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CONTENTS.

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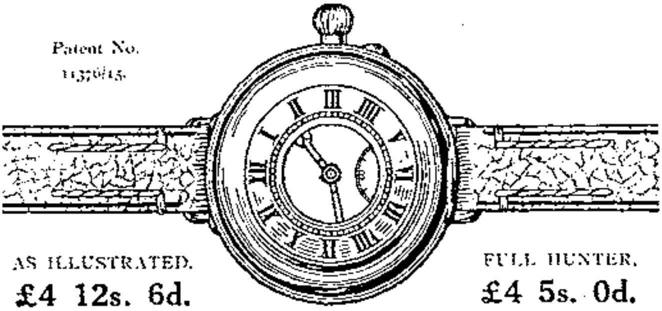

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CONTENTS.

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MILITARY BRIDGES.

SOME NOTES ON THE DISTRIBUTION OF HEAVY LOADS.

By LIEUT. W. N. THOMAS, R.E.

IN order to design a bridge, the decking of which is carried by several girders, it is obviously not sufficient merely to know the *average* load borne by each girder, but it is necessary to determine—at any rate approximately—the maximum proportion of the total load to which any particular girder may be subjected.

It is frequently stated in text-books that the distribution of the main load on to the supporting girders depends upon the relative stiffnesses of the decking and of the girders, and these stiffnesses are dependent upon—

(*a*). The value of E for the material of which the decking is composed.

(*b*). The value of E for the material of which the girders are composed.

(*c*). The moment of inertia of the decking cross-sectional area.

(*d*). The moment of inertia of the girder cross-sectional area.

(*e*). The span of the main girders, their distance apart, and the methods by which their ends are fixed or supported.

(*f*). The initial distribution of the load on the decking, and the manner in which this load is transferred on to the main girders, are also factors which affect the final distribution.

The unevenness of the distribution under ordinary conditions is not however very generally appreciated, and hence it has been thought worth while to give in the following a few curves and calculations to show how the proportion of the total load brought on to each girder varies with varying conditions, and to indicate to some extent the magnitude of this variation.

There are so many variables which affect the distribution of the load on to the main girders, that it would be too complex to attempt a perfectly general solution, and consequently the investigations have been confined to the case of a road bridge, 10 ft. wide between the ribbands, to carry the 6-in. gun. This gives a live load of 17 tons on two wheels, each of which is 20 in. wide, and the wheel base measures 9 ft. from outside to outside of tyres.

If a live load factor of $1\frac{1}{2}$ be adopted, the equivalent dead load on each wheel is 12·75 tons, and the calculations have been based on this figure. If a live load factor of 2 be adopted, the results are all increased in the ratio of $1\frac{1}{2}:2$.

Two particular positions of the gun relative to the central axis of the bridge have been considered—(1), when the gun is in the centre of the roadway, and the loading is consequently symmetrical; and (2) when one wheel of the gun is on the edge of the roadway, *i.e.* close up against the ribband. *Figs.* 1 and 2 show these two cases.

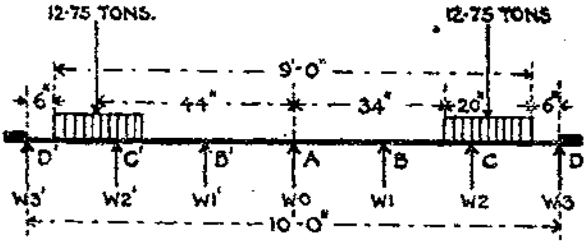


FIG. 1.

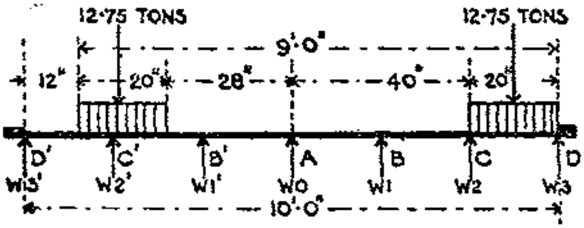


FIG. 2.

The following example dealing with a bridge having seven main girders, and carrying the gun in the eccentric position (*Fig.* 2) will now be taken to illustrate the method of calculating the reactions on the different girders.

The total live load, as already stated, is 17 tons, giving an equivalent dead load of 25·5 tons on the two wheels, or 12·75 tons on each wheel of 20-in. width.

The first step is to obtain, by means of the equations given in the Appendix, an expression for the deflection of B below A, by considering the strip of decking which is carrying the two wheel loads, and so causing the reactions w_3', w_2', w_1', w_0, w_1, w_2, and w_3 on the main girders.

It is convenient to assume this deflection as the algebraic sum of the separate deflections caused by each of the individual forces acting on the decking either to the right or to the left of A.

Thus if the forces to the right of A are taken, there are four separate deflections, viz. :—

(i.) That due to the reaction w_1 upwards.
(ii.) „ „ w_2 „
(iii.) „ „ w_3 „
(iv.) „ to the wheel load 12·75 tons downwards, and in addition must be considered
(v.) „ to the slope of the beam at A, assumed positive downwards to the right.

Calculating these partial deflections separately we have—

(i.) From Equation 5 in Appendix

$$EI\delta_1 = w_1 \frac{20^3}{3} = 2{,}666{\cdot}\dot{6}w_1.$$

(ii.) From Equation 4

$$EI\delta_2 = w_2 \left\{\frac{40 \,.\, 20^2}{2} - \frac{20^3}{6}\right\} = 6{,}666{\cdot}\dot{6}w_2.$$

(iii.) From Equation 4

$$EI\delta_3 = w_3 \left\{\frac{60 \,.\, 20^2}{2} - \frac{20^3}{6}\right\} = 10{,}666{\cdot}\dot{6}w_3.$$

(iv.) From Equation 1

$$EI\delta_4 = 12{\cdot}75\left\{\frac{50 \,.\, 20^2}{2} - \frac{20^3}{6}\right\} = 110{,}500.$$

(v.) $$EI\delta_5 = i_A \,.\, 20 \,.\, EI.$$

The total deflection of B below A may therefore be written as

$$\delta = \frac{1000}{EI}\left\{110{\cdot}5 - 2{\cdot}\dot{6}w_1 - 6{\cdot}\dot{6}w_2 - 10{\cdot}\dot{6}w_3 + {\cdot}02 i_A EI\right\}.$$

Similar expressions for these partial deflections at the points C, D, B′, C′, D′, are tabulated in Table I. and reduced in Table II.

TABLE I.

EIf at	Due to $\frac{W}{2}$ (downwards).	w_1 or w_1' (upwards).	w_2 or w_2' (upwards).	w_3 or w_3' (upwards).	i_A (downwards).
B	$12{\cdot}75\left\{50\,.\,\frac{20^2}{2}-\frac{20^3}{6}\right\}$	$\frac{w_1 20^3}{3}$	$w_2\left(\frac{40\,.\,20^2}{2}-\frac{20^3}{6}\right)$	$w_3\left(\frac{60\,.\,20^2}{2}-\frac{20^3}{6}\right)$	$20i_A EI$
C	$12{\cdot}75\left\{\frac{50\,.\,40^2}{2}-\frac{40^3}{6}\right\}$	$w_1\left(\frac{20^3}{3}+\frac{20^2\,.\,20}{2}\right)$	$\frac{w_2 40^3}{3}$	$w_3\left(\frac{60\,.\,40^2}{2}-\frac{40^3}{6}\right)$	$40\,.\,i_A EI$
D	$12{\cdot}75\left\{\frac{20^3}{8}+\frac{3\,.\,40^2\,.\,20}{4}+\frac{40\,.\,20^2}{2}+\frac{40^3}{3}\right\}$	$w_1\left(\frac{20^3}{3}+\frac{20^2\,.\,40}{2}\right)$	$w_2\left(\frac{40^3}{3}+\frac{40^2\,.\,20}{2}\right)$	$\frac{w_3\,.\,60^3}{3}$	$60\,.\,i_A EI$
B′	$12{\cdot}75\left\{\frac{38\,.\,20^2}{2}-\frac{20^3}{6}\right\}$	$\frac{w_1' 20^3}{3}$	$w_2'\left(\frac{40\,.\,20^2}{2}-\frac{20^3}{6}\right)$	$w_3'\left(\frac{60\,.\,20^2}{2}-\frac{20^3}{6}\right)$	$-20i_A EI$
C′	$12{\cdot}75\left\{\frac{20\,.\,12^2}{4}-\frac{12^3}{6}+\frac{12^4}{24\,.\,20}+\frac{28^2\,.\,12}{2}+\frac{28\,.\,12\,.\,20}{2}+\frac{28^2\,.\,20}{4}+\frac{28^3}{3}\right\}$	$w_1'\left(\frac{20^3}{3}+\frac{20^2\,.\,20}{2}\right)$	$\frac{w_2'\,.\,40^3}{3}$	$w_3'\left(\frac{60\,.\,40^2}{2}-\frac{40^3}{6}\right)$	$-40i_A EI$
D′	$12{\cdot}75\left\{\left(\frac{20^3}{8}+\frac{3\,.\,28^2\,.\,20}{4}+\frac{28\,.\,20^2}{2}+\frac{28^3}{3}\right)+\left(\frac{20^2}{6}+\frac{28\,.\,20}{2}+\frac{28^2}{2}\right)12\right\}$	$w_1'\left(\frac{20^3}{3}+\frac{20^2\,.\,40}{2}\right)$	$w_2'\left(\frac{40^3}{3}+\frac{40^2\,.\,20}{2}\right)$	$\frac{w_3'\,.\,60^3}{3}$	$-60i_A EI$

TABLE II.

$\frac{EI\delta}{1000}$ at	Due to $\frac{W}{2}$ (downwards).	w_1 or w_1' (upwards).	w_2 or w_2' (upwards).	w_3 or w_3' (upwards).	i_A (downwards).
B	110·5	$2\dot{6}w_1$	$6\dot{6}w_2$	$10\dot{6}w_3$	$\cdot 02 i_A EI$
C	374	$6\dot{6}w_1$	$21\dot{3}w_2$	$37\dot{3}w_3$	$\cdot 04 i_A EI$
D	692·75	$10\dot{6}w_1$	$37\dot{3}w_2$	$72w_3$	$\cdot 06 i_A EI$
B′	79·9	$2\dot{6}w_1'$	$6\dot{6}w_2'$	$10\dot{6}w_3'$	$-\cdot 02 i_A EI$
C′	252·144	$6\dot{6}w_1'$	$21\dot{3}w_2'$	$37\dot{3}w_3'$	$-\cdot 04 i_A EI$
D′	440·397	$10\dot{6}w_1'$	$37\dot{3}w_2'$	$72w_3'$	$-\cdot 06 i_A EI$

But an expression for the deflection of B below A may also be obtained by considering the deflections of the main girders due to w_1 and w_0 respectively, when the difference gives the deflection of B below A.

Thus
$$\delta = K\,.\,\frac{w_1 L^3}{E_1 I_1} - K\,\frac{w_0 L^3}{E_1 I_1}$$
$$= \frac{KL^3}{E_1 I_1}(w_1 - w_0)$$

where K is a constant depending

(i.). Upon the distribution of the loads w_0, w_1, etc., upon the main girders, *i.e.*, whether concentrated or distributed evenly or unevenly on the whole or part of the span.

(ii.). Upon the distance of the loads w_0, w_1...from the abutments of the bridge, *i.e.*, whether central on the main girders or otherwise (K may thus have a slightly different value for each girder of a skew bridge if the decking is laid at right angles to the girders).

(iii.). Whether the ends of the girders are simply supported, or built in.

Thus, assuming K, E_1, I_1 and L to be the same for all the girders, we get, by equating these two expressions for the deflection of B below A—

$$\frac{KL^3}{E_1 I_1}(w_1 - w_0) = \frac{1000}{EI}\{110\cdot 5 - 2\dot{6}w_1 - 6\dot{6}w_2 - 10\dot{6}w_3 + \cdot 02 i_A EI\}$$

or
$$\frac{c}{1000}(w_1 - w_0) = 110\cdot 5 - 2\dot{6}w_1 - 6\dot{6}w_2 - 10\dot{6}w_3 + \cdot 02 i_A EI \ldots (1),$$

where
$$c = \frac{KL^3 EI}{E_1 I_1}.$$

Similarly by equating the expressions for the deflections of C, D, B′, C′, D′, below A, we get

$$\frac{c}{1000}(w_2 - w_0) = 374 - 6\cdot\dot{6}w_1 - 21\cdot\dot{3}w_2 - 37\cdot\dot{3}w_3 + \cdot 04 i_A EI \text{ ....(2).}$$

$$\frac{c}{1000}(w_3 - w_0) = 692\cdot 75 - 10\cdot\dot{6}w_1 - 37\cdot\dot{3}w_2 - 72w_3 + \cdot 06 i_A EI \text{ ......(3).}$$

$$\frac{c}{1000}(w_1' - w_0) = 79\cdot 9 - 2\cdot\dot{6}w_1 - 6\cdot\dot{6}w_2 - 10\cdot\dot{6}w_3 - \cdot 02 i_A EI \text{ ....(4).}$$

$$\frac{c}{1000}(w_2' - w_0) = 252\cdot 144 - 6\cdot\dot{6}w_1' - 21\cdot\dot{3}w_2' - 37\cdot\dot{3}w_3' - \cdot 04 i_A EI \text{ ...(5).}$$

$$\frac{c}{1000}(w_3' - w_0) = 440\cdot 397 - 10\cdot\dot{6}w_1' - 37\cdot\dot{3}w_2' - 72w_3' - \cdot 06 i_A EI \text{ ...(6).}$$

There are now eight unknown quantities—w_0, w_1, w_2, w_3, w_1', w_2', w_3', and i_A, and it is necessary therefore to find two more equations before the values of these can be determined.

One equation may be obtained by making use of the fact that the Bending Moment at A (or at any other particular point along D′D) is the same whether loads to the right are considered or those to the left, *i.e.*,

$$20w_1 + 40w_2 + 60w_3 - 12\cdot 75 \times 50 = 20w_1' + 40w_2' + 60w_3' - 12\cdot 75 + 38.$$

I.e. $20(w_1 - w_1') + 40(w_2 - w_2') + 60(w_3 - w_3') = 12\cdot 75 \times 12.$

Or $(w_1 - w_1') + 2(w_2 - w_2') + 3(w_3 - w_3') = 7\cdot 65$ ....(7).

The eighth equation depends upon the fact that the algebraic sum of the reactions is equal to the total load, *i.e.*,

$$(w_1 + w_1') + (w_2 + w_2') + (w_3 + w_3') + w_0 = 25\cdot 5 \text{ ....(8).}$$

These eight equations may now be solved by the ordinary methods of algebra, and are sufficient to determine the eight unknowns for any particular value of c.

Thus if $c = 1000$

$w_0 = \cdot 03$ tons.
$w_1 = \cdot 79$ „
$w_2 = 5\cdot 57$ „
$w_3 = 6\cdot 46$ „
$w_1' = 3\cdot 66$ „
$w_2' = 7\cdot 15$ „
$w_3' = 1\cdot 90$ „

If these values be determined for several values of c the curves as shown in *Fig.* 4 may be drawn.

When the load is symmetrically placed about the axis of the bridge (*Fig.* 1) the calculations are much simplified because

$$w_1 = w_1',$$
$$w_2 = w_2',$$
$$w_3 = w_3',$$
$$i_A = 0.$$

There are now only four unknowns, w_0, w_1 (or w_1'), w_3 (or w_2'), w_3 (or w_3'), and only the four equations (1), (2), (3), and (8) are necessary.

The curves given in *Fig.* 3 are therefore easily derived, and indicate

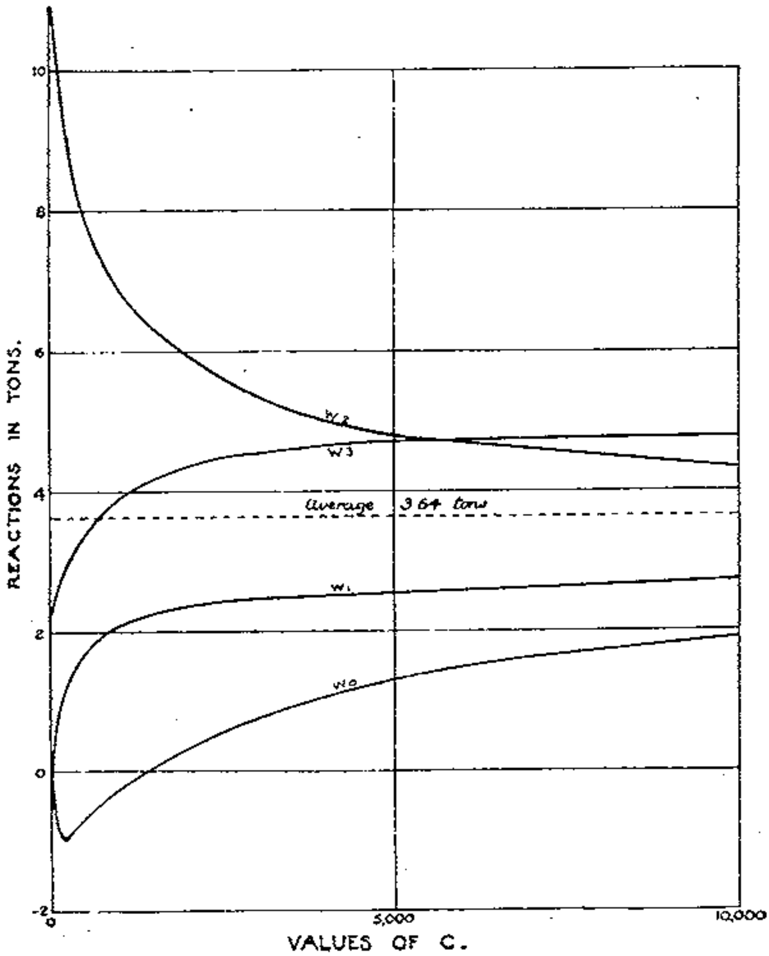


FIG. 3.—7 *Girders. Symmetrical Loading.*

the values of the reactions on the girders for various values of c when the gun is in the centre of the roadway and when there are 7 girders.

Similar curves may be drawn for bridges having any other number of supporting girders, but owing to limitations of space more are not reproduced here.

Figs. 5 and 6, however, have been abstracted from such diagrams to show the *maximum* curves for several cases of symmetrical loading (*Fig.* 5) and for the same cases with eccentric loading (*Fig.* 6).

An examination of these diagrams (*Figs.* 3—6) shows how much in excess of the average one or more of the girders may be loaded, even when the load is in a symmetrical position.

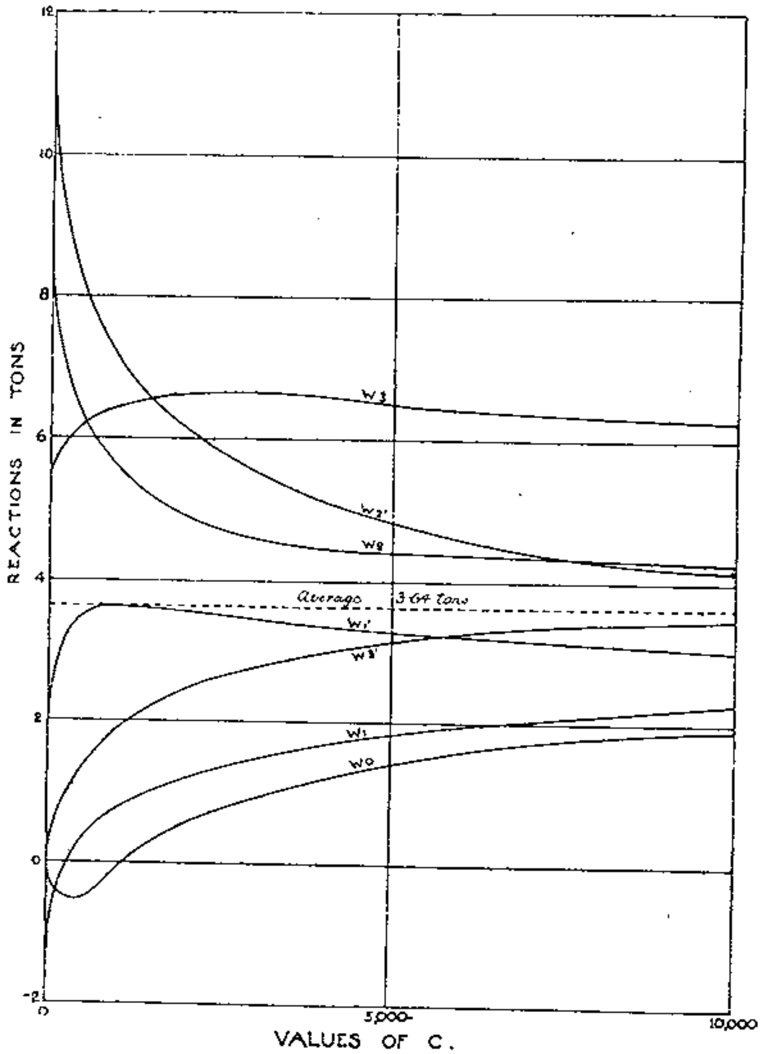


FIG. 4.—7 *Girders. Eccentric Loading.*

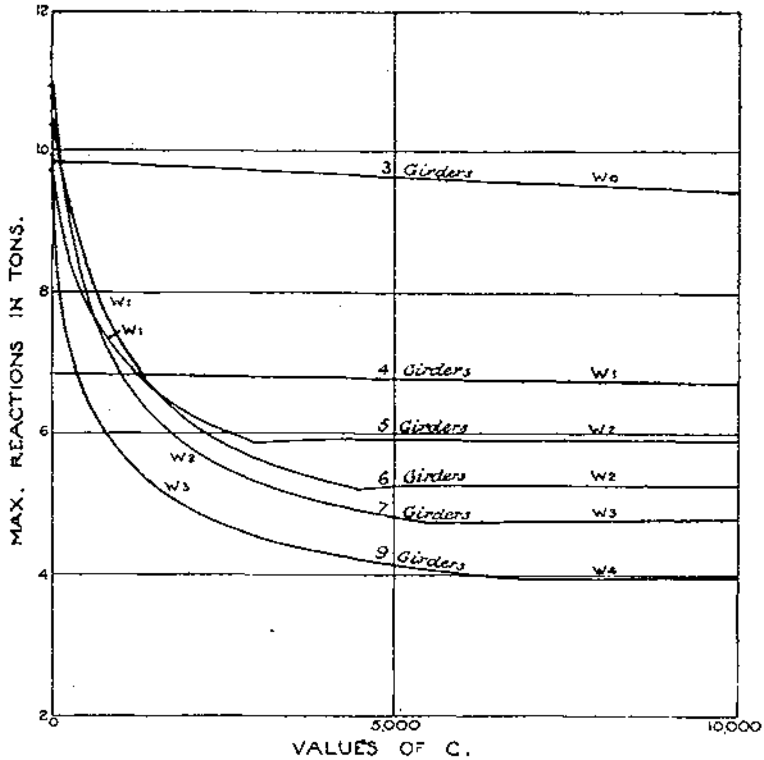


FIG. 5.—*Maximum Reactions on Girders. Symmetrical Loading.*

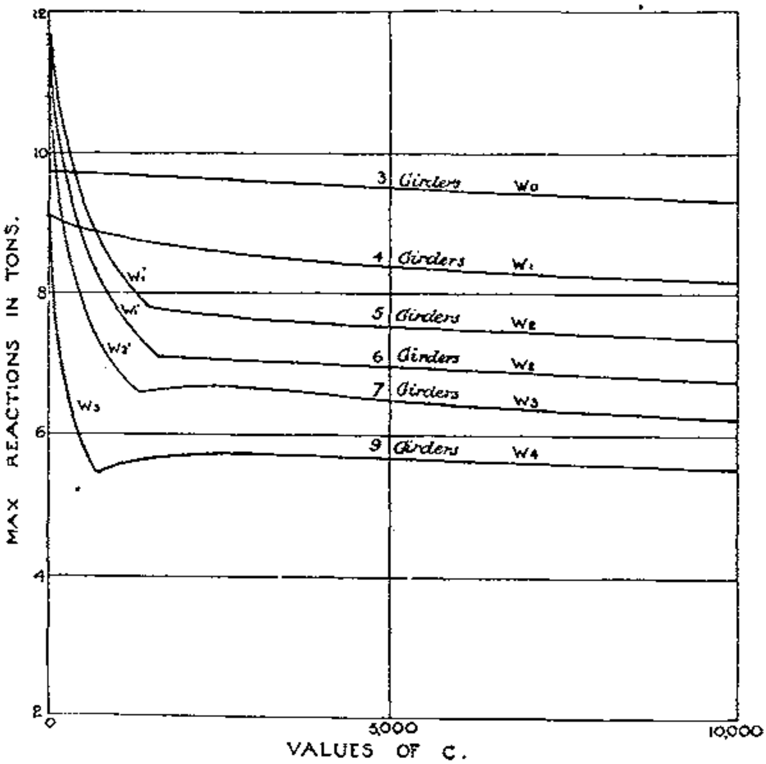


FIG. 6.—*Maximum Reactions on Girders. Eccentric Loading.*

Fig. 7, which deals with the case of an eccentrically loaded bridge with 7 supporting girders, perhaps shows rather more clearly how uneven is the distribution, particularly when the stiffness of the decking is very low compared with that of the girders (*i.e.* when c has a very low value, as for instance at the abutments of the bridge, when, even with a very stiff decking the value of c would approximate to $c=o$).

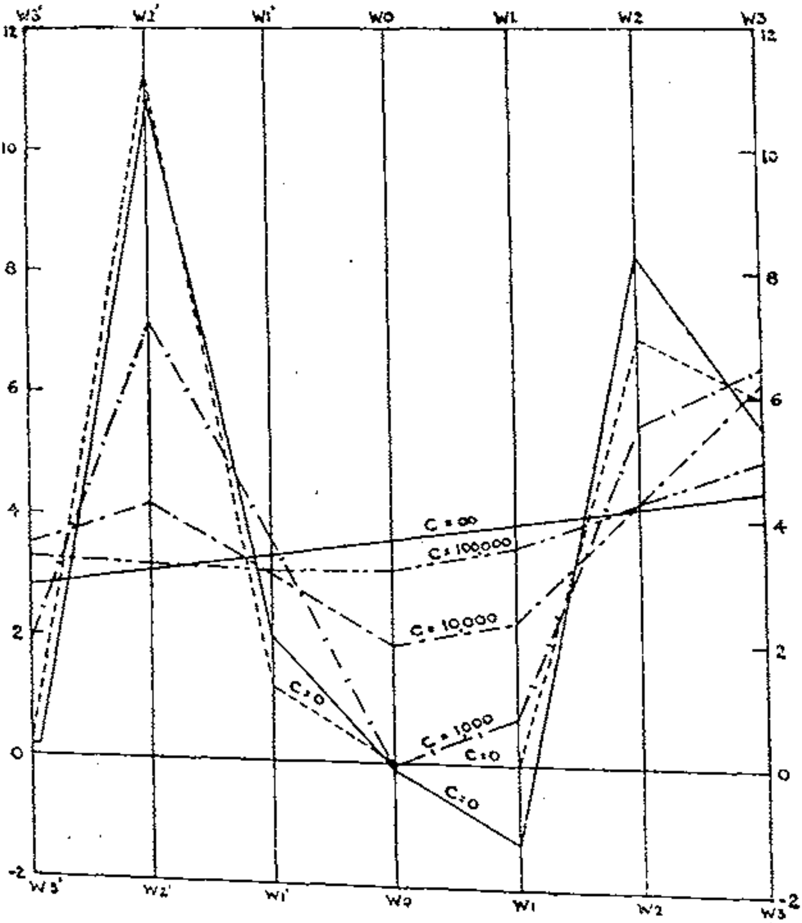


FIG. 7.—7 *Girders. Eccentric Loading.*

The distribution improves as c increases, and approaches a straight line limit when c becomes infinite, as shown by the unbroken line (*Fig.* 7), though the distribution is still very uneven for such high practical values of c as $c=5{,}000$ or $c=10{,}000$.

It is important that this fact should be recognized when determining the size of girders required.

It must be borne in mind, however, that the curves in *Figs.* 3—7 are only for one set of conditions, viz. when the girders are equally spaced, and when the distance from centre to centre of the two extreme ones is 10 ft.

It is evident that the girders may be more widely spaced than this, or they may be unevenly spaced if necessary, and the distribution of the load on the various girders will be altered accordingly.

To illustrate this *Fig.* 8 has been drawn to show the maximum reaction curves for 3 cases of an eccentrically loaded bridge having 7 girders—

(i.) Equally spaced at 20″ centres.
(ii.) " " " 21″ "
(iii.) " " " 22″ "

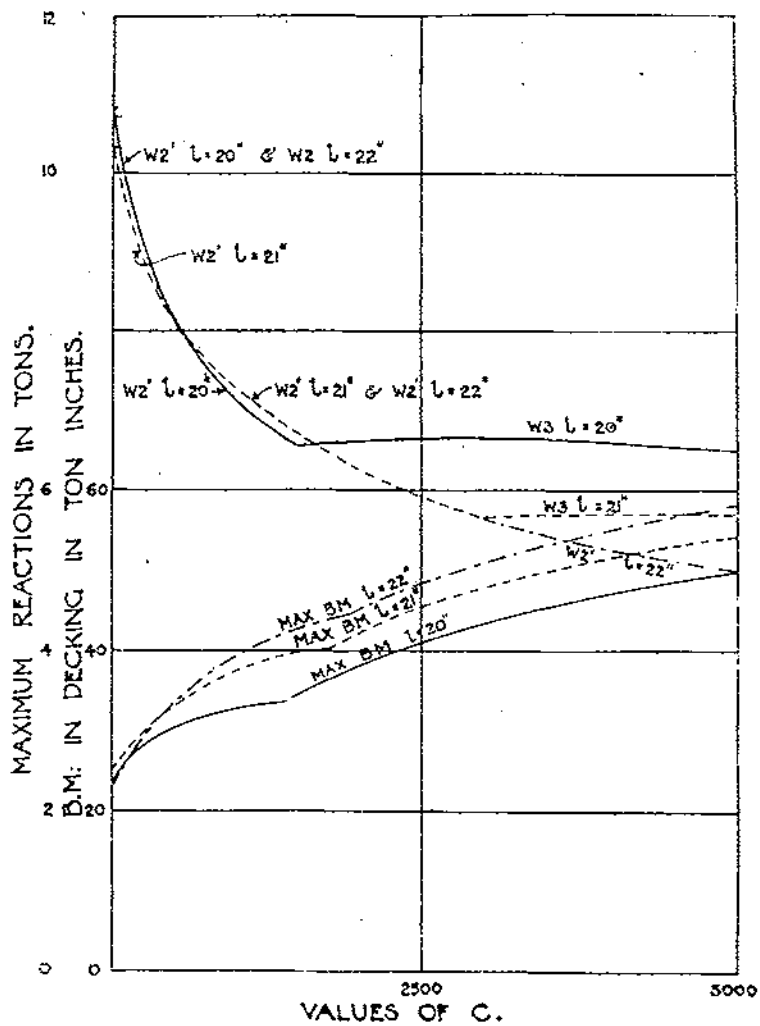


FIG. 8.—7 *Girders. Eccentrically Loaded.*

In this particular example, the maximum load brought on to a main girder is practically the same in each case, for values of c nearly up to 2,000.

Except for low values of c however, the increased spacing results in increased stresses in the decking as is shown by the lower curves of the figure. These show the maximum B.M.'s produced in the decking for the same distribution of the load and the same values of c as for the upper reaction curves.

Another point to which attention should be drawn is that when c has a low value, the results depend upon what assumptions are made as regards the *downward* pull that the girders are capable of exerting on the decking—*i.e.* the method by which the decking is secured, etc.

For instance when $c=0$ in the case of an eccentrically-loaded bridge containing 7 main girders (*e.g.* at the abutments) if the girders are capable of exerting a downward pull on the decking, the reactions are approximately

w_3'	w_2'	w_1'	w_0	w_1	w_2	w_3
·20	10·80	2·03	−·09	−1·25	8·28	5·53 tons.

While if the girders are not considered capable of exerting any downward pull on the decking, the reactions are

w_3'	w_2'	w_1'	w_0	w_1	w_2	w_3
·13	11·25	1·22	0	0	6·93	5·97 tons.

These values are shown in *Fig.* 7 by the two lines indicated $c=0$.

The Bending Moments on the decking for these two assumptions are easily calculated, and are respectively shown in Curves 3 and 4, *Fig.* 10.

Bending Moments in Main Girders.—When a girder is subjected to a travelling load of any description, the deflection of the girder varies with the position of the load upon the span.

An example of this is seen in Equation 8 in the Appendix, which gives an expression for the deflection of a simply supported girder, at a point immediately under a concentrated load W, when this is at a distance a from one abutment, and b from the other.

Thus if the deflection formula be written

$$\delta = K \cdot \frac{W \cdot L^3}{EI},$$

then

$$K = \frac{a^2 b^2}{3 L^4},$$

i.e., a quantity which varies as a and b vary, and having values $K = \frac{1}{48}$ or $\cdot 0208\dot{3}$ when the load is in the centre of the span—(*i.e.*, when $a=b=\frac{1}{2}L$), and $K=0$ when the load is over one of the abutments (*i.e.*, when either $a=0$ or $b=0$). A graph showing values of K for other values of a and b is given in *Fig.* 9.

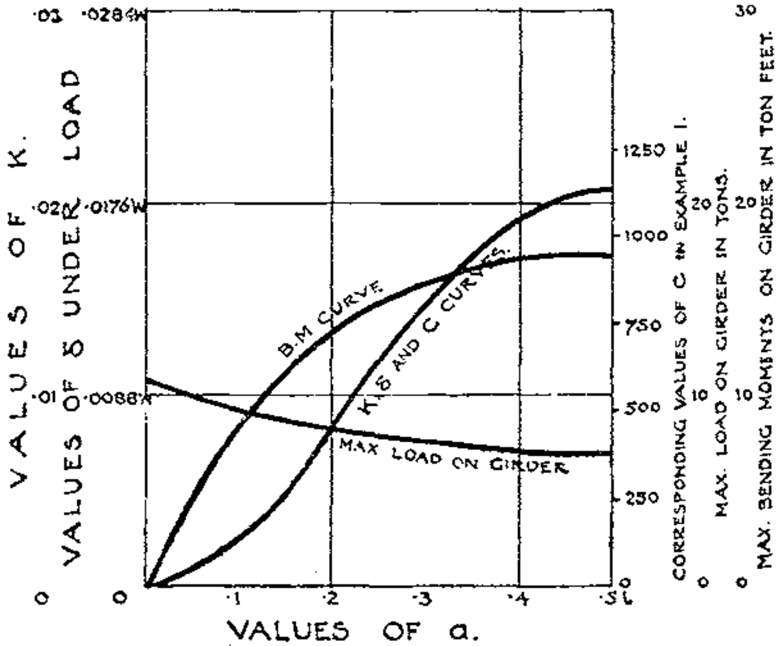


FIG. 9.

But c is proportional to K when L, E, I, E_1, and I_1 are constant, so that the K curve also represents c, but to a different scale, which scale depends upon the values of L, E, I, E_1, and I_1. For example in the case of 10 in. × 5 in. × 30 lbs. R.S.J. of 10-ft. span and 10-in. × 5-in. timber decking $c=1143$ when $K=\cdot 0208\dot{3}$. This determines the scale for the c curve of this example, which may be drawn on the diagram as shown to enable any other values to be scaled direct. But, as has been shown in *Figs.* 3 to 8, the maximum load which is brought on to any one girder varies as the value of c varies: in general, since c decreases as the load travels from the centre of the bridge to the abutments, the maximum load brought on to any one girder is considerably increased as the abutments are approached.

The particular value of this maximum reaction for any particular position of the load on the span may be ascertained by

Firstly, noting the value of c on the curve in *Fig.* 9 which corresponds to this position of the load on the span, and

Secondly, noting the value of the maximum reaction from *Fig.* 6 which corresponds to this value of c—the bridge being eccentrically loaded.

Thus at ·3 of the span from one abutment, $K=\cdot 0147$ $c=807$ and the maximum load on one girder of a 7-girder bridge is approximately 7·5 tons. Other points can be obtained in this way, and a maximum-load curve plotted as in *Fig.* 9, which refers to a 7-girder bridge eccentrically loaded.

It may be noted however that it is not necessarily the same girder which receives the maximum load at different positions of the load across the bridge, *e.g.*, in *Fig.* 4, for values of $c=0$ to about $c=1500$ w_2' receives the maximum load, while for values of c greater than $c=1500$, w_3 receives the maximum load.

Now, for any definite position of a concentrated load on a simply supported girder, the maximum B.M. occurs under the load, and the B.M. diagram is a triangle. Knowing then, the maximum load which comes on to a girder at any particular point, the B.M. due to that load at that point is easily calculated.

For example, at ·3 span, the load is approximately 7·5 tons, and the B.M.$=\frac{3\cdot 7}{10}\times 7{\cdot}5=15{\cdot}75$ ton-ft. By plotting values of this maximum B.M. for several points on the span, an influence line of maximum B.M. may be constructed as shown by the curve in *Fig.* 9.

The ordinate of this curve thus gives the maximum B.M. at any point along the girder when the load is at that particular point; and, as the curve has its maximum value at the centre of the span, the girder is evidently stressed most highly when the load is at the centre of the bridge, and it is sufficient to consider this point only when deciding what sizes of girder and decking to adopt.

Had the maximum load brought on to a girder remained constant, as the load travelled from the centre of the span to the abutments, this result would have been obvious since the influence line of maximum B.M. would then have been a parabola. In this case, however, with the varying load, the ordinates of the parabola are increased as shown, in proportion as the load increases, and it is therefore not evident at first sight, at which point on the span the main girders are subjected to the greatest B.M.

Bending Moments in Decking.—The bending moments in the decking are easily calculated when the reactions on the various girders are known, and as has been explained already these can be easily obtained for the case of 7 girders from *Figs.* 3 and 4 when c is known.

For example, Curve 1, *Fig.* 10, shows the B.M.'s in the decking when $c=1143$, a value which occurs at the centre of the span of a 7-girder bridge of 10-ft. span when the main girders are 10 in. × 5 in. × 30 lbs. R.S.J. and the decking is of 10-in. × 5-in. timber.

Similarly Curve 2 shows the B.M.'s when $c=500$—*i.e.*, at ·21 of the span from one abutment under the same conditions (see *Fig.* 9).

Curves 3 and 4 give the B.M.'s at the abutments when $c=0$ under the two assumptions mentioned previously in the paper.

If the maximum values for a number of similar curves be abstracted, the results may be plotted to give a maximum B.M. curve for various values of c. Such curves are shown in *Figs.* 11 and 12 for bridges having different numbers of girders, both for symmetrical and for eccentric loading as in *Figs.* 1 and 2.

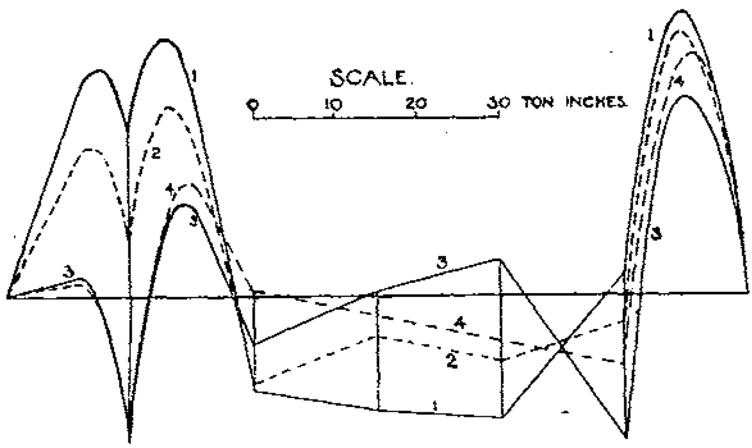


FIG. 10.—*B.M. Diagrams for Decking.*

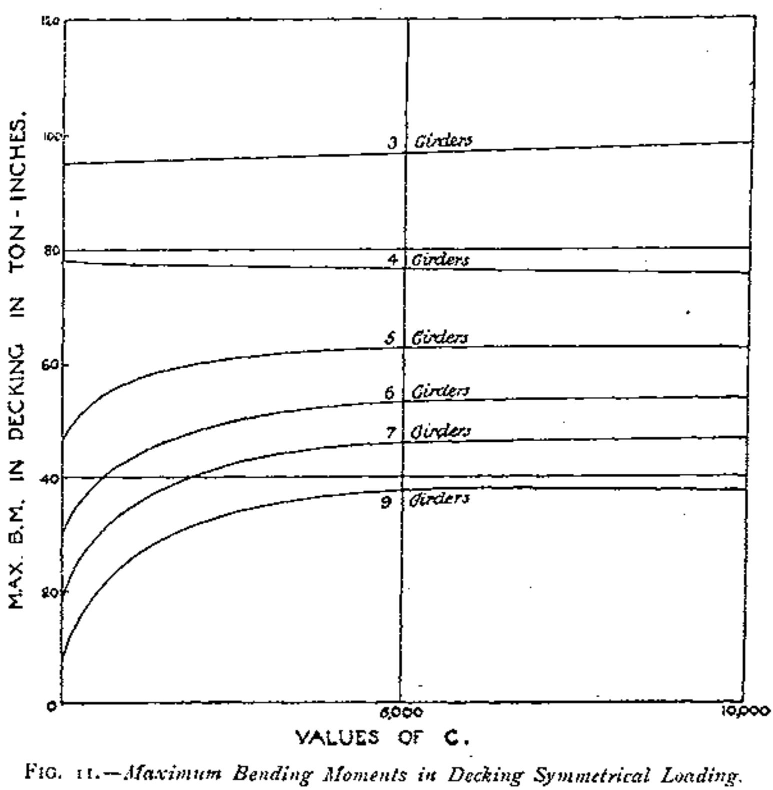


FIG. 11.—*Maximum Bending Moments in Decking Symmetrical Loading.*

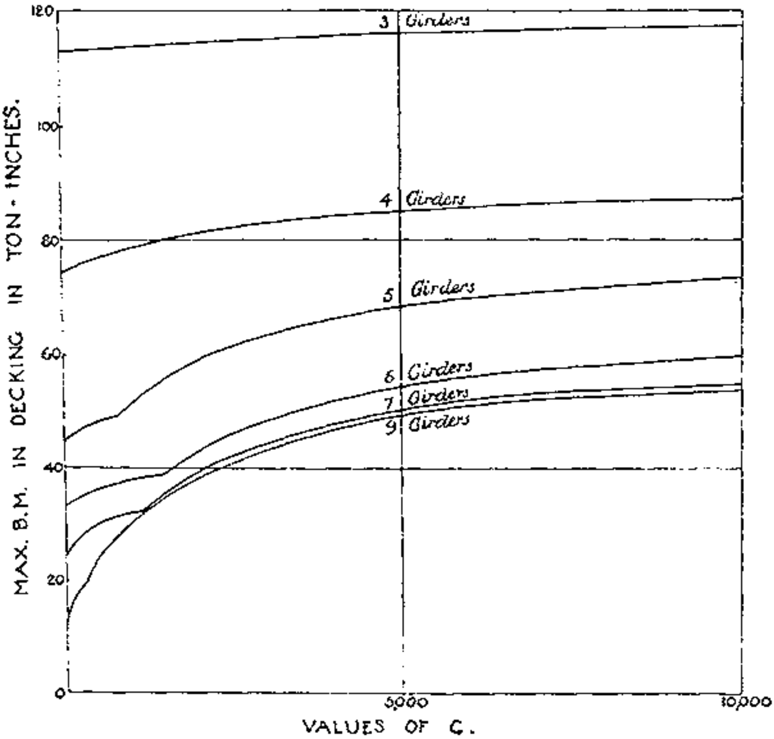


FIG. 12.—*Maximum Bending Moments in Decking Eccentric Loading.*

It will be seen from these that the value of the maximum B.M. increases as c increases, and hence in any particular case, the greatest value occurs when the load is at the centre of the span.

This is very convenient, as the maximum B.M. on the main girders also occurs when the load is in the centre of the span, as has been shown above.

Examples.—To show the application of the foregoing curves, a few concrete cases will be considered.

(i.). Suppose a bridge of 10-ft. span is required, and that 10 in. × 5 in. × 30 lb. R.S.J. are available for the main girders and 10-in. × 5-in. timbers for the decking.

The safe central dead load on a single girder at $7\frac{1}{2}$ tons per square inch stress = 7·28 tons; and the moment of resistance of the decking is about 37·3 ton-inches, when the limiting stress is taken at 2,000 lbs. per square inch. An upper decking of $1\frac{1}{2}$-in. (say) timber should be provided to take the wear of the traffic, so that this stress is not excessive.

Reference to Table III. shows $\frac{KEI}{E_1 I_1} = 6{\cdot}63$, and hence

$$c = 6{\cdot}63 \times 10^{-4} \times 120^3 = 1143 \text{ about.}$$

On inspection of *Figs.* 5 and 6, it is seen that for this value of c, at least 7 girders are required to ensure that the maximum load on a girder shall not exceed 7·28 tons.

Similarly *Figs.* 11 and 12 show that for the B.M. in the decking not to exceed 37·3 ton-inches, at least 7 girders are required.

Hence the bridge should contain 7 main girders simply supported at their ends. This gives a maximum reaction of 6·8 tons—a figure which allows a margin for the extra stresses due to the dead load of the bridge—and a maximum B.M. of 36 ton-inches in the decking.

(ii.). For the same span of 10 ft., suppose 9 in. × 4 in. × 21 lbs. are the only R.S.J. available.

The maximum concentrated dead load such a simply supported girder can carry in the centre is about 4·5 tons.

Reference to *Figs.* 5 and 6, however, shows that even with exceptionally stiff decking, the maximum reaction would be well above this figure—even with 9 girders.

If the girders are "fixed" at their ends and well embedded in concrete, they should be capable of supporting 9 tons concentrated in the centre.

K is now $\frac{1}{192}$ and hence with 9-in. × 4-in. decking

$$c = \frac{1}{192} \cdot \frac{600 \,.\, 48}{13500 \,.\, 81{\cdot}1} \,.\, 120^3 = 236 \text{ about.}$$

Reference to *Figs.* 5 and 6 shows that when $c=236$, at least 7 girders are required to bring the maximum reaction below 9 tons.

The moment of resistance of the decking is 21·5 ton-inches, nearly, and for the B.M. to be below this value when $c=236$, *Figs.* 11 and 12 show that 9 girders are necessary.

Nine girders should therefore be adopted.

With 10-in. × 5-in. decking, $c=515$, and the moment of resistance of the decking is 37·3 ton-inches.

To bring the maximum reaction now on any girder below 9 tons, either 4 or at least 6 girders are required. And to bring the B.M. on the decking below 37·3 ton-inches, at least 6 girders are required.

Hence 6 girders should be adopted in this case.

(iii.). Suppose 12-in. × 12-in. baulks are available for the same span of 10 ft. then with 9-in. × 4-in. decking $c=1000$ approximately.

The safe central dead load on a girder is 8·57 tons if the limiting stress is taken at 2,000 lbs. per square inch, and the moment of resistance of the decking is 21·5 ton-inches.

The strength of girders therefore necessitates at least 5 girders, but for the decking to be satisfactory, even 9 girders will be insufficient.

With 10-in. × 5-in. decking, having a moment of resistance of 37·3 ton-inches, $c=2180$, and hence the strength of the girders necessitates at least 5 girders, while for the decking requirements, 7 girders would be barely sufficient.

Seven girders might however be adopted, and the stress in the main girders—exclusive of that produced by the dead weight of the bridge would be 1,550 lbs. per square inch—a more satisfactory figure for these members than 2,000 lbs. per square inch.

(iv.). With 18-in. × 9-in. main timber girders of 20-ft. span, and 10-in. × 6-in. decking having a moment of resistance of 53·6 ton-inches, $c = 11850$.

The maximum reaction on a girder should not exceed 7·23 tons, so that if 6 girders are provided, the requirements both of the decking and of the girders should be satisfied.

In all these examples the girders have been taken as equally spaced, though possibly some economy might be effected by unequal spacing.

It may be noted too, that for large spans, the effect of other wheel loads—*e.g.* those of the tractor hauling the gun—would need to be included in the calculations, but for spans such as the above these loads are spaced sufficiently far from the gun, to be neglected.

In conclusion I wish to thank Lance-Corpl. B. G. Norton, R.E., for his assistance in preparing the diagrams.

APPENDIX.

The following is the notation that has been adopted in the paper :—

W = total equivalent dead load on the two wheels, *i.e.* $(17 \times 1\frac{1}{2})$ tons = 25·5 tons.

$w_0\, w_1\, w_2\, w_3 \ldots$ / $w_0'\, w_1'\, w_2'\, w_3' \ldots$ } The load carried by each girder or roadbearer—taken outwards on each side of the centre of the roadway.

E = modulus of elasticity of the decking material.

E_1 = ,, ,, ,, girder ,,

I = moment of inertia of the section of decking carrying the load.

I_1 = ,, ,, of the section of a main girder.

d = width of wheel tyre (20 in. in this case).

d_1 = distance from centre of roadway to inside of wheel.

$\delta\, \delta_0\, \delta_1 \ldots$ = the deflection in inches of decking or girders.

L = span of main girders in inches.

l = distance from centre to centre of main girders in inches.

$c = \frac{KL^3}{E_1 I_1}$. E.I. where

K = coefficient of deflection for main girders.

e.g., $K = \frac{1}{48} = \cdot 02083$ for a simply supported girder and a concentrated central load.

$= \frac{1}{192} = \cdot 00521$ for a girder with fixed ends and a concentrated central load, etc.

Table III. shows a few slide rule values of $\frac{K.E.I.}{E_1 I_1} \times 10^4$ when $K = \frac{1}{48}$ from which c may be easily obtained, when the span L is known.

TABLE III.

Girders.		Decking.					
		9″×3″	9″×4″	10″×5″	12″×5″	10″×6″	12″×6″
		Values of I.					
		20·25	48	104·16	125	180	216
		Values of MR.					
		12·05	21·5	37·3	44·6	53·6	64·3
Size.	I_1	Approx. values of $K . \frac{E.I.}{E_1 I_1} . 10^4$.					
R.S.J.'s. in. in. lbs.							
18×7×75	114·9	·163	·387	·842	1·01	1·45	1·74
15×6×59	628·9	·298	·708	1·54	1·845	2·655	3·18
12×6×54	375·5	·50	1·185	2·58	3·09	4·45	5·33
12×6×44	315·3	·595	1·41	3·065	3·68	5·29	6·35
10×6×42	211·5	·887	2·105	4·67	5·48	7·90	9·47
10×5×30	145·6	1·29	3·06	6·63	7·96	11·45	13·72
9×4×21	81·1	2·32	5·48	11·92	14·30	20·60	24·70
8×4×18	55·69	3·37	7·98	17·40	20·80	29·95	35·95
Timber. in. in.							
10× 5	416·6	10·13	24·0	52·1	62·5	90	108
12× 6	864	4·88	11·58	25·15	30·2	43·5	52·3
12× 9	1296	3·26	7·73	16·7	20·12	29·0	34·8
12×12	1728	2·44	5·79	12·6	15·07	21·7	26·1
14×14	3201·3	1·32	3·12	6·79	8·14	11·7	14·05
18× 9	4374	·965	2·285	4·96	5·95	8·57	10·3

The chief formulæ that have been employed, and which may be derived by the usual methods of the calculus, are as follows :—

(*a*). Cantilever carrying a distributed load over part (d) of its length.

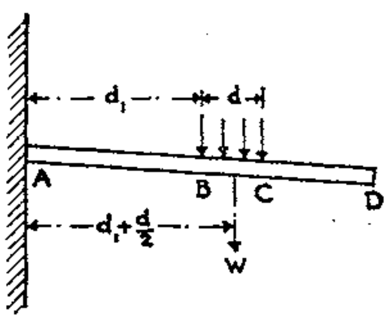


FIG. 13.

The deflection (δ) at a distance x from A, between A and B (*Fig.* 13)—

$$\delta = \frac{W}{EI}\left(d_1 + \frac{d}{2}\right)\frac{x^2}{2} - \frac{Wx^3}{6EI} \quad \text{.......................(1).}$$

The deflection (δ) at a distance x from B, between B and C (*Fig.* 13)—

$$\delta = \frac{W}{EI}\left\{\frac{d \cdot x^2}{4} - \frac{x^3}{6} + \frac{x^4}{24d} + \frac{d_1^2 x}{2} + \frac{d_1 dx}{2} + \frac{d_1^2 d}{4} + \frac{d_1^3}{3}\right\} \quad \text{........(2).}$$

The deflection (δ) at a distance x from c, between c and D (*Fig.* 13)—

$$\delta = \frac{W}{EI}\left\{\left(\frac{d^3}{8} + \frac{3d_1^2 d}{4} + \frac{d_1 d^2}{2} + \frac{d_1^3}{3}\right) + \left(\frac{d^2}{6} + \frac{d_1 d}{2} + \frac{d_1^2}{2}\right)x\right\} \quad \text{......(3).}$$

(*b*). Cantilever carrying a single concentrated load at a distance d_1 from the fixed end.

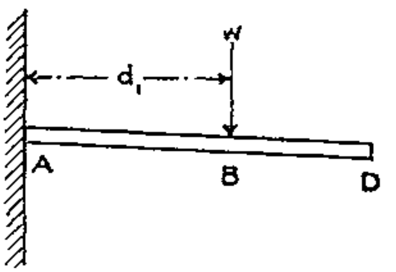


FIG. 14.

The deflection (δ) at a distance x from A, between A and B (*Fig.* 14) –

$$\delta = \frac{W}{EI}\left\{\frac{d_1 x^2}{2} - \frac{x^3}{6}\right\} \quad \text{..............................(4).}$$

The deflection (δ) at the point immediately under the load—

$$\delta = \frac{W \cdot d_1^3}{3 \cdot EI} \quad \text{..............................(5).}$$

The deflection (δ) at a distance x from B between B and D—

$$\delta = \frac{W}{EI}\left(\frac{d_1^3}{3} + \frac{d_1^2 x}{2}\right) \quad \text{..............................(6).}$$

Note.—Equations (4), (5), and (6) are special cases of equations (1), (2), and (3) respectively, *i.e.*, when d approaches 0.

(*c*). A simply supported beam of span l, carrying a central distributed load over a length $d = nl$.

The maximum deflection—

$$\delta = \frac{W \cdot l^3}{EI}\left\{\frac{1}{48} - \frac{4n^2 - n^3}{384}\right\} \quad \text{.....................(7).}$$

(*d*). A simply supported beam of length l, carrying a concentrated load W, at a distance a from one support and b from the other.

The deflection under the load—

$$\delta = \frac{1}{3}\frac{a^2 b^2}{l} \cdot \frac{W}{EI} \quad \text{..............................(8).}$$

Or when $a = b$

$$\delta = \frac{1}{48}\frac{Wl^3}{EI} \quad \text{..............................(9).}$$

AEROPLANE SHED.

By CAPT. A. E. MANN, R.E.

IN the issue of the *R.E. Journal* for March, 1917, an article by Capt. G. C. Gowlland, R.E., on the "Construction of Aeroplane Sheds in the Field" is published. In connection with it, the following account and drawings of some Temporary Aeroplane Hangars which have been erected at —— may be of some interest.

The erection of four sheds each 60-ft. span by 45 ft. deep and 14 ft. high at sides was asked for and completion at an early date specified. It was decided to build the sheds in couples and the putting in of concrete foundations and erection of the steel rails was commenced during the first week in August, 1917. On the 16th at 7 a.m. the first couple of sheds was completed and in use by R.F.C. for erection of aeroplanes, and work was commenced on second couple. At 11 a.m. a violent storm occurred which caused several of the reversed suspension cables (composed of 1-in. steel wire rope) to snap owing to upward thrust occasioned by whirlwind action of the wind. The remainder of these cables snapped like fiddle strings and the whole span of 120 ft. of canvas roof lifted bodily above the tops of centre supports. Complete dismantling, except taking down of rails, was necessary, and this was completed by 6 p.m. It was then decided to use 2-in. steel wire cables in reversed suspension cables as had been used for upper cables, an upward thrust of 10 lbs. per sq. ft. being assumed for purposes of calculation.

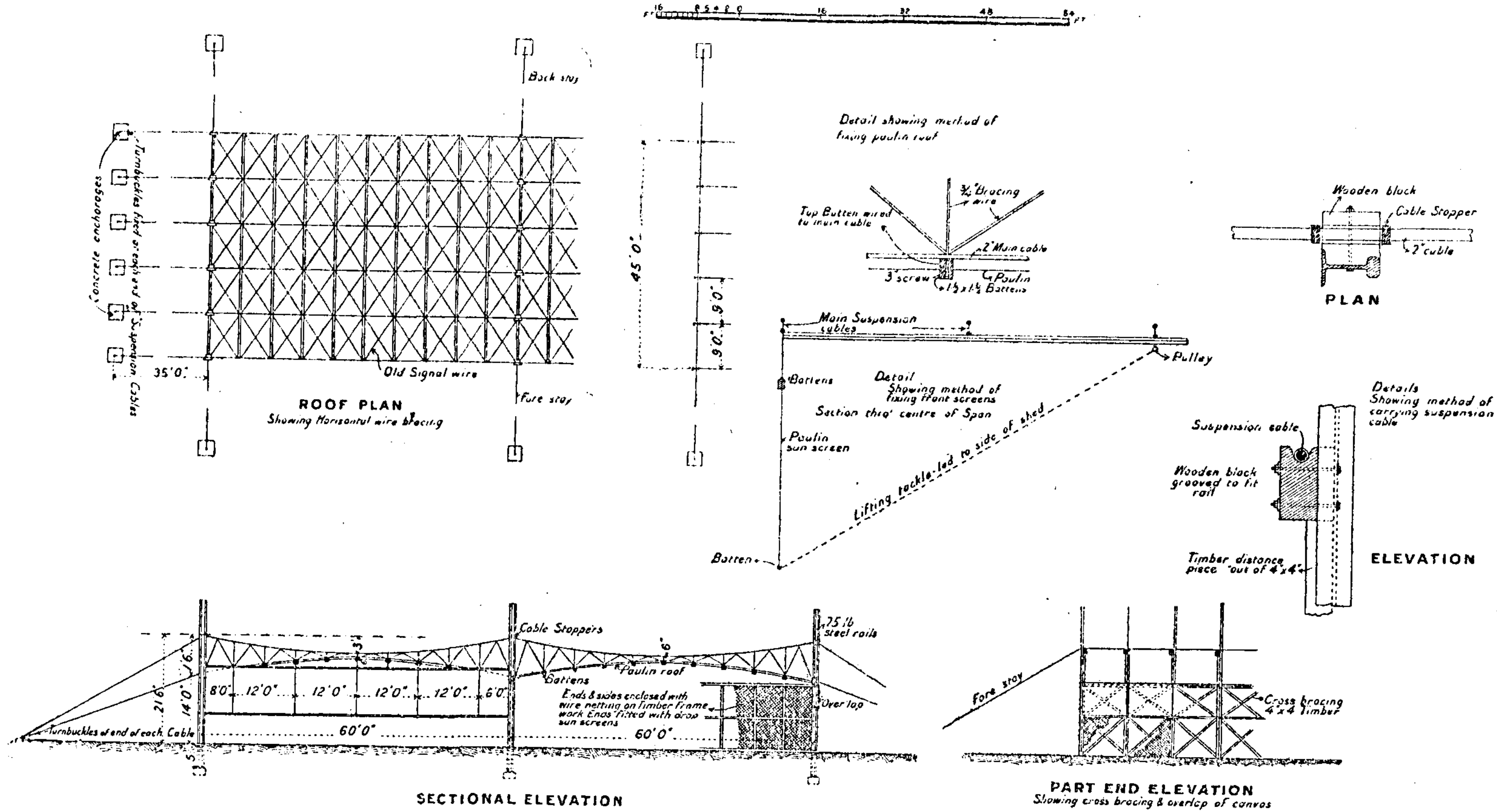
On the 21st August the second couple of hangars was completed and occupied by the R.F.C. and work recommenced on first couple. These were finished on the morning of 25th August.

The sheds were built with the aid of certain native carpenters, assisted by a small gang of local unskilled labour. These sheds have withstood several heavy storms, and would appear to be of as permanent construction as is required for aeroplane hangars in the field. The renewal of Paulin roof when necessary would be a small matter.

The drawings which accompany this will explain construction and the calculations are simple, although the assumption as regards wind pressure must necessarily be vague.

Experience has shown that an allowance of 10 lbs. per sq. ft. over the whole of roof surface, for both upward and downward thrust would appear to be ample.

DESIGN FOR
TEMPORARY AEROPLANE HANGARS.



TRANSCRIPT.

APPARENT DIELECTRIC STRENGTH OF VARNISHED CAMBRIC.

(From the *Journal of the Franklin Institute*).

In December, 1913, a paper by Mr. F. M. Farmer was read before the American Institute of Electrical Engineers in New York on "The Dielectric Strength of Thin Insulating Materials." A large number of experimental observations were recorded in the paper, on the apparent dielectric strength of thin sheets of varnished cambric, hard rubber, oil, and air, when tested between opposed parallel circular disk electrodes of various diameters. It was shown that in all cases the apparent dielectric strength diminished when the diameter of the disk electrodes was increased. With varnished cambric sheets the dielectric strength diminished 13.4 per cent. between 1.1 and 5.1 cm. of disk diameter.

It is generally accepted that, provided the tested dielectric sheet has a thickness not exceeding, say, 5 per cent. of the disk diameter, the electric field across the sheet is very nearly uniform. It might therefore be supposed that the area of the tested sheet would not affect the breakdown voltage, which, in a strictly uniform field, should be simply proportional to the thickness of the test sheet and independent of the area.

The only reason that was suggested in the discussion following the paper for the apparent diminution in breakdown voltage with area was a "weak-spot" theory. That is, it was supposed that a large disk would probably cover more accidental weak spots than a small disk, and so would be likely to invoke a lesser breakdown voltage. It is impossible to deny the validity of this argument, and yet it is not easy to assign a quantitative value to this diminution according to such a theory. Moreover, essentially the same phenomenon was presented with films of oil and air, fluid media in which weak spots are not supposed to occur.

The subject received attention in the M.I.T. laboratories during 1913—1914 in thesis work. Mr. L. H. Webber repeated and confirmed a number of the original observations in the Farmer paper. Again, in 1914—1915, Mr. G. Y. Fong repeated the tests, with sheet cambric previously immersed in oil. The diminution in rupturing voltage with disk diameter was then found to be distinctly less with oil-immersed cambric than with air-immersed cambric.

A complete series of dielectric strength tests was then carried on in the years 1915—1917 by Dr. R. J. Wiseman, under an appropriation from the American Telephone and Telegraph Company. A great variety of mechanical and electrical conditions were tried. The simplest arrangement arrived at was to support a test sheet of varnished cambric upon a fixed flat horizontal metallic disk electrode 10 cm. in diameter. The upper electrode was then laid on top of the test sheet so as to lie symmetrically over the lower fixed electrode. The breakdown voltage was supplied from a sine-wave alternator, through a 10-kva. step-up transformer. The voltage on the primary or low-tension side of the transformer was regulated, by varying the field excitation of the alternator, in such a manner that the secondary electromotive force impressed on the test sheet rose at the rate of approximately 1,000 r.m.s. volts per second. The electrodes of the test sheet were connected directly to the secondary terminals of the transformer by relatively short copper wires. Intermediate water resistances were used, at first, in these tests; but they were afterward removed without appreciable effect. A specially calibrated voltmeter in a tertiary circuit of the transformer enabled the r.m.s. electromotive force applied to the test sheet to be noted at the moment when rupture occurred.

It was found that when the upper electrode was a single metallic disk, the r.m.s. breakdown voltage fell off 13.3 per cent., as the area of the upper disk was increased from 1.1 to 18 sq. cm.

When, however, the upper electrode was formed of a number of separate brass disks, each 1.13 sq. cm. area, all resting on the test sheet and each connected to a common terminal by a straight, fine copper wire 40 cm. long, there was only about 1 per cent. diminution in breakdown voltage when the number of the little upper disks was increased from 1 to 16, with a corresponding increase in total active area from 1.1 to 18.1 sq. cm.

It thus became evident that the diminution in apparent dielectric strength with increase in size of the disk electrodes did not depend upon the active electrode surface, but upon the way in which the electrode surface was put together. This test was checked with different observers and apparatus at the Electrical Testing Laboratories in New York.

It was further ascertained that when the multiple upper electrode disks were set together into a connecting brass backing or frame the diminution in breakdown voltage with increase of active area from 1.1 to 18.1 sq. cm. increased to about 15.4 per cent., or even more than with the original single brass disks.

Again, when the multiple upper electrode disks were set into a hard-rubber back frame and connected together by short, strong copper wires immediately above the rubber frame, the diminution of voltage was 10.8 per cent.; whereas, if the connection was made by fine, straight copper wires about 40 cm. long to a common terminal, the diminution fell to 5.8 per cent.

By the courtesy of Mr. Farmer, all of these tests were repeated at the New York laboratories and checked in substance, although the agreement as to diminution was not precise in detail.

No satisfactory demonstration has yet been obtained as to the reasons for the above-mentioned phenomena. They suggest, however, the possibility of the existence of very high-frequency electric oscillations superposed upon the voltage wave of the testing frequency, which was 60 cycles per second throughout. It is conceivable that when a high-potential alternating electromotive force is impressed upon the two disk electrodes, which form, with the interposed test sheet, a condenser, high-frequency disturbances may be set up between different parts of the condenser, considered as an oscillating system. If such high-frequency oscillations occurred, air pocketed between the surface of the varnished cambric and either electrode would be ionized, and the ions might actively bombard the dielectric in the destructive manner which Ryan and other high-frequency experimentalists have already demonstrated. When the disk electrodes are enlarged, the frequency of such parasitic free oscillations would be lowered, but their amplitude and energy would be increased. If, however, the electrode surface is broken up into elements connected together by relatively long, thin wires, such oscillations would be damped and hindered. Confirmatory experimental evidence will, of course, be necessary before such a theory of diminution in breakdown voltage with disk diameter can be reliable.

A more detailed description of the tests and apparatus appears in *Electrical World* for December 15th, 1917, Vol. 70, No. 24.

REVIEWS.

THE PRISMATIC COMPASS AND HOW TO USE IT.

By MAJOR A. D. ST. G. BREMNER, M.C., R.E.—(E. R. Watts & Son. 2s.).

THIS Pocket Manual on Military Magnetic Compasses should prove invaluable not only to those who have little or no technical knowledge of the subject but also to those who are more experienced in it. For the benefit of the former it is written in simple language, and elementary mathematics only are used.

The first of the three parts into which it is divided explains the principal of the magnetic needle, and briefly describes a number of Military Types of Magnetic Compass Part II. gives instruction in handling and testing the instrument, and in its use in marching and traversing. Part III. gives methods of range-finding, measuring the distance between inaccessible points, triangulation for sketching, etc.; working out many problems with no higher mathematics than simple arithmetic.

The book is profusely illustrated with plates and diagrams, and contains much useful information.

J.D.B.

ELEMENTARY MATHEMATICS AND THEIR APPLICATION TO WIRELESS TELEGRAPHY.

By S. J. WILLIS.—(The Wireless Press, Ltd.).

THIS small book consists of a collection of instructional articles which were originally published in *The Wireless World*, and is obviously intended as a help to wireless students who have not had a thorough grounding in elementary mathematics. It would however undoubtedly prove useful in refreshing the memory of others about to enter upon a special study of Wireless Telegraphy. A moderately large field is covered in a clear and concise manner, the subjects treated being Logarithms, Geometry, Algebra and Trigonometry in their elementary stages, with further chapters on Sectors and the Use of Squared Paper. In the last-named chapter the author touches very lightly on the Differential Calculus, more, apparently, with a view to arousing an interest in the subject than anything else.

The author has endeavoured to concentrate on points which have a more immediate application in wireless telegraphy and gives a fair number of practical examples on these points.

Tables of Logarithms and Trigonometrical Functions, to four figures, are given at the end of the book.

PAGES D'HISTOIRE, 1914—1917.

Published by the Librairie Militaire Berger-Levrault, 5—7, Rue des Beaux-Arts, Paris.

The 139th number of the above series is entitled *Le Traitement des Plaies de Guerre*, it is from the pen of Monsieur A. Sartory, Professor at the École Supérieure de Pharmacie, Paris, and Chief Bacteriologist at the École Supérieure de Pharmacie, Nancy, and deals with surgery as practised in the French Army during the present War. The volume is illustrated; although its contents are likely more particularly to appeal to members of the medical profession, yet there is much therein which may well claim the attention of the ordinary layman.

In an introduction to the volume, it is pointed out that the question of the infection of wounds is a matter which is receiving much attention at the present day. The Great War is continually posing new problems for solution in every calling in life, and particularly so in the field of surgery.

The infection germs, which more especially make their presence felt at the Front, take birth and develop with a rapidity particularly disconcerting to the bacteriologist and the biologist; these germs find a suitable soil for their growth in the persons of wounded men.

The modern inventions used in the War of to-day have enormously increased the number and the types of wounds. Bullets, the shock of high explosives, bombs, grenades, torpedoes, inflammable and corrosive liquids cause injuries of very diverse kinds. Fortunately, the progress of modern science has not resulted in the development of destructive agencies alone; it has been responsible, though perhaps in a minor degree, in contributing means for alleviating human suffering also.

Destruction is at all times more easily effected than repair; the barbarity of the Germans has been responsible for much destruction, but to the patriotic zeal of savants, of surgeons, of physicians has it been due that, at the same time, the formidable task of salvage of human wreckage has been carried on with an extraordinary measure of success.

In connection with the treatment of the wounded not only have miracles of science been performed, but there have also been miracles of devotion on the part of the nursing staff, who have rendered invaluable assistance to the medical men by their co-operation in tending suffering humanity.

At the outbreak of hostilities an organization was hastily introduced to provide first aid to the wounded. Many methods of treatment were proposed and tried; but a great number of them were eliminated by the surgeons as soon as the superior efficaciousness of certain methods became evident. The mistakes made in the first days of the War were remedied, and, among other things, the practice of sending distinguished surgeons to the actual battlefield to carry out surgical operations was abandoned, since the adoption of this course seriously compromised the efficiency of the Army Medical Services.

During the three years and more that the War has been in progress experience has taught that the surgeon must seek the co-operation of the bacteriologist and the histologist in his every-day work, since, in the treatment of wounds, so much depends on the state of infection thereof. It is now fully recognized that a correct diagnosis of the condition of wounds cannot be based on a bacteriological, biological or chemical analysis alone, but must proceed on more comprehensive lines, so that the information obtained in relation thereto may be mutually corroborative.

Antiseptic and aseptic methods of treatment and the use of serums and nutritive artificial liquids have added seriously to the complications in carrying out operations on patients and have also been responsible for considerable additions to the surgical arsenal. However, surgeons have been amply repaid by the results obtained by them for the courage they have exhibited in cutting themselves adrift from old and useless traditions. At the present date, surgery has definitely abandoned methods of empiricism and has resorted instead to experimental science for the data required for its beneficent work, much to the advantage of the wounded heroes of the War.

Monsieur Sartory treats his subject under eleven heads. The first section of the volume deals with the microbic infection of War wounds. It is pointed out that since the introduction of antiseptic surgery three groups of methods have been successively in use: (1), the antiseptic method; (2), the aseptic method; (3), the rational or specific method in which serums or artificial nutritive liquids are used.

All War wounds are unfortunately infected by micro-organisms from the outset. The presence of these infection germs and their growth are factors that make the treatment of War wounds a matter requiring special care, and give rise to the adoption of suitable measures for the protection of the tissues owing to the presence of pathogenetic agencies. The growth and development of microbic culture in wounds is briefly traced in this section.

The second section deals with the histological development of War wounds during the first few hours after they have been caused. It is pointed out that War wounds are not only characterized by several stages in the development of their microbic infection, but also by the series of very special transformations which the tissues forming the walls of the wound suffer in their structure. These two developments, the microbic and the histological, which occur in wounds, are intimately related to one another; in both cases the nature of the force producing the wound determines their character. A brief account is given of the nature of certain kinds of wounds, and the precautions to be taken in treating them.

The third section deals with the question of antiseptics and the methods of treatment of infected wounds at the period immediately preceding the present War. Monsieur Sartory recalls that it is only within the last half-century that such powerful aids as antiseptic practice have been placed within the reach of the surgeon. From time immemorial medical practitioners have used certain substances and certain methods in the treatment of injuries; more recently it has been recognized that these methods of treatment were clearly on antiseptic lines. The ointments and balms, which occupied so large a place in the therapeutic surgery of the doctors of antiquity and of the Middle Ages, were employed above all things for the purpose of isolating a wound and for providing it thus with protection from the atmosphere and from external agencies. It was on these foundations that Guérin and Lister built up the methods adopted by them, methods which have made their names famous and placed suffering humanity under a great debt of gratitude to them.

The fourth section gives a brief outline of the antiseptic methods employed and those that have been recently proposed.

The fifth section deals with the antiseptic methods advocated during the present War. The Carrel, Mencière and Vincent methods are briefly described.

The sixth section gives a short account of the methods of treatment based on the use of therapeutic serums. It is stated that the serums used hitherto have been obtained from the blood of animals, principally the horse, and prepared so as to provide those inoculated therewith with a great measure of immunity against the contraction of various contagious diseases. Descriptions are given of the methods employed in the preparation of certain serums.

The seventh section deals with methods of treatment where serums or nutritive artificial liquids, improperly called physiological serums, are used. Short accounts are given of what has been done in this field by the principal workers therein.

The eighth section is on the subject of ambrine. Ambrine is a mixture of paraffin and resinous gums; its value in surgery was discovered some 16 years ago by Dr. Barthe de Sandfort. The method of its preparation, its physiological effects and the manner in which it is employed, and other particulars regarding its use are briefly described.

The ninth section gives a short account of the means employed to alleviate the sufferings of the wounded during their transport and contains a reference to the articulated splints invented by Surgeon-Major Dutard.

The tenth section briefly discusses the question of the measures which should be taken to prevent the infection of War wounds. It is from their soiled clothing that wounded soldiers run the greatest risk of dangerous infection; the main requirement then is to render these garments inocuous by frequent washings and sterilization. The wearing of a garment in the nature of a dust-coat is a great protection; such garments should be undyed, dust-proof, waterproof, and washable. The rainproof of rubbered or oiled materials worn by some French officers is said to possess protective qualities of a very effective order. The garments ordinarily worn can also be rendered harmless to some extent by treating them with antiseptic substances.

The eleventh section contains the conclusion. There are, it is stated, three stages in the treatment of wounds:—(1), the mechanical stage; (2), the antiseptic or chemical stage; (3), the stage for physiological measures. It is for the foregoing reasons that surgeons require as their collaborators men in other fields of medical science, the bacteriologist, the histologist, and the biologist, in order that they may jointly follow, step by step, the developments of the infection germs in War wounds. By means of such collaboration remarkable results have been obtained during the present War, a fact to which some of the illustrations contained in the volume under review bear ample testimony.

The 140th number is entitled *Pourquoi nous nous battons*, and contains two short articles dealing with the French War Aims, and an account of the proceedings in the French Chamber of Deputies on the occasion of the special meeting held on the 5th June, 1917. The two articles are from the pens of General Petain and Monsieur E. Lavisse, of the Académie Francaise.

General Petain's article has already appeared in the *Bulletin des Armées de la République, No.* 252; in it he tells us that many have but a hazy idea, or maybe have forgotten, why it is that France is fighting to-day. He continues: "We are fighting because we have been attacked by Germany.

"We are fighting to drive the enemy out of our territories and in order to prevent, by means of a peace established on a secure and firm basis, a repetition of a similar act of aggression at a future time.

"We are fighting because it would be a crime to betray, by a shameful surrender, both our dead and the rising generations of France.

"We are fighting in order to secure for our land a peace which will restore a state of ease and comfort in the existence of its people and which will rid France from the continual state of anxiety which, in the event of an inconclusive termination of the War, would render the life of its people more intolerable than it is at present.

"We are fighting with tenacity, we are fighting with discipline, because therein live the essentials for victory."

The General discusses the question: Who is it that originally wished for and still wishes for War? He feels that so much documentary evidence has been published, which conclusively brings home the responsibility for the War to its true authors, that it is almost out of place to raise again the question as to this responsibility. But, for some time past, the Germans have been busy attempting, by means of new lies, to obscure the situation, and it is therefore necessary to expose their tricks anew. Further, the Kaiser's socialist commercial travellers are going about saying: "What matters the origin of the War? The responsibility therefor can only be established in the distant future." Unfortunately, there are some in certain neutral countries, and even in France, who have been persuaded to adopt the same cry: "What matters the origin of the War?"

The origin of the War, however, is a matter of considerable importance. It was Germany that prepared for, wished for and precipitated the War; it is Germany that is responsible for its continuance; she still hopes to be able to establish a tyrannical domination over the remainder of the World. The origin of the War discloses to us the aims of which Germany has been in pursuit; aims she has made desperate endeavours to dissimulate by means of successive and different statements, which, however, all bear the mark of deceit upon them.

The history of the events of the summer of 1914 has been told many times. Every Government, including that of the enemy, has published its diplomatic correspondence, and Germany stands condemned by the evidence she has herself made public.

General Petain recalls that Austria unjustly attempted to saddle Serbia with the murder of the heir to the Hapsburg throne and endeavoured under the guise of "reparations" to rob Serbia of her independence. Humiliating as were the Austrian terms Serbia was counselled by Russia to accept them and intimated her readiness to acquiesce. But on Germany's promptings Austria expressed herself dissatisfied with Serbia's reply. Germany wished for war and by mobilizing her troops on the 31st July, 1914, imposed the adoption of a similar measure on Russia, and, therefore, in spite of the efforts of the Entente Group to maintain peace in Europe, hostilities broke out; by degrees a great part of the civilized world has found itself drawn into the Titanic struggle.

Germany had for many years been preparing her schemes against Russia and against France; the former she had wished to push back towards Asia, the latter she had hoped utterly to crush out; being thus enriched and aggrandized Germany would finally have been able to reach the culminating point of her ambition, the domination of Europe.

France, being tied by a solemn obligation, felt bound to stand by Russia in her day of trial. Her desire for peace had been so great that in the past decade she had submitted to many an affront from insolent Germany without taking the steps necessary to insist on an ample apology. And even in the autumn of 1914, the French Government took the precaution, General Petain reminds us, of withdrawing its troops to a distance of 10 kilometres from the Frontier in order that no unfortunate incidents might occur to precipitate a War. The Germans crossed over into French territory without declaring War, but finding that the French were not to be provoked thus, Germany finally declared War on France; an excuse had to be found, so the latter was accused of having committed unneutral acts. It was alleged among other things that French aviators had thrown bombs on the railway at Nuremberg, and this excuse was solemnly communicated to the French Government by the German Ambassador at Paris. On the 3rd April, 1916, the Municipal Authorities of Nuremberg admitted that no such acts as alleged had taken place.

Attention is called to the violation of Belgium's neutrality by Germany and to the admission of the wrongfulness of this act by Bethman-Hollweg, who finally, as is well known, resorted to equivocations with the object of explaining away the effect of his words, when he realized that universal reprobation had been brought down on the Fatherland in consequence of her treacherous act.

General Petain refers briefly to Germany's War aims, and points out that the Pan-German programme provides for depriving France of her Northern and Eastern Departments (Flanders, Artois, Lorraine), of her most valuable mineral, industrial and agricultural resources; with this loss of territory France is threatened with a still further reduction of her population. This programme also provides that France after she has been bled white, shall be mulct in a sum tenfold as great as that extorted from her by Germany in 1871 as a War indemnity; further, the intention clearly exists that France shall be placed in a position of economic bondage, the labour of her sons devoted to producing the fruits of her soil and the output of her factories are to be exploited in the interests and to the profit of the King of Prussia. Like unto Germany's designs on France are also her designs on Europe.

Although beaten at the Marne and on the Yser, held in check at Verdun, obliged at several points to yield ground, with the cordon formed round her in Europe tightening, Germany nevertheless has not yet been brought into that frame of mind which should lead her to renounce her odious dreams of conquest. The more desperate has her position been made, the louder has she cried out for "compensation."

Humiliated by the checks that her troops have met with, reduced to a state of famine by the blockade of her frontiers, bled also in the heavy fighting, no doubt Germany desires peace, but it is a peace which must be, in her own words, "full of honour," that is to say, one *full of profit*. It is such a peace that she has offered to the Entente Powers; a peace that will enable her to prey on those who may foolishly allow themselves to fall victims into her power.

It is only the blind who are likely to be caught in the snare set by Germany. The proof of Germany's bad faith is to be found in President Wilson's reply to her peace offer. Whilst still the Chief of a Great Neutral Power, being anxious to assist in the restoration of peace in the World, he called upon the belligerents to make known their War aims. The Entente Powers at once responded to his appeal, not so Germany; her Imperial Chancellor absolutely declined to make known his country's War aims.

Germany's reticence can alone be due to the fact that she still cherishes her design to dominate the World. She wished for War in order that she might accomplish her purpose. She alone of all the Powers in Europe had made complete preparations for War; alone in Europe she desired it, rushed headlong towards it, precipitated and declared it, rendered it inexpiable by her proceedings, barbarous by the means employed; and now by reason of the fact that she has not the frankness to avow openly her exorbitant pretensions to dominate the World, she remains the only obstacle to a durable and honourable peace.

Whilst Germany is fighting as a beast of prey, so on the other hand France is fighting honourably in defence of her liberty and to safeguard her future existence.

Monsieur Lavisse's article opens with a reference to the economic causes of the War and to industrial Germany. He calls attention to the great change in the conditions of the Fatherland which took place within an exceedingly short space of time. During the first quarter of the last century 80 per cent. of Germans were engaged in agriculture, and that of a poor kind. To-day Germany is one of the greatest industrial Powers of the World. After 1871, her economic progress received a fillip; since 1895, it has advanced by leaps and bounds to giddy heights. *At no period of history has there been seen in any other country, in so short a space of time, a growth in its industries and in its wealth on so formidable a scale as has been seen in Germany in the past four decades.*

At the same time, the increase of population in the Empire has been phenomenal; the population which was 41 millions in 1871 had nearly reached 70 millions immediately prior to the War. The change in the condition of Germany to which reference has been made has led to results which have made themselves felt throughout the World.

Germany, owing to the energy and method of its people, produces much *more than is needed for home consumption ; it is therefore necessary to seek markets outside the limits of the Empire for the surplus not required at home. Such markets are essential. By reason of this overproduction Germany's fate is to be expansionist.*

She has expanded in many ways. Her children have emigrated, temporarily or permanently, into different parts of the Old World and of the New for the purpose of establishing themselves in business. Forming powerful groups, encouraged and assisted from the Capital of the Fatherland, whence they have received directions and money from the banks, they have set to work steadfastly everywhere and everywhere have they succeeded. When the War broke out Great Britain, France and Italy found that Germany had obtained a hold on their economic life which in a short time would have ended in strangulating them. Practically every other country in the World made a similar discovery.

Germany's expansion has also been assisted by her Colonial policy. Although the greater part of colonizable lands was already in the possession of those nations whose people had first concerned themselves with colonial enterprise, Germany too had dreams of founding a vast Colonial Empire which was to have had a great future. No complaint can be made against her for having such ambitions. If in the competition between nations her people proved themselves more hard-working, more energetic, more expert than the people of other lands so much the better for Germany and so much the worse for other nations. But Germany was not content with the measure of success vouchsafed to her. It was painful to her to feel that she was an importer of iron, coal, copper, cotton and even cereals ; this state of affairs seemed to her intolerable. *Germany wished then to have, by right of ownership, all the raw materials required for her manufactures, for her commerce, for her food supplies. Her wish was to possess these in what place soever in the four quarters of the earth they might be found, to what people soever they might belong.* Covetousness was at the bottom of it all, and one of the causes of this War, and not the most insignificant one, was this same covetousness. War is a business with Germany, a wholesale business, *ein grosses Geschäft. By War she wishes to satisfy the appetite which has increased as she has continued to devour.*

Monsieur Lavisse next deals with the moral causes of the War, and German vanity. He reminds us that the vanity of no other people in the World, even that of the Romans not excepted, has at any time been equal to the vanity of Germany ; the Germans claim the property in every virtue of the heart and of the mind. Their tomes are overflowing with declarations of admiration and affection addressed by themselves to themselves ; the most striking and the most extraordinary among these declarations are those to which expression is given by the philosophers and renowned thinkers, by celebrated professors, by generals, by statesmen, aye, by the Kaiser Wilhelm himself.

It is more than a century ago that Fichte, one of Germany's great philosophers, told his compatriots :

" It is you who, among modern nations, have been specially gifted with the germs of human perfection, and it is to you that the premier place for

bringing about its development has been confided. Should you go under humanity will succumb with you without any hope of future regeneration."

It is but 10 years ago that the Kaiser Wilhelm declared:

"*One and all, the middle classes, peasants, labourers, are alike imbued with the same sentiments of love and fidelity for their Fatherland; the German people are the block of granite whereon the Lord our God will be able to raise up and complete the civilization of the Universe; then will come true the prophesy of the poet: 'The World one day will owe its salvation to the German Empire.'*"

It is the Kaiser who is also responsible for the following:—

"*The dear Lord would not have troubled Himself so much about our German Fatherland had He not reserved a great destiny for us; we are the salt of the earth; God has intended us to undertake the task of civilizing the World.*"

These sayings show the extraordinary infatuation of the Germans; they verily believe that they are the Elect of the Lord at the present day, much as were the Jews the chosen people in a former age. They have persuaded themselves that it is to them that the Almighty has revealed His schemes and laws; it is to them that He has entrusted the mission of instructing other peoples and of imposing upon them His decrees.

The Germans would have us believe that it is not the right only to exercise mastery over the World that has been accorded them, but indeed a charge has been laid upon them to undertake this mastery as a solemn duty. Monsieur Lavisse tells us German vanity has undoubtedly been one of the causes responsible for the present.

The political causes of the War and Prussianized Germany are the subjects next introduced. It is pointed out that Germany lived for a long time in a state bordering upon anarchy. During this period Germany consisted of more than a hundred separate States, each living its individual life. The authority of the Emperor was a negligible quantity. But, among these States one acquired a markedly predominating position; this was Prussia. At the beginning of the XVIII. Century, it was an insignificant kingdom with a population of about a couple of million souls. However, in the time of Frederick William I. and that of Frederick II. it blossomed into a military Power. Everything became subordinated to the needs of the Army. The finances were administered with rigid economy; no luxuries were allowed in any part of the kingdom; there was no extravagance at the Court; everybody worked hard. In other countries, the nobility and upper classes claimed a measure of independence; they resisted the oppression of the Crown; they were occasionally in a state of rebellion; in Prussia, on the other hand, the nobility and upper classes served the Crown; it was held by the Prussian squire to be an honour to serve, he took pride in doing so. Succeeding generations, from father to son, served in the Army. A military caste came into existence; it held the lower orders in contempt; it was harsh on the peasantry; it was always docile towards the master and stood erect before him, heels together, the right hand at the salute. In this state no one was allowed to think for himself; the phrase, *nicht raisonnieren*, contained the injunction of the master which bound all.

The organization of Prussia was based on the requirements of War. The small kingdom of Prussia, consisting as it did of small slices of separated territory, needed a War so that other territories might be conquered, in order that the separated slices might be linked up and welded together.

It was towards the end of the Napoleonic Wars that Prussia became one of the great Powers in Europe; under the political leadership of Bismarck, it acquired the position of Sovereign Mistress of Germany.

Prussia has continued to retain her instinct for War. The King of Prussia, when he became a German Emperor, retained his status of King in Prussia. The lust of conquest continues to dominate his whole policy. *War, the national industry of Prussia, has to-day become the national industry of Germany.*

Monsieur Lavisse summarizes the situation in Germany to be as follows:—

It consists of a people who have become an enormous overproductive, ambitious and covetous industrial Power. This people is suffering from mental derangement due to its vanity; it believes itself to be charged by its God with the mission of governing and saving the World.

This people is governed by a soldier, imbued by heredity with military instincts, a conqueror by tradition, who commands the vastest military force the World has ever known.

Combine all these things, or rather consider them as combined; trade, philosophy, religion, militarism, they all tend towards the same end, which is the supremacy, the hegemony of Germany. And the Chief, the Kaiser Wilhelm, though he may raise a smile in us when he proclaims himself the representative of God, has, on the other hand, the right to say that he does represent his people and that to a nicety, for he honours trade, he philosophizes, he preaches, he is the War Lord. . . .

Never, in any place, at any time, have a people steered so directly and consistently for War as have the German people.

Monsieur Lavisse gives under the heading "The Programme of German Ambitions," a brief recapitulation of Germany's War aims. These aims have been fully set out in the notice on the 137th volume of the *Pages D'Histoire* series (*vide R.E. Journal* for December, 1917, and January, 1918), it is therefore not necessary to repeat them here.

In conclusion, it is stated that having considered the words and acts of Germany's leaders, and having shown that the acts confirm the words, it is possible with an easy conscience to lay the accusation: *Germany wished to become Mistress of the World.*

To the question "Why then are we fighting?" Monsieur Lavisse makes reply:

We are fighting to defend our land, inherited from our ancestors; to resume possession of Alsace and Lorraine, of which the enemy violently deprived us in 1871, in spite of the unanimous protests of the people of those provinces, who are still French at heart. We are fighting in order to avenge our dead and our ruins, in order to punish those who have played the part of bandits and assassins, those who have been responsible for the destruction of our monuments and of our land, those who have submitted our civil population to a *régime* comparable only to the harshest conditions of old-time slavery. The Germans have proved themselves ruffians of a species hitherto unknown, for they have had behind them all the forces of modern science, forces which they have misused; their acts of barbarity have been inspired and regulated by precepts systematically co-ordinated to form a doctrine. The Germans, builders of systems of philosophy, have originated a brutal philosophy of War.

We are fighting, our Allies and ourselves, in order to defend the liberty of our labour against a Power that desires to dominate the Universe with a view to exploit it in the interests of its own industries and its own commerce.

We are fighting in order to defend our liberty of thought, for this Power desires to place under its own directive control the intellectual and moral progress of humanity, under the pretext of providing for the salvation of mankind. A German has said that Germany must, as did Rome in ages past, dictate to men "the forms of their ideas." Nothing could be more intolerable than the domination of the mind of man by a Power infatuated with itself, holding in contempt every one who is not bone of its bone and flesh of its flesh, insolent, brutal and whose great "idea" is that Might alone creates Right.

Finally, in fighting against the most redoubtable military Power that the World has known, we are making War against War. We are firmly resolved that peace shall be organized on so powerful a basis that every disturbing State will in future be brought to reason by the goodwill of the other States, strongly armed for the purpose. We wish for a complete victory in order to spare our children from the horrors that have caused humanity to weep so many bitter tears during the past three years.

The concluding article in the volume relates to the extraordinary meeting of the French Chamber of Deputies which was held on Tuesday, 5th June, 1917. After the preliminary business had been dealt with, the Government permitted the following motion to be submitted to the Chamber:—

"The Chamber of Deputies, the direct expression of the sovereignty of the French people, sends greetings to the Russian Democracy and to the Democracies of her other Allies.

"In complete sympathy with the terms of the protest which, in 1871, was addressed to the National Assembly by the representatives of Alsace-Lorraine, provinces torn from France against the wishes of their peoples, the Chamber now declares that at the conclusion of the War, which has been imposed on Europe by the aggression of Imperialist Germany, in addition to the liberation of the invaded territories, there must be returned to their Motherland Alsace-Lorraine also, and just compensation made for all damage done.

"The aims of France being far removed from all schemes of conquest or of the subjection of foreign peoples to a state of slavery, the Chamber relies on the efforts of the Armies of the Republic and of the Armies of her Allies, after Prussian Militarism has been crushed, to secure guarantees for a durable peace and for the future independence of communities, large and small, which will be organized, on lines now being worked out, into a Society of Nations.

"Confident that the Government will obtain these results by the co-ordinated action of the military and diplomatic services of all its Allies, the Chamber rejects all schemes of annexation and moves that normal business be resumed."

Monsieur Alexander Ribot, the French Minister, wound up the debate on this motion by calling on the Chamber to accept the above motion; he expressed the hope that its acceptance would restore unanimity in the Chamber.

During the course of his speech Monsieur Ribot repelled the charge that there had been anything in the nature of secret diplomacy on the part of the French Government; such methods of conducting the affairs of the nation were impossible in the Republic. The diplomacy of France, he claimed, was based on a policy of sincerity, frankness and unequivocal dealings.

Referring to the terms of the motion set out above Monsieur Ribot told his audience that though France had, 45 years ago, suffered from a policy of oppression, the revenge which she was seeking to-day was not revenge of a kind that would result in producing oppression, but rather the revenge which consists in translating into the rights of nations the ideas of justice, liberty and equity held in France. He advised the members of the Chamber not to be deceived by formulas framed by those who wish to dissimulate and hide their true intentions. The desire of the inventors of these formulas is to lead the democracies of the world astray, to create a widespread belief that France is seeking the conquest of new territories. He proceeded: "No! We seek justice and right, we wish to re-occupy those provinces which have never ceased to be anything but French at heart. (*Loud Applause*). They were French by their own wish, for they gave themselves to France. During the course of the great Revolution of 1790, they attended the *fête* of the Federation in order to signify their adhesion to France.

"Since then they have lived the life of France, they have formed an integral part of France, and when they were torn from us, we felt that there was a void that wanted filling in this noble land of France. It is necessary that they should be returned to France, because they belong to her, because they do not belong to those who took them from us, not by persuasion as we had done, but by violence, by the harsh right of War, a right which we repudiate." (*Applause*). "We wish for no annexations by acts of violence; we desire simply the restitution to us of that which is ours." (*Applause*).

Monsieur Ribot concluded by making a strong appeal to the Chamber to support the motion before it and pointed out that it contained the true answer to those who, by their manœuvres, were attempting to divide France and to deceive her. "This will be," he said, "the only, the true answer; France cannot be vanquished."

The 141st number contains the official communiqués issued by the Central Government to the French Provincial authorities during the month of June, 1917; it is the 31st volume dealing with this subject.

The 142nd number contains the Diary of the War for the period 1st January to 30th June, 1917; it is the sixth volume of the kind issued with these series.

W. A. J. O'MEARA.

NOTICES OF MAGAZINES.

REVUE MILITAIRE SUISSE.

No. 10.—*October*, 1917.

THE NEUTRALITY OF BELGIUM.

One of the saddest things in the present War is the persistence with which Germany has been attempting to disparage Belgium in the eyes of the whole world by accusing her of having acted dishonourably. Much literature has been published in which a critical examination is made of the insidious charges directed against Belgium by Germany, notably from the pens of Max Waxweiler, of Fernand Passelecq, and of Baron Bayens; needless to say, these charges have been proved to be entirely baseless and most unjust. The Belgian Propaganda Bureau at Havre has given the widest circulation possible to the literature in question.

Major Marsily contributed an article entitled *Les Chefs d'État-Major de l'Armée Belge et le respect de la Neutralité* to the number of the *Revue* for June, 1917 (*vide R.E. Journal* for November, 1917), in which he examines the German charges from the point of view of Belgium's military preparations for War. The Belgian Propaganda Bureau has recently republished the article in question in pamphlet form at the price of 75 centimes. A copy of this pamphlet accompanies the number of the *Revue* under notice. The reproduced article is accompanied by a map, and also by three official memoranda which have not hitherto been made public; the memoranda consist of a statement made by Baron Beyens, the Belgian Foreign Minister, in March, 1917; of a note relating to the Barnardiston-Ducarne and the Jungbluth-Bridges incidents; and of a statement made by Baron de Broqueville, late War Minister, at a secret session of the Belgian Parliament held in 1913.

In the last-mentioned statement Baron de Broqueville informed his audience that the Belgian Government had learnt, some time before the War, from an authoritative source that the then recent increases of the German Army had been deliberately planned in order to provide for the invasion of France *viâ* Belgium, and he told them that an important personage, now known to be the late King of Roumania, had in a friendly spirit counselled Belgium to take seriously in hand preparations for her defence, as it was improbable that the miracle of 1870 would be repeated.

IMPRESSIONS FROM THE AUSTRO-HUNGARIAN FRONT.

VIII.—*The Army of Transylvania.*

The Valley of the Uz.

The article begun in the *Revue* for August, 1916 (*vide R.E. Journal* for November, 1916), is continued in the number under notice; the text is accompanied by a panoramic view of the country in which the engagement near Sosmezo was fought.

At the end of December, 1916, the front of the I. Austro-Hungarian Army (General von Arz) extended along the frontier of Roumania, from the Valley of the Uz, a tributary of the Trotus, to the summit of Magura, S. of Dorna Watra; this front was about 75 miles long.

The Gyimes Pass, which connects the Valleys of the Haut-Maros and the Trotus, is the most important feature in this region; the only lateral railway in this locality passes through it. Von Arz's Army consisted of two Austrian Army Corps and a Bavarian Division; on its right was von Gerok's Army group and on its left the VII. Army (Kövess).

The G.H.Q. of the I. Army was situated about 50 miles from the front, at Szekely Udvarhely. This village had suffered in an earlier phase of the War, having been pillaged and destroyed by the Roumanians in their retreat.

The writer of the original article relates his personal experiences with the VI. Austro-Hungarian Corps which formed the right wing of von Arz's Army; its headquarters were at Csik Czekefalva when he joined them. He was struck with the admirable manner in which the supply services had been organized.

A short account is given of a visit to the headquarters of the 39th Honved Division during the last days of 1916 and the opening days of 1917. This division held a front of some 6 miles on heights south of the Uz, and had the 61st Division on its left. There was a lull in the fighting at that time.

The Engagement at Sosmezo.

The Valley of the Oïtoz or Oituz lies some 12½ miles south of that of the Uz; the Oïtoz is a tributary of the Trotus. A good road leads from Kezdivasarhely, where the headquarters of von Gerok's Army were located, *viâ* Sosmezo, to Onesti, on the Trotus. This road ends at Bereczk, some 15½ miles on the Austrian side of the frontier.

The XXXIX. German Reserve Army Corps and the 71st Austro-Hungarian Division took part in the engagement at Sosmezo, which was fought on the 5th January, 1917. These formations advanced with their centre on the main road; their wings pushed forward to the heights of Runcul (3,634 ft.) and of Sandor (5,376 ft.). The village of Sosmezo had been in the hands of the 71st Division since the previous day. The road had been destroyed in many places between Beresk and Sosmezo by the retreating Roumanians, who had also blown up all bridges over the river. However by dint of hard work Austrian Engineers had bridged the river in several places by the time that the advance in question began.

The Austro-German Artillery, consisting of 12-in., 6-in. and 4-in. howitzers and field pieces, were in position in rear and in front of Sosmezo and in the forest near Harja.

The main Austro-German infantry attack was directed against the heights N. of Harja, whilst the artillery devoted its attention more particularly to the Russo-Roumanian forces occupying M. Paltinisu.

The Austro-German infantry made good progress on the right bank of the river; they established themselves in new positions, made a fair number of prisoners and captured quantities of munitions of various kinds.

Preparations for Trench Warfare in the Swiss Army.

It is stated that little is known of the methods and details of trench warfare in the Swiss Army. Trench warfare involves the employment of an immense artillery force and results in an enormous expenditure of ammunition. Without this artillery nothing can be done either on the defensive or in the offensive. The Swiss Army is without such artillery and as it is situated, so to speak, between the two belligerents, it occupies a somewhat precarious position. In view of this state of affairs some there are who have contested the utility of the Swiss fortresses. The writer of the original article points out that in spite of the views of those who depreciate the value of these fortresses, they are of immense value and in the early days of a war would enable Switzerland to make the most of the mobile portion of her army on the open part of her frontier. In view of the fact that Switzerland may become a belligerent at any time and, in consequence, may have to employ her army in trench warfare, it is urged that measures should be taken to familiarize Swiss troops with the details of this kind of fighting. An outline of a programme of instruction is given.

Capt. Adrien Balédent.

Capt. Balédent was a contributor to the pages of the *Revue*; he was recently killed in action. Colonel Mayer pays a tribute to the memory of a fallen comrade and furnishes some extracts from the diary kept by Capt. Balédent during the present War—the last of the entries is dated 26th April, 1917. The deceased officer was much struck by what he saw of the British Army; he was a most enthusiastic officer and an excellent companion.

Notes and News.

Switzerland.—A special correspondent writes that in his notes published in the number of the *Revue* for July, 1917, he contested the views of Monsieur Ador, who had invited the Federal Council to consider the desirability of cutting down expenditure in the Swiss Army. The motion of Monsieur Ador was, however, adopted by 86 votes against 50 in the National Council, after an interesting discussion; the leading points of this discussion are touched upon in the original contribution.

It is stated that in spite of the action taken in the Chamber the Swiss people are willing that the necessary credits should be provided for the maintenance of the Army and for works in connection with national defence. The present situation, it is alleged, has been brought about by the ineptitude of the Higher Command, the weakness of the Executive Power and the apathy of the Legislative Power. It is hoped that, by the co-operation of the Federal Council with the newly-elected Chamber, the harm done in matters connected with national defence may even now be repaired and that the Swiss Army may once more become a democratic institution purged of all antipatriotic and caste spirit.

International Matters.—The policy of the Confederation during the present War is alleged to have been paradoxical. The Swiss Confederation, it is claimed, is in advance of Europe so far as concerns the interior organization of Switzerland and the progressive spirit encouraged in that country. The Swiss Confederation is nothing more than a Society of Nations; an arrangement which, it is claimed by some, will tend to reduce the frequency of wars.

The War has, it is said, tested this society and the experience has been an encouraging one; in that under circumstances in which the forces tending to produce *dissociation* were strong, nevertheless *association* has continued to exist. It is explained that the forces of disruption have been neutralized; firstly, by the tradition which has long created affinities between the Swiss cantons which have caused the greatest importance to be attached to the continuance of their association as providing the safeguard for their free existence, and as providing an organization preferable to any other political combination. In the second place, there stands the high respect that the cantons have always maintained in regard to the treaties binding them together. These two circumstances, the policies based on traditions of reciprocal tolerance and of respect for contractual obligations, have enabled the Swiss to realize their wish and their will to live united.

The paradox of neutrality is, it is said, the doctrine known as the "*principe d'État*"; this doctrine is accepted as a fundamental article of political faith by the Swiss Confederation. The question is whether Switzerland should give countenance to those who have violated the principle involved by their conduct towards Belgium, or those who went to the assistance of the latter country in support of the principle in question. If the Latin and Romande Swiss were alone concerned, there is no doubt as to what the attitude of Switzerland would be, but the attitude of the German Swiss has to be reckoned with. Under the circumstances the best has to be made of the situation and, in order that internal strife may not be introduced into the country, Switzerland has to abandon the idea of acting deliberately in support of principles held to be essential by her and has, so to speak, to put her sovereignty into her pocket. This painful necessity for the line of conduct imposed upon her is spoken of as a virtue.

On the other hand, by remaining neutral when the interests of International and the Moral Law demanded the adoption of another course, the Swiss Confederation has shown itself, it is said, behind Europe. It is for this reason that Helvetic policy during the War is considered paradoxical.

Necrology.—The death is announced of Colonel E. Secretan, who was in command of the Swiss 1st Division. He rendered great services to the State and to the Swiss Army. He was one of those who was responsible, by his attitude in the Federal Chamber, of putting an end to the politician-officers; therefore to him was due, in a large measure, the regeneration of the Swiss Army. He was a military author of no mean order and contributed largely to the pages of the *Revue*.

INFORMATION.

France.—In the number of the *Revue* for July, 1917 (*vide R.E. Journal* for December, 1917) an article appeared under the title *La guerre de mouvement*. The author of the article in question has provided a further contribution on the subject in the number of the *Revue* under notice. He states that the Allies are far from being in a position at present of crushing the German Army. The equilibrium established between the Allied forces and the German Army towards the end of 1914 has not been as yet upset. The forces at play in the two camps at the end of 1914 being indicated by the symbols MH and M, simply in one case, and by the same letters with subscripts in the other (where the former represents human material and the latter material pure and simple), if they be equated we have

$$MH + M = M_1H_1 + M_1.$$

By July, 1917, the summation on each side had grown X-fold; this naturally, as already stated, left the two sides as evenly matched as they were two-and-a-half years earlier. During this period the means of attack have only increased in the same proportion as have the means of defence. It is a repetition of the old contest, half a century long, between artillery and armour plates.

It has taken years for the French Revolution to bring about that state of affairs in France which has enabled her to organize victory; it has taken Great Britain nearly two years to bring her "contemptible little army" up to the dimensions of the French Army. It will be two years or nearly so, according to the author of the original article, before the Allies are in a position to crush the German Army. But he does not think that Germany will fight on to the end. The minds of the German people have already passed through two phases. During the first months of the War, they little cared that Germany had forced on the world the most terrible War of all time. They had before them but the visions of the final supremacy of the Fatherland definitely established throughout the Universe. By degrees, as success receded into the dim distant future, aye and even became problematical, they felt that their armies were only fighting to maintain for "Deutschland" that position which she had acquired during four decades of peace. The German mind has yet to go through a third phase; after having abandoned all hope of a rapid triumph, it must allow the idea of resistance to be transformed into the idea of submission.

The augmentation of the forces of the Western Allies by the immeasurable resources of America must at last upset the balance in favour of the Entente Powers, and the collapse of Germany is therefore a sure thing.

This number of the *Revue* concludes with bibliographical notices relating to recent publications and with a list of works received for review.

W. A. J. O'MEARA.

RIVISTA DI ARTIGLIERIA E GENIO.

July—August, 1917.

INFLUENCE OF INTENSE AND PROLONGED CANNONADING ON THE RAINFALL.

At the meeting of the Academy of Science on the 25th April of the current year Mons. Deslandres made an interesting communication on this subject.

When the first artillery, he said, announced the fact that the long cannonading consequent from great battles provoked the fall of rain, this relation of cause and effect was generally admitted as probable after the War of the Revolution and of the Empire. It was confirmed that violent rain followed the Battle of Ligny (16th June, 1815) and that this delayed the Battle of Waterloo, allowing the entry into action of the Prussian troops. So, also at the end of the Battle of Solferino there was a violent storm which favoured the Austrian retreat. The present War also offers several similar examples.

The supposed relation of cause and effect is stated to be denied by several authors, to such an extent that the question to-day remains unsolved. In fact to arrive at certain conclusions it is necessary to know accurately in each case, the local and general conditions of the atmosphere to be able to attribute the fall of rain exclusively to cannonading. But, documentary evidence is wanting, and the necessary information is not complete.

The author adds that he has not the time or the documents required for this study and limits himself to showing that the facts relating to artillery, examined in the light of modern physical science, appear possible and even probable, and seem to be borne out by recent discoveries regarding the condensation of vapour. In fact, discharges of artillery should cause electrization and ionization in the atmosphere, and the water vapour when saturated is condensed more rapidly when the air is ionized and especially when the ionization is negative.

There are many causes by which the air is ionized by the effects of gun-fire.

1. The air is stirred up and violently displaced and in consequence the gaseous molecules colliding one against the other are electronized.

2. The same violent displacements caused by projectiles and the fragments of shells cause a sensible ionization of the air.

3. The earth broken up by the explosions, sets free the air contained within its pores, which is strongly ionized.

4. The incandescent gas, caused by chemical reaction, issuing from the muzzle of the gun in the act of firing, and that caused by the bursting of the shells are strongly ionized and rich with solid particles and those of aqueous vapour; this very warm gas expands from heat in the upper strata of the atmosphere. The electric field of the atmosphere acts also on these free ionized particles, drawing downwards the positive ions and upwards the negative ones. This ascent of warm ionized gas which expands and becomes cooler, doubtless provokes in more hurried air the condenzation of aqueous vapour; and may well modify the electrical state and the general equilibrium of the upper clouds and

cause the transformation of their small particles into drops of rain. The action thus exercised may become notable as in the battles of the present War where the rifles count by hundreds of thousands, and the cannon by thousands firing, for several days without intermission.

The influence of discharges of artillery on the rainfall is then admissible, but usually these discharges have less effect than other causes, which in the ordinary course of things produce changes of weather. The atmospheric currents which carry humid air across the oceans, and the depressions caused by rain and storms which occur on the surface of the earth, have always the greatest influence.

It may be noted that cannonading does not produce any meteorological effect when the air is dry, and to have such effect the air should be damp and saturated. Gun-fire then accelerates, and immediately provokes rain which was on the point of falling. In the absence of shock caused by artillery on the surface of the ground, the rain perhaps might fall later on or farther off, and again perhaps it might be diffused in the atmosphere in a state of vapour.

These considerations tend to show how interesting is the problem and how a special complete research might be useful. A conclusion is only possible when the conditions are carefully collected, case by case, containing the elements of the phenomenon. It may be particularly useful to register the degree of ionization of the air, and also the intensity of the electrical field.

On these communications of Signor Deslandre, Signor Lemoine observes that according to his view, if frequent and prolonged discharges of artillery have any influence on the rainfall, it can only be on slight rainfall; since heavy and prolonged rain, such as causes inundations, can only be explained by the action of strong atmospheric currents. This question, adds Lemoine, is connected with another on the effect of artillery or hail storms which were spoken of previous to the War. It is useful to record that in Italy long and well-organized experiments were made by the Italian Government, which were only interrupted when it was not found possible to come to a positive conclusion on the effects of gun-fire on the formation of hail.

At the following meeting of the Academy of Science, during a discussion, General Sebert observed that Deslandre had only considered local action laying aside the effects of violent and prolonged cannonading at great distances. Sebert, also adds, that Lemoine limits the possible effects of these artillery actions to rain of short duration. But it may be asked if owing to the intensity caused by the recent cannonading on the whole of the Western French front, and the explosion of mines, there may not occur atmospheric disturbances sufficient to produce violent and persistent rain in several directions, and also at great distances.

Many unusual facts observed since the commencement of the War have formed in France a strong conviction that the violent cannonading has been the cause of unexpected rain. There are many noticeable facts in several places of changes of weather and lowering of the barometer that could not be foreseen. Sometimes there has been abundant rain after days of sunshine and fine weather, without any warning. During the winter there are changes of temperature which cannot be accounted for, with snow in the southern regions of France, and even in Spain and Algeria. These facts would seem to extend to regions far from the action of unusual and repeated disturbances and it is difficult to see the origin of events equally unusual, caused by the operations of the present War; and it is natural that these two phenomenal conditions should be placed in relation.

Sebert relates that the same problems were formerly objects of discussion. During the second Empire, the chemist Le Maout, of Saint-Brienne, called attention to these singularities, and affirmed as a fact that the violent fire of artillery provoked heavy rain at great distances. During the Crimean War, when owing to the want of telegraphic communication the notices of military events were much delayed Le Maout pretended that he could anticipate the official notices by some days, exclusively by means of observation of the rainfall in Saint Brienne, that violent battles had taken place in the Crimea. His announcement of the Battle of Inkerman and the assault of Sebastopol obtained for him some notoriety, and he was allowed to make initial official experiments to explain whether artillery fire could provoke rain. These experiments, which naturally could not be made under analogous conditions to those of great battles, made it apparent that when the air is saturated with aqueous vapour, a violent disturbance such as that produced by the fire of guns or as mine explosions is sufficient to provoke the condensation of vapour and then rain follows. But the chemist Le Maout persisted in making reports on the fall of rain, and he made studies of distant battles that took place at that time and during the Italian Campaign of 1859, and he continued with more or less success to discover the official notices of the actions in Italy with the enemy's armies.

The facts alleged by Maout could only be explained by admitting that the atmospheric disturbances produced by violent cannonading could be reproduced at great distances in certain directions, probably by means of currents of air or gas, propagated in the upper regions of the air. These explanations, says Sebert, do not appear to be inadmissible when one remembers that for a long period after the violent eruption of Krakatoa notable disturbances, even as far as Europe were observed in the upper regions of the atmosphere. It is then quite reasonable to express the conviction that rain falling suddenly and frequently in different places is produced by violent cannonading at the Front. The official Journals have frequently sought to contradict this opinion, with the assistance of pretended scientific considerations, and the advice of competent officials, who declare that there is nothing to justify these convictions, since the official meteorological observations do not bring to light any facts that are reliable. In fact, the average reports for rain and temperature are almost similar to those of the preceding years, without such meteorological phenomena that could give indications of disturbances due to the action of artillery.

In order to justify their point of view, competent persons have called special attention to the fact that in such an enormous map as surrounds the globe, the gas produced by the action of artillery and mines can only have insignificant effects on the whole of the atmosphere. But, it may be asked if the question is correctly put on these terms. It is true that a movement is not supposed to be imposed on the whole map of the atmosphere, or even on a considerable part of it. It can well be admitted instead, that violent fire of artillery, or strong and numerous explosions of mines, produce ascending currents of warm air, which raised above the regions of the firing and explosions produce volumes of cold air in the upper regions of the atmosphere; and that this cold air passing to a certain distance in various directions according to the prevailing winds, may provoke rain in such places when it meets with strata of warmer air and air saturated with moisture.

There is then no need to suppose a general displacement of the air; it is sufficient to mention more limited cases, as for example the small displacement of air caused by the issuing of warm gas from factory chimneys, or even small fireplaces. To verify the exactitude of the hypothesis as formulated, it is necessary to set aside the localities in which on certain days violent cannonading has taken place, and on the other hand where rain of an unusual character had been observed at short intervals of time, also, if possible, observing from meteorological bulletins the direction of the wind blowing at certain times in the upper region of the atmosphere. By collecting combined observations of the direction of the wind and of the barometrical pressure made in certain localities it is possible to trace on a card the movements of the atmosphere in that region at a certain moment.

In a well-known work published at Geneva in 1910 by René de Saussure there is shown a method of which starting from a tracing of isobar curves and completed with the direction of the wind in several observatories, provides for tracing on a meteorological card curves indicating the movements of the atmosphere, and the direction of the wind for each point. Such a card would be beneficial to agriculture and also to navigation.

This discussion on the influence of cannonading on the production of rain, has been renewed owing to the extraordinary and torrential rains in Flanders at the commencement of the British offensive, after a violent fire of artillery. It cannot be denied that the long and furious bombardment did not leave in the air millions and millions of solid and gaseous particles which caused the air to be condensed and to fall in rain.

Taking part in this discussion, there are two articles in *La France Militaire* signed Géneral Chapel. These premise that Arago at first drew attention to the relations between ballistics and meteorology. This illustrious scientist in his researches, about 1836, with regard to the belief very prevalent among sailors that gun-fire had the faculty of dissolving temporary clouds, and preventing the occurrence of storms, came to the conclusion that this belief was not founded on concrete facts, and also that several observations tended to show to the contrary. As, for example the attack on Rio de Janeiro in September, 1711, in which 15 great ships of the line took part with violent fire of artillery and musketry which culminated in a storm producing very strong and uninterrupted discharges of electricity. The same fact has been noted on the occasion of other battles.

In order to clear up the question, Arago formed the idea of examining the records of the school of artillery at Vincennes, where the series was complete dating from 1806, and of examining the meteorological state of the atmosphere before and after each day of fire. The days of fire examined were 602. Arago found that the sky was entirely clouded 158 times on the morning after these days and only 128 times the day before, from which, says Arago, it may be concluded that instead of dissolving and driving away the clouds, the sound of the artillery fire condensed and brought them down. After citing the pamphlet of the chemist Le Maout, *Les Cannonades de Sebastopol*, the author of the articles refers also to the reports of one of the Army commanders in the Russian-Japanese War, in which he says that both at the Battle of Liao-tang, and of Scia-ho on the 14th October, 1904, the great amount of gun-fire was the cause of a storm burst followed by a real deluge. The author concludes by drawing attention to the studies made by him during the last 30 years, on the decisive influence in all great meteorological disturbances, meteors, falling stars, and aerolites, falling with enormous velocities. Although the velocity of artillery projectiles is infinitely inferior to that of falling stars and aerolites, their mechanical energy is considerable, and their numbers when fired in modern battles are sufficient to cause sensible atmospheric disturbances.

In the author's view the production of rain is due not so much to the sound of the artillery fire, according to Arago, not even to the vibration in the atmosphere caused by the projectiles, or to electrization, but to the cold that is produced by the rarefaction and expansion of the air caused by the passage of the projectiles, sufficient to determine the endless condensation of the aqueous particles suspended in the atmosphere. This explanation, at first sight may appear paradoxical since the movement of the projectile loses its force from the resistance of the air, and then increases the temperature of the air; but it is necessary to consider that the phenomenon produced by the passage of a projectile is double. In front of the projectile the warm particles of air diverge, diffusing their heat into space; behind, however, the particles being cooler converge in the direction of the trajectory, forming in the passage of the projectile a condensed stream, a kind of small cloud in the form of a fine cirrus which may cause rain. From this it may be inferred that cannonading of itself is not sufficient to cause rain, but only when the hygrometric state of the atmosphere approaches sufficiently to saturation.

Finally, in a communication of the Academy of Science of Paris, H. Hildebranson adheres to the opinion of Deslandres, and considers that following the intense and prolonged action of artillery there are currents of ascending air, since those of an anticyclone with its currents of descending air do not undergo condensation. From this last point of view he cites an experiment made in America to ascertain if it is possible to produce rain by means of violent explosions. The Governor of Texas granted a large sum for this purpose and the trial was made on the 25th and 26th October, 1892, at S. Antonio, in a district that had suffered for long periods from want of rain. Boxes containing rosselit were placed at intervals and were exploded like batteries in a battle. On the evening of the 25th, 2,000 kilogrammes of rosselit were exploded and also 150 bombs in the air and eight balloons filled with detonating gas;

the temperature was 22°C. and some clouds were observed coming from the west. No results were obtained. The following day the air was moist: they exploded 2,270 kg. of rosselit, 175 bombs, and 10 exploding balloons. In the night they repeated the firing and explosions, but always without any result. According to Hildebranson this failure might have been foreseen considering the atmospheric conditions; under other conditions the result might possibly have been otherwise.

This is the state of the debated question.

September, 1917.

REVIEW OF BOOKS AND PERIODICALS.

Infernal Machines, Torpedoes and Bombs.—By Ettore Bravetta, Vice-Admiral. With an appendix on Explosives for War. Milan: F. Treves, Editor, 1917. Price 6 lire.—The author is well known and appreciated for his works and also for his publications in this *Review*. This book is written with a clearness of expression and an agreeable style suitable for persons not acquainted with the technicalities of the subject. But, differing from many so-called scientific works, hastily compiled, Admiral Bravetta's work is distinguished by a rigorous technical exactitude and terminology.

The author treats especially of subaqueous infernal machines used in former times prior to the use of prussic powder, such as Greek fire, etc.

Treating of the earlier period of the art of submarine warfare, the author explains its development up to more recent times, with anchored mines and torpedoes, and ship torpedoes, etc., up to the first appearance of the Whitehead torpedo in 1864–68. From this time until its perfection, Bravetta explains the different changes, and gives a most detailed description of one of the most recent models.

Following the description of torpedoes is that of bombs, fixed and turning on an axis, both ancient and modern with special directions for the placing of torpedoes in submarines and particularly for the recent proposal made by the Engineer Cerio, for a repeating bomb-thrower that can be given to a revolver in the form of a revolving cylinder containing six chambers for as many bombs.

The author possesses in a high degree the art of holding one's interest, for in minute descriptions of complicated mechanism, and when it happens that in spite of his ability the material becomes a little too dry, he has the good sense to advise the reader to omit it.

Resuming his descriptions, Admiral Bravetta expresses his view that the torpedo, although a weapon of great power and of a marvellously ingenious kind, has its limitation, and that it will not succeed in replacing the gun, which will continue to be the real weapon of battle both by land and sea. An appendix follows, but it is an appendix that gives, as it were, in small volume, the principal parts of the book and retains the value of perspective, of exactness, and of facility of reading.

With other necessary definitions he describes the great development of picric powder, smokeless powder, guncotton, nitroglycerine, dynamite, and glycerine explosives. He then passes to the description of fulminate of mercury and what may be called the high explosives used for the internal charges of projectiles, and especially those with picric acid as their base, trinitroluene, and those with bases of ammonia, etc.

He concludes by asking if it may be possible to discover explosives more powerful than those now known. The question is very important as more journalists have from time to time put forward notices of new inventions, capable of resolving in a few weeks this immense world War. The author's reply to this question is apparently in the negative.

It may be said that in addition to investigations of technical minuteness the reply of Bravetta is based on a highly physical and philosophical conception of our earth in the system of the universe; science has not yet in any manner, either chemically or electrically succeeded in producing a temperature of 4,000 C. scarcely two-thirds that of the sun. It would be contrary to natural laws, and to the harmonious order of the universe, that it should be possible for this planet, in addition to the natural energy now existing, to produce an artificial force similar and equal to that, for instance, which regulates the material of the sun or the star Sirius. There is not, then, much hope—or danger according to the point of view—of success in concentrating in explosives a greater amount of powerful chemical energy.

We commend the book to the attention of those who wish to form a precise idea of arms and explosives which are of so much importance in the present War.

Germany.

Suspension of the Construction of Zeppelins.—From notices reported from the *United States Naval Institute Proceedings* it would seem that after the death of Count Zeppelin, who, it was always stated, was assisted in his designs by the Kaiser, a certain number of workmen employed on the construction of Zeppelins at Friedrichshafen have been sent to the Front, so that the preparation for the framework of a great airship that can usually be completed in six weeks, now occupies several months.

According to this Journal the general opinion at Friedrichshafen seems to be that no more new Zeppelins will be constructed.

E. T. Thackeray.