ROYAL ENGINEERS JOURNAL. SEPTEMBER. 1922. Pages 129—192.

THE ROYAL ENGINEERS JOURNAL.

Vol. XXXVI. No. 3. SEPTEMBER, 1922.

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MILITARY MINING.

ACHIEVEMENTS AND LIMITATIONS OF WIRELESS TELEGRAPHY.

A lecture delivered at the S.M.E., Chatham, on 5th January, 1922, by L. B. TURNER, ESQ., M.A., M.I.E.E., *Fellow and Lecturer of King's College, Cambridge.*

1. INTRODUCTION.

WHEN I was honoured by the invitation to deliver a lecture on wireless telegraphy to the S.M.E., I accepted rather light-heartedly; for I felt that this was a subject on which there was plenty to say, and that suitable material could be selected and arranged without much difficulty. Later, however, when I had to abandon this comfortable vagueness and get on with the job, I found it very difficult to select my subject more definitely. The relation of wireless telegraphy to military operations seemed appropriate; but of the tactical aspect I am not qualified to speak, and the technical aspect presents problems of detail design, rather than of general interest. If I were to devote my brief hour or so to any reasonably limited technical topic, I should be unintelligible to all except wireless experts. I have, therefore, gone boldly to the other extreme, and propose to range sketchily over the whole field of wireless as it is and may be.

Wireless telegraphy, like (say) organic chemistry, is such a specialized subject, with a jargon of its own, that unless a man makes it his special study he is very apt to ignore it altogether. It seems likely, therefore, that many of those present have very vague notions, not only of the quantitative relations, the exact science of wireless, but even of the nature of the processes of the art. In this belief my object is to paint for you some picture of these processes, necessarily in the crudest colours; dwelling a little on the outstanding practical problems and difficulties, so that we may come to some appreciation of what are the limitations obtaining to-day, and how far they may or may not reasonably be expected to vanish after further experience, invention and research.

2.—THE THREE PROCESSES OF WIRELESS TELEGRAPHIC SIGNALLING.

The act of signalling without wires involves the setting up at will of a disturbance at the transmitting station, the propagation of the effects of this disturbance to the receiving station far away and not connected by wire, and the perception of these effects at the receiving station. That is, it involves the three processes of transmitting, propagating and receiving. We will take them in this order.

3.—RADIATION.

It can be shown from familiar electrical principles that, wheneve the current in an electric circuit changes, the consequent disturbance of the æther of space causes energy to leave the circuit, and an æther pulse travels away with the velocity of light. If the current is constantly changing, as in any ordinary alternating current circuit, power is constantly radiated from the circuit. In any such ordinary circuits, and at such ordinary rates of change, *e.g.*, 50 to 100 periods per second, the radiation, though necessarily present, is quite insensible in amount; but by merely modifying the form of the circuit and by increasing the frequency of the current in it, we can augment its radiating properties, and, in fact, arrive at the wireless telegraph transmitter. It is a difference of quantity only, not of quality.

The form the circuit assumes is that of the familiar aerial, a giant condenser whose one " plate " is a network of wires (an economical substitute for a sheet of metal) carried on masts high above the earth's surface, which constitutes the other " plate." Between the two plates is some form of generator (G, *Fig.* 1), pumping an alternating current of very high frequency into the condenser, the frequency being usually between (say) ten thousand periods per second, approached in long-range fixed-station work, and ten million periods per second, approached in highly portable military apparatus.

An accepted (though, perhaps, inaccurate) formula for the power radiated from such a transmitting aerial of height h kilometres is :—

$$1 \cdot 8 \times 10^{-8}\, h^2 n^2 \mathscr{I}^2 \text{ watts}$$

where $\mathscr{I}$ is the alternating current in amperes, of frequency n periods per second, pumped into the aerial by the generator G. This expression shows the importance of making the aerial high and the frequency large.

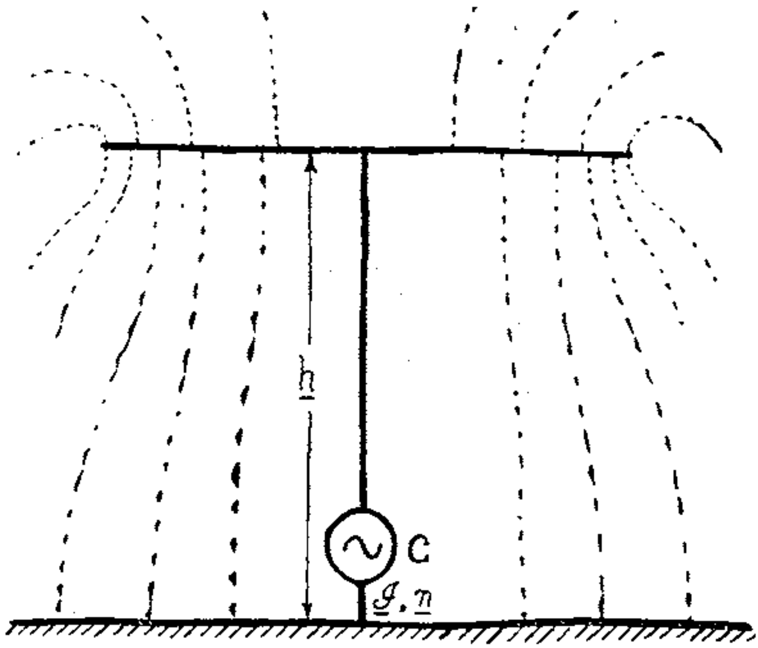
The wave motion set up in the surrounding æther by the alternating current in the aerial spreads out in all directions over the surface of the earth, with a speed of propagation approximately equal to that of light, *viz.*, 3×10^5 kilometres per second. Hence, if λ is the wave-length—the distance between neighbouring crests or troughs at any instant—we have the relation :—

$$\lambda n = 3 \times 10^5$$

allowing us to re-write the former expression in the form :—

$$1600\, \mathscr{I}^2 \left(\frac{h}{\lambda}\right)^2$$

This form shows us that for powerful radiation a large ratio $\frac{h}{\lambda}$ is wanted; or, for long waves, high aerials must be used.



POWER RADIATED (WATTS)

$$= 1{\cdot}8 \times 10^{-8}\, h^2 n^2 \mathcal{I}^2 \quad (\text{km., p.p.s., amps.})$$

$$= 1600\, \mathcal{I}^2 \left(\frac{h}{\lambda}\right)^2 \qquad \because \quad \lambda n = 3 \times 10^5$$

FIG. 1.

4.—PROPAGATION.

Let us postpone description of the generator G, and pass on at once to consider the propagation of the radiated energy over the surface of the globe. If the Earth were flat and a good conductor, and if the atmosphere were a good insulator throughout, the intensity of the radiated power at increasing distances d would be inversely proportional to d^2. But modern science has taught us that the Earth is not flat, and that the atmosphere is even quite a good conductor up in the rarer altitudes. Consequently, the rate of falling off of intensity is, in the event, more rapid than the d^2 law, and is expressible by some such formula as :—

Intensity of radiation at distance d kilometres

$$\propto \frac{1}{d^2\, \epsilon^{\frac{\cdot 003\, d}{\sqrt{\lambda}}}}.$$

If numerical values are attached to this formula, it will be found that at large distances d the rate of decrease becomes very rapid. Thus, for example, if the wave-length λ is four kilometres—a very ordinary wave-length, corresponding with a frequency of 75,000 periods per second—the following table shows the intensity at several distances between 10 and 10,000 kilometres, taking the intensity at 10 kilometres as unity.

Range d km.	Intensity of Radiation.
10	1
100	0·008,8
1,000	0·000,025
5,000	0·000,000,002,1
10,000	0·000,000,000,000,29

The table shows that in passing, say, from 1,000 to 10,000 kilometres, the power is reduced no less than about one hundred million times.

5.—WAVE-LENGTH COMPROMISE.

A closer inspection of this exponential function shows that in order to minimize the rate of fall of intensity with distance it is necessary to use great wave-lengths for great ranges. There is, therefore, a practical conflict between short waves to give good radiation at the transmitter (with any feasible or economical height of masts), and long waves to give good propagation between transmitter and receiver. The compromise will obviously lead to the adoption of longer waves for greater ranges.

The high-frequency generators hitherto used, moreover, have been such as to require longer waves—or, rather, lower frequencies—with increased powers; and this has constituted an independent reason for the adoption of long waves for great ranges. For these, and perhaps other, reasons, the evolution of the wireless telegraphy of to-day has, as a matter of history, involved a striking procession from short to longer waves. Hertz produced waves of some two metres; in Marconi's early experiments the wave-length was of the order of 20 metres, which had grown to some 200 metres when the first practically useful wireless telegraphy had been achieved; by the early days of trans-Atlantic signalling the advance had been carried to 2,000 metres; and to-day the Bordeaux station is transmitting regularly at over 20,000 metres; from 1887 to 1922 an increase in wave-length of ten thousand times. Whereas Hertz's achievement was the production of waves of frequencies invisibly low—for with electric waves of visible frequency all creatures with eyes are familiar—difficulties are experienced to-day because the frequencies employed tend to be—indeed, are—no longer even inaudibly high.

There is reason to suppose that this tendency to ever longer waves is receiving a check, and that the fashion will swing towards shorter waves. At the moment, the wave-lengths used for ranges of, say, 2,000 miles and upwards vary from about 6 kilometres (*e.g.*, at Clifden, Ireland) to 23 kilometres (Bordeaux): the frequencies corresponding to these wave-lengths are 50,000 and 13,000 periods per second; and the heights of the masts at the two stations named are about 200 ft. and 800 ft., respectively.

6.—High-Frequency Generators.

There are three chief methods of producing the high-frequency currents of powerful wireless telegraph transmitters. The first is that of the Poulsen arc, the principle of which is indicated in *Fig.* 2.

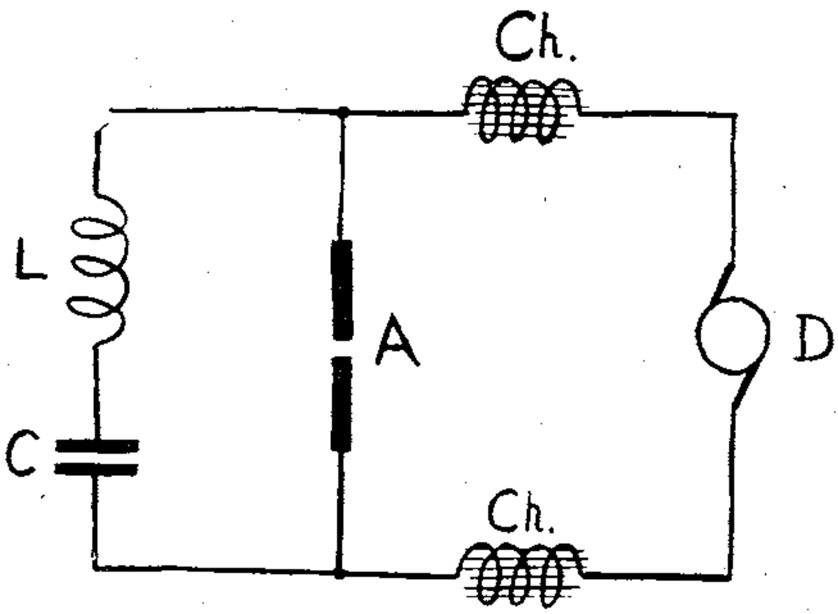


Fig. 2.

A is an arc, somewhat akin to an ordinary arc used for lighting purposes, fed with a current from the dynamo D, through the steadying chokes Ch. Across the arc is shunted an inductance L in series with a condenser C. With suitable relations between the electrical dimensions, an alternating current is set up and maintained in the circuit LCA. Its frequency is governed by the product of the sizes of L and C, and is approximately

$$n = \frac{1}{2\pi\sqrt{LC}}.$$

This alternating current is used for exciting the transmitting aerial.

This is the old singing arc phenomenon of Duddell, with modifications of the arc introduced by Poulsen to make it work at very

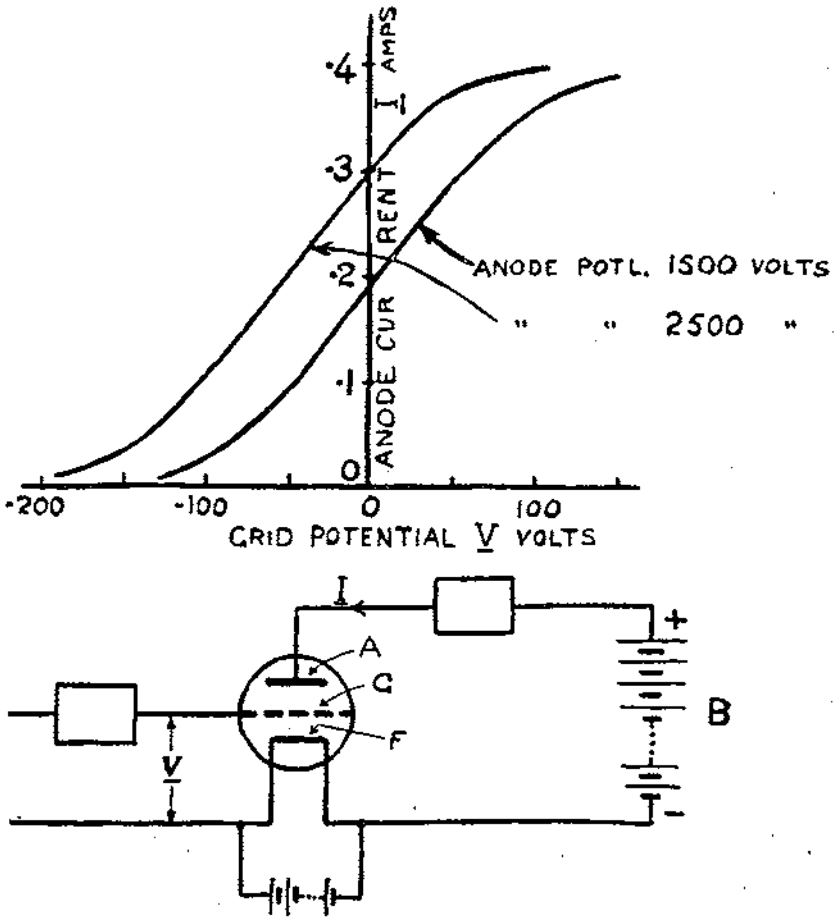

·4
·3
·2
·1
0
ANODE CURRENT I AMPS
ANODE POTL. 1500 VOLTS
" " 2500 "
-200
-100
0
100
GRID POTENTIAL V VOLTS
I
A
G
F
V
B
+
-

Fig. 7.

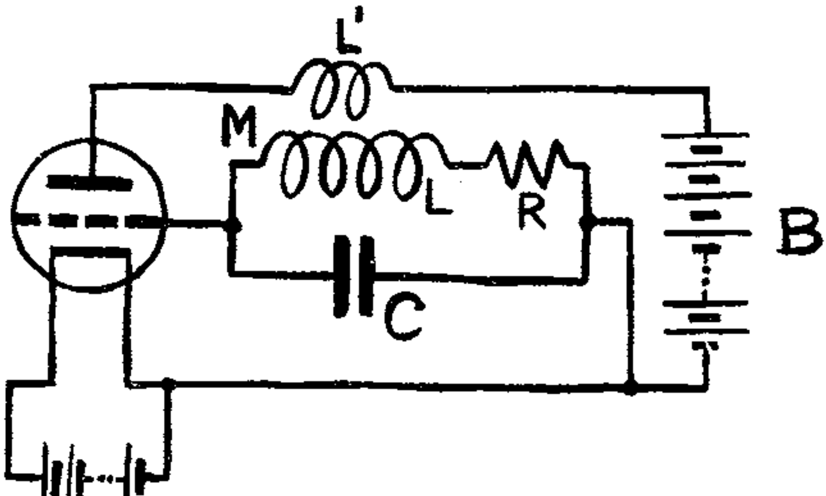

L'
M
L
R
C
B

Fig. 8.

high frequencies. These modifications include the provision of a hydrogenous atmosphere around the arc, and a powerful magnetic field across it. *Fig.* 3 is a photograph of an enormous arc of thi character, that used at Bordeaux station, capable of dealing with an input of 1,000 kilowatts. The hydrogenous atmosphere is obtained by feeding into the arc chamber either hydrogen itself, or coal gas, or drops of methylated spirit and petrol. *Fig.* 4 is a view of the other side of a similar rather smaller arc.

The second method of generating the high-frequency current is that of the familiar electro-mechanical alternator. This method is not, strangely enough, merely the wild dream of an over-worked designer of 50-cycle machines, dementedly setting himself the nightmare task of multiplying his accustomed frequency a thousand times; it is the fine accomplishment of bold engineering design and construction, successfully and variously undertaken in America, in Germany, and in France. *Fig.* 5 is an example of such an alternator (the Alexanderson alternator at New Brunswick), a machine capable of an output of 200 kilowatts at a frequency of 22,000 periods per second.

Thirdly, there is the newest method of generating high-frequency currents, that of the thermionic triode oscillator—the "valve"—destined, in the opinion of some, to replace all other methods. I can only attempt to sketch the action of the triode in the very scantiest manner here; but I must not omit that, for the triode is a device which is already responsible for magnificent developments in wireless telegraphy and telephony, and in wire telephony, and is destined to render aid in a great variety of technical processes and scientific investigations,

Fig. 6 is a photograph of a transmitting triode. It consists of a vacuous glass bulb containing a central filament of tungsten (as in an ordinary electric lamp), surrounded by a cylindrical wire "grid," which is itself surrounded by an outer metal cylinder, the "anode." These parts are indicated diagrammatically in *Fig.* 7 as F, G, and A, respectively. When the filament is made white hot, electrons—*i.e.*, atoms of electricity, constituents of all forms of matter—escape from it into the vacuous space; the electricity may properly be said to be boiled out of the filament. Under the action of the battery, B, some of these electrons pass through the interstices of the grid, G, and reach the anode, A, so constituting a current of electricity traversing the vacuous space in the battery–anode–filament circuit. Now the magnitude of this current I is very much influenced by the potential V of the grid, as is shown by the curves in *Fig.* 7. The grid, therefore, acts as a sort of tap, which may be turned on and off extremely quickly, for the only moving parts in the whole system are the tiny electrons travelling across the vacuum with speeds approaching that of light.

This thermionic instrument will perform all sorts of services with astonishing elegance and ease, and one of these services is the generation of high-frequency currents with which we are at the moment concerned. A general idea of how this is achieved may be had by reference to *Fig.* 8, which shows one way of introducing the necessary retroaction or back-coupling between the grid and anode circuits.

Imagine that, by any means, the LCR circuit has been disturbed and so set oscillating with its natural frequency

$$n=\frac{1}{2\pi\sqrt{LC}}.$$

The fluctuation of grid potential thus caused produces a fluctuation of the anode current, and this current, flowing through Coil L^1 impresses an alternating E.M.F. in coil L owing to the mutual inductance M between the two coils. Under suitable conditions this E.M.F. suffices to introduce into the LCR circuit from the battery B enough (or more than enough) energy to make up for the loss taking place in the unavoidable resistance R. The grid and anode may be described as working upon each other according to a scheme of "tit-for-tat" in which quiescence is never reached because the tat is never weaker than the tit which evoked it. In other words, any incipient oscillation in the LCR circuit is augmented or maintained. This high-frequency alternating current is available for exciting our aerial, and needs but to be turned on and off by a Morse key to constitute a wireless transmitter.

The triode method is already very widely used for small powers—up to, say, 5 or 10 kilowatts input, but particularly for much smaller powers—and is likely soon to be applied in large sizes. *Fig.* 8*a* is a photograph of what is probably the largest triode transmitter yet constructed (the Marconi experimental set at the Canarvon station). There is here a panel of 48 triodes, each rather larger than that of *Fig.* 6; and the input from the high-tension source B may be 100 kilowatts or so at some 10,000 volts.

7.—RECEPTION.

So much for the transmission of the signal. Let us turn now to the process of perceiving the feeble æther waves which reach the receiving station whenever the operator at the distant transmitter depresses his Morse key.

For perceiving *very* high-frequency æther waves, those of light, man has evolved an extraordinarily fine type of receiving station which he builds all complete in his own head—his eyes. Our eyes, however, are not sensitive to frequencies below about ten million million periods per second; so that for perceiving the much longer æther waves of wireless telegraphy, we have to construct extraneous receiving apparatus on a larger scale. The function of this apparatus is to make the æther waves declare themselves in some way to which our sense organs—eyes or ears or others—are sensitive.

While the key at the transmitting station is down, we have a very tiny alternating potential gradient in space at the receiving station (and everywhere else)—perhaps a small fraction of a microvolt per centimetre of height. We therefore set up a receiving aerial, and tune it to the transmitter frequency so as to obtain in it as large a sympathetic alternating current as possible. It is this tiny high-frequency current which must be rendered perceptible to the receiving operator. I take the common case when perception is to be by the operator's ear held against a telephone receiver. If the aerial current were made to pass through the telephone, nothing would be heard, neither telephone nor human ear being sensitive for frequencies above a few thousand periods per second. We therefore "rectify" the alternating current before passing it into the telephone, as indicated in *Fig.* 9. The alternating

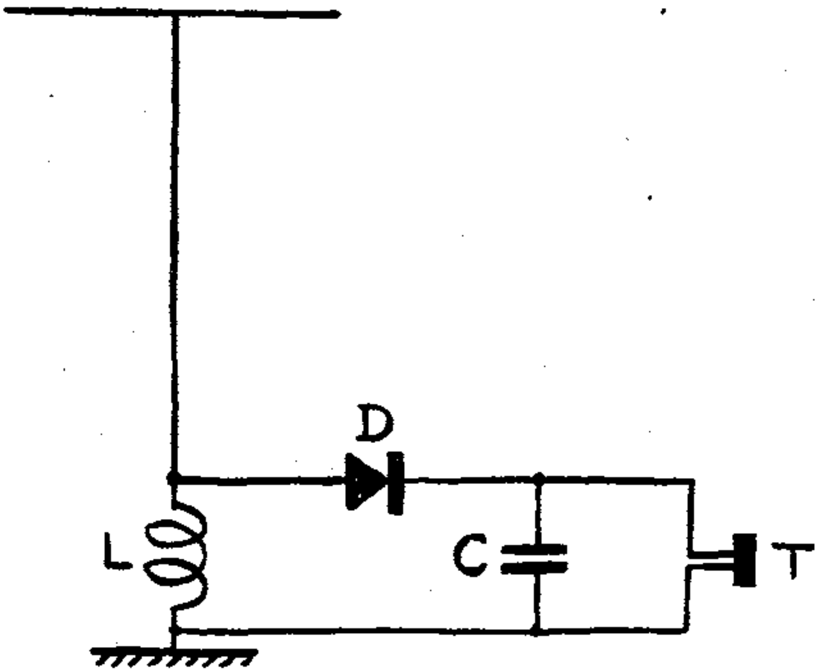


FIG. 9.

current in the aerial produces an alternating P.D. across the coil L, which P.D. is applied to the "detector" D *via* the condenser C. A "detector" is the (unsatisfactory) name for a rectifier, or asymmetric conductor, which allows current to pass more freely through it in one direction than the other. The condenser C therefore accumulates a charge, and a unidirectional current flows from it through the telephone, T. The form of the detector I will not discuss, except to mention that here again the thermionic tube is utilized.

The signal will thus produce a steady, and therefore still inaudible, current in the telephone ; whereas we want a current varying at some suitable acoustic rate. This is effected by mixing with the incoming signal of high-frequency n_1, say, a locally produced signal of slightly different frequency n_2, say ; so that we have a beat effect, a slow fluctuation of resultant amplitude as when two nearly-equal musical tones are sounded together. The rectified telephone current is then no longer steady, but fluctuates in amplitude at the beat frequency $(n_1—n_2)$. By adjusting n_2, the frequency of the local oscillator, the operator makes the beat frequency assume some convenient value, such as 1,000 periods per second. Then, while the transmitting-key is down, he hears a shrill musical note, and when it is up, nothing.

8.—INTERFERENCE.

Our wireless telegraph system is now complete, and by the short and long signals of the Morse Code, the transmitting operator can signal to the receiving operator, *if* :—

(*a*) the received signals are intrinsically strong enough to be audible ; and

(*b*) they are not drowned by undesired interfering signals.

These are big *ifs* ; or, at least, they both were until the advent of the modern triode amplifier made the importance of (*a*) vanishingly small compared with that of (*b*).

We have seen how in the triode the control over the anode circuit exercised by the grid potential may be made to produce oscillation ; and the adaptation of this control to give amplification effects is probably fairly obvious. As a fact, it is now ordinary easy practice to amplify an extremely feeble signal by passing it through the successive triodes of a multi-stage amplifier so that enormous amplifications are obtained ; and a signal, however weak at the input end of the amplifier, may be made of perceptible strength at the output end. *Fig.* 10 is a photograph of a well-known pattern of receiving triode used for such operations. It differs substantially only in scale from the transmitting triode of *Fig.* 6. Such triodes are used in large groups ; and it is clear that, if in each triode an amplification of the signal E.M.F. of, say, four times were obtained, a chain of, say, five triodes would give an amplification $4^5 = 1,000$ times—or, in terms of power, an amplification of $1,000^2 =$ one million times. *Fig.* 11 shows a 7-triode amplifier (Marconi Co.), with triodes of a different external appearance.

I may remark in passing that the use of these powerful amplifiers enables us to dispense with expensive and inconvenient large receiving aerials, a small aerial plus amplifier serving as well as a large aerial without amplifier.

The difficulty, therefore, is no longer to make the signal strong enough to be perceptible, but to make it strong enough without at the same time making the disturbances strong enough to drown the signal. It is the second *if* which places the limit on wireless achievement to-day, and it is mainly in improvements in means of filtering signal from disturbances that any sensational advance is to be expected.

Of what, then, do these disturbances consist? They may be classified under two heads :—

(*a*) Signals from other wireless stations ;
(*b*) Atmospherics or natural electric disturbances.

9.—Interference from other Stations.

As regards interference from other transmitting stations of the sort I have described, *i.e.*, "continuous wave" stations, sufficient protection is fairly easily got by the mere tuning or resonance properties of the receiving circuit. A lightly-damped oscillator, mechanical or electrical, responds very sensitively to slight amounts of mistuning of the rhythmic stimulus acting on it. This is illustrated quantitatively in a numerical case in *Fig.* 12, where the ordinates of the curve show the amplitude of the oscillation for various small amounts of distuning. It is seen that 1 per cent. of distuning here makes the response of the oscillator drop to about one-sixth of its tuned value. Much finer tunings, *i.e.*, more sharply peaked resonance curves, are easily obtained with electrical oscillatory circuits—dependent yet again upon the triode.

In order to enhance the selective property of the receiver, the simple receiving circuit of *Fig.* 9 is, in practice, complicated by the insertion of other tuned circuits, in the nature of successive filters, after the fashion of *Fig.* 13.

An interesting fact, of growing practical importance, is that the very process of keying a transmitter may cause more unwanted disturbing energy to be delivered to nearby receiving stations than if the key were held down continuously. That turning the transmitter *off* itself causes disturbance is a true—if at first sight somewhat paradoxical—statement, only to be explained properly in terms of a differential equation. This aggravation of the disturbance from other transmitting stations becomes more and more serious as speeds of keying are increased from the ordinary hand speeds of 10 or 20 words per minute to the automatic speeds of 100 words per minute and upwards now being demanded and, indeed, provided.

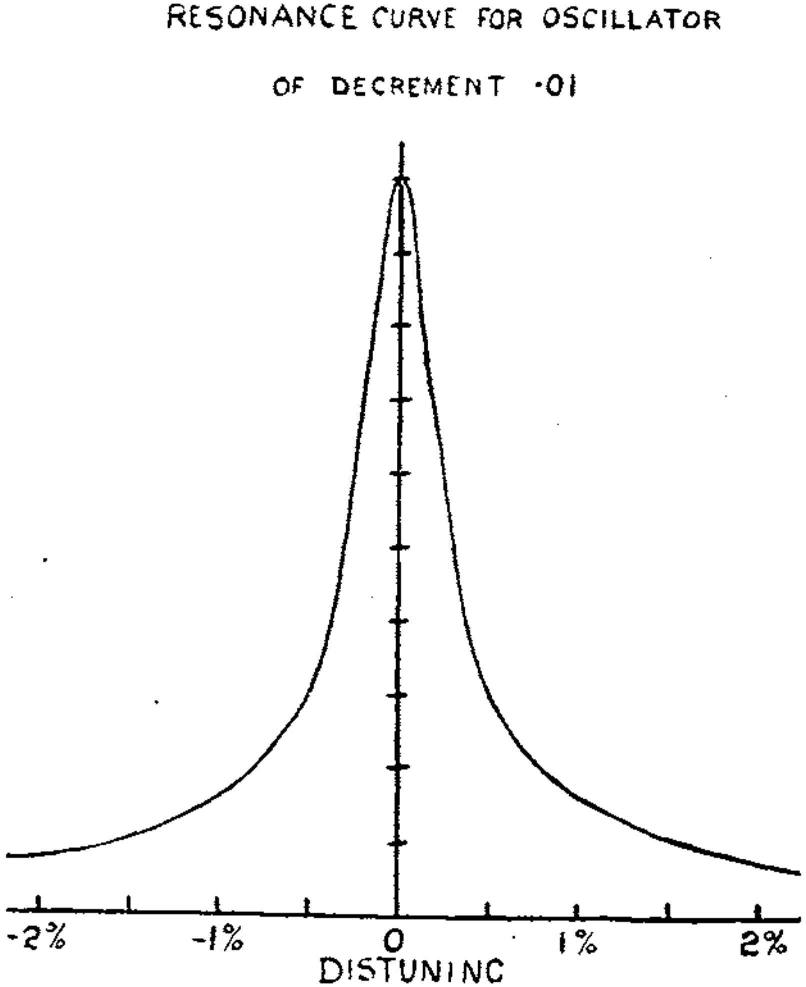

RESONANCE CURVE FOR OSCILLATOR
OF DECREMENT ·01
-2%
-1%
0
1%
2%
DISTUNING

Fig. 12.

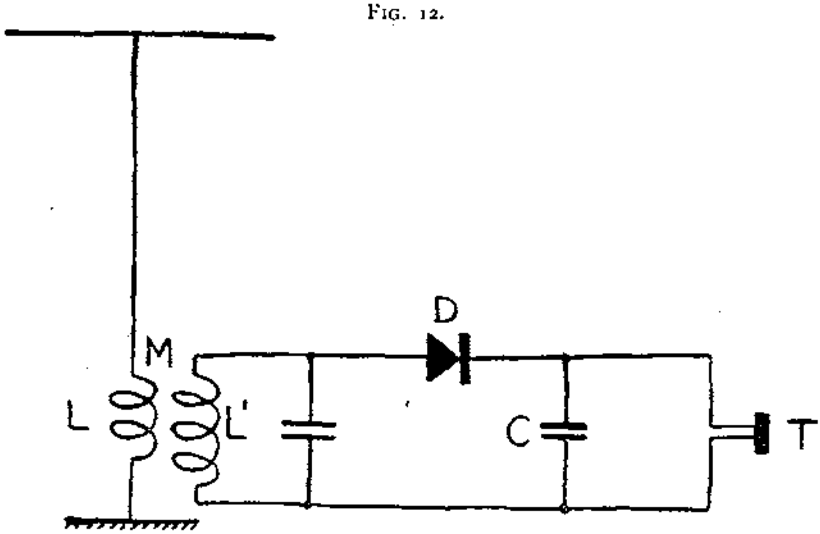

D
M
L
L'
C
T

Fig. 13.

10.—Atmospherics.

We turn now to disturbances of the second class, atmospherics. Just as any change of current in a circuit causes radiation, so any natural electrical disturbance in the earth or the atmosphere sets up a pulse which travels away and is competent, if strong enough, to affect receiving stations. The physics of the origins of these disturbances is very obscure; but, whatever the cause, they occur in some places with such violence and rapidity as to make wireless telegraphy, with apparatus hitherto used, quite impracticable during bad periods, which may last many hours per day on many days of the year.

It is probable that atmospherics arrive at the receiving aerial in great variety, but that they all give something in the nature of a violent shock to the receiving circuits and set them oscillating with their own natural frequencies. The one thing that the atmospheric clearly cannot be is a long-sustained isochronous periodic stimulus like that due to the transmitting station with key held down; so that it might seem that it must be possible to filter signal from atmospheric by resonance effects. The trouble is, however, that the signal must not itself be regarded as a sustained isochronous periodic stimulus. It must have a beginning and an end for each Morse dot and dash, and the transition periods with the long waves and high speeds of present endeavour have encroached until the whole Morse dot is nothing but a rise and a fall with no sensibly steady state in between. It is, therefore, not possible, even for the theoretician with paper and pencil in his study, to do more than *reduce* the disturbance by mere methods of fine tuning in the various ingenious elaborations which have fired and disappointed so many inventors.

11.—Method of Reducing Atmospheric Interference.

Beside tuning methods mainly relied upon hitherto, there are other lines of defence against atmospherics, which we may class as :—

(*a*) Atmospheric balancing;
(*b*) Atmospheric limiting;
(*c*) Directive reception.

All these methods involve in practice a weakening of the signal; but, with the modern amplifier, any device is welcome, although it enfeebles the signal, provided only that it enfeebles the atmospheric still more.

12.—Atmospheric Balancing.

Hitherto in this lecture, in conformity with all wireless practice until quite recently, we have contemplated receiving circuits precisely tuned to the incoming signal. Very interesting effects can, however, be obtained with combinations of distuned circuits.

If I take two pendulums of precisely equal natural frequencies, and act equally upon each with a blow or a periodic force of any frequency, they are both set in motion exactly alike. If we imagine the two motions to be combined in such a way that the resultant is the difference of the two, we have an *in*-sensitive system. The two pendulums are to be thought of as two aerials, A_1, A_2 (*Fig.* 14), the resultant or combination effect being taken to the receiving apparatus R. Simultaneous equal currents in A_1 and A_2 produce no effect in R.

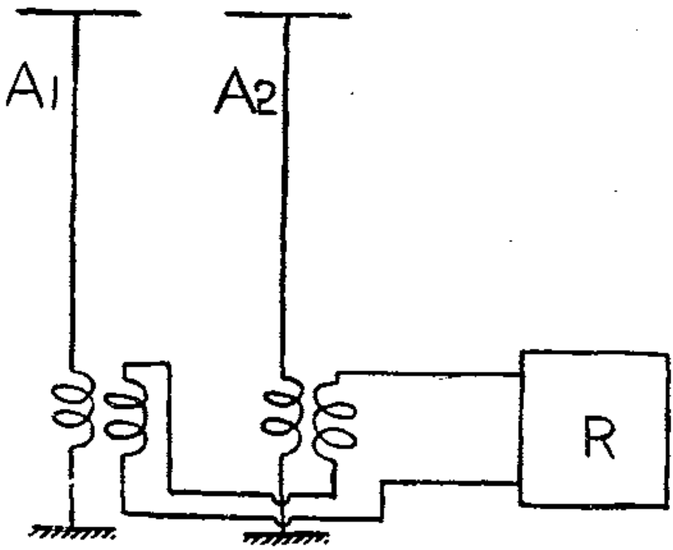


FIG. 14.

But if I distune the two pendulums a little in opposite directions (by shortening and lengthening them respectively), and act upon them with a rhythmic force of their former common frequency, both pendulums are set in motion, but now with a phase difference; one swings to the right while the other is swinging to the left. Our aerial combination is then sensitive to the rhythmic impulse, the incoming signal. If I apply a blow or shock, instead of the rhythmic force, to the pendulums (representing an atmospheric arriving at the aerials) both are jerked into motion, but *in* phase. Appreciable phase difference develops only later, when the motion has been to some extent damped down. The receiving circuit is thus protected from the early violent onslaught of the atmospheric, because in the initial stages the atmospheric balances out in the combining circuit. This anti-atmospheric device is of special interest in that it does not demand the use of circuits whose damping is small.

13.—Atmospheric Limiting.

The reason for the incomplete success of resonance methods is that the atmospheric forces an ingress by sheer violence despite its handicap in not being tuned to the receiving system. If we could insert between the aerial and the ordinary selective receiving circuits some limiting device whose output could not exceed a certain limited amount, however great the input—like a slipping belt or a friction-clutch in mechanics—we could destroy the overpowering strength superiority of the atmospheric, and so exclude it in the subsequent filtering process.

This method—of course, not so easy to practise as to preach in these simple terms—is, in my opinion, of great promise. Here again it is to the invaluable thermionic triode to which we turn for an appropriate limiting instrument.

14.—Directive Reception.

Directive wireless receivers came into great prominence during the War, where they were largely used for locating enemy transmitting stations—for example, those on raiding airships. They depend on the use of a receiving aerial system which can be made *in*-sensitive to waves arriving from any particular direction, variable by the operator. The use of such a receiver gives protection against atmospherics, provided that the direction of the atmospherics is well defined and does not coincide with that of the desired signals.

Many forms of directive receiver are possible and practicable, the characteristic feature of them all being the use of two or more aerials spaced an appreciable distance apart. The spacing of the aerials A_1, A_2 in the plan view of *Fig.* 15 involves a phase difference

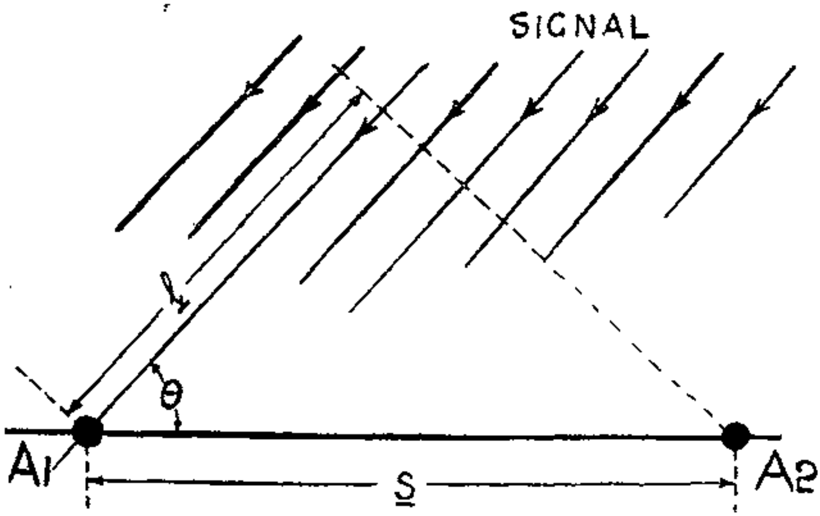


Fig. 15.

of the E.M.F. impressed in them by the arriving signal, the difference varying according to the length l, from a maximum for the direction containing the aerials to zero for the perpendicular direction. Thus, if the two aerials are both tuned to the signal, the polar curve connecting sensitivity with direction of signal is a figure-of-eight as in *Fig.* 16. The length of the intercept r measures the sensitivity to a ray in the direction θ. There are here two blind directions, NO and N'O.

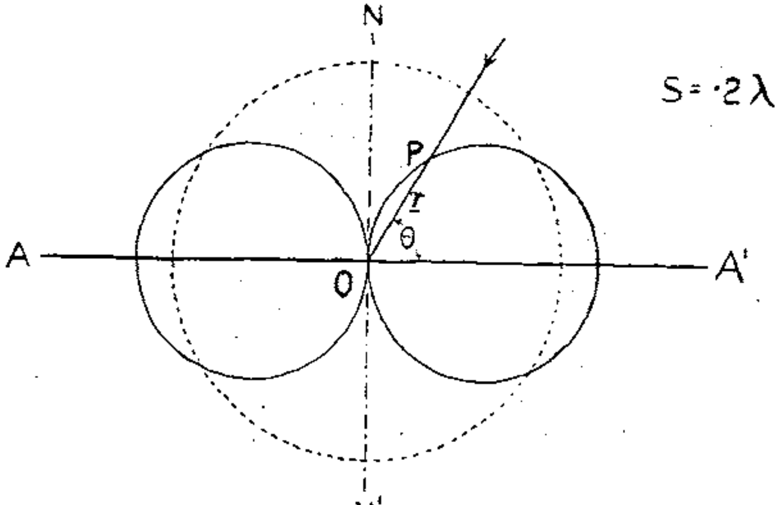


FIG. 16.

By distuning the aerials from the incoming wave we can make the resultant signal vanish for pairs of directions movable at will, obtaining sensitivity curves of the form of *Fig.* 17, where the two blind directions are ± 30°.

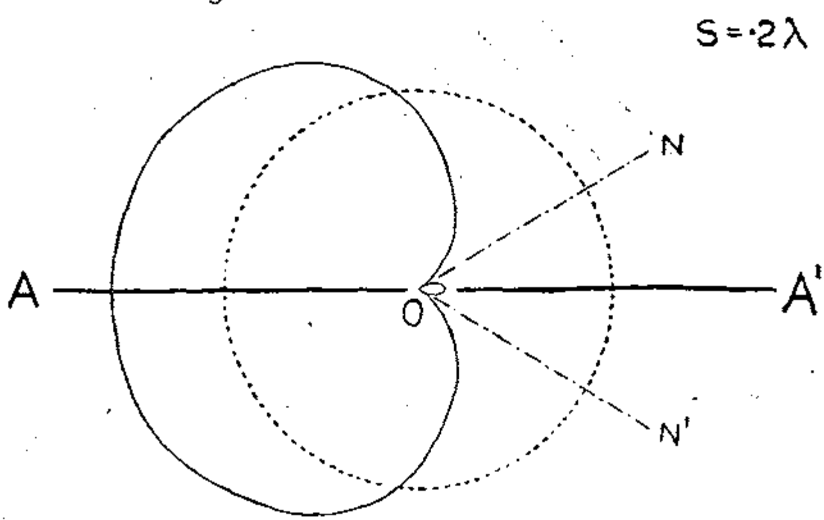


FIG. 17.

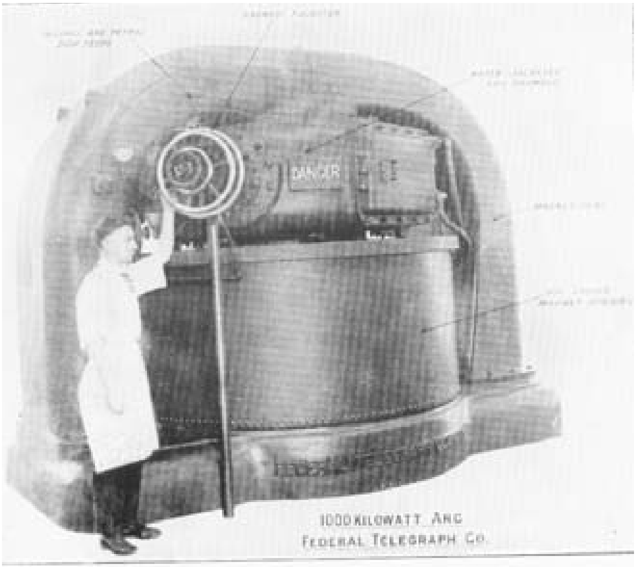


FIG. 3.

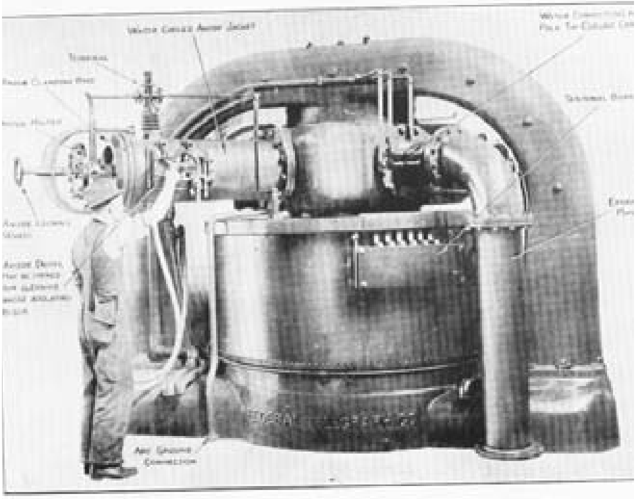


FIG. 4.

TELEGRAPH

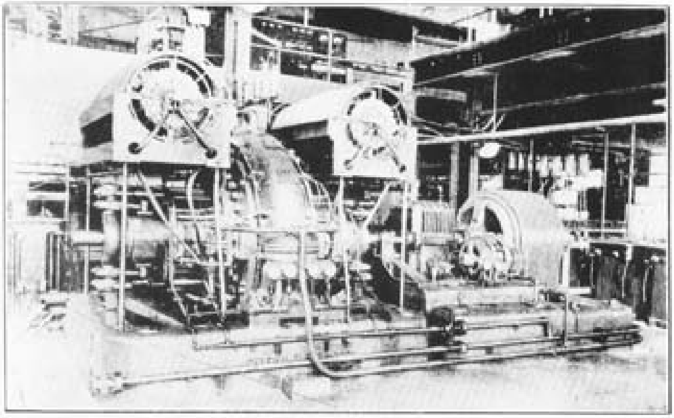


Fig. 5.

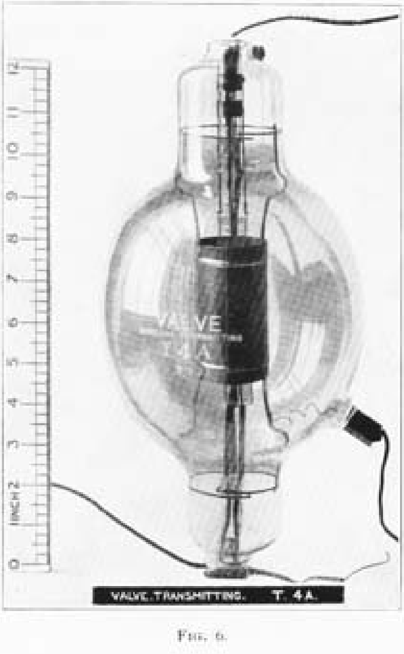


Fig. 6.

VALVE TRANSMITTING

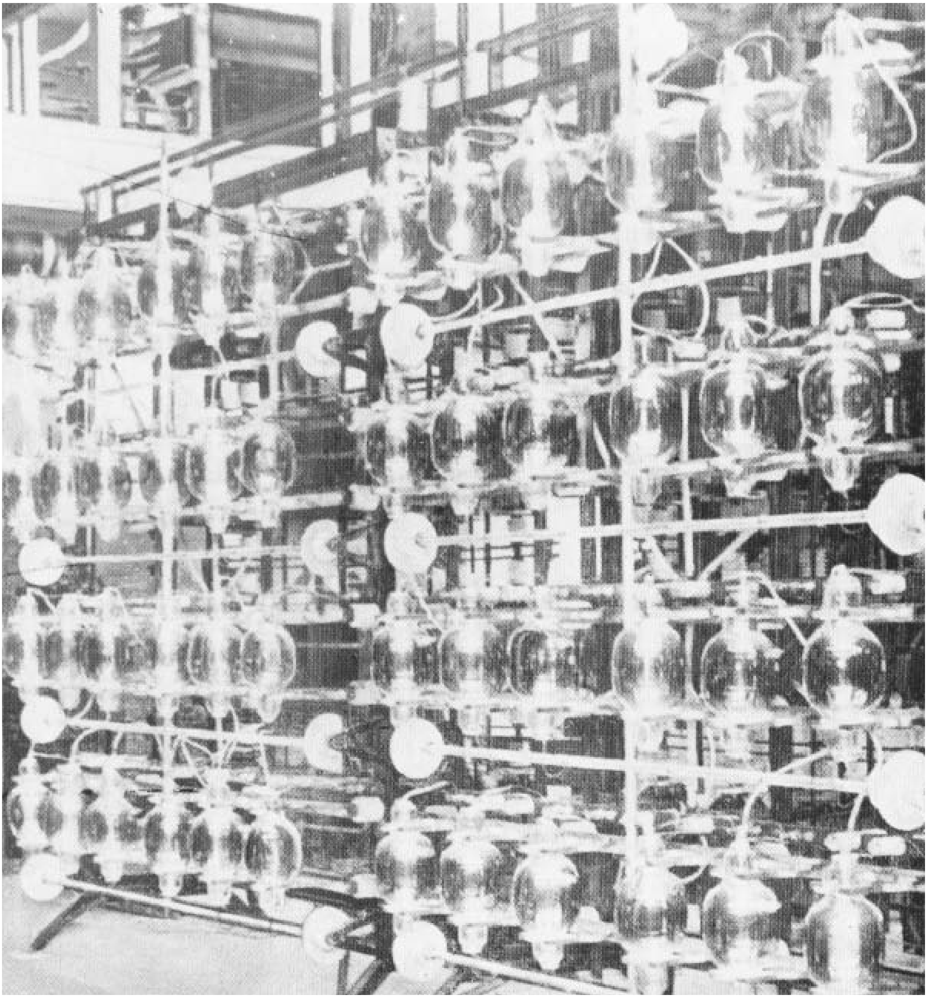


FIG 8A

Fig. 10

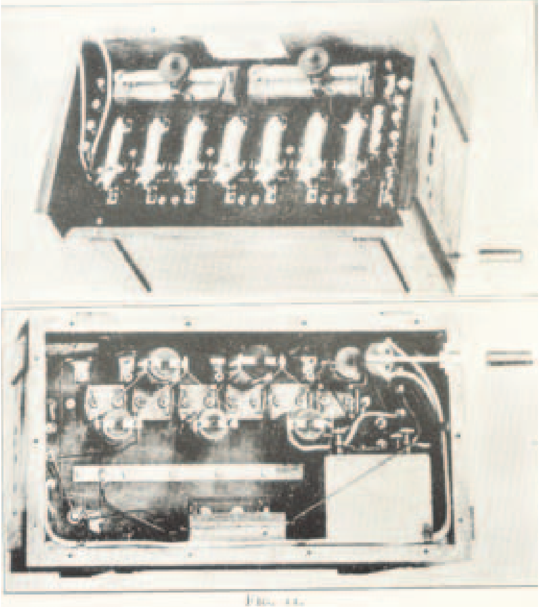


Fig. 11.

CONNECTION PINS

15.—Conclusion.

Despite all these efforts at combating disturbance at the receiver, success has hitherto been very incomplete; and in tropical climates at least the atmospherics problem dominates the situation. I do not wish to seem gloomy, but probably any competent wireless engineer, unless in the throes of that well-known derangement, inventor's optimism, would agree that anything approaching complete protection against atmospherics is not likely to be reached in his day or generation. For atmospherics when they are bad are very, very bad; and to halve the number of unworkable hours during the year might require an improvement in protection, not twice, but perhaps a hundredfold.

An aggravation of the difficulty due to atmospheric disturbance is the other propagation phenomenon, the fading of signal strength, sometimes very apparent over long ranges. The opacity of the space between the two stations becomes at times much greater than normal, a phenomenon probably as incalculable and as unalterable as other meteorological conditions. The converse phenomenon, of exceptionally good propagation, is also well known, when fresh ranges are obtained, a small station being heard perhaps near its antipodes. The incomplete reports of such exceptional successes have been very misleading to the layman.

The directive effects obtainable, as we have seen, at the receiver can also, if economically desirable, be produced by corresponding devices at the transmitter; but whether the heterogeneous distribution of the radiation near the transmitter is retained at large distances is highly doubtful. In any case, it is to be noted that the directiveness hitherto obtained in wireless telegraphy is of a different order from the directiveness of, say, a telescope or a searchlight. A telescope is wholly insensitive to sources of light lying outside a certain cone; but the wireless receiver of, say, *Figs.* 16 or 17 is sensitive (though not equally sensitive) to disturbance from any quarter. A return to the concentrated beam technique of Hertz, practicable only with very short waves, may prove useful over short ranges, but does not appear feasible for long distances.

The Morse code, whose units are the simple on and off for long and short periods, may be likened to the key of a cheap lock with only a single ward. It is obvious that a more complicated code might be devised analogous to a good lock of many wards, which would not be forceable by the burglar atmospheric. But here, once more, speed of signalling is a fearsome barrier.

The favourite and undeniably fruitful method of getting signals through over greater distances and with fewer interruptions is to increase the radiation at the transmitter. Great advances have been made in this direction; but the economic is here a controlling factor;

and, of course, the minor interference problem—interference from other stations—assumes a growing importance with enlargements at the transmitter.

The later portions of this paper may have, I fear, a rather pessimistic appearance; for I have dwelt upon the fact that the interference problem is a very tough one and still remains to be solved. But I am far from wishing to belittle the overwhelming advances in wireless achievement of the last few years, although I have given them small explicit mention here. They are such as to fill one with enthusiasm; and he would be a rash prophet who ventured to predict that obstacles at present apparently insuperable will never be surmounted or circumvented.

References to certain illustrative experiments carried out by the lecturer with pendulum models are here omitted.

UMPIRING WITH ENGINEERS.

By MAJOR P. G. H. HOGG, D.S.O., R.E.

THE *Training and Manœuvre Regulations* (1913) has a chapter on "Umpiring," in which three sections give special points with regard to umpiring with Cavalry, Artillery and the Air Force; there is, however, no section dealing specially with umpiring with Engineers.

As Staff Officer to the Chief Umpire, Experimental Brigade, Aldershot Command (Major-General C. Corkran, C.B., C.M.G.), I was asked to draw up some notes on the subject. Colonel-Commandant R. N. Harvey, C.B., C.M.G., D.S.O., A.D.C., Chief Engineer, Aldershot Command, kindly looked through these notes and made some very helpful suggestions.

The notes are here given in their final form, as approved by the Chief Umpire and issued to Umpires, in case they may be of use to any officers having to carry out umpiring duties.

SPECIAL POINTS WITH REGARD TO UMPIRING WITH ENGINEERS.

1.—The work of an Umpire with Engineers calls for even a more vivid imagination than with other arms. Cavalry, Artillery and Infantry can move about, use blank ammunition and thus make a semblance of War; but Engineers, in peace, as in war, can do little without the expenditure of time and material; and, as there is seldom the requisite time and never a sufficient grant to carry out any but the simplest jobs on manœuvres, most works have to be left to the imagination. Thus the work of an Umpire with Engineers on manœuvres will usually consist in judging on the efficiency of execution of certain works which, owing to manœuvre conditions, cannot be carried out practically.

2.—The following list gives an idea of some of the works that might be required in war, divided among the various phases of operations, and which will have to be imagined in manœuvres :—

In Advance.—Engineer Reconaissance. Repair or construction of bridges from materials obtained locally, either by the demolition of barns and houses or by the felling of trees. Making deviations for tanks round unsafe bridges. The clearing of roads which may have been blocked (*a*) by mine craters; (*b*) by overhead bridges being blown down; (*c*) by felled trees.

The Attack or immediate preparation therefor.—Engineer reconnaissance. Making of gaps in hedges, railings, walls or fences. General preparations for any eventuality, *e.g.*, (*a*) success; (*b*) defeat; (*c*) a return to the situation in *statu quo*. Camouflage.

The Pursuit.—Similar to the advance, but the works will necessarily be of a more hasty nature.

The Retreat.—Demolition of bridges. Blocking roads by mining or tree-felling. The putting of buildings into a state of defence. Destruction of railway tracks. Destruction of water supply.

3.—The question of Engineer reconnaissance should receive the careful attention of an umpire. A Field Company of Engineers carries a limited quantity of tools, but practically no stores, except explosives; in order, therefore, to carry out works in the field, Engineers are largely dependent for materials on the resources of the country in which they are operating. The only way to get information regarding these resources is by sending out small reconnaissance parties who must visit outlying farms and hamlets, find out what tools and materials are available and send in written reports to their C.O. In any cases affecting such reconnaissances, umpires should make a point of asking to see the reports in order to satisfy themselves that, not only has the reconnaissance been carried out, but that it could have been made out under war conditions.

It should be remembered that, with the exception of the officers, the personnel of a Field Company is dismounted and that the C.O., in order to send out parties to any distance, has not available more than one motor-cycle and 18 bicycles (*vide* Appendix Z, to accompany C.R.A.C. 2/83692/4 (G) dated 25. 4. 1922). Umpires must use their judgment as to the number of reconnaissance parties that can be sent out, the distance to which they could go and the time they must necessarily take.

4.—When the demolition of a bridge comes in as part of a rear-guard scheme, the umpire must be careful to ascertain that the responsibility for giving the actual order for firing the demolition charge has been delegated to some officer by name (see *Engineer Training*, 1922, Section 57, para. 6).

5.—In the case of the demolition of simple steel girder bridges, where gun-cotton slabs can be fixed to the girders without any structural damage to the bridge, such work should always be carried out practically, substituting dummy primers and detonators for the service article.

6.—In other cases the umpire must make use of Appendix F, *Training and Manœuvre Regulations* (1913), and will take great care before signing it that it represents a true statement of affairs; he must be certain that the necessary orders have been given and calculations made, that the working party, as stated, was present during the time mentioned and actually had all the requisite tools in its possession during that time (see *Training and Manœuvre Regulations* [1913], Section 71, paras. 4 and 5).

7.—The *Manual of Field Works* (All Arms), 1921, will assist an umpire in coming to a correct decision.

PROFESSIONAL NOTE.

A RIVER-CROSSING SCHEME.

A Senior Officers' Class, for officers of all arms was held at the School of Military Engineering from 10th to 15th July; the last class of this nature having been held in 1914. One of the outdoor exercises was a scheme for forcing a passage across the Medway between Aylesford and Snodland. This proved to be a problem of a particularly interesting nature, illustrating the difficulties to be overcome in securing co-ordination between engineers and infantry in such a case. It is thought that its publication would be of general interest, so the details of the scheme are given below.

The subsequent discussion brought out several points illustrating special difficulties. One was a technical difficulty. With a 13 ft. difference of level between high and low tide, and a considerable stretch of mud on both sides of the water at low tide, would it be possible to devise and construct, within two or three hours of zero, a light bridge for wheeled transport which could be used at all states of the tide?

Some of the syndicates (all of which included R.E. officers) were in favour of trying it by means of a high trestle-bridge (lots of long timbers being handy), but the majority opinion was that it would take too long and that the interruption of traffic for two hours before and after low tide must be accepted until a second bridge for low levels could be constructed. The adoption of a pontoon, capable of sustaining its load when grounded, would meet such a difficulty as this.

Another question was one of organization. The question was asked: Assuming that the footbridges were made up under cover at some 400 yards' distance from the river-bank, who should be made responsible for the operation of carrying them to the crossing-places and launching them—the officer commanding the infantry battalion concerned, or the commander of the engineer section?

Some of the officers advocated the responsibility being laid on the commander of the engineers, on the grounds that the operations would be of a technical character beyond the competence of the infantry commander. These proposed that the infantry parties required to assist in carrying the bridges should be attached to the engineers, and put under the command of the commander of the latter, and that the officer commanding the infantry should stand aside from the operation until the bridges were reported to be in position, when he would order his men to cross them.

Others were of opinion that the operation of carrying the made-up footbridge, launching it and passing over it were a tactical operation, with very little that is technical in it. They considered that the officer commanding the infantry should be responsible for the two bridges required by his battalion and that the necessary engineers for manning the leading bays of bridge, guying it while launching, etc., and repairing damages, should be placed under his orders. In favour of this course it was pointed out that only one section of engineers would probably be available to each battalion, that at the best its commander would be a subaltern and that it frequently happens from various causes that a section is commanded by a serjeant or even a corporal, that each section would have two bridges to deal with, so that at one—if not both of the crossing-places—the engineer commander would be a junior N.C.O. By putting the operation under the infantry commander it could be ensured that officers of some experience and seniority would be in charge at each bridge-crossing. Previous reconnaissance by the infantry officers concerned and explanations from the R.E. would enable them to understand what they had to do. Previous rehearsal of the operation in a rear area would be advisable.

This point elicited an interesting discussion, the majority (but not the whole) of the infantry officers present being in favour of the first of the two courses described above.

ATTACK SCHEME.

(River Crossing.)

Reference 1 *in. O.S. Map Sheet* 116.

Narrative.—A Westland force, based on London, having been forced to withdraw from a defensive position in the neighbourhood of Sittingbourne has retired west of the Medway.

On the evening of the 12th July the Eastland force, of which the 3rd Division forms a part, has reached the line Chatham–Maidstone.

Information has been received that all the bridges across the Medway from Chatham–Maidstone (both inclusive) have been destroyed and that Westland intends to make a stand west of the river.

During the 13th July, by minor engagements, the whole ground east of the river is cleared of the enemy's posts, and the G.O.C., Eastland Force, determines to attack the enemy's position west of the river on the early morning of the 18th July.

Boundaries of the 3rd Division are as follows :—

North.—Burham–Snodland–Paddlesworth (all exclusive).

South.—Lower Bell Inn–Aylesford–Cobdown–Main Sevenoaks Road (all inclusive).

First Objective.—Line of railway from Snodland–New Hythe–Borough Court–Cobdown.

Second Objective.—Rookery Farm–Lunsford–Larkfield.

Attack to be on a two-brigade front. Dividing line: Eccles–New Hythe–Lunsford (all inclusive) to right brigade.

During the afternoon and evening of the 13th the G.O.C., 3rd Division, accompanied by his C.R.A., C.R.E. and G.S.O.I., makes a personal reconnaissance of the river.

The following information is available:—

(*a*) Intelligence report on the River Medway, from Aylesford–Snodland.

(*b*) Aeroplane photos.

(*c*) Maps, O.S., scale—6 in. to one mile; sheets XXXI N.W. and S.W.

INTELLIGENCE NOTES ON THE RIVER MEDWAY, FROM AYLESFORD TO SNODLAND.

General Details.—The river follows a winding course in a flat, marshy valley, about one mile broad.

The valley is overlooked by high ground on both banks. On the east from the Bluebell Hill ridge, about 1½ to 2 miles away and 500 ft. high. On the west from high ground, which is rather further away, 2 to 3 miles, and somewhat lower, 400 ft.

The country is cut up by small plantations, scattered houses and cement works.

Details of River.—The river is tidal with a rise and fall of about 13 ft. at Snodland (Spring Tides).

Depth at low water, 5 ft. to 6 ft.

Width: Aylesford, 159 ft. (high water);
Snodland, 220 ft. (high water).

Bed, deep mud, with occasional harder patches.

Banks: On each side of the river are marshes which are below highwater level, but in many cases have been reclaimed and drained, the water being kept out by dykes. The marshes are intersected with drainage channels.

The cement works and brick works along the river have wharves for barges where the banks are revetted (often with concrete) and firm.

Strength of current at half-tide about 3 knots.

Probable Approaches.—

(1) Aylesford Bridge.

(2) Court Lodge; thence past western edge of the Friars (west of Aylesford).

(3) By path running down to east bank, 200 yards south-west of Sewage Works (Maidstone Corporation).

(4) By track from Rowe Place (500 yards south of Eccles), northern edge of Bushey Wood–southern edge of West Kent Cement Works to river bank opposite New Hythe.

(5) By track from Eccles to Burham Brick Works.

Of the above, metalled roads are available on the far sides at (1), (2) and (4) only.

Special Features.—The North Kent Railway line runs parallel to the general line of the river on the west bank.

This is a double line of railway, carried on an embankment across the marshes. Height of the embankment at Snodland, about 8 ft. above the general height of the marshes.

Fords.—At Mill Hall and New Hythe, the river is fordable at extreme low water. The bottom is hard shale and shingle, and the depth of water, 18 in. to 2 ft. This condition only lasts for about half an hour.

There are two level-crossings at Aylesford Station and one at New Hythe, and ramps leading up the embankments 600 yards south of Snodland Station.

Where footpaths are shewn passing under the railway, the culverts give about 8 ft. 6 in. headroom and 9 ft. width.

The big drain running west of the railway south of Snodland is reported to be about 14 ft. wide.

Snodland Common consists of marshy ground, and is intersected by small drains.

The enemy have sunk all barges, boats, etc., on the river.

Note.—Sunrise: 0506 (Summer Time) on 18th July, 1922.
Full moon: 9th July.
High Tides: 18th July, 1922, 0631 hours.

I.T., S.M.E.
4. 7. 22.

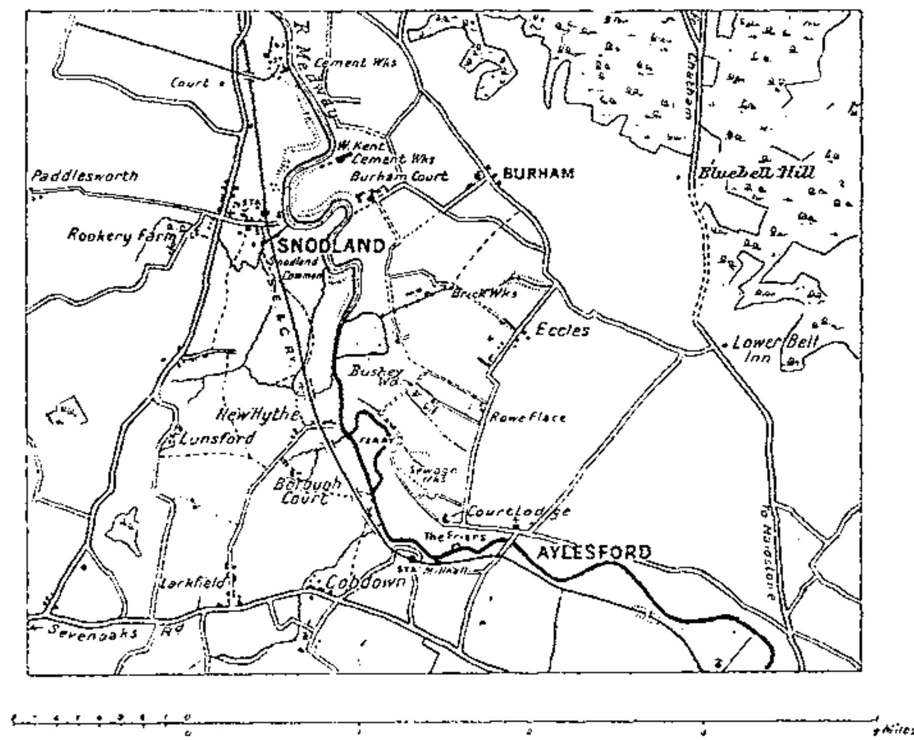
Problem I.—As C.R.E., carry out the reconnaissance of the river, and report for the information of the G.O.C. what arrangements can be made for getting the infantry, field-guns and horse-transport of the Division across the river and where the best crossing-places would be.

Also, roughly, the number of men that can be got across by the end of one hour and by the end of two hours after work commences.

Problem II.—On the assumption that the G.O.C. approves of your suggested arrangements, what orders would the C.R.E. issue to his companies to carry these out.

Note.—Syndicates of six will be divided into two, one-half to work up stream from Burham Court to New Hythe and the other half down stream from Aylesford to New Hythe.

Meet New Hythe Ferry, east bank, 1300 hours with one combined solution per syndicate.


R. Medway
Cement Wks
Court
W. Kent Cement Wks
Burham Court
BURHAM
Bluebell Hill
Paddlesworth
Rookery Farm
SNODLAND
Snodland Common
Brick Wks
Eccles
Lower Bell Inn
Bushey Wd
Rowe Place
New Hythe
Lunsford
Borough Court
Sewage Wks
Court Lodge
The Friars
AYLESFORD
Larkfield
Cobdown
Sevenoaks Rd
To Maidstone
Miles

THE TACTICAL THEORIES OF CAPTAIN LIDDELL HART.

(*A Criticism.*)

By BT. LIEUT.-COLONEL L. V. BOND, R.E.

1. ALL who are interested in infantry tactics will be grateful to Capt. Liddell Hart for the résumé of the French Infantry Regulations which he has contributed to the issue of the *Royal Engineers Journal* for May, 1922. The solution of the difficult problems of the handling of infantry under the conditions of war for which our Allies have to provide cannot but be of extreme value to ourselves.

2. The task of criticizing his ideas is one of some delicacy, but it appears, nevertheless, to be a task which it is permissible to attempt. The confident and oracular tone of his pronouncements invite assault. I could have wished that one better qualified than myself would have attempted the task. But the time has fully arrived when the attempt must be made.

3. It will generally be admitted, it is indeed a fundamental truth, that no system of tactics can be sound which does not take into account the physical and spiritual nature of man.

War—as Marshal Foch so continually insists—is not a game of chess, an affair of lines and angles, or of diagrams. It is, on the contrary, a chaotic business, " a dreadful and impassioned drama " which displays and exploits all the strengths and weaknesses of human nature.

No system of tactics can, therefore, be sound which does not react correctly to every *human* test.

No system of tactics for the British Empire can stand which does not bear the impress of the racial characteristics of our fighters; of Private " Nobby " Clark, brave, careless, improvident, tenacious, irrepressible, but not gifted in the mass with any great brain-power or initiative; of Lance-Corporal " Alf " Skinner, of Corporal " Dusty " Millar—magnificent fellows, but not all gifted with the *coup d'œil militaire*; men who share in a very full measure the Briton's love for *jargon*, for catchwords as a substitute for tactical thinking; of Sepoy Thakur Singh; of Naik Kamaluddin; of Jemadar Ramji Lal; of Subadar Bir Bahadur.

These, in conjunction with vigorous individuals from the Dominions; these—and not guns, or rifles, or tanks—are the principal weapons with which our armies fight. And the characteristics of these weapons must be the foundation, as well as the criterion, of our tactical teaching.

No one will be found to dissent from this proposition; to do so would be to argue that there is no difference in military characteristics between men of our race, of the French, the Russians and Portuguese—which is absurd.

Yet one may search Captain Hart's lectures almost in vain for any sign that he recognizes the fundamental importance of the human factor. Equally vainly may one search his recent article in the *Journal* for any hint that he realizes that what is true for the Briton is not necessarily true for the Frenchman, or that what is possible for a long-service army is not, perhaps, possible for a short-service army.

I will readily admit that the article which he has contributed to the current (May) number of the *National Review* strikes a much truer note than any of his previous work. But I am at present concerned mainly with his system of tactics—his "man-in-the-dark" theory—and this, failing further explanation, must stand or fall by his lectures.

4. Nothing is more remarkable in the tactical work of officers in these days than the difference in outlook of the true "front-line soldier" and of the "back-line soldier." Where the latter quotes the Regulations and Pamphlets, the former refers continually to the men: such and such a manœuvre is all very well in theory, but the men won't do it: a method looks all right, but, as a matter of fact, the men will be much more "for it" if another method is followed: it is no good talking about so and so because you won't be able to get your orders to the men. This objective outlook is the basis of all the reasoning of the "front-line" soldier; and such objective reasoning alone can provide a true basis for tactical theories.

5. And, if it is true that our tactical theory must take account of the psychology of our men, it is equally true that the interpretation of that theory into practice must vary not only with the nature of our own organization and armaments, but with the general character of the theatre of war, and yet more with the nature, armament and fighting methods of our enemy. The method which was perfectly suitable against the German of 1918, under the conditions of 1918, might well have been unsuitable in 1914: it would even more probably prove unsuitable, if not altogether impracticable, were we to have to fight the Afghans in 1923.

To take an example of this elementary truth, Captain Hart proposes as a "maxim" that, in the presence of unlocated enemy, the leading sections should always send ahead a couple of scouts. That may be true of most forms of warfare, but to teach such a rule on many parts of our N.W. Frontier of India would lead to the certain loss of two men and two rifles with no useful result.

In another "maxim" Captain Hart lays down the rule that battalion and infantry brigade-commanders will move with their support unit until this is engaged and will then move with the reserve unit. This rule may have been true for battalion-commanders in France in 1918, though even this is very much open to argument. It is certainly not true for the valleys of Waziristan, where, if he would control his unit and be controlled by the higher command, the battalion-commander must move by bounds and must select his successive command-posts in places from which he can see. The rule is yet more untrue for brigade-commanders in the hills, while few brigade-commanders will admit that it was invariably true, or even generally true of the conditions of France in 1918. The choice of the command-post, in fact, depends on a large number of practical considerations which Captain Hart conveniently and totally ignores.

6. I repeat, then, that the objective outlook is sadly lacking in the lecture in which Captain Hart develops his system. Nor is there anything to show that his theory has been tested and that it reacts correctly to the human test under every variety of conditions.

I do not say that he is invariably wrong; there is, indeed, very much good sense in what he says; but I do say that he will not carry conviction until he supports his argument at every step by reference to the actual experiences of himself and others.

Every war is distinguished by a series of special conditions, of facts which must be faced. It is through ignoring this simple truth that Captain Hart comes most heavily to grief.

7. The outbreak of a new jargon is a phenomenon observable after every considerable war. The Great War has brought no exception to this rule. Thus, Captain Hart and many others repeat with a certain unction, as embodying new lessons of the late war, such phrases as "soft spot tactics." It is observable that the *Infantry Training*, as issued, avoids the use of this disastrous catchword. Yet, if Captain Hart were to have his way, we should, I fear, continue to see bodies of dejected men roaming about "looking for a soft spot," or platoons contentedly "held up" (another catchword beloved of Captain Hart), because the spot they have found is not quite so soft as they would like it to be.

8. The truth is that "jargon" is a disease to which we are all subject, and that Captain Hart has suffered a somewhat severe infection. He talks continually of "modern conditions." It is on modern conditions that he raises the whole structure of his system. What does he mean by modern conditions? He means the condition of things which obtained in France in 1918, a condition characterized by the possession by both sides of vast armaments and of practically unlimited gun ammunition.

9. But, in war, it is with the particular conditions of each particular case that we have to deal, with stark facts that must be faced,

that must be taken into account, that cannot be charmed out of our path by even the most euphonious of catchwords. It is, therefore, for the facts of their immediate future that we must prepare our infantry; not for the conditions of the past.

When Captain Hart builds his theory on the widely-dispersed defensive groups which were characteristic of the fighting in France in 1918, he builds a theory which will, *prima facie*, only be applicable, and, failing further investigation, must be held to be true—if indeed it is true at all—only in the conditions which obtained in France in 1918. When he goes further and deduces from his theory, for universal employment, rules and formations and set forms, he threatens to become a public danger to all who are training for war under other conditions.

10. Captain Hart tells us that the system, as defined in the lectures published in the *R.E. Journal* for April and May, 1921, is intended to be a framework of tactics adjustable to all the normal situations of battle, a system in which our leaders can be drilled until to apply its "maxims" becomes a habit.

He suggests that his idea of creating such a framework is both daring and novel. Daring certainly it is, but novel it most certainly is not. It has been a constant phenomenon of all wars that the so-called lessons tend to crystallize into some such system which remains unchanged and generally unchallenged until it is washed away in blood by the "abnormal" conditions of the next conflict. The geographical strategy of the Austrian, and the oblique order of battle of the Prussian broke down before the commander who ignored the "rules of war." The battalions which, in the Peninsula, could "go anywhere, and do anything," failed to live up to their reputation when transferred to the American scene.

Indeed, up till quite recent times, the "absolute form," as Jomini calls it, or the universal framework, has always been a characteristic of our text-books. Before the South African War—if my memory serves me—we had a very definite system. We deployed in three bodies: a firing-line extended at two paces, supports in single rank, reserves in close order. Each body reinforced the firing-line as the advance progressed, until we had built up a dense firing-line for the assault. We certainly—in my college cadet corps—drilled very smartly in some such system. It was, presumably, a lesson of 1870. Probably the Germans and the French were practising much the same thing, with this difference that, whereas in the assault we shouted "Hurrah!" the German cried "Hoch!" while the Frenchman, raising his *képi* on his bayonet (a fascinating manœuvre), cried himself out (*s'écria*), "*en avant à la baïonnette!*"

Whatever the system may have been, the period of warning which preceded the outbreak of the War did not suffice to produce an official admission of its unsuitability to the special conditions of South Africa; "yet," says Colonel Henderson,* "our officers realized, before even a shot was fired, that what they had practised in peace was utterly unsuited to the Mauser-swept battlefield."

Since then wiser counsels have prevailed. But there is still a danger of the misapplication of unsuitable methods, if our text-books fail to distinguish with the most unmistakable clearness between what is universal and what is merely special to the particular case, the conditions of which must be clearly defined.

11. There is, then, nothing novel in Captain Liddell Hart's idea of an universal framework. It is a manifestation of the same old phenomenon. The false lessons of a war are embodied in a more or less rigid system, the true lessons are forgotten—if, indeed, they are ever formulated.

The forms, the methods, the jargon which are the product of the special conditions of the War survive, the lessons which are true for future wars are lost. Why is this? It is because the forms are tangible, men have been drilled in them, they can be embalmed in diagrams; because jargon is a refuge from thinking and is, therefore, acceptable to the mass of men. The true lessons are avoided because they are of their nature spiritual, difficult to express, difficult to teach, impossible to draw.

What, then, are the true tactical lessons of the Great War? I say, unhesitatingly, that they are the same as for every war in which we have been engaged. We should have learnt three things: the psychology of our soldiers, the material and moral effect of existing weapons in various circumstances, the necessity at all times of thinking objectively, that is to say, of basing action not on theories—on what we should *like* to do—but on the hard facts of the particular case—on what we *can* do.

It would, doubtless, be possible to elaborate these lessons; but of lessons of universal application, these are, I think, the chief. Armed with this knowledge, with this habit of thought, with the true spirit of the basic principles of war, and with the will to win, our leaders ought to be certain of victory wherever their duty calls them. Equipped with the purely mechanical system of Captain Liddell Hart, based, as it is, on conditions with which, as we have lately been authoritatively informed,† "we are unlikely to meet again," we court defeat in nine cases out of ten.

12. It will, perhaps, have dawned on the reader—if he has been able to follow me thus far—that I hold Captain Hart's so-called

* See *The Science of War*, page 372.

† Mr. Winston Churchill recently stated that the War Office policy was based on the improbability of another "national" war within the next ten years. And in ten years, what changes must there not be in our armament, our organisation and our tactics!

science of infantry tactics to be based on error. And it can reasonably be argued that a system based on error cannot but be false.

Even his initial simile of the "man-in-the-dark" I hold to be erroneous, since it presupposes that the man and his opponent are more or less similarly armed and similarly situated. Yet, similarity of armament, of organization and of technique are not normal conditions in the wars of our Empire.

There is always this danger in the use of analogy—that we may be tempted to press the parallel too far. Captain Hart has done so. We must, if we wish to use this form of argument, make sure that what we assume to be "likes" are not, in fact, "unlikes." Captain Hart has failed to take this necessary precaution. He tells us, for example, that he deduced his system of penetration from a study of Nature's method in the bursting of water through an earthen dam. Yet, can there be anything more unlike than inanimate water bursting through a passively resisting dam, and a trickle of tired men, torn and bewildered by the psychological impact of battle, passing through a gap in an actively resisting hostile front to meet fresh, unknown and unlocated dangers ahead? The two things are totally dissimilar.

Equally well might Captain Hart have used the successive impact and retirement of the waves of the rising tide as an argument for a perpetual leap-frogging of fresh units in the attack. Or, better still, he might have "deduced" from the action of one of those rotary brushes, which remove with such exquisite precision the sludge of a London street, a system distinguished by an oblique order of battle combined with a continuous *roulement* of platoons within the battalion. The train of reasoning in the latter analogy would have been no less sound than that of his "expanding torrent," while it has this supreme advantage—that it permits of the use of a French catchword, the pronunciation of which is particularly soothing to the palate.

I do not wish to press the point too far. But I trust that I have said enough to show that, in basing his tactical theories on expanding torrents, Captain Hart has, consciously or unconsciously, attempted to dope us with flap-doodle of the most misleading kind.

13. Rashly ignoring the fact that the authority which he quotes has itself laid down that war is an art and not a science, and that it is therefore not subject to rigid rules (*F.S.R.*, Vol. II, Sec. 3), he tells us that he intends to build up a "science of infantry tactics." Careless in his use of analogy, he is, it is to be feared, equally careless in his use of terms. Science has but one method of procedure, and that is invariable.* It aims first, with a just and open mind, at the collection and correct observation of facts—of phenomena. It

* See Chap. II. of *The Psychology of Insanity*, by Bernard Hart.

proceeds then to classify these phenomena into groups or series. Finally it endeavours to find a formula which shall explain all these facts, which shall be universally *true* for all the observed phenomena. Produce one instance where the formula fails and there is no science. A science must be universal or it cannot exist. Yet Captain Hart's system, as we have already shown, owes nothing, as far as we have been allowed to see, to the patient collection and examination of actual phenomena. On the contrary, it appears to be the result of pure theory unconnected with experience.

Nor is it, in its nature, universal; since, as we have also seen, it is based on the consideration of one special case, namely, that resulting from a struggle between armies, each provided with vast armaments, a condition of things which, as we know, implies the complete mobilization of the national life to the business of war. This is not a normal condition in the wars of our empire. It is not a condition which we are likely to see again for some time. It is not a condition which is normal to the commencement of any great war.

Captain Hart's so-called science is, therefore, not universal in its nature. Nor, as we have already seen, are the formulæ which it proposes true of all cases with which it deals. It is, therefore, not a science, but a non-science.

14. I do not wish to be so dogmatic as to say that there can be no science of infantry tactics. But I do insist that such a science must be universal and must therefore be based on the phenomena which are common to all wars. What are those universal phenomena? They are those which Napoleon intended that we should find when, in comparatively modern times, he recommended the study of the campaigns of Alexander, of Cæsar and of Hannibal. They are the phenomena due to whatever is universal and unchanging in the nature of man.

All men have the instinct of self-preservation; all are susceptible to fear, to hunger, to cold, to fatigue, to discouragement, to death and wounds; all are probably susceptible to the fear of encirclement, of the attack in flank while engaged with an enemy in front; all are liable to the panic which is the child of surprise.

If, then, there is to be a science of infantry tactics, it is upon the observation and classification of these and similar phenomena that it must be built up. I do not find these matters anywhere mentioned in Captain Liddell Hart's lectures.

15. In truth, to construct a theory of tactics, it is not sufficient to draw on maps, pre-arranged for the purpose, a variety of objects generally resembling bifurcated tadpoles. Tactics are a matter appertaining to human nature; they cannot be compounded of paper and printer's ink. His recent article in the *National Review* shows that Captain Hart realizes this as well as do the rest of us. But let

the reader look at the four plates illustrating his " expanding torrent " system which follow Captain Hart's lecture in the *Journal* for May, 1921. Replace the brainy and bifurcated tadpoles by the men whom we have tried to describe, men brave, but not brainy; men who are stunned or controlled by the psychological impact of battle; men whose main idea—if it is not to find " a better 'ole "—is to finish their bit of the job and to consolidate themselves while others take up the advance. Replace the heads of the tadpoles by leaders who seldom can have any certain knowledge of what is happening, whose main idea is, perhaps, not to " lose the barrage "; who, if they have conceived a plan, may be struck down before that plan is communicated. Take this picture, and a variety of practical questions present themselves—questions which cannot be solved by an appeal to an " expanding torrent " or even to the more attractive " rotary road brush."

Can the platoon leaders know enough of the situation to manœuvre with the necessary skill?

If not, to what extent can the company-commander expect to control his platoon-leaders?

Under the effective fire of the defence, as they must be if there is no overwhelming attacking artillery, can platoons be induced to manœuvre to a flank?

If not, what are the limiting conditions of fire for this to be possible?

If we have an overwhelming artillery, which must of its nature function on a timed programme, how will these complicated manœuvres and the doctrine of free-will for platoon-commanders fit in with the advance of the barrage?

To what extent are we sure that a platoon which has performed one task will voluntarily proceed to another?

In view of the supreme difficulty always experienced in keeping direction, what are the chances of, say, No. 7 Platoon, after its circuitous wriggle, starting off again in the right direction?

It being natural for human beings to move either in line or one behind the other, could the arrow-head formation really be retained by sections during these wanderings?

What about the supply of ammunition, bombs, etc., to the platoons destined eventually to push right through to the battalion objective?

Who decides when a platoon is exhausted, and, therefore, under Captain Hart's scheme, excused from further pressing forward to the battalion objective?

And so on.

16. I may be wrong. I trust that I am wrong. But it certainly does seem to me that the highly complicated manœuvres illustrated

in these *Plates* can only succeed if we assume the following conditions, viz. :—

(*a*) an enemy in widely separated and distinct posts ;
(*b*) a perfect knowledge of the positions of those posts ;
(*c*) leaders who can be relied on to take correct tactical decisions ;
(*d*) no time-table to adhere to, as with a barrage ;
(*e*) troops under complete control, and ready and willing to attack a series of objectives ;
(*f*) a passive enemy.

I presume that Captain Hart writes from experience. And I shall certainly not accuse him of proposing what he knows from experience to be impossible. I must presume, therefore, that these conditions were found on the Western Front in 1918. I am glad to know it. It is news to me.

But I cannot think of any probable war in the near future in which several of these conditions will not be absent. I conclude, then, as before, that Captain Hart's universal system of the " expanding torrent " is not universal. And if this theory fails at the practical test, it furnishes strong presumptive evidence that, whatever other theories he may have based on similar arguments should also be similarly examined.

17. There are, indeed, many *dicta* among his writings of which we should like a fuller explanation, supported, if possible, with instances from his experience.

As engineer officers, and peculiarly interested in theories of defence, we should like to know more of the working of the system illustrated by the sketch on page 220 of the *Journal* for May, 1921 : a sketch which, by the way, contains in its bottom left-hand corner, our old friend of " shop " days—the " impossible contour." What, for example, happens when the attacker ignores—as he may well do—the advice of Captain Hart, and breaks through in the left-hand half of the sketch, or along the whole of the battalion front ? Will this not provide an unpleasant surprise for the manœuvre platoons shown as distributed in posts presenting their flanks, if not their sterns, to the break through ? Captain Hart bases his system on the supposition that " the phase of fixing is carried out by the forward bodies." How does he reconcile this with the system of *F.S.R.*, Vol. II, which is based on the lesson of experience, that, under " modern conditions," the troops in the outpost or forward zone cannot be expected to fix the attack ? The two systems are irreconcilable,

To take another instance : many officers of experience would wish to hear further arguments on the subject of the " unlimited objective." They are aware that, in theory, the limitation of the freedom and of the objectives of units is to be deprecated. But they were under the impression that it was the insuperable argument of facts that had forced us to the conclusion that, wherever strong and active resistance in depth was to be expected, control could only be ensured by allotting definite units to definite objectives, by limiting objectives, by attacking fresh objectives with fresh troops; and they understood that it was the number and nature of the objectives which determined whether or not this system should be carried down to the platoon. The arguments for this view will be found stated with great authority on pages 36 to 39 of Lieut.-General Sir G. M. Harper's *Notes on Infantry Tactics and Training*; arguments which, I must invite Captain Hart to notice, are based solely on practical considerations. Those arguments apply to France. But they have proved equally true of Mesopotamia. While an examination of recent campaigns in Waziristan will show that leap-frogging by companies and platoons, with the consolidation of limited objectives—a system long in use on the frontier—is even more necessary now than it used to be.

To this body of argument Captain Hart has, so far, opposed a single paragraph which is to be found on page 181 of the *Journal* for May, 1921; a paragraph which is typical of the method of his lectures. Readers who care to refer to it will find that it consists of a handful of jargon strung together on an argument of amazing inconsequence. There is in it nothing of experience; nothing of the practical outlook. We want something better than that to convince experienced officers.

18. It is true that, in support of his point of view, he quotes in his recent article a phrase from the French Infantry Regulations. Speaking apparently of the handling of reserves, these Regulations say: "every unit ought to pursue its effort to the full limit of its offensive capacity." We cannot say, without seeing the context, whether he is justified in taking this to support his doctrine of the unlimited objective. But the phrase might quite as well refer to the necessity of a unit being prepared to employ its full power, even to the exhaustion of its reserves, in order to attain its objective, whether limited or unlimited. If that is the meaning of the phrase, then it not only does not support Captain Hart's argument for the unlimited objective, but it actively opposes his strangely defeatist attitude on the handling of reserves which would apparently require us always to admit defeat rather than to throw our reserves into the battle.

19. We wish that Captain Hart would give us something of his experience on which his views are based. There is at this time a great need that the individual experience of officers of the Great War should be recorded while it is still comparatively fresh in our minds. Yet, while our military periodicals deal fully with the interesting but unimportant vagaries of the late Colonel Hentsch, they ignore the vitally important strata of military history.

What were the experiences of a certain platoon of Captain Hart's battalion on a given day? How did the men comport themselves before zero? What was the effect, if any, on their morale of the long wait on the forming-up tapes? How did they go "over the top"? How was it that the platoon lost direction? What were the conditions which resulted in the platoon being held up? What efforts were made to get it forward? To what extent did they succeed? How much of the situation was the platoon-commander able to see?

It is for such details as these that the next generation of soldiers will hunger. And unless an effort is made to satisfy them they will hunger in vain. These are the really important aspects of history; but I know nowhere where an attempt is being made to preserve and to classify them.*

Yet the need is great. Many officers will unhesitatingly undertake to criticize the strategy of Ludendorff; comparatively few will offer a confident opinion as to the psychological effect on the infantry soldier of lying down to fire during the attack, or as to the measures necessary to rally troops falling back before an enemy attack. Yet it is on the answers to such elementary questions as these that the whole structure of tactics is based.

20. It is, therefore, to the public interest that Captain Hart should continue the good work of his *National Review* article and that he should make another attempt to explain himself.

But, if he would be convincing, he must abandon altogether the methods of his lectures. He must deny himself the use of catch-words and the easy path of flap-doodle. He must put away his "man-in-the-dark," his "expanding torrent," his "human tank," and his other dummies. He must eliminate his intelligent and invulnerable tadpoles. And in their place he must show us Private Clark, Sepoy Thakur Singh, Corporal Millar, Subadar Bir Bahadur Gurung, Lieut. Jones, Major Pott and Colonel Blunderbore as they are; not as super-men, but as human beings, with all their characteristic limitations. He must exhibit them operating his universal system, not in diagrams, but in the mud, blood and barrages of Flanders, under the sun of the Sahara, on the plains of Iraq, or amid the rocks and nullahs of Waziristan. He must show them fighting with the organization, the armament and the gun-power with which mobilization will actually provide them. Fighting, too, not against a chequer of shaded blobs, but against real and varied enemies.

If he can show us his universal system working smoothly in all these circumstances, we shall acclaim him a benefactor to the Empire. Meanwhile . . . . "*ziyādă hăd-i-ādăb*," as they say in India!

* Nowhere, that is to say, except it be in the *Journal* of the R.U.S.I., which has already given us several human documents, and which, in its May issue, publishes an admirable example of what is required in an article by Bt.-Major Hudson, V.C., D.S.O., M.C.

A CORPS LAUNDRY.

By MAJOR W. HYDE KELLY, D.S.O., R.E.

THE title of this article lacks lustre, but I do not think the subject has been dealt with before in the *R.E. Journal.*

A laundry has become a necessary feature in the administrative services of an army corps, necessary to the cleanliness and health of the troops, and necessary also in the corps area, as any site further towards the rear becomes too far distant for practical purposes. Laundries grew up, as did everything else, from small beginnings. The first bathing establishment where men who had spent three weeks or more without taking off their clothes could be given the luxury of hot water and soap was established in Armentières in November, 1914, where some big brewers' vats were made use of as bath tubs. But this did not solve the problem of bathing more than a fraction of the number of troops, nor did it provide them with fresh clean underclothes in exchange for their old ones. The demand, therefore, for properly organized laundries arose very quickly, and the following account of one which was established at Aire may be of interest.

The place selected was a corner of the old French infantry barracks of the town. The river Lys ran along the south edge of the barracks, furnishing all the water that was required. A troop stable, which had been recently used by the French as a sick horse depôt and had a concreted dipping bath alongside, was taken over for the washing operations; part of a men's barrack block for the mending, ironing and dispatching stages, and a large wooden stable for drying shed. The daily output to be catered for was 10,000 pieces, five "pieces" constituting the soldier's underclothes. The labour was to be provided by Frenchwomen of the town, but, as Aire at that time was a favourite attraction for the enemy's night-bombers, the inhabitants left the town at dusk and slept in the surrounding villages. Washing was to be done in wooden tubs, of which a good supply was obtainable on the spot from the local breweries. No laundry machines were provided; everything had to be improvised.

The first step was to ensure a constant supply of hot water. Fortunately, the French had left us an old vertical boiler which blew steam through a 1,000-gallon tank erected on a stage 15 ft. high in the middle of the stable. This was a nucleus which saved a lot of work, but there was no supply of water to feed the tank. A small "Valiant" engine used for fire purposes was procured from an Electrical and Mechanical Company, and this was installed outside the stable, with a 3-in. suction pipe led into the river Lys 15 ft. away. This supplied all the water necessary for the preliminary dipping tank, for the hot water tank, and for the cold rinsing tanks. The horse dipping bath was, of course, chosen for the preliminary soaking of the clothes. A wooden partition was wedged across the dip where the sloping entry ended, to prevent clothes from stranding at the shallow end. Disinfectant was poured in, and the dip filled with cold water. The clothes, as they arrived, were turned into this bath, and kept turned over and over by long-handled wooden blades, worked by hand. From this bath, they were carried in barrows to a large rinsing bath, home-made out of 9 in. by 3 in. timber, tongued on the spot, and well white-leaded at the joints, and clamped with iron rods running through each member and screwed up top and bottom. From the rinsing bath, the clothes went to the wash-tubs. There were 100 of these, raised on long wooden benches, about 18 in. above the floor, and fed by 1-in. piping suspended vertically between every alternate pair of tubs, and furnished with short lengths of rubber hose pipes so that four tubs could be filled from each overhead pipe. This pipe system was run direct from the hot water tank on its platform in the middle of the building. Each woman at the tubs had a scrubbing board, and behind them the mangers of the stable were covered over and provided a further scrubbing bench. From the wash-tubs, the clothes went to two more wooden tanks, 8 ft. by 8 ft. by 8 ft. each, and were rinsed in cold water. Thence they were hand-wrung and hung outside on wires (galvanized) stretched across the parade-ground; or, if the weather was bad, the clothes were hung in the wooden stable, which was closed up and fitted with four stoves, with their flue-pipes carried gradually upwards along the shed.

After drying, the clothes went to the mending-room, in the barrack block; next, to the ironing-room, which boasted ironing benches and a useful device for heating irons in tiers round a stove. From the ironing process, the clothes passed into the next room to be made up into bundles, and then they were thrown out of the window into an enclosed wooded "chute" with a turn in it, so that the bundles fell through the window on to the floor of the room below, which was the storing and issuing department, whence lorries carried them off to the various bathing places. The river Lys not only provided the water for the laundry, but it also carried off the foul water from the wash-house floor. This was first filtered through a box containing gravel and clinker, but, as the town was practically uninhabited, the pollution of its river did not alarm the local authorities in any way. The water from the disinfecting bath was pumped separately into the barrack drains.

The work was carried out by the 552nd (Aberdeen) Army Troops Company (T.F.).

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 VI.

PALESTINE: THE SECOND OFFENSIVE. THE CAPTURE OF BEERSHEBA AND GAZA.—Sir Edmund Allenby's recommendations—Description of the Turkish position—British preparations for the offensive—The Yilderim Army intended to recapture Bagdad—Plan for the capture of Beersheba—Advance of the Desert Mounted Corps and XXth Corps—First attack on Gaza—The Turkish counter-stroke north of Beersheba—The break-through on to the Plain of Philistia—Charge of 5th Mounted Brigade at Huj.

PALESTINE: THE SECOND OFFENSIVE. THE CAPTURE OF BEERSHEBA AND GAZA.

GENERAL SIR EDMUND ALLENBY assumed the command of the Egyptian Expeditionary Force on 28th June, 1917, when the general situation locally was as follows:—

In the Sudan and Western Desert all was clear. The Abyssinians had reaffirmed their friendliness. Siwa had been garrisoned. Only on the north coast we were troubled by enemy submarines lurking and collecting information of our shipping through the canal. Egypt itself was quiet.

The Arabs in the Hedjaz had steadily gained ground and adherents. Medina alone had resisted their attacks; but the Hedjaz railway was continually being interrupted by their action. The Emir Feisal's army was to be moved up the Red Sea coast to Akaba, to be still more on the flank of the Turkish line of communications with Medina.

On the Palestine front there had been a deadlock in May and June. The Turks had greatly reinforced and extended that front since the Second Battle of Gaza, and had dug and wired themselves in; and the British had done the same. In front of Gaza position warfare prevailed. Our right flank was open, but we could not move there for lack of water and transport.

In Mesopotamia, the Turks had set themselves in earnest to retake Bagdad, and the Yilderim Army had been formed. Germany had appointed von Falkenhayn to the chief command, and had provided an Asia Corps and much material for these operations.

Sir Edmund Allenby had been instructed to report on the conditions under which offensive operations against the Turks in Palestine might be undertaken. He very soon went up to that front, and personally reconnoitered the country from south-west of Beersheba to Sheikh Ajlun. He reported that, given a force of seven infantry and three mounted divisions, Gaza and Beersheba could be attacked with the prospect of reaching Jerusalem. The chief reinforcements immediately required were :—

Two fully-trained divisions ;
Eleven 18-pdr. and 4·5-in. howitzer batteries ;
Six groups of heavy artillery ;
Three squadrons of R.F.C.

In fulfilment of these demands, the 60th and 10th Divisions were transferred from Salonika ; some heavy artillery from Italy, and most of the remainder from the United Kingdom, and also Indian Cavalry from France.

The Turkish Position, Gaza–Beersheba (*Plates* VI. and VII.).—The country between Gaza and Beersheba constitutes the southern edge of the Plain of Philistia, and may be termed " open " ground of varying character, as it changes from the sea-coast sand dunes of Philistia to the rocky limestone spurs of the Judean Hills.

Further east, after Sheria, the rolling downlands merge into bare sandy hillocks, and rocky outcrops, which rise into rough and arid hills 1,200 ft. to 1,500 ft. high. This ground, east of Wadi Sheria, is difficult for transport and offers no overhead cover. Tel el Khuweilfeh and Towal Abu Jerwal, respectively 12 and 6 miles north of Beersheba, are prominent outlying features of the Hebron range. South and south-west of Beersheba is a lower, but very similar, block of limestone hills, devoid of water, which extends for about eight miles towards the upper Wadi Ghuzzee.

Beersheba itself is about 900 ft. above the sea, and lies in a hollow. The town is dominated by Tel es Saba on the east, Ras Ghanam on the south, and Hill 1070 on the south-west. Six roads converge on Beersheba. Three of these, Jerusalem–Hebron, the Gaza, and the Asluj roads had been roughly metalled, and could be used for motor traffic. The other roads were only well-worn tracks, all passable by horsed vehicles and light cars, but with steep crossings at the big wadis. All this country is drained by three affluents of the Wadi Ghuzzee, viz. :—

Wadi Sheria, which crossed the Turkish line at Hareira ;
Wadi Imleh, which crossed the Beersheba Railway at Irgeig ;
Wadi Saba, which passes through Beersheba itself and comes down from Hebron.

All these *wadis* are torrent beds, with steep-cut sides—5 to 30 ft. high—and stony floors.

Wadi Ghuzzee, under various names, falls south-south-east towards Shellal, after passing through Khalasa, Asluj, Esani and Gamli. Patriarchal springs and wells exist at all those places, and water could be speedily developed with modern appliances.

West of Shellal, the country formed a sandy plateau, falling gently to the sea. It was passable, but not easily, by horsed vehicles, and on swept tracks by light Ford vans and motor-cars—but not by motor lorries.

East of Shellal was a broad cultivated plain, famous for its barley, which extended through Karm to Towal el Habari. It afforded fairly good going for all transport, including motor-lorries, and it boasted a few wells.

By July, 1917, Gaza had become a well-armed, equipped, and garrisoned fortress. To prevent its envelopment, the Turks had constructed a chain of strongly entrenched localities extending almost to Beersheba along 30 miles of front. Besides the works immediately covering Beersheba, there were five other systems of redoubts: Kauwukah, Hareira, Baha, Atawineh, Sihan. These works supported each other, except on the extreme left of the Turks, where a gap of about 4½ miles occurred between the Kauwukah and the Beersheba defences.

The Turkish communications in rear were fairly good. The Gaza–Beersheba road connected up these groups, and the country north of it generally was passable for horsed transport. The Wadi Surar Junction–Beersheba railway (3 ft. 6 in. gauge) passed through Sheria and the Tine–Gaza branch was completed to the Wadi Hesi, and was being extended to Army Headquarters and its Reserve Centre at Huj.

The Turkish forces in Southern Palestine consisted of the XXth and XXIInd Corps, with the 3rd Cavalry Division—in all, nine divisions, 25 regiments of infantry and three cavalry regiments—total about 50,000 rifles, 1,500 sabres and 300 guns. These forces at first were under Ahmed Jemal Pasha, G.O.C. IVth Army, with Colonel von Kressenstein as Chief of Staff. But, at the end of October, they were brought under the Yilderim Army Group. Then von Kressenstein became G.O.C. VIIIth Army, with Headquarters at Huleikat, and Fezvi Pasha, G.O.C. VIIth Army, with Headquarters at Hebron, and Jemal was passed on to the line of communication.

The British Position and Preparation.—The British line directly in front of Gaza was not much altered at first after the second battle in April. But, above Tel el Jemmi, the right flank was pushed up to the Wadi Ghuzzee. The British held Shellal for its water; and, when the railway approached Shellal in July, infantry were moved on to the plain near there, and mounted troops went further up to Tel el Fara and Gamli. But the bulk of the depôts and reserves were kept between Rafa and Khan Yunus. The front in July extended for about 22 miles. During the summer numerous reconnaissances were made east of the Wadi Ghuzzee, and the Turks became accustomed to our troops approaching the Wadis Imleh, Sheria and Saba. These reconnaissances had confirmed that the weakest part of the Turkish chain of defences was between Kauwukah and Irgeig. There was the gap of 4½ miles between the end of the Hareira defences and the beginning of the Beersheba system.

The following considerations affected the selection of the locality for the main assault:—

(*a*) Gaza itself.—A naturally strong position, was now heavily armed, entrenched and garrisoned. To pass that fortress would involve hewing a way through by sheer strength of artillery. Such operations are unavoidable when no flank is available, but offer no more than local success. If the Turks should elect to retire from Gaza they had as good a position behind the Wadi Hesi, by Deir Seneid.

(*b*) The Atawineh area similarly, if penetrated, offered no substantial advantage.

(*c*) The Hareira–Sheria sector seemed the weak spot. If British troops could reach and overrun it, the whole of the Gaza position would be turned; and they would be on the flank of the Turks as they fell back and there would be scope for the large British force of mounted troops.

(*d*) Beersheba had abundant water; but the locality would only be of service as a rendezvous for another bound forward. The place would be an incumbrance if the British were checked there.

(*e*) The conclusion, therefore, was that the main attack ought to be directed against the Turkish left—the defences Sheria–Hareira, but, that it was essential first to seize Beersheba by a surprise, as it was necessary to secure the water, and the space to develop the principal attack.

(*f*) The Turks seemed predisposed to expect that Gaza would still be the objective of the main attack; and, to encourage this belief to the very end, it was determined also to attack Gaza.

Immediately after his return from reconnoitring the Palestine front, Sir E. Allenby reorganized the command, and moved his G.H.Q. from Cairo to near Rafa. The Eastern Force was abolished; and the troops east of the canal were formed into the XXth Corps, XXIst Corps, Desert Mounted Corps and Palestine Lines of Communication (see *Appendix* I for fighting strengths). Kantara supplanted Alexandria as the principal base; quays for ocean steamers were built along the Suez Canal, and immense depôts of ordnance stores, supplies, and remounts grew up there.

The doubling of the military railway, and of the 12-in. pipe-line was accelerated. Large quantities of mechanical transport were assembled at Kantara to go up the line as soon as they could be utilized.

In the immediate front, a great deal of work was put in hand, especially in improving the forward communications, and water, and in preparation for heavy artillery reinforcements. Light railways, heavy telegraphs, wire roads, cleared tracks for Ford vans, water cisterns, surf-boats—and much of the latest equipment of trench warfare, such as sound-ranging, balloons, listening sets—all were utilized. Throughout the five months of preparation the trench warfare was actively offensive; and the impression gained ground that Gaza again would be subjected to direct assault.

The change of Commander-in-Chief, and the British preparations in the summer, were duly appreciated by the enemy. It is known now that, in August, the German Staff in Palestine concluded that the British would make another effort to break through, and realized that, unless the Turks were very heavily reinforced, the attack would probably succeed. They wished to shorten their line by withdrawing from Beersheba; but Constantinople would neither permit that, nor allow them the troops they requested.

Turkish pride and prestige had been deeply wounded by the loss of Bagdad. The plan to retake it had the backing of Berlin. The Asia Corps was on its way to Mesopotamia. To the appeals of Palestine, the reply was :—

> "Every man sent to Sinai decreases the chance of success in retaking Bagdad."

To this the Palestine Command urged :—

> "If the Sinai front is broken, Palestine and Syria will fall into the enemy's hands; and not only will Bagdad not be retaken, but the armies in Mesopotamia will be caught with the British across their lines of communications at Aleppo."

Not until mid-October did this argument prevail, and then it was too late. Von Falkenhayn was in time to supersede Jemal Pasha; and his Yilderim troops, diverted from Mesopotamia, were on their way to Palestine when Sir Edmund Allenby's force captured Beersheba on 31st October.

The general idea of the British operations was to deliver the main blow, in overwhelming force, against the left of the enemy's principal line of defences at Hareira–Sheria. The infantry would then roll up the Turkish line, while the mounted Corps pressed through into Philistia on the enemy's communications. The first step must be the capture of Beersheba; and, to confuse the enemy, Gaza itself was to be subjected to prolonged intensive bombardment, and attacked simultaneously, but with limited objects in view.

Beersheba lay 18 miles from Shellal. The country between was totally devoid of food or forage. The road tracks could not be relied on at first for motor transport. Water was scarce. It was necessary, therefore, to provide special transport to assure supplies and water for the troops operating against Beersheba. It was decided to carry the 4 ft. 8½ in. gauge railway over the Wadi Ghuzzee at Shellal on a trestle-bridge, to strip the XXIst Corps units in front of Gaza of most of their divisional transport, and to build out a pipe-line from the Shellal reservoirs to the concentration area at Karm. By this means the XXth Corps and Desert Mounted Corps were given sufficient transport to enable them to move out 20 miles from railhead. About 30,000 camels were utilized in this task.

The plan for the capture of Beersheba was to envelop the place. Two mounted divisions were to attack from north-east, east, and south-east, and two infantry divisions simultaneously were to assault the works on the west, and south-west, while a third infantry division covered the left of the main infantry attack. The mounted troops had to make a circuit of 50 miles from Gamli, through Esani, Khalasa, Asluj to Kasim Zana.

As soon as Beersheba was seized, then Gaza was to be attacked with naval assistance, and two very important localities occupied, while our Beersheba forces were preparing for their next stage—the main attack on Hareira. The Turk was to be kept fully occupied, and yet uncertain as to where the main blow would fall.

Originally, it was expected to deliver the attack near the end of September, but, in waiting for reinforcements, the operations were postponed five or six weeks. Force Order No. 54 was issued on 22nd October, and Zero day was fixed for the 31st.

Paras. 5 and 6 of this Operation Order were as follows:—

"5 (*a*) The XXth Corps will move into position during the night Z–1/Zero, so as to attack the enemy at Beersheba on Zero day south of the wadi with two divisions, while covering his flank, and the construction of the railway east of Shellal, with one division on the high ground overlooking Wadis el Suffi and Hannafish. The objective of the Desert Mounted Corps will be the enemy's defences from the south-east to the north-east of Beersheba, and the town of Beersheba itself."

"6. The G.O.C. Desert Mounted Corps will endeavour to turn the enemy's left with a view to breaking down his resistance at Beersheba as quickly as possible. With this in view, the main weight of his force will be directed against Beersheba from the east and north-east. As soon as the enemy's resistance shows signs of weakening, G.O.C. Desert Mounted Corps will be prepared to act with the utmost vigour against his retreating troops so as to prevent their escape, or at least drive them well beyond the high ground immediately overlooking the town from the north. He will also be prepared to push troops rapidly into Beersheba, in order to protect from damage any wells and plant connected with the water supply not damaged by the enemy before Beersheba is entered. Special instructions will be issued to G.O.C. Desert Mounted

Corps, and a copy of these instructions will be forwarded for information to G.O.C. XXth Corps."

Special instructions were issued to G.O.C., Desert Mounted Corps, in which he was informed :—

(*i*) The main attack of the XXth Corps could not be launched earlier than between 1000 and 1100 on Zero day.

(*ii*) The mounted divisions must be east of Beersheba early enough to attack it before the enemy should realize the infantry attack of the XXth Corps.

(*iii*) Men and horses were to be kept as fresh as possible for the second, and principal, stage of their operations, in which their rôle would be to pass round the enemy's left and establish the Corps about Tel el Nejile–Wadi Hesi.

Special instructions to the XXth Corps dealt mainly with the action to be taken if the enemy should evacuate Beersheba before we could attack.

The measures taken to mislead the enemy were very carefully elaborated. It must be remembered that the bulk of the troops out of the trench line were kept opposite Gaza, in well-marked camps between Tel el Jemmi–Deir el Belah, and Rafa. In June, as the force spread out towards Shellal, the detachments on the Wadi Ghuzzee had formed similar camps to which the Turkish airmen were well accustomed. The Desert Mounted Corps always had a division in rest on the coast, near Khan Yunus. When the assembly marches began, in the last week of October, all moves took place at night. The brigades departing always left tents standing, and stepped up to an existing camping ground. Camps which were finally vacated were kept going, and arrangements were made to water horses and to create dust at the usual hours and in the usual places. Thus, the enemy's airmen—who got over only at a great height—saw merely the camps to which they were accustomed and no marked changes in them.

The French contingent had their camps and stores at Khan Yunus. Great camel lines existed near Deir el Belah. Extensive light railways had been built, primarily for ammunition supply, conveniently in front of Gaza. A dummy main-line station was constructed at the Wadi Ghuzzee crossing, near the Belah–Gaza road. The enemy was also misled by our indiscreet use of wireless—doctored messages in indifferent cipher—and by other information which he prized, but which was not as good as it seemed.

Finally, Gaza was subjected to eight days' continuous bombardment, as had never been before in all Asia. The evidence to the enemy that Gaza was the enemy's main objective was reasonably conclusive, and when the move on Beersheba became obvious, he considered it to be merely a bluff.

Capture of Beersheba.—The steady bombardment of Gaza commenced on 26th October, when the troops began to take post for the attack on Beersheba. On the evening of 30th October, the XXth Corps and Desert Mounted Corps were concentrated ready for the night march to their position of deployment. There was a full moon, and the weather was sultry.

The approach movements of the three divisions now with the XXth Corps for this concentration were very carefully screened.

First, an outpost line of the 53rd Division was pushed out on the left, to the north-west of Beersheba.

On the right of the 53rd Division, the Desert Mounted Corps furnished a screen about midway between the Wadi Ghuzzee and Beersheba.

Then, on 29th October, the XXth Corps Cavalry Regiment had replaced the Australians; while that night (29th–30th October) the 60th and 74th Divisions, in brigade groups, were moving across the broken ground in the triangle, Esani–Gamli–Beersheba, and lying up by day in the *wadis*.

These divisions were given three lines to work to:—A line for deployment, the enemy's trench-line, and the intended outpost-line to be occupied after the assault, and beyond which units were forbidden to pursue. It was a complex manœuvre to move out three divisions like this by night so far, and get them deployed as required without alarming the enemy.

The 74th and 60th Divisions were allotted the hostile works between the Khalasa road and the Wadi Saba; and part of the 53rd Division further north covered the left of the attack. The right of the 60th Division was covered by the 7th Mounted Brigade.

The first step was to seize Hill 1070, in order to enable the guns to be brought up close enough for wire-cutting in front of the inner defences. The 60th Division took Hill 1070 by 0845 hours. Wire-cutting then proceeded, the main assault was delivered at 1215 hours and by 1300 hours the works between the Khalasa road and Wadi Saba were taken. The defences north of that road took longer to secure, but were captured by 1930 hours and the road into Beersheba from the west was then clear. The only troops of the XXth Corps to go that night into Beersheba were part of the 521st Field Co., R.E., sent in to develop the water supply.

The Desert Mounted Corps had a difficult march; they used two roads—very rough going—and covered from 25 to 35 miles during the night, and commenced their attack to time. Then they met much opposition, and the ground east of the town favoured the defence, being almost flat and commanded by high ground on the north-east and south-east, and flanked by Tel es Saba. Progress was slow until about 1830 hours, when the 4th Australian Light Horse Brigade (Brig.-General Grant) extended, and galloped over two lines of Turks in trenches, and entered Beersheba

Two regiments rode in this attack, which was delivered in three lines, each of two squadrons, and supported by one section of machine-guns. One regiment was in reserve covering the left rear. The brigade captured 1100 prisoners and 10 guns. They lost 31 killed and 33 wounded. They found the water supply intact; although the wells had been prepared for demolition, the Turks had neglected to fire the charge. The whole operation was a complete success. The Turks were surprised, they were given no time to reinforce, and a very strong position was taken with relatively small loss.

The First Attack on Gaza.—The XXth Corps now required a short time to assemble and deploy for the attack on the Sheria–Hareira defences. Meanwhile, the XXIst Corps was directed to capture the line Umbrella Hill–Sheikh Hasan, a frontage of about 6,000 yards to a maximum depth of 3,000 yards. It was expected that this attack would draw Turkish reserves towards Gaza.

This operation was executed in two stages. At 2300 hours on 1st November, Umbrella Hill was rushed. The next stage was fixed for four hours later, and for two hours the Turks kept up a heavy bombardment, which closed down just in time for the British assault on Sheikh Hasan to proceed.

The preliminary bombardment by the XXIst Corps had been so destructive that in one division the Turks lost a third of their troops, and were obliged to replace that division by another from the General Reserve. So, the blow on the left also achieved its purpose: it had seriously threatened the whole Gaza sector, it had compelled the Turks to bring reserves into Gaza, and had convinced them that Gaza was the objective of the main attack.

Very sultry weather now set in, and hampered the preparations of the troops about Beersheba, so that an additional day was required to complete them.

The Turkish Counter-stroke north of Beersheba.—While the XXth Corps and the Desert Mounted Corps were making ready, on 1st and 2nd November, the 53rd Division moved out about seven miles north of Beersheba. The 10th Division (General Longley) took post at Irgeig. The Australian Mounted Division relieved the Yeomanry Division in General Reserve.

On 3rd November, the 53rd Division moved on towards Khuweilfeh over difficult country. General Mott now met with strong opposition, and on 4th and 5th November he was counter-attacked. The Turks brought up eight battalions and three cavalry regiments, and repeatedly tried to throw the 53rd Division back on Beersheba, without success.

This attack has been judged to have been a bold effort to induce us to alter our plans, and to attract a large force into the hill country up the Hebron road.

Sir Edmund Allenby's comment was :—

"Had the enemy succeeded in drawing considerable forces against him in that area, the result might easily have been an indecisive fight, ... and my own main striking force would probably have been made too weak effectively to break the enemy's centre in the neighbourhood of Sheria–Hareira. However, the enemy's action was not allowed to make any essential modification to the original plan."

The Break-Through on to the Plain of Philistia.—The attack on the Kauwukah and Rushidi works of the Hareira sector of defences was ordered for dawn on 6th November, and, it was intended to secure Sheria and its water by nightfall. The 53rd Division and Imperial Camel Corps continued to be heavily engaged all day on the 6th November holding off the last of von Kressenstein's counter-stroke at Khuweilfeh.

The 10th and 60th Divisions, supported by the 74th Division (General Girdwood), successfully stormed the Hareira lines ; while the Desert Mounted Corps, again rejoined by the Australian Mounted Division, stood by to push into the gap made by the infantry. At 1600 hours the Desert Mounted Corps started northwards, and later, the 60th Division (Major-General Shea) was directed to follow it up into Sheria, which was occupied that evening. Still the enemy was given no respite. The second assault on Gaza was ordered for this night (6th–7th November).

Outpost and Middlesex Hill on our right were to be taken at 2330 hours, and Turtle Hill on the left at 0500 hours. Observe again the successive blows right and left. But the Turk had had enough. That night he withdrew. Only the Atawineh works were still held ; Gaza was empty and some of the XXIst Corps moved through it on 7th November.

It was now the turn of the XXIst Corps to take the road. The 52nd Division (General Hill), preceded by the Imperial Service Cavalry Brigade (Brig.-General Harbord), advanced by the coast, drove in the Turkish rearguards, and reached Deir Seneid on the evening of the 8th November. The 75th Division (Major-General Palin) stayed to deal with the Atawineh Redoubts, and the 54th Division (Major-General Hare) was left to clear up Gaza itself.

The Desert Mounted Corps was strongly opposed, and made little progress without infantry support. The Cavalry were in difficulties for water, which was in deep wells and its distribution slow. On the night 7th–8th November, the Turks managed to extricate the garrison of Atawineh, before the gap could be closed.

On the 8th November the Australian and New Zealand Mounted Division secured a good water supply at Jemmameh, after obstinate fighting. The Australian Mounted Division, closely supported by the 60th Division, marched towards Huj; and a large amount of Turkish artillery was captured. But, in the afternoon, the 60th Division was checked in open country, about a mile west of Huj, by a strongly-posted Turkish rearguard of about two battalions with well-concealed machine-guns and artillery. Part of the 5th Mounted Brigade were close by, and the G.O.C., 60th Division, called on these troops to charge and clear the way. The 1/1st Warwick Yeomanry (Lieut.-Colonel Cheape), and part of 1/1st Worcester Yeomanry—altogether, ten troops—about 170 sabres—were moved rapidly to the right flank, under shelter of a fold in the ground, unseen by the enemy, to within 800 yards of the flank of the hostile batteries. The Yeomanry then charged home, in three lines; and, in spite of desperate resistance, cut down the gunners and dispersed the infantry. They captured a field battery, a mountain battery, and four machine-guns. The Yeomanry lost 75 all ranks, killed and wounded, including Lieut.-Colonel Cheape, killed. This gallant action provides a fine example of the cavalry charge; it was sudden, rapid and opportune; use was made of the ground, surprise was achieved, and the way was opened for the infantry.

The Turkish VIIIth Army now was in full retreat, northwards. The Royal Flying Corps bombers did much execution against the Turkish columns, crowded on the two roads from Gaza. All reports showed that the enemy was greatly disorganized, and persistent pursuit would complete his rout.

Comments.—This phase of the campaign, leading to the capture of Beersheba, is remarkable in several respects.

First, for the most careful and long preparation devoted to it—July to November—during which time much was done in building railways, organizing transport, developing water, and massing the artillery and other reinforcements.

Next, for the secrecy with which the real plan was shrouded, and preserved from the enemy. And, without this secrecy, the operations would have had little hope of success.

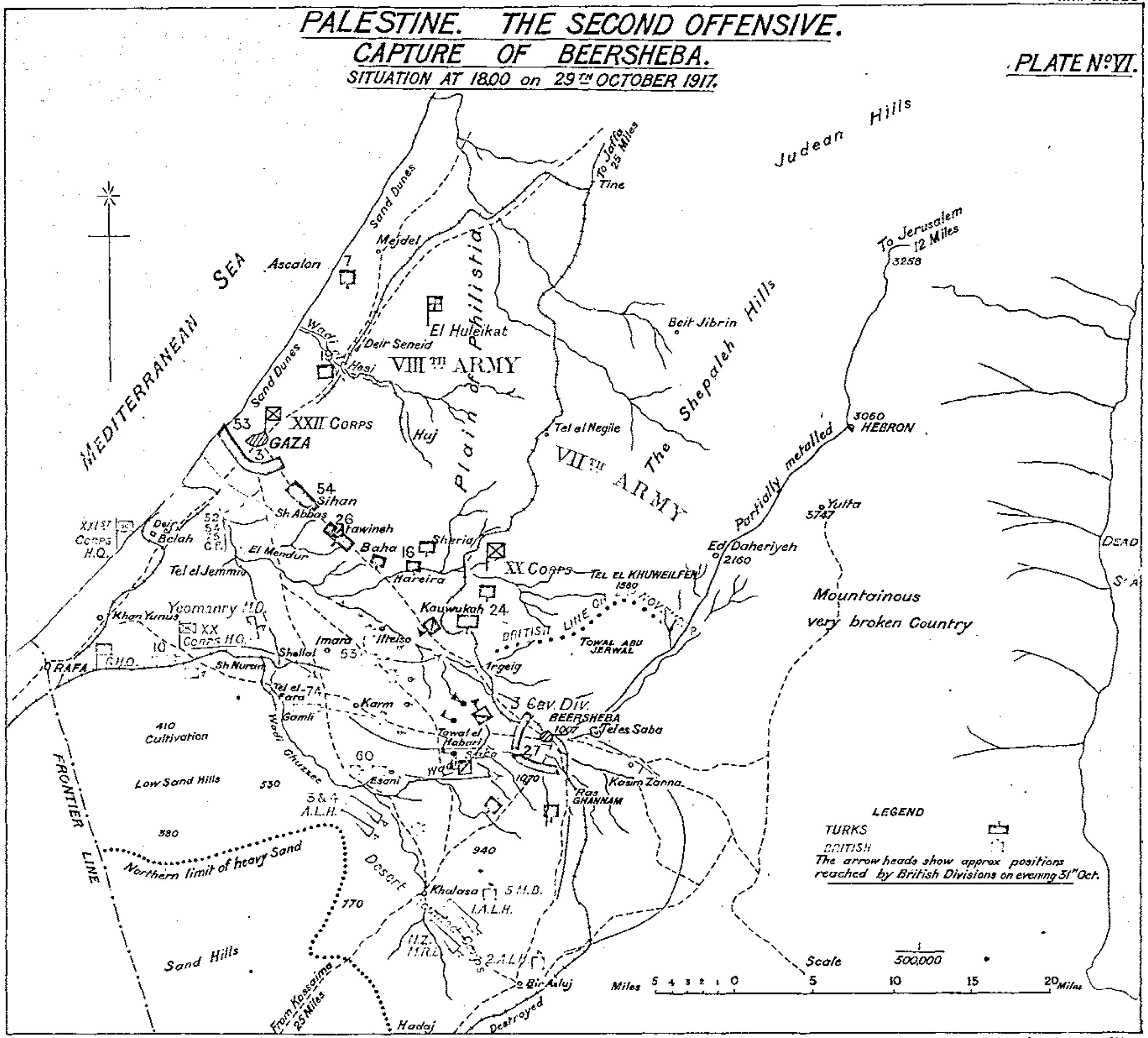
Lastly, these operations are remarkable in that they dealt simultaneously with both stationary and open warfare, and brought in the artillery co-operation of the Royal and Allied navies.

There was Gaza, a stabilized front, and the scene of an extensive bombardment, and of brilliant local operations of trench warfare. And 35 miles away, was the rather exposed outpost at Beersheba, secure, apparently, behind a wide belt of arid country, but still open to surprise and seizure by determined mobile troops. It will be noticed that the mounted divisions were used away on the right, in the dry desert, where the ground was suitable for a great enveloping movement.

In the next phase, these same mounted divisions were brought across to the coast to fight in the fertile plain of Philistia.

(*To be continued.*)

MAP No. 330



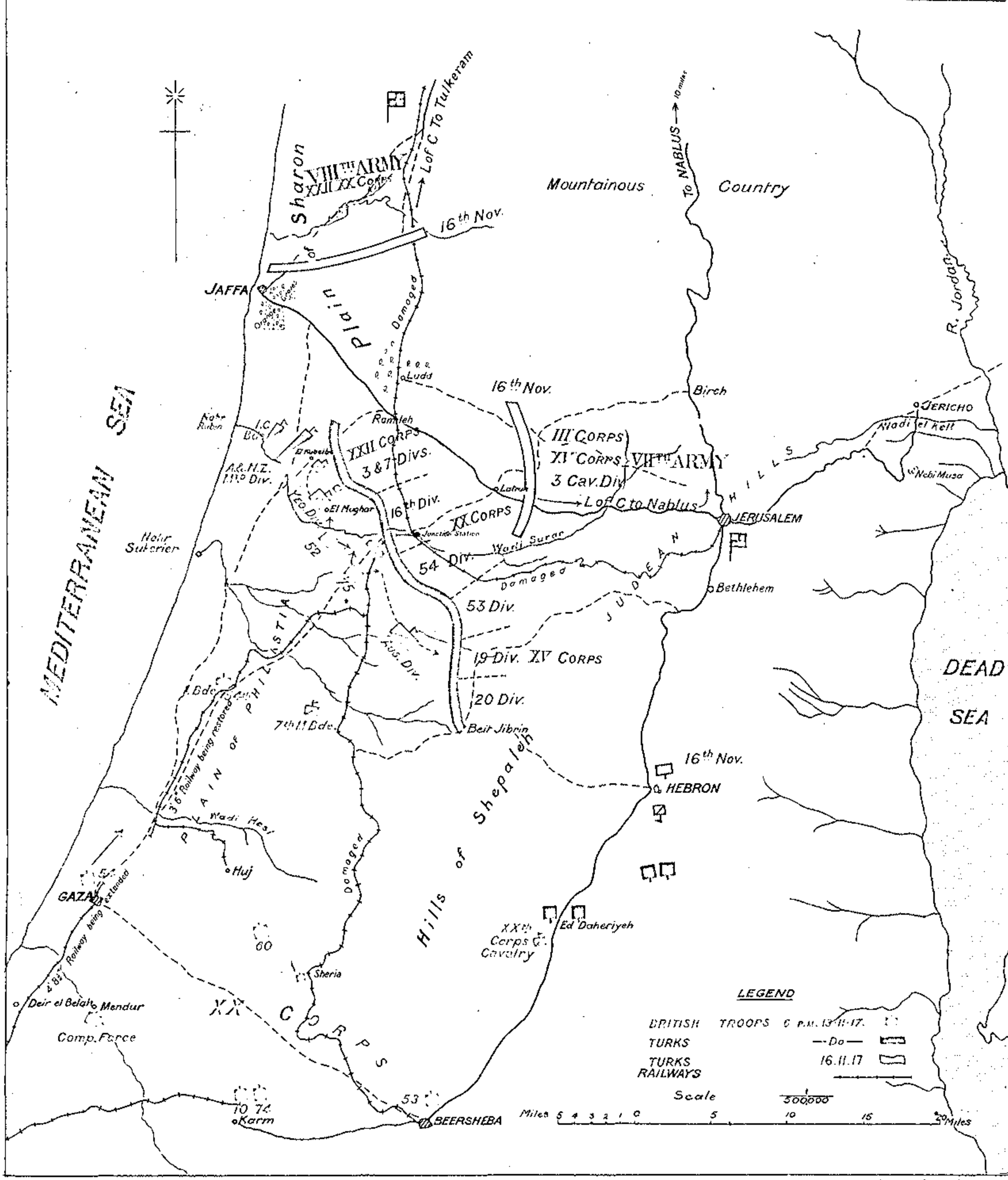
Ordnance Survey, January 1921.

Map No 330

SITUATION of TURKISH ARMY at the end of THE SECOND OFFENSIVE

13th - 16th November 1917.

PLATE No VII



Ordnance Survey, January 1921

APPENDIX I.

EGYPTIAN EXPEDITIONARY FORCE.

FIGHTING STRENGTH—WEEK ENDING 20TH OCTOBER, 1917.*

	Officers.	O.R.
I. *Desert Mounted Corps.*		
Anzac Mounted Division	212	4981
Australian Mounted Division	202	4929
Yeomanry Mounted Division	197	4739
7th Mounted Brigade	54	1118
Imperial Camel Corps Brigade	80	2168
Total	745	17935
II. XX*th Corps.*		
10th Division	399	9252
53rd Division	359	11855
60th Division	346	11683
74th Division	331	11381
Total	1435	44171
III. XXI*st Corps.*		
52nd Division	349	10675
54th Division	340	11147
75th Division	295	9227
Composite Force	170	3710
Total	1154	34759
Grand Total	100,189	

* Infantry and mounted regiments only.

REVIEWS.

MANUAL OF ANTI-AIRCRAFT DEFENCE.

By MAJOR A. E. KING, R.G.A.

General Considerations.—The means employed consist of:—

Machine-guns in aeroplanes; anti-aircraft guns on the ground; small arms on the ground. (NOTE.—Units of other arms are responsible for their own defence against aircraft below 3,000 ft.); searchlights (as an adjunct to the above three at night); sound locators (ditto); balloons and aerial obstacles; alterations of landscapes and employment of false areas; obscuration of lights at night in factories, etc.; smoke screens.

Stress is laid on the speed at which an enemy moves, and the consequent necessity of quick communication and rapidity of fire, *e.g.*, a plane flying directly over a gun, at 15,000 ft. at 100 miles per hour, would only be in range for about four minutes by *day*. (This is comparable to the time available in the case of a torpedo-boat at 35 knots being picked up in a beam at 2,000 yards by *night*, allowing for the return journey.) Hence advanced observers with sound locators must be used to give timely notice of the enemy, so that civilians, as well as the guns and lights can be warned. Operation orders will be standing orders as in the case of anti-torpedo-boat work.

Organization and Administration.—The Anti-Aircraft Brigade will consist of:—

R.A.F.	1 or more squadrons.
R.A.	2 Brigades of 16 to 40 guns.
R.E.	1 Battalion of 96 to 144 searchlights and proportion of locators.
Signal Corps	1 Section.

The O.C., Anti-Aircraft Defences, will be directly under the G.O.C.-in-C., and will issue the necessary warnings to civilians as to obscuration of lights, etc. Normally there will be one Anti-Aircraft Defence Brigade to two Divisions of the line.

Anti-Aircraft Artillery.—Light mobile guns will be used in front areas, and light and heavy fixed guns in back areas. Telephones are most important, especially when co-operating with other means of defence.

Gunnery.—The gun corrections necessary to allow for travel of target, are given in terms of vertical and horizontal deflection. To estimate these, it is assumed that the target will fly in a straight line and at constant speed during the time of flight of the shell (as is usual in gunnery). It is obviously essential to make these two assumptions, and equally obvious that, owing to the great speed of the target, they will often be sufficiently false to make the round miss the target. Therein lies the great difficulty of Anti-Aircraft gunnery.

A point can be fixed in space by its height, angle of sight and bearing. The height of an aeroplane is fairly constant compared to its range, which alters at a great rate. It is, therefore, found convenient to set the gun-sights for height. The angle of sight and bearing are automatically found by laying the gun. The additional information required to hit the target is the fuze setting, tangent elevation, and the correction for travel in the vertical, and in the horizontal planes.

For a given range, the fuze setting and tangent elevation vary considerably for different heights. For instance, the correct fuze for a certain horizontal range would burst nearly 2,000 ft. above a vertical target at the same range. But it is easy to make a graph of the loci of a given fuze setting at different heights, and, by graduating the sights in fuze settings, instead of yards, the necessity of ordering tangent elevation is obviated.

Such a graph is mounted vertically as a gun sight, and corresponds to the tangent sight on an ordinary gun. It is read by a pointer which is first set for height. Thus the height and fuze are ordered, instead of the range and fuze in a field-gun.

The *height* is found and constantly checked by a "height-finder." The "single station" height-finder is a modified Barr & Stroud range-finder, which also measures the angle of sight. It is so geared that when coincidence is obtained, the height, instead of the range, is registered. Other height-finders depend on the principle that when two planes are mounted on horizontal axes parallel to each other at a known distance apart, the height of their intersection above their axes can be calculated. Observers rotate the planes until each is aligned on the target. The angle which each plane then makes with the horizontal normal to its axis is transmitted to a central station where the height is estimated. In some instruments the height is automatically shown as the planes are rotated.

The *fuze setting* (*i.e.*, the range, fuze and T.E.) is found by a "height fuze indicator." This instrument has a graph similar to that mentioned above and mounted vertically. The index of the instrument is adjustable for height, and is moved by a telescopic sight which is kept laid on the target. The vertical angle between the telescope and the bar on which the index slides, is set according to the predicted angular movement of the target during the time of flight, plus the "lost time" (*i.e.*, the time between the observation being made, and the gun being fired). The instrument then gives the correct fuze setting (which includes the T.E. and vertical deflection) to burst the shell at the spot where the target will be when the shell reaches it. In fact, the instrument functions exactly like a position finder.

The *correction to allow for travel* is found by a "Broq." This instrument consists of a telescope moved by two handles ; one in the vertical, and one in the horizontal plane. The handles are each geared to a dynamo, and the instrument is so constructed that the E.M.F. generated by the dynamos are proportional to the angular speed of the target. The E.M.F. is adjusted by resistance to compensate for the time of flight, and the predicted angular movements are then read on two instruments on the principle of volt-meters.

The sequence of events is thus :—

(*a*) The height is found by the height-finder ;
(*b*) The height is set on the height fuze indicator and on the gun-sights ;
(*c*) The fuze is obtained from the height fuze indicator ;
(*d*) The Broq is set to the fuze obtained from (*c*) and then gives the prediction ;
(*e*) The prediction obtained from (*d*) is set on the height fuze indicator ;
(*f*) The operations (*c*), (*d*) and (*e*) are repeated until a balance is obtained ;
(*g*) The predicted fuze is given to the gun and to the loading numbers, and horizontal and vertical deflections are given to the gun.

In some cases the Broq or the gun itself can be used as a height fuze indicator.

Methods of Fire.—The system of engaging an enemy is to fire a group of rounds with the same fuze-setting so as to form a zone through which the enemy must pass. Possibly, with a new equipment, or with heavier guns, it will be advisable to change the fuze for each round.

Observation of fire and the consequent correction of bursts, is extremely difficult. It will rarely be possible to judge from the guns whether bursts are short or over. Aeroplanes fitted with wireless telegraphy and flying parallel to the enemy at the same height, are likely to give valuable information, but, in many cases, reliance must be placed on the height-finding instruments, rather than on observation of bursts.

Firing at an Unseen Target.—Barrage-fire is employed against aeroplanes behind clouds, etc. Its principal value is its moral effect, as small high-explosive shells have little forward effect, and only a radial effect of about 20 yds. Also it is difficult to predict the course of the target.

Sound locators placed about five miles ahead of the gun positions can determine the height, speed and course of a target sufficiently accurately and quickly to enable the guns to put up a barrage which will scare the enemy away. The sound locator is described later.

Bombing by Aeroplanes.—The following table gives some idea of the difficulty of hitting a small target from an aeroplane. The table shows the horizontal distance at which a bomb must be dropped from an aeroplane travelling at 100 miles per hour, in order to allow for the horizontal travel of the bomb after release :—

Height (feet).	*Horizontal Distance (yards).*
2,000	600
4,000	700
6,000	800
8,000	900
10,000	950
12,000	1,000

Searchlights.—These are used to point out targets to our aeroplanes or guns, and to help them in the subsequent engagement. Two good beams on a target are enough for our aeroplanes, but a gun prefers to have three beams. Searchlights on the boundary of a lighted area expose their beams at as low an elevation as is possible and useful, so as to give an early indication of the target. Not more than three beams are exposed on one target so as not to cause confusion. Defending aircraft are responsible for giving signals to show that they are friendly. Our aeroplanes often find it difficult to pick up an enemy in daylight, and it is almost impossible to do so at night, or to maintain contact without searchlights.

The equipment of searchlights, consisting of generator, cables and projector, must be capable of rapid transit to, and action in, a new position. The lorry used has an engine directly coupled to a dynamo (after the Tillings-Stevens system), which can be used either to drive the lorry by a motor, or to run the light.

The projector is mounted to give all-round traverse and 90 degrees elevation. It is controlled in the horizontal plane by a control-arm, about 15 ft. long. If the arm is rotated, the beam moves vertically. The operator of the control-arm has a head and breast set to the sighting number on the sound locator, from whom he obtains instructions when picking up an invisible aeroplane, as to the direction in which the aeroplane can be heard. When the operator of the control-arm sees the target, he takes over control of the beam, and it is found that 15 ft. is far enough away from the beam to prevent him being blinded by the light.

Sound Locators.—Sound travels by means of waves varying in length. Those audible to the human ear vary from $\frac{1}{3}$in. to 70 ft. Sounds from aircraft vary from 10 to 15 ft. The ear is sensible to phase difference, *i.e.*, can detect whether the top or the bottom of a wave is hitting it. When trying to find an audible object, the head is instinctively turned until both ears are in phase, and the object is then in front.

The principle of the sound locator is that the sound is collected in four trumpets fixed parallel to each other in a frame. They are arranged in pairs, and each pair is connected by tubing to the ears of a listener. One listener can move the locator horizontally, and the other vertically. The listeners move the locator until the sound is at a maximum, and an observer then endeavours to pick up the target by looking over the sights fixed parallel to the trumpets.

At night the observer directs a searchlight to move so that the beam is in prolongation of his sights. Corrections are made for the travel of the target during the time the sound takes to reach the locator. Locators can be used up to six miles. When used in advanced positions for intelligence, a fair estimate of the course of the target can be deduced from the angles of elevation and trainings given by the locator. When observations from two locators are available, the height, course and speed can be worked out.

Passive Defence (Aerial Obstacles).—The mere fact of stationary balloons being up has a moral effect on aircraft pilots as they cannot see the wire cable. In the "Apron" system, sets of three balloons are linked together by a horizontal cable carrying streamers weighted at the ends.

Obscuration of lights.—Small towns can be completely hidden at night by obscuring the lights. Large towns cannot be concealed in this way, and it is a question whether the great drawback of darkness is compensated for by the advantage of partial concealment. Signal lights on railways and dimmed lights on road vehicles are invisible, but the glare from the furnace shows up a train. Division of the country into areas is necessary to prevent the wholesale stoppage of work, etc.

Smoke Screens.—These, on a small scale, *e.g.*, for a small factory, merely draw attention to an area worth bombing, and on a large scale are difficult to organize, and are liable to interfere with Anti-aircraft lights, guns, etc.

NOTES ON SPORTING RIFLES.

By COLONEL H. V. BIGGS, D.S.O. (late R.E.).

IN case they may not have heard of it, I would like to call the attention of any brother officers interested in sporting rifles to a most useful little book, called *Notes on Sporting Rifles for use in India and elsewhere*, by Major Gerald Burrard, D.S.O., late R.F.A., price 4/6, published by Edward Arnold.

It first appeared several years ago as a series of articles in the *Field*, but has since been published in book form. It appears to me the most practical one that has been published since *The Modern Sportsman's Gun and Rifle* of the early 'eighties. It gives most useful tables of practically all modern rifles, showing charge of explosive, weight of bullet, with M.V. and energies at sporting ranges; also, separately, tables of trajectories. In addition, it is full of most useful notes and tips about big game shooting generally, sights and sighting, cleaning and care of rifles, etc., as well as much information that is not ordinarily known to those who have not made a special study of rifles. Anyone about to buy a rifle would, I am sure, do well to first obtain this book and study it carefully.

Major Burrard deprecates a rifle under about 8 lbs. weight and recommends barrels of 26 in. to 28 in. length. This is undoubtedly correct generally and for one's main battery. At the same time, one is often disinclined to carry a heavy rifle in great heat, or towards the end of a long day, and I found that I lost so many shots from not always having a rifle in my hand that I finally got a light magazine rifle of about $7\frac{1}{4}$ lbs. weight with only about 22-in. barrel, which I always carried myself, generally over one shoulder in the way Major Burrard advocates, and found this a great advantage. Barrels are apt to catch when traversing dense jungle unless they are very short, especially when carried over the shoulder as one must do on steep ground where the use of the hands is necessary for climbing.

The method he recommends of having the distance for which a rifle is sighted dependent upon its trajectory, instead of the arbitrary hundred yards, is one I have practised for some 30 years or more, and had many disputes with gunmakers about. I, however, always took 2 in., instead of his $2\frac{1}{2}$ in., as the maximum height of bullet above the line of sight.

He strongly recommends black powder express rifles for jungle-shooting, for those who cannot afford expensive H.V. rifles. They are certainly excellent for this, and I found them—with heavy bullets—kill more instantaneously than H.V. rifles of greater power. I think he, however, to some extent underestimates the disadvantages of black powder. I have shot charging game on foot at close range with it and for a second or two have not known what had happened; whether the beast was stopped or was coming on. Often I have fired at animals, and when the smoke cleared there was nothing to be seen; and, except for the sound of the striking bullet, one did not know whether the animal was hit or not, nor anything about its whereabouts; whether it had dropped or gone on, or was lying in wait. Of course, if there is any breeze, the smoke does not matter, it is blown away at once. With smokeless powder one can almost see the bullet hit, and knows exactly what the animal has done.

Another disadvantage of black powder rifles for those who cannot afford more than one weapon is that they are generally unsuitable for hill shooting, as most of them shoot low at high altitudes; the amount varying with the altitude and differing with almost every rifle. A D.B. ·500 Express that I had, firing 6 drs. of powder and a 480-grain bullet, with 26-in. barrels, shot 10 in. low at 100-yds. range at 7,000-ft. altitude. Another ·500 Express, of slightly different load and with a lighter bullet carefully tested with mine, shot 18 in. low under the same conditions. The latter would, quite possibly, shoot 3 ft. low at 14,000 ft. altitude or even more. I well remember the tales brought back from Kashmir in the early 'eighties of the extreme difficulty of judging distance in the hills; some even returning empty-handed in spite of numerous apparently easy shots. It may doubtless have been partly due to the difficulty of judging distance in the hills, but, I am sure, it was mostly due to the different shooting of the old Express rifles at different altitudes, the amount varying as one moved up or down a hillside. The old Service Martini-Henry rifle, however, though firing black powder, did not shoot low at high altitudes, but slightly high, practically in accordance with theory—due to the more rarified air giving less resistance, and therefore a flatter trajectory. I have not known any H.V. smokeless powder rifle do otherwise than shoot slightly high at high altitudes, more or less in accordance with theory. Those I tested shot $\frac{3}{4}$ in. to $1\frac{1}{2}$ in. high at 100 yds. range at 8,000 ft. altitude. The only reason I can assign for this behaviour of the Express rifles is, having, as they had, as a rule, light bullets with comparatively short barrels and very heavy powder charges, that the lessened resistance in the barrel of the air at high altitudes to the passage of the bullet was insufficient to develop the full force of the powder and that some of it was probably blown out unburnt. The fact that certain Expresses, such as Henry's, which had shallowing grooves that would give resistance right up the barrel, did not shoot low at high altitudes, would lend support to this theory.

My experience of down-hill shooting does not accord with that of Major Burrard, *viz.*, that the high shooting is due to the difficulty of craning one's neck sufficiently; but I may be wrong. I nearly always had two completely independent sets of sights on my rifles. One set, the open V (almost a straight line) with a fine bead foresight on a rather high block; and, secondly, a Lyman peep-hole backsight with a Beach combination foresight, but with the knife-edge removed and the pivot distance increased so that, when turned down, it lay below the top of the block of the bead foresight; and when turned up, stood clear above the bead. With a rifle with these sights I put up two targets at the same distance, but one on a level and the other at a steep downward slope. I then fired alternate shots at each target with the open sights, using an improvised gunmaker's rest. I have not the notes of this test, but I know that the result showed that, at the down-hill target, the centre of the group was the equivalent of at least 12 in. high at 100 yds., compared with the horizontal target. I think it was a little over 12 in. I then substituted other targets and repeated the test with the peep-hole sights and found that there was no appreciable difference in height between the two groups.

Major Burrard rightly condemns the ordinary Express hollow-nosed bullet generally used with black powder rifles. If these are cut down longitudinally, it will generally be found that there is only a little over ⅛ in. thickness of lead at sides and base. If one of these bullets strikes an animal in a soft place—like between the ribs behind the shoulder—it will probably prove deadly and drop the animal in its tracks. If, however, it strikes a hard part—like the shoulder muscles—it flies to pieces just under the skin, making a purely superficial wound, only about 2 in. deep. A long, heavy bullet, with a small hollow only extending about half-way down and with a solid, heavy base is, however, quite a different matter. I used bullets like this, cast from melted-down Martini-Henry bullets, of 480 grs. weight, from a ·500 Magnum Express, and it was the most deadly rifle I ever had. Any at all well-placed bullet usually dropped an animal in its tracks, and even badly-placed bullets seemed to have a paralysing effect. With tigers, I, on two occasions, broke the opposite shoulder with it. For H.V. smokeless powder rifles the Westley-Richards capped bullet was quite the best of all that I tried.

The book does not mention a rather curious fact occasionally met with and referred to on pages 362–3 of *The Modern Sportsman's Gun and Rifle*, *viz.*, that some rifles with the same sight, fired on a level range, shoot higher at 150 yds. than at 100 yds. I came across two rifles that did this, one of which I owned. In both cases they were short-barrelled weapons, almost carbines, with the backsight rather far forward, so that the sights were comparatively rather close together. As mentioned before, I had two sets of sights on most of my rifles, and had on this one. I therefore carefully tested it; first with the open sights with a gunmaker's rest at 50 yds., 100 yds. and 150 yds., taking the centres of groups. The 100-yds. centre was lower than the 50-yds. centre, but slightly less than it should have been by theory; but the 150-yds. centre was ¾ in. to 1 in. higher than at 100 yds. I then repeated the test on the same range in exactly the same way with the peep-hole sights and found that the centres in each case dropped regularly with each longer range, practically in accordance with the theoretical trajectory. It is, therefore, difficult to explain this result with the open sights, unless it may be due to some different focus of eye at different distances, with sights rather close together. It is a great advantage when this happens, as it practically does away with judging distance at ordinary sporting ranges.

As recommended by Major Burrard, it is always best to buy a first-class rifle, either new or second-hand. I believe that it will be found that the eventual cost of doing this—that is, the difference between purchase price and the price when subsequently sold—will not very much exceed that for an inferior weapon. A first-class rifle by a well-known maker, if taken care of, will generally fetch a fair price when it comes to be sold. This certainly used to be the case in India. On the other hand, an inferior weapon will fetch very little.

The following results of experiments with the sun in different positions may be useful to remember when sighting or testing a rifle for 100-yds. range.

WITH OPEN SIGHTS.

Sun on left front makes one shoot about 2 in. right and 1 in. high.
,, ,, right ,, ,, ,, ,, ,, 2 in. left ,, 1 in. ,,
,, ,, left rear ,, ,, ,, ,, 2 in. right ,, 1 in. low.
,, ,, right ,, ,, ,, ,, ,, 2 in. left ,, 1 in. ,,

Shading the sights makes one shoot about 1 in. high.

It is not, however, known if the above results would be affected by giving a reverse slope, that is, towards the breech, to all parts of both sights, so as to prevent any light being reflected to the eye. In that case it is quite possible that the position of the sun might not affect the shooting.

WITH PEEP-HOLE SIGHTS.

The alignment is not so much affected, but the sun in rear makes one shoot about 2 in. to 2½ in. higher than if in front. Shading the sights makes one shoot about 1½ in. higher than if unshaded.

H.V.B.

NOTICES OF MAGAZINES.

MILITÄR WOCHENBLATT.

No. 47.—A review by General von Kuhl of Field-Marshal Conrad von Hötzendorf's Memoirs (First Volume from 1906–1909) appears. He commences by an appreciation of the dangers which threatened Austria-Hungary at the time of his appointment as Chief of the General Staff in 1906—dangers due no less on account of her mixed population than to the rivalries and aspirations of her neighbours. Conrad, he tells us, lacked no courage in facing them. Any conciliating weakness towards internal Nationalist movements directed against the unity of the empire he held to be wrong. He did not consider that he could escape the external dangers which threatened from Serbia, Italy and Russia by a "wait and see" policy. Military action alone could, in his opinion, relieve the State from this pressure. Von Kuhl declares that Conrad continually emphasized this point of view with the Foreign

Minister and also with the Emperor Franz Josef, and urged upon them the necessity for conducting war at the right time and on no account to delay it till their opponents considered it opportune to begin, as they would then run the risk of facing crushing odds.

Thus, according to von Kuhl, in 1907 Conrad was desirous of waging war with Italy, but his proposal was opposed by Ahrental, Foreign Minister, and by the Emperor. Again, during the crisis of 1908–9, Conrad was in favour of deciding the quarrel with Serbia by recourse to arms. His idea was to annex that country; in his opinion this would, so far as could be foreseen, be the last opportunity for a successful war with Serbia. These opportunities having been allowed to lapse, Conrad endeavoured to prepare the Austro-Hungarian armed forces for the coming fight for existence, but met with much obstruction. Von Kuhl questions whether the Monarchy was virile enough to take the line of escape proposed by Conrad.

In 1909 Conrad and Moltke were collaborating in the event of a common action. The latter deplored the failure of Austria to make use of her opportunity against Serbia. The agreements arrived at, says von Kuhl, had great influence in the opening phases of the campaign in the East in 1914. It was agreed that Germany should first employ her main forces against France in order to obtain a decision in that quarter, after which the main forces of both countries were to be employed against Russia. Meanwhile the Germans were to hold the Russians with 12—13 divisions in East Prussia, while Austria carried on the campaign alone. Moltke estimated that Germany would obtain a decision against France in three to four weeks. Von Kuhl stated that the movement of German troops to the Eastern Front was actually commenced "according to plan" under the mistaken notion that a decision had been obtained in the West.

According to the agreement, Austria was free to commence operations against Russia in whatever way she might decide. The situation obviously became increasingly difficult if Russia were to begin an offensive after Conrad had dispatched strong forces against Serbia, in which case only a negligible force would remain in hand to meet it. Moltke desired to leave his commander in the East a free hand; but, as a result of Conrad's importunity, he definitely pledged himself to attack in support of the Austrian offensive. Conrad maintains that the agreement was killed by the German failure on the Marne, and that the Austrians were left to bear the brunt against a much superior enemy single-handed, and did so successfully.

Von Kuhl questions the wisdom of Conrad's course of action. After dwelling on the geographical disadvantages of the situation, he emphasizes the difficulties inherent in delivering an attack from a central point on an enemy disposed on a wide arc. In addition, he points out that Austria had made the further mistake of detaching half its armies against Serbia, apparently in the vain hope of restricting the war to that country. He should have realized the futility of this.

In conclusion, von Kuhl condemns the two simultaneous offensives against Russia and Serbia, on the lines actually carried out, as doomed to failure.

The Examination for the Admission to the French War Academy, 1922.—Von C. draws as his conclusion from a study of the questions set in the above examination, that the French encourage a perfect knowledge of the regulations and their application to the solution of the problems, in contradistinction to the Germans, who prefer to test the candidate's power of arriving at a decision and capacity for taking responsibility, together with a logical appreciation for the solution offered and the writing of clear and concise orders. He points out that, whereas the Germans demanded only a general knowledge of the particular period of military history set and tested the candidate's aptitude for applying the lessons learnt to later and present-day problems, the French require a detailed knowledge of the campaign, and set direct questions on it. It is suggested that campaigns are deliberately selected so as to fire the imagination of the young officer. After examining the French treatment of the subjects of International Law and Geography, von C. is of the opinion that the examination is framed with a view to promoting purely military knowledge and to direct the national aspirations towards a selected goal.

In conclusion, von C. points out that knowledge alone does not ensure success in war, but rather the power of initiative developed in the individual. A lesson can, however, be learnt from the second intention, *viz.*, the focussing of the youth of military age on a great national ideal.

No. 48.—The first instalment of an article eulogizing the work of the captive balloons in the German offensive between Arras–La Fère, in March, 1918, appears.

A Danish correspondent contributes an article in which he records the results of the great Parliamentary Commission for the reorganization of the Danish armed forces. Every member made his own separate proposal, no two members agreeing. The proposals ranged from complete military disarmament and the substitution of a civilian reserve police force, 6,000 strong (proposed by the Social Democrats) to an army of peace strength of 13,000, expanding to 150,000 in time of war (proposed by the Generals).

As the Left and Right parties together have a majority in the House, he thinks it probable that the compromise will be more or less based on the proposals made by the Left, which takes up for a standing army 6,700, expanding to 67,000 on mobilization. Even this would not provide for any reduction in annual expenditure.

The correspondent points out that the Left (or Peasant's Party) has always been Germanophobe. They desire to transfer two-thirds of the Army to Jutland. Military opinion also recommends "paying great attention to our Southern neighbour." Germany should realize that her neighbours have no intention to disarm.

A Hungarian correspondent records that the Treaty stipulations respecting the Hungarian Army have now been complied with. Hungary remains with a professional army numbering 1,750 officers, and about 33,000 men. They are said to be organized in seven brigades, four independent regiments of Hussars, four independent batteries and three pioneer battalions. Each brigade is given as consisting of two infantry regiments, each of three battalions, one cyclist battalion, one squadron of Hussars, one mixed artillery detachment and complement of mine-throwers, telephonists, and A.S.C.

Von W. deplores the new reform law for the Dutch Army, which he summarizes as being an acceptance of the Militia principle, always, in his opinion, a very doubtful step for a nation averse to military pursuits. He estimates the war strength of the Army as fifteen times the peace strength. Considerable economies are effected, but involving, he thinks, great sacrifices from the military point of view.

An article appearing in *Voena i Mir* ("War and Peace"), a new Russian journal published in Berlin, is reviewed. According to the author, the inadequate training of the higher leaders was abundantly proved in the late war. This made them too dependent on their General Staffs, tending to lessen their authority. The French, it is stated, recognized the need for such training and had introduced a *Centre des Hautes Etudes Militaires.* The war intervened, however, before appreciable results were possible. England was wholly unprepared for the problems of a Continental war. In the opinion of the *Militär Wochenblatt* these criticisms are in the main justified. The French have entirely remodelled the training of their higher commanders since the war. The courses given ensure that future leaders are not only efficient as soldiers, but also not lacking in political and economic knowledge. This, it declares, is a new and most noteworthy departure.

In an article entitled "Training of Officers in the Czecho-Slovakian Army" it is stated that not only Poland, but also Czecho-Slovakia are taking the French Army as their model. Particulars are given.

No. 49.—In a Francophobe article, Lucius Cincinnatus depicts that country as being at the root of all trouble in Europe. He takes comfort in statistics according to which, notwithstanding her losses in territory, Germany will, in 1940, possess a population twice that of France, and more than have made up the leeway incurred in surrendering two provinces.

Captain Mischer concludes his article on the work of the captive balloons in the 1918 offensive.

Italy is stated to be cutting down her army expenditure. 800 active officers are said to have been relegated to the reserve and are to be followed by a further 3,000 to 4,000 next year. Reductions in the rank and file are also being provided for.

Various reasons are assigned for Italy's growing loss of power in the arena of foreign politics. By the Treaty of Lana she is represented as being confronted with an alliance more dangerous to her than Austro-Hungary ever was.

In an article, Captain Prigers condemns the hostile attitude adopted by the Union of present and former professional soldiers towards the officer caste. Membership of this Union has lately been forbidden to serving soldiers.

No. 50.—Nothing of special interest.

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

REVUE MILITAIRE GÉNÉRALE.

May, 1922.

The Military Potentialities of Germany To-day.—By General D'Urbal. Under present circumstances Germany could not take the initiative in a war. Her peace-time force is strictly limited, and can only be considered as the framework of her war units; but her large population must, in the end, ensure her numerical superiority. Her mobilization must be slow, whereas France should have with the colours a nucleus sufficient to enable her completely to mobilize her whole army at once. Germany requires time, and will not depend on diplomacy alone to ensure it. Time can always be gained by retiring the base of concentration, but this means loss of territory; and when the latter includes the Ruhr basin and Essen, it is a matter for grave consideration. Her better plan would be to depend on the resistance of a strong covering position, not on the Rhine, for that would assume too great an inertia on the part of the adversary. The mountainous region stretching parallel to the Rhine and 30 to 50 kilometres to the east of it offers a strong defensive position of suitable depth; but Essen is in front of it. It would be worth taking the risk of France advancing into the dangerous corridor between the Rhine and the Dutch frontier and to hold the Rhine from that frontier to Ruhrort and the Ruhr, from Duisburg to Werden, after which the line would probably run past Solingen, Lingen, Wetzlar, Hanau and the river Main as far as Mittenberg, and thence through the Black Forest to Switzerland. Behind this line, held by local levies, the Germans could complete their mobilization and concentration. The Rhine would not be entirely abandoned; light units would take the field in the valley to evacuate mobilizable men, horses and material, while disputing the ground as far as possible, or even to facilitate an advance of the main body to the Rhine, should France give the opportunity. To furnish troops and material for the defensive line of 500 kilometres, recourse must be had to camouflage. It will be bad luck if, in Essen and other places, a quantity of material could not be concealed, and the 70,000 workmen might contain a few thousand soldiers, while sports' and veterans' associations could provide a force sufficiently trained to offer some resistance until the main covering-position is occupied, and could be constituted, ultimately, into regular units. Once firmly posted in the covering-position, the Germans would have France at their mercy, could bide their time, dare her to advance on a new war of attrition, and could detach a few divisions to take Poland in rear in her war with Russia, and so open the way for the Red armies. When they have incorporated Austrian units in their army and arrived at their full strength, a frontal attack, combined with infiltration through Holland and a strong flank attack by the Swiss plain on Dijon and the valley of the Seine, would probably oblige the French to abandon the Rhine and fight a battle in the open with all the advantages against them.

If this forecast is correct, strategical railways, leading to and along the covering position, may soon be commenced, concrete platforms—for tennis courts—may be expected, and civil aviation will never have enough hangars; but if the last two, and stocks of warlike stores, and military organizations disguised as sports' clubs, may escape the attentions of commissions of control, the railways will be enough to show the intentions of the German military authorities.

The Revision of the Regulations.—Continuation of the article by "Lucius."—*Sixth period—The Great German Offensive in the Spring of* 1918 *and the Reappearance of Open Warfare.* Taught by experience on their Eastern Front, the Germans fully agreed with their Chief, Ludendorff, in the possibility of breaking the line and developing the success. The submarine war entered into in February, 1917, had not fulfilled expectations, and the arrival of U.S. troops in France now appeared inevitable, while the attack had proved its superiority to the defence. As a rapid decision was imperative for the Germans, Ludendorff concentrated 203 out of a total of 241 divisions on the Western Front, a superiority of 30 divisions over the Allied Forces, and, abandoning strategy, selected the neighbourhood of St. Quentin for his attack, for the tactical reasons that it was the weakest part of the Allied line, and the ground offered fewer difficulties.

The characteristics of the German offensive doctrine were surprise in the preparations and rapidity and continuity in the execution.

1st.—Surprise.—Stragetical surprise was sought by manœuvre (the same signs of attack developed in Champagne and Picardy), and by concentration of the reserves in a central position so as not to reveal the real plan. Tactical surprise was obtained by careful concealment of the preparations, by strict control of traffic, by a drastic reduction of telephonic messages and correspondence, by secret transmission of orders which were invariably copied by hand by an officer, by assembling the troops at night, and, except in the case of artillery, only at the last moment, and by the brevity and violence of the artillery preparation.

2nd.—Rapidity and Continuity in Execution.—The guiding principle enounced was that rapid progress gives the maximum of protection and ensures success, consequently (*a*) the infantry attack, once opened, must be pressed on as rapidly and as far as possible without halt; (*b*) the enemy's artillery, which is the backbone of the defence, must be overwhelmed in the first onslaught, which should reach a depth of eight kilometres or more, up to or beyond the enemy's artillery position; (*c*) since the artillery cannot change position as quickly as the infantry, the attack will comprise two stages, (1) the battle of position, in which the infantry is supported by artillery, and (2) the battle for the intermediate zone, commencing when the infantry has partly lost touch with the artillery and the conduct of the fight devolves on the junior commanders, for which reason infantry must be given means to carry on the action with their own resources; (*d*) strong points need not be captured, until, by permeation into the intermediate gaps where resistance is less, it will be possible to attack them in flank and rear; (*e*) to sustain such an attack, reserves must not only be numerous, but must not be engaged without real necessity, *i.e.*, only when the front line units are at their last gasp.

3rd.—Employment of the Larger Formations.—Under such conditions, the battle presents a series of successive efforts aiming at objectives as distant as possible to ensure rupture, and then open warfare; in its initial stage a comparatively easy matter with all arms acting in combination. In order to husband the reserves, front-line divisions will occupy narrow fronts of 1,800 to 2,000 metres and must not expect to be relieved for several days. The great point is to hold back the reserves until it is absolutely necessary to use them, with a view to maintaining progress to the greatest possible depth. The commanders' duty is, therefore, (*a*) to economize infantry; (*b*) never to send his reserves into action until the favourable moment, and in places where the advance is making the best progress; (*c*) to maintain a sufficiently deep formation to cover the flanks and ward off counter-attacks; (*d*) to reconstitute his reserves during the battle to ensure continuity of effort, and to maintain pressure on the enemy, especially where success has been obtained; (*e*) to make certain of good intercommunications and to follow the fight closely, all staffs should be in the field, and those of the divisions well to the front.

4th.—Employment of the Various Arms: Infantry.—Infantry will not only have to occupy the ground, but must be able to overcome all resistance without artillery aid, to which end it was ordained that each regiment should have under its orders a field battery from the divisional artillery and six *Minenwerfers*, in addition to its heavy and light machine-guns, rifles, bayonets, grenades and trench-mortars. Even in the first stage of the battle, the artillery barrage might fail somewhere. In the second stage the attack ceases to be automatic, and the enemy artillery position, once captured, assumes the character of open warfare. Mechanical method fails, and individuality finds scope. The pursuit of the enemy must be rapid and continuous; units do not wait for each other, but must guard themselves effectively against unforeseen resistance. If the enemy halts to fight, he must be quickly driven in, even at the expense of considerable loss to the attackers. Should the enemy have time to occupy a rear position with fresh reserves, the zone in front of it must be cleared of his troops and the position reconnoitred. The ensuing attack will be ordered by superior authority with all arms combined and preceded by an artillery preparation; in fact, the same process as before, but greater rapidity is possible. As in open warfare, so in the battle for rupture, the junior commanders from company and battalion upwards, must, once the artillery barrage commences, be allowed full liberty of action and tactical initiative, for on these depends the development of the success.

Artillery.—Brevity and violence in the artillery preparation are obtained by expert arrangements obviating the necessity for ranging, and by the use of gas-shell for neutralizing, instead of destroying, the hostile artillery. But as neutralization is only temporary, the infantry attack must follow quickly. Counter-battery fire for systematic destruction should, however, be increased before the infantry advance. *Minenwerfer*, the range of which now attains 2,000 metres, should be employed during the preparation for the destruction of obstacles and other defensive organizations to set guns free for other duties. As to the duration of the artillery preparation, the paralysis of the artillery and destruction of the essential features of the defence requires several hours. Efforts to secure surprise must not lead to hasty and partial artillery preparation. A Note of 16th February lays down two hours for the length of the artillery preparation against the hostile artillery and as much against the infantry positions. It should, as a rule, commence at night, so as not to detain the infantry too long in their position of departure. In the first stage the rolling barrage will be executed by the largest possible number of batteries, and allow the infantry to advance without halting. It will be double, mortars and heavy guns aiming in front of the field artillery. Ludendorff laid down that a battery of four field guns should engage a front of 70 to 80 metres, and preferred that the advance of the barrage should be regulated by visual signals from the infantry rather than by a fixed time-table. In the second stage it is necessary that the infantry should never be without powerful artillery support—a most difficult task; the guns which have prepared the way can only partially fulfil it, and other powerful and mobile guns are required. The artillery should be distributed in three groups—the regimental guns marching with the infantry, the batteries intended to change position and participate in the advance to the attack, and those remaining in position—the foremost of which will cover the advance of the preceding. Experience gained at Riga led to the abandonment of entrusting the artillery command to the commander of the divisional artillery reinforced to that end, and to placing it in the hands of a special chief, generally the commander of the corps artillery. Thus, for counter-battery work, the Germans adopted the same procedure as the French.

Aviation.—As the German air force was decidedly inferior to that of the Allies, it was only expected to attempt mastery in the air at the moment of attack to assure the operation of the infantry *liaison* planes which flew low and brought machine-guns to bear on the hostile infantry. Distant reconnaissance was undertaken by isolated machines, flying at a great height. Night bombardment in the back areas was entrusted to complete squadrons. It is noteworthy that none of Ludendorff's rules and instructions mention the use of cavalry for developing the success after a rupture.

A. R. REYNOLDS, *Colonel.*