives his account of the happenings from November, 1921, to February, 1922. As a result of demobilization the men under arms have been reduced to 1½ millions, including Navy, Police and Frontier Troops, of whom about one-half are fighting troops.

The law of conscription provides for service from 18 to 40 years of age, of which two years are with the colours.

Reorganization is still in progress. Many institutions appertaining to the old army are being reintroduced—much is being done to promote better conditions of service, especially as regards accommodation which is very bad. One-third of the officers are of the old régime.

Training of leaders is receiving more attention. Courses of instruction are being held. To be a member of the working or peasant class is no longer considered the only qualification necessary. Those who have taken part in the courses of instruction form their own detachments which are especially reliable from the political point of view.

The first class, numbering 60 to 70, has passed out of the Red Staff College after a course of instruction lasting three years.

The first big manœuvres took place in the district of Kiev. One side consisted of 24 battalions, six squadrons and six batteries. He reports the scheme of the higher command as being well thought out and well executed. The capacity for work of the rank and file is described as satisfactory, but the execution was faulty in detail. Arrangements for reinforcements were totally lacking.

The famine is stated to be increasing. According to Nansen, 19 million inhabitants are directly threatened with starvation, of whom

15 millions cannot now be saved. The Soviet Republic is not in immediate danger, as there has been no revolt as a result of the famine.

The Ninth Congress of the Councils sat in December and confirmed their programme, which included :—Safeguarding the peasant for a long term of years in the use of the land which is his " provisional " property, fixing the value of the rouble, cessation of the issue of paper money, safeguarding personal property.

The foreign policy favours the conclusion of economic treaties with the border states, with the idea of preventing their employment for intervention by Europe.

Russia's efforts to obtain recognition by the Powers are described.

Von W. thinks that her salvation should lie in aiding agriculture so as to increase production. The coming harvest, under the most favourable conditions, will yield less than last year.

Trade and finance are reported on as having recommenced, especially with Germany. Many fetters of the Communistic creed have been loosened ; the practice in banking, for instance, is said to be no different to that in vogue in capitalistic countries. The rouble continues to fall.

Notes on Tactical Leadership in the War, by Julius Frontinus.—The writer points out the efforts made during the late war to keep tactics up-to-date, together with the obvious difficulty of doing so with subordinate leaders continually decreasing in efficiency. Encounters generally developed very differently to that foreseen in the revised instructions. This, for reasons easily understood, was never brought out sufficiently clearly in the reports. Where a success was obtained, the battalion commander and the lieutenant were content to let their superiors believe that it was done according to the newly-prescribed procedure. The latter indulged in an optimism, which increased as the square of the distance from front line, as to the value of their new instructions.

Written instructions of this nature, rather than the rarer documents from front line, are always a principal source of information for military history, which, in consequence, unconsciously succumbs to such deception. Behind the front line the relation between cause and effect becomes more obscure.

Frontinus does not like the elastic defence, the training effect of which he especially deplores and which requires, in order to be effective, first class troops.

In his opinion, the ideal in war still remains to get the will of the commander conveyed without distortion right down through the chain of command to the fighter in the front line. This, he declares, is more important than the practising of the latest procedure, which is certain to be out of date very shortly. It is not essential that the operation should be " right " according to the latest text-book. The main object is to make the soldier an instrument capable of working with precision according to the will of his leader. Not, however, mechanically like a pianola, but able to attune himself to the necessities of every case. This adaptability is less a quality required of the private soldier than of the junior officer. The man who is always seeking as a guide for every situation a precedent in the histories of former wars, or whose orders are

solely inspired by back files, is no leader, but rather he who is resolute and possessed of the ability relentlessly to convert his own decision into deeds.

Reviews.—The following are among the books that receive favourable notice :—

Kurzer Strategischer Überlick über den Weltkrieg 1914–18, by GENERAL-LIEUTENANT A. D. OTTO V. MOSER.

Der Gaskampf und die Gasschutzgeräte im Weltkrieg 1914–18, by OBERBERGRAT ING. G. RYBA.

H. DE C. TOOGOOD, *Captain, R.E.*

REVUE MILITAIRE GÉNÉRALE.

January, 1922.

The Cavalry We Require.—By General Robillot. This article enumerates the duties of cavalry, and enters a strong plea for its retention or even augmentation in the French Army, for such duties cannot effectively be performed by any other arm, or combination of arms, at present existing. On several occasions the Germans, owing to lack of cavalry, failed to develop successes they had gained. Consideration is given to the establishment required, to organization, equipment and training.

The Revision of the Regulations.—A continuation of the article by "Lucius," embracing the 5th period, or the latter half of 1917, which was marked by a radical change of procedure. Before the Battle of the Aisne it had been generally accepted that victory in the field could alone put an end to the War, and that economic, financial and political difficulties would not suffice. Till that time a rupture of the enemy's front was aimed at; now the offensive was again confined to "limited objectives." When General Pétain assumed command of the French Armies, the country regarded the pause on the Aisne as a check, and, these misgivings spreading to the Army, the *poilu* had come to think that the sacrifices he had made were rated too cheaply, and signs of mutiny appeared in certain units which were met with tact and firmness by the C.-in-C. Secondly, further checks had to be avoided and the available reserves of men and material, though superior to those of the enemy, in view of the defection of Russia were estimated as insufficient to force a decision until early in 1918 when the assistance of the United States could be counted upon. For these considerations it was decided to wear down the enemy's forces, to hinder any aggression on his part, and to keep him in a state of nervousness by local attacks, which would at the same time raise the morale and confidence of the French troops.

Such were the principles enunciated by the C.-in-C. and developed later in the Instruction of 31st October and 20th December, 1917. The costly attacks deep into the enemy's position were to be replaced by attacks on limited objectives on as wide fronts as possible, prepared for in every detail, supported by a maximum of artillery to economize the infantry, and making use of surprise, which meant the organization of

almost the whole front for offensive operations. It was laid down that little or no change of position was to be made by the guns, but that capture of the enemy's guns was always to be reckoned as a possibility, that field works undertaken must be so constructed as to alter the aspect of the field of battle as little as possible, that the attainment of surprise must not be endangered by a prolonged artillery preparation, for the numbers of large-bore Q.F. guns now admitted of ranging being carried out simultaneously with the installation of the batteries, and gas-shell could be used to neutralize the enemy's artillery, especially during the execution of the attack. The commander must order the advance of the infantry as soon as he was satisfied that the artillery had caused sufficient damage, although absolute destruction of the enemy's works had not been obtained. Defensive organization must ensure reinforcing with order and method in a minimum of time, by both artillery and infantry, any sector threatened or attacked, and also that formations were ready where required for counter-attack or relief. Railways and motor vehicles would play an important part in these arrangements, and besides a transport plan, a retreat plan should be prepared with the object of determining by how few effectives unthreatened sectors could be held. The possibility of a voluntary retirement of the enemy must not be lost sight of, necessitating a pursuit plan. To meet these various situations each army could, leaving aside periods of crisis, count on a fixed proportion of the troops available, as decided by the General-in-Chief, and to be understood to include reliefs for instruction and rest.

Special executive rules had been issued by the C.-in-C. on 20th June, 1917; with limited objectives infantry has no longer to advance beyond the zone bombarded by its artillery, and the question of halts to enable the guns to change position does not arise. Method can be exercised without hindrance as in siege warfare, risks and the unforeseen are eliminated, and continuity and rapidity in the attack recede to the background. Surprise is of the highest importance, and is facilitated by rapidity in the final arrangements, in the installation of batteries and in the artillery preparation. The rules, reflecting the spirit of organization and method, dealt with the offensive and defensive organization of the front, its division into sectors, the distribution of men and materials between the larger commands, the employment of the troops in line and in reserve, the necessity for considered forecasts of procedure in case of attack or defence, the well-being of the troops, the importance of instruction and discipline, and banishing any necessity for improvisation were a great advance on any hitherto promulgated. The rules were *secret* in that they were only issued to the higher commanders, but the guiding principle of them was unfortunately divulged during July by the Minister for War in the Chamber, and so brought to the knowledge of the troops and this may have had some effect in raising the waning morale of the enemy. Attacks on limited objectives were, however, only a temporary expedient to be renounced directly the period of equilibrium should be altered.

An amendment issued 27th July, 1917, modified to some extent the Instruction of 27th December, 1916. (1) The lesson drawn from the Battle of the Somme, advising a broad conception of operations, was

omitted; (2) it was left an open question whether attacks should be strictly limited to wearing down the enemy, or should also aim at rupture "if the general situation permitted of such a result being obtainable," and the original chapter on the development of the success was re-published; (3) the battle for rupture was conceived of as a series of attacks following each other rapidly, and each prepared for by the previous assembly of every possible resource, especially a powerful artillery. Each successive objective was, therefore, to be determined in accordance with the radius of action of the guns without change of position, its capture then entailed a halt until the batteries could as rapidly as possible take up their new positions; (4) nothing was to be attempted by infantry unless it was sure of artillery support. New points in the Amendment were:—(1) manœuvres were to be based (*a*) on a profound study of the enemy's organizations and resources; (*b*) on surprise, and (*c*) on the peculiarities of the ground which might necessitate certain sectors being taken before others were attacked. (2) The front of attack was not only to be as wide as possible, but must be proportionate to the force available, and the depth of the thrust must be decided not only by the effective range of the guns, but by the limited capacity for penetration of the infantry; *e.g.*, the average front of a battalion would be 300 to 400 metres and its penetration 500 to 1,000 metres, making the battle front of a division 1,000 to 1,200 metres.

The Offensives of the end of 1917.—Outlines are given of the operations for the reduction of the Messines salient (7th June), in Flanders (31st July), North of Verdun (20th August), Malmaison (23rd October), and Cambrai (20th November). All were successful, some extremely so, and fulfilled the object of inflicting on the enemy greater loss than was sustained by the attackers, while the morale and confidence of the latter were enhanced. All presented similar characteristics—(*a*) the ascendancy of system; everything was pre-arranged with mathematical precision from which no departure was made; (*b*) the incessant augmentation of material resources, artillery, aviation, and tanks; (*c*) prolonged artillery preparation in order to husband infantry, but, except at Malmaison, neutralization of the enemy's batteries was not attempted prior to the infantry attack; (*d*) complete absence of surprise except at Cambrai, in spite of the C.-in-C.'s instructions; (*e*) attacks facilitated owing to there being no change of position of the guns during the action. As a result, each battle followed a mechanical plan, and development of the success was neglected, since it was impossible to forecast at what time and place it might occur. In conclusion, it may be said that the problem of wearing down the enemy was a nice one. To attain it, it is necessary to aim at the capture of one complete defensive system, and to drive the enemy back to another as far to his rear as possible. By this means only can the situation be cleared up, and time obtained for the victor to consolidate his gains without being subject to the continual annoyance which would occur if the enemy remained in too close proximity.

The French Cavalry During the First Three Months of the War.—By Colonel Monsenergue. This article does not pretend to give a detailed history of the operations of each of the ten cavalry divisions.

Personal reminiscences, which alone have been published hitherto, give little or no idea of the influence of the cavalry operations as a whole on the conduct of the war, and the writer proposes to take a wider view. Chapter I gives a general sketch of the screening operations during the concentration of the French armies, Chapter II deals with General Sordet's 1st Cavalry Corps in Belgium from 8th to 23rd August, 1914. A map is attached showing diagrammatically the German concentration in Luxemburg and Belgium.

(To be continued.)

A. R. REYNOLDS, *Colonel.*

REVUE MILITAIRE SUISSE.

No. 2.—*February*, 1922.

Article 18 of the Swiss Constitution.—The original article is contributed by M. Agénor Krafft, who discusses therein the rights of the Swiss citizen under the provisions of Art. 18 of the Swiss Constitution of 1874, which runs: "*Tout Suisse est tenu au service militaire.*" It was in Art. 1 of the general military regulations of August 20th, 1817, that the statement was made that every Swiss *is* a soldier. In order to keep within the Vote for the Swiss Army, it has recently been necessary to cut down the numbers in the annual contingents called to the colours. The Swiss Government, in their difficulty, caused a reduction to be made in the numbers of the calling-up notices by bringing about a large proportion of rejections on medical grounds: M. Krafft questions the legality of the procedure adopted. He is of opinion that it is mischievous for the Government to direct the medical authorities, on some vague pretext, to certify that a young man who, in normal circumstances, would have received his calling-up notice is disqualified for military service.

Search for a New Discipline.—Captain Cingria's article on this subject, begun in the number of the *Revue* for November, 1921, is continued. In this part of his article Captain Cingria quotes various articles of the Swiss Regulations and comments upon them. His view appears to be that many of the words of command, and the custom and procedure in connection with the duties of guards and sentries, are archaic and require to be remodelled so as to be brought more in consonance with modern thought on social relationships between the various classes of the community. He is of opinion that as much latitude should be allowed in matters relating to sentry duty as are permitted in connection with the manner and method in which Town Police perform their duties. *(To be continued.)*

Disarmament?—Colonel Knapp, Commandant, 22nd Inf. Bde., the author of the original article, calls attention to a contribution to the *Journal Militaire Suisse* by Colonel Sarasin, who makes a pressing demand for disarmament and a reduction in military expenditure. Colonel Knapp points to the several economies which have been effected

in recent times in the Swiss Army; he considers it rank hypocrisy for the people of Switzerland to raise the cry of poverty as an excuse for cutting down expenditure on national defence, so long as they can afford to spend a milliard (£40,000,000 at par) a year on luxuries, such as alcohol and tobacco for instance. He agrees, however, that it is up to soldiers to assist in a reorganization of the Swiss Army with a view to a reduction in the cost of its upkeep to the greatest extent possible.

NOTES AND NEWS.—*Switzerland.*—A comparative statement showing the expenditure on the several items of the Army Budget of 1920 and the amounts taken up in the Budgets for 1921 and for 1922 for these items is published in the Notes. In the case of the majority of the items the Budget provisions for 1921 and for 1922 differ but little from the expenditure in 1920; however, the sums taken up in the Budgets for 1921 and for 1922 for training are double the expenditure incurred under this head in 1920, whilst the amount provided in the Budget for 1922 in respect of contributions to military societies is quintuple the expenditure on this item in 1920. The Budget for 1922 makes up for an expenditure of 81 million francs as compared with an actual expenditure of 60 million francs in 1920.

France.—A special correspondent deals with the French Budget for 1922: the establishment of the French Army for the year in question has been fixed at 701,726 all ranks, involving a reduction of 50,000 all ranks in the establishment, as compared with the previous year. The establishment has been calculated upon the following basis:—

A.—Chargeable to the ordinary Budget.	*Men.*
Home Service	398,917
Algeria, Tunis and China	63,533
Morocco	85,951
Occupation Corps, Constantinople	6,926
Levant	50,000
Missions (extraordinary)	450
Sarre	7,765
B.—Expenditure which is recoverable.	
Rhine Provinces	86,959
Plebiscite regions	760
Commission on Control duty	465
Grand Total ...	701,726

In the Budget for 1921 provision was made for an establishment of 38,549 officers; this number is reduced in the current Budget to 35,953. In theory, service with the colours is now two years, but, in practice, in order that the expenditure shall not exceed the sums voted, a large number of men are given long leave. Apparently in no country can the civilian element resist the temptation to interfere in the military domain; complaints are rife that such interference is increasing in France.

W. A. J. O'MEARA.

REVUE DU GÉNIE MILITAIRE.

December, 1921.

The first article by Colonel Audouard is a study of turning problems considering a train of vehicles drawn by a lorry and a description of a type of vehicle giving correct turning.

This article goes very fully into the question and the various conditions necessary to obtain correct turning are discussed. A type of vehicle is thus evolved which has been tried and given satisfactory results in actual practice, and which has been adopted for certain tractor-drawn bridging vehicles to carry long loads.

Some words on the Fortress of Metz by Commandant Tricaud.—The author gives a historical sketch of the Fortress, and briefly mentions the work done by Clovis about 480, the construction of an enceinte in 1444, the work done by the Duc de Guise in 1552, the construction of the Citadel in 1562, minor improvements by Vauban, the construction by Cormontaigne of the fortifications of Belle-Croix to cover the artillery acting towards Saint-Julien, and the fortifications of the three fronts on the Moselle facing towards the Northern slopes of Saint-Quentin. Some years before 1870 the French decided to abandon many of the forts along the frontier and to improve and retain only a few, including Metz, Langres, and Belfort. There were two schools of thought, the one that these fortresses should be large defended localities to give an army a favourable battle-ground, and the other that they should be bridge-heads to give an army room for manœuvre in front of an obstacle.

Marshal Niel's ideas were followed in the reorganization of Metz. He was much impressed with the power of artillery, and decided that certain well-chosen localities around Metz should be provided with forts of massive construction, having deep and wide ditches, and a powerful artillery.

He placed these forts on the near edge of the plateaux around Metz, so that, with their high command, they dominated the plateaux and yet were very little visible from the enemy's artillery positions and observation posts.

On these lines were built the forts of Queuleu, Saint-Quentin, Plappeville; with the exception of Saint-Quentin, where space was not available, they were all of large area. Later it was decided to construct intermediate forts, but in 1870 the possession of the Fortress passed to the Germans.

Up to 1900 the Germans contented themselves with building the forts planned by the French, and then adding a profusion of shelters, small forts, armoured and earth battery emplacements.

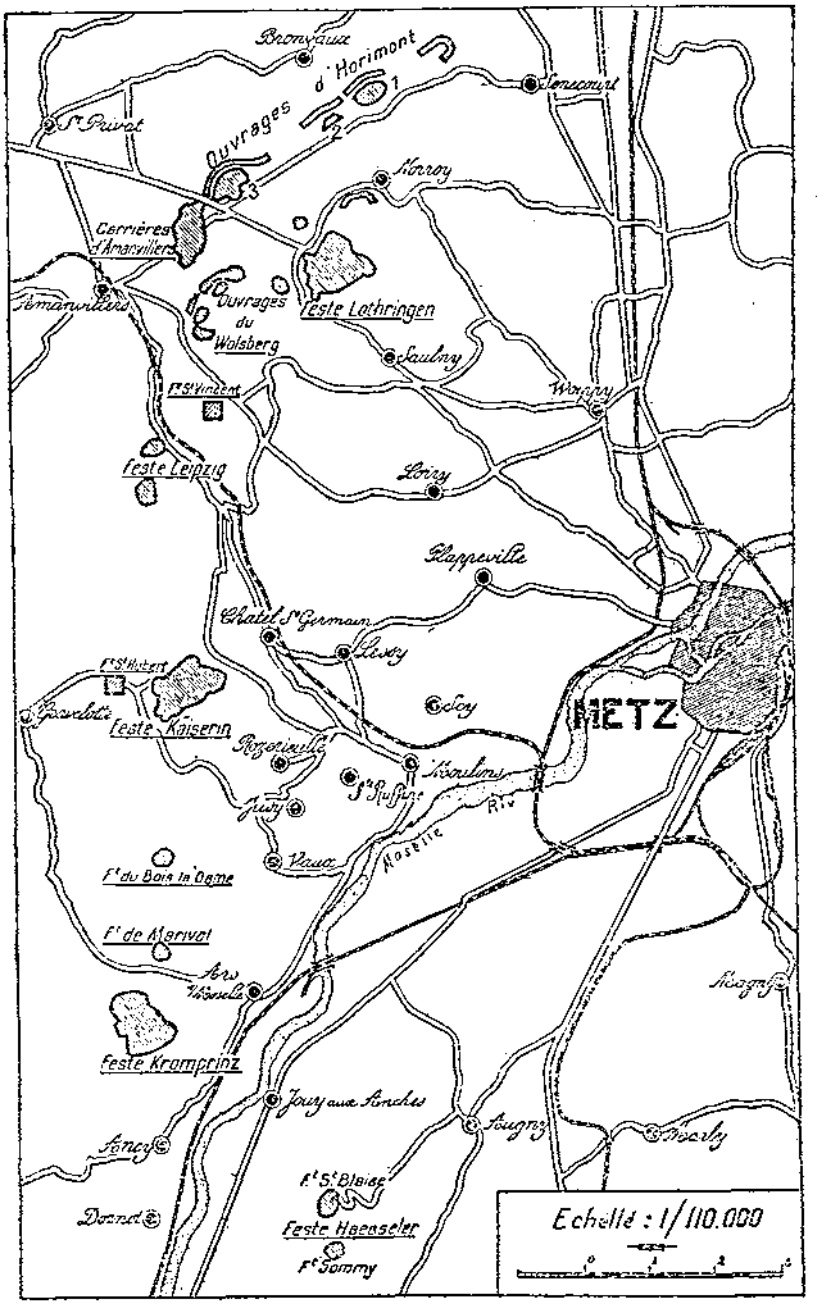
On the introduction of high-explosive shell they merely added one metre of concrete to their defences. There is no doubt but that the French Artillery could have breached these works very quickly.

About 1900 the Germans decided on a new form of defence and began the creation of *feste* on the more threatened sectors.

These *feste* are analogous in their rôle to the forts built by Marshal Niel: they consisted of an arrangement to safeguard from assault a certain number of turrets for heavy-calibre guns. These guns were

intended to keep the enemy at a distance and to prevent his advance. The most perfect of these *feste* is *Kaiserin*, which includes 12 heavy gun turrets in four batteries, protected in front by a ditch and elsewhere by a continuous trench behind a wire obstacle.

The ditch is flanked by an infantry work provided with field guns in



casemates. The wire obstacle is swept from counterscarp positions, from casemates and from caponiers.

The author criticizes the visibility of the forts and the technical faults in their construction.

About 1908 the Germans, having realized the weaknesses of their *feste*, began to provide for close defence and for the flanking of the intervals. This was done with great skill, the method varying according to the ground. An example is given of the work done on the North-West sector of the defence from Horimont to Kronprinz.

(*a*) Horimont, a narrow, long, undulating spur, very steep on the enemy's side. The undulations would give dead ground from *feste* at either extremity. The Germans constructed a continuous ditch on the enemy side of the crest and, at intervals, placed a two-storeyed casemate in the ditch, the lower storey to fire along the ditch and the top one to provide fire over the ground in front. Behind the ditch are a very large number of shelters, trenches, O.P.'s, magazines, machine-gun and gun emplacements so scattered and concealed that it is difficult to imagine an artillery bombardment being very effective.

(*b*) Between Horimont and Leipzig two very interesting areas are found—the quarries of Amanvillers and Wolsberg. The former is fortified to defend the interval between Horimont and Wolsberg. The works consist of a group of trenches liberally supplied with mined dug-outs, and surrounded by a ditch cut in the solid rock defended from counterscarp chambers.

(*c*) The interest of Wolsberg lies in the fact that it is a field position carried out with all the resources of the art of engineering. It is a position for two battalions, each having its rest barracks provided with everything necessary to live under a prolonged bombardment. In front of the barrack is a support line with dug-outs in the trench itself or immediately adjacent to it. In front again is the front line provided with numerous shelters, O.P.'s, listening posts, machine-gun emplacements, emplacements for portable guns, in addition to the O.P.'s for the guns in the *feste Lothringen*, which has little field of view.

West of the position four heavy guns are sited to give flanking fire towards Saint-Hubert and Bois la Dame. In prolongation of this line a position for one battalion has been constructed on similar lines at the farm of Saint-Vincent.

The reason of the above system of defence is that the ground is very flat and under observation everywhere, and consequently, protection from artillery fire has been sought in dispersion.

(*d*) The plateau, including the *Feste Leipzig* and *Kaiserin* has not been fortified since 1908, presumably because the Germans did not have time to fortify it in accordance with their subsequent principles.

(*e*) From *Feste Kaiserin* to the ravine of Ars-sur-Moselle extends a plateau open to the North and wooded to the South and West. All the wooded portion is full of heavy guns covered by a continuous trench behind a wire obstacle, flanked by numerous works. In the open portion this flanking is obtained from three extensive works, built of earth, but provided with concrete shelters scattered over a large area. In the wooded portion the flanking works are concentrated in posts

provided with ditches and means for producing flanking fire. At Bois la Dame there is a kind of Bourges casemate on the right flank and an armoured machine-gun casemate on the left flank. Bois la Dame is also interesting in that it is exceptionally well concealed, growing trees being left standing in pockets in made ground.

The last of the posts of this position—Marival—still incomplete, possesses a Bourges casemate for flanking the approaches to *Kronprinz*.

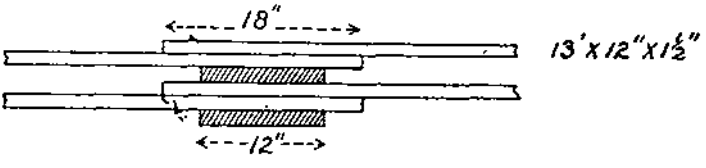
In conclusion, the author briefly shows how the method of defence has been made to conform with the ground all along the front and emphasizes that Metz offers a very interesting study to the military engineer since the study of the past permits the foreseeing of the future.

Assault Bridges of Floating Planks.—Colonel Thomas describes a type of assault bridge used with great success on several occasions in 1916, 1917 and 1918.

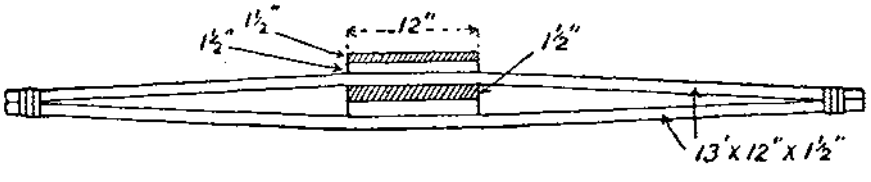
The bridge is described as being stable, light, easily constructed, hidden and carried. It is constructed of timber, approximately 13 ft. by 12 in. by 1½ in.

Bays are 11 ft. 6 in. from centre to centre of piers, which consist of single planks, or, if weaker timber is used, of two planks lashed together at their ends. The sketches below, which are sections along and across the bridge near a pier, show the method of construction.

The upper and lower planks of the roadway are either fastened together with ordinary lashings or holes are bored to take the lashings through the planks in the overlap, avoiding the cross timbers.



Section along Bridge.



Section across Bridge.

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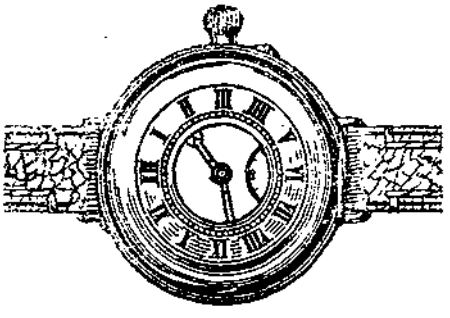

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