THE ROYAL ENGINEERS JOURNAL.



Vol. XXXVI. No. 5.

NOVEMBER, 1922.

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ERRATA.-IMPERIAL ORGANIZATION.

R.E. Journal, October, 1922.

Page 194, line 35.—" She has a practical monopoly of ... timber." This statement must be modified in view of the fact that the Board of Trade reports that in 1921 the imports of timber into Great Britain from the United States amounted in value to £20,000,000.

" Page 202, line 15.-For " 13 miles " read " 116 miles."

Page 204, line 28-29.—For "Nairobi (Uganda)" read "Nairobi (Kenya)."

Page 204, line 39.--" A great empire like Malaysia." For "Malaysia" read "Malaya."

Page 206, times 1-2.--For "Emir Feisal, a nephew of the ruler of Medina ". read "Emir Feisal, son of Hussein, King of the Hediaz."

Page 206, lines 5-7. - For "Africa . . . South Africa " read " In Africa there are also Protectorates (that portion of Kenya Colony and Protectorate on the mainland which belongs to the Sultan of Zanzibar, Zanzibar Island, Uganda, Nigeria, Northern Bechuanaland, Somaliland, Nyasaland), the Bechuanaland Protectorate being under the High Commissioner and Governor-General of South Africa."

Page 206, line 9.—" Further certain Protectorates . . ." For "Protectorates " read " Protected Territories " or " Mandated Territories."

Page 207, line 17.—" Gibraltar . . . War Office." For " War Office." read " Colonial Office." ADVERTISEMENTS.



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Lecture delivered at the S.M.E., Chatham, on 9. 3. 22 by Brig.-General G. P. CAMPBELL, C.I.E., C.B.E. (late Chief Engineer, Waziristan Force).

My intention this evening is to draw your attention to one of the great fields of activity still open to the R.E. Officer in peace as well as in war, that is, Road Construction on the N.W. Frontier of India. I intend, also, to bring out certain points which are not found in text-books.

In these trans-Indus regions, Baluchistan and the N.W. Frontier Province, all engineering work, except railways and irrigation, is carried on by the Military Works Services, which is wholly an R.E. organization—hence the R.E. Officers posted to these Provinces have charge of all civil works, as well as those pertaining to military requirements, and so they have a wider scope of employment and interest than falls to the lot of most R.E.'s. It is in these Provinces that all the most important roads have been, and will be, made.

On *Plate* I, I have indicated in *continuous* lines the older of the main strategic roads, most of which were built generations ago and are being gradually improved; and I have shown, in *chain-dotted* lines, the newer roads, some of which are being extended, as the broken lines indicate.

Beginning at the south of this map, the old main frontier roads are the following :---

(A). From Sibi, at the foot of the Baluchistan ranges, through the celebrated Bolan Pass and Quetta, and across the upland plain of the Peshin District to, and over, the well-known Khojak Range and down to Chaman, which faces Kandahar (in Afghanistan).

(B). From Harnai through Loralai away out to Fort Sandeman, which, from the edge of Baluchistan, faces Waziristan in the N.W. Frontier Province.

(C). From Dera Ismail Khan (in the N.W.F.P.) to Tank and on to Murtaza Post, which faces the foot of the great Gomal Pass.

(D). From Dera Ismail Khan to Bannu and Kohat and on to Khushalgarh on the Indus.

(E). From Kohat to Parachinar near the famous Peiwar-Kotal.

(F). From Kohat via the Kohat Pass to Peshawar.

(G). From Peshawar through the historic Khyber Pass to Landi Kotal and Landi Khana, which look towards Jellalabad and Kabul. (I refer more fully to this road later on.) (H). From Attock to Peshawar :- This is really a continuation of the Grand Trunk Road, which begins at Calcutta, nearly 2,000 miles distant.

(I). From Nowshera through Mardan (the home of the famous Guides) and up the Malakand Pass and on down to Chakdara, facing Swat, Chitral, etc.

For the most part these old roads are wonderfully well graded, and they would disclaim any relationship with the goat-tracks which Devonshire endures, or with some of the roads in Kent. But, of course, they were designed only for medium-paced traffic, and not for motor transport, which has tried them sorely in the recent campaigns. Their defects in these days of fast-moving traffic are:—

- (a) Narrowness.
- (b) Sharp, unbanked corners.
- (c) Shortage in metalling, both in width and depth.
- (d) Inadequate sizes of bridges and culverts.
- (e) Defective retaining walls.

These old communications are being gradually improved, and a considerable amount has been done in remedying (a) and (b), but defects (c), (d) and (e) necessitate heavy expenditure, and their claims are too often met by the heart-breaking reply, "as funds become available."

The modern frontier roads (on all of which, by the way, I have been employed from the rank of Subaltern to that of Brigadier-General) are the following :--

(J). The Takki-Zam Valley Road.—This takes off from Road (C) above, and after rising to the upland of Manzai (where is a new Cantonment) it reaches the right bank of the River Zam at Khirgi Post. From the lofty cliffs of this bank the road descends to the river, which is crossed twice by transferred railway bridges before reaching the next military post, Jandola, seven miles from Khirgi. This " double crossing," which theoretically appears to be an unnecessary luxury, is an example of the fact that, in aligning a frontier road there are other considerations besides those of the engineer. In this case, there were both political and strategical objections to a continuous adherence to the right bank of the river, where the gradients in the broken hills would have necessitated a long detour away from the general direction of the march, and into country that was politically dangerous. As it actually worked out, it was cheaper to construct the two bridges than to make the long detour.

After leaving Jandola, the Zam River is crossed by a third bridge, whose superstructure, like that of those already mentioned, was erected by the N.W. Railway Bridge Engineer (Mr. Everall).

I must here tell you the history of these bridges, as it shows the great value of intelligent co-ordination whenever this can be established :- When the N.W. Railway, and other Lines in India, increased the size and speed of their locomotives (and rolling stock generally) it became necessary to scrap their old bridges and substitute far heavier sections. The scrapped lattice girders, etc., of these superseded bridges were lying idle in various railway depôts, when a "brain-wave" prompted the M.W.S. to ask for the transfer of these materials, which would be quite adequate for road traffic. They were then collected in the workshops of the Bridge Engineer, N.W. Railway (Mr. Everall), whose services are placed at our disposal and who co-operates with any frontier engineer requiring bridges, and these are devised accordingly. The R.E. officer then designs and constructs the abutments, piers, training-works, etc., and arranges for road transport of the superstructure, which the Bridge Engineer delivers at railhead, and, afterwards, erects on the piers. It is an admirable and economical arrangement, as we get inexpensive bridges, and the railway department concerned gets rid of "surplus material."

I draw your attention to *Plates* II and III, in which are diagrams of two of these bridges. One diagram shows how a *deep* girder can be utilized with shallow ones. The other shows two cantilevers and their anchorages. *Plates* IIA and IIIA are respective photographs of these two bridges.

To continue, as to the Takki-Zam Valley Road.—From the bridgehead at Jandola the road crosses a high stony plain, passes through a small range, and rejoins, and then recrosses, the river, whose right bank it traverses to our further outpost, which is near Makin—the capital of Waziristan. This road is to be extended northwards up over the Razmak Pass to meet the Tochi Road, west of Miran Shah (Dardoni). This latter road I now proceed to describe.

(K). The Tochi Valley Road from Bannu to Datta Khel (which looks towards Ghazni in Afghanistan) covers a distance of eighty miles. I personally made the first survey and alignment of this road, which I began in 1896–97. Since then the work has progressed "as funds became available" (as I have said before), and latterly it has been immensely augmented by Major A. H. Bell, R.E., who wrote an excellent and interesting description of it in the *R.E. Journal* of October, 1921.

During the recent Waziristan Expedition, in 1919-20, the Tochi River was spanned by two lattice girder bridges transferred and erected by the N.W. Railway. These bridges (shown in *Plates* V and VI) were inserted so as to enable us to divert the road away from a dangerous hill which produced landslides like avalanches, and frequently blocked the road for a week at a time. The result now is that the first forty miles of the Tochi Road, *i.e.*, as far as Dardoni (the cantonment of Miran Shah) are always open, and the military posts can always be rapidly reinforced at any season of the year.

Westward of Dardoni, the Tochi Road to Datta Khel was in course of completion, under Major Bell, when orders were received for the evacuation of the Upper Tochi, owing to the Afghan War of 1919—but the construction will now be resumed and a "ring fence" will then encircle Waziristan.

(L). The Khyber Pass Road.—I have already referred to this vide (G) above—under the heading of "Old Frontier Roads," but it has been so much improved in recent years that it has now come under the designation of a "Modern Frontier Road." For many centuries this celebrated Pass has been the main outlet from Central Asia to India, and it has probably seen more fighting than any locality in the world. From generation to generation that unconquerable force called "Trade" has evoked, and invoked, the transit of great camel-caravans, whose owners and guards, called "Powindahs," have fought their way, step by step, with the produce of Central Asia or the products of Hindustan (including "Manchester goods").

When I took over the Khyber, about eleven years ago, there existed what is called a "cart road," which was duplicated for a few miles, and which possessed all the defects of frontier roads. The advent of fast-moving traffic, and the needs of modern warfare, rendered imperative the complete modernization of this important Line of Communication, and, at last, "funds were forthcoming." Hence, I was able to transform, and duplicate, the road from Jamrud (which is at the foot of the Pass on the Indian side) to Landi Khana, which is twenty-five miles distant, and on the Afghan Border.

The circle formed by what we called the "North Road" and the "South Road" would now provide an excellent arena for "motor trials."

These three roads, namely, the Tochi Valley, the Takki-Zam and the Khyber Pass, embody the latest specifications of the Government of India, as expressed by the Director General of Military Works, for the construction of Indian Frontier Roads. In them, rigid economy has been practised, and (to quote from General Sir George Scott-Moncrieff's article in the January number of the *R.E. Journal*) the "Best" has not been allowed to become the enemy of the "Good."

I shall refer to these roads again, when describing the laying-out and construction of a frontier road.

The Life History (to use an entomological expression) of a frontier road is as follows :---

(a) Orders arrive from G.H.Q. for the construction of a motor transport road between, say, point A and point B, which hitherto have been connected only by a camel-track mostly in the bed of a

wide river. A rough approximate estimate is called for, simultaneously.

(b) The Engineer Officer in charge proceeds to make a road reconnaissance. This is a matter of his own *personal* labour, and must be done on foot, not once, and not in one direction, but dozens of times and from each end of the route. This necessitates many excursions up side ravines (or *nullahs*, as they are called) and on to adjacent hills and spurs. As reliable maps of the country may not exist, a rapid survey must be made, so as to indicate clearly to co-ordinating officers the general direction proposed, and the adjacent features of the land. During this preliminary prospecting, the Engincer Officer in charge will choose his engineering obligatory points, such as the lowest point for crossing a range, or bridging a river, or the point of diversion, so as to avoid a rotten hillside, or to steer clear of a precipice.

(c) The next step will be the consultation with officers of other branches, or Services, who, you will find, may have a good deal of influence on the route to be adopted. These officers are :---

- (i) The General Staff of the force in occupation.
- (ii) The local Political Officer.
- (iii) The local Irrigation and Forest Officers.
- (iv) The Officers commanding posts, etc., en route.

With reference to (i) and (ii) I have given already (in the case of the Takki-Zam Valley Road) an example of the strategical and political considerations affecting the choice of a route which, though favourable from an engineering point of view, was unfavourable from the points of view of the G.S. and the Political Department. Furthermore, the Political Officer will point out cemeteries or irrigated lands or Mosque property, etc., which it is necessary to avoid.

With regard to (iii) it might happen that the best engineeringalignment would seriously interfere with some projected irrigation scheme, such as a catchment-area, or site of a reservoir, etc., or possibly the road-making might ruin a forest-conservation, or destroy an area most suitable for forest-nurseries, etc.

As to (iv) an Officer who spends all his days and nights in a certain outpost has many small needs which the new road may affect adversely, or greatly improve. These small points do not come under the wide vision of the G.S., but they are important to the little garrison. I specify such items as aligning the road so as not to spoil the access to water-supply, or the field of fire, or the vegetable garden, or the conservancy area, or the ventilation, which a high embankment might cut off.

There are other important considerations which would seem to require a sort of prophetic vision, on account of the vagaries of strategical and political policies. Among the frontier hills there are

very few level, or even moderately smooth, pieces of ground which could be utilized for "landing grounds" for aeroplanes, or camping grounds for troops, or station yards for railways, or dumping grounds for military stores. Therefore, unless wide areas can be provided on both sides of the road, it is wiser to skirt these attractive level patches than to bisect them with the road alignment. I urge this consideration particularly because, on a certain occasion, railhead was suddenly extended to the north instead of to the west, and. simultaneously, an aerodrome was ordered near the site of the new railhead, and consequently I had to " cross lift " my bran new completed road, for some hundreds of yards, and at huge expense. In this regard, it may be necessary to readjust the levels of the formation line of the road, so as to admit of easy access to it from the future aerodrome, dump, etc. If all these things are thought out carefully in the initial stages, the Engineer Officer will save himself much criticism and the "hot-weather irritation" which the recasting of a completed work always causes.

(d) The next phase is a more detailed survey of the alignment, with an Abney's level or Clinometer, and the ever-insistent tapemeasure. During this stage the sizes and numbers of culverts, bridges, retaining walls, cuttings, embankments, and motor-sidings and so forth, will be noted, as also the localities for water and stone, and their "lead."

(e) With these details there is prepared the "Rough Approximate Estimate," for which the Engineer Officer in charge will be "reminded" by G.H.Q. very early in the proceedings. Generally, orders to commence actual work accompany the sanction to this "Rough Approximate Estimate."

(f) While awaiting the sanction of this Approximate Estimate, the Engineer Officer sets about preparing contracts, gets into touch with the headmen of tribes (for earthwork contracts), makes arrangements for the transfer or purchase of steam-rollers, coal, tools and plant, and tents, etc., for engaging the necessary staff of officers, overseers, draftsmen and estimators (and possibly Labour Corps). All these things should be carefully anticipated so that when work commences the Engineer-in-Charge is not worried by unnecessary "office work" and "eleventh-hour" indents and requisitions, and so on, and so forth. All this "appreciation of the situation" is called, in Hindustani, "Bundobust," which is an admirable and comprehensive term. It is by bundobust a man is judged and succeeds, it is by bundobust a man is saved worry by day and insomnia by night.

(g) On receipt of the sanction of the "Rough Approximate Estimate" and of authority to begin construction, the *bundobusts*, referred to above, are made operative. Frequently the sanction is accompanied by a long list of criticisms and suggestions, which must be attended to and adopted unless authority is obtained for one or other alternative, which only local knowledge can maintain.

(h) Thereafter the "man on the spot" leads a strenuous and very happy life. Before him there lies a job, an intelligent job, an interesting job, and he feels that, though he may not be "making History" he is undoubtedly "making Geography." Given health and strength, a man needs no finer task than this, and he is reminded of Rudvard Kipling's address to the Students of the North London Hospital: "Well, Gentlemen, I wish you what all MEN desire-Enough work to do, and enough strength to do the work." Of course, there arise many obstacles, but they are merely interesting problems to solve. There are also long hours, and journeys, and belated meals and bad weather, and, at times, it seems as if Nature had signed an offensive alliance with Human Nature, by causing a sudden and urgent need of labour just when " Labour " either refuses to stay on the works, or develops "mumps" (a not infrequent disease in Labour Corps). This embankment "sits down," that cutting "falls in," such-and-such a culvert is badly " scoured out," there has been a landslip on such-and-such a slope, and the Zakka-Khel labourers. or the Mahsuds, find the weather too hot and they want to go back to their own hills. But all these difficulties are not comparable with the real trouble occasioned by lack of bundobust in the preface of the job. For instance :--It is very trying, indeed, to see road metal ready for consolidation but no rollers at site, labour arriving, but not enough overseers or tools present, a rock-cutting held up for want of fuzes or detonators, time wasted by workmen going to the springs, or the river, as there are no water-carts. These are the real exasperating troubles which make young men grev, and old men haggard. I stress this subject of initial bundobust because I have seen so many instances of collecting "arms" while the "fight" is on.

During the progress of the work the Engineer finds who are the principal enemies and the chief friends of the road.

The road's Enemies are as follows :--

- (i) Water.
- (ii) Bad quality of stone.
- (iii) Adverse strata of hillsides.
- (iv) Rotten soil.

Of these enemies Water is the most persistent in frontier roadmaking. For long months it will never ar pear, and then it comes down like a "wolf on the fold," the whole annual rainfall of England delivered pell-mell in a few days. Down come the rivers in wide, foaming spate, and down the nullahs tear Niagara-like rapids, ripping and delving, and inundating with shingle as well as water, and overflowing from the choked drains and devastating the carefully graded road surface and embankments, and converting the culverts into grotesque *islands*. Water is a plague, and worse than that, as it often makes the most careful engineer imagine that he has mistaken his vocation. To meet most of its attacks the engineer must take the following steps in the very inception of the road.

- (a) Make an accurate survey of the drainage area for every culvert and bridge. This is most important.
- (b) Ascertain from local and careful enquiries the highest flood level—and then don't trust the local statements—add 20 per cent.
- (c) Add 20 per cent. to the waterways and foundations, etc., given by the best calculations and data of all your text-books.

As to the second "enemy"—bad stone—This may be friable sandstone or laminated shale. The former will crush or wear away to dust, the latter will never consolidate. Fortunately, most river-beds and ravines on the frontier contain masses of sound limestone boulders, which break up into the "prisms" needed for the bonding together of "road metal." Otherwise one must carry stone from a distant and "almost inaccessible" quarry, which is a very slow and expensive business. On the D.I. Khan-Tank road, during the Waziristan Expedition, the cost of metalling ran to Rs.50 per 100 cub. ft., whereas in other localities the rate was Rs.10 or Rs.12.

Enemies (iii) and (iv) (as instanced in my remarks about the rotten hillside on the Tochi Road) necessitate great expenditure and invariably let one down at some time or other. It is cheaper and better to incur the extra initial cost of a long detour than to tackle a "natural fault."

The "Friends" of the road are as follows :---

- (v) Water.
- (vi) Knowledge of the vernacular.
 - (vii) Good temper.
- (viii) An "eye."

Of these "friends," Water is quite indispensable. It is required for consumption, consolidation, the steam-rollers, the mortar, the animals, the building, and for sanitation. It is well worth while spending your savings on the bringing of it close to the site of the works by a small irrigation channel, or a pump and piping.

Friend (vi) saves misunderstandings, delay and expense, and so it must be acquired at a very early stage. I recall an occasion of an officer's whole day being spoilt by his ignorance of the vernacular and his trusting a native who spoke a little broken English. The officer ordered the servant to follow him out to a certain place with his *telescope*. The servant arrived, hours afterwards, with his master's R.E. blazer saying, "I bringing Master's tennis coat"! A knowledge of the vernacular is a most impressive attribute, and

Plate I.



Sketch Map showing North-West Frontier of India.







Northern Waziristan, Tochi Valley. Lower Shinki Bridge Across the Tochi River on the Tochi Datta Khel Road (Trans Frontier).



Plan and Cross Section of Normal Piece of Hill Road. Scale :--4' to i''.



Lower Zam-Valley Bridge, S. Waziristan. [Vide also Plate II.]

Plate IIIA.



Lower Shinki Bridge, Tochi Valley, N. Waziristan. [Vide also Plate III.]



Upper Zam-Valley Bridge, S. Waziristan.

Plate VI.



Upper Shinki Bridge, Tochi Valley, N. Waziristan.

Plate VII.



Dry Stone Wall 45ft, High, Tochi Valley, N. Waziristan.

it saves much injustice on the part of the unscrupulous native overseer.

Friend (vii).—Before I first went to the frontier I received the following advice from Captain (now General) 'Ferrier :—" Always keep a thick stick handy and always keep your temper." A thick stick is always a weapon drawn, and ready to keep at a distance a fanatic's knife. A bad temper evokes such a knife, and, at the least, causes discontent, inferior work and slow progress, as these proud frontier workmen resent being "cussed "! Good temper and cheerfulness are worth six " road-rollers."

Friend (viii).—The possession of an "eye" is a priceless one. By "eye" I do not mean only the power of observation, but the power of assortment. It is this latter power which produces what General Duperier, of the Corps, used to call "taste" in road aligning. Curiously enough some men never possess or acquire it, and so their roads somehow do not seem to fit the country. There exists a slanderous story about a certain engineer officer in the Terah Campaign, who is reported to have diverted his road round a rose-bush ! This attribute of the "eye" is mostly exercised in the laying out of the alignment.

The other attribute, observation, makes one think of Tosti's song, "The night has a thousand eyes," for it sees everything, everywhere, every moment. Bad work, bad system, bad material, bad personnel, are pounced upon at once and eradicated forthwith. The wide area of the "works" demands keen observation.

As the time is getting on, I must now turn to the question of Specifications, and points of Construction.

The special orders for the construction of military frontier roads in India are laid down in a pamphlet entitled "General Specifications for Military Frontier Roads," which was issued by the D.G., Military Works, in 1919-20. But the general orders for military road-making are contained in that *vade mecum* of M.W.S. officers, namely, *The Military Works Handbook*.

On *Plate* |V| I have indicated the main details of a normal piece of hill-road according to the particular specifications issued by the D.G.M.W. You will observe that the items are as follows:—

- (i) Clear width of road, 20 ft.
- (ii) Width of soling, 17 ft. (and 6 in. thick).
- (iii) Width of metalling, 16 ft. (and 6 in. thick when consolidated).
- (iv) Clear width of culverts, 20 ft.
- (v) Clear width of causeways, 18 ft.
- (vi) Clear width of bridges, 18 ft.
- (vii) Motor sidings, 66 ft. long by 16 ft. maximum width. The outer edge an arc of 39 ft. radius, and whole area metalled, up to road-metalling line.

Additional orders, and variations, which could not be included in this plate are as follows :---

- (viii) Ruling-gradient, 1 in 20.
 - (ix) Maximum ditto, 1 in 13 for not more than a length of 100 yds.
 - (x) Corners—Minimum, Centre-Line-Radius, 35-ft. Road to be level throughout and for 20 ft. on each side of curve. Width of road to be 24 ft. and metalling correspondingly widened on outer edge.
 - (xi) Corners-Banking, 1 in 10 (for 35-ft. radius).
- (xii) Camber on the flat, I in 40 and continued across the berms.
- (xiii) Camber on gradients, nil.

 (xiv) Extra soling, (a) Embankments 3 ft. high and over (b) At blind salients in hills 	To cover whole width of road.
(c) On exceptionally soft	, Ditto, and 9 in
ground	I to 12 in. thick.

- (xv) Ramps of causeways, I in 14 to 11 ft. above H.F.L.
- (xvi) Handrails or parapets, $2\frac{1}{2}$ ft. high.
- (xvii) Parapet guard walling, 2½ ft. high and in lengths of 6 ft., with 1 ft. intervals.

I may here refer, for information, to one or two subsidiary points, or "odd jobs," which the maker of the main road will have to carry out :—

- (i) Ruling gradient for camel road, I in 10.
- (ii) Maximum gradient for camel road, I in 8 for not more than a length of 400 ft., and provided that there is a similar and adjacent length of I in I2, and rise in I mile does not exceed 500 ft.
- (iii) Ruling gradient for mule road, 1 in 7.
- (iv) Maximum gradient for mule road, I in 5, for not more than 200 ft., and if "easies," as above, are provided and rise in mile does not exceed 750 ft.

While on the subject of gradients, I may remark that there used to be a rule that, to avoid an ascent, it is advantageous to make a detour equal in length to twenty times the height of the ascent. In other words, it is better to "go round" half a mile than "cut through" by an ascent of 100 ft. For camel and mule roads it is useful to *remember* (if you are running a rapid section, say, with an Abney's level) that $\frac{1}{8}$ equals 7°, and $\frac{1}{7}$ equals 8°. Also I in 20 equals 3° nearly, and I in I3 equals $4\frac{1}{8}$ ° nearly.

For wheeled traffic (which includes Field Artillery and A.T. carts) the rise per mile should not exceed 240 ft.

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Lastly, at a slope of I in 20, a horse's tractive power decreases by 50 per cent.

So much for the general lay-out of the road. The following are the chief points as to the materials employed, and how they are used :---

- (i) Preparing Ground.—Before laying down the soling, the ground surface must be barrelled or levelled (according to whether the road is across flat land, or on a gradient), and watered and rammed.
- (ii) Soling consists of large boulders hand-packed (on the graded and barrelled ground surface) 6 in. thick, with interstices filled with splinters of stone, so that the whole forms a rigid foundation for the metalling. Soling should not be laid on embankments till they are thoroughly consolidated. Soling, when laid, must be passed by an officer, or at least a reliable upper subordinate, as nothing, afterwards, can make good the defects of bad soling, except uprooting and relaying the road. Soling is not required on hard rocky ground.
- (iii) Metalling.—On, and along, each edge of the soling, when laid, there is made a small earth border or "bund," puddled on inner face, and of same height as the metalling, which these "bunds" keep accurately in position during the rolling. As I mentioned above, under the heading of "Enemies of the Road," metalling must consist of tough, hard limestone "prisms." To obtain these shapes from the breaking of boulders, no boulder of less than 8 lbs. in weight should be broken into road metal. These prisms should pass in any direction through a ring 2 in. in diameter. Before being used, the broken stone is passed over a ½-in. screen, and the screenings are carefully collected, and stacked, for "top dressing."
- (iv) Laying Metal.—A layer of $4\frac{1}{2}$ in. is first spread on the soling, and this is consolidated to 3 in. before the next $4\frac{1}{2}$ -in. layer is put down.
- (v) Consolidation.—Rolling commences at the edges and works towards the middle gradually. The metal is rolled dry twice, and thereafter it is freely flooded during the rolling. The number of traverses of the roller varies with the quality of the stone used, amount of water, etc., but the usual test of "completion" is that a light cart makes no impression on the rolled metal. Generally, a 10-ton roller consolidates about 1250 sq. yds. daily.
- (vi) Top Dressing.—After complete consolidation of the two layers (of $4\frac{1}{2}$ in. each) to 6 in. packed, the "screenings"

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alluded to above, together with sand or gravel, are spread evenly to a depth of not more than $\frac{1}{2}$ in. and watered and rolled. This fills up the interstices of the metal and makes a water-tight surface. No earth should be allowed for this, or any, process of consolidation. The native, if left to himself, would put a layer of earth on top of the soling, or even mix it with the metalling ; this forms a sort of " mud concrete," which is easy to consolidate, but produces disaster as the earth dries and " works out" and all the metalling wears loose at once.

In the adaptation of existing metalled roads, *i.e.*, "Old Frontier Roads," etc., the Director General's Specification orders the following :---

- (i) If existing metal is less than 4 in. thick and there is no soling, reconstruct entirely like a "New Road."
- (ii) If existing metal of an unsoled road is 4 in. thick, or more, lay on top of it the usual two layers of new metal 4½ in. thick (consolidated to 3 in.).
- (iii) If existing road has soling under the metalling, add enough new metal to the old to give a total consolidated thickness, including the soling, of 12 in.

As the 10-ton steam-roller is universally employed on Indian roadwork, I mention its performances, etc., for a 10-hour day :---

(a) Consolidates about 1,250 sq. yds. of metalling.

(b) Consumes 5 cwt. of coal or 12 cwt. of wood.

- (c) Evaporates 300 gallons of water.
- (d) Load on front wheel, 4 tons.
- (e) Load on each hind wheel, 3 tons.
- (f) Raises steam in $1\frac{1}{4}$ hours.

I have now disucssed the prominent points of frontier roadmaking, viz. :---

(a) Selection of the alignment.

(b) General construction.

(c) The metalling.

Time does not admit of detailing information as to :---

Culverts. Causeways. Drainage. Retaining walls. Training Works, etc., etc.

All of which follow principles common also to other localities in

India, besides the Frontier. But I may specify the following peculiarities of Indian hill-roads, as differing from English road-work.

- (a) Extensive use of dry-stone-walling. For instance, in the Tochi Valley, Major Bell built two dry stone retaining walls 45 ft. high. (See Plate VII). (Again a case of the "Best" not being allowed to be an "enemy of the Good.")
- (b) Dry-stone culverts up to 4-ft. span.
- (c) Causeways, or Irish bridges, or "Gaps," vice culverts or bridges.—These are the "abomination of desolation," especially to motorists.
- (d) "Training Bunds," which are earthwork spurs, boulder-faced, and designed to direct an erring stream in the way it should flow, *i.e.*, under the bridge (and not round it).

So much for a task, the successful completion of which, in spite of every difficulty and of many trials, must recall to the builder's mind these lines (which, curiously enough, appeared in *Punch*) :---

" Pluck wins, it always wins, tho' days be slow, And nights be long, 'twixt days that come and go, Still, Pluck will win, its average is sure. He wins the prize, who doth the most endure, Who faces issues, he who Never shirks, Who waits, and watches, and who Always works."

> REMARKS re LANTERN SLIDES. (Some of which are reproduced in this issue.)

1. I am indebted to the D.G. Military Works, India, for the larger view in the Tochi.

To Major A. H. Bell, O.B.E., D.S.O., R.E., for the smaller of the Tochi views.

To Major Wauhope, I.A. (a Memoir of whose father appeared in the March issue of the R.E. Journal) for the views in the Zam.

2. Generally, these views show the nature of the wild, barren country of "The Frontier."

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THE WORK OF THE SURVEY OF INDIA.

By COLONEL SIR CHARLES CLOSE, K.B.E., C.B., C.M.G., F.R.S.

THE last annual report of the Survey of India deals with the year, Ist October, 1920 to 30th September, 1921, and the outstanding features of the report may be briefly summarized as follows :—The total out-turn of topographical survey was almost exactly 40,000 square miles, a "fairly full" programme of work having been carried out. The scales were mostly one inch and half-inch to the mile. No field operations were carried out by the astronomical, trigonometrical, pendulum or base-line parties, but tidal and levelling operations were continued, as were the observations at certain stations of the magnetic survey.

From a military point of view, the progress of the new topographical survey is a matter of moment, and it will be interesting to note what the report has to say on the subject. The total area of the Indian Empire, which is to come under the scheme for modern topographical mapping, is 1,821,600 square miles. The original programme dates from 1905, and is based upon the report of a Committee which was appointed to consider the future work of the Survey. This Committee recommended the one-inch as the standard scale, a very doubtful recommendation which was adversely commented upon at the time. Subsequently, in 1913, the Secretary of State "sanctioned a scheme for the reduction of the scale of survey of certain sparsely populated areas."

The total area which remained to be surveyed in September, 1921, was 1,240,865 square miles, or two-thirds of the whole; and if the original ideas had been adhered to the programme would not have been completed until about 1950 and would have taken some 45 years. These figures are, of course, only approximate, but they may serve to fix the ideas. It should be noted that, as was natural, during the war years the out-turn fell—from average of about 40,000 square miles to 25,000.

Of the 1,240,865 square miles remaining for survey, it is stated that 569,800 are likely to be surveyed on the half-inch or smaller scales, leaving 671,065 for the one-inch scale.

There is a good working rule that, other things being equal, the cost of a map varies roughly as the scale. Thus, a one-inch map will cost twice as much as a half-inch map and so on. The same applies to the time required for survey. In 1920-21, the Survey executed, in round numbers, 2,000 square miles of two-inch work, 27,000 of one-inch, and 10,000 of half-inch. This is equivalent to about

36,000 square miles of one-inch survey, and we may, perhaps, take this as a likely figure for future years.

Of the area which will probably be mapped on the half-inch or smaller scale, we may, for want of exact information, allow 285,000 for the quarter-inch and a similar area for the half-inch. Accepting the above premises, the conclusion follows that it will take 25 years from 1921, to complete the programme commenced in 1905; the early sheets will then be more than 40 years old.

In the above calculation, no allowance has been made for revision, and yet it is certain that some areas will need revision during the 40 years indicated. If any revision is undertaken, either the department must be materially strengthened, a contingency which does not appear very probable, or the completion of the modern surveys will be still further delayed. Is it unreasonable to suggest that the remedy is to reduce the area allotted for one-inch survey very considerably and to survey the bulk of the Indian Empire on the halfinch scale ?

The field work of this great department has always been of an admirable quality, and in recent years the maps have been well printed in colours. This could not be said twenty or thirty years ago. For in those days the standard sheets did not do justice to the skill and care of the field topographers. The writer can well remember the disappointment with which he examined the printed maps resulting from a field season in Burma in 1890–91. But since Sir Coote Hedley's visit to India—which was one of the good results of the report of the Committee above-mentioned—the maps have steadily improved in appearance and legibility, and are now excellent examples of colour printing.

In this the Survey of India profited from the experience of the Ordnance Survey; but the debt is not entirely one-sided, for, in a day in which the scientific side of surveying was dead in the United Kingdom, the scientific spirit was kept alive in India, and reacted favourably on the Home Survey later on. Moreover, the topographical field methods now in use, not only on the Ordnance Survey for training the Survey Companies, but in the Survey School at Chatham, and in the Crown Colonies and Protectorates, are directly derived from India. The two Surveys have, in fact, always much to learn from each other.

Before closing this brief outline of the present activities of the Survey of India, mention should be made of the excellent progress that India has made with the International Map of the World. No fewer than 15 sheets of this series are in hand or published, and, of these, nine have already been issued. This is a larger block of sheets than is to the credit of any other country. Geographers interested in the *Carte du Monde* are much encouraged by the splendid progress made by the Survey of India.

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AN OUTLINE OF THE EGYPTIAN AND PALESTINE CAMPAIGNS. 1914-1918.

By MAJOR-GENERAL SIR M. G. E. BOWMAN-MANIFOLD, K.B.E., C.B., C.M.G., D.S.O., p.s.c.

(Continued).

CHAPTER X.

THE ARAB ARMY.—The Desert Arab temperamentally unfitted for normal warfare —Creation of a regular army for the Hedjaz—Feisal's move to Wejh—Captain T. E. Lawrence's theory of a warfare suited to the Arab—Capture of Akaba from inland— Investment of Maan—Tasks of the Arab Army during the Beersheba-Jerusalem operations—Growth of the Arab Army: Feisal's flying column.

THE ARAB ARMY.

AFTER the Sherif of Mecca's revolt in June, 1916, the Turks sent reinforcements by rail to Medina, and seriously intended to crush the Arabs, and retake Mecca.

Although the desert Arabs of the Hedjaz were fired with enthusiasm for the cause of freedom, and wished to win it for their country, and their less fortunate kin, they were temperamentally unfitted to oppose trained troops in normal warfare. They were volatile, and handicapped by tribal traditions and jealousies. They came and went as they pleased, and generally would not serve outside their tribal area. Their blood feuds complicated their concentrations and actions.

When the Turks easily brushed aside the tribesmen, posted on apparently impregnable positions, it was urged that a more stable. and highly-trained and organized force was necessary to resist them, and the idea of creating a Hedjaz regular army arose. The nucleus for such a force existed in the peasants from villages near Medina, who had been driven out by the Turks, and from others near Mecca. At the same time Captain T. E. Lawrence, who was then with Sherif Feisal, saw that the Hedjaz would best be defended, not directly by blocking the Mecca road—but by getting on the flank and nerves of the Turks. He prevailed upon Feisal to adopt this strategy and, with the assistance of the Royal Navy, to convey his men along the coast to Wejh, about 250 miles north of where he then was. The Arabs entered Wejh on 22nd January, 1917, and found themselves 150 miles behind Medina. (*Plate* I.)

Immediately the Turks became alarmed. In a short time 11,000 men were put to garrison posts along that line, and all danger to Mecca ceased.

Map Nº 332.



Ordnance Survey, Junuary 1921

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At Wejh, the training of a regular Arab force seriously began. Some British and Egyptian officers and N.C.O.'s were provided as instructors, and Feisal's Arabs were augmented by about 1,000 ex-prisoners—Arabs of the Turkish Army—for the most part infantry already trained to the rifle. These were now trained principally to special work, machine and "Lewis" gunners, field gunners, and sappers drilled to demolitions.

During this stage, Lawrence evolved his theory of a warfare adapted to the Arab character, and for ousting the Turks from the Arabian countries. The underlying principle was that the valuable desert Arab should not be wasted in close fighting. His enthusiasm, intelligence and mobility and the fluidity and dispersion of his many tribes should be utilized to harass the Turks far and wide, and oblige them to scatter their strength and waste their material. The more Turks drawn into Arabia, where they could effect nothing, the less Turks elsewhere in the active armies. The Turks in Medina and along the railway were positively beneficial.

Lawrence conceived the idea of attaching to the Arab cause all the tribes up through Edom, Moab and Syria, until there should be set up "a ladder of tribes," up and down which the leaders and their small regular force might move. And each tribe in turn should engage in harassing enterprises against the enemy :—

For the Arabs-propaganda and plunder.

For the Turks-perpetual raids and loss.

The capture of Akaba.—The next step for Feisal's force was to occupy Akaba. The orthodox and obvious approach would seem to be to move by sea, and to land, covered by the Navy, and work up to the plateau of Edom. But, the track up from Akaba to the plateau rises nearly 4,000 ft. and for many miles is at the bottom of a winding gorge only 100 yards wide, and the defile is worse than the Khyber Pass. It was defended by a series of fortified posts, garrisoned by four battalions, with artillery. The Hedjaz railway is 70 miles from Akaba, and 45 miles of the road lie through these defiles.

Lawrence opposed the idea of disembarking on the Akaba beach, and urged that Akaba ought to be taken from the interior. He was told to try his method, and set out in April with a bodyguard of 17 Arabs. He rode 700 miles up country, through Jauf and Azrak, nearly to Damascus, and visited the chiefs *en route*. Lawrence found a tribe of the Howeitat willing to undertake the capture of Akaba, and after adjusting various tribal differences and blood feuds, he came down with 700 men and camped on the edge of the Jafar depression.

Maan was strongly garrisoned, but Fuweila, the post at the head of the defile, was held by a battalion of *Gendarmerie*. Sheikh Wad Abu Tai arranged for the post to be rushed at night, and the garrison were cut up. The defences of the remainder of the posts down the defile all faced seawards. The troops depended on a weekly convoy for food; their supplies were cut off, and they all surrendered. Akaba was occupied on 6th July; and Feisal and the Wejh force then moved on there by sea. At this moment Sir Edmund Allenby arrived in Egypt. He welcomed the presence of the Arabs on his flank, and further assisted the development of the Arab Army, which now proceeded to invest Maan.

After the fall of Jerusalem, the task set to the Arabs was to close the gap by which the Turks might move round the south end of the Dead Sea and worry the British flank at Beersheba or Hebron. Also, they were to stop the Turkish grain traffic along the Dead Sea. This they did by capturing the southern port and half the grain fleet—one of the few occasions on which a fleet has been captured by mounted troops.

The recruiting and training of the Arab Army continued all through the summer of 1918. By August, the regulars amounted to about 8,000, with 52 guns (of 17 varieties) and 150 machine-guns. Besides, depôts of arms were formed in the Leja, north-east of Deraa, in charge of the Salut tribe, ready to equip a horde of irregulars.

Up to August, 1918, the only transport, other than the tribal camels in the vicinity, were 700 baggage camels for the Akaba Convoy. But in August, when the Imperial Camel Corps were broken up, 2,000 riding camels were given to Feisal. These were the foundation on which his flying column was built up; and it numbered about 1,000 men in all, distributed as follows :—

450 camel-riding infantry ; 100 machine-gunners ; 150 Algerian artillery ; 4 65-mm. mountain guns ; 300 bodyguards, engineers, etc. ; A small party of British R.A.F. and R.A.M.C. personnel.

CHAPTER XI.

EFFECT OF THE GERMAN OFFENSIVE IN FRANCE, MARCH-APRIL, 1918.—Withdrawal of British troops from Palestine for France—Replacement by Indian troops, largely untrained—Local offensives on the Main Front—The Turkish-German attack on Abu Tellul.

EFFECT OF THE GERMAN OFFENSIVE IN FRANCE, MARCH-APRIL, 1918.

WHEN the XXIst Corps had moved to the Wadi Ballut on 12th March, preparations proceeded for a further advance in the coastal sector about the middle of April. But the success of the German offensive in France against the Vth Army, and on the Lys, rendered it necessary to draw on Palestine for reinforcements. The provision of manpower was at an acute stage. It was decided that the Egyptian Expeditionary Force must send as many British troops as possible

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to France, and must expect no more British reinforcements. Only Indian troops and reinforcements could be furnished to fill the gaps. Hitherto, the divisions had been all British, with the 20th and 49th Indian brigades non-divisional. The Palestine front now must adopt the Indian pattern of division, and entirely reorganize its formations.

The first instalment to go was two complete divisions, out of the seven in Palestine. The 52nd Division embarked in the first week and 74th Division in the second week of April. The Yeomanry regiments were withdrawn from the Descrt Mounted Corps and replaced by Indian Cavalry. The Imperial Camel Corps was disbanded. One division only, the 54th, was retained on a British establishment. In all others, nine British battalions were withdrawn for service in France, or to be used as drafts. Altogether, 48 British battalions and six Yeomanry regiments and a quantity of artillery were lost to the Egyptian Expeditionary Force.

This depletion temporarily crippled Sir Edmund Allenby's forces, and forbade an offensive on a large scale until the force had been reorganized, and had trained its new personnel.

The reconstitution was effected thus :----

Mesopotamia sent the 3rd and 7th Indian Divisions; and India provided men for 24 battalions, many of whom had very little training. Six Indian battalions were raised locally by withdrawing a company from each of the 24 Indian battalions already in the force.

The cavalry, perhaps, were the best off, as France had previously released the 5th Indian Cavalry Division and, with the reinforcements from India, these experienced cavalry regiments went to form the 4th and 5th Cavalry Divisions, which replaced the Yeomanry Divisions and Imperial Camel Corps.

From May to early September, intensive training was in progress in all divisions. The new Indian battalions and other units were devoid of specialists; Lewis and machine-gunners, signallers, drivers, etc., had to be provided for three-quarters of the units, and most of these were trained in the field; and, in view of the great difficulties of language and the lack of experienced N.C.O.'s, it certainly was a remarkable feat thus entirely to alter the organization and composition of an army, carry out its training in face of the enemy, and within five months fit it for a victorious campaign.

Local Offensive Operations on the Main Front.—Although the larger operation, planned for April, had to be cancelled, the XXIst Corps was able to proceed with a limited offensive to improve its line, especially in the hills on the right. Kefr Ain, Berukin, and Rafat, all across the Wadi Ballut, were captured between 9th and 11th April. This enabled the British to use the Wadi Ballut for lateral communications and to benefit fully from the water it contained. Again, on 8th June, the XXIst Corps made an advance, but on its left, to secure ground north of Richard I Castle at Arsuf. This gain entirely prevented the enemy from overlooking the British position on the left and gave good observation of the enemy's lines on this flank. The concealment of the ground here was particularly important in view of the use to which it was put in the autumn. On both corps fronts, the Turks were kept busy by frequent minor enterprises, raids and improvements of the British line.

In these operations the newly-raised troops gained experience and confidence. The most noteworthy was on August 12th, when the 29th Brigade raided the El Burj-Gurabeh ridge, north-west of Sinjil. Here, one British and two Indian battalions surprised the Turks on a frontage of 2½ miles. The advance had to traverse 2,000 yards of rocky ground and climb 900 ft. to attack an enemy behind sangars. The Turks were attacked on both flanks and completely surprised, and the raiders returned with 239 prisoners and 13 machine-guns.

The Turkish-German Attack on Abu Tellul.—After the Es Salt raid, the Jordan valley front was taken over by the Desert Mounted Corps, now of four divisions. Normally, one division was down in the valley and the remainder were echeloned back towards Jerusalem on higher ground. The retention of a strong formation in the valley, in spite of the severity of the summer there, accentuated the impression on the Turkish command that the aim of the British was to break out on that flank towards Deraa.

Under German pressure, a serious effort was made on 12th July to overrun the line and deprive the British of essential ground.

On the night of 11th-12th July, the enemy concentrated troops on both banks of the Jordan. A German "Pasha" battalion, and some 3,000 Turks, assembled near Abu Tellul, and another group near Henu Ford. Abu Tellul was attacked and captured at 0330 hours, so that the advanced line of the Desert Mounted Corps at Mussalabeh was isolated; but, although surrounded, the posts held out. Within an hour, the 1st Australian Light Horse Brigade counter-attacked, and by 0500 hours Abu Tellul was retaken; and the enemy, driven back against our isolated posts, lost heavily.

In this operation the Turkish infantry badly let down their German Allies, and left them to execute the dangerous work unsupported. The 1st Australian Light Horse captured 276 Germans and 62 Turks.

The enemy on the left bank fared no better. The Imperial Service Cavalry Brigade was crossed over to forestall the Turks moving on Henu. By skilful use of ground, they got within charging distance and made the most of their opportunity; 90 Turks were speared and 91 captured.

CHAPTER XII.

INITIAL PREPARATIONS FOR THE AUTUMN OFFENSIVE.—The necessity for training newly-raised units caused the postponement of large operations to the autumn— Railway construction: Light railways, roads—Improvement of communications, Water supply, bases, etc.—Considerations affecting the strategy of the autumn campaign—Numbers and situation of the VIIth, VIIIth and IVth Armies—The plan of campaign—Instructions to the various Corps—Preparations for the attack: Steps taken to mislead the enemy—German appreciation of the situation at end of August—Initial operations by the Arab Army—Attack on Deraa.

INITIAL PREPARATIONS FOR THE AUTUMN OFFENSIVE.

THE strategical plan for the destruction of the Turkish Army was drafted in May, and was then communicated to Corps Commanders. The necessity of training the newly-raised Indian battalions had made it desirable to postpone the offensive operations on a large scale for several months.

The opening of the wet season in November rendered it necessary to complete the campaign by the end of October; so that the middle of September was decided on for the opening moves. (See *Plate* XII.)

The preparations, besides training, dealt chiefly with improvement of communications, accumulation of supplies, and lines of local First of all, the railway from Ludd to Jerusalem was defence. converted from 3 ft. 6 in. to standard gauge-a very difficult task in the mountain section. The Turkish railway from Junction Station to Beersheba was connected to the Rafa-Beersheba branch line at Irgeig, and similarly widened. This gave Sir Edmund Allenby a double track from Rafa to Ludd; and the double line already existed from Rafa to Kantara. At Kantara, a swing railway bridge was built over the Suez Canal. Light railways multiplied immensely on both the XXth and XXIst Corps fronts. On the right, a line was built out from Jerusalem to Bireh. On the left. Jaffa was reconnected to Ludd, and a line taken up nearly to Abud. Another light railway from Jaffa ran north, across the Nahr Auja, nearly to Arsuf. Perhaps the enemy had been misled previously by the light railways on the British left flank at Gaza, but he does not seem to have let their development round Jaffa lead him to suspect a main attack on that flank again.

Road-making was on a grand scale. The Jaffa-Jerusalem-Jericho road, and the Nablus road within our lines, were widened and improved out of all recognition. Four great spur roads were run out towards the front, two in the XXth Corps area, two in the XXIst; and lateral roads were built to cross-connect these. A semi-permanent bridge was built over the Jordan at Ghoranieh, and many masonry bridges over *wadis*.

The port of Jaffa was improved, and the landing of supplies there :

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much accelerated. Ludd became an immense supply and ordnance area, with Rafa as an advanced base. But Jerusalem and Talaat ed Dumm also developed very large dumps, and the lorry traffic down the Jericho road was very heavy. Water supplies all along the front were improved; and extensive pipe-lines and pumps laid down to aid concentrations of troops. Much wiring of the line was put in hand to enable portions to be held thinly, when troops should be drawn out to concentrate elsewhere.

The anti-aircraft defence was highly organized, and elaborate arrangements were provided for notifying by wireless the approach of hostile aircraft, with the result that the observation of our lines was rendered extremely dangerous to the enemy; and, towards the end of the summer, his aeroplanes were practically driven out.

Considerations affecting the strategy of the Autumn Offensive.— At the beginning of September, the Turkish forces on the Palestine front were in three Army Groups :—

IVth Army.—Headquarters, Amman; 2,000 sabres, 6,000 rifles' 74 guns, facing us east of the Jordan; with a further 6,000 rifles and 30 guns, south along the Hedjaz railway at Maan;

VIIth Army — Headquarters, Nablus; 800 sabres, 7,000 rifles, III guns; on both sides of the Jerusalem-Nablus road, on a 20-mile front;

VIIIth Army.—Headquarters, Tulkeram; 1,200 sabres, 10,000 rifles, 157 guns, holding from Furkah to the sea;

General Reserve.—3,000 rifles, and 30 guns. dispersed between Tiberias and Haifa.

Total enemy fighting strength, approximately :---

4,000 sabres, 32,000 rifles, 400 guns.

Ration strength, south of the line Beirut–Damascus, about 104,000 men.

These forces were commanded by General Liman von Sanders, who had relieved von Falkenhayn in February; and who had already fought against British troops in the Dardanelles.

The British and Overseas Forces in Palestine at this time were :--

4 cavalry and mounted divisions ; -

7 infantry divisions ; and besides,

A French contingent equivalent to a brigade group.

Their total fighting strength was, approximately :---

12,000 sabres, 57,000 rifles, 540 guns ;

a superiority of nearly two to one over the enemy. (See Appendix III. Orders of Battle.)
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The Arab forces, under Sherif Feisal, were approximately 8,000 fighting men; a valuable adjunct on the flank of the British in an advance.

Sir Edmund Allenby, in his despatch of 31st October, 1918, wrote as follows :----

"I was anxious to gain touch with the Arab forces east of the Dead Sea, but the experience gained in the raids against Amman and Es Salt, in March and May, had proved that the communications of a force in the hills of Moab were liable to interruption, as long as the enemy was able to transfer troops from the west to the east bank of the Jordan. This he was in a position to do, as he controlled the crossing at Jisr ed Damie. The defeat of the VIIth and VIIIth Turkish Armies, west of the Jordan, would enable me to control the crossing. Moreover, the destruction of these armies, which appeared to be within the bounds of possibility, would leave the IVth Army isolated, if he continued to occupy the country south and west of Amman. I determined, therefore, to strike my blow west of the Jordan."

The whole of the Turkish forces west of the Jordan—except the small scattered reserve—was enclosed in a rectangle 45 miles in length, but only 12 miles in depth, whose northern edge was a line from Jisr ed Damie through Nablus and Tulkeram to the sea. (See *Plates* XI and XII.) All the enemy's communications ran northwards from the eastern half of this line for 25 miles to Afule, or Beisan; and thence eastwards up the Yarmuk valley to Deraa Junction. El Afule, Beisan and Deraa were the vital points of the enemy's communications, to which his front was parallel. If these points could be seized, his retreat would be cut off. Deraa was beyond the reach of the British, but was accessible to the Arab forces moving wide over the desert.

El Afule, in the Plain of Megiddo, and Beisan in the valley of Jezreel, might be reached by our cavalry, if a gap could be made in the enemy's defensive line for them to pass through. It was essential that this gap should be made at the outset of the operations, so that the cavalry should reach the vital points before the enemy had time to man the passes of the mountains of Samaria, leading into the Plain of Esdraelon.

The operations of the XXth Corps, in the hills north of Jerusalem, had proved that an advance of five miles a day was the most to be expected in such mountainous country. A far more rapid and decisive advance than this was necessary, and the easy ground of the Plain of Sharon gave scope for this. Moreover, the approach by the coast would enable the cavalry to cross the mountains of Samaria at their narrowest point; and would facilitate the railway and road developments necessary for the maintenance of an advancing army.

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Such were the reasons for which Sir Edmund Allenby decided to deliver his main attack in the Coastal Plain, rather than in the hill region north of Jerusalem.

The Plan of Campaign.—Briefly, the plan of campaign was to transfer the bulk of the cavalry (to be three divisions) secretly to the coast; to transfer the 60th Division from the XXth to the XXIst Corps, and so, to concentrate an overwhelmingly superior force of infantry and guns against the right of the Turks. It was intended to begin with a short but intense bombardment, then to deliver the assault, create a gap at the coast, and immediately push the cavalry through to capture El Afule and Beisan. Simultaneously, the Arab Army was to attack the Hedjaz railway about Deraa.

The enemy held two lines of defence in the coastal plain of Sharon.

The first, 14,000 yards across and 3,000 yards deep, ran north-west from Bir Adas to the sea, a series of redoubts connected by continuous fire-trenches.

The second line, 3,000 yards further north, extended from Et Tireh to the Nahr Falik; and near the coast the ground was marshy with few crossing places.

When the Desert Mounted Corps (less the Australian and New Zealand Mounted Division) and the 60th Division had assembled behind the XXIst Corps, the British numbers on the front of the main attack were, approximately :—

9,000 cavalry; 35,000 rifles; 383 guns; to act against 1,200 cavalry;

8,000 rifles ; 130 guns.

Instructions to the various Corps, etc.—Lieut.-General Sir Edward Bulin, commanding XXIst Corps, had at his disposal the 3rd, 7th, 54th, 60th and 75th Divisions; the French contingent, 5th Australian Light Horse Brigade, two brigades mountain artillery and 18 batteries of heavy siege artillery. The instructions he received were :—

- (i) To break through the enemy's defences between the railway and the sea;
- (ii) To open a way for the cavalry ;
- (iii) To seize the foothills south-east of Jiljulieh, and then
- (iv) To swing the XXIst Corps to the right, pivoting on the French Contingent and 54th Division, on the line Hableh-Tul Keram, and advance north-east so as to drive the enemy up the Messudie Jenin road into the cavalry at El Afule.

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The G.O.C., Desert Mounted Corps had the 4th and 5th Cavalry Divisions, and the Australian Mounted Division. Lieut.-General Sir Harry Chauvel was directed to advance along the coast immediately the infantry had secured the crossings over the Nahr Falik. On reaching the line Jelame-Hudeira, he was to turn northeast, cross the hills of Samaria, and enter the plain of Esdraelon at El Lejjun, and Abu Shusheh.

The Desert Mounted Corps was to seize El Afule and Jenin, send a detachment to Nazareth, leave sufficient force at El Afule to cut off the retreat of the Turks there, and go on to Beisan, and also seize the Mejamie railway bridge over the Upper Jordan. (See also page 223).

The XXth Corps, under Lieut.-General Sir Philip Chetwode, now contained only the 53rd and 10th Divisions, who were on the flanks of his position; the centre was now very thin. He was ordered to advance his right on the night preceding the main attack, so as to place the 53rd Division in a favourable position later to block the exits to the Lower Jordan valley.

Major-General Sir Edward Chaytor, with the Australian and New Zealand Mounted Division, Imperial Service Infantry Brigade, and four unbrigaded battalions (Chaytor's Force) was ordered to cover the British right flank and execute a series of demonstrations in the Lower Jordan valley, to induce the enemy to believe that an attack east of the Jordan, towards Amman or Magdeba, was beginning. The enemy's suspicions that such an attack was in preparation had already been strengthened by every possible means.

The functions of Sherif Feisal's Arab forces were twofold. First, they were to ensure that the Egyptian Expeditionary Force, in its advance, east or north, would be welcomed—not resisted—by the Arabs whose territories it would traverse.

Second, a flying column, consisting at the outset of about 1,000 Arab regular troops, was to assemble at Kasr el Azrak early in September. Thence, it was to cut the Hedjaz railway, and all the enemy telegraphs, effectively, south and east and north of Deraa, on a particular day—not sooner nor later, and keep them cut. Afterwards, gathering strength from the Arab tribes, and arming them from the previously-formed depôts in the Leja, the column was to cover the right of the British advance.

Kasr el Azrak was conveniently situated in the desert, 50 miles east of Amman. If the column were discovered, its presence there would serve also to convince the Turks that a concerted advance on Amman was in preparation.

The object of attacking round Deraa was to draw up there the small available Turkish reserves from Afule: and adherence to the exact date was important, so that the enemy should neither first get wind of the greater attack on the coast, nor have time to get back from Deraa to oppose the cavalry who were to break through into the Plain of Esdraelon.

The arrangements with Sherif Feisal were made in the simplest manner. No operation orders, no written instructions. Colonel T. E. Lawrence came over by aeroplane to General Headquarters and there received the personal directions of the Commander-in-Chief which, on return to Fuweila, he conveyed to Sherif Feisal.

The task of the Royal Air Force, prior to the main attack; was to prevent hostile aircraft from detecting the great concentration of troops in the XXIst Corps area. Very early in the morning of attack a Handley-Page aeroplane was to open the offensive by bombing El Afule; and a special bombing squadron was to attack all the other known telegraph centres behind the line, so as to break up the enemy's inter-communication system at the outset of operations.

The Royal Navy arranged to co-operate with two destroyers who were to fire upon any enemy using the road along the coast.

Preparations for the Attack.—The chief difficulty to be overcome was to effect the concentration without disclosing what was afoot. The marches of the mounted troops from the Jordan were effected by night, while the infantry sent to replace them moved by day. Even a practised observer would have had difficulty in detecting the changes, as the Desert Mounted Corps had long had rest camps by the coast, and the roads contained troops moving both east and west.

The Desert Mounted Corps, and 60th Division, when they arrived in the coastal area, were hidden in the orange groves, olive yards and vineyards, between Ludd, Ramleh, Jaffa, and Sarona. Great care was taken in the watering of horses, and in concealing the vehicles, and in using air patrols to prevent enemy observation of our lines.

Elaborate arrangements were made to mislead the enemy in the Jordan valley. The Headquarters of the Desert Mounted Corps at Talaat ed Dumm, in view from the hills in the enemy's lines, remained standing for a fortnight after the Corps Staff had departed to the coast. It was lit up every night, and the wireless traffic to and from it continued with normal regularity, as though the Corps were in the valley.

The thinning of the line behind the XXth Corps was stiffened by dummy camps, complete with transport, horse-lines and isolated parties grazing (all wood and canvas camouflage).

G.H.Q. commandeered and closed the principal hotel in Jerusalem as an advanced report centre. The Staff to occupy it was nominated, rooms allotted, and telephone system fitted up a week before the attack opened. But no one ever occupied it then.

Special steps were taken to facilitate the rapid advance of the

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railway and the supply of the troops on the move. At Rantieh, within two miles of the enemy front line, a railway station and supply depôt was laid down by night, and camouflaged.

The supply of water to troops, when they should arrive about Jiljulieh, was assured by arrangements to lav on a 4-in. pipe-line from the Nahr Auja for six miles on Zero Day.

The enemy knew an offensive was in preparation, he was led to expect it from the east; and, in spite of his captures from patrols during the concentration period, he remained in ignorance of the real direction of the attack.

An appreciation of the situation, exactly three weeks before the blow fell, issued to Constantinople by the German *Liaison* Officer with the Turkish VIIIth Army reads :---

". . . the English will carry out this autumn, like last year, a well-prepared attack, whose strategic objective would be primarily Deraa, and its political objective the occupation of Damascus. (See *Plate* XIII.) In any case, the English will try to tie down as great a force as possible in the coastal sector. . . . But they will probably confine themselves more or less to demonstrations—just as they did last year at Gaza. They will use most of their forces—attack troops and cavalry in this case—against the country nearest the Jordan, and they will be able to take advantage of the help of their Arab allies."

As a preliminary step, on 16th September, the Arab flying column, which had moved on to Umtaiye from Kasr el Azrak, attacked the Hedjaz railway, 16 miles south of Deraa, and destroyed a bridge. Next day (Z-2) they carried out extensive demolitions north and west of Deraa. They moved to Tel Arar, destroyed a bridge, and broke every rail for ten kilometres northwards; then they entered Mezerib, on the Yarmuk valley branch, and wrecked the station. (See *Plate* XIII.)

On 18th September, the Arabs crossed again below Deraa, destroyed the Nasib bridge, and caught the construction train at work on their first day's damage. On the same day the Royal Flying Corps heavily bombed Deraa Station. All traffic to Palestine ceased in consequence.

These diversions were highly successful; the German battalion at Haifa was sent up to Deraa on 17th September, and enemy aircraft were diverted to search for and bomb the Arab force.

(To be continued.)

APPENDIX III.

ORDERS OF BATTLE, SEPTEMBER, 1918,...

(Abridged).

(a) EGYPTIAN EXPEDITIONARY FORCE.

Commander-in-Chief: Sir Edmund Allenby.

XXth Corps.

10th, 53rd, 60th Divisions.

XXIst Corps.

54th, 3rd (Lahore), 7th (Meerut), 74th Divisions. Détachement français de Palestine et Syrie. Distaccamento Italiano di Palestina.

Desert Mounted Corps.

4th and 5th Cavalry Divisions. Australian Mounted Division. Australian and New Zealand Mounted Division.

Palestine Lines of Communication.

(b) TURKISH FORCES (YILDERIM ARMY GROUP).

Commander-in-Chief: General der Kavallerie, Liman von Sanders.

IVth Army (2nd and 8th Corps).

Composite Division, 48th Division, 24th Division.

VIIth Army (3rd and 20th Corps).

1st, 11th, 26th and 53rd Divisions.

VIIIth Army (22nd and Asia Corps).

7th, 16th, 19th, 20th and 46th Divisions.

Cavalry.

3rd Cavalry Division, 2nd Caucasian Cavalry Brigade.

3 German squadrons.

2 Machine-gun Companies.

The German Asia Corps consisted of 3 German infantry battalions, 4 batteries, and detachments of Engineers, and technical troops.

WITH DIVISIONAL R.E. IN PALESTINE.

A lecture delivered at the S.M.E., Chatham, on 10-11-21, by MAJOR AND BT. LIEUT.-COLONEL E. M. S. CHARLES, C.M.G., D.S.O., R.E.

I PROPOSE to tell you this evening of the adventures of the 10th Divisional Engineers in the Judæan Hills from about January 1st, 1918, until the end of hostilities, since time does not permit of my saying anything about the operations from the battle of Gaza— Beersheba up to the capture of Jerusalem. These adventures were in all probability very similar to those of other divisions operating in the hills, but down in the plains the engineers doubtless had different problems to tackle.

I must first of all say a few words on our organization. The division was organized on a modified pack basis, which means that some of the transport was on wheels and some on pack. The equipment of field companies was carried on camels, and in addition to the ordinary equipment each company had special water equipment, such as extra pumps and troughs. All the artillery was wheeled, and the infantry were partly on wheel and partly on pack; their Lewis guns were carried on limbered G.S. wagons, so our first job was to improvise a pack equipment so that battalions could take forward a certain number of guns if they got into mountainous and roadless country.

My field company commanders, I think, preferred being on a pack basis, as it allows of a greater elasticity for work. There are certain disadvantages—for instance, you require more animals to carry your equipment, and this means longer columns on the march and consequently more tiring marching. It also means that the Q.M.G. has far more mouths to feed, and it makes a very serious difference to him.

We had had over a year's experience of pack transport in Macedonia, where our animals were mules, and we were new to camels. For some reason the camel is universally objurgated. I am sure all officers who had anything to do with camels in Palestine will join with me in saying that they have been grossly libelled, and that, when properly looked after, and organized, they are very good military servants. They don t mind shell-fire in the least, and even when wounded, provided a leg is not broken, they carry on as if nothing had happened until they die.

In order that you may visualize the problems that confronted us, I must give you a short description of the country across which we were to advance. The hill system is rather like a fish s skeleton; the backbone, 2,500 ft. to over 3,000 ft. high, runs roughly along the Jerusalem-Nablus road, and a series of spurs are thrown out on either side, those on the west reaching to within a few miles of the railway, and those on the east running down into the Jordan valley which varies from 600 ft. to 1,300 ft. below sea-level. Our own particular bit of country was just to the west of the Nablus road.

These spurs are all, or almost all, steep-sided and are either rocky or drop down in natural or artificial terraces to the water-courses, which are nothing more than narrow torrent beds. Very few of these water-courses had permanent running water in them, nor, even after heavy rain, do I remember them hampering our communications except in one case.

I have not attempted on the map to show any of the hill features, as it would confuse the detail too much, but at certain points I have shown the heights above sea-level of the water-courses and the hilltops or passes.

As regards cultivation, any more or less level patches and the terraced hillsides were planted with either olives or fig trees.

The road and railway system when we came on the scene was simplicity itself. The metalled roads were :--Junction Station-Latron, Jaffa-Jerusalem, Jerusalem-Nablus, Nablus-Tul Keram and Tul Keram-Ramleh, metalled in places. There was, in addition, the track shown from Ludd to Beit Sira, continued up into the higher hills and marked "Roman Road," parts of which were I in 4 and could not be improved without prohibitive work. A 13-pounder gun had also been got up to Lower Beth Horon.

These were the only roads passable to wheels that concerned our division.

There is nothing much to be said about the railways, except that at the end of 1917 a single line was working as far northwards as Junction Station.

I shall now ask you to imagine yourselves in the middle of Judæa on the line occupied by the roth Division at the end of 1917 and the beginning of 1918. Our right, in touch with the 53rd Division, was just to the east of Harasheh (marked 2500 in the map), the highest hill in the neighbourhood, and our left at Deir El Kuddis, in touch with the Australian Mounted Division. We had succeeded in reaching this position, after two or three days' fighting, from a general line through the two Beth Horons. In front of us we had no roads at all, and behind us our communications north of Beit Sira were of the most exiguous nature. We had a battle road from Suffa to Ain Arik, with a branch up the Wady Sad. There was also a guntrack from Lower Beth Horon running up the spur south of Ain Arik and ending nowhere in particular—its sole object had been to enable guns to get within range of the Nablus road in the course of the fight and shell the retreating Turks, and this it accomplished—but as a feeding road it was useless, being too steep and narrow, and it did not run in the required direction. To show the nature of the native tracks I might mention that in the course of the fighting, during which we made use of donkey convoys to carry up food and ammunition, at certain places we had to place parties of men to lift the donkeys over the bad places. There was no direct communication with the division on our right, and if the Corps Commander wished to reinforce either flank, the only road was *via* Latron and Jerusalem.

It was therefore of prime importance to improve our communications rearwards and to make lateral roads for wheel transport within our Corps, and to do so as economically as possible.

The lower part of the Wady Ain Arik carried a lot of water after rain, which washed away our road, such as it was, so it was decided that the line of the permanent road after leaving Suffa should run up the Wady Sad valley, and then drop down to the village of Ain Arik, thence up the valley, and so on to Ram Allah, the division on our right working to meet us from Ram Allah. This road was christened " Irish Road."

As regards road construction, our infantry had had a good deal of experience in Macedonia, so different portions of the road were allotted to different battalions and they did the entire work, with the exception of culverts and any retaining walls required, which was done by the sappers. A spirit of competition was set up and all the officers, from the C.O.'s downwards, were as busy as bees. The pioneers were employed on special stretches where skilled labour was required—two companies blasted their way down from the elevated valley of the Sad into the Ain Arik valley, and another was employed on the zigzags necessary to drop from Suffa into the main watercourse.

Stone throughout was plentiful and handy, but had to be sorted out from a lot of worthless stuff. All metal and soling had to be carried by hand, since wheeled traffic could not be used except in a very few cases. It was found that in favourable circumstances of stone being handy-say, not more than 100 yds. carry-a daily rate of progress of 2 ft. per man of road, 12 ft. wide, could be made, and this was made the task where applicable. It was often exceeded . by the road being made 14 ft. wide and the same progress maintained. After the first 3 in. of metal had been worked in by the traffic, a second coat was added, and in spite of the rapidity with which the road had been made, it stood lorry traffic well. A steam-roller was a luxury beyond our means. A 12-ft. road as a main communication is a constant source of annoyance. Traffic is much delayed by having to wait at passing places, and moreover, a narrow road requires more constant upkeep than a broad one, so, as soon as communication was through, the road was widened throughout to 18 ft.

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At this juncture I should like to say a few words on road gradients. I once made a resolve that I would never have a road steeper than I in 15 in Palestine, but I am afraid that good intention has gone to pave the roads in another place. It is all a question of time and labour available, but if in a mountainous country you can keep your ruling gradient to I in 10 with the labour at your disposal in a division, you will be lucky. One of my main roads, after rising 1,000 ft. in about 5 miles, finished up, I regret to say, with a 50-yd. stretch of I in $7\frac{1}{2}$, and I was never able to get labour to improve this last part. Our train did the trip fully-laden, day after day, and never seemed any the worse for it.

To revert to our situation in the Judæan hills, other roads were made, besides all sorts of tracks up to battalion and company headquarters. The fourth company of pioneers also started on a road from Beit Sira northwards. My idea was that any advance must be made in this direction, and also the road would help in feeding our left.

Turning now to the water situation, we were in clover compared with what we had been up to Christmas. In the Beth Horon position all our personnel in front of D.H.Q. had to rely on water in cisterns round the different villages. As the cisterns got empty new ones had to be discovered, and the inhabitants cannot be blamed for not helping us, as we were drinking up all their water. Horse lines had to be kept miles in rear at Yalo or Latron, so horses required at or in front of Brigade Headquarters could only water once a day on account of the distance to water. Now, however, our right and centre were well off with large springs near Ain Arik and Ain Kanieh, and running water at the foot of Harasheh. Our left, at Kuddis, still had to rely on cistern water, but there were some very large cisterns there and not many inhabitants.

As for defences, the rocky nature of the ground prevented all digging, and the railway was not working sufficiently well yet to be able to bring up any R.E. material. The defences consisted solely of stone sangars, which the infantry soon became adepts at building. The nature of the country permitted the front line being held entirely by observation by day; indeed, this continued right up till the final advance in September.

In the course of February our organization was changed, and we reverted entirely to wheel transport, but whenever an advance was contemplated our train was reinforced by companies of pack transport, either camel or donkey, so that we should always be sure of getting our supplies even if we could not make roads.

Before January was over reconnaissances were pushed out to see how best our advance could be continued. On our right you will see from the heights shown on the map that the country was impossible for a main supply road. Starting from our left we found a good



alignment from Beit Sira to Job's Well, thence one branch up to Beit Ello and another up the Wady bed to Shukheidin, and thence round point 2665 to Bir ez Zeit, although this latter road was steep in parts. On February 1st therefore work was started in earnest on what was called " The Great North Road " from Beit Sira to Harith, with orders to have it finished and ready for lorry traffic by March 1st. Eight battalions, in addition to the pioneers and one field company, were at one time working on it, and the same system adopted as on Irish Road. As, however, the road was made 18 ft, wide from the start and was much more carefully made, such rapid progress could not be expected, and as a matter of fact the progress did not average more than 4 in. to 6 in. per man per day. Additional reasons for the slower progress were that the formation was more difficult, the soling was more carefully built, 6 in. of metal was put on in two layers instead of a single layer of 3 in., and rammed in by hand-rammers, and "water-tables" and side-drains made. The pioneers' portion was from the Wady crossing at point 713 northwards for about threequarters of a mile, involving a good deal of blasting, retaining walls and zigzags to gain height. By February 28th the road had been continued 1,200 yds. beyond Harith, and all but two battalions were taken off for other work. These two battalions, together with some companies of pioneers, continued the road as an unmetalled one, and eventually joined up near point 2665 (except for certain portions in enemy view) with a track that had been made from Ain Kanieh. Other parties had also been at work on a road from Job's Well to Beit Ello, but the continuation of this road involved labour beyond our resources at that time.

While this road-making was going on an outpost line had gradually been pushed out for the protection of the road-makers.

The plan for our next advance was for two brigades to advance northwards, one roughly each side of point 2665 and the third to advance from the Beit Ello direction. The objective was the ridge Jiljilia—Arura and thence to Beit Rirva. Owing to the difficulties of communication the left brigade was practically a detached force, and as such one field company was put under its brigadier.

The roads required for the battle were :---

- (1) The completion of the Harith-Bir ez Zeit road.
- (2) A track towards Attara, to enable guns to advance to the support of the right.
- (3) A track branching off from (2) to allow guns to advance to the support of the centre brigade.
- (4) A track branching to Umm Suffa to allow guns to advance and support the attack on Arura.

The troops allotted were :---

No. 1. Two Cos. of pioneers.

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- No. 2. One Fd. Co., R.E., and one Co. pioneers. The Fd. Co. was also to look after the water supply of the right brigade and divisional troops.
- No. 3. One Fd. Co., $\hat{R}.E.$, which also had to look after the water supply of the centre brigade group.
- No. 4. One Co. pioneers with such infantry as might be allotted. The allotment to No. I was perhaps rather excessive, but I felt that later on it might prove difficult to bring back labour on to this road, which was our main line of supply.

The road programme was carried through as intended. The Attara party got shelled from time to time, but carried on. The pioneers on the track to Umm Suffa had a difficult job getting off from the hog's-back ridge which runs from Bir ez Zeit to Point 2791. By eleven o'clock I saw they would require assistance, so sent back a message to D.H.O. for the divisional reserve of two battalions to be sent up, along with my pontoon wagons, which had been loaded up with road tools. By the time these troops arrived a route had been reconnoitred, so they were marched straight on to the work in the order in which they arrived. To a Sapper, one battalion is very like another, but to the Staff, it makes a difference as to where particular battalions work, and delay was caused by having to change the battalions round. (Moral-Consult the Staff beforehand as to their wishes in the matter). It was II p.m. before this road was finally through, owing to one of the battalions being required for fighting shortly after it started work.

The brigade of artillery that used this road had a trying day. They came into action in the early morning near Beit Ello, and to get into their next day's positions they had to go back to Job's Well and then on to Umm Suffa *via* Bir ez Zeit, since a crossing over the Wady Zerka was estimated to be an eight-days' job for 800 men.

The following day the battle continued for the possession of the north side of the Wady Jib. The R.E. and pioneers spent the time improving the sketchy communications and searching for a practicable road or roads across the Jib. In this connection I want to bring forward an instance of the *liaison* that ought to exist between a field company and the brigade it is helping, even though it is not under the brigadier's orders. Both D.H.Q. and I received reports respectively from Brigade Headquarters and the field company as to the possibility of a road down to the Jib and the amount of labour required. Of course, both messages were made out by the field company, but the point is that Brigade Headquarters were then warned and so had troops earmarked, and were ready to start work on the word "Go" from D.H.Q. On a previous occasion I had received an equally good report, but apparently the brigade had been out of touch with an R.E. officer, for they were taken by surprise when D.H.Q. ordered them to provide the labour, and this surprise resulted in avoidable hardship on the infantry. Meanwhile an exceedingly steep track was made down to Ajul, and pack tracks improved or new ones made from Beit Ello to Arura. On the right a way was found up to Jiljilia, but it took two battalions, two companies of pioneers and two sections of a field company five days to make. The hillside was so steep and rocky that in places men were employed solely in holding up those who were drilling the holes for blasting. The gradient of this road was I in 10 throughout most of its length.

Further roadmaking from the position we then held seemed so hopeless that for the time being an advance on wheels was postponed and our attention was turned to improving our communications. We actually did get out a scheme for improvising pack equipment to enable one brigade group to go forward, but this was knocked on the head by our having to send nine out of our twelve British battalions as reinforcements to France and elsewhere, these battalions being replaced by Indian battalions.

By the middle of March the last rains had cut up our main line of supply so badly that lorries could not get within eight miles of D.H.Q., and had to send back two battalions, some pioneers and some sappers to work on bad bits of road as far as eight to ten miles in rear of D.H.Q. We had a certain number of local inhabitants at work, but they were not much good. Our lateral communications were improved by a branch to the Nablus road from Bir ez Zeit, and a new alignment from that village to Umm Suffa, defiladed from enemy view, was made and continued to Neby Saleh and eventually linked up to Beit Ello; tracks were also run from Neby Saleh to Beit Rima and Deir Ghussaneh, as well as various other tracks to suitable gun positions. A road was eventually made from Umm Suffa to Arura, necessitating a good deal of screening from enemy view, and later on this was continued to other gun positions.

You will notice that we had no road communication with the corps on our left. The first one to be made was what might be called a tactical track from Beit, Rima westwards, and later on a battalion of Indian pioneers made a more sheltered road from Neby Saleh to Abud. Part of this road was made by an Egyptian Labour Corps company and I was so short of officers through sickness and other causes that I had to put my medical officer in charge of this, in addition to his other duties.

Our division was well off for water in spite of living on the mountain tops, even after various winter sources had dried up. There were anxious moments, of course, as native reports as to which springs diminished or dried up and which did not were untrustworthy. One spring that I was assured never diminished fell from 2,000 to 300 g.p.h. in a week. All springs were measured carefully every Monday morning and records kept, so that our fingers were always on the water pulse.

Our right was watered by three or four groups of springs between Attara and Bir ez Zeit, some of which had to be piped down to convenient places. Our centre relied on a large spring near Ajul for forward positions and two more in the Wady Darah for horse lines, etc. One of these was in an inaccessible spot, and with some difficulty a small engine and pump were man-handled down a steep hillside to it. It was in enemy view, as was also the rising main, which once got cut when the enemy were searching for a 6-in. battery. Besides watering many hundreds of horses and several battalions and other units from two watering points about a mile apart, the overflow of the spring formed a good bathing pond much appreciated during the summer.

Our left was not so well off but had three or four groups of springs round Neby Saleh. The principal group, Ain Reiya, was the only one at which there was space to water horses, and only gave 800 gallons per hour when we arrived in March. By searching for all the sources and piping them together into a reservoir we were able to utilize every drop of water. In this connection I was able to arrive at a rough rule for calculating the loss by soakage if the water ran over ground instead of in pipes, and in this particular soil the flow of a spring diminished by one gallon per hour for every yard it flowed over ground—thus a spring yielding 100 g.p.h. at its source ceased to have any flow 100 yards from its source. Of course, this rule does not hold for all kinds of ground.

Most of the horse lines for the left of our division watered in the Wady Zerka, where there was a plentiful supply. There was also a good supply at Beit Ello which required a pump and pipe line, where our troops in training watered, and our train watered a couple of miles in rear of Bir ez Zeit.

It is a great advantage to have several different water points, as when more than 300 or 400 horses water at one point you get a lot of congestion, more especially in hilly country. Also when there are a lot of watering points, units are more careful, as they get to look upon the watering place as part of their camping ground.

While on the subject of water I should like to impress on young officers the importance of an elementary knowledge of geology. My own ignorance of the subject was a great drawback to me. I do not know if geology teaches you also to know how to increase the flow of a spring, but I do know that in some cases it is possible to do so, and in other cases not, and the knowledge you want to acquire is to know where labour can be profitably expended.

Also, while on the subject of water, I want to mention the expedient adopted by the C.R.E. 74th division. His division had advanced alongside ours and were badly off for water. They had a good spring in one place, but it required a pump and engine, and it was quite inaccessible to wheels, so the C.R.E. went to the Air Force and borrowed a sausage balloon, tied it to the pump and engine and walked away with the whole bag of tricks to the spring.

It was rarely possible to dig anywhere, so the defences consisted of stout stone sangars, about 4 ft. thick at the top. They were never occupied by day, as they were on forward slopes, and at night the garrisons were usually working; eventually we had a double belt of wire entanglement across our entire front and, in addition, in places there were thick blocks of entanglement. On the reverse slope was a line of strong points, also wired and connected together by entanglements, and on the south side of the Jib was a line of defended localities, the villages of Attara and Deir Ghussaneh being put in a state of defence. A rear system was also started from behind Bir ez Zeit to Deir en Nidham.

In various places we built covered gun emplacements, some 30 being specially built for a raid on the El Burj ridge in front of Jiljilia. Owing to lack of girders we could only make the roofs splinter-proof, but the intention was as girders became available to make them 59 in. proof.

In August it was decided to have a large raid by night on the Turkish position on El Buri. There was a No Man's Land 2,000 vds. wide and 1,000 ft. deep in places. The idea was that a battalion should penetrate each flank and other parties then mop up, joining hands in the middle. Routes had been reconnoitred by various patrols and as far as we could see the Turkish wire entanglement would be a nasty obstacle if the guns failed to cut it, or if the infantry failed to hit off the exact spots cut by the guns. Another difficulty was to let all the troops know exactly when to return and to ensure that they returned in the right direction and did not penetrate further into the Turkish lines. To help the infantry over the wire we made several bridges out of bamboo and wire netting. Each bridge consisted of a sort of stretcher about 6 ft, long, which was meant to rest on top of the wire, and a second stretcher about 12 ft. long hinged to the first, which acted as a ramp. The wire netting was covered with a grass-filled mattress. The infantry reported very favourably on them after the raid.

On their outward journey the infantry unreeled tracing tape so that on their return they could follow it back.

The signal to return was to be the lighting of a bonfire, whose glow would also give the raiders the direction to make for if they could not find a tape. The bonfire was lit electrically by a sapper who was in telephonic communication with the brigadier. There were also two other bonfires which were to be lit as soon as the first one was seen to be alight.

We also prepared various devices to distract the enemy, such as rows of electrically-lit torches in different places and a series of gun-

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cotton slabs arranged to represent the firing of a six-gun battery, but the Turks were so distracted by the raid itself that they required no other distraction.

Preparations were now being made for the final battle. The general idea, as you doubtless remember, was for the infantry down in the Plain of Sharon to make a break through and for the main force of cavalry to gallop for the valley of Esdraelon and close the roads through Nazareth and Beisan, while the only other outlet. viz., across the Jordan at Jisr ed Damieh to Ammam was to be closed by another mounted force on the extreme right. To ensure the break through on the left, the XXth Corps was reduced from three to two divisions. 10th and 53rd, and our task was first to pin the enemy in front and then to capture as many as we could. A frontal attack, besides bringing us up against strong positions, could only have the effect of pushing the enemy backwards along his line of retreat, so the two divisions were to sidestep outwards, leaving a gap of several miles, and then to converge on Huwara, by which manœuvre it was hoped to bottle up a good many Turks.

The divisional plan was for an attack by two brigades, the right one directed on Furkah and Selfit, and the jumping-off place was near Berukin.

The first thing to be done was to make a good road down to this place from Neby Saleh, since it was impracticable to continue the road from Deir Ghussaneh. As all our guns and most of our transport would be moving down this road while wounded were being evacuated, it would have to take a double line of traffic.

The results of reconnaissance for a road forward from this point were not encouraging, and it was finally decided to make our battleroad up the Wady Mutwy to join on to the Turkish track which ran down that Wady for a certain distance. It was quite impossible to reconnoitre this route for any distance without fighting, and we did not wish to attract so much attention as fighting would entail. As, moreover, our part of the battle was to start at night, you can see that there was a decided element of chance in the success of making a road by night along an unreconnoitred route.

The labour at my disposal, in addition to three field companies, consisted of two battalions of infantry. Of the three field companies one was kept in reserve; one section of each of the other two was told off for water duties for each of the two attacking brigades, and a second section of one of these was told off to accompany a battalion that had a very difficult cross-country march to do in the dark, so as to be able to help it. The remainder of the companies were on road work. As regards the infantry, to avoid the confusion of leapfrogging companies of two battalions forward in the dark, one half of the road was allotted to each battalion, the second of which, of course, could not start work until the ground was captured from the Turk. The hour of starting work of the first battalion had to be arranged so as not to interfere with the assembly of troops for the attack, and for the second battalion we had to make a guess as to when the ground would be captured. As it turned out we were not quite optimistic enough.

I interviewed all the officers of each battalion and explained to them exactly what was required, told them the arrangements, and laid stress on the fact that what we wanted was not a road but a track along which guns and transport could go once only, but we wanted that track quick.

For our previous battles I had made various kinds of signalling arrangements for getting back R.E. information during the progress of the battle, but none of them had been satisfactory. This time I made others, including a private telephone line, but I am reluctantly convinced that the surest and quickest way is to rely on the individual who has facetiously been termed a "runner."

The attack started at 7.45 p.m. on September 19th, and went quicker than was expected, as the XXIst Corps had been so successful in their attack that they had completely broken through. However, advancing over mountains in the dark is slow work and road-making in the dark is slower still. By six in the morning we had joined up a very rough track to the Turkish road, but it was some hours before it was improved sufficiently to ensure that wagons would not break any wheels in going over it. The valley had received a certain amount of shelling during the night, but fortunately for the roadmaking parties all the shells were bursting up the hillsides. The Turks, who had not made a long stand at Furkah, put up a good fight on the Haris-Iskaka ridge and kept us there all day, denying us the use of the Mutwy-Selfit road on which we had counted. The only artillery support to an advance from Selfit could be given by the guns at Arura, at extremely long range, so at three in the afternoon we started on a track from the Ain Mutwy up the valley to Selfit. Our infantry, who had worked all night and well into the day, were too tired to be put on to this work, so I turned on some Egyptian Labour Corps whom I had begged from the Corps that morning; the track was completed by 6 p.m.

At about 5.30 p.m. the Divisional Commander received a message from the Corps Commander to the effect that the cavalry mass were well on their way to blocking the Nazareth and Beisan roads—that the 53rd Division on our right were held up by appalling difficulties of the country, and the cavalry on its right had accordingly been unable to shut the door at Jisr ed Damieh. We were therefore to push on at all costs and block the road from Nablus to Jisr ed Damieh.

The division accordingly resumed its advance at II p.m., two brigades one behind the other, along the Selfit-Iskaka road and the third via Jemmain. The Turks had been turned out of the Haris

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position and the division pushed on to about a mile south of Huwara. Here the reserve brigade took up the running on the morning of September 21st.

The Iskaka road, which had been reported as capable of all kinds of traffic in dry weather, was the worst track I have ever seen narrow, no possibility of getting off it, and with great rocks the size of an armchair sticking up. I do not know how the guns and transport got along it at all, but they did, as did also the Ford cars. The sappers could not do much to improve it as nothing short of blasting would have made any real difference, and blasting would have meant too much delay.

At Huwara is a sudden change in the country, there being a plain about a mile in width running up to Nablus. On the west side the hills are high, culminating in Ebal and Gerizim; on the east side they are low but gradually increase in height till Neby Belan is reached.

From a point about a mile south of Huwara the Divisional Commander had seen the tantalizing sight of dense columns of transport moving along the road to Kh Ferweh, out of reach of his infantry.

Up the Nablus plain the 30th Brigade advanced in their race for Neby Belan; the rear battalion, who had been much delayed by the transport on the Iskaka road, ran for three miles in order to rejoin the brigade and be in at the death. There was no serious opposition in front, but all along the plain they were fired into by machine-guns on the hills on each side. By about midday they had reached Neby Belan.

The heavies, which turned up in tow of motor lorries soon after the start of the infantry, went into action and tried to block the Ferweh road by shell-fire, but the Air Force were on the spot and relays of machines bombed this road from eight till twelve. This road drops down from the Nablus plain by a very steep track cut out of the hillside and forms a defile some three miles long west of Neby Belan; the road also forms shorter defiles at intervals towards Jisr ed Damieh and Beisan and every one of these defiles was a tangled mass of guns, lorries, motor-cars, wagons and dead animals.

The last road was thus closed, and in the next few days the prisoners who surrendered amounted to 5,400. The amount of booty that fell to the 10th Division and the Corps cavalry regiment was : 131 guns, 1,392 wagons, 97 lorries, 32 motor-cars.

Our fighting had come to an end.

COLONEL BOND'S CRITICISMS : A REPLY.

By CAPTAIN B. H. LIDDELL HART.

OWING to the courtesy of the Editor I am enabled to reply to the somewhat violent attack made by Lieut.-Colonel L. V. Bond, R.E., in the current (September) issue of the R.E. Journal.

I regret that his criticisms are purely destructive; it would have been more helpful "to all who are training for war "—to whom I am regarded as a public danger—if Colonel Bond had proved his possession of constructive faculties. Moreover, his criticisms of my "flapdoodle" are couched in language so strong at times that I am tempted to wonder if Colonel Bond has forgotten that "abuse is no argument." Possibly, however, he is acting on the old adage, "If you have no case, abuse the plaintiff."

The object of all of us, I hope, is to get at the truth which lies hidden behind the mass of facts and theories. Unprovoked violence is scarcely a helpful method of criticism. For one who criticizes parts of my writings as "a handful of jargon strung together on an argument of amazing inconsequence"! I humbly suggest that he might in his own criticism have kept more to the point. Out of an article of some 480 lines approximately 340 are unconnected with any definite points of criticism.

I had hoped for some really helpful criticism which would take us a further measure towards the common goal of all students of war—*truth*. One who wanders so repeatedly from the path is scarcely likely to be a useful guide.

To ascend, however, to the purer air of abuse-free argument I would point out that my theories are directed primarily to warfare against a civilized enemy, in the course of which I suggest a normal course or choice of courses of action. In so discussing the principal form of warfare I only follow the example of F.S.R., which bases its doctrine on a similar foundation, relegating to a subsidiary chapter the discussion of warfare against an uncivilized enemy. If I have erred, I have at any rate done so in good company. I pretend to no knowledge of the latter form of fighting. Yet it would appear that my ideas are not so unsuitable to such conditions by the fact that the General Officer Commanding a Division and District on the N.W. Frontier reprinted my original R.U.S.I. lecture (similar to that given at the S.M.E.) in pamphlet form for issue to the officers under his command, and that my own reprint in booklet form (Framework of a Science of Infantry Tactics) was ordered by

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a considerable number of commanding officers in other commands in India for issue to their officers. This, I think, proves that Colonel Bond is somewhat presumptuous in arrogating to himself the right to speak on behalf of all senior officers, even in India. Colonel Bond speaks of my "confident and oracular tone." I am almost inclined to suspect that he is deficient of either the sense of proportion or humour. For "a confident and oracular tone " surely some of his own phrases would be difficult to surpass :---" I do not sav that he is invariably wrong," "It will not carry conviction," "No one will be found to dissent from this proposition," " Equipped with the purely mechanical system of Captain Liddell Hart we court defeat in nine cases out of ten," " Captain Hart has attempted to dope us with flapdoodle of the most misleading kind." Whilst I made no attempt to prescribe for Indian frontier conditions. Colonel Bond has no hesitation in speaking in confident terms of the European theatre of war; which, so far as I understand, he never saw.

This brings us to a further point of his, on which he lays great stress, that all theories put forward should be based upon personal experience. One is reminded of the old-time general who based his claim as an authority on war upon the fact that he had seen so many campaigns, whereupon Marshal Saxe pointed out a mule which had been through even more and "was still a mule at the end." The experience of a single individual, or even of a number of individuals, is a very inadequate test ! My own small experiences as a platoon and company commander in France were, I freely admit, far less than those of many others—even less a foundation, possibly, than those of a senior R.E. officer on which to build a theory of infantry tactics. They were, however, sufficiently painful to show the defects of the existing tactics.

Colonel Bond forgets that the independence of a regimental officer of infantry is restricted in considerable measure by the existing tactical doctrine laid down by the higher command, and that he can scarcely obtain a free hand for the conduct of extensive experiments. On the other hand, few can appreciate more directly the disadvantages of the existing system.

I can, however, conceive of no editor of a Service journal being able to afford from his limited space sufficient to set down in detail the quantity of data from which even my humble theories were gradually built up. To give one or two isolated experiences of my own or of others might be interesting, but from the point of view of serious scientific investigation affords no practical test.

Colonel Bond is so anxious to find any stick to beat me with that, whilst in one place he calls for my personal experiences, in another he, rightly, points out that any science of tactics must be founded not on individual, or even on multitudinous personal experiences of any one time, but on universal experience as contained in history.

This universal experience is the foundation on which in the first place I built up my framework of principles. If he chances to see the United Service Magazine for April, 1920, or the National Review for June, 1920, he will find some indication of how first I endeavoured to discover and formulate the universal principles. For this purpose I examined both the elemental factor in all war—man—and tested the principles disclosed in individual combat by the campaigns of military history, a few of which I sketched, though necessarily briefly owing to limitations of printed space.

Whilst principles are eternal, the form of tactics in any age vary with the available weapons. But I maintain that if the weapons and organization existing at any one time be tested by these principles, we shall be able to deduce the tactical methods which are suitable to the current conditions.

In the forthcoming second edition of my book (the first having been exhausted by the demands of those who do not find it all "flapdoodle") I have enlarged it in order to trace how, by applying the principles in the form of a test to each successive problem, a normally correct solution or alternative solutions can be evolved for warfare against a civilized enemy.

Let us now examine the few concrete criticisms which Colonel Bond puts forward.

3.—Colonel Bond appears to regard racial characteristics, rather than the actual weapons, "guns, rifles, or tanks," as the true source of tactics. History hardly bears him out. The main tactical developments in history have surely been the product of new weapons. "Changes in tactics have usually followed changes in weapons." Gunpowder, the musket, the shell, the magazine rifle, the machine-gun, the quick-firing field-gun, the tank, have had a very similar effect on tactics among whatever nations they were used.

Personally, I should prefer to say that the tactics of any period must be based on human nature as affected by the weapons of the day.

If we followed out the implications of Colonel Bond's half-digested theory, we should have a distinct tactical doctrine and a different manual for south country regiments, north country regiments, London regiments, Scottish regiments, Australian regiments, Sikh regiments, Gurkha regiments, etc., not forgetting Irish regiments. What a prospect !

Colonel Bond first criticizes the omission of the human factor from my lecture, and then admits that in the *National Review* I deal fully with it. Does he realize that there is such a thing as limitation of space in a journal? In the one I deal with what may be termed paraphrase an old proverb : Half a loaf is better than the unbaked

dough. 4.—From my own small experience I have discovered that "the men" are capable of more intelligent action than their leaders often give them credit for. On the Somme, in 1916, when the serried waves imposed by authority broke down under machine-gun fire, the men often coalesced into natural groups and settled German machine-gun nests by manœuvre, which is, after all, but a form of stalking, a natural reversion to the elemental hunting instinct.

5 and 6.—Colonel Bond speaks of the influence of changing conditions on the tactics to be employed.

May I point out that I emphasized that my framework was a "flexible" one, to be adapted to ground and weapons; that I dealt with its "broad application" only.

He picks out two points for criticism—the "maxim" that the leading sections should always send ahead a pair of scouts, and the "maxim" regarding the position of the battalion commander.

Both are accepted in *Infantry Training*, 1921, so that presumably infantry officers of experience approved of them. The distance that the scouts are to be ahead is intentionally left undefined. I would, however, point out that I adopted this particular "maxim" in some measure because I found it universal. There is much to be said for the argument that a section is so small, such an insignificant target, and so controllable that it does not need to move with ground scouts ahead.

7.--If Colonel Bond had read my writings with more care before launching his counter-attack, he might have discovered that, unlike him (See March R.E. Journal), I never use the phrase "soft spot tactics," for the simple reason that I regard the "fix and manœuvre tactics " as an advance upon the former, in that the idea of fixing, if properly fulfilled, does away with the danger of the original soft spot tactics—a weakening of the will to close with the enemy. Nevertheless, even with this inherent danger the original soft spot tactics of 1918 were a vast improvement on the former tactics of piling up the reinforcements, and incidentally the dead bodies, in front of the enemy's strongest points. Does Colonel Bond advocate a return to this latter method? He is careful to keep any ideas that he may have nebulous, so that they can only be guessed at by inference.

Can he honestly contend that my exposition of the act of *fixing*, either in the man-in-the-dark simile or on page 179 of the *Journal*

for April, 1921, gives the slightest encouragement to any action, or lack of it, which would give rise to "bodies of dejected men roaming about, looking for a soft spot or platoons contentedly held up"? I would refer him also to Maxim 1 of the "Expanding Torrent" method.

Surely, I have sufficiently emphasized that continuous and direct movement forward is necessary to fix the enemy, that fire alone will never succeed? (I suggest that there is a greater danger in the prescription of the authority whom he quotes on page 162 that "fire should always bring about a decision at a range of from 100 to 150 yards without it being necessary for the infantry to assault.")

The essential point of difference between these fix and manœuvre tactics and the old is that, whilst in both it is the duty of the forward sub-unit to press on relentlessly to gain the objective, in my "flapdoodle" theories the supporting sub-unit is used to manœuvre when the former's rate of advance is delayed instead of merely increasing the target and the casualties by direct reinforcement.

The French infantry regulations point out, and I think most infantry officers will agree, that in any advance the leading groups form a very irregular line (even before any definite soft spot is discovered) presenting salients and re-entrants.

By taking advantage of these irregularities, the manœuvre bodies of the less quickly advancing forward units can bring flanking fire to bear on the resistance opposing the forward body of their unit, and ultimately outflank it.

In passing, may I suggest that Colonel Bond is not entirely free from "the infection of catchwords." His "objective outlook" covers a multitude of subjective preconceived prejudices.

8.—When I speak of "modern conditions" I refer essentially to the magazine rifle, the light automatic, and the machine-gun, none of which are now confined to the Great Powers.

Colonel Bond kindly informs me what I meant by "modern conditions." The dogmatic complacency with which he explains, quite wrongly, what I meant, is quite delightful.

9.—The above misinterpretation naturally invalidates his argument in this paragraph.

10.—I suggest that there is a vast gulf between the "absolute form" spoken of by Jomini and a flexible framework.

It is the difference between the skeleton or bony framework of a man and the complete man clothed in flesh and blood. The conditions of life are such that hardly any two men resemble each other, yet at the same time every man's skeleton is composed of bones which correspond in number, position and relative function.

Jomini, moreover, refers to the major operations of war. These vary so greatly that only the main bones of the framework apply in every case. But in a large action, it is the opinion of many with whom I have discussed the question, that the various situations

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and phases of battle met with by most of the infantry units have a very considerable similarity.

A study of military history seems to confirm this conclusion as regards the small sub-units. If this conclusion is accurate, it surely cannot be denied that the major framework can be enlarged to comprise more bones, without falling into the opposite danger of being rigid in detail. There is still a vast difference between a complete skeleton and a complete body, such as the precise and detailed systems of the past which Colonel Bond rightly anathematizes.

12.—Colonel Bond's criticisms in this paragraph are based on the mistaken assumption that I deduced the actual details of execution from the "man-in-the-dark" or the "expanding torrent," whereas in reality I only drew from them the broad principles.

In order to discover the framework I examined all fighting from the elemental—man—upwards to the main campaigns of history. As I found that the principles were similar in each case I naturally used the simplest and most readily grasped source for explanatory purposes in the brief time available.

In the case of the "expanding torrent" I actually thought out the method first, and then the parable by which to make it live in the mind. The rising tide would scarcely be an apt metaphor for advocating speed of advance and penetration! The rotary brush suffers from the defect of being artificially controlled. Viewed broadly, there is a distinct analogy between a bank and a force which has taken up a position of resistance.

I admit that there is a certain danger in similes or parables, but I think that in most cases their illustrative and teaching value more than counterbalances such possible defects. The greatest of all Teachers used them continually. It might even be suggested that Colonel Bond's literary style might be lightened by them. It is to be remembered that the ordinary British officer or N.C.O. has not the hypercritical mind which examines such parables meticulously. Similes might possibly be used with advantage to lighten their paths through the morasses or sterile descrts of the ordinary textbook.

13.—Colonel Bond here finds fault with my use of terms. It would have been as well if he had verified his own data, before criticizing my failure in this respect. He assumes that his own view of what constitutes "science" is compulsory on all.

Colonel Bond restricts the definition of "science" to a very narrow use. I did not claim to evolve an *exact* science. I prefer to follow the definition in the *New English Dictionary*:—"A department of practical work which depends on the knowledge and conscious application of principles; an art, on the other hand, being understood to require merely knowledge of traditional rules and skill acquired by habit." Or again, in Webster's *Dictionary*:— "Systematized knowledge," "Knowledge classified and made available in work, or the search for truth."

Thomas Huxley's definition is perhaps even better, that science is "organized common-sense . . . the rarest of all the senses." (!)

Colonel Bond here repeats his assumption that my theories are based on conditions which I did *not* found them upon.

15.—Colonel Bond raises so many questions in this paragraph that I am restricted to comparatively brief replies if I am to deal with each one.

General and Question I.—Firstly, let me say that I do not expect the "Expanding Torrent" method to be infallible. The commander who awaits a perfect method will never act. It is not the leader who makes no mistakes who wins, but the one who makes fewest. I agree, further, that this method requires a high standard of training. But that it is feasible I do believe, and apparently others more experienced than myself concur. To give one example, it is taught at the Small Arms School at Hythe, the staff of which represent at least as great and as wide experience of war as could be found in any similar number of individual officers in any army. To give another—it has been introduced by General King to the U.S. General Service Schools.

I repeat again that I am fully aware of its imperfections and possible defects, but can any better alternatives be put forward? Are we to revert to the method of massed waves and direct reinforcements, or again to the trench-warfare system of extreme limitation of objectives—down to the section or platoon? The one is surely too costly to be ever again employed against modern small arms fire, the other is too slow for open warfare, and entails severe risk of confusion owing to repeated direct passing through of one unit by another.

Question 2.—Surely the last war has disposed of the fallacy that troops cannot manœuvre under fire. (It is unlikely also that in the near future we shall see a fire zone so deep or so thoroughly beaten.)

The presumable origin of the idea that this procedure was impossible lay in the well-known psychological fact that troops were magnetically drawn towards a visible enemy who was firing directly at them. This attraction has been proved from Frederick's battles onwards. But I suggest that, so long as the firer is invisible and there is no clear evidence that you are being directly aimed at by a particular post near at hand, this magnetic attraction does not exist. Thus I would postulate that, whilst manœuvre to a flank is impossible for any forward sub-unit engaged with a definite defence post, it is possible normally for the supporting units, who do not feel the spell of direct fire contact.

Question 3.—In this and other questions Colonel Bond, despite his opening remarks on frontier conditions, appears to reveal his possession of what may be described as a mind saturated in Western Front trench warfare—at second hand.

Let me refer him to his own quotation of Mr. Winston Churchill as my authority for retorting that I do not visualize an overwhelming artillery or creeping barrages in the near future. How curiously inconsistent he is in his criticisms !

Question 4.—The emphasis which is now laid on the constant use of compass bearings should help to meet this danger.

Question 5.—I do not imagine that in practice the arrowhead will be meticulously maintained. In movement it is often likely to approximate to file, and, when halted, to line. But for training it has the advantage that, whilst ensuring control, it teaches men to keep alive to their direction instead of, as in file, lapsing into a somnolent gaze at their predecessor's back.

Question 6.—The supply of ammunition (not bombs) is undoubtedly one of the biggest problems due to the introduction of the light automatic. I confess that I can see no effective solution save the supply tank, as suggested in my lecture on page 180, *R.E. Journal*, April, 1921, and in *Infantry Training*, Vol. II. (War), 1921, Sect. 60, 11. I would, however, call his attention to page 218, *R.E. J.*, May, 1921, in which I point out that one of the advantages of the "Expanding Torrent" method is that the units who lead the advance will automatically be those who have expended least ammunition or have been able to refill.

Question 7.—I must again refer Colonel Bond to my lecture, pages 217 and 218, R.E.J., May, 1921, in which it is clearly stated that the decision as to the replacement of a forward platoon rests with the company commander. The "Expanding Torrent" method gives the immediately superior commander a much higher degree of control over his sub-units than previous methods. Further, looking back may have disadvantages, but it does at least ensure that the immediately superior commander can apply a brake to the advance of his forward sub-units.

16.—Colonel Bond asserts that this method can only succeed if we assume certain conditions, which I will recapitulate with my own comments :—

- (a) An enemy in separated and distinct posts.—I suggest that the machine-gun and light automatic, and the grouping tendency, which has always been inherent in human nature, will cause these to be normal in any system of defence in depth—to counter which is the purpose of the "E.T." method.
- (b) A perfect knowledge of the positions of these posts.—The "E.T." method is based on the fact that the exact points at which resistance will occur cannot be anticipated, and that a method is needed which will allow of adjustment to the

degree of resistance at any particular spot. The platoon leap-frogging method, which Colonel Bond appears to favour, *does*, on the other hand, demand exact knowledge of the enemy defence posts.

- (c) Leaders who can be relied on to take correct tactical decisions.—

 I agree that modern war has no use for stupid leaders.
 We must be ruthless in selection and persevering in training.
 See F.S.R., Vol. II, Section 1, 2.
- (d) No time-table to adhere to, as with a barrage.—My training theories are not based on a recurrence of trench-warfare. I again refer Colonel Bond to his own quotation of Mr. Winston Churchill.
- (e) Troops under complete control, and ready and willing to attack a series of objectives.—See my answer to question 7, for the first part. For the second part, I would point out that the men will start the attack with but one objective impressed on them—to gain the battalion objective.
- (f) A passive enemy.—Surely the experience of the war proved that the danger of temporarily exposed flanks in the case of platoons and companies was overrated. On the Somme, in July, 1916, I can even remember a whole brigade having both flanks in the air for forty-eight hours, during and after an attack, without accident. Moreover, the "E.T." system has the specific advantage of covering the flanks of a forward unit which is able to progress, with the least possible delay. Moreover, by means of it, an enemy counterattack against an exposed flank will itself be taken in flank.

Finally, when Colonel Bond implies that I put forward the "Expanding Torrent" as a universal system, he is guilty of still another deliberate distortion of my meaning. In my introductory remarks I specifically pointed out the special conditions which it was designed to meet.

- 17.—(i) The method of disposing manœuvre or supporting units on a flank is now accepted both in the French and British infantry regulations, which would prove that " officers of experience " consider it to be sound.
- (ii) The natural tendency for any attacker is to take the line of least resistance. To go dead in the face of this tendency is to violate human nature.
- (iii) Posts will be sited to support each other mutually with fire (See I.T. and lecture). "Each post will form a selfcontained centre of resistance, capable of all-round fire."
- (iv) Colonel Bond's next criticism is hardly creditable to his common sense. Is he really incapable of distinguishing between the parts and the whole, or of realizing that the

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fixing of their immediate attackers by the minor infantry units is different from the fixing or stabilizing of the whole battle referred to in F.S.R.?

In the case of the whole force, with which F.S.R. deals, the portion of it which is assigned to hold the position corresponds to the *forward body* (of my lecture and *Infantry Training*), whilst the general reserve for the counter-stroke corresponds to the manœuvre (or supporting) body. The object of the first body in either case is to fix the enemy (*i.e.*, absorb his attention, vigour, and reserves) ready for the counter-blow by the second body. Incidentally, the outpost zone defined in F.S.R. does not correspond with the forward of the two portions of a force. It is an area of ground, not a body of troops, and is garrisoned by only the advanced fraction of that portion of the force which is holding the defensive position.

(v) On the subject of the limitation of platoon and company objectives, Colonel Bond refers to a distinguished author whose book is based on trench-warfare conditions of the period during which it was written.

In the first place I would refer him to Infantry Training, 1921. where the doctrine is accepted that the platoons and companies of a battalion should have as their mission to gain the battalion objective. In the second place I would suggest to him that, save in trench-warfare and other exceptional conditions, a battalion will be required to make an advance of considerably more than 800 yards. In what normal theatre of war in which the British Army has been. or is likely to be, engaged has the commander had so many troops or such unlimited time to waste that he could afford to ask only such a short advance? But if a longer advance is required, and platoons are to be assigned to definite objectives in depth and then to sit down while other platoons leap-frog them, the battalion will be strung out over a distance too great for the retention of control. Again, how rarely does our Army operate in terrain so well known that separate objectives can be allotted beforehand to each platoon! If no objective of any sort is assigned beforehand, what confusion and loss of direction will ensure !

18.—If I quote the whole paragraph, No. 111, from the French regulations, perhaps Colonel Bond will be satisfied that I am justified. "In the course of the combat the reliefs are made in the form of 'dépassements' or 'passages de ligne' which can generally only take place at the end of a halt of some duration. In principle, every unit engaged ought to pursue its effort to the full limit of its offensive capacity. At the same time, it is for the commander to judge whether it is not preferable and whether it is possible to withdraw from the leading echelon those elements which, owing to fatigue, have no longer sufficient efficiency. These elements are capable, after several hours or days in reserve, of furnishing a fresh effort, whereas if kept in the leading echelon they would obtain little result and would even diminish the *élan* of fresh reinforcements. This operation is carried out above all, between battalions of the first and second echelon, and sometimes between companies of the first echelon. On the contrary, inside the company, the groups, in principle, are not relieved."

19.—The answer to this paragraph is contained in my opening remarks on the question of experience. Nevertheless, it cannot be doubted that individual experiences have a certain value, which increases in proportion to their number. But in the first place it is necessary to find an Editor who will give the space to a quantity of individual experiences, whilst, secondly, the British officer is diffident about giving the undue prominence of print in a Service journal to his own necessarily limited personal experiences.

Colonel Bond's criticism, taken as a whole, appears to be, 20. directed, above all, to the feasibility and practicability of a framework, and its value. May I refer him to an article of mine in the R.U.S.I. Journal for November, 1921, which discussed at some length the arguments in favour of a framework. Colonel Bond asks for personal experiences. The strongest impression which I derived from my own small experience of active service was of the confused and at the same time inelastic method of thought common to almost every officer, old or new, when confronted with the solution of any tactical problem. The confusion resulted from the unclassified mass of precepts and reservations which they had imbibed from the textbooks and manuals. The lack of elasticity arose from the fact that each individual's tactical thought was cramped and deformed in its infancy by the experiences of that individual, which even in the case of the most experienced were narrow and infinitesimal compared with the universal experience of war as a whole.

Laying no claim to Colonel Bond's omnipotence, or to any immunity from the defects common to human nature, I freely admit that I floundered in common with the rest. A minority, however, who are sufficiently keen, will always fight their way out of the morass to a foothold on the bedrock principles. It would appear from the very names—Major Pott and Colonel Blunderbore —which Colonel Bond gives to his typical leaders, that he does not regard the ordinary senior officer to be of the type who would be capable of the study, the reflection, the patience and the analytical power needed for evolving for themselves an effective tactical doctrine of classified principles. After all, military history bears witness to the rarity of generals even of the past who have succeeded in this respect.

But the subaltern and serjeant, who are usually the company and platoon commander respectively in war, are even less likely to have the time or ability to work out a tactical doctrine or framework for themselves. To give the ordinary manual, with its mass of unclassified precepts and considerations, into their hands is simply to give them mental indigestion. Nor are they likely to gain a clear grasp of the principles from the highly imaginary conditions of a tactical exercise in peace-time or from the narrow range of their experiences in war. In any case, to evolve a scientific method of tactical thought requires so prolonged an apprenticeship that by the time they have acquired it they will no longer be company and platoon commanders.

It is evident, from Colonel Bond's article on the "Principles of War" in the R.E. Journal for March, that he does realize the need for supplying the ordinary officer with a ready-made foundation of principles on which to develop his tactical knowledge and experience, and in order to obtain a common method of appreciating a tactical problem.

I fear, however, that so diffuse and unclassified a list as he gives is of no practical use to the ordinary officer groping for light. How can the latter possibly, when confronted with a problem, weigh up seven so-called principles to each of which is appended a number of means and considerations, none of which are classified according to proportionate values nor arranged in any sort of relation.

Colonel Bond's sublime disregard of the beam in his own eye when searching for the mote in mine, is shown by the fact that he states the seven "basic principles of war," without the slightest attempt to show from what source or by what means he deduced these principles upon which we are invited to build up our tactical doctrine. Perhaps he considers that "a confident and oracular tone" will take the place of any deductive reasoning.

There is certainly one of his universal principles, "that victory can only be gained by defeating in battle the armed forces of the enemy," which was shown by the last war to be distinctly unstable. The conquest of the enemy nation's will to resist is the fundamental principle and if, with new developments, this can be effected without the former result, the armed forces can and will be neglected as the main objective.

The ordinary officer seeking a foundation to clear-cut principles which he can apply to any problem in order to obtain a sound solution, requires something more concrete than the vaguely phrased and uncorrelated platitudes.

Colonel Bond's criticisms were so violent in tone that he could scarcely have complained if I had counter-attacked in similar style, Let me, however, suggest, in conclusion, that it is always a pity when any searcher after truth quits the path of dispassionate and logical constructive argument in order to abuse a fellow searcher. "Thinking in a passion" is the last means by which we can draw nearer to truth, and is only one degree less harmful than mental inertia. When the mass of people who lie dozing are awakened merely to see those who are awake hurling verbal brickbats at each other, they turn disgusted on the other side and fall asleep again, deaf to the pressing problems of national security. So, in another sphere of the search after truth, did the Arian and Roman creeds fight each other, until both were engulfed by the barbarians, and the Dark Ages followed. So, again, did the Roman Catholics persecute the Protestants, and the Protestants the Catholics, while Europe fell prey to unrestrained anarchy and tyranny. So in our own England, the High Church Party of James I, Charles I, and Laud persecuted the Puritans, and with the swing of the pendulum the Puritans oppressed the former. So now the world has fallen into the gross slumber of materialism because the rival creeds cannot refrain from warring with each other.

How often have the searchers after truth found their greatest opposition, not from the somnolent multitude whom they set out to awaken, but from the previous body of searchers who, having climbed a few steps up the difficult path, devote their future efforts, not to climbing further but to pushing down any fresh climbers. The cases of Roger Bacon, Galileo, Stephenson, Darwin, are but a few outstanding examples of the violence with which the supporters of the established theory of the moment oppose any further researches on unorthodox lines. The Medical Authorities' attitude to, Sir Herbert Barker is an even more recent example of this perverted instinct on the part of the professed seekers after truth to suppress fresh truths, and of their refusal to adapt themselves to changing Surely in the military sphere which so vitally concerns realities. the security and continuance of our country, we should avoid this pharasaical tendency. The theory of uncontrolled liberty of tactical dispositions which Colonel Bond supports had, in its turn, an uphill fight against the formalism of last century. Is it not possible that the pendulum has now swung too far towards individualism, and that a mean course might be more effective in order to prevent confusion in the minds and actions of the junior leaders, resulting in possible chaos and defeat? I suggest that such a mean is represented by a framework of principles, together with a superstructure of normal methods based on these principles which are to be understood as flexible and necessarily adaptable to situations which are unusual.

Again, it is possible that both Colonel Bond and I have gone too far in our opposing directions. But in any case it is surely to the advantage of our common goal—military truth—that we should have a spirit of mutual toleration.

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GERMAN REPAIR OF RAILWAYS IN FRANCE AND BELGIUM.

"Das deutsche Militär-Eisenbahnwesen im Weltkrieg 1914-1918. Die Wiederherstellung der Eisenbahnen auf dem Westlichen Kriegsschauplatz." VON W. KRETSCHMANN. (Berlin: Mittler, 180 Marks.)

THIS account of the repair of railways in the Western theatre of warthe first instalment of the history of the German railway service during the war-appears to be an official one; for the author describes himself as *Archivrat* and member of the *Reichsarchiv*, an institution which has taken the place and continues the work of the banned Historical Section of the General Staff. During the war he was Major in the General Staff of the Chief of the Field Railway Service.

His text is full of matters of interest; there is, besides, an excellent map showing the dates on which the sections of the railway system were opened for traffic and the new lines built; and there are 59 photographs, besides numerous diagrams, showing mostly the demolition and repair of railway bridges.

The peace establishment of the German military railway service consisted of two brigades (Berlin and Hanau) containing 28 companies (Railway Regiments Nos. 1, 2 and 3 with eight each, and No. 4 with four), and a Traffic Section (three companies), all under the Prussian Inspector of Railway Troops; and an Independent Bavarian battalion of three companies. Each brigade had charge of a depot of railway stores.

On mobilization there were formed 90 companies :

- 30 Railway Construction Companies,
- 26 Reserve Railway Construction Companies,
- 7 Landwehr Railway Construction Companies,
- **II** Fortress Railway Construction Companies,
 - 4 Railway Labour Battalions (later called Railway Auxiliary Battalions) each of 4 companies.

The strength of the active and reserve companies was, excluding medical officers and paymaster, 9 officers and 275 men; Landwehr, 5 and 229; Fortress, 5 and 330; Labour Battalion, 23 and 1148. Total, in round figures, 26,000 men.

The Staffs consisted of :-Brigade, 3 officers, 2 clerks; Regiment, 2 officers, 1 clerk; and 8 spare officers. These numbers proved wholly insufficient.

The railway troops, too, were found inadequate in numbers. Very early in the war the number of Construction Companies had to be increased, and a number of special units formed, e.g., for removing débris of bridges from canals and rivers, for working labour-saving

machinery, for repairing tunnels, and restoring signalling systems, water supply, etc. The numbers employed are not given. Eventually, recourse was had to private firms and contractors for rebuilding important bridges.

The railway stores of the peace establishment proved suitable and sufficient, except as regards oxygen-cutting plant and cranes for very heavy weights. The stores of each company were carried in ten railway trucks, but the construction trains gradually increased in length and proved a nuisance, at any rate in the East where sidings were few. Each company had five four-horse wagons, so that it could push on in front of railhead to do repairs ; but they could not carry much, whereas Austrian companies had sufficient horse-transport to carry all their stores. The author does not mention motor lorries.

The German Army possessed two types of standard railway bridges : Sch (Schultz) and L (Lübbecke) ; the former for a span of 30-36 metres and the latter for 20-60 metres. They were not popular, and the Austrian patterns Kohn and Roth-Waagner, with spans up to 100 metres,



THE KOHN BRIDGE.

proved superior. Both of these constructions were parallel, square-framed girders, whose members were connected their not at

junctions by hinged bolts, but secured by riveted web plates and joined by bolts. The crection of the bridge was, if possible, carried out on scaffolding, but it could also be built out without it. As the elements of the bridge were formed by very few parts, the erection was extraordinarily simple and easy to

superin- 🖡 tend. The principle o b s erved in our



bridges, that no part should be heavier than a man could handle, was departed from in the Austrian patterns with great advantage.

Germany took into the field a 60-cm. narrow gauge railway. But the author savs :---

"The war has shown that only standard gauge railways are in a position to deal with the tremendous transport demands of modern armics, and the narrow gauge is out of the question as a substitute for damaged railways or lack of standard gauge railways in mobile warfare. The construction of narrow gauge lines always requires time and labour out of proportion to their value, which could be employed with greater profit in the rapid repair of the standard gauge, and this applied even in the Eastern theatre of war, which was poor in railways. The carrying power of the light railways, especially at first, is trifling. . . . The experiences of the war have repeatedly confirmed and proved these principles :- That the construction of narrow gauge railways is only justified for supplying the front positions in trench warfare and for economic purposes behind the front."

The repair of signal, telegraph and telephone systems and water supply gave far more trouble than repair of the lines.

The railway organization, with a Chief of the Field Railways at G.H.Q., who was responsible both for constructions and traffic, proved satisfactory.

Fifteen advanced sections, each of 2 officers, 8 N.C.O.'s and 81 men, were formed on mobilization to assist detraining. Parties were also formed for reconnaissance of damaged railways; no photographic apparatus was included in their equipment, and this was much wanted.

The arrangements for the protection of railways were insufficient; special measures had to be taken to prevent depredations by the German troops themselves, who often smashed signals, telephones, etc., because they were in enemy country.

It is stated that the damage done to their railways by the Belgians did not take long to restore, except the destruction of the Trois Ponts tunnel and the bridge over the Ourthe at Melreux; but we find that the line, "so important for shifting troops from the left to the right wing," Thionville-Libramont-Namur, was not fit for traffic until the 8th September, and even then the Meuse bridge at Namur had not been restored. In France so many bridges and tunnels had been thoroughly demolished that their rapid repair was out of the question. Demolition of tunnels at both ends and in the centre caused great delay. During the battle of the Marne only four lines of rail were available:

- 1. Aix-la-Chapelle-Brussels-Cambrai, whence there were three branches to Roye, Chauny and St. Quentin.
- 2. Liége-Namur-Charleroi-Berzée, whence there was a single line to Anor, just inside French territory, and north of Hirson.
- 3. A single line from Malmedy to Libramont, and thence to Marbehan and just over the French frontier, short of Montmedy.
- 4. Thionville-Longuyon, again only just into France.

The author states that the railway connection with Kluck's Army was "favourable beyond expectation;" and this remark is justified, for that commander's furthest south was only fifty miles from his railheads, and the centre of his Ourcq front was less than thirty; and during the battle of the Marne the Chauny line was extended to Noyon on the 8th, and Compiègne on the 9th, only just behind the front. Kluck's excuses that his Army had outrun the railway service seem therefore to have no basis.

For the repair of the most important bridges and viaducts, civilian contractors were called in as early as the 1st September, 1914. Steel construction was used. A 130-metre span bridge at Namur was built in 27 days between the 4th and 30th September, 1914; others in France took from 37 to 43 days. The firms received 10 to 15 per cent. profit on the cost.

In 1915-1916 three strategic double tracks were built, mostly by contract with prisoner labour, in order to improve the connection between the home railways and Belgium.

These were :---

 Aix-la-Chapelle-Visé-Tongern, along the Dutch frontier (44.5 km.).

- 2. Born to Vielsalm (22 km.) and the single line doubled from here to Rivage (south of Liége).
- 3. St. Vith-Gouvy (20.9 km.) and the single line doubled from here to Libramont (57 km.).

There are full details of the work done on reconstruction of bridges and the three new lines.

DESIGN OF PIPE-LINES, ETC., AND ACCURATE MEASURE-MENT OF WATER.

IN Hydraulic Flow Reviewed (Spon: Price 15/- nett), Mr. A. A. Barnes gives the results of very careful investigations into the flow of water. He has devised a series of formulæ, variations of one general formula, by means of which pipe-lines can be designed with greater accuracy, and, in the long run, with greater ease, than by means of the formulæ now in general use; and the following notes on his book may, I think, be of interest and value to R.E. officers engaged on this kind of work.

I.-FLOW OF WATER IN PIPES, CHANNELS, CANALS AND RIVERS.

In considering the above, the following symbols are used :---

v = mean velocity of flow in feet per second

Q = quantity flowing in cubic feet per second

A = cross-sectional area of pipe or channel in square feet

w.p. = wetted perimeter in feet

m = mean hydraulic depth = A/w.p.

i =hydraulic slope=(for pipes) $\frac{\text{net fall}}{\text{length of centre-line of pipe}}$

=(for channels) sin θ , not tan θ .

The best-known of the formulæ now in general use is probably Chezy's, which dates from 1775 and is

$v = c \sqrt{mi}$.

The difficulty in applying this formula lies in the fact that the coefficient "c" is not even a constant for any one class of pipe or conduit, but varies also with the size of pipe and with the gradient ; varies, that is to say, with m and i. It was therefore concluded that the square-root powers were not the correct indices of m and i and that the true formula was in the nature of

$$v = K m^{\alpha} i\beta$$
.

Mr. Barnes appears to have shown conclusively that for any type of pipe or channel values can be found for K, α and β , which will give the value of "v" very closely, whatever the size or slope may be, and he has also shown how these values may be obtained.

In his book he gives details of over 800 observations and experiments which have been made by various reliable authorities in the course of the past 100 years or so and which cover most types of water-course from small glass pipes up to the Mississippi River. These are summarized in Table I and the formulæ deduced from them given. The closeness between the measured flow and that given by his formulæ is very striking.

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I.E.E.
The following is one of the examples which he gives to illustrate the use of the formule : —

A conduit is to be constructed of concrete with a flat invert and vertical side-walls. It is required to supply permanently a city of one and a half million inhabitants with 30 gallons per head per day. The available fall is 2 ft. per mile, and an easement has been acquired sufficient to accommodate a channel of 6 ft. internal width. Find the necessary height of the side walls.

Quantity=1,500,000 \times 30=45,000,000 gallons per day. Add 5% for deterioration of channel, making 47,250,000 gallons per day. Hence Q=87.64 cub. ft. per second.

 $i = \frac{2}{5280} = 0003788$; log $i = \overline{4}.57840$

The formula for new concrete is :---

$$v = 95.1 m^{-567} i^{-471}$$

Working by trial and error, try a depth of 5 ft.

Then $m = \frac{6 \times 5}{6 + 5 + 5} = 1.875$; log m = 27300.

From formula, $\log v = \log 95^{\circ}1 + (567 \log 1.875) + (471 \log i)$.

$$\log v = 1.97818 + (.567 \times .27300) + (.471 \times 4.57840)$$

= 1.97818 + 15479 - 1.61157
= .52140

Hence v=3.322 ft. per second

 $Q=Av=bdv=6\times5\times3\cdot322=99\cdot66$ cub, ft. per second

Hence 5 ft. is too deep, for the required Q is only 87.64 cub. ft. per second.

Now assume for the moment that "v" remains constant,

then
$$A = \frac{Q}{v} = \frac{87.64}{3.322} = 26.4 \text{ sq. ft.}$$

 \therefore approx. depth = $\frac{A}{b} = \frac{26.4}{6} = 4.40 \text{ ft.}$

Since the velocity, however, will be slightly less for the shallower depth, we should take a depth of 4.50 ft.

This, when tested, is found to be correct. Hence the side walls should be 4 ft. 6 in. high.

For pipes the calculations are simpler, since, as $m = \frac{D}{4}$, no trial and error working is needed.

It may be objected that it is unnecessary to work to such extreme accuracy as is demanded by the use of a formula involving indices with three places of decimals when an allowance of as much as 55%may be made for deterioration. The indices, however, are those read off from the graphical determination to be described later, and there seems nothing to be gained by altering them. As shown above, too, the formulæ are very simple to use, even though they may at first sight

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look alarming. The only thing, indeed, which can be said against them on this score is that they require the use of logarithms instead of merely a slide-rule, not a very big objection in designing an expensive piece of work. Surely, too, it is better to know what discharge a new pipe-line will give to one or two per cent. and to make a reasonable allowance for deterioration than it is to use a formula, such as Chezy's, which may easily give an initial error of 30 or 40 per cent.

The formula for earth channels and rivers might have, it is pointed out, a particular interest for exploration parties, who might get valuable information as to the discharge of rivers without having the time or apparatus for a long and costly series of current-meter observations. If a fairly regular reach of a river can be found, *i.e.*, a length in which the fall of the water is approximately parallel to the bed and the width and depth are more or less constant, it should not be difficult to take a few soundings for a cross-section and approximately to measure the slope of the water, possibly by aneroid if the reach is long enough, so getting the values of m and i. The discharge should then be given with a very small percentage error by the formula:---

 $v = 58.4 m^{-694} i^{-496}$.

which may be modified without serious error, if preferred, to :--

 $v = 58.4 \ m^{-70} \ i^{-50}$.

GRAPHICAL DETERMINATION OF FORMULA.

Mr. Barnes gives very fully the steps by which he arrived at his method for determining the values of K, α and β ; and the necessary construction may be of interest, even without a full explanation. Three measurements only are required, provided that these are made with sufficient accuracy. All that is required is to have two short experimental channels constructed of exactly similar materials, with their inverts of different known slopes.

In the first channel two observations are made at velocities of, say, 3 ft, and 7 ft, per second, and the respective values of m measured.

In the second channel one observation is made at any velocity and m measured.

Suppose that the three sets of readings have been taken in, say, a brick channel and that the values obtained are as follows:—

Observation	i	log i	m	log m	υ	log v	Point on diagram
1	·005025	$\overline{3.7011}$	-284	1.4533	3 665	·5641	A
2	·005025	$\overline{3.7011}$	-779	1.8915	6 716	·8271	B
3	·0000668	$\overline{5.8248}$	2-284	0.3587	1 716	·2346	C

On the largest practicable scale, with values of log m on the x-axis and of log v on the y-axis, plot the points A, B and C. (See Fig. 1).

Join A B and produce as required.

Through C draw C E parallel to A B.

Mark against A B and C E their respective $\log i$ values.

Draw any line normal to A B—say O F. This is the $\log i$ scale.

The values of log i on it are known at the two points of intersection with A B and C E.

Complete the scale. Let R be the point in O F where $\log i=0$.

Through R draw P R S parallel to A B cutting the x- and y-axes in P and S respectively.



Now at S, $\log m = \log i = 0$, $\therefore m = i = 1$

 \therefore from general formula $v = K m^{\alpha} i\beta$ \therefore v = K

 \therefore log K=log v=length O S=1.964, K=92.1

And a=index of m=slope of P S= $\frac{O}{O} = \frac{1.964}{3.263} = \frac{.602}{.602}$.

Now $\log v = \log K + a \log m + \beta \log i$.

Substitute the values found for "K" and "a" and the values given by observation (I) for v, m and i.

Hence it is found that $\beta = 466$.

For brick channels therefore the flow formula is :---

 $v = 92^{\circ}1 m^{\circ 602} i^{\circ 466}$.

If much work has to be done with one class of pipe or channel the diagram can easily be altered to give direct readings by looking up a number of anti-logarithms.

N.B.—The critical velocity is one foot per second, and the formulæ will not be accurate for lower values of v.

II.-ACCURATE MEASUREMENT OF FLOW.

In order to construct a formula in the manner just described it is necessary to be able to make very accurate measurements of flow in the initial experiments, and the second part of the book deals with methods of doing this by means of notches, weirs with and without end contractions and circular orifices.

The general formula is now :---

$$v = K m^{\alpha} H^{\beta}$$

which is of the same nature as the other, since slope is a function of H.

TABLE I.						
List of Formulæ for	FLOW OF WATER IN	PIPES, CHANNELS,	CANALS, AND	RIVERS.		

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Materials of Construction	Formula for MEAN VELOCITY in feet per second	Formula for FRICTION HEAD in feet.	Formula for Q in cu. ft. per sec. (pipes) h.m.d. in ft. (channels).	Number of experi- ments by various authori- ties.	Range of Experiments.	Comparison of Formula with observations.	For purposes of DESIGN to allow for deterioration.
PIPES :	$v = 174 \cdot 1 m \cdot 769 i \cdot 529$	$ \begin{array}{c} h = 0000581 \frac{lv^{1.691}}{m^{1.454}} \\ = 000436 \frac{lv^{1.691}}{d^{1.454}} \end{array} $	$Q = 47.087 d^{2.769} i^{.529}$	79	d=3 in, to 614 in, i=0000689 to 0681 v=1.00 to 8.70	60 agree to 2%	Add 45% to Q
New uncoated cast- iron pipes	$v = 136.6 m^{-600} i^{-512}$	$\begin{array}{c} h = 0000675 \frac{lv 1.953}{m^{1.172}} \\ = 000343 \frac{lv^{1.953}}{d^{1.172}} \end{array}$	$Q = 46.699 \ d^{2.600} \ i^{.512}$	37	$d=3\frac{1}{10}$ in. to $19\frac{1}{10}$ in. i=00045 to $17072v=1.175$ to 16.168	25 agree to 2%	Add 55% to Q
New asphalted, screw-jointed riveted wrought	$v = 190.2 \ m^{-508} \ i^{-557}$	$ \begin{array}{l} h = 0000809 \frac{lv^{1.795}}{m^{1.092}} \\ = 000368 \frac{lv^{1.795}}{d^{1.092}} \end{array} $	$Q = 64.305 \ d^{2.508} \ i^{.557}$	14	$d=3\frac{1}{2}$ in. to $11\frac{1}{2}$ in. i=00070 to $15605v=1.171$ to 19.720	11 agree to 2%	Add 33% to Q
New asphalted single - riveted wrought iron and steel pipes	v = 171.4 m.723 i.527	$h = 0000576 \frac{lv^{1.833}}{m^{1.372}}$ $= 000386 \frac{lv^{1.833}}{d^{1.372}}$	$Q = 49.409 \ d^{2.723} \ i^{.627}$	16	$d = 10\frac{2}{5} \text{ in. to } 25\frac{7}{5} \text{ in.}$ i = 00502 to 03318 v = 4.383 to 12.605	14 agree to 2%	Add 33% to Q
New asphalted double - riveted wrought iron and steel pipes (taper evidenciate)	$v = 129.9 m \cdot 440 i \cdot 520$	$ \begin{array}{c c} h = 0000862 & \frac{lv^{1.933}}{m^{1.646}} \\ = 000279 & \frac{lv^{1.923}}{d^{1.646}} \\ \end{array} $	$Q = 55.436 d^{2.440} i^{.520}$	65	$d = 17$ in. to $103\frac{3}{6}$ in. i = 0000676 to $06672v = 1.06$ to 20.143	31 agree to 2%	Add 33% to Q
Clean lead pipes	$v = 232.8 \ m^{-679} \ i^{-591}$	$ \begin{array}{c} h = 0000988 \frac{lv^{1.512}}{m^{1.149}} \\ = 000486 \frac{lv^{1.692}}{d^{1.149}} \end{array} $	$Q = 71^{-}330 d^{2 \cdot 679} i^{\cdot 591}$	24	$d = \frac{1}{4}$ in. to $1\frac{1}{3}\frac{9}{2}$ in. i = .00778 to $3.873v = 1.089$ to 14.290	15 agree to 3%	Add 5% to Q
Clean glass pipes	$v = 143.0 \ m^{-562} \ i^{-556}$	$ \begin{array}{c} h = \cdot 0001329 & \frac{lv^{1.799}}{m^{1.011}} \\ = \cdot 000539 & \frac{lv^{1.799}}{d^{1.011}} \end{array} $	$Q = 51.532 d^{2.362} i^{.556}$	8	$d = \frac{2}{3} \frac{1}{2}$ in. to 2 in. $i = \cdot 00771$ to $\cdot 12918$ $v = 1 \cdot 591$ to $6 \cdot 916$	All agree to 1율%	Add 5% to Q
TROUGHS OR PIPES: Clean planed wood troughs or flumes and new smooth wood stave pipes	v == 223·3 m·660 i·586	$h = 0000981 \frac{lv^{1.707}}{m^{1.126}}$	$m = 000276 \frac{v^{1.515}}{i.888}$	57	m = 0261 to 1.510 i = 000106 to 15849 v = 1.075 to 7.346	33 agree to 2%	Add 8% to Q
Clean unplaned wood troughs or flumes and new unplaned wood stave pipes	$v = 182.5 m^{-666} i^{-569}$	$h = 0001066 \frac{lv^{1.757}}{m^{1.171}}$	$m = 000\pm03 \frac{v^{1.502}}{v^{1.854}}$	123	m = 146 to 1.097 i = 00107 to .0343 v = 1.80 to 10.635	29 are correct 93 agree to 2%	Add 8% to Q
Clean neat cement channels or pipes	v = 136.3 m.635 i.484	$h = 0000389 \frac{lv^{2-066}}{m^{1-312}}$	$m = 000435 \frac{v^{1.575}}{i^{.762}}$	33	m = 168 to 1.034 i = 000675 to 0049 v = 3.005 to 8.07	26 agree to 2%	Add 6% to Q
CONDULTS, Channels and							
WATERCOURSES : Clean hard brick well-pointed con- duits	v=92.1 m.eoz i.zee	$h = 0000609 \frac{lv^{3.146}}{m^{1.292}}$	$m = 000546 \frac{v^{1.661}}{i^{.774}}$	81	m = 192 to 3.839 i = 0000334 to 00503 v = 1.064 to 6.716	75 agree to 5%	Add 5% to Q
Clean smooth-faced concrete conduits	$v = 95.1 m^{-567} i^{-471}$	$h = 0000631 \frac{lv^{2 \cdot 123}}{m^{1 \cdot 204}}$	$m = 000324 \frac{v^{1.704}}{i^{.831}}$	52	m = 8794 to 3838 i = 0000947 to 0003157 v = 1.37 to 3.02	All agree to 4%	Add 5% to Q
Dressed masonry channels in cement with no projecting surfaces	$v = 109.7 \ m^{.713} \ i^{.483}$	$h = 0000597 \frac{lv^{2-070}}{m^{1-476}}$	$m = 0.001376 \frac{v^{1.403}}{i^{.477}}$	12	m = 0416 to 1.774 i = 00084 to 5160 v = 3222 to 18.17	11 agree to 5%	Add 8% to Q
Rock-faced masonry channels in cement	$v = 80.5 m^{-653} i^{-482}$	$h = 0001112 \frac{lv^{2 \cdot 075}}{m^{1 \cdot 355}}$	$m = 001208 \frac{v^{1.581}}{i^{.738}}$	17	m = 324 to 4.20 i = 000151 to 1010 v = 1.24 to 21.09	15 agree to 5%	Add 8% to Q
Hammer-dressed dry masonry watercourses	$v = 70.0 \ m^{-820} \ i^{-500}$	$h = 0002041 \frac{lv^{2 \cdot 000}}{m^{1 \cdot 640}}$	$m = 0.005622 \ \frac{v^{1+220}}{i^{-410}}$	27	m = 213 to 1.57 i = 00033 to 0300 v = 1.257 to 11.26	21 agree to 7%	Add 10% to Q
CANALS AND RIVERS: — Earth channels and canals in average working condition and rivers free from vegetation	v= 58.4 m. 584 j. 496	$h = 0002746 \frac{lv^{2 \cdot 016}}{m^{1 \cdot 398}}$	$m = 002850 \frac{v^{1.441}}{i^{.715}}$	162	m = 0.073 to $64.52i = 0.000097$ to $0.04569v = 1.093$ to 13.943	133 agree to 8%	Use the "working condition" formula direct
Sewers:	Any section $v = 107 m^{.70} i^{.50}$		Circular, running full Q=31.85 d ^{2.70} i ^{.50}				Use the formulæ direct

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In foot-second Units.

Form of Measurement.	Velocity.	Discharge.	Remarks.		
Right-angled V notch	v = 2.462 m00703 H.48703	Q=2·48 H ^{2·48}	$ \begin{array}{c c} & m = H/2\sqrt{2} \text{ for } 90^{\circ} \text{ V notch.} \\ \text{If velocity of approach } (u) \text{ is great} \\ & \text{than } 0.50 \text{ ft. per second take} \\ & \text{H=observed } h + \frac{1}{100} u^2 \end{array} $		
Smaller V notch	Ditto	Q = A v			
Weirs with end contractions (Francis weirs)	$v = 3.324 \ m^{.11} \ H^{.39}$	$Q = 3.324 H^{1.49} L^{1.11} (L + 2H)11$	$m = \frac{L H}{L + 2H}; L = \text{length of weir-lip};$ Take H = observed $h + \frac{1}{70} u^2$		
Weirs without end contrac- tions (Bazin weirs)	$v = 3.324 \ m^{-0.02} \ H^{.51}$	$Q = 3.324 H^{1.49} L^{.98} (L+2H)^{.02}$	$m = \frac{L H}{L + 2H}$ Take H = observed $h + \frac{1}{50} u^2$		
Circular orifices	v = 4.652 m015 H.500	$Q = 3.73 D^{1.985} \sqrt{H}$	$m = \frac{D}{4}$		

Note.—For notches and weirs, measure H and u at a point 6 ft. upstream from the notch or weir.

The formulæ are detailed in Table II and should all give results with errors of well under 1 per cent.

The following are the chief points to notice in using them :--

(A) Triangular Notches (suitable for flows from 10 gallons per minute up to 1,000 gallons per minute).

H =head from dead-water to apex of notch.

A = area of the triangle of this depth H.

w p.=perimeter which would be wetted if the water ran through the notch with depth H (not perimeter actually wetted).

m = A/w.p.

v = mean velocity through area A.

Q =discharge through notch.

All units in feet and/or seconds.

The formulæ are for a thin-surface notch of 1/16th inch thickness.

The head should be measured with a hook gauge 6 ft. up-stream.

On the up-stream side the channel should be proportioned to give a mean velocity of not more than 0.50 ft. per second. If this is impossible $\frac{7}{2}$

add $\frac{v^2}{100}$ to the observed head to allow for the velocity of approach (u).

Up-stream, the width of the channel should be at least 4 ft. up to a 9-in. head and at least 6 ft. for higher heads. There must be no projecting surfaces whatever, since these would interfere with the "stream-line" flow of the water to the notch.

The depth from the bottom of the notch to the bottom of the channel should be at least 6 in. on the down-stream side and on the up-stream side should be at least 12 in. for heads up to 9 in., and at least 18 in. for higher heads.

The down-stream water level may rise to the apex of the notch, but no higher.

These rules ensure proper contraction and will also probably keep the velocity of approach within the requisite limit.

The critical head is 2 in., and the formula will not hold except for higher heads. A 2-in. head, however, is only equivalent to 10 gallons per minute with a 90° apex.

The velocity formula is also true for smaller angles than a right angle.

(B) Rectangular Weirs with Full End and Bottom Contractions.

This means that the weir should be so much narrower than the channel of approach, and its lip so much higher than the bed of the channel that every particle of water passing over it may assume that direction which it would take up if passing out of a pool of infinite dimensions.

The weir should therefore comply with the following rules :--

(1) Neither of the sides of the channel should be nearer any point of the weir crest than twice the head, and the distance from the bottom of the channel to the weir-crest should be not less than three times the head, the minimum distance in every direction being 12 in.

(2) On the down-stream side neither the bed nor the sides should be nearer the weir than 6 in. The tail-water may be allowed to rise to within 3 in. of the weir-crest but not higher.

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These down-stream conditions are necessary to allow the water to expand freely sideways after leaving the weir, and to ensure there being a clear space under the falling water which will be in direct communication with the air and therefore at atmospheric pressure.

The weir-lip should be $\frac{1}{4}$ in. or less in thickness, with the upper lip sharply formed so that the water springs clear.

There is no " critical head " with weirs,

The weir may be divided into two or more bays. The distance between adjacent bays must then be at least four times the head, otherwise full end contraction will not be obtained.

(C) Rectangular Weirs without End Contractions.

This method, which is almost as accurate as the above, might on occasions be more convenient than a weir with end contractions, e.g., for very large quantities of water indeed, or for a conduit with no special gauging-site.

The bottom contraction still exists and so the water should still spring quite clear of the weir-crest. The tail-water should, therefore, not rise higher than 3 in. below the crest and air-pipes must be passed through the side walls immediately below crest level so that the underside of the "nappe" may, as before, be at atmospheric pressure. This is important.

(D) Circular Orifices.

H=head in feet above centre of orifice.

The well from which the water flows should have a large area so that the velocity of approach may be negligible.

The contraction of the jet should be complete, the sides and bottom of the well being at least three diameters away from the edge of the orifice.

Low heads are to be avoided, especially with large quantities of water, as vortices may form.

The critical head is 18 in. for orifices of $\frac{3}{4}$ in. diameter and upwards; 2 ft. for a $\frac{1}{2}$ -in. orifice, and 4 ft. for a $\frac{1}{4}$ -in. orifice.

The formula holds good up to 12-in. diameters at least, and at the other extreme will measure quantities of little more than 1 gallon per minute.

At the end of the book, several diagrams are given which eliminate the calculations demanded by the formulæ for most cases. They give direct-reading values for flow in cast-iron pipes, steel pipes, brick channels, earth channels and rivers and "slimy sewers"; also for measurement of flow by circular orifices and both kinds of weirs.

The collection under one cover of all the standard experiments forms a very valuable feature of the work, and nothing could be fairer than the comparison of the actual observation with the result obtained by the use of the formula in each case.

I have to acknowledge Mr. Barnes' very great kindness in allowing me to reproduce Tables I and II, and to take so many *verbatim* extracts from his book. I am confident that the book itself would prove of very great interest to a large number of R.E. officers.

J. S. BAINES, Capt., R.E.

OTHER PUBLICATIONS.

THE Editor has received An Introduction to Forecasting Weather, by P. Raymond Zealley, F.R.MET.SOC. (Cambridge: W. Heffer & Sons, Ltd.), price Is, a short and clear explanation of the preparation of Synoptic Charts; and also, from Lieut.-Colonel R. H. Rowe, D.S.O.; M.C., R.A., Surveyor-General, Gold Coast Survey, a folding map of Accra to the scale of I/I25,000, as a specimen of the work of the Gold Coast Survey, which is being carried out under the authority of Brig.-General Sir F. G. Guggisberg, K.C.M.G., D.S.O., Governor. The map is reproduced and printed by Messrs. W. and A. K. Johnston, Ltd., Edinburgh, and is notable for its clearness, while the amount of useful information which it gives about the Colony may be estimated from the fact that it is accompanied by a table of 89 conventional signs. Accra is one of nine sheets. Price per sheet, 5s. unmounted, 6s. mounted.

NOTICES OF MAGAZINES.

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MILITAR WOCHENBLATT.

No. 4.—July 22nd, 1922.

THE RUSSIAN ARMY IN THE WORLD WAR.—A review by Gen. von Kuhl of the work entitled *Mémoires de Russie*, by Prof. Jules Legras, who was sent to Russia by the French Government in February, 1916, on a special mission (propaganda work). Attention is called to those parts of the volume in question which deal with the causes which led to the "cracking up" of the Russian Army; the chief of these causes were the incompetence of the higher leaders, the aloofness of staff officers and the failure on the part of officers to appreciate that it was more than ever necessary for them to set to their subordinates a good example in all things.

TRAINING FOR LEADERSHIP,-An article bearing on the criticism that the only kind of training provided in Germany prior to the World War was that necessary to prepare an Army for a war of movement. The author of the original article points out that movement and nimbleness of mind and body-the latter qualities being fostered by mobility-are the principal means by which, in a military situation, inferiority in numbers can, to some extent, be neutralized. On these grounds the pre-war methods of training practised in Germany are held to be right. At the same time, the suggestion is thrown out that the strength of the forces-some three or four Army Corps-employed in the normal autumn manœuvres may possibly have been too small, and the view is expressed that the ease with which a force of these relatively small dimensions was handled in mimic warfare may have been responsible for creating a totally false impression of the difficulties which would inevitably arise, in view of the enormous technical developments of recent times, in conducting a real campaign with the enormous numbers of troops which take the field in a modern war. False lessons learnt in

these circumstances may, it is argued, have exercised a prejudicial influence on the German leaders in the measures adopted by them during August and September, 1914, in the initial stages of the World War.

THE FUNDAMENTALS OF INFANTRY TACTICS.—An anonymous article contributed by a "young officer," who points out that the Peace Treaty deprives Germany of three important weapons: "heavy artill ry, aircraft and tanks." He restates the factors which play the most important part in the planning of a modern battle, the element of surprise naturally being one of them; he seems fearful lest German statesmen and military leaders may overlook one essential requirement, namely, the provision of the "Ersatzmittel" needed to replace the weapons aforesaid taken away by the provisions of the Treaty of Versailles, which presumably has some day to be treated as a "mere scrap of paper."

THE ENGLISH HISTORY OF THE NAVAL WAR.—A brief review of *Naval Operations*. Vol. II. By the late Sir J. Corbett. The comments refer mainly to the Dardanelles Expedition.

No. 5.- July, 29th, 1922.

THE WAR OF IDEAS, CATCH-PHRASES AND PARTY BANNERS.—A plea by Lieut.-General v. Altrock for unity among the German people. The General feels that the great need of the moment in his country is sound intellectual guidance; instead thereof, his compatriots are having flung at them mystic catch-phrases and obscure ideas. The situation thus created is one fraught with considerable danger, since every person interprets the phrases and ideas which he hears in that sense which best fits in with his own particular bias. It is, says the General, only by a combination of effort by all his compatriots to secure a common end that the future of the Fatherland can be assured. His exhortation to his fellow countrymen is expressed in the following terms: "Away, then, with strife under party banners; away also with the war of catchphrases and abstruse ideas!"

HANS DELBRÜCK versus LUDENDORFF.—A bitter attack by Dr. Karl Berger on the well-known German historian and politician, Delbrück, for the criticisms contained in the latter's work, entitled Ludendorff's Selbstporträt, on Hindenburg's famous Chief of Staff. Dr. Berger calls in aid two works by retired officers published recently for the purpose of vindicating the character and reputation of Ludendorff, viz., Hans Delbrück—ein Porträtmaler? by Lieut.-Colonel Wolfgang Færster, and Ludendorff als Mensch und Politiker by Lieut.-Colonel Hans Eggert. The two soldier-authors having taken up cudgels on behalf of Ludendorff and soundly trounced Delbrück, Dr. Berger now comes forward to proclaim their great victory.

AMERICAN ESTABLISHMENTS.—Particulars relating to the armament authorized for the Anti-Aircraft units of the U.S. Army.

THE RED ARMY.—A few details relating to the armament, etc., of the "Reds" in Russia.

No. 6.-4ugust 5th, 1922.

Monarchists and Republicans.—An appeal by Lieut.-General v. Cramon for mutual forbearance towards one another on the part of the members of the two great groups into which Germany is divided to day. With the wonderful pair of field-glasses with which the General has provided himself, he discerns that it is neither on the right nor on the left that the enemies of his country now stand; it is " in the first line " that the external foes of the Fatherland are at the moment assembled and threaten its very existence. In these circumstances Germany cannot to-day do without the aid and succour of a single one of her citizens, be he monarchist or republican; her sons must show a united front in order that a brighter and untrammelled future may be won for the Fatherland.

JUDGMENT OF THE COURT OF HONOUR in re LIEUT.-GENERAL SCHEUCH, MINISTER FOR WAR.—A somewhat lengthy account of the proceedings of the Court of Honour assembled at the instance of Lieut.-General Scheüch to examine into the several accusations made against him and the alleged calumnies uttered in connection with his conduct in October and November, 1918, during the tenure by him of the position of Commander-in-Chief of the German Home Defence Army. The several matters in relation to which evidence was taken before the Court and the findings in each case are set out. The Court pronounced an acquittal in respect of the whole of the charges and declared that the General's escutcheon was untarnished and spotless. The Court also expressed the opinion that, rather than censure, the General merited the thanks of the Army ; he had proved himself a faithful servant of his Kaiser and Fatherland, and also a blameless officer.

PUBLICITY AND THE REICHSWEHR.—A word of advice to the Officer Corps on the desirability of its members avoiding participation in public in political movements and matters, which may identify them individually with one or other of the political parties in the country. In private, it is fully recognized that officers to-day, as in days gone by, retain complete liberty of action, and may hold whatever political views they may wish.

THE FRANCO-GERMAN CRISIS OF 1875.—A review of the book entitled Forschungen und Darstellungen aus dem Reichsarchiv, by Dr. Hans Herzfeld. Since the outbreak of the World War in the autumn of 1914. the view has widely prevailed in foreign countries that the available evidence all points to the fact that the responsibility of having set the conflagration in Europe alight rests on Germany. German writers, of course, contest this view, and also contradict the statement that in the year 1875 Bismarck contemplated springing another war-a" preventive war" (sic)-on France, because in his opinion the Republic was recovering too rapidly from the effects of the knock-down blow administered five years earlier by her Eastern neighbour. With a view to proving that his country did not harbour any such evil design as attributed to it, Dr. Herzfeld has apparently been rummaging among State papers in Berlin ; he announces in the book under review that he has failed to find among the papers to which he has had access any document, memorandum, or writing containing any project or plan of

campaign for an attack on France prepared by von Moltke at the period in question. *Ergo*, no such wicked idea as a "Präventivkrieg" can have been under the consideration of the advisers of Kaiser Wilhelm I, as alleged.

No. 7.—August 12th, 1922.

No More War-Away with the Reichswehr?-An article by Lieut.-General v. Altrock commenting upon a contribution, opening with the catch-phrase "Nie wieder Krieg," by the Social Democrat Winnig to the Disch. Allg. Zeitung, No. 325. Winnig apparently desires to substitute for the cry "No more war," a call to the proletariat of all lands, urging them to unite with a view to preventing the enforcement on Germany of the provisions of the Treaty of Versailles. General v. Altrock thinks, and he may not be mistaken, that Winnig's call will fall on deaf ears. The General is somewhat concerned, at the same time, lest the cry for the abolition of the Reichswehr may meet with success ; it would seem that this organization has been openly attacked in the German Press as being a costly encumbrance, etc. The General, on the other hand, considers that it is the first duty of every German citizen to uphold the Reichswehr.

CAVALRY IN THE WORLD WAR: FRENCH VIEWS.—An article by Lieut.-General v. Poseck, Inspekteur der Kavallerie, who takes strong exception to the strictures passed by General Féraud, Inspector General of Cavalry in France, on the German cavalry, in a contribution to the *Revue des deux Mondes* of June 15th last. General v. Poseck seems particularly to be annoyed that the French General should have contrasted the work of the French cavalry and that of the German cavalry in such a manner as to throw added lustre on the former, and quotes from Hanotaux's *Histoire de la Guerre de* 1914 and from the work by Colonel Egli, entitled *Der Aufmarsch und die Bewegung der Heere Frankreichs, Belgiens, und Englands*, in order to prove that the handling of the French cavalry was not altogether faultless. The cause of all this pother is no doubt rooted in the fact that the German cavalry has not come out of the World War with the wonderful reputation which it acquired in the 1870 campaign. (*To be continued.*)

THE GERMAN AIRCRAFT INDUSTRY AND THE ENDLESS WAR.—A complaint against the restrictions imposed on Germany by the Treaty of Versailles in connection with the manufacture of aircraft. It is stated in the article that, in accordance with the terms of the Peace Treaty, Germany has already surrendered 14,000 flying-machines and 27,700 aircraft motors: The claim is put forward that the German aircraft industry should be freed from servitude and that Germany should be at liberty to compete without any restrictions in the markets of the world.

GERMAN PROPAGANDA IN 1918.—A statement relating to the leaflets broad-casted by aeroplanes on the 'Western Front by the German Propaganda Bureau in May, 1918, with the purpose of shaking the morale of the French soldier. The German peace conditions offered at the time to France were set out in the leaflet and are reproduced in the M.W.B. article. The readers of that journal are requested to compare the favourable terms of Germany's offer with the harsh conditions imposed on Germany by the Peace Treaty. Yes, but there is sometimes a vast difference between the promise and its performance, and the *poilu* was clever and sharp-witted enough to recognize this fact, particularly when he knew the quarter from which the promise came.

W. A. J. O'MEARA.

REVUE DU GÉNIE MILITAIRE. January, February, 1922.

Permanent Fortification during the War.—By General Benoit. The article opens with a short history of fortification, and then describes the different practices of various European Nations as regards modern forts. The French place the bulk of the guns outside the forts; the few placed in them are specially protected, and are destined for a special object, possibly the flanking of the intervals.

The Russians followed the same practice till 1912, when they adopted the Belgian system, in which the guns are placed in independent turrets inside the forts.

The Germans followed the Belgian system, but grouped several turrets to form batteries, and in addition allowed for Artillery in the gaps between forts. Flanking fire by specially told-off guns only began to be arranged for by the Russians and Germans after 1909. The thickness of armour varied in the different countries. France was using 30-cm. special steel, lined with 3-cm. sheet steel, and employed disappearing mountings.

Germany had turret mountings, 16-cm. armour with a 4-cm. lining, Belgium, 20-cm. armour with a double lining, each 2 cm. thick.

Concrete.—The French protected old works by thickening the masonry with I metre of sand and $2\frac{1}{2}$ metres of concrete (400 km. of cement to the cubic metre). The other European nations used weaker concrete (250 km. of cement to the cubic metre), and smaller thicknesses. For new works, the Germans used, at first, 3 metres of plain concrete, and later, an inner layer of concrete faced with 50 cm. or I metre of ferro-concrete. The French used up to 1.80 metres of ferro-concrete. Belgians, Austrians and Russians used weaker concrete and smaller thicknesses than the Germans.

DEFENCE.

France.—Formerly, important towns alone were protected by fortification, and no *liaison* was maintained between them.

Later, forts were placed in districts, such as the north of France, on the main roads leading into the country, with the object of delaying the enemy by forcing him to besiege each in turn.

About 1816, General de Maureilhan expressed the opinion that fortresses should cover an area from which armies could sally to oppose the enemy; one fortress would be quite insufficient for this and that, therefore, fortresses should be in groups.

This idea began to be carried out, after 1870, by General Séré de la Rivière. A continuous line was not aimed at, but fortified regions were created as close as possible to the frontier to keep under artillery fire all the more important road and railway approaches. Gaps were

left through which the invader was intended to advance, when he would be liable to attack in flank from armies collecting under the shelter of the fortified regions. The three gaps left on the Franco-German Frontier were those of Charnes, Stenay and the Oise. If the enemy beat off the counter attacks, and advanced through these gaps, it was intended that he should find a second line similar to the first. This line was not completed, except the positions of La Fère—Laon—Rheims.

Germany.—The above ideas were copied by the Germans when they built the fortified regions of the Moselle and of Alsace. The gap between was reduced to 20 or 30 km. along both banks of the Sarre.

The second line was the fortified line of the Rhine.

Belgium.—In 1855, the Belgians realized that many small fortified towns merely absorbed their available men, and decided to be satisfied with defending the Meuse. With this object, they built Liége and Namur, and connected them together by the small fortress of Huy. These towns had no enceinte, and only a single ring of forts. Much dead ground lay only 12 km. from the town, affording positions for the enemy artillery. No arrangements had been made for flanking fire or for the defence of the intervals between the forts.

In addition, the forts did not cover with their fire the whole length of the Meuse, only 130 yards wide and easily crossed in many places. One other fortress was built, namely, Antwerp, to act as a pivot of manœuvre for the field army, and as a keep in the event of defeat.

Russia.—Russia had likewise been content to defend the principal crossings over rivers running parallel to its frontiers.

THE STATE OF OPINION AS REGARDS THE FORTIFICATIONS.

The Germans had not completed the fortifications of the Alsace-Lorraine front in 1914, but nevertheless, they realized their importance in giving them the possibility of a very powerful offensive base against France, and the power of either placing all their troops in Alsace-Lorraine or only a small force there with the rest advancing through Belgium against the French Northern Frontier.

The German estimate of the French defences can be seen from the following :---

In 1879, the Emperor of Germany, in a letter to Bismarck, stated that the French front was nearly hermetically sealed, and that even if a breach were made, a pursuit, as in 1870, would be out of the question until the fortified regions had been captured.

Moltke's plan of campaign was an attack through the gap between Epinal and Toul. Waldersee, his successor, had the same plan, but recognized that the organization of the field positions at Nancy and Baddonviller had to be captured first, and that the whole problem was a very stiff one.

Count Schliffen, who succeeded Waldersee in 1891, decided that the position must be turned through either Switzerland or Belgium. The former was undesirable, and therefore, the latter was decided on as a military necessity.

This argument was put forward to the British Ambassador on August 4th, 1914, by Mr. de Tagow, German Minister of Foreign Affairs. Germany, fearing much loss of time in attacking the French forts, invaded Belgium to attack the French Northern Frontier which was not in a state to offer resistance. This invasion of Belgium brought England immediately into the war and, therefore, it can be stated that this was done by the fortifications on the French Eastern Frontier. This alone justified the money spent on them, which, indeed, only amounted to the cost of three or four days of the war.

France.—In 1911, French opinion was that wars would be short and decided in two or three large battles. Some forts would be necessary to cover mobilization, but that, apart from exceptional cases, forts to fulfil other rôles would not be required, and that the defence of the country must be carried out by Field Armies.

For these reasons, certain fortresses, notably most of those on the Northern Frontier, were disarmed. Lille, whose disarmament was proposed, but never carried out, was declared an open town on 24th August, 1914. The fortresses retained, whilst blocking the approaches within their reach, were to protect the screening forces until they were strong enough to protect themselves, when they were to act as supporting points, and to cover the concentration of the Field Armies. If these Armies were forced to retreat, the fortresses were intended to threaten the enemy's communications, and to deny him the use of the railways within reach of their armament.

THE RôLE PLAYED BY THE FORTIFICATIONS IN BELGIUM.

At Liege, the last forts to fall had resisted for 12 days in all, and only for three or four of bombardment by 420-mm. guns.

Namur, attacked on the 20th August, fell on the 26th, chiefly owing to the destruction wrought by the 300 and 420-mm. guns. The fort of Emines, for instance, was bombarded by two batteries of 305, and one battery of 420 from 0400 hours to 1630 hours, with the result that three heavy turrets out of four, and two small ones out of three were put out of action.

Antwerp was masked to the south by the 3rd and 9th German Corps on the 21st August.

On the 25th a Belgian sortie was attempted with no permanent success, except to draw back the 4th German Army from its march south.

On the 4th of September, a German assault failed, and on the 9th, the Belgians attacked again. They had some success, but German reinforcements and heavy artillery drove them back by the 13th. The reinforcements consisted of the 6th Division and 9th Army Corps, diverted from their march towards the Aisne,

After this the Belgians, moving by roads still unclosed, effected a junction between their armies and the French, leaving Antwerp with only its garrison.

The Germans brought up their heaviest artillery and began their attack on the 28th September. Antwerp fell on the 10th October.

Remarks,—(i).—The Belgian fortifications fulfilled their rôle as far as their defects and the small number of their defenders permitted,

The small Belgian army could not hope, even with the help of fortifications, to stop the German advance, but these fortifications delayed it sufficiently long to permit the French to complete their change of front.

(ii).—The defences of the Meuse (two fortresses 40 miles apart, affording each other no mutual support) were insufficient.

These could not prevent the river being crossed, and an obstacle, however serious, has no value if unswept by direct or flanking fire.

The rôle played by the fortifications in Russia and in Austria.—Details are given of the fighting in 1914, the sieges of Przemysl, and at the fortresses on the Memel, Bobr, Narew and the Vistula.

The rôle played by the French fortresses at the beginning of the war.— The first fortresses encountered by the Germans were old-fashioned and untenable, and most of them the French did not attempt to hold. Longwy held out under attack from the 21st to the 26th August when, all the shelters having been rendered useless, and the Germans preparing an assault, the fortress surrendered.

Manonvillers.— The German heavy artillery took up positions 8 km. and more from the fortress, outside the reach of its guns. The steel turrets were destroyed the first day; observation became impossible, owing to the heavy smoke and dust, and the mounds of earth thrown up in front of the embrasures.

It was found that the garrison ran the risk of being asphyxiated by the fumes from bursting shells admitted through the ventilators.

This fortress had been strengthened with reinforced concrete, and the material damage done was not considerable, only three of the garrison were killed and nine wounded; the moral effect of the heavy bombardment was such as to stun the men, and almost to deprive them of their reason. The fortress was bombarded from 0930 hours on the 25th, to 1530 hours on the 27th August.

Maubeuge held out for 13 days in all and eight of intense heavy bombardment. The forts on the north and north-east, being of brick work, were quickly destroyed. Those on the south and south-west were not very much damaged. The fortress held up considerable German forces, which would have been invaluable to them at the battle of the Marne.

The Heights of the Meuse were attacked on the r2th of September, after bombardment with 305-mm. projectiles. The presence of a Field Army and flanking fire from the fort Genicourt enabled the attack to be repulsed. On the 24th and 25th September, the Germans bombarded the Heights on a front of 25 km., between the forts Troyon and Liouville. The Germans crossed the Meuse at Saint Mihiel, captured the fort "Camp de Romains" and the village of Chauvoncourt.

The bombardment did much damage to the unstrengthened forts, the hardened steel turret at Liouville was definitely put out of action.

Damage done to the fortifications.—All the old French forts which had not beeen strengthened were completely destroyed. Ordinary masonry, barbed wire, etc., were useless.

Manonvillers was the only concrete fortress attacked during this

period, and was afterwards completely destroyed by the Germans, so it is hard to arrive at an accurate estimate of the damage done.

From the reports of witnesses it is believed that the counterscarp gallery was badly damaged by a 420-mm. shell, and a gallery under the ditch was pierced by a 280-mm. shell falling on the same place as a 210-mm. onc.

The vibrations set up by repeated bursts, although the concrete was not pierced, caused the sand and masonry to fall into the chambers below.

The Belgian and Russian fortresses, not being so thickly protected or so well constructed, put up very slight resistance to heavy shells. It is known that one 420-mm. shell pierced the concrete roof of a casemate, destroyed it completely and, in addition, the two adjacent ones. -(To be continued.)

The Sound Location of Aeroplanes.-By Capt. René Bailland. Some 42 pages deal with the problem in considerable detail.

C. LA T. T. JONES, Captain, R.E.

REVUE MILITAIRE GÉNERALE June, 1922 (continued).

The Revision of the Regulations, by "Lucius," (continued).--Sixth period, 11.--Application to the German Offensives in the Spring (continued)

From this severe blow (Foch's counter-offensive of the 18th July, 1918) Ludendorff endeavoured to extract lessons, and in a Note of 22nd July stated that, when the enemy received the attack with infantry strongly distributed in depth, and abandoned an advance zone several kilometres deep, more elasticity must be allowed in the execution of the attack to enable it to adapt itself to the enemy's attitude. " To fix details for several hours in advance leads to a breakdown in the system. It is then that the junior commanders below the division must act on their own initiative." Improvements in offensive procedure should be effected under the following heads: (a) Counterbattery fire before an engagement may be the shorter the fewer the targets. Rounds must not be wasted by firing on non-existent batteries. On the contrary, after the engagement of the infantry, counter-battery fire must be continued and even strengthened. For this a few batteries must be pushed well ahead, and junior officers will carry out counterbattery fire within their allotted zones of fire. "It may be hoped that for a depth of 7 to 10 kilometres the enemy's artillery, thus threatened, will be sufficiently neutralized to be unable to oppose a serious obstacle to the advance of the infantry and particularly of their regimental guns."

(b) Guns firing against infantry need not carry out a long bombardment of the lightly-held trenches of the advanced zone; after partial destruction the infantry should come into action. To this end the preparation preceding the barrage, which is generally directed on the first lines, will be reduced, the use of minenwerfers will suffice, bombardment of the strongly defended lines further to the rear will be prolonged, and should immediately precede the infantry attack. The rolling barrage

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should be less regular, and adapt itself to the ground and positions of resistance, against which a regular preparation should be undertaken. He recognized the difficulty of attaining this, but considered that it should be tried and signals arranged for : after 3 or 4 kilometres a barrage arranged by time-table was bound either to lift beyond, or delay the infantry, and beyond this distance should be carried out by batteries sent forward in good time. However, in spite of improvements in artillery attack, success will depend more than ever on the infantry. The soldier must realize that after he has reduced the first line he will have to fight hard for a distance of several kilometres, where his success will depend on the way he makes use of his own particular weapons, combined with good communication with the artillery and his own alertness.

III.-Conclusion.-Thus, in spite of much improved procedure, the Germans failed to shatter the Allied front. Among many reasons for this may be mentioned; (a) Their successive attacks followed at too long intervals, about a month, to prevent the Allies from reconstituting reserves. The cause of this was the necessity for moving the guns from one sector to another, and for re-organizing the attacking infantry. If the order had not been given to retain units in action until their offensive capacity was exhausted, it is possible that their reorganization would not have taken so long. (b) The rapidity in execution so much extolled by Ludendorff was still insufficient, and this was due to the German infantry losing faith in their success as attack succeeded attack, while at the same time discipline relaxed, and increasing the number of the regimental guns could not revive their waning morale. (c) Reserves, as has been shown above, were perhaps insufficient; a superiority of 30 to 35 divisions, or about one-fifth, was not enough to maintain the constant offensives and above all exploit their results. On the other hand, the reserves were not always employed judiciously. On 21st March Ludendorff threw all he had into the balance, while on 9th June he arrested the offensive when he had 40 infantry divisions in reserve under the Bavarian Crown Prince. However, the fresh divisions rapidly decreased in number. Lastly, the 2nd and 3rd line divisions were fatigued by numerous night marches and difficult ground before they became engaged. A means must be found for bringing reserves up at the critical moment as fresh physically as morally. Whatever the results may have been, there is no doubt that Ludendorff's instructions were most apt to the conditions obtaining at the time on the Western Front. They all agreed on putting into practice the great and ever-true principles of surprise, rapidity, and concentration of forces, while extracting the best results from new inventions. All his plans were based on the true notion of the preponderating part played by infantry in the battle. Fortunately the value of the German infantry decreased as its numbers fell, but Ludendorff, great tactician as he was, never realized the value of tanks and cavalry-two fatal errors for Germany.

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(To be continued.)









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