CONTENTS.

Authors alone are responsible for the statements made and the opinions expressed in their papers.—(G. 5281).

TABLE OF DIMENSIONS FOR SUSPENSION BRIDGES.

By LIEUT. J. E. SWINDLEHURST, R.E. (T.), B.A. (Cantab.), A.M.I.C.E.

THE accompanying tables have been compiled with a view to presenting in a readily understandable form those details which it is necessary to know before it is possible to construct a suspension bridge.

The minimum and maximum spans, viz. :—80 ft. and 200 ft., have been chosen as representing the more usual gaps over which a bridge of this type would be constructed, but in no sense are they to be taken as representing finality in this direction.

The question of the number and size of the bays for any given span is a very debatable one. One point however must always be borne in mind. To ensure an even stress throughout the suspending cable it is necessary to attach a sling at its lowest point. From this it follows that an odd number of slings must be employed and consequently an even number of bays must result. This is a most important point and must not be lost sight of. The length of bay is usually determined by the length of the material available for road-bearers, etc., the lengths suggested in the tables being those which have been proved by practical experience to give the best results in the span under consideration.

Passing from this point to the length of sling required it will be noticed that in no case is the length of the centre sling taken as less than 3 ft., though it is in some cases more than this. The reason for the variation is to be found in the column devoted to "Height of Pier." For the purpose of this table this measurement is taken as the distance between the ground level of the bank of the gap and the cap-sill on which the cables rest. It has been established by experience that it is not practicable to give the necessary head-room and to so attach the diagonal braces as to give the necessary lateral stability if the height of the pier be less than 15 ft. Now since this height is the sum of three measurements namely, the dip, camber, and length of centre sling, and the first two of these for any given fraction of the span do not permit of variation, the necessary addition must be brought about by the lengthening of the sling.

Attention is also drawn to the last two columns in each table, namely, those dealing with the length of cable required and the size of that cable. In the former case sufficient length has been allowed for the turn round the anchor log and the seizing but a slightly longer length may be taken with advantage if the stores available will permit of this.

In the latter case it will be noticed that the size is given to the nearest ½ in.; in practice, although a large "factor of safety" is employed throughout, the next larger should be employed. For example, if the calculation gives the size as 8·5 in. employ a 9 in.

It must be clearly understood that all these figures are based on the supposition that due care has been exercised in the selection of site, anchorages, etc., and that material of good average standard can be drawn on. The *utmost* care should be taken that nothing of a doubtful nature is employed in the construction.

The formulæ, etc., on which these figures are based are those given in the *Manual of Military Engineering*, Parts 3A and 3B, and all results may be taken as accurate to the second decimal place.

SUSPENSION BRIDGE.

Calculated to carry Infantry in File (crowded at a check).

Span.	Bays.	Dip.	Height of Pier.	Size of Anchor Log.	Depth of Anchorage.	Jk. for Cable.	Jk. for Anchorage.	Slings.					Tension at H.	Length of Cable.	Size of Cable.
								Centre	3 & 5	2 & 6	1 & 7				
ft. in.	ft.		ft.	ft. in.	ft. in.	ft.	ft.	ft.	ft.	ft.	ft.		lbs.	fath.	in.
80 0	10·00	a/10	15·00	18 × 12	5 0	37·50	50·00	5·66	6·50	8·33	11·16		56,160	73	5·0
,,	,,	a/11	,,	,,	5·50	41·25	56·375	6·40	7·18	8·86	11·49		60,944	77	5·0
,,	,,	a/12	,,	,,	5·50	45·00	61·50	7·00	7·75	9·33	11·75		65,728	80	5·5
	,,	a/13	,,	,,	5·50	48·75	66·625	7·52	8·23	9·72	11·98		70,720	82	6·0
	,,	a/14	,,	,,	5·50	52·50	71·75	7·89	8·58	9·91	12·10		75,712	87	6·0
	,,	a/15	,,	,,	5·50	56·25	76·875	8·33	9·00	10·34	12·33		80,704	90	6·5
								Centre	4 & 6	3 & 7	2 & 8	1 & 9			
90 0	9·00	a/10	15·00	18 × 12	5·50	37·50	51·25	4·50	5·16	6·54	8·64	11·46	63,180	78	5·5
,,	,,	a/11	,,	,,	5·50	41·25	56·375	5·32	5·94	7·23	9·16	11·76	68,562	81	6·0
,,	,,	a/12	,,	,,	5·50	45·00	61·50	6·00	6·60	7·80	9·60	12·00	73,944	84	6·0
,,	,,	a/13	,,	,,	5·50	48·75	66·625	6·80	7·38	8·51	10·19	12·43	79,560	88	6·5
,,	,,	a/14	,,	,,	6·00	52·50	73·50	7·07	7·63	8·70	10·28	12·38	85,176	92	6·5
,,	,,	a/15	,,	,,	6·50	56·25	81·45	7·50	8·04	9·06	10·58	12·54	90,792	96	7·0
								Centre	4 & 6	3 & 7	2 & 8	1 & 9			
100 0	10·0	a/10	15·00	18 × 12	5·50	37·50	51·25	3·33	4·06	5·60	7·93	11·06	70,200	80	6·0
,,	,,	a/11	,,	,,	5·50	41·25	56·375	4·25	4·94	6·36	8·52	11·40	76,180	84	6·0
,,	,,	a/12	,,	,,	5·50	45·00	61·50	5·00	5·66	7·00	9·00	11·66	82,160	88	6·5
,,	,,	a/13	,,	,,	6·00	48·75	68·25	5·65	6·29	7·54	9·42	11·90	88,400	92	6·5
,,	,,	a/14	,,	,,	6·50	52·50	75·25	6·20	6·82	8·00	9·77	12·10	94,640	96	6·5
,,	,,	a/15	,,	,,	6·50	56·25	50·625	6·66	7·27	8·40	10·06	12·27	100,880	99	7·0
								Centre	4 & 6	3 & 7	2 & 8	1 & 9			
110 0	11·00	a/10	15·83	18 × 12	5·50	39·58	53·33	3·00	3·81	5·50	8·07	11·52	77,220	86	6·0
,,	,,	a/11	15·00	,,	6·00	41·25	57·75	3·16	3·93	5·50	7·87	11·04	83,798	89	6·5
,,	,,	a/12	,,	,,	6·50	45·00	64·50	4·00	4·73	6·21	8·41	11·34	90,376	93	6·5
,,	,,	a/13	,,	,,	6·50	48·75	69·875	4·47	5·18	6·56	8·62	11·34	97,240	97	7·0
,,	,,	a/14	,,	,,	6·50	52·50	75·25	5·31	6·00	7·30	9·25	11·82	104,104	100	7·0
,,	,,	a/15	,,	,,	6·50	56·25	80·625	5·83	6·50	7·75	9·58	12·01	110,968	103	7·5

SUSPENSION BRIDGE—*cont.*

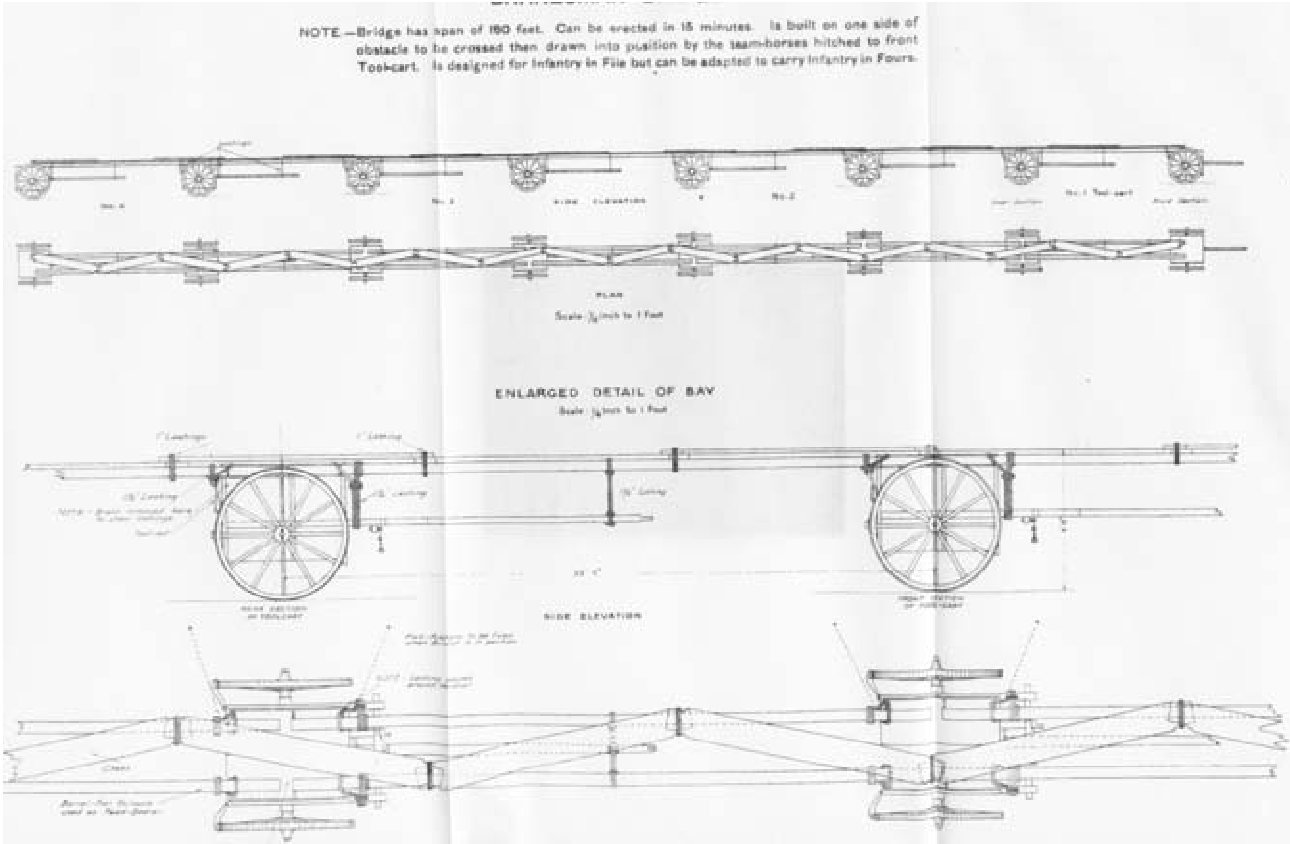
Calculated to carry Infantry in File (crowded at a check)—cont.

Span.	Bays.	Dip.	Height of Pier.	Size of Anchor Log.	Depth of Anchorage.	Jk. for Cable.	Jk. for Anchorage.	Slings.							Tension at H.	Length of Cable.	Size of Cable.
ft. in.	ft.		ft.	ft. in.	ft.	ft.	ft.	Centre ft.		5 & 7 ft.	4 & 8 ft.	3 & 9 ft.	2 & 10 ft.	1 & 11 ft.	lbs.	fath.	in.
120 0	10·00	a/10	17·00	18 × 12	6·00	42·50	57·50	3·00		3·66	5·00	7·00	9·66	13·00	84,240	93	6·5
,,	,,	a/11	15·90	,,	6·50	43·725	61·60	3·00		3·63	4·87	6·73	9·17	12·06	91,416	95	7·0
,,	,,	a/12	15·00	,,	6·50	45·00	64·50	3·00		3·61	4·77	6·50	8·77	11·60	98,592	97	7·0
,,	,,	a/13	15·00	,,	6·50	48·75	69·875	3·77		4·36	5·46	7·08	9·20	11·85	105,080	100	7·5
,,	,,	a/14	15·00	,,	7·00	52·50	77·00	4·43		5·00	6·04	7·57	9·56	12·04	113,568	104	7·5
,,	,,	a/15	15·00	,,	7·00	56·25	82·50	5·00		5·55	6·54	8·00	9·88	12·16	120,056	108	8·0
								Centre		5 & 7	4 & 8	3 & 9	2 & 10	1 & 11			
130 0	10·83	a/10	18·16	18 × 12	6·50	45·40	61·65	3·00		3·72	5·16	7·33	10·21	13·84	91,260	99	6·5
,,	,,	a/11	16·96	,,	6·50	46·75	64·125	3·00		3·69	5·03	7·04	9·69	13·01	99.034	101	7·0
,,	,,	a/12	16·00	,,	6·50	48·00	67·50	3·00		3·66	4·92	6·79	9·25	12·33	105,808	103	7·0
,,	,,	a/13	15·16	,,	7·00	49·27	72·02	3·00		3·64	4·83	6·58	8·89	11·76	114,720	105	7·5
,,	,,	a/14	15·00	,,	7·00	52·50	77·00	3·55		4·17	5·30	6·95	9·11	11·80	129,632	108	8·0
,,	,,	a/15	15·00	,,	7·00	56·25	82·50	4·18		4·78	5·86	7·42	9·47	12·00	131,144	111	8·0
								Centre	6 & 8	5 & 9	4 & 10	3 & 11	2 & 12	1 & 13			
140 0	10·00	a/10	19·33	18 × 12	6·50	48·325	64·58	3·00	3·62	4·81	6·57	8·90	11·81	15·29	98,280	105	7·0
,,	,,	a/11	18·06	,,	6·50	50·00	68·535	3·00	3·59	4·70	6·34	8·49	11·16	14·37	106,652	106	7·0
,,	,,	a/12	17·00	,,	7·00	51·00	72·00	3·00	3·59	4·63	6·15	8·14	10·61	13·56	114,424	108	7·5
,,	,,	a/13	16·10	,,	7·00	52·325	75·075	3·00	3·55	4·52	5·94	7·85	10·15	12·87	123,760	110	8·0
,,	,,	a/14	15·33	,,	7·00	53·655	78·155	3·00	3·53	4·48	5·84	7·60	9·76	12·35	132,496	111	8·0
,,	,,	a/15	15·00	,,	7·50	56·25	84·375	3·33	3·85	4·76	6·00	7·71	9·75	12·19	141,232	116	8·5
								Centre		5 & 7	4 & 8	3 & 9	2 & 10	1 & 11			
150 0	12·50	a/10	20·50	18 × 15	6·00	51·25	66·25	3·00		3·83	5·49	8·00	11·33	15·50	98,900	113	7·0
,,	,,	a/11	19·14	,,	6·50	52·64	70·52	3·00		3·80	5·35	7·66	10·73	14·55	114,270	115	7·5
,,	,,	a/12	18·00	,,	6·50	54·00	73·50	3·00		3·76	5·22	7·38	10·23	13·76	123,630	117	8·0
,,	,,	a/13	17·04	,,	6·50	55·25	75·35	3·00		3·74	5·11	7·13	9·80	13·09	132,600	119	8·0
,,	,,	a/14	16·21	,,	7·00	56·75	81·25	3·00		3·72	5·02	6·93	9·43	12·52	141,960	121	8·5
,,	,,	a/15	15·50	,,	7·00	58·20	84·45	3·00		3·69	4·94	6·75	9·11	11·02	151,320	123	8·5

SUSPENSION BRIDGE—*cont.*

Calculated to carry Infantry in File (crowded at a check)—cont.

Span.	Bays.	Dip.	Height of Pier.	Size of Anchor Log.	Depth of Anchorage.	Jk. for Cable.	Jk. for Anchorage.	Slings.										Tension at H.	Length of Cable.	Size of Cable.
								Centre	7&9	6&10	5&11	4&12	3&13	2&14	1&15					
ft. in.	ft.		ft.	ft. in.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.			lbs.	fath.	in.
160 0	10·00	a/10	21·66	18×15	6·50	54·15	70·40	3·00	3·58	4·66	6·25	8·33	10·90	14·00	17·60			112,320	118	7·5
,,	,,	a/11	20·20	,,	6·50	55·55	73·43	,,	3·56	4·57	6·04	8·00	10·35	13·20	16·50			122,888	120	8·0
,,	,,	a/12	19·00	,,	6·50	57·00	78·00	,,	3·54	4·50	5·88	7·66	9·87	12·50	15·54			131,872	122	8·0
,,	,,	a/13	18·00	,,	7·00	58·50	81·25	,,	3·52	4·43	5·73	7·41	9·47	11·93	14·76			141,440	124	8·5
,,	,,	a/14	17·09	,,	7·00	59·50	84·00	,,	3·51	4·37	5·61	7·19	9·13	11·43	14·10			151,524	126	8·5
,,	,,	a/15	16·33	,,	7·00	61·23	87·48	,,	3·50	4·33	5·50	7·00	8 83	11·00	13·50			161,408	128	9·0
,,	,,							Centre	7&9	6&10	5&11	4&12	3&13	2&14	1&15					
170 0	10·625	a/10	22·83	18×15	6·50	57·08	73·33	3·00	3·62	4·77	6·45	8·66	11·40	14·70	18·54			119,340	121	8·0
,,	,,	a/11	21·28	,,	6·50	58·52	76·40	,,	3·61	4·67	6·23	8·28	10·80	13·81	17·36			129,506	124	8·0
,,	,,	a/12	20·00	,,	7·00	60·00	81·00	,,	3·58	4·59	6·12	7·96	10·29	13·10	16·36			140,114	128	8·5
,,	,,	a/13	19·00	,,	7·00	61·43	84·20	,,	3·56	4·53	5·90	7·69	9·87	12·48	15·53			150,280	130	8·5
,,	,,	a/14	18·00	,,	7·00	63·00	87·50	,,	3·54	4·48	5·77	7·46	9·51	11·95	14·81			160,888	132	9·0
,,	,,	a/15	17·16	,,	7·50	64·35	91·50	,,	3·53	4·42	5·66	7·25	9·19	11·50	14·18			171,496	135	9·0
,,	,,							Centre	8&10	7&11	6&12	5&13	4&14	3&15	2&16	1&17				
180 0	10·00	a/10	24·00	18×15	6·50	60·00	76·25	3·00	3·55	4·55	6·00	7·88	10·22	13·00	16·22	19·88		126,360	129	8·0
,,	,,	a/11	22·36	,,	7·00	61·50	80·75	,,	3·53	4·46	5·82	7·65	9·71	12·27	15·22	18·60		137,124	131	8·5
,,	,,	a/12	21·00	,,	7·00	63·00	84·00	,,	3·52	4·40	5·66	7·30	9·29	11·66	14·40	17·51		148,356	134	8·5
,,	,,	a/13	19·85	,,	7·00	65·50	88·25	,,	3·50	4·34	5·54	7·06	8·93	11·16	13·71	16·61		159,120	136	9·0
,,	,,	a/14	18·86	,,	7·50	66·00	92·25	,,	3·49	4·29	5·43	6·88	8·63	10·71	13·10	15·82		170,352	138	9·0
,,	,,	a/15	18·00	,,	7·50	67·50	95·63	,,	3·48	4·25	5·33	6·70	8·36	10·33	12·60	15·14		181,544	140	9·5
,,	,,							Centre	9&11	8&12	7&13	6&14	5&15	4&16	3&17	2&18	1&19			
190 0	9·50	a/10	25·16	18×15	6·50	62·90	79·15	3·00	3·51	4·39	5·66	7·30	9·33	11·74	14·52	17·70	21·23	133,380	132	8·0
,,	,,	a/11	23·43	,,	7·00	64·41	83·66	,,	3·49	4·32	5·51	7·04	8·90	11·11	13·68	16·60	19·83	144,742	137	8·5
,,	,,	a/12	22·00	,,	7·00	66·00	87·00	,,	3·47	4·27	5·37	6·81	8·53	10·60	12·96	15·67	18·67	156,958	139	9·0
,,	,,	a/13	20·78	,,	7·50	67·54	91·91	,,	3·47	4·22	5·26	6·60	8·23	10·13	12·35	14·88	17·68	167,960	142	9·0
,,	,,	a/14	19·73	,,	7·50	69·06	95·31	,,	3·45	4·18	5·16	6·43	7·86	9·78	11·86	14·21	16·85	179,816	145	9·5
,,	,,	a/15	18·83	,,	8·00	70·61	100·61	,,	3·45	4·16	5·09	6·30	7·75	9·46	11·43	13·64	16·11	191,672	148	10·0
,,	,,							Centre	9&11	8&12	7&13	6&14	5&15	4&16	3&17	2&18	1&19			
200 0	10·00	a/10	26·33	18×15	7·00	65·83	83·33	3·00	3·53	4·46	5·80	7·53	9·66	12·20	15·13	18·46	22·20	140,400	142	8·5
,,	,,	a/11	24·51	,,	7·00	67·40	86·70	,,	3·51	4·38	5·64	7·25	9·20	11·54	14·23	17·30	20·72	152,360	144	8·5
,,	,,	a/12	23·00	,,	7·50	69·00	91·50	,,	3·49	4·36	5·50	7·01	8·82	11·00	13·50	16·33	19·50	164,840	146	9·0
,,	,,	a/13	21·72	,,	7·50	70·60	94·97	,,	3·49	4·28	5·38	6·79	8·50	10·54	12·87	15·50	18·46	176,800	148	9·5
,,	,,	a/14	20·62	,,	8·00	72·17	100·17	,,	3·47	4·24	5·28	6·61	8·22	10·14	12·33	14·80	17·58	189,280	151	10·0
,,	,,	a/15	29·66	,,	8·00	73·73	103·73	,,	3·47	4·20	5·20	6·47	8·00	9·80	11·87	14·20	16·80	201,760	153	10·0



Brakesman Bridge

BRAKESMAN BRIDGE.

By LT.-COL. G. F. WILKINSON, *Director of Engineers, Australia.*

THE accompanying plate and drill detail demonstrate the use of R.E. tool carts for light bridging purposes.

A bridge as described was constructed by Lieut. C. J. H. Keeley during the training of Engineer reinforcements at Seymour, Victoria. It was put together on dry ground and pulled into position by a team of six horses across a river of an average depth of 4 ft. 6 in. It was used for the passage of infantry.

GENERAL PRINCIPLES.

The bridge will be formed by the brakesmen of the double tool carts and the G.S. waggons of Engineer Companies.

Stores.—Baulks, 5 ft.×3 ft., 18, 21 ft. in length.
Chesses, ordinary R.E.
Lashings, 1½ 4—6 fathoms.

Prepare to Form Bridge.—Tool carts are lined up in column of route, full interval.

Prepare to Dismount.—Dismount, unhook.
Brakesmen of tool carts dismount on off sides of tool carts.
Brakesmen of waggons on off and near sides respectively.

Unload Stores.—Brakesmen of tool carts disengage iron section of tool carts and run back same about 18 ft. G.S. waggon brakesmen unload stores, the near side man doubles round and covers off side man. Baulks are unloaded from off side of waggon and placed on off side of tool carts, near side stores on near side, chesses are placed three to each bay on near side. Two spare men detailed as gear men place the lashings for baulks, poles, and chesses, in their respective positions.

Form Bridge.—Poles of rear cart are extended to full length. Baulks are placed in position on top of tool carts, which are held horizontal to the ground to facilitate the lashing securely of the baulks to either side guard rail.

The poles are lashed up taut with a V-shaped lashing to the baulks, which is done by the spare men (or men who are providing the lashings).

Anchors.—Three or six men where necessary are detailed to make anchors from crossed pick heads and helves to which they attach the cable.

Provision for Entry to and Exit from the Bridge is made by extra baulks, chesses, and lashings being placed on front bay of bridge before mounting drivers; rear approach laid on bank of river.

Prepare to Mount.—Teams are hooked into front carts. Drivers and brakesmen prepare to mount in the usual manner, anchor men mount in the centre of bridge and coil up ready for casting anchor.

Walk March.—The site being selected beforehand team drivers will follow No. 1 to selected position, when in position the command "Halt" will be given.

Anchors.—Spare men will cast anchors and will temporarily belay.

Unhook.—Leading brakesmen will release traces of wheel horses and allow horse team to get clear.

Shore Bays.—The two front brakesmen will push out the landing bay and lash. The two rear brakesmen will push out rear bay for entry to bridge and lash same.

Make Fast.—Belay, anchor men will belay cables and brakesmen will make fast all lashings, and screw brakes down tight.

Drill Detail.

Brakesmen Dismount.

Unlimber.—Brakesmen of front and rear carts unlimber and run rear cart back 18 ft. No. 1 takes hold of pole. No. 2 takes out rear pin and fixes front pin in when pole is extended.

Baulks.—Brakesmen take baulks and place them on carts with 18-in. bearings.

Lashings.—Nos. 1 of each sub-section lift pole, Nos. 2 make V-lashing. The two lashing men deal with spare bays.

Lash Bearers.—On rear sections of carts commence with a clove hitch standing part inside V stay of rail, make a figure of eight lashing around baulk and guard rail and finish off with a clove hitch.

Pole.—Bight of double rope through hole of pin of front cart back to pole and thence to baulks finished with a round turn and two half hitches back to pole and finish off.

Front of Cart.—Commence with a magnus hitch on bearer, then to stay of rail and continue round baulk down to top support of carriage front, finish off on the standing parts with half hitches.

Chesses.—These are placed diagonally across bearers connected with timber, hitch and four turns, and finished on road bearer with clove hitch.

This bridge has been run across a river by a team of six horses (medium draught) and been built in seven minutes by partially trained men. The bearers are lashed in such a way that the bridge can be completely turned around in its own length. In deep water it has been floated by filling the lower well of tool carts with kerosene tins. A deep river can be spanned by fixing a line to pole of front tool cart connecting same through a pulley block on the far side and attaching horses to pull same on the shore side.

MEASURES FOR REINFORCING THE SUPPLY, PRESENT AND FUTURE, OF OFFICERS FOR THE SCIENTIFIC SERVICES OF THE ARMY AND NAVY, INCLUDING THE IMPERIAL AIR SERVICES.

By COLONEL B. R. WARD, R.E., C.M.G., MEMB. AER. INST.

A MEETING called by the Aeronautical Institute was held in the Institute's Rooms on March 22nd. Sir William Cospatrick Dunbar, Bart., C.B., was in the chair. The meeting was convened for the reading of a Paper by Colonel B. R. Ward on the problem of permanently securing the best and most abundant supply of officers for the Scientific Services of our Imperial Fighting Forces. The Paper (a summary of which by the courtesy of the Editor of *Air*, the official organ of The Aeronautical Institute of Great Britain) was read in the absence of the author, who had telegraphed his regrets at being unable to be present, at the same time expressing his desire to associate himself with any Committee of the Institute which might be formed to promote the objects outlined in the Paper.

The Author set forth:—

1. The fundamental idea put forward consists in the conception that the Scientific Services of our fighting forces can preserve the highest standard of efficiency, prestige and personnel only by maintaining direct contact with the great professional engineering organizations of civilian life, and by maintaining practical connection with the vast and varied engineering and scientific work of civilian national life

2. The verdict of history shows that, if divorced from the whole body of engineering practice and experience in general, the Scientific Services must inevitably become atrophied, and decline in power.

3. A case in point is furnished by the history of the Corps of United States Engineers, previous to the Panama Canal undertaking.

Only quite recently the prestige of the Corps had fallen to a very low ebb. More than six years ago, however, the officers of the Corps were placed in charge of the Panama Canal Works, undoubtedly the biggest engineering job that has ever been tackled by a corps of military engineers. Their prestige at the present moment, therefore, is distinctly high in the American Army; but it rests on the execution of a civil engineering work.

Years ago, before the American Civil War, 1861—1865, the prestige of the Corps of the U.S.E. was very high indeed. The officers of the Corps were employed in several branches of civil engineering, and the head boy of the West Mount Military Academy almost invariably joined the Corps of Engineers on completing the four-year course.

On the outbreak of the Civil War, all engineering officers were taken for field service.

The Corps consisted of about 150 officers, and the proportion of distinguished generals drawn from this body was very great. At the end of the War all the engineering jobs of these officers were being run by civilians; and when the U.S. Army was re-organized after the War, the Corps of Engineers was unable to get back more than a very small portion of the civilian engineering work that they had previously done. In addition to their work of barrack and fort construction and repair, they had charge of national parks and harbour works. The U.S. Military Authorities, after a time, began to think it was not necessary to retain these, as they were civilian engineering jobs. Pressure was, no doubt, being brought to bear, all the time, by civilian engineers in order that they should get control of these works. In order to retain national parks and harbour works as part of the work of the Corps, the U.S. Engineers recognized that they would have to fight for themselves, as no one else was likely to do it for them. What they did was to join the American Institute of Civil Engineers in a body; and they succeeded in getting one of their members elected President.

By this policy of agreeing with an adversary quickly whilst they were in the way with him, they undoubtedly saved themselves from practical extinction. Even this policy was unable to save the Corps of Engineers from considerable lowering of prestige as compared with its former high position before the War, and had it not been for the execution of the Panama Canal, more drastic measures would probably have been necessary in order to keep the Corps of United States Engineers as a body of real value to the country.

4. Obviously an Engineer Corps whose officers are not highly qualified engineers must eventually recruit a lower type of *personnel* than would be the case if they were men of recognized standing in their profession.

5. Our Royal Army Medical Corps offers a parallel example to the history of the United States Engineers, and shows how the backing of the civil profession is necessary for a military technical body to obtain its proper status and high efficiency in the Army.

Medical Officers used to be attached to Regiments, and were under Commanding Officers of Regiments and Battalions. They had no strong central organization of their own, and their interests were liable to be lost sight of, or pushed on one side, by the higher military authorities. It was not until the civil medical profession as a body demanded army rank, that the centrally-organized Army

Medical Corps, the R.A.M.C. as we now know it, succeeded in attaining its present high position and prestige.

6. In 1907, the Military authorities in Canada, influenced by such considerations as outlined in Par. 3, approved a scheme for interesting, practically, the engineering students of various Canadian Universities in the military side of the engineering profession.

7. Undoubtedly without the support of the civilian engineering professions, it would be very difficult for our Corps of Royal Engineers to retain in the twentieth century the prestige which it had gained during the nineteenth. That prestige is due to certain special circumstances. First and foremost, perhaps, is the fact of the expansion of the Empire during that period. This expansion gave scope to engineering officers and companies to develop colonies whilst in an embryonic condition, and gave them opportunities which, owing to the high developments in the dominions beyond the seas, are now entirely closed to them.

8. The absolute necessity for having men of high standing and honour in a corps like the R.E. will be appreciated when it is considered that the responsibility for the expenditure of enormous sums of money falls upon them continually.

9. Looking at the whole question from the wider national point of view, and with the experience of the last two and a-half years of war, it is now more evident than ever that the country can never put forth its full strength unless and until all civilian engineers (including Mechanical, Electrical, Aeronautical, Automobile, Railway, Mining, Constructional Engineers, etc.) are definitely organized in connection with the various corps of the fighting services, whose work is of an engineering nature. War now is a war of engineers, ironworkers and chemists to a degree never dreamt of before.

10. The practical thing, therefore, is to organize the civilian engineering profession in such a manner that, whenever war breaks out, every engineer will know in what branch of the Army, Navy or Flying Services his work will be required.

11. This result can probably be best attained by arranging that young civilian engineers should be attached to military units for occasional courses, and that young officers of the Royal Engineers, the Flying Services, etc., should be attached to Engineering Establishments, Railways, Aeronautical Works, etc.

12. With this end in view the author approached the Institution of Civil Engineers, between whom and the Corps of Royal Engineers an arrangement already existed whereby the latter body is supplied—under control of the War Office—with Special Reserve Officers. It is satisfactory to be able to state that Mr. C. L. Morgan, of the London, Brighton and South Coast Railway, and Capt. Sankey (late Royal Engineers) have brought the whole matter to the notice of the Council of the Institution of Civil Engineers, and a

small Committee is to be formed with authority to approach the Army Council with a view to establishing closer relations, on certain definite lines, between the Institution of Civil Engineers and Royal Engineers.

13. The author has urged similar action on the part of the Institution of Mining and Metallurgy and the Royal Institute of British Architects, for the supply of constructional engineers to the Corps of Royal Engineers. A further suggestion embodied the idea that these Institutions should subsequently set up a central co-ordinating Committee among themselves, to handle the whole matter in the most simplified form, and to co-operate most helpfully with the War Office.

14. In order to pursue the subject to its conclusion, the author proposes that the Institutions of Mechanical Engineers, Electrical Engineers, Automobile Engineers, the Aeronautical Institute with other organizations capable of dealing with the training and employment of Mechanical Engineers in civil life should—first separately and then in combination—organize a system for feeding a proposed Corps of Mechanical Engineers for the benefit of the Army, Navy, and Flying Services.

15. The author suggests that this proposed Corps of Mechanical Engineers may be most efficiently co-ordinated under the present Ministry of Munitions, which, in most essential respects, is the lineal successor of the old Board of Ordnance. The new Ministry of Munitions seems to be the best organization to give to the newer scientific Services of the Army, Navy, and Air Organizations the same kind of assistance which the old Board of Ordnance gave to the older Scientific Corps: the Royal Engineers and the Royal Artillery.

16. Only by means of some such scheme as the one outlined in the Paper would the Ministry of Munitions—or some other organization of similar scope and independent authority—be able to mobilize the entire mechanical engineering strength of the country.

AIRCRAFT AND MOTOR CAR ENGINE DESIGN.

By MR. LOUIS COATALEN.

AT a period when the management and equipment of our aircraft services is attracting public attention throughout the length and breadth of the land, as well as in the theatres of war in which British arms are engaged, more than ordinary interest attaches to the paper of Mr. Louis Coatalen, delivered to the members of the Aeronautical Society of Great Britain on the above subject, in that he stands in the unique position of being a signally successful designer and constructor of both types of engines, besides being the only motor car manufacturer in these islands who had ready and standardized at the time war broke out more than one model of aircraft engine of original design and of sufficient power to be of use for the needs of our air services during the War, in the course of which he has also evolved, at the request of the authorities, a wider variety of practical standardized models than any constructor in this or any other country.

Mr. Coatalen opened by saying that our national habit of decrying our own achievements and praising that of foreigners, notably the Germans, was never more in evidence than in the case of the aircraft engine problem ; nor was it ever less justified. The case of the latest 6-cylinder Mercedes engine to be captured by the Allies might be taken by way of illustration. Without water and radiator it weighed $3\frac{1}{2}$ lbs. per horse-power ; whereas the latest British water-cooled aircraft engine in the same condition weighed 1 lb. less per horse-power. As regards efficiency, he claimed that this country had produced engines that were out and away superior to anything which our enemies had employed in the campaign to date. He pointed out that the belief which appears to obtain in some quarters to the effect that the design and production of an aircraft engine is akin to that of a motor car one is erroneous. Flexibility, silence, and cost of production are governing factors in designing a motor car engine ; they are practically of no consequence in the case of an aircraft one. On the other hand, weight, a very high brake mean effective pressure, the capability to work at full power for long periods, and comparative great horse-power output—reckoned in terms of hundreds instead of tens—are of prime importance in aircraft engine construction and of comparative unimportance in motor car engine design and production. On this, and sundry other grounds the lecturer detailed, the design of the two types must start from fundamentally opposite points of view.

The aircraft engine proposition calls, notably, for the exploitation of new methods of achieving lubrication, in that the system that suffices for a car proves inefficient for aircraft engines of high output, which are alone useful in warfare to-day. The lubricant becomes too hot, therefore too fluid, resulting in the reduction of pressure to the main bearings, hence the evolution of the dry sump system for lubricating aircraft engines.

"We must not lose sight of the likelihood that the rapid evolution of the aircraft engine during this war and the extraordinarily wide manufacturing experience which is the outcome of that, will at some future time exercise more than a temporary effect on the design and manufacture of engines for car service," he said. He held that there was a closer analogy between the motor car engine designed and built specially for racing before the War and the wartime aircraft engine, than there was between either that type of car engine and the standardized car motor, or, again, the standardized car motor and the aircraft engine of to-day. For instance, the racing car engine resembles the latest aviation types in that a very high mean effective pressure has to be obtained with it. As the problem in both cases is power for weight and engine volume, and not silence and low cost, great freedom is allowed the designer of a racing car engine as regards piston clearances, valve timing, compression, largeness of valve area, strength of valve springs and so forth, the particulars in this connection approximating much more to aviation than to standard car practice.

The chief desiderata in designing aircraft engines are light weight combined with low fuel and oil consumption per horse-power; also with reliability. Minor desiderata, which have already been largely realized, embrace simplification to the utmost in face of aircraft engines being placed, for the most part, in the hands of semi-skilled talent whether as regards actually using or merely maintaining them. Hence the demand for that quality which is generally called "fool proof"; for accessibility, particularly in face of the fortunes of war rendering it necessary on occasions to replace the most vital parts; and suitability of exterior form that the power plant may be accommodated conveniently in the aircraft and occasion the minimum displacement.

For the first time in the story of motor engineering we are making aircraft engines of high output in series instead of some half-a-dozen examples at a time.

There are strict limits to the sizes which are practicable for radial engines, whether of the rotary or stationary types. In regard to either vertical or V-type engines, the nature of the particular service to which each individual machine is to be put likewise imposes certain limits on design. Sometimes this may concern the overall length of the engine, particularly when in waging war in the air it is essential to lose the minimum time in altering the attitude of the machine from a diving position to a very steep climbing one. Again, some series of air craft call for the minimum head resistance but are less imperative as to overall length. Hence six cylinder types would be suitable for such service, whereas V-shaped varieties might not be.

At this period it is impossible to lay down any arbitrary rules as to any one type of aircraft engine being suitable for the needs of all aircraft service. Those needs are almost as various as are the demands for special varieties of steel and alloys. Moreover, they are likely to multiply with the lapse of time. Aircraft engine design resembles motor car engine production in this particular, that it is all the time a question of compromise. The most successful designer is he who exercises the soundest judgment in weighing a hundred and one factors of the hour and who makes the shrewdest estimate of the value of each.

Continuing, Mr. Coatalen said that in the circumstances of being in mid-campaign it was not possible to state definitely the size of aircraft engine which would most likely be adopted as standard in the near future. Experience gained by our aviators at the beginning of the War, together with the demands for the engineer to meet their ever-growing needs, have called for continuous evolution in the design of aircraft, which has inspired corresponding enterprise in regard to engine construction and production.

For short flights the rotary type of engine generally, and the air-cooled varieties, have shown up to advantage to date, though with them the consumption of fuel and lubricating oil may be comparatively high; this is offset by the relative lightness of their starting weight. But for longer flights, in connection with which petrol and oil consumption have to be reckoned with as part of the engine weight, water-cooled stationary type engines have proved most suitable.

Speaking broadly, as regards weight per horse-power, progress in the design of the ordinary water-cooled type of aircraft engine has been very marked. In the brief period of two years Sunbeam-Coatalen aircraft engines of this type have been reduced in weight from 4·3 lbs. per horse-power to 2·6 lbs. per horse-power. The design of the engine head, cylinders, the valves and the valve gear is one of the cardinal features of successful aircraft engine production. For water-cooled aircraft engines Mr. Coatalen favours two overhead exhaust and two overhead inlet valves per cylinder, a conclusion which would appear to be justified by the horse-power obtained from engines designed and standardized on this principle. Incidentally, it allows of the best sparking plug position, namely, in the centre of the cylinder head in the vertical position. Three valves per cylinder, namely, one inlet and two exhaust valves, have been found practicable for certain varieties of work. He holds that more than four valves per cylinder is an undesirable scheme as it seems hardly possible to place them so as to leave an even jacket all round each valve without the employment of very complicated gear. We have an example of this in the Maybach (German) aircraft engine which has three exhaust and two inlet valves per cylinder. In this little water space is provided between the valve seats, while the sparking plug is, besides, set horizontally on the side of the cylinder barrel.

Not only has there been much improvement in cast iron available for cylinders ; aluminium alloys employed with knowledge and skill for that purpose have been found, besides, of great advantage, of course, reducing weight per horse-power to an extraordinary extent. Though we are merely on the threshold of realising the possibilities of aluminium alloys for cylinder castings, it cannot be doubted that within a very brief period they will be recognized as the standard materials for this work, cast iron thenceforward being discarded in favour of them. For two years Mr. Coatalen has standardized aluminium alloy pistons with excellent results.

It is to note, further, that air-cooling is coming into favour increasingly. The introduction of aluminium alloy in the manufacture of the cylinders has exercised a marked effect in regard to this tendency. In the near future air-cooled engines of greater power may be expected to materialize. Tests on Sunbeam-Coatalen aircraft engines have shown the petrol consumption of ·52 pints per horse-power per hour and the oil consumption of ·22 pints per horse-power per hour, representing a distinct advantage in consumption by engines using ordinary type carburettors so recently as at the beginning of the War. Nevertheless, there is room for a deal of improvement yet. Whereas at the beginning of the War the maximum mean effective pressure was 106·135 lbs., to-day it has been increased to 134 lbs. per square inch measured from the brake horse-power and, in some cases, actually through the reduction gear. In regard to methods of engine rating, Mr. Coatalen wishes to propose that the horse-power per unit capacity obtained from any given engine should be taken as the standard for preparing the different " duties " of aircraft engines. The capacity taken would be the capacity per cylinder multiplied by the number of cylinders, and by the number of complete cycles per minute. To serve the aim in view, the horse-power per litre engine capacity per thousand cycles, otherwise per two thousand crankshaft revolutions per minute, is proposed.

HYDROLOGY OF THE ISTHMUS OF PANAMA.

By Brig.-General Henry L. Abbot, *United States Army, Retired.*

The following paper kindly forwarded to us by General Abbot, late Corps of Engineers, U.S.A., was recently read before the National Academy of Science.

The Panama Canal being now opened to traffic, there remains for study only one important hydraulic problem—the sufficiency of the available water supply to meet the needs for lockage, for mechanical power to operate the canal and railroad, and for the electric lighting of the Canal Zone. It should not be forgotten, however, that if a larger volume of water be desirable for these and other uses, the plan proposed by the New French Company to supplement the volume of its smaller projected lake is still available; namely, the construction of a masonry dam near Alhajuela, where a good site exists for creating an upper lake to hold back the surplus water which during the rainy months now runs to waste through the spillway.

The Canal Zone lies between the ninth and tenth degrees of north latitude in a region of exceptional rainfall; where the sun, closely followed by rain clouds raised from the oceans in his annual journey between the tropics, exerts a controlling influence upon the volume of local rainfall. When near his southern limit, in January, February, March and April, precipitation upon the Isthmus is at its minimum; December and May are usually intermediate in volume; in the remaining six months, when near his northern limit, heavy downpours are the rule. Furthermore, the local annual rainfall is not uniform across the Isthmus. As one passes from the Atlantic to the Pacific coast, the volume falls off gradually from about 130 inches at Colon to about 70 inches at Panama. It will be noticed that even the latter is more than double the usual downfall in the United States, a fortunate circumstance for our great artery of commerce. Another local advantage is the fact that the atmosphere of the Isthmus is nearly saturated with aqueous vapour, which largely reduces the losses by lake evaporation. Our hydraulic problem seems therefore to be specially concerned with Isthmian rainfall and outflow, and the relation between them.

To determine accurately the average annual rainfall at any locality, the records should cover at least half a century. Although the Isthmus has been known to civilization for more than 400 years, the first annual rainfall records date from 1863, when they were begun by the agents of the Panama Railroad Company. As to the outflow from the watershed, the records are even less complete. The volume received from the clouds, after reduction by evaporation, by plant growth, and by possible infiltration, represents the available flow at the dam site. To determine to what extent existing data throw light upon this quantity, has seemed to me to be of primary interest.

The earlier records are given in a paper published in the *Monthly Weather Review* in May, 1899; they include those of the Railroad company, and those at that date collected by the two French Companies and the Liquidation. A gap of a few years in the former is supplied by a paper by Mr. A. P. Davis, published in the Twenty-second Annual Report of the United States Geological Survey for 1900–1901. These data are supplemented and discussed by the writer in papers published in the *Monthly Weather Review* of February, 1904, and of June, 1908, together with some later data collected by the American engineers. In March, 1913, Mr. Caleb M. Saville contributed a valuable paper upon the Hydrology of the Canal to the transactions of the American Society of Civil Engineers, bringing the records up to 1910. The Annual Reports of the Isthmian Canal Commission, of course, cover the American operations. The first point for consideration is, how these data can best be grouped for study?

The narrow limits to which the earlier observations were restricted suggest that the basin of the Chagres River above Bohio should be adopted until Gatun Lake began to fill early in 1910. Its area has been accurately determined by recent surveys to be 779 square miles. The early rain records were mostly restricted to Colon and Gamboa. Fortunately, Colon is situated near the Atlantic Coast line where the rainfall is largest, and Gamboa well represents the Pacific limit of the watershed. A careful analysis of the more ample records of recent years (1898—1907) has shown that the average rainfall in the basin above Bohio is about 89 per cent. of that at Colon, 124 per cent. of that at Gamboa, and 52 per cent. of the aggregate of the two stations. To avoid a change in the standard, these ratios have been used throughout the following table to estimate the annual rainfall in the basin; and where a few dry months are missing in the early railroad records the vacancies have been supplied by the mean values of the missing months.

The Chagres River is a torrential stream, and the first French Company early established a fluviograph at Gamboa to register continuously the heights of the water. This record has been carefully kept since 1883; until the rise of the lake in 1910 began to affect the local water level. At the times of freshets the oscillations are so sudden that their number and duration are readily noted, and they furnish valuable checks upon the discharge estimates.

For this study they are assumed to begin and end at a stage 10 ft. above low water, which is rarely exceeded.

Accurate measurements of discharge were inaugurated by the Liquidation and the New French Company, the continuous record dating from 1890. The annual outflow is given in the tables under the forms of cubic feet per second and depth in inches upon the watershed; the latter to permit a direct comparison with the rainfall. Years of great floods are also indicated, with the same object in view.

The first table is intended to present, for the basin above Bohio, all available hydraulic data prior to the date when Gatun Lake began to fill, with some later figures added for comparison with those of the second table, which includes the entire watershed above Lake Gatun during the filling of the lake. In future studies this latter basin will doubtless be adopted, as the net outflow is easily determined and rainfall measurements are now made at many stations. For the second table I first adopted the mean of the rainfall records at nine stations—Colon, Gatun, Trinidad, Camacho, Empire, Culebra, Gamboa, Alhajuela and El Vigia—as well representing the average volume falling upon the lake watershed near the Canal Zone. Seven new stations then unknown to me had been added, and the figures now given are taken from the noteworthy paper by Mr. Willson in the *Transactions of the International Engineering Congress at San Francisco.*

Hydrology of the Watershed Above Bohio; 779 Square Miles.

Year.	Precipitation. Colon, Inches.	Gamboa, Inches.	In the Basin above Bohio. Rainfall, Inches.	Outflow. Ft.-sec.	Inches.	Gamboa Freshets. Annual No.	Duration, Hours.	Authority.
1863	134·3		120					Panama Railroad Records.
1864	123·4		110					
1865	107·4		96					
1866	129·7		115					
1867	120·8		108					
1868	120·0		107					
1869	114·8		102					
1870	149·6		133					
1871	99·6		81					
1872	168·5		150					
1873	87·1		78					
1874	137·7		123					
1875	94·7		84					
1876	124·5		111					
1877	115·5		103					
1878	86·7		77					
*1879	164·2		130					
1880	136·4		121					
1881	102·3	89·5	100					de Lesseps French Cie.
1882	124·1	79·6	106					
1883	115·3	76·6	100			21	201	
1884	86·5	95·9	95			25	334	
*1885	146·3	97·5	127			37	437	
1886	137·2	102·9	125			43	437	
1887	154·9	136·2	151			46	709	
*1888		102·6	127			29	596	
1889		75·7						Collapse. Liquidation.
*1890	154·3	105·0	135	6,304	110·0	34	308	
1891	124·7	77·7	105	4,476	78·1	10	115	
1892	145·3	104·4	130	6,513	113·6	24	269	
*1893	131·9	117·8	130	7,081	123·3	12	220	
1894	153·7	90·6	127	6,098	106·4	25	263	
1895	151·5		135	4,482	78·2	7	54	The New French Cie.
1896	131·5		117	4,216	73·5			
1897	138·0	107·8	128	4,830	84·2	16	157	
1898	115·5	82·6	103	3,944	68·8	8	51	
1899	133·0	80·0	111	3,384	59·0	8	57	
1900	116·1	78·7	101	3,509	61·2	12	84	
1901	107·7	91·6	104	3,855	67·2	13	107	
1902	112·6	97·7	109	4,179	72·9	5	37	
1903	126·3	99·3	117	3,958	69.0	12	94	
1904	126·9	84·5	110	4,110	71·7	13	94	U.S. in charge.
1905	115·4	82·2	103	2,800	48·8	6	48	
*1906	138·1	97·8	123	4,169	72·7	12	178	
1907	125·6	78·1	106	3,597	62·7	11	69	
1908	137·7	77·5	112	3,732	65·1	14	131	
*1909	183·4	122·1	159	7,335	128·0	27	466	
1910	150·0	116·0	138	6,340	110·6	15	77	Lake began to fill.
1911	112·8	70·6	95					
1912	117·6	89·1	107					
1913	131·2	86·3	113					
1914	132·7	77·4	109					

Hydrology of the Watershed Above Lake Gatun; 1,320 Square Miles.

Year.	Lake Above Mean Sea Level, Feet.	In the Lake Watershed. Rainfall, Inches.	Net Outflow. Foot-Seconds.	Inches.	Lake Evaporation, Foot-Seconds.
*1909	3·63	162·42	10,704	110·1	
1910	13·07	149·66	11,938	122·9	
1911	15·15	98·41	5,710	58·8	
1912	31·24	102·83	4,985	51·3	
1913	57·87	102·40	5,272	54·3	484
1914	85·26	100·54	5,118	52·7	704
1915	86·17	118·17	7,106	80·2	733

* Great flood of the Chagres River.

An inspection of these tables shows a satisfactory correspondence between the observed annual rainfall and the outflow and river oscillations as indicated by the number and duration of the freshets. There is, furthermore, a suggestion of a tendency to a progressive annual change between years of maxima and minima in these quantities, which is worthy of notice. If future records confirm this suggestion, it will be needful to study the reason for it, as is now the case with sola spots, aurora borealis, and other natural phenomena. As to the second table, it must not be forgotten that it covers a period when the area of the lake was gradually increasing, causing a variable loss due to evaporation. The values given for it for the last three years are taken from the official reports, and are based probably on direct measurements.

The tropical conditions of the Canal Zone are so different from those in the Continental United States that it is interesting to compare them. This may be done from Rafter's tables, in his valuable paper published as the Water-Supply and Irrigation Paper, No. 80, of the Geological Survey. It is done in the following table :—

AVERAGE RAINFALL, RUN-OFF, AND DIFFERENCE.

Watershed.	Area, Square Miles.	Period, Years.	Rainfall, Inches.	Losses. By Outflow. Inches.	Per Cent.	By Evap., Etc. Inches.	Per Cent.
Muskingum River	5,828	8	39·7	13·1	33	26·6	67
Genessee River	1,070	9	40·3	14·2	35	26·1	65
Croton River	339	23	49·4	22·8	46	26·6	54
Lake Cochituate	19	38	47·1	20·3	43	26·8	57
Sudbury River	78	26	46·1	22·6	49	23·5	51
Mystic Lake	27	18	44·1	20·0	45	24·1	55
Neshaming Creek	139	16	47·6	23·1	49	24·5	51
Perkiomen Creek	152	16	48·0	23·6	50	24·4	50
Tohickon Creek	102	15	50·1	28·4	57	21·7	43
Hudson River	4,500	14	44·2	23·3	53	20·9	47
Pequannock River	64	9	46·8	26·8	57	20·0	43
Connecticut River	10,234	8	43·0	22·0	51	21·0	49
Chagres River	779	21	118·1	82·1	69	36·0	31
Gatun Lake Basin	1,320	6	119·4	75·0	63	28·3	24

An inspection of the last four columns will show how much more favourable to the operation of a canal are the hydraulic conditions prevailing upon the Isthmus than those existing near the Atlantic Coast of the United States. Considerably more than double the volume of rainfall is available, and the losses from evaporation, plant growth, and percolation are represented by only about 30 per cent. as against 50 per cent. of that volume. As stated above, it remains to be determined by the observations of many future years whether there is a tendency to a normal variation in annual rainfall upon the Isthmus, as seems to be suggested by the figures already on record.

REVIEW.

THE YEAR BOOK OF WIRELESS TELEGRAPHY AND TELEPHONY, 1917.

The Wireless Press, Ltd. (Marconi House, W.C.), have recently published the Fifth Annual number of *The Year Book of Wireless Telegraphy and Telephony;* the high standard of the previous issues of this useful handbook is fully maintained in the current number. Although the size of the volume has been increased to 928 pages, and the War must have increased the cost of production, nevertheless the publishers have decided not to raise the price of this volume which remains at 3s. 6d. net.

It is pointed out in the Preface that questions of public policy have affected the completeness of the reference section devoted to call letters, and other particulars relating to Land and Ship Stations. Otherwise this information has been brought up to date and is thoroughly reliable.

The Wireless Map of the World inserted in the present number has been enlarged into a duplicated Mercator, showing Australia and the Far East as reached both by the Eastern and Western routes. The volume is also provided with a series of photographic reproductions of apparatus of historical interest and with portraits of some of the prominent workers in the field of wireless telegraphy.

"The Record of the Development of Wireless Telegraphy and Telephony" with which the volume opens is brought down to 1916. Under 1916, entries record that "during the course of a severe blizzard in the United States during February wireless telegraphy was extensively used for train despatching, as the telegraph wires had been destroyed"; that "the determination of the difference in longitude between Paris and Washington with the aid of wireless telegraphy, which had been in progress since October, 1913, was completed in May, the result expressed in terms of time, being 5 hours 17 minutes 35·67 seconds, and has a probable accuracy of the order of ·01 second"; that "the initiation of the newly-established Trans-Pacific Wireless Service between the United States and Japan was celebrated on Wednesday, November 5th, by an interchange of messages between the Mikado and President Wilson."

Under the heading "National and International Wireless Laws and Regulations" a brief review is given of the legislative steps taken to bring about an efficient control of wireless telegraphy and in relation to the inter-communication by wireless telegraphy between stations under the control of the various Powers. Attention is called to the fact that despite the War at present raging, the "Berne Bureau" continues its distribution of information.

The texts of the International Radio-Telegraphic Convention of July, 1912, and of the International Convention on Safety of Life at Sea of January, 1914, have both been reprinted in this volume. The laws and regulations of the British dependencies and of foreign countries are included; a number of these have been amended since the last issue of the *Year Book* and in consequence the subject matter of this section has been carefully revised and brought up to date. These laws and regulations are preceded by a copious index which greatly facilitates reference to the matters dealt with in them. This section of the work covers 255 pages.

An increase has taken place in the numbers of both the Land Stations and the Ship Stations; the former now occupy 62 pages of small print and the latter 141 pages of small print. The number of Land Stations shown as having a normal day range exceeding 2,000 nautical miles is now seven, *i.e.*, Sayville, N.Y. (4,500 nautical miles), Tuckerton, N.J. (4,000 nautical miles), Bolinas, Cal. (3,500 nautical miles), Glace Bay (3,215 nautical miles), S. San Francisco (2,500 nautical miles), Island of Oahu, Hawaii (one station with range of 2,500 nautical miles and another with range of 2,200 nautical miles). The stations at Iquitos and San Cristobal (Peru) have both a night range of 2,400 nautical miles. The number of Ship Stations having a night range of 1,000 nautical miles and more has increased to 64; of these three have a range as high as 1,500 nautical miles.

In an article entitled "The Fleming Valve and De Forest Audion" particulars are given relating to the very important and interesting patent action brought by the Marconi Wireless Telegraph Company of America against the De Forest Radio Telephone and Telegraph Company and Lee de Forest, before Judge Mayer and the United States District Court. The suit was in respect of an infringement of claims 1 and 37 of U.S. Letters Patent No. 803,684, for "Instrument for Converting Electric Currents into Continuous Currents," filed April 19th, 1905, and issued November 7th, 1905, to plaintiff, as assignee of John Ambrose Fleming, of London, England. There was a counter-claim by defendants on various claims in ten patents of Lee de Forest.

The case was thoroughly threshed out in Court, important witnesses being called by both sides. Judge Mayer delivered his opinion on the case in extremely lucid language; it is well worth study in the original. The learned judge points out that "whatever differences may exist between men of science in respect of the theories by which they account for the movement and action of unseen forces about which so much has been testified and argued in this case, the solution of the points of the controversy with a single exception is not difficult. This, because courts in an art of this kind, place their decisions upon things demonstrable and cannot speculate as to theories in regard to which there is not a common agreement among recognized authorities."

"In endeavouring to resist plaintiff's attack, defendants have proceeded on the theory that beginning with his present patent No. 979,275 antedating Fleming, de Forest gradually developed his first conception until finally it found practical exemplification in the two so-called three electrode Audion devices to which the plaintiff has confessed judgment. In line with this plan of defence, defendants have elaborately built up an unsteady theoretical structure and upon this have superimposed an observatory from which they can see in the mind's eye only that which they call "Audion" action. Therefore, in these circumstances, it is desirable, in order to avoid confusion, to consider first the patents in issue and then the question of infringement; for when their true value is assigned to the patents, the controversy as to the infringement will be better understood. The patents deal with those instrumentalities which, in the art, are aptly named detectors."

Judge Mayer then dealt exhaustively with the subject of detectors, and proceeded to describe the nature of Dr. Fleming's invention. He continued: "Whether right or wrong in his theory, the result of Fleming's invention was to give the art a new, valuable and easily obtainable detector, which has gone into important commercial use. This Fleming detector is highly sensitive, quickly adjusted by an operator of even inferior skill, and only momentarily disturbed by static or strong signals. The thoroughness and earnestness of this litigation is its most significant testimonial."

. . . .

"In the absence of a well-accepted theory of operation which needed merely some physical embodiment and, in the absence also in the art of the physical device itself, at a time when men of great skill were constantly endeavouring to bring forth an advance in this branch of the art, the contribution of Fleming was clearly invention and is entitled to liberal interpretation and consideration, unless impeded by de Forest."

The learned judge next examines de Forest's patents and skilfully explains the differences between de Forest's invention and that of Dr. Fleming. He summarizes the situation in the following words:—"Within the limits of an opinion it is, of course, impossible to analyze at length a mass of experiments, tests and theses and an infinity of detail necessarily involved in the testimony of experts in an art of this kind; but, if plaintiff's theory that his own device and that of defendants operate on the same principle has not been proved (and I think it has as far as such proof is yet possible), at least defendant's theory has not been satisfactorily demonstrated, and finally, the physical facts all support plaintiff's claim."

The learned judge declared his opinion to be that "the broad Claim No. 1 of the Fleming patent is infringed."

In conclusion, he stated "De Forest in his three-electrode Audion has undoubtedly made a contribution of great value to the art and, by the confession of judgment thereof, defendant company may enjoy the just results of this contribution; but, on the other hand, Fleming's invention was likewise a contribution of value and is to be treated liberally and not defeated either by unconfirmed theory or by association in apparatus where later developments have taught how other useful adjuncts can be employed."

Under the heading "Heroic Wireless Operators" are recorded the achievements of ships' telegraphists who performed their duty in the face of extreme peril. The portraits of six wireless men who have won official recognition are published in the volume. It is recognized by the publishers that "it is always invidious to make *any* selection where all are meritorious: it is especially so when one attempts to make selections amongst those who have 'quitted themselves like men' in the dark hours of danger."

A leading feature of the *Year Book* from its earliest days has been the series of articles on scientific and other subjects contributed by distinguished and prominent workers in the field of wireless telegraphy and telephony. A number of such articles appear in the volume under review. The first of them by Dr. J. A. Fleming, F.R.S., treats of "The Electric Arc as a Generator of Persistent Electric Oscillations." In this article it is pointed out that the necessity of obtaining some simple method of producing high frequency persistent or undamped electric oscillations for the accomplishment of wireless was evident at an early stage in the development of radio communication. It was first in 1900, when Duddell described his so-called musical arc, that the power of the direct current arc to become a generator of high frequency persistent oscillations was generally recognized. Duddell appreciated the fact that in order to produce such oscillations the arc itself, as a conductor, must have a falling characteristic curve; that is to say, it must possess a quality such that if current through the arc is increased, the potential difference of the carbons is decreased, and *vice versa*. Later Prof. Poulsen, of Copenhagen, made the important discovery that if the arc be formed in an atmosphere of hydrogen or hydro-carbon vapour, and be struck between electrodes of carbon (negative) and copper (positive), oscillations of great energy and frequency of the order of a million or so could be created in a suitable condenser-inductance shunt circuit. It was subsequently found that a strong transverse magnetic field across the arc was of great assistance. Poulsen applied, in 1903, for patents covering the application of his discovery to wireless telegraphy.

Dr. Fleming examines, in his article, the processes taking place in the arc-oscillation generator in the light of the electron hypothesis of electricity. He calls attention to the fact that in a gaseous conductor the current does not increase steadily with the potential difference of the electrodes, but tends towards a "limiting value" and that "as the ions are moved towards the electrodes, unless these latter remove them or absorb them sufficiently quickly, the accumulation of negative ions near the positive electrode and of positive ions near the negative electrode will diminish the potential difference of the electrodes and create a condition in which increase of current—that is the increase in migration of ions—causes a decrease in the potential difference of the electrodes." In this case there exists a falling characteristic or volt-ampère curve.

When the two carbons of an electric arc are first brought together to start it, the contact resistance causes their tips to become incandescent. When the arc is started a continual liberation of electrons takes place; these ionise the carbon vapour and liberate more ions. The potential difference of the carbons causes the positive and negative ions to migrate in opposite directions. If the current increases, the accumulation of ions reduces the potential difference of the carbons, and the result is a falling characteristic curve.

In an electric arc there is a double transport of matter. The positive carbon ions are heavier and slower in movement than the negative and the result is that an erosion of the positive pole takes place, a crater being formed in it, whilst a less rapid wear of the negative pole takes place, or even carbon may be deposited thereon, producing the "mushroom" tip.

Where an arc is formed in air an oxidation of the incandescent carbon takes place and many of the positive carbon ions are prevented from reaching the negative electrode, being oxidised on the way. The characteristic curve is not very steep, and an increase in the current does not result in a sensible decrease in the potential difference of the electrodes. If, however, the arc is formed in an atmosphere of hydrogen or hydro-carbon, which excludes oxygen from reaching the arc, then the removal or re-composition of positive carbon ions does not take place and a characteristic curve with a steeper downward slope is obtained.

To form or maintain an electric arc it is essential that the negative electrode shall be incandescent ; at the same time, it is an advantage to cool the positive electrode where an increase in the steepness of the characteristic curve is desired. Poulsen formed his arc between a carbon rod as the negative electrode and a water-cooled copper rod as the positive electrode.

Dr. Fleming gives a brief explanation showing why it is that a steep characteristic curve is of advantage and how this is utilised in the case of an arc shunted by a condenser and inductance to transform a direct into an alternating current and to obtain thus oscillations of high frequency possessing considerable energy. Poulsen's discovery enabled oscillations of a frequency of the order of one million or so, and therefore suitable for radio-telephony, to be obtained. The energy of these oscillations is increased by the use of a strong transverse magnetic field, but this field has the tendency to make the arc unstable and easily ruptured or destroyed. It is pointed out that the arc considered as a transforming device is not a very efficient one.

Some practical details of the Poulsen arc apparatus are given in the original article, as also a brief description of Dr. Fleming's own arc generator.

The work of other experimentalists in this field is also referred to and it is pointed out that " the conditions necessary for obtaining oscillations of a frequency suitable for radio-telephony seem to be that the arc shall be formed in an atmosphere not containing oxygen, and that the capacity and inductance in the shunt circuit shall be so adjusted that the natural frequency of that circuit shall not be less than about 250,000, whilst the ratio of the inductance reckoned in centimetres or electro magnetic units to the capacity reckoned in centimetres or electrostatic units shall be at least 20 or even 40. Under these conditions we obtain oscillations in the shunt circuit suitable for radio-telephony." Unfortunately the carbon arc generator possesses the unsatisfactory features of unsteadiness and liability to discontinuities or interruptions in the steady flow of oscillations. It is impossible to secure good telephony under these conditions. Dr. Fleming is of opinion that for radio-telegraphy some mechanical means of creating closely sequent or uniform musical spark discharges provides a more simple, efficient and easily controlled transmitter appliance than the arc generator and that for radio-telephony over short distances some modification of the thermionic generator employing a double anode or grid and plate in conjunction with a Fleming incandescent cathode in vacuo promises the best results. He recognizes the possibilities of the arc generator in connection with radio-telephony, if only some means can be discovered of creating an absolutely steady arc. It is a case for an extended and a thoroughly scientific research into the physical phenomenon attending the production and maintenance of the arc between solid and liquid electrodes.

Mr. Alfred Noyes contributes an article entitled " The Wireless Drama." He points out that " the world at large hardly realizes the immense changes which have been wrought in its own life by the invention of wireless telegraphy." He thinks that the centre of the romance of wireless is probably the apparatus on the roof of the Admiralty in London and hopes that, some day it may be written.

Attention is drawn to the fact that in the Admiralty records of ships attacked by the "U" boat a large number of masters report that the enemy's first attempt has been to destroy the wireless aerials by gunfire, also that the adventures of the wireless operators are among the most stirring tales of the world-war. The experiences of one of these operators is related by Mr. Noyes.

The third article deals with "Ionic Valves" and is from the pen of Dr. W. H. Eccles, who points out that the vacuum tube as used in modern wireless telegraphy is one of the most striking examples of applied physics, for here some quite recondite regions of molecular physics are carried into actual manufacturing processes. In order to understand the uses of these vacuum tubes, and especially to plan new developments, some acquaintance with molecular theory is required." As an introduction, Dr. Eccles points out that great diversity exists in the nomenclature of these tubes and that no term is universally accepted. It is suggested that the term "ionic valve" is general enough to include all types. He then explains that the ion does not usually come into notice in the operation of valves unless, and until, it is charged electrically. The principal kind of ion, the atom of electricity, is usually called an electron; it is a disembodied negative charge quite devoid of matter. Positive ions, on the other hand are, so far as is yet ascertained, molecules of matter minus an electron. For simplicity, Dr. Eccles starts on the supposition that the ionic valve to be studied first is perfectly evacuated and that the solid parts—*i.e.*, the glass and metal—are perfectly free from occluded or absorbed gas. In such a tube containing a hot filament and one or more other electrodes, the whole of any current that is passed through the tube from a positive electrode to the filament, which acts as the negative electrode, is conveyed *by ions that are all electrons*.

"Thermionic theory," Dr. Eccles tells us, "shows that if the incandescent filament is absolutely clean, and if the vacuum is perfect, the rate of emission of electrons from each unit of area of filament surface can be calculated from the molecular theory of gases and the electron theory of conductors. On this latter theory, every conductor always contains a large number of free electrons interspersed between its molecules. The electrons are much smaller than the molecules, but share with them the irregular vibratory motion which we call heat. The electrons are at ordinary temperatures almost perfectly confined to the inside of the conductor by the inward attraction that exists at the surface of all solids. But as the temperature is raised the vivacity of the motion of both molecules and electrons increases till at 1,000° C. large numbers of electrons are continually breaking their way through the surface of the metal. The process is very analogous to the evaporation of a liquid, but in that case material molecules are escaping from the surface and forming vapour."

The dimensions of electrons are touched upon; their diameter has been estimated at $3{\cdot}7 \times 10^{-13}$ cm. whereas the diameter of a *molecule* of hydrogen is $2{\cdot}7 \times 10^{-8}$ cm., *i.e.*, 60,000 times greater. It has been estimated that the number of *free electrons* in a cubic cm. of cold metal is about 10^{22}. When a tungsten filament is raised to a temperature of 2,300° C., $4{\cdot}3 \times 10^{19}$ electrons escape per square centimetre of its area, representing a current of 0·67 ampères. The emission from earthy oxides when heated is much greater than that from metals, and therefore lime-coated filaments are sometimes used in certain types of valves.

The motion of electrons in an electric field is next examined by Dr. Eccles. He tells us that in rising through 1 volt the speed gained by electrons is 6,000 cm./sec. According to thermionic calculations the electrons escaping from the surface of a metal at high temperature have an average speed corresponding to less than $\frac{1}{20}$th of a volt. In thermionic valves the anode is as a rule a clean metal plate or cylinder placed at a distance of a cm. or less from the glowing filamentary cathode.

Dr. Eccles describes what takes place in such valves as follows :—
" The electrons escaping from the hot cathode find themselves in the electric field established by the battery which is connected between anode and cathode, and they gather speed corresponding to this potential difference, whatever the distance between the places, by the time they reach the anode, which is a matter of $\frac{1}{100000}$ second. Most of them enter the anode and, it is thought, join the current that passes along the external wires, flowing, of course, in the direction opposite to the nominal direction of the current. Some are reflected at the anode, but if no other conductor is near are drawn back by the electric field."

* * * * * * *

" The cloud of flying particles exerts electric force and, in virtue of their motion, magnetic force also. The latter, it is found, may be disregarded in practical applications, but the electric force has important consequences. It affects the potential gradient across the space between the two electrodes, with the result that the current is not proportional to the voltage as might at first sight be expected, but is proportional to the square root of the cube of the voltage."

Tubes provided with electrodes arranged on the above principle act as very perfect rectifiers of alternating currents, for when an E.M.F. is applied to the terminals of such tubes half of the complete wave produces a considerable flow of current, while the other half of the E.M.F. wave produces no current, and therefore the result is a pulsating unidirectional current. When a tube is to be used as an amplifier, the method in use consists in adapting a third electrode in such a manner as to influence the distribution of potential in the electron stream between anode and cathode, which in turn alters the value of the previously steady current through the tube. The most efficient arrangement of this third electrode, in the case of the pure electron discharge, appears to be that in which it is placed between cathode and anode in the form of a grid. Further details concerning these grids and sketches of some types of ionic valves are given in the original article. An expanded explanation of the action of the third electrode is also furnished by Dr. Eccles.

A description, with diagrams, is given in the original article of the " Circuits used with Valves." This part of the article deals with (*a*) the valve as generator of oscillations ; (*b*) valve circuits for receiving (use of valve as a detector and use of valve as amplifier) ; and (*c*) use of valve in Beat Reception.

The fourth article is entitled " The Inductance Capacity and Natural

Frequency of Aerials"; it is contributed by Professor G. W. O. Howe, who points out that an aerial may be regarded from two different standpoints; from one it is an oscillatory circuit, from the other an open transmission line. He considers the latter the more accurate and instructive point of view.

The subject is treated mathematically and cannot therefore be usefully condensed.

The fifth article is from the pen of Professor E. W. Marchant and deals with "The Heaviside Layer."

It is pointed out that many explanations were forthcoming in the early days of long distance wireless telegraphy to account for the fact that with an antenna, a few hundred feet high, signals could be sent round or over a wall of water and earth nearly 100 miles high, between the transmitting and receiving stations. "Two obvious theories," says Professor Marchant, "were advanced—the first, that the transmission was not really effected by electro-magnetic waves at all, but by currents distributed over the surface of the earth or water, a theory which had many facts to support it, the most notable of which was that the signals were transmitted more readily over sea-water than over land. . . . This theory still deserves consideration, as it seems likely that some of the energy received at a station may be transmitted by such means.

* * * * * * *

The second, and perhaps more obvious, theory is that the waves were diffracted round the earth's surface; and calculations have been made, and the theory of such transmission worked out, notably by Professor H. M. McDonald."

Professor Marchant refers to the suggestion put forward in 1900 by Heaviside that there existed in the upper regions of the atmosphere a permanently ionised layer capable of reflecting electro-magnetic waves; it is to this that the expression "Heaviside layer" has been applied. The fact that recently signals sent from Tuckerton, N.J., were received by the *s.s. Ventura* when 530 miles S.W. of Samoa, *i.e.*, at a distance of approximately 8,000 miles or nearly one-third the earth's circumference from Tuckerton, has naturally increased interest in the subject. "The Heaviside layer," Professor Marchant tells us, "is supposed to consist of a mass of ionised clouds or fog in the upper regions of the atmosphere, at a height of about 50 miles, which acts as a reflecting shell and behaves like an outer corona or spherical envelope to the earth, against which the electro-magnetic waves which transmit wireless signals impinge and from which they are reflected in much the same way as a hollow sphere with the inner surface made reflecting would reflect all light produced inside it. Although the earth and the Heaviside layer by this analogy might be regarded as equivalent to a polished ball with an outer concentric shell, having its inner surface polished, the phenomena occurring in wireless cannot be compared exactly with that existing in the space between the inner and outer spheres of such a model."

Professor Marchant refers in his article to the investigations carried out by Mr. L. F. Fuller, the remarkable results in connection with which were recently communicated by the latter to the American Institute of Electrical Engineers, and in conclusion summarizes the history of the

Heaviside layer theory and some of the propositions that have been put forward to explain its existence. "All the evidence now recorded," Professor Marchant tells us, "supports the view that the Heaviside layer exists, and that it exercises an important influence on the strength of wireless signals received over very long distances."

In the sixth article entitled "Wireless to the Rescue" Mr. H. J. B. Ward makes a few remarks on the achievements of radio-telegraphy at sea. He points out that "it was not until wireless telegraphy had for nearly eighteen years been demonstrating its utility for sea-going vessels that the British Government issued, on the 20th of July, 1916, an Order in Council insisting upon the provision of a wireless installation in the case of "every British ship of 3,000 tons gross tonnage or upwards." The numbers of rescues effected annually at sea by the instrumentality of wireless telegraphy have been, he further points out, increasing in a geometrical and not an arithmetical ratio. A table is given of "Timely Rescues"; it covers more than nine closely printed pages of the *Year Book*.

In the seventh article Mr. C. H. Taylor describes "Some Features of the Long Distance Stations of the American Marconi Station" in an interesting article in which a great number of technical details are given.

In the eighth article Mr. W. P. Harris deals with "The Achievements of Wireless Telegraphy." He expresses the opinion that in spite of "widespread interest in the science and the constant record of progress which is brought under the eye of the intelligent newspaper reader, it is safe to say that very few members of the general public fully realize the ubiquity of wireless, its reliability and the extent to which it has contributed to the world's progress."

The important part wireless telegraphy is playing in this War, both on land and on the sea, is briefly touched upon. But, as Mr. Harris points out, wireless is best known for its services to mercantile vessels in the happy days of peace. He also informs us that the wireless service is now handling business messages at rates which are in all cases substantially lower than those of the cables, the Marconi Trans-Atlantic rate between London and New York, for example, being 8d. per word for ordinary telegrams as against 1s. per word by cable. These messages are transmitted directly and without relaying between the British shores and the coast of America by day as well as by night.

Mr. Harris sums up the present situation with regard to wireless in the following words:—"It is now possible to work regularly day or night over thousands of miles; automatic duplex high-speed working—once thought by most telegraph officials to be an absolute impossibility in wireless—is now firmly established; automatic recording of messages is carried out daily at many long-distance receiving stations; the apparatus on both ship and shore stations, once delicate and erratic, is now thoroughly strong, reliable and fool-proof, and manufactured to standard specifications. Accurate calculations of range and power has taken the place of the methods of trial and experiment, and if it is desired to erect a pair of stations to communicate over 2,000 miles, the specifications can be drawn up and the station erected with certainty that they will fulfil all requirements."

There are, it is pointed out, one or two outstanding problems requiring to be solved, but it is hoped that the experts who are tackling them will soon find an answer to the riddles Nature has set the world.

In an article entitled " International Time and Weather Signals " the opinion is expressed that wireless telegraphy will play a great part in days to come in regions of activity of which at present it only touches the fringe. Prominent among such future spheres of action is likely to be world-surveying. Through radio agency the differences of longitude between Paris and many French towns have already been established, as well as the difference of longitude between Paris and Washington, as stated earlier in this review. The Commissioners engaged on the Franco-Liberian and Franco-German frontiers resorted to wireless telegraphy for the purpose of determining the longitudes of the boundaries, and a similar use was made of wireless on the occasion of the rectification of the frontier line between Brazil and Bolivia. It is further expected that very considerable use will be made of wireless in the future in connection with time signalling and meteorological services. Particulars are given of the nature of the wireless time and weather signal services which have been provided by the various countries hitherto.

In an article giving " Particulars of Wireless Telegraph Patents in 1916 " it is stated that though far from reaching the pre-War standard, the number of patent applications filed during the past year is few short of 18,700. Applications with reference to wireless telegraphy and telephony, however, have exceeded by 50 the total number of similar applications filed in the year 1913, making in all 190 applications."

Attention is called to the fact that a system of compulsory licences has been introduced to enable British firms to work enemy patents on payment of royalties, such royalties being held in trust for the patentees by the Public Trustee.

Lists are given with brief descriptions of the British and United States applications for wireless patents during 1916.

" Definitions of Terms used in Wireless " are included in the volume under review. These have been compiled by Dr. J. Erskine Murray from the Report of the Committee of Standardization of the Institute of Radio Engineers and from other sources.

A " Dictionary of Technical Terms " in five languages, viz., English, French, Italian, Spanish and German and " Useful Formulæ and Equations " both specially compiled under the supervision of Dr. Erskine Murray are contained in the *Year Book*.

International units and symbols, other useful data, particulars concerning the leading companies engaged in the commercial development of wireless telegraphy, biographical notices of prominent workers in the wireless field, the literature of wireless telegraphy and telephony and directories of wireless societies and Lloyd's Signal Stations are also included in the volume and add very considerably to the usefulness of a valuable and well-got-up handbook, which ought to have its place with other leading books of reference in the busy man's office or library.

W. A. J. O'MEARA.

NOTICES OF MAGAZINES.

REVUE MILITAIRE SUISSE.

No. 4.—April, 1917.

On Cavalry.

The article begun in the *Revue* for February, 1917, is concluded in the number under review (see *R.E.J.*, June and July).

The writer of the original article expresses the opinion that Von Kluck made excellent use of the large cavalry force under his command. He certainly placed great confidence in the fighting qualities of his cavalry for it was on this arm that he relied to mask his movements, to prevent the enemy from penetrating into the gap created in the German front on the morning of the 6th September, 1914, and to frustrate, under excessively difficult circumstances, the hostile enveloping movements.

The important *rôle* played by the German cavalry at the Battle of the Marne comes home to us when it is remembered that it was at the time that Von der Marwitz made it known that he could no longer keep the enemy in check that definite orders for the retreat were given. It was the breaking point in the endurance of the cavalry that constituted the decisive factor in the situation.

The writer of the original article considers that the two factors which enabled the German cavalry to perform the task allotted to it with such success were first, the lack of energy and push in the handling of the British Army, and secondly, the fact that the two cavalry corps under Von der Marwitz and Von Richthofen composed really a combined force of some magnitude and one capable of acting independently on a wide front. It consisted of 12,000 sabres, 6 to 8 battalions of infantry and 72 guns, together with a large number of machine guns and cyclists.

It should be noted that it was by dismounted action that the German cavalry obtained nearly all its successes. To those who argue that infantry could have achieved results similar to those obtained by the German cavalry, the author of the original articles replies "Yes, perhaps." He is, however, of opinion that under circumstances similar to that in question, no other arm has quite the same value as cavalry. Infantry might have been able to do as much as the cavalry, but, he thinks, it *is very probable that it would have actually done less, owing to its comparative lack of mobility*. Infantry could not have reinforced threatened points with the same rapidity that the German cavalry succeeded in doing.

It is considered that the use that Von Kluck made of his cavalry during the Battle of the Marne affords a most interesting study in the tactical employment of that arm.

On no previous occasion in actual warfare has cavalry been called upon to play exactly the same *rôle* that Von Kluck's troopers played. Not that the principle involved was entirely new, for Article 481 of the Swiss Regulations, it is pointed out, lays it down that among the tasks that independent cavalry may have to undertake is that of "seizing or guarding points or sectors possessing strategic or tactical importance."

But what was not foreseen was the fact that a task of this kind might involve operations on so extended a front and last for so long a time as they did in September, 1914. The lessons learnt will, it is expected, not be lost sight of in the future. One of the most important tasks likely to be assigned to the larger formations of cavalry in future will be that of moving with rapidity to fill up large gaps in the battle front. The tactics employed on the Marne will no doubt be copied in such cases.

The writer of the original article feels the time is past when a large body of cavalry can hope to be able to deliver an effective charge, and cavalrymen must therefore become reconciled to the idea that their arm must fight dismounted to a great extent. Small bodies of cavalry, he thinks, may still be able to deliver a charge and cavalry should therefore always be on the look-out for an opportunity to do so; the present War affords many examples of charges being delivered by small bodies of cavalry. He does not agree with those who argue that the "cavalry spirit" will be adversely affected by the employment of this arm extensively in dismounted action. Indeed his own view on the subject is that the more cavalry is called upon to fight dismounted, the better mounted will it become and the better prepared will it be for mounted action. By employing cavalry thus the spirit of offensive action will be encouraged, a disposition to arrive at prompt decisions will be developed and a tendency to handle cavalry boldly will be inculcated. It is urged that cavalry should do its utmost to perfect itself in both kinds of fighting, and that it should devote more and more attention to that kind which is the newest and one in which it can do the most for its side. "*Let us learn*," says the author of the *Revue* article, "*to cover great distances across country in such a way as to arrive at the decisive point before the enemy does so, in order that we may surprise him, attack him and harass him by hanging on to his flanks*."

It is further urged that the troopers should individually be taught to become good marksmen and that machine-gun teams should be taught to become adepts in handling their weapons in small groups, to run risks where the occasion requires and not to seek for protection too anxiously. To fulfil these duties with success, however, cavalry must be employed in force. "*A weak cavalry force*," says the author of the *Revue* article, "*serves no useful purpose whatever*."

The use of large formations of cavalry alone without the addition of infantry units, it is suggested, will rarely be resorted to in the future; the tendency is towards the employment of *combined detachments*. It is suggested that it was largely due to the fact that battalions of Chasseurs and batteries of artillery accompanied the German cavalry that it met with so much success in the present War. If at times the rate of advance of cavalry was slowed down by the addition of the less mobile troops accompanying it, on the other hand when cavalry was held up the presence of these less mobile troops shortened the delay brought about by the resistance of the enemy.

It has been suggested that the German cavalry have on occasions made a misuse of their Chasseurs. Infantry have, in some cases, been started off two to three hours before the cavalry for the purpose of "*clearing the road.*" There is much to be said for employing the infantry in this manner, but the author of the *Revue* article considers that infantry should, as a rule, be employed to support the cavalry, to hold important points in rear of the advancing cavalry, either to keep the route open or in order that such points may serve as pivots of manœuvre. The infantry may also be with advantage employed to hold an enemy in front whilst the cavalry is busy sweeping round its flanks.

The art of handling a *combined detachment* is not something to be acquired by instinct alone; like other branches of the art of war it requires study.

So far as reconnaissance duties are concerned, the experience of the first two months of war on the Western Front teaches no new lessons. There is not sufficient evidence available yet to say whether better results can be obtained by employing a whole squadron, or whether by employing smaller groups of cavalry, for reconnoitring purposes.

The heliograph has proved itself an indispensable part of the equipment for cavalry.

The attachment of cyclists to the cavalry reconnoitring squadrons has also met with considerable success on the Western Front. The use of aeroplanes and observation balloons has not, in the opinion of the author of the *Revue* article, materially affected the importance of the reconnoitring duties formerly and still undertaken by the cavalry. Detailed information cannot be obtained by airmen; nor are they of much use in misty weather and in wooded country. Reconnaissance duty on the battlefield, however, falls exclusively in the province of the air service.

So far as march and manœuvre formations are concerned it is more than ever necessary to avoid massing the men; cavalry should move in echelons of squadrons and of troops with as great a distance separating the several units or groups as the situation will permit; attention is called to Colonel Carrère's *Cavalerie son Emploi dans la Guerre Moderne* (Lavauzelle, Paris, 1916). Further information on this subject can be obtained from the pages of the volume referred to.

The author of the *Revue* article in conclusion states that he has dealt more particularly with the German cavalry because he was able to obtain more information concerning it than concerning the cavalries of the other belligerent Powers. However, he recognizes that many valuable lessons are to be learnt from a study of the part played by the French, the Belgian and the British cavalry in the early operations of the War. He is convinced that there still remains a useful *rôle* for cavalry in modern war and quotes a passage from General Bonnal's *Les Conditions de la Guerre Moderne* which fully bears out his own contention that cavalry is far from being in a bankrupt condition but is still well able to undertake the obligation of paying its way to fame and glory in a modern theatre of war.

The Italo-Austrian Theatre of Operations.

The present Italo-Austrian theatre of operations, it is pointed out, consists of two distinct regions, viz.:—The Trentino or Alps front and the Carso front.

The *Revue* article is illustrated by diagrams showing in sectional elevation the different sectors of the two fronts (as below) and also a sketch map showing the Trentino region. The two fronts have together an extent of approximately 373 miles, from the Gulf of Trieste to the Stelvio Pass, and may be considered as being made up of the following five sectors :—

I.—The Julian Alps Sector (from Gulf of Trieste, south of Monfalcone to M. Cergnala)	62 miles.
II.—The Carnic Alps Sector (from M. Cergnala to Cra. di Casa Vecchia)	75 ,,
III.—The Cardoria Sector (from Cra. di Casa Vecchia to Val Sugana, south of Strigno)	93 ,,
IV.—The Dolomites Sector (from Val Sugana to Riva on L. Garda)	62 ,,
V.—The Judicaria-Stelvio Sector (from Riva to Stelvio Pass)	81 ,,

The sectional elevations of these sectors published in the *Revue* bring home very vividly the very difficult nature of the theatre of operations in which the Italian Army is engaged.

Attention is drawn to the fact that the theatre in which the Italian and Austrian Armies are at grips at the present time has on many previous occasions been the battle ground on which nations have endeavoured to settle their quarrels; to mention but a few dates the author of the *Revue* article mentions the campaigns of 1796, 1797, 1799, 1805, 1848, 1859 and 1866.

In all these campaigns the main idea has been to seize the Trentino and the upper valley of the Adige. For it has always been felt that an army that obtained mastery of these regions obtained, at the same time, domination over the plains of Lombardy and the Po Valley.

The Italians have always looked upon the possession of the Trentino region as being of extreme strategical importance in relation to the defence of their country. This region is the key to the defence of the Po Valley and its possession excludes the possibility of a flank attack on any Italian Army in the Venetian theatre; from the Trentino lines of advance diverge on to the front Vicenza-Verona-Brescia (about 70 miles in extent).

The region is equally important from the Austrian point of view as providing a suitable central position from which Austrian Armies can advance to meet their enemies on hostile territory.

When Italy came into the War in 1915, the Trentino had not lost any of its former importance. It was rumoured during the winter of 1915 and 1916 that the Austrians intended to launch an offensive, in the grand old style, into the plains of Lombardy from the Trentino, hoping thus to threaten the Italian Army in the Venetian zone. Such an operation is one attended by certain difficulties owing to the fact that the Trentino is excentrically situated from the point of view of the railway communications of the Dual Monarchy; only two railways are available for the transport of troops and supplies to this front, viz. :—those in the Eisak and Puster Valleys which converge on Franzensfeste Railway Junction and lead thence to Trent (55 miles further south).

The Trentino front from the Adige to the Val Sugana has an extent of nearly 45 miles, as the crow flies. It is at a considerable distance from the Isonzo front and provides neither shelter nor food for an army. Extensive preparations must therefore be undertaken in this region by armies intending to operate therein, and little secrecy can be maintained in relation to the military measures which may be put into execution.

The Italians have estimated that the Austrian Army concentrated in the Trentino consisted of 18 divisions and 2,000 guns of various calibres, including 40 12-in. guns, 4 15-in. guns and 4 16·5-in. guns: a total force of approximately 400,000 men.

The Austrian artillery attack began on the 14th May and reached its maximum intensity on the following day; towards the evening the infantry joined in the fight, which was of the character usual in mountainous countries, each side fighting for the possession of the highest ground.

An Austrian offensive for the possession of the plains of Lombardy and Venice affords the greatest chance of success if combined with an offensive from the east against the Isonzo front.

The Austrian offensive of 1916 was confined to the Trentino front; in consequence, the Italians were given an opportunity of concentrating the bulk of their army on this front.

Although the Italian left had at first to retire in the Adige Valley under the intense Austrian artillery fire yet finally it was able to hold up the Austrian advance at Ala (on the Adige) and at Pasubio further east. The Italians thus remained masters of the routes in the Adige Valley leading to Verona. The Italian centre, between the Terragnola and Astico Valleys, was at one time in extreme jeopardy. The intensity of the Austrian artillery fire caused the Italians to give ground and whilst they were doing so Austrian infantry deployed in considerable strength and forced the Italians to continue their retreat; on the 19th May, 1915, they reached Cimone, north of Arsiero. The retirement was continued towards the end of the month, and the Austrians very nearly succeeded in reaching the plains. However, the Italians in spite of the violence of the further Austrian attacks held on to their ground and checked the further advance of the enemy.

On the high plateau of the seven communes north of Asiago, the Italians were also obliged to abandon their first-line defences. On the 21st May, they retired to their second line at Mont Verena on the Campolong summit and later to the slopes of the Val d'Assa and those north of Roana. The Austrians were not able to continue their attacks, so that the Italians finally established themselves on the line Monts Pau and Magnaboschi and the heights south and east of Asiago. The situation which was a critical one for the Italians changed for the better on the 10th June, 1915. The possession of the region about Asiago by the Austrians would have enabled them to turn the Italian positions along the Val Sugana and to cut off all communication between the positions in question and the plain between Thienne and Bassano.

The Italian right was astride the Val Sugana, in the neighbourhood of Roncegno. Here also the Italians gave ground gradually and retired at first to their second line, Civaron-Telbe. On the 25th May, just at the time when the Dodici summit was abandoned by the Italian centre, their right was withdrawn still further to the eastward of the second line last referred to.

The Austrians attacked the Italian positions to the north of Asiago on the 26th May; the Italians in their turn counter-attacked and the operations in this region then came to a standstill also.

The author of the *Revue* article considers the operations on the Trentino front of special interest to the Swiss Army as containing valuable lessons in mountain warfare of the kind which this army might have to undertake.

The success which attended the first push of the Austrians was the natural sequel to the decision taken by them to launch the offensive at a time selected by themselves and in accordance with a programme prepared by themselves. The whole campaign bears the stamp of having been worked out with great exactness. The formidable Austrian offensive was met with skill and energy by the Italians in their defensive positions. Without losing sight of the necessity of holding the Austrians in the mountain regions, the Italian High Command concentrated a field army in the plains, ready to play its part should it be required to do so. Some idea of the magnitude of the task carried through by the Italian General Staff may be gathered from the fact that it involved the movement of half a million men, 75,000 animals and 15,000 vehicles, without taking into consideration the transport of enormous quantities of food supplies, stores and ammunition.—(*To be continued*).

THE INSTRUCTION OF INFANTRY IN BATTLE TACTICS.

Instruction.

The article begun in the number of the *Revue* for March, 1917, is concluded in the issue under review (*vide R.E. Journal* for July).

The author of the original article considers that the basis of instruction in the Swiss Army should be drills rather than manœuvres. To leave no doubt as to what he means a definition clause is added by him: "To drill is to repeat a movement, an evolution, a deployment, until perfection in execution of the same is obtained. To manœuvre is to apply in practice the lessons learnt at drill."

What, in Switzerland, is referred to as "company drill" consists, according to the author of the original article, as a rule in giving out some general idea, which starts with an advance guard or outpost scheme and develops into an extension for the attack or the execution of a deployment. A criticism on the exercise follows; this criticism may be sound but does not, it is suggested, teach either the men or their leaders how to correct the mistakes made. It is stated that all the failings of the Swiss infantry arise from the fact that they are not sufficiently well drilled.

Every situation arising at manœuvres requires a long explanation, whereas what is wanted is a series of short episodes, which can be repeated until the machine works quickly and correctly. The author gives schemes of instruction for the individual soldier, the group, section and company. The principal points to which attention is drawn are the following:—

I. *The Instruction of the Individual Soldier.*—Practical and theoretical instruction must proceed simultaneously. As examples in practical instruction the soldier should be taught :—

(*a*). To make the best use of the features of the ground and to handle pioneer tools for the purpose of assisting him in the advance.

(*b*). To make the best use of his weapons at short ranges so as to assist him in the advance.

(*c*). To acquire skill in the use of the bayonet.

(*d*). To throw hand grenades properly.

II. *The Instruction of the Group.*—Some variety, it is suggested, should be introduced in the instruction now given by introducing incidents from the present War.

As examples the following exercises are suggested :—

(1). A group of bombers may be made to advance, under the protection of the fire of the remainder of the section (imaginary), and on arrival within throwing range, the group should make a bombing attack on the enemy.

(2). The group may be supposed to belong to the second wave and should be made to take cover, so as to avoid casualties from artillery fire directed at the first wave.

(3). The group may be employed on a "cutting out" adventure against imaginary hidden enemy machine guns.

(4). The group may be supposed to be nearly cut off in an isolated commanding position and should be withdrawn into a less dangerous position so as to gain time for the remainder of the company to come into action.

(5). The group may be employed on "sniping" expeditions.

III. *The Instruction of the Section.*—The points requiring special attention, in the opinion of the author of the original article, are :—

(*a*). The need for rapidity in taking up extended order formations.

(*b*). Skill in utilizing the features of the ground during an advance.

(*c*). Fire discipline.

(*d*). The delivery of the assault.

(*e*). In defence practices, the main thing is to teach a section to remain concealed as long as possible, and then suddenly to pour in heavy fire against a flank of an imaginary attacking force.

IV. *The Instruction of the Company.*—Small incidents or short phases of a battle should, it is suggested, be continually practised. The points requiring special attention are the same as those stated above in relation to the instruction of the section.

The author of the *Revue* article gives details of a number of incidents, etc., which may be practised.

V. *Co-operation with Machine Guns.*—Co-operation between infantry and machine-gun detachments is of the utmost importance. Instruction should be afforded in the co-operation between a section of infantry and a machine-gun detachment (*a*) during the advance from long and medium ranges and (*b*) in fire discipline.

Similar instruction should also be provided in relation to the co-operation between a company of infantry and machine-gun detachments.

VI. *Co-operation of the Several Arms of the Service.*—Owing to the importance of very close co-operation between the several arms in actual war, the necessity for combined training is more necessary than ever before. The author of the *Revue* article urges that even in combined training, the exercises carried out should be in the nature of drills and should not consist of manœuvres. Different phases of the attack, the counter-attack and the defence of positions should be executed as drills, full use being made for the purpose of all the most modern devices with which armies are to-day equipped.

NOTES AND NEWS.

International News.—A reference is made to the entry of the United States of America into the great conflict of arms that has now been in progress for nearly three years. It is felt that the entry of the United States of America into the War is likely to make the position of neutral Switzerland at a Peace Conference one of considerable difficulty. The national conscience of Switzerland is torn by two conflicting forces, one impelling the Swiss to act honourably by their treaty obligations and the other demanding that steps shall be taken to safeguard the future interests and existence of the Confederation. Some anxiety is felt that the European States may not, *in 1918*, so readily accommodate themselves as they did in 1815, to acknowledge the state of Perpetual Neutrality by which Switzerland feels herself bound.

It is suggested that now Russia has got rid of an autocracy to the advantage of her people and the United States of America has come into the conflict for the protection of the rights of her people, whilst the Prussian Government has had to admit a check in relation to measures under discussion concerning the prime rights of the Prussian citizens, the signification of the Great War becomes clearly visible. It is a War for the emancipation of democracy. It is rapidly becoming apparent to all in Switzerland that in the defeat of the Central Powers lies the safety of the Swiss Confederation.

The opinion is expressed that we are in sight of the end of the War and also that the Central Powers have been virtually defeated. The War represents a conflict between bureaucracy and liberalism, and it is bureaucracy that must go under.

It is pointed out that President Wilson is above all things a pacifist, but now that his country has been forced into the War he is determined to employ all the resources of the American Continent to fight not the German people but the German Government. He typifies the perfectly logical man. President Wilson's attitude, or rather his pacifism, forms an interesting and comforting contrast to that of the Russian extremists. The former's pacifism is that of an educated person, familiar with the lessons of history, who does not allow his humanitarian instincts to lead him to adopt a line of conduct which would completely overlook the realities of the situation, that is to say a pacifism which would make him an accomplice of evil doers. The pacifism of the Russian extremists, on the other hand, is the pacifism of ignorami. The intentions of these extremists may be of the best, but these extremists are steeped in mysticism ; and mysticism never yet was born of good sense. It is felt that the Russian extremists belong to that category of pacifists which wrecks nations and brings down misfortunes on their own heads and numberless others in a position similar to their own. This kind of pacifism has been seen in different guises in France, where it contributed to the lack of preparations existing in 1914, in spite of the teachings of 1870. Great Britain did not escape from its wiles, and pacifism might have brought about the downfall of the British Empire had not the Germans themselves applied the whip to the British conscience by invading Belgium. History teems with records of the mischief done by a certain kind of pacifism. Pacifism is good or bad, according as it is the attitude of a person with a clear brain and educated intelligence or that of a person with an illogical and unreasoning mind.

SUPPLEMENT.

A further part of the Supplement entitled *L'Occupation des Frontières par les Troupes Suisses en* 1870—1871 is issued with the number of the *Revue* for April, 1917.

Chapter III. relating to the Defensive Period (January and February, 1871) is continued in this part. This chapter deals with the " Occupation of the Western Frontier." The Federal Council seems to have formed the opinion that Bourbaki would withdraw his Army into Belfort. On the 17th January, 1871, the available troops of the Swiss 5th Division were called up for service; one of its infantry brigades and one of its artillery brigades had already been incorporated into the 3rd Division. The Headquarters of the 5th Division were established at Basle. On the following day the Commander of the Swiss Army, General Herzog, requested the Federal Council to send the troops of the 5th Division to Basle, and at the same time recommended that the 4th Division should be mobilized and concentrated at Bienne as a reserve. The move of the 5th Division to Basle was approved, but the Federal Council postponed their decision regarding the mobilization of the 4th Division.

Bourbaki had about this period ordered the French 24th Corps to occupy the Lomont Heights, in order to cover the plateaus adjacent to the great loop of the Doubs. After the battle on the Lisaine had finished, fighting between the French and German troops still continued for some days in the region contiguous to the Swiss frontier near Porrentruy, and, in consequence, on the night of 18th January, 1870, the French peasants in this region fled from their homes into Switzerland.

On the following morning thousands of refugees arrived at Porrentruy, where they were lodged and cared for by the Swiss. The situation was, however, one that caused much embarrassment to the Swiss military authorities.

General Herzog, having established his Headquarters at Basle on the 20th January, immediately wrote to the Swiss Government pointing out that the object the Germans had in view in acting on Bourbaki's left flank was to force the French troops into Switzerland.

The troops of the Swiss 5th Division commenced to arrive at Basle on the 21st January; at the same time definite information reached the Headquarters of the Swiss Army regarding Bourbaki's retreat. It became clear that the part of the Swiss frontier now most menaced was that in the region of Neuchatel and that there was no longer need for anxiety regarding the Basle frontier · in consequence, the Swiss

5th Division was moved, on the evening of the date last mentioned, to Laufon (half-way between Basle and Delemont).

The situation had now so completely altered that orders were issued for the Swiss 4th Division to mobilize; four companies of Carbineers (of the Vaud) and a company of Guides (of Geneva) were also called up.

The Headquarters of the 4th Division were established at Chaux de Fonds (about 8 miles north-west of Neuchatel), and the units of the Division were located at various points in the Franches Montagnes and in the Juras north of Neuchatel; the positions selected being all occupied by the 27th January.

A collision now appeared imminent between a French Division that had arrived on the 20th January at Pont-de-Roide (about 17 miles west of Porrentruy) and German reinforcements which had arrived at Delle and Croix. The inhabitants of Abbevilliers, taking alarm, moved in a body into Switzerland.

Precautionary steps were taken, on the 23rd January, along the frontier by the Swiss military authorities in anticipation of a fight between the French and German troops, but no collision occurred in the neighbourhood of the Porrentruy frontier.

On the date last mentioned, the Swiss 5th Division was echeloned along the Delemont Valley and on the same day General Herzog established his Headquarters at Porrentruy. A few days later Von Manteuffel, having occupied Dôle, cut the direct communications between Besançon and Lyons. Reports reached the Swiss Headquarters on the 26th January to the effect that the whole of Bourbaki's Army was retiring on Pontarlier. The Commander of the Swiss Army at once adopted measures to meet this situation. The situation was now becoming critical and orders were given for the Swiss 4th and 5th Divisions to move to their left immediately, so as to cover the Neuchatel frontier more effectually. These movements were in progress when information arrived that a French force, estimated at about 40,000 men, had arrived at Morteau (about 12 miles south-west of Chaux de Fonds). Swiss troops were in consequence hurried to the neighbourhood of Locle (nearly opposite to Morteau) and other movements were also ordered.

On the evening of the 26th January, the Federal Council warned the Cantonal Authorities to arrange for the accommodation of 10,000 prisoners of war in the barracks at certain places named, and at the same time issued instructions regarding their treatment and the provision of guards.

The movements of Bourbaki's troops were from time to time met by alterations in the dispositions of the Swiss Army.

On the morning of the 28th January, a staff officer of the Swiss 12th Brigade had gone, in plain clothes, to Pontarlier in connection with a difficulty which had arisen in relation to a contract for the purchase of salt by the Cantonal Authorities of Neuchatel. He naturally took advantage of the opportunity to glean what information he could. He ascertained that there were 70,000 French soldiers in and around Pontarlier under General Clinchant, who had succeeded Bourbaki. He formed the opinion that some of these troops were still in a condition to give a good account of themselves, but that the greater part of them were utterly demoralized. The view was, he found, generally held that this French force would march into Switzerland. The increase in the number of French troops on the Swiss frontier led the Cantonal Authorities of the Vaud, on the 28th January, to call out the Militia in the frontier towns and villages of the Canton.

On the evening of the 28th January, General Herzog received information that a force of 120,000 French soldiers was in and about Pontarlier and that this force was marching southward on Mouthe with Von Manteuffel's troops on its heels. It was now felt that practically the whole of the Swiss western frontier as far south as Geneva was menaced, but that the situation at Porrentruy and Franches Montagnes had eased considerably. The Commander of the Swiss Army, in consequence, decided to move troops from his right wing to support the centre and left of the 4th Division (Headquarters, still at Chaux de Fonds). On the 29th January, the Headquarters of the Swiss Army were moved to Neuchatel, and certain changes took place in the dispositions of the 3rd, 4th and 5th Divisions to meet the latest situation on the frontier.

On the day previous to that last mentioned information had been received concerning the armistice concluded between the belligerent forces. In consequence, orders were issued that no French soldier was under any pretext to be allowed to enter Switzerland. In order to ensure the execution of these orders strong guards (found by the local Militia) were posted on all the frontier roads. An agreement was, at the same time, arrived at between Generals Herzog and Clinchant in this matter and the latter arranged to post guards also on his side of the frontier. However difficulties arose as large bodies of deserters and others suffering from smallpox crossed the Swiss frontier into Verrieres. The infectious cases were taken to Neuchatel and arrangements were at once made for the establishment of a quarantine station, under the Swiss Military Authorities, at Verrieres to deal with future cases.

On the morning of the 31st January the officer in command at Verrieres received information that Von Manteuffel declined to recognize the armistice as applying to the French Army of the East, and from a second message he learnt that a long column of French artillery was advancing on Verrieres and had already arrived to within 3 miles of the frontier. He at once blocked the roads and railways by placing his troops in position; at the same time, he sent an orderly officer to interview the French Commander; the French column was then within a quarter of a mile of the frontier. A French officer (of high rank) came up to the frontier to meet him and stated that he had received no orders as to entering Switzerland, or not, from higher authority; however, he halted his force, in order that instructions might be sought from the Headquarters of the Swiss Army. Shortly afterwards instructions were received from General Herzog stating that if the French troops were driven back by the Germans they were to be allowed to enter Switzerland, but they were to be required immediately to lay down their arms. The French Commander on the spot hesitated to give the necessary undertaking to disarm his men. Whilst these negotiations were in progress, General Clinchant's senior A.D.C. arrived on the scene and asked to be taken to the senior Swiss officer at the nearest Headquarters. He came to enquire on behalf of his Chief whether in the event of the French Army retiring into Switzerland, it would be possible for the Swiss Authorities to feed these troops. During the interview the roar of artillery could be distinctly heard; an engagement between the French and Germans was in progress only a few miles distant.—(*To be continued*).

W. A. J. O'Meara.

Rivista di Artiglieria e Genio.

October, November, and December, 1916.

Résumé of Military Operations from August to September, 1916.

The capture of M. Sabatino and of M. S. Michele being assured it only remained to possess the bridgehead of Gorizia and complete the storming of the imposing rampart on the heights immediately west of the city. The battles, sanguinary and incessant, were continued up to the 8th August. The broken and intricate nature of the ground, the numerous and powerful lines of defence erected by the enemy, the vicinity of Gorizia, a conspicuous centre for the enemy's resources, facilitated a tenacious defence, and assisted them in making violent counter-attacks. Step by step at the price of great sacrifices, the Italian infantry, with unceasing co-operation of artillery, gained the whole of the difficult ground, storming one by one the numerous trenches, surrounding and compelling the surrender of the enemy, and repelling violent counter-attacks.

The Tuscan Brigade (77th and 78th Regiments) and the 143rd and 144th Regiments of the 48th Division distinguished themselves by manœuvring in rear of the enemy's lines on T. Peumica and on the hill overlooking the village of Peuma, thus determining its capture. Other not less heavy counter-attacks of the enemy, preceded by powerful bombardment, were repulsed by the brave defenders of M. Sabatino and M. S. Michele.

On the afternoon of the 8th August owing to the victorious action of the Italians all the heights to the right of the Isonzo, with the bridgehead of Gorizia and the M. S. Michele on the left of the river, were in possession of the Italians. The lines of the Isonzo and the valley of Tolmino were entirely assured. At dusk, detachments of the Brigade-Casale and Pavia passed on to the Isonzo Ford, the bridges of which the enemy had damaged. A column of cavalry and of bersaglieri cyclists was sent in pursuit. Under the enemy's fire detachments of engineers speedily constructed bridges, and repaired those damaged by the enemy.

On the morning of the 9th August the Italians entered Gorizia while a column of cavalry and cyclists traversed the plain around the city, dispersing the last resistance of the enemy. On the 10th Italian infantry occupied the western slopes of the heights near Gorizia, and the lines of Vertoibizza more to the south.

The capture of Gorizia deserves to be considered as one of the finest military operations of Italy. In three days, the most important of the enemy's fortifications on the Isonzo front fell into her possession. It may be opportune to relate that during peace time Austria had always guarded Gorizia with the greatest care, especially during the time of Italian neutrality. Its value had been increased with defensive works, and the experience of the first months of the European war had rendered it formidable. On the declaration of war by Italy, strong and imposing forces had been concentrated at Gorizia by the enemy, who as attested by the prisoners, were under the illusion that the great endeavours made by the Italians to arrest the Austrian invasion in the Trentino would for some considerable time exhaust their offensive capacity.

In consequence the manœuvres by internal lines on the Isonzo front which were conducted with rapidity, precision, and secrecy, were responsible, on the morning of the 6th August, for the Italian offensive breaking in full violence against an enemy morally unprepared. The efficacy of the counter-attacks on Monfalcone completed the surprise.

On the same date the action of the Italian artillery showed a really classical example of concentration of fire against fortified lines. It was most minutely studied and prepared. Thanks to the exploration of the ground by aeroplanes, patrols, and optical observations, the enemy's positions were perfectly known and drawn on the map; the targets accurately distinguished in extension and in depth, and the range of fire established with scrupulous precision. In consequence, at a fixed moment, a storm of iron and fire was hurled unexpectedly on the enemy's positions, overthrowing the defences, beating down the parapets, destroying the stations and observatories, and thus interrupting communications. The advance of the Italian infantry was magnificent. After three days of unceasing action under the concentrated and violent fire of the enemy's artillery, mitrailleuses, and bombs, they overthrew the successive lines of the enemy's resistance, bayoneting the defenders, and strongly sustaining the intense bombardment and furious counter-attacks of the enemy.

The Storming of the Lines of Carso beyond Vallone.

On the day of the 6th August whilst on the southern margin of the Carso the Italians captured M. St. Michele in the zone of Montfalcone, and the 3rd and 4th Battalions of bersaglieri cyclists seized the heights of Quota 85, resisting several violent counter-attacks of the enemy. During the following days, up to the 9th, the enemy made desperate efforts to retake the position M. St. Michele; but each time was energetically repulsed, and also lost the village Boschini strongly fortified on the southern slopes of the mountain. Further south the Italian infantry stormed some trenches near S. Martino del Carso. On the 10th a vigorous assault was made against all the strong enemy's lines between Vippacco and M. Cosich, which was crowned with full success. The enemy in rout abandoned all the zone west of Vallone, maintaining only strong rear guards on the heights of Debeli and of Quota 121. Several other important places were occupied by the Italians. On the 12th the crest of Nad Logem, which was obstinately defended, was stormed by the valorous troops of the 23rd Division (Sardinian Grenadiers Brigade), Lombardy Brigade, 73rd and 74th Regiments, Catanzan Brigade, 141st and 142nd Regiments. At the same time the Italian troops seized upon Oppacchiasella and pushed forward to the occupation of about a kilometre east of that locality. Finally, on the southern margin of the Carso, the heights of Quota 121 and of Debeli were captured by the Italians. On the following days, up to the 15th, very sharp actions continued with notable success to the Italians, who broke through lines of trenches east of Nad Logem and on the western slopes of M. Pecinka. After this, the operations, here as well as in the zone of Gorizia, were carried on in a methodical manner, owing to the necessity of reinforcing the troops and services, and systematizing the defence of the occupied positions, arranging positions for the artillery, and improving the communications. The work was disturbed by frequent storms which rendered difficult the conditions of camp life. During the operations from the 4th to the 15th August 18,758 prisoners, of whom 393 were officers, 30 guns, 63 bomb throwers, 92 mitrailleuses, 12,225 rifles, 5 million cartridges, 3,000 rounds for artillery, 60,000 bombs, and a rich booty of war material of every kind were captured from the enemy.

If the capture of the bridgehead of the town of Gorizia constituted a military event of the first order, the storming of the zone to the west of the lines of Vallone was of no less importance. The plain of Carso Goriziana dominated the smaller plains of the lower Isonzo up to Cormous and Gorizia, on the one side as far as the sea, and on the other to a formidable position protected by the deep depression of the Isonzo, improved on the flanks by the formidable bulwarks of S. Michele a Nord, Cosich, Debeli and Quota 121 to the south. The surface of the higher ground, broken by numerous shell holes, and undulating thus, created an intricate network of trenches, deeply excavated in the rocks, and furnished with numerous lines of barbed wire, which gave rapid and secure positions to the troops on the defensive. It was said that the Austrians considered that it was impossible for this complete and perfect position to be captured.

Operations on the Remaining Fronts.

During the period under consideration small operations of a diverse nature took place on the Stelvio with a view of improving the local occupations and preparing for a vast offensive. Those of greater importance were carried on in the steep and elevated mountainous zone between Avizio and the T. Vanoi-Cismon.

On the 21st the Italian columns advanced in the direction of Cima Cece and captured the important heights of Quota 2354 further to the south. On the night of the 23rd the enemy, by a violent attack, succeeded in retaking the position, but our counter-attack finally drove them out. Further to the south-west, Alpine detachments of the Feltre and M. Rosa Battalions, supported by a mountain battery, commenced an attack on the mountainous crest at the head of T. Vanoi (Cismon-Brenta). Overcoming the difficulties of the steep ground, the enemy's strong defences, and the bad weather which often prevented artillery action, they succeeded on the evening of the 27th August in storming the summit of Cauriol between steep rocks, at a height of 2,485 metres. On the following days the operations were extended along the crest north-east of Cauriol. The enemy soon concentrated a violent fire of artillery against the Italian positions and on the 3rd September launched two violent attacks. The Alpines of the Valle Brenta Battalion arrested the attacks each time, and finally broke through the trenches and dispersed the enemy, inflicting heavy losses.

Owing to the altitude and the steepness of the ground, the offensive earth to settle and the smoke to vanish; when factories have to be blown up it is necessary to wait a little to avoid accidents that might occur from falling material such as beams, stones, etc. These however would be of slight importance in view of the losses that would be incurred from the enemy's fire, especially of mitrailleuses, if he should be left time to recover from the surprise of the explosion.

The attacking infantry should be accompanied by bombers with the usual scope of overcoming the eventual resistance on the part of the adjacent trenches, and to constitute defences for the flanks.

7. *Premature Firing of Mines.*—It is necessary to be careful to avoid firing mines before the moment at which they would have good effect; otherwise, the enemy would not be disconcerted and would again occupy the craters formed. The frequent explosion of the enemy's mines executed prematurely when they were still at a distance from our lines, are stated, perhaps rightly, to have been caused by panic and demoralization.

8. When the enemy has exploded a mine prematurely, possibly from nervousness, or it may be to render the ground unusable for mining work, the best method is to direct a gallery towards it so as to gain possession of the crater, and to turn around it and proceed.

9. When the enemy has exploded two mines at a certain distance from each other, it is best to wait until he pushes forward a gallery between the two craters; in this case it is advisable to arrange small mines in the branches of the gallery that may be formed in that direction, and to proceed with the work of excavation of the main gallery.

10. *Listening Service.*—The man on guard, listening in the galleries, should be free from all equipments, experience teaching that it is necessary to avoid the smallest sounds which might be mistaken for work far from the mine. The listening service should be carried on at determined intervals and amidst absolute silence, and immobility of everyone found in the gallery.

11. It should not be forgotten that after the explosion of a mine the gallery leading to it remains still utilizable up to 2 or 3 metres from the crater; in occupying a crater formed by the explosion of the enemy's mine it is advisable to be content with holding the extremity nearest to our positions, until listening galleries can be pushed forward.

12. It may be necessary for the listening services to excavate deep pits with short branches for listening galleries; in other cases the construction of blind galleries is sufficient.

13. When it is known that the enemy is engaged on mining work but has no indication of the direction of the attack, the listening galleries should be connected laterally at about 20 metres from our trenches.

14. In all the listening galleries when it is known that the enemy is working at mines or countermines in the vicinity, holes should be perforated about 15 to 25 cm. in width and 4 to 5 metres in depth for the purpose of placing and exploding charges of from 22 to 44 kg. of explosives. For this purpose there should always be about 100 kg. of explosives in readiness.

15. Listening galleries should never be left without sentries.

16. Long galleries may be excavated to a length of about 270 m.; where galleries have to be made of this length it is preferable to make

them deep, so as not to run the risk of meeting the enemy's countermines, or of sustaining losses from the fire of guns of heavy calibre.

17. In long galleries a small binary should be used with little cars to accelerate the removal of the earth.

18. Where it may be necessary to abandon temporarily part of a long gallery it is necessary to place and explode a charge to prevent the enemy from breaking through, and the side towards the enemy should be closed by sandbags so arranged that when the enemy removes them he closes the circuit of an alarm bell and automatically causes the explosion of the charge.

19. A straight gallery on a level plane requires less ventilation than an uneven gallery with turns; in a well-constructed gallery one ventilator every 30 m. is sufficient, while in a badly constructed gallery in similar ground a ventilator is required at about every 12 m.

20. For rapid progress the first half or two-thirds of the gallery should be 1·20 m. in height for about 1 m. in width at the base.

21. In the construction of a gallery in argillaceous dry soil, where few beams are required to sustain the earth, it may be possible to give an elliptical shape which sustains itself and the following system may then be employed :—Eight miners work for a relief of eight hours alternating by squads of four each hour; in the squad one digs, a second splays the earth, and the other two fill the sandbags taking it thus in turns so that the miner at the head being frequently changed can work with energy. Fatigue parties of infantry carry the sacks to the mouth, forming a chain, and emptying them in old trenches, in craters, etc., in places concealed from view, carrying back the empty sacks. The progress of excavation is a little more than 7 metres a day with a maximum of about 12 m., and a minimum of 5·5. When it is necessary to support the excavation a frame should be placed at each 1·20 to 1·80 m.

22. It is necessary to remember that excavation in blue argillaceous soil requires little or no framing, but after some time the consistency of the earth diminishes and produces looseness and landslips where there are no supports; when this process of dissolution commences great movements of strata may be produced. In yellow soil this does not take place to the same degree.

23. *Ventilation.*—In long galleries exceeding 90 m. when the air in the galleries becomes foul it is necessary to renew the air by a ventilating fan or bellows. Two of these instruments may be united by a tube for conducting the air and connected by the necessary metal joints.

24. When the gallery is of considerable length, or more than 100 m., ventilation may be increased by means of a small stove placed in a pit at the end of the gallery to promote a current of air. In this case it is necessary to ensure that the smoke from the stove should be carried away outside by means of a good pipe or chimney.

25. *Mineshafts.*—When in progress of mining, as for example an attack on a salient, two long galleries are provided; it is not advisable to start both galleries from the same shaft, as the excavation for the shaft requires longer time and presents greater difficulties than that of the galleries.

26. *Removal of the Excavated Soil.*—In good soil the excavation proceeds more rapidly than the removal of the earth. To facilitate this

the best plan is to make smooth the floor of the gallery and to draw the bags of earth along this by ropes attached to small cars up to the shaft where a man can liberate the full sacks from the ropes. This system avoids all noise and reduces the number of men employed in the gallery and gives greater rapidity of work than by the passage of the sacks from hand to hand.

27. *Borers.*—Boring instruments—"Burnside"—noiseless, for perforations of 15-cm. diameter can be used where the ordinary system of opening out galleries is not convenient owing to the small depth of the excavation, or for want of time; from the more advanced point of the gallery several perforations are made at suitable angles to arrive under the enemy's trenches. With these boring instruments perforations of 9 m. or more can be made with a rate of progress of from 1·8 to 2·4 m. per hour.

28. *German Mine System.*—The German system does not differ greatly from ours, but they make greater use of borers of which there are two types but with these they are not able to perforate beyond 17 m. owing to the inclination of the bore to the horizon being such that a greater distance is not feasible.

Suggestions from the Experience of the Present War.

29. *Mine Galleries.*—It is preferable to attack points of the enemy's trenches between the openings of two communication trenches. Such points should be ascertained and the galleries directed towards these points and then if there is time the heads of the two galleries should be connected with another transverse gallery and the charges placed in diverse points under the enemy's trenches. The mines that correspond with the positions of the communication trenches should be first exploded so as to prevent the arrival of reinforcements. It is essential that this work should be placed in the hands of skilled sappers.

30. *Countermines.*—Men should be selected for the purpose of listening for the work of the enemy's miners; they should be practised for listening in our own mining works.

In tracing listening galleries, it is well to remember that the probable direction of the enemy's galleries is towards our communication trenches. Countermining work requires more skill than mining work; attempts at the former work made by less practised miners have not been successful.

Examples of Mine Exploding.

A.—Depth of shaft 4·8 m.; length of gallery about 71 m.; distance of mine cavity from the enemy's trenches from 1·5 to 3 m.; the charge is about 450 kg. of guncotton, placed in a mine cavity of $90 \times 90 \times 90$ cm. at the head of the gallery; the tamping consisted of a first solid banking of sandbags of about 2 m. in thickness and a similar second one distant 1·5 m. from the first and about 45 cm. in thickness. The explosion destroyed 72 m. of German trenches.

B.—Depth of shaft 4·8 m.; length of gallery about 66 m.; charge 292 kg. of gunpowder, in a cavity of $60 \times 90 \times 90$ cm. The tamping consisted of three bankings; the first 2·10 m. in thickness, the second distant 1·2 m. from the first 1·5 thick; the third 1·5 m. from the second, 1·5 in thickness. This effected the destruction of the mouth of the communication trench and overturned the trench for about 27 m.

E. T. THACKERAY.